Genex Power Ltd
11-Jan-2019

Kidston Pumped Storage Hydro Project

Impact Assessment Report

Kidston Pumped Storage Hydro Project

Impact Assessment Report

Client: Genex Power Ltd

ABN: 18 152 098 854

Prepared by

AECOM Australia Pty Ltd
Level 5, 7 Tomlins Street, South Townsville Qld 4810, PO Box 5423, Townsville QLD 4810, Australia
T +61 7 4729 5500 F www.aecom.com
ABN 20 093 846 925

11-Jan-2019

Job No.: 60544566

AECOM in Australia and New Zealand is certified to ISO9001, ISO14001 AS/NZS4801 and OHSAS18001.

Quality Information

Document Kidston Pumped Storage Hydro Project

Ref 60544566

Date 11-Jan-2019

Prepared by Tim Wallis, Reece Fraser

Reviewed by Nicky Lee, James Tuff, Dr Mohand Amghar

Revision History

Rev	Revision Date	Details	Authorised	
			Name/Position	Signature
0	28-Aug-2018	Draft for Genex Review	Rouven Lau Associate Director - Environment	
1	31-Aug-2018	Draft for OCG Review	Rouven Lau Associate Director - Environment	
2	25-Oct-2018	Final for Genex Review	Rouven Lau Associate Director - Environment	
3	31-Oct-2018	Final for OCG Submission	Rouven Lau Associate Director - Environment	
4	15-Nov-2018	Revised Final OCG Submission	Rouven Lau Associate Director - Environment	
5	6-Dec-2018	Revised Draft Issued to Specialists to Amend	Rouven Lau Associate Director - Environment	
6	11-Jan-2019	Revised Final OCG Submission	Rouven Lau Associate Director - Environment	

Table of Contents

Executive Summary i
Acronyms i
1.0 Introduction 1
2.0 Background 2
2.1 Overview of the Project 2
2.2 Initial Advice Statement 2
2.3 Approvals Context 2
2.4 Other Project Aspects 3
2.5 Community and Stakeholder Consultation 4
3.0 Assessment Approach 5
3.1 Methodology 5
3.2 IAR Structure 5
4.0 Activity Description 8
4.1 Project Description 8
4.1.1 Construction Phase 10
4.1.2 Release Infrastructure 11
4.1.3 Operational Phase 13
4.1.4 Rehabilitation 13
4.1.5 Timeframe for the Project 13
4.2 Project Need, Justification and Alternatives Considered 14
4.2.1 Project Objectives 14
4.2.2 Design Refinement and Assessment of Alternatives 16
4.2.3 Design consistency with Management Hierarchy for Surface or Groundwater (EPP Water) 22
4.3 Kidston Site Overview 25
4.3.1 Existing Kidston Site Water Management 25
4.4 Pit Water Quality 28
4.4.1 History of Pit Development 28
4.4.2 Pit Water Quality Assessment 31
4.5 Project Water Balance 39
4.5.1 Overview 39
4.5.2 Water Balance Metrics 39
4.5.3 Base Case – Estimated Water Excess and Deficit 40
4.5.4 Unmitigated Case – Estimated Uncontrolled Releases 40
4.5.5 Project Water Balance Summary 42
4.6 Requirement for Water Releases 43
4.6.1 Operational Phase Water Release Objectives 43
4.6.2 Construction Phase Water Release Objectives 43
4.7 Proposed Water Release Approach 44
4.7.1 Release Event Type 1 - Controlled Discharges to Maintain Water Levels 44
4.7.2 Release Event Type 2 – Pass-Through Discharge 44
4.8 Representative Release Water Quality 50
4.8.1 Pit Water Mixture Calculation 50
4.8.2 Sensitivity Analysis for Mixed Releases from Both Pits 50
4.8.3 Release Water Quality 51
4.9 Release Water Toxicity Assessment 54
4.9.1 Overview 54
4.9.2 Comparison to Historical Water Quality Ranges in the Pits 54
4.9.3 Dilution Water 61
4.9.4 Ecotoxicology Tests 61
4.9.5 Results 62
4.10 Unexpected Water Quality Changes 63
4.11 Replenishment of Freshwater 63
5.0 Baseline Receiving Environment 65

5.1	Overview	65
5.2	Copperfield River Catchment Overview	65
	5.2.1 Climate	65
	5.2.2 Geology & Soils	67
	5.2.3 Land Use	67
	5.2.4 Water Users	67
	5.2.5 Historical Releases	70
5.3	Surface Water Quality	72
	5.3.1 Sample Sites and Frequency	72
	5.3.2 Summary of Water Quality Statistics	75
5.4	Environmental Values	88
	5.4.1 Site Specific Environmental Values	90
	5.4.2 Site Specific Environmental Values Applicable to the Release Regime	101
	5.4.3 Management Intent	102
5.5	Default Water Quality Objectives	104
	5.5.1 Copperfield River Classification	104
	5.5.2 Default Water Quality Objectives	104
	5.5.3 Water Quality Data Protocols	111
5.6	Comparison of Baseline Water Quality and Default Water Quality Objectives	113
	5.6.1 Hardness Modification	114
	5.6.2 pH	115
	5.6.3 Sulfate	116
	5.6.4 Total and Dissolved Aluminium	117
	5.6.5 Dissolved Cadmium	118
	5.6.6 Dissolved Chromium	118
	5.6.7 Dissolved Copper	119
	5.6.8 Total Manganese	120
	5.6.9 Dissolved Zinc	122
	5.6.10 Total Iron	122
	5.6.11 Nitrogen	123
	5.6.12 Summary of Site Specific Water Quality Objectives	123
5.7	Comparison of Water Quality and Stream Flow	125
	5.7.1 pH	125
	5.7.2 Electrical Conductivity	125
	5.7.3 Zinc	126
	5.7.4 Other Parameters	127
5.8	Representative Water Quality Baseline Site (WB)	128
5.9	Hydrology	130
	5.9.1 Development of Water Resource Model	130
	5.9.2 Model Validation	133
	5.9.3 Streamflow Assessment	133
5.10	Hydraulics and Fluvial Geomorphology	139
	5.10.1 Stream Hydraulics	139
	5.10.2 Fluvial Geomorphology	142
5.11	Hydrogeology	144
	5.11.1 Previous Studies	144
	5.11.2 Regional Geology	144
	5.11.3 Local Geology	144
	5.11.4 Structural Geology	145
	5.11.5 Hydrogeological Setting	145
	5.11.6 Hydraulic Properties	145
	5.11.7 Groundwater Levels	145
	5.11.8 Groundwater Flow	145
	5.11.9 Recharge and Discharge	146
	5.11.10 Groundwater Quality	146
	5.11.11 Registered Groundwater Bores	149
	5.11.12 Groundwater Dependant Ecosystems	150
5.12	Sediment Quality	152

	5.13	Aquatic Ecology	160
		5.13.1 Approach	160
		5.13.2 Riparian Vegetation	163
		5.13.3 Aquatic Habitat Characteristics and Condition	164
		5.13.4 Physico-chemical Water Quality Parameters	164
		5.13.5 Macroinvertebrates	165
		5.13.6 Fish Communities	167
		5.13.7 Turtles	167
		5.13.8 Macroinvertebrate Findings	167
	5.14	Dry Season Copperfield River Field Survey	168
		5.14.1 Sample Sites	168
		5.14.2 Dry Season Water Quality Results	173
		5.14.3 Comparison against Post-2011 surface water quality dataset	177
	5.15	Summary	179
6.0	Impact Assessment – Operational Releases		183
	6.1	Approach	183
		6.1.1 Assessment of Dilution Ratio and Assimilative Capacity	183
	6.2	Water Quality Impact Assessment	191
		6.2.1 Near Field Mixing Zone Assessment (CORMIX)	191
		6.2.2 Far Field Assessment of Sustainable Load (Downstream Mass Balance)	199
		6.2.3 Assessment of Water Quality Impacts to Environmental Values	207
		6.2.4 Conclusions of Water Quality Impact Assessment	210
	6.3	Hydrology Impact Assessment	211
		6.3.1 Estimated Releases and Post-Release Flushes	211
		6.3.2 Discharge and Flow Duration	219
		6.3.3 Flow Spells	221
		6.3.4 Conclusions of Hydrology Impact Assessment	225
	6.4	Aquatic Ecology Impact Assessment	226
		6.4.1 Water quality	226
		6.4.2 Hydrology	226
		6.4.3 Erosion and Sedimentation	227
	6.5	Hydraulics and Fluvial Geomorphology Impact Assessment	228
		6.5.1 Hydraulic Impacts Assessment for Releases	228
		6.5.2 Fluvial Geomorphology	230
	6.6	Hydrogeology Impact Assessment	232
7.0	Impact Assessment – Temporary Construction Releases		234
	7.1	Approach	234
	7.2	Preliminary Construction Phase Assessment	234
		7.2.2 Constituents of Most Concern	237
	7.3	Water Quality Impact Assessment	242
		7.3.1 Near Field Mixing Zone Assessment	242
		7.3.2 Far Field Assessment of Sustainable Load (Mass Balance)	243
		7.3.3 Dissolved Zinc Mass Balance Results	244
		7.3.4 Assessment of Water Quality Impacts to Environmental Values	251
		7.3.5 Conclusions of Water Quality Impact Assessment	254
	7.4	Hydrology Impact Assessment	255
		7.4.1 Estimated Construction Phase Releases	255
		7.4.2 Estimated Construction Post-Release Flushes	259
		7.4.3 Conclusions of Hydrology Impact Assessment	262
	7.5	Aquatic Ecology Impact Assessment	264
		7.5.1 Water Quality	264
		7.5.2 Hydrology	264
		7.5.3 Erosion and Sedimentation	265
		7.5.4 Development of the Release Point	265
	7.6	Fluvial Geomorphology Impact Assessment	266
	7.7	Hydrogeology Impact Assessment	266
8.0	Risk Assessment		268

	8.1	Methodology	268
	8.2	Project Risk Assessment	269
9.0	Release Criteria and Monitoring		284
	9.1	Summary of Proposed Release Criteria	284
		9.1.1 Approach to Releases	286
	9.2	Monitoring	287
	9.3	Adaptive Mitigation Strategies	291
		9.3.1 Extending the Flushing Period through Asymmetrical Release Triggers	291
		9.3.2 Extended Flushing using Releases from the Copperfield Dam	291
		9.3.3 Cessation of Releases during the Dry Season	291
10.0	Summary		293
11.0	References		298
12.0	Standard Limitations		301

Appendix A
Receiving Environment Water Quality Charts A

Appendix B
Water Quality Statistics Table B

Appendix C
Pit Profiling C

Appendix D
Pit Water Quality Time Series D

Appendix E
Wet Season Aquatic Ecology Survey - 2018 E

Appendix F
DTA - May 2018 F

Appendix G
DTA - June 2018 G

Appendix H
AGE 2019 Groundwater Memorandum H

Appendix I
Draft REMP I

Appendix J
Eldridge Pit Water Quality Data – August 2018 J

Appendix K
Preliminary Construction Assessment K

Appendix L
Modelling Information L

Appendix M
Decision Notice M

Appendix N
Other Matters N

List of Tables

Table 1	Other Project aspects, applicable legislation and proposed management and mitigation measures	3
Table 2	Project Release Infrastructure	12
Table 3	Project Development Timeframes	14
Table 4	Summary of Options from the 2016 Workshop	18
Table 5	Review of the Proposed Design against Management Hierarchy for Surface or Groundwater (EPP (Water), Part 5, Sec, 13)	23
Table 6	Contaminant generation rates (mg/m^2 per day) sourced from (Australasian Groundwater & Enviornmental Consultants, Gilbert & Associates, Dobos & Associates, 2001)	30
Table 7	Pit water quality statistics (results are in mg/L unless otherwise stated)	32
Table 8	Parameters exceeding default WQOs in each Pit	37
Table 9	Base Case Annual Project Water Balance – Estimated Excess and Deficit	40
Table 10	Unmitigated Case – Uncontrolled Releases	41
Table 11	Event-Based Hydrologic Assessment Scenarios	46
Table 12	Event-Based Hydrologic Assessment of Buffer and Freeboard Compartment Capacity - Results	48
Table 13	Release Water Quality Assumptions	51
Table 14	Water quality of samples submitted for DTA analysis	57
Table 15	Occurrence and habitat of species subject to DTA	62
Table 16	Dilution ratios from DTA toxicity testing for different species protection levels	62
Table 17	Annual Rainfall Statistics - Kidston Gold Mine (30027), 1915 – 2002 (BoM)	66
Table 18	Timeline of releases	70
Table 19	Monitoring Locations used to Assess Baseline Quality of Copperfield River in Vicinity of Proposed Release Location	72
Table 20	Summary of Water Quality Data for Monitoring Site WB	76
Table 21	Summary of Water Quality Data for Monitoring Site W1	79
Table 22	Summary of Water Quality Data for Monitoring Site W2	82
Table 23	Summary of Water Quality Data for Monitoring Site W3	85
Table 24	Suite of Environmental Values that can be Chosen for Protection	88
Table 25	Catchment Areas	90
Table 26	Mapping Rules Used to Identify Potential Users of the Copperfield River	93
Table 27	Mapped Potential Water Users for the Copperfield River between the Proposed Release Zone and the Confluence with The Einasleigh River	96
Table 28	Surface Water Environmental Values Potentially Relevant to the Project Site	101
Table 29	Comparison of WQOs	106
Table 30	Hardness statistics for receiving water sites (all values mg/L)	115
Table 31	Hardness Modified Trigger Values	115
Table 32	80th percentile of dissolved and total aluminium at each site in the Copperfield River	118
Table 33	80th percentile of dissolved copper at each site in the Copperfield River	120
Table 34	80th percentile of total and dissolved manganese at each site in the Copperfield River	121
Table 35	80th percentile of dissolved zinc at each site in the Copperfield River	122
Table 36	80th percentile of Total Iron at each site in the Copperfield River	123
Table 37	Site-Specific Water Quality Guidelines	124
Table 38	Summary of Development of IQQM Model	131
Table 39	Water Plan (Gulf) 2007 Performance Indicators for Assessing Periods of Medium to High Flow at a Node (Copperfield River at Project Site)	134
Table 40	Flow Spells Assessment – Adopted Definitions	137
Table 41	Flow Spells Summary - All Years (Wet Season, Nov-Apr)	137
Table 42	Flow Spells Summary - Inter-Annual Summary (Wet Season, Nov-Apr)	137
Table 43	Hydraulic Model Parameters	139
Table 44	Regional Stratigraphy	144
Table 45	Registered groundwater bores within 10km of the proposed release area	149
Table 46	Summary of GDEs	150
Table 47	REs downstream Copperfield River	150

Table 48	All Sediment Results to Date for the Copperfield River	157
Table 49	In-situ physico-chemcial water quality results	165
Table 50	Dry Season Sample Locations	168
Table 51	Dry Season Copperfield River Field Survey Water Quality Results	174
Table 52	Dry Season and Post-2011 comparison of W1 and W3	177
Table 53	Information sources used to estimate dilution ratios and constituents of most concern	184
Table 54	Dilution ratios required to achieve WQOs	185
Table 55	Worst-Case Final Concentrations of Constituents in Receiving Environment (Operations Phase)	188
Table 56	Key CORMIX Assumptions	192
Table 57	CORMIX Scenarios Assessed	196
Table 58	CORMIX Scenario Results for Estimated Mixing Zones (CORMIX1 Single Port Assessment)	197
Table 59	Operational Phase Downstream Mass Balance Scenarios Assessed	200
Table 60	Operational Phase Downstream Mass Balance – Key Assumptions	200
Table 61	Scenario 1a – Downstream Mass Balanced Concentrations for Dissolved Zinc (Annual Simulation, Median Release Concentration)	201
Table 62	Scenario 1b – Downstream Mass Balanced Concentrations for Dissolved Zinc (Annual Simulation, maximum Release Concentration)	202
Table 63	Scenario 2a - Downstream Mass Balanced Concentrations for Dissolved Zinc (Life of Project (50 yr) Simulation)	203
Table 64	Scenario 2b - Downstream Mass Balanced Concentrations for Dissolved Zinc (Life of Project (50 yr) Simulation, Maximum Release Concentration)	204
Table 65	Operations Phase Mass Balance Results	206
Table 66	Potential Operations Phase Water Quality Impacts to Relevant Environmental Values	207
Table 67	Hydrology Impact Assessment Summary	211
Table 68	Scenario 1 - Annual Controlled Release Statistics (Annual Simulation)	212
Table 69	Scenario 1 - Post-Release Flush Statistics (Annual Simulation, Proposed Release Point)	214
Table 70	Scenario 1 – Post-Release Flush Ratios (Annual Simulation, Proposed Release Point to Einasleigh)	215
Table 71	Scenario 2 – Mean Annual Controlled Release Statistics (Life of Project (50yr) Simulation)	216
Table 72	Scenario 2 – Post-Release Flush Statistics (Life of Project (50yr) Simulation)	217
Table 73	Scenario 2 – Post-Release Flush Ratios (Life of Project (50yr) Simulation, Proposed Release Point to Einasleigh)	218
Table 74	Water Plan (Gulf) 2007 Performance Indicators – Baseline and with Releases	219
Table 75	Flow Spells Assessment – Adopted Definitions	221
Table 76	Flow Spells Summary - All Years (Wet Season, Nov-Apr, 1890 to 2017) - Baseline and with Releases	223
Table 77	Flow Spells Summary - Inter-Annual Summary (Wet Season, Nov-Apr) - Baseline and with Releases	224
Table 78	Estimated Changes to Rates of Rise and Fall	225
Table 79	Impact Scenarios Flows	229
Table 80	Hydraulic Impact Assessment Scenario Results (Mean Results for 200m Reach Downstream of the Proposed Release Point	230
Table 81	Guideline Values for Average Stream Powers, Velocity and Shear Stresses for Streams within the Bowen Basin (DNRM, 2014)	231
Table 82	Potential Impacts of Project Water Discharges	232
Table 83	Key Construction Phase Stages	236
Table 84	Proposed Temporary Construction Phase Release Conditions	237
Table 85	Worst-Case Final Concentrations of Constituents in Receiving Environment (Construction Phase)	238
Table 86	Construction Phase Downstream Mass Balance Scenarios Assessed	243
Table 87	Construction Phase Downstream Mass Balance – Key Assumptions	244

Table 88	Scenario 1a – Downstream Mass Balanced Concentrations for Dissolved Zinc (Eldridge Pit, Median Release Concentration)	245
Table 89	Scenario 1b – Downstream Mass Balanced Concentrations for Dissolved Zinc (Eldridge Pit, Maximum Release Concentration)	246
Table 90	Scenario 2a – Downstream Mass Balanced Concentrations for Dissolved Zinc (Mixed Pit Water Release, Medium Release Concentration)	247
Table 91	Scenario 2b – Downstream Mass Balanced Concentrations for Dissolved Zinc (Mixed Pit Water Release, Maximum Release Concentration)	248
Table 92	Scenario 3 Construction Phase Mass Balance Results – Releases from Eldridge Pit only	249
Table 93	Scenario 4 Construction Phase Mass Balance Results – Releases of Mixed Pit Water	250
Table 94	Potential Construction Phase Water Quality Impacts to Relevant Environmental Values	251
Table 95	Hydrology Impact Assessment Summary	255
Table 96	Construction Phase Controlled Release – Mean Annual Statistics	256
Table 97	Construction Phase Controlled Release – Wet Season (Nov through April) Statistics	256
Table 98	Construction Phase Controlled Release – Dry Season (May through October) Statistics	257
Table 99	Construction Phase Post-Release Flush – Annual Statistics	259
Table 100	Construction Phase Post-Release Flush – Wet Season (November through April) Statistics	260
Table 101	Construction Phase Post-Release Flush – Dry Season (May through October) Statistics	260
Table 102	Construction Phase Post-Release Flush Ratios – Annual Statistics	261
Table 103	Construction Phase Post-Release Flush Ratios – Wet Season (Nov through April) Statistics	262
Table 104	Construction Phase Post-Release Flush Ratios – Dry Season (June through October) Statistics	262
Table 105	Potential Impacts of Project Water Discharges	267
Table 106	Description of Sensitivity Criteria	268
Table 107	Description of Magnitude Criteria	269
Table 108	Significance Assessment Matrix	269
Table 109	Risk Assessment and Mitigation Measures	270
Table 110	Proposed Project Release Criteria	284
Table 111	Overview of Receiving Environment Monitoring Program	288
Table 112	Existing Eldridge Pit Water Quality Profiling (Entura, 2016)	C-1

List of Figures

Figure 1	Impact Assessment Approach	5
Figure 2	Schematic of pumped hydro storage (Hydro-Electric Corporation, 2018)	8
Figure 3	Kidston Project General Overview	9
Figure 4	Kidston Project Below-Ground Hydropower Infrastructure	10
Figure 5	Design Option 5 Excavation Areas	21
Figure 6	Additional Storage Sections for Design Option 5 (refer to Figure 5 for Cross Section Locations)	22
Figure 7	Existing Surface Water Management and Groundwater Locations	27
Figure 8	Probability Distribution - Unmitigated Case Wises Upper Reservoir Uncontrolled Releases	41
Figure 9	Probability Distribution - Unmitigated Case Wises Upper Reservoir Water Level (Spillway is at 551.5 and FSL at 551.5 m)	42
Figure 10	Comparison of composite sample to ranges in the Eldridge Pit	55
Figure 11	Comparison of the composite sample to ranges in the Wises Pit	55

Figure 12 Comparison of W2 dilution water sample with historical distribution and default WQOs 61
Figure 13 Monthly Rainfall - Kidston Gold Mine (30027), 1915 – 2002 (BoM) 66
Figure 14 Indicative Release Location 69
Figure 15 Number of Samples per Year since 2003 for Relevant Surface Water Monitoring Sites 73
Figure 16 Copperfield River Surface Water Sampling Locations 74
Figure 17 Copperfield river potential users 94
Figure 18 Simplified decision tree for assessing toxicants in ambient waters (ANZECC (2000)) 105
Figure 19 Running 80th percentile of sulfate values for the Copperfield River based on 24 previous samples 116
Figure 20 Long-Term Running 80th Percentile of Dissolved Aluminium (Using the previous 24 Values) 117
Figure 21 Time Series of Dissolved Cadmium Values 118
Figure 22 Time Series of Dissolved Chromium Values 119
Figure 23 Long Term 80th Percentile (from the Previous 24 values) for Dissolved Copper in the Copperfield River 120
Figure 24 Long-Term Running 80th Percentile (from the Previous 24 samples) for Total Manganese 121
Figure 25 Long-Term Running 80th Percentile Data for Zinc (from the Previous 24 Values) 122
Figure 26 Relationship between pH and flow 125
Figure 27 Relationship between EC and flow in the Copperfield River 126
Figure 28 Plot of total zinc against flow 126
Figure 29 Plot for dissolved zinc against flow 127
Figure 30 Relationship between EC and sulfate as SO4 in receiving water samples 128
Figure 31 Piper diagram of local waters compared to pit water samples 129
Figure 32 Development of IAR IQQM Model 132
Figure 33 Flow Duration Comparison – WRP Model and IAR Model (Downstream of Gilbert and Einasleigh Rivers Confluence) 133
Figure 34 Estimated Annual Discharge for Copperfield River at Project Site (Water Years Nov – Oct) 134
Figure 35 Annual Flow Duration Plot for Copperfield River at Project Site (Water Years Nov – Oct) 135
Figure 36 Mean Daily Discharge for Copperfield River at Project Site 136
Figure 37 Daily Flow Duration Plot for Copperfield River at Project Site 136
Figure 38 Flow depth along channel in HEC-RAS model for three investigated flows (downstream to upstream, left to right) 140
Figure 39 Velocity along channel in HEC-RAS model for three investigated flows (downstream to upstream, left to right) 140
Figure 40 Shear stress along channel in HEC-RAS model for three investigated flows (downstream to upstream, left to right) 141
Figure 41 Stream Power along channel in HEC-RAS model for three investigated flows (downstream to upstream, left to right) 141
Figure 42 Active Flow width along channel in HEC-RAS model for three investigated flows (downstream to upstream, left to right) 142
Figure 43 Groundwater Bore Locations 147
Figure 44 Variation in sulfate concentrations (in mg/L) and EC (in µS/cm) in groundwater sampled from the Project site monitoring bores ('ABxx', 'BAxx'), surface water sampled from sumps and TSF spillways (e.g., 'SUMP xx', 'TP1', etc.), and surface water quality monitoring points W1 to WB 148
Figure 45 Particle Size Distributions for Sediment Samples 153
Figure 46 Stream sediment levels in samples analysed for <63µm fraction for arsenic, cadmium, copper and nickel 155
Figure 47 Stream sediment levels in samples analysed for <63µm fraction for lead and zinc 156
Figure 48 Aquatic ecology sample site locations 162
Figure 49 Dry Season Copperfield River Field Survey 169

Figure 50 Typical Co-Flowing Diffuser Arrangement (Doneker & Jirka, 2017) 195
Figure 51 Scenario 1 – Mixing Zone (CORMIX1 Single Port Assessment) 197
Figure 52 Scenario 2 – Mixing Zone (CORMIX1 Single Port Assessment) 198
Figure 53 Scenario 3 – Mixing Zone (CORMIX1 Single Port Assessment) 198
Figure 54 Scenario 4 – Mixing Zone (CORMIX1 Single Port Assessment) 199
Figure 55 Scenario 1a – Downstream Mass Balanced Concentrations for Dissolved Zinc (Annual Simulation, Median Release Concentration) 201
Figure 56 Scenario 1b – Downstream Mass Balanced Concentrations for Dissolved Zinc (Annual Simulation, Maximum Release Concentration) 202
Figure 57 Scenario 2a - Downstream Mass Balanced Concentrations for Dissolved Zinc (Life of Project (50yr) Simulation, Median Release Concentration) 203
Figure 58 Scenario 2b - Downstream Mass Balanced Concentrations for Dissolved Zinc (Life of Project (50yr) Simulation, Maximum Release Concentration) 204
Figure 59 Example of Controlled Releases and Post-Release Flushes 213
Figure 60 Scenario 1 – Post-Release Flush Ratios (Annual Simulation, Proposed Release Point to Einasleigh) 215
Figure 61 Scenario 2 – Post-Release Flush Ratios (Life of Project (50yr) Simulation, Proposed Release Point to Einasleigh) 218
Figure 62 Annual Flow Duration Plot for Copperfield River at Project Site (Water Years Nov – Oct) - Baseline and with Releases 220
Figure 63 Mean Daily Discharge for Copperfield River at Project Site - Baseline and with Releases 220
Figure 64 Daily Flow Duration Plot for Copperfield River at Project Site – Baseline and with Releases 221
Figure 65 Release Location along channel in HEC-RAS model 228
Figure 66 Cross Section of channel at Simulated Release Location 229
Figure 67 Scenario 1a – Downstream Mass Balanced Concentrations for Dissolved Zinc (Eldridge Pit, Median Release Concentration) 245
Figure 68 Scenario 1b – Downstream Mass Balanced Concentrations for Dissolved Zinc (Eldridge Pit, Maximum Release Concentration) 246
Figure 69 Scenario 2a – Downstream Mass Balanced Concentrations for Dissolved Zinc (Mixed Pit Water Release, Medium Release Concentration) 247
Figure 70 Scenario 2b – Downstream Mass Balanced Concentrations for Dissolved Zinc (Mixed Pit Water Release, Maximum Release Concentration) 248
Figure 71 Temporal Distribution of Releases During the Construction Phase 258
Figure 72 Construction Phase Post-Release Flush Ratios – Annual Results 261
Figure 73 Effective Utilisation of Dissolved Zinc Assimilative Capacity Utilisation with Changing Receiving Environment Concentration (0.503% Release Ratio) 285
Figure 74 Effective Utilisation of Dissolved Zinc Assimilative Capacity Utilisation with Changing EOP Release Concentration (0.503% Release Ratio) 286
Figure 75 REMP Monitoring Points 290
Figure 76 Example of Controlled Releases and Post-Release Flushes with use of Asymmetrical Release Triggers 292
Figure 77 Metal concentrations with depth in the Eldridge Pit (Entura, 2016) C-2
Figure 78 Location and depths of water quality pit profiles C-4
Figure 79 Depth Profiles for Filtered Oxygen and Turbidity C-6
Figure 80 Depth Profiles for ORP and Temperature C-7
Figure 81 Depth Profiles for pH and EC C-8
Figure 82 August 2018 Depth Profiles C-4
Figure 83 EC time series for Eldridge and Wises Pits D-2
Figure 84 Sulfate time series concentration D-3
Figure 85 Relationship between EC and SO4 in the pit water. D-4
Figure 86 Aluminium concentrations in the Eldridge and Wises Pits D-5
Figure 87 Arsenic Concentrations in the Eldridge and Wises Pits D-6
Figure 88 Cadmium Concentrations in the Eldridge and Wises Pits D-7
Figure 89 Cobalt Concentrations in the Eldridge and Wises Pits D-8
Figure 90 Copper concentrations in the Pits over time D-9
Figure 91 Manganese Concentrations in the Eldridge and Wises Pits D-10

Figure 92	Molybdenum Concentrations in the Eldridge and Wises Pits	D-11
Figure 93	Nickel Concentrations in the Eldridge and Wises Pits	D-12
Figure 94	Zinc Concentrations in the Eldridge and Wises Pits	D-13
Figure 95	Total Cyanide Concentrations in the Wises and Eldridge Pits	D-14

Executive Summary

AECOM Australia Pty Ltd (AECOM) has prepared this Impact Assessment Report (IAR) on behalf of Genex Power Limited (Genex) for the purpose of assessing the impacts of water releases from the Kidston Pumped Storage Hydro Project (the Project) in support of an approval application.

The Project

The Project is proposed as a beneficial reuse of the closed Kidston Gold Mine in Kidston, Queensland. The Project has a planned capacity of 250 megawatts (MW) and is proposed to be supported by an associated solar farm, and through a direct connection into the National Electricity Market. The Project effectively acts as natural battery storage, allowing solar energy to be stored and harnessed as baseload power on demand. This innovative use of the old Kidston mine infrastructure for the purpose of developing a regional renewable energy industry makes the Project unique.

The Coordinator-General declared the Project a Coordinated Project under the Queensland *State Development and Public Works Organisation Act 1971* (SDPWO Act) on 28 September 2018 for which an IAR is required. The primary activity for which an approval is being sought under the Coordinated Project process is for the water discharges as a result of excess water following significant rainfall events during operation, and to allow the lowering of water levels to facilitate construction of the Project.

Approvals

Release of mine-affected water is a common practice across Queensland. This activity is typically managed through a range of management and monitoring requirements in line with industry standards prescribed under the *Environmental Protection Act 1994* and regulated by the Department of Environment and Science (DES).

The Project presents a unique situation, in which a new non-resource project is proposed over an existing resource tenure. The Queensland legislative framework currently does not make provision for the land use transition of decommissioned mine sites to hydroelectric renewable energy projects, and as such no existing legislative mechanism allows for the approval and regulation of water releases required for the Project.

Through extensive consultation with government regulators in relation to approval mechanisms and best practice assessment for the Project, an approval pathway has been agreed between Genex and the relevant State government regulators. The following is a high level summary of the approval elements for the Project.

- Coordinated Project, IAR process under the SDPWO Act – to assess the proposed water discharges from the Project.
- Development Permit under *Planning Act 2016*:
  - to assess the change in land use under the Etheridge Shire Council Planning Scheme and clearing of native vegetation managed under *Vegetation Management Act 1994.*
  - to assess the dam design, risks and operation managed under the *Water Supply (Safety and Reliability) Act 2008*.

As highlighted above, the three key elements of the approval process for the Kidston Project, includes:

1. water discharge
2. change in the land use of the Project area
3. design, construction and operation of the dam structure requiring failure impact assessment under the relevant legislation.

Items 2 and 3 above have been obtained and will not form part of the IAR process, as there is a clear delineation and process in the Queensland legislation for assessment of these elements.

Other Project aspects discussed in the IAS, which do not form part of this IAR include land use, native title, cultural heritage, contaminated land, waste management, failure impact assessment, traffic, noise and vibration, air quality and fisheries waterways. A summary of these aspects are included in Appendix N for context.

An Initial Advice Statement (IAS) was submitted to the Coordinator General in September 2018. The Project was subsequently declared a Coordinated Project on 28 September 2018. It was declared that the Project would be assessed by an IAR, pursuant to Section 26(1)(b) of SDPWO Act.

Assessment Approach

The approach adopted for this IAR has been developed in accordance with the requirements of the DES Technical Guideline - Wastewater release to Queensland waters (ESR/2015/1654, Version 2) (herein referred to as “the Guideline”). The Guideline supports a risk-based assessment approach to managing release of waste water to surface water and applies the philosophy of the Australian and New Zealand Environment and Conservation Council (ANZECC) & Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000) Water Quality Guidelines and the intent of the Environmental Protection (Water) Policy 2009. The assessment approach in the IAR follows four key steps, as identified within the Guideline and illustrated in Figure E1.

Figure E1 Impact Assessment Approach

Receiving Environment

The main outcomes of the investigation of the baseline receiving environment are summarised as follows.

<u>Surface Water Quality</u>

- Environmental Values (EV) for the Gilbert River basin have not been defined under the EPP Water. In this instance, the EPP Water prescribes the application of all default EVs. EVs have been described for the Copperfield River over a 44km stretch downstream from the former Kidston mine site to the confluence of the Einasleigh River.
- Macroinvertebrate data supports the distinction of a ‘Slightly Disturbed’ aquatic ecosystem condition under the EPP Water. The management intent for this water type is to gradually improve water quality and to aim to achieve a Highest Ecological Value (HEV) waterway classification, however HEV Water Quality Objectives (WQOs) may not be achievable in the Copperfield River as there are a number of regionally based negative influences on water quality.
- The Queensland Water Quality Guidelines (QWQG) and EPP Water do not specify WQOs for the Gulf Rivers region or the Gilbert Basin. Instead they recommend the use of the ANZECC (2000) guidelines, cautioning that these values may not be appropriate for intermittent and ephemeral inland streams. In cases where more than one WQO is available for a particular parameter, the most stringent value from all EVs is applicable. Where applicable, site-specific trigger values were derived based on the upstream dataset for monitoring location WB. Hardness Modified Trigger Values (HMTVs) were developed for the area in the immediate vicinity of the release point, using the median baseline hardness values at monitoring location W2.
- Some anomalies in the receiving environment water quality datasets were noted and led to the exclusion of samples collected prior to 2012 (providing an adequate dataset size for analysis of 40 to 60 samples). Ongoing monitoring is recommended for parameters with limited dataset sizes.
- The baseline assessment indicated that a number of parameters are elevated above WQOs in the receiving environment. Monitoring site W2 has indicated potential impacts from seepage.

Hydrology

- In the absence of stream gauging, hydrological modelling was used to undertake a flow spells analysis which showed a definite seasonal distribution with a distinct high flow season occurring from December through April.
- Cease to flow conditions (less than 1 ML/d) are present on approximately 55% of all days for any day and reduce to approximately 32% during the wet season (November through April).

Aquatic Ecology

- The macroinvertebrate assessment determined that communities inhabiting the Copperfield River both upstream and within the receiving environment are in good condition. AusRivAS modelling determined that assemblages at some locations were considered to be significantly impacted. However these scores may be typical of the region and PET scores and taxa richness determined sensitive taxa were well represented.

Hydrogeology

- The groundwater flow regime of the Project has been modified by the construction of the tailings dam, interception drains, and by dewatering of the two pits. In their current state, Wises Pit and Eldridge Pit are both understood to function as groundwater 'sinks', as groundwater levels in the surrounds of both pits are higher than the surface water level in the pits.
- One confirmed wetland spring, Middle Spring, lies within the vicinity of the mine area. This spring is located west-northwest of the former mine; although it is not considered to be hydraulically connected to the groundwater regime of the proposed release area, it is recommended that this is further assessed/monitored as part of water modelling refinement and design phase work.

Sediment Quality

- The braided nature of the Copperfield River results in sediment transport that is limited to a few months per year during the wet season when discharge is high enough. Very little fine sediment is stored in the channel bed in the upper to mid catchments.
- Sediment samples have been collected annually between 2009 and 2013. No whole-sediment samples exceeded the SQG, indicating that sediment within the Copperfield River is considered to be unaffected by the historical mining processes. Although the <0.063 mm samples reported a number of SQG exceedances, this fraction is considered less useful for comparison to guideline values.
- For toxicants in the <0.063 mm fractions, exceedances reported around the potential release sites (e.g., W1 and W2) are also reported in the upstream and downstream monitoring sites (e.g., WB and W3, respectively) suggesting that there are no widespread impacts from historical mining activities evident within the Copperfield River and that the concentrations of metals found are a result of the overall catchment drainage. Additional sampling and monitoring is recommended in accordance with the REMP.

Dry Season Survey

- Six semi-permanent waterholes were identified within the floodplain of the Copperfield River through a drone flyover in September 2018. These waterholes were sampled in late September 2018, along with monitoring locations W1 and W3.
- Previous significant rainfall in the catchment occurred in March 2018, therefore the water in the pools is assumed to have been standing for a long duration and were likely subjected to evapo-concentration.
- Total manganese, total iron, total nitrogen and total phosphorus recorded results above their respective WQOs both upstream and downstream of the proposed release point.
- A comparison against the long-term (post 2011) dataset for W1 and W3 did not indicate any clear trends with regards to water quality.

Operational Releases

The operational releases will continue to be required throughout the life of the Project. The development of appropriate discharge limits has been used as a primary mitigation measure to ensure that environmental impacts are appropriately minimised. For operational releases, it is proposed that a maximum of 69% of the assimilative capacity of the receiving environment be utilised (this equates to an effective dilution ratio of 200 parts receiving environment to one part release water). By limiting the use of assimilative capacity to 69%, this allows for preservation of a portion of the capacity for future development. The assumptions behind calculating effective dilution ratios are highly conservative (based on maximum pit water qualities). In reality the actual assimilative capacity usage will be lower than 69% in most cases.

A comprehensive assessment has been undertaken to develop an understanding of the potential impacts of operational releases on the Environmental Values (EVs) of the receiving environment including potential impacts on water quality, hydrology, geomorphology, hydrogeology and ecology of the receiving environment. Key findings are summarised below.

Water Quality Impacts for Operational Releases

An assessment of near-field and far-field water quality modelling and Direct Toxicity Assessment (DTA) results indicates no significant adverse impacts to EVs relevant to the Project area resulting from operational releases. This is evidenced by the following.

- Parameters relevant to the aquatic ecosystem EV are below the Water Quality Objectives (WQO) at all locations, with the exception of total nitrogen and dissolved zinc.
- Proposed releases are subject to initial mixing within the near field and predicted water quality within the mixing zone reaches the HMTV for dissolved zinc (the constituent of most concern), within a maximum (worst-case) distance of 625 m. Other modelled scenarios indicate a much smaller mixing zone of between 50 and 70 m downstream.
- The concentration of total nitrogen is modelled to drop below the WQO by Einasleigh. Nitrogen does not have many toxicological impacts on aquatic organisms; rather it is a nuisance nutrient that promotes algal growth. It is noted however that there is no evidence of algal growth currently and phosphorus concentrations (required to trigger algal growth) in the Copperfield River are low.
- Under a worst case scenario, there may be rare exceedances of the default 95% species protection WQO for dissolved zinc from Charles Creek to Chinaman Creek. Given that these exceedances represent a ‘maximum’ modelled value, the likelihood of these concentrations being released is very low. In addition, the exceedances are within the likely margin of error of the various methods used in the assessment. For the scenarios assessed, the 90% species protection WQO will not be exceeded at any location in the receiving environment.
- The mass balance assessment indicates that the HMTV will not be exceeded in either of the two semi-permanent pools (Pond 4 and Pond 5) located downstream of the release location; therefore impacts to these pools are therefore anticipated to be negligible.
- During the operations phase, the simulated releases are well in excess (200:1) of the minimum dilution ratio for toxicity-related impacts in the receiving environment (9:1).
- Concentrations of parameters relevant to other EVs (including drinking water, irrigation, farm supply, stock watering, human consumption, industrial use and recreation) are all modelled to be below the specified WQO.

Hydrology Impacts for Operational Releases

Over the operational phase of the Project, median annual release volume is estimated to be 294 ML and the median release event volume of 68ML (refer to Table E1). The median number of release events is estimated to be 4.0 per year and with a median duration of 7.0 days per event.

Table E1 Annual Controlled Release Statistics Operational Phase

Statistic	Annual Volume Releases	Mean Volume Released per Event	Annual Number of Release Days	Annual Number of Release Events[1]	Mean Release Event Duration
	ML	ML	days	1/ 1yr	d
Mean	530	152	33.6	4.2	8.9
P5	10	6	3.0	1.0	2.1
P10	33	14	8.0	1.8	3.0
P20	70	22	12.0	2.0	4.1
P50	294	68	32.0	4.0	7.0
P80	920	207	51.8	6.0	11.9
P90	1,483	359	64.0	7.0	15.0
P95	1,737	537	74.4	8.0	19.5

As a result of the proposed release of water from the Project, some minor changes are expected to the magnitude of flows that are a direct result of the additional water added during releases. The magnitude of the increases is however small and is not expected to be of material impact to the existing flow regime.

Due to the event-based nature of the proposed releases, no changes to key temporal indicators (timing, frequency and duration of flow events) were noted as a result of the proposed releases. Some minor increases to the rates of rise and fall were noted; however, they are not considered to be of sufficient magnitude to result in any adverse impacts.

Confirming that sufficient streamflow continues in the Copperfield River after cessation of any potential releases is required to ensure that potential releases continue to move downstream, are subject to ongoing dilutionary inflows and do not become stranded due to natural streamflow recession. The median duration of each post release flush at the proposed release point is 32 days with a volume of 1,758 ML.

Aquatic Ecology Impacts for Operational Releases

It is suggested that the adoption and application of appropriate release management strategies for operational releases will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values for the following reasons.

- The proposed controlled releases will only be undertaken during flow events within the receiving environment with a minimum flow trigger stipulated and the cessation of the release occurring prior to natural flows subsiding to allow for an additional flushing effect.
- The proposed release ratio during the operational phase is 200:1, well above that required to achieve 95% species protection determined through DTA.

[1] A release event is the continuous controlled release of water occurring for one or more consecutive days

- Mixing zone modelling has indicated that the use of a diffused discharge outlet structure will facilitate rapid near field mixing at the outlet such that the WQO for the contaminant of most concern (dissolved zinc) will be met within 625m for the range of scenarios and outlet configurations assessed (most modelled scenarios suggest a mixing zone of between 50 and 70 m downstream). There are no known permanent or semi-permanent pools within 625 m downstream of the release location which could provide refuge for aquatic ecology. There are no other known sensitive receptors within this mixing zone.
- All fish species found to be occurring within the Copperfield River display relatively broad tolerances to a wide range of water quality characteristics, however, the macroinvertebrate communities were comprised of families sensitive to environmental change.
- As the releases are to be managed to occur as event-based, no changes to key temporal indicators (timing, frequency and duration of flow events) are expected. While some minor increases to the rates of rise and fall are expected, they are not considered to be of sufficient magnitude to result in any adverse impacts to the aquatic ecology values of the system. Fish passage will not be reduced by the minor increases in flow.
- The potential impacts to the downstream environment from increased erosion and sedimentation during the operation are anticipated to be restricted to the immediate area surrounding and downstream of the release point. Appropriate design and management of the diffuser will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values.

Hydraulics and Fluvial Geomorphology Impacts for Operational Releases

The base-case hydraulic model confirmed that the release into the channel at a ratio of 200:1 does not have a significant impact on the hydraulic characteristics of the Copperfield River. Minor increases to main channel depth of up to 0.01m were predicted, however this did not alter the overall water surface elevation for the river reach. The velocity for the high flow events did not change, and minor increases of 2% were noted in the medium flow scenario. With shear stress values increasing by only minor values (less than 2%) for the 'with releases' scenario, there is unlikely to be any increase in sediment transport as a result of Project releases.

Hydrogeology Impacts for Operational Releases

During the operational phase of the Project, the predictive groundwater modelling indicates that the Eldridge Pit will continue to act as a groundwater sink, reducing seepage migration risks to the north of the Project (and downstream in the Copperfield River). During operations the water discharged from the Project will contribute a maximum of 0.5% additional flow volume to the Copperfield River and only occur during medium and high flow events. The scale and timing of these discharges is therefore not expected to materially influence the groundwater regime.

Construction Releases

Temporary construction releases are anticipated to be required for a duration of approximately 2.15 years. For temporary construction releases, it is proposed that a maximum of 76.3% of the assimilative capacity of the receiving environment be utilised (this equates to an effective dilution ratio of 200 parts receiving environment to one part release water from the Eldridge Pit). By limiting the use of assimilative capacity to 76.3%, this allows for preservation of a portion of the capacity for future development. The assumptions behind calculating effective dilution ratios are highly conservative (based on the maximum pit water quality for Eldridge Pit). In reality the actual assimilative capacity usage will be lower than 76.3% in most cases.

A comprehensive assessment has been undertaken to develop an understanding of the potential impacts of temporary construction releases on the EVs of the receiving environment including potential impacts on water quality, hydrology, geomorphology, hydrogeology and ecology of the receiving environment. Key findings are summarised below.

<u>Water Quality Impacts for Temporary Construction Releases</u>

An assessment of far-field water quality modelling and DTA results indicates that any impacts occurring as a result of construction releases are temporary and reversible. This is evidenced by the following.

- Construction phase releases will occur over a short, finite period (approximately 2.15 years).
- Parameters relevant to the aquatic ecosystem EV are below the WQO at all locations, with the exception of total nitrogen and dissolved zinc.
- Proposed releases are subject to initial mixing within the near field and predicted water quality within the mixing zone reaches the HMTV for dissolved zinc (the constituent of most concern), within a maximum (worst-case) distance of 625 m. Other modelled scenarios indicate a much smaller mixing zone of between 50 and 70 m downstream.
- The concentration of total nitrogen is modelled to drop below the WQO by Einasleigh. Nitrogen does not have many toxicological impacts on aquatic organisms; rather it is a nuisance nutrient that promotes algal growth. It is noted however that there is no evidence of algal growth currently and phosphorus concentrations (required to trigger algal growth) in the Copperfield River are low.
- Under a worst case scenario, there may be rare exceedances of the default 95% species protection WQO for dissolved zinc from Charles Creek to Chinaman Creek. Given that these exceedances represent a 'maximum' modelled value, the likelihood of these concentrations being released is very low. In addition, the exceedances are within the likely margin of error of the various methods used in the assessment. For the scenarios assessed, the 90% species protection WQO will not be exceeded at any location in the receiving environment.
- The mass balance assessment indicates that the HMTV will not be exceeded in either of the two semi-permanent pools (Pond 4 and Pond 5) located downstream of the release location, therefore impacts to these pools are therefore anticipated to be negligible.
- During the construction phase, the simulated releases are well in excess (200:1) of the minimum dilution ratio for toxicity-related impacts in the receiving environment (9:1).
- Concentrations of parameters relevant to other EVs (including drinking water, irrigation, farm supply, stock watering, human consumption, industrial use and recreation) are all modelled to be below the specified WQO.

<u>Hydrology Impacts for Temporary Construction Releases</u>

Over the construction phase of the Project, median annual release volume is estimated to be 409 ML and the median release event volume of 101ML (refer to Table E2). The median number of release events is estimated to be 4.4 per year and with a median duration of 7.7 days per event. Releases may be made throughout the duration of the construction phase.

Table E2 Annual Controlled Release Statistics Construction Phase

Statistic	Mean Annual Release Volume	Mean Volume Released per Event	Mean Annual Number of Release Days	Mean Annual Number of Release Events[2]	Mean Release Event Duration
	ML	ML	days	1/ 1yr	d
Mean	612	157	38.1	4.5	9.1
P5	74	19	13.0	2.3	3.6
P10	124	25	17.4	2.8	4.1
P20	194	41	23.0	3.2	5.3
P50	409	101	33.1	4.2	7.7
P80	954	248	50.9	5.6	12.5
P90	1,420	332	67.0	6.9	14.9
P95	1,636	550	81.2	7.7	19.4

Construction phase releases are proposed to utilise the same release conditions (including a release trigger of 400 ML/d) as operational phase releases. This is unlikely to materially impact on the existing flow regime in terms of the timing, frequency, duration and magnitude of flows. Releases will coincide with naturally occurring streamflow events in the Copperfield River at the proposed release point and cease as streamflow recesses below the proposed 400 ML/d trigger. The use of the same dilution ratio (200 to 1) during the construction phase as the operational phase dilution ratio will result in a similar contaminant mass loading per release event. Possible stranding of releases in downstream pools and waterholes is, however, considered unlikely due to the significant post release flush volumes following each release event.

Ongoing tributary inflows downstream of the proposed release point provide significant additional flushing such that the median mean flush ratio of 5.6 % at the release point is reduced to 0.9 % by Einasleigh.

Aquatic Ecology Impacts for Temporary Construction Releases

It is suggested that the adoption and application of appropriate release management strategies for temporary construction releases will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values for the following reasons:

- The proposed controlled releases will only be undertaken during flow events within the receiving environment with a minimum flow trigger stipulated and the cessation of the release occurring prior to natural flows subsiding to allow for an additional flushing effect.
- The proposed release ratio during the operational phase is 200:1, well above that required to achieve 95% species protection determined through DTA.
- Mixing zone modelling has indicated that the use of a diffused discharge outlet structure will facilitate near field mixing at the outlet such that the WQO for the contaminant of most concern (dissolved zinc) will be met within 625m for the range of scenarios and outlet configurations assessed (most modelled scenarios suggest a mixing zone of between 50 and 70 m downstream).

[2] A release event is the occurrence of controlled releases occurring for one or more consecutive days

- All fish species found to be occurring within the Copperfield River display relatively broad tolerances to a wide range of water quality characteristics, however, the macroinvertebrate communities were comprised of families sensitive to environmental change.
- As the releases are to be managed to occur as event-based, no changes to key temporal indicators (timing, frequency and duration of flow events) are expected. While some minor increases to the rates of rise and fall are expected, they are not considered to be of sufficient magnitude to result in any adverse impacts to the aquatic ecology values of the system. Fish passage will not be reduced by the minor increases in flow.
- The potential impacts to the downstream environment from increased erosion and sedimentation during the construction phase are anticipated to be restricted to the immediate area surrounding and downstream of the release point. This is particularly relevant to the first wet season discharges when a temporary outfall structure may be utilised for a short period of time. Stabilisation of banks where discharge is proposed may be necessary to minimise these impacts. This will be further considered during detailed design.

Hydraulics and Fluvial Geomorphology Impacts for Temporary Construction Releases

The base-case hydraulic model confirmed that the release into the channel at a ratio of 200:1 does not have a significant impact on the hydraulic characteristics of the Copperfield River. Minor increases to main channel depth of up to 0.01m were predicted; however this did not alter the overall water surface elevation for the river reach. The velocity for the high flow events did not change, and minor increases of 2% were noted in the medium flow scenario. With shear stress values increasing by only minor values (less than 2%) for the ‘with releases’ scenario, there is unlikely to be any increase in sediment transport as a result of Project releases.

The discharge release infrastructure design will consider the potential risk of scouring as a result of the construction discharges which may cause localised erosion resulting in increased sedimentation. This may increase the sediment coarse fraction, which may impact the downstream environment by affecting turbidity. In order to ensure that erosion and scouring impacts are not occurring as a result of temporary construction releases, it is proposed that visual inspections of the outlet structure and surrounds are undertaken at appropriate times during the construction of the Project.

Inspections will look for signs of:

- Localised changes to channel bed and stream bank morphology such as undercutting, slumping or rotation,
- localised changes, loss or damage to riparian vegetation;
- Localised downstream sedimentation visible through the development of new lateral depositional features;
- Notable changes to instream water clarity (turbidity) immediately downstream of the release point; and,
- Notable damage to any hydraulic structures.

In the instance that signs of erosion or sedimentation are noted the following would be undertaken:

- Record, report and assess for severity and determine any requirement for mitigation.
- If required, suitable measures including (but not limited to) placement of appropriately dimensioned hard rock material, gabions, etc. could be employed to prevent further worsening.
- Issues not requiring immediate action will be subject to additional monitoring to determine the rate of, or potential for, ongoing propagation and any requirement for future mitigation (noting that the dynamic nature of bed material transport is to some extent, a natural part of fluvial process at the proposed release point).

Hydrogeology Impacts for Temporary Construction Releases

During the construction phase of the Project, the predictive groundwater modelling indicates that the Eldridge Pit will continue to act as a groundwater sink, reducing seepage migration risks to the north of the Project (and downstream in the Copperfield River). During construction, the water discharged from the Project will contribute a maximum of 0.5% additional flow volume to the Copperfield River and only occur during medium and high flow events. The scale and timing of these discharges is therefore not expected to materially influence the groundwater regime.

Project Controls

The proposed controlled release of water from the Project is governed by the availability of a release opportunity in the Copperfield River at the proposed release point; the amount of water released is dependent on the release ratio and discharge capacity. Table E3 summarises the key proposed release criteria that is required.

Table E3 Proposed Project Release Criteria

Aspect	Construction	Operations	Comment
Controlled Release Triggers	400 ML/d	400 ML/d	No releases into receiving environment when flows are equalled or less than 400 ML/d.
Dilution Ratio	200 parts receiving water to 1 part release water	200 to 1	
Release Ratio	0.5%	0.5%	Operational release ratio is based on a 69% utilisation of the available assimilative capacity for the contaminant of most concern, dissolved zinc which results in an effective total dilution ratio of 200:1. During construction, the utilisation of available assimilative capacity may increase to 76% due to the higher concentration of dissolved zone in the Eldridge Pit.
Maximum controlled release capacity	86.4 ML/d (1.0 m^3/s)	86.4 ML/d (1.0 m^3/s)	

It is important to note that the proposed release ratio (i.e. the ratio of the release flow to the receiving flow) is dependent on assumptions regarding:

- Concentration of the contaminant of most concern (dissolved zinc) in the potential release water
- Concentration of the contaminant of most concern (dissolved zinc) in the receiving environment; and
- Adopted utilisation of the available assimilative capacity for the contaminant of most concern.

However, real time monitoring in the receiving environment and the Eldridge and Wises Pits for metals such as dissolved zinc is not practical. Potential changes to the concentration of contaminants in either the release water or the receiving environment can influence the effective assimilative capacity utilisation. The proposed release ratio of 0.5% for the operational phase of the Project has been based on:

- A conservatively high release concentration of 1.5874 mg/L for dissolved zinc (based on the maximum values observed in the Wises and Eldridge Pits)
- A median (monitoring point W2) receiving environment concentration of 0.0025 mg/L for dissolved zinc;
- A conservative adoption of a 69% utilisation of the dissolved zinc available assimilative capacity; and,
- Maintenance of the same release ratio (0.5%) during the construction phase may result in a slightly greater use of the available assimilative capacity (76%) when water is released solely from the Eldridge pit where the observed maximum concentration of dissolved zine is 1.75 mg/L.

Consequently, at the proposed release ratio of 0.5%, these assumptions provide additional contingency to allow for possible increases to either the receiving environment or release concentrations releases to continue to meet the dissolved zinc HMTV.

Approach to releases

Definition of the proposed release operation is subject to ongoing refinement through detailed design however an indicative approach of the proposed release strategy would likely include the following key steps:

1. Continuous real-time monitoring of flow and other physical parameters such as temperature, electrical conductivity, pH, etc. in the receiving environment upstream and downstream of the proposed release location.
2. Continuous monitoring of flow in Copperfield River upstream of the proposed release location will provide an indication of when the proposed flow release trigger of 400 ML/d has been exceeded and a potential release opportunity is available.
3. The maximum release rate can be determined by multiplying the upstream monitored flow rate by the release ratio and could be adjusted based on real time data from the upstream stream gauge.
4. Verification that the releases are supporting downstream WQOs can be undertaken by collection of water quality samples at the downstream monitoring location(s) downstream of the proposed release point during the release event to demonstrate that the sustainable load objective is being met and environmental outcomes achieved.
5. Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d.
6. On the basis of ongoing monitoring of the receiving environment, water in the pits and collection of samples during release events, adjustments would be made to the release ratio as required.

Monitoring and mitigation opportunities

A draft REMP for the Project has been prepared and will be finalised following the approvals process. The following types of monitoring are proposed:

1. Surface water quality;
2. Sediment;
3. Biological;
4. Flow; and
5. Groundwater quality and level.

A number of strategies have been identified to provide further mitigation strategies. These strategies are adaptive in their nature and can be applied if found to be necessary based on feedback from the downstream monitoring programme outlined in the REMP. Strategies include:

- Extending the Flushing Period through Asymmetrical Release Triggers
- Extended Flushing using Releases from the Copperfield Dam
- Cessation of Releases during the Dry Season

Conclusions

This impact assessment has investigated the implications of the Project on the identified receiving environment receptors. The assessment has been largely desktop-based, with some supplementary testing and analysis completed, and as such is subject to limitations of the largely historical database. In addition, model outcomes are determined by the assumptions made, which are based on the information available.

The assessment first determined a set of WQOs, supported by the DTA, with which to design the modelled operational and temporary construction releases. These models were used to simulate the likely Project regimes. Available information was used to assess the impacts of the Project regimes on the receptors.

Outcomes of the assessment indicate that both operational and temporary construction releases are likely to result in relatively low impacts on the receptors in the receiving environment.

The Project REMP will be developed and implemented as part of the Project (refer to draft REMP contained in Appendix I). The Project REMP includes monitoring of surface water quality, sediment, biology, stream flow and groundwater quality/level. The main objectives of the Project REMP are to verify assumptions presented in this assessment and report against relevant WQOs in order to monitor whether impacts to the receiving environment and associated EVs are potentially occurring and if further refinement of the release program is required to achieve acceptable environmental outcomes.

Acronyms

AusRivAS	Australian River Assessment System
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agricultural and Resource Management Council of Australia and New Zealand
CEMP	Construction Environmental Management Plan
COPC	Constituent of Potential Concern
DES	Department of Environment and Science
DTA	Direct Toxicity Assessment
DNRM	Department of Natural Resources and Mines
DNRME	Department of Natural Resources, Mines and Energy
DO	Dissolved oxygen
EA	Environmental Authority
EC	Electrical Conductivity
EHP	Department of Environment & Heritage Protection
EMP	Environmental Management Plan
ESA	Ecotox Services Australia
EV	Environmental value
FSL	Full Supply Level
GDE	Groundwater-dependant ecosystem
GL	Gigalitre
HEV	Highest Ecological Value
IAR	Impact assessment report
IQQM	Integrated Quantity and Quality Model
LOR	Limits of Reporting
MOL	Minimum Operating Level
NEM	National Electricity Market
OCG	Office of the Coordinator-General
RAP	River Analysis Package
RE	Regional Ecosystem
REMP	Receiving Environment Monitoring Program
REZ	Renewable Energy Zone
RO	Reverse Osmosis
ROPs	Resource Operation Plans
TEP	Transitional Environment Program
TSF	Tailings Storage Facility
WAD	Weak Acid Dissociable
WBM	Water Balance Model

WPs	Water Plans
WQOs	Water Quality Objectives

1.0 Introduction

AECOM Australia Pty Ltd (AECOM) has prepared this Impact Assessment Report (IAR) on behalf of Genex Power Limited (Genex) for the purpose of assessing the impacts of water releases from the Kidston Pumped Storage Hydro Project (the Project) in support of an approval application.

The Coordinator-General declared the Project a Coordinated Project under the Queensland *State Development and Public Works Organisation Act 1971* (SDPWO Act) on 28 September 2018 for which an IAR is required. The primary activity for which an approval is being sought under the Coordinated Project process is for the water discharges as a result of excess water following significant rainfall events during operation, and to allow the lowering of water levels to facilitate construction of the Project.

Release of mine-affected water is a common practice across Queensland for a range of activities. This activity is typically managed through a range of management and monitoring requirements in line with industry standards prescribed under the *Environmental Protection Act 1994* and regulated by the Department of Environment and Science (DES). Industry standards include model mining conditions (ESR/2016/1936) and the Technical Guideline for water release to Queensland waters (ESR/2015/1654).

Coupled with the reasons driving the need for a Coordinated Project declaration (the strategic significance of the Project and the lack of a defined approval process), the relevant existing practices and industry standards, the ‘fit for purpose’ IAR process was considered to be the most appropriate for the Project, and is the subject of this report.

2.0 Background

2.1 Overview of the Project

The Project is proposed as a beneficial reuse of the closed Kidston Gold Mine in Kidston, Queensland. The Project has a planned capacity of 250 megawatts (MW) and is proposed to be supported by an associated solar farm, and through a direct connection into the National Electricity Market (NEM).

The Project effectively acts as natural battery storage, allowing solar energy to be stored and harnessed as baseload power on demand. This innovative use of the old Kidston mine infrastructure for the purpose of developing a regional renewable energy industry makes the Project unique.

The significance of the Project has been recognised by the State of Queensland by being declared as both a Prescribed Project and a Project of Critical Infrastructure under the SDPWO Act on 3 March 2016 and 27 June 2017 respectively. Under section 76(E) of the SDPWO Act the Minister may declare a Project to be Critical Infrastructure if the Minister considers the Project is critical or essential to the State for economic, environmental or social reasons. The Project is also supported by the Australian Renewable Energy Agency through a funding agreement.

The key component of the Project, which is seeking approval and conditioning from the Coordinated Project process, is the construction and operational water releases associated with the Project. These are further defined and assessed in the body of this IAR.

2.2 Initial Advice Statement

An Initial Advice Statement (IAS) was submitted to the Coordinator General in September 2018. The Project was subsequently declared a Coordinated Project on 28 September 2018. It was declared that the Project would be assessed by an IAR, pursuant to Section 26(1)(b) of SDPWO Act.

The IAS provided information regarding the potential environmental, social and economic impact of the Project, as well as project need, justifications and alternatives considered. The IAS concluded that potential impacts associated with water quality and aquatic ecology would be subject to detailed assessment through the IAR process as relevant to the water releases.

The IAS detailed other Project aspects, and their potential impacts on environmental values that are subject to environmental management plans and / or approvals under Commonwealth or State legislation, separate to the Coordinated Project process. These items are discussed further in Section 2.3 below.

2.3 Approvals Context

The Project presents a unique situation, in which a new non-resource project is proposed over existing resource tenure. The Queensland legislative framework currently does not make provision for the land use transition of decommissioned mine sites to hydroelectric renewable energy projects, and as such no existing legislative mechanism allows for the approval and regulation of water releases required for the Project.

Through extensive consultation with government regulators in relation to approval mechanisms and best practice assessment for the Project, an approval pathway has been agreed between Genex and the relevant State government regulators. The following is a high level summary of the approval elements for the Project.

- Coordinated Project, IAR process under the *State Development and Public Works Organisation Act 1971* – to assess the proposed water discharges from the Project.
- Development Permit under *Planning Act 2016*:
  - to assess the change in land use under the Etheridge Shire Council Planning Scheme and clearing of native vegetation managed under *Vegetation Management Act 1994*
  - to assess the dam design, risks and operation managed under the *Water Supply (Safety and Reliability) Act 2008*.

As highlighted above, the three key elements of the approval process for the Kidston Project, includes:

1. water discharge
2. change in the land use of the Project area
3. design, construction and operation of the dam structure requiring failure impact assessment under the relevant legislation.

Items 2 and 3 above will not form part of the IAR process, as there is a clear delineation and process in the Queensland legislation for assessment of these elements. These approvals have been obtained and a copy of the Decision Notice is included in Appendix M. The conditions are not anticipated to conflict with any conditions that may be issued by the Coordinator-General.

Construction phase approvals may also be required dependant on the final detailed design. These may include the following.

- A development permit for waterway barrier works under the *Planning Act 2016*, pending the detailed design of the outfall structure and how it interacts with the waterway.
- A development permit for clearing of native vegetation under the *Planning Act 2016*, if vegetation clearing is required outside of the current approved footprint.
- A development permit for quarrying in a watercourse under the *Planning Act 2016* and environmental authority under the *Environmental Protection Act 1994*, if sand is required for a watercourse for concrete batching.

These approval requirements are typical of a large infrastructure project, and are expected to be obtained within the construction timeframes.

2.4 Other Project Aspects

Other Project aspects discussed in the IAS, which do not form part of this IAR are detailed in Table 1 below. A summary of these aspects are included in Appendix N for context. Table 1 identifies the mitigation and management strategies associated with each aspect. These aspects are not considered further in this IAR, but are provided for overall Project context and will be managed through a Construction Environmental Management Plan (CEMP) to be developed by the construction contractor.

Table 1 Other Project aspects, applicable legislation and proposed management and mitigation measures

Aspect	Applicable legislation	Management and Mitigation
Land Use	• *Planning Act 2016*	• Development in line with Development Permit issued by Etheridge Shire Council.
Land Management	• *Environmental Protection Act 1994*	• CEMP, including: - Contaminated land management and procedures - Erosion and sediment control.
Air Quality	• *Environmental Protection Act 1994* • Environmental Protection (Air) Policy	• CEMP, including: - Standard air quality management procedures in line with legislative requirements and site specific triggers.
Noise and Vibration	• *Environmental Protection Act 1994* • Environmental Protection (Noise) Policy	• CEMP, including: - Standard noise management procedures in line with legislative requirements and site specific triggers.

Aspect	Applicable legislation	Management and Mitigation
Terrestrial Ecology	• *Planning Act 2016* • *Vegetation Management Act 1994* • *Nature Conservation Act 1992*	• Development in line with Development Permit issued by State Government. • CEMP, including: - Pre-clearing surveys - Spotter catcher - Delineation of clearing areas. - Supplementary planting and revegetation where required.
Cultural Heritage	• *Aboriginal Cultural Heritage Act 2003*	• Development in line with Cultural Heritage Management Agreement. • Direct negotiations with traditional owners and the State. • CEMP, including: - cultural heritage inductions - unexpected finds protocol.
Traffic and Transport	• *Planning Act 2016* • *Transport Infrastructure Act 1994*	• Development in line with Development Permit issued by Etheridge Shire Council, including: - Road User Agreement with Etheridge Shire Council. • Traffic Management Plan

2.5 Community and Stakeholder Consultation

A number of consultation activities have been undertaken by Genex to date. Consultation has largely included the following stakeholders:

- directly affected land owners
- local, State and Commonwealth government regulators
- relevant infrastructure providers.

Consultation activities have been undertaken with the Etheridge Shire Council and State Government stakeholders. Genex met with Etheridge Shire Council formally to discuss the Project in a pre-lodgement forum and as part of the Material Change of Use development approval which was granted on 19 September 2018.

State Government regulators have also been consulted through the application stage of the Project. State Government regulators include:

- Coordinator-General
- Department of State Development, Manufacturing, Infrastructure and Planning
- Department of Natural Resources, Mines and Energy
- Department of Environment and Science
- Department of Agriculture and Fisheries
- Ergon Energy
- Powerlink Queensland.

A number of consultation activities have been undertaken with the indigenous party for the area, being the Ewamian People. A Cultural Heritage Management Agreement has been executed between Genex and the Ewamian People which makes provision for the discharge infrastructure proposed outside of the mine lease area.

3.0 Assessment Approach

3.1 Methodology

The activity of discharging mine affected waters is typically managed through a range of management and monitoring requirements in line with industry standards prescribed under the *Environmental Protection Act 1994* and regulated by the DES. Given the unique nature of the Project, extensive consultation has been undertaken with a range of key regulatory stakeholders to determine an appropriate assessment approach.

The approach adopted for this IAR has been developed in accordance with the requirements of the DES Technical Guideline - Wastewater release to Queensland waters (ESR/2015/1654, Version 2) (herein referred to as "the Guideline"). The Guideline supports a risk-based assessment approach to managing release of waste water to surface water and applies the philosophy of the Australian and New Zealand Environment and Conservation Council (ANZECC) & Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000) Water Quality Guidelines and the intent of the Environmental Protection (Water) Policy 2009.

The assessment approach in this IAR follows four key steps, as identified within the Guideline and illustrated in Figure 1.

Figure 1 Impact Assessment Approach

3.2 IAR Structure

This IAR has been structured as follows.

- Section 4 – This section aligns to Step 1 in the Guideline, and describes the:
  - Project construction, operation and decommissioning characteristics as relevant to this process
  - Project need, justification and alternatives considered for the Project
  - current, and historic pit water quality
  - proposed water releases.
- Section 5 – This section aligns to Step 2 in the Guideline, and describes the baseline receiving environment.
- Section 6 and 7 – This section aligns to Step 3 in the Guideline and presents the assessment of impacts from the Project on the baseline receiving environment.
- Section 9 – This section aligns to Step 4 in the Guideline and defines the proposed release and monitoring criteria for the Project.

This page has been left blank intentionally.

Step 1 – Activity Description

“Describe the Proposed Activity”

4.0 Activity Description

4.1 Project Description

Pumped storage hydro is a form of hydroelectric energy storage (Figure 2). The method stores energy in the form of the gravitational potential energy of water, which is gained when the water is pumped from a lower elevation reservoir to a higher elevation reservoir. During periods of high energy demand, this stored potential energy is converted to kinetic energy by releasing the stored water from the upper reservoir, through electricity-generating turbines into a lower reservoir. In periods of low energy demand, the water is pumped from the lower reservoir back into the upper reservoir to begin the electricity generation cycle again. Low-cost surplus off-peak power is typically used to run the pumps. Pumped storage allows energy from intermittent renewable energy sources to be saved for periods of higher demand. Pumped storage hydro is recognised as the largest-capacity form of grid energy storage available in the current market. The technique is currently the most cost-effective means of storing large amounts of energy. Capital costs and the presence of appropriate landforms and geography are critical decision factors in site selection of such projects.

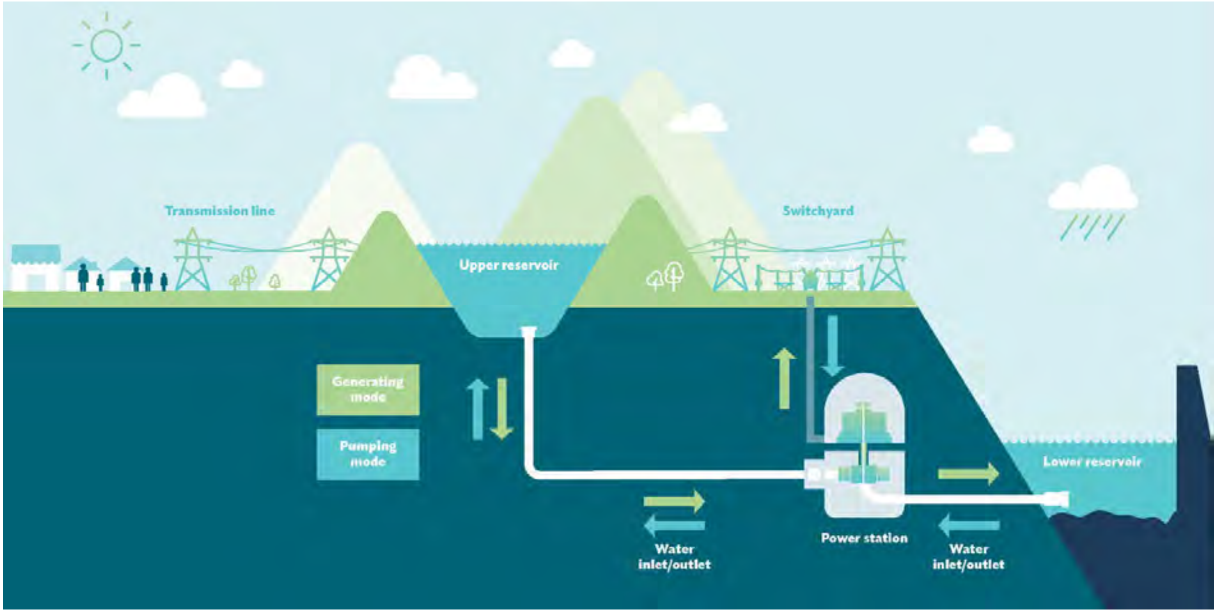


Figure 2 Schematic of pumped hydro storage (Hydro-Electric Corporation, 2018)

The Project utilises two pit voids from the decommissioned Kidston Gold Mine; Wises and Eldridge as the upper and lower reservoirs respectively. A concrete lined pressure tunnel and powerhouse will connect the upper and lower reservoir allowing water to be conveyed between the two pits, in pumping or generation mode. During daytime/off peak periods, water will be pumped from the lower Eldridge Pit to the upper Wises Pit reservoir. During peak power demand periods, the stored water will release from the upper reservoir to generate electricity. Figure 3 illustrates the general Project arrangement showing the final Wises Pit Dam at full water capacity and the Eldridge Pit at a reduced water level.

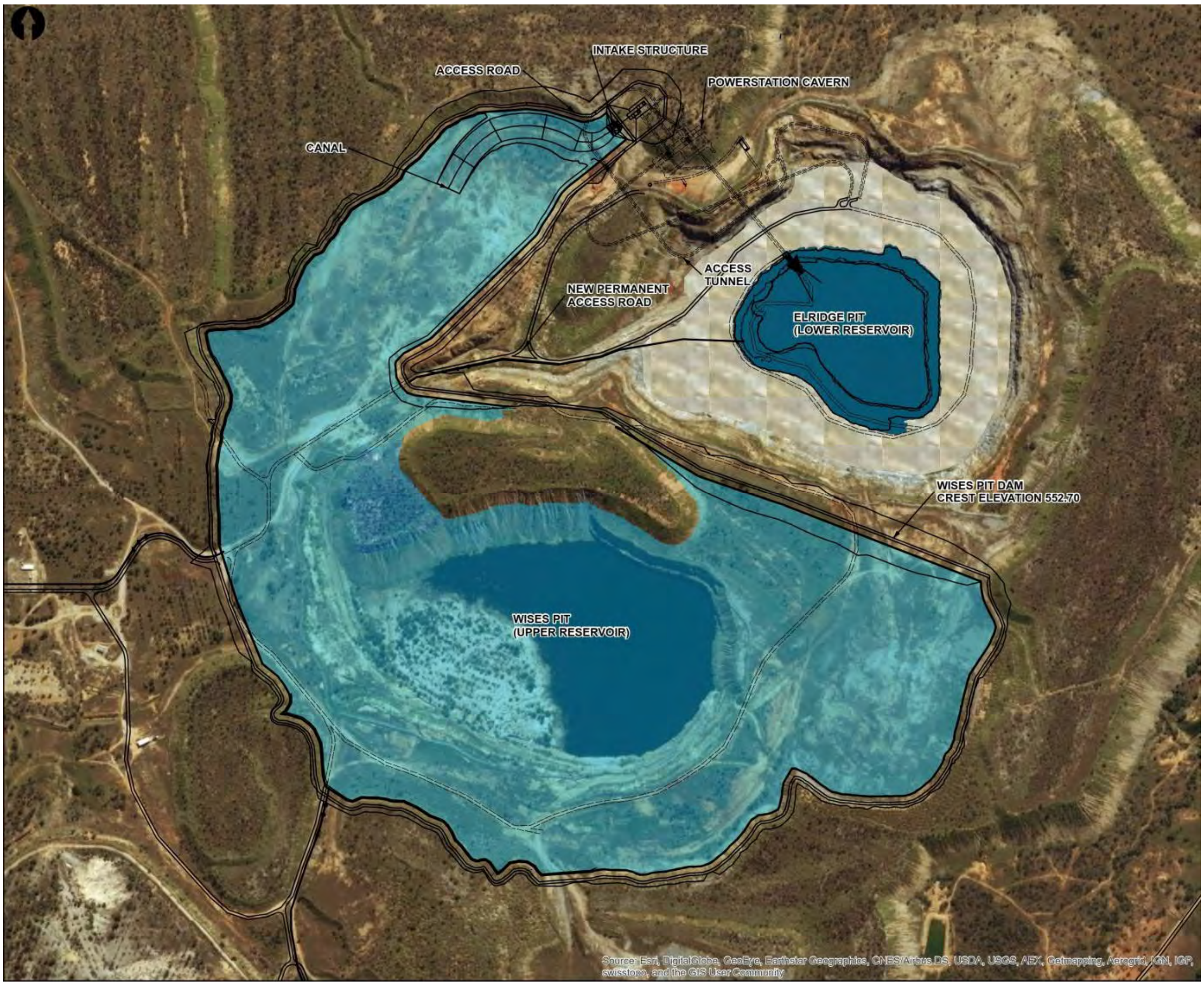


Figure 3 Kidston Project General Overview

Since 2015, the Project has undergone a technical feasibility study and a number of design optimisations resulting in the two-pit solution, utilising the existing mining voids. The Project has been sized to 250MW (approximately 1,870 megawatt hours (MWh)). Release of water from the pits will be required during both construction and operation to facilitate the Project. Water release requirements are discussed in detail in Section 4.6 - 4.7.

The Project consists of the following arrangement and civil components:

- Upper reservoir formed by excavating waste rock from the existing Wises Pit, and utilising a portion of this to build a dam of up to 20m high around the existing Wises Pit, with the balance to be relocated within the Project site.
- Lower reservoir utilising the existing Eldridge Pit.
- Upper gated intake to control the release of water.
- Lower reservoir intake/outlet with stoplog gates to cut off or stop the flow of water.
- Water conveyance shafts, short power tunnels and tailrace tunnel. Once passed through the power station, the tailrace tunnel is where the water passes through to the reservoir.
- Powerhouse cavern to accommodate two fixed speed reversible Francis pump-turbines, main transformers and auxiliaries; and Main Inlet Valve (MIV), which is the valve between the headrace water conveyance shaft and the pump-generator turbines.
- Transformer access tunnel parallel to the powerhouse cavern.

- Single construction and access tunnel from the Eldridge Pit to the powerhouse.
- Cable, vent and emergency access shaft(s).
- Switchyard and control building including offices, store rooms and workshop.
- Pipework and spillway from Wises Pit Dam to Copperfield River for flood management and water balancing.
- Onsite access roads.

Figure 4 shows the below ground hydropower infrastructure proposed between the completed Wises and Eldridge Reservoirs.

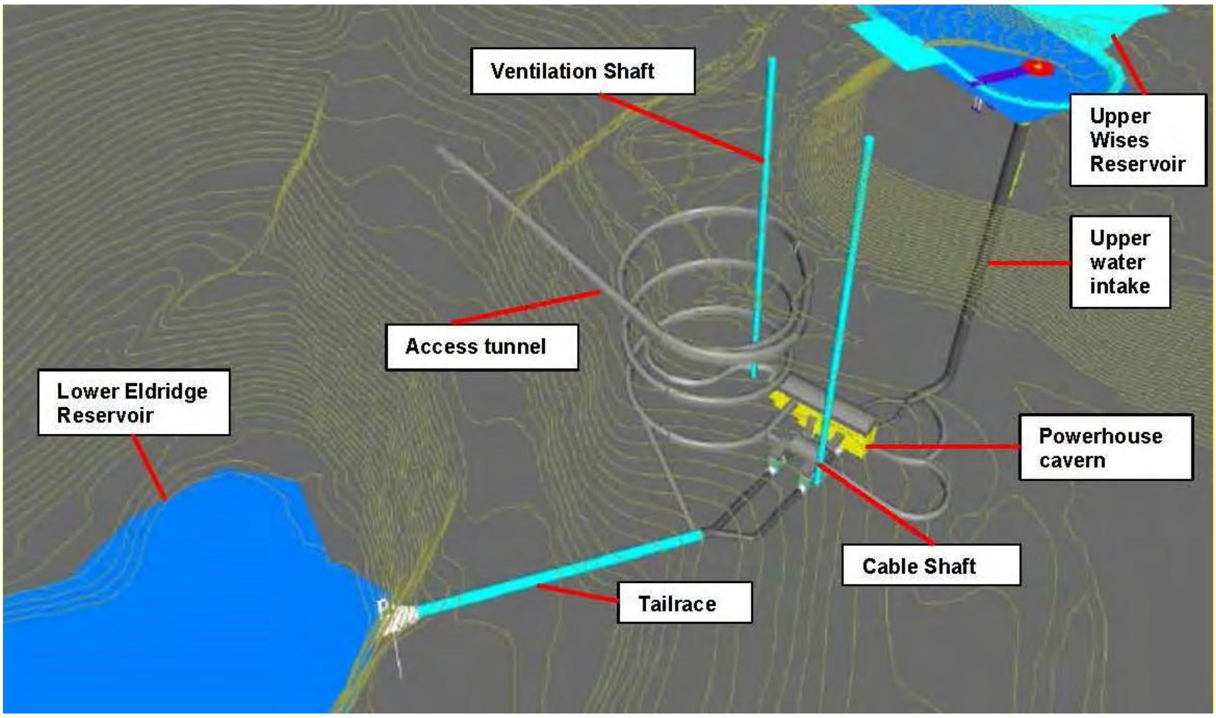


Figure 4 Kidston Project Below-Ground Hydropower Infrastructure

4.1.1 Construction Phase

The existing pits are to be upgraded to make them suitable for operational storage and water discharge requirements. This will include increasing the storage volume of the Wises Pit by excavating existing waste rock (refer to Section 4.2.2.5 for further detail), building a dam (utilising a portion of this waste rock), construction of tunnel infrastructure and dewatering the Eldridge Pit to gain access to allow completion of tailrace outlet construction. The conceptual design and construction methodology will continue to be revised as the Project detailed design progresses and as additional information becomes available (e.g., revising slope stability). The proposed construction works will be carried out in accordance with relevant requirements to protect the integrity of liners. Further details of the construction elements of both the Wises and Eldridge Pits are described below:

Wises Pit (Upper Reservoir)

- An area of the existing waste rock stored within the Wises Pit will be excavated to create additional storage within the Wises Pit, totalling approximately 1.6 million m^3 (of which 200,000 m^3 is virgin rock).
- The dam will be constructed by utilising 130,000 m^3 of this waste rock and a further 900,000 m^3 of waste rock material surrounding the Wises Pit. This will include the re-grading of existing waste rock dump slopes (approximately 5km of the total 5.5km levee) and the construction of a new embankment section (approximately 0.5km of the total 5.5km levee).

- The balance of the excavated waste and virgin rock material (totalling approximately 1.5 million m^3 will be stored at a site adjacent to the dam wall and managed to ensure compliance with the existing Environmental Authority (EA) which was granted over the site following mine closure.
- A high-density polyethylene (HDPE) liner will be installed on the water side of the dam to reduce seepage loss from the dam.
- The water side of the rockfill dam will be overlain by both a transition layer and a fine material layer; the HDPE liner will be installed on these.
- The HDPE liner will be connected to the rock foundation through a reinforced concrete plinth anchored to the rock and from which consolidation grouting can be executed.
- A spillway structure will be constructed to direct excess water from the dam to the adjacent Copperfield River. The detailed design of this structure will incorporate an appropriate dispersion device to facilitate mixing.

Eldridge Pit (Lower Reservoir)

- The lower reservoir will make use of the existing Eldridge Pit. As part of the original pit construction, cable bolting was undertaken to maintain the stability of the excavated slopes. To limit the need for slope stabilisation around the pit, the permanent access tunnel has been elevated with a portal at an elevation in the pit which will minimise the requirement to dewater before tunnelling can start.
- Underground excavation between the Wises Pit and the Eldridge Pit will commence to construct access tunnels, the powerhouse cavern as well as shafts using a variety of construction methods such as drill and blast, rock bolting and shotcreting.
- Construction work will include the installation of temporary services such as ventilation, power, water supply, and installation of gantry cranes.
- Dewatering will be staged to suit the construction program of the Wises Pit Dam (which will need to store this water). The outfall portal entry has been designed to remove the requirement for full Eldridge Pit dewatering before the tunnelling can start.
- Underground construction of key infrastructure will include the powerhouse cavern, the tailrace (channel that carries water away from the dam) and pressure piping.
- Once the tunnelling has been competed, installation of the turbines can then proceed, including supply and installation of electrical, transformer, instrumentation and controls.

HDPE liners may leak if damaged during or after installation. Suitable mitigation measures to minimise the likelihood of any damage and also limit potential environmental impacts are as follows:

- regular inspections as part of the operations and maintenance phase works
- all water leaked will report to Eldridge Pit as part of the existing drainage system
- site will continue to be monitored and managed under the existing Environmental Authority.

4.1.2 Release Infrastructure

The same release point on the Copperfield River will be used during both the construction phase and operational phase however the source of water potentially released, conveyance of water to the proposed release point and actual release infrastructure will differ from the construction to operational phase as summarised below in Table 2. All releases during the construction phase will be Type 1 controlled releases; during the operational phase releases would predominately be Type 1. During extreme rainfall conditions a Type 2 discharge may be employed (Section 4.7).

Table 2 Project Release Infrastructure

Aspect	Construction Phase	Operational Phase
Release location	Subject to detailed site constraint analysis but indicative location shown on Figure 14 and Figure 49.	As per construction phase
Source of release water	Water will initially be sourced from the Eldridge Pit only. This will continue until the final stage of dewatering of the Eldridge Pit has completed and construction of the tailrace works has commenced. For the remainder of the construction phase releases will be from the Wises upper reservoir at the operational phase mixture of 9 parts Eldridge water to 1 part Wises.	Releases will be from the Wises upper reservoir at the operational phase mixture of 9 parts Eldridge water to 1 part Wises.
Conveyance of release water to proposed release point	Until completion of dewatering of Eldridge Pit (and prior to commencement of construction of the tailrace outlet works) the temporary pit dewatering infrastructure (pontoon mounted submersible pumps and HDPE pipes) will be utilised. When a release opportunity arises water will be pumped directly to the proposed release point via a temporary network of pipes laid out to the proposed release point. Upon completion of dewatering of Eldridge Pit and during construction of the tailrace outlet works the completed Wises Pit spillway chute and conveyance channel (gravity flow) will be used to direct water to the proposed release point. Water will enter the spillway chute via a gated structure inset into the spillway.	Water released from Wises upper reservoir will be conveyed to the potential release point via the spillway chute and conveyance channel (gravity flow). Water will enter the spillway chute via a gated structure inset into the spillway.
Release infrastructure into the Copperfield River	Design and construction of the operational phase outlet works has been identified for early works and is proposed to be completed as close to commencement of construction phase dewatering operations as possible. In the event that the works are not complete prior to this, initial releases during the construction phase may be via a simple outfall structure (incorporating relevant erosion and sedimentation control measures). This is necessary for the Project to take advantage of potential release opportunities as soon as the construction phase commences. It is anticipated that this would only be required for a short period during the first wet season of the construction phase. Ongoing releases during the remainder of the construction phase are anticipated to be via the completed operational phase release infrastructure (instream diffused, outlet structure). Use of any temporary outfall structure would cease following the commissioning of the operational phase outlet works. Decommissioning and removal of any temporary outfall structure would be completed as soon as practical following commissioning of the operational phase outlet works.	Releases will be via an instream diffused, outlet structure.

4.1.3 Operational Phase

The Project will seek to sell electricity during peak demand periods when prices are high (typically in the morning and evening). This will be achieved by releasing water from the upper reservoir, through a reversible turbine-generator system, into the lower reservoir (known as a generation cycle).

Once the generation cycle is completed, the reversible turbine-generator system will pump the water back into the upper reservoir when prices are lowest, typically overnight by using grid power (known as a pumping cycle) or during the day by utilising the electricity produced from Genex's proposed co-located solar project (K2S).

4.1.4 Rehabilitation

The Project is located predominantly on a freehold site which was a former open cut gold mine. During the final stages of the mining operation and following the closure in 2001, a number of key rehabilitation works occurred. The major rehabilitation works included:

- grading and revegetation of the tailing's facility and waste rock dumps
- implementing a water management plan for surface and groundwater flows within the existing site, including flooding of the pits
- removing all mining related buildings and revegetation of associated footprints during these activities.

An EA was granted over the site in October 2013 to govern the management of the site following closure and rehabilitation of the mine. This was inherited by Genex following its acquisition of the site in 2015 and included providing an environmental bond to the Queensland State Government of $3.8 million.

While managing the site under the terms of the EA, Genex is seeking to beneficially reuse the site through a new productive industrial use, being a renewable energy generation and storage facility. Genex completed the development of its 50MW Kidston – Stage 1 Solar Farm (KS1) on the old tailings site, which was energised in December 2017. Stage 2 of the development involves further reuse of the site through repurposing the existing mine pits into a new pumped storage hydro facility (the Project) and developing the associated K2S solar farm.

Based on current design specifications, the Project will have a minimum lifespan of 50 years, with various components having a lifespan extending beyond this. With operation anticipated to commence in 2021, the Project lifespan would run until 2071 at a minimum.

On this basis, Genex considers that it would be extremely difficult to foresee the available rehabilitation methods at this future date, given it is highly likely that there will be significant advances and modifications to rehabilitation methods, available technologies to assist with rehabilitation, and changes to government policies on adequate rehabilitation procedures.

Notwithstanding this, Genex considers that it or the asset owner would have several available options once the Project nears the end of its design life, which would include:

- spending capital to upgrade the facility to extend the economic life of the Project
- repurposing the facility for an alternative solution (e.g. tourism)
- closing the facility and proceeding with rehabilitation works.

Genex considers that the most likely option would be to upgrade the facility to extend the economic life of the Project. If Genex or the asset owner took the decision to repurpose or close the facility at the end of its design life, Genex considers that to achieve a successful rehabilitation program, Genex or the asset owner at the time would need to take into account current rehabilitation methods (including technology advances), current government policies on rehabilitation and best-industry practices for safety and environmental protection.

4.1.5 Timeframe for the Project

For the purpose of the IAR, the following timeframes in Table 3 are anticipated.

Table 3 Project Development Timeframes

Milestone	Timeframe
• Feasibility Study	Completed November 2016
• Optimisation Study	Completed October 2017
• Selection of preferred EPC Contractors	Completed October 2017
• Selection/procurement of hydroelectric turbine equipment package	Completed April 2018
• Financial Close	Q2 2019
• Construction Phase (including construction phase releases)	2019 - 2022
• Commissioning & operation (including operations phase releases)	2022

4.2 Project Need, Justification and Alternatives Considered

4.2.1 Project Objectives

The Project, along with the proposed co-development of K2S, has several objectives which benefit Genex, the State of Queensland and the NEM. These can be summarised as follows.

- To underpin a new Renewable Energy Zone (REZ) in Far North Queensland, where an abundance of wind and solar resources exist, through the provision of energy storage and ancillary services to support further renewable generation projects, including localised load, inertia, voltage control and other ancillary services.
- To facilitate the development of new transmission infrastructure as a cornerstone of the new REZ, which will be required to support further renewable generation projects.
- Improving the reliability and system strength of the Queensland transmission network through the addition of new dispatchable, synchronous generation.
- Helping to maintain the affordability of electricity for consumers in Queensland, through supporting development of additional low cost renewable generation.
- To contribute to the overall lowering of carbon emissions, through supporting the development of renewable projects, including Genex's co-located solar projects.
- To re-purpose an abandoned mine site into a new industrial use for the next 50+ years.
- To benefit the local and regional community through providing local employment opportunities for over 500 people, future growth of tourism and support of the local indigenous community through sponsorship of tourism projects.
- To deliver commercial returns to Genex's shareholders.

4.2.1.1 Project Need, Justification and Strategic Benefits

The Project offers a large-scale, low-cost and flexible solution to Queensland's growing peaking power requirements. The Project is well positioned to take advantage of the combined effects of an oversupply of baseload generation capacity and escalating peak power prices being driven by increasing gas turbine fuel costs. As renewable power gains momentum in Queensland, especially the prevalence of rooftop solar but increasingly supplemented by the deployment of large-scale solar projects, the need for energy storage and energy management will play a far more important role in the electricity network.

Large-scale storage projects such as the Project will provide stability in supply to the grid which will become even more important because of intermittent generation issues associated with renewable energy. The Project will significantly contribute towards alleviating the growing pressure on peaking power demand and peak power prices in Northern Queensland and in Queensland more generally.

Besides delivering rapid response, flexible and renewable peaking power into the network in Northern Queensland, the Project also is expected to create more than 370 jobs in the construction phase as well as numerous indirect jobs and demand generally for services in the greater Etheridge Shire. The Project is also expected to create approximately 9 jobs during the operation phase.

Queensland Peaking Power Deficit and Rising Prices

The Northern Queensland region is currently a net importer of electricity from the Central Queensland region, with a forecast growing peaking power deficit. Once operational, the Project will significantly alleviate this emerging issue.

The Queensland electricity market is currently experiencing high peak prices during hot summer days and cold winter days, and frequent power price spikes compared with other Australian States. Furthermore, the Mount Stuart Power Station (a peaking power generation station) is scheduled for decommissioning in 2023. This issue is further compounded by the increase of liquefied natural gas (LNG) export which is making existing gas generators (for peaking and shoulder generation) costly to run.

At 250MW, the Project will add significantly to the State's peaking and shoulder power generation capacity. Aside from the capacity issues, the Project will also mitigate price increases forecast as a direct consequence of open cycle gas turbine peaking generators operating in an environment of escalating gas prices.

Blackstart Capability and Ancillary Services

Approximately 90% of Queensland's power needs are met through the operation of coal fired power stations (59%) and gas turbines (31%). These generators have a restricted ability to self-start in the event of a power grid failure. Hydroelectric power plants are renowned for their ability to offer rapid response grid "blackstart" capabilities, that is, the ability to restart other generators and the electricity grid within seconds in the event of network shutdown. With potential cyclone events and bushfire threats, the Project will provide Queensland with a more reliable solution during these events.

The Project will also provide a full range of ancillary services to the grid, including frequency and voltage control, load levelling, synchronous generation capacity and capacity deferral. In addition, it has the potential to support grid stability through inertial spinning reserve and fast ramp rates, which is particularly important in the context of growing deployment on the network of intermittent renewable energy.

Economic Stimulus and Employment – Etheridge Shire

The Project will significantly contribute to the economic wellbeing of the Etheridge Shire. It will require extensive use of local building materials, construction services and human resources during construction and operation, in a region that could considerably benefit from economic and social uplift.

KS1 is already providing economic activity and employment opportunities to Kidston and the Etheridge Shire, and more than 160 jobs were created during the construction period.

As noted in Section 4.2.1.1, it is anticipated that the Project and K2S will generate a total of more than 500 jobs during construction, which Genex anticipates will be filled primarily by personnel from within the immediate Local Government Area (Etheridge Shire) and other nearby locations (Townsville, Cairns etc.). The Project alone will generate over 250 of those jobs.

In addition to these economic benefits, Genex currently supplies water on a voluntary basis, at no cost, to the local township of Kidston and to surrounding cattle stations.

The Copperfield Dam, which is the source of the water for Kidston, also plays an important role in regulating the river flow down to Einasleigh. The dam is currently maintained by the State with Kidston Gold Mines Limited (KGML, 100% owned by Genex) providing 100% of private sector funding via its water services agreement with the State. The success of the Project will ensure the continuation of the various social benefits to residents in and around the Kidston area as a result of being able to use the Copperfield Dam.

A Global First for Queensland in Innovation and Clean Energy Leadership

Once completed, the Project will be the first in the world to utilise two disused mine pits for hydroelectric power generation, and the first hybrid large-scale solar photovoltaic and pumped hydro storage plant. The Project has already found interest internationally, and Queensland, as the host State, will receive recognition as an enabling partner in this innovative and ground-breaking use of a redundant mining asset for a clean energy power solution.

Queensland currently has over 11,000 abandoned/closed mines of various scales, most of which are in locations with excellent solar resources. The maintenance of abandoned mines and their environmental footprint currently poses a significant financial drain on the State. If the Project is successful, it is possible for the scheme to be duplicated across a number of sites within Queensland. This would not only substantially alleviate environmental costs and liability to the State, but also demonstrate an innovative approach for repurposing mining projects for new industrial uses beyond the end of mine life.

4.2.2 Design Refinement and Assessment of Alternatives[3]

The Project design has progressed through a number of design iterations that have considered key selection criteria including environmental impact, constructability, operations and maintenance, and relative costs (capital and operational). A summary of the development of the proposed design is outlined below.

Approximately 27.5 GL of water is required to be removed from Eldridge Pit to gain access for construction of the tailrace outlet works. In the following discussion, ‘excess construction water’ refers to the residual volume of water from the Eldridge Pit not able to be accommodated in onsite storage for each design option.

4.2.2.1 Design Option 1 – Original Design (Prefeasibility)

The initial prefeasibility design called for a 330MW installed capacity based on a market study of the optimum installed capacity.

Limited availability of survey information (due to the pits being full of water) resulted in uncertainty regarding the available driving head (i.e. the difference in water level between the upper and lower reservoir - a key driver of generating capacity) and the storage volumes of these reservoirs.

Whilst a higher capacity was considered preferable, the prefeasibility study concluded that current pit capacity without modification would only allow for 220MW installed capacity by using the pits in their current configuration.

[3] Note that the following section summarises in part, high level preliminary documentation that utilised contemporary information and data that, in some instances has been subsequently revised and/or updated. For example the current estimated volume of water required to be dewatered from Eldridge Pit is around 28 GL due to additional inflows over the 2017/18 wet season. Similarly, initial estimates of the current capacity of the existing Wises pit have also been refined and are now in the order of 8.5 GL.

Key concerns arising from prefeasibility design included:

- Significantly large volume of excess construction water (approximately 27.5 GL) that would need to be removed from the Eldridge Pit ahead of construction to allow installation of the tailrace. As the existing Wises Pit can only hold approximately 10 GL, and the balance of 17.5 GL would need to be released.
- Potential stability issues associated with construction of key infrastructure such as the access road into Eldridge Pit
- The high dollar per MW cost resulting from a smaller installed capacity; especially in light of the high cost of required enabling infrastructure such as the transmission line.

4.2.2.2 Design Option 2 – Turkeys Nest Design (Feasibility)

The feasibility-level Design Option 2 sought to overcome the geometric deficiencies (head difference and volume able to be transferred between pits) in the original design. Genex initially advised that an installed capacity of 330MW was not optimised and that alternatives should be considered. An alternative design was proposed to Genex which involved the construction of a turkey's nest reservoir (a ring dam with no external catchment) on top of the northern waste rock dump area in order to overcome the deficiencies inherent in the original design.

This option presented additional benefits including having Wises Pit as a balancing reservoir instead of as the upper reservoir, increased head and therefore potential for higher installed capacities, and a potential reduction in the volume of water required to be released from Eldridge Pit if the turkeys nest dam was used to hold water removed from Eldridge Pit. However, the turkey's nest only provided for an additional 4.4 GL of storage; meaning that, in combination with the additional 10 GL provided by Wises Pit in its current configuration, this still left a water surplus of approximately 13 GL - which would need to be removed during construction.

Genex engaged a number of specialist sub-consultants such as Water Treatment Services (for in pit treatment) and AGE (for groundwater modelling[4]) as well as consulting several suppliers to assess a range of potential options to address the surplus water volume to avoid the need for discharging the water to the Copperfield River. Several options were compared for the management of surplus water as follows, and summarised in Table 4.

- It was found that Options A, B and C provided optimum solutions for the storage of a portion of the water from the Eldridge Pit and it was recommended that these options were carried forward along with Option D (raising of Wises Pit full supply level (FSL) to 543 m AHD).
- Options E (in pit treatment) and F (reverse osmosis) were able to provide technically viable solutions but at considerable additional cost, complexity, generation of additional waste streams and energy consumption, and significant risk to the construction schedule due to the need to treat additional interim inflows from weather events during construction. For these reasons these options were not considered to be feasible.
- Option G (evaporative blowers) and H (dilution using water from the Copperfield Dam) were only able to provide potential additional contingency measures for the removal of up to 2 GL each and were not considered viable alternatives for treatment of the large volume of excess construction water.

[4] AGE assumed an FSL of 551m AHD as a 'worst case' throughout modelling of Option D, which was nevertheless considered to present a low risk of impact to groundwater.

Table 4 Summary of Options from the 2016 Workshop

Options		Volume addressed (GL)	Treatment cost ($M)	Pumping cost ($M)	Option ranking	Notes
Probable options						
A	Store in Wises Pit, current capacity up to 530m AHD	10	N/A	5.6	1	No constraints except ensuring adequate freeboard maintained in case of heavy rain during construction.
B	Store in Turkey's Nest (up to 581.5m AHD)	Up to 4.1GL	N/A	N/A	1	Not available until 1.5 years after the commencement of construction
C	Water use during construction	~0.3	N/A	0.1	1	Could be used for the construction of turkey's nest, Wises Dam, etc.
	Subtotal	14.4	N/A	5.7	N/A	Currently 10GL storage available straight away but the rest only during construction
Potential options						
D	Storage in Wises Pit between 530m and raising to FSL of 543m AHD	11	2.7	2.4	2	Potential risk of impact to groundwater. This risk was assessed and considered to be low based modelling work undertaken by AGE. AGE assumed an FSL of 551m AHD as a 'worst case' throughout modelling of Option D, which was nevertheless considered to present a low risk of impact to groundwater.
E	In pit treatment and release	17.5	>9.5		4	Costs of in pit treatment higher than anticipated and not viable.
F	Reverse osmosis and release	12	14.5	3.4	3	Approximately 400 days required to treat 14 GL of water. This treated water would still need to be released to the Copperfield River. Significant volumes of brine concentrate would need to be stored.
G	Evaporative blowers	2	6.5	N/A	N/A	2 GL over 2 year construction window assuming normal years (not heavy rain)
H	Dilution	2	1.2	0.8	N/A	Requires regulatory approval for release.

Key factors which made this design unfeasible included:

- Large scale earthworks associated with construction of the turkey's nest dam.
- Unacceptable geotechnical risks associated with construction of the turkey's nest dam on modified ground conditions.
- The construction of the turkey's nest was necessary for dewatering of Eldridge Pit and therefore added significant time to the construction program.
- None of the options assessed were able to completely address the construction water surplus.
- The high cost per MW due to the cost of the proposed turkeys nest dam was only considered viable for a 450MW project, but not for a 250MW project.

The following option was therefore recommended to be taken forward:

- Upgrading the Wises Pit by creating a dam to an FSL of 551m AHD (crest of 552.7m AHD) and excavating its northern dump area down to 546.90m AHD.
- Raising the entrance of the access tunnel to disconnect the underground works from the Eldridge Pit dewatering and pumping of 11 GL from Eldridge Pit to the Wises Pit.
- Once the dam has been built and infrastructure to transfer water between the pits was constructed, to pump the remaining 16.5 GL of water from the Eldridge Pit to the upgraded Wises Dam thereby allowing for storage of this water without discharge.

4.2.2.3 Design Option 3 – Optimised Reference Design

At the feasibility level it was concluded that the concept of utilising the two existing mine pits as the upper and lower reservoirs was optimum for a 250MW installed capacity. While the turkey's nest concept was well accepted, it was only deemed necessary for higher installed capacities. In addition, a number of geotechnical and operational risks were identified with its proposed location on the northern waste rock dump.

Groundwater modelling undertaken for the feasibility stage was updated to include this 250MW concept and concluded that the Eldridge Pit would continue to act as a sink and intercept potential groundwater seepage from the Wises Pit for this revised design option.

Dewatering of the Eldridge Pit to enable the construction of the underground infrastructure was considered further. Of the approximately 27.5 GL of water required to be removed from the Eldridge Pit to enable access to the tailrace outlet, the majority (95%, 26 GL) could be temporarily stored in the upgraded Wises Pit reservoir up to the FSL of 551m AHD.

Water sampling and chemical analysis from the Eldridge Pit showed that any water released (including potential additional inflows from rainfall) would require significant time-consuming and expensive treatment to enable the water to be released from site (e.g. to the Copperfield River) without dilution by receiving environment waters.

The design team concluded that the most effective solution to this dewatering issue would be an engineering solution involving the modification of the Wises Pit to store the excess water if possible.

This design phase also established that treatment of surplus water from significant rainfall inflows during the operational phase of the Project would be impractical to treat given that the volumes of water requiring treatment are highly variable. A number of key aspects of this design required further consideration including:

- Management of excess water during the dewatering of Eldridge Pit along with any additional rainfall inflows during the construction period.
- Minimising discharge of surplus water during the significant rainfall events during the operational phase of the Project.

4.2.2.4 Design Option 4 – Proposed Design

This design phase confirmed that the Optimised Reference Design (Design Option 3) concept of utilising the two existing mine pits as the upper and lower reservoirs was optimum for a 250 MW installed capacity. A number of engineered solutions were explored in order to enlarge the constructed Wises Pit upper reservoir to provide sufficient capacity to contain the entirety of the water required to be dewatered from Eldridge Pit during construction of the tailrace outlet. These included removal of the backfilled waste rock material in Wises Pit and an additional raising of the proposed Wises Pit embankment.

Similar to the costs associated with treatment options explored during the Optimised Reference Design, the costs of including additional capacity to Wises Pit were found to be unacceptably high. In addition, the provision of a fixed capacity solution (in terms of either storage or treatment capacity) could still present a risk to the Project construction resulting from additional ingress of water during storm events occurring during the dewatering of Eldridge Pit and the subsequent tailrace construction period.

The Proposed Design has also included an engineered mitigation for the management of excess water during operations. The design proposed for the Wises Pit upper reservoir incorporates an additional 0.5 GL buffer volume between 550.56 m AHD and 551 m AHD. The purpose of the buffer is to limit the likelihood of uncontrolled discharge by:

- Allowing the Project to store some additional water without unacceptable impacts to power generation and general operations.
- Allowing for the temporary storage of water until an opportunity to release is presented by naturally occurring stream flow in the Copperfield River.
- Act as a balancing storage during storm events when the rate of inflow is higher than the rate of water able to be released.

Key advantages of the Proposed Design include:

- Minimal volume of excess water during construction (reduced from 17.5 GL to potentially less than 1.5 GL).
- Significant operational flexibility provided by the buffer storage volume to absorb stormwater inflow or control the timing of potential releases.
- No generation of additional waste streams or handing of large quantities of chemicals resulting from water treatment processes.
- Low technology risk solution.

4.2.2.5 Design Option 5 – Optimised Proposed Design

Following discussion and consultation with DES during 2018, Genex reconsidered the Proposed Design in light of the requirement to discharge over 1.5 GL of water during the construction phase to facilitate construction of the tailrace outlet structure within Eldridge Pit.

This resulted in the development of the Optimised Proposed Design, which was based on the Proposed Design but incorporated the following additional attributes:

- Excavation of additional waste rock (1.3 million m^3 from Site A in Figure 5) and virgin rock (200,000m^3 from Site B in Figure 5) material from within Wises Pit to create an additional 1.5GL of water storage below the proposed MOL of 546m AHD
- Temporarily raising the spillway level in Wises Dam to 552.0m AHD (from 551.5m AHD during operation) to temporarily store a further 1.0 GL of water during construction of the tailrace within Eldridge Pit.

Further detail on these two attributes is provided below.

On the basis that the Optimised Proposed Design was able to further minimise the construction phase water discharges, it was selected as the final design to be adopted for the Project.

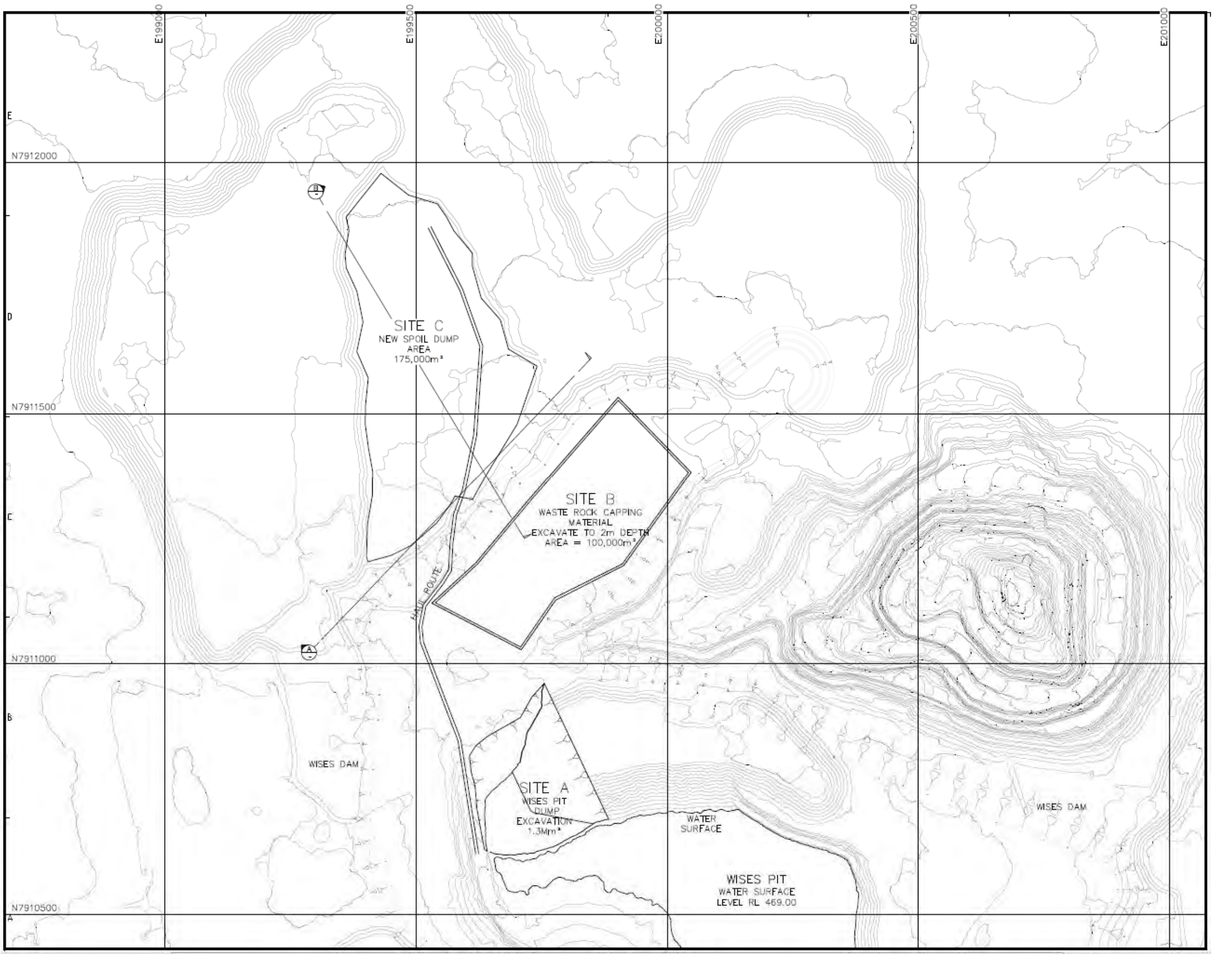


Figure 5 Design Option 5 Excavation Areas

Excavation of additional rock

Site C was selected as it is an area that was previously cleared by the mine site but is not a rehabilitated waste rock dump (the site was prepared but never utilised as a waste rock dump). The material from Site A will be placed, capped with material from Site B and vegetated in compliance with the existing EA. The design of this new rock dump will incorporate appropriate drainage arrangements to allow potential seepage from the dump to be contained on site and directed to the Wises and/or Eldridge pits or to one of the existing collection points and pump stations around the site. Cross sections of the preliminary design are shown in Figure 6.

It is noted that the Wises Dam design incorporates drainage arrangements around the full perimeter of the dam levee to firstly ensure water pressure does not build up against the outside of the dam levee and secondly to capture and direct seepage from the existing waste rock dumps (including the new rock dump at Site C) to the Eldridge pit and/or the existing seepage capture points and pump stations on site.

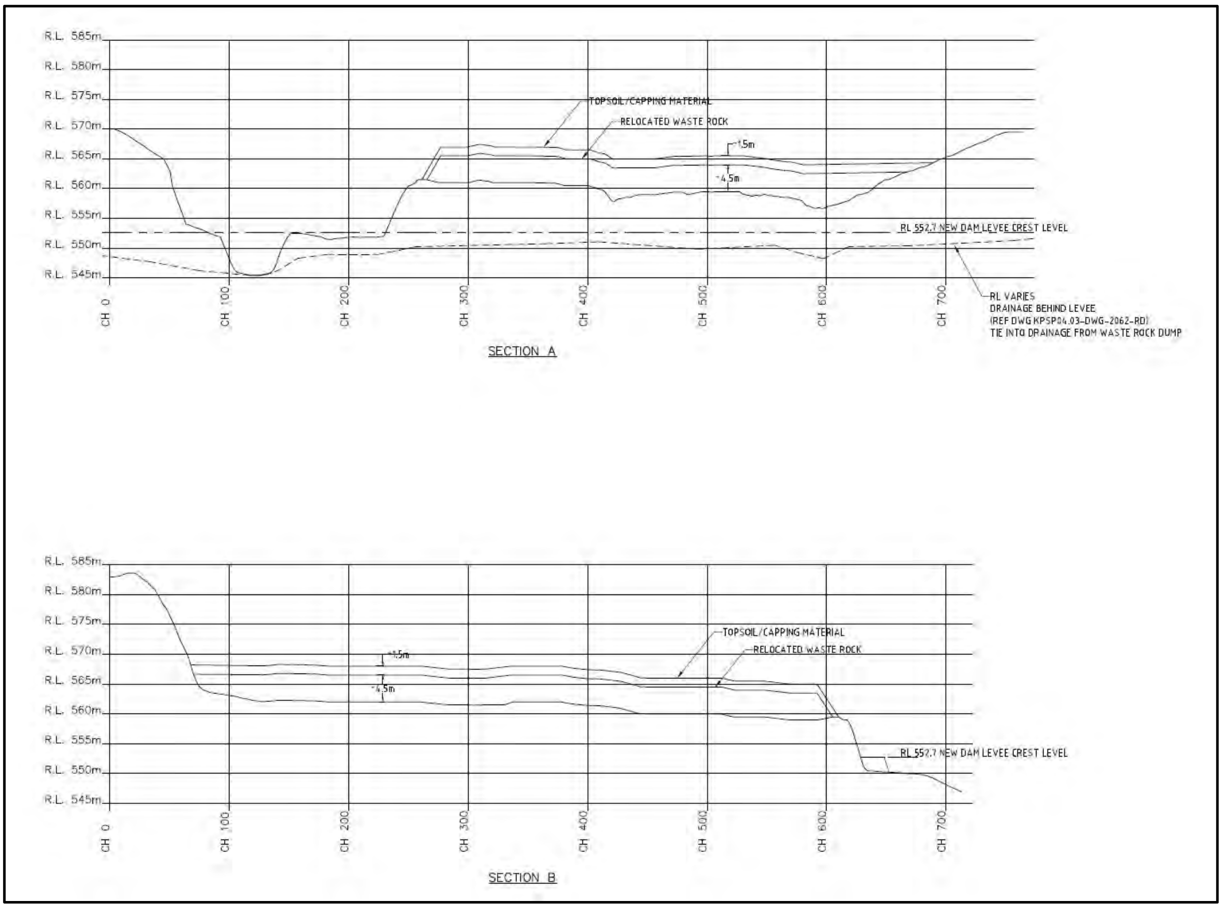


Figure 6 Additional Storage Sections for Design Option 5 (refer to Figure 5 for Cross Section Locations)

Temporary raising of spillway

DNRME has confirmed to Genex that it is comfortable with the proposal of temporarily holding excess water in Wises Dam above the FSL of 551.0m AHD (with the final design incorporating a spillway at 551.5m AHD and the dam crest of 552.7m AHD). The dam design incorporates a hydraulic gate arrangement that can be raised and lowered to adjust the effective spillway level to allow this temporary additional storage capacity in the dam and this functionality would be used temporarily to raise the spillway level. It is intended that this will only to be undertaken for the period during which the tailrace portal is being constructed, comprising approximately 6 months.

4.2.3 Design consistency with Management Hierarchy for Surface or Groundwater (EPP Water)

The Optimised Proposed Design has been reviewed against the management hierarchy for surface and ground water outlined in the EPP (Water). Table 5 provides a summary of the review of the Optimised Proposed Design against each step of the management hierarchy.

Table 5 Review of the Proposed Design against Management Hierarchy for Surface or Groundwater (EPP (Water), Part 5, Sec, 13)

Step 1 – Water Conservation	Step 2 – Waste Prevention	Step 3 – Treatment or Recycling	Step 4 – Release Options
Development of the Optimised Proposed Design has progressively reduced the excess construction water by approximately 18.0 GL. During operations, water conservation measures are not applicable as the generation of pumped storage hydro power does not consume water as a process input. The existing body of water contained in the pit is effectively continually recycled around a semi-closed loop consisting of power generation and pump back. In the absence of evaporative losses and wet season inflows, the volume would remain constant. Water is still required to replace evaporative losses as evaporation typically exceeds rainfall during an annual cycle. While this may be considered a process water input there is little operational flexibility to minimise this demand as the successful operation of the Project requires that the total volume of water in both pits is maintained at an optimum level.	Development of the Optimised Proposed Design from the Proposed Design considered mitigating the requirement to discharge excess construction water, such that this volume has now been reduced to zero and water can be managed in line with the operational phase. During operations, the generation of additional volumes of potentially contaminated water has been minimised to the greatest extent possible through the passive diversion of stormwater runoff around the Eldridge Pit (Wises Pit has only a very small external catchment). Rainwater falling directly on each dam's water surface will however continue to contribute additional inflows. The lining of the embankment of Wises Pit has been designed to mitigate any potential for ongoing deterioration in water quality	Onsite reuse of water for bulk earthworks including construction of the Wises Pit dam is estimated to use approximately 0.3 GL of water from the pits. Due to the quality of the water within the pits, no practical offsite reuse of the excess water is possible. Water stored in the pits does not currently meet water quality objectives (WQOs) for stock watering or irrigation without extensive treatment. There are no identified industrial demands for the untreated water within a reasonable distance. The presence of the Copperfield Dam also provides a significant alternative source of uncontaminated water that does not require treatment. A number of treatment options have been explored, most extensively as part of Design Option 2. Options investigated considered reverse osmosis, forced evaporation (mechanical blowers) and in-pit treatment. A key reason for why treatment options were found to be unviable for the Project was that the volumes of water requiring treatment are highly variable. The operational water balance model shows that releases caused by heavy rainfall could exceed 1GL per year. The periodic nature of the generation of excess water volumes and the requirement for intermittent operation is not suited to membrane filtration water treatment which must remain	There are no practical options for disposal of excess water at a waste treatment facility due to the remote nature of the Project location. The ability of irrigation to land to remove surplus water during the wet season is very limited as soils are typically at or near saturation point and unable to absorb irrigation water. Whilst irrigation to land was considered during the development of the Proposed Design, especially during construction, it was considered unsuitable given the volumes able to be removed and given the land area available. The subsequent Optimised Proposed Design was developed to store excess construction water such that releases of excess water are only required to cater for seasonal inflows during both the construction and operational phases under a controlled, event-based release of water from the Project under conditions that will not cause unacceptable environmental harm to downstream EVs is deemed to present the best option for the periodic release of excess water from the Project.

Step 1 – Water Conservation	Step 2 – Waste Prevention	Step 3 – Treatment or Recycling	Step 4 – Release Options
	through mobilisation of potential sources of contamination originating from waste rock dump material used in the embankment construction.	continuously operational for optimum use. The use of enhanced evaporation does not provide a suitable disposal solution as treatment rates are slow, largely unavailable during wet weather (low evaporative potential) and are subject to high running costs and low reliability. The subsequent Optimised Proposed Design was developed to store excess construction water such that treatment or recycling of excess construction water is not required.	

4.3 Kidston Site Overview

4.3.1 Existing Kidston Site Water Management

The seepage interception system (SIS) consists of a number of interception dams, evaporation ponds and or sumps that also have pump-back systems directing poor quality seepage originating from the waste rock dump (WRDs) and Tailings Storage Facility (TSF) to one or other of the existing pit voids (refer to Figure 7). During the initial period of closure planning it was assumed that capping of the WRD's and TSF would in the long term eliminate expression of poor quality seepage to the existing collection points including:

- North Dump Dam
- East Dump Dam
- South-East Dump Dam; and
- TSF Reclaim Pond.

Medium term planning identified the use of a series of sulfate reducing bacteria (SRB) wetlands for passive treatment of poor quality seepage. However, seepage flow rates have not significantly decreased and the SRB strategy has not proven to be effective in reducing sulfate concentrations. Consequently, active pump-back systems are still being utilised. Following the extreme 2011/2012 wet season, the following additional pump-back locations were installed at the request of DES (formerly DEHP):

- Sedimentation dams HD2, HD3 and HD5
- Managers Creek; and
- South-East Dump seepage point.

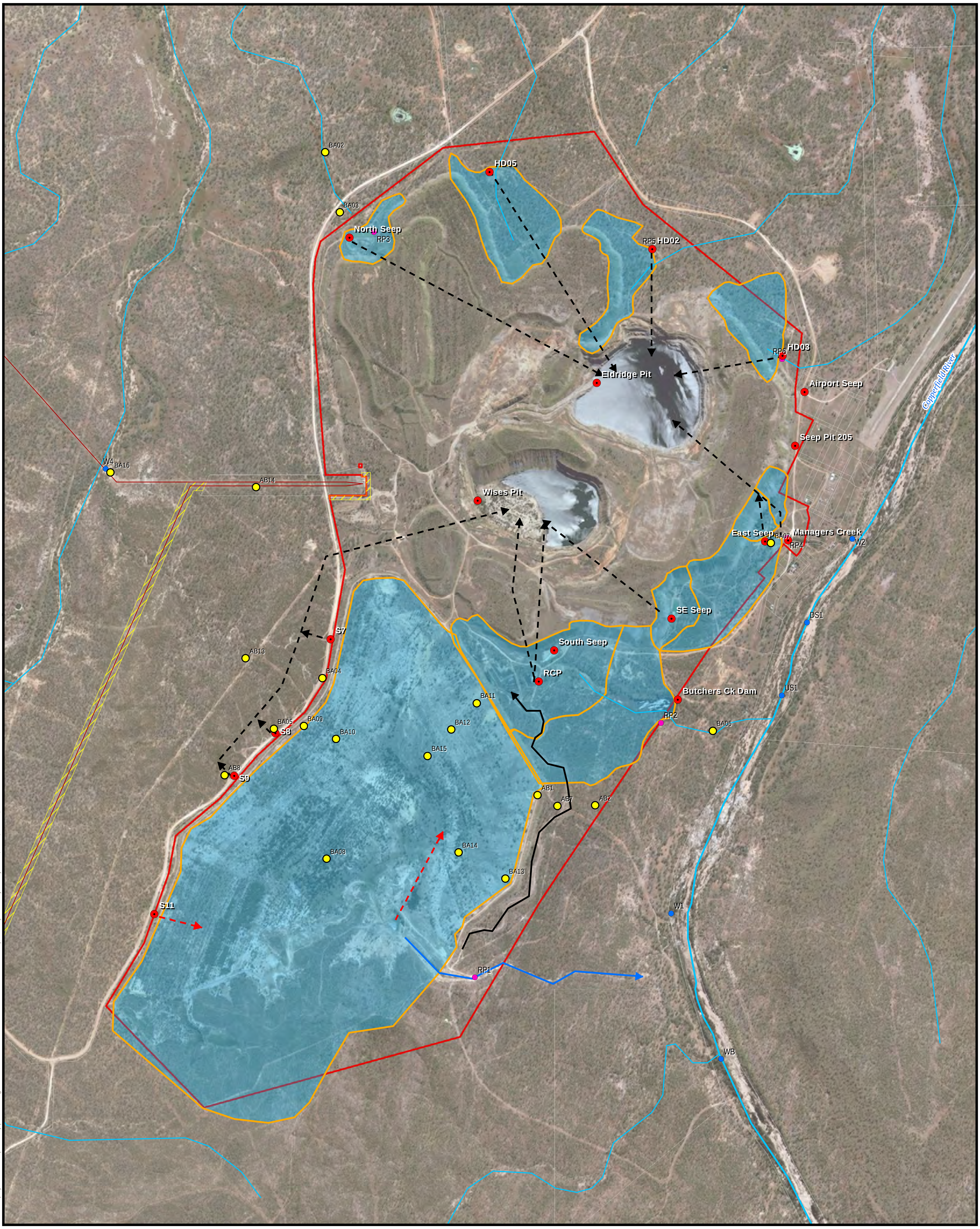
(Barrick Australia, 2013)

Discharge of seepage from the SIS to the receiving environment can occur during periods of intense or prolonged rainfall. SIS pump back locations around the WRDs (refer to Figure 7) are subject to ingress of surface runoff as well as seepage. In addition, surface runoff from the TSF can exceed the capacity of the TSF sediment dam during the wet season. Quantification of the temporality, volume and concentration of discharges from key locations such as the TSF sediment dam has not been undertaken due to a lack of available data. However, examination of baseline receiving environment data (Sections 4.9.3. and 5.6) for monitoring point W2 indicates a localised elevation of key contaminant concentrations which are likely to be as a result of release of seepage water from point sources in the SIS as well and more diffuse subsurface sources entering the Copperfield River at or near to W2.

While the discharge of water from the SIS concurrent with the proposed controlled release of water from the Project is possible during periods of intense or prolonged rainfall, it is noted that:

- Estimation of available assimilative capacity in the receiving environment at the proposed release location (Section 7.1.1) has been informed with water quality data taken from monitoring site W2.
- A review of data for W2 indicates a strong likelihood that water quality at W2 is already impacted by possible discharges (point or diffuse) of poor quality runoff or seepage from the Project site.
- The resultant estimation of available assimilative capacity in the receiving environment therefore includes partial inclusion of the existing contaminant load leaving the Project site.
- Ongoing and proposed additional monitoring (refer to Section 9.2 and Appendix I (Receiving Environment Monitoring Program (REMP)) will allow for the refinement and understanding of the existing potential for export of contaminant loadings from the Project to the receiving environment. This information will be used to revise and update estimations of the available assimilative capacity in the receiving environment and inform refinement of the proposed release conditions as required and outlined in Section 9.1.

Potential changes to the SIS as a result of the Project are not able to be reliably assessed due to a lack of relevant data. However, no significant changes to the SIS are expected as a result of either the construction or operation of the Project. Key activities with the potential to alter fluxes to and from the SIS are related to the excavation and placement of waste rock material from within the existing Wises Pit (refer to Section 4.2.2.5). It is noted however that the contemporary design of the new rock dump will incorporate appropriate drainage arrangements to allow potential seepage from the dump to be contained on site and directed to the Wises and/or Eldridge pits or to one of the existing collection points and pump stations around the site. Detailed design of the new rock dump will determine any requirements for enhanced capture and/or conveyance (i.e. pump transfer capacity) that may be required. It is noted however that the new rock dump will minimise any potential additional contribution of seepage to the existing SIS through contemporary capping design criteria which are designed to minimise infiltration of surface water into the dump.



LEGEND

- Groundwater Monitoring Bores
- SIS Pump Back Locations
- Existing Monitoring Point
- Reference Site
- Release Point
- Kidston Substation
- Electrical Network - TR CABLE
- Electrical Network - TR LINE
- Watercourse - Major
- Watercourse - Minor
- Easements
- Cathments
- Site Boundary
- Property Boundaries Queensland
- Pumped To Surface Discharge
- Pumped Seepage Flow
- TSF Seepage Toe Drain
- TS1 Overflow

Data sources:

AECOM
www.aecom.com

N

DATUM GDA 1994, PROJECTION MGA ZONE 56

0 250 500 1,000
metres

1:20,000 (when printed at A3)

KIDSTON PUMPED STORAGE HYDRO PROJECT
IMPACT ASSESSMENT REPORT

Existing Surface Water Management and Groundwater Locations

PROJECT ID	60544566
CREATED BY	RF
LAST MODIFIED	RF - 11 Jan 2019
VERSION:	1

Figure
7

A3 size

Filename: P:\605X\60544566\4. Tech Work Area\4.99 GIS\02_MXDs\Hydro\G60544566_002_ExistingWaterManagementt_v4_A4_2018011.mxd

4.4 Pit Water Quality

This section summarises the water quality of the Eldridge and Wises Pits and describes water quality processes operating within the pits. This is undertaken to define the likely range in quality of the water that may be released by the Project. Wises Pit currently has a relatively shallow water column to a depth of ~ 10 m and is expected to be unstratified with homogeneous water quality. In contrast, Eldridge Pit has been filled with water to a depth of ~ 240 m, which has the potential for stratification and varying water quality.

To provide an indication of the possible variation in water quality at depth and to assess the potential impact of this water following transfer to the Wises Pit, two water quality profiling exercises have been undertaken. The first profiling was undertaken by Entura in November 2015 (Entura, 2016). This exercise undertook profiling of the top 200m of the water column in the Eldridge Pit but did not reach the base of the pit. The exercise found that the Eldridge Pit was largely un-stratified in terms of physio-chemical parameters (pH, EC, temperature etc). The second profiling campaign was undertaken by AECOM in March 2018 to confirm the findings of the earlier study and to attempt to analyse the physio-chemical parameters to the base of the pit. Furthermore, additional profiling samples were collected in August 2018 by Genex in order to assess whether similar trends were observed. A summary of all profiling investigations is provided in Appendix C.

Overall, the August 2018 results are comparable to the 2016 Entura profiles. In general, dissolved metal/metalloid concentrations reported from the August 2018 profile sampling are slightly lower than those recorded in 2016. The August 2018 results also indicate an apparent homogeneity along the pit profile. The differences may be due to the different sampling methods (a Niskin bottle was used in the 2016 study, whereas HydraSleeves were employed in the 2018 work) and/or may reflect seasonal variations (the 2016 study was completed in the wet season, whereas the 2018 study was conducted in the dry season).

The 2016 study reported variations in water quality both at the top and the base of the pit profile, which are not observed (or not observed in the same magnitude) in the 2018 investigation. Differences in surface water quality may reflect seasonal variations. The 2016 study may have perturbed the base of the pit leading to marked variations in water quality in the lowest section of the profile; these were not observed in the 2018 study. August 2018 dissolved nickel concentrations are reportedly higher than total nickel concentrations; however, total suspended solids are recorded at or below limits of detection for most of the 2018 profile. In addition, repeat analysis of profile samples indicates that the total and dissolved concentrations are within analytical precision. It is suggested, therefore, that there were very little suspended solids entrained in the water column during sampling and that the total and dissolved concentrations are equivalent.

The water quality statistics for both pits are outlined in Section 4.4.2. As part of this baseline investigation, variations in the water quality since pit rehabilitation have been assessed and are included as time-series trends of key parameters in Appendix D. The conclusions of this section are drawn upon in the assessment of water quality against relevant guideline values.

4.4.1 History of Pit Development

Mining in the Wises Pit ceased in August 1997 and commenced in the Eldridge Pit to 2001 (Metago Environmental Engineers, 2008). The Wises Pit had been installed to 292m AHD, approximately 252m below ground level. The Wises Pit was then backfilled with co-disposed tailings (27 million tonnes) and waste rock (35 million tonnes) from the Eldridge Pit (Metago Environmental Engineers, 2008).

The Eldridge Pit was mined to a depth of approximately 270m below ground level (260m AHD). It was closed and rehabilitated in 2001. A pit lake began to form from groundwater ingress once dewatering had ceased. Rehabilitation of the pit involved accelerated flooding over a five year period to the estimated equilibrium groundwater level (i.e. the level estimated following groundwater rebound and inflow). This was undertaken to cover any exposed potentially acid forming rock and reduce the generation of metalliferous drainage from oxygen ingress. Water was sourced from the Copperfield River Dam as well as Wises Pit and the Tailings Storage Facility to accelerate flooding of the pit to this level. Water was pumped into the pit until a water level of 450m AHD, approximately 80m below the pit's full supply level, was achieved.

Since closure of the mine, seepage from the waste rock dumps into a series of seepage collection dams has been pumped back into the Eldridge and Wises Pits. This seepage pumpback system operates autonomously and is also designed to prevent the uncontrolled discharge of low quality water into the Copperfield River and Charles Creek receiving environments. Data for the pumpback system was only available for 2012 to 2015, but suggests that seepage pumpback water has an average electrical conductivity of between 3,500µS/cm and 4,000µS/cm.

The water quality in the pit since 2001 would therefore be determined by the composition of rocks comprising the Eldridge Pit walls, seepage pumpback water, rainfall and runoff, as well as the composition of water in Eldridge Pit once accelerated flooding activities ceased.

A comprehensive wall wash analysis was undertaken by Australian Laboratory Services (ALS) to determine contaminant generation rates for all rock types found in the pit (Metago Environmental Engineers, 2008). The rock exposure of the Eldridge Pit final wall and floor was mapped as (Metago Environmental Engineers, 2008):

- Einasleigh Metamorphics (51%)
- Quartz feldspar porphyry (1%)
- Metamorphic breccia (36%)
- Sheeted veins and mineralisation (12%).

The above geologies were tested in a comprehensive wall wash analysis (Australasian Groundwater & Enviornmental Consultants, Gilbert & Associates, Dobos & Associates, 2001). Tests indicated that the highest cadmium and zinc concentrations originate from sheeted vein areas and copper, arsenic and sulfate are generated from the breccia zones (Table 6).

Table 6 Contaminant generation rates (mg/m^2 per day) sourced from (Australasian Groundwater & Enviornmental Consultants, Gilbert & Associates, Dobos & Associates, 2001)

	Sheeted Veins		Metamorphic Breccia		Metamorphics		Porphyry	
	Low Generation	High Generation	Low Generation	High Generation	Low Generation	High Generation	Low Generation	High Generation
Ca	2.33	94.3	1.53	116.5	0.238	10.75	0.377	20.7
Mg	0.323	19.9	0.28	21.8	0.015	0.72	0.069	4.3
Na	0.265	16.01	0.53	130.2	0.046	2.12	0.073	5.9
K	0.035	1.9	0.068	6.2	0.015	0.45	0.019	1.02
SO4	8.04	2.96	5.78	484.1	0.417	10.26	1.19	62.2
As	0.115	0.001	0.00015	0.019	0.000068	0.00233	0.0011	0.049
Cd	0.00048	0.061	0.000015	0.009	0.000027	0.00092	0	0
Cu	0.00004	0.015	0.000027	0.0047	0.000014	0.00047	0	0.002
Zn	0.067	3.3	0.00013	0.049	0.000027	0.00092	0.000014	0.003

Heavy metals and sulfide that may be made soluble from the rocks in question largely reside in sulfide minerals. The potential release rate of these metals and sulfate is governed almost wholly by the rate at which oxygen can access sulphide minerals. Generally acidification is also associated with oxygenation of sulfide minerals. However acidification has not been experienced historically in pit waters of the site as a result of high acid neutralising capacity of the host rocks.

4.4.2 Pit Water Quality Assessment

Each pit has been sampled eighteen times over a period of approximately 15 years, which is approximately one sample per year since 2003. Generally, samples were collected towards the end of the dry season in October to November, when the effects of evapo-concentration are the greatest. As a result, the water quality is likely to represent the worst-case in any given year.

All water samples have been collected from the surface of each pit lake close to each access ramp. The sampling regime provides an indication of long-term water quality changes but does not provide an indication of the potential seasonal water quality variability. As outlined above, two depth profile investigations have been conducted (Appendix C). Water quality data for the Eldridge Pit, collected in August 2018 is presented in Appendix J.

Table 7 presents statistics of water quality sampled from each pit. The water quality statistics are compared to the default WQOs applicable to relevant EVs, as set out in Section 5.5. Where applicable, site-specific WQOs (including HMTVs) are used in preference to default WQOs, as justified by an assessment of the baseline water quality in the Copperfield River (refer to Section 5.6).

Cells which exceed the lowest WQO are highlighted in Table 7. Parameters which are elevated above the default WQOs are listed in Table 8.

Table 7 Pit water quality statistics (results are in mg/L unless otherwise stated)

Variable	Site	Num Obs	# Missing	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD	Default WQO
pH	E	21	0	7.4	7.5	7.6	7.6	7.85	7.9	7.9	7.93	8	8	8	7.774	0.189	
	W	19	0	7.4	7.7	7.836	7.865	7.92	8.175	8.2	8.24	8.42	8.564	8.6	7.996	0.272	6-8
Electrical Conductivity (EC) (µS/cm)	E	21	0	2000	2200	2300	2310	3020	3340	3360	4100	4150	4662	4790	3017	750.2	
	W	19	0	3800	4192	4590	4760	5300	6614	7060	8040	8380	9676	10000	5858	1637	500
Cations / Anions																	
Calcium	E	9	12	302	313.2	317.2	318	342	400	404	427	461	488.2	495	362.1	62.13	
	W	8	11	452	460.4	484.8	503	585	604	608.2	625	639	650.2	653	558.6	72.94	
Magnesium	E	9	12	77.8	87.56	90.6	91	98	100	102	109.2	117.6	124.3	126	98.42	13.04	
	W	8	11	130	134.9	137.4	137.8	139	144.5	146.6	161.3	175.7	187.1	190	145.6	18.72	
Sodium	E	3	18	41.9	90.92	139.9	164.5	287	296.5	298.4	302.2	304.1	305.6	306	211.6	147.3	
	W	3	16	135.5	226.6	317.7	363.3	591	596	597	599	600	600.8	601	442.5	265.9	
Potassium	E	3	18	44	44	44	44	44	150.7	172	214.7	236.1	253.1	257.4	115.1	123.2	
	W	3	16	116	116.2	116.4	116.5	117	374.8	426.3	529.4	581	622.2	632.5	288.5	297.9	
Chloride	E	3	18	62	66.92	71.84	74.3	86.6	88.8	89.24	90.12	90.56	90.91	91	79.87	15.63	
	W	3	16	181	181	181	181	181	209	214.6	225.8	231.4	235.9	237	199.7	32.33	
Sulfate as SO4	E	21	0	240	1000	1200	1200	1625	1870	2110	2200	2400	2480	2500	1591	546.3	
	W	19	0	2300	2404	2660	2755	3210	3900	4000	4134	4283	4377	4400	3302	670.2	250
Fluoride	E	2	19	2.8	2.85	2.9	2.925	3.05	3.175	3.2	3.25	3.275	3.295	3.3	3.05	0.354	
	W	2	17	4.3	4.38	4.46	4.5	4.7	4.9	4.94	5.02	5.06	5.092	5.1	4.7	0.566	1
Alkalinity	E	3	18	45	46	47	47.5	50	110	122	146	158	167.6	170	88.33	70.77	
	W	3	16	28	40.2	52.4	58.5	89	90	90.2	90.6	90.8	90.96	91	69.33	35.81	
Hardness	E	2	19	1130	1139	1148	1153	1175	1198	1202	1211	1216	1219	1220	1175	63.64	

Variable	Site	Num Obs	# Missing	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD	Default WQO
	W	2	17	1700	1702	1704	1705	1710	1715	1716	1718	1719	1720	1720	1710	14.14	
Metals																	
Aluminium (Filtered)	E	9	12	0.005	0.005	0.005	0.005	0.005	0.005	0.011	0.02	0.02	0.02	0.02	0.008	0.006	0.57*
	W	8	11	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0	
Aluminium (Total)	E	20	1	0.005	0.0095	0.01	0.0175	0.025	0.0354	0.05	0.136	0.191	0.206	0.21	0.0477	0.0599	1.52*
	W	18	1	0.0038	0.005	0.005	0.005	0.025	0.025	0.07	0.32	0.399	0.44	0.45	0.081	0.141	
Arsenic (Filtered)	E	8	13	0.01	0.01	0.0108	0.0115	0.0183	0.0335	0.044	0.056	0.056	0.056	0.056	0.0258	0.0196	0.013
	W	7	12	0.0226	0.0258	0.0288	0.03	0.044	0.19	0.223	0.623	0.906	1.133	1.19	0.242	0.426	
Arsenic (Total)	E	20	1	0.012	0.0177	0.0206	0.0218	0.0255	0.0415	0.0526	0.083	0.118	0.232	0.26	0.0466	0.0563	0.01
	W	18	1	0.007	0.0234	0.05	0.05	0.072	0.184	0.206	0.243	0.432	1.158	1.34	0.17	0.302	
Barium (Filtered)	E	1	20	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	N/A	
	W	1	18	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	N/A	
Barium (Total)	E	1	20	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	N/A	1
	W	1	18	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	N/A	
Beryllium (Filtered)	E	1	20	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A	0.00013
	W	1	18	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A	
Beryllium (Total)	E	1	20	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A	
	W	1	18	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A	
Boron (Filtered)	E	2	19	0.025	0.0288	0.0326	0.0345	0.044	0.0535	0.0554	0.0592	0.0611	0.0626	0.063	0.044	0.0269	0.37
	W	1	18	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	N/A	
Boron (Total)	E	2	19	0.0025	0.00855	0.0146	0.0176	0.0328	0.0479	0.0509	0.057	0.06	0.0624	0.063	0.0328	0.0428	0.5
	W	1	18	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	N/A	
Cadmium	E	8	13	0.0011	0.0093	0.0134	0.0139	0.0217	0.0245	0.0258	0.0287	0.0304	0.0318	0.0321	0.0193	0.0097	0.0003*

Variable	Site	Num Obs	# Missing	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD	Default WQO
(Filtered)	W	7	12	0.0002	0.0004	0.0005	0.0005	0.0006	0.0007	0.0008	0.0010	0.0011	0.0012	0.0012	0.0006	0.0003	
Cadmium (Total)	E	20	1	0.0001	0.0005	0.0074	0.0127	0.0210	0.0256	0.0276	0.0366	0.0406	0.0449	0.0460	0.0195	0.0132	
	W	18	1	0.0004	0.0005	0.0005	0.0007	0.0010	0.0016	0.0026	0.0038	0.0041	0.0045	0.0046	0.0016	0.0013	0.002
Cobalt (Filtered)	E	8	13	0.003	0.0037	0.004	0.004	0.005	0.0068	0.0092	0.0171	0.0231	0.0278	0.029	0.0083	0.0087	
	W	7	12	0.0005	0.0005	0.0006	0.0008	0.0020	0.0020	0.0020	0.0100	0.0160	0.0208	0.022	0.0042	0.0078	0.0028
Cobalt (Total)	E	19	2	0.005	0.005	0.005	0.0055	0.025	0.025	0.0282	0.0504	0.456	3.163	3.84	0.223	0.876	
	W	17	2	0.001	0.002	0.002	0.002	0.005	0.025	0.025	0.175	0.438	0.56	0.591	0.0673	0.165	0.05
Chromium (Filtered)	E	8	13	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0000	
	W	7	12	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0000	0.0017*
Chromium (Total)	E	2	19	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0000	
	W	2	17	0.0005	0.0006	0.0006	0.0006	0.0008	0.0009	0.0009	0.0010	0.0010	0.0010	0.0010	0.0008	0.0004	0.05
Copper (Filtered)	E	8	13	0.0005	0.0009	0.0010	0.0010	0.0020	0.0020	0.0020	0.0029	0.0040	0.0048	0.0050	0.0019	0.0014	
	W	7	12	0.0005	0.0008	0.0010	0.0010	0.0010	0.0015	0.0018	0.0032	0.0041	0.0048	0.0050	0.0016	0.0016	0.003*
Copper (Total)	E	19	2	0.0010	0.0020	0.0020	0.0020	0.0050	0.0100	0.0112	0.0232	0.0420	0.0564	0.0600	0.0102	0.0151	
	W	18	1	0.0020	0.0020	0.0024	0.0033	0.0050	0.0058	0.0060	0.0121	0.0249	0.0610	0.0700	0.0088	0.0157	0.2
Iron (Filtered)	E	1	20	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	N/A	
	W	1	18	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	N/A	0.3
Iron (Total)	E	4	17	0.025	0.0325	0.04	0.0438	0.105	0.193	0.212	0.251	0.271	0.286	0.29	0.131	0.121	
	W	4	15	0.025	0.025	0.025	0.025	0.128	0.433	0.554	0.797	0.919	1.016	1.04	0.33	0.483	0.43*
Mercury (Filtered)	E	1	20	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	N/A	
	W	1	18	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	N/A	0.00005
Mercury (Total)	E	1	20	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	N/A	
	W	1	18	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	N/A	0.001

Variable	Site	Num Obs	# Missing	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD	Default WQO
Manganese (Filtered)	E	8	13	0.091	0.273	0.405	0.452	1.235	1.773	2.280	2.860	2.860	2.860	2.860	1.316	1.063	1.9
	W	7	12	0.001	0.001	0.002	0.002	0.003	0.095	0.115	1.005	1.662	2.188	2.320	0.360	0.866	
Manganese (Total)	E	16	5	0.001	0.228	0.484	0.516	1.320	1.925	2.600	3.050	3.373	3.691	3.770	1.473	1.130	0.1
	W	14	5	0.001	0.008	0.025	0.025	0.055	0.087	0.098	0.194	0.950	2.022	2.290	0.220	0.599	
Molybdenum (Filtered)	E	8	13	0.05	0.05	0.05	0.05	0.0565	0.06	0.06	0.0607	0.0615	0.0621	0.0623	0.0557	0.0054	0.034
	W	7	12	0.045	0.0456	0.0472	0.049	0.054	0.0673	0.0728	0.0791	0.0811	0.0826	0.083	0.0592	0.0148	
Molybdenum (Total)	E	19	2	0.012	0.025	0.0382	0.0485	0.053	0.0632	0.0648	0.0678	0.0739	0.0948	0.1	0.0524	0.0202	0.01
	W	17	2	0.025	0.043	0.052	0.056	0.0765	0.23	0.278	0.3	0.304	0.317	0.32	0.134	0.109	
Nickel (Filtered)	E	8	13	0.0020	0.0153	0.0218	0.0225	0.0255	0.0283	0.0286	0.0317	0.0349	0.0374	0.0380	0.0240	0.0103	0.019
	W	7	12	0.0005	0.0005	0.0006	0.0008	0.0020	0.0025	0.0028	0.0058	0.0079	0.0096	0.0100	0.0027	0.0033	
Nickel (Total)	E	19	2	0.0020	0.0164	0.0202	0.0225	0.0250	0.0325	0.0380	0.0424	0.0441	0.0448	0.0450	0.0268	0.0112	0.02
	W	17	2	0.0010	0.0020	0.0020	0.0020	0.0025	0.0150	0.0230	0.0250	0.0400	0.0880	0.1000	0.0134	0.0241	
Lead (Filtered)	E	8	13	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0000	0.0075*
	W	7	12	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0000	
Lead (Total)	E	19	2	0.0005	0.0005	0.0005	0.0005	0.0005	0.0010	0.0010	0.0034	0.0307	0.1580	0.1900	0.0112	0.0434	0.01
	W	17	2	0.0005	0.0005	0.0005	0.0005	0.0020	0.0025	0.0025	0.0082	0.0106	0.0125	0.0130	0.0029	0.0037	
Selenium (Filtered)	E	2	19	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0	0.011
	W	2	17	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0	
Selenium (Total)	E	2	19	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0	0.01
	W	2	17	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0	
Vanadium (Filtered)	E	1	20	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A	0.006
	W	1	18	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A	
Vanadium	E	1	20	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A	0.1

Variable	Site	Num Obs	# Missing	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD	Default WQO
(Total)	W	1	18	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A	
Zinc (Filtered)	E	8	13	0.097	0.114	0.124	0.126	0.745	1.2	1.27	1.47	1.61	1.722	1.75	0.761	0.625	
	W	7	12	0.023	0.0404	0.0538	0.0565	0.106	0.12	0.122	0.205	0.266	0.315	0.327	0.115	0.1	0.014*
Zinc (Total)	E	20	1	0.006	0.0145	0.029	0.0353	0.22	0.989	1.238	1.918	2.09	2.242	2.28	0.632	0.76	
	W	18	1	0.011	0.0345	0.0464	0.0473	0.092	0.149	0.169	0.301	0.727	2.545	3	0.27	0.687	2
Nutrients																	
Ammonia	E	2	19	0.2	0.318	0.436	0.495	0.79	1.085	1.144	1.262	1.321	1.368	1.38	0.79	0.834	
	W	2	17	0.1	0.121	0.142	0.153	0.205	0.258	0.268	0.289	0.3	0.308	0.31	0.205	0.148	0.5
Nitrate	E	2	19	5.13	5.162	5.194	5.21	5.29	5.37	5.386	5.418	5.434	5.447	5.45	5.29	0.226	
	W	2	17	0.01	0.039	0.068	0.0825	0.155	0.228	0.242	0.271	0.286	0.297	0.3	0.155	0.205	0.7
Nitrite	E	2	19	0.005	0.0135	0.022	0.0263	0.0475	0.0688	0.073	0.0815	0.0858	0.0892	0.09	0.0475	0.0601	
	W	2	17	0.005	0.0055	0.006	0.00625	0.0075	0.00875	0.009	0.0095	0.00975	0.00995	0.01	0.0075	0.00354	1
TKN	E	1	20	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	N/A	
	W	0	19	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Total Nitrogen	E	2	19	7	7.02	7.04	7.05	7.1	7.15	7.16	7.18	7.19	7.198	7.2	7.1	0.141	
	W	2	17	0.9	0.91	0.92	0.925	0.95	0.975	0.98	0.99	0.995	0.999	1	0.95	0.0707	0.15
Reactive Phosphorous	E	2	19	0.0050	0.0070	0.0090	0.0100	0.0150	0.0200	0.0210	0.0230	0.0240	0.0248	0.0250	0.0150	0.0141	
	W	2	17	0.0200	0.0220	0.0240	0.0250	0.0300	0.0350	0.0360	0.0380	0.0390	0.0398	0.0400	0.0300	0.0141	
Total Phosphorous	E	2	19	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0	
	W	2	17	0.02	0.027	0.034	0.0375	0.055	0.0725	0.076	0.083	0.0865	0.0893	0.09	0.055	0.0495	0.01
Other																	
Cyanide (Total)	E	3	18	0.002	0.002	0.002	0.002	0.002	1.111	1.333	1.776	1.998	2.176	2.22	0.741	1.281	
	W	3	16	0.002	0.002	0.002	0.002	0.002	0.188	0.225	0.3	0.337	0.367	0.374	0.126	0.215	0.08

Variable	Site	Num Obs	# Missing	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD	Default WQO
Cyanide (WAD).	E	13	8	0.002	0.002	0.002	0.002	0.0025	0.0025	0.0025	0.0189	0.0258	0.0292	0.03	0.006	0.00921	
	W	12	7	0.002	0.002	0.002	0.002	0.0025	0.0025	0.0025	0.0111	0.0341	0.0556	0.061	0.008	0.0169	

Notes:

Red values denote a concentration above the default WQO. An exceedance in the release water is not necessarily indicative of an exceedance in the receiving environment.

Analysis included an initial screen of key contaminants; not every constituent with a WQO was analysed.

*Site-specific WQO (refer to Section 5.6.12 for further detail).

Table 8 Parameters exceeding default WQOs in each Pit

Eldridge Pit	Wises Pit
Electrical conductivity	Electrical conductivity
Sulfate	Sulfate
Fluoride	Fluoride
Aluminium (total)	Aluminium (total)
Arsenic (filtered)	Arsenic (filtered)
Arsenic (total)	Arsenic (total)
Cadmium (filtered)	Cadmium (filtered)
Cadmium (total)	Cadmium (total)
Cobalt (filtered)	Cobalt (filtered)
Cobalt (total)	Cobalt (total)
Copper (filtered)	Copper (filtered)
Iron (total)	Iron (total)

Eldridge Pit	Wises Pit
Manganese (filtered)	Manganese (filtered)
Manganese (total)	Manganese (total)
Molybdenum (filtered)	Molybdenum (filtered)
Molybdenum (total)	Molybdenum (total)
Nickel (filtered)	Nickel (total)
Nickel (total)	Lead (total)
Lead (total)	Zinc (filtered)
Zinc (filtered)	Zinc (total)
Zinc (total)	Total Nitrogen
Ammonia as N	Total Phosphorus
Nitrate as N	Cyanide (total)
Total Nitrogen	
Total Phosphorus	
Cyanide (total)	

4.5 Project Water Balance

4.5.1 Overview

The Project site water balance model (WBM) has been developed to assess the site water budget (balance of inputs and outputs to identify water excess or deficit) at a variety of temporal scales and under a range of assumed operating scenarios. A full description of the model, its development and key input data and assumptions is provided in Appendix L. While it is expected that on an annualised basis, the site water balance will typically be negative, there is significant potential for a high degree of inter-annual variability as a result of rainfall variability. The distinct wet season experienced at the Project site results in the majority (88%, 620mm) of the mean annual rainfall total (705mm) occurring during the wet season months of November through March. These short term, rapid influxes of water to the Project (through direct rainfall and runoff) drive a strongly positive, short to medium term water balance that is often compounded by consecutive large, above average wet seasons.

In the absence of a controlled release option, the rapid accumulation of water within the Project during the wet season has the potential to impact both the ability of the Project to meet its power generation obligations whilst also presenting a significant risk to the receiving environment via the uncontrolled discharge of water from the Project.

In order to better understand the overall Project water balance and how the Project may be impacted by the aggregation of excess water within the system, two model scenarios are presented below.

- **A base case** that considers the estimated excess water ingress to the Project assuming the maintenance of the Wises upper reservoir no higher than FSL (RL 551 m AHD). Any excess water in the system above the Wises FSL is considered as excess. Water deficit is any water topup from the Copperfield Dam which is required to maintain Wises upper reservoir at the minimum operating level (MOL) required for power generation.
- **An unmitigated case** that assumes no excess water is removed from the system (i.e. no Type 1 releases). Excess water in the system therefore continues to aggregate above FSL and eventually spillway level when an uncontrolled discharge occurs.

This model simulation is a simple representation of the Project operational phase in the absence of any mitigated measures such as the controlled release of excess water.

4.5.2 Water Balance Metrics

Key metrics for assessing the Project water balance are:

- Project excess water – the volume of water above the Wises upper reservoir FSL. This volume is assumed as excess and removed from the system without reference to any controlled release conditions or opportunity to release. It is a measure of the excess volume of water in the system over and above the FSL.
- Project water deficit – the additional topup water required from the Copperfield Dam to replace evaporative losses. The topup maintains water level in Wises upper reservoir at the MOL.
- The number of days that the water level in the Wises upper reservoir is above the FSL of RL 551 m AHD. Continual or prolonged storage of water above this level progressively reduces the available freeboard allowance and increases the likelihood of uncontrolled discharges either though spillway overflows or wave-induced run-up.
- Uncontrolled releases:
  - Number of days uncontrolled spillway discharges occurred
  - Number of uncontrolled spillway discharge events occurred; and
  - Total uncontrolled spillway discharge volume.

4.5.3 Base Case – Estimated Water Excess and Deficit

Table 9 provides results from the base case water balance based on an annual simulation:

- The overall water balance is negative on an annual basis for all results indicating that replenishment of evaporative losses with additional top-up water will be a normal operating requirement.
- The mean annual excess is 335 ML and the median 94 ML.
- It is noted that excess water volumes have been estimated assuming maintenance of water levels in Wises upper reservoir at or below FSL. Operational phase water management objectives will need to consider potential seasonal requirements for provision of the buffer storage volume below the FSL (refer to Section 4.7.1) in order to provide additional containment capacity for wet season inflows.

Table 9 Base Case Annual Project Water Balance – Estimated Excess and Deficit

Statistic	Annual Water Excess	Annual Water Deficit
	ML/yr.	ML/yr.
Mean	335	1,046
P5	-	608
P10	-	677
P20	-	760
P50	94	950
P80	633	1,349
P90	1,029	1,577
P95	1,290	1,712

4.5.4 Unmitigated Case – Estimated Uncontrolled Releases

In the absence of any controlled releases the continued aggregation of water can eventually result in an uncontrolled spillway discharge. Table 10 shows the estimated number of days the water level in the Wises upper reservoir is in excess of the FSL and the number and volume of uncontrolled discharges:

- The mean number of days Wises upper reservoir is estimated to be above FSL is 85 days per year increasing to 219 days for the P95 result.
- The mean number of uncontrolled releases per year consists of approximately:
  - 4 days
  - 1 event; and
  - A volume of 100 ML.
- The high degree of rainfall variability experienced at the site results in a significant increase in uncontrolled releases for lower probability results such that the P95 result indicates an estimated uncontrolled release of 674 ML.
- Figure 8 shows the estimated probability distribution for uncontrolled releases from the Wises upper reservoir. It can be seen that uncontrolled releases are concentrated in the wet season months of January through March. The estimated frequency and rate of uncontrolled releases becomes increasingly unlikely through April and May.
- Figure 9 shows the estimated probability distribution for water levels in Wises upper reservoir. A distinct seasonal variation can be seen with water levels at their peak through the wet season

months of January through March and, in the absence of any controlled releases, only gradually subside through the following dry season.

- Median water levels can be seen to remain relatively consistent during the months of September to November. This indicates that water levels are being maintained at the MOL through the addition of top-up water from the Copperfield Dam.

Table 10 Unmitigated Case – Uncontrolled Releases

Statistic	Days Wises Above FSL	Uncontrolled Release Days	Uncontrolled Release Events	Uncontrolled Release Volume
	d/yr	d/yr	d/yr	ML/yr
Mean	85	4	1	101
P5	0	0	0	0
P10	0	0	0	0
P20	0	0	0	0
P50	39	0	0	0
P80	202	1	1	20
P90	219	17	3	414
P95	240	24	4	674

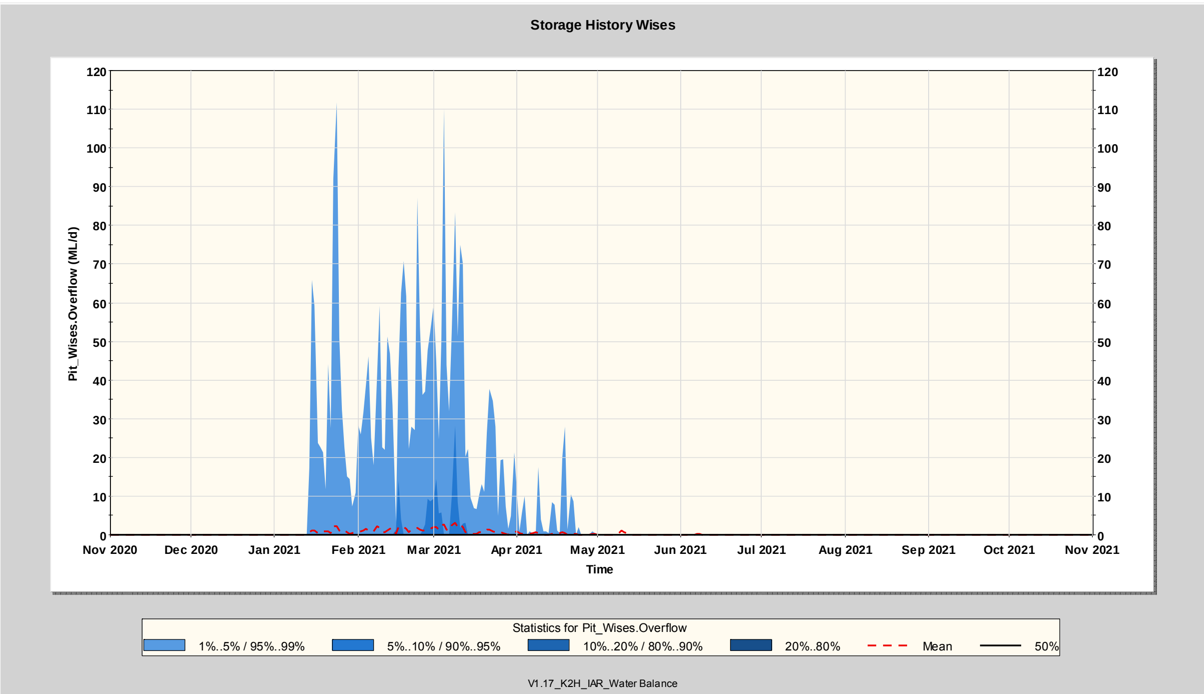


Figure 8 Probability Distribution - Unmitigated Case Wises Upper Reservoir Uncontrolled Releases

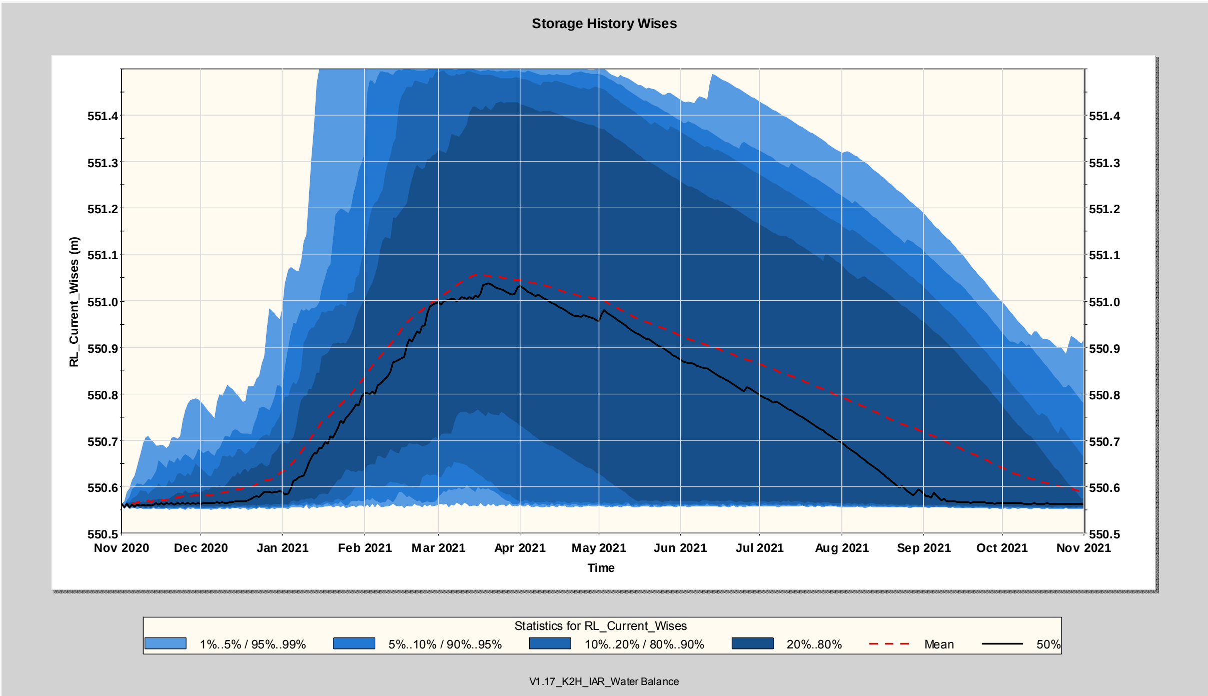


Figure 9 Probability Distribution - Unmitigated Case Wises Upper Reservoir Water Level (Spillway is at 551.5 and FSL at 551.5 m)

4.5.5 Project Water Balance Summary

The results of the base case water balance assessment indicate that on an annualised basis, the Project has a negative water balance and will typically require additional top-up water to replenish evaporative losses. However, due to the pronounced wet season experienced at the Project site the intra-annual water balance is considered to be of much greater significance and the driver of the need to release water from the system.

A positive water balance during the wet season months of January through March is likely to result in the uncontrolled discharge of water from the system and/or loss of power generating opportunity. In the absence of the ability to release excess water, predominately during the wet season, inflows will gradually aggregate in the system until uncontrolled releases of water will occur and/or the duration of a power generation cycle becomes uneconomic (refer to Section 4.2). In addition, the continued aggregation of wet season inflows results in prolonged periods where the estimated water level in the Wises upper reservoir remains above FSL, significantly reduces the ability of the system to contain subsequent inflows without triggering a controlled release.

4.6 Requirement for Water Releases

As discussed above, the Project is subject to a variable water balance which, while largely negative annually, is subject to significant and rapid inflows during the wet season. It is proposed therefore for the Project to periodically release water to the Copperfield River during the operational phase, as well as temporarily during the construction phase as outlined below:

4.6.1 Operational Phase Water Release Objectives

Operational phase water releases may be required in order to:

- Ensure the safe operation of the Wises upper reservoir by, as far as practical, minimising the prolonged storage of water above the FSL.
- Maintain sufficient water storage capacity to temporally contain, without uncontrolled release, inflows from significant wet season inflows.
- Ensure that Project power generation potential is not adversely impacted by the excessive aggregation of excess water within the system.

4.6.2 Construction Phase Water Release Objectives

Construction phase water releases will be required in order to:

- Facilitate the construction of the access and tailrace tunnel works in Eldridge Pit which require the dewatering of Eldridge Pit.
- To maintain the ongoing safety and integrity of key construction activities such as the construction of the tailrace tunnel works by ensuring that water levels in both the Wises upper reservoir and the Eldridge Pit are kept at optimum levels.

4.7 Proposed Water Release Approach

In order to facilitate the release of water from the Project in accordance with the required need to release outlined above, a number of different approaches to water releases are proposed. Each approach is differentiated by the need to respond to different causal events and results in two distinct approaches to the release of water from the Project. However the release location on the Copperfield River will be the same (refer to Section 4.1.2)

4.7.1 Release Event Type 1 - Controlled Discharges to Maintain Water Levels

Operational Phase

The Project has been designed with additional contingency water storage that affords the Project the ability to temporally store up to 500ML of additional water without exceeding the FSL. This buffer compartment therefore gives the Project ability to temporally buffer the rate of water inflow against the opportunity to release excess water (e.g. when the Project is subject to a significantly localised rainfall event that does not generate a requisite opportunity to release).

It is noted that effective use of the buffer compartment will necessitate the use of seasonal operating rules. While these are subject to ongoing definition as the Project design progresses it is noted that:

- During the wet season the effectiveness of the buffer allowance to provide contingency storage and reduce the likelihood of an uncontrolled discharge will be progressively limited as water accumulates in the reservoirs.
- Maintenance of additional water in the buffer allowance in the lead up to, and during the dry season (when the likelihood of significant inflow events is low) provides an opportunity for reduced reliance on an external water source (Copperfield Dam).

Therefore water management objectives for the buffer allowance are likely to be subject to seasonally varying operating rules.

Release of excess water is primarily planned to consist of the controlled release of water during naturally-occurring streamflow events in the Copperfield River. This type of release (Type 1 - Controlled Discharges) will be made to ensure that Project water equilibrium is maintained. Releases will only be made in accordance with the proposed release criteria outlined in Section 9.0. These criteria outline when a release may commence and must stop as well defining the potential rate at which water may be released. The release criteria have been developed to ensure that relevant downstream EVs are protected and that the WQOs are not exceeded. Additional description of release infrastructure is given in Section 4.1.2.

Construction Phase

Potential releases during the construction phase would also utilise a Type 1 controlled release with discharges to the Copperfield River being made at the same location as that utilised by operational phase releases. Proposed release trigger conditions (i.e. minimum streamflow in the Copperfield River at the proposed release point) for construction phase releases (Section 9.0) would also remain the same as per operations. However, due to the additional sensitivity of the Project to further inflows during this critical period releases are proposed to be made at a lower dilution ratio than operational phase releases and with a higher maximum discharge capacity (refer to Section 7.2.1.4). Additional description of release infrastructure is given in Section 4.1.2.

4.7.2 Release Event Type 2 – Pass-Through Discharge

In the event of an extreme rainfall event being forecast (e.g. cyclonic or major regional monsoonal trough, during the operational phase of the Project), a pass-through discharge (Type 2 release event of rainfall may be required. A Type 2 release is considered an option of last resort (i.e. an emergency response) to maintain the integrity of key Project infrastructure, minimise the ingress of excessive volumes of water to the system and to ensure resumption of normal Project operation within as minimal a timeframe as reasonably possible.

A Type 2 release would be achieved by using the pump-turbines in pump back mode to maintain the upper reservoir at spillway level so that any additional rainwater entering the Wises Dam would pass-through the reservoir during the event and discharge via the spillway. Depending on the duration and timing of the event, the power generation cycle would likely be required to stop. It is also likely that some additional Type 1 water releases would need to be made following the rainfall event to remove any surplus water collected in the lower reservoir.

By their definition, Type 2 discharges are considered rare in their occurrence and as such, limited controls are available for the Project to regulate the rate and quality of water being discharged. While a Type 2 pass through discharge is effectively uncontrolled (the rate of release being proportional to the rate of ingress as compared to a Type 1 release where the rate of release is dictated by the availability of a release opportunity and assimilative capacity) cessation of the release could be facilitated at any time by allowing water to pass back into the lower reservoir.

4.7.2.1 Type 2 Releases – Event-Based Hydrologic Assessment

Type 2 discharge events have not been dynamically assessed for causality, frequency or discharge volume and quality. Dynamic operational phase water balance modelling indicates no requirement to make such a release. However, inclusion of this type of release recognises the fact that any open system remains vulnerable to extreme events that may not be present in the recorded climate data. In addition, potential causal events are a function of short to medium term antecedent conditions and contemporary operating conditions. As described in Section 4.2.2.4, potential differences between the rate of water accumulated during storm events and the ability of the Project to compliantly release water have been mitigated through the provision of up to 530 ML of temporary buffer storage. In addition to the buffer volume, an additional 625 ML of storage is possible through utilisation of the freeboard volume between RL 551 and 551.5 m AHD.

In order to assess the potential airspace afforded by both the buffer and freeboard compartments, a volumetric hydrologic assessment has been completed using intensity-frequency-duration date (IFD) sourced from the Bureau of Meteorology (BOM) 2016 IFD service. Key criteria for the assessment have been adopted from Section 2.2.2.1 of the Manual for assessing consequence categories and hydraulic performance of structures[5] (DEHP, 2016):

- Use of the 72-hour duration storm for estimation of the storm event inflow as per estimation of the extreme storm surge (ESS); and
- 100% runoff of all rainfall.

A total of 3 scenarios were assessed as per Table 11. It is reiterated however, that the buffer compartment is only intended to be utilised for short term balancing of stormwater inflows and the ability to release water to the Copperfield River and its availability will be dependent on the final defined seasonal operating rules. Similarly, the freeboard volume is not intended as a water storage compartment. This assessment has been completed to demonstrate, *in the absence of any releases of water*, the estimated stormwater ingress that could be accommodated before an overflow would occur and henceforth, the relatively unlikely need to conduct a Type 2 pass though discharge.

[5] The use of 'The Manual' is not intended to imply regulation of the Project water storage structures, criteria were adopted for comparative purposes only.

Table 11 Event-Based Hydrologic Assessment Scenarios

Scenario	Description	Capacity (ML)	Comments
1	Buffer capacity	530	• Buffer empty at start of event – initial water level of RL 550.56 m AHD • Buffer capacity of 530 ML from RL 550.56 to 551 m AHD • Normal operational conditions – Eldridge lower reservoir maintained at MOL • Instantaneous transfer of direct rainfall and catchment runoff from Eldridge to Wises during 72 hour storm event • 100% runoff of the rainfall from catchment (i.e. runoff coefficient assumed is1.0) • No evaporation was assumed
2	Freeboard capacity	625	• Buffer is full at start of storm event – initial water level of RL 551 m AHD • Freeboard capacity of 625 ML from RL 551 to 551.5 m AHD • No transfer of water from Eldridge to Wises during the storm event – only potential ingress to Wises (direct rainfall) considered • 72-hour storm event, direct rainfall over Wises upper reservoir only considered • No evaporation was assumed
3	Combined buffer and freeboard capacity	1,155	• Buffer and freeboard empty at start of event – initial water level of RL 550.56 m AHD • Buffer and freeboard capacity of 1,155 ML from RL 550.56 to 551.5 m AHD • Normal operational conditions – Eldridge lower reservoir maintained at MOL • Instantaneous transfer of direct rainfall and catchment runoff from Eldridge to Wises during 72 hour storm event • 100% runoff of the rainfall from catchment (i.e. runoff coefficient assumed is1.0) • No evaporation was assumed

Results

Scenario results are presented in Table 12 below:

- Referring to Scenario 1:
  - The buffer compartment, under normal operating conditions is capable of containing at least the 1 in 2 AEP 72-hour storm event;
  - This is indicative of its intended purpose of providing short- to medium-term storage to balance potential stormwater inflows against the ability to release water to the Copperfield River.
- Referring to Scenario 2:
  - Assuming that the buffer compartment was full prior to the storm event and that only the additional contribution of direct rainfall to Wises upper reservoir is included, the freeboard compartment has sufficient capacity to contain the 1 in 2,000 AEP 72-hour storm event without overflow.

- Referring to Scenario 3:
    - Under normal operating conditions, the combined buffer and freeboard compartments are capable of containing up to the 1 in 200 AEP 72-hour event.

Table 12 Event-Based Hydrologic Assessment of Buffer and Freeboard Compartment Capacity - Results

AEP	63.2%	50%	20%	10%	5%	2%	1%	1 in 200	1 in 500	1 in 1,000	1 in 2,000
AEP (1 in xx)	1.58	2	5	10	20	50	100	200	500	1,000	2,000
Event Frequency Description	Frequent				Infrequent			Rare			
72-Hour Rainfall Depth (mm)[1]	113	129	180	214	247	291	324	354	396	429	461
Scenario 1 - Buffer compartment (525 ML)											
Estimated 72-hour rainfall event (ML)[2,3]	369	421	***588***	***699***	***806***	***950***	***1,058***	***1,156***	***1,293***	***1,400***	***1,505***
Scenario 2 - Freeboard compartment (625 ML)											
Estimated 72-hour rainfall event (ML)[2]	141	161	225	268	309	364	405	443	495	536	576
Scenario 3 - Combined buffer and freeboard compartments (1,155 ML)											
Estimated 72-hour rainfall event (ML)[2,3]	369	421	588	699	806	950	1,058	***1,156***	***1,293***	***1,400***	***1,505***

Notes:

Bold italics **indicate storm event inflow exceeds nominated scenario capacity**

1 – Bureau of Meteorology (BOM) IFD (2016) for -18.8878 144.1625 (decimal degrees)

2 – As per *Manual for assessing consequence categories and hydraulic performance of structures* (DEHP, 2016),*structures* , sect. 2.2.2.1, use of the 72-hour duration storm for estimation of the extreme storm surge (ESS)

3 – Runoff contribution at 100% of rainfall as per (DEHP, 2016),

4.7.2.2 Summary

In summary, the following points are made in relation to Type 2 pass through discharges:

- Type 2 pass through discharges have been identified as a practical way for the Project to manage rare and extreme storm events. Due to the potential for interruption to the power generation cycle, the semi-uncontrolled nature of the release and the relative rarity of the casual storm events, regular releases of water from the Project via Type 2 pass-through discharges are not expected, not planned and are not the preferred method of water release.
- Continuous, dynamic, life of Project water balance modelling (Section 6.3.1.2) indicates that the proposed operational phase release criteria for Type 1 releases (Section 9.0) are sufficient to negate the requirement for a Type 2 release under the modelled climatic conditions and assumed operational rules. As a result, the causality, frequency, discharge volume or quality of potential Type 2 pass-through discharges has not been identified and cannot be quantified.
- In order to demonstrate the degree of conservatism adopted in the Project design, a volumetric based hydrologic assessment of the potential storage capacity afforded by the buffer and freeboard compartments indicates that *in the unlikely absence of any releases of water to the Copperfield River,* the Project could contain up to the 1 in 200 AEP 72-hour storm event. This is intended to demonstrate the relatively unlikely requirement for a Type 2 discharge. Under normal operations, the ability to discharge excess water afforded by Type 1, controlled releases of water is considered sufficient to maintain Project operations and safeguard the integrity of key infrastructure.
- However, it must be reiterated that any open system remains vulnerable to extreme rainfall events beyond measured climatic data and the identification of potential for a Type 2 discharge is cognisant of this. A Type 2 release provides a practical and safe way to minimise disruptions to Project operations and to safeguard key infrastructure as a result of rare and extreme storm events. Regulation of discharges made via a Type 2 discharge is not considered any more practical than regulation of overflow discharges from any other water containment structure. The Project has demonstrably provided a number of contingency measures (buffer storage compartment, freeboard) as well as the proposed use of Type 1 releases as a way to ensure that the likelihood of a Type 2 discharge is a low a practical. However, the requirement to make a Type 2 discharge, despite its expected rarity, remains the most practical way for the Project to manage extreme and rare events.
- It is noted that if a Type 2 discharge were to be made, a number of potentially mitigating circumstances could limit any potential for harm to downstream environmental values:
    - The magnitude of any causal event leading up to a Type 2 pass through discharge is highly likely to induce a similarly sized streamflow event in the Copperfield River. Water discharged during the Type 2 release is therefore expected to be subject to significant dilution upon entering the Copperfield River.
    - Differences in water density between the incident rainfall and water already within the Project are likely to result in some initial separation. While the rapidity of any potential mixing has not been estimated (and is not proposed), it is possible that the incident rainfall will remain at least partially separated from the higher density pit water during a pass through discharge event. This may potentially afford some additional dilution prior to discharge into the Copperfield River at the proposed discharge point.

Initiation of a Type 2 discharge during the construction phase by raising the water level in the Wises upper reservoir to the spillway elevation preceding the event would not be possible as the pump-turbines would not be available.

4.8 Representative Release Water Quality

Sources of release water for the two Project phases are listed following:

1. Operations phase releases:
   - All releases during the operations phase will consist of a mixture of water from both the Eldridge and Wises Pits.
2. Temporary construction phase releases:
   - During the initial stages of construction, releases will most likely originate from the Eldridge Pit only
   - During the latter stages of construction, it is possible that a mixture of water from both the Eldridge and Wises Pits will be released.

The likely composition of water for mixed releases (i.e. the relative proportion of water from each pit presented as a ratio) is presented in Section 4.8.1 below.

4.8.1 Pit Water Mixture Calculation

The volumes of water within both the Wises Pit and the Eldridge Pit were estimated to calculate the mixing volumes of two waters representing the operational water mixture for the Project, and potentially the latter stages of the construction phase. The following assumptions were incorporated to determine this mixture:

- The water level in the Eldridge Pit at 482.31m AHD represents 28.5GL at ~ 238m depth.
- Wises Pit currently stores 0.8GL as ‘free water’ at a water surface elevation of 493.7m AHD at ~ 10m depth.
- Water pumped into Wises from Eldridge may also mix with pore water stored in the tailings used to backfill the pit. An estimate of the volume of water that could likely interact with the main body of water in the Wises Pit was assessed based on the following assumptions:
  - A porosity of space of 30% within the tailings.
  - Any water addition or extraction from the Wises Pit may cause water to interact with pore water within 27m of the surface (Genex, *pers. comm*), ~ 14m below the floor of the pit. This is ~ 2.2GL.
  - Therefore the mixture of water in the Wises Pit that would affect the representative sample is ~ 3.0GL.

The representative water mixture for the operation is taken to be 28.5GL of Eldridge Pit water to 3.0GL of Wises Pit water, assuming that pore water up to 14m below the base of the Wises Pit may interact with water stored in the pit as ‘free water’. This is a conservative estimate of the potential contribution from the Wises Pit (which generally has poorer water quality). The mixing volumes correspond to 90.5% per volume of Eldridge Pit water to 9.5% per volume of Wises Pit water. This was rounded to 90% Eldridge Pit water and 10% Wises Pit water (i.e. a nine to one ratio of water from the Eldridge Pit versus the Wises Pit).

4.8.2 Sensitivity Analysis for Mixed Releases from Both Pits

In order to determine the potential range of release water quality for mixed releases, various combinations of water qualities were assessed, including:

- 50^{th} percentile of Wises Pit plus 50^{th} percentile of Eldridge Pit mixed together at 1 to 9 ratio
- 80^{th} percentile of Wises Pit plus 80^{th} percentile of Eldridge Pit mixed together at 1 to 9 ratio
- 90^{th} percentile of Wises Pit plus 90^{th} percentile of Eldridge Pit mixed together at 1 to 9 ratio
- 95^{th} percentile of Wises Pit plus 95^{th} percentile of Eldridge Pit mixed together at 1 to 9 ratio
- Maximum of Wises Pit plus maximum of Eldridge Pit mixed together at 1 to 9 ratio

- 50% Eldridge Pit and 50% Wises Pit
  - 50th percentile
  - 80th percentile
  - Maximum
- 20% Eldridge Pit and 80% Wises Pit
  - 50th percentile
  - 80th percentile
  - Maximum
- Depth-averaged values from Entura, 2016 (the maximum from either the Wises or Eldridge Pits)
- Composite 1 sample submitted for Direct Toxicity Assessment (DTA) analysis (refer to Section 4.9 for further detail)
- Composite 2 sample submitted for DTA analysis (refer to Section 4.9 for further detail), with the W2 50th percentile adjusted to equal the Limits of Reporting (LOR) (instead of half of the LOR applied otherwise).

As a result of the sensitivity analysis, it was determined that the 'worst case scenario' (i.e. highest overall parameter concentrations) for a mixed pit water release was achieved by using the maximum concentrations observed over the full dataset, mixed at a ratio of nine parts Eldridge Pit to one part Wises Pit.

4.8.3 Release Water Quality

In summary, the following release water qualities were assessed for the Project:

- Construction Phase:
  - 50th percentile value for Eldridge Pit
  - Historical maximum value for Eldridge Pit
  - 50th percentile value for each pit, mixed at a ratio of nine parts Eldridge to one part Wises
  - Maximum value for each pit, mixed at a ratio of nine parts Eldridge to one part Wises
- Operations Phase:
  - 50th percentile value for each pit, mixed at a ratio of nine parts Eldridge to one part Wises
  - Maximum value for each pit, mixed at a ratio of nine parts Eldridge to one part Wises.

Assumed values for key parameters for releases (prior to mixing in the receiving environment) are presented in Table 13.

Table 13 Release Water Quality Assumptions

Parameter	Units	WQO	Median Value Eldridge Pit	Maximum Value Eldridge Pit	Median Value Mixed at 9 Parts E to 1 part W	Maximum Value Mixed at 9 Parts E to 1 part W
Electrical Conductivity @ 25°C	µS/cm	500	**2950**	**4790**	**3179**	**5311**
Total Hardness as CaCO3	mg/L		1274	1754	1374	1810
Total Alkalinity as CaCO3	mg/L		107.5	170.0	105.7	162.1

Parameter	Units	WQO	Median Value Eldridge Pit	Maximum Value Eldridge Pit	Median Value Mixed at 9 Parts E to 1 part W	Maximum Value Mixed at 9 Parts E to 1 part W
Sulfate as SO4 - Turbidimetric	mg/L	250	**1500**	**2500**	**1671**	**2690**
Chloride	mg/L	175	91	91	100	100
Calcium	mg/L		349	495	372.1	506.8
Magnesium	mg/L		98	126	102	132.4
Sodium	mg/L	115	**287**	**287**	**317.9**	**318.4**
Potassium	mg/L		44	44	51.25	51.3
Aluminium (F)	mg/L	0.57*	0.005	0.02	0.005	0.0185
Arsenic (F)	mg/L	0.013	0.013	**0.056**	**0.0155**	**0.1694**
Beryllium (F)**	mg/L	0.00013	0.0005	0.0005	0.0005	0.0005
Barium (F)	mg/L		0.036	0.036	0.0362	0.0362
Cadmium (F)	mg/L	0.0003*	**0.0203**	**0.0321**	**0.0183**	**0.0290**
Chromium (F)	mg/L	0.0017*	0.0005	0.0005	0.0005	0.0005
Cobalt (F)	mg/L	0.0028	**0.005**	**0.029**	**0.0047**	**0.0283**
Copper (F)	mg/L	0.003*	0.002	**0.005**	0.0019	**0.0047**
Lead (F)	mg/L	0.0075*	0.0005	0.0005	0.0005	0.0005
Manganese (F)	mg/L	1.9	1.21	**2.86**	1.0893	**2.59**
Molybdenum (F)	mg/L	0.034	**0.0565**	**0.06**	**0.05625**	**0.0623**
Nickel (F)	mg/L	0.019*	**0.025**	**0.038**	**0.0227**	**0.0352**
Selenium (F)	mg/L	0.011	0.005	0.005	0.005	0.005
Uranium (F)	mg/L	0.01	NM	NM	NM	NM
Vanadium (F)	mg/L	0.006	0.005	0.005	0.005	0.005
Zinc (F)	mg/L	0.014*	**0.688**	**1.75**	**0.6298**	**1.5874**
Boron (F)	mg/L	0.37	0.025	0.025	0.0285	0.0285
Iron (F)	mg/L	0.3	0.025	0.025	0.025	0.025
Mercury (F)	mg/L	0.00006	0.00005	0.00005	0.00005	0.00005
Aluminium (T)	mg/L	1.52*	0.025	0.21	0.025	0.234
Arsenic (T)	mg/L	0.01	0.026	**0.26**	0.0306	**0.368**
Beryllium (T)	mg/L	0.06	0.0005	0.0005	0.0005	0.0005
Barium (T)	mg/L	1	0.042	0.042	0.0422	0.0422
Cadmium (T)	mg/L	0.002	**0.0221**	**0.046**	**0.01999**	**0.04186**
Chromium (T)	mg/L	0.05	0.0005	0.0005	0.00055	0.00055
Cobalt (T)	mg/L	0.05	0.025	**3.84**	0.02305	**3.52**
Copper (T)	mg/L	0.2	0.005	0.06	0.005	0.061
Lead (T)	mg/L	0.01	0.0005	**0.19**	0.00065	**0.1723**

Parameter	Units	WQO	Median Value Eldridge Pit	Maximum Value Eldridge Pit	Median Value Mixed at 9 Parts E to 1 part W	Maximum Value Mixed at 9 Parts E to 1 part W
Manganese (T)	mg/L	0.1	**1.34**	**3.77**	**1.21**	**3.62**
Molybdenum (T)	mg/L	0.01	**0.052**	**0.1**	**0.054**	**0.122**
Nickel (T)	mg/L	0.02	**0.025**	**0.045**	**0.023**	**0.0505**
Selenium (T)	mg/L	0.01	0.005	NM	0.005	NM
Uranium (T)	mg/L	0.01	NM	NM	NM	NM
Vanadium (T)	mg/L	0.1	NM	NM	NM	NM
Zinc (T)	mg/L	2	0.152	**2.28**	0.1496	**2.35**
Boron (T)	mg/L	0.5	NM	NM	NM	NM
Iron (T)	mg/L	0.43*	0.16	0.225	0.2075	0.3065
Mercury (T)	mg/L	0.001	0.00005	0.00005	0.00005	0.00005
Free Cyanide	mg/L	0.08	NM	NM	NM	NM
Total Cyanide	mg/L		0.002	2.22	0.002	
Weak Acid Dissociable Cyanide	mg/L		0.0025	0.03	0.0025	
Fluoride	mg/L	1	**2.8**	**2.8**	**2.99**	**3.03**
Ammonia as N	mg/L	0.5	0.2	0.2	0.211	0.211
Nitrite as N	mg/L	1	0.005	0.005	0.005	0.005
Nitrate as N	mg/L	0.7	**5.45**	**5.45**	**4.935**	**4.935**
Nitrite + Nitrate as N	mg/L		NM	NM	NM	NM
Total Kjeldahl Nitrogen as N	mg/L		NM	NM	NM	NM
Total Nitrogen as N	mg/L	0.15	**7**	**7**	**6.39**	**6.39**
Total Phosphorus as P	mg/L	0.01	**0.025**	**0.025**	**0.0315**	**0.0315**
Reactive Phosphorus as P	mg/L		NM	NM	NM	NM

NM = Not measured. Analysis included an initial screen of key contaminants; not every constituent with a WQO was analysed.
F = Filtered
T = Total
Values highlighted in grey indicate an exceedance of the WQO pre-release. Note that an exceedance in the release water is not necessarily indicative of an exceedance in the receiving environment.
*Site-specific WQO (refer to Section 5.6.12 for further detail).
**LOR above WQO

4.9 Release Water Toxicity Assessment

4.9.1 Overview

DTA allows for the assessment of the absolute toxicity of discharge waters and the development of a dilution ratio based on laboratory observed impacts to suitable test species. DTA tests are limited to off-the-shelf toxicity tests that utilise standard species (Water Quality and Investigation, Department of Environment and Science, 2018).

Whole of effluent toxicity testing was used in a Species Sensitivity Distribution (SSD) to derive a safe dilution of effluent. The concentration that causes an effect to 10% of the test population (i.e., the EC_{10} value) is used as the input into the SSD. Safe dilution is then extrapolated from the data according to the method of ANZECC & ARMCANZ (2000) to ensure protection of 95% of species in the aquatic ecosystem of the receiving environment. The nature of the test ensures that the dilution ratio between pit water and receiving waters takes into consideration all contaminants, no matter which is the most toxic.

Ecotoxicology testing was undertaken for the Project by Ecotox Services Australia (ESA). Hydrobiology Pty Ltd were commissioned to interpret the ecotoxicology results and to create a SSD for each sample to advise of a dilution ratio between each composite sample and waters from W2 that would achieve a 95% species protection level. The ecotoxicology testing results as well as the assessments by Hydrobiology are provided in Appendix F and Appendix G Release Water (Composite Samples)

Water samples collected from the Eldridge and Wises Pits were mixed at the ratio that is expected to represent the release water quality, to provide an indicator mixed water composition for analysis and ecotoxicology studies.

Eldridge Pit and Wises Pit were sampled on 24 April 2018. These samples were dispatched to ESA for DTA. Instead of the 90% Eldridge – 10% Wises volume mixes, mixtures of 10% Eldridge to 90% Wises were erroneously made up; this mistake was not identified until the results were available from ALS Laboratories and the DTA had been completed. This composite sample is dated 11 May 2018 and is hereafter referred to as “Composite 1”.

The pits were re-sampled on 13 June 2018 and a composite sample was created by AECOM with a mixture of 90% Eldridge and 10% Wises; a composite with the same volume mixes was created independently by ALS Laboratories. This composite was then re-submitted to ESA for DTA analysis. The sample name of this mixture is “Composite Sample 20/06” and is hereafter referred to as “Composite 2”.

The composite samples are discussed below in the context of the historical water quality concentrations in the pits. In addition, sensitivity analysis was conducted on the composite samples to provide an indication of the potential variability in the mixed water concentrations.

4.9.2 Comparison to Historical Water Quality Ranges in the Pits

Composite 2 water sample concentrations were compared to the historical water quality in the Wises and Eldridge Pits (represented as percentile values on box and whisker plots) in and to provide an indication of how the mixture compared to the temporal variations in the pits. Although the Wises Pit shows higher concentrations for a number of parameters (including electrical conductivity, sulfate, lead and molybdenum), the volume of water contributing from the Wises Pit is relatively small (10%), and most concentrations are expected to be reduced when mixed with the greater-volume Eldridge water.

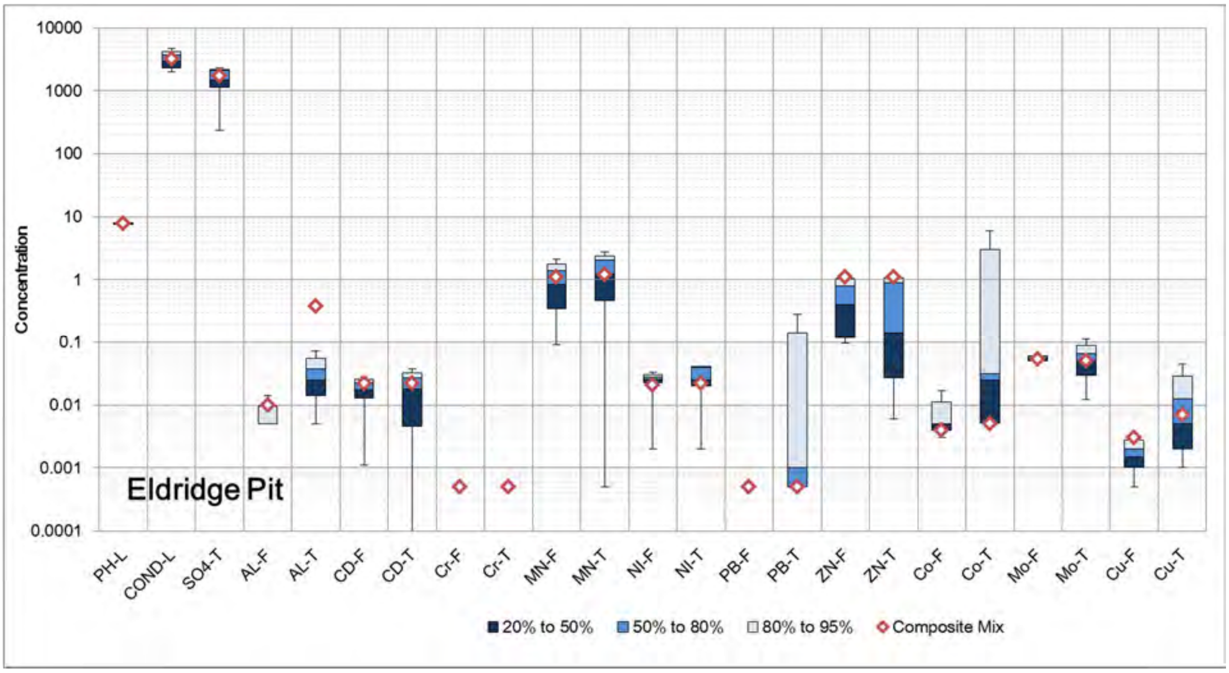


Figure 10 Comparison of composite sample to ranges in the Eldridge Pit

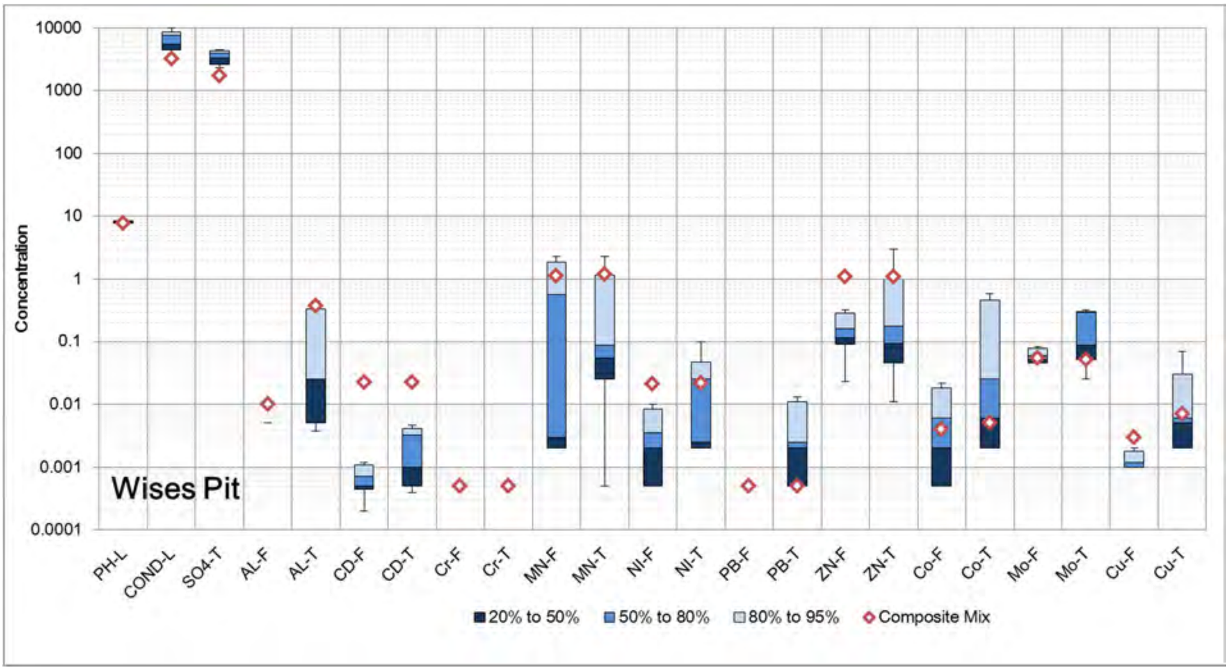


Figure 11 Comparison of the composite sample to ranges in the Wises Pit

Comparison of the Composite 2 concentrations with the historical ranges of the two pits shows the following parameters may be considered ‘low’ in the composite sample compared to the historical data, and may be reported at or below the limits of reporting (LOR):

- Total and dissolved lead
- Total and dissolved cobalt
- Total and dissolved molybdenum.

However, the historical samples themselves generally report these parameters at lower concentrations than parameters such as zinc, which reports among the highest trace-element concentrations and therefore governs the ultimate dilution ratio required to meet the WQOs.

The water quality of each of the samples collected for the DTA is provided in Table 14 and is referred to in the following sections.

Table 14 Water quality of samples submitted for DTA analysis

Parameter	Units	LOR	Composite 1 (10% Eldridge, 90% Wises)		Composite 2 (90% Eldridge, 10% Wises)		Default WQO [SSTV/HMTV]
			Composite	Receiving Environment (W2 May 2018)	Composite	Receiving Environment (W2 June 2018)	
pH Value	pH Unit	0.01	**7.82**	**7.74**	**7.78**	**8.1**	6 – 7.5 [6.0 – 8.4]
Sodium Adsorption Ratio		0.01	6.04	0	4.02	0.62	
Electrical Conductivity @ 25°C	µS/cm	1	**4600**	98	**3210**	153	500
Total Dissolved Solids (Calc.)	mg/L	1	2990	0	2090	99	
Total Hardness as CaCO3	mg/L	1	1530	27	1230	50	
Hydroxide Alkalinity as CaCO3	mg/L	1	0.5		0.5	0.5	
Carbonate Alkalinity as CaCO3	mg/L	1	0.5		0.5	0.5	
Bicarbonate Alkalinity as CaCO3	mg/L	1	84	0	48	60	
Total Alkalinity as CaCO3	mg/L	1	84	43	48	60	
Sulfate as SO4 - Turbidimetric	mg/L	1	**2630**	2	**1720**	7	250
Chloride	mg/L	1	161	6	107	8	175
Calcium	mg/L	1	410	6	338	10	
Magnesium	mg/L	1	124	3	94	6	
Sodium	mg/L	1	544	10	324	10	
Potassium	mg/L	1	110	2	52	2	

Parameter	Units	LOR	Composite 1 (10% Eldridge, 90% Wises)		Composite 2 (90% Eldridge, 10% Wises)		Default WQO [SSTV/HMTV]
			Composite	Receiving Environment (W2 May 2018)	Composite	Receiving Environment (W2 June 2018)	
Aluminium (F)	mg/L	0.01	0.005#	**0.47**	0.01	0.005#	0.055 [0.57]
Arsenic (F)	mg/L	0.001	**0.247**	0.0005	**0.047**	0.0005#	0.013
Beryllium (F)	mg/L	0.001	**0.0005***	NM	**0.0005***	0.0005*#	0.00013
Barium (F)	mg/L	0.001	0.042	NM	0.037	0.023	1
Cadmium (F)	mg/L	0.0001	***0.0012***	0.00005#	**0.0221**	0.00005#	0.0002 [0.0003]
Chromium (F)	mg/L	0.001	0.0005#	0.0005#	0.0005#	0.0005#	0.001 [0.0017]
Cobalt (F)	mg/L	0.001	0.002	0.0005#	**0.004**	0.0005#	0.0028
Copper (F)	mg/L	0.001	**0.002**	0.0005#	**0.003**	0.0005#	0.0014 [0.003]
Lead (F)	mg/L	0.001	0.0005#	0.0005#	0.0005	0.0005#	0.0034 [0.0075]
Manganese (F)	mg/L	0.001	0.236	0.02	1.11	0.004	1.9
Molybdenum (F)	mg/L	0.001	0.042	0.0005#	0.054	0.0005#	
Nickel (F)	mg/L	0.001	0.003	0.0005#	**0.021**	0.0005#	0.011 [0.019]
Selenium (F)	mg/L	0.01	0.005#	NM	0.005#	0.005#	0.011
Uranium (F)	mg/L	0.001	**0.006**	NM	**0.006**	NM	0.0005
Vanadium (F)	mg/L	0.01	0.005	NM	0.005	0.005	0.006
Zinc (F)	mg/L	0.005	***0.08***	0.0025#	**1.09**	0.0025#	0.008 [0.014]
Boron (F)	mg/L	0.05	0.08	NM	0.05	0.025	0.37
Iron (F)	mg/L	0.05	0.025	NM	0.025	0.025	0.3

Parameter	Units	LOR	Composite 1 (10% Eldridge, 90% Wises)		Composite 2 (90% Eldridge, 10% Wises)		Default WQO [SSTV/HMTV]
			Composite	Receiving Environment (W2 May 2018)	Composite	Receiving Environment (W2 June 2018)	
Mercury (F)	mg/L	0.0001	0.00005#	NM	0.00005#	0.00005#	0.00005
Aluminium (T)	mg/L	0.01	0.14	**0.69**	**0.38**	0.06	0.2 [1.52]
Arsenic (T)	mg/L	0.001	**0.25**	0.0005	**0.05**	0.0005	0.01
Beryllium (T)	mg/L	0.001	0.0005	NM	0.0005	0.0005	0.06
Barium (T)	mg/L	0.001	0.043	NM	0.05	0.027	1
Cadmium (T)	mg/L	0.0001	0.0015	0.00005#	**0.0222**	0.00005#	0.002
Chromium (T)	mg/L	0.001	0.0005#	0.0005	0.0005#	0.0005#	0.05
Cobalt (T)	mg/L	0.001	0.003	0.025	0.005	0.0005#	0.05
Copper (T)	mg/L	0.001	0.002	0.0005	**0.007**	0.0005#	0.0014
Lead (T)	mg/L	0.001	0.0005#	0.0005#	0.0005#	0.0005#	0.01
Manganese (T)	mg/L	0.001	**0.256**	0.028	**1.21**	0.053	0.1
Molybdenum (T)	mg/L	0.001	**0.056**	0.0005#	**0.051**	0.0005#	0.01
Nickel (T)	mg/L	0.001	0.003	0.0005#	**0.022**	0.0005#	0.02
Selenium (T)	mg/L	0.01	0.005	NM	0.005	0.005	0.01
Uranium (T)	mg/L	0.001	0.007	NM	0.006	NM	0.01
Vanadium (T)	mg/L	0.01	0.005#	NM	0.005#	0.005#	0.1
Zinc (T)	mg/L	0.005	0.081	0.0025	1.1	0.0025#	2
Boron (T)	mg/L	0.05	0.09	NM	0.05	0.0025#	0.5
Iron (T)	mg/L	0.05	0.08	***0.71***	***0.6***	0.16	0.2 [0.43]
Mercury (T)	mg/L	0.0001	0.00005#	NM	0.0005#	0.00005#	0.001

Parameter	Units	LOR	Composite 1 (10% Eldridge, 90% Wises)		Composite 2 (90% Eldridge, 10% Wises)		Default WQO [SSTV/HMTV]
			Composite	Receiving Environment (W2 May 2018)	Composite	Receiving Environment (W2 June 2018)	
Free Cyanide	mg/L	0.004	0.002#	NM	NM	NM	
Total Cyanide	mg/L	0.004	0.002#	NM	NM	NM	0.08
Weak Acid Dissociable Cyanide	mg/L	0.004	0.002#	NM	NM	NM	#N/A
Fluoride	mg/L	0.1	**4.9**	NM	**2.8**	0.2	1
Ammonia as N	mg/L	0.01	0.35	NM	0.16	0.02	0.5
Nitrite as N	mg/L	0.01	0.01	NM	0.005	0.005	1
Nitrate as N	mg/L	0.01	0.31	NM	**5.19**	0.005	0.7
Nitrite + Nitrate as N	mg/L	0.01	0.32	NM	5.19	0.005	
Total Kjeldahl Nitrogen as N	mg/L	0.1	0.4	NM	0.6	0.2	
Total Nitrogen as N	mg/L	0.1	**0.7**	NM	**5.8**	**0.2**	0.15
Total Phosphorus as P	mg/L	0.01	**0.09**	NM	**0.03**	0.005	0.01
Reactive Phosphorus as P	mg/L	0.01	0.04	NM	0.01	0.005	

Values in red exceed the default WQO

Italicised values exceed the SSTV/HMTV

Values below the LOR are reported as 50% of the LOR

*LOR above default WQO

NM = Not measured

4.9.3 Dilution Water

W2 is considered to be the most representative location for water quality at the proposed release location within the Copperfield River. Site W2 is in close proximity to the proposed release location and also receives releases from the TSF and overflows from Butchers Creek Dam and Manager's Creek Dam. Historically it has the poorest water quality of all monitored sites in the Copperfield River. Analysis of water quality parameters indicates that the site may be impacted by waters from the historical Kidston mine as a majority of W2 samples show a relationship between EC and SO_4 that is similar to those shown in the pit water (refer Section 5.8). This relationship is not found at the other receiving environment sites.

Concentrations of the W2 samples from are overlaid on the historical distribution of all water quality at the site, and also compared to default WQOs for all EVs in Figure 12. Generally the sample collected in May 2018 and used for the dilution with the incorrect composite sample (Composite 1) shows higher concentrations of aluminium and manganese than the follow up sample taken in June 2018. The sample collected for dilution water for the DTA testing with the correct composite sample (Composite 2) in June shows relatively low concentrations for most metals as well as EC and SO_4 compared to the historical percentiles of each parameter at W2.

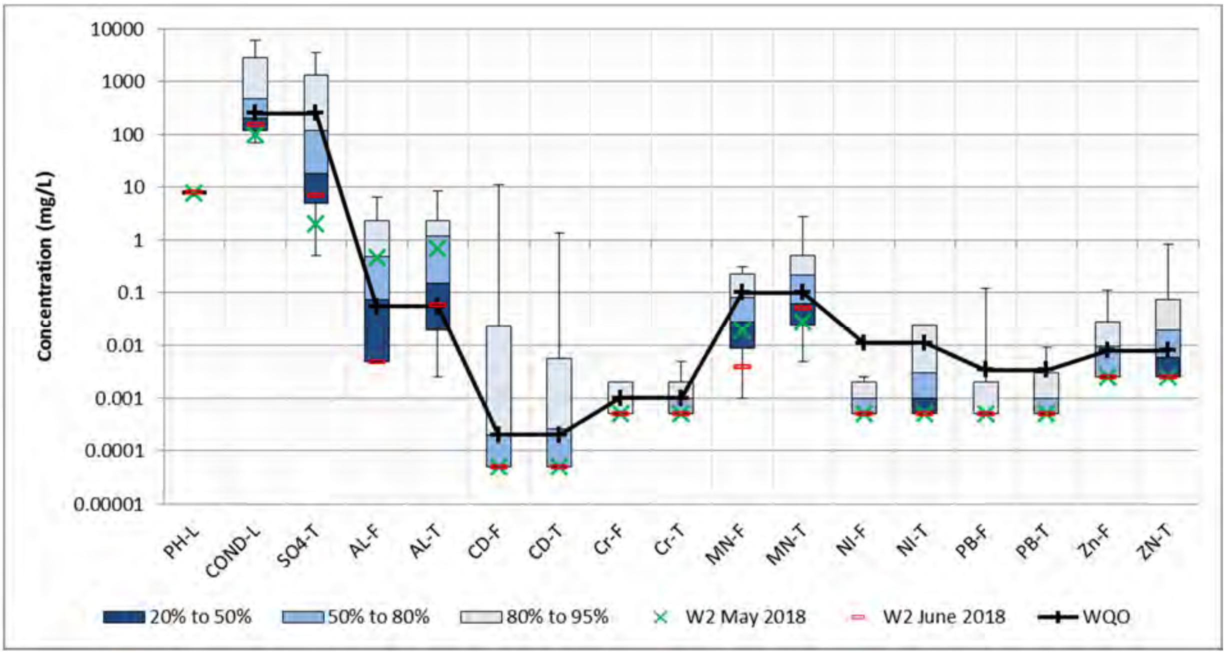


Figure 12 Comparison of W2 dilution water sample with historical distribution and default WQOs

The sample collected from W2 in May 2018 exceeds the default WQO for Aquatic Ecosystems (pH and dissolved aluminium), Long Term Irrigation (total iron) and Recreation (total aluminium). The sample collected from W2 in June 2018 exceeds the default WQO for Aquatic Ecosystems (pH and total nitrogen) (not shown in Figure 12).

4.9.4 Ecotoxicology Tests

A minimum of five tests from four taxonomic groups are required to enable the derivation of safe dilutions of discharges using a species sensitivity distribution (SSD) approach (ANZECC & ARMCANZ, 2000). The following established laboratory tests were undertaken on both DTA samples:

- 96hr growth inhabitation of the freshwater duckweed *Lemna aequinoctialis* (based on OECD method 221, 2006)
- 72hr microalgal growth inhibition (cell yield) test using the freshwater alga *Chlorella vulgaris* (based on USEPA method 1003.0)
- 96hr population growth toxicity test using *Hydra viridissima* (based on Riethmullet et al 2003)

- Fish embryonic development and post-hatch survival toxicity test using the rainbowfish *Melanotaenia splendida splendida* (based on USEPA 2002)
- 7 day reproductive impairment toxicity test using the freshwater cladoceran *Ceriodaphnia dubia* (based on USEPA 2002 and Bailey et al 2000).

The above tests are sub-chronic to chronic tests that are preferred and satisfy the minimum data requirement of ANZECC & ARMCANZ (2000). The majority of these tests have been used to undertake toxicity assessments for mine water releases in the Northern Territory and Queensland (Harford, Trenfield, Cheng, & van Dam, 2014). The occurrence of the species tested is outlined below in Table 15.

Table 15 Occurrence and habitat of species subject to DTA

Common Name	Scientific Name	Occurrence
Freshwater duckweed	*Lemna aequinoctialis*	Widespread in freshwater habitats of tropical areas. Found at Einasleigh
Freshwater algae	*Chlorella vulgaris*	Generic algae species commonly found in waterways
Green hydra	*Hydra viridissima*	Generic hydra found commonly in waterways
Rainbow fish	*Melanotaenia splendida splendida*	Rainbow fish are generally found in streams east of the Great Dividing Range between Gladstone to Cape York Peninsula. They are abundant in almost every kind of freshwater habitat
Water Flea	*Ceriodaphnia dubia*	Generic water flea species found in waterways

The rainbow fish is the only species that is not found at the subject site. Known distributions do not place any of this species in the Gulf Rivers region. Instead the Checkered Rainbowfish (*Melanotaenia splendid inornata*) was found during the Aquatic Ecology survey (Appendix E). The Checkered Rainbowfish is considered an acceptable species to use for DTA assessment at Kidston (refer Section 5.13.6 and Appendix E).

4.9.5 Results

A summary of the release rates calculated by Hydrobiology for the two samples submitted for DTA are presented in Table 16. As is expected, the results indicate that the dilution ratio is required to be much higher for the Composite 1 (with a high percentage of Wises Pit water) than for the more representative discharge ratio Composite 2 (with 90% Eldridge Pit water), which is considered to be more representative of the release water.

Table 16 Dilution ratios from DTA toxicity testing for different species protection levels

Level of Protection	Dilution Ratios for Composite 1 (10% Eldridge, 90% Wises) (May 2018) (Appendix F)	Dilution Ratios for Composite 2 (90% Eldridge, 10% Wises) (June 2018) (Appendix G)
99% species	19.4	1.6
95% species	9.0	1.0
90% species	5.7	0.8
80% species	3.8	0.6

For both samples it appears that EC is the main factor contributing towards toxicity. The most sensitive species to Composite 1 was the *Chlorella vulgaris* where the EC_{10} was estimated to be 11.8% (Appendix F). In Composite 2 the most sensitive species was the freshwater cladoceran, *Ceriodaphnia cf. dubia* where the EC_{10} was estimated to be 54.3% (Appendix G). The EC_{10} for *Ceriodaphnia cf.dubia* in Composite 1 was 30.9%.

The DTA results indicated a minimum dilution ratio required to meet 95% species protection. Both during the construction phase and during the operational phase of the Project, the simulated releases are expected to significantly exceed this minimum dilution ratio, thereby indicating that the proposed releases will not result in toxicity-related impacts to aquatic ecosystems during mixing.

4.10 Unexpected Water Quality Changes

As a contingency management strategy, and in the unlikely event that water quality in the pits should begin to change beyond an acceptable limit for infrastructure (eg. chloride ≤ 100 mg/L), it may be necessary to release additional water from the Project over and above that gained through inflow of rainfall. It is envisaged that this would be managed through the use of a Type 1 release as described above. Based on work undertaken as part of this assessment it is unlikely that such an event would be required. As such this potential scenario is not proposed to be included in this approval application.

4.11 Replenishment of Freshwater

The Project has an annual water allocation of 4,650 ML per annum from the Copperfield Dam under an existing water services agreement between Genex and DNRME. Genex plans to use the water allocation during the construction and operation phases to mitigate the risk of water deficiency caused by extended drought or unforeseen weather events, and to avoid having to supplement water from other sources such as the Copperfield River. It is understood that additional water allocations may be available if required.

Step 2 – Baseline Receiving Environment

"Describe the receiving environment"

5.0 Baseline Receiving Environment

5.1 Overview

The baseline assessment and field investigations included the following elements:

- Comprehensive review of existing information including information provided by Genex and review of site records held by the DES.
- Review of Copperfield River catchment, including climate, geology, soils, land use, water users and an overview of historic releases from the Kidston site.
- Review and assessment of EVs.
- Review of relevant WQOs.
- Review and additional sampling of current water quality characteristics and trends, including an assessment of the relationship between water quality and stream flow and comparison against default WQOs.
- Modelling of Stream hydrology (spells analysis).
- Modelling and assessment of stream hydraulics (HEC-RAS modelling).
- Review of stream geomorphology.
- Review of hydrogeology and surface water interaction.
- Assessment of sediment quality.
- Desktop assessment and field investigation of aquatic ecology values.
- Additional field survey of Copperfield River during the dry season to identify the location of ponded water, and collection of dry season water quality samples.

The findings of the baseline assessment are presented below.

5.2 Copperfield River Catchment Overview

The Copperfield River lies in the Gilbert River basin, draining towards the Gulf of Carpentaria. The nearest townships include Einasleigh to the north and Georgetown to the north-west.

5.2.1 Climate

The climate for the Project site is located within the grassland zone (hot, winter drought), according to the Köppen Classification system. No open Bureau of Meteorology (BoM) weather stations are located within close proximity to the Project site however data is available for the closed Kidston Gold Mine recording station (30027, open 1915 to 2002). Monthly and annual rainfall statistics were obtained for the station from the BoM online climate data service and are presented in Figure 13 and Table 17.

From Table 17 it can be seen that rainfall is seasonally distributed with a distinct wet season typically commencing in November and extending through March. The winter dry season extends from April through October.

The total annual (calendar year) rainfall is highly variable. The 90^{th} and 95^{th} percentile totals represent approximately 145% and 186% of the mean respectively i.e. there is a 10% and 5% probability that annual rainfall may exceed the mean by 145% and 186% respectively.

The majority (88%, 620mm) of the mean annual rainfall total (705mm) occurs during the wet season months of November through March. Mean monthly rainfall during the dry season months of April through October ranges from a minimum of around 7mm per month in July through September to approximately 22mm in April; median rainfall for May through September is zero.

Monthly rainfall variability during the wet season is high with significant potential for both flood and drought. Variability is greatest during January where total rainfall ranges from approximately 47mm (5th percentile) to 506mm (95th percentile).

The closest open temperature recording station for the Project site is located in Georgetown (BoM station 30018, approximately 90 km north west) which indicates that mean daily maximum summer temperatures are around 35-36°C and approximately 12-28°C during winter.

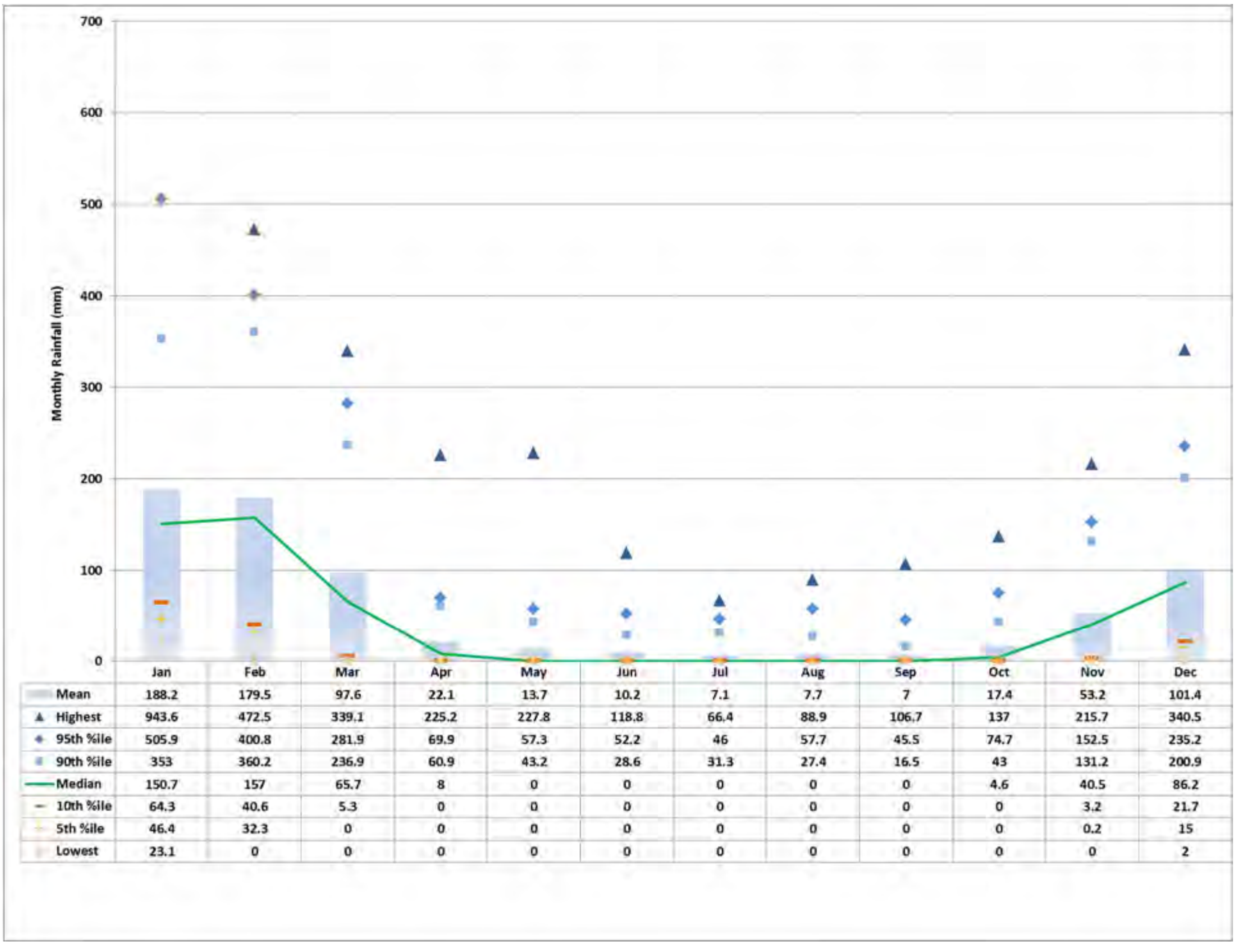


Figure 13 Monthly Rainfall - Kidston Gold Mine (30027), 1915 – 2002 (BoM)

Table 17 Annual Rainfall Statistics - Kidston Gold Mine (30027), 1915 – 2002 (BoM)

Statistic	Annual Total (mm)
Mean	704.7
Lowest	101.9
5th %ile	346.9
10th %ile	383.7
Median	631.4
90th %ile	998.4
95th %ile	1,276.3
Highest	1,535.2

5.2.2 Geology & Soils

The Project Site is located on the Einasleigh - Copperfield Plain within the geological Pre-Cambrian Georgetown Inlier of the North Australian Craton. The Georgetown Inlier is a member of the Etheridge Province, which represents one of four inliers where Precambrian Paleoproterozoic rocks outcrop in northern Queensland (Jell, 2013).

Regional geology, as described in the 1: 100,000 Einasleigh Sheet (7760) geological map (Department of Natural Resources and Mines (DNRM), 2003a), comprises complex geology inclusive of the Precambrian Einasleigh Metamorphics, Siluro-Devonian Oak River Granodiorite, Carboniferous to Early Permian elements (rhyolite, microgranite, microdiorite, dolerite, gabbro, and andesite), and Quaternary Chudleigh Basalt and alluvial sediments. Further details on geology are found in Section 5.11.1.

Soils were mapped of “rolling metamorphics”, CH (Chromosol) in the Copperfield upstream of the study area and downstream of the dam. The upper catchment around East Creek consists of Calcarosols. Upstream of the Copperfield Dam consists of significant areas of tenosols and rudosols. Downstream, around the confluence with the Oak River, soils change to Sodosols.

5.2.3 Land Use

The dominant land use within the region is agriculture. Up to 95% of the entire Gilbert, Norman and Mitchell basins comprise grazing land uses (Tait, Rizvi, & Waller, 2015). Cattle grazing occupies almost all land uses between the mine site and the Copperfield Dam to the south and extends to Einasleigh in the north. The land use surrounding the Project is consistent with the broader Basin. The surrounds consist predominantly of agricultural land which is primarily used for grazing.

The Project site is a historically disturbed mine site. Directly adjoining the mine is the Kidston Township to the east, and the proposed K2S Project, to the west. Other land uses within immediate proximity to the site, includes transmission lines and road infrastructure.

The Gilbert River Basin has been the focus of specific proposals for ‘green field’ irrigation. More than 6,000 ha of soils moderately suited to irrigated crop production are located downstream of the Copperfield Dam and around the township of Einasleigh (Petheram, Watson, & Stone, 2013). It was determined that while it is physically possible for the Copperfield Dam to support a small irrigation development near the town of Einasleigh, there is limited economic capacity to support a forage-based development under the default price of hay (Petheram, Watson, & Stone, 2013).

There are historical ‘dead’ mining leases in the upstream areas of East Creek. There is minimal data on these historical mining leases but available data from Queensland Spatial shows the following:

- Three mining leases covered 275ha.
- Mining leases consisted of ML3316, ML3322, ML3315.
- All mining leases were approved in 1978 and expired in 1991.
- Authorised entity was Allstate Explorations NL.
- Minerals identified are Copper, Lead, Iron, Molybdenum, Zinc, Uranium and Silver.
- Inspection of aerial photographs does not show any visible signs of historic mining infrastructure or rehabilitated landforms.

The presence of these mining leases implies that there could be historical legacy contamination issues in East Creek which drains into the proposed study area.

5.2.4 Water Users

There are a number of identified water uses within the Project area and surrounds. Identification of water users has been undertaken based on desktop information, and includes the following.

- Copperfield Gorge Dam used for stock and domestic water supply as well as recreation.

- Copperfield Dam is located upstream of the Project and was constructed in 1984 to provide water supply to the Kidston Gold Mine. Lease to the company ended when mining ceased in 2005. Dam is now owned by Queensland and managed by DNRME. In October 3,000ML of water is released from the dam to top up the Einasleigh River downstream for use by local farmers and the Etheridge Shire Council (Petheram, Watson, & Stone, 2013).
  - Releases made from the Copperfield Dam for the supplementation of downstream usage (e.g. the Gorge at Einasleigh) are not anticipated to effect potential discharges of water from the Project. Supplementary releases from the Copperfield Dam occur during the dry season when there are limited drivers for or opportunity to release from the Project.
  - In the event that releases are made from the Copperfield Dam for augmentation of supply to downstream users, no releases would be made from the Project into the streamflow. In addition, the streamflow resulting from such releases is unlikely to exceed the release flow trigger of 400 ML/d.
- A search of the water entitlements database shows that there are no water licences, water permits, seasonal water allocations or interim water allocations from the Copperfield River between the Copperfield Dam and the Einasleigh township.
- A water licence (44967K) held by Department of Environment and Heritage Protection (EHP) for any purpose – Max rate of take = 200L/s, for 4,650ML per year, daily max limit is 16ML/day.

N

DATUM GDA 1994, PROJECTION MGA ZONE 56

0 250 500 1,000
metres

1:20,000 (when printed at A3)

AECOM
www.aecom.com

LEGEND

- Boundary Points
- Water Intake Pipeline
- Key Project Infrastructure Footprint
- Spillway Options Corridor
- Mining Lease Boundary
- K2S Boundary
- Watercourses
- Major Roads
- Minor Roads
- Cadastral Parcel

Data sources:

KIDSTON PUMPED STORAGE HYDRO PROJECT
IMPACT ASSESSMENT REPORT

Indicative Release Location

PROJECT ID	60544566
CREATED BY	RF
LAST MODIFIED	RF - 11 Jan 2019
VERSION:	1

Figure
14

5.2.5 Historical Releases

The Kidston site has historically released water to the receiving environment via a number of mechanisms. An understanding of historical releases is required in order to properly assess the baseline condition of the receiving environment at the time of this application.

Table 18 represents a timeline of known releases from the historical Kidston mine site. This data was assembled from records made available for the site from DES as well as records provided by Genex. The majority of releases have occurred into the Charles Creek catchment, which collects runoff from the western portions of the mining lease and transmits flows towards the Copperfield River downstream from the proposed release area.

Table 18 Timeline of releases

Date	Description of Release
23 February 2014 – 26 March 2014	Discharge of water from the TSF. pH, aluminium and copper exceeded at upstream and downstream sites. However when using 95th percentile of upstream sites compared to impact sites, no exceedance occurs.
February 2013	Transitional Environmental Program (TEP) Approved (MAN17662) to allow mixing zone for discharges to the Copperfield River.
11 September 2009	Water from Butchers Creek lower dam spillway into the Copperfield River. Department of Environment and Heritage Protection (EHP) notified. Water overflow was because of a pump failure. Higher EC was input into the Copperfield River as a result of the TSF. Cadmium had significant number of exceedances. However there are instances which show excess cadmium coming from upstream of WB. Cadmium in the river was higher (0.266mg/L) compared to Butchers Creek (0.04mg/L).
2009	An Environmental Investigation Notice (EIN) was issued in 2009 as a result of discharges to the Charles Creek catchment. A subsequent Environmental Investigation was undertaken and found: • Short term exceedance of trigger limits of sulfate, EC and manganese at W2 occurred but did not produce any likely environmental harm
2008	TEP (MAN4413) granted on 2 December 2008 to collect additional information for the Voluntary Environmental Management Plan (EMP).
5-6 February 2008	Release from the “North Reclaim Dam” following monsoonal storms to the Charles Creek catchment. There was no discharge to the Copperfield River.

Date	Description of Release
2005	Placer Dome submitted a Voluntary EMP with the purposes of improving water quality on site, as well as improving water quality monitoring and reporting frameworks within the EA. There were 6 Action Plans including: • Review trigger levels for sulfate in receiving waters • On site contaminant redirection of discharges • Risk assessment • Fencing of existing dams and drains • Fencing of proposed dams • Research study on the effects of sulfate uptake by cattle
1995	Release of poor quality water from Kidston North Dump Dam. Release from 10th to 16th September into Charles Creek.

Water quality analysis presented in the sections below indicates that the W2 site is potentially impacted by seepage. Review of graphs in Appendix A shows that the site is consistently elevated for a majority of parameters. A potential relationship exists between sulfate and EC in samples from W2 (Section 5.8). However a thorough review of the data of the W2 sampling site shows that it is not possible to definitively separate samples which are impacted by mining activities from samples which are not impacted by mining activities. It is theorised that seepage from waste rock dumps has affected the sampling results at this site. The mechanism for this impact is not known, whether that is seepage from the toes of waste rock dumps which accumulates in pools in the receiving environment, or seepage into shallow groundwater which expresses at the W2 monitoring point.

The available information suggests that there were no long-lasting impacts to the Copperfield River (aside from at W2) as a result of releases to the environment. The majority of releases have been to the Charles Creek catchment.

5.3 Surface Water Quality

5.3.1 Sample Sites and Frequency

Water quality data has been assessed from the monitoring points outlined in Table 19 and Figure 16. Site WB is upstream of all influences of the mine and is used to determine contaminants that enter the Copperfield River upstream from the site. Site W3 is the most downstream site on the Copperfield River and is located at the Gilberton Road crossing used to gain access to the site. E1 and E2 are additional sites on the Copperfield River used to monitor the influence of East Creek. These two monitoring locations were added for the studies supporting this IAR and as such have only been sampled once.

Table 19 Monitoring Locations used to Assess Baseline Quality of Copperfield River in Vicinity of Proposed Release Location

Monitoring Location	Proximity to Proposed Release Location	Easting	Northing	Period of Record	Description
WB	2km upstream	201087	7907273	13/09/2004 – 05/06/2017	Upstream of all historic mining impacts
W1	1.2km upstream	200799	7908133		Copperfield River below the TSF Dam Spillway
W2	1.1km downstream	201851	7910299		Copperfield River below Butchers' Creek Dam and Manager's Creek Dam
W3	7.4km downstream	202667	7915973		Downstream monitoring site at the Causeway
E1#	Additional upstream / control site	203774	7912124	24/03/2018	East Creek 900m upstream of confluence with the Copperfield River
E2#	4.3km downstream	202887	7912971		Copperfield River immediately downstream of the confluence with the East Creek

Additional site added as part of this IAR assessment.

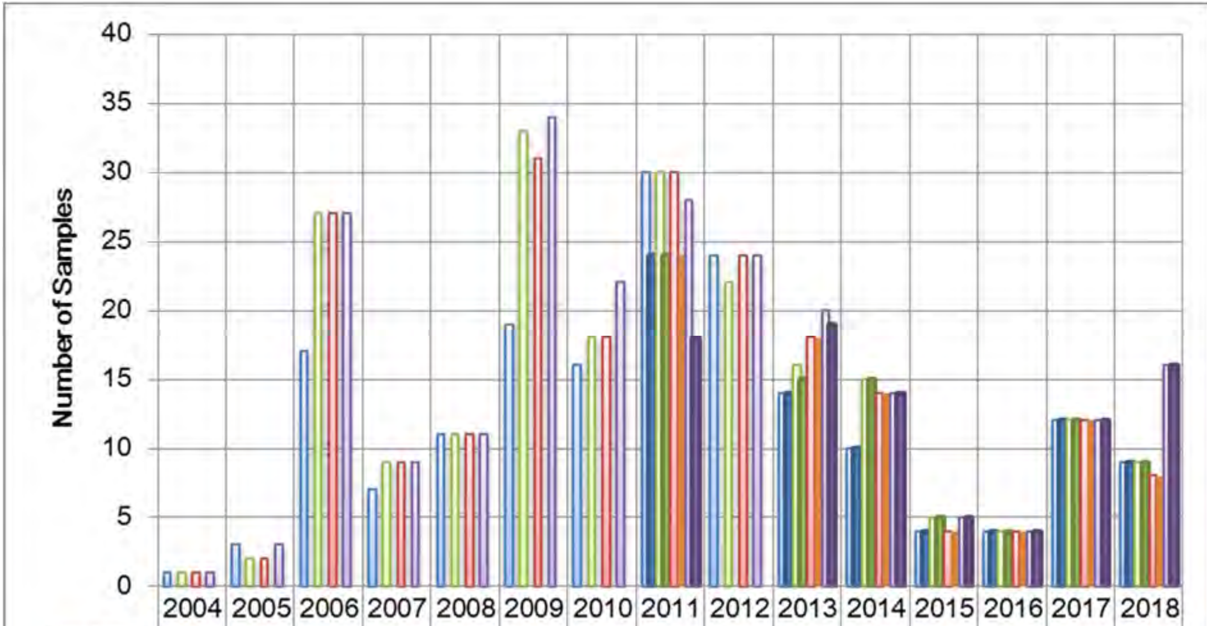
The majority of water quality samples from the monitoring sites were collected from 2009 to 2012, with a lower number of samples collected in 2015 and 2016 (Figure 15). During 2017 there were 12 samples collected from each site (Figure 15).

Not all grab samples were analysed for total as well as dissolved metals. Collection of dissolved metal concentrations following filtration through a 0.45µm filter commenced in 2011. These dissolved fraction samples are required to assess against ANZECC (2000) default WQOs for toxicants while total concentrations are required to assess against WQOs of most other EVs. The number of samples with total metals analysis (T) and filtered metals analysis (F) is shown for each site in Figure 15. There are adequate background water quality samples for calculation of the required statistics as outlined in Section 5.5.3 and no additional reference sites are required.

Metals which have been analysed as part of the historical mining activities at the Kidston site include:

- Aluminium
- Arsenic
- Cadmium
- Chromium (partially)
- Cobalt

- Copper
- Iron (partially)
- Manganese
- Molybdenum
- Nickel
- Lead
- Zinc.



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
WB-T	1	3	17	7	11	19	16	30	24	14	10	4	4	12	9
WB-F								24	0	14	10	4	4	12	9
W1-T	1	2	27	9	11	33	18	30	22	16	15	5	4	12	9
W1-F								24	0	15	15	5	4	12	9
W2-T	1	2	27	9	11	31	18	30	24	18	14	4	4	12	8
W2-F								24	0	18	14	4	4	12	8
W3-T	1	3	27	9	11	34	22	28	24	20	14	5	4	12	16
W3-F								18	0	19	14	5	4	12	16

Figure 15 Number of Samples per Year since 2003 for Relevant Surface Water Monitoring Sites

AECOM
www.aecom.com

N

DATUM GDA 1994, PROJECTION MGA ZONE 56

0 250 500 1,000
metres

1:30,000 (when printed at A3)

LEGEND
- Monitoring Point
- Existing Release Points
- Key Project Infrastructure Footprint
- Spillway Options Corridor
- Major Watercourse
- Minor Watercourse

Data sources:

KIDSTON PUMPED STORAGE HYDRO PROJECT
IMPACT ASSESSMENT REPORT

Surface Water Sampling Locations

PROJECT ID	60544566
CREATED BY	RF
LAST MODIFIED	RF - 11 Jan 2019
VERSION:	1

Figure
16

Filename: P:\605X\60544566\4. Tech Work Area\4.99 GIS\02_MXDs\Hydro\H60544566_002_SurfaceWaterSamplingLocations_20190111_A3L_v1.mxd

A3 size

5.3.1.1 Water Quality Data Controls and Checks

The water quality database supplied by Genex was screened for water quality data inconsistencies, using the following methods:

- Comparison of the level of dissolved contaminant compared to total contaminant (i.e. whether dissolved zinc was greater than total zinc for that sample). Where these were found, the analyses were removed.
- Values that were below the LOR were transformed to 50% of the LOR (i.e. <0.001 mg/L becomes 0.0005 mg/L) for statistical interrogation.
- All values were graphed and checked visually for obvious outliers.

A number of anomalies were found in the time-histories for receiving environment data, which included:

- Total cadmium concentrations in early 2011 were elevated by several orders of magnitude at all receiving environment sites.
- One total cobalt reading was elevated by several orders of magnitude at W1 in 2006. One reading at W3 in 2006 was an order of magnitude too-low and was potentially a typo.
- An elevated total chromium concentration in March 2011 at WB and W3.
- Total copper concentrations were elevated by several orders of magnitude at WB in one sample from 2007 and 2010, in one sample from 2006 at W1, and in one sample in 2011 at W3.
- Erroneously low values of total manganese in 2007 for W1, March 2009 and September 2011 for WB and January 2012 for W3. These values were excluded from the dataset.
- Elevated values of total nickel at WB and W3 in March 2011, which were several orders of magnitude above surrounding values. It is unknown whether or not these were due to error.
- Elevated value of total lead at W3 in March 2011. It is unknown whether this is a real value, but it is an order of magnitude above all values prior to and following this sampling event. This value corresponds to the elevated total nickel at the time at W3.
- W1 records a total zinc concentration several orders of magnitude above all other values in 2006.

The majority of anomalies in the datasets occur prior to 2012. Therefore the water quality dataset was only analysed for samples which have been collected during or after 2012 for the receiving environment sites. This nevertheless provides a dataset of 40-60 samples with dissolved metal analyses and provides an adequate dataset.

5.3.2 Summary of Water Quality Statistics

Key statistics for receiving environment monitoring locations WB, W1, W2 and W3 are presented in Table 20 to Table 23 respectively. Statistics for both the full dataset and the post 2011 dataset are presented.

Table 20 Summary of Water Quality Data for Monitoring Site WB

Parameter	Unit	LOR	Full dataset							Post 2011 Dataset						
			Count	Min.	P20	P50	P80	P95	Max.	Count	Min.	P20	P50	P80	P95	Max.
pH	pH Unit	0.01	179	6.47	7.378	7.65	7.96	8.16	8.73	77	6.47	7.47	7.73	7.99	8.29	8.73
Electrical Conductivity @ 25°C	µS/cm	1	179	55	88.6	110	190.4	274.2	1200	77	55	88.2	111	218	266	313
Sulfate as SO4 - Turbidimetric	mg/L	1	179	0.5	1	2	4	10.1	24	77	0.5	1	2	4.8	8.6	20
Aluminium (T)	mg/L	0.01	174	0.005	0.025	0.41	1.522	3.948	7.6	77	0.005	0.02	0.54	2.066	3.802	5.57
Arsenic (T)	mg/L	0.001	179	0.0005	0.0005	0.0005	0.002	0.0025	0.005	77	0.0005	0.0005	0.0005	0.001	0.002	0.005
Cadmium (T)	mg/L	0.0001	179	0.00005	0.00005	0.00005	0.0001	0.00205	1.17	77	0.00005	0.00005	0.00005	0.00005	6E-05	0.0009
Cobalt (T)	mg/L	0.001	179	0.0005	0.0005	0.0005	0.0025	0.025	0.05	77	0.0005	0.0005	0.0005	0.0005	0.002	0.003
Chromium (T)	mg/L	0.001	123	0.0005	0.0005	0.0005	0.001	0.003	0.068	77	0.0005	0.0005	0.0005	0.002	0.003	0.005
Copper (T)	mg/L	0.001	179	0.0005	0.0005	0.002	0.005	0.009	0.534	77	0.0005	0.0005	0.002	0.004	0.0082	0.01
Manganese (T)	mg/L	0.001	150	0.0025	0.0238	0.0365	0.0822	0.28535	0.988	77	0.009	0.024	0.047	0.1114	0.443	0.988
Molybdenum (T)	mg/L	0.001	179	0.0005	0.0005	0.0005	0.0025	0.025	0.025	77	0.0005	0.0005	0.0005	0.0005	0.0005	0.007
Nickel (T)	mg/L	0.001	179	0.0005	0.0005	0.001	0.003	0.025	0.055	77	0.0005	0.0005	0.0005	0.002	0.003	0.004
Lead (T)	mg/L	0.001	179	0.0005	0.0005	0.0005	0.001	0.005	0.007	77	0.0005	0.0005	0.0005	0.002	0.006	0.007
Zinc (T)	mg/L	0.005	179	0.0025	0.0025	0.0025	0.0124	0.0271	0.5	77	0.0025	0.0025	0.0025	0.0108	0.028	0.074
Free Cyanide	mg/L	0.004	52	0.002	0.002	0.002	0.002	0.002	0.002	52	0.002	0.002	0.002	0.002	0.002	0.002
WAD Cyanide	mg/L	0.004	123	0.002	0.002	0.002	0.0025	0.0025	0.014	24	0.002	0.002	0.002	0.002	0.002	0.002
Total Alkalinity as CaCO3	mg/L	1	3	30	36	45	53.4	57.6	59	1	45	45	45	45	45	45

Parameter	Unit	LOR	Full dataset							Post 2011 Dataset						
			Count	Min.	P20	P50	P80	P95	Max.	Count	Min.	P20	P50	P80	P95	Max.
Iron (T)	mg/L	0.05	17	0.01	0.062	0.16	0.432	0.728	0.96	1	0.67	0.67	0.67	0.67	0.67	0.67
Calcium	mg/L	1	53	0.5	3.8	7	14	18.8	24	52	0.5	3.4	7	14	18.9	24
Magnesium	mg/L	1	54	0.5	2	4	9	12	17	53	0.5	2	4	9	12	17
Sodium	mg/L	1	3	0.001	3.9206	9.8	9.92	9.98	10	1	10	10	10	10	10	10
Potassium	mg/L	1	2	2	2	2	2	2	2	1	2	2	2	2	2	2
Chloride	mg/L	1	3	0.82	2.892	6	6	6	6	1	6	6	6	6	6	6
Aluminium (F)	mg/L	0.01	123	0.005	0.005	0.22	0.568	2.867	5.14	77	0.005	0.005	0.28	0.818	3.09	5.14
Arsenic (F)	mg/L	0.001	77	0.0005	0.0005	0.0005	0.0005	0.0012	0.004	53	0.0005	0.0005	0.0005	0.0005	0.002	0.004
Cadmium (F)	mg/L	0.0001	77	0.0000 5	0.0000 5	0.0000 5	0.0000 5	0.0002	0.519	53	0.0000 5	0.0000 5	0.0000 5	0.0000 5	0.0000 5	0.0000 5
Cobalt (F)	mg/L	0.001	77	0.0005	0.0005	0.0005	0.0005	0.001	0.002	53	0.0005	0.0005	0.0005	0.0005	0.001	0.002
Chromium (F)	mg/L	0.001	77	0.0005	0.0005	0.0005	0.0005	0.001	0.002	53	0.0005	0.0005	0.0005	0.0005	0.001	0.002
Copper (F)	mg/L	0.001	77	0.0005	0.0005	0.002	0.003	0.005	0.015	53	0.0005	0.0005	0.002	0.003	0.005	0.015
Manganese (F)	mg/L	0.001	77	0.0005	0.003	0.016	0.0478	0.2892	0.877	53	0.0005	0.01	0.029	0.0888	0.3612	0.877
Molybdenum (F)	mg/L	0.001	77	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	53	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Nickel (F)	mg/L	0.001	77	0.0005	0.0005	0.0005	0.0005	0.0012	0.0025	53	0.0005	0.0005	0.0005	0.001	0.002	0.0025
Lead (F)	mg/L	0.001	77	0.0005	0.0005	0.0005	0.0005	0.002	0.582	53	0.0005	0.0005	0.0005	0.001	0.002	0.582
Zinc (F)	mg/L	0.005	77	0.0005	0.0025	0.0025	0.006	0.0114	0.019	53	0.0005	0.0025	0.0025	0.005	0.0112	0.019
Bicarbonate	mg/L	1	2	54.9	58.316	63.44	68.564	71.126	71.98	1	54.9	54.9	54.9	54.9	54.9	54.9
Total Dissolved Solids	mg/L	1	1	62	62	62	62	62	62	1	62	62	62	62	62	62
Hardness	mg/L	1	53	3.3	17.7	33.9	71.9	91.74	124.7	52	3.3	16.7	33.9	71.9	91.945	124.7

Parameter	Unit	LOR	Full dataset							Post 2011 Dataset						
			Count	Min.	P20	P50	P80	P95	Max.	Count	Min.	P20	P50	P80	P95	Max.
Selenium (F)	mg/L	0.01	1	0.005	0.005	0.005	0.005	0.005	0.005	1	0.005	0.005	0.005	0.005	0.005	0.005
Iron (F)	mg/L	0.05	1	0.21	0.21	0.21	0.21	0.21	0.21	1	0.21	0.21	0.21	0.21	0.21	0.21
Selenium (T)	mg/L	0.01	1	0.005	0.005	0.005	0.005	0.005	0.005	1	0.005	0.005	0.005	0.005	0.005	0.005

Table 21 Summary of Water Quality Data for Monitoring Site W1

Parameter	Unit	LOR	Full dataset							Post 2011 Dataset						
			Count	Min.	P20	P50	P80	P95	Max.	Count	Min.	P20	P50	P80	P95	Max.
pH	pH Unit	0.01	207	5.66	7.40	7.69	8.00	8.33	9.10	83	6.7	7.46	7.75	8.00	8.38	9.05
Electrical Conductivity @ 25°C	µS/cm	1	207	63	96.2	139	244	352.4	3420	83	70	95.8	135	235	312.8	3420
Sulfate as SO4 - Turbidimetric	mg/L	1	207	0.5	1.2	4	12	80.7	634	83	0.5	2	4	11.6	36.7	634
Aluminium (T)	mg/L	0.01	209	0.005	0.025	0.24	1.418	2.96	7.15	83	0.005	0.054	0.55	1.512	2.817	5.11
Arsenic (T)	mg/L	0.001	214	0.00025	0.0005	0.0005	0.0015	0.003	0.007	83	0.0005	0.0005	0.0005	0.002	0.003	0.007
Cadmium (T)	mg/L	0.0001	214	0.00005	0.00005	0.00005	0.0002	0.01185	0.708	83	0.00005	0.00005	0.00005	0.00005	0.00058	0.0024
Cobalt (T)	mg/L	0.001	214	0.00025	0.0005	0.0005	0.005	0.025	0.47	83	0.0005	0.0005	0.0005	0.0005	0.002	0.005
Chromium (T)	mg/L	0.001	147	0.0005	0.0005	0.0005	0.001	0.004	0.009	83	0.0005	0.0005	0.0005	0.001	0.0029	0.006
Copper (T)	mg/L	0.001	214	0.0005	0.001	0.002	0.005	0.0187	3.2	83	0.0005	0.001	0.002	0.004	0.0107	0.114
Manganese (T)	mg/L	0.001	176	0.00025	0.025	0.0405	0.094	0.211	0.459	83	0.016	0.0284	0.046	0.102	0.1906	0.459
Molybdenum (T)	mg/L	0.001	214	0.00025	0.0005	0.0005	0.0074	0.025	0.025	83	0.0005	0.0005	0.0005	0.0005	0.0019	0.002
Nickel (T)	mg/L	0.001	214	0.0005	0.0005	0.001	0.003	0.025	0.54	83	0.0005	0.0005	0.0005	0.001	0.003	0.005
Lead (T)	mg/L	0.001	214	0.0005	0.0005	0.0005	0.001	0.003	0.012	83	0.0005	0.0005	0.0005	0.001	0.0086	0.012
Zinc (T)	mg/L	0.005	214	0.00025	0.0025	0.0055	0.016	0.06275	53	83	0.0025	0.0025	0.0025	0.009	0.0893	0.177
Free Cyanide	mg/L	0.004	59	0.002	0.002	0.002	0.002	0.002	0.005	59	0.002	0.002	0.002	0.002	0.002	0.005
WAD Cyanide	mg/L	0.004	153	0.00025	0.00025	0.002	0.002	0.0025	0.012	23	0.002	0.002	0.002	0.002	0.002	0.012

Parameter	Unit	LOR	Full dataset							Post 2011 Dataset						
			Count	Min.	P20	P50	P80	P95	Max.	Count	Min.	P20	P50	P80	P95	Max.
Total Alkalinity as CaCO3	mg/L	1	3	42	42.4	43	53.2	58.3	60	1	43	43	43	43	43	43
Iron (T)	mg/L	0.05	22	0.025	0.09	0.205	0.432	0.8905	0.95	1	0.71	0.71	0.71	0.71	0.71	0.71
Calcium	mg/L	1	60	2	5	8	13	18.05	20	59	2	5	8	13	18.1	20
Magnesium	mg/L	1	61	1	2	5	10	14	16	60	1	2	5	10	14	16
Sodium	mg/L	1	2	9	9.4	10	10.6	10.9	11	1	11	11	11	11	11	11
Potassium	mg/L	1	2	1.8	1.84	1.9	1.96	1.99	2	1	2	2	2	2	2	2
Chloride	mg/L	1	2	5	5.2	5.5	5.8	5.95	6	1	5	5	5	5	5	5
Aluminium (F)	mg/L	0.01	138	0.005	0.005	0.13	0.552	2.1195	5.71	83	0.005	0.005	0.19	0.776	2.727	5.71
Arsenic (F)	mg/L	0.001	84	0.0005	0.0005	0.0005	0.001	0.00285	0.005	60	0.0005	0.0005	0.0005	0.001	0.003	0.005
Cadmium (F)	mg/L	0.0001	84	0.00005	0.00005	0.00005	0.00005	0.00131	0.591	60	0.00005	0.00005	0.00005	0.00005	0.00005	0.0014
Cobalt (F)	mg/L	0.001	84	0.0005	0.0005	0.0005	0.0005	0.001	0.002	60	0.0005	0.0005	0.0005	0.0005	0.000525	0.001
Chromium (F)	mg/L	0.001	84	0.0005	0.0005	0.0005	0.0005	0.001	0.002	60	0.0005	0.0005	0.0005	0.0005	0.002	0.002
Copper (F)	mg/L	0.001	84	0.0005	0.0005	0.002	0.0034	0.005	0.024	60	0.0005	0.0005	0.002	0.004	0.005	0.006
Manganese (F)	mg/L	0.001	84	0.0005	0.0036	0.012	0.0254	0.0557	0.162	60	0.0005	0.007	0.017	0.0282	0.0567	0.1
Molybdenum (F)	mg/L	0.001	84	0.0005	0.0005	0.0005	0.0005	0.001	0.003	60	0.0005	0.0005	0.0005	0.0005	0.001	0.002
Nickel (F)	mg/L	0.001	84	0.0005	0.0005	0.0005	0.0005	0.002	0.003	60	0.0005	0.0005	0.0005	0.0006	0.002	0.0025
Lead (F)	mg/L	0.001	84	0.0005	0.0005	0.0005	0.0005	0.002	0.033	60	0.0005	0.0005	0.0005	0.0006	0.002	0.033
Zinc (F)	mg/L	0.005	84	0.0025	0.0025	0.0025	0.007	0.01455	0.237	60	0.0025	0.0025	0.0025	0.008	0.012	0.077
Bicarbonate	mg/L	1	1	52.46	52.46	52.46	52.46	52.46	52.46	1	52.46	52.46	52.46	52.46	52.46	52.46

Parameter	Unit	LOR	Full dataset							Post 2011 Dataset						
			Count	Min.	P20	P50	P80	P95	Max.	Count	Min.	P20	P50	P80	P95	Max.
Total Dissolved Solids	mg/L	1	1	61	61	61	61	61	61	1	61	61	61	61	61	61
Hardness	mg/L	1	60	9.1	20.7	40.5	76.32	98.315	104.9	59	9.1	20.7	40.5	76.64	98.53	104.9
Selenium (F)	mg/L	0.01	1	0.005	0.005	0.005	0.005	0.005	0.005	1	0.005	0.005	0.005	0.005	0.005	0.005
Iron (F)	mg/L	0.05	1	0.23	0.23	0.23	0.23	0.23	0.23	1	0.23	0.23	0.23	0.23	0.23	0.23
Selenium (T)	mg/L	0.01	1	0.005	0.005	0.005	0.005	0.005	0.005	1	0.005	0.005	0.005	0.005	0.005	0.005

Table 22 Summary of Water Quality Data for Monitoring Site W2

Parameter	Unit	LOR	Full dataset							Post 2011 Dataset						
			Count	Min.	P20	P50	P80	P95	Max.	Count	Min.	P20	P50	P80	P95	Max.
pH	pH Unit	0.01	206	6.82	7.40	7.72	8.00	8.39	8.81	84	6.89	7.52	7.77	8.00	8.55	8.81
Electrical Conductivity @ 25°C	µS/cm	1	206	68	120	203	479	2825	6100	84	68	106	170	294.8	556.1	910
Sulfate as SO4 - Turbidimetric	mg/L	1	206	0.5	5	18	118	1300	3600	84	0.5	4	10.5	31.4	121.5	260
Aluminium (T)	mg/L	0.01	208	0.0025	0.02	0.15	1.17	2.2965	8.61	84	0.005	0.02	0.455	1.396	2.02	3.92
Arsenic (T)	mg/L	0.001	213	0.0005	0.0005	0.002	0.005	0.0194	0.039	84	0.0005	0.0005	0.001	0.003	0.01085	0.032
Cadmium (T)	mg/L	0.0001	213	0.00005	0.00005	0.00005	0.00026	0.00552	1.38	84	0.00005	0.00005	0.00005	0.00005	0.000185	0.0013
Cobalt (T)	mg/L	0.001	213	0.0005	0.0005	0.0005	0.004	0.025	0.025	84	0.0005	0.0005	0.0005	0.0005	0.002	0.003
Chromium (T)	mg/L	0.001	139	0.0005	0.0005	0.0005	0.001	0.002	0.005	84	0.0005	0.0005	0.0005	0.001	0.002	0.005
Copper (T)	mg/L	0.001	213	0.0005	0.0005	0.002	0.005	0.0094	0.024	84	0.0005	0.0005	0.002	0.003	0.00585	0.018
Manganese (T)	mg/L	0.001	174	0.005	0.025	0.0625	0.217	0.545	2.81	84	0.008	0.0332	0.075	0.226	0.3893	1.72
Molybdenum (T)	mg/L	0.001	213	0.0005	0.0005	0.001	0.025	0.0258	0.12	84	0.0005	0.0005	0.0005	0.001	0.003	0.006
Nickel (T)	mg/L	0.001	213	0.0005	0.0005	0.001	0.003	0.025	0.025	84	0.0005	0.0005	0.0005	0.001	0.002	0.004
Lead (T)	mg/L	0.001	213	0.0005	0.0005	0.0005	0.001	0.003	0.009	84	0.0005	0.0005	0.0005	0.001	0.003	0.009
Zinc (T)	mg/L	0.005	213	0.0025	0.0025	0.006	0.02	0.0762	0.84	84	0.0025	0.0025	0.0025	0.0108	0.0294	0.115
Free Cyanide	mg/L	0.004	59	0.002	0.002	0.002	0.002	0.002	0.008	59	0.002	0.002	0.002	0.002	0.002	0.008
WAD Cyanide	mg/L	0.004	153	0.002	0.002	0.002	0.0025	0.0025	0.067	24	0.002	0.002	0.002	0.002	0.002	0.031
Total Alkalinity as CaCO3	mg/L	1	3	30	35.2	43	53.2	58.3	60	1	43	43	43	43	43	43

Parameter	Unit	LOR	Full dataset							Post 2011 Dataset						
			Count	Min.	P20	P50	P80	P95	Max.	Count	Min.	P20	P50	P80	P95	Max.
Iron (T)	mg/L	0.05	21	0.025	0.07	0.22	0.59	0.71	1.2	1	0.71	0.71	0.71	0.71	0.71	0.71
Calcium	mg/L	1	60	3	6	12	19.2	34	41	59	3	6	12	19.4	34	41
Magnesium	mg/L	1	61	1	3	7	12	20	30	60	1	3	7	12.4	20.15	30
Sodium	mg/L	1	10	0.0005	0.0005	0.004	1.8888	9.73	10	1	10	10	10	10	10	10
Potassium	mg/L	1	2	1.8	1.84	1.9	1.96	1.99	2	1	2	2	2	2	2	2
Chloride	mg/L	1	10	0.005	0.044	0.07	1.352	6	6	1	6	6	6	6	6	6
Aluminium (F)	mg/L	0.01	130	0.005	0.005	0.075	0.482	2.36	6.48	84	0.005	0.005	0.16	0.808	3.016	6.48
Arsenic (F)	mg/L	0.001	84	0.0005	0.0005	0.0005	0.002	0.005	0.022	60	0.0005	0.0005	0.0005	0.002	0.00905	0.022
Cadmium (F)	mg/L	0.0001	84	0.00005	0.00005	0.00005	0.0002	0.023875	10.9	60	0.00005	0.00005	0.00005	0.00005	0.000105	0.0253
Cobalt (F)	mg/L	0.001	84	0.0005	0.0005	0.0005	0.0005	0.0005	0.002	60	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Chromium (F)	mg/L	0.001	84	0.0005	0.0005	0.0005	0.0005	0.002	0.002	60	0.0005	0.0005	0.0005	0.0005	0.002	0.002
Copper (F)	mg/L	0.001	84	0.0005	0.0005	0.002	0.003	0.00585	0.017	60	0.0005	0.0005	0.002	0.003	0.006	0.007
Manganese (F)	mg/L	0.001	84	0.001	0.0086	0.0275	0.082	0.22595	0.309	60	0.001	0.0168	0.038	0.113	0.2443	0.309
Molybdenum (F)	mg/L	0.001	84	0.0005	0.0005	0.0005	0.002	0.004	0.008	60	0.0005	0.0005	0.0005	0.001	0.002	0.006
Nickel (F)	mg/L	0.001	84	0.0005	0.0005	0.0005	0.001	0.002	0.0025	60	0.0005	0.0005	0.0005	0.001	0.002	0.0025
Lead (F)	mg/L	0.001	84	0.0005	0.0005	0.0005	0.0005	0.002	0.125	60	0.0005	0.0005	0.0005	0.0006	0.002	0.125
Zinc (F)	mg/L	0.005	84	0.0025	0.0025	0.0025	0.0094	0.02755	0.114	60	0.0025	0.0025	0.0025	0.007	0.0121	0.028
Bicarbonate	mg/L	1	1	52.46	52.46	52.46	52.46	52.46	52.46	1	52.46	52.46	52.46	52.46	52.46	52.46
Total Dissolved	mg/L	1	1	64	64	64	64	64	64	1	64	64	64	64	64	64

Parameter	Unit	LOR	Full dataset							Post 2011 Dataset						
			Count	Min.	P20	P50	P80	P95	Max.	Count	Min.	P20	P50	P80	P95	Max.
Solids																
Hardness	mg/L	1	61	0	27.3	56.2	101.7	162.9	208	60	0	27.24	57.45	101.7	163.97	208
Selenium (F)	mg/L	0.01	1	0.005	0.005	0.005	0.005	0.005	0.005	1	0.005	0.005	0.005	0.005	0.005	0.005
Iron (F)	mg/L	0.05	1	0.2	0.2	0.2	0.2	0.2	0.2	1	0.2	0.2	0.2	0.2	0.2	0.2
Selenium (T)	mg/L	0.01	1	0.005	0.005	0.005	0.005	0.005	0.005	1	0.005	0.005	0.005	0.005	0.005	0.005
Ammonia as N	mg/L	0.01	1	0.02	0.02	0.02	0.02	0.02	0.02	1	0.02	0.02	0.02	0.02	0.02	0.02
Nitrite as N	mg/L	0.01	1	0.005	0.005	0.005	0.005	0.005	0.005	1	0.005	0.005	0.005	0.005	0.005	0.005
Nitrate as N	mg/L	0.01	1	0.06	0.06	0.06	0.06	0.06	0.06	1	0.06	0.06	0.06	0.06	0.06	0.06
Nitrite + Nitrate as N	mg/L	0.01	1	0.06	0.06	0.06	0.06	0.06	0.06	1	0.06	0.06	0.06	0.06	0.06	0.06
Total Kjeldahl Nitrogen as N	mg/L	0.1	1	0.2	0.2	0.2	0.2	0.2	0.2	1	0.2	0.2	0.2	0.2	0.2	0.2
Total Nitrogen as N	mg/L	0.1	2	0.2	0.22	0.25	0.28	0.295	0.3	2	0.2	0.22	0.25	0.28	0.295	0.3
Total Phosphorus as P	mg/L	0.01	1	0.005	0.005	0.005	0.005	0.005	0.005	1	0.005	0.005	0.005	0.005	0.005	0.005

Table 23 Summary of Water Quality Data for Monitoring Site W3

Parameter	Unit	LOR	Full dataset							Post 2011 Dataset						
			Count	Min.	P20	P50	P80	P95	Max.	Count	Min.	P20	P50	P80	P95	Max.
pH	pH Unit	0.01	223	6.70	7.32	7.60	7.98	8.18	8.51	95	6.81	7.48	7.80	8.05	8.23	8.51
Electrical Conductivity @ 25°C	µS/cm	1	223	21	96.4	131	258.4	309.7	404	95	60	98.8	150	285.4	338.5	404
Sulfate as SO4 - Turbidimetric	mg/L	1	223	0.5	2.2	5	10	17.9	56	95	0.5	2	4	10	18.9	56
Aluminium (T)	mg/L	0.01	225	0.005	0.025	0.32	1.482	4.57	16	95	0.005	0.01	0.52	1.642	5.849	16
Arsenic (T)	mg/L	0.001	229	0.00025	0.0005	0.0015	0.0025	0.003	0.116	95	0.0005	0.0005	0.001	0.0022	0.004	0.016
Cadmium (T)	mg/L	0.0001	230	0.00005	0.00005	0.00005	0.0002	0.016135	72.4	95	0.00005	0.00005	0.00005	0.00005	0.0005	0.0005
Cobalt (T)	mg/L	0.001	223	0.00005	0.0005	0.0005	0.003	0.025	0.125	88	0.0005	0.0005	0.0005	0.0005	0.001	0.004
Chromium (T)	mg/L	0.001	153	0.0005	0.0005	0.0005	0.001	0.004	0.123	95	0.0005	0.0005	0.0005	0.001	0.0053	0.022
Copper (T)	mg/L	0.001	230	0.0005	0.0005	0.002	0.005	0.00855	0.116	95	0.0005	0.0005	0.002	0.004	0.0096	0.024
Manganese (T)	mg/L	0.001	184	0.0005	0.025	0.046	0.0894	0.2007	0.34	88	0.0005	0.0328	0.064	0.0958	0.2003	0.333
Molybdenum (T)	mg/L	0.001	223	0.0005	0.0005	0.0005	0.0025	0.025	0.025	88	0.0005	0.0005	0.0005	0.0005	0.001	0.002
Nickel (T)	mg/L	0.001	230	0.0005	0.0005	0.001	0.003	0.025	0.12	95	0.0005	0.0005	0.0005	0.002	0.004	0.013
Lead (T)	mg/L	0.001	230	0.0005	0.0005	0.0005	0.001	0.004	0.114	95	0.0005	0.0005	0.0005	0.002	0.006	0.018
Zinc (T)	mg/L	0.005	230	0.0025	0.0025	0.005	0.014	0.0412	0.17	95	0.0025	0.0025	0.0025	0.012	0.0414	0.09
Free Cyanide	mg/L	0.004	69	0.002	0.002	0.002	0.002	0.002	0.002	69	0.002	0.002	0.002	0.002	0.002	0.002
WAD Cyanide	mg/L	0.004	162	0.002	0.002	0.002	0.0025	0.0025	0.056	32	0.002	0.002	0.002	0.002	0.002	0.028

Parameter	Unit	LOR	Full dataset							Post 2011 Dataset						
			Count	Min.	P20	P50	P80	P95	Max.	Count	Min.	P20	P50	P80	P95	Max.
Total Alkalinity as CaCO3	mg/L	1	11	24	29	32	50	70.5	80	8	24	27.2	30	32	43.7	50
Iron (T)	mg/L	0.05	31	0.025	0.15	0.4	2.04	6.275	15.6	8	0.65	2.064	3.32	6.652	12.996	15.6
Calcium	mg/L	1	70	2	4	9	18	20.55	24	69	2	4	8	18	20.6	24
Magnesium	mg/L	1	71	1	2	5	10	12	15	70	1	2	5	10	12	15
Sodium	mg/L	1	17	0.0005	0.0016	4	4	11.2	12	8	4	4	4	4.6	8.9	11
Potassium	mg/L	1	9	1	2	2	2	2	2	8	1	2	2	2	2	2
Chloride	mg/L	1	17	0.05	0.062	3	4	6.2	7	8	3	3.4	4	4.6	5.65	6
Fluoride	mg/L	0.1	7	0.05	0.05	0.05	0.05	0.05	0.05	7	0.05	0.05	0.05	0.05	0.05	0.05
Aluminium (F)	mg/L	0.01	152	0.005	0.005	0.12	0.568	2.1485	6.25	95	0.005	0.005	0.22	0.958	3.561	6.25
Arsenic (F)	mg/L	0.001	88	0.0005	0.0005	0.0005	0.0016	0.002	0.006	70	0.0005	0.0005	0.0005	0.002	0.00255	0.006
Cadmium (F)	mg/L	0.0001	88	0.00005	0.00005	0.00005	0.0001	0.07886	1.08	70	0.00005	0.00005	0.00005	0.00005	0.0005	0.0005
Cobalt (F)	mg/L	0.001	81	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	63	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Chromium (F)	mg/L	0.001	88	0.0005	0.0005	0.0005	0.0005	0.00165	0.003	70	0.0005	0.0005	0.0005	0.0005	0.002	0.003
Copper (F)	mg/L	0.001	88	0.0005	0.0005	0.002	0.0026	0.004	0.027	70	0.0005	0.0005	0.002	0.0022	0.00455	0.027
Manganese (F)	mg/L	0.001	81	0.0005	0.005	0.019	0.039	0.106	0.221	63	0.0005	0.013	0.023	0.0476	0.1069	0.221
Molybdenum (F)	mg/L	0.001	81	0.0005	0.0005	0.0005	0.0005	0.001	0.001	63	0.0005	0.0005	0.0005	0.0005	0.00095	0.001
Nickel (F)	mg/L	0.001	88	0.0005	0.0005	0.0005	0.0005	0.002	0.004	70	0.0005	0.0005	0.0005	0.0006	0.002	0.004
Lead (F)	mg/L	0.001	88	0.0005	0.0005	0.0005	0.0005	0.00165	0.116	70	0.0005	0.0005	0.0005	0.0005	0.002	0.116

Parameter	Unit	LOR	Full dataset							Post 2011 Dataset						
			Count	Min.	P20	P50	P80	P95	Max.	Count	Min.	P20	P50	P80	P95	Max.
Zinc (F)	mg/L	0.005	88	0.001	0.0025	0.0025	0.0025	0.00965	0.054	70	0.001	0.0025	0.0025	0.0025	0.00855	0.038
Bicarbonate	mg/L	1	8	29.28	33.184	36.6	39.04	53.314	61	8	29.28	33.184	36.6	39.04	53.314	61
Total Dissolved Solids	mg/L	1	1	68	68	68	68	68	68	1	68	68	68	68	68	68
Hardness	mg/L	1	70	9.1	18.2	42.18	87.14	99.2	121.5	69	9.1	18.2	40.5	88.28	99.2	121.5
Beryllium (F)	mg/L	0.001	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Barium (F)	mg/L	0.001	1	0.03	0.03	0.03	0.03	0.03	0.03	1	0.03	0.03	0.03	0.03	0.03	0.03
Selenium (F)	mg/L	0.01	1	0.005	0.005	0.005	0.005	0.005	0.005	1	0.005	0.005	0.005	0.005	0.005	0.005
Vanadium (F)	mg/L	0.01	1	0.005	0.005	0.005	0.005	0.005	0.005	1	0.005	0.005	0.005	0.005	0.005	0.005
Boron (F)	mg/L	0.05	1	0.025	0.025	0.025	0.025	0.025	0.025	1	0.025	0.025	0.025	0.025	0.025	0.025
Iron (F)	mg/L	0.05	1	0.19	0.19	0.19	0.19	0.19	0.19	1	0.19	0.19	0.19	0.19	0.19	0.19
Beryllium (T)	mg/L	0.001	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Barium (T)	mg/L	0.001	1	0.032	0.032	0.032	0.032	0.032	0.032	1	0.032	0.032	0.032	0.032	0.032	0.032
Selenium (T)	mg/L	0.01	1	0.005	0.005	0.005	0.005	0.005	0.005	1	0.005	0.005	0.005	0.005	0.005	0.005
Vanadium (T)	mg/L	0.01	1	0.005	0.005	0.005	0.005	0.005	0.005	1	0.005	0.005	0.005	0.005	0.005	0.005
Boron (T)	mg/L	0.05	1	0.025	0.025	0.025	0.025	0.025	0.025	1	0.025	0.025	0.025	0.025	0.025	0.025

5.4 Environmental Values

EVs are qualities designed to provide requirements to make water suitable for supporting aquatic ecosystems and human uses. They require protection from the effects of habitat alteration, waste releases, contaminated runoff and changed flows to ensure healthy aquatic ecosystems and waterways that are safe for community use. The EVs of waters are protected under EPP Water. The policy sets WQOs, which are physical and chemical measures of the water (i.e. pH, nutrients, salinity etc.) to achieve the EVs set for a particular waterway or water body. EVs define the suitable uses of the water (i.e. aquatic ecosystems, human consumption, industrial use etc.).

Table 24 lists the EVs that can be chosen for protection and provides definitions of each. EVs for the Gilbert River basin have not been defined under the EPP Water. Therefore EVs relevant to the Project have been identified following a review of all available information and site specific knowledge.

Table 24 Suite of Environmental Values that can be Chosen for Protection

Environmental Value	Definition
Aquatic ecosystem	A community of organisms living within or adjacent to water, including riparian or foreshore area (EPP Water, Schedule 2). The intrinsic value of aquatic ecosystems, habitat and wildlife in waterways and riparian areas, for example, biodiversity, ecological interactions, plants, animals, key species (such as turtles, platypus, seagrass and dugongs) and their habitat, food and drinking water. Waterways include perennial and intermittent surface waters, groundwaters, tidal and non-tidal waters, lakes, storages, reservoirs, dams, wetlands, swamps, marshes, lagoons, canals, natural and artificial channels and the bed and banks of waterways.
Irrigation	Suitability of water supply for irrigation, for example, irrigation of crops, pastures, parks, gardens and recreational areas.
Farm water supply	Suitability of domestic water supply, other than drinking water. For example, water used for laundry and produce preparation.
Stock watering	Suitability of water supply for production of healthy livestock.
Aquaculture	Health of aquaculture species and humans consuming aquatic foods (such as fish, molluscs and crustaceans) from commercial ventures.
Human consumption of aquatic foods	Health of humans consuming aquatic foods, such as fish, crustaceans and shellfish from natural waterways.

Environmental Value	Definition
Primary Recreation	Health of humans during recreation which involves direct contact and a high probability of water being swallowed, for example, swimming, surfing, windsurfing, diving and water-skiing. Primary recreational use, of water, means full body contact with the water, including, for example, diving, swimming, surfing, water-skiing and windsurfing. (EPP Water, s. 6).
Secondary recreation	Health of humans during recreation which involves indirect contact and a low probability of water being swallowed, for example, wading, boating, rowing and fishing. Secondary recreational use, of water, means contact other than full body contact with the water, including, for example, boating and fishing. (EPP Water, s. 6).
Visual recreation	Amenity of waterways for recreation which does not involve any contact with water - for example, walking and picnicking adjacent to a waterway. Visual recreational use, of water, means viewing the water without contact with it. (EPP Water, s. 6).
Drinking water supply	Suitability of raw drinking water supply. This assumes minimal treatment of water is required, for example, coarse screening and/or disinfection.
Industrial use	Suitability of water supply for industrial use, for example, food, beverage, paper, petroleum and power industries. Industries usually treat water supplies to meet their needs.
Cultural and spiritual values	Indigenous and non-indigenous cultural heritage, for example: • Custodial, spiritual, cultural and traditional heritage, hunting, gathering and ritual responsibilities • Symbols, landmarks and icons (such as waterways, turtles and frogs) • Lifestyles (such as agriculture and fishing). • Cultural and spiritual values, of water, means its aesthetic, historical, scientific, social or other significance, to the present generation or past or future generations. (EPP Water, s. 6).

Source: Adapted from EHP 2009

A review of the available literature was undertaken to define the catchment characteristics upstream and downstream of the proposed release zone (refer Section 5.1). EVs were assessed for the Copperfield River over a 44km stretch downstream from the former Kidston mine site to the confluence of the Einasleigh River. This is considered to be a sufficient distance downstream from the Project site in that the additional streamflow generated by the increased catchment area is likely to result in an insignificant risk to EVs further downstream. This may also be demonstrated through the catchment areas presented in Table 25.

Table 25 Catchment Areas

Catchment Description	Area (km^2)
Approximate Copperfield River catchment area reporting to the proposed release site	1,566
Approximate Copperfield River catchment area downstream of the proposed release site	1,455
Approximate Einasleigh River catchment area reporting to the confluence with the Copperfield River at Einasleigh	5,180
Approximate total reporting catchment area downstream of the potential release site and the downstream extent of area considered for nomination of site-specific EVs	6,635

The receiving environment for the EVs assessment includes the following details:

- Approximately 95% of the Gilbert Catchment is comprised of cattle grazing land uses. Cattle have access to the river directly for various stretches.
- The Copperfield River associated with the Project site is mapped as a High value under the Aquatic Conservation Assessment, with the Einasleigh River mapped as Very High value.
- There are no mapped Groundwater Dependent Ecosystems (GDEs) or springs within the Copperfield River catchment area, with the closest occurring west of the Project site within the neighbouring Oak River upper catchment. Oak River enters Copperfield River immediately prior to the confluence with the Einasleigh River.
- No wetlands of national or international importance are known to occur within the Copperfield River catchment or within a 50km radius of the Project site. The closest nationally important wetlands occur far afield downstream (>200km) within the coastal plain associated with the Gilbert River (Tait, 2015). Approximately 6.5% of the Gilbert Basin area is comprised of wetlands however, the majority of these are located within the downstream coast alluvial plains (Tait, 2015). Note, the Kidston Dam is currently mapped as a lacustrine wetland.
- The diverse array of aquatic flora and fauna (including migratory wetland birds) known to occur within the region based the detailed over presented in Tait (2015).
- A sub-dominant, of-concern Regional Ecosystem (RE) occurs in the riparian vegetation of the Copperfield River (RE 9.3.3a).
- Cultural heritage studies through the catchment have identified numerous artefacts and have identified that major watercourses such as the Einasleigh and Copperfield Rivers were a focus of indigenous occupation.
- Recreational use of waters from the Copperfield River occurs at Einasleigh in the Copperfield Gorge, 50km downstream from the Project.
- There are occasional releases from the Copperfield Dam to 'top up' the water level at the Copperfield Gorge.
- There is the potential for domestic supply to be sourced from the Copperfield River at Einasleigh, approximately 50km downstream from the proposal.
- There are no registered water licences, water permits, seasonal water allocations or interim water allocations in the Copperfield River between the Copperfield Dam and Einasleigh.

5.4.1 Site Specific Environmental Values

Schedule 1 of the EPP Water lists rivers and catchments where EVs have been determined and issued by the regulatory authority. The Copperfield River, as part of the Gilbert River Basin, does not fall within Schedule 1 of the EPP water and therefore no EVs have been designated. In this instance the EPP Water prescribes the use of default EVs. Section 2.1.3 of the (ANZECC, 2000) guidelines also suggests that where a clear and agreed set of EVs has not been designated that *appropriate* EVs apply to the resource as default. A site-specific assessment of the Copperfield River has been undertaken from the Kidston site to the confluence of the Copperfield River with the Einasleigh River, 44km downstream in order to determine which EVs are specifically relevant for the study area.

Three exercises were undertaken for this site specific assessment:

- Literature and internet review
- Search of the Queensland Entitlements Database
- Aerial imagery mapping.

5.4.1.1 Literature and Internet Review

The literature and internet review was undertaken to provide data from a wide range of sources that may indicate environmental values or users of the water between the Project and Einasleigh. This search included the following:

- Queensland Wetland Mapping (Version 4.0)
- Wetland Protection Areas
- Matters of State Environmental Significance (MSES)
- Aquatic Conservation Assessments
- Vegetation Management Wetlands Mapping
- Groundwater Dependent Ecosystems (GDE) mapping version 1.5 including potential GDE aquifers
- Fish Habitat Areas
- Water Feature Mapping (dams, rockpools, waterholes, waterfalls, flats or swamps, pondage areas)
- River Improvement Trust Areas
- Bureau of Meteorology Geofabric
- Aquatic Ecosystem Monitoring Programs
- World Heritage Areas
- RAMSAR wetlands
- Agricultural Land Audit
- Search engine queries.

The literature review identified that the Newcastle Range – The Oaks Nature Refuge is a MSES and occurs on the Western bank of the Copperfield River approximately 635m downstream from its confluence with East Creek and extends for a further 8km. The beginning of this nature refuge is approximately 3.3km downstream from the proposed release zone.

A number of potential GDEs were identified in the region, most outside of the range of the Project influence (see Section 5.11.12).

No other layers consulted above showed any features in the Copperfield River and the township of Einasleigh.

The literature and internet review showed that there is a high level of recreational use of the Copperfield River at the Copperfield Gorge (approximately 46km downstream of the proposed release location), with publically accessible areas for swimming and recreational fishing tournaments held associated with the Einasleigh Races around Easter of each year (Einasleigh Progress Association, 2018). However, there were no specifically identified uses of the Copperfield River outside the immediate vicinity of Einasleigh.

5.4.1.2 Search of the Queensland Entitlements Database

A search of the Queensland water entitlements database showed no results for the following entitlements within the Copperfield River catchment between the Copperfield Dam and Einasleigh:

- Active water licences
- Active water permits
- Interim water allocations
- Seasonal water allocations
- Riverine protection permits
- Works acknowledgement notices
- Quarry Material Allocation Notices.

Subsequently, there are no licenced users of water from the Copperfield River catchment between the Copperfield Dam and Einasleigh.

5.4.1.3 Aerial Imagery Mapping

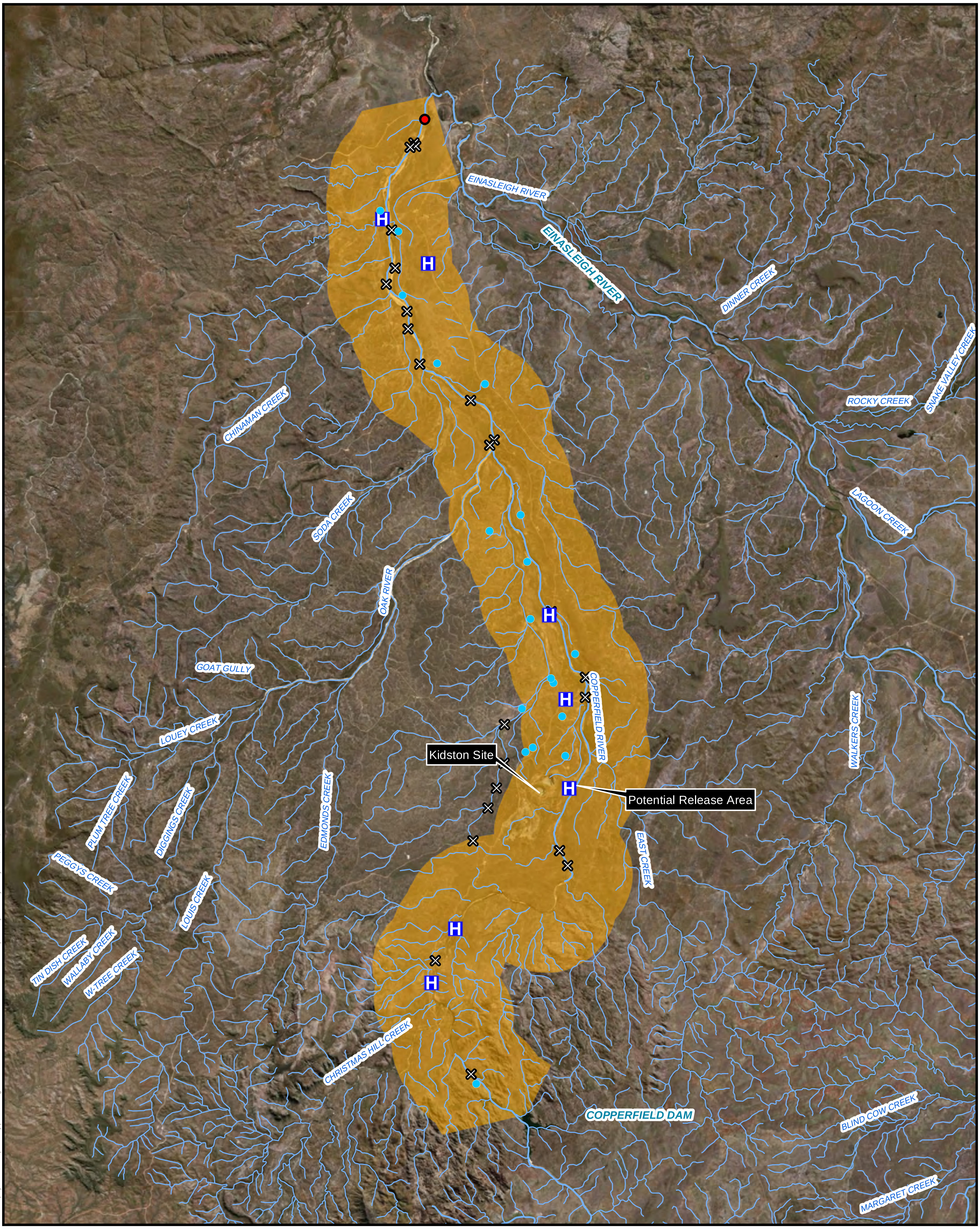
Aerial photographs of the Copperfield River catchment were obtained from ESRI ArcGIS Online streaming services as well as Queensland Government online streaming services. The available aerial images were taken in 2014. Potential water users, in the context of all EVs, were mapped at a scale of 1:20,000 which covered approximately 3.5km of use either side of the Copperfield River. This was considered a reasonable mapping extent as the cost of extracting water using pipeline and pumping infrastructure for agricultural requirements increases significantly at distances >3.5km from the river, the probability of infrastructure beyond a 3.5km corridor either side of the Copperfield River to extract from the Copperfield River itself (rather than a tributary that may be closer) is considered to be low.

Mapping rules as outlined in Table 26 were used to constrain potential water users of the Copperfield River within the 3.5km buffer. A map showing all potential users is provided in Figure 17. The results of this exercise were also correlated with distance downstream from the proposed release area (Table 27).

This assessment assumes that Aquatic Ecosystems, Stock (Cattle) Watering and Cultural and Spiritual Uses are applicable to all waters in the study area. The assessment seeks to identify locations where recreational use (via access points to the river), unlicensed drinking water use (provided by the location of farm dams or homesteads within the 3.5km corridor), or other additional uses of the water are possible.

Table 26 Mapping Rules Used to Identify Potential Users of the Copperfield River

Surface Water Environmental Value	Mapping Rules	Justification	Mapping Category (Legend)
Recreation (all including human consumption of aquatic foods)	Any track within 200m of the main channel of the Copperfield River Any cleared vegetation associated with linear infrastructure (transmission line, fence, track) within 200m of the Copperfield River banks	Represents areas where the public *could* potentially access the Copperfield River for recreational uses such as swimming, fishing etc.	Potential Access
Drinking Water and Primary Industries	Any farm dams visible within the mapping extent	Any dams that are within 3.5km of the Copperfield River could reasonably extract water from the river via pipelines that are not visible in the aerial photographs. Water could be conveyed to nearby potable users via similar pipelines with limited treatment (chlorination etc.).	Farm Dams
Drinking Water Only	Any homesteads or buildings visible	Homesteads *could* extract water from the Copperfield River and use for drinking within the mapping extent (3.5km)	Homesteads
Aquatic Ecosystems	Not mapped	Assumed to apply to all waterways	
Stock Watering (Cattle Drinking)	Not mapped	Assumed to apply to all waterways	
Cultural and Spiritual values	Not mapped	Assumed to apply to all waterways	
Industrial use	Only adjacent to the Einasleigh township.	Only visible potential industrial use of water apart from Kidston itself	Included in “Einasleigh Township” legend category.



N

AECOM
www.aecom.com

DATUM GDA 1994, PROJECTION MGA ZONE 56

0 2,500 5,000 10,000
metres

1:200,000 (when printed at A3)

LEGEND

- Copperfield Assessment Area
- Sub-Catchments
- Einasleigh Township
- Farm Dam
- Homestead
- Potential Access
- Major Watercourse
- Minor Watercourse

Data sources:

KIDSTON PUMPED STORAGE HYDRO PROJECT
IMPACT ASSESSMENT REPORT

Copperfield Potential Users

PROJECT ID	60544566
CREATED BY	RF
LAST MODIFIED	RF - 11 Jan 2019
VERSION:	1

Figure
17

A3 size

Filename: P:\605X\60544566\4. Tech Work Area\4.99 GIS\07_Working\RF_WORKING\Water\COPPERFIELD_POTENTIAL_USERS.mxd

The assessment identified a number of potential locations where access of the Copperfield River may be possible within the downstream environment (Table 27). The first location where access to the Copperfield River can be granted is approximately 6.2km downstream of the release location (Table 27). This is the causeway crossing of the Copperfield River used to access the Kidston site. This location could potentially be used for public recreation (fishing, swimming etc.); however it is not a location where potable drinking water would be sourced.

The closest location that may potentially source water from the Copperfield River for potable – albeit unlicensed – supplies is at the Oaks homestead, approximately 11.3km downstream of the proposed release point (Table 27). The homestead consists of several buildings within 50m of the high bank of the Copperfield River as well as several small farm dams situated nearby. Farm dams located closer to the release point are not likely to be used to source potable supply given the close proximity of the homestead to the river. Therefore, conservatively this is considered the most sensitive human water user in the immediate receiving environment.

Significant dilution of any water released from the Project will occur at the confluence of East Creek, approximately 2.6km downstream of the proposed release point. East Creek drains 242km^2 compared to the 412km^2 catchment area of the Copperfield River below the Copperfield Dam. Mixing/dilution of release water will also occur within the Copperfield River prior to the confluence with East Creek.

Several other drainage lines enter the Copperfield River further downstream. The most significant is Charles Creek which enters the Copperfield River approximately 17km downstream of the proposed release point and has a catchment area of 141km^2 compared to the 800km^2 catchment of the Copperfield River below the Copperfield Dam. This would provide further dilution to any releases from the Project.

The Oak River joins the Copperfield River 22km downstream. The Oak River drains a 526km^2 catchment while the catchment area of the Copperfield River downstream of the Copperfield Dam is 944km^2 to its confluence with the Oak River. If the Copperfield Dam was not overflowing and runoff was generated evenly in both catchments from local rainfall, any flows along the Copperfield River would be diluted by approximately 35% by flows entering from the Oak River.

Although there are several points nominated in (Table 27) where access to the Copperfield River could occur via visible tracks, fences or other cleared linear features, the use of these areas for recreation (fishing, swimming etc.) is considered to be very unlikely compared to the Copperfield Gorge, situated 44km downstream of the potential release zone, which has easy, signed access and is advertised as a local tourist attraction. Recreational use of the Copperfield River upstream of the Einasleigh township is expected to be limited to a few local individuals and tourists seeking unique, out of the way, fishing and swimming spots.

Table 27 Mapped Potential Water Users for the Copperfield River between the Proposed Release Zone and the Confluence with The Einasleigh River

Distance Downstream	Cumulative Distance Downstream	Rural Property Name	Mapped Feature	Description	Relevant User Category
2.6km	2.6km	Oak (Western Bank) Carpentaria Downs (Eastern Bank)	None	Confluence with East Creek, a 242km^2 clean water catchment that combines with the Copperfield River.	N/A
+3.6km	6.2km	Oak (Western Bank) Carpentaria Downs (Eastern Bank)	Access to the Copperfield River	Causeway across the Copperfield River used to access the Kidston site. Also corresponds to monitoring point W3.	• Recreation
+0km	6.2km	Oak (Western Bank) Carpentaria Downs (Eastern Bank)	"Homestead"	Oaks Rush Resort, 1km away from the Copperfield River. NOTE: Oaks Rush Resort sources drinking water from the Copperfield Dam pipeline which also supplies the Project. Therefore this is not considered a potential user of drinking water.	• Recreation
+0.8km	7km	Oak (Western Bank) Carpentaria Downs (Eastern Bank)	2x Farm Dam	2x Small farm dams 1.7km west from the Copperfield River.	• Drinking Water • Stock Watering • Farm Water Supply/Use
+0.2km	7.2km	Oak (Western Bank) Carpentaria Downs (Eastern Bank)	Potential Access	Gilberton Road comes within 200m of the high bank of the Copperfield River. Potential access for recreation.	• Recreation
+1.8km	9km	Oak (Western Bank) Carpentaria Downs (Eastern Bank)	1x Farm Dam	1x farm dam 450m east of the Copperfield River.	• Drinking Water • Stock Watering • Farm Water Supply/Use
+2.25km	11.25km	Oak (Western Bank) Carpentaria Downs (Eastern Bank)	Homestead	"The Oaks" homestead 50m from the high bank of the Copperfield River. Chances of water withdrawal use, although unlicensed, is high.	• Drinking Water • Stock Watering • Farm Water Supply/Use

Distance Downstream	Cumulative Distance Downstream	Rural Property Name	Mapped Feature	Description	Relevant User Category
+0.35km	11.6km	Narrawa (Western Bank) Carpentaria Downs (Eastern Bank)	Farm Dam	Farm Dam 1km west of the Copperfield River. Near The Oaks homestead. Closer to Charles Creek.	• Drinking Water • Stock Watering • Farm Water Supply/Use
+0.9km	12.5km	Narrawa (Western Bank) Carpentaria Downs (Eastern Bank)	Farm Dam	Farm Dam 280m west of the Copperfield River.	• Drinking Water • Stock Watering • Farm Water Supply/Use
+2.1km	14.6km	Narrawa (Western Bank) Carpentaria Downs (Eastern Bank)	Farm Dam	Farm Dam 1.5km west of the Copperfield River.	• Stock Watering • Farm Water Supply/Use
+0.6km	15.2km	Narrawa (Western Bank) Carpentaria Downs (Eastern Bank)	Farm Dam	Farm Dam 700m east of the Copperfield River.	• Drinking Water • Stock Watering • Farm Water Supply/Use
+4.36km	19.56km	Narrawa (Western Bank) Carpentaria Downs (Eastern Bank)	Potential Access	Cleared easement or fence within 200m of the Copperfield River western high bank. Access to this location would be difficult. Just downstream of the confluence of the Copperfield and Oak Rivers.	• Recreation
+0.3km	19.86km	Narrawa (Western Bank) Carpentaria Downs (Eastern Bank)	Potential Access	Small cleared track from Glenlyon Road to the high eastern high bank of the Copperfield River.	• Recreation
+1.0km	20.86km	Narrawa (Western Bank) Carpentaria Downs (Eastern Bank)	Potential Access	Small cleared 1.3km track from the Gregory Development Road to the eastern bank of the Copperfield River.	• Recreation

Distance Downstream	Cumulative Distance Downstream	Rural Property Name	Mapped Feature	Description	Relevant User Category
+1.7km	22.56km	Narrawa (Western Bank) Carpentaria Downs (Eastern Bank)	Farm Dam	Small farm dam or borrow pit adjacent to the Gregory Development Road, 1km east of the Copperfield River.	• Drinking Water • Stock Watering • Farm Water Supply/Use
+3.0km	25.56km	Narrawa (Western Bank) Carpentaria Downs (Eastern Bank)	Farm Dam and Access Track	Small farm dam 500m east of the Copperfield River. Access track to the dam provided from the Gregory Development Road.	• Drinking Water • Stock Watering • Farm Water Supply/Use • Recreation
+0.7km	26.26km	Narrawa (Western Bank) Baroota (Eastern Bank)	Potential Access	Powerline easement or fence extending from Beverley Hills Road approximately 1km to the western bank of the Copperfield River around the confluence with Soda Creek.	• Recreation
+2.20km	28.46km	Narrawa (Western Bank) Baroota (Eastern Bank)	Potential Access	Fence extending 3.3km from the Gregory Development Road to the eastern bank of the Copperfield River.	• Recreation
+1.00km	29.46km	Narrawa (Western Bank) Baroota (Eastern Bank)	Potential Access	Fence or other clearing extending from Beverley Hills Road for 1.1km to the western bank of the Copperfield River.	• Recreation
+0.86km	30.32km	Narrawa (Western Bank) Baroota (Eastern Bank)	Farm Dam	Farm Dam 100m from the eastern bank of the Copperfield River with a track leading to it. Access to the Copperfield could be granted for recreational activities.	• Drinking Water • Stock Watering • Farm Water Supply/Use • Recreation

Distance Downstream	Cumulative Distance Downstream	Rural Property Name	Mapped Feature	Description	Relevant User Category
+0.30km	33.32km	Narrawa (Western Bank) Baroota (Eastern Bank)	Potential Access	Beverley Hills Road crosses Chinaman Creek 500m upstream from its confluence with the Copperfield River. Access to the Copperfield River could be granted on foot from this location.	• Recreation
+0.64km	33.96km	Narrawa (Western Bank) Baroota (Eastern Bank)	Potential Access	500m cleared track or road extending from Beverley Hills Road to the western bank of the Copperfield River.	• Recreation
+0.98km	34.94km	Narrawa (Western Bank) Baroota (Eastern Bank)	Potential Access “Homestead”	2.25km cleared track or fence extending from the Gregory Development Road to the eastern bank of the Copperfield River. Also near a quarry/borrow pit adjacent to the Gregory Development Road which could theoretically source water for potable supply from the Copperfield River.	• Drinking Water • Recreation
+2.05km	36.99km	Narrawa (Western Bank) Baroota (Eastern Bank)	Farm Dam Potential Access	Farm dam 360m from the eastern high bank of the Copperfield River Potential to the eastern bank from a fence line	• Drinking Water • Stock Watering • Farm Water Supply/Use • Recreation
+0.76km	37.75km	Narrawa (Western Bank) Stockman’s Creek (Eastern Bank)	Homestead Potential Access Farm Dam	Narrawa homestead located 150m from the western bank of the Copperfield River. Includes a farm dam.	• Drinking Water • Stock Watering • Farm Water Supply/Use • Recreation

Distance Downstream	Cumulative Distance Downstream	Rural Property Name	Mapped Feature	Description	Relevant User Category
+4.3km	42.05km	Narrawa (Western Bank) Stockman's Creek (Eastern Bank)	3x Potential Access	3x potential access along fence lines. 2x extending approximately 800m from the "Etheridge Railway" and 1.5km from the Etheridge Forsayth Road providing access to the western bank. The other provides access to the eastern bank approximately 2km west of the Gregory Development Road.	• Recreation
+0.76km	42.81km	Freehold Land	Primary Industries	"Einasleigh Dump" located approximately 400m from the western bank of the Copperfield River. Theoretically could withdraw unlicensed water from the river for use.	• Industrial Use • Stock Watering • Farm Water Supply/Use
+0.70km to +1.4km	43.51km to 44.21km	Freehold Land	"Einasleigh Township"	First identified feature of the Einasleigh Township – rural residential properties. Theoretically could withdraw unlicensed water from the Copperfield River for any use.	• Drinking Water • Stock Watering • Farm Water Supply/Use • Recreation • Industrial Use
+0km	44.21km	Freehold Land	Gregory Development Road Crossing of Copperfield River	Bridge crossing of the Copperfield River at the Einasleigh Township. Provides easy access to the Copperfield River. Potentially any use.	• Drinking Water • Stock Watering • Farm Water Supply/Use • Recreation • Industrial Use
+0.07km	44.28km	Freehold Land	Copperfield Gorge	Significant tourist feature. Primary use would be recreation.	• Recreation
+0.7km	44.98km	Freehold Land	Confluence with the Einasleigh River	Confluence with the Einasleigh River. End of assessment area.	

5.4.2 Site Specific Environmental Values Applicable to the Release Regime

An evaluation of site specific EVs that are relevant to the proposed release regime and the local receiving environment is provided in Table 28 and is based on the mapping exercise undertaken in Table 27.

Table 28 Surface Water Environmental Values Potentially Relevant to the Project Site

Environmental Value	Copperfield River	Justification
Aquatic ecosystems (incorporating Habitat value)	✓	The macroinvertebrate field survey and desktop assessment supports the definition of a 'Slightly Disturbed' aquatic ecosystem condition (waters that have the biological integrity of high ecological value waters with slightly modified physical or chemical indicators but effectively unmodified biological indicators) as discussed in Section 3.3.3.
Irrigation (Short Term < 20 years)	✓	There are no known irrigation operations within the receiving environment. There are no current water allocations. However there is the potential for irrigation subject to economic feasibility (Petheram, Watson, & Stone, 2013). Therefore this EV is considered relevant.
Irrigation (Long Term ~100 years)	✓	There are no known established irrigation operations within the receiving environment. There are no current water allocations. However there has been an assessment of the ability for irrigation to occur in the catchment. Economic factors were found to be the main limiting factor. Economic factors within the next 100 years could change and ensure irrigation projects within the receiving environment, sourcing water from the Copperfield Dam, are feasible. Subsequently this environmental value has been applied.
Farm supply (e.g. fruit washing, milking sheds, intensive livestock yards)	✓	There are no intensive farm uses within the downstream receiving environment. There are no water allocations within the receiving environment. There are a number of farm dams that *could* obtain water via unlicensed extraction from the Copperfield River. Therefore this EV is considered applicable.
Stock watering (e.g. grazing cattle)	✓	The majority of the land use of the downstream receiving environment comprises cattle grazing. Cattle are able to directly access the river upstream and downstream of the proposed release location.
Aquaculture	×	Whilst this EV has been assessed and is potentially relevant to the larger catchment, it is not considered to be relevant to the receiving environment immediately downstream. The ephemeral nature of the Copperfield River catchment means that future use for aquaculture is highly unlikely.
Human consumption (e.g. of wild or stocked fish)	✓	As outlined in the site specific assessment there are a number of locations where the Copperfield River could be accessed (Table 27).

Environmental Value	Copperfield River	Justification
Primary recreation (fully immersed in water e.g. swimming)	✓	As outlined in the site specific assessment, there are a number of locations where the Copperfield River *could* be accessed (Table 27). The most likely location for primary recreation and secondary recreation is at the Copperfield Gorge 44km downstream. Although outside the expected area of impact, this EV has been nominated as applicable to the receiving environment.
Secondary recreation (possibly splashed with water, e.g. sailing)	✓	
Visual appreciation (no contact with water, e.g. picnics)	✓	Visual appreciation is applicable downstream at Einasleigh in the Copperfield Gorge. It could be applicable at possible access points as outlined in Table 27.
Drinking water (raw water supplies taken for drinking)	✓	The closest location that could *potentially* extract water from the Copperfield River for potable supply is at the Oaks Homestead, 11.2km downstream from the proposed release point; however it has not been confirmed. There is no municipal water supply to Einasleigh township. Personal communications with Etheridge Shire Council on 16 May 2018 indicated that there are a number of unlicensed spears into the river in the vicinity of Einasleigh township; it is assumed that these could be used for domestic supply.
Industrial use (e.g. power generation, manufacturing, road maintenance)	✓	The only industrial user of water in the receiving environment is the Project and its co-located solar projects. There is a potential for industrial use in the Einasleigh township.
Cultural and spiritual values	✓	There are a large number of indigenous artefacts identified in the Copperfield River catchment. The Copperfield and Einasleigh Rivers were focuses of indigenous occupation of the area.

5.4.3 Management Intent

Generally the condition of aquatic ecosystems in the vicinity of the proposed release falls within the category of “Slightly to Moderately Disturbed” as outlined in the ANZECC (2000) and QWQG (2009). However the EPP water (2009) allows for the separation of slightly disturbed waters from moderately disturbed waters. The definitions of both of these levels of aquatic ecosystem protection are outlined below:

- **Slightly disturbed waters** (waters that have the biological integrity of high ecological value waters with slightly modified physical or chemical indicators but effectively unmodified biological indicators) – the measures for the slightly modified physical or chemical indicators are progressively improved to achieve the water quality objectives for high ecological value water.
- **Moderately disturbed waters** (waters in which the biological integrity of the water is adversely affected by human activity to a relatively small but measurable degree):
  - If the measures for indicators of the environmental values achieve the water quality objectives for the waters – the measures for the indicators are maintained at levels that achieve the water quality objectives for the waters;

    or

- If the measures for the indicators of the environmental values do not achieve the water quality objectives for the waters – the measures for indicators of the environmental values are improved to achieve the water quality objectives for the water.

Macroinvertebrate monitoring from 2009 – 2013 shows that the aquatic health of Copperfield River sites falls into the Australian River Assessment System (AusRivAS) “Band A” category, which infers that the receiving environment sites are relatively undisturbed. There is more of a change in macroinvertebrate composition from year to year than between sites, indicating that any impact (if present) is regional in nature and felt across upstream and downstream sites. The 2018 Aquatic Ecology study (Appendix E) compares the AusRivAS macroinvertebrate data to Central Queensland Guidelines and finds that upstream and downstream sites (WB, W3) fall into “Band B” but interim sites (such as W1, W2) fall into “Band A” for edge habitat.

The macroinvertebrate data supports the distinction of a ‘Slightly Disturbed’ aquatic ecosystem condition. The management intent is to gradually improve water quality and to aim to achieve a Highest Ecological Value (HEV) waterway classification. HEV WQOs may not be achievable in the Copperfield River as there are a number of regionally based negative influences on water quality, including:

- Large-scale historical clearing
- Cattle grazing and direct access to the river by cattle
- Flow regulation by the Copperfield Dam.

5.5 Default Water Quality Objectives

5.5.1 Copperfield River Classification

The ANZECC (2000) guidelines separate upland and lowland freshwaters at an elevation of 150m AHD. The guidelines also define upland freshwaters as small (first or second order) streams that are moderate to fast flowing as a result of steep gradients and have cobble, gravel or sand beds. Lowland streams are defined as larger streams (greater than 3rd order) that meander with generally slower flows and beds comprised of sand, silt and mud. The Copperfield River falls into both of these classifications as it is above an elevation of 150m AHD but is a large 5th order stream with a bed of sand, silt, rock and mud. For the purposes of this assessment the Copperfield River in the vicinity of the Project has been classified as upland freshwater.

5.5.2 Default Water Quality Objectives

The QWQG and EPP Water do not specify WQOs for the Gulf Rivers region or the Gilbert Basin. Instead they recommend the use of the ANZECC (2000) guidelines, cautioning that these values may not be appropriate for intermittent and ephemeral inland streams. In cases where more than one WQO is available for a particular parameter, the most stringent value from all EVs is applicable. As outlined above, the WQOs for Aquaculture (specifically referring to commercial aquaculture operations) have not been incorporated into the assessment of the lowest WQO from all EVs.

The simplified decision tree for assessing toxicants in ambient waters was applied from the ANZECC (2000) guidelines to select and refine WQO's for the Project. Figure 18 provides a description of how the decision tree was applied and provides an 'index' for the following sections.

The default WQOs as outlined in Table 29 were evaluated against the local background water quality data collected for the site. The evaluation was undertaken in accordance with the decision tree framework outlined in ANZECC (2000) as shown in Figure 18.

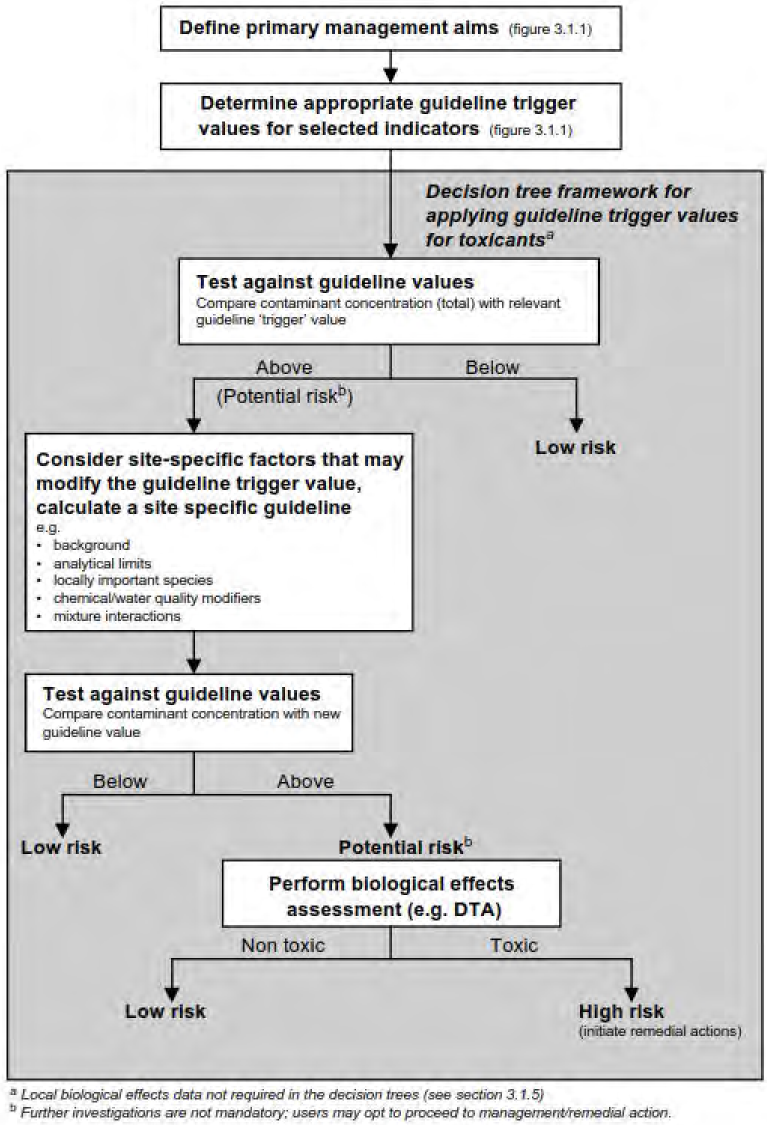
	Appropriate guidelines and trigger values (WQOs) were assembled for the applicable EVs that are outlined in Table 28. Default WQOs were assembled (Table 29). Section 3.5 tests the assembled WQOs against data held by the site for the Copperfield River. DTA was then undertaken to identify locally relevant guidelines based on toxicity. This is outlined in Section 4.9.

Figure 18 Simplified decision tree for assessing toxicants in ambient waters (ANZECC (2000))

The default WQOs for the Project are provided below in Table 29.

Table 29 Comparison of WQOs

Parameter (all units mg/L unless otherwise specified)	Default WQOs For Each EV									
	Aquatic Ecosystems (95% species protection)	Cattle Drinking Water	Long Term Irrigation	Short Term Irrigation	Human Consumption	Recreation	Drinking Water – Health	Drinking Water – Aesthetic	Lowest Applicable WQO[3]	Source[3]
pH value	6.0-7.5[1]		6-9	6-9		6.5-8.5			6.0 – 7.5	ANZECC (2000) Tropical Australia upland freshwaters
Electrical Conductivity (µS/cm)	500[2]	6150*							500	QWQG Gulf Rivers Region
Sulfate as SO_4^{2-}		1000				400	500	250	250	Drinking Water - Aesthetic
Aluminium (total)		5	5	20		0.2			0.2	Recreation
Aluminium (dissolved)	0.055							0.2	0.055	ANZECC (2000) trigger value for 95% species protection
Arsenic (total)		0.5	0.1	2		0.05	0.01		0.01	Drinking Water – Health
Arsenic (dissolved)	0.013								0.013	ANZECC (2000) trigger value for 95% species protection
Cadmium (total)		0.01	0.01	0.05		0.005	0.002		0.002	Drinking Water – Health
Cadmium (dissolved)	0.0002								0.0002	ANZECC (2000) trigger value for 95% species protection
Cobalt (total)			0.05	0.1		1			0.05	Long Term Irrigation
Cobalt (dissolved)	0.0028#								0.0028	ANZECC (2000) trigger value for 95% species protection – low reliability trigger
Chromium (total)		1	0.1	1		0.05	0.05		0.05	Drinking Water - Aesthetic/Recreation

Parameter (all units mg/L unless otherwise specified)	Default WQOs For Each EV									
	Aquatic Ecosystems (95% species protection)	Cattle Drinking Water	Long Term Irrigation	Short Term Irrigation	Human Consumption	Recreation	Drinking Water – Health	Drinking Water – Aesthetic	Lowest Applicable WQO[3]	Source[3]
Chromium (dissolved)	0.001								0.001	ANZECC (2000) trigger value for 95% species protection
Copper (total)		1	0.2	5.0	1.0		1	1	0.2	Long Term Irrigation
Copper (dissolved)	0.0014								0.0014	ANZECC (2000) trigger value for 95% species protection
Manganese (total)			0.2	10		0.1	0.5	0.1	0.1	Recreation
Manganese (dissolved)	1.9								1.9	ANZECC (2000) trigger value for 95% species protection
Molybdenum (total)		0.15	0.01	0.05			0.05		0.01	Long Term Irrigation
Nickel (total)		1	0.2	2		0.1	0.02		0.02	Drinking Water – Health
Nickel (dissolved)	0.011								0.011	ANZECC (2000) trigger value for 95% species protection
Lead (total)		0.1	2	5		0.05	0.01		0.01	Drinking Water – Health
Lead (dissolved)	0.0034								0.0034	ANZECC (2000) trigger value for 95% species protection
Zinc (total)		20	2	5	5	5		3	2	Long Term Irrigation
Zinc (dissolved)	0.008								0.008	ANZECC (2000) trigger value for 95% species protection
Total Cyanide	0.1[3]					0.1	0.08		0.08	Drinking Water – Health
Iron (total)			0.2	10		0.3		0.3	0.2	Long Term Irrigation

Parameter (all units mg/L unless otherwise specified)	Default WQOs For Each EV									
	Aquatic Ecosystems (95% species protection)	Cattle Drinking Water	Long Term Irrigation	Short Term Irrigation	Human Consumption	Recreation	Drinking Water – Health	Drinking Water – Aesthetic	Lowest Applicable WQO[3]	Source[3]
Iron (dissolved)	0.3[#]								0.3	ANZECC (2000) trigger value for 95% species protection
Chloride			175			400		250	175	Long Term Irrigation
Sodium			115			300		180	115	Long Term Irrigation
Boron (total)		5	0.5				4		0.5	Long Term Irrigation
Boron (dissolved)	0.37								0.37	ANZECC (2000) trigger value for 95% species protection
Barium (total)						1.0			1.0	Recreation
Beryllium (total)			0.1	0.5			0.06		0.06	Drinking Water - Health
Beryllium (dissolved)	0.00013[#4]								0.00013	ANZECC (2000) trigger value for 95% species protection – low reliability trigger
Mercury (total)		0.002	0.002	0.002		0.001	0.001		0.001	Drinking Water – Health/Recreation
Mercury (dissolved)	0.00005								0.00005	ANZECC (2000) trigger value for 95% species protection
Selenium (total)		0.02	0.02	0.05		0.01	0.01		0.01	Drinking Water – Health/Recreation
Selenium (dissolved)	0.011								0.011	ANZECC (2000) trigger value for 95% species protection
Uranium (total)		0.2	0.01	0.1			0.017		0.01	Long Term Irrigation

Parameter (all units mg/L unless otherwise specified)	Default WQOs For Each EV									
	Aquatic Ecosystems (95% species protection)	Cattle Drinking Water	Long Term Irrigation	Short Term Irrigation	Human Consumption	Recreation	Drinking Water – Health	Drinking Water – Aesthetic	Lowest Applicable WQO[3]	Source[3]
Uranium (dissolved)	0.0005[#]								0.0005	ANZECC (2000) trigger value for 95% species protection – low reliability trigger
Vanadium (total)			0.1	0.5					0.1	Long Term Irrigation
Vanadium (dissolved)	0.006[#]								0.006	ANZECC (2000) trigger value for 95% species protection – low reliability trigger
Fluoride		2	1	2			1.5		1	Long-Term Irrigation
Ammonia as N	0.9							0.5	0.5	Drinking Water - Aesthetic
Nitrate as N	0.7[5]	400				10	50		0.7	ANZECC (2000) trigger value for 95% species protection
Nitrite as N		30				1	3		1	Recreation
Total N	0.15[1]		5	125					0.15	ANZECC (2000) default trigger value for physical and chemical stressors for tropical Australia for slightly disturbed systems
Total P	0.01[1]		0.05	12					0.01	ANZECC (2000) default trigger value for physical and chemical stressors for tropical Australia for slightly disturbed systems

[#] Low reliability trigger for 95% species protection as outlined in Volume 2 of ANZECC (2000)
* derived from a TDS concentration for cattle drinking water by using a conversion of EC to TDS = EC x 0.64
[1] Sourced from ANZECC (2000) Aquatic Ecosystem Guidelines for Upland & Lowland Rivers for Tropical Australia – Table 3.3.4
[2] Sourced from Table G.1 of the Queensland Water Quality Guidelines for the Gulf Rivers region (75^{th} percentile value)

[3] A cyanide value of 0.007mg/L (as un-ionised hydrogen-cyanide) is recommended by the ANZECC (2000) guidelines. However the Leading Practice Sustainable Development Program for the Mining Industry publication on Cyanide Management (2008) states:

"Measurement of total cyanide values below 0.1 mg/L and Weak Acid Dissociable (WAD) cyanide below 0.05 mg/L present in mining related discharges may be unreliable and should be reported as 'less than' and not used for compliance purposes… The possible reasons for reporting measured levels of cyanide in surface waters or treated effluent needs to be taken into account when interpreting results of a monitoring program. The first is analytical error; the second is naturally produced cyanide excreted by plants, micro-organisms and insects; and the third is manufactured cyanide. Incorrect conclusions can easily be drawn, with potentially serious consequences if valid measurements are not used" pp 14

Following from these conclusions it is recommended that a total cyanide WQO of 0.1mg/L is set for the Project. If this value is exceeded further investigation may be warranted.

[4] The default WQO for beryllium (0.00013 mg/L) is below the standard LOR of 0.001 mg/L, therefore it is not possible to accurately assess concentrations against the WQO.

[5] There is no scheduled default physico-chemical stressor guideline value for nitrate in the Gulf Rivers region. There is currently insufficient data available to establish a site-specific value for nitrate and there is a lack of published data available for an adjacent similar catchment, therefore the ANZECC (2000) trigger value for the protection of 95% species is applied. Nitrate monitoring in the receiving environment will form part of the REMP in order to gather sufficient information to establish a site-specific WQO for nitrate.

5.5.3 Water Quality Data Protocols

5.5.3.1 Data Requirements for Background Data

The QWQG 2009 provides a framework for developing locally relevant Water Quality Objectives (WQOs). Background data can be used if samples are collected from a suitable location and there are enough samples collected over a relevant time period. It is preferable to have 18 samples over 24 months. (Claus, Dunlop, & Ramsay, 2017). Until minimum data requirements have been established, comparison of test site median should be made with reference to the default guidelines. A discussion of the water quality monitoring sites and data suitability is outlined below.

5.5.3.2 Water Quality Data Controls and Checks

The water quality database supplied by Genex was screened for water quality data inconsistencies, using the following methods:

- Comparison of the level of dissolved contaminant compared to total contaminant (i.e. whether dissolved zinc was greater than total zinc for that sample). Where these were found, the analyses were removed.
- Values that were below the LOR were transformed to 50% of the LOR (i.e. <0.001 mg/L becomes 0.0005 mg/L) for statistical interrogation.
- All values were graphed and checked visually for obvious outliers.

A number of anomalies were found in the time-histories for pit water samples, which included:

- Total manganese appears to be erroneously low at Eldridge Pit in samples dated 14/11/2006, and in the Eldridge and Wises Pits in 16/10/2012. Considering that the concentrations in samples prior to and following these anomalous readings are of the order of 1 mg/L for the Eldridge Pit, it is concluded that these low values are outliers and they have been excluded from the dataset.
- Total nickel concentration in the 21/02/2013 sample from Eldridge Pit appears to be erroneously low compared to results prior to and following this sample date. This value was removed.
- Total lead concentrations from samples in the Eldridge Pit on 14/11/2006 appear to be artificially elevated at a concentration of 0.19 mg/L. A pit sample taken one month prior had a concentration of 0.001 mg/L.
- Total cobalt concentrations in the Eldridge (3.84 mg/L) and Wises Pit (0.591 mg/L) samples on 16/10/2012 are elevated by an order of magnitude compared to the sample results before and after. It is unknown whether this is an anomaly or real data so the sample results were included.
- Total cadmium concentrations in the Eldridge Pit are erroneously low in three samples (August 2006, October 2006 and October 2012). These values were removed from the dataset.
- A total aluminium concentration from November 2006 in the Eldridge Pit potentially represents an outlier and is erroneously low. This value was removed from the dataset.

There are only 20 representative samples from each pit, with 10 samples collected since 2012, and the entire (i.e., including pre-2012) pit dataset has been included, with obvious outliers removed.

5.5.3.3 Requirements for comparison with WQOs for Aquatic Ecosystems

The recommended method to assess whether a WQO has been exceeded depends on the parameter type (ANZECC, 2000). For Slightly to Moderately Disturbed water, the assessment is:

- **Physical and chemical stressors**[6]

  Trigger values are exceeded when the median of at least 8 samples (preferably 24 collected over a 2 year period) at a test site exceed the WQO. Alternatively, if suitable background data exists,

[6] Includes nutrients, biodegradable organic matter, dissolved oxygen, turbidity, suspended particulate matter, temperature, salinity, pH.

when the median of the 8 to 24 samples exceeds the 80th percentile of the reference site (from the same number of samples), the TIL is exceeded (ANZECC (2000) Guidelines).

- **Toxicants**[7]

  A trigger value is exceeded when the 95th percentile of the test distribution exceeds the default value; no action is triggered if 95% of all values fall within the default WQO.

  If background data exists, compare the 80th percentile of background data (calculated over at least 10 to 24 samples gathered over the previous 24 months) to the default WQO. If the 80th percentile exceeds the WQO, then the 80th percentile becomes the new WQO and exceedance occurs if the running median (from the same period of samples) of the test site exceeds the running 80th percentile of background data (EHP, 2013).

Statistical measures (medians, 80th percentiles, 95th percentiles) for this assessment are calculated from the entire dataset, rather than the most recent 10 to 24 samples. Where an exceedance of the default WQO applies, time series data is then investigated.

With reference to comparison of site data to ANZECC (2000) WQOs for Aquatic Ecosystems it is important to note that Section 3.4.3.2 of the ANZECC (2000) guidelines states:

"… Comparison of total concentrations will, at best, overestimate the fraction that is bio-available. The major toxic effect of metals comes from the dissolved fraction so it is valid to filter samples (e.g. to 0.45µm) and compare the filtered concentration against the trigger value" (pp 3.4-15)

There are numerous references that cite that complex metals are less harmful to fish and aquatic organisms than their free (i.e. Zn^{2+}) forms (Baker & Walden, 1984). Throughout the rest of this assessment, site data from 'filtered' samples is compared to default WQOs for Aquatic Ecosystems. However if the WQO is sourced from an alternate EV (such as recreation or cattle drinking etc.) the 'total' concentration from site data is compared.

[7] Includes ammonia, heavy metals and other toxic compounds

5.6 Comparison of Baseline Water Quality and Default Water Quality Objectives

Project water quality data was assessed against the default WQOs identified in Table 29 to determine whether there are any site-specific exceedances that need to be considered (as outlined in Figure 18).

Water quality showing the 20th percentile, 50th percentile (median), 80th percentile and 95th percentile values for each parameter at WB, W1, W2 and W3 is provided in Section 3.3.2.

Parameters Compliant with WQOs

The following parameters do not exceed the default WQOs at site WB, W1, W2 or W3 and are not considered further in this assessment:

- Dissolved arsenic
- Dissolved cobalt
- Dissolved molybdenum
- Dissolved nickel
- Dissolved lead
- Cyanide (Weak Acid Dissociable (WAD) or Total).

Following the decision tree framework outlined in Figure 18, the above criteria are considered 'low risk'.

Parameters Not Analysed

The following parameters have not been analysed at all receiving environment sites:

- Chloride
- Sodium
- Boron
- Beryllium
- Mercury
- Selenium
- Uranium
- Vanadium
- Ammonia
- Nitrate
- Nitrite
- Total N
- Total P
- Fluoride.

These parameters are represented by only one or two samples collected from W2 in 2018 as a result of sampling for DTA analysis. The risk of these parameters is not known.

The above parameters are not listed on the current EA applicable to the historic mining activity, but are listed in the Model Mining Conditions. Therefore it is recommended that future sampling, and the REMP to be developed for this Project, incorporate these parameters.

Parameters above WQOs

The following parameters exceed[8] the default WQOs (Table 29) at site WB, W1, W2 or W3:

- Dissolved aluminium (95th percentile exceeds the default WQO for Aquatic Ecosystems for all sites).
- Total arsenic (95th percentile exceeds the default WQO for Drinking Water - Health at W2).
- Dissolved chromium (95th percentile exceeds the default WQO for Aquatic Ecosystems at W1, W2 and W3).
- Dissolved copper (95th percentile exceeds the default WQO for Aquatic Ecosystems at WB, W1, W2 and W3).
- Total manganese exceeds the default WQO for Drinking Water Recreation at all sites.
- Total iron exceeds the default WQO for long-term irrigation at all sites.
- Dissolved zinc (95th percentile exceeds the default WQO for Aquatic Ecosystems at WB and W1; the 80th percentile is in exceedance at W2).

pH and Electrical Conductivity (EC) are considered physical and chemical stressors, rather than toxicants like the parameters outlined above and median values are compared to the WQO (250µS/cm for EC, pH 6.0-7.5 for pH). As physical and chemical stressors, EC is compliant with the default WQO while the median for pH lies outside the default WQO range for ANZECC (2000) Tropical Australia upland freshwaters.

Following the decision tree framework provided in Figure 18 the above parameters are considered ‘high risk’. Further evaluation is undertaken for each parameter in the sections below.

5.6.1 Hardness Modification

Calcium and magnesium ions may inhibit uptake of trace metals in aquatic organisms (Riethmuller, 2000). Calcium is known to stabilise gill membranes of fish, reducing ionic permeability (Riethmuller, 2000). Increasing calcium concentrations may compete with free ions (i.e. Zn^{2+}, Cu^{2+} etc) for binding sites on the gill surface (Riethmuller, 2000). Increases in water hardness, which is primarily composed of calcium and magnesium in solution, may decrease the bioavailability of many dissolved metal species.

Hardness Modified Trigger Values (HMTV) are derived for cadmium, chromium, copper, nickel, lead and zinc for WQOs for Aquatic Ecosystems. The HMTVs account for the potential toxicity impact of these dissolved metals considering site-specific pH and alkalinity.

Hardness or calcium and magnesium values have not been analysed for all samples. Instead, approximately 25-30% of the available dataset possesses hardness or calcium and magnesium values (from which hardness can be calculated) for each receiving environment monitoring site.

Hardness statistics for the receiving water sites are provided in Table 30. The median hardness (50th percentile) for each site is between 33.9 – 56.2 mg/L with the highest values at site W2. ANZECC/ARMCANZ 2000 default WQOs have been calculated using a hardness of 30 mg/L CaCO3. As stated in footnote H of Table 3.4.1 of the guidelines, these should be adjusted to the site-specific hardness.

The median hardness in the receiving environment at W2 is 56 mg/L, therefore the procedure outlined in Section 3.4.4 of the ANZECC/ARMCANZ 2000 (‘Applying guideline trigger values to sites’), was applied, using a hardness value of 56 mg/L. This is considered to be a conservative estimate of the trigger value, as once mixed with the release water (median hardness of 1374 mg/L) the hardness will be higher than 56 mg/L, thereby resulting in a higher HMTV.

[8] An exceedance in this instance means that the 95th percentile is above the WQO

Table 30 Hardness statistics for receiving water sites (all values mg/L)

Parameter	WB	W1	W2	W3
Minimum	3.3	9.1	11.6	9.1
20th Percentile	17.7	20.7	27.3	18.2
50th Percentile	33.9	40.5	56.2	42.2
80th Percentile	71.9	76.3	101.7	87.1
Maximum	124.7	104.9	208	121.5

Table 31 Hardness Modified Trigger Values

Parameter	Default TV (mg/L)*	HMTV** (mg/L)
Cadmium	0.0002	0.0003
Chromium(III)	0.001	0.002
Copper	0.0014	0.0024
Lead	0.0034	0.0075
Nickel	0.011	0.019
Zinc	0.008	0.014

*ANZECC/ARMCANZ 2000, Table 3.4.1.
**Calculated using algorithms presented in Table 3.4.4 of ANZECC/ARMCANZ 2000, applying a hardness value of 56 mg/L (median hardness at Copperfield River monitoring location W2).

5.6.2 pH

The pH of the water indicates the activity of hydrogen ions and is used to indicate whether water is acidic (low pH), neutral (pH ~ 6.5) or alkaline (high pH). The ANZECC 2000 Tropical Australia upland freshwaters WQO recommends a range of 6.0 to 7.5. This small pH range is at odds with the water quality at the Copperfield River (Section 5.3.2), which reports the median pH of the upstream site (WB) at 7.73. Statistics from the dataset collected between 2012 and present show a 20th percentile of 7.47 and an 80th percentile of 7.99.

Approximately 20 pH readings that have been recorded from the DNRME gauge “Copperfield River at Spanner Waterhole” (gauge ID 917115A), which was sampled between 1984 and 1991, report an 80th percentile pH of 8.4. The “Spanner Waterhole” gauge is a known reference site in Queensland (QWQG, 2009); a further 40 samples were field analysed for pH between 1997 and 2017 and reported a median pH of 8.6. A similar dataset exists for the Kidston Dam Tailwater gauge (gauge ID 917118A) which shows an 80th percentile of 8.6 and 8.66 for laboratory and field pH, respectively.

Given that the sampling campaigns report pH outside the ANZECC range, it is recommended that a site specific WQO for the upper pH limit is adopted for the site, whilst retaining the ANZECC Tropical Australia upland freshwaters WQO as the lower value. The recommended WQO is therefore a pH range of 6 - 8.4.

5.6.3 Sulfate

The ANZECC (2000) guidelines for Aquatic Ecosystems do not provide a default WQO for sulfate. More recent studies in the Fitzroy Basin in Australia have undertaken toxicity testing that has determined a 95% species protection level of 770 mg/L based on a representative water type of the entire basin (Dunlop, Hobbs, Mann, Nanjappa, Smith, & Vink, 2011). The report also found that macroinvertebrates from the Fitzroy Catchment and those from South-East Queensland have similar tolerances to sulfate. A separate study found a 95% species protection level for the Fitzroy Basin of 545 mg/L for the salt Na_2SO_4, where the Na^+ ion does not contribute significantly to toxicity (Dunlop, et al., 2016). The study reinforced that water hardness plays a pivotal role in sulfate toxicity (Dunlop, et al., 2016). (Hydrobiology, 2012) similarly identified that water hardness (Ca and Mg) as well as chloride concentrations play the highest role in contributing to sulfate toxicity. Other studies have found that sulfate is not attributable to toxic effects in *Corella sp.* (alga) but that the overall electrical conductivity (as an indicator of the overall ion concentration of the water) was a better indicator of toxicity (van Dam, Harford, Lunn, & Gagnon, 2014). This suggests that the guideline values cannot be extrapolated to other areas and that a site specific assessment is recommended.

In lieu of a WQO for sulfate for Aquatic Ecosystem EVs, site specific data are evaluated against the WQO for Drinking Water Quality - Aesthetic guideline, which provides a relatively conservative (i.e., stringent) value of 250 mg/L.

Analysis of a long-term running 80th percentile (based on the previous 24 values) in accordance with the ANZECC (2000) methodology shows that sulfate exceedances are limited to W2 between 2006 and 2011 (Figure 19). Sulfate values within the Copperfield River at all sites have gradually diminished since this date and are well below the default WQO for Recreation. Since the sulfate values within the Copperfield River have decreased it is evident that the source of elevated values is no longer present and is not affecting contemporary processes.

Following the decision tree framework provided in Figure 18 sulfate is considered ‘high risk’ given its historical exceedances of the default WQO for recreation. Despite this, the more recent observations of reduced sulfate concentrations demonstrates that this risk is expected to reduce. Notwithstanding this, sulfate levels will be monitored as part of the REMP (refer to Section 9.2).

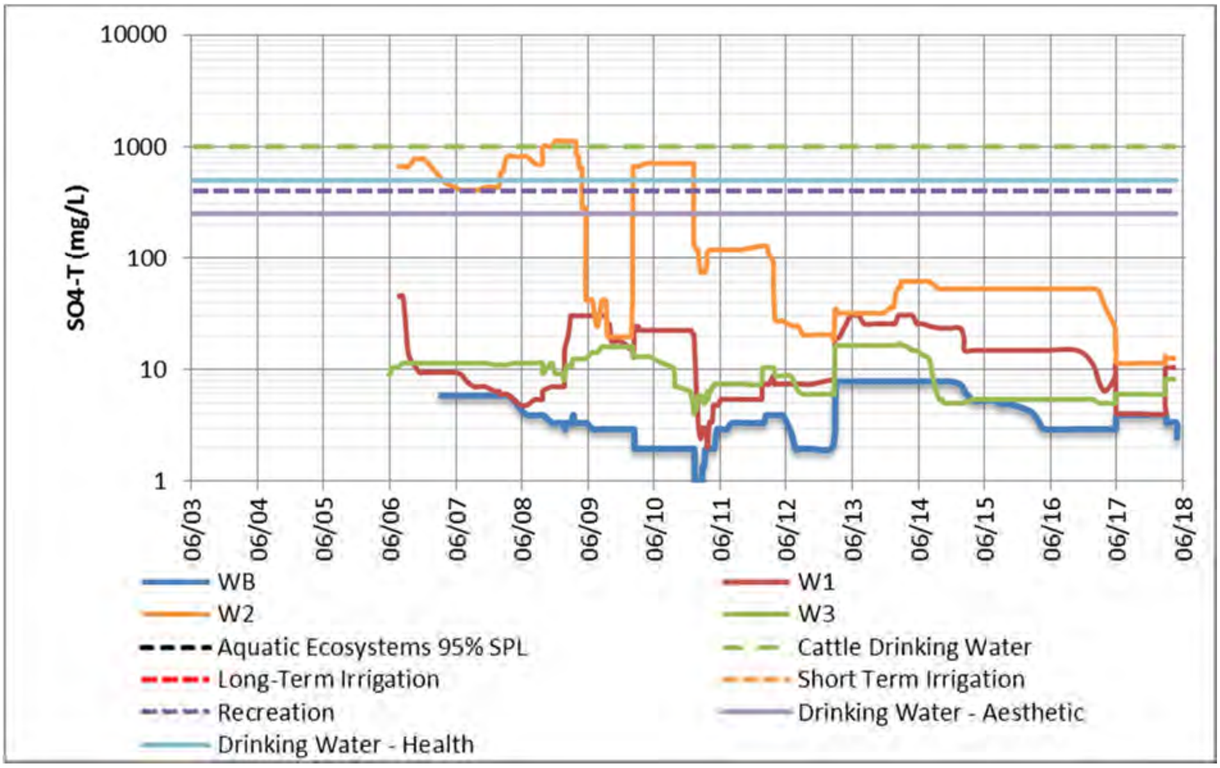


Figure 19 Running 80th percentile of sulfate values for the Copperfield River based on 24 previous samples

5.6.4 Total and Dissolved Aluminium

Aluminium typically bonds to colloids less than 0.45µm that pass through a filter. When aluminium is bonded to these colloids it is typically not bio-available and subsequently of minimum risk to aquatic ecosystems, but it is reported as 'dissolved' aluminium in laboratory results. Lead & Wilkinson (2006) show that 10-15% of aluminium is bound in fine colloids in waters from Northern Britain, 75-85% from Nova Scotia, 99% in Sacremento (USA), 55-85% in New Jersey (USA) and 35-91% in the Amazon basin.

Dissolved and total aluminium concentrations in all Copperfield River sites (WB, W1, W2 and W3) are high and are well above relevant WQOs (0.055 mg/L dissolved and 0.2 mg/L total). The upstream site (WB) also shows high concentrations of dissolved and total aluminium compared to WQOs, indicating that aluminium is sourced from areas upstream of the Kidston site.

There have been two water quality analyses for dissolved aluminium from the Copperfield River at Spanner Waterhole DNRM gauge (DNRM ID 917115A). The gauge is an official 'reference site' according to the Queensland Water Quality guidelines and is suitable to set WQOs if there is sufficient data. This gauge is located above the Copperfield Dam, upstream of the Project. The average of these samples is a dissolved aluminium concentration of 0.245 mg/L. This shows that dissolved aluminium concentrations throughout the catchment are expected to be high and are unlikely to be a result of mining activities at Kidston. The source of aluminium entering the river system before site WB is attributed to natural denudation and weathering of the parent geology. A common occurrence in Queensland is the mobilisation of soils that have a high aluminium concentration into waterways from erosion. This increases the naturally occurring aluminium concentrations in these waterways, which can often be above the ANZECC 95% species protection level of 0.055 mg/L.

The running 80th percentile (from the previous 24 values) dissolved aluminium concentrations shows that aluminium is consistently elevated above WQOs (Figure 20), including at the reference site WB. Aluminium concentrations in the receiving environment also appear to be increasing.

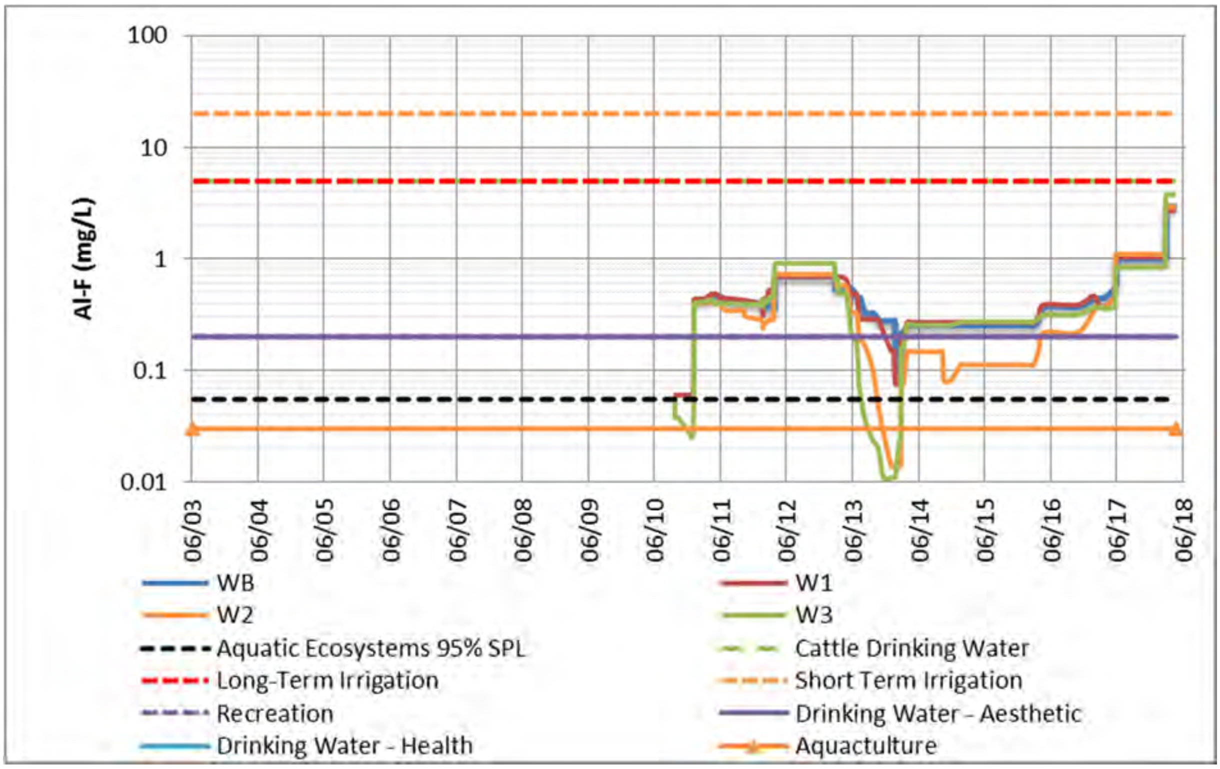


Figure 20 Long-Term Running 80th Percentile of Dissolved Aluminium (Using the previous 24 Values)

The 80th percentile values of dissolved aluminium in the receiving environment are shown below in Table 32. It is recommended that the long-term 80th percentile value for aluminium at WB (0.57 mg/L dissolved and 1.52 total) is adopted as the site specific trigger values for the Project.

Table 32 80th percentile of dissolved and total aluminium at each site in the Copperfield River

Site	Aluminium 80th percentile for full dataset (mg/L)		Aluminium 80th percentile post 2011 (mg/L)	
	Dissolved	Total	Dissolved	Total
WB	0.568	1.522	0.818	2.066
W1	0.552	1.418	0.776	1.512
W2	0.482	1.170	0.808	1.396
W3	0.568	1.482	0.050	1.642

5.6.5 Dissolved Cadmium

Time-series values for dissolved cadmium show a periodic spike in the data in 2011 (Figure 21). The majority of samples at WB, W1, W2 and W3 since this date have shown concentrations at or below the LOR (<0.0001 mg/L). Following the decision tree framework provided in Figure 18 cadmium is not considered 'high risk' but will be evaluated further with DTA because of the historically high concentrations.

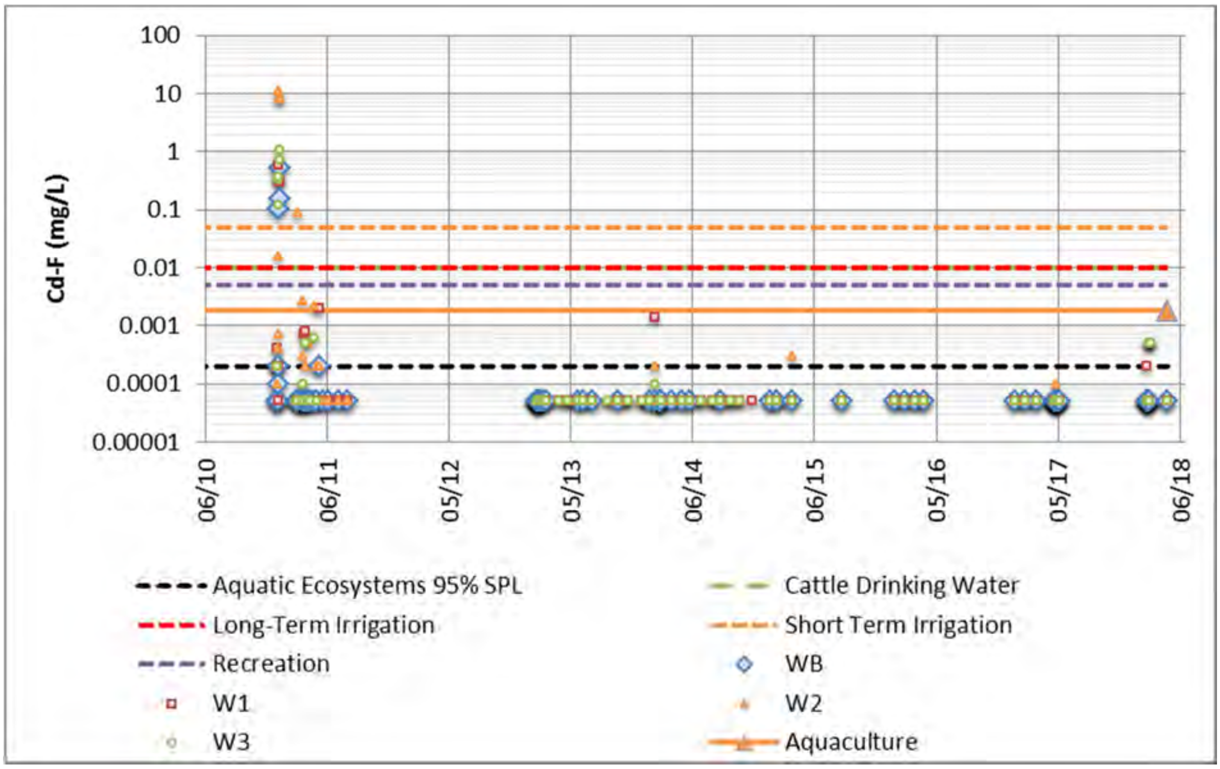


Figure 21 Time Series of Dissolved Cadmium Values

5.6.6 Dissolved Chromium

There have been no long-term exceedances of dissolved chromium. A time-series plot shows that the majority of dissolved chromium is below the ANZECC 95% species protection level for Aquatic Ecosystems (Figure 22). Chromium concentrations generally increase at all sites in unison, indicating that chromium in the system is likely to be sourced from areas upstream of the site. However, the long-term 80th percentile for dissolved chromium is below the LOR (<0.001 mg/L) for all sites. Following the decision tree framework provided in Figure 18 chromium is not considered 'high risk' but will be evaluated further with DTA because of the high concentrations that have been found upstream of the mine at WB.

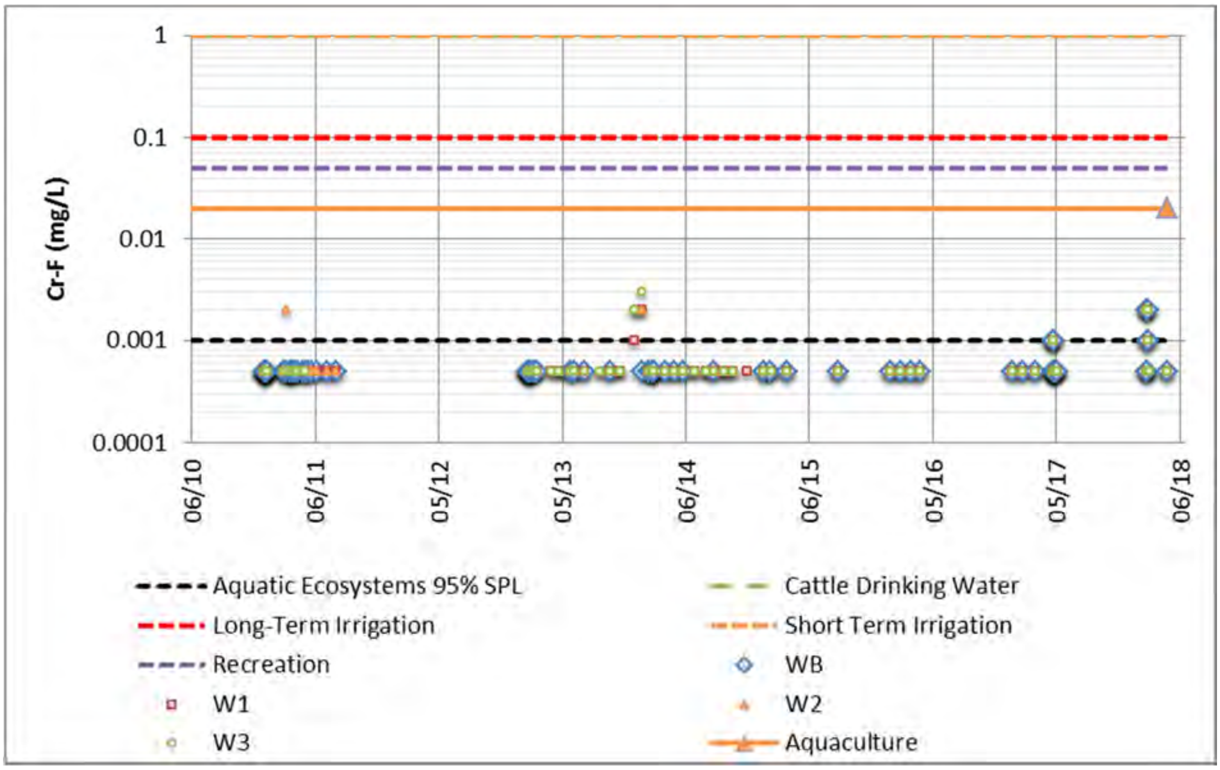


Figure 22 Time Series of Dissolved Chromium Values

5.6.7 issolved Copper

The concentration difference between optimal growth conditions (for algae) and copper toxicity to freshwater organisms is relatively low (ANZECC, 2000). The most toxic inorganic species of copper are free copper (Cu^{2+}) and copper hydroxyl species. As for aluminium, copper is readily adsorbed onto colloidal material.

The long-term running 80th percentile of dissolved copper (from the previous 24 samples) shows that concentrations were generally elevated above the 95% Aquatic Ecosystem species protection level at WB, W1 and W2 for a period of several years (Figure 23). Concentrations at W3 have only increased in the most recent sampling. This suggests that dissolved copper entering the Copperfield River was potentially sourced from historic mining activities between WB and W2, but that there are other sources of copper entering the waterway above the Kidston site as well.

There has been one sample from the Copperfield River at Spanner Waterhole DNRM Gauge (DNRM ID 917115A). This sample shows a dissolved copper concentration of 0.05 mg/L, much higher than is experienced at the site (80th percentile of 0.003 mg/L at monitoring location WB). The gauge on the Copperfield Dam Tailwater (917118A) contains two samples of dissolved copper (0.04 mg/L and 0.02 mg/L). This confirms the data from site WB indicating that there are sources of copper entering the Copperfield River above the Kidston site.

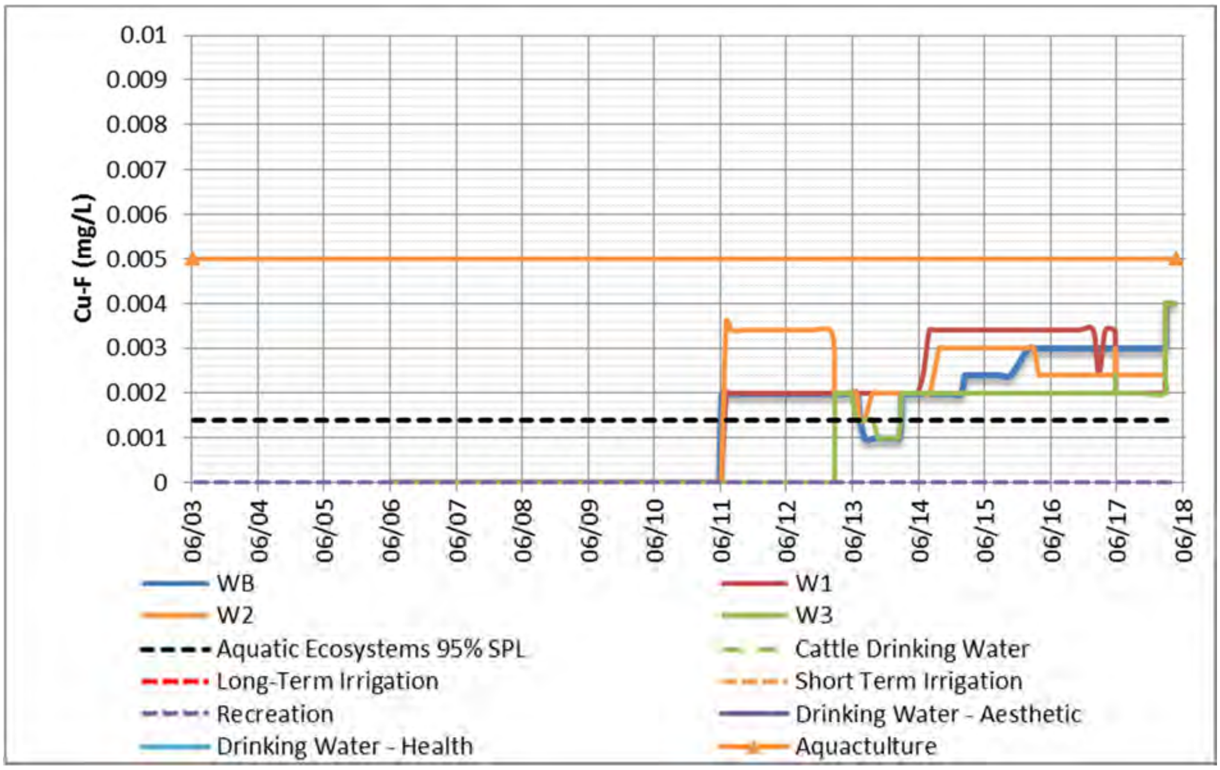


Figure 23 Long Term 80th Percentile (from the Previous 24 values) for Dissolved Copper in the Copperfield River

The long-term 80th percentile for copper at each site is outlined below in Table 33, calculated from the entire dataset. All of these values are higher than the default WQO (0.0014mg/L). It is recommended that the long-term 80th percentile value for dissolved copper at WB (0.003 mg/L) is adopted as the site specific trigger values for the Project.

Table 33 80th percentile of dissolved copper at each site in the Copperfield River

Site	Dissolved Copper 80th percentile for full dataset (mg/L)	Dissolved Copper 80th percentile post 2011 (mg/L)
WB	0.0030	0.0030
W1	0.0034	0.0040
W2	0.0030	0.0030
W3	0.0026	0.0022

5.6.8 Total Manganese

Total manganese is provided with a Recreation WQO of 0.1 mg/L from Table 29 for total manganese. The recreation WQO is sourced from the 'aesthetic' trigger value of the Drinking Water Guidelines, which states that a value of 0.1 mg/L should be found at the tap. The long-term running 80th percentile shows that even site WB has values that are above this WQO (Figure 24), although generally manganese concentrations are highest at W2.

Iron and manganese in their divalent forms (i.e. Fe^{2+} and Mn^{2+}) can precipitate based on various water quality parameters such as pH, redox potential, dissolved CO_2, sulfur, organic matter and the presence of microorganisms (NHMRC, 2011). The 'aesthetic' guideline from the Drinking Water Guidelines is to protect against the potential formation of dark scales on pipe and tap fittings as a result of manganese precipitation.

The site-specific EV assessment in Section 5.4.2 reveals that recreational use of the Copperfield River will not occur until Site W3, approximately 6.2km downstream from W2 and the proposed release point for the Project. The historic mining activity was assigned a WQO of 1.9 mg/L attributable to the WQO for Aquatic Ecosystems (refer EA EMPL00817013 dated 4 October 2013) for dissolved manganese.

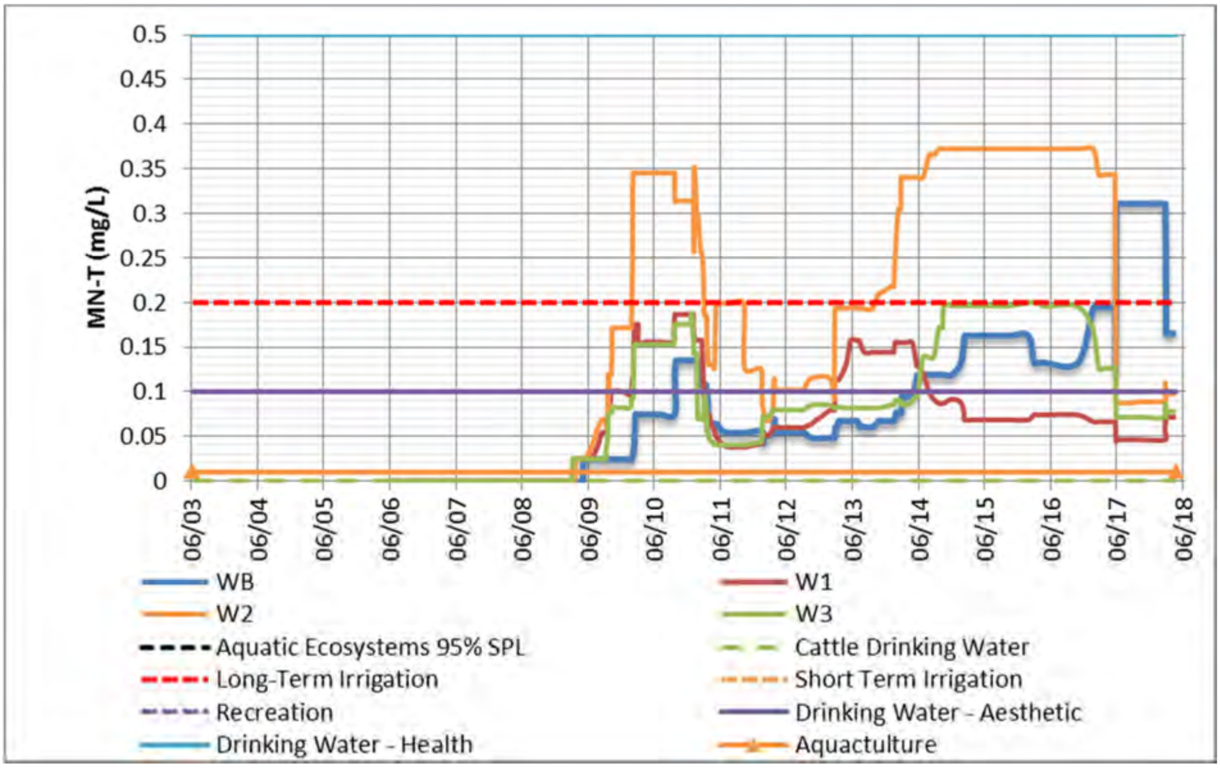


Figure 24 Long-Term Running 80th Percentile (from the Previous 24 samples) for Total Manganese

The long-term 80th percentile for each site is shown below in Table 34 for dissolved and total manganese. The total manganese 80th percentile at WB (0.111 mg/L) exceeds the Recreation WQO of 0.1 mg/L post 2011.

Table 34 80th percentile of total and dissolved manganese at each site in the Copperfield River

Site	Manganese 80th percentile for full dataset (mg/L)		Manganese 80th percentile post 2011 (mg/L)	
	Dissolved	Total	Dissolved	Total
WB	0.048	0.082	0.089	0.111
W1	0.025	0.094	0.028	0.102
W2	0.082	0.217	0.113	0.226
W3	0.039	0.089	0.048	0.096

5.6.9 Dissolved Zinc

The running 80th percentile (from the previous 24 values) shows that dissolved zinc concentrations in the Copperfield River historically (Figure 25) exceed the Aquatic Ecosystems 95% species protection level (0.008 mg/L). The results also show that zinc concentrations are increasing at all sites (WB, W1, W2, W3) over recent times (since 2017). Since 2017 there has only been one sample at WB, two samples at W1 and three samples at W2 that have exceeded the trigger value of 0.008 mg/L. No samples from W3 have exceeded this value in this time.

A HMTV of 0.014 mg/L has been adopted for dissolved zinc.

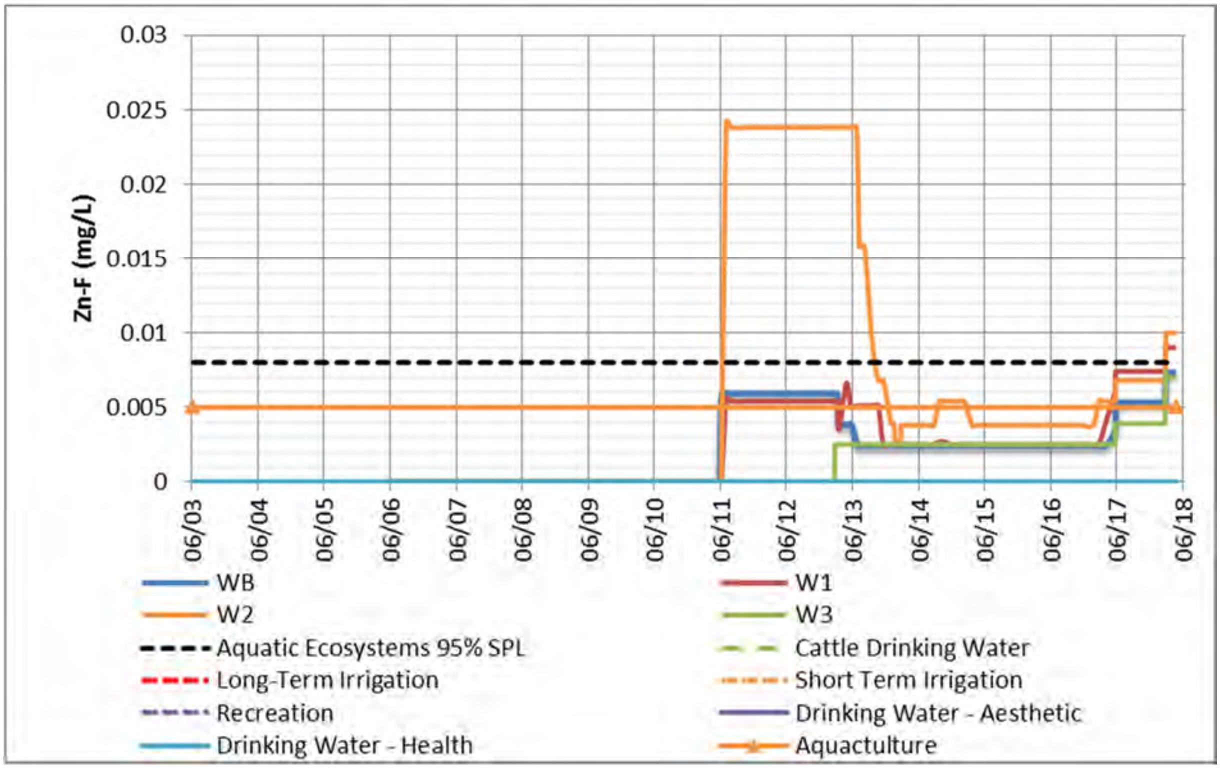


Figure 25 Long-Term Running 80th Percentile Data for Zinc (from the Previous 24 Values)

The 80th percentile values for dissolved zinc are presented in Table 35 below.

Table 35 80th percentile of dissolved zinc at each site in the Copperfield River

Site	80th percentile full dataset (mg/L)	80th percentile post 2011 (mg/L)
WB	0.006	0.005
W1	0.007	0.008
W2	0.009	0.007
W3	0.0025	0.0025

5.6.10 Total Iron

The default WQO for total iron (0.2 mg/L) is based on the long term irrigation EV (ANZECC 2000). There have been numerous exceedances of iron in the receiving environment. The 80th percentile for all sites exceeds the WQO for Long Term Irrigation, Drinking Water – Aesthetic and Recreation (Appendix A). Receiving water sites generally have higher iron concentrations than the Pit waters (Appendix A).

Table 36 80th percentile of Total Iron at each site in the Copperfield River

Site	80th percentile*
WB	0.43
W1	0.43
W2	0.59
W3	2.04

*Given that only one sample has been analysed for total iron post 2011 at sites WB, W1 and W2, statstics for the full data set are presented above (based on a minimum of 17 samples).

Iron concentrations are also elevated at DNRM gauges situated upstream. There are 14 samples that have been collected and analysed for soluble iron concentrations between 1984 and 1991 at the "Spanner Waterhole" gauge (gauge ID 917115A) situated upstream of the Kidston Dam. The 80th percentile of soluble iron concentrations at this gauge is 0.64 mg/L. This aligns with the values found at the WB monitoring site. However the concentrations at the DNRM gauge (80th percentile of 0.64 mg/L) applies to 'dissolved' iron rather than total iron as analysed from the site specific data and provided in Table 36.

Elevated iron concentrations are a naturally occurring phenomenon and not a result of mining activities. Since there is considerable evidence of elevated iron concentrations it is recommended that the 80th percentile of WB is adopted as the site-specific WQO for the Project. The default WQO of 0.43 mg/L is to protect against possible scaling in the catchment. Data from the site as well as upstream gauges indicate that this is likely to be a problem throughout the catchment regardless of the Project. Furthermore, the iron concentration in Pit water is generally lower than that found in the receiving environment, posing little risk to downstream users.

5.6.11 Nitrogen

There have only been two samples for nutrients collected within the receiving environment. Both of these samples were taken in 2018 as part of the DTA analysis from site W2. Total nitrogen was found to be 0.3 mg/L on 24 March 2018 and 0.2 mg/L on 13 June 2018. Both of these values are above the WQO of 0.15 mg/L.

Ammonia (0.02 mg/L for both samples), nitrite (0.005 mg/L for both samples), and nitrate (0.06 mg/L and 0.005 mg/L) were all below the WQOs.

There are no samples from any other receiving water sites. Subsequently it is recommended that nutrients are monitored at all receiving environment sites as a priority to establish whether these values are elevated in areas upstream of the site (site WB) or if they are sourced from the historical mining activities.

It is noted that there is no scheduled default physico-chemical stressor guideline value for nitrate in the Gulf Rivers region. There is currently insufficient data available to establish a site-specific value for nitrate and there is a lack of published data available for an adjacent similar catchment, therefore the ANZECC (2000) trigger value for the protection of 95% species is applied. Nitrate monitoring in the receiving environment will form part of the REMP in order to gather sufficient information to establish a site-specific WQO for nitrate.

5.6.12 Summary of Site Specific Water Quality Objectives

Based on the assessment of baseline water quality in the Copperfield River presented above, several site-specific WQOs (including HMTVs) are proposed. These are outlined in Table 37 below.

Table 37 Site-Specific Water Quality Guidelines

Parameter	Concentration	Source
Total iron	0.43 mg/L	Long-term 80th percentile for WB
pH – lower limit	6.0 pH units	ANZECC 2000 Tropical Australia upland freshwaters WQO lower limit
pH – upper limit	8.4 pH units	80th percentile for DNRME gauge “Copperfield River at Spanner Waterhole” (gauge ID 917115A)
Dissolved aluminium	0.57 mg/L	Long-term 80th percentile for WB
Total aluminium	1.52 mg/L	Long-term 80th percentile for WB
Dissolved copper	0.003 mg/L	Long-term 80th percentile for WB
Dissolved cadmium	0.0003 mg/L	HMTV
Dissolved chromium	0.0017 mg/L	HMTV
Dissolved lead	0.0075	HMTV
Dissolved nickel	0.019	HMTV
Dissolved zinc	0.014	HMTV

5.7 Comparison of Water Quality and Stream Flow

Stream flow data were extracted from the Integrated Quantity and Quality Model (IQQM) on a daily basis and compared to site water quality data. There is an apparent relationship between pH and flow as well as EC and flow, although the latter is difficult to quantify.

5.7.1 pH

There is a distinct relationship between pH and flow (Figure 26). Higher flow values (>10,000 ML/d) generally correlate with neutral pH; very low flows correspond to higher pH. This may represent occasions when there is standing water as waterholes in the Copperfield River.

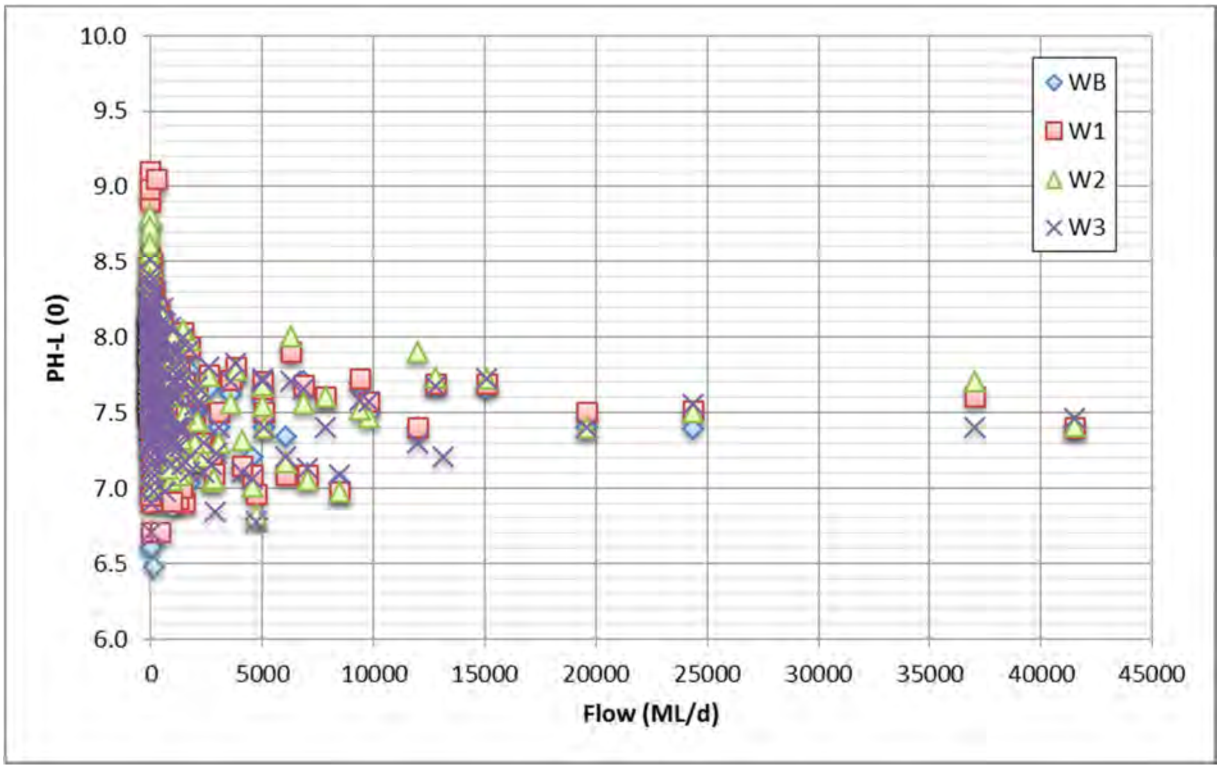


Figure 26 Relationship between pH and flow

5.7.2 Electrical Conductivity

There is an apparent ‘loose’ relationship between EC and stream flow at the majority of sites. However curve fitting algorithms will not fit a curve[9] to the data for any of the sites. W2 has been chosen to represent the receiving environment in the calculations outlined below. EC values are generally lower at higher flow events. It is obvious from Figure 27 that W2 has the highest EC values out of all sites and that these higher EC values mostly correspond to low flow periods. High flow events generally have a lower EC with two notable exceptions sampled at W2 (Figure 27).

[9] In this instance, a R^2 value above 0.2 cannot be obtained with curve-fitting software for any site

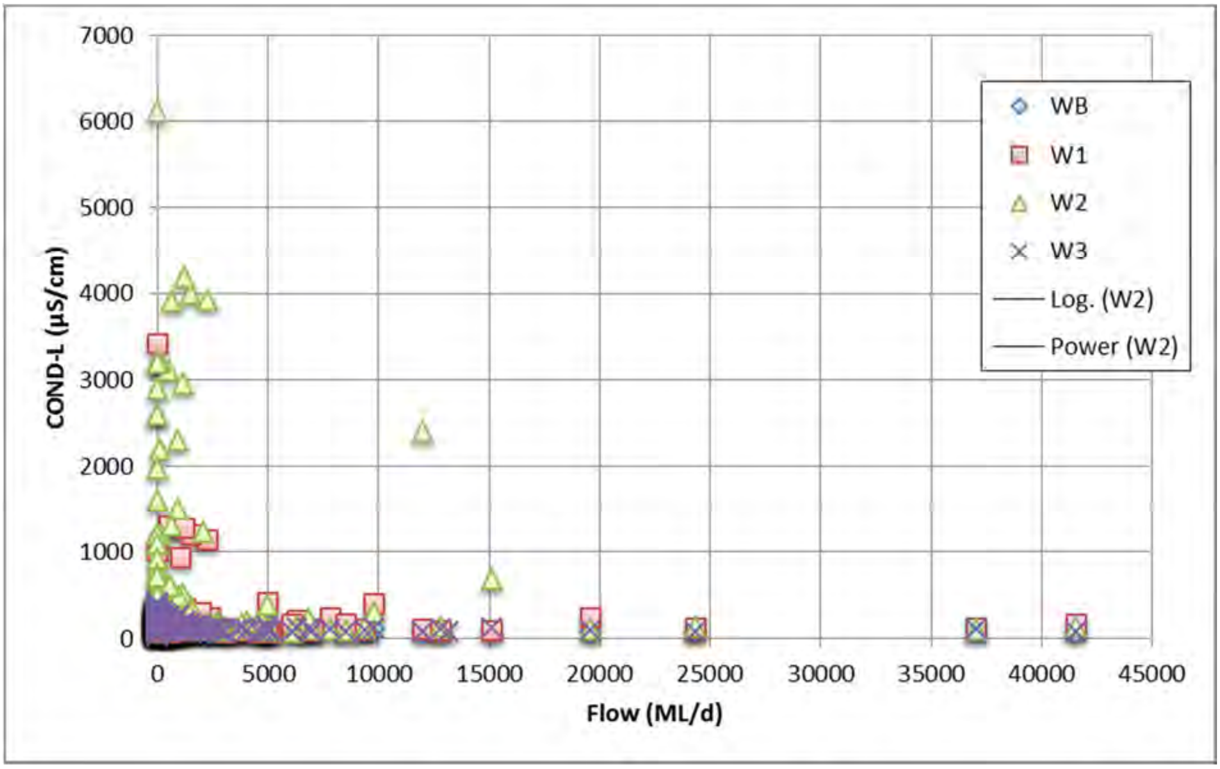


Figure 27 Relationship between EC and flow in the Copperfield River

5.7.3 Zinc

There is no correlation between zinc concentrations and flow values in the Copperfield River. Whereas EC values decline with increasing flow, high total zinc values remain at higher flow rates in the Copperfield.

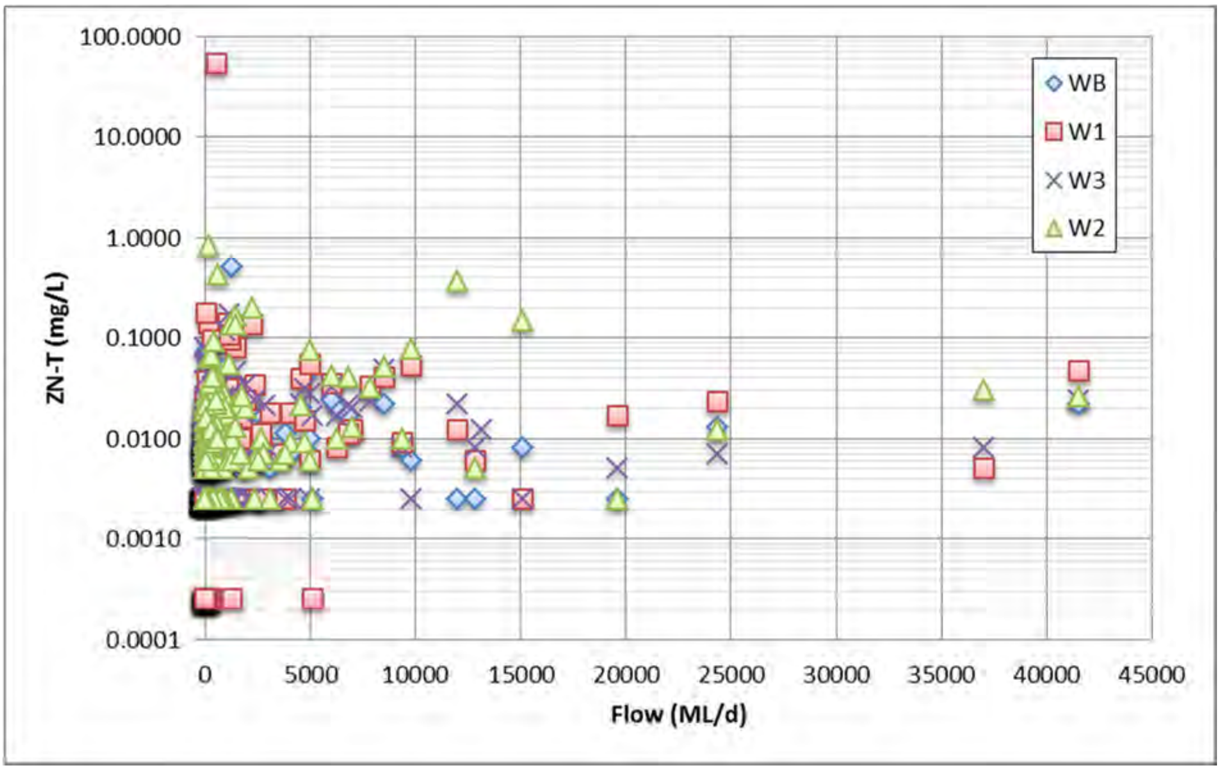


Figure 28 Plot of total zinc against flow

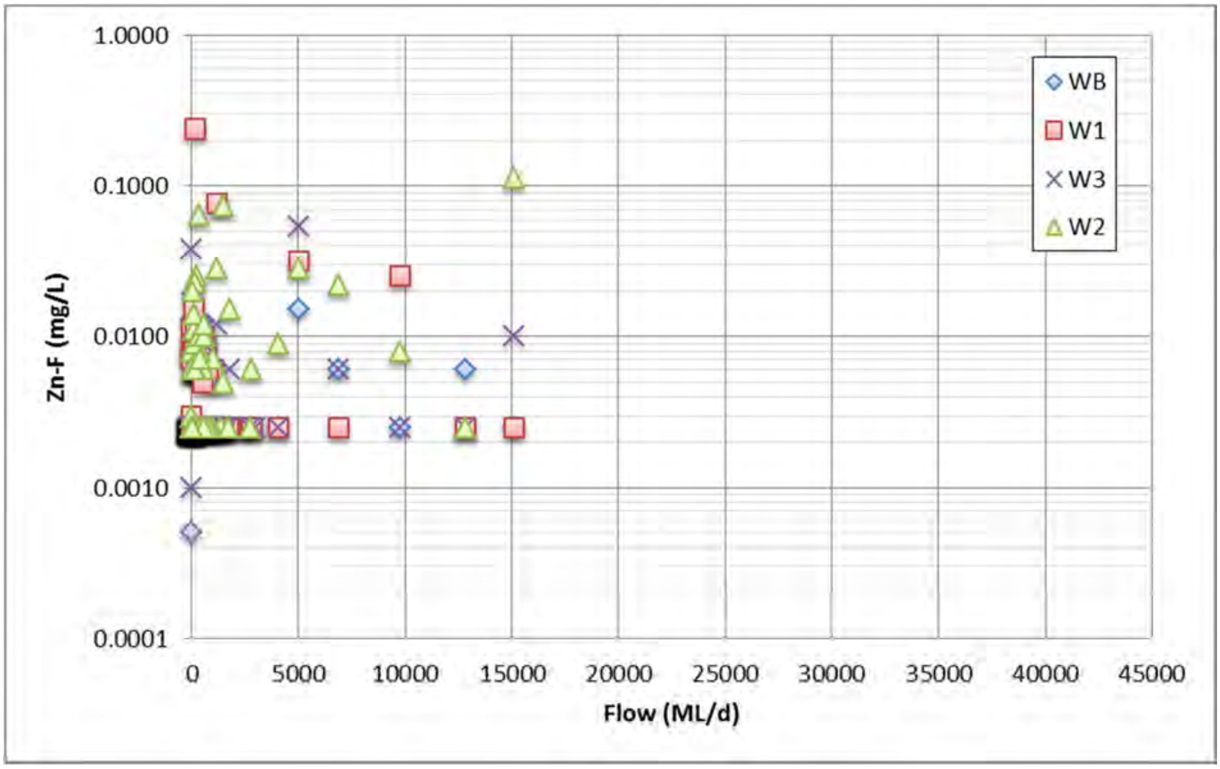


Figure 29 Plot for dissolved zinc against flow

5.7.4 Other Parameters

There are no relationships between any other parameters that are routinely monitored and flow found in the receiving environment sites.

5.8 Representative Water Quality Baseline Site (WB)

The furthest upstream monitoring location is site WB, situated 2km upstream from the proposed release location. The site shows elevated concentrations of parameters such as aluminium, copper and manganese. Although the site is situated upstream, the AGE (2001) study suggested potential limited transport of seepage to the Copperfield River in the vicinity of the WB monitoring site or further upstream, although it is noted that this is based primarily on model results, rather than observations.

There is a distinct 'signature' to mine affected water on the Kidston site. A relationship between EC and sulfate exists in samples taken from the Eldridge and Wises Pits (refer Appendix F and G). This relationship is also partially evident at site W2 (Figure 30). This indicates that W2 has received mine-affected water in the past via either seepage, releases or another mechanism.

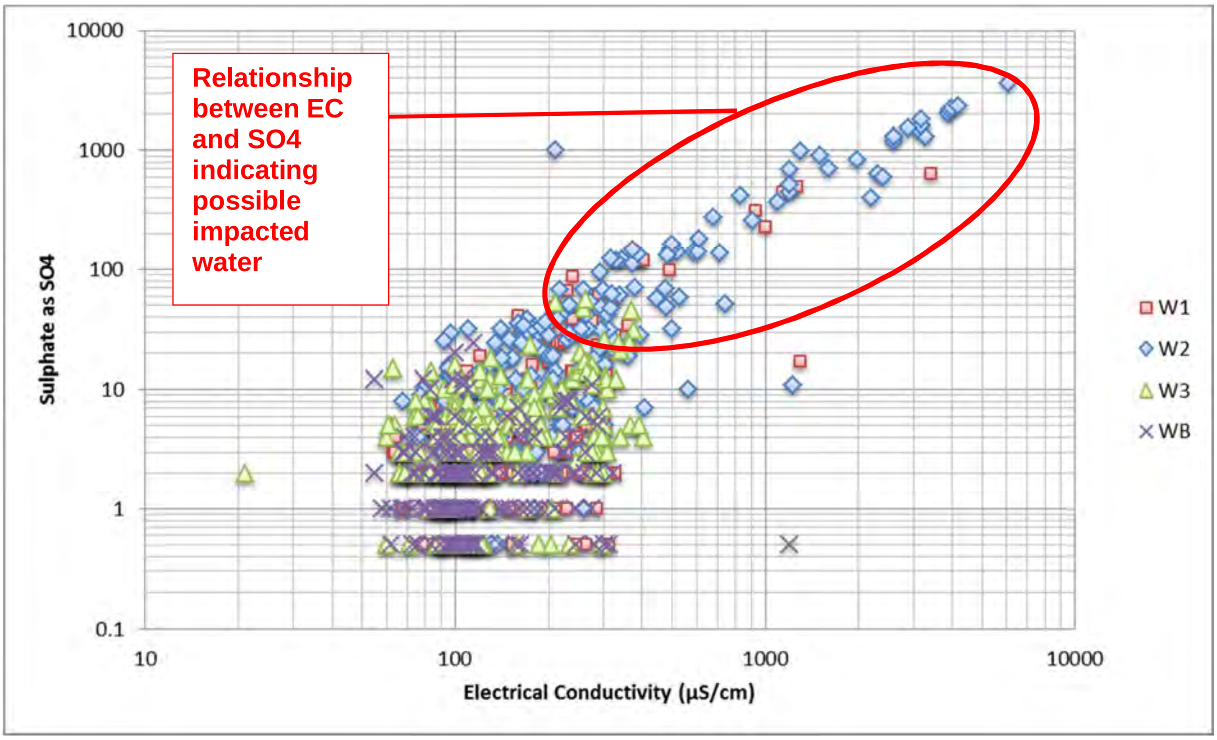


Figure 30 Relationship between EC and sulfate as SO4 in receiving water samples

Samples at WB do not show a relationship between EC and sulfate. In addition, waters from the mine generally have lower aluminium concentrations (80th percentile of 0.0376 mg/L for the Eldridge and 0.025 mg/L for the Wises Pit) than water in all receiving water locations (80th percentile of 0.568 mg/L). Only one sample has been collected from the East Creek monitoring location (dated 24/04/2018) and this sample has a concentration (0.08 mg/L) that is above the 80th percentile of the pit waters. This shows that aluminium is naturally elevated in the receiving environment. Therefore, if mine-affected water was impacting on the WB monitoring location it would be expected to result in low concentrations of aluminium in the sample results.

A piper diagram of available cation and anion data was produced for the receiving environment sites as well as available DNRM stream gauges in Copperfield catchment and nearby areas. The position of WB, W1 and W3 sites plot very closely to the historical gauged data from the tailwater of the Kidston Dam (DNRM gauge ID 917118A) (Figure 31). Sites W1, W3, WB and the Kidston tailwater gauge fall within the Na-HCO_3 water facies, whereas those from the the Wises and Eldridge Pits plot in the top-right corner of the piper diagram indicating Na-SO_4 facies water. The W2 site is a Ca-HCO_3 dominated facies water. Its position on the piper diagram (Figure 31) indicates a marginal impact from waters with a similar composition of the Eldridge and Wises Pits. If the WB site was impacted by water from mining activities, its position in the Piper Diagram would be expected to be similar to that of the W2 site.

The lack of a relationship between EC and sulfate, the comparison between low aluminium bearing pit waters and high aluminium concentrations in receiving waters, and water composition data indicates that there are likely to be minimal impacts from the mine at site WB.

The site does not meet the criteria required for a ‘reference site’ as outlined in the QWQG (2009) as the Copperfield Dam regulates upstream from the monitoring point. As the site is in reasonable condition and represents the only long-term monitoring dataset on the Copperfield River downstream of the Copperfield Dam and upstream of the historical Kidston mine, the site is used to identify which parameters naturally occur above WQOs in the receiving environment.

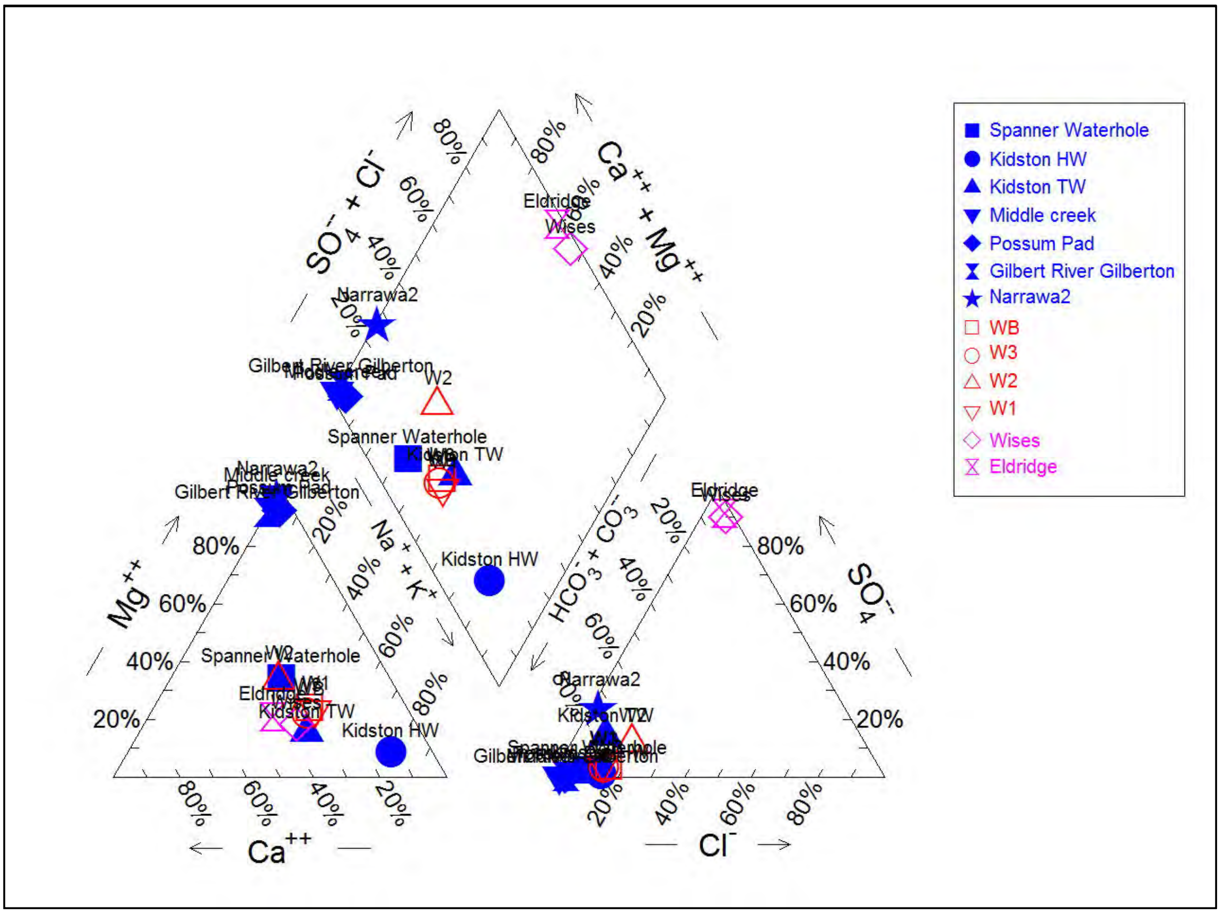


Figure 31 Piper diagram of local waters compared to pit water samples

5.9 Hydrology

Streamflow in the Copperfield River at the Project site is currently ungauged. The closest open, readily available stream gauge located on the Copperfield River is approximately 23 km upstream from the Project (Copperfield River at Spanner Waterhole, 917115A). Although the gauge is located reasonably close to the Project site it is located upstream of the Copperfield River Dam and catchment area scaling of the gauge data would therefore be unable to account for the impact of the dam on streamflow regulation.

Quantification of streamflow at the Project site is required in order to complete a flow spells analysis which is used to assess the magnitude, frequency and duration of streamflow events (a flow spell). The analysis enables quantification of the following key characteristics of the receiving environment flow regime:

- Flow seasonality
- Flow variability (both seasonally (intra-annual) and in response to climatic conditions (inter-annual))
- Flow predictability (expressed as the flow rate likely to be exceeded for a given probability)
- Flow volume (expressed as a daily volume); and
- Flow event duration (expressed as length of time/number of times flow of a certain likelihood is continuously exceeded).

5.9.1 Development of Water Resource Model

A water resource model was developed using the IQQM software for the purpose of simulating a long term streamflow record for the Copperfield River at the Project site. The model was developed to provide additional capability for conducting both near and far field water quantity and quality assessment of proposed releases of water from the Project.

IQQM is a well-known software package that is used in Australia for water resource modelling and planning including the DNRME. DNRME has used IQQM for water resource planning during development and assessment of WPs (water plans) and ROPs (resource operation plans).

A fully-developed model of the Gilbert Basin which was used as recently as 2016[10] for water planning assessment of the Water Plan (Gulf) 2007 was obtained from DES (herein referred to as the WRP Model) through the DES hydrology request facility. The supplied WRP Model was revised and updated (to allow increase of the model simulation length from 1890 to 2003 to 1890 to 2017) for use in the IAR assessment as summarised in Table 38 and shown in Figure 32.

A number of additional nodes were added to the IAR model downstream of the Project site in to assist in completion of the impact assessment. These are also shown on Figure 32 and are discussed in more detail in Section 5.9.2.

[10] Pers. Com. Paul Roe, Senior Hydrologist, Queensland Hydrology, 10/04/2018

Table 38 Summary of Development of IQQM Model

Aspect	WRP Model (Provided by DES)	IAR Model
IQQM Version	6.42	Updated to 7.53.6 to leverage graphical user interface and statistical analysis tools
Model Spatial Representativeness	Gilbert Basin including all major tributaries	All nodes and links representation of WRP Model for all watercourses upstream and directly downstream of the Project site: • Copperfield River; and • Einasleigh River between confluence with Copperfield River and confluence with Gilbert River. All other tributary inflows were reduced to single nodal inflow points using input flows at key locations extracted from the WRP Model outputs (refer to Figure 32)
Input Data	1890 to 2003	All input data informing the model catchments reporting to Einasleigh were extended to allow the model to run to 31/12/2017. Due to the spatially distributed nature of the input climate data[11] it was not practical to extend the remaining model inputs within the available timeframe. Consequently, model results for any nodes below Einasleigh are only valid until the end date of the WRP Model – i.e. 2003. This has no impact on the model's ability to estimate streamflow for the Copperfield River and Einasleigh River above Einasleigh to the the end of 2017.
Demands, Transmission Losses, Dam Operations, etc.	As per received model	All nodes and links taken from the WRP Model were replicated identically in the IAR Model (refer to Figure 32) including any associated data or assumptions (e.g. routing parameters). Input data and assumptions for the Copperfield Dam were adopted as per the WRP Model and consisted of: • Storage curve data; • Spillway capacity; • Outlet works; • Demand (Kidston Gold Mine) – 4,650 ML/yr; and • Environmental release – 1,143 ML/d pass though.
Model simulation capability	1890 to 2003	• 1890 to 2017 for catchment reporting to Einasleigh (Copperfield River and Einasleigh River upstream of Einasleigh) • 1890 to 2003 for Einasleigh River downstream of Einasleigh to Gilbert River.

[11] Averaged SILO Data Drill for every grid point within every calibration catchment

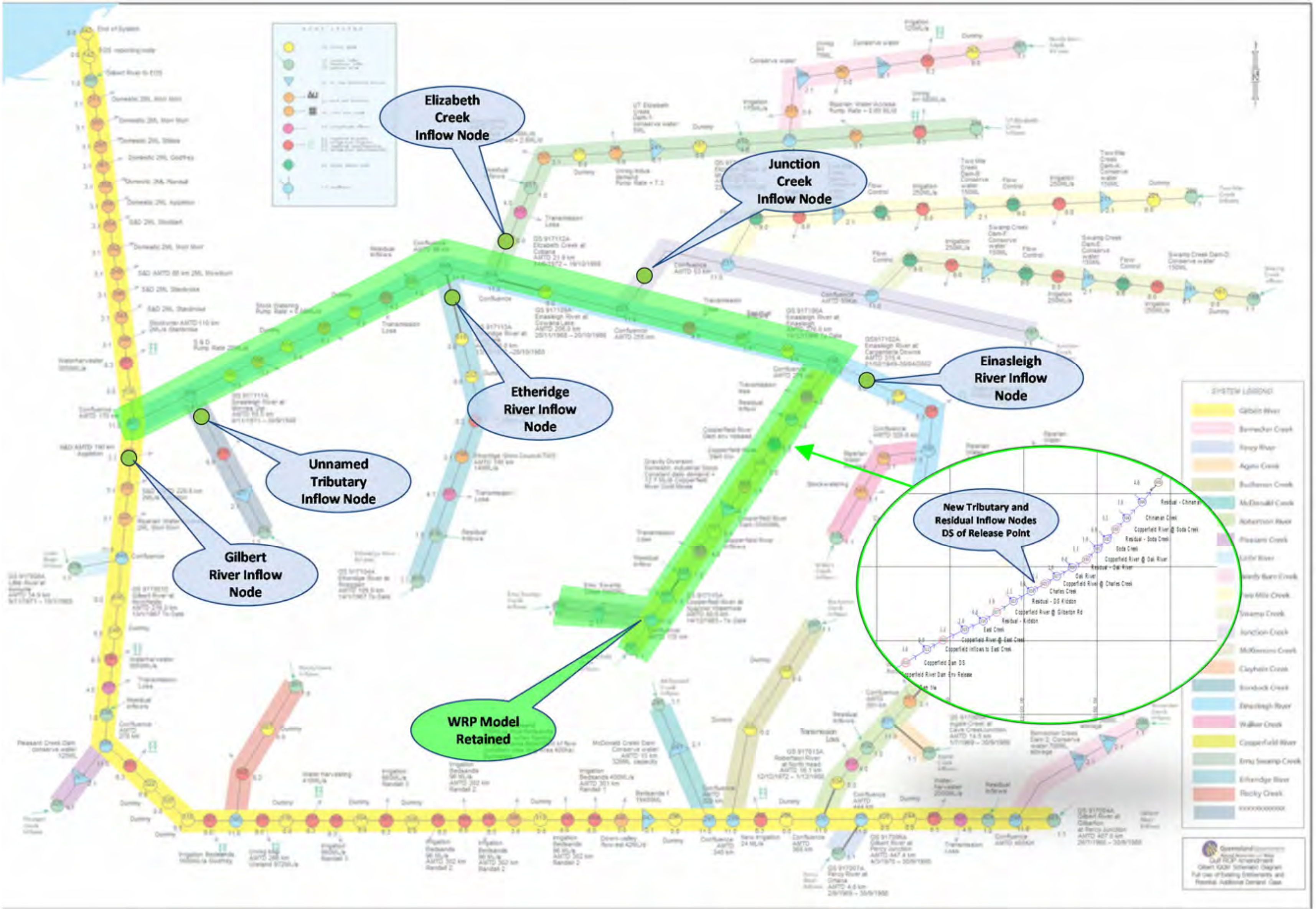


Figure 32 Development of IAR IQQM Model

5.9.2 Model Validation

Once the model was developed, the IAR Model was compared to the WRP Model to ensure consistency in results over the concurrent simulation period (1890 to 2003). Figure 33 shows the modelled daily flow duration curve for the Gilbert River immediately downstream of the confluence with the Einasleigh River (the effective end of the IAR Model). It can be seen that the IAR model replicated the WRP Model. In addition, when compared to the WRP Model, the IAR Model exhibited a volume ratio of 100.0% and a coefficient of determination (R^2) of 1.0 when comparing daily flows from both models over the same period.

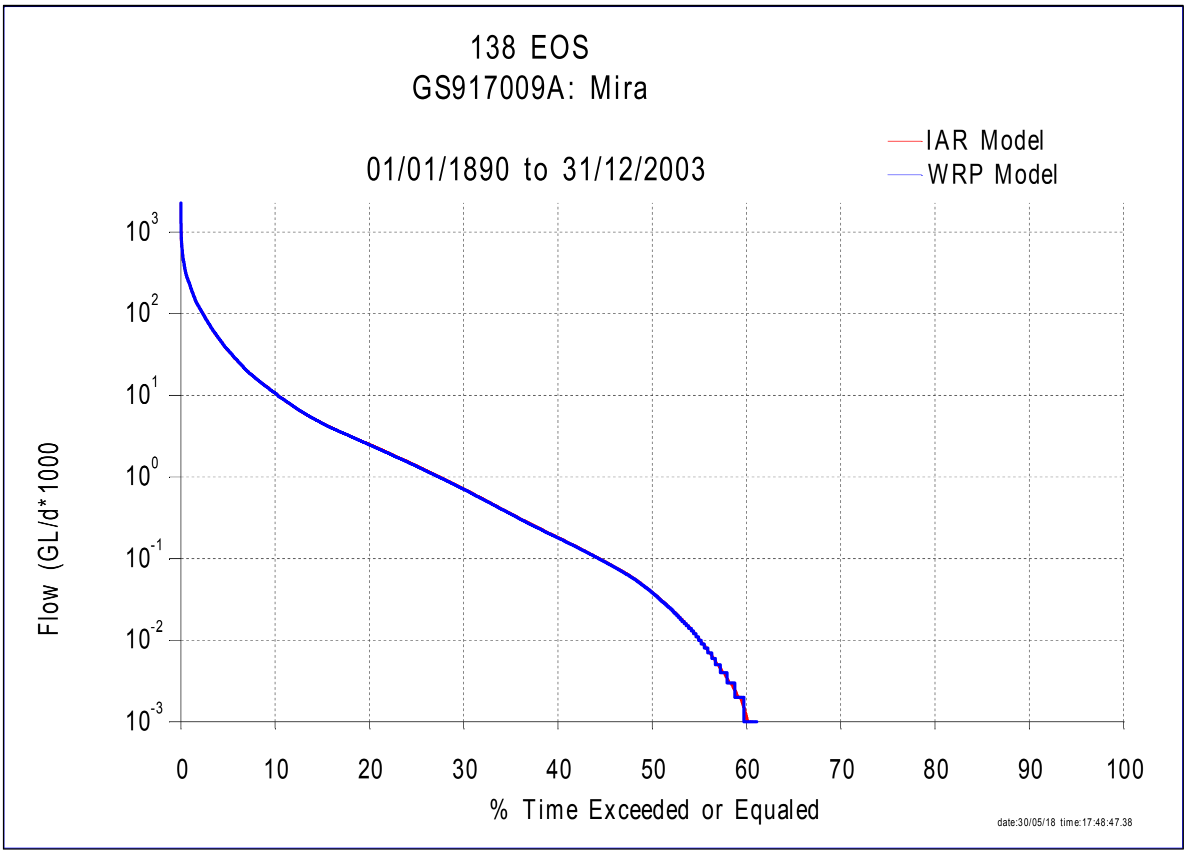


Figure 33 Flow Duration Comparison – WRP Model and IAR Model (Downstream of Gilbert and Einasleigh Rivers Confluence)

5.9.3 Streamflow Assessment

The IAR model was used to generate a long term streamflow record for the Copperfield River at the Project site. The simulation was conducted over 127 years for the period 1/1/1890 to 31/12/2017. The output streamflow record was subsequently subjected to statistical analysis using the River Analysis Package (RAP (v3.08), available from the eWater Toolkit).

Table 39 shows key environmental flow performance indicators that are used by the Water Plan (Gulf) 2007 to assess medium to high modelled streamflow at a node within the WRP Model. Mean annual discharge in the Copperfield River is estimated to be 162 GL/yr. and the 10% daily flow is approximately 391 ML/d. Annual (water year, November through October) discharge and annual flow duration (representing the likelihood that annual discharge of a specific volume will be exceeded for any given year) are shown in Figure 35 and Figure 34 respectively. From the figures it can be seen that total annual discharge is highly variable ranging from approximately 1,300 GL/yr. to less than 1 GL/yr.

Table 39 Water Plan (Gulf) 2007 Performance Indicators for Assessing Periods of Medium to High Flow at a Node (Copperfield River at Project Site)

Indicator*	Units	Discharge
Mean Annual Flow	GL/yr	162
Median Annual Flow	GL/yr	69
10% Daily Flow	ML/d	391
1.5 Year Daily Flow Volume	ML/d	4,674
5 year Daily Flow Volume	ML/d	30,325
20 year Daily Flow Volume	ML/d	97,694

* As per Section 17 (b)

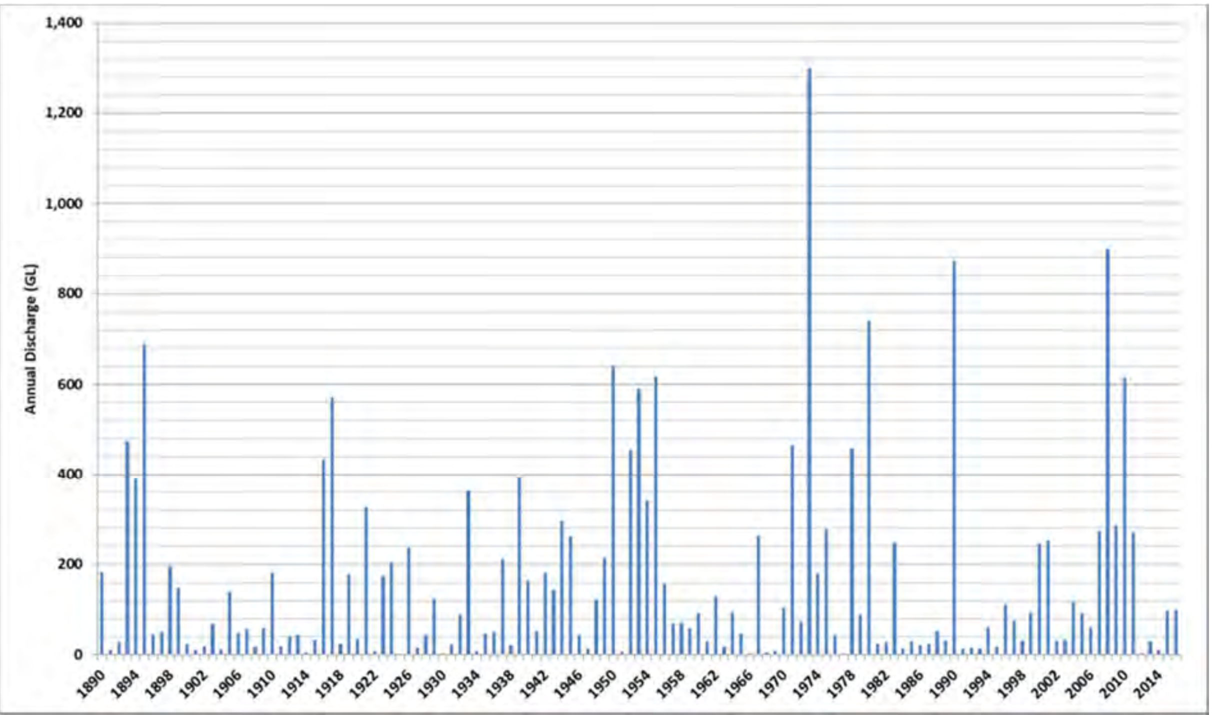


Figure 34 Estimated Annual Discharge for Copperfield River at Project Site (Water Years Nov – Oct)

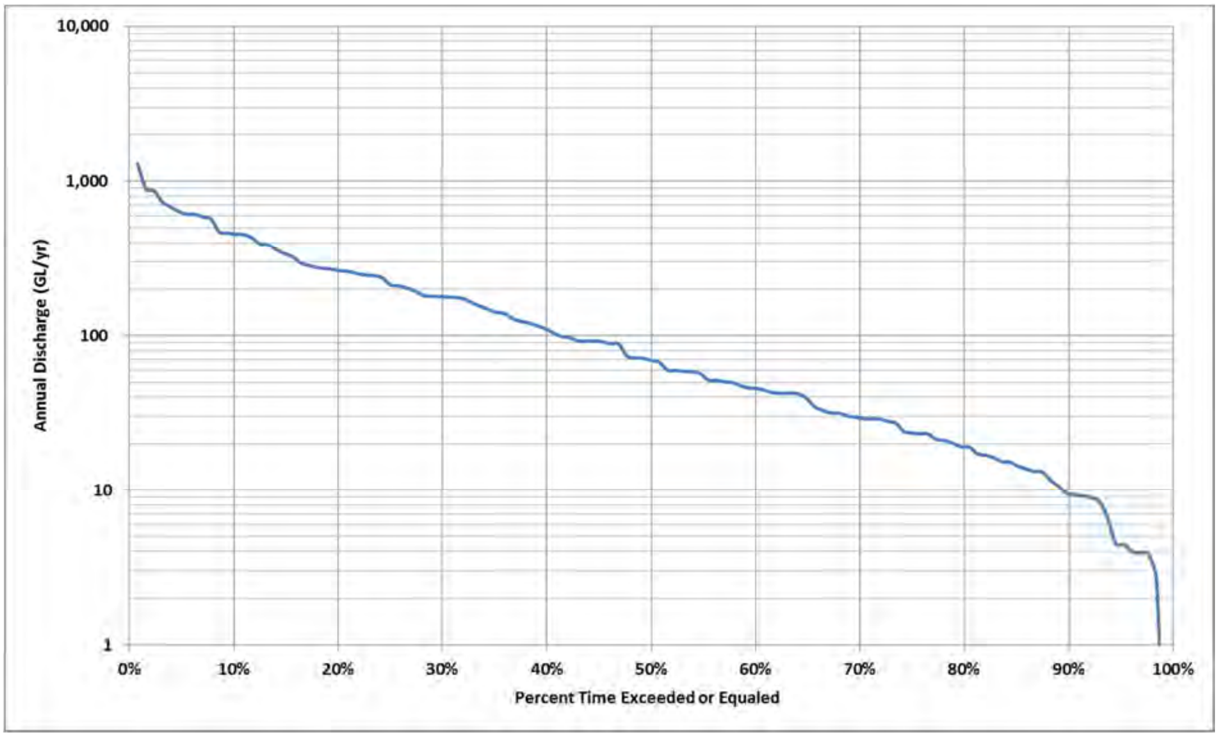
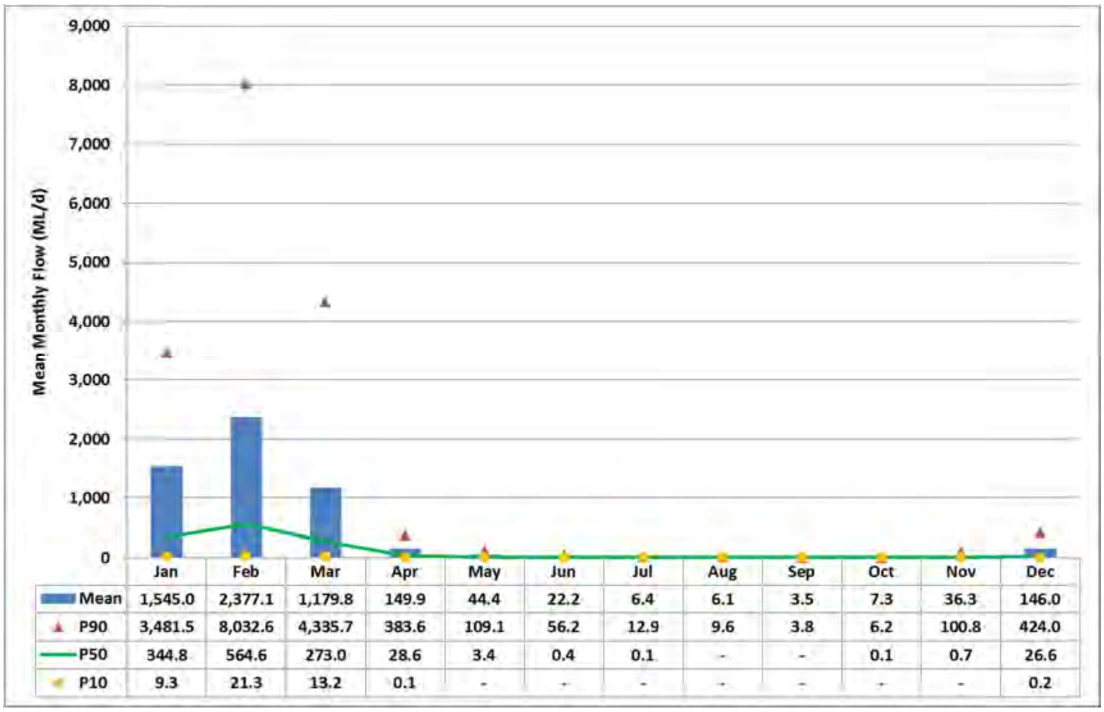


Figure 35 Annual Flow Duration Plot for Copperfield River at Project Site (Water Years Nov – Oct)

Mean daily discharge is shown in Figure 36 and the daily flow duration curve (representing the likelihood that flow of a specific rate will be exceeded on any given day) for all daily flows is shown in Figure 37:

- Streamflow shows a distinct seasonal distribution with a distinct high flow season occurring from December through April; however the majority of mean daily flow is restricted to the months of January through March (Figure 36).
- Significant variability in streamflow can be seen during the high flow period of January through March which is reflective of the wet season rainfall variability discussed in Section 5.2.1 , for example, mean daily flow for February ranges from approximately 2,400 ML/d (P90 result) to 22 ML/d (P10 result).
- Cease to flow conditions (less than 1 ML/d) are present on approximately 55% of all days for any day and reduce to approximately 32% during the wet season (November through April).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	1,545.0	2,377.1	1,179.8	149.9	44.4	22.2	6.4	6.1	3.5	7.3	36.3	146.0
P90	3,481.5	8,032.6	4,335.7	383.6	109.1	56.2	12.9	9.6	3.8	6.2	100.8	424.0
P50	344.8	564.6	273.0	28.6	3.4	0.4	0.1	-	-	0.1	0.7	26.6
P10	9.3	21.3	13.2	0.1	-	-	-	-	-	-	-	0.2

Figure 36 Mean Daily Discharge for Copperfield River at Project Site

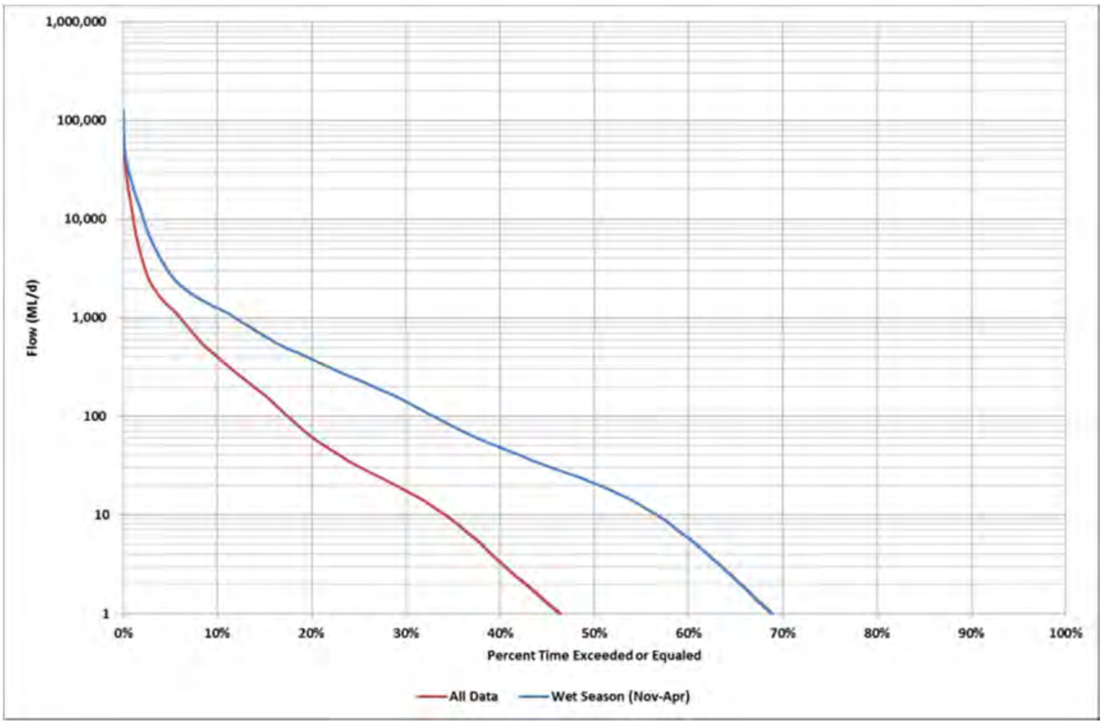


Figure 37 Daily Flow Duration Plot for Copperfield River at Project Site

The simulated streamflow record for the Project site was subjected to a flow spells analysis as per the definitions shown in Table 40. Summary results are presented below in Table 41 and Table 42 for the flow spells statistics relevant to the proposed release of water i.e. high flow spell and during the wet season. Results for cease to flow conditions are also included for context:

- When assessed continually for the 127 years of streamflow data, the 10% flow (391 ML/d) has a mean duration of approximately 9 days during the wet season (Table 41) with a mean duration between spells of around 82 days. The estimated mean duration of cease to flow conditions is approximately 20 days.

- Wet season inter-annual results (Table 42):
  - Show that the 10% flow (391 ML/d) occurs approximately 3 times during the wet season, has a duration of approximately 8 days and with approximately 14 days between spells (median results).
  - Cease to flow conditions may occur approximately 8 times with a duration of around 19 days (median results).

Table 40 Flow Spells Assessment – Adopted Definitions

Aspect	Adopted Definition
Seasons	Wet – November through April
	Dry – May through October
Flow Spells	High flow spell - 10%, 5% and 2% daily flow exceedance probability
	Low flow spell – cease to flow condition

Table 41 Flow Spells Summary - All Years (Wet Season, Nov-Apr)

Statistic	Units	High Spell Daily Exceedance Probability			Cease to Flow Conditions
		10%	5%	2%	
Spell Threshold	ML/d	391	1,254	3,790	-
Number of Spell	Count	509	387	188	1,032
Longest Spell	Days	123	77	42	272
Mean of Spell Peaks	ML/d	6,961	10,356	21,398	-
Mean Duration of Spell	Days	9.1	6.0	4.9	19.6
Mean period Between Spells	Days	82	114	241	25.4

Table 42 Flow Spells Summary - Inter-Annual Summary (Wet Season, Nov-Apr)

Statistic	Units	High Spell Daily Exceedance Probability			Cease to Flow Conditions
		10%	5%	2%	
Spell Threshold	ML/d	391	1,254	3,790	-
Mean of Wet Season Number of High Spell	Count	3.7	2.9	1.5	8.8
Mean of Wet Season Longest High Spell	Days	22.4	11.3	6.8	88.3
Mean of Wet Season Mean Duration of High Spell	Days	11.6	6.5	4.5	21.5
Mean of Wet Season Mean period Between High Spells	Days	16.6	16.9	18.1	35.7
Median of Wet Season Number of High Spell	Count	3.0	3.0	1.0	8.0
Median of Wet Season Longest High Spell	Days	16.0	9.0	5.0	81.5
Median of Wet Season Mean Duration of High Spell	Days	7.7	5.0	4.0	18.7

Statistic	Units	High Spell Daily Exceedance Probability			Cease to Flow Conditions
		10%	5%	2%	
Median of Wet Season Mean period Between High Spells	Days	14.0	13.0	13.9	25.1

The IQQM streamflow record for the Project site indicates that streamflow is highly seasonal and variable. Medium to high flow conditions of 391 ML/d (defined as the flow likely to be exceeded on 10% of all days) typically occur multiple times during the wet season and persist over a number of days. However cease to flow conditions are also likely during the wet season as a result of the highly variable rainfall described in Section 3.2.1.

5.10 Hydraulics and Fluvial Geomorphology

5.10.1 Stream Hydraulics

5.10.1.1 Model Development

A one-dimensional hydraulic model was developed using software HEC-RAS to assess impacts to the Copperfield River. Model data, inputs and parameters are listed below.

Available Data

Freely available LiDAR from Geoscience Australia's online portal *ELVIS* was used for the development of the hydraulic model. The Digital Elevation Model (DEM) used has a resolution of 5m.

Aerial Imagery available through ArcGIS's World Imagery Layer has been utilised for this study. Inspection of the aerial imagery was undertaken for purposes of understanding vegetation cover for catchment roughness.

Inputs & Parameters

Hydraulic inputs and parameters used in the development of the HEC-RAS model are listed below in Table 43.

Table 43 Hydraulic Model Parameters

Parameter	Information
Scenarios Modelled	Base-case (without releases); Design-case (with releases)
Flow inputs	Three flow cases were modelled for each scenario: • Medium flow of 400 ML/d (10th percentile daily flow) • High flow of 1,270 ML/d (5th percentile daily flow) • 2% High flow of 3,790 ML/d (2nd percentile daily flow)
Hydraulic Modelling Approach	HEC-RAS 5.05
Model Extent	4,100m upstream and 7,500m downstream of release point
Manning's Roughness	Main Channel n=0.035, Overbanks n=0.05
Downstream Boundary Condition	Average Hydraulic Slope=0.2%

Model Scenarios

As described in Table 43 two scenarios being the base-case (without releases) and design-case (with releases) were modelled for the three flow cases.

5.10.1.2 Baseline Results

HEC-RAS was setup to assess hydraulic base-case characteristics such as velocity, water level, shear stress, stream power and active flow width. The base-case model is defined as the 'without releases' scenario. Channel flow rates considered for the 'without releases' scenario cover the expected ranges that may provide release opportunities. Medium, High and 2% High flow rates were developed and applied to the model.

The flow depths, velocities, shear stresses, stream power and active flow widths from the 'without releases' HEC-RAS model are reported in Figure 38 to Figure 42.

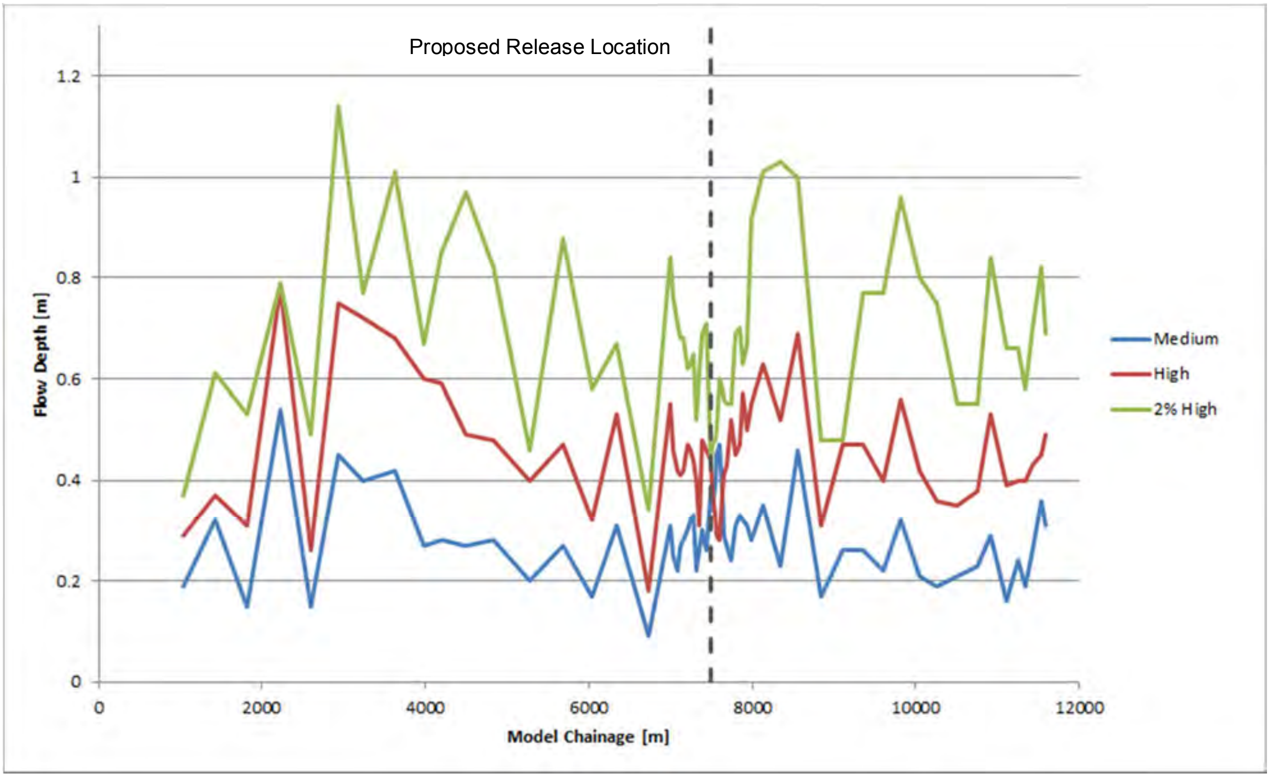


Figure 38 Flow depth along channel in HEC-RAS model for three investigated flows (downstream to upstream, left to right)

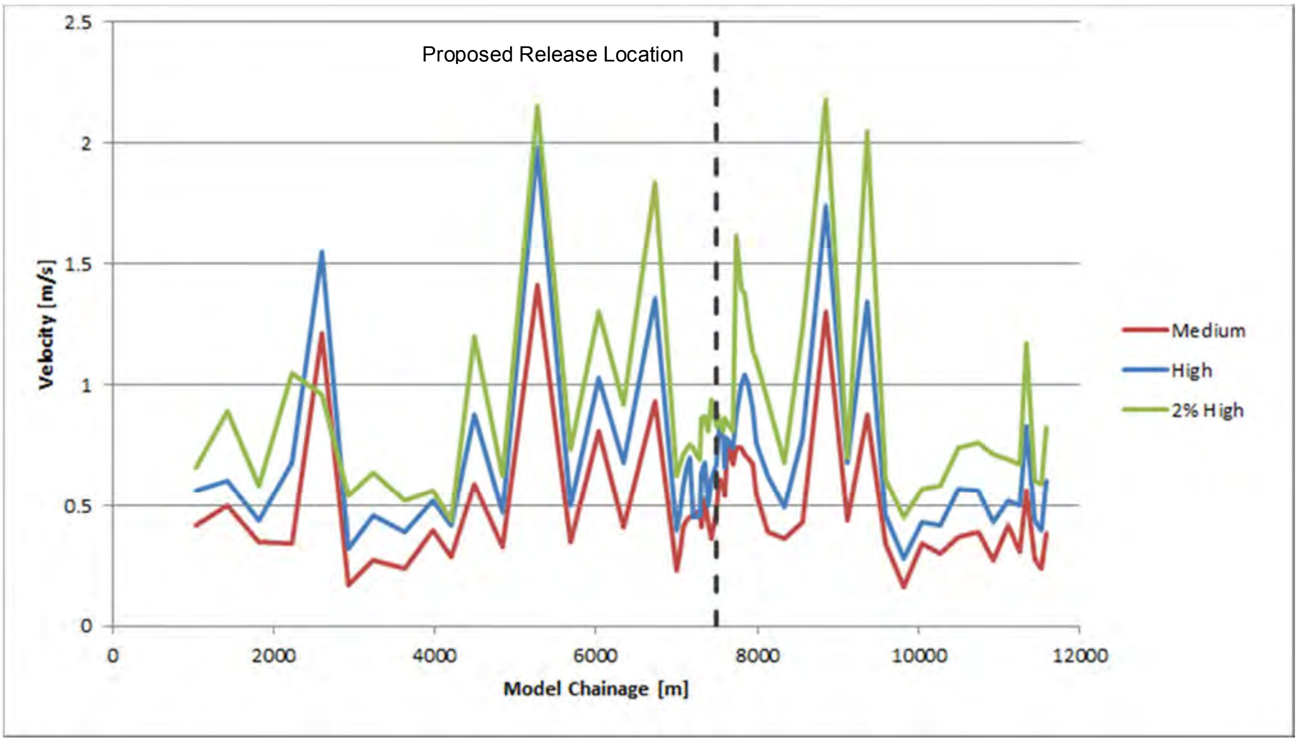


Figure 39 Velocity along channel in HEC-RAS model for three investigated flows (downstream to upstream, left to right)

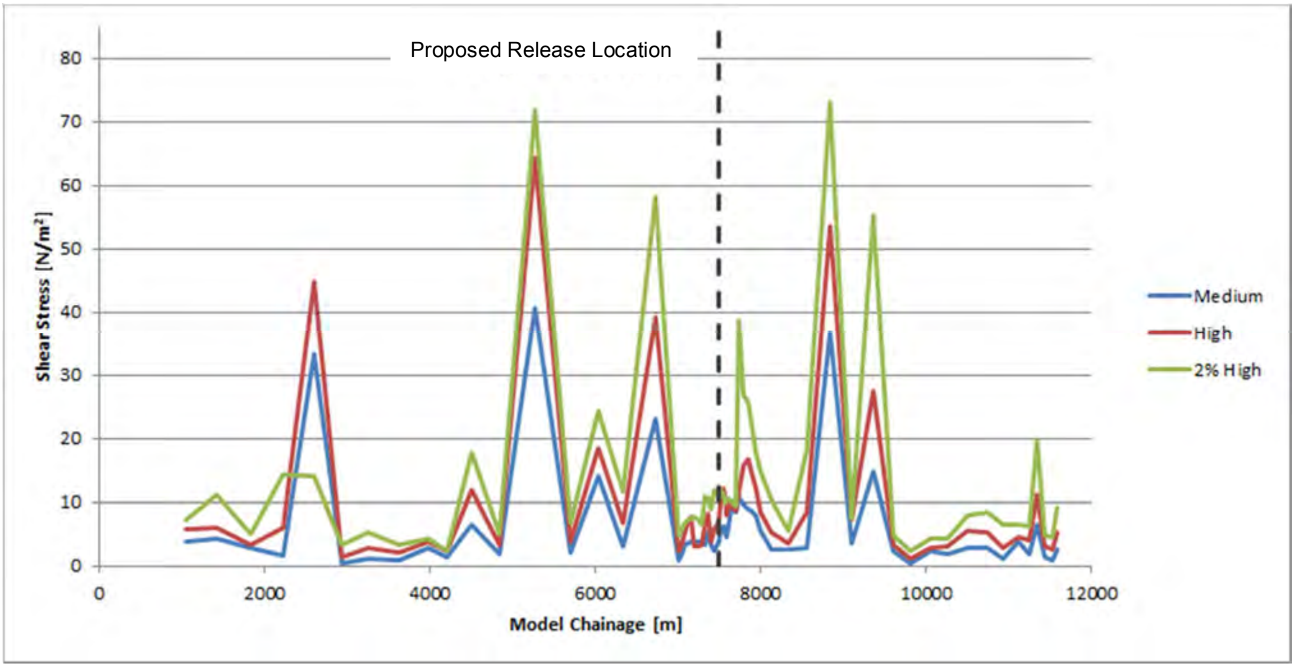


Figure 40 Shear stress along channel in HEC-RAS model for three investigated flows (downstream to upstream, left to right)

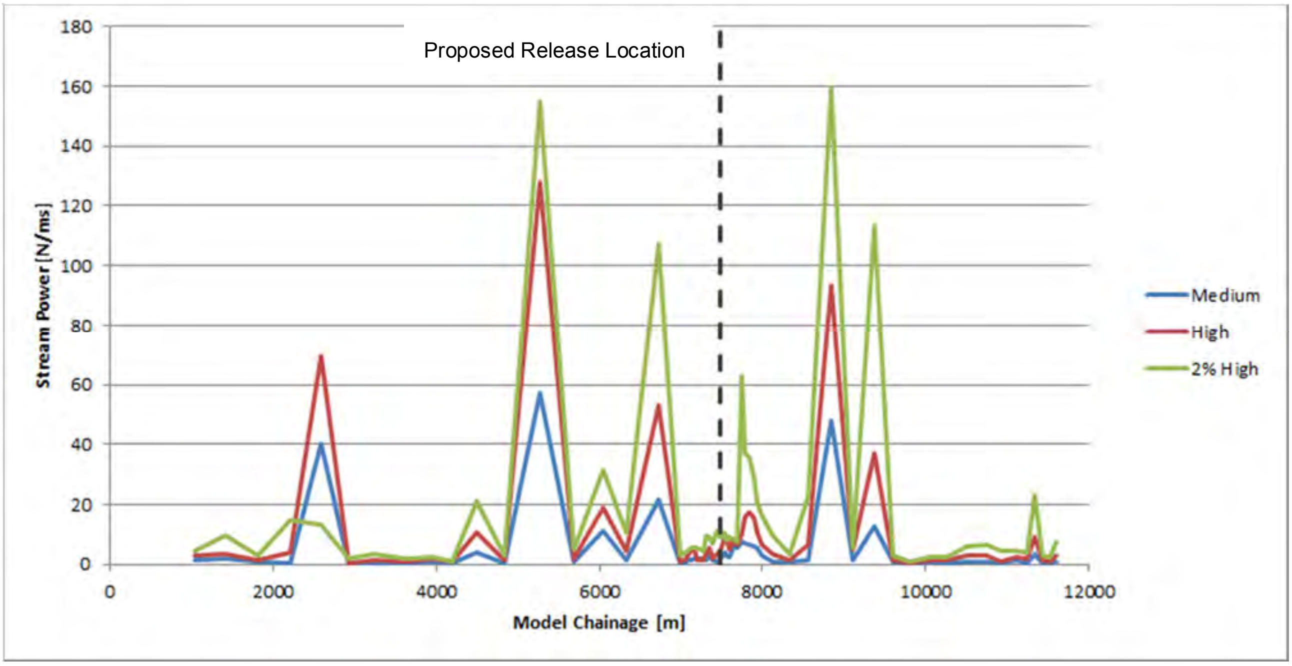


Figure 41 Stream Power along channel in HEC-RAS model for three investigated flows (downstream to upstream, left to right)

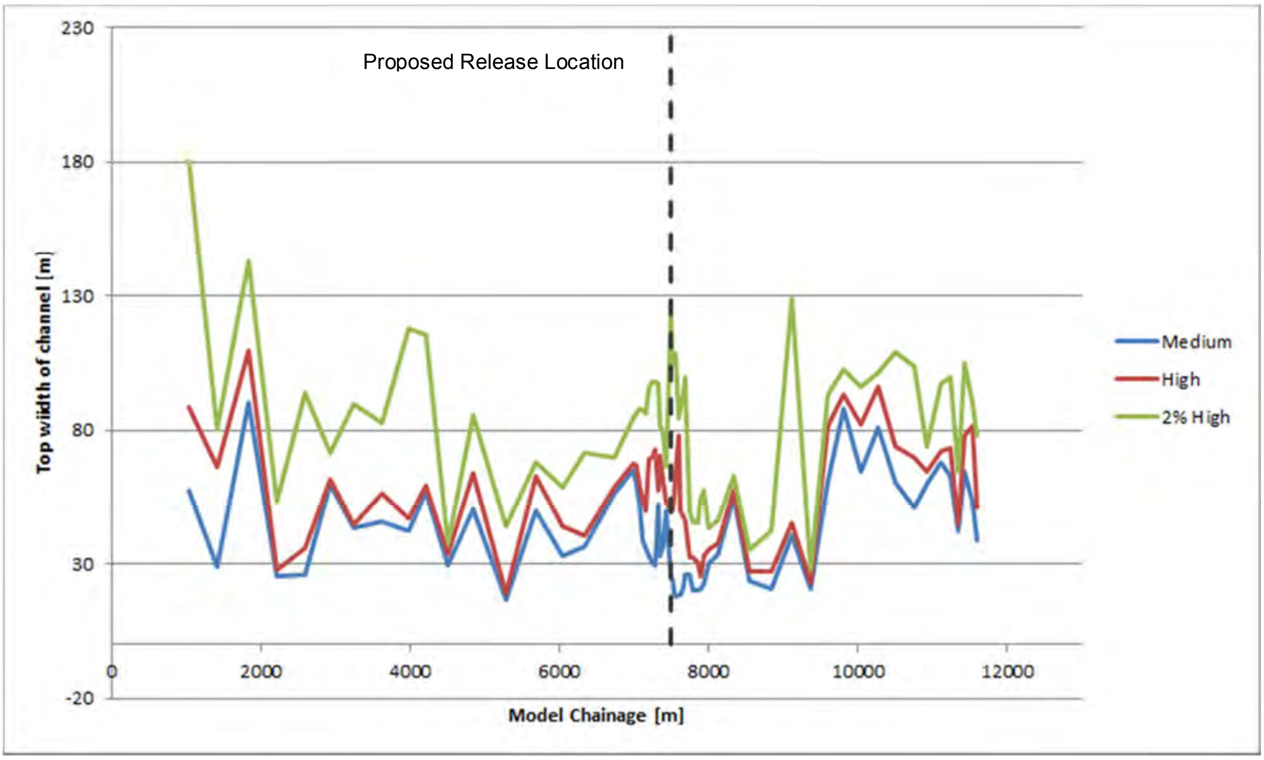


Figure 42 Active Flow width along channel in HEC-RAS model for three investigated flows (downstream to upstream, left to right)

5.10.2 Fluvial Geomorphology

The Project site is located adjacent to the Copperfield River, a major tributary of the Einasleigh River which is in turn, a major tributary of the Gilbert River which gives its name to the Basin. Key watercourses generally flow in a north-west to south-east alignment as a result of the underlying structural controls relating to uplift, warping, doming, faulting and subsidence that that provide a strong influence on both relief and drainage (Tomkiins, 2013). Major rivers such as the Gilbert and Einasleigh can be seen to follow this alignment which is consistent with regional lineaments (a large scale linear feature expresses in terms of surface topography and an expression of the underlying structural features) and many of the ranges and plateaux like the Gregory and Newcastle Ranges are up-warped features (Tomkiins, 2013).

The Gilbert Basin consists of a number of distinct physiographic regions (morphological unit with an internal coherence in its landform characteristics). At the division level, the Basin is split between the Eastern Uplands Division to the south east and the Interior Lowlands Division to the north east (Pain, Gregory, Wilson, & McKenzie, 2011). Located in the far south east of the Gilbert basin, the Copperfield River catchment is located within the Peninsular Uplands Province which includes the upland and coastal areas of the western part of the Cape York Peninsula and the great Escarpment.

Upper headwater tributaries and the main channel of the Copperfield River to approximately 10km below the Copperfield River Dam are located within the Newcastle Ranges (Pain, Gregory, Wilson, & McKenzie, 2011) region which is comprised of rugged hills on acid volcanic, granitic and metamorphic rocks. The dissected ranges show maximum elevation to around 1,000 m and comprise notable outcrops of resistant porphyry forming a high erosion plain with bare, rounded slopes.

The remaining lower half of the Copperfield River catchment (including the Project site) is part of the Einasleigh Plains physiographic region and characterised by undulating to irregular plains and low hills on granite and metamorphic rocks with ridges and mesas formed of basalts, sandstones, siltstones and porphyry dykes (Tomkiins, 2013). Drainage density is low and contained within shallow until the basalt flows at Einasleigh where valleys become more gorge-like.

Adjacent to the Project site and downstream to the confluence with East Creek, the Copperfield River comprises a wide and relatively shallow bedload-dominated channel. Relatively frequent structural controls result in features such rock outcrops, ledges and pools that are interspersed by extensive deposits of medium to coarse grained sands, gravels and some occasionally larger material up to cobble and occasionally boulder sizes. A well-defined low flow channel traverses the broad sand deposits which are, at times partially vegetated with stands of trees and bushes. While showing signs of a high degree of lateral mobility in some reaches, the low flow channel also has a well-developed but narrow and discontinuous band of riparian vegetation comprised of an open forest structure dominated by Melaleuca and Acacia *spp.*

It is possible that the characteristically high bedload in the Copperfield River and common to the region is the remnant from a past period of more active transport when flow conditions were higher. These periods are linked to the more hydrologically effective climates associated with the glacial/inter-glacial cycles when stream power and potential sediment transport were much greater than present (Nanson, Jones, Price, & Pietsch, 2005). This bedload is typically only reworked downstream during the high energy wet season flow events however it is probable that even during these events that only some of the surface sediment is actively reworked and transported a distance downstream at present, with the remainder stored in the channel bed (Tomkiins, 2013).

5.11 Hydrogeology

5.11.1 Previous Studies

There have been a number of previous investigations of the hydrogeology of the Kidston Gold Mine area. Most of these studies have concentrated on the local regime around Wises and Eldridge Pits and the tailings dam (see Section 8.3 in AGE [2001] for a description of these studies). The studies have tested rock properties and drilled holes to collect geological and hydrogeological information. There has been limited regional scale studies, with AGE (2001) providing some regional context to the hydrogeology, including the development of a groundwater flow model of the Kidston area to investigate groundwater behaviour around the tailings dam.

More recent studies looking at the Project by AGE (including the most recent January 2019 memorandum presented in Appendix H) rely on their original work, and modelling, reported in AGE (2001). The 2019 memorandum (refer to Appendix H) presents predicted changes to the groundwater flow regime from the Project. The modelling has been done through a steady state approach and thus assumes the Project is in place for infinite time. The Project is represented by its extreme pit levels during operation, and this combined with the steady state representation maximises the predicted extent of changes to the groundwater system from the Project. Further to this the model adopts reasonably high hydraulic conductivities to what has been measured in the field for fresh rock. This means that the predicted impacts extend further than would be the case applying the actual measurements for the fresh rock.

The modelling (Appendix H) also indicates potential changes to baseflow to and seepage from Copperfield River, though as the pathline analysis indicates those changes may not occur during the life of the Project.

5.11.2 Regional Geology

The Project Site is located on the Einasleigh - Copperfield Plain within the geological Pre-Cambrian Georgetown Inlier of the North Australian Craton. The Georgetown Inlier is a member of the Etheridge Province, which represents one of four inliers where Precambrian Paleoproterozoic rocks outcrop in northern Queensland (Jell, 2013).

Regional geology, as described in the 1: 100,000 Einasleigh Sheet (7760) geological map (DNRM, 2003a), comprises complex geology inclusive of the Precambrian Einasleigh Metamorphics, Siluro-Devonian Oak River Granodiorite, Carboniferous to Early Permian elements (rhyolite, microgranite, microdiorite, dolerite, gabbro, and andesite), and Quaternary Chudleigh Basalt and alluvial sediments.

The stratigraphy in the region is presented in Table 44.

Table 44 Regional Stratigraphy

Period	Unit	Lithology	Thickness (m)
Quaternary	Alluvium	Sand, gravel, clay, silt	5-6 m in proximity to surface water features
	Chudleigh Basalt	Basalt	
Early Permian			
Carboniferous			
Silurian	Oak River Granodiorite	Granodiorite	
Precambrian	Einasleigh Metamorphics	Gneiss, migmatite, textural granulite, minor schist, quartzite, amphibolite	unknown

5.11.3 Local Geology

The Copperfield River, at the proposed release area, drains through Quaternary alluvial sediments which directly overlie the Einasleigh Metamorphics.

The alluvial sediments (comprising clay, silt, sand, and gravel) extend laterally from the river bed as flood-plain alluvium. Drilling indicates limited thickness of alluvial sediments within the Copperfield River, some 5 to 6 m.

The Einasleigh Metamorphics, predominantly biotite gneisses, outcrop adjacent and (in some sections) within the Copperfield River.

5.11.4 Structural Geology

Regionally, a series of northeast trending faults related (sympathetic) to the Gilberton Fault (described as the Gilberton Corridor) and northwest trending structures parallel to Paddy's Knob dyke swarm and regional foliation are the dominant structures of the area (Genex, 2015).

Near the proposed release area of the Copperfield River, vertical foliation and a platy alignment (dipping east 68 degrees) is mapped in the river bed upstream from the proposed release area; a vertical platy alignment with a dip of 80 degrees westwards is located downstream.

5.11.5 Hydrogeological Setting

The alluvial aquifer is constrained to the terrace containing the Copperfield River.

5.11.6 Hydraulic Properties

Recent investigations by Entura (2015) included in situ permeability testing (packer tests) of seven boreholes measured from less than 8.6×10^{-4} m/day to more than 8.6×10^{-1} m/day with average of 4×10^{-2} m/day. Testing was performed on both 'fresh' and 'weathered' intervals and their results are skewed upwards by testing of the weathered zone.

5.11.7 Groundwater Levels

Two registered bores (BA06 and BA07) are known to be screened in the alluvium. One bore, RN126212, is reported to be constructed in granite as a water supply bore, considered to be the Einasleigh Metamorphics within the mine area. As a result, the impact assessment focused on results from these three locations only. All other bores are designed to monitor the site operations and are not relevant to the assessment of impacts associated with the proposed releases.

The locations of existing groundwater bores are shown in Figure 43.The bore report cards, report that water levels for these alluvial bores range from 1.57 metres below ground level (mbgl) for monitoring well BA07 to 2.8 mbgl for bore BA06.

Water level data for the alluvial bores provided by Genex (2015), in the form of a time-series graph, indicates water levels for bore BA06 varied over time but generally reflects an unconfined aquifer with low water levels during the dry season and elevated levels just after commencement of the wet season. It is noted that from December 2014 through June 2015 (no data was available after June 2015) bore BA06 has been dry.

5.11.8 Groundwater Flow

Regional groundwater flow within the alluvium is considered to mimic the topography of the Copperfield River and subsequent flow direction, generally north.

AGE described the groundwater regime in 2001 as follows:

> *"In the Kidston Mine area the regional watertable is between RL 515-525m and groundwater flow is to the north consistent with the regional drainage pattern. In the area of Eldridge Pit pre-mining water levels ranged from about RL 500m to RL 525m as measured in July 1994. The groundwater flow system around the mine however has been grossly modified by dewatering of the two mine pits and by construction of the tailings dam and interception drains. Dewatering of the pits has created a very steep cone of depression in the water table with a gradient of about 1:1, around the pits."*

The cone of depression around the pits continues to this day and is indicative of the tight host rock that exists around the mine, although the gradient in the cone of depression has become less as the pits received water to aid in their recovery after mining.

The hydrological regime of the Copperfield River is ephemeral; flows are highly episodic and likely sustained only during and immediately after significant rainfall events and the wet season. As such, no permanent pools have been identified through a desktop review of aerial photographs in proximity to the proposed release location. However, the locations of semi-permanent waterholes within the floodplain of the Copperfield River were identified through flyover with a drone by Genex in September 2018.. Section 5.14 provides information regarding the location of these semi-permanent pools, along with the results of dry season water quality sampling undertaken in September 2018.

The presence of semi-permanent pools suggests the river is, at least for some parts of the year, fed by groundwater discharge. The fact that the pools do not persist throughout the year indicates that the groundwater source aquifer (likely the alluvium in the surrounds of the river) has limited storage. Groundwater inflows to the river are potentially sourced from surface water that has infiltrated the alluvium when the river is in flood.

In 2001, AGE further identified that the Gilberton Corridor may be tenuously connected to the Copperfield River (AGE, 2001). No further conceptualisation was performed by AGE; however, it is considered that in the instance a hydraulic connection between the fault system and the river is present, there is potential for migration between the former mine area and the Copperfield River.

5.11.9 Recharge and Discharge

The unconfined alluvial sediments are directly responsive to rainfall and surface water recharge, which occurs during periods of high flows and during the extensive wet season. The alluvial aquifer is considered to have limited groundwater resource potential due to limited (and discontinuous) lateral extent from the Copperfield River, limited saturated thickness, and is expected to have limited effective storage (bores are dry during dry season).

During the operation of the Project, surrounding groundwater will flow into Eldridge pit based on hydraulic gradients. AGE (2019) have estimated this inflow could conservatively be 770 kL/day, but this dependent on an established cone of depression within a more permeable simulated environment than exists at the site. Mounding of groundwater around Wises pit is also predicted to occur as there will be seepage through its base and the elevated groundwater here will interrupt the natural flow of groundwater north, causing water to deviate around the operation, with some of the water moving north being intercepted by the cone of depression around Eldridge Pit.

5.11.10 Groundwater Quality

Alluvial aquifer

Limited hydrochemistry data for the alluvium associated with the Copperfield River is available. Groundwater quality monitoring data provided by Genex was assessed and bore reports from the DNRME registered GWBD were interrogated for groundwater quality data in proximity to the proposed release area.

Two registered bores are reported to be constructed to intersect the floodplain alluvial sediments of the Copperfield River, RN139937 (KGM monitoring bore BA06) and RN139938 (KGM monitoring bore BA07) located adjacent to the mine pits and north and south of the proposed release area.

The available groundwater quality data for these bores, provided by Genex, comprises monitoring from October 2008 through October 2017, which includes some seasonal variability (wet and dry season monitoring) and spatial variability.

Figure 43 Groundwater Bore Locations

- The available data from monitoring bore BA06 indicates magnesium/calcium-sulfate-rich water quality. Sulfate concentrations have varied throughout the monitoring period but generally ranged between ~ 2,500 and 3,000 mg/L, although a marked increase was observed in January 2017, to ~ 5,000 mg/L.
- The available quality data for monitoring bore BA07 indicates a greater proportion of dissolved sodium and chloride, and lower dissolved sulfate concentrations (< 1,000 mg/L) than bore BA06. The January 2017 sulfate 'spike' observed in BA06 was also observed in water quality from BA07 sampled on the same date; however, sulfate concentrations reported subsequently decreased in both bores (to < ~ 1,000 mg/L). Electrical conductivity trends mirror sulphate concentrations.

Samples from both bores record relatively high alkalinity (~ 200-500 mg/L) and pH has remained consistently between 7 and 8 for both bores throughout the monitoring period. Recorded dissolved metals concentrations are generally at or below laboratory LOR in samples from both monitoring bores.

The location of BA07 (just east and down topographic gradient from the former mine pits) and the marked variation in water quality from bore BA06, suggests that seepage from the former mine area may be acting as artificial recharge to the alluvial sediments in proximity to the proposed release area. Figure 44 illustrates the potential impact of former site operations on the water quality at BA06 and BA07. Of the surface water quality samples, monitoring location W2 potentially records some impact, although it is unclear as to whether this is directly from BA07, or from other former mine site sources. The other monitoring points record relatively unimpacted water quality. The assessment of assimilative capacity usage and surface water quality impacts associated with releases are based on historical data from the Copperfield River at monitoring location W2 and therefore take into account the potential seepage impacts as a 'worse case' scenario.

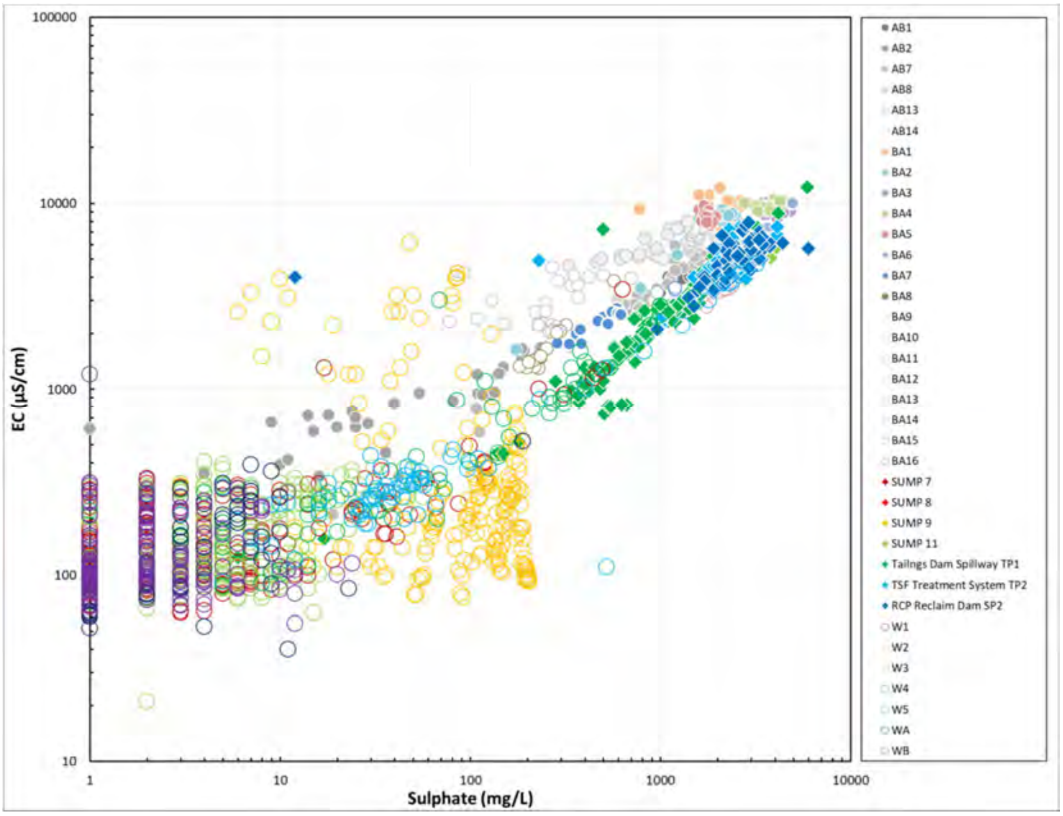


Figure 44 Variation in sulfate concentrations (in mg/L) and EC (in µS/cm) in groundwater sampled from the Project site monitoring bores ('ABxx', 'BAxx'), surface water sampled from sumps and TSF spillways (e.g., 'SUMP xx', 'TP1', etc.), and surface water quality monitoring points W1 to WB

Einasleigh Metamorphics

One bore, RN126212, is reported to be constructed in granite as a water supply bore, considered to be the Einasleigh Metamorphics. Groundwater collected from RN126212 is brackish, with 2,850 mg/L total dissolved solids (TDS).

Regionally, other bores are understood to be installed in the Einasleigh Metamorphics, however these are located northwest of the former mine area considered to be a different hydrogeological system and no corresponding water quality data is available.

5.11.11 Registered Groundwater Bores

The registered groundwater bore database (GWBD), maintained by the DNRME, was interrogated in June 2018 to identify registered groundwater bores within and adjacent to the Project area. The search identified nine bores within a 10 km radius of the proposed Project area. Of the nine bores, eight are identified as monitoring bores (assumed to be for the former mine) and one is reported as a water supply bore. All bores are reported to be existing and sub-artesian groundwater conditions.

Table 45 below presents the registered bore details as recorded in the DNRME GWBD.

Table 45 Registered groundwater bores within 10km of the proposed release area

Registered Number (RN)	Site Name	Easting	Northing	Depth (m)	Geology	Water Level (mbgl)	Yield (L/s)	Type / Name
RN126212	N/A	201242	7908347	25.0	Fractured Granite	9.95	0.26	-
RN139932	BA01	198611	7913081	22.0	Decomposed granite, sandy granite, granite	5.90	-	Monitoring Bore 1
RN139933	BA02	198831	7912522	17.0	Sandy loam, decomposed granite, granite	5.80	-	Monitoring Bore 2
RN139934	BA03	198912	7912195	13.0	Decomposed granite, granite	0.37	-	Monitoring Bore 3
RN139935	BA04	198780	7909475	17.0	Decomposed granite, sandy granite, granite	3.0	-	Monitoring Bore 4
RN139936	BA05	198500	7909198	23.0	Decomposed granite, sandy granite, granite	2.0	-	Monitoring Bore 5
RN139937	BA06	201067	7909160	6.0	River loam, sand	2.80	-	Monitoring Bore 6
RN139938	BA07	201595	7910262	5.0	River loam, sand	1.57	-	Monitoring Bore 7
RN139946	BA16	197557	7910673	17.0	Decomposed granite, granite	1.90	-	Monitoring Bore 16

5.11.12 Groundwater Dependant Ecosystems

A search of the State of Queensland (2018) Queensland Globe was undertaken for known GDEs from south of Kidston to Einasleigh. A total of four (4) known GDEs were identified in the search area where the reported information for each spring is included in Table 46. No registered springs are located within the proposed release area.

A review of the Queensland Wetlands (2013) map for the Einasleigh area (sheet 7760) indicates one confirmed wetland spring, Middle Spring, within the vicinity of the former mine area. As included in Table 45 above, this spring is located west-northwest of the former mine and not considered to be hydraulically connected to the groundwater regime of the proposed release area, however it is recommended that this spring is further assessed as part of water modelling refinement and design phase work.

Table 46 Summary of GDEs

GDE Name	GDE Type	Spring vent ID	Status	Source Rock Type	Source Aquifer	Direction from Project	Distance from Project
Middle Spring	Surface expression (Spring)	482_1	Permanent / near permanent	Fractured rock (predominantly secondary porosity)	Einasleigh Metamorphics	West-northwest	~4.8 km
Topwater Spring	Surface expression (Spring)	438_1	Permanent	Fractured rock (predominantly secondary porosity)	Beverley Hills Granite	Northwest	~22 km
Pigeon	Surface expression (Spring)	437_1	Permanent	Fractured rock (predominantly secondary porosity)	Oak River Granodiorite	North	~34 km
Pigeon II	Surface expression (Spring)	439_1	Permanent	Alluvial sediments	Quaternary Alluvium	North	~34 km

A desktop assessment of riparian REs in the Copperfield River, downstream of the Project site has been undertaken. Additionally, the desktop assessment identified alluvial REs in Copperfield River from the Project site to its confluence with Oak River some 20 km downstream, to determine if GDEs were present. Four REs were identified and are presented in Table 47 below. None of these REs were identified as GDEs and as a result, there is no risk of impact to alluvial vegetation communities in Copperfield River as a result of stream flows.

Table 47 REs downstream Copperfield River

RE	Short Description
RE 9.3.3a	*Corymbia* spp. and *Eucalyptus* spp. dominated mixed woodland on alluvial flats, levees and plains.
RE 9.3.12a	Sandy river beds sometimes with patches of ephemeral grassland, herbland or sedgeland, which can include *Heteropogon contortus* (black speargrass), *Bothriochloa spp.*, and *Ammannia multiflora.*
RE 9.3.13	*Melaleuca* spp., *Eucalyptus camaldulensis* and *Casuarina cunninghamiana* fringing open forest on streams and channels.
RE 9.3.20	*Eucalyptus microneura* +/- *Corymbia* spp. +/- *E. leptophleba* woodland on alluvial plains.

Appendix H presents groundwater level changes predicted by AGE on a map containing the GDE mapping from the National Atlas of Groundwater Dependent Ecosystems (BOM, 2018). From a groundwater perspective, the mapping indicates:

> *"… that terrestrial GDEs may be present over large areas of land close to the K2-Hydro Project. Areas of highest potential are located along the drainage lines. It is possible that high potential GDEs along the Copperfield River could see a reduction in groundwater as a result of the Project. The majority of the area predicted to draw down by more than 1 m is unclassified over the historically disturbed mining areas, or at low potential for terrestrial GDEs.*
>
> *Potential aquatic GDEs are located along many of the nearby drainage lines, with the locations correlating strongly with the high potential terrestrial GDE mapping. The majority of aquatic GDEs are classified as moderate or low potential, with a small area of high potential along the Copperfield River to the northeast of the K2 Project. It is possible that GDEs along the Copperfield River could see a reduction in groundwater inputs as a result of the K2 Project.*
>
> *Although there are potential changes in groundwater levels predicted in the vicinity of several potential GDEs additional work will be required to determine if the changes could result in a negative impact to the vegetation communities.*
>
> *There is one permanent spring (SPR482 - Middle Spring), located approximately 4.8 km west-northwest of the Project. This is close to the edge of the model domain and is predicted to be impacted by less than 0.2 m from a very conservative steady state assessment."*

It is important to note that last comment, in that the steady state predictions AGE make in their memo (AGE, 2019) are reasonably conservative and assume there is sufficient time for the drawdowns and mounding to propagate to the presented extents.

5.12 Sediment Quality

The Copperfield River is a braided river system. Geomorphic models of this kind of river system place it as transport limited; that is, there is not enough stream power to transport the sediment that it is required to carry. Sediment transport throughout the region is limited to a few months per year during the wet season when discharge is high enough to enable sediment transport. The majority of sediment throughout the region is transported as bedload (Tomkins, 2013). Suspended sediment is transported further during flow events or deposited overbank with very little fine sediment stored in the channel bed in the upper to mid catchments (Tomkins, 2013).

Sediment infilling rates for the Copperfield River Dam are between 12% and 22% over a 30 year period (Tomkins, 2013). The predicted sediment yield of the Copperfield River to the Copperfield Dam is approximately 109,002 tonnes per year (Tomkins, 2013).

Sediment sampling to date has been guided by the EA for the historical mining activities as well as the REMP. Sediment samples have been collected annually between 2009 and 2013. An additional set of sediment samples was collected as part of this assessment in accordance with the methods outlined in the REMP (Genex Power, 2015). Sediment samples have been collected from monitoring locations WB, W1, W2 and W3. Additional sediment samples were also collected from sites E1 and E2 as part of this assessment.

Each sample has been analysed for particle size distribution as well as a limited number of metals as outlined in the site's current EA. Sediment samples have been collected in accordance with the Australian/New Zealand Standard "Water Quality Sampling Part 12: Guidance on Sampling of Bottom Sediments" (AS/NZS 5567.12). All sediment samples were collected by creating a composite sample while walking at a right angle to the stream bank and taking a 100g scoop of sediment approximately every 10 steps as outlined in the REMP (Genex Power, 2015). Sediment trigger values and contaminant limits are based on the Sediment Quality Guidelines (SQG) and SQG-High found in Simpson, Graeme, & Chariton (2013).

Generally the Copperfield River consists of 60% coarse sands (between 0.6 mm to 2 mm), 20% medium sands (between 0.15mm to 0.6mm), and 10% fine gravel (between 2.36 mm to 4.75 mm) (Figure 45). Approximately 5% of the sediment distribution in the river is greater than 4.75 mm in diameter (Figure 45). The percentage that comprises fine clay and silts (<0.063 mm) is generally around 1 to 3% of each sample (Figure 45). Particle size distribution of each sample is highly variable between sites as well as between years (Figure 45). This is a result of the inherent uncertainty with sediment sampling within an ephemeral river system over time.

A selection of samples have undergone metals analysis on the total composite sample as well as the <0.063 mm fraction only (Table 48). Total samples are analysed on the whole sediment fraction after undergoing a mineral acid dissolution after oven drying to establish dry weight (Genex Power, 2015). A similar process is undertaken after sieving the sample to <0.063 mm to determine metal concentrations. The <0.063 mm sediment fraction is the most readily ingested by organisms (Simpson, Graeme, & Chariton, 2013). Particles <0.063 mm are more common in the gut of sediment-ingesting biota (Simpson, Graeme, & Chariton, 2013). Assessment of the <0.063 mm fraction is considered warranted when more detailed investigations of bioavailable contaminants are required (Simpson, Graeme, & Chariton, 2013).

Metal analyses for the total sediment fraction indicate that there are no samples that exceed the SQG provided by Simpson, Graeme, & Chariton (2013) (Table 48). Sediment within the Copperfield River at the nominated monitoring sites is therefore considered to be unaffected by historical mining processes.

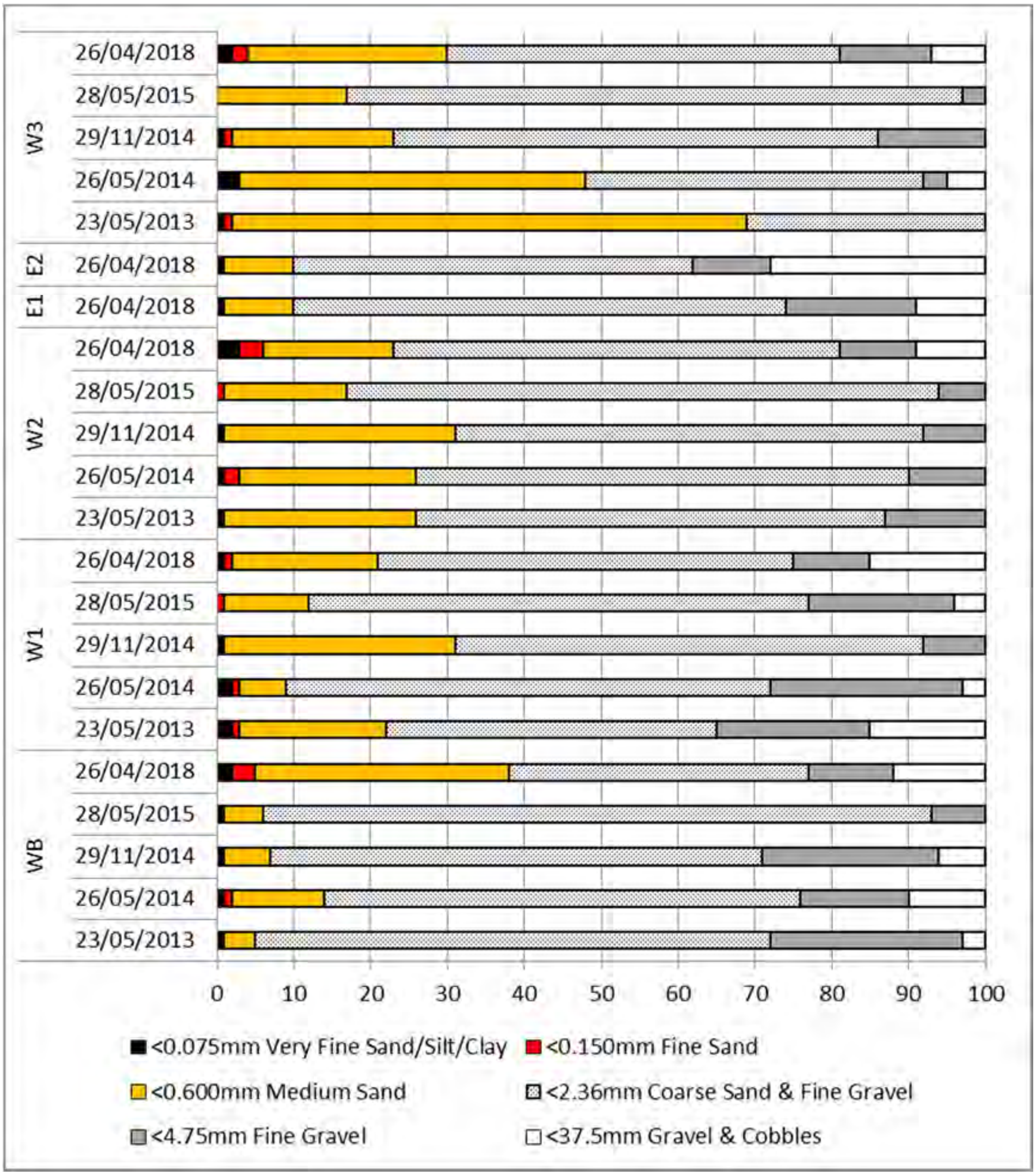


Figure 45 Particle Size Distributions for Sediment Samples

Metal concentrations for the <0.063 mm fraction are high compared to the total sample results (Table 48). Graphs produced of these in Figure 46 and Figure 47 show that all metals analysed have an exceedance of the trigger values in at least one receiving environment monitoring location. This is expected as the <0.063 mm fraction contains the largest surface area per mass and is therefore the most geochemically reactive. Contemporary guidelines (Simpson, Graeme, & Chariton, 2013) do not recommend comparison of the <0.063 mm fraction to sediment trigger values at the outset and this analysis is only considered worthwhile for metal speciation and bioaccumulation studies.

The ANZECC (2000) guidelines (Table 2.2.2) recommend that an exceedance occurs in toxicants in sediments when the 95th percentile exceeds the ISQG low (i.e. trigger level). The 20th, 50th, 80th and 95th percentiles for metal concentrations in the <0.063 mm fraction have been plotted on Figure 46 and Figure 47 as well as the trigger levels and contaminant limits outlined in (Simpson, Graeme, & Chariton, 2013). The 95th percentile exceeds the trigger value at almost all sites for almost all metals. Concentrations are highest at interim sites (W1 and W2) whereas the concentrations at the upstream and downstream site (WB and W3 respectively) are generally similar.

Where trigger levels are exceeded, they are also exceeded at the upstream site (WB). Arsenic and zinc are the only parameters that exceed guideline values in the <0.063 mm fraction at either site W1 or W2, or where the trigger value is not exceeded at the upstream site (WB). This indicates that there are no widespread impacts from historical mining activities evident within the Copperfield River and that the concentrations of metals found are a result of the overall catchment drainage.

Although the <0.063 mm fraction shows exceedances of most trigger values and some contaminant limits, the total sediment fraction does not. Although not specifically outlined in any documentation, including the DES's latest Monitoring and Sampling Manual (2018), contemporary stream sediment monitoring programs for mines involve:

- Targeted sampling at areas of finer sediments such as scour holes or waterholes.
- Fractionation of the sediment sample into <0.063 mm and <2 mm and subsequent metals analysis on both.
- Some degree of initial replication of samples to define variability and refine sampling methodology.

It is recommended that future monitoring occurs in accordance with the above guidance. The REMP developed for the Project will incorporate this sampling design into the sediment monitoring sections.

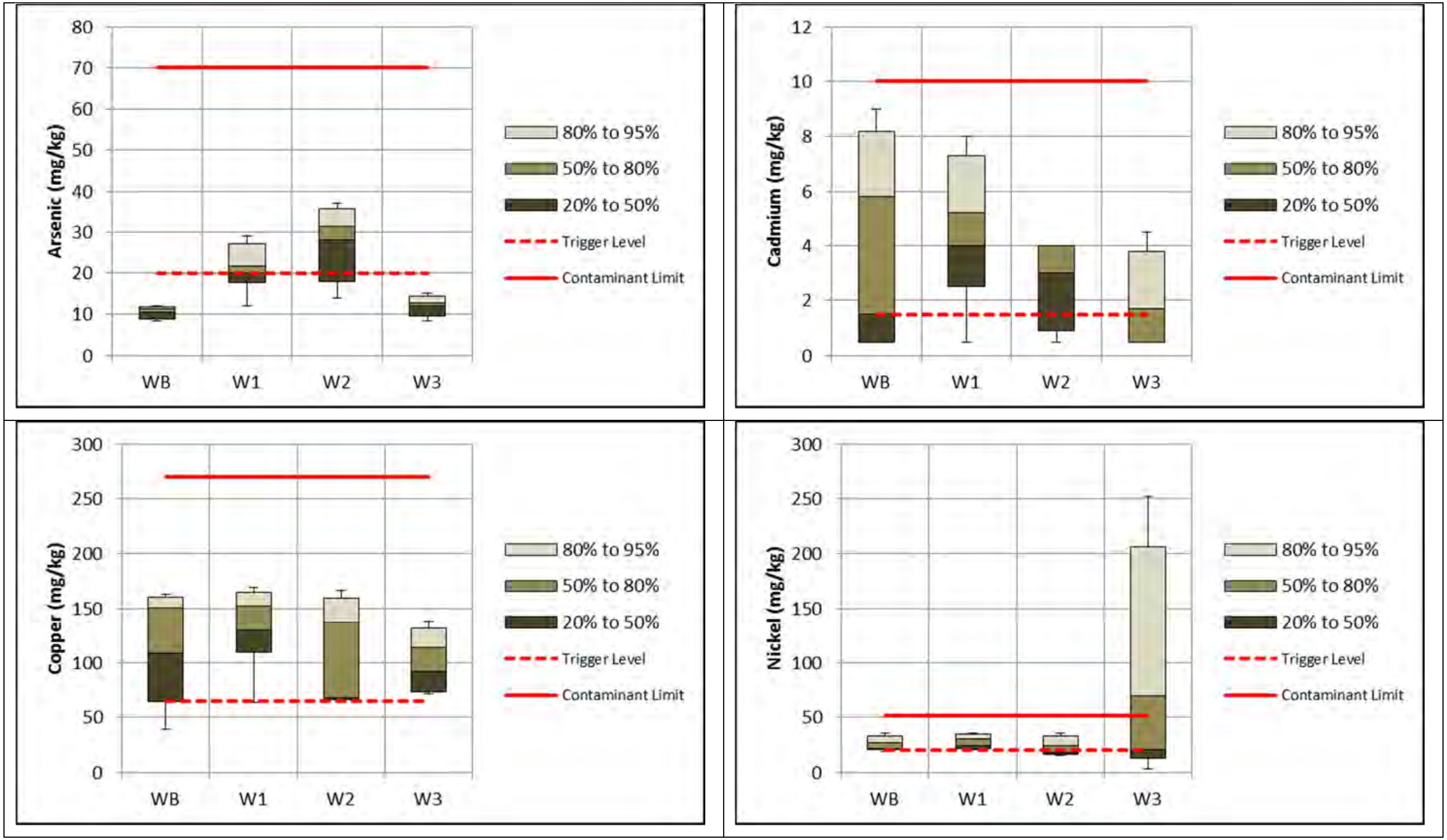


Figure 46 Stream sediment levels in samples analysed for <63µm fraction for arsenic, cadmium, copper and nickel

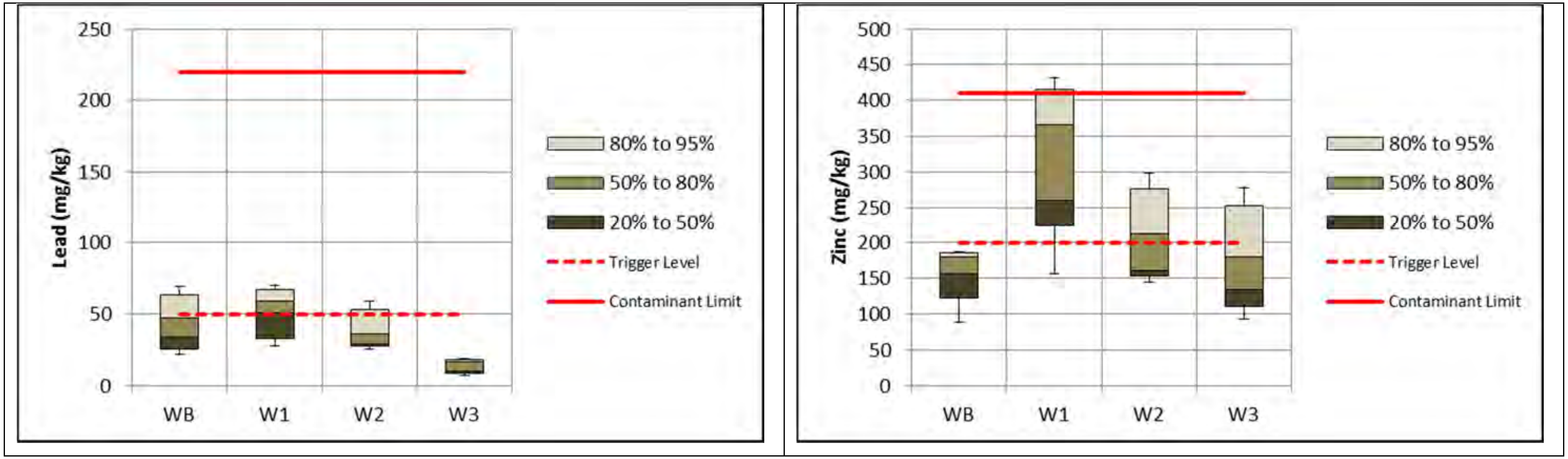


Figure 47 Stream sediment levels in samples analysed for <63µm fraction for lead and zinc

Table 48 All Sediment Results to Date for the Copperfield River

Site	Date	Arsenic		Cadmium		Copper		Nickel		Lead		Zinc		Chromium	WAD CN
		Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Total[1]
SQG		20		1.5		65		21		50		200		80	0.1
SQG-High		70		10		270		52		220		410		370	0.1
WB	19/03/2009	<5	--	<0.5	--	3	--	<3	--	3	--	9	--	--	<0.5
WB	19/09/2010	<5	--	<1	--	<5	--	<2	--	<5	--	<5	--	2	<1
WB	28/06/2011	<5	--	<1	--	<5	--	2	--	<5	--	6	--	2	<1
WB	7/05/2012	<5	--	<1	--	<5	--	<2	--	<5	--	<5	--	<2	<1
WB	23/05/2013	<5	11	<1	<3	<5	**109**	2	**22**	<5	42	10	178	4	<1
WB	19/11/2013	<5	*<21*	<1	**<10**	<5	**163**	<2	**25**	<5	34	5	156	2	<1
WB	26/05/2014	<5	9	<1	<1	<5	**71**	<2	21	<5	27	<5	130	<2	<1
WB	29/11/2014	<5	12	<1	<1	<5	40	3	**36**	<5	22	14	88	6	<1
WB	28/05/2015	<5	<17	<1	**9**	<5	**148**	<2	19	<5	**69**	8	188	2	<1
WB	26/04/2018	<5		<1		<5		3		<5		13		5	--
W1	19/03/2009	<5	--	<0.5	--	7	--	**16**	--	<5	--	50	--	--	<0.5
W1	19/09/2010	<5	--	<1	--	<5	--	<1	--	<5	--	8	--	3	<1
W1	28/06/2011	<5	--	<1	--	<5	--	3	--	5	--	22	--	6	<1
W1	7/05/2012	<5	--	<1	--	<5	--	<2	--	<5	--	5	--	3	<1
W1	23/05/2013	**10**	**20**	<1	<8	11	**121**	5	**22**	13	**51**	71	**350**	7	<1
W1	19/11/2013	<5	**29**	<1	**4**	5	**169**	3	**30**	7	**70**	32	***431***	4	<1
W1	26/05/2014	7	12	<1	**3**	<5	64	<2	21	<5	34	18	**242**	3	<1
W1	29/11/2014	<5	19	<1	<1	<5	**130**	3	**36**	<5	28	15	156	4	<1
W1	28/05/2015	<5	**20**	<1	**8**	<5	**148**	<2	**25**	<5	**56**	30	**260**	3	<1

Site	Date	Arsenic		Cadmium		Copper		Nickel		Lead		Zinc		Chromium	WAD CN
		Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Total[1]
SQG		20		1.5		65		21		50		200		80	0.1
SQG-High		70		10		270		52		220		410		370	0.1
W1	26/04/2018	<5		<1		<5		<2		<5		5		3	--
W2	19/03/2009	**15**	--	<0.5	--	5	--	8	--	<3	--	18	--	--	<0.5
W2	19/09/2010	<5	--	<1	--	<5	--	<2	--	<5	--	<5	--	2	<1
W2	28/06/2011	<5	--	<1	--	<5	--	<2	--	<5	--	10	--	2	<1
W2	7/05/2012	<5	--	<1	--	<5	--	<2	--	<5	--	7	--	4	<1
W2	23/05/2013	<5	**30**	<1	*<8*	<5	**68**	2	16	<5	29	12	191	4	<1
W2	19/11/2013	**15**	**37**	<1	**3**	<5	**167**	<2	18	<5	30	29	**298**	3	<1
W2	26/05/2014	<5	14	<1	1	<5	**67**	<2	**22**	<5	26	8	144	2	<1
W2	29/11/2014	<5	19	<1	<1	<5	**130**	3	**36**	<5	28	15	156	4	<1
W2	28/05/2015	<5	**28**	<1	*<8*	<5	64	<2	17	<5	**59**	10	161	4	<1
W2	26/04/2018	<5		<1		<5		<2		<5		9		3	--
W3	19/03/2009	<5	--	<0.5	--	<3	--	<3	--	3	--	10	--	--	<0.5
W3	19/09/2010	<5	--	<1	--	<5	--	<2	--	<5	--	6	--	4	<1
W3	28/06/2011	<5	--	<1	--	<5	--	<2	--	<5	--	7	--	3	<1
W3	7/05/2012	<5	--	<1	--	<5	--	2	--	<5	--	8	--	5	<1
W3	23/05/2013	<5	<17	<1	*<9*	<5	**138**	4	**21**	<5	19	19	156	8	<1
W3	19/11/2013	<5	12	<1	<1	<5	**108**	<2	15	<5	10	10	**277**	6	<1
W3	26/05/2014	<5	15	<1	<1	<5	**72**	2	**24**	<5	9	9	134	4	<1
W3	29/11/2014	<5	12	<1	<1	<5	**92**	4	3	<5	16	16	115	9	<1
W3	28/05/2015	<5	10	<1	*<2*	<5	**74**	<2	***252***	<5	7	7	92	3	<1

Site	Date	Arsenic		Cadmium		Copper		Nickel		Lead		Zinc		Chromium	WAD CN
		Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Total[1]
SQG		20		1.5		65		21		50		200		80	0.1
SQG-High		70		10		270		52		220		410		370	0.1
W3	26/04/2018	<5		<1		<5		2		<5		9		4	--
E1	26/04/2018	<5		<1		<5		2		<5		6		6	--
E2	26/04/2018	<5		<1		<5		<2		<5		8		4	--

Legend

Exceeds SQG-High

Exceeds SQG

LOR above SQG

[1] Total refers to the whole sediment sample
[2] Fine references the <0.063mm fraction

5.13 Aquatic Ecology

An aquatic ecology assessment was undertaken for the Project by C & R Consulting in April 2018. The purpose of this study was to determine aquatic ecological values present within the receiving environment to facilitate an impact assessment and propose mitigation strategies. The study involved a review of existing data from desktop sources and previous assessments and field surveys to identify the potential for conservation significant species as well as characterise habitat available for aquatic organisms and stream health.

The Copperfield River is a large ephemeral, braided watercourse which runs through the Eiansleigh Uplands bioregion in Far North Queensland, approximately 250km southwest of Cairns North. Access for sampling during the wet season is restricted from a safety perspective due to increased velocities of flows and inherent risks to the sampler. The high flow rates experienced in the Copperfield River over the wet season limits the establishment of aquatic flora and small bodied fauna communities. Successful recruitment in these systems can then occur once peak flows have subsided.

During the dry season the Copperfield River typically becomes a series of disconnected pools with reduced water quality. These pools experience large diurnal fluctuations which limit the diversity of remnant flora and fauna communities. The pools can be heavily impacted by cattle and feral pigs as they become the final refuges for these exotic species to water. Therefore aquatic ecology surveys in such systems often target the end of the wet season once significant flows have reduced as this is the period when the system will maintain its most diverse and healthy aquatic flora and fauna assemblages.

As such the aquatic ecology field survey was undertaken between 21 to 25 April 2018, approximately six weeks following significant flows in the receiving environment in accordance with AusRivAS methods. The provision of a late wet season aquatic ecology survey is considered suitable to provide an understanding of the condition of the receiving environment in the Copperfield River.

The following sections summarise the findings of the 2018 survey and previous data where available. For further details, refer to the Aquatic Ecology Survey Report in Appendix E.

5.13.1 Approach

The aquatic ecology survey assessed the values stated below. Full details of the methodology are outlined in Appendix E:

- Aquatic habitat characteristics and condition (using AusRivAS procedures)
- Water quality – physicochemical parameters and a suite of analytes
- Aquatic flora communities – including macrophytes and algae
- Fish communities (using backpack electrofishing, baited traps, seine nets, tangle nets, dip nets). Data analysis including:
  - Species richness
  - Total abundance
  - Abundance of listed aquatic species
  - Abundance of exotic species; and
  - Abundance of each life history stage present (e.g. juvenile, intermediate or adult)
- Turtles (visual surveys and baited cathedral traps)
- Other aquatic vertebrates (via database searches)
- Aquatic macroinvertebrate communities - using Queensland AusRivAS procedures and analysis of the following indices to categorise stream health:
  - **Taxonomic richness** – total number of macroinvertebrate taxa collected at each site. Typically healthier communities have a greater diversity

- **PET taxa richness** – indicates the number of families collected from three orders which are considered sensitive to environmental change (Plecoptera, Ephemeroptera and Trichoptera). A low diversity of families collected from these orders may suggest habitat degradation
- **SIGNAL 2 Index** – The Stream Invertebrate Grade Number Average Level (SIGNAL) is a measure of the sensitivity of freshwater macroinvertebrate families to pollutants and other physical and chemical stressors. The SIGNAL 2 score is a weighted score based on the community composition and scored against background assessments for the region or stream specific boundaries if sufficient data is available. This study has adopted interim boundaries based on the Central Queensland regional guidelines as a basis for comparison as these appear most relevant (QWQG, 2009)
- **Band Rating** – Band rating is determined by applying data to the AusRivAS modelling programme to provide an indication of the level of biological impairment experienced at the target sites. Sites are categorised into five potential bands based on this biological impairment as outlined below:
  - **Band X**: site is richer than reference sites within the region suggesting a potential biodiversity ‘hotspot’ or mild organic enrichment
  - **Band A**: site is in similar condition to reference sites i.e. in similar condition to the natural state of streams in the region
  - **Band B**: site is significantly impacted likely due to mild impact to water quality and/or habitat
  - **Band C**: site is severely impacted likely due to severely impacted water quality and/or habitat resulting in a loss of diversity
  - **Band D**: site is impoverished due to highly degraded water quality and/or habitat.

Surveys were undertaken at six locations which were co-located with historical water quality sampling sites (See Figure 47). Four of these sites were chosen based on historic monitoring locations (WB, W1, W2 and W3) to ensure historical trends in water quality and macroinvertebrate assemblages could be compared against the findings. Two additional sites were included (E1 and E2) to provide further information on the influence of East Creek.

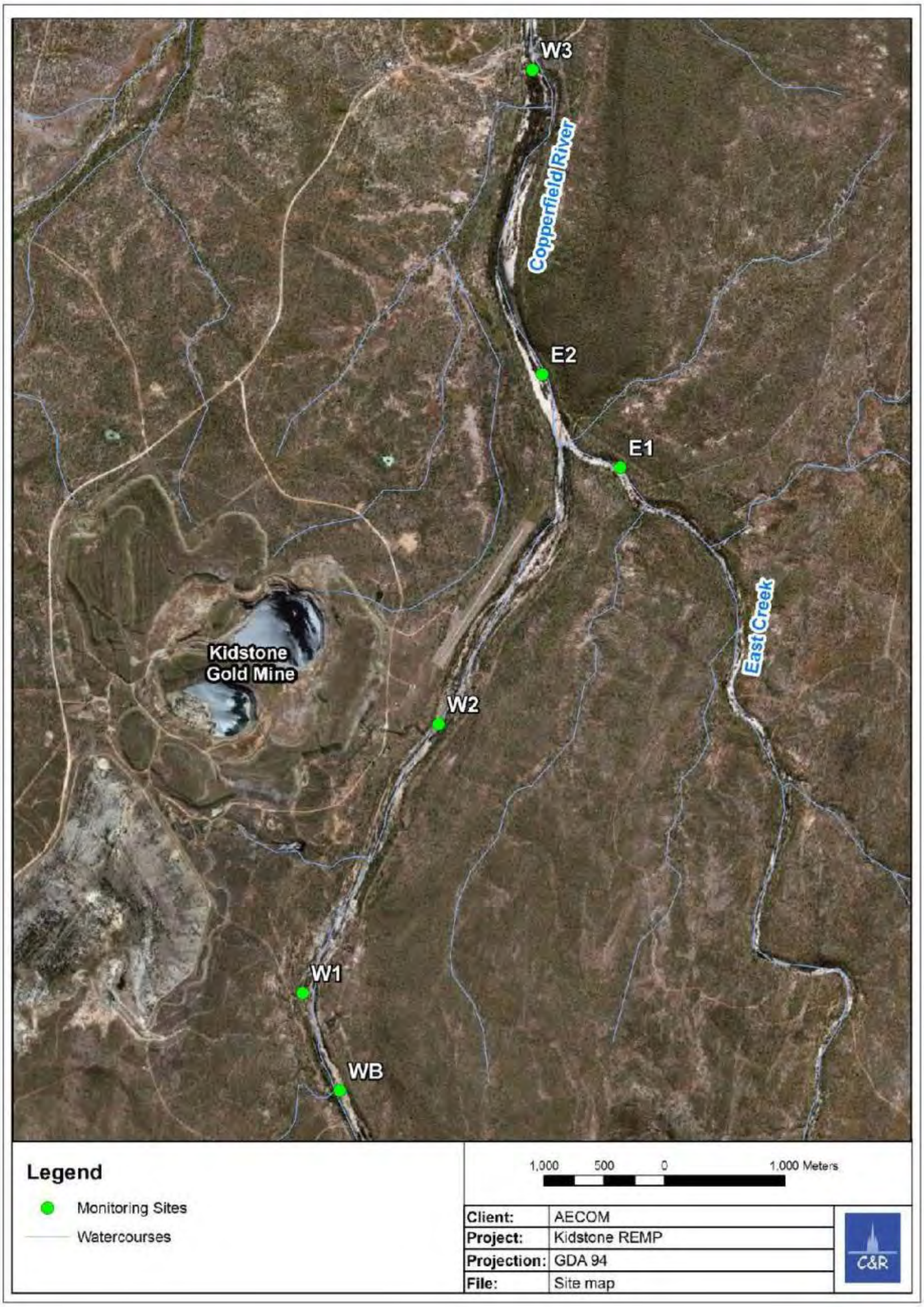


Figure 48 Aquatic ecology sample site locations

5.13.2 Riparian Vegetation

A desktop review found the following sub-dominant of concern Regional Ecosystems (RE) along banks of the Copperfield River in the vicinity of the Project.

RE	Full Description
RE 9.3.20 Least Concern Eucalyptus microneura +/- Corymbia spp. +/- E leptophleba woodland on alluvial plains	• Woodland to low open woodland of *Eucalyptus microneura (Georgetown box) +/- Corymbia pocillum +/- E. leptophleba (Molloy red box) +/- Terminalia spp.* • There is an absent to sparse mixed shrub layer which can include juvenile canopy species, *Gardenia vilhelmii (breadfruit), Dolichandrone alternifolia (lemonwood), Atalaya hemiglauca (whitewood), Melaleuca spp. and Carissa lanceolata (currantbush)*, with some of these species sometimes forming an open sub-canopy layer. • The grassy ground layer is generally dominated by *Heteropogon contortus (black speargrass), Eragrostis spp. and Aristida spp*. • Occur on alluvial plains. (BVG1M: 18d)
RE 9.3.3a Of Concern Corymbia spp. and Eucalyptus spp. dominated mixed woodland on alluvial flats, levees and plains	**RE 9.3.3** • Mixed woodland to open woodland often dominated by *Eucalyptus leptophleba* (Molloy red box) but also including combinations of the species *E. platyphylla* (poplar gum), *Corymbia clarksoniana* (Clarkson's bloodwood), *E. crebra* (narrow-leaved ironbark), *C. tessellaris* (Moreton Bay ash), and *Erythrophleum chlorostachys* (Cooktown ironwood) +/- *C. grandifolia subsp. grandifolia and C. polycarpa* (long-fruited bloodwood). • An open sub-canopy dominated by canopy species often occurs. • An absent to a mid-dense shrub layer of *Melaleuca spp., Planchonia careya* (cocky apple), *Carissa lanceolata (currantbush)* and juveniles of canopy species can occur. • The mid-dense to dense ground layer is dominated by *Heteropogon spp., Themeda triandra* (kangaroo grass) and *Sarga plumosum* (plume sorghum). • Occurs on alluvial plains, terraces and levees. Soils are generally sandy alluvium. (BVG1M: 16b) **RE9.3.3a** • Woodland to low open woodland of *Eucalyptus leptophleba* (Molloy red box) +/- *E. platyphylla* (poplar gum) +/- *Corymbia confertiflora* (broad-leaved carbeen) +/- *E. crebra* (narrow-leaved ironbark) or *E. cullenii* (Cullen's ironbark) +/- *C. clarksoniana* (Clarkson's bloodwood). • The subdominant species may be codominant in this community. • An open sub-canopy of canopy species can occur. • The shrub layer is absent to sparse and contain juvenile canopy species, *Carissa lanceolata* (currantbush) and *Atalaya hemiglauca* (whitewood). • The dense grassy ground layer is dominated by *Heteropogon contortus* (black speargrass) and *Bothriochloa spp.* (bluegrasses). • Occurs on alluvial plains and terraces. Floodplain (other than floodplain wetlands). (BVG1M: 16b)

5.13.3 Aquatic Habitat Characteristics and Condition

During the survey period the Copperfield River was still experiencing flow conditions, while East Creek retained water in a series of pools connected by subsurface flows. The following aquatic habitat factors were identified within the Project site;

- Run
- Riffle
- Deep pool
- Shallow pool
- Undercut/eroded bank
- Bedrock; and
- Complex woody debris.

Details of aquatic habitat within each site can be found in Table 3 of Appendix E.

An AusRivAS habitat condition assessment was completed for each sample location which included assessing the following habitat factors to provide a rating of habitat quality:

- Bottom substrate and available cover
- Embeddedness
- Velocity / depth of cover
- Channel alteration
- Bottom scouring and deposition
- Pool/riffle, run/bend ratio
- Bank stability
- Bank vegetative stability; and
- Streamside cover.

The results of these assessments determined that five of the six sites were in ‘good’ condition, with one site (E1) observed in a ‘Moderate’ condition. The similarity of condition observed at the majority of sites is likely due to the relative uniformity of flowing habitats comprised of riffle and run units during the assessment. Lack of flows and subsequent reduced diversity of habitats in E1 is likely to have reduced the score at this reach.

Only two species of macrophytes were encountered at the monitoring sites. These included rice sedge (*Cyperus difformis*) and *Cyperus sp.*. Prolonged flows immediately prior to the survey is a probable cause of the low diversity of macrophyte species encountered.

5.13.4 Physico-chemical Water Quality Parameters

In-situ water quality analysis results were relatively stable across the majority of parameters (Table 49) with the exception of temperature. Stability of the majority of parameters is expected due to consistent flow mixing water in the system and variability in observed temperatures is largely due to time of sampling during each day.

Table 49 In-situ physico-chemcial water quality results

Site	Temperature (°C)	Electrical Conductivity (µS/cm)	pH (pH units)	Dissolved oxygen (% saturation)
WB	23.23	107	7.75	N/A
W1	20.99	113	7.75	91.7
W2	25.67	108	7.81	100.9
E1	22.50	116	7.78	105.9
E2	22.20	112	7.9	100.9
W3	25.00	115	7.63	99.2

5.13.5 Macroinvertebrates

5.13.5.1 Historical Survey Results

Macroinvertebrate assessments were previously conducted at four of the six sites between 2009 and 2013. A number of indicators have been derived from macroinvertebrate surveys undertaken during this period including (Barrick Australia, 2013):

- Diversity of taxa
- Shannon Diversity Index / Shannon Equitability Index
- SIGNAL 2 Index; and
- AusRivAS Band Scores.

A summary of previous macroinvertebrate sampling from the REMP (Genex Power, 2015) indicates that there is little to no impact resulting from historic mining activities at Kidston as:

- All sites fell into "Band A", indicating no significant deviation of species and families from what would be expected at reference sites.
- SIGNAL 2 values are equivalent at the upstream, intermediate and downstream sites, indicating that the receiving environment did not vary from what is expected within the other areas in the system.
- Cluster analysis suggests a larger difference in macroinvertebrate assemblage between years rather than between sites.
- Results suggest slightly higher overall environmental health at WB and W1 than sites further downstream. The differences between sites are very minor and may be attributable to differences in habitat structure rather than contaminant release from the site.

5.13.5.2 Survey Results 2018

The 2018 macroinvertebrate assessment (Appendix E) compared values and indices from the data collected against guidelines from Central Queensland as there are no guidelines specifically developed for the region. Due to natural spatial variation in water quality, guidelines need to be interpreted in a local context or against site-specific predictions. The Central Queensland guidelines are considered most appropriate because of several watercourse characteristics, including:

- Highly seasonal flow regime
- Substrates typically dominated by sand and interspersed with bedrock barrages and intermittent riffle zones
- High amount of sediment movement within the channel during flow events; and
- Turbid waters.

Although similarities in watercourse characteristics do exist between the regions, no specific guidelines have been developed for the region. As such the Central Queensland guidelines are used as a reference, but conclusions drawn from the results are not definitive. More value is derived from the macroinvertebrate data from comparison of upstream sites to downstream sites.

The earlier studies (2009-2013) do not state which set of guidelines data were compared against. Therefore comparison of the AusRivAS modelling and resultant classification from the 2009-2013 dataset to the 2018 dataset could be misleading.

Taxonomic Richness

Fifty one macroinvertebrate taxa were recorded during the field survey, a higher diversity than were recorded for each sampling event between 2009 and 2013.

For bed habitat, five of the six sampling locations achieved the 20th percentile value stipulated by the QWQG for the Central Coast region. Where this criteria was not met (site E2) the bed substrate was dominated by sand. The reduced richness at this location is likely attributable to the lack of structural complexity.

Only two sites (W1 and E1) were compliant with the QWQG 20th value for the Central Coast region with no sites exceeding the 80th percentile. Edge habitat is typically more diverse than bed habitat leading to greater rates of primary production and in turn higher diversity of macroinvertebrate taxa. This was true of the edge habitat observed during the survey which consisted primarily of exposed roots with scouring from recent flows evident. However, lack of diversity of habitat units, with almost all sites being within riffle habitat, may have limited macroinvertebrate diversity. Further, as no guidelines are available for this area, this may be consistent with regional trends.

PET Richness

Both bed and edge habitats recorded PET richness scores significantly above the 20th percentile guideline value and often equal or above the 80th percentile guideline value for the Central Queensland region. These results suggest that the macroinvertebrate communities are in excellent condition. However, the possibility that these guidelines are not relevant to the region must still be considered.

SIGNAL 2

SIGNAL 2 / Family bi-plots is a simple biotic index for freshwater macroinvertebrates which provides an indication of how pollutants and other anthropogenic and environmental stressors are impacting the structure of macroinvertebrate assemblages. Results from the bed and edge habitat were compared against the Central Queensland guidelines.

Only one SIGNAL 2 score fell outside of quadrant 1. Site E2 fell into quadrant 3 suggesting that this location was experiencing toxic pollution or harsh environmental conditions. An analysis of a suite of analytes determined that at this location all of these parameters were compliant with the default ANZECC and ARMCANZ (2000) water quality objectives for 95% Species Protection level, with the exception of dissolved aluminium. However these levels of dissolved aluminium are not outside of the range experienced in the system naturally, with higher recordings at upstream sites. It is likely that the quadrant positon of E2 was a result of harsh environmental conditions experienced naturally in the region and the lack of habitat diversity at the site.

For edge habitat, both upstream and downstream sites fall into quadrant three, suggesting that all sites were experiencing harsh conditions, either naturally or from anthropogenic impacts. This result may have been influenced by high flow rates in the previous month, limiting the ability of some families to recolonise and reducing the diversity of available habitat. These results are consistent with both upstream and downstream sites and as such they are unlikely a result of activities associated with the Kidston Gold Mine.

AusRivAS Modelling

Macroinvertebrate data was interpreted using AusRivAS modelling which categorises bed and edge habitat for each site into a 'Band' which provides an indication of the degree of biological impairment. Bed and edge habitat fell within either Band A or Band B for all sites. Brief descriptions of the Bands are below:

- Band A classed as *similar to reference sites*; and
- Band B classed as *significantly impaired.*

The results of this modelling indicated that bed habitat was more biologically impaired than edge habitat. Bed habitat at all sites was evaluated to be within Band B, while at four of the six sites (W1, W2, E1 and E2) the edge habitat was within Band A.

These results were consistent with PET richness and taxonomic richness which suggested that bed habitat was not as favourable for establishment or persistence of macroinvertebrate assemblages.

Other Macroinvertebrates

Other macroinvertebrates observed during the survey consisted of three larger-bodied decapod species. These included redclaw (*Cherax quadricarinatus*), freshwater prawn (*Macrobrachium australiense*) and inland freshwater crab (*Austrothelphus transversa*). None of these species are listed as threatened under the *Nature Conservation Act 1992* (NC Act) or the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

5.13.6 Fish Communities

Seven species of freshwater fish were identified during the field survey. These included:

- Checkered rainbowfish (*Melanotaenia mogurnda*)
- Northern trout gudgeon (*Mogurnda mogurnda*)
- Hyrtl's tandan (*Neosuluris hyrtlii*)
- Spangled perch (*Leiopotherapon unicolor*)
- Sooty grunter (*Hepthaestus fuliginosus*)
- Bony bream (*Nematolosa erebi*); and
- Barred grunter (*Amniataba percoides*).

Site W3 had the highest species richness identified during the survey (six species) and also the highest abundance (approximately 90 individuals). Site W2 recorded the lowest abundance (approx. 30) and species richness (3) out of all monitoring sites (Appendix E). Comparatively the East Creek upstream site (E1) had a similar species richness as W2 (3 species) but a much higher abundance (approximately 65).

5.13.7 Turtles

No turtles were encountered during the assessment using visual surveys and baited cathedral traps. Shallow water at the majority of sites prevented the use of cathedral traps except at site W1, where the cathedral trap was deployed for a total of 15 hours. Electrofishing surveys for fish also did not find any turtles (Appendix E, Section 2.2.8). Anecdotal evidence suggests that the common Krefft's turtle (*Emydura macquari krefftii*) can be found in waterholes and farm supply dams throughout the area (Appendix E, Section 3.6.1).

5.13.8 Macroinvertebrate Findings

The macroinvertebrate assessment determined that communities inhabiting the Copperfield River both upstream and within the receiving environment are in good condition. AusRivAS modelling did determine that assemblages at some locations were considered to be significantly impacted. However these scores may be typical of the region and PET scores and taxa richness determined sensitive taxa were well represented. This is consistent with the findings of previous macroinvertebrate assessments (Genex, 2015).

5.14 Dry Season Copperfield River Field Survey

5.14.1 Sample Sites

The locations of semi-permanent waterholes within the floodplain of the Copperfield River were identified through flyover with a drone in September 2018. Six locations were identified, and water quality was sampled at each waterhole between 22 and 23 September 2018. Standing water was present at long term monitoring points W1 and W3, and these two sites were also sampled as part of the dry season Copperfield River field survey. The location of the dry season sampling points is provided in Table 50 and Figure 49.

Rainfall records at Georgetown Airport (BOM station 030124) indicate that the most recent rainfall prior to this sampling event was 2mm on 17 April 2018. However, 429.8mm was recorded during March 2018 and is likely to be the most recent period of flow in the Copperfield River.

The majority of waterholes found were minor remnant pools occurring in-channel. Only two substantial pools were noted downstream of the Project site (Pond 5 near W3 and the Sandy Creek site). These two pools have the potential to persist year round, providing refuge to aquatic fauna. The longevity of these pools would be highly correlated with the hydrology of the system on a yearly basis.

Table 50 Dry Season Sample Locations

Monitoring Location	Proximity to Proposed Release Location	Easting	Northing	Description
Pond 1	2km upstream			Copperfield River upstream of the TSF Dam Spillway
Pond 2	1.7km upstream			Copperfield River upstream of the TSF Dam Spillway
Pond 3	1.4km upstream			Copperfield River upstream of the TSF Dam Spillway
W1	1.2km upstream	200799	7908133	Copperfield River below the TSF Dam Spillway
Pond 4	5.4km downstream			Copperfield River downstream
Pond 5	5.8km downstream			Copperfield River downstream
W3	6.2km downstream	202667	7915973	Downstream monitoring site at the Causeway
Sandy Creek	20km downstream			Copperfield River immediately upstream of the confluence with Sandy River

AECOM
www.aecom.com

N

DATUM GDA 1994, PROJECTION MGA ZONE 56

0 250 500 1,000

metres

1:30,000 (when printed at A3)

LEGEND

- Monitoring Point
- Ponding Identified
- Existing Release Points
- Key Project Infrastructure Footprint
- Spillway Options Corridor
- Major Watercourse
- Minor Watercourse

Data sources:

KIDSTON PUMPED STORAGE HYDRO PROJECT
IMPACT ASSESSMENT REPORT

Dry Season Copperfield River Survey

PROJECT ID	60544566
CREATED BY	RF
LAST MODIFIED	RF - 11 Jan 2019
VERSION:	1

Figure
49

Filename: P:\605X\60544566\4. Tech Work Area\4.99 GIS\02_MXDs\Hydro\H60544566_002_DrySeasCopperfieldRiverFieldSurvey_20190111_A3L_v1.mxd

A3 size

Plate 1 Pond 1 drone snapshot

Plate 2 Pond 2 drone snapshot

Plate 3 Pond 3 drone snapshot

Plate 4 W1 drone snapshot

Plate 5 Pond 4 drone snapshot

Plate 6 Pond 5 drone snapshot

Plate 7 W3 drone snapshot

Plate 8 Sandy Creek drone snapshot

5.14.2 Dry Season Water Quality Results

The results of the semi-permanent waterhole water quality samples are presented in Table 52. Many of the parameters returned a result below the LOR.

Table 52 also presents the applicable WQO for each parameter, including recommended site-specific objectives, as outlined in sections 3.5.2 and 3.6.12. Exceedances of these WQOs are highlighted in the table below. Total manganese, total iron, total nitrogen and total phosphorus recorded results above their respective WQOs both upstream and downstream of the proposed release point.

Table 51 Dry Season Copperfield River Field Survey Water Quality Results

Parameter	Unit	LOR	Upstream					Downstream			Applicable WQO
			Pond 1	Pond 2	Pond 3	W1	Sandy Creek	Pond 4	Pond 5	W3	
pH value	pH unit	0.01	7.56	7.74	7.90	7.94	7.75	7.88	7.67	8.79	6.0 – 8.4*
Electrical Conductivity	(µS/cm)	1	189	669	194	289	192	245	170	217	500
Sulfate as SO_4^{2-}	mg/L	1	2	<1	2	20	<1	11	<1	1	250
Aluminium (total)	mg/L	0.01	0.01	<0.01	0.06	0.02	<0.01	0.02	0.03	0.02	1.52*
Aluminium (dissolved)	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.57*
Arsenic (total)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.01
Arsenic (dissolved)	mg/L	0.001	0.002	<0.001	<0.001	<0.001	0.002	0.001	0.002	0.001	0.013
Cadmium (total)	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.002
Cadmium (dissolved)	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0003*
Cobalt (total)	mg/L	0.001	0.001	0.009	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.05
Cobalt (dissolved)	mg/L	0.001	0.002	0.012	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0028
Chromium (total)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.05
Chromium (dissolved)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0017*
Copper (total)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.2
Copper (dissolved)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003*
Manganese (total)	mg/L	0.001	1.26	6.88	0.056	0.079	0.487	0.192	0.117	0.038	0.1
Manganese (dissolved)	mg/L	0.001	0.881	5.81	0.004	0.012	0.286	0.076	0.095	0.004	1.9
Molybdenum (total)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.01
Nickel (total)	mg/L	0.001	0.001	0.002	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.02
Nickel (dissolved)	mg/L	0.001	0.001	0.003	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.019*

Parameter	Unit	LOR	Upstream					Downstream			Applicable WQO
			Pond 1	Pond 2	Pond 3	W1	Sandy Creek	Pond 4	Pond 5	W3	
Lead (total)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01
Lead (dissolved)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0075*
Zinc (total)	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	2*
Zinc (dissolved)	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.014
Total Cyanide	mg/L	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.08
Iron (total)	mg/L	0.05	1.10	1.64	0.11	<0.05	0.79	0.26	0.61	0.10	0.43*
Iron (dissolved)	mg/L	0.05	0.22	1.95	<0.05	<0.05	0.19	0.09	0.15	<0.05	0.3
Chloride	mg/L	1	7	8	8	26	8	21	7	7	175*
Sodium	mg/L	1	12	11	18	26	13	27	13	21	115
Boron (total)	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.5
Boron (dissolved)	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.37
Barium (total)	mg/L	0.001	0.084	0.153	0.042	0.037	0.076	0.046	0.045	0.039	1.0
Beryllium (total)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.06
Beryllium (dissolved)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00013
Mercury (total)	mg/L	0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	0.001
Mercury (dissolved)	mg/L	0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	0.00005
Selenium (total)	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Selenium (dissolved)	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.011
Uranium (total)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01
Uranium (dissolved)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0005
Vanadium (total)	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.1

Parameter	Unit	LOR	Upstream					Downstream			Applicable WQO
			Pond 1	Pond 2	Pond 3	W1	Sandy Creek	Pond 4	Pond 5	W3	
Vanadium (dissolved)	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.006
Fluoride	mg/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	1
Ammonia as N	mg/L	0.005	0.08	0.23	0.04	0.13	0.02	0.05	0.07	0.08	0.5
Nitrate as N	mg/L	0.002	0.006	0.018	0.008	0.022	0.004	0.024	0.023	0.006	0.7
Nitrite as N	mg/L	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	1
Total N	mg/L	0.01	0.77	0.61	0.48	0.91	0.23	0.30	0.62	0.36	0.15
Total P	mg/L	0.005	0.079	0.036	0.026	0.042	0.020	0.014	0.039	0.016	0.01

* Site-specific WQO (refer Section 3.6.1.2)

5.14.3 Comparison against Post-2011 surface water quality dataset

Long term water quality data is available for monitoring points W1 and W3 (Section 3.3.1). Table 52 presents the median post-2011 water quality and the dry season results at these sites for comparison. Exceedances against the WQOs for these datasets are also highlighted in the table below. The following comparisons were noted:

- pH, electrical conductivity, chloride and sodium were recorded to be higher at both sites during the dry season than the long term post-2011 median dataset. pH at W3 during the dry season exceeded the WQO.
- Sulfate and total manganese were recorded to be higher at W1 during the dry season than the long term post-2011 median dataset. The parameters were both lower at W3 during the dry season.
- Total aluminium was recorded to be lower at both sites during the dry season than the long term post-2011 median dataset.
- Total iron was recorded to be below the WQO during the dry season, but exceeded the WQO in the post-2011 median dataset.

Table 52 Dry Season and Post-2011 comparison of W1 and W3

Parameter	Unit	W1		W3		Applicable WQO
		Post-2011 Median	Dry Season	Post-2011 Median	Dry Season	
pH value	pH unit	7.75	7.94	7.8	8.79	6.0 – 8.4*
Electrical Conductivity	(µS/cm)	135	289	150	217	500
Sulfate as SO_4^{2-}	mg/L	4	20	4	1	250
Aluminium (total)	mg/L	0.55	0.02	0.52	0.02	1.52*
Aluminium (dissolved)	mg/L	0.19	<0.01	0.22	<0.01	0.57*
Arsenic (total)	mg/L	0.0005	<0.001	0.001	<0.001	0.01
Arsenic (dissolved)	mg/L	0.0005	<0.001	0.0005	0.001	0.013
Cadmium (total)	mg/L	0.00005	<0.0001	0.00005	<0.0001	0.002
Cadmium (dissolved)	mg/L	0.00005	<0.0001	0.00005	<0.0001	0.0003*
Cobalt (total)	mg/L	0.0005	<0.001	0.0005	<0.001	0.05
Cobalt (dissolved)	mg/L	0.0005	<0.001	0.0005	<0.001	0.0028
Chromium (total)	mg/L	0.0005	<0.001	0.0005	<0.001	0.05
Chromium (dissolved)	mg/L	0.0005	<0.001	0.0005	<0.001	0.0017*
Copper (total)	mg/L	0.002	<0.001	0.002	<0.001	0.2
Copper (dissolved)	mg/L	0.002	<0.001	0.002	<0.001	0.003*
Manganese (total)	mg/L	0.046	0.079	0.064	0.038	0.1
Manganese (dissolved)	mg/L	0.017	0.012	0.023	0.004	1.9
Molybdenum (total)	mg/L	0.0005	<0.001	0.0005	<0.001	0.01
Nickel (total)	mg/L	0.0005	0.001	0.0005	<0.001	0.02
Nickel (dissolved)	mg/L	0.0005	0.001	0.0005	<0.001	0.019*
Lead (total)	mg/L	0.0005	<0.001	0.0005	<0.001	0.01
Lead (dissolved)	mg/L	0.0005	<0.001	0.0005	<0.001	0.0075*

Parameter	Unit	W1		W3		Applicable WQO
		Post-2011 Median	Dry Season	Post-2011 Median	Dry Season	
Zinc (total)	mg/L	0.0025	<0.005	0.0025	<0.005	2*
Zinc (dissolved)	mg/L	0.0025	<0.005	0.0025	<0.005	0.014
Total Cyanide	mg/L	0.002	<0.004	0.002	<0.004	0.08
Iron (total)	mg/L	0.71	<0.05	3.32	0.10	0.43*
Iron (dissolved)	mg/L	0.23	<0.05	0.19	<0.05	0.3
Chloride	mg/L	5	26	4	7	175*
Sodium	mg/L	11	26	4	21	115
Boron (total)	mg/L	-	<0.05	0.025	<0.05	0.5
Boron (dissolved)	mg/L	-	<0.05	0.025	<0.05	0.37
Barium (total)	mg/L	-	0.037	0.032	0.039	1.0
Beryllium (total)	mg/L	-	<0.001	0.0005	<0.001	0.06
Beryllium (dissolved)	mg/L	-	<0.001	0.0005	<0.001	0.00013
Mercury (total)	mg/L	-	<0.00004	-	<0.00004	0.001
Mercury (dissolved)	mg/L	-	<0.00004	-	<0.00004	0.00005
Selenium (total)	mg/L	0.005	<0.01	0.005	<0.01	0.01
Selenium (dissolved)	mg/L	0.005	<0.01	0.005	<0.01	0.011
Uranium (total)	mg/L	-	<0.001	-	<0.001	0.01
Uranium (dissolved)	mg/L	-	<0.001	-	<0.001	0.0005
Vanadium (total)	mg/L	-	<0.01	0.005	<0.01	0.1
Vanadium (dissolved)	mg/L	-	<0.01	0.005	<0.01	0.006
Fluoride	mg/L	-	<0.1	0.05	0.1	1
Ammonia as N	mg/L	-	0.13	-	0.08	0.5
Nitrate as N	mg/L	-	0.022	-	0.006	0.7
Nitrite as N	mg/L	-	<0.002	-	<0.002	1
Total N	mg/L	-	0.91	-	0.36	0.15
Total P	mg/L	-	0.042	-	0.016	0.01

* Site-specific WQO (refer Section 3.6.1.2)

5.15 Summary

The main outcomes of the investigation of the baseline receiving environment are summarised below:

Surface Water Quality

- EVs for the Gilbert River basin have not been defined under the EPP Water. In this instance, the EPP Water prescribes the application of all default EVs. EVs have been described for the Copperfield River over a 44km stretch downstream from the former Kidston mine site to the confluence of the Einasleigh River.
- Macroinvertebrate data supports the distinction of a 'Slightly Disturbed' aquatic ecosystem condition under the EPP Water. The management intent for this water type is to gradually improve water quality and to aim to achieve a HEV waterway classification, however HEV WQOs may not be achievable in the Copperfield River as there are a number of regionally based negative influences on water quality.
- The QWQG and EPP Water do not specify WQOs for the Gulf Rivers region or the Gilbert Basin. Instead they recommend the use of the ANZECC (2000) guidelines, cautioning that these values may not be appropriate for intermittent and ephemeral inland streams. In cases where more than one WQO is available for a particular parameter, the most stringent value from all EVs is applicable. Where applicable, site-specific trigger values were derived based on the upstream dataset for monitoring location WB. HMTVs were developed for the area in the immediate vicinity of the release point, using the median baseline hardness values at monitoring location W2.
- Some anomalies in the receiving environment water quality datasets were noted and led to the exclusion of samples collected prior to 2012 (providing an adequate dataset size for analysis of 40 to 60 samples). Ongoing monitoring is recommended for parameters with limited dataset sizes.
- The baseline assessment indicated that a number of parameters are elevated above WQOs in the receiving environment. Monitoring site W2 has indicated potential impacts from seepage.

Hydrology

- In the absence of stream gauging, hydrological modelling was used to undertake a flow spells analysis which showed a definite seasonal distribution with a distinct high flow season occurring from December through April.
- Cease to flow conditions (less than 1 ML/d) are present on approximately 55% of all days for any day and reduce to approximately 32% during the wet season (November through April).

Hydrogeology

- The groundwater flow regime of the Project has been modified by the construction of the tailings dam, interception drains, and by dewatering of the two pits. In their current state, Wises Pit and Eldridge Pit are both understood to function as groundwater 'sinks', as groundwater levels in the surrounds of both pits are higher than the surface water level in the pits.
- One confirmed wetland spring, Middle Spring, lies within the vicinity of the mine area. This spring is located west-northwest of the former mine; although it is not considered to be hydraulically connected to the groundwater regime of the proposed release area, it is recommended that this is further assessed/monitored as part of water modelling refinement and design phase work.

Sediment Quality

- The braided nature of the Copperfield River results in sediment transport that is limited to a few months per year during the wet season when discharge is high enough. Very little fine sediment is stored in the channel bed in the upper to mid catchments.
- Sediment samples have been collected annually between 2009 and 2013. No whole-sediment samples exceeded the SQG, indicating that sediment within the Copperfield River is considered to be unaffected by the historical mining processes. Although the <0.063 mm samples reported a number of SQG exceedances, this fraction is considered less useful for comparison to guideline values.

- For toxicants in the <0.063 mm fractions, exceedances reported around the potential release sites (e.g., W1 and W2) are also reported in the upstream and downstream monitoring sites (e.g., WB and W3, respectively) suggesting that there are no widespread impacts from historical mining activities evident within the Copperfield River and that the concentrations of metals found are a result of the overall catchment drainage. Additional sampling and monitoring is recommended in accordance with the REMP.

Aquatic Ecology

- The macroinvertebrate assessment determined that communities inhabiting the Copperfield River both upstream and within the receiving environment are in good condition. AusRivAS modelling determined that assemblages at some locations were considered to be significantly impacted. However these scores may be typical of the region and PET scores and taxa richness determined sensitive taxa were well represented.

Dry Season Survey

- Six semi-permanent waterholes were identified within the floodplain of the Copperfield River through a drone flyover in September 2018. These waterholes were sampled in late September 2018, along with monitoring locations W1 and W3.
- Previous significant rainfall in the catchment occurred in March 2018, therefore the water in the pools is assumed to have been standing for a long duration and were likely subjected to evapo-concentration.
- Total manganese, total iron, total nitrogen and total phosphorus recorded results above their respective WQOs both upstream and downstream of the proposed release point.
- A comparison against the long-term (post 2011) dataset for W1 and W3 did not indicate any clear trends with regards to water quality.

This page has been left blank intentionally.

Step 3 – Impact Assessment

“Predict Outcomes of Impacts of the Proposed Wastewater Release”

6.0 Impact Assessment – Operational Releases

6.1 Approach

A comprehensive assessment has been undertaken to develop an understanding of the potential impacts of the Project on the EVs of the receiving environment. The assessment included an impact assessment of both the construction and operational phases of the Project. This section addresses the potential impacts relating to operational releases on water quality, ecology, hydrology, geomorphology and hydrogeology of the receiving environment.

The operational impacts will endure throughout the life of the Project and the development of appropriate discharge limits has been used as a primary mitigation measure to ensure that environmental impacts are appropriately minimised. To achieve this, applicable EVs were used to set WQOs with consideration of practical discharge requirements. Where WQOs were available for more than one EV, the lowest, more stringent value was applied (in most cases, this was associated with the protection of aquatic ecosystems). This approach ensures that relevant EVs are protected, including downstream users of the Copperfield River.

6.1.1 Assessment of Dilution Ratio and Assimilative Capacity

The assimilative capacity of the receiving environment is its capacity to receive some anthropogenic input of contaminants or alteration without causing the water quality to deteriorate so that the WQOs are no longer met. Since the assimilative capacity can be related to the dilution ratio achieved in the mixed water (downstream of the release point), it provides a constraint on the rate at which water may be released from the Project. Dilution ratio is therefore an important aspect of this impact assessment. As stated in ESR/2015/1654, it should be demonstrated "that the assimilative capacity of the receiving waters is not exceeded and that some assimilative capacity is preserved for future ecologically sustainable development – the proportion proposed to be consumed should be determined".

The assimilative capacity for any given parameter is defined as the difference between the WQO and the median baseline water quality (refer to Equation 1).

Equation 1 Assimilative Capacity:

$$\text{Assimilative Capacity} = [\text{WQO}] - [\text{Median baseline concentration}]$$

This section evaluates release water quality effects on the receiving environment water quality in order to assess which of the water quality parameters have the lowest assimilative capacity once release water is added to the receiving environment.

6.1.1.1 Dilution Ratio and Constituents of Concern

The dilution ratio applied to each parameter is calculated using Equation 2. This function represents a ratio between the concentration of the release water and the available assimilative capacity of the receiving environment. Dilution rates between the release water and Copperfield River baseline (at monitoring location W2) were calculated for each parameter.

Equation 2 Dilution ratios incorporating background water quality:

$$\text{Dilution ratio} = \frac{[\text{Release water concentration}]}{[\text{WQO}] - [\text{Median baseline concentration}]}$$

Target water quality was calculated using Equation 3. Information sources used to estimate dilution ratios and constituents of most concern are outlined in Table 53.

Equation 3 Target water quality:

Target Water Quality = [Assimilative Capacity Utilisation %]* ([WQO]-[Median baseline conc.])+[Median baseline conc.]

Table 53 Information sources used to estimate dilution ratios and constituents of most concern

Description	Information Source/s	Justification/Detail
Release water concentration	Historical maximum of both pits mixed at 9 parts Eldridge to 1 part Wises.	Use of the historical maximum considered as a highly conservative estimate (unlikely to be observed in reality) of release water concentration. As discussed in Section 4.8.2, a sensitivity analysis has been undertaken for a variety of release scenarios. As a result of the sensitivity analysis, it was determined that the 'worst case scenario' (i.e. highest overall parameter concentrations) for a mixed pit water release was achieved by using the maximum concentrations observed over the full dataset, mixed at a ratio of nine parts Eldridge Pit to one part Wises Pit.
Baseline receiving environment concentration	The median baseline concentration was taken to be the 50th percentile of water quality at the W2 monitoring site.	W2 was chosen as it is closest to the proposed release location and most representative of baseline water quality in this section of the Copperfield River (refer section 5.5.3.2 and Appendix A). Use of W2 is considered a conservative estimate.
WQOs	Default WQOs are set out in Section 5.5.1. For the dilution ratio calculations the SSTV has been adopted as the WQO. Where applicable, HMTVs have been applied (refer to Section 5.6.1 above).	Modifications to WQOs based on data at the upstream site (WB) are recommended for dissolved aluminium, total aluminium dissolved copper and total iron. HMTVs have been adopted for dissolved cadmium, chromium, lead, nickel and zinc. Further detail regarding HMTVs is presented in Section 5.6.1 above.

Table 54 summarises the dilution ratios from the worst case release scenario (historical maximum value for both pits, mixed at nine parts Eldridge Pit to one part Wises Pit), noting that all dilution ratios presented in the table represent use of 100% of the assimilative capacity of the receiving environment. As can be seen in Table 54, dissolved zinc is the constituent of most concern in the releases, requiring a dilution ratio of 138:1.

There are a number of parameters where there is limited historical information. These parameters include selenium, vanadium, mercury, beryllium, uranium, ammonia, nitrite, nitrate, total N, total P and fluoride. Historic data is lacking in either the Pit water samples or for the receiving environment. In most cases for many parameters there is only one sample available from each. Dilution ratios have been calculated based on these individual samples. The dilution ratios required to ensure that the WQOs are met by these parameters are an order of magnitude lower than that required for other Constituent of Potential Concerns (COPCs) and would need to be presented in concentrations that are an order of magnitude larger than current measured values in order to have an impact on dilution ratio calculations. Ongoing monitoring recommended in the Project REMP will ensure that these parameters are monitored on a regular basis and that these thresholds are incorporated.

Table 54 Dilution ratios required to achieve WQOs

Parameter	WQO (mg/L)[1]	Release Water Concentration (EOP) (mg/L)[2]	Baseline Receiving Water Concentration (mg/L)[3]	Dilution Ratio Required[4]
Zinc (F)	0.014	1.5874	0.0025	138.0
Manganese (T)	0.1	3.622	0.073	134.1
Cadmium (F)	0.00030	0.02901	0.00005	116.0
Cobalt (T)	0.05	3.5151	0.0005	71.0
Arsenic (T)	0.01	0.368	0.001	40.9
Cobalt (F)	0.0028	0.0283	0.0005	31.4
Nickel (F)	0.00190	0.0352	0.0005	25.1
Cadmium (T)	0.002	0.04186	0.00005	21.5
Lead (T)	0.01	0.1723	0.0005	18.1
Electrical Conductivity @ 25°C	500	5311	167	15.9
Arsenic (F)	0.013	0.1694	0.0005	13.6
Molybdenum (T)	0.01	0.122	0.0005	12.8
Sulfate as SO4 - Turbidimetric	250	2690	10	11.2
Nitrate as N	0.7	4.935	0.0325	7.4
Total Phosphorus as P	0.01	0.0315	0.005	6.3
Mercury (F)	0.00006	0.00005	0.00005	5.0
Vanadium (F)	0.006	0.005	0.005	5.0
Fluoride	1	3.03	0.2	3.8
Sodium	115	318.4	10	3.0
Nickel (T)	0.02	0.0505	0.0005	2.6
Copper (F)	0.003	0.0047	0.001	2.4
Molybdenum (F)	0.034	0.0623	0.0005	1.9
Iron (T)	0.43	0.3065	0.22	1.5
Manganese (F)	1.9	2.5868	0.035	1.4
Zinc (T)	2	2.352	0.0025	1.2
Selenium (F)	0.011	0.005	0.005	<1
Chloride	175	100	7	<1
Ammonia as N	0.5	0.211	0.02	<1

Parameter	WQO (mg/L)[1]	Release Water Concentration (EOP) (mg/L)[2]	Baseline Receiving Water Concentration (mg/L)[3]	Dilution Ratio Required[4]
Chromium (F)	0.00170	0.0005	0.0005	<1
Copper (T)	0.2	0.061	0.002	<1
Aluminium (T)	1.52	0.234	0.45	<1
Iron (F)	0.3	0.025	0.113	<1
Boron (F)	0.37	0.0285	0.025	<1
Lead (F)	0.00750	0.0005	0.0005	<1
Mercury (T)	0.001	0.00005	0.00005	<1
Aluminium (F)	0.57	0.0185	0.16	<1
Barium (T)	1	0.0422	0.027	<1
Chromium (T)	0.05	0.00055	0.0005	<1
Beryllium (T)	0.06	0.0005	0.0005	<1
Nitrite as N	1	0.005	0.005	<1
Beryllium (F)	0.00013	0.0005	0.0005	NA[5]
Total Hardness as CaCO3		1809.8	56.2	NA[5]
Total Nitrogen as N	0.15	6.39	0.25	NA[5]

[1] Including site-specific WQOs and HMTVs as presented in Section 5.6.12.

[2] Maximum value for Eldridge Pit and Wises Pit, mixed at 9 parts Eldridge to 1 part Wises

[3] Median value for W2 (based on data collected since 2012)

[4] Assuming use of 100% assimilative capacity

[5] Baseline receiving environment concentration (or LOR) above WQO.

6.1.1.2 Dilution Ratio for Adoption

As stated in ESR/2015/1654, it should be demonstrated "*that the assimilative capacity of the receiving waters is not exceeded and that some assimilative capacity is preserved for future ecologically sustainable development – the proportion proposed to be consumed should be determined*".

As outlined in Section 6.1.1.1, a maximum dilution ratio of 1 to 138 was found for dissolved zinc, based on use of 100% of assimilative capacity. This is to account for a 'worst case scenario', representing the maximum historical water quality for any parameter in the Wises Pit mixed together with the maximum historical water quality for any parameter in the Eldridge Pit at a proportion of 1 part Wises to 9 parts Eldridge.

If 69% of the assimilative capacity of the receiving environment is used, this results in an effective dilution ratio of 200:1. This equates to an effective release ratio of 0.5% (refer to Equation [2], Section 6.1.1.1) and is proposed to be adopted for the operational phase of the Project. By limiting the use of assimilative capacity to 69%, this allows for preservation of a portion of the capacity for future development. The assumptions behind calculating effective dilution ratios are highly conservative (based on maximum pit water qualities). In reality the actual assimilative capacity usage will be lower than 69% in most cases.

6.1.1.3 Constituents of Most Concern

Applying the adopted operations period dilution ratio of 200:1 for the operations phase, a simple mass balance has been undertaken to determine the likely concentration in the receiving environment post mixing of a release. This has been undertaken by applying the maximum concentration of each parameter observed in both pits and mixing at a ratio of nine parts Eldridge Pit to one part Wises Pit and is considered to be a conservative, worst-case assessment. Results are presented in Table 55.

The assessment indicates that only total nitrogen will exceed the WQO post-mixing. It should be noted that the baseline concentration of total nitrogen at W2 already exceeds the WQO, and there were only limited data points available for the pits. Additional monitoring of the Eldridge Pit subsequently confirmed these samples to be reported. Further monitoring of total nitrogen will continue to be undertaken as part of the REMP (refer to Appendix I).

At the lower dilution rates proposed for the construction phase of the Project (refer to Section 7.2.2), the following parameters are predicted to exceed the WQO in the receiving environment post-mixing and are therefore considered to be constituents of most concern (COPCs) (in order of importance):

- Dissolved zinc
- Dissolved cadmium
- Total cobalt
- Total manganese
- Total arsenic
- Dissolved cobalt
- Total nitrogen
- Electrical conductivity (no guideline exceedance, but included at the request of DES)
- Sulfate (no guideline exceedance, but included at the request of DES).

The downstream (far-field) dilution of these parameters is therefore also assessed further in Section 6.2.2 for the operational phase.

Whilst a number of parameters were present at concentrations above the WQO in the release water (assuming use of maximum historical values), the high dilution rate being applied during the operations phase (200:1) means that concentrations in the receiving environment post-release will be diluted sufficiently below WQOs.

The DTA results (refer to Section 4.9.4) indicated a minimum dilution ratio of nine parts receiving environment water to one part release water (using the worst case construction phase mix for release water), required to meet 95% species protection. During the operations phase, the simulated releases are well in excess (200:1) of this minimum dilution ratio, thereby indicating that the proposed releases will not result in toxicity-related impacts to aquatic ecosystems, even in the near-field mixing zone where WQOs might not necessarily be met immediately (refer to Section 6.2.1 below).

Table 55 **Worst-Case Final Concentrations of Constituents in Receiving Environment (Operations Phase)**

Parameter	WQO (mg/L)[1]	Release Water Concentration (EOP) (mg/L)[2]	Baseline Receiving Water Concentration (mg/L)[3]	Final Concentration in Receiving Environment for Operational Period Releases (mg/L)
Electrical Conductivity @ 25°C	500	*5311*	167	194
Total Dissolved Solids (Calc.)		NA	NA	NA
Total Hardness as CaCO3		1809.8	56.2	65
Hydroxide Alkalinity as CaCO3		NA	NA	NA
Carbonate Alkalinity as CaCO3		NA	NA	NA
Bicarbonate Alkalinity as CaCO3		NA	NA	NA
Total Alkalinity as CaCO3		162.1	51.5	52.3
Sulfate as SO4 - Turbidimetric	250	*2690*	10	23.45
Chloride	175	100	7	7.5
Calcium		506.8	12	14.5
Magnesium		132.4	7	7.7
Sodium	115	*318.4*	10	11.6
Potassium		51.3	2	2.3
Aluminium (F)	0.57	0.0185	0.16	0.1601
Arsenic (F)	0.013	*0.1694*	0.0005	0.0013
Beryllium (F)[4]	0.00013	0.0005	0.0005	0.0005
Barium (F)		0.0362	0.023	0.0232
Cadmium (F)	0.0003	*0.02901*	0.00005	0.0002
Chromium (F)	0.0017	0.0005	0.0005	0.0005
Cobalt (F)	0.0028	*0.0283*	0.0005	0.0006
Copper (F)	0.0024	*0.0047*	0.001	0.0010
Lead (F)	0.0075	0.0005	0.0005	0.0005

Parameter	WQO (mg/L)[1]	Release Water Concentration (EOP) (mg/L)[2]	Baseline Receiving Water Concentration (mg/L)[3]	Final Concentration in Receiving Environment for Operational Period Releases (mg/L)
Manganese (F)	1.9	*2.5868*	0.035	0.0479
Molybdenum (F)	0.034	*0.0623*	0.0005	0.0008
Nickel (F)	0.019	*0.0352*	0.0005	0.0007
Selenium (F)	0.011	0.005	0.005	0.0050
Uranium (F)	0.01			
Vanadium (F)	0.006	0.005	0.005	0.0050
Zinc (F)	0.0136	*1.5874*	0.0025	0.0104
Boron (F)	0.37	0.0285	0.025	0.0251
Iron (F)	0.3	0.025	0.113	0.1131
Mercury (F)	0.00006	0.00005	0.00005	0.0001
Aluminium (T)	1.52	0.234	0.45	0.4512
Arsenic (T)	0.01	*0.368*	0.001	0.0028
Beryllium (T)	0.06	0.0005	0.0005	0.0005
Barium (T)	1	0.0422	0.027	0.0272
Cadmium (T)	0.002	0.04186	0.00005	0.0003
Chromium (T)	0.05	0.00055	0.0005	0.0005
Cobalt (T)	0.05	*3.5151*	0.0005	0.0181
Copper (T)	0.2	0.061	0.002	0.0023
Lead (T)	0.01	*0.1723*	0.0005	0.0014
Manganese (T)	0.1	*3.622*	0.073	0.0911
Molybdenum (T)	0.01	*0.122*	0.0005	0.0011
Nickel (T)	0.02	*0.0505*	0.0005	0.0008
Selenium (T)	0.01	NA	NA	NA
Uranium (T)	0.01	NA	NA	NA
Vanadium (T)	0.1	NA	NA	NA
Zinc (T)	2	*2.352*	0.0025	0.0143
Boron (T)	0.5	NA	NA	NA
Iron (T)	0.43	0.3065	0.22	0.2215
Mercury (T)	0.001	0.00005	0.00005	0.0001

Parameter	WQO (mg/L)[1]	Release Water Concentration (EOP) (mg/L)[2]	Baseline Receiving Water Concentration (mg/L)[3]	Final Concentration in Receiving Environment for Operational Period Releases (mg/L)
Free Cyanide	0.08	NA	NA	NA
Total Cyanide		NA	NA	NA
Weak Acid Dissociable Cyanide		NA	NA	NA
Fluoride	1	*3.03*	0.2	0.2152
Ammonia as N	0.5	0.211	0.02	0.0211
Nitrite as N	1	0.005	0.005	0.0050
Nitrate as N	0.7	*4.935*	0.0325	0.0572
Nitrite + Nitrate as N		NA	NA	NA
Total Kjeldahl Nitrogen as N		NA	NA	NA
Total Nitrogen as N[4]	0.15	*6.39*	**0.25**	**0.2820**
Total Phosphorus as P	0.01	*0.0315*	0.005	0.0052
Reactive Phosphorus as P		NA	NA	NA

[1] Including site-specific WQOs and HMTVs as presented in Section 5.6.12.
[2] Maximum value for Eldridge Pit and Wises Pit, mixed at 9 parts Eldridge to 1 part Wises
[3] Median value for W2 (based on data collected since 2012)
[4] Baseline receiving environment concentration (or LOR) above WQO.
NA = No data available
Red italicised values denote an exceedance of the WQO in the release water (i.e. prior to release). This does not necessarily indicate that concentrations in the receiving environment will also be above the WQO.
Grey shaded values denote an exceedance of the WQO post-release.

6.2 Water Quality Impact Assessment

Potential impacts to water quality associated with operational releases are as follows:

1. Increased water temperature and reducing natural thermal variability.
2. Increased toxicant loads in Copperfield River resulting in adverse impacts to aquatic ecosystems.
3. Impacts to drinking water quality.
4. Visual impact at Einasleigh Gorge, through precipitation of dissolved contaminants.
5. Residual water quality changes following discharge events, pooling in Copperfield River.
6. Accumulation of contaminants in sediment.
7. Water quality changes in Pit water as level in Eldridge Pit rises and falls and exposes pit walls.

In order to assess whether these impacts are likely to occur the following key tasks were undertaken:

- In order to assess the rate of near field dilution and mixing downstream from the proposed release point, the mixing zone model CORMIX was used. The model predicts estimated mixing zone length based on the distance downstream at which the relevant WQO is reached. Design of the modelled scenarios has considered releases into a number of different receiving flows and potential release rates based on the constituent of most concern, dissolved zinc at a dilution ratio of 200:1. Detail is presented in Section 6.2.1.
- A mass balance analysis has been undertaken in order to develop an understanding of the mass loading at various locations from the release point down to Einasleigh. Mass balance modelling was undertaken for selected key constituents. Detail is presented in Section 6.2.2.
- Results of the near-field (CORMIX modelling) and far-field (mass balance) assessments described above were used to assess the water quality-related impacts to each EV, as presented in Section 6.2.3.

6.2.1 Near Field Mixing Zone Assessment (CORMIX)

The capacity of the receiving environment to accept releases in terms of mass carried and flow rate is a crucial aspect of the Project. This was investigated by assessing the load potential of the receiving environment at the proposed release location.

As the zone in which the release water meets the receiving water, the mixing zone is expected to experience the largest initial changes in water quality and potential impacts may be greatest here. Modelling of the mixing zone was therefore undertaken to provide constraints on the mixing dynamics.

The mixing zone model CORMIX was used to assess the rate of near field dilution and mixing downstream from the proposed release point. CORMIX is a United States Environmental Protection Authority (US EPA) supported, Windows-based software system for the analysis, prediction and design of continuous, steady-state point source releases into water bodies. CORMIX is also recommended as a mixing zone model by the DES (EHP, 2016). The model focuses on the geometry and dilution characteristics of the initial (near-field) mixing zone as well as predicting the behaviour of the release plume at larger distances (far-field).

The results of CORMIX's hydrodynamic simulations have been extensively validated and generally agree with available field and laboratory data. In particular, CORMIX predicts highly complex release situations involving boundary interactions, internal layer formation, buoyant intrusions, and large-scale induced currents in shallow environments.

6.2.1.1 CORMIX Model Limitations

Modelling of releases into a water body should be regarded as a tool for the identification and prediction of potential impacts to the water quality of the receiving environment within the study area. When reviewing release modelling outputs, it is important to interpret the results in the context of the model limitations. The most significant limitations of the CORMIX system are related to the use of idealised representations of ambient geometry, currents and stratification (and assumptions around diffuser configuration, as discussed below). This is however considered conservative for the purpose of this assessment.

Mixing processes in the near-field region are noted to be sensitive to the release design conditions and this is particularly notable when applied to the current assessment where release and ambient conditions are subject to a significant range of variability. Actual process changes can result in variations of one or more of three parameters associated with the release: flow rate, density, or release concentration as well as the release geometry. These changes can result in different mixing rates in the near-field. In contrast, mixing conditions at large distances (far-field) often show little sensitivity unless the ambient conditions change substantially or drastic process variations are introduced.

6.2.1.2 CORMIX Model Scenario Inputs and Assumptions

A total of four scenarios have been assessed for the proposed releases. Design of the scenarios has considered releases into a number of different receiving flows and potential release rates based on a dissolved zinc dilution ratio of 200:1 as outlined in Section 6.1.1. Receiving flow rates have been selected to result in as broad a range of release flow rates as possible within the limitation of the proposed discharge capacity of 1 m^3/s (86.4 ML/d). Table 56 below summarises key assumptions adopted for the modelling.

Table 56 Key CORMIX Assumptions

Aspect	Assumption	Comment
Release concentration	1.5874 mg/L	• Dissolved zinc • Equivalent to 1.585 mg/L excess over the receiving environment background concentration • Based on the maximum values from Wises and Eldridge Pits mixed at a 1:9 ratio. Refer to Section 6.0.
Release water density	998.65 kg/m^3	• Total dissolved solids (TDS) of 2,090 mg/L assuming Wises and Eldridge Pits mixed at a 1:9 ratio • Assumed temperature of 25ºC (assumes releases predominantly occurring during summer)
Receiving concentration	0.0025 mg/L	W2 median concentration (Zinc (F))
Receiving water density	997.16 kg/m^3	• TDS of 108 mg/L (W2 median value) • Assumed temperature of 25ºC (assumes releases predominantly occurring during summer)
Water quality objective	0.014 mg/L	• Hardness modified trigger value (HMTV) • Equivalent to 0.0115 mg/L excess over the receiving environment concentration
Assimilative capacity utilisation	69%	Refer to Section 6.1.1
Effective dilution ratio	200:1	Refer to Section 6.1.1
Effective release ratio	0.5%	Refer to Appendix L for detailed discussion on the use and application of release ratios.
Ambient conditions	Bounded Highly irregular Mannings of 0.035	For all scenarios

Aspect	Assumption	Comment
• Ambient geometry conditions Average depth • Depth at release • Channel width	Dependant on scenario – refer to	• Values taken from HEC-RAS model (Section 5.10.1 cross sections. • Mean values derived over 500m up and downstream of proposed release point
CORMIX model	• Preliminary multiport assessment using CORMIX2 • CORMIX1 single port assessment as recommended by CORMIX	• Initial model runs were conducted using CORMIX2, multiport assessment however the conceptual configurations assessed are more suited to a single port assessment which resulted in a better representation of near field mixing. • To complete the CORMIX1 single port assessment the discharge flowrate was simply divided by the number of ports.
Adopted diffuser type	Co-flowing	
Diffuser length	Dependant on scenario – refer to Table 57	
No. of ports		
Diameter of ports		

6.2.1.3 Conceptual Diffuser Configurations Used

Two different conceptual diffuser configurations have been adopted for the purpose of the near field mixing zone assessment (refer to Table 57) as proof of concept assessment. Both conceptual configurations utilise a unidirectional, multiport diffuser with a perpendicular alignment known as a co-flowing diffuser (Figure 50).

Each conceptual configuration has been selected to demonstrate that, under the adopted conditions and assumptions detailed in Table 56 and for the ambient and discharge conditions simulated, potential releases of water from the Project are able to be mixed to meet proposed water quality and mixing zone objectives. It is noted however that the final outlet structure and diffuser design will be subject to ongoing design refinement as the Project progresses through to detailed design and will need to consider a number of additional criteria that were not considered as part of this high level assessment.

The relatively wide range of potential discharge capacity (up to 1 m^3/s (86.4 ML/d) and potential receiving flow rates (from 4.6 m^3/s (400 ML/d) at the release trigger to 198.8 m^3/s (17,176 ML/d) at the maximum discharge capacity) necessitates that releases will need to be made via multiple diffuser configurations in order to realise water quality and mixing zone objectives i.e. a single diffuser arrangement can only be optimised for a relatively narrow range of discharge and receiving flow conditions.

The effect of reducing discharge rates through a specific arrangement is to gradually reduce the outlet velocity relative to the receiving environment ambient velocity. This reduces the ability of the discharge to mix in the near field zone around the outlet. Eventually a low pressure zone may form at the diffuser outlet causing a 'wake' effect downstream of the diffuser outlet and preventing effective mixing.

- Alternatively, as discharge through a specific diffuser arrangement increases, continuity necessitates that the outlet velocity must increase. High discharge outlet velocities are undesirable for a number of reasons including harm to aquatic fauna, erosion risk and increasingly poor mixing due to the high discharge to receiving velocity ratio.
- The current assessment has demonstrated that a single configuration is capable of meeting mixing objectives for a range of release flow rates (two configurations were each assessed against two different discharge flow rates). However, assessment of discharge potential (6.3.1) has considered a continuously variable rate of release (based on a daily timestep simulation) up to the proposed release capacity of $1m^3/s$. Ongoing detailed design and practical considerations of providing optimised outlet configurations for such a wide discharge capacity will likely need to consider a 'stepped' or incremental rate of release such that each configuration operates at or approximates a fixed discharge rate. The number of potential release rates or 'steps' and potential diffuser configurations is again, subject to ongoing assessment through detailed design.
- The following additional criteria have not been considered for this assessment but will need to inform the final design of the proposed outlet structure:
  - Fish passage requirements (refer to Section 2.4)
  - Geomorphic stability – The potential for the lateral migration of braided channels evident at the proposed release location will need to addressed through possible solutions including training, armouring, etc. of the channel in the vicinity of the release structure
  - Constructability
  - Erosion and sedimentation
  - Maintenance, etc
- Final selection of the proposed release location has yet to be determined however site assessment will include (but is not limited to) key selection criteria such as accessibility, geomorphic suitability, presence of riparian and aquatic vegetation, etc.

In summary, the proposed diffuser configurations simulated in this mixing zone assessment represent a conceptual level of design that is considered appropriate for the current level of design progression. The results of the assessment indicate that the low adopted use of available assimilative capacity and resultant high effective dilution ratio combined with the adopted diffuser configurations provide for a rapid mixing of potential releases and compliance with the relevant WQOs.

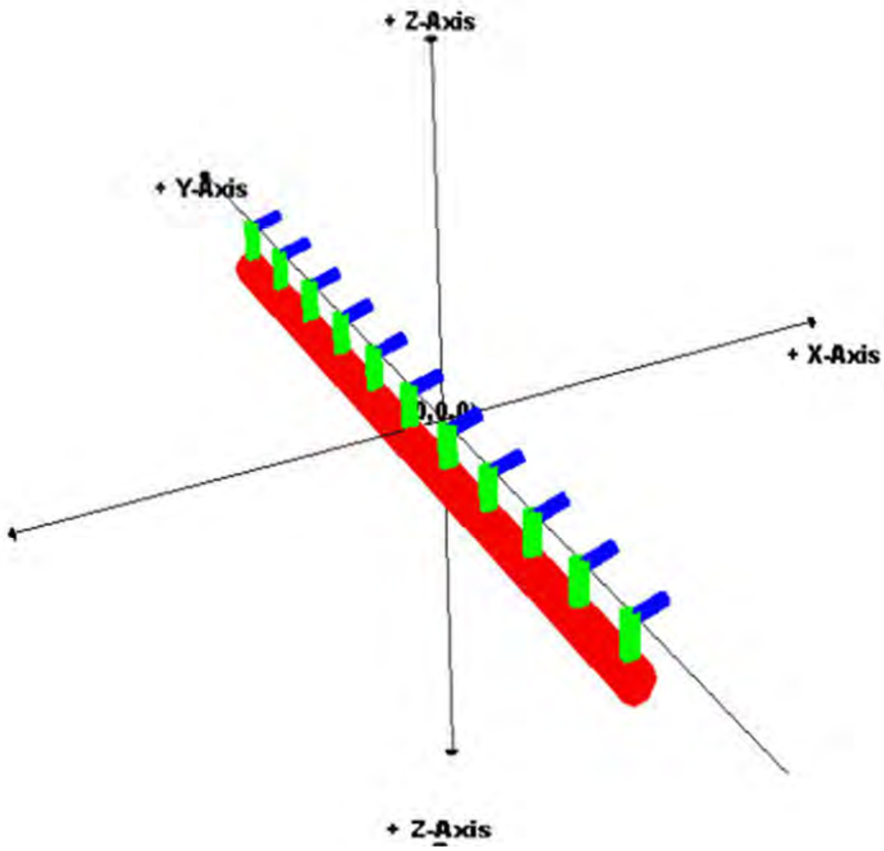


Figure 50 Typical Co-Flowing Diffuser Arrangement (Doneker & Jirka, 2017)

6.2.1.4 CORMIX Scenarios

Table 57 details the four modelled scenarios assessed. Ambient environment data was obtained from the HEC-RAS hydraulic model (refer to Section 5.10.1). For the purpose of the assessment the proposed release location was assumed to be at model chainage 7846km and average channel dimensions were based on the average of all cross sections 500m up and downstream of the proposed release point. The diffuser was assumed to be located in the channel centre for the purpose of the assessment however due to large expansion in flow width associated with each incremental increase in the ambient flow rate the distance from the bank to the diffuser also increases.

Table 57 CORMIX Scenarios Assessed

Scenario	Description	Receiving Flow	Release Flow	Ambient Assumptions			Adopted Conceptual Diffuser Configuration				
				Depth at Discharge (m)	Average Width (m)	Average Depth (m)	Length (m)	Distance to Banks (m)	Port Height[12] (m)	Port Diameter (m)	No. of Ports
1	Minimum rate of release – receiving flow at the release trigger	400 ML/d ($4.63\ m^3/s$)	2.0 ML/d ($0.023\ m^3/s$)	0.38	31.8	0.31	18	3.5	0.1	0.11	4
2	Release into the 2% daily flow	3,790 ML/d ($43.87\ m^3/s$)	19.1 ML/d ($0.221\ m^3/d$)	0.43	82.8	0.63	18	18	0.1	0.11	4
3	Release into the 1% daily flow	11,098 ML/d ($128.45\ m^3/s$)	55.9 ML/d ($0.646\ m^3/s$)	0.87	124.5	0.94	25	49.5	0.1	0.125	10
4	Release at maximum discharge capacity	17,176 ML/d ($198.8\ m^3/s$)	86.4 ML/d ($1.00\ m^3/s$)	1.16	134.0	1.17	25	54	0.1	0.125	10

[12] Height of the release port centres above the channel bed

6.2.1.5 Scenario Results

Initial results from multi-port modelling using CORMIX2 were compared to a single port assessment using CORMIX1 as recommended by CORMIX based on the adopted configurations assessed. For all scenarios use of a CORMIX1 single port assessment resulted in a longer mixing zone and therefore only these results have been presented.

Figure 51 to Figure 54 show CORMIX1 mixing zone results for each of the four modelled scenarios assessed. The estimated mixing zone length is summarised in Table 58 along with the mixing zone to channel width. From the results it can be seen that the proposed releases are subject to initial mixing within the near field and that predicted water quality within the mixing zone reaches the WQO for dissolved zinc, being the contaminant of most concern, within a maximum distance of 623m. Other modelled scenarios indicate a much smaller mixing zone of between 50 and 70 m downstream. The difficulty in optimising diffuser performance across a wide of range of discharge and ambient conditions (as discussed in Section 6.2.1.3) is highlighted by the estimated mixing zone length for scenario 2. While both scenarios 1 and 2 utilise the same configuration, the changes in discharge and flow rate and ambient flow rate result in a significant difference in the estimated mixing zone length.

Table 58 CORMIX Scenario Results for Estimated Mixing Zones (CORMIX1 Single Port Assessment)

Scenario	Estimated Mixing Zone Length (m)	Estimated Scenario Channel Width (m)
1	51.3	31.8
2	622.7	82.8
3	66.9	124.5
4	62.5	134.0

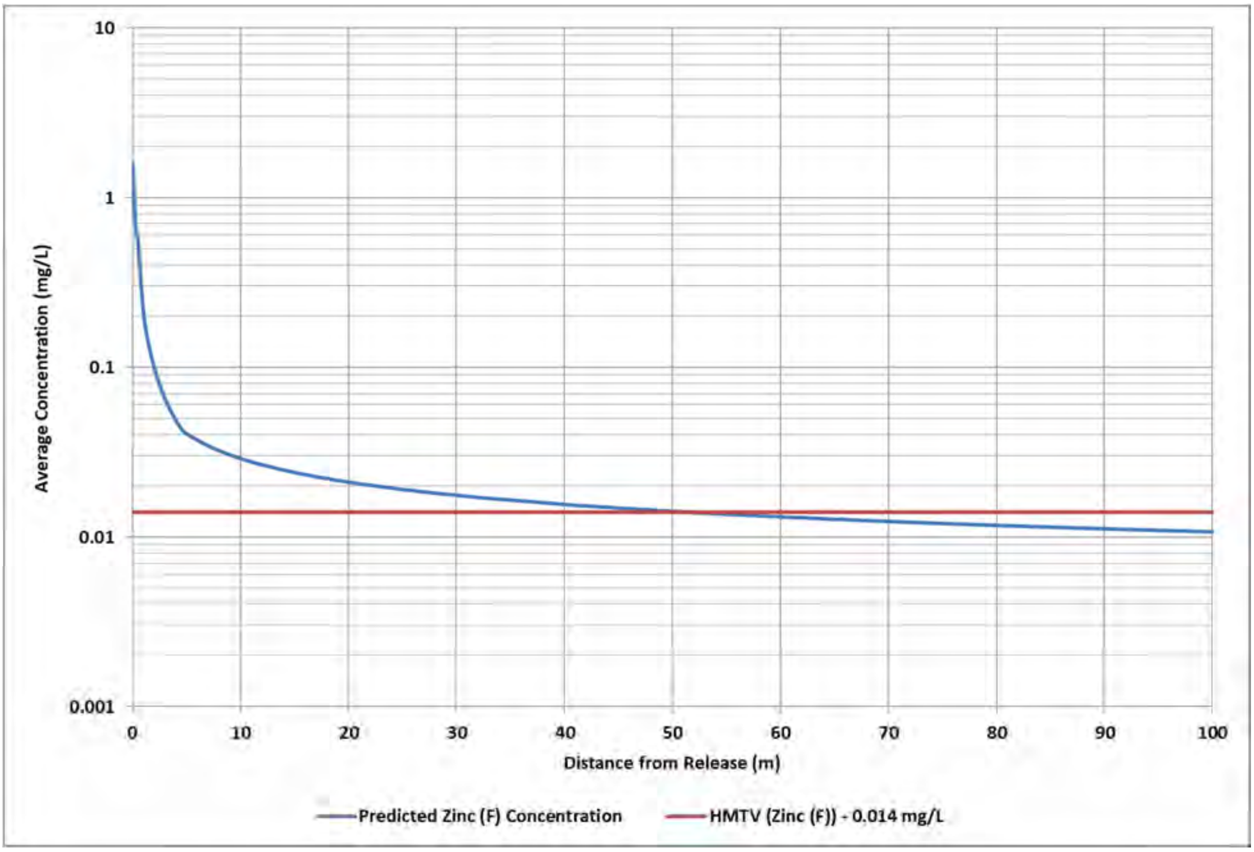


Figure 51 Scenario 1 – Mixing Zone (CORMIX1 Single Port Assessment)

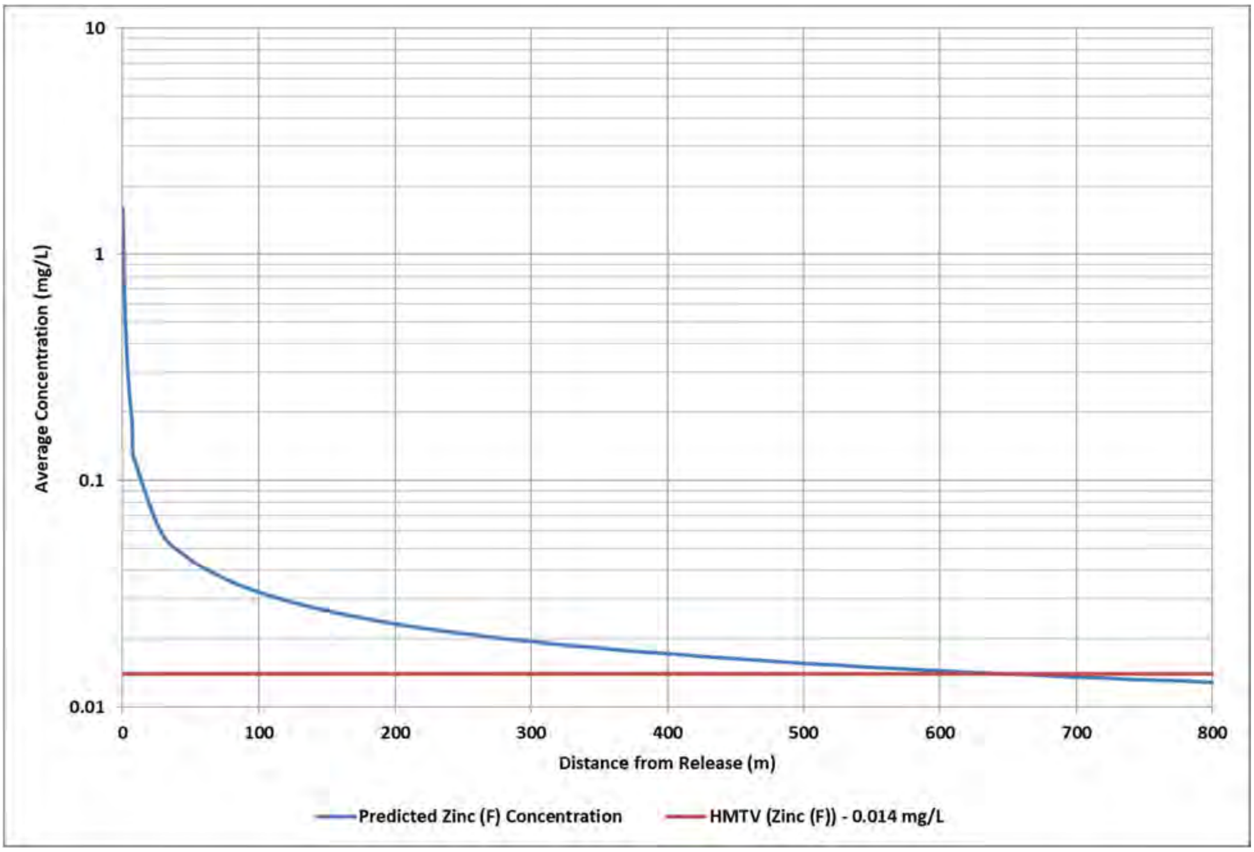


Figure 52 Scenario 2 – Mixing Zone (CORMIX1 Single Port Assessment)

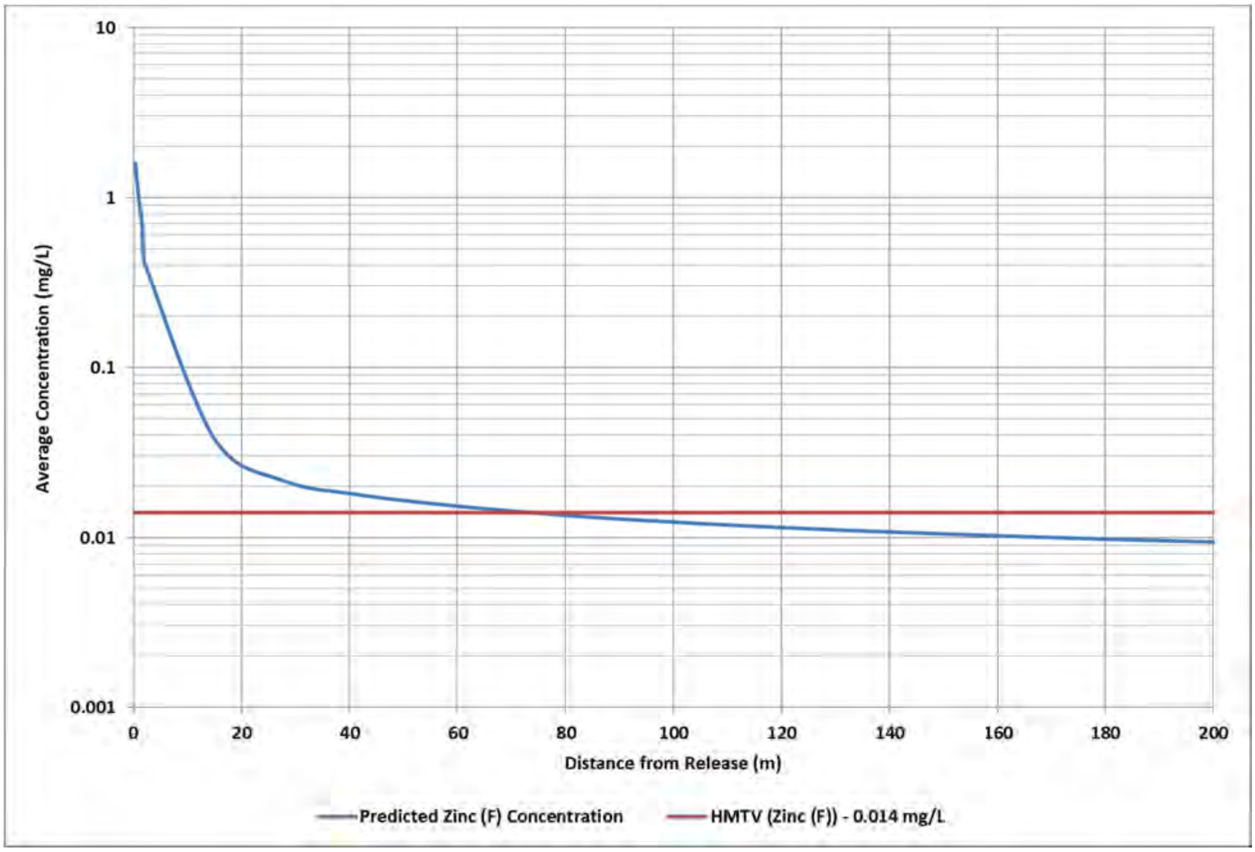


Figure 53 Scenario 3 – Mixing Zone (CORMIX1 Single Port Assessment)

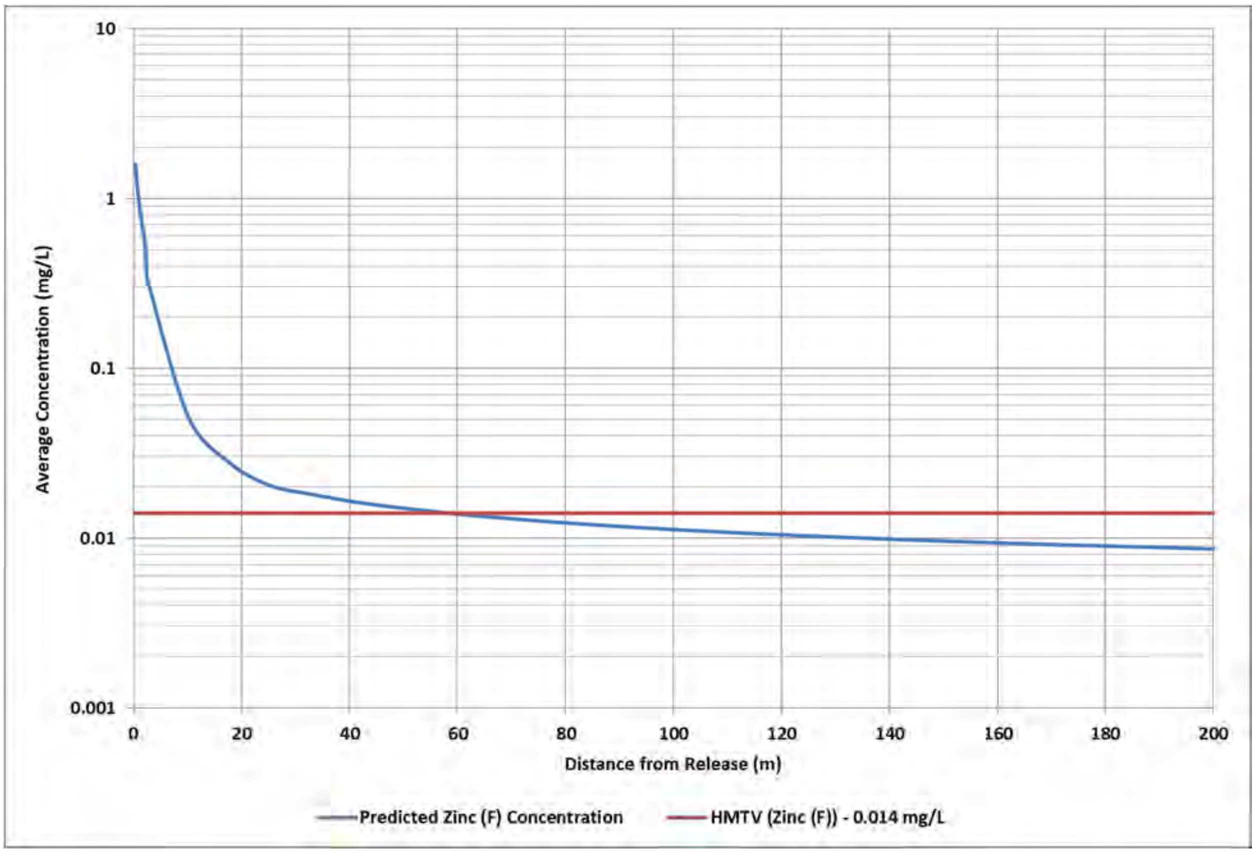


Figure 54 Scenario 4 – Mixing Zone (CORMIX1 Single Port Assessment)

6.2.2 Far Field Assessment of Sustainable Load (Downstream Mass Balance)

A mass balance analysis has been undertaken in order to develop an understanding of the release potential of water from the Project and to assess the sustainable load in terms of frequency, volumes, mass loading and downstream cumulative impact. The analysis has been conducted using water balance assessment as per the model described in Appendix L. Detailed discussion of the model development, assumptions and limitations is also provided in Appendix L.

The following release water quality assumptions were modelled:

1. Assumed release water quality based on the median value of parameters in both pits, mixed at a ratio of nine parts Eldridge to one part Wises, using a receiving environment dilution ratio of 200 parts receiving environment water to one part release water.
2. Assumed release water quality based on the maximum value of parameters in both pits, mixed at a ratio of nine parts Eldridge to one part Wises, using a receiving environment dilution ratio of 200 parts receiving environment water to one part release water.

In terms of other potential catchment pollutant sources, Section 5.4 indicates that 95% of the Gilbert Catchment is comprised of cattle grazing land uses. The only identified potential industrial use of water (apart from Kidston itself) is adjacent to Einasleigh township. Loads associated with these sources have not been accounted for in the mass balance assessment, except where they form part of inflows to the Copperfield River (i.e. water quality monitoring data for tributaries such as East Creek)

In-stream concentrations for each downstream location have only been estimated on those days when releases occurred and have been calculated assuming mass-conserved advective transport only. Concentrations have been estimated for the contaminant of most concern (dissolved zinc) (refer to Section 6.1.1) as well as a number of additional contaminants that are either expected to potentially exceed WQOs during the construction phase or are considered common stressors in the receiving environment.

A number of scenarios were assessed for the assessment as outlined in Table 59 below. Key assumptions are shown in Table 60 with all release parameters based on the contaminant of most concern, dissolved zinc.

For dissolved cadmium and dissolved zinc, the HMTV has been applied up to approximately 7 km downstream of the release location (junction with East Creek) due to the elevated baseline in the receiving environment (median hardness of 56 mg/L at Copperfield River monitoring location W2).

Table 59 Operational Phase Downstream Mass Balance Scenarios Assessed

Scenario	Release Water Quality Assumption	Description	Comment
1a	Median	Annual simulation	Detailed downstream mass balance assessment focused on contaminant of most concern, Dissolved zinc
1b	Maximum		
2a	Median	Life of Project (50 year) simulation	Detailed downstream mass balance assessment focused on contaminant of most concern, dissolved zinc
2b	Maximum		
3a	Median	Annual simulation	Comparative downstream mass balance assessment for: • EC and sulfate, • Cadmium (F), cobalt (F), dissolved zinc, arsenic (T), cobalt (T), manganese (T) and total nitrogen (as N)
3b	Maximum		

Table 60 Operational Phase Downstream Mass Balance – Key Assumptions

Scenario	Release Parameters Derived for Contaminant of Most Concern (Dissolved Zinc)			Assumed Concentration for Contaminant of Most Concern (Dissolved Zinc)
	Dilution Ratio (1 in xx)	Release Ratio	Assimilative Capacity Utilisation	
1a	200	0.5%	27.4%	Median: 0.6298 mg/L
1b	200	0.5%	69.0%	Maximum: 1.5874 mg/L
2a	200	0.5%	27.4%	Median: 0.6298 mg/L
2b	200	0.5%	69.0%	Maximum: 1.5874 mg/L
3a	200	0.5%	27.4%	Median: 0.6298 mg/L plus median concentrations for 8 additional contaminants as detailed in Table 59.
3b	200	0.5%	69.0%	Maximum: 1.5874 mg/L plus maximum concentrations for 8 additional contaminants as detailed in Table 59.

6.2.2.1 Dissolved Zinc Mass Balance Results

The following is a high-level summary of the dissolved zinc mass balance assessment set out in Sections . to 6.2.2.4.

- Scenario 1a: All mass balance calculations for dissolved zinc are below the relevant WQO for 95% species protection (HMTV down to East Creek, and default WQO from Charles Creek to Einasleigh).
- Scenario 2a: All mass balance calculations for dissolved zinc are below the relevant WQO for 95% species protection (HMTV down to East Creek, and default WQO from Charles Creek to Einasleigh).
- Scenario 2b: Under a life of Project maximum (worst-case) scenario, dissolved zinc is below the HMTV for 95% species protection down to East Creek. At Charles Creek, results are slightly above the default WQO for 95% species protection, but well below the WQO for 90% species protection. From Oak Creek to Einasleigh, all results are below the default WQO for 95% species protection.

- Scenario 1a - Annual Mass Balance Simulation for Contaminant of Most Concern - Dissolved Zinc, Median Release Concentration

Table 61 and Figure 55 below show estimated downstream concentrations for dissolved zinc based on releases at the assumed median concentration of 0.6298 mg/L. Results are shown at key tributary inflows on the Copperfield River downstream of the proposed release point with the final point at the confluence with the Einasleigh River at Einasleigh. Estimated concentrations at each location are based on a fully conserved mass balance and assumed 27.4% usage of the available assimilative capacity (as per Table 60).

The mass balance results in Table 61 and Figure 55 show that additional dilution occurs between the proposed release point and Einasleigh. The conservative utilisation of 27.4% of the available assimilative capacity ensures that the mass-balanced concentration is significantly below the WQO at the proposed release point and continues to reduce with increasing downstream distance.

Table 61 Scenario 1a – Downstream Mass Balanced Concentrations for Dissolved Zinc (Annual Simulation, Median Release Concentration)

Statistic	Proposed Release Point After Discharge	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Mean	0.0055	0.0050	0.0048	0.0044	0.0043	0.0042	0.0032
P5	0.0049	0.0045	0.0042	0.0038	0.0037	0.0036	0.0029
P10	0.0053	0.0048	0.0045	0.0040	0.0038	0.0037	0.0029
P20	0.0055	0.0049	0.0046	0.0042	0.0040	0.0039	0.0030
P50	0.0056	0.0051	0.0049	0.0044	0.0042	0.0041	0.0032
P80	0.0056	0.0053	0.0051	0.0047	0.0046	0.0045	0.0034
P90	0.0056	0.0054	0.0053	0.0050	0.0049	0.0048	0.0037
P95	0.0056	0.0055	0.0054	0.0051	0.0051	0.0050	0.0040
Distance from Release (km)	0	6.9	19.58	23.43	30.39	35.72	48.32

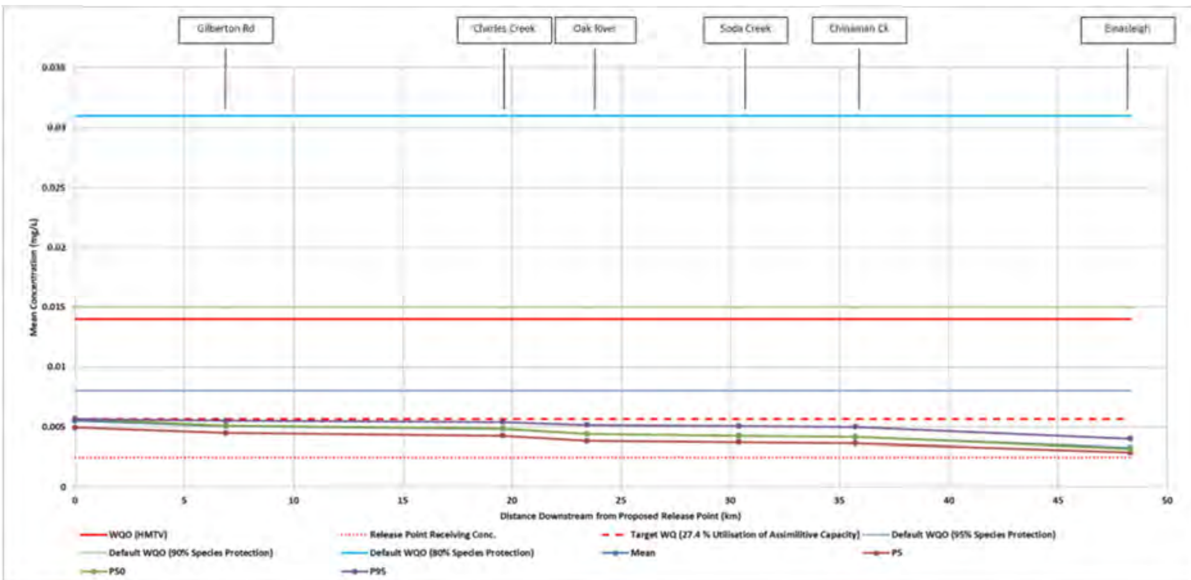


Figure 55 Scenario 1a – Downstream Mass Balanced Concentrations for Dissolved Zinc (Annual Simulation, Median Release Concentration)

6.2.2.2 Scenario 1b - Annual Mass Balance Simulation for Contaminant of Most Concern - Dissolved Zinc, Maximum Release Concentration

Table 62 and Figure 56 below show estimated downstream concentrations for based on releases at the maximum assumed concentration of 1.5874 mg/L. Although the higher release concentration (and utilisation of assimilative capacity (69.0%)) results in a higher concentration at the proposed release point, significant additional dilution occurs between the proposed release point and Einasleigh as a result of tributary inflows.

Table 62 Scenario 1b – Downstream Mass Balanced Concentrations for Dissolved Zinc (Annual Simulation, maximum Release Concentration)

Statistic	Proposed Release Point After Discharge	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Mean	0.0101	0.0089	0.0084	0.0073	0.0070	0.0068	0.0044
P5	0.0086	0.0075	0.0069	0.0059	0.0056	0.0054	0.0035
P10	0.0097	0.0083	0.0076	0.0062	0.0058	0.0056	0.0036
P20	0.0100	0.0086	0.0079	0.0067	0.0063	0.0061	0.0038
P50	0.0104	0.0091	0.0085	0.0073	0.0069	0.0067	0.0042
P80	0.0104	0.0095	0.0090	0.0080	0.0077	0.0075	0.0049
P90	0.0104	0.0098	0.0095	0.0087	0.0085	0.0083	0.0055
P95	0.0104	0.0100	0.0098	0.0092	0.0089	0.0088	0.0063
Distance from Release (km)	0	6.9	19.58	23.43	30.39	35.72	48.32

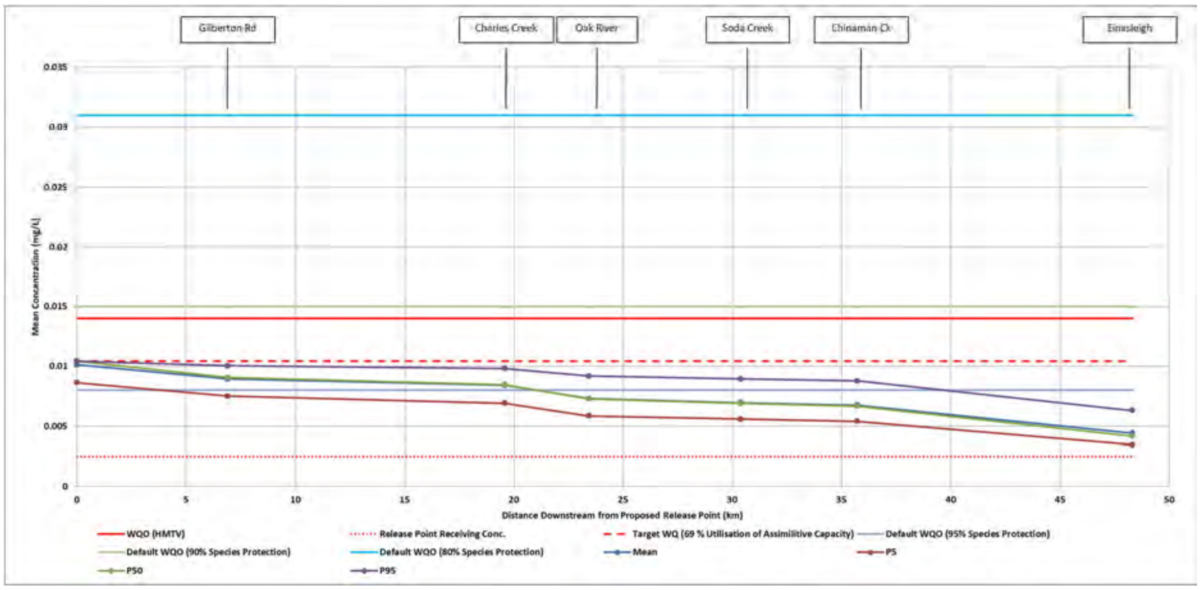


Figure 56 Scenario 1b – Downstream Mass Balanced Concentrations for Dissolved Zinc (Annual Simulation, Maximum Release Concentration)

6.2.2.3 Scenario 2a – Life of Project Mass Balance Simulation (50 Year) for Contaminant of Most Concern - Dissolved Zinc, Median Release Concentration

Table 63 and Figure 57 below again show that significant additional dilution occurs between the proposed release point and Einasleigh although the moderating effect of averaging results over the 50 year life of Project means that results show significantly less variation than Scenario 1a and 1b (annual simulations). Estimated concentrations at each location are based on a fully conserved mass balance and assumed 27.4% usage of the available assimilative capacity (as per Table 60).

Table 63 Scenario 2a - Downstream Mass Balanced Concentrations for Dissolved Zinc (Life of Project (50 yr) Simulation)

Statistic	Proposed Release Point After Discharge	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Mean	0.0055	0.0050	0.0048	0.0043	0.0042	0.0041	0.0032
P5	0.0054	0.0049	0.0047	0.0043	0.0041	0.0040	0.0031
P10	0.0054	0.0049	0.0047	0.0043	0.0041	0.0041	0.0031
P20	0.0055	0.0050	0.0048	0.0043	0.0042	0.0041	0.0031
P50	0.0055	0.0050	0.0048	0.0043	0.0042	0.0041	0.0032
P80	0.0055	0.0051	0.0048	0.0044	0.0042	0.0042	0.0032
P90	0.0056	0.0051	0.0049	0.0044	0.0042	0.0042	0.0032
P95	0.0056	0.0051	0.0049	0.0044	0.0043	0.0042	0.0032
Distance from Release (km)	0	6.9	19.58	23.43	30.39	35.72	48.32

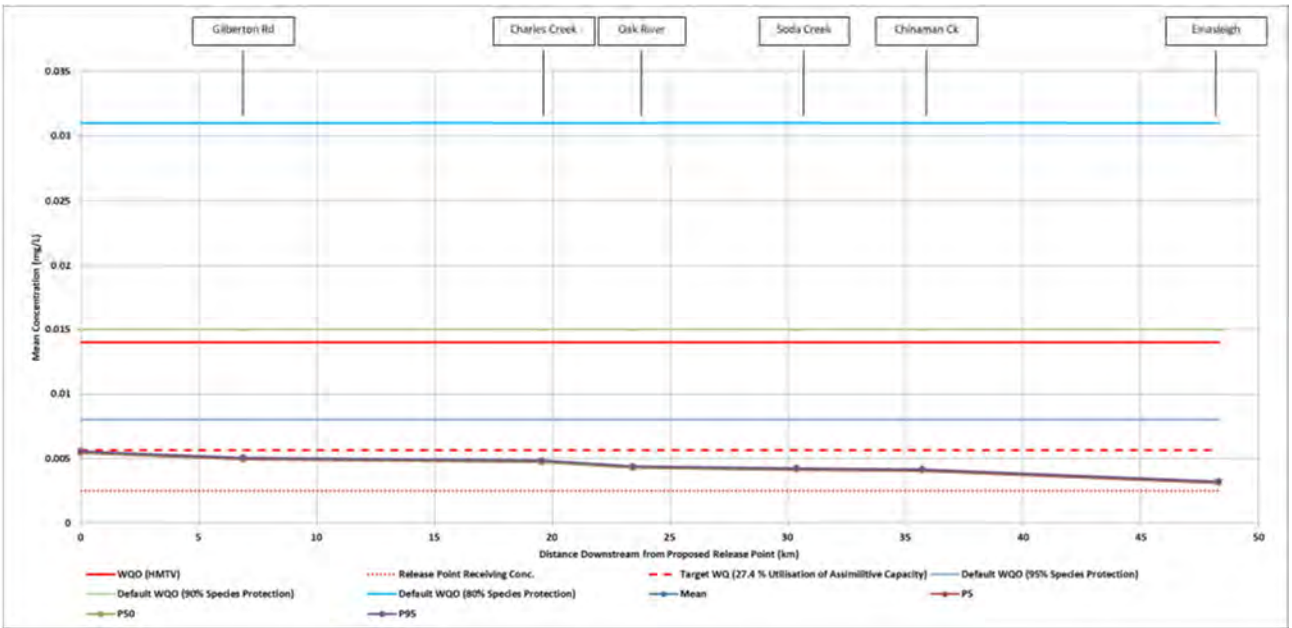


Figure 57 Scenario 2a - Downstream Mass Balanced Concentrations for Dissolved Zinc (Life of Project (50yr) Simulation, Median Release Concentration)

6.2.2.4 Scenario 2b – Life of Project Mass Balance Simulation (50 Year) for Contaminant of Most Concern - Dissolved Zinc, Maximum Release Concentration

Table 64 and Figure 58 below again show that significant additional dilution occurs between the proposed release point and Einasleigh. Estimated concentrations at each location are based on a fully conserved mass balance and assumed 69.0% usage of the available assimilative capacity.

Table 64 Scenario 2b - Downstream Mass Balanced Concentrations for Dissolved Zinc (Life of Project (50 yr) Simulation, Maximum Release Concentration)

Statistic	Proposed Release Point After Discharge	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Mean	0.0100	0.0088	0.0083	0.0071	0.0068	0.0066	0.0042
P5	0.0098	0.0086	0.0081	0.0070	0.0066	0.0064	0.0041
P10	0.0099	0.0087	0.0081	0.0070	0.0066	0.0064	0.0041
P20	0.0099	0.0087	0.0082	0.0070	0.0067	0.0065	0.0041
P50	0.0100	0.0088	0.0083	0.0072	0.0068	0.0066	0.0042
P80	0.0102	0.0090	0.0084	0.0073	0.0069	0.0067	0.0043
P90	0.0102	0.0090	0.0084	0.0073	0.0069	0.0067	0.0043
P95	0.0102	0.0090	0.0084	0.0073	0.0069	0.0067	0.0044
Distance from Release (km)	0	6.9	19.58	23.43	30.39	35.72	48.32

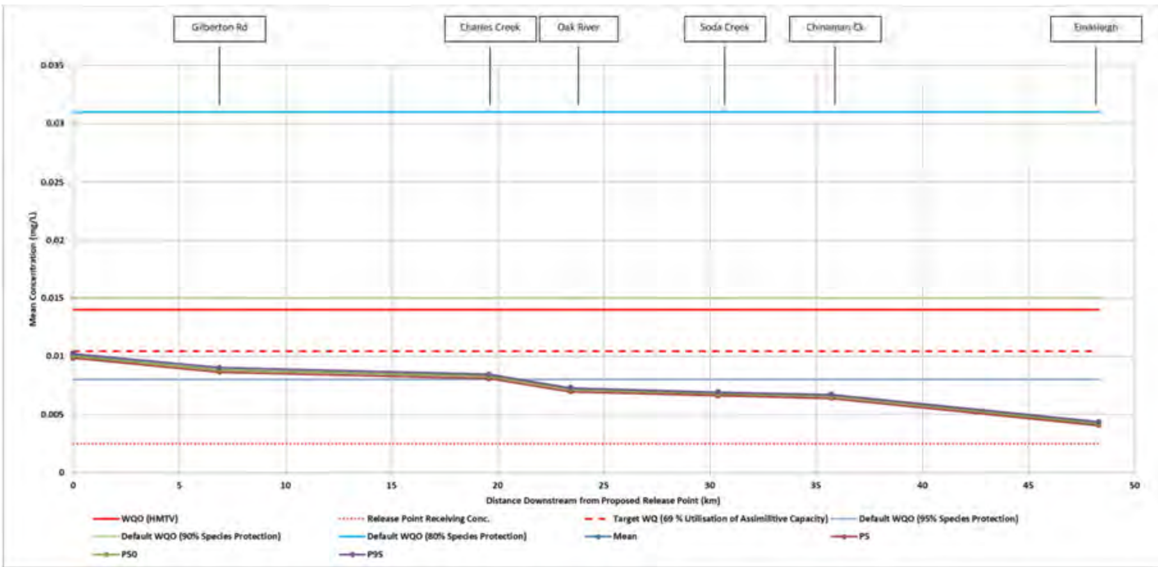


Figure 58 Scenario 2b - Downstream Mass Balanced Concentrations for Dissolved Zinc (Life of Project (50yr) Simulation, Maximum Release Concentration)

6.2.2.5 Scenario 3 – Annual Mass Balance Simulation for Comparative Assessment of Nine Constituents of Most Concern

Results of the annual mass balance simulation for the operations phase are presented in Table 65.

The assessment indicates that parameters relevant to the aquatic ecosystem EV are below the WQO at all locations, with the exception of total nitrogen and dissolved zinc. The concentration of total nitrogen is above the WQO at all modelled locations. It should be noted however that the baseline concentration of total nitrogen at W2 already exceeds the WQO, and there are only two data points available for the pits, therefore this is a low-reliability indication. Further monitoring of total nitrogen will be undertaken as part of the REMP.

Under a worst case scenario, there may be rare and very minor exceedances of the default 95% species protection WQO for dissolved zinc from Charles Creek to Chinaman Creek (modelled P95 concentrations of 0.009 or 0.010 mg/L compared with the default WQO of 0.008 mg/L). For the scenarios assessed, the 90% species protection WQO will not be exceeded at any location in the receiving environment.

Table 65 Operations Phase Mass Balance Results

Description		Median Concentration for Releases (Scenario 3b)									Worst Case Maximum Concentrations for Releases (Scenario 3a)								
Contaminant		Electrical Conductivity @ 25°C	Sulfate as SO_4 - Turbidimetric	Cadmium (F)	Cobalt (F)	Zinc (F)	Arsenic (T)	Cobalt (T)	Manganese (T)	Total Nitrogen as N	Electrical Conductivity @ 25°C	Sulfate as SO_4 - Turbidimetric	Cadmium (F)	Cobalt (F)	Zinc (F)	Arsenic (T)	Cobalt (T)	Manganese (T)	Total Nitrogen as N
Relevant Environmental Value		Aquatic Ecosystems (physico-chemical stressor)	Drinking Water - Aesthetic	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Drinking Water - Health	Long Term Irrigation	Recreation	Aquatic Ecosystems (physico-chemical stressor)	Aquatic Ecosystems (physico-chemical stressor)	Drinking Water - Aesthetic	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Drinking Water - Health	Long Term Irrigation	Recreation	Aquatic Ecosystems (physico-chemical stressor)
Units		µS/cm	mg/L	mg/L*	mg/L	mg/L*	mg/L	mg/L	mg/L	mg/L	µS/cm	mg/L	mg/L*	mg/L	mg/L*	mg/L	mg/L	mg/L	mg/L
Baseline Median at W2		167	10	0.00005	0.0005	0.0025	0.001	0.0005	0.073	0.25	167	10	0.00005	0.0005	0.0025	0.001	0.0005	0.073	0.25
WQO (80% species protection for aquatic ecosystems)		**N/A**	**N/A**	**HMTV 0.0014 [0.0008]**	**N/A**	**HMTV 0.0527 [0.031]**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**HMTV 0.0014 [0.0008]**	**N/A**	**HMTV 0.0527 [0.031]**	**N/A**	**N/A**	**N/A**	**N/A**
WQO (90% species protection for aquatic ecosystems)		**N/A**	**N/A**	**HMTV 0.0007 [0.0004]**	**N/A**	**HMTV 0.0255 [0.015]**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**HMTV 0.0007 [0.0004]**	**N/A**	**HMTV 0.0255 [0.015]**	**N/A**	**N/A**	**N/A**	**N/A**
WQO (95% species protection for aquatic ecosystems)		**500**	**250**	**HMTV 0.0003 [0.0002]**	**0.0028**	**HMTV 0.0140 [0.008]**	**0.0100**	**0.0500**	**0.1000**	**0.1500**	**500**	**250**	**HMTV 0.0003 [0.0002]**	**0.0028**	**HMTV 0.0140 [0.008]**	**0.0100**	**0.0500**	**0.1000**	**0.1500**
Proposed Release Point (0 km)	Mean	180.191	17.921	0.00014	0.001	0.006	0.001	0.001	0.078	0.279	190.5	22.8	0.0002	0.0006	0.010	0.003	0.017	0.090	0.279
	Median	182.075	18.313	0.00014	0.001	0.006	0.001	0.001	0.079	0.280	192.7	23.4	0.0002	0.0006	0.010	0.003	0.018	0.091	0.280
	P95	182.075	18.313	0.00014	0.001	0.006	0.001	0.001	0.079	0.281	192.7	23.4	0.0002	0.0006	0.010	0.003	0.018	0.091	0.281
East Creek (Gilberton Rd) (6.9 km)	Mean	169.345	15.483	0.00012	0.001	0.005	0.001	0.001	0.072	0.273	178.0	19.6	0.0002	0.0006	0.009	0.002	0.015	0.081	0.273
	Median	170.236	15.583	0.00013	0.001	0.005	0.001	0.001	0.072	0.273	179.0	19.8	0.0002	0.0006	0.009	0.002	0.015	0.082	0.273
	P95	178.539	17.513	0.00014	0.001	0.005	0.001	0.001	0.077	0.275	188.7	22.4	0.0002	0.0006	0.010	0.003	0.017	0.088	0.275
Charles Creek (19.6 km)	Mean	164.336	14.358	0.00012	0.001	0.005	0.001	0.001	0.069	0.270	172.3	18.2	0.0002	0.0006	0.008	0.002	0.014	0.078	0.270
	Median	164.878	14.353	0.00012	0.001	0.005	0.001	0.001	0.069	0.270	172.8	18.2	0.0002	0.0006	0.008	0.002	0.014	0.078	0.270
	P95	176.379	17.024	0.00013	0.001	0.005	0.001	0.001	0.075	0.273	186.2	21.7	0.0002	0.0006	0.010	0.003	0.017	0.086	0.273
Oak River (23.4 km)	Mean	154.146	12.073	0.00011	0.001	0.004	0.001	0.001	0.063	0.264	160.6	15.2	0.0001	0.0006	0.007	0.002	0.011	0.070	0.264
	Median	154.197	11.831	0.00011	0.001	0.004	0.001	0.001	0.062	0.264	160.6	14.9	0.0001	0.0006	0.007	0.002	0.011	0.070	0.264
	P95	170.641	15.725	0.00013	0.001	0.005	0.001	0.001	0.072	0.268	179.6	20.0	0.0002	0.0006	0.009	0.002	0.015	0.082	0.268
Soda Creek (30.4 km)	Mean	150.888	11.342	0.00010	0.001	0.004	0.001	0.001	0.061	0.262	156.9	14.2	0.0001	0.0006	0.007	0.002	0.010	0.068	0.262
	Median	150.497	11.035	0.00010	0.001	0.004	0.001	0.001	0.060	0.262	156.3	13.8	0.0001	0.0006	0.007	0.002	0.010	0.067	0.262
	P95	168.375	15.212	0.00012	0.001	0.005	0.001	0.001	0.071	0.266	177.0	19.3	0.0002	0.0006	0.009	0.002	0.015	0.080	0.266
Chinaman Creek (35.7km)	Mean	149.005	10.920	0.00010	0.001	0.004	0.001	0.001	0.060	0.261	154.8	13.7	0.0001	0.0006	0.007	0.002	0.010	0.066	0.261
	Median	148.352	10.587	0.00010	0.001	0.004	0.001	0.001	0.059	0.261	153.9	13.2	0.0001	0.0006	0.007	0.002	0.010	0.065	0.261
	P95	166.950	14.890	0.00012	0.001	0.005	0.001	0.001	0.070	0.265	175.4	18.9	0.0002	0.0006	0.009	0.002	0.014	0.079	0.265
Einasleigh (48.3 km)	Mean	127.152	6.025	0.00007	0.001	0.003	0.001	0.001	0.047	0.249	129.8	7.3	0.0001	0.0005	0.004	0.001	0.005	0.050	0.249
	Median	125.583	5.527	0.00007	0.001	0.003	0.001	0.001	0.046	0.248	127.9	6.5	0.0001	0.0005	0.004	0.001	0.004	0.048	0.248
	P95	144.483	9.805	0.00009	0.001	0.004	0.001	0.001	0.057	0.252	149.6	12.2	0.0001	0.0006	0.006	0.002	0.009	0.062	0.252

*Indicates HMTV. Default WQO presented in brackets.

Red values denote exceedance of WQO (for 95% species protection where multiple levels of protection are available). The HMTV has been applied up to ~7km downstream due to the elevated baseline in the receiving environment (median hardness of 56 mg/L at Copperfield River monitoring location W2).

6.2.3 Assessment of Water Quality Impacts to Environmental Values

Results of the DTA, near-field (CORMIX modelling) and far-field (mass balance) assessments were used to assess the water quality-related impacts to each EV as a result of operational releases. Results are presented in Table 66.

Table 66 Potential Operations Phase Water Quality Impacts to Relevant Environmental Values

Environmental Value	Relevant Parameter and Copperfield River Location	Impact Assessment
Aquatic ecosystems (incorporating Habitat value)	From the CORMIX modelling results it can be seen that the proposed releases are subject to initial mixing within the near field and that predicted water quality within the mixing zone reaches the HMTV for dissolved zinc (the constituent of most concern), within 625 m under the worst-case scenario. Other modelled scenarios indicate a much smaller mixing zone of between 50 and 70 m downstream. Mass balance assessment indicates that parameters relevant to the aquatic ecosystem EV are below the WQO at all locations, with the exception of total nitrogen and dissolved zinc. The concentration of total nitrogen is above the WQO at all modelled locations, partly due to the elevated baseline concentrations (also above the WQO). Under a worst case scenario, there may be rare and very minor exceedances of the default 95% species protection WQO for dissolved zinc from Charles Creek to Chinaman Creek (modelled P95 concentrations of 0.009 or 0.010 mg/L compared with the default WQO of 0.008 mg/L). For the scenarios assessed, the 90% species protection WQO will not be exceeded at any location in the receiving environment. The exceedances are within the likely margin of error of the various methods used in the assessment. Whist concentrations of nitrate are elevated in release waters,	Baseline total nitrogen is already elevated in the receiving environment and is thereby contributing to the exceedance of the WQO. Elevated nitrogen concentrations in waterways may under certain circumstances lead to algal blooms, which can impact aquatic ecosystems. Whilst the levels of nitrogen exceed the WQO, the exceedance is not likely to cause such impacts given the nature of the receiving environment and composition of the discharge water, namely the limited availability of phosphorus. Monitoring undertaken as part of the REMP (refer to Section 8.2) will ensure that any impacts are appropriately managed, and if necessary that additional mitigation measures are implemented (see Section 9.3). Nitrate concentrations are expected to be well below the WQO post-release and therefore impacts associated with nitrate are considered negligible. Although there may be rare and very minor exceedances of the 95% level of protection for dissolved zinc from Charles Creek to Einasleigh, the DTA results (refer to Section 4.9) indicate that the proposed releases will not result in toxicity-related impacts to aquatic ecosystems. Under the DTA, a minimum dilution ratio of nine parts receiving environment water to one part release water is required to meet 95% species protection. In addition, the exceedances are within the likely margin of error of the various methods used in the assessment. During the operations and construction phases, the simulated releases are well in excess (200:1) of this minimum dilution ratio. With regards to scour at the outfall contributing to sedimentation, modelling suggests that the increased flow from the releases will not have any significant effect on the hydraulics of the natural system (refer to Section 6.5 below for detail). Detailed design and construction will need to take into consideration the potential for erosion, and ensure that engineering solutions appropriately mitigate this impact to avoid downstream impacts.

Environmental Value	Relevant Parameter and Copperfield River Location	Impact Assessment
	concentrations post-release are expected to be well below the WQO for aquatic ecosystem protection post-release during the operations and construction phases (refer to Table 55). It was therefore considered unnecessary to include nitrate in the mass balance assessment.	The potential impacts to the downstream environment from increased erosion and sedimentation associated with the release point are expected to be minimal as construction of this component will be strictly limited to the dry season. During operation, impacts are anticipated to be restricted to the immediate area surrounding and downstream of the release point. Appropriate design and management of the diffuser will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values. Further, photographic monitoring of the release point over time will document and monitor the rate of erosion and deposition occurring at and downstream of the release point.
Irrigation (Short Term < 20 years)	As set out in Section 5.4, WQOs for short term irrigation do not apply as the lowest applicable WQO for any parameter.	Modelling has shown that more stringent WQOs for other EVs will not be exceeded as a result of Project releases. It therefore concluded that the Project is unlikely to result in impacts to the short term irrigation EV during the operations period when dilution rates are high (200:1).
Irrigation (Long Term ~100 years)	The WQO for total cobalt is specific to the protection of the long term irrigation EV. Modelling has shown that the WQO for total cobalt will not be exceeded post-mixing in the receiving environment.	Impacts to long term irrigation during the operations phase are not anticipated, as concentrations of total cobalt post releases are modelled to be below the relevant WQO for long term irrigation at all downstream locations.
Farm supply (e.g. fruit washing, milking sheds, intensive livestock yards)	As set out in Section 5.4, WQOs for farm supply do not apply as the lowest applicable WQO for any parameter.	The high dilution rate for the operations phase of the Project (200:1) means that all relevant WQOs will be met post-release in the receiving environment. The ANZECC/ARMCANZ 2000 guidelines includes trigger values for assessing the corrosiveness and fouling potential of water. pH and hardness in the releases post-mixing indicates limited potential for both corrosion and fouling potential. Impacts to the farm supply EV in the receiving environment are therefore considered highly unlikely.
Stock watering (e.g. grazing cattle)	As set out in Section 5.4, WQOs for stock watering do not apply as the lowest applicable WQO for any parameter.	ANZECC/ARMCANZ 2000 WQOs for stock watering are presented in Table 29. The worst case concentrations in the receiving environment based on maximum concentrations (Table 55) indicates that WQOs for stock watering will not be exceeded. It therefore concluded that the Project is unlikely to result in impacts to the stock watering EV during the operations period.

Environmental Value	Relevant Parameter and Copperfield River Location	Impact Assessment
Aquaculture	This EV was considered and is not applicable to downstream receiving environment	This EV was considered and is not applicable to downstream receiving environment
Human consumption (e.g. of wild or stocked fish)	As set out in Section 5.4, WQOs for human consumption do not apply as the lowest applicable WQO for any parameter.	ANZECC/ARMCANZ 2000 WQOs for human consumption are presented in Table 29. The worst case concentrations in the receiving environment based on maximum concentrations (Table 55) indicates that WQOs for human consumption will not be exceeded. It therefore concluded that the Project is unlikely to result in impacts to the human consumption EV during the operations period.
Primary recreation (fully immersed in water e.g. swimming)	The WQO for total manganese is specific to the protection of the recreation EV. Modelling has shown that the WQO for total manganese will not be exceeded post-mixing in the receiving environment.	Impacts to recreation during the operations phase are not anticipated, as concentrations of total manganese post releases are modelled to be below the relevant WQO for recreation at all downstream locations.
Secondary recreation (possibly splashed with water, e.g. sailing)		
Visual appreciation (no contact with water, e.g. picnics)	No specific WQOs associated with the protection of visual appreciation. See above for recreation.	Modelling has shown that more stringent WQOs for other EVs will not be exceeded as a result of Project releases. It therefore concluded that the Project is unlikely to result in impacts to the visual appreciation EV during the operations period when dilution rates are high (200:1).
Drinking water (raw water supplies taken for drinking)	The WQOs for sulfate and total arsenic are specific to the protection of the drinking water EV (sulfate for aesthetics and arsenic for health). Modelling has shown that the WQO for these parameters will not be exceeded post-mixing in the receiving environment.	Impacts to drinking water during the operations phase are not anticipated, as concentrations of sulfate and total arsenic post releases are modelled to be below the relevant WQO for drinking water at all downstream locations.
Industrial use (e.g. power generation, manufacturing, road maintenance)	As set out in Section 5.4, WQOs for industrial use do not apply as the lowest applicable WQO for any parameter.	Modelling has shown that more stringent WQOs for other EVs will not be exceeded as a result of Project releases. It is therefore concluded that the Project is unlikely to result in impacts to the industrial use EV during the operations period when dilution rates are high (200:1).
Cultural and spiritual values	No specific WQOs associated with the protection of cultural and spiritual values.	It is assumed that by protecting other EVs relevant to the receiving environment, cultural and spiritual values will also be protected.

6.2.4 Conclusions of Water Quality Impact Assessment

An assessment of near-field and far-field water quality modelling and DTA results indicates no significant adverse impacts to EVs relevant to the Project area resulting from operational releases. This is evidenced by the following:

- For operational releases, it is proposed that a maximum of 69% of the assimilative capacity of the receiving environment be utilised (this equates to an effective dilution ratio of 200 parts receiving environment to one part release water). The assumptions behind calculating effective dilution ratios are highly conservative (based on maximum pit water qualities). In reality the actual assimilative capacity usage will be lower than 69% in most cases.
- Parameters relevant to the aquatic ecosystem EV are below WQOs at all locations, with the exception of total nitrogen and dissolved zinc.
- Proposed releases are subject to initial mixing within the near field and predicted water quality within the mixing zone reaches the HMTV for dissolved zinc (the constituent of most concern), within a maximum (worst-case) distance of 625 m. Other modelled scenarios indicate a much smaller mixing zone of between 50 and 70 m downstream.
- Under a worst case scenario, there may be rare and very minor exceedances of the default 95% species protection WQO for dissolved zinc from Charles Creek to Chinaman Creek (95^{th} percentile concentrations). In addition, the exceedances are within the likely margin of error of the various methods used in the assessment. For the scenarios assessed, the 90% species protection WQO will not be exceeded at any location in the receiving environment.
- The mass balance assessment indicates that the HMTV will not be exceeded in either of the two semi-permanent pools (Pond 4 and Pond 5) located downstream of the release location, therefore impacts to these pools are therefore anticipated to be negligible.
- During the operations phase, the simulated releases are well in excess (200:1) of the minimum dilution ratio for toxicity-related impacts in the receiving environment (9:1).
- Concentrations of parameters relevant to other EVs are all modelled to be below the specified WQO.

Further information regarding potential water quality impacts and mitigation measures is presented in the risk assessment (Section 8.0).

6.3 Hydrology Impact Assessment

The event-based nature of the proposed release of water from the Project is unlikely to alter the existing hydrologic regime as potential releases only will take place when the receiving flow exceeds the flow trigger of 400 ML/d. (McGregor, Marshall, & Takahashi, 2011) suggest assessing changes to the flow regime through the following flow parameters:

- Timing of flows
- Frequency of flows
- Duration of flows
- Magnitude of flows; and
- Rate of rise and fall of flows.

Streamflow data from the GoldSim model (Appendix L) for the Copperfield River at the proposed release point inclusive of potential releases based on the proposed release criteria presented in Section 1.0 has been subjected to a number of different analysis as described below and summarised in Table 67:

1. Analysis of releases and flushes (Section 6.3.1) – assessment of the timing, duration and volume of potential releases as well as the timing, duration and volume of naturally occurring streamflow after cessation of any releases i.e. post-release flushing.
2. Assessment of potential changes to streamflow discharge and flow duration (Section 6.3.2) – deterministic assessment using RAP (v3.08, eWater) to assess potential changes to key environmental flow performance indicators of the Water Plan (Gulf) 2007.
3. Assessment of potential changes to the existing flow regime (Section 6.3.3) – deterministic flow spells analysis using RAP (v3.08, eWater) to assess potential changes to key flow parameters including timing, frequency and duration of flows as well as rates of rise and fall.

Table 67 Hydrology Impact Assessment Summary

Aspect	Scenarios Assessed	Reference
Analysis of releases and flushes	Scenario 1 - annual assessment	Section 6.3.1.1
	Scenario 2 – life of project (50 yr.) assessment	Section 6.3.1.2
Assessment of potential changes to streamflow discharge and flow duration	Single deterministic (1890 to 2017) simulation	Section 6.3.2
Assessment of potential changes to the existing flow regime	Single deterministic (1890 to 2017) simulation	Section 6.3.3

6.3.1 Estimated Releases and Post-Release Flushes

Confirming that sufficient streamflow continues in the Copperfield River after cessation of any potential releases is required to ensure that potential releases continue to move downstream, are subject to ongoing dilutionary inflows and do not become stranded due to natural streamflow recession.

Estimated releases and post-release flushes have been assessed on both an annual basis (Scenario 1) as well as on a life of Project (50 years) basis (Scenario 2). Estimated releases for Scenario 1 and 2 are provided below in Sections 6.3.1.1 and 6.3.1.2 respectively.

6.3.1.1 Scenario 1 - Annual (1 Year) Simulation

Annual controlled release statistics are shown in Table 68:

- There is a large variation in the volume, timing and associated loading of potential releases which is a function of the significant variability in both rainfall and streamflow as described in Sections 5.2.1 and 5.9 respectively. Periods of heavy, frequent and prolonged rainfall are likely to result in significant generation of excess water within the Project and a commensurate requirement to release. This would however predominately be expected to be accompanied by a corresponding increase in receiving flow in the Copperfield River.
- While the median mean annual release volume is estimated to be 294 ML, the P95 and P5 results range from 1,737 ML to 10 ML respectively.
- The median volume released per event is 68 ML and varies from 6 ML (P5 result) to 537 ML (P95 result).
- The mean annual number of release days, events and duration are similarly broadly distributed:
  - The median mean number of release days is estimated to be 33.6 per year and the median number of release events is 4.2 per year with an estimated duration of 7.0 days
  - The P95 number of release days and events is 74.4 and 8.0 respectively with an estimated duration of 19.5 days; and
  - P5 results indicate 3.0 release days and 1.0 release event per year with a duration of 2.1 days.
- Median mean annual loading for the contaminant of most concern (dissolved zinc) is 467 kg and ranges from 16 kg to 2,757 kg (P5 and P95 respectively).

Table 68 Scenario 1 - Annual Controlled Release Statistics (Annual Simulation)

Statistic	Annual Volume Releases	Mean Volume Released per Event	Annual Number of Release Days	Annual Number of Release Events[13]	Mean Release Event Duration	Annual Mass Loading
	ML	ML	days	1/ 1yr	d	kg
Mean	530	152	33.6	4.2	8.9	841
P5	10	6	3.0	1.0	2.1	16
P10	33	14	8.0	1.8	3.0	53
P20	70	22	12.0	2.0	4.1	111
P50	294	68	32.0	4.0	7.0	467
P80	920	207	51.8	6.0	11.9	1,460
P90	1,483	359	64.0	7.0	15.0	2,354
P95	1,737	537	74.4	8.0	19.5	2,757

Confirming that sufficient streamflow continues in the Copperfield River after cessation of any potential releases is required to ensure that potential releases continue to move downstream, are subject to ongoing dilutionary inflows and don't become stranded due to natural streamflow recession.

The post-release flush is the period of continued streamflow in the Copperfield River after a controlled release has ceased. The flush duration is taken from the time of release cessation to commencement of the next release or when flow in the Copperfield reaches zero; whichever is sooner (refer to Figure 59 for an example of how this occurs).

[13] A release event is the occurrence of controlled releases occurring for one or more consecutive days

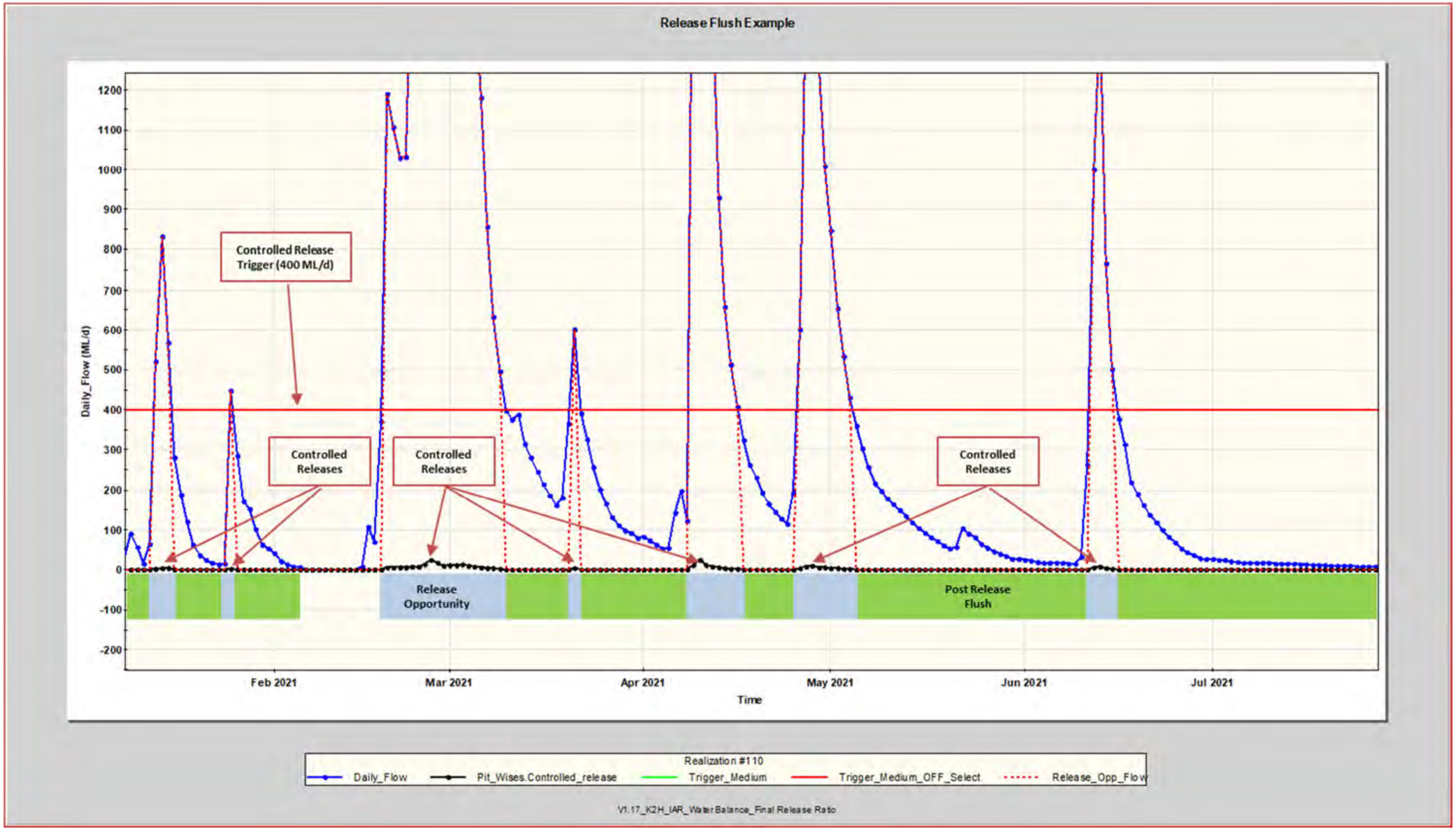


Figure 59 Example of Controlled Releases and Post-Release Flushes

Table 69 provides details of the estimated annual post-release flush afforded by the Copperfield River at the potential release point while Table 70 and Figure 60 show the flush ratio (mean release volume divided by the mean flush volume) from the proposed release point to Einasleigh:

- The median duration of each post release flush at the proposed release point is 32 days with a volume of 1,758 ML (Table 69).
- Reflective of the wide variation in streamflow described in Section 5.9.3, there is a large variation in the duration and volume associated with post-release flushes at the proposed release point which range from 13.6 days/704 ML (P5 result) to 78.0 days/9,895 ML (P95 result) (Table 69).
- The median release to flush ratio at the proposed release point is estimated to be 3.5% with P5 and P95 ratios estimated to be 0.5% and 14.1% (Table 69) respectively i.e. the results show that for 95% of releases, the post release flush at the proposed release point is estimated to exceed 7 times the release volume.
- At increasing distance from the proposed release point, the additional contribution of tributary inflows adds to the post-release flush volume. This provides a continual reduction in the post release flush ratio as shown in Table 70 and Figure 60:
    - The median post-release flush ratio shows continual reduction as distance from the proposed release point increases such that by Einasleigh, the flush ratio has reduced from 3.5% at the proposed release point to 0.6% (Table 70). This indicates that at Einasleigh, for 95% of releases, the post release flush at the proposed release point is estimated to exceed 41 times the release volume.
    - It should be noted that due to the manner in which the post release flush duration is calculated (refer to Section 6.3.1.1), no changes in the mean post release duration are incurred as distance downstream from the proposed release point increases.

Table 69 Scenario 1 - Post-Release Flush Statistics (Annual Simulation, Proposed Release Point)

Statistic	Mean Post Release Flush[14] Duration	Mean Post Release Flush Volume (per Release)	Mean Volume Released per Event	Release to Flush Ratio[15]
	days	ML	ML	%
Mean	35.9	2,709	152	4.8
P5	13.6	704	6	0.5
P10	17.5	830	14	1.1
P20	20.9	1,194	22	1.6
P50	32.0	1,758	68	3.5
P80	43.6	2,916	207	7.4
P90	59.7	4,546	359	9.4
P95	78.0	9,895	537	14.1

[14] The post-release flush is the period of continued streamflow in the Copperfield River after a controlled release has ceased. The flush duration is taken from the time of release cessation to commencement of the next release or when flow in the Copperfield reaches zero; whichever is sooner.
[15] The release to flush ratio is the mean volume per release event divided by the mean flush volume following each release event. The result is expressed as a percentage.

Table 70 Scenario 1 – Post-Release Flush Ratios (Annual Simulation, Proposed Release Point to Einasleigh)

Statistic	Proposed Release Point	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	%	%	%	%	%	%	%
Mean	4.8	3.9	3.5	2.7	2.4	2.3	0.8
P5	0.5	0.5	0.5	0.4	0.4	0.4	0.1
P10	1.1	0.9	0.8	0.6	0.6	0.5	0.2
P20	1.6	1.4	1.2	1.0	0.9	0.8	0.3
P50	3.5	2.9	2.6	2.0	1.8	1.7	0.6
P80	7.4	6.1	5.6	4.1	3.7	3.5	1.3
P90	9.4	8.1	7.4	5.9	5.5	5.2	1.9
P95	14.1	11.0	9.6	7.2	6.3	5.9	2.4
Distance downstream (km)	0.0	6.9	19.6	23.4	30.4	35.7	48.3

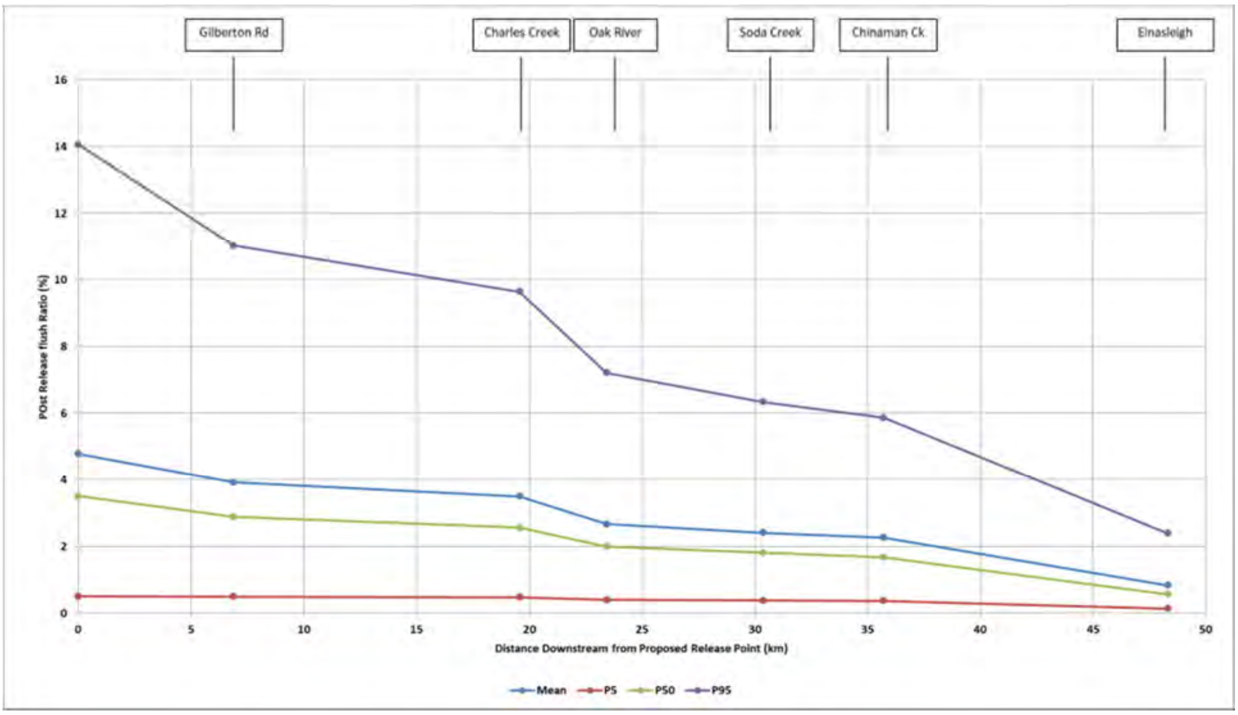


Figure 60 Scenario 1 – Post-Release Flush Ratios (Annual Simulation, Proposed Release Point to Einasleigh)

6.3.1.2 Scenario 2 – Life of Project (50 Year) Simulation

Mean annual controlled release statistics for the 50-year life of Project are shown in Table 71:

- The mean annual results are derived over the 50-year life of Project and consequently there is significantly less variability when compared to the annual (1 year) results (refer to Section 6.3.1.1). The estimated median mean annual release volume is 529 ML with P5 and P95 mean annual volumes of 427 ML and 625 ML respectively.
- The median volume released per event is 126 ML and varies from 99 ML (P5 result) to 151 ML (P95 result).
- The median mean annual number of release days and events is 33.4 days and 4.2 events respectively and the estimated median release duration is 7.9 days.
- Median mean annual mass loading for the contaminant of most concern (Dissolved zinc) is 840 kg and ranges from 678 kg to 992 kg (P5 and P95 results respectively).

Table 71 Scenario 2 – Mean Annual Controlled Release Statistics (Life of Project (50yr) Simulation)

Statistic	Annual Volume Releases	Mean Volume Released per Event	Annual Number of Release Days	Annual Number of Release Events[16]	Mean Release Event Duration	Annual Mass Loading
	ML	ML	days	1/ 1yr	d	kg
Mean	530	127	33.3	4.2	8.0	841
P5	427	99	29.8	3.8	7.0	678
P10	441	103	30.6	3.9	7.1	699
P20	466	109	31.6	4.0	7.5	740
P50	529	126	33.4	4.2	7.9	840
P80	580	145	35.2	4.3	8.6	921
P90	613	148	36.4	4.5	8.8	973
P95	625	151	36.9	4.6	8.9	992

[16] A release event is the occurrence of controlled releases occurring for one or more consecutive days

Table 72 provides details of the estimated annual post-release flush afforded by the Copperfield River at the potential release point while Table 73 and Figure 61 show the flush ratio (mean release volume divided by the mean flush volume) from the proposed release point to Einasleigh:

- The median duration of a post release flush is 31.6 days and has a median volume of 2,867 ML. This ranges from 29.9 days/1,972 ML (P5 result) to 33.9 days/3,679 ML (P95 result).
- As noted previously in Section 6.3.1.1, the volume of receiving flow available after cessation of potential releases provides a significant opportunity for continued down-system movement of released water. The median release to flush ratio is estimated to be 4.5% and does not exceed 6.2% (P95 result). This indicates that at the proposed release point, 95% of releases would be flushed by a minimum of 16 times the release volume.
- At increasing distance from the proposed release point, the additional contribution of tributary inflows adds to the post-release flush volume. This provides a continual reduction in the post release flush ratio as shown in Table 70 and Figure 60:
  - The median post-release flush ratio shows continual reduction as distance from the proposed release point increases such that by Einasleigh, the flush ratio has reduced from 4.5% at the proposed release point to 0.8%. This indicates that at Einasleigh, for 95% of releases, the post release flush at the proposed release point is estimated to exceed 125 times the release volume.
  - It should be noted that due to the manner in which the post release flush duration is calculated no changes in the mean post release duration are incurred as distance downstream from the proposed release point increases.

Table 72 Scenario 2 – Post-Release Flush Statistics (Life of Project (50yr) Simulation)

Statistic	Mean Post Release Flush[17] Duration	Mean Post Release Flush Volume (per Release)	Mean Volume Released per Event	Release to Flush Ratio[18]
	days	ML	ML	%
Mean	31.6	2,761	127	4.7
P5	29.9	1,972	99	3.6
P10	30.3	2,014	103	3.8
P20	30.9	2,164	109	4.0
P50	31.6	2,867	126	4.5
P80	32.2	3,141	145	5.7
P90	32.6	3,611	148	5.9
P95	33.9	3,679	151	6.2

[17] The post-release flush is the period of continued streamflow in the Copperfield River after a controlled release has ceased. The flush duration is taken from the time of release cessation to commencement of the next release or when flow in the Copperfield reaches zero; whichever is sooner.
[18] The release to flush ratio is the mean volume per release event divided by the mean flush volume following each release event. The result is expressed as a percentage.

Table 73 Scenario 2 – Post-Release Flush Ratios (Life of Project (50yr) Simulation, Proposed Release Point to Einasleigh)

Statistic	Proposed Release Point	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	%	%	%	%	%	%	%
Mean	4.7	3.9	3.5	2.7	2.5	2.3	0.8
P5	3.6	3.1	2.9	2.3	2.1	2.0	0.7
P10	3.8	3.3	3.0	2.3	2.1	2.0	0.7
P20	4.0	3.4	3.1	2.4	2.2	2.0	0.7
P50	4.5	3.8	3.4	2.7	2.5	2.3	0.8
P80	5.7	4.6	4.0	3.0	2.7	2.5	0.9
P90	5.9	4.8	4.2	3.1	2.8	2.6	0.9
P95	6.2	5.1	4.5	3.3	3.0	2.8	0.9
Distance downstream (km)	0.0	6.9	19.6	23.4	30.4	35.7	48.3

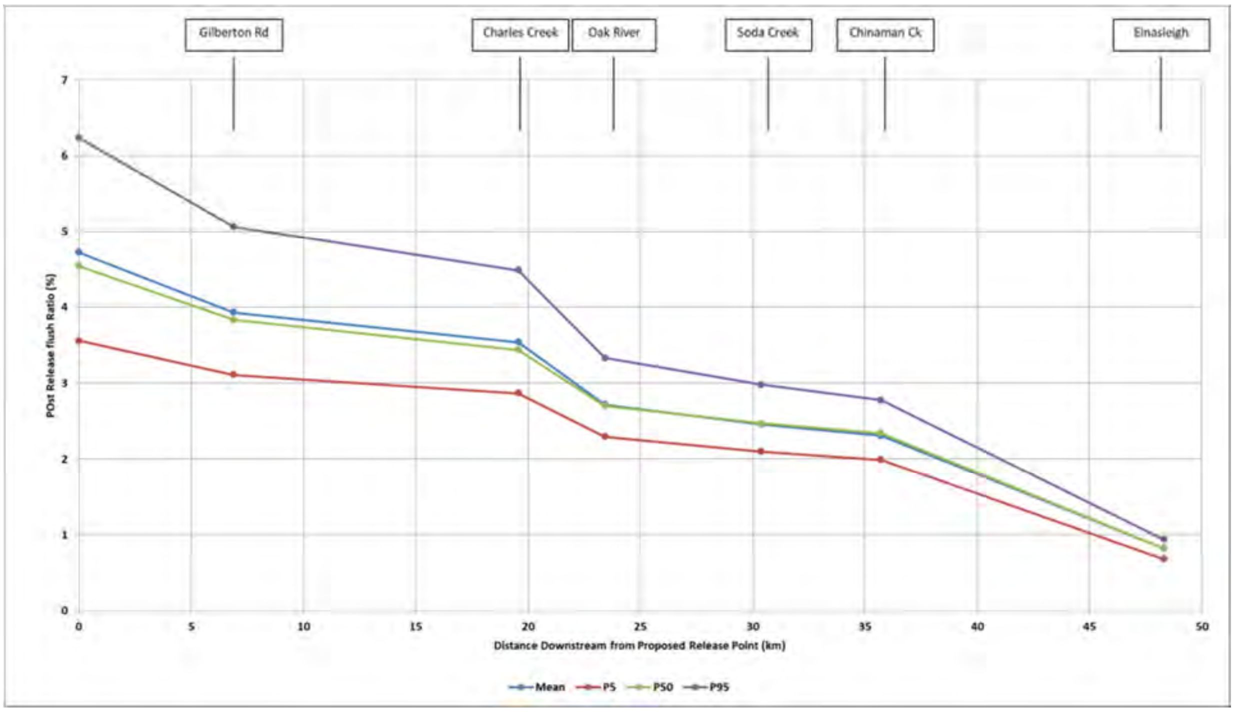


Figure 61 Scenario 2 – Post-Release Flush Ratios (Life of Project (50yr) Simulation, Proposed Release Point to Einasleigh)

6.3.2 Discharge and Flow Duration

Note that the results presented and discussed in the following sections have been based on assessment of deterministic output from the water balance model (Appendix L). The water balance simulation was conducted continuously from 1890 through 2017 with the output analysis using the River Analysis Package (RAP (v3.08).

Table 74 below shows key environmental flow performance indicators of the Water Plan (Gulf) 2007 to assess medium to high modelled streamflow at a node of interest within the WRP Model. Estimated mean and median annual flows show slight increases of 0.53 GL (0.3%) and 0.30 GL (0.5%) respectively as a result of the proposed releases which is consistent with the estimated median mean annual life of Project release volume of 529 ML (refer to Section 6.3.1.2). Event-based flows show a maximum increase for the 1.5 year daily flow of 0.5% reducing to a 0.1% increase for the 20 year event.

Table 74 Water Plan (Gulf) 2007 Performance Indicators – Baseline and with Releases

Indicator*	Units	Discharge			
		Baseline	With Releases	Change	% Change
Mean Annual Flow	GL/yr	162.18	162.71	0.53	0.3%
Median Annual Flow	GL/yr	69.30	69.61	0.31	0.4%
10% Daily Flow	ML/d	391	391	0.00	0.0%
1.5 Year Daily Flow Volume	ML/d	4,674	4,697	22.51	0.5%
5 year Daily Flow Volume	ML/d	30,325	30,413	87.94	0.3%
20 year Daily Flow Volume	ML/d	97,694	97,819	125.41	0.1%

* As per Section 17(b)

Figure 62 below shows annual (hydrological year, November through October) flow duration (representing the likelihood that annual discharge of a specific volume will be equalled or exceeded for any given year). There is no material difference to the annual flow duration curve as a result of the proposed releases. The estimated median mean annual life of project (Section 6.3.1.2) release volume of 529 ML is also shown on the chart for context.

Mean daily discharge for the proposed release point with and without releases is shown below in Figure 63. Daily flows for the dry season months of June through September show no change as a result of the proposed release of water from the Project. During the wet season months of November through May, mean daily flow is slightly increased as a result of potential water releases. The largest increase occurs during the peak wet season month of February when mean daily flow increases from 2,377 ML/d to 2,385 ML/d.

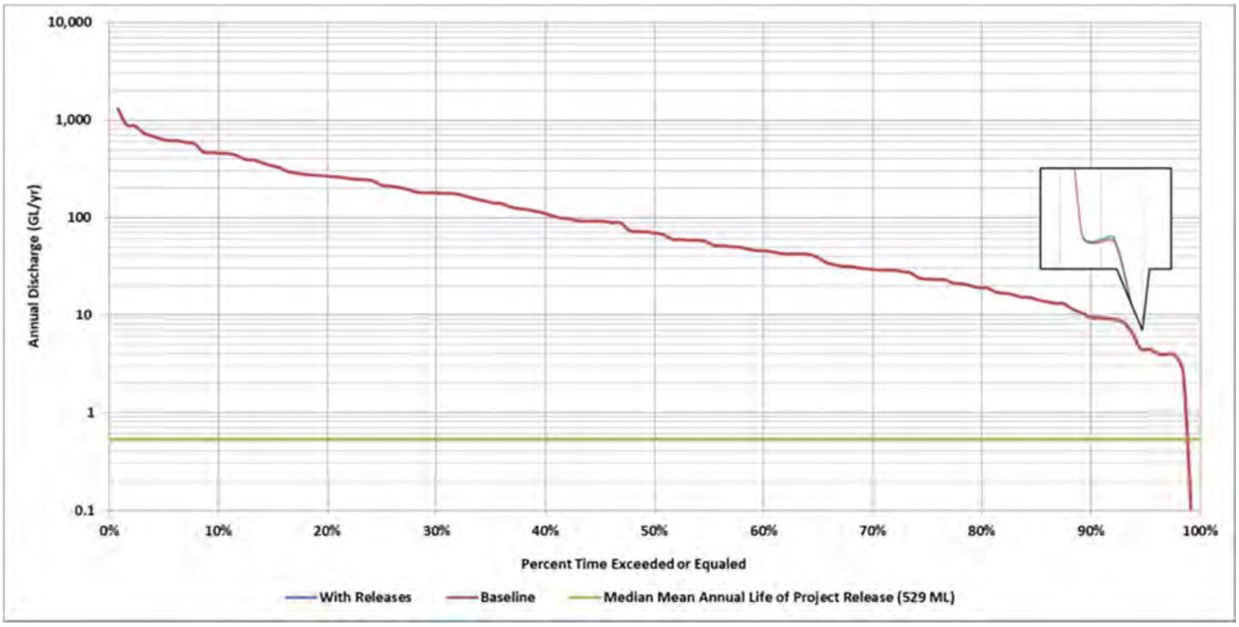
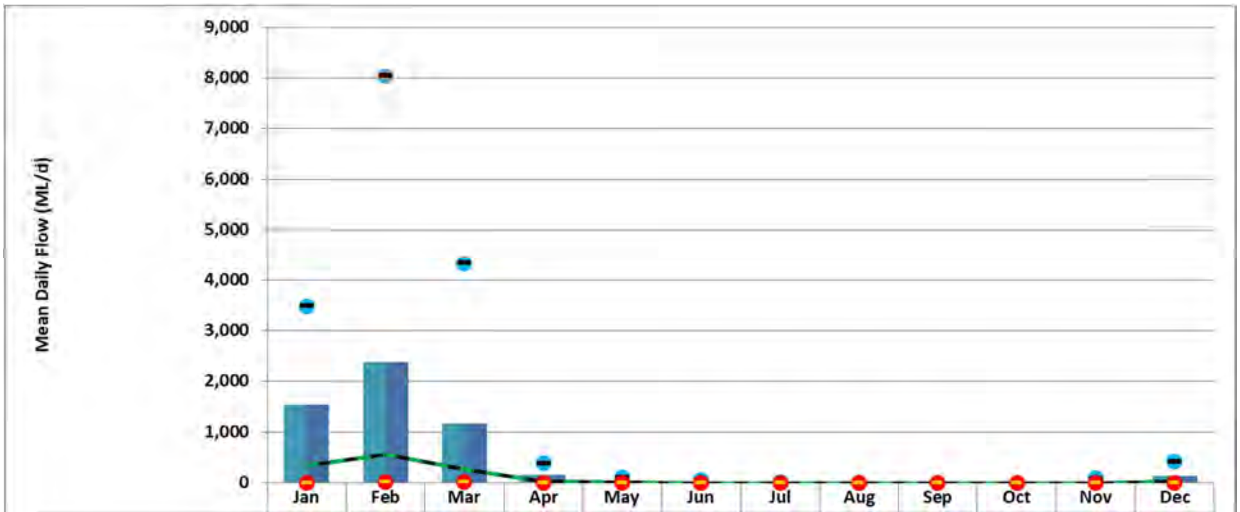


Figure 62 Annual Flow Duration Plot for Copperfield River at Project Site (Water Years Nov – Oct) - Baseline and with Releases



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Baseline	1,545	2,377	1,180	149.9	44.4	22.2	6.4	6.1	3.5	7.3	36.3	146.0
Mean With releases	1,550	2,385	1,184	150.3	44.5	22.2	6.4	6.1	3.5	7.3	36.4	146.5
P90 Baseline	3,482	8,033	4,336	383.6	109.1	56.2	12.9	9.6	3.8	6.2	100.8	424.0
P90 With releases	3,494	8,056	4,357	384.9	109.5	56.2	12.9	9.6	3.8	6.2	101.1	425.9
P50 Baseline	344.8	564.6	273.0	28.6	3.4	0.4	0.1	-	-	0.1	0.7	26.6
P50 With releases	346.4	567.0	274.1	28.6	3.4	0.4	0.1	-	-	0.1	0.7	26.6
P10 Baseline	9.3	21.3	13.2	0.1	-	-	-	-	-	-	-	0.2
P10 With releases	9.3	21.3	13.2	0.1	-	-	-	-	-	-	-	0.2

Figure 63 Mean Daily Discharge for Copperfield River at Project Site - Baseline and with Releases

Daily flow duration for the wet season is shown in Figure 64 below. From the figure it can be seen that the proposed releases have no impact on daily flow duration. The proposed release trigger of 400 ML/d is also shown on the figure for reference. It is reiterated that potential release of water from the Project would not occur whilst receiving flow is below the flow rate.

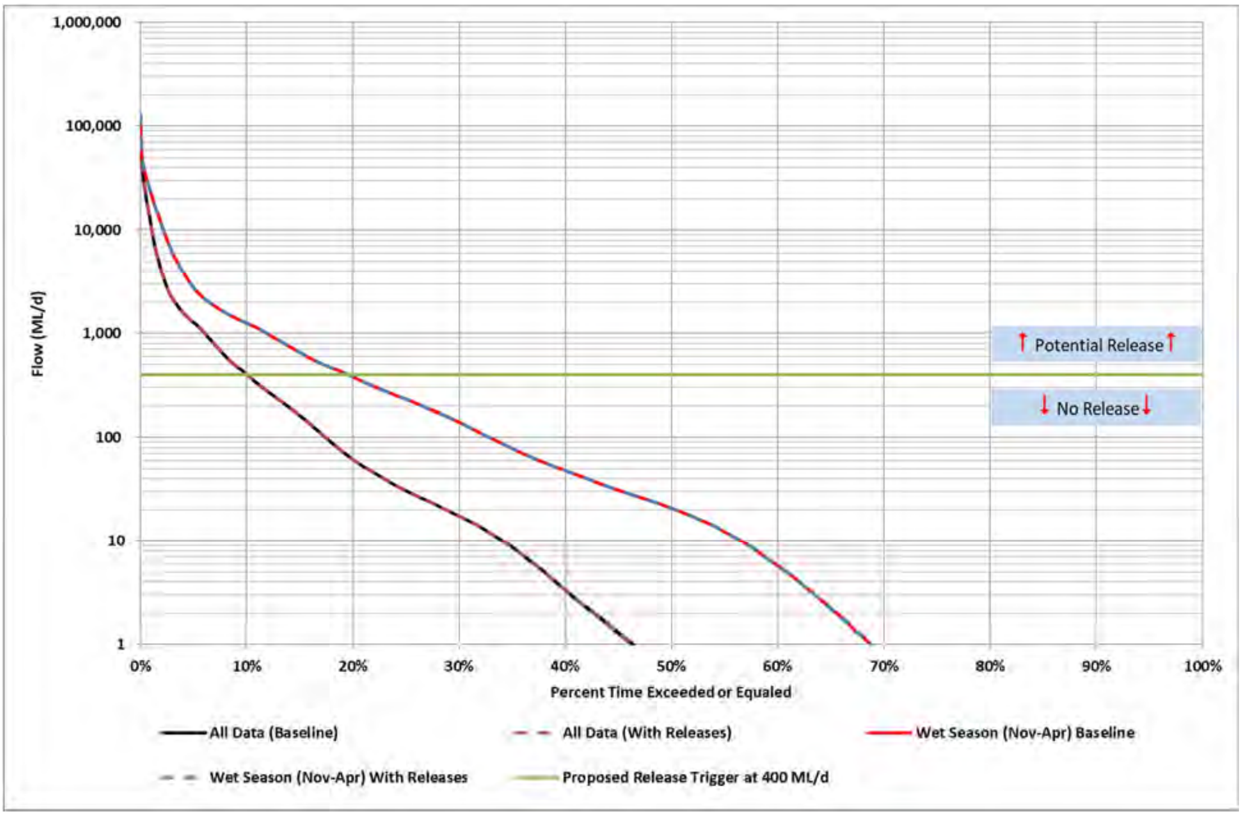


Figure 64 Daily Flow Duration Plot for Copperfield River at Project Site – Baseline and with Releases

6.3.3 Flow Spells

Modelled streamflow data at the proposed release point inclusive of potential releases was subjected to the same statistical analysis as previously described in Section 5.9.3. Adopted definitions are as previously used and are shown in Table 75 below.

Table 75 Flow Spells Assessment – Adopted Definitions

Aspect	Adopted Definition
Seasons	Wet – November through April
	Dry – May through October
Flow Spells	High flow spell - 10%, 5% and 2% daily flow exceedance probability
	Low flow spell – cease to flow condition

Referring to both Table 76 and Table 77:

- There are small changes to the volumetric indicators as a result of the additional water released:
    - The spell threshold for the 5% and 2% events shows slight increases from 1,254 ML/d to 1,260 ML/d and from 3,790 ML/d to 3,809 ML/d due to the additional volumes associated with releases.
    - Discharges for the mean peaks for each spell threshold also show minor increases (Table 76).

- Due to the event-based nature of the proposed releases no changes are noted between the baseline and the baseline with releases (Table 76 and Table 77). This is a result of the proposed releases only occurring during naturally-occurring flow events such that the frequency, duration and timing of flows remain unchanged. Some minor changes to the magnitude of events can be seen which result from the additional water released during a release opportunity.

Table 76 Flow Spells Summary - All Years (Wet Season, Nov-Apr, 1890 to 2017) - Baseline and with Releases

Statistic	Units	High Spell Daily Exceedance Probability						Cease to Flow Condition	
		10%		5%		2%			
		Baseline	Releases	Baseline	Releases	Baseline	Releases	Baseline	Releases
Spell Threshold	ML/d	391	391	1,254	1,260	3,790	3,809	-	-
Number of Spell	Count	509	509	387	388	188	188	1,032	1,032
Longest Spell	Days	123	123	77	77	42	42	272	272
Mean of Spell Peaks	ML/d	6,961	6,980	10,356	10,366	21,398	21,453	-	-
Mean Duration of Spell	Days	9.1	9.1	6.0	6.0	4.9	4.9	19.6	19.6
Mean period Between Spells	Days	82	82	114	113	241	241	25.4	25.4

Table 77 Flow Spells Summary - Inter-Annual Summary (Wet Season, Nov-Apr) - Baseline and with Releases

Statistic	Units	High Spell Daily Exceedance Probability						Cease to Flow Conditions	
		10%		5%		2%			
		Baseline	Releases	Baseline	Releases	Baseline	Releases	Baseline	Releases
Spell Threshold	ML/d	391	391	1,254	1,260	3,790	3,809	-	-
Mean of Wet Season Number of High Spell	Count	3.7	3.7	2.9	2.9	1.5	1.5	8.8	8.8
Mean of Wet Season Longest High Spell	Days	22.4	22.4	11.3	11.2	6.8	6.8	88.3	88.3
Mean of Wet Season Mean Duration of High Spell	Days	11.6	11.6	6.5	6.5	4.5	4.5	21.5	21.5
Mean of Wet Season Mean period Between High Spells	Days	16.6	16.6	16.9	16.9	18.1	18.1	35.7	35.7
Median of Wet Season Number of High Spell	Count	3.0	3.0	3.0	3.0	1.0	1.0	8.0	8.0
Median of Wet Season Longest High Spell	Days	16.0	16.0	9.0	9.0	5.0	5.0	81.5	81.5
Median of Wet Season Mean Duration of High Spell	Days	7.7	7.7	5.0	5.0	4.0	4.0	18.7	18.7
Median of Wet Season Mean period Between High Spells	Days	14.0	14.0	13.0	13.0	13.9	13.9	25.1	25.1

Table 78 shows estimated changes to the rates of rise and fall of flow events which relates to the increase and decrease of flow over time during a storm event. These fluctuations in the flow regime serve important ecological and geomorphic functions in a river system. For example, rapid rates of flow reduction can result in fish stranding and bank erosion and the reproductive success of some species can also be affected by the magnitude and rate of the rise and fall of the flow during breeding seasons (McGregor, Marshall, & Takahashi, 2011).

Some changes to the rate of rise and fall can be seen as a result of the proposed releases however the relative change is rather small. The maximum changes are associated with the mean dry season mean rates of rise and fall which show increases of 2.7% and 2.6% respectively. Potential changes for all other statistics are 2.0% or less.

Table 78 Estimated Changes to Rates of Rise and Fall

Statistic	Units	Baseline	With Releases	Change
Mean rate of Rise	ML/d	523.3	533.9	2.0%
Mean rate of Fall	ML/d	265.3	270.6	2.0%
Mean of Wet Season Mean rate of Rise	ML/d	810.2	813.7	0.4%
Mean of Wet Season Mean rate of Fall	ML/d	403.8	405.4	0.4%
Median of Wet Season Mean rate of Rise	ML/d	309.3	310.8	0.5%
Median of Wet Season Mean rate of Fall	ML/d	139.7	140.5	0.6%
Mean of Dry Season Mean rate of Rise	ML/d	28.1	28.9	2.7%
Mean of Dry Season Mean rate of Fall	ML/d	4.8	5.0	2.6%
Median of Dry Season Mean rate of Rise	ML/d	2.0	2.0	0.0%
Median of Dry Season Mean rate of Fall	ML/d	0.5	0.5	1.7%

6.3.4 Conclusions of Hydrology Impact Assessment

The streamflow record for the proposed release point which includes additional flow as a result of the proposed release conditions outlined in Section 1.0 has been evaluated to assess potential changes to the:

- Timing of flows
- Frequency of flows
- Duration of flows
- Magnitude of flows; and
- Rate of rise and fall of flows.

As a result of the proposed release of water from the Project some minor changes are expected to the magnitude of flows which are a direct result of the additional water added during releases. The magnitude of the increases, however is small and not expected to be of material impact to the existing flow regime.

Due to the event-based nature of the proposed releases, no changes to key temporal indicators (timing, frequency and duration of flow events) were noted as a result of the proposed releases. Some minor increases to the rates of rise and fall were noted however they are not considered to be of sufficient magnitude to result in any adverse impacts.

6.4 Aquatic Ecology Impact Assessment

6.4.1 Water quality

The Project proposes to undertake water releases to the Copperfield River during certain flow events as described in Section 6.2. Such releases have the potential to influence the quality of downstream waters as outlined in Table 65.

Targeted DTA assessments were conducted to determine the required mixing ratios to reduce the potential for environmental harm and ensure 95% species protection is achieved within the receiving environment during operational discharges. The DTA assessment has found that the potential for impacts to aquatic organisms is considered to be relatively low at the dilution ratios and release regimes proposed.

The DTA assessments showed that the dilution ratio to achieve a 95% species protection level ranged from 1:1 (the most likely case) to 1:9 (for a mixture of pit waters composed predominantly from Wises Pit water; i.e. worst case scenario). Proposed releases during the operational phase of the Project exceed this minimum dilution.

The proposed controlled releases will only be undertaken during flow events within the receiving environment with a minimum flow trigger stipulated and the cessation of the release occurring prior to natural flows subsiding to allow for an additional flushing effect.

The proposed release ratio during the operational phase is 200:1, well above that required to achieve 95% species protection. Mixing zone modelling has indicated that the use of a diffused discharge outlet structure will facilitate near field mixing at the outlet such that the WQO for the contaminant of most concern (dissolved zinc) will be met within 625m for the range of scenarios and outlet configurations assessed (most modelled scenarios suggest a mixing zone of between 50 and 70 m downstream). There are no known permanent or semi-permanent pools within 625 m downstream of the release location which could provide refugia for aquatic ecology (refer to Section 5.14). There are no other known sensitive receptors within this mixing zone. All fish species found to be occurring within the Copperfield River display relatively broad tolerances to a wide range of water quality characteristics (refer to Section 3.12.6). However, the macroinvertebrate communities were comprised of families sensitive to environmental change. It is suggested that the adoption and application of appropriate release management strategies, as discussed above, will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values.

A REMP has been drafted (Section 5.2, and Appendix I) which will be developed to monitor the receiving environment for potential impacts from controlled releases. Further, the sensitivity of the macroinvertebrate community suggests it will be an ideal biological indicator for the future Project REMP.

6.4.2 Hydrology

The release of water has the potential to increase flow volumes experienced within the receiving environment. The contribution of flow during the operational phase is considered to be negligible with a release ratio of 200:1.

Assessment of the proposed release regime found that the maximum increase in daily flow volume (compared to natural flows) expected to occur was 1.18%, with mean and median annual flow increases estimated to be 0.44% and 0.88%, respectively. These increases are minor compared to natural variations that would be observed in the system from a year to year basis based on rainfall received.

Many of the fish species that occur in the Copperfield River migrate upstream during the wet season to spawn (refer to Section 3.12.6). Furthermore, macroinvertebrate communities are highly seasonal with water availability and stage in the flow cycle (especially in ephemeral tropical Australian watercourses) a defining factor on their community composition. The extension of flows and/or the permanency of water in the system will allow aquatic flora and fauna to utilise more of the watercourse for a longer period of time each year. Further, if the permanency of water is increased upstream of the Project site, new refuges for aquatic flora and fauna may be developed. This may allow fish to access further upstream (on the Copperfield River or associated tributaries) during subsequent flow events which will last up to an additional nine days. While, if this occurs, it would be considered a change in natural conditions it may not be considered an adverse impact. Note; fish passage will not be reduced by this minor increase in flow. As noted in Section 5.14, there are several identified semi-permanent pools within close proximity to the release location. The majority of waterholes found were minor remnant pools occurring in-channel. Only two substantial pools were noted downstream of the Project site (Pond 5 near W3 and the Sandy Creek site). These two pools have the potential to persist year round, providing refuge to aquatic fauna. The longevity of these pools would be highly correlated with the hydrology of the system on a yearly basis.

As the releases are to be managed to occur as event-based, no changes to key temporal indicators (timing, frequency and duration of flow events) are expected. While some minor increases to the rates of rise and fall are expected, they are not considered to be of sufficient magnitude to result in any adverse impacts to the aquatic ecology values of the system.

6.4.3 Erosion and Sedimentation

Releases have the potential to increase erosion and sedimentation through physical processes/forces. The method in which the water is released (i.e. spillway overtopping, open ended pipe, pump outlet, diffuser, etc.) and the rate can result in scouring of the immediate downstream area and subsequently cause sedimentation further downstream. Erosion and sedimentation processes are known to impact aquatic communities through smothering and the reduction of primary production (Wood & Armitage, 1997; Gleason *et al.*, 2003).

A diffuser will be employed for releases to ensure the mixing rate is maximised. Diffusers also reduce the potential for erosion to occur as a result of the release. The design of the release point and associated diffuser will be finalised during detailed design. However, conceptualisation through CORMIX modelling has shown that appropriate mixing can be achieved, and modelling suggests that the increased flow from the releases will not have any significant effect on the hydraulics of the natural system. Detailed design and construction will need to take into consideration the potential for erosion, and ensure that engineering solutions appropriately mitigate this impact to avoid downstream impacts.

The potential impacts to the downstream environment from increased erosion and sedimentation associated with the release point are expected to be minimal as construction of this component will be strictly limited to the dry season. During operation, impacts are anticipated to be restricted to the immediate area surrounding and downstream of the release point. Appropriate design and management of the diffuser will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values. Further, photographic monitoring of the release point over time will document and monitor the rate of erosion and deposition occurring at and downstream of the release point.

6.5 Hydraulics and Fluvial Geomorphology Impact Assessment

6.5.1 Hydraulic Impacts Assessment for Releases

The existing condition (base-case) hydraulic model (refer Section 5.10.1) was modified to incorporate the release flow rate into the channel at a release ratio of ratio of 0.503% (based on adopted 200:1 dilution ratio for dissolved zinc). Releases were assumed to be made from the proposed release location as shown by the highlighted cross section in Figure 65 below. The profile for the cross section (7486) is shown in Figure 66.

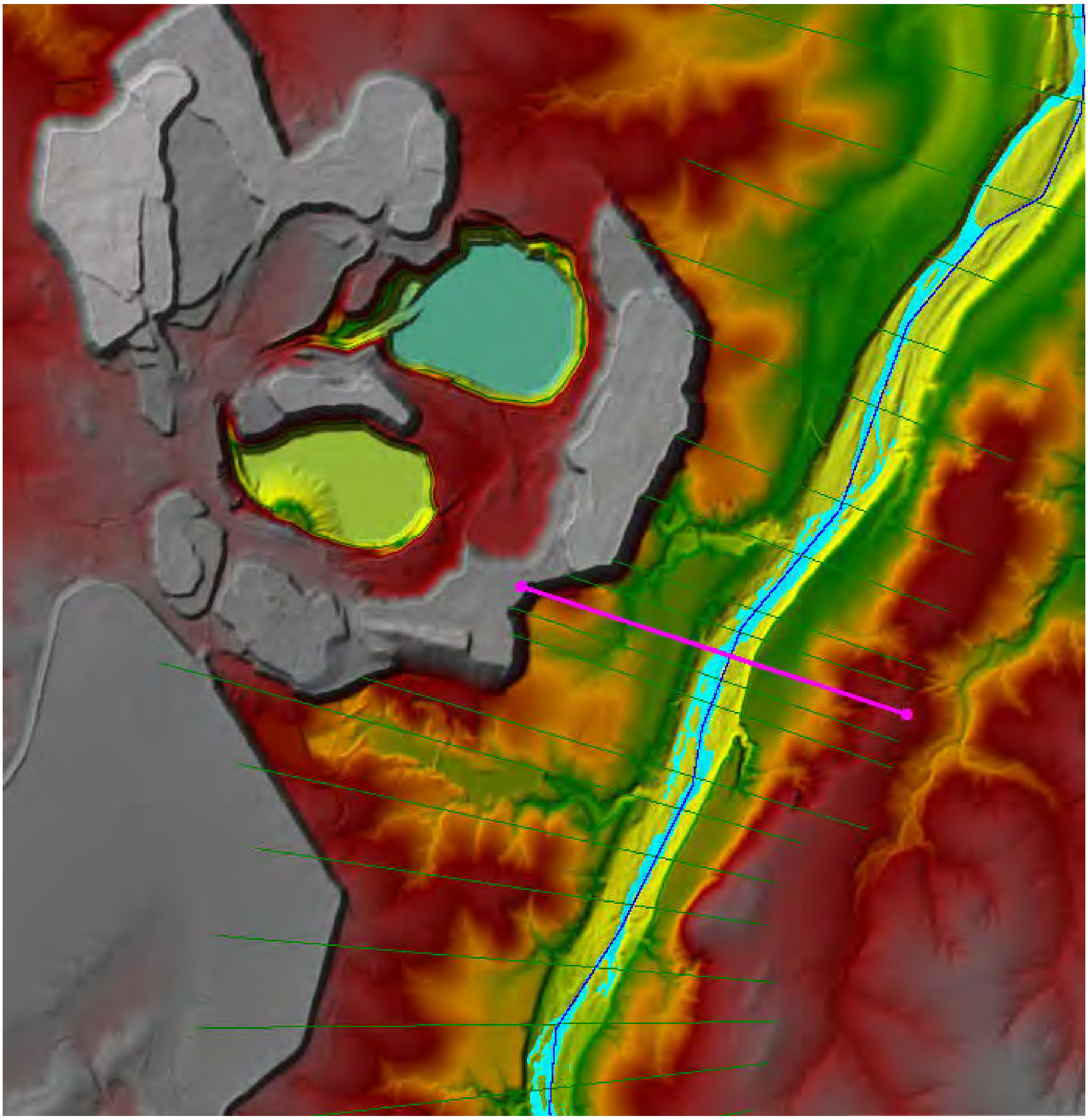


Figure 65 Release Location along channel in HEC-RAS model

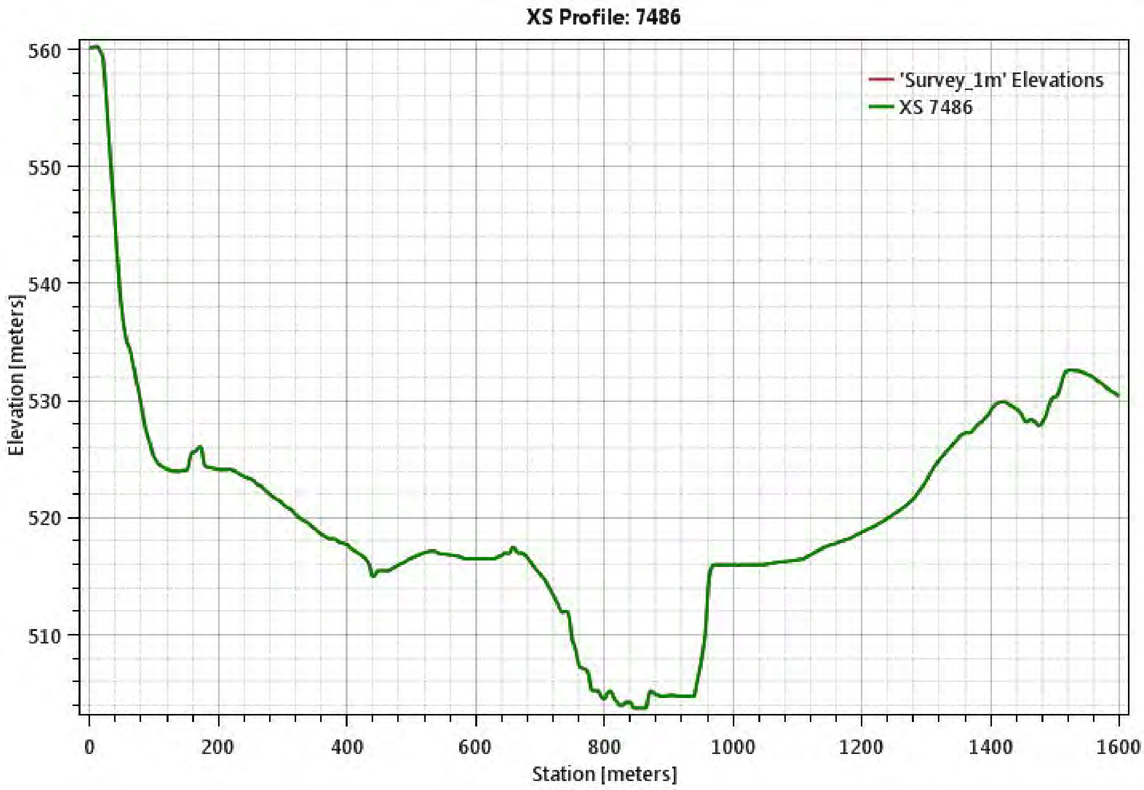


Figure 66 Cross Section of channel at Simulated Release Location

Table 79 below summarises the hydraulic impact assessment scenarios assessed. Release flows are based on an assumed 0.503% release ratio. Mean maximum results value for key hydraulic parameters including velocity, water level, water depth, shear stress, stream power and top width for a 200m reach downstream of the proposed release point were then compared to the receiving flow without the releases to assess potential changes.

Table 79 Impact Scenarios Flows

Hydraulics Assessment Scenario	Description	Receiving flow (m^3/s)	Release flow (m^3/s)	Combined flow (m^3/s)
1	10% receiving flow	4.63	0.024	4.654
2	5% receiving flow	14.7	0.075	14.775
3	2% receiving flow	43.87	0.225	44.095

The results presented in Table 80 show that the proposed release ratio of 0.503% has a negligible impact on the hydraulic characteristics of the channel:

- A maximum change (scenario 2) in water depth of 0.35%
- Maximum increase to shear stress and stream power of 0.27% and 0.43% respectively (scenario 2)
- A maximum increase to channel velocity of 0.31% (scenario 1)
- The estimated increases to water depth are not expected to have a material impact on the integrity of downstream structures or property.

Table 80 Hydraulic Impact Assessment Scenario Results (Mean Results for 200m Reach Downstream of the Proposed Release Point

Parameter	Units	Scenario 1 (10% Receiving Flow)			
		Without Release	Release	Difference	Difference (%)
Water Depth	m	0.29	0.29	0.00	0.00%
Shear Stress	N/m^2	3.68	3.69	0.01	0.23%
Stream Power	N/ms	1.69	1.70	0.01	0.36%
Channel Velocity	m/s	0.45	0.45	0.00	0.31%
Parameter	Units	Scenario 2 (5% Receiving Flow)			
		Without Release	Release	Difference	Difference (%)
Water Depth	m	0.42	0.42	0.00	0.35%
Shear Stress	N/m^2	5.80	5.81	0.02	0.27%
Stream Power	N/ms	3.57	3.59	0.01	0.43%
Channel Velocity	m/s	0.59	0.59	0.00	0.00%
Parameter	Units	Scenario 3 (2% Receiving Flow)			
		Without Release	Release	Difference	Difference (%)
Water Depth	m	0.60	0.60	0.00	0.09%
Shear Stress	N/m^2	10.04	10.04	0.00	0.04%
Stream Power	N/ms	8.49	8.50	0.00	0.05%
Channel Velocity	m/s	0.83	0.83	0.00	0.00%

6.5.2 Fluvial Geomorphology

Hydraulic modelling of the proposed releases shows negligible to minor changes to the key hydraulic parameters which are drivers of channel shape and floodplain morphology (e.g. velocity, depth, shear stress and stream power). The estimated changes were found to be negligible and within the bounds of modelling uncertainty for all scenarios. Results for flows with and without the proposed releases are noted be significantly lower than the DRNR 2014 guideline values for stream power, velocity and shear stress (Table 81) which is indicative of the broad channel and downstream of the proposed release location. Once flows exceed the capacity of the low flow channel ongoing increases to streamflow typically result in a greater emphasis in lateral expansion of the flow width rather than increased depth and velocity.

Consequently it is not therefore expected the proposed operational phase releases of water will result in any changes to sediment transport and loads or channel stability – baseline critical shear stress thresholds will not be exceeded more frequently, or for longer, than would otherwise have been the case for a ‘no release’ scenario. Release volumes as a percentage of the existing flow are sufficiently small that there will be only a negligible increase in overbank events.

Design and construction of the proposed outlet structure will need to make appropriate consideration of the potential for enhanced erosion and scour as a direct result of potential discharge outlet velocities as well as a result of any associated in-stream structures. In order to ensure that erosion and scouring impacts are not occurring a result of operational releases, regular (quarterly) visual inspections of the outlet structure and surrounds are proposed (refer to Section 9.2 for further detail).

Table 81 Guideline Values for Average Stream Powers, Velocity and Shear Stresses for Streams within the Bowen Basin (DNRM, 2014)

Flow	Stream Power (N/ms)	Velocity (m/s)	Shear Stress (N/m^2)
50% AEP (vegetated)	<60	<1.5	<40
2% AEP (vegetated)	<150	<2.5	<50

It is proposed to confirm the location of the actual release point as the Project progresses through detailed design. Key criteria for site selection will include not only consideration of geomorphic stability but additional factors such as riparian vegetation, constructability, accessibility (construction and operation) and the Kidston cultural heritage area.

6.6 Hydrogeology Impact Assessment

During operations the predictive groundwater modelling by AGE, 2019 (Appendix H) indicates that the Eldridge Pit will continue to act as a groundwater sink, reducing seepage migration risks to the north of the Project (and downstream in the Copperfield River).

During operation the water discharged from the Project will contribute a maximum of 0.5% additional flow volume to the Copperfield River and only occur during medium and high flow events. The scale and timing of these discharges is therefore not expected to materially influence the groundwater regime. Further groundwater impact considerations during the operational phase are provided in Table 82 below.

Table 82 Potential Impacts of Project Water Discharges

Potential Impact	Operation	Decommissioning	Cumulative
Impacts on water levels affecting GDEs and licensed groundwater users	Limited change in surface water levels during discharge is unlikely to alter surface water-groundwater interaction (refer to Section 5.11.12).	None	None
Water quality alteration of groundwater resources (including alluvial groundwater)	Discharge of water into the Copperfield River is not expected to significantly influence groundwater quality (recharge during high flow events). It is anticipated that by the time that the flow in the Copperfield River has reached the trigger level required prior to discharges commencing that the stream alluvial beds have been largely saturated. The concentrations of key contaminants will be monitored during both construction and operational discharges as part of the additional monitoring. The post discharge flushing will aim to return the water quality in any standing water to baseline condition, monitoring will be undertaken to confirm the efficacy of the discharge flushing. Refer to Section 6.2 for further detail.	None – flush with time	Potential minimal additional groundwater recharge not considered a negative impact on seasonal groundwater resources
Change in groundwater flow, including throughflow impacting on down gradient users	Limited increased groundwater recharge during high flow (discharge) events (refer to Section 5.11.9).	None	Minor additional groundwater recharge not considered a negative impact on seasonal groundwater resources

Potential Impact	Operation	Decommissioning	Cumulative
Water quality alteration of surface water resources	Potential for migration between former mine area and Copperfield River where a hydraulic connection between the fault system and river is present, impacting water quality in semi-permanent pools. Refer to Section 6.2 for further detail.	None	Potential minor impact to surface water quality

As discussed in Section 5.11.8, it is considered that in the instance a hydraulic connection between the fault system and the river is present, there is potential for migration between the former mine area and the Copperfield River. In order to ensure that impacts are not occurring as a result of potential migration between the former mine area and the Copperfield River, ongoing water and sediment quality monitoring is proposed at the following semi-permanent waterhole locations (refer to Section 5.14 for detail regarding these waterholes):

- Pond 3 (approximately 1.4 km upstream of the proposed release location)
- Pond 5 (approximately 5.8 km downstream of the proposed release location).

Furthermore, potential impacts to groundwater will be assessed through ongoing monitoring at bores BA06 and BA07. Further detail regarding monitoring is presented in Section 9.2.

7.0 Impact Assessment – Temporary Construction Releases

7.1 Approach

A comprehensive assessment has been undertaken to develop an understanding of the potential impacts of the Project on the EVs of the receiving environment. The assessment included an impact assessment of both the construction and operational phases of the Project. This section addresses the potential impacts relating to temporary construction releases on water quality, ecology, hydrology, geomorphology and hydrogeology of the receiving environment.

Whilst any construction impacts are considered to be temporary, the development of appropriate discharge limits (similar to operational releases) has been used as a primary mitigation measure to ensure that environmental impacts are appropriately minimised. To achieve this, applicable EVs were used to set WQOs with consideration of practical discharge requirements. Where WQOs were available for more than one EV, the lowest, more stringent value was applied (in most cases, this was associated with the protection of aquatic ecosystems). This approach ensures that relevant EVs are protected, including downstream users of the Copperfield River.

Extensive monitoring as outlined in the REMP (Appendix I) is proposed to be undertaken during the construction and operational phases to ensure potentially unacceptable impacts are identified in a timely manner so that adaptive management of the release regime can respond and where necessary implement further mitigation strategies (refer to Section 9.3).

7.2 Preliminary Construction Phase Assessment

7.2.1.1 Key Objectives

A preliminary construction phase assessment (refer to Appendix K) has been completed with the key objectives of:

- Completing a detailed review of the proposed construction and pit dewatering staging schedule in order to confirm and define:
  - Dewatering volumes and rates
  - Critical dates
  - Key schedule-based objectives
  - Model objective functions – i.e. key metrics with which to compare the relative efficacy of each model scenario.
- Reviewing and developing model assumptions for the transition of Wises Pit from its existing condition as an open cut mine pit with an external (runoff) catchment to its constructed condition with an extensive water surface area and no external catchment.
- Completing a number of model simulations to test the sensitivity of key assumptions (dilution ratio, discharge capacity, catchment area and runoff coefficient for Wises Pit, increases to the storage capacity, FSL and spillway RL of the Wises upper reservoir, and additional water disposal) against adopted model objective functions.

7.2.1.2 Construction Stages and Model Objective Functions

A key requirement of the Project construction phase is the need to dewater the existing Eldridge Pit down to RL 305 m AHD in order to facilitate various construction works associated with both the access and tailrace tunnel construction. Key aspects of the construction phase are summarised in Table 83 and as follows:

- Stage 1 will transfer approximately 7.64 GL (the maximum volume able to be added to Wises Pit at its current capacity) from Eldridge Pit into the Existing Wises Pit.
- Upon completion of the proposed Wises upper reservoir embankment the remaining volume of water (20.39 GL) will be transferred from Eldridge Pit to the fully constructed Wises upper reservoir (stage 2).
- Based on the current water inventory in both pits and without the revised design measures outlined in Section 4.2.2.5 and assessed below, the stage 2 transfer would result in a final water level in the Wises upper reservoir of approximately 552.60 m AHD or approximately 1.1 m above the planned spillway elevation and 1.6m above the FSL:
  - This could result in an estimated construction phase water excess of 1.85 GL if the proposed Wises upper reservoir spillway elevation (551.5 m AHD) is not exceeded by dewatering pumping; or
  - 2.56 GL if the proposed FSL elevation (551 m AHD) is not exceeded by dewatering pumping.

These high excess water volumes were found to be the primary driver in the requirement for a significantly lower dilution ratio and higher maximum discharge capacity when compared to the operational phase. Consequently, further optimisation of the Project design (refer to Section 4.2.2.5) has been completed in include increases to the capacity of the Wises upper reservoir as well as temporary increases to its FSL and spillway RL during the construction phase. This has resulted in a significant reduction in the excess construction water volume and allowed operational phase release criteria to be adopted for the construction phase.

For the purpose of construction phase scenario assessment, the key model objective functions adopted were:

- Target the scheduled stage 2 dewatering duration of 268 days up to the 80th percentile (P80). Due to the whilst adopting the operational phase release conditions (refer to Section 9.1) i.e.:
  - 400 ML/d day release trigger in the Copperfield River at the proposed release location
  - 200 to 1 dilution ratio for dissolved zinc (0.5033% release ratio); and
  - A maximum release capacity of 1.0 m^3/s (86.4 ML/d).

Table 83 Key Construction Phase Stages

Stage	Description	Stage Schedule Details		
		Scheduled Stage Start	Scheduled Stage End	Scheduled Stage Duration (days)
1	Dewatering of Eldridge Pit for safe access to allow main access tunnel construction. Dewatering to continue up to the maximum allowable fill (RL 525m AHD) in the existing Wises Pit without impacting ongoing embankment works.	11/12/2019	16/04/2020	127
2	Final dewatering of Eldridge Pit to the completed Wises upper reservoir. Eldridge lowered to RL suitable for the safe construction of tailrace outlet works (305 m AHD).	18/11/2020	13/08/2021	268
3	Refill of Eldridge Pit to MOL RL (328.4 m AHD)	28/01/2022	11/02/2022	779 (total from start of stage 1 to end of stage 3)

7.2.1.3 Construction Phase Assessment

A total of 30 sensitivities and scenarios (refer to Appendix K) were assessed in order identify how the Project operational phase release conditions outlined above and in Section 9.1 could also be employed during the construction phase whilst still meeting the stage 2 dewatering objective. In summary, this was achieved by:

- Increasing the storage capacity of the Wises upper reservoir by 1.5 GL through the removal of 1.5 Mm^3 of waste rock material from below the MOL;
- Temporarily increasing the Wises upper reservoir spillway RL during the critical part of the construction phase (refer to Section 4.2.2.5) by 300mm to 551.8 m AHD; and
- Temporarily increasing the Wises upper reservoir FSL to 551.7 m AHD during the critical part of the construction phase (refer to Section 4.2.2.5).

The assessment also indicated that possible releases of Genex's existing allocation (4,650 ML) from the Copperfield Dam to augment streamflow in the Copperfield River at the proposed release point would not be required. In addition, it was also assumed that construction activities such as dust suppression and bulk earthworks would consume up to 0.5 ML/d of water from the pits during the construction phase. No uncontrolled (overflow) discharges were noted under the proposed conditions, input climate data and assumed operational rules.

Sensitivity Assessment

Additional modelling scenarios were completed to assess the sensitivity of key model input assumptions regarding the existing Wises Pit catchment area. The sensitivities considered both the runoff coefficient applied to the catchment as well as the size and timing of the catchment as it becomes part of the Wises upper reservoir (and transfers from an external runoff catchment into a direct rainfall catchment). The sensitivity assessment found that the key model result of the estimated stage 2 dewatering duration was relatively insensitive to the Wises Pit runoff catchment area or runoff coefficient.

7.2.1.4 Proposed Construction Phase Release Conditions

Proposed temporary construction phase release conditions are presented in Table 84 below.

Table 84 Proposed Temporary Construction Phase Release Conditions

Aspect	Proposed Condition	Comment
Copperfield River release trigger	400 ML/d	As per operational phase. Releases may be made at any time during the construction phase as long as the receiving flow is in excess of the trigger.
Dilution ratio	200:1	As per operational phase
Release ratio	0.503%	As per operational phase
Release capacity	1 m^3/s	As per operational phase
Temporary spillway RL	551.8 m AHD	For construction phase only
Temporary FSL RL	551.7 m AHD	For construction phase only

7.2.2 Constituents of Most Concern

Applying the adopted construction period dilution ratio of 200:1 for the construction phase, a mass balance assessment has been undertaken to determine the likely concentration in the receiving environment post mixing of a release. This has been undertaken by applying:

1. The maximum concentration of each parameter in the Eldridge Pit
2. The maximum concentration of each parameter observed in both pits and mixing at a ratio of nine parts Eldridge Pit to one part Wises Pit.

These values are considered to be highly conservative given that the maximum value was applied. Results are presented in Table 85.

- Only total nitrogen is predicted to exceed the WQO in the receiving environment post-mixing during the construction period. Elevated baseline concentrations (above the default WQO) are contributing to these exceedances.

Table 85 Worst-Case Final Concentrations of Constituents in Receiving Environment (Construction Phase)

Parameter	WQO (mg/L)[1]	Release Water Concentration (EOP) (mg/L)		Baseline Receiving Water Concentration (mg/L)[4]	Final Concentration in Receiving Environment for Construction Period Releases (mg/L)	
		Maximum Mixture for Both Pits[2]	Maximum for Eldridge Pit[3]		Maximum Mixture for Both Pits	Maximum for Eldridge Pit
Electrical Conductivity @ 25°C	500	*5311*	*4790*	167	194	191
Total Dissolved Solids (Calc.)		NA		NA	NA	NA
Total Hardness as CaCO3		1809.8	1754	56.2	65.2	65.0
Hydroxide Alkalinity as CaCO3		NA	NA	NA	NA	NA
Carbonate Alkalinity as CaCO3		NA	NA	NA	NA	NA
Bicarbonate Alkalinity as CaCO3		NA	NA	NA	NA	NA
Total Alkalinity as CaCO3		162.1	170	51.5	52.3	52.4
Sulfate as SO4 - Turbidimetric	250	*2690*	*2500*	10	23.5	22.5
Chloride	175	100	91	7	7.5	7.5
Calcium		506.8	495	12	14.5	14.5
Magnesium		132.4	126	7	7.7	7.6
Sodium	115	*318.4*	*287*	10	11.6	11.4
Potassium		51.3	44	2	2.3	2.2
Aluminium (F)	0.57	0.0185	0.02	0.16	0.16	0.16
Arsenic (F)	0.013	*0.1694*	*0.056*	0.0005	0.0013	0.0008
Beryllium (F)[5]	0.00013	0.0005	0.0005	0.0005	0.0005	0.0005

Parameter	WQO (mg/L)[1]	Release Water Concentration (EOP) (mg/L)		Baseline Receiving Water Concentration (mg/L)[4]	Final Concentration in Receiving Environment for Construction Period Releases (mg/L)	
		Maximum Mixture for Both Pits[2]	Maximum for Eldridge Pit[3]		Maximum Mixture for Both Pits	Maximum for Eldridge Pit
Barium (F)		0.0362	0.036	0.023	0.0232	0.0232
Cadmium (F)	0.0003	*0.02901*	*0.0321*	0.00005	0.0002	0.0002
Chromium (F)	0.0017	0.0005	0.0005	0.0005	0.0005	0.0005
Cobalt (F)	0.0028	*0.0283*	*0.029*	0.0005	0.0006	0.0006
Copper (F)	0.0024	*0.0047*	*0.005*	0.001	0.0010	0.0010
Lead (F)	0.0075	0.0005	0.0005	0.0005	0.0005	0.0005
Manganese (F)	1.9	*2.5868*	*2.86*	0.035	0.048	0.049
Molybdenum (F)	0.034	*0.0623*	*0.06*	0.0005	0.0008	0.0008
Nickel (F)	0.019	*0.0352*	*0.038*	0.0005	0.0007	0.0007
Selenium (F)	0.011	0.005	0.005	0.005	0.005	0.005
Uranium (F)	0.01	NA	NA	NA	NA	
Vanadium (F)	0.006	0.005	0.005	0.005	0.005	0.005
Zinc (F)	0.0136	*1.5874*	*1.75*	0.0025	0.0104	0.0113
Boron (F)	0.37	0.0285	0.025	0.025	0.0251	0.0251
Iron (F)	0.3	0.025	0.025	0.113	0.1131	0.1131
Mercury (F)	0.00006	0.00005	0.00005	0.00005	0.0001	0.0001
Aluminium (T)	1.52	0.234	0.21	0.45	0.4512	0.4511
Arsenic (T)	0.01	*0.368*	*0.26*	0.001	0.0028	0.0023
Beryllium (T)	0.06	0.0005	0.0005	0.0005	0.0005	0.0005
Barium (T)	1	0.0422	0.042	0.027	0.0272	0.0272
Cadmium (T)	0.002	*0.04186*	*0.046*	0.00005	0.0003	0.0003
Chromium (T)	0.05	0.00055	0.0005	0.0005	0.0005	0.0005

Parameter	WQO (mg/L)[1]	Release Water Concentration (EOP) (mg/L)		Baseline Receiving Water Concentration (mg/L)[4]	Final Concentration in Receiving Environment for Construction Period Releases (mg/L)	
		Maximum Mixture for Both Pits[2]	Maximum for Eldridge Pit[3]		Maximum Mixture for Both Pits	Maximum for Eldridge Pit
Cobalt (T)	0.05	*3.5151*	*3.84*	0.0005	0.0181	0.0197
Copper (T)	0.2	0.061	0.06	0.002	0.0023	0.0023
Lead (T)	0.01	*0.1723*	*0.19*	0.0005	0.0014	0.0015
Manganese (T)	0.1	*3.622*	*3.77*	0.073	0.0911	0.0919
Molybdenum (T)	0.01	*0.122*	*0.1*	0.0005	0.0011	0.0010
Nickel (T)	0.02	*0.0505*	*0.045*	0.0005	0.0008	0.0007
Selenium (T)	0.01	NA	NA	NA	NA	NA
Uranium (T)	0.01	NA	NA	NA	NA	NA
Vanadium (T)	0.1	NA	NA	NA	NA	NA
Zinc (T)	2	*2.352*	*2.28*	0.0025	0.0143	0.0139
Boron (T)	0.5	NA	NA	NA	NA	NA
Iron (T)	0.43	0.3065	0.225	0.22	0.2215	0.2211
Mercury (T)	0.001	0.00005	0.00005	0.00005	0.0001	0.0001
Free Cyanide	0.08	NA	NA	NA	NA	NA
Total Cyanide		NA	NA	NA	NA	NA
Weak Acid Dissociable Cyanide		NA	NA	NA	NA	NA
Fluoride	1	*3.03*	*2.8*	0.2	0.2152	0.2140
Ammonia as N	0.5	0.211	0.2	0.02	0.0211	0.0210
Nitrite as N	1	0.005	0.005	0.005	0.0050	0.0050
Nitrate as N	0.7	*4.935*	*5.45*	0.0325	0.0572	0.0598
Nitrite + Nitrate as N		NA	NA	NA	NA	NA

Parameter	WQO (mg/L)[1]	Release Water Concentration (EOP) (mg/L)		Baseline Receiving Water Concentration (mg/L)[4]	Final Concentration in Receiving Environment for Construction Period Releases (mg/L)	
		Maximum Mixture for Both Pits[2]	Maximum for Eldridge Pit[3]		Maximum Mixture for Both Pits	Maximum for Eldridge Pit
Total Kjeldahl Nitrogen as N		NA	NA	NA	NA	NA
Total Nitrogen as N[5]	0.15	*6.39*	*7*	0.25	0.2820	0.2850
Total Phosphorus as P	0.01	*0.0315*	*0.025*	0.005	0.0052	0.0051
Reactive Phosphorus as P		NA		NA	NA	NA

[1] Including site-specific WQOs and HMTVs as presented in Section 5.6.12.
[2] Maximum value for Eldridge Pit and Wises Pit, mixed at 9 parts Eldridge to 1 part Wises
[3] Maximum value for Eldridge Pit
[4] Median value for W2 (based on data collected since 2012)
[5] Baseline receiving environment concentration (or LOR) above WQO.
NA = No data available
Red italicised values denote an exceedance of the WQO in the release water (i.e. prior to release). This does not necessarily indicate that concentrations in the receiving environment will also be above the WQO.
Grey shaded values denote an exceedance of the WQO post-release.

7.3 Water Quality Impact Assessment

Potential impacts to water quality associated with temporary construction releases are as follows:

1. Increased water temperature and reducing natural thermal variability.
2. Scouring of Copperfield River near the temporary outfall or diffuser location resulting in increased sediment suspension.
3. Increased toxicant loads in Copperfield River resulting in adverse impacts to aquatic ecosystems.
4. Impacts to drinking water quality.
5. Visual impact at Einasleigh Gorge, through precipitation of dissolved contaminants.
6. Residual water quality changes following discharge events, pooling in Copperfield River.
7. Accumulation of contaminants in sediment.
8. Water quality changes in Pit water as level in Eldridge Pit falls and exposes pit walls.

In order to assess whether these impacts are likely to occur the following key tasks were undertaken:

a. A mass balance analysis has been undertaken in order to develop an understanding of the mass loading at various locations from the release point down to Einasleigh. Mass balance modelling was undertaken for selected key constituents. Detail is presented in Section 7.3.2 and Section 7.3.3. Near-field CORMIX modelling was not undertaken for temporary construction releases, as mass balance calculations have indicated that the concentration of the constituent of most concern (dissolved zinc) will be similar to operational releases.
b. Results of the far-field (mass balance) assessments described above were used to assess the water quality-related impacts to each EV.

7.3.1 Near Field Mixing Zone Assessment

As the Project construction phase will utilise the same release conditions as those proposed for the operational phase additional CORMIX near field modelling has not been completed for the construction phase. The CORMIX modelling previously undertaken for the operational phase is considered to be applicable to the temporary construction phase. Construction phase releases will be made under the same release criteria and consequently it is expected that any additional assessment will result in the same rate of nearfield mixing as that previously estimated in Section 6.2.1. CORMIX modelling completed for the operational phase (Section 6.2.1) has shown that near field mixing of released water can meet downstream WQOs under a range of potential release conditions and conceptual outlet arrangements

As outlined in Section 4.1.2, design and construction of the operational phase outlet works has been identified for early works however, in the unlikely event that the works are not complete prior to this, initial releases during the construction phase may be via a simple outfall structure (incorporating relevant erosion and sedimentation control measures). This is necessary for the Project to take advantage of potential release opportunities as soon as the construction phase commences. It is anticipated that this would only be required for a short period during the first wet season of the construction phase prior to commissioning of the operational phase release infrastructure.

Ongoing releases during the remainder of the construction phase are anticipated to be via the completed operational phase release infrastructure (instream diffused, outlet structure). Any temporary outfall structure would subsequently be decommissioned and removed as soon as practical following commissioning of the operational phase outlet works.

7.3.2 Far Field Assessment of Sustainable Load (Mass Balance)

A mass balance analysis has been undertaken in order to develop an understanding of the release potential of water from the Project and to assess the sustainable load in terms of frequency, volumes, mass loading and downstream cumulative impact. The analysis has been conducted using water balance assessment with development of the model described in Appendix L.

Estimated downstream dilution of released water by tributary and residual inflows has been assessed for the following construction phase scenarios:

- Assumed release water quality based on the median value of parameters in the Eldridge Pit, using a receiving environment dilution ratio of 200 parts receiving environment water to one part release water (scenario 3a, refer to Table 86 below).
- Assumed release water quality based on the maximum value of parameters in the Eldridge Pit, using a receiving environment dilution ratio of 200 parts receiving environment water to one part release water (scenario 3b, refer to Table 86 below).
- Assumed release water quality based on the median value of parameters in both pits, mixed at a ratio of nine parts Eldridge to one part Wises, using a receiving environment dilution ratio of 200 parts receiving environment water to one part release water (scenario 4a, refer to Table 86 below).
- Assumed release water quality based on the maximum value of parameters in both pits, mixed at a ratio of nine parts Eldridge to one part Wises, using a receiving environment dilution ratio of 200 parts receiving environment water to one part release water (scenario 4b, refer to Table 86 below).

In-stream concentrations for each downstream location have only been estimated on those days when releases occurred and have been calculated assuming mass-conserved advective transport only. A number of scenarios were considered for the assessment as outlined in Table 86 below. Key assumptions are shown in Table 87 with all release parameters based on the contaminant of most concern, dissolved zinc.

For dissolved cadmium and dissolved zinc, the HMTV has been applied up to approximately 7 km downstream of the release location (junction with East Creek) due to the elevated baseline in the receiving environment (median hardness of 56 mg/L at Copperfield River monitoring location W2).

Table 86 Construction Phase Downstream Mass Balance Scenarios Assessed

<table>
<tr><th>Scenario</th><th>Release Water Quality Assumption</th><th>Comment</th></tr>
<tr><td>1a</td><td>Median</td><td rowspan="2">Detailed downstream mass balance assessment focussed on contaminant of most concern, dissolved zinc in releases of water from Eldridge Pit only</td></tr>
<tr><td>1b</td><td>Maximum</td></tr>
<tr><td>2a</td><td>Median</td><td rowspan="2">Detailed downstream mass balance assessment focussed on contaminant of most concern, dissolved zinc in release of water from both pits mixed at a ratio of nine parts Eldridge to one part Wises</td></tr>
<tr><td>2b</td><td>Maximum</td></tr>
<tr><td>3a</td><td>Median</td><td rowspan="2">Comparative downstream mass balance assessment of releases from Eldridge Pit only for:
• EC and sulfate,
• Cadmium (F), cobalt (F), dissolved zinc, arsenic (T), cobalt (T), manganese (T) and total nitrogen (as N)</td></tr>
<tr><td>3b</td><td>Maximum</td></tr>
<tr><td>4a</td><td>Median</td><td rowspan="2">Comparative downstream mass balance assessment of releases mixed pit water at a ratio of nine parts Eldridge to one part Wises for:
• EC and sulfate,
Cadmium (F), cobalt (F), zinc (F), arsenic (T), cobalt (T), manganese (T) and total nitrogen (as N)</td></tr>
<tr><td>4b</td><td>Maximum</td></tr>
</table>

Table 87 Construction Phase Downstream Mass Balance – Key Assumptions

Scenario	Release Parameters Derived for Contaminant of Most Concern (Dissolved Zinc)			Assumed Concentration for Contaminant of Most Concern (Dissolved Zinc)
	Dilution Ratio (1 in xx)	Release Ratio	Assimilative Capacity Utilisation	
1a	200	0.5%	29.9%	Median Eldridge: 0.688 mg/L
1b	200	0.5%	76.3%	Maximum Eldridge: 1.750 mg/L
2a	200	0.5%	27.4%	Median mixed release: 0.6298 mg/L
2b	200	0.5%	69.0%	Maximum mixed release: 1.5874 mg/L
3a	200	0.5%	Dependant on contaminant. Maximum of 29.9% for dissolved zinc.	Median Eldridge Pit concentrations for all 9 contaminants as detailed in Table 86.
3b	200	0.5%	Dependant on contaminant. Maximum of 76.3% for dissolved zinc.	Maximum Eldridge Pit concentrations for all 9 contaminants as detailed in Table 86.
4a	200	0.5%	Dependant on contaminant. Maximum of 27.4% for dissolved zinc.	Median concentrations from both pits mixed at a ratio of nine parts Eldridge to one part Wises for all 9 contaminants as detailed in Table 86.
4b	200	0.5%	Dependant on contaminant. Maximum of 69.0% for dissolved zinc.	Maximum concentrations from both pits mixed at a ratio of nine parts Eldridge to one part Wises for all 9 contaminants as detailed in Table 86.

Detailed mass balance results for dissolved zinc for scenarios 1a to 2b are presented in Sections 7.3.3.1 to 7.3.3.4 below. Mass balance results for scenarios 3a to 4b are presented in Section 7.3.3.5 and a summary discussion is presented in Section 7.3.5.

7.3.3 Dissolved Zinc Mass Balance Results

Sections 7.3.3.1 to 7.3.3.4 below present results for the dissolved zinc mass balance assessment (scenarios 1a to 2b):

- Scenario 1a: All mass balance calculations for dissolved zinc are below the HMTV (release point to East Creek) or default WQO (Charles Creek to Einasleigh) for 95% species protection.
- Scenario 1b: Mass balance calculations for dissolved zinc indicate that concentrations will be below the HMTV at the release point down to East Creek. There may be minor exceedances of the default WQO from East Creek to Chinaman Creek (approximately 36 km downstream), however given this is a 'maximum' modelled value, the likelihood of these concentrations being released is very low. All results for this scenario are below the guideline for 90% species protection.
- Scenario 2a: All mass balance calculations for dissolved zinc are below the HMTV (release point to East Creek) or default WQO (Charles Creek to Einasleigh) for 95% species protection.

- Scenario 2b: All mass balance calculations for dissolved zinc are below the HMTV at the release point down to East Creek. There may be minor exceedances of the default WQO from East Creek to Charles Creek (approximately 20 km downstream), however given this is a ‘maximum’ modelled value, the likelihood of these concentrations being released is very low. All results for this scenario are below the guideline for 90% species protection.

7.3.3.1 Scenario 1a – Median Eldridge Concentration for Dissolved Zinc

Table 88 Scenario 1a – Downstream Mass Balanced Concentrations for Dissolved Zinc (Eldridge Pit, Median Release Concentration)

Statistic	Proposed Release Point After Discharge	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Mean	0.0059	0.0053	0.0051	0.0046	0.0044	0.0044	0.0033
P5	0.0057	0.0051	0.0048	0.0043	0.0041	0.0040	0.0030
P10	0.0057	0.0052	0.0049	0.0043	0.0041	0.0041	0.0031
P20	0.0058	0.0052	0.0050	0.0044	0.0042	0.0041	0.0031
P50	0.0059	0.0053	0.0051	0.0046	0.0044	0.0044	0.0033
P80	0.0059	0.0054	0.0052	0.0048	0.0046	0.0045	0.0034
P90	0.0059	0.0055	0.0053	0.0048	0.0047	0.0046	0.0036
P95	0.0059	0.0055	0.0053	0.0050	0.0049	0.0048	0.0037
Distance from Release (km)	0	6.9	19.58	23.43	30.39	35.72	48.32

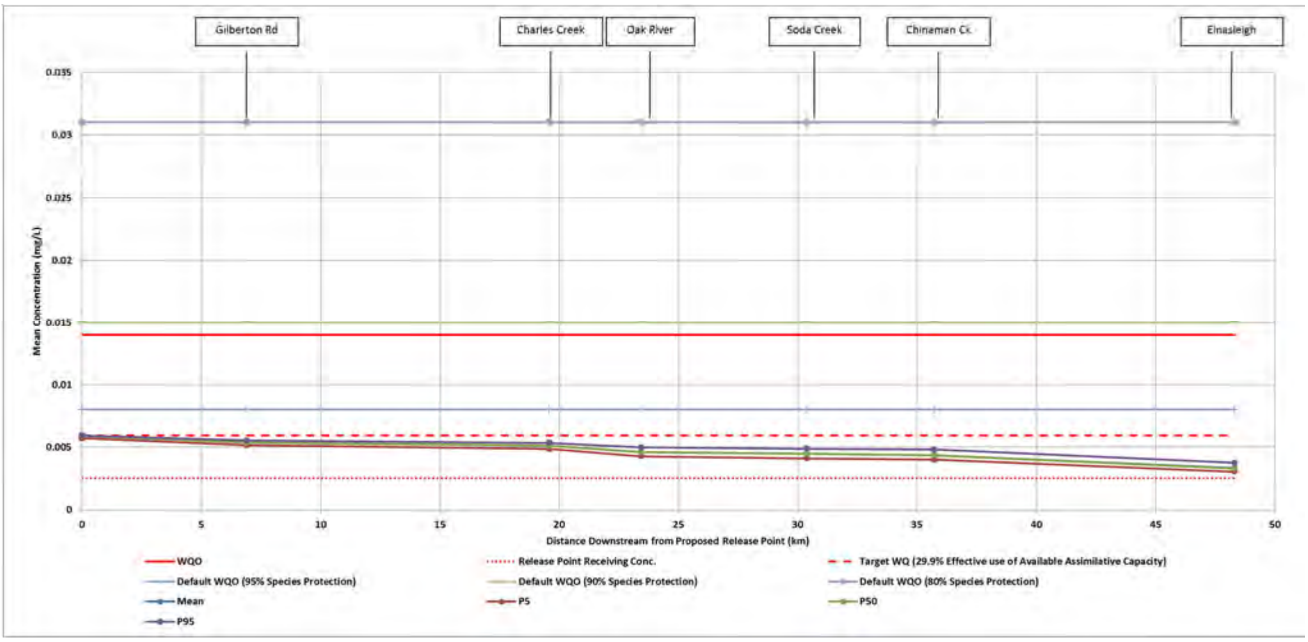


Figure 67 Scenario 1a – Downstream Mass Balanced Concentrations for Dissolved Zinc (Eldridge Pit, Median Release Concentration)

7.3.3.2 Scenario 1b – Maximum Eldridge Concentration for Dissolved Zinc

Table 89 Scenario 1b – Downstream Mass Balanced Concentrations for Dissolved Zinc (Eldridge Pit, Maximum Release Concentration)

Statistic	Proposed Release Point After Discharge	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Mean	0.0111	0.0097	0.0091	0.0079	0.0075	0.0072	0.0046
P5	0.0107	0.0092	0.0085	0.0070	0.0065	0.0063	0.0038
P10	0.0107	0.0093	0.0086	0.0071	0.0067	0.0065	0.0040
P20	0.0109	0.0094	0.0088	0.0074	0.0069	0.0067	0.0041
P50	0.0111	0.0097	0.0091	0.0079	0.0075	0.0072	0.0045
P80	0.0113	0.0100	0.0094	0.0083	0.0078	0.0076	0.0049
P90	0.0113	0.0101	0.0096	0.0084	0.0080	0.0078	0.0052
P95	0.0113	0.0102	0.0097	0.0088	0.0085	0.0083	0.0056
Distance from Release (km)	0	6.9	19.58	23.43	30.39	35.72	48.32

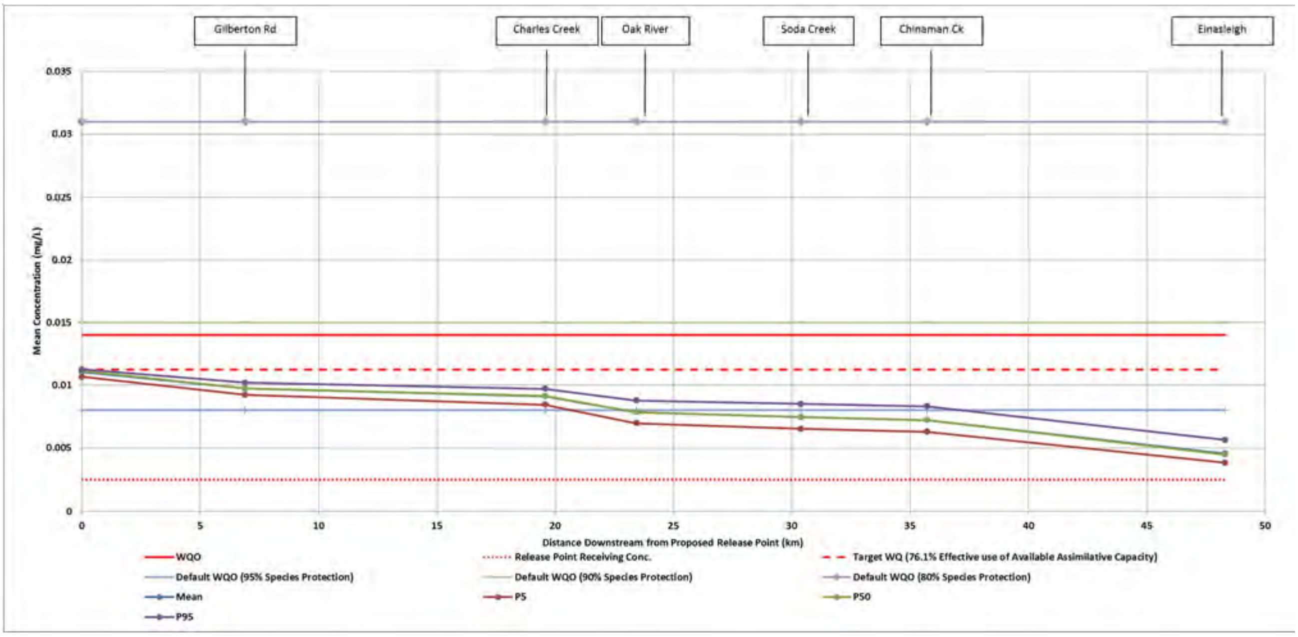


Figure 68 Scenario 1b – Downstream Mass Balanced Concentrations for Dissolved Zinc (Eldridge Pit, Maximum Release Concentration)

7.3.3.3 Scenario 2a – Median Mixed Pit Water Release Concentration for Dissolved Zinc

Table 90 Scenario 2a – Downstream Mass Balanced Concentrations for Dissolved Zinc (Mixed Pit Water Release, Medium Release Concentration)

Statistic	Proposed Release Point After Discharge	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Mean	0.0056	0.0051	0.0049	0.0044	0.0043	0.0042	0.0032
P5	0.0054	0.0049	0.0046	0.0041	0.0039	0.0039	0.0030
P10	0.0055	0.0049	0.0047	0.0042	0.0040	0.0039	0.0030
P20	0.0055	0.0050	0.0047	0.0042	0.0041	0.0040	0.0031
P50	0.0056	0.0051	0.0049	0.0044	0.0043	0.0042	0.0032
P80	0.0056	0.0052	0.0050	0.0046	0.0044	0.0043	0.0033
P90	0.0056	0.0052	0.0050	0.0046	0.0045	0.0044	0.0035
P95	0.0056	0.0053	0.0051	0.0048	0.0047	0.0046	0.0036
Distance from Release (km)	0	6.9	19.58	23.43	30.39	35.72	48.32

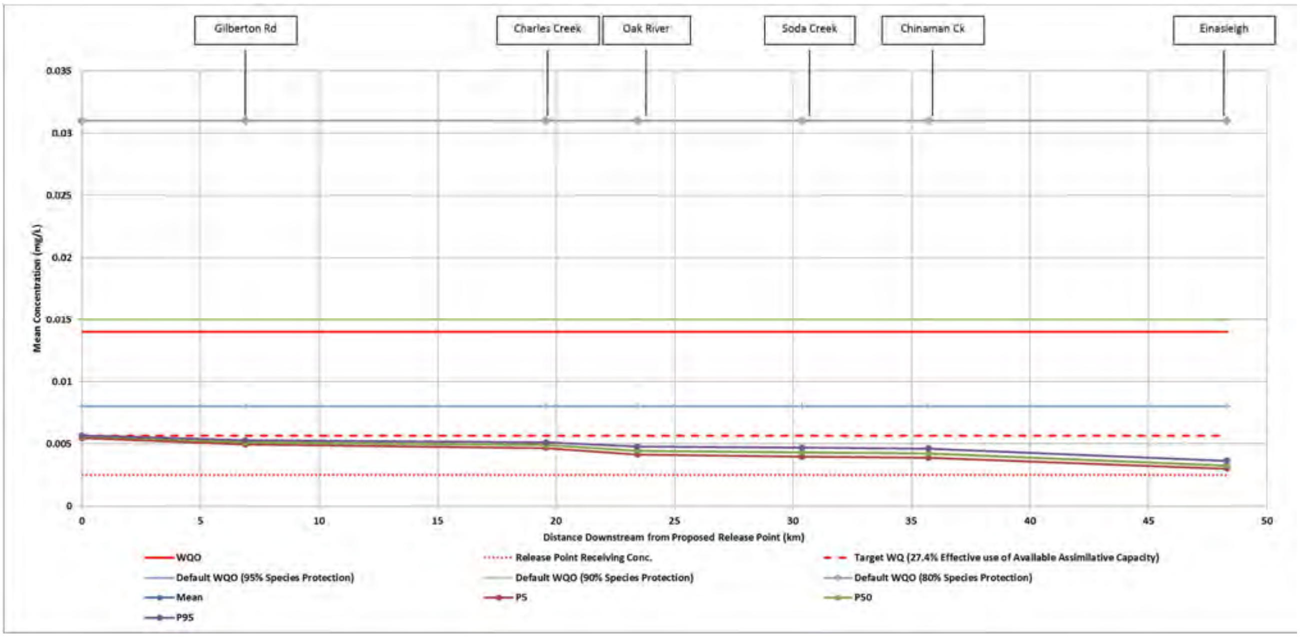


Figure 69 Scenario 2a – Downstream Mass Balanced Concentrations for Dissolved Zinc (Mixed Pit Water Release, Medium Release Concentration)

7.3.3.4 Scenario 2b – Maximum Mixed Pit Water Release Concentration for Dissolved Zinc

Table 91 Scenario 2b – Downstream Mass Balanced Concentrations for Dissolved Zinc (Mixed Pit Water Release, Maximum Release Concentration)

Statistic	Proposed Release Point After Discharge	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Mean	0.0103	0.0091	0.0085	0.0074	0.0070	0.0068	0.0044
P5	0.0099	0.0086	0.0079	0.0066	0.0062	0.0059	0.0037
P10	0.0100	0.0087	0.0080	0.0067	0.0063	0.0061	0.0038
P20	0.0101	0.0088	0.0082	0.0069	0.0065	0.0063	0.0039
P50	0.0103	0.0091	0.0085	0.0074	0.0070	0.0068	0.0043
P80	0.0104	0.0093	0.0088	0.0077	0.0073	0.0071	0.0046
P90	0.0104	0.0094	0.0089	0.0079	0.0075	0.0073	0.0050
P95	0.0104	0.0095	0.0090	0.0082	0.0079	0.0078	0.0053
Distance from Release (km)	0	6.9	19.58	23.43	30.39	35.72	48.32

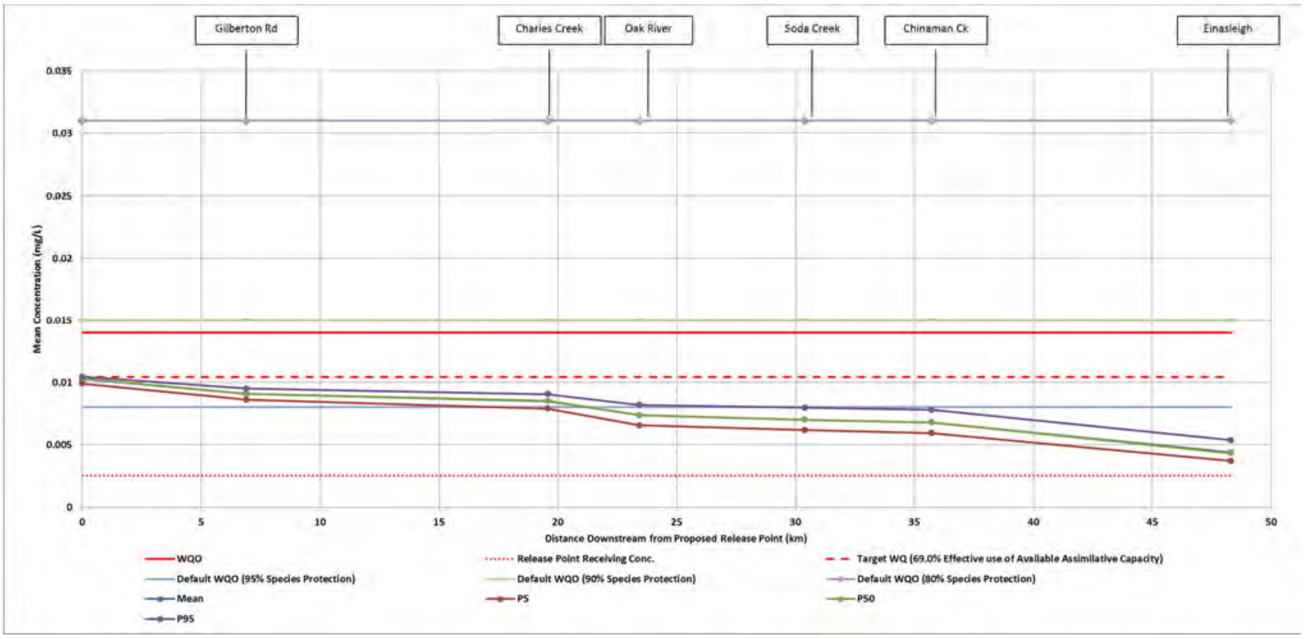


Figure 70 Scenario 2b – Downstream Mass Balanced Concentrations for Dissolved Zinc (Mixed Pit Water Release, Maximum Release Concentration)

7.3.3.5 Scenarios 3 & 4 - Annual Mass Balance Simulation for Comparative Assessment of Nine Constituents of Most Concern

Concentrations have been estimated for the contaminants of most concern as per the assumptions detailed in Section 6.1.1.3. Results are presented in Table 92 (releases from Eldridge Pit) and Table 93 (mixed pit water releases).

Table 92 Scenario 3 Construction Phase Mass Balance Results – Releases from Eldridge Pit only

Description		Median Concentrations for Releases from Eldridge Pit (Scenario 3a)									Worst Case Maximum Concentration for Releases from Eldridge Pit (Scenario 3b)								
Contaminant		Electrical Conductivity @ 25°C	Sulfate as SO_4 - Turbidimetric	Cadmium (F)	Cobalt (F)	Zinc (F)	Arsenic (T)	Cobalt (T)	Manganese (T)	Total Nitrogen as N	Electrical Conductivity @ 25°C	Sulfate as SO_4 - Turbidimetric	Cadmium (F)	Cobalt (F)	Zinc (F)	Arsenic (T)	Cobalt (T)	Manganese (T)	Total Nitrogen as N
Relevant Environmental Value		Aquatic Ecosystems (physico-chemical stressor)	Drinking Water - Aesthetic	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Drinking Water - Health	Long Term Irrigation	Recreation	Aquatic Ecosystems (physico-chemical stressor)	Aquatic Ecosystems (physico-chemical stressor)	Drinking Water - Aesthetic	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Drinking Water - Health	Long Term Irrigation	Recreation	Aquatic Ecosystems (physico-chemical stressor)
Units		µS/cm	mg/L	mg/L*	mg/L	mg/L*	mg/L	mg/L	mg/L	mg/L	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Baseline Median at W2		167	10	0.00005	0.0005	0.0025	0.001	0.0005	0.073	0.25	167	10	0.00005	0.0005	0.0025	0.001	0.0005	0.073	0.25
WQO (80% species protection for aquatic ecosystems)		**N/A**	**N/A**	**HMTV 0.0014 [0.0008]**	**N/A**	**HMTV 0.0527 [0.031]**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**HMTV 0.0014 [0.0008]**	**N/A**	**HMTV 0.0527 [0.031]**	**N/A**	**N/A**	**N/A**	**N/A**
WQO (90% species protection for aquatic ecosystems)		**N/A**	**N/A**	**HMTV 0.0007 [0.0004]**	**N/A**	**HMTV 0.0255 [0.015]**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**HMTV 0.0007 [0.0004]**	**N/A**	**HMTV 0.0255 [0.015]**	**N/A**	**N/A**	**N/A**	**N/A**
WQO (95% species protection for aquatic ecosystems)		**500**	**250**	**HMTV 0.0003 [0.0002]**	**0.0028**	**HMTV 0.0140 [0.008]**	**0.0100**	**0.0500**	**0.1000**	**0.1500**	**500**	**250**	**HMTV 0.0003 [0.0002]**	**0.0028**	**HMTV 0.0140 [0.008]**	**0.0100**	**0.0500**	**0.1000**	**0.1500**
Propose Release Point (0 km)	Mean	180.647	17.306	0.00015	0.00052	0.0059	0.0011	0.00062	0.079	0.283	189.669	22.210	0.00021	0.00064	0.011	0.0023	0.019	0.091	0.283
	Median	180.765	17.369	0.00015	0.00052	0.0059	0.0011	0.00062	0.079	0.283	189.865	22.315	0.00021	0.00064	0.011	0.0023	0.019	0.091	0.283
	P95	180.937	17.462	0.00015	0.00052	0.0059	0.0011	0.00062	0.079	0.284	190.151	22.469	0.00021	0.00064	0.011	0.0023	0.020	0.092	0.284
East Creek (Gilberton Rd) (6.9 km)	Mean	169.704	14.932	0.00013	0.00052	0.0053	0.0010	0.00060	0.073	0.276	177.323	19.073	0.00018	0.00062	0.010	0.0020	0.016	0.083	0.276
	Median	169.925	14.973	0.00013	0.00052	0.0053	0.0010	0.00060	0.073	0.276	177.572	19.089	0.00018	0.00062	0.010	0.0020	0.016	0.083	0.276
	P95	173.683	15.674	0.00014	0.00052	0.0055	0.0011	0.00061	0.075	0.279	181.664	20.047	0.00019	0.00063	0.010	0.0021	0.017	0.086	0.279
Charles Creek (19.6 km)	Mean	164.604	13.827	0.00013	0.00052	0.0051	0.0010	0.00059	0.070	0.273	171.571	17.613	0.00017	0.00061	0.009	0.0019	0.015	0.079	0.273
	Median	164.814	13.875	0.00013	0.00052	0.0051	0.0010	0.00059	0.070	0.273	171.839	17.667	0.00017	0.00061	0.009	0.0019	0.015	0.079	0.273
	P95	170.216	14.971	0.00013	0.00052	0.0053	0.0010	0.00060	0.073	0.276	177.821	19.044	0.00018	0.00062	0.010	0.0020	0.016	0.083	0.276
Oak River (23.4 km)	Mean	154.202	11.573	0.00011	0.00051	0.0046	0.0009	0.00058	0.063	0.267	159.840	14.637	0.00015	0.00059	0.008	0.0016	0.012	0.071	0.267
	Median	154.061	11.569	0.00011	0.00051	0.0046	0.0009	0.00058	0.063	0.267	159.764	14.649	0.00015	0.00059	0.008	0.0016	0.012	0.071	0.267
	P95	162.571	13.349	0.00012	0.00052	0.0050	0.0010	0.00059	0.068	0.272	169.218	16.961	0.00017	0.00060	0.009	0.0018	0.014	0.077	0.272
Soda Creek (30.4 km)	Mean	150.878	10.853	0.00011	0.00051	0.0044	0.0009	0.00057	0.061	0.265	156.092	13.686	0.00014	0.00058	0.007	0.0015	0.011	0.068	0.265
	Median	150.616	10.832	0.00011	0.00051	0.0044	0.0009	0.00057	0.061	0.265	155.870	13.686	0.00014	0.00058	0.007	0.0015	0.011	0.068	0.265
	P95	159.969	12.790	0.00012	0.00052	0.0049	0.0009	0.00058	0.067	0.270	166.290	16.225	0.00016	0.00060	0.009	0.0017	0.014	0.075	0.270
Chinaman Creek (35.7km)	Mean	148.959	10.437	0.00010	0.00051	0.0044	0.0008	0.00057	0.060	0.264	153.929	13.138	0.00014	0.00058	0.007	0.0015	0.011	0.067	0.264
	Median	148.570	10.395	0.00010	0.00051	0.0044	0.0008	0.00057	0.060	0.264	153.580	13.110	0.00014	0.00058	0.007	0.0015	0.011	0.066	0.264
	P95	158.432	12.459	0.00012	0.00051	0.0048	0.0009	0.00058	0.066	0.269	164.560	15.790	0.00016	0.00059	0.008	0.0017	0.013	0.074	0.269
Einasleigh (48.3 km)	Mean	126.999	5.683	0.00007	0.00051	0.0033	0.0006	0.00053	0.047	0.250	129.170	6.863	0.00009	0.00053	0.005	0.0009	0.005	0.050	0.250
	Median	126.391	5.545	0.00007	0.00051	0.0033	0.0006	0.00053	0.046	0.250	128.496	6.665	0.00009	0.00053	0.004	0.0009	0.005	0.049	0.250
	P95	135.588	7.562	0.00009	0.00051	0.0037	0.0007	0.00054	0.052	0.256	138.887	9.355	0.00011	0.00055	0.006	0.0011	0.007	0.056	0.256

*Indicates HMTV. Default WQO presented in brackets.

Red values denote exceedance of WQO (for 95% species protection where multiple levels of protection are available). The HMTV has been applied up to ~7km downstream due to the elevated baseline in the receiving environment (median hardness of 56 mg/L at Copperfield River monitoring location W2).

Table 93 Scenario 4 Construction Phase Mass Balance Results – Releases of Mixed Pit Water

Description		Median Concentrations for Mixed Pit Water Releases (Scenario 4a)									Worst Case Maximum Concentration for Mixed Pit Water Releases (Scenario 4b)								
Contaminant		Electrical Conductivity @ 25°C	Sulfate as SO4 - Turbidimetric	Cadmium (F)	Cobalt (F)	Zinc (F)	Arsenic (T)	Cobalt (T)	Manganese (T)	Total Nitrogen as N	Electrical Conductivity @ 25°C	Sulfate as SO4 - Turbidimetric	Cadmium (F)	Cobalt (F)	Zinc (F)	Arsenic (T)	Cobalt (T)	Manganese (T)	Total Nitrogen as N
Relevant Environmental Value		Aquatic Ecosystems (physico-chemical stressor)	Drinking Water - Aesthetic	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Drinking Water - Health	Long Term Irrigation	Recreation	Aquatic Ecosystems (physico-chemical stressor)	Aquatic Ecosystems (physico-chemical stressor)	Drinking Water - Aesthetic	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Drinking Water - Health	Long Term Irrigation	Recreation	Aquatic Ecosystems (physico-chemical stressor)
Units		µS/cm	mg/L	mg/L*	mg/L	mg/L*	mg/L	mg/L	mg/L	mg/L	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Baseline Median at W2		167	10	0.00005	0.0005	0.0025	0.001	0.0005	0.073	0.25	167	10	0.00005	0.0005	0.0025	0.001	0.0005	0.073	0.25
WQO (80% species protection for aquatic ecosystems)		N/A	N/A	HMTV 0.0014 [0.0008]	N/A	HMTV 0.0527 [0.031]	N/A	N/A	N/A	N/A	N/A	N/A	HMTV 0.0014 [0.0008]	N/A	HMTV 0.0527 [0.031]	N/A	N/A	N/A	N/A
WQO (90% species protection for aquatic ecosystems)		N/A	N/A	HMTV 0.0007 [0.0004]	N/A	HMTV 0.0255 [0.015]	N/A	N/A	N/A	N/A	N/A	N/A	HMTV 0.0007 [0.0004]	N/A	HMTV 0.0255 [0.015]	N/A	N/A	N/A	N/A
WQO (95% species protection for aquatic ecosystems)		500	250	HMTV 0.0003 [0.0002]	0.0028	HMTV 0.0140 [0.008]	0.0100	0.0500	0.1000	0.1500	500	250	HMTV 0.0003 [0.0002]	0.0028	HMTV 0.0140 [0.008]	0.0100	0.0500	0.1000	0.1500
Propose Release Point (0 km)	Mean	181.769	18.145	0.00014	0.00052	0.0056	0.0011	0.00061	0.079	0.280	192.224	23.142	0.00019	0.00064	0.010	0.0028	0.018	0.090	0.280
	Median	181.897	18.215	0.00014	0.00052	0.0056	0.0011	0.00061	0.079	0.280	192.442	23.255	0.00019	0.00064	0.010	0.0028	0.018	0.091	0.280
	P95	182.083	18.318	0.00014	0.00052	0.0056	0.0011	0.00061	0.079	0.281	192.760	23.421	0.00020	0.00064	0.010	0.0028	0.018	0.091	0.281
East Creek (Gilberton Rd) (6.9 km)	Mean	170.652	15.640	0.00013	0.00052	0.0051	0.0010	0.00059	0.072	0.274	179.481	19.860	0.00017	0.00062	0.009	0.0024	0.015	0.082	0.274
	Median	170.883	15.672	0.00013	0.00052	0.0051	0.0010	0.00059	0.072	0.274	179.736	19.881	0.00017	0.00062	0.009	0.0024	0.015	0.082	0.274
	P95	174.684	16.422	0.00013	0.00052	0.0053	0.0011	0.00060	0.074	0.276	183.898	20.885	0.00018	0.00062	0.009	0.0026	0.016	0.085	0.276
Charles Creek (19.6 km)	Mean	165.471	14.474	0.00012	0.00052	0.0049	0.0010	0.00059	0.069	0.271	173.544	18.333	0.00016	0.00061	0.009	0.0023	0.014	0.078	0.271
	Median	165.660	14.515	0.00012	0.00052	0.0049	0.0010	0.00059	0.069	0.271	173.828	18.384	0.00016	0.00061	0.009	0.0023	0.014	0.078	0.271
	P95	171.163	15.668	0.00013	0.00052	0.0051	0.0010	0.00059	0.072	0.274	179.974	19.817	0.00017	0.00061	0.009	0.0024	0.015	0.082	0.274
Oak River (23.4 km)	Mean	154.904	12.097	0.00011	0.00051	0.0044	0.0009	0.00057	0.063	0.265	161.437	15.219	0.00014	0.00059	0.007	0.0019	0.011	0.070	0.265
	Median	154.771	12.095	0.00011	0.00051	0.0044	0.0009	0.00057	0.063	0.265	161.378	15.231	0.00014	0.00059	0.007	0.0019	0.011	0.070	0.265
	P95	163.399	13.967	0.00012	0.00052	0.0048	0.0010	0.00058	0.068	0.270	171.099	17.648	0.00015	0.00060	0.008	0.0022	0.013	0.077	0.270
Soda Creek (30.4 km)	Mean	151.526	11.337	0.00010	0.00051	0.0043	0.0009	0.00056	0.061	0.263	157.568	14.225	0.00013	0.00058	0.007	0.0018	0.010	0.068	0.263
	Median	151.273	11.320	0.00010	0.00051	0.0043	0.0009	0.00056	0.061	0.263	157.314	14.228	0.00013	0.00058	0.007	0.0018	0.010	0.068	0.263
	P95	160.756	13.377	0.00011	0.00051	0.0047	0.0010	0.00058	0.066	0.268	168.079	16.877	0.00015	0.00060	0.008	0.0021	0.013	0.075	0.268
Chinaman Creek (35.7km)	Mean	149.578	10.899	0.00010	0.00051	0.0042	0.0009	0.00056	0.060	0.262	155.336	13.651	0.00013	0.00058	0.007	0.0018	0.010	0.066	0.262
	Median	149.193	10.858	0.00010	0.00051	0.0042	0.0009	0.00056	0.059	0.262	154.998	13.626	0.00013	0.00058	0.007	0.0018	0.010	0.066	0.262
	P95	159.194	13.029	0.00011	0.00051	0.0046	0.0009	0.00058	0.065	0.267	166.295	16.422	0.00015	0.00059	0.008	0.0021	0.012	0.073	0.267
Einasleigh (48.3 km)	Mean	127.269	5.885	0.00007	0.00050	0.0032	0.0007	0.00053	0.047	0.250	129.784	7.087	0.00008	0.00053	0.004	0.0011	0.005	0.049	0.250
	Median	126.653	5.733	0.00007	0.00050	0.0032	0.0006	0.00053	0.046	0.249	129.092	6.882	0.00008	0.00053	0.004	0.0010	0.004	0.049	0.249
	P95	135.998	7.869	0.00008	0.00051	0.0036	0.0007	0.00054	0.052	0.255	139.821	9.696	0.00010	0.00055	0.005	0.0013	0.007	0.056	0.255

*Indicates HMTV. Default WQO presented in brackets.

Red values denote exceedance of WQO (for 95% species protection where multiple levels of protection are available). The HMTV has been applied up to ~7km downstream due to the elevated baseline in the receiving environment (median hardness of 56 mg/L at Copperfield River monitoring location W2).

7.3.4 Assessment of Water Quality Impacts to Environmental Values

Results of the DTA and far-field (mass balance) assessment was used to assess the water quality-related impacts to each EV as a result of temporary construction releases. Results are presented in Table 94.

Table 94 Potential Construction Phase Water Quality Impacts to Relevant Environmental Values

Environmental Value	Relevant Parameter and Copperfield River Location	Impact Assessment
Aquatic ecosystems (incorporating Habitat value)	Mass balance assessment indicates that parameters relevant to the aquatic ecosystem EV are below the WQO at all locations, with the exception of total nitrogen and dissolved zinc. The concentration of total nitrogen is above the WQO at all modelled locations, partly due to the elevated baseline concentrations (also above the WQO). Under a worst case scenario, there may be rare and very marginal exceedances of the default 95% species protection WQO for dissolved zinc from Charles Creek to Soda Creek (modelled concentrations of 0.009 or 0.010 mg/L compared with the default WQO of 0.008 mg/L). For the scenarios assessed, the 90% species protection WQO will not be exceeded at any location in the receiving environment. The exceedances are within the likely margin of error of the various methods used in the assessment. Whist concentrations of nitrate are elevated in release waters, concentrations post-release are expected to be well below the WQO for aquatic ecosystem protection post-release during the construction phase (refer to Table 85). It was therefore considered unnecessary to include nitrate in the mass balance assessment.	Baseline total nitrogen is already elevated in the receiving environment and is thereby contributing to the exceedance of the WQO. Elevated nitrogen concentrations in waterways may under certain circumstances lead to algal blooms, which can impact aquatic ecosystems. Whilst the levels of nitrogen exceed the WQO, the exceedance is not likely to cause such impacts given the nature of the receiving environment and composition of the discharge water, namely the limited availability of phosphorus. Monitoring undertaken as part of the REMP (refer to Section 8.2) will ensure that any impacts are appropriately managed, and if necessary that additional mitigation measures are implemented (see Section 9.3). Nitrate concentrations are expected to be well below the WQO post-release and therefore impacts associated with nitrate are considered negligible. Although there may be rare and very marginal exceedances of the 95% level of protection for dissolved zinc from Charles Creek to Chinaman Creek, the DTA results (refer to Section 4.9) indicate that the proposed releases will not result in toxicity-related impacts to aquatic ecosystems. Under the DTA, a minimum dilution ratio of nine parts receiving environment water to one part release water is required to meet 95% species protection. In addition, the exceedances are within the likely margin of error of the various methods used in the assessment. During the construction phase, the simulated releases are well in excess (200:1) of this minimum dilution ratio. The mass balance assessment indicates that the HMTV will not be exceeded around the release location (down to East Creek, which is located approximately 7 km downstream). As outlined in Section 5.14, there are two semi-permanent pools (Pond 4 and Pond 5) located downstream of the release location, however they are both less than 7 km downstream and therefore the HMTV is not expected to be exceeded in either pool. Impacts to these

Environmental Value	Relevant Parameter and Copperfield River Location	Impact Assessment
		pools are therefore anticipated to be negligible. With regards to scour around the outfall contributing to increased sedimentation, modelling suggests that the increased flow from the releases will not have any significant effect on the hydraulics of the natural system (refer to Section 7.6 for further detail). Detailed design and construction will need to take into consideration the potential for erosion, and ensure that engineering solution appropriately mitigate this impact to avoid downstream impacts. The potential impacts to the downstream environment from increased erosion and sedimentation associated with the release point are expected to be minimal as construction of this component will be strictly limited to the dry season. Appropriate design and management of the diffuser will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values. Further, photographic monitoring of the release point over time will document and monitor the rate of erosion and deposition occurring at and downstream of the release point.
Irrigation (Short Term < 20 years)	As set out in Section 5.4, WQOs for short term irrigation do not apply as the lowest applicable WQO for any parameter.	Modelling has shown that more stringent WQOs for other EVs will not be exceeded as a result of Project releases. It therefore concluded that the Project is unlikely to result in impacts to the short term irrigation EV during the construction period due to high dilution rates (200:1).
Irrigation (Long Term ~100 years)	The WQO for total cobalt is specific to the protection of the long term irrigation EV. Modelling has shown that the WQO for total cobalt will not be exceeded post-mixing in the receiving environment.	Impacts to long term irrigation during the construction phase are not anticipated, as concentrations of total cobalt post releases are modelled to be below the relevant WQO for long term irrigation at all downstream locations.

Environmental Value	Relevant Parameter and Copperfield River Location	Impact Assessment
Farm supply (e.g. fruit washing, milking sheds, intensive livestock yards)	As set out in Section 5.4, WQOs for farm supply do not apply as the lowest applicable WQO for any parameter.	The high dilution rate for the construction phase of the Project (200:1) means that all relevant WQOs will be met post-release in the receiving environment. The ANZECC/ARMCANZ 2000 guidelines includes trigger values for assessing the corrosiveness and fouling potential of water. pH and hardness in the releases post-mixing indicates limited potential for both corrosion and fouling potential. Impacts to the farm supply EV in the receiving environment are therefore considered highly unlikely.
Stock watering (e.g. grazing cattle)	As set out in Section 5.4, WQOs for stock watering do not apply as the lowest applicable WQO for any parameter.	ANZECC/ARMCANZ 2000 WQOs for stock watering are presented in Table 29. The worst case concentrations in the receiving environment based on maximum concentrations (Table 55) indicates that WQOs for stock watering will not be exceeded. It therefore concluded that the Project is unlikely to result in impacts to the stock watering EV during the construction period.
Aquaculture	This EV was considered and is not applicable to downstream receiving environment	This EV was considered and is not applicable to downstream receiving environment
Human consumption (e.g. of wild or stocked fish)	As set out in Section 5.4, WQOs for human consumption do not apply as the lowest applicable WQO for any parameter.	ANZECC/ARMCANZ 2000 WQOs for human consumption are presented in Table 29. The worst case concentrations in the receiving environment based on maximum concentrations (Table 55) indicates that WQOs for human consumption will not be exceeded. It therefore concluded that the Project is unlikely to result in impacts to the human consumption EV during the construction period.
Primary recreation (fully immersed in water e.g. swimming)	The WQO for total manganese is specific to the protection of the recreation EV. Modelling has shown that the WQO for total manganese will not be exceeded post-mixing in the receiving environment.	Impacts to recreation during the construction phase are not anticipated, as concentrations of total manganese post releases are modelled to be below the relevant WQO for recreation at all downstream locations.
Secondary recreation (possibly splashed with water, e.g. sailing)		
Visual appreciation (no contact with water, e.g. picnics)	No specific WQOs associated with the protection of visual appreciation. See above for recreation.	Modelling has shown that more stringent WQOs for other EVs will not be exceeded as a result of Project releases. It therefore concluded that the Project is unlikely to result in impacts to the visual appreciation EV during the construction period due to dilution rates (200:1).

Environmental Value	Relevant Parameter and Copperfield River Location	Impact Assessment
Drinking water (raw water supplies taken for drinking)	The WQOs for sulfate and total arsenic are specific to the protection of the drinking water EV (sulfate for aesthetics and arsenic for health). Modelling has shown that the WQO for these parameters will not be exceeded post-mixing in the receiving environment.	Impacts to drinking water during the construction phase are not anticipated, as concentrations of sulfate and total arsenic post releases are modelled to be below the relevant WQO for drinking water at all downstream locations.
Industrial use (e.g. power generation, manufacturing, road maintenance)	As set out in Section 5.4, WQOs for industrial use do not apply as the lowest applicable WQO for any parameter.	Modelling has shown that more stringent WQOs for other EVs will not be exceeded as a result of Project releases. It is therefore concluded that the Project is unlikely to result in impacts to the industrial use EV during the construction period due to high dilution rates (200:1).
Cultural and spiritual values	No specific WQOs associated with the protection of cultural and spiritual values.	It is assumed that by protecting other EVs relevant to the receiving environment, cultural and spiritual values will also be protected.

7.3.5 Conclusions of Water Quality Impact Assessment

An assessment of far-field water quality modelling and DTA results indicates that any impacts occurring as a result of construction releases are temporary and reversible. This is evidenced by the following:

- For temporary construction releases, it is proposed that a maximum of 76.3% of the assimilative capacity of the receiving environment be utilised (this equates to an effective dilution ratio of 200 parts receiving environment to one part release water from the Eldridge Pit). The assumptions behind calculating effective dilution ratios are highly conservative (based on maximum pit water qualities). In reality the actual assimilative capacity usage will be lower than 76.3% in most cases.
- Parameters relevant to the aquatic ecosystem EV are below WQOs at all locations, with the exception of total nitrogen and dissolved zinc.
- Under a worst case scenario, there may be rare and very minor exceedances of the default 95% species protection WQO for dissolved zinc from Charles Creek to Chinaman Creek. Given that these exceedances represent a ‘maximum’ modelled value, the likelihood of these concentrations being released is very low. In addition, the exceedances are within the likely margin of error of the various methods used in the assessment. For the scenarios assessed, the 90% species protection WQO will not be exceeded at any of the modelled location in the receiving environment.
- The mass balance assessment indicates that the HMTV will not be exceeded in either of the two semi-permanent pools (Pond 4 and Pond 5) located downstream of the release location, therefore impacts to these pools are therefore anticipated to be negligible.
- During the construction phase, the simulated releases are well in excess (200:1) of the minimum dilution ratio for toxicity-related impacts in the receiving environment (9:1).
- Concentrations of parameters relevant to other EVs are all modelled to be below the specified WQO.

Further information regarding potential water quality impacts and mitigation measures is presented in the risk assessment (Section 8.0).

7.4 Hydrology Impact Assessment

Streamflow data from the GoldSim model (Appendix L) for the Copperfield River at the proposed release point inclusive of potential releases based on the key criteria presented in Section 7.2.1.4 has been subjected to a number of different analysis as described below and summarised in Table 95:

1. Analysis of releases - volumes, timing and duration of potential releases during the construction phase were assessed. Analysis was conducted both annually and under both wet and dry season conditions.
2. Assessment of post release flushes - timing and duration of potential post-release flushes during the construction phase were assessed. Analysis was again conducted on both an annual and seasonal (wet and dry) basis.

Deterministic analysis to form the basis for additional assessment of flow duration and flow spells analysis was not considered due to the short period assessed for the construction period (approximately 2.15 years). Typically such analysis requires longer duration simulation (at least ten years) and extended simulation of the construction phase is not considered appropriate given the staged nature of construction and dewatering during the proposed construction phase[19]. As a result assessment has focussed on analysis of release s and release post-release flushing as outlined in Table 95. In addition, the utilisation of the same release conditions for the construction phase as those proposed for the operational phase is likely to result in a similar outcome.

Table 95 Hydrology Impact Assessment Summary

Aspect	Aspects Assessed	Reference
Analysis of releases	Volumes, release events and durations, seasonal variation (wet and dry season).	Section 7.4.1
Analysis of post release flushing	Flush volumes, durations, flush ratio, spatial and seasonal (wet and dry season) variation.	Section 7.4.2

7.4.1 Estimated Construction Phase Releases

Referring to Table 96, Table 97 and Table 98:

- The median mean annual release volume is 409 ML (Table 96) however:
  - The majority of releases are restricted to the wet season with a median release volume of 400 ML (Table 97);
  - The median dry season release volume is 0 ML (Table 98);
  - This strong temporal distribution of release volumes is also shown on Figure 71 which shows that the probability of a release occurring between May through November is less than 5%.
- The median mean annual number of release days is 33.1 (Table 96), 32.4 during the wet season (Table 97) and zero during the dry season (Table 98).
- The median release event:
  - On an annual basis is approximately 101 ML, occurs 4.2 times and has an estimated duration of 7.7 days per event (Table 96);
  - During the wet season is approximately 107 ML, occurs 4.2 times and has an estimated duration of 7.7 days per event (Table 97); and
  - During the dry season (Table 98) is 0 ML.

[19] Long term deterministic simulation of the operational phase was considered appropriate as the system operates under a fixed set of assumptions and can therefore be modelled over extended periods.

- Median mass loading for dissolved zinc during the wet season is 701 kg (Table 97, reducing to 0 kg in the dry season (Table 98). Note that this is a worst case result assuming releases from the Eldridge pit only and at the maximum concentration of 1.75 mg/L. Under all the additional release water source scenarios considered in Section 7.2, mass loading would be lower.

Table 96 Construction Phase Controlled Release – Mean Annual Statistics

Statistic	Mean Annual Release Volume	Mean Volume Released per Event	Mean Annual Number of Release Days	Mean Annual Number of Release Events[20]	Mean Release Event Duration	Mean Annual Mass Loading (zinc (F))
	ML	ML	days	1/ 1yr	d	kg
Mean	612	157	38.1	4.5	9.1	1,071
P5	74	19	13.0	2.3	3.6	130
P10	124	25	17.4	2.8	4.1	216
P20	194	41	23.0	3.2	5.3	340
P50	409	101	33.1	4.2	7.7	716
P80	954	248	50.9	5.6	12.5	1,670
P90	1,420	332	67.0	6.9	14.9	2,485
P95	1,636	550	81.2	7.7	19.4	2,863

Table 97 Construction Phase Controlled Release – Wet Season (Nov through April) Statistics

Statistic	Mean Season Release Volume	Mean Volume Released per Event	Mean Number of Release Days per Season	Mean Number of Release Events[21] per Season	Mean Release Event Duration	Mean Mass Loading per Season (zinc (F))
	ML	ML	days	1/ 1yr	d	kg
Mean	605	166	37.0	4.2	9.5	1,059
P5	72	19	12.4	1.9	3.6	127
P10	108	26	16.1	2.3	4.2	188
P20	193	41	22.7	2.8	5.3	337
P50	400	107	32.4	4.2	8.3	701
P80	954	250	50.4	5.1	12.4	1,669
P90	1,405	374	64.8	6.1	15.4	2,459
P95	1,624	573	79.7	7.2	21.6	2,842

[20] A release event is the occurrence of controlled releases occurring for one or more consecutive days
[21] A release event is the occurrence of controlled releases occurring for one or more consecutive days

Table 98 Construction Phase Controlled Release – Dry Season (May through October) Statistics

Statistic	Mean Season Release Volume	Mean Volume Released per Event	Mean Number of Release Days per Season	Mean Number of Release Events[22] per Season	Mean Release Event Duration	Mean Mass Loading per Season (zinc (F))
	ML	ML	days	1/ 1yr	d	kg
Mean	7	11	1.1	0.3	1.7	12
P5	-	-	-	-	-	-
P10	-	-	-	-	-	-
P20	-	-	-	-	-	-
P50	-	-	-	-	-	-
P80	12	16	2.8	0.6	3.2	21
P90	19	27	3.2	0.9	4.1	34
P95	25	44	3.7	0.9	5.6	43

[22] A release event is the occurrence of controlled releases occurring for one or more consecutive days

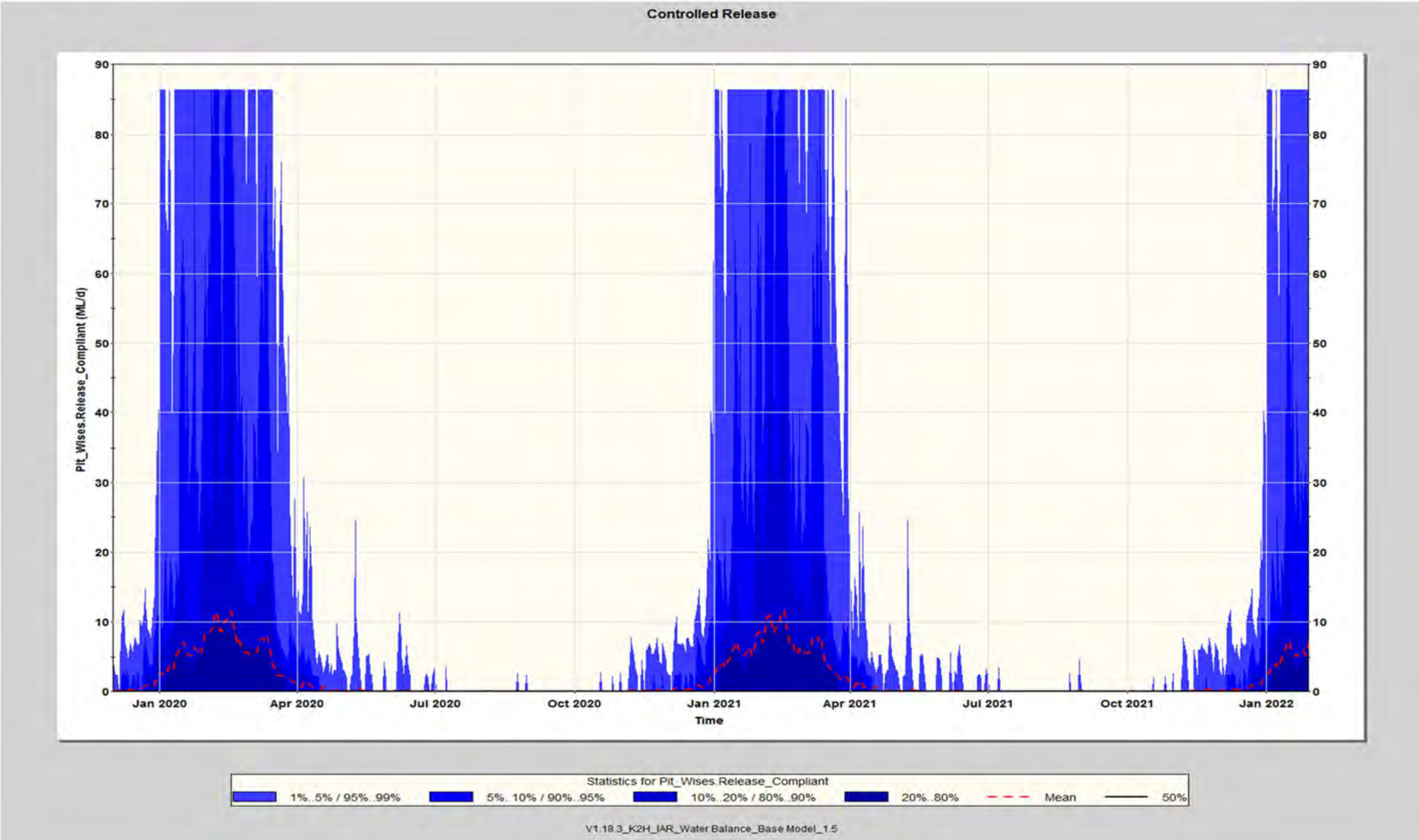


Figure 71 Temporal Distribution of Releases During the Construction Phase

7.4.2 Estimated Construction Post-Release Flushes

Table 99, Table 100 and Table 101 detail the estimated post release flush duration and volume at the proposed release point (mean release volume per event is also shown for context) on an annualised basis as well as per the wet and dry seasons. In summary:

- The estimated median post release flush is 28.9 days in duration and 1,676 ML (Table 99) at the proposed release point, compared to a median event release volume of 101ML.
- During the wet season (Table 100), the estimated median post release flush is 19.6 days in duration and 1,650 ML.
- Based upon the estimated median result, no release, and consequently no post release flush is expected during the dry season (Table 101).

Table 99 Construction Phase Post-Release Flush – Annual Statistics

Statistic	Mean Post Release Flush[23] Duration	Mean Post Release Flush Volume	Mean Volume Released per Event
	days	ML	ML
Mean	31.6	1,830	157
P5	15.9	921	19
P10	18.7	1,147	25
P20	22.7	1,318	41
P50	28.9	1,676	101
P80	39.6	2,229	248
P90	46.2	2,606	332
P95	53.9	3,399	550

[23] The post-release flush is the period of continued streamflow in the Copperfield River after a controlled release has ceased. The flush duration is taken from the time of release cessation to commencement of the next release or when flow in the Copperfield reaches zero; whichever is sooner.

Table 100 Construction Phase Post-Release Flush – Wet Season (November through April) Statistics

Statistic	Mean Post Release Flush[24] Duration	Mean Post Release Flush Volume	Mean Volume Released per Event
	days	ML	ML
Mean	20.8	1,667	166
P5	10.9	937	19
P10	13.2	1,091	26
P20	15.4	1,276	41
P50	19.6	1,650	107
P80	25.1	1,990	250
P90	29.2	2,279	374
P95	35.3	2,559	573

Table 101 Construction Phase Post-Release Flush – Dry Season (May through October) Statistics

Statistic	Mean Post Release Flush[25] Duration	Mean Post Release Flush Volume	Mean Volume Released per Event
	days	ML	ML
Mean	20.7	652.8	11
P5	-	-	-
P10	-	-	-
P20	-	-	-
P50	-	-	-
P80	43.4	1,021	16
P90	56.4	1,760	27
P95	86.4	2,899	44

Table 102, Table 103 and Table 104 show post-release flush ratios (the mean event release volume divided by the mean post-release flush volume) at the proposed release point as well as a number of locations downstream to Einasleigh.

[24] The post-release flush is the period of continued streamflow in the Copperfield River after a controlled release has ceased. The flush duration is taken from the time of release cessation to commencement of the next release or when flow in the Copperfield reaches zero; whichever is sooner.
[25] The post-release flush is the period of continued streamflow in the Copperfield River after a controlled release has ceased. The flush duration is taken from the time of release cessation to commencement of the next release or when flow in the Copperfield reaches zero; whichever is sooner.

From the tables it can be seen that the tributary inflows downstream of the proposed release point provide continual additional flow during the post-release flush period resulting in a continual reduction in the flush ratio with increasing distance downstream of the proposed release point. Figure 72 provides additional representation of the reduction flush ratio with increasing distance from the proposed release point. Flush ratios are generally seen to be higher during the wet season (Table 103) than the dry (Table 104). This is a function of the low frequency of dry season releases (0.7 per dry season, Table 98, P50 result). During the wet season, the number of releases is significantly higher (4.0, Table 97, P50 result) and predominantly occur within a relatively discrete period (Figure 71). Consequently, there is a greater likelihood that that the recessional flow contributing to the post release flush volume is curtailed by the commencement of another streamflow event and release. Conversely, during the dry season, the continuing recessional flow is less likely to be curtailed by another event.

Table 102 Construction Phase Post-Release Flush Ratios – Annual Statistics

Statistic	Proposed Release Point	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	%	%	%	%	%	%	%
Mean	7.4	6.0	5.4	4.1	3.7	3.4	1.2
P5	1.7	1.4	1.3	1.0	0.9	0.8	0.3
P10	2.0	1.6	1.5	1.1	1.0	0.9	0.3
P20	2.9	2.3	2.1	1.5	1.4	1.3	0.4
P50	5.6	4.6	4.1	3.1	2.8	2.6	0.9
P80	11.8	9.8	8.8	6.6	5.9	5.5	1.9
P90	15.1	12.5	10.9	8.2	7.3	6.8	2.4
P95	18.0	14.8	13.5	10.7	9.7	9.1	3.4

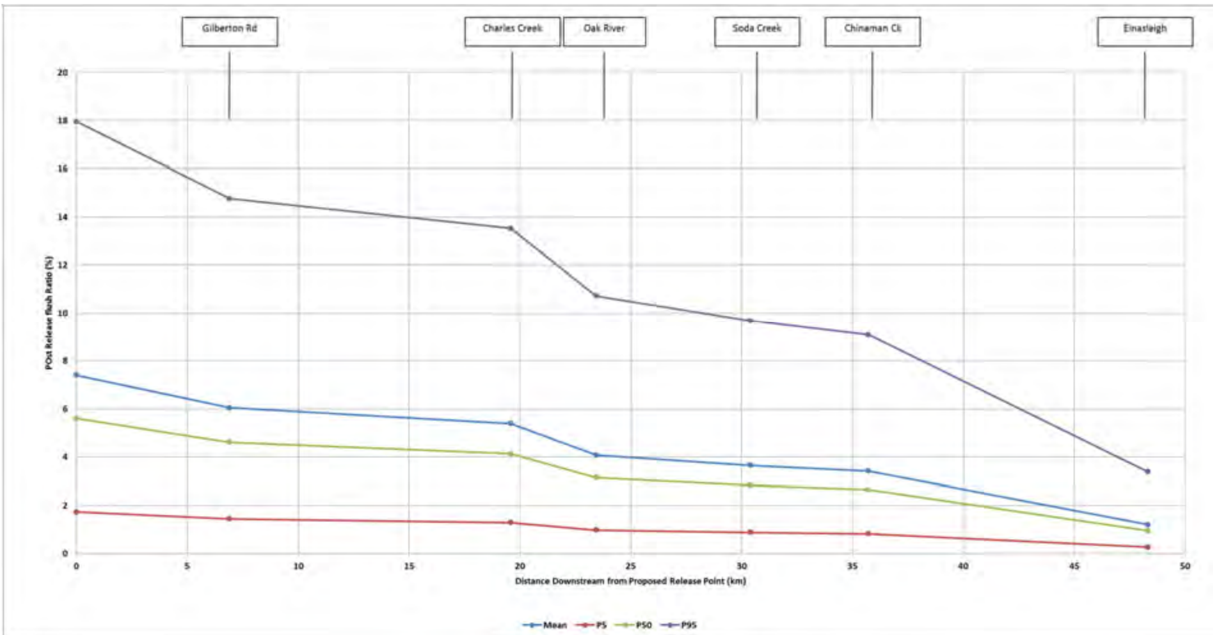


Figure 72 Construction Phase Post-Release Flush Ratios – Annual Results

Table 103 Construction Phase Post-Release Flush Ratios – Wet Season (Nov through April) Statistics

Statistic	Proposed Release Point	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	%	%	%	%	%	%	%
Mean	9.1	7.5	6.7	5.0	4.5	4.2	1.5
P5	1.7	1.4	1.3	1.0	0.9	0.8	0.3
P10	2.1	1.7	1.5	1.1	1.0	1.0	0.3
P20	3.0	2.4	2.1	1.6	1.4	1.3	0.5
P50	6.6	5.1	4.7	3.6	3.2	3.0	1.0
P80	13.6	11.0	9.9	7.4	6.6	6.2	2.0
P90	18.3	15.9	14.4	10.6	9.6	9.0	3.1
P95	27.8	23.3	20.8	15.7	14.3	13.4	5.0

Table 104 Construction Phase Post-Release Flush Ratios – Dry Season (June through October) Statistics

Statistic	Proposed Release Point	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	%	%	%	%	%	%	%
Mean	0.8	0.7	0.7	0.5	0.5	0.5	0.3
P5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P50	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P80	1.8	1.5	1.4	1.2	1.1	1.0	0.5
P90	2.5	2.1	1.9	1.5	1.4	1.3	0.7
P95	3.3	2.9	2.7	2.3	2.1	2.0	1.2

7.4.3 Conclusions of Hydrology Impact Assessment

Construction phase releases are proposed to utilise the same release conditions (including a release trigger of 400 ML/d) as operational phase releases. As shown previously in Section 6.3.3, this is unlikely to materially impact on the existing flow regime in terms of the timing, frequency, duration and magnitude of flows. Releases will coincide with naturally occurring streamflow events in the Copperfield River at the proposed release point and cease as streamflow recesses below the proposed 400 ML/d trigger. The use of the same dilution ratio (200 to 1) during the construction phase as the operational phase dilution ratio will result in a similar contaminant mass loading per release event. Possible stranding of releases in downstream pools and waterholes is however considered unlikely due to the significant post release flush volumes following each release event. In summary:

- By all measures assessed, estimated potential releases made during the dry season represent a minor proportion of the total release potential. For example, the median mean annual dry season release volume was estimated to be 0 ML compared to 400 ML for the wet season.
- The estimated median mean number of releases during the dry season was found to be 0, whereas the number of release events during the wet season was estimated to be 4.2 with a release duration of 8.3 days and a release volume of 107 ML.

- Post-release flushing was estimated from the proposed release point to Einasleigh in order to examine the effect of progressive tributary inflows on the post-release flush ratio. Ongoing tributary inflows downstream of the proposed release point provide significant additional flushing such that the median mean flush ratio of 5.6 % at the release point is reduced to 0.9 % by Einasleigh.
- Assessment of wet and dry season flush ratios indicates that flush ratios during the dry season are typically lower than during the wet season. This results from the greater number of releases occurring during the wet season and their tendency to occur within a relatively discrete period (Figure 71). Consequently, there is a greater likelihood that that the recessional flow contributing to the post release flush volume is curtailed by the commencement of another streamflow event and release. Conversely, during the dry season, the continuing recessional flow is less likely to be curtailed by another event.

7.5 Aquatic Ecology Impact Assessment

7.5.1 Water Quality

The Project proposes to undertake water releases to the Copperfield River during certain flow events as described in Section 4.7.1. Such releases have the potential to influence the quality of downstream waters as described in Section 4.4.1.4.

Targeted DTA assessments were conducted to determine the required mixing ratios to reduce the potential for environmental harm and ensure 95% species protection is achieved within the receiving environment during operational discharges. The DTA assessment has found that the potential for impacts to aquatic organisms is considered to be relatively low at the dilution ratios and release regimes proposed.

The DTA assessments showed that the dilution ratio to achieve a 95% species protection level ranged from 1:1 (the most likely case) to 9:1 (for a mixture of pit waters composed predominantly from Wises Pit water; i.e. worst case scenario). All proposed releases during both the construction phase of the Project exceed this minimum dilution.

The proposed controlled releases will only be undertaken during flow events within the receiving environment with a minimum flow trigger stipulated and the cessation of the release occurring prior to natural flows subsiding to allow for an additional flushing effect.

The proposed release ratio during the operational phase is 200:1, well above that required to achieve 95% species protection. Mixing zone modelling has indicated that the use of a diffused discharge outlet structure will facilitate near field mixing at the outlet such that the WQO for the contaminant of most concern (dissolved zinc) will be met within 625m for the range of scenarios and outlet configurations assessed (most modelled scenarios suggest a mixing zone of between 50 and 70 m downstream). There are no known permanent or semi-permanent pools within 625 m downstream of the release location which could provide refugia for aquatic ecology (refer to Section 5.14). There are no other known sensitive receptors within this mixing zone. All fish species found to be occurring within the Copperfield River display relatively broad tolerances to a wide range of water quality characteristics (refer to Section 3.12.6). However, the macroinvertebrate communities were comprised of families sensitive to environmental change. It is suggested that the adoption and application of appropriate release management strategies, as discussed above, will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values.

A REMP has been drafted (Section 5.2, and Appendix I) which will be developed to monitor the receiving environment for potential impacts from controlled releases. Further, the sensitivity of the macroinvertebrate community suggests it will be an ideal biological indicator for the future Project REMP.

7.5.2 Hydrology

The release of water has the potential to increase flow volumes experienced within the receiving environment. The contribution of flow during temporary construction releases is considered to be negligible with a release ratio of 200:1.

Assessment of the proposed release regime found that the maximum increase in daily flow volume (compared to natural flows) expected to occur was 1.18%, with mean and median annual flow increases estimated to be 0.44% and 0.88%, respectively. These increases are minor compared to natural variations that would be observed in the system from a year to year basis based on rainfall received.

Many of the fish species that occur in the Copperfield River migrate upstream during the wet season to spawn (refer to Section 3.12.6). Furthermore, macroinvertebrate communities are highly seasonal with water availability and stage in the flow cycle (especially in ephemeral tropical Australian watercourses) a defining factor on their community composition. The extension of flows and/or the permanency of water in the system will allow aquatic flora and fauna to utilise more of the watercourse for a longer period of time each year. Further, if the permanency of water is increased upstream of the Project site, new refuges for aquatic flora and fauna may be developed. This may allow fish to access further upstream (on the Copperfield River or associated tributaries) during subsequent flow events which will last up to an additional nine days. While, if this occurs, it would be considered a change in natural conditions it may not be considered an adverse impact. Note; fish passage will not be reduced by this minor increase in flow. As noted in Section 5.14, there are several identified semi-permanent pools within close proximity to the release location. The majority of waterholes found were minor remnant pools occurring in-channel. Only two substantial pools were noted downstream of the Project site (Pond 5 near W3 and the Sandy Creek site). These two pools have the potential to persist year round, providing refuge to aquatic fauna. The longevity of these pools would be highly correlated with the hydrology of the system on a yearly basis.

As the releases are to be managed to occur as event-based, no changes to key temporal indicators (timing, frequency and duration of flow events) are expected. While some minor increases to the rates of rise and fall are expected, they are not considered to be of sufficient magnitude to result in any adverse impacts to the aquatic ecology values of the system.

7.5.3 Erosion and Sedimentation

Releases have the potential to increase erosion and sedimentation through physical processes/forces. The method in which the water is released (i.e. spillway overtopping, open ended pipe, pump outlet, diffuser, etc.) and the rate can result in scouring of the immediate downstream area and subsequently cause sedimentation further downstream. Erosion and sedimentation processes are known to impact aquatic communities through smothering and the reduction of primary production (Wood & Armitage, 1997; Gleason *et al.*, 2003).

A diffuser will be employed for releases to ensure the mixing rate is maximised. Diffusers also reduce the potential for erosion to occur as a result of the release. As outlined in Section 4.1.2, design and construction of the operational phase outlet works has been identified for early works however, in the unlikely event that the works are not complete prior to this, initial releases during the construction phase may be via a simple outfall structure (incorporating relevant erosion and sedimentation control measures). The design of the release point and associated diffuser will be finalised during detailed design. However, conceptualisation through CORMIX modelling has shown that appropriate mixing can be achieved, and modelling suggests that the increased flow from the releases will not have any significant effect on the hydraulics of the natural system. Detailed design and construction will need to take into consideration the potential for erosion, and ensure that engineering solutions appropriately mitigate this impact to avoid downstream impacts.

The potential impacts to the downstream environment from increased erosion and sedimentation associated with the release point are expected to be minimal as construction of this component will be strictly limited to the dry season. During operation, impacts are anticipated to be restricted to the immediate area surrounding and downstream of the release point. Appropriate design and management of the diffuser will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values. Further, photographic monitoring of the release point over time will document and monitor the rate of erosion and deposition occurring at and downstream of the release point. On-going sediment quality monitoring will be undertaken at numerous locations as part of the REMP (refer to Section 9.2) in order to assess whether any impacts are occurring.

7.5.4 Development of the Release Point

The discharge release infrastructure design will consider the potential risk of scouring as a result of the construction discharges which may cause localised erosion resulting in increased sedimentation. This is particularly relevant to the first wet season discharges when a temporary outfall structure may be utilised (refer to Section 4.1.2). Stabilisation of banks where discharge is proposed may be necessary to minimise these impacts. This will be further considered during detailed design.

The construction of the release point can impact the aquatic ecology values of the receiving environment through various pathways, including:

- Clearing of riparian vegetation to allow access;
- Disturbing the substrate; and
- Spills of potential contaminants.

The major concerns associated with the construction activities are the increase in sedimentation and the potential for contaminants to enter the system. However, all of these pathways are feasibly easily mitigated against using best practice environmental management techniques. The main mitigation measures are proposed to be that:

- All spillway infrastructure construction works will be undertaken during the dry season when flows have subsided;
- Silt curtains (or other similar measure) will be employed for any remnant pools;
- All spills will be cleaned up immediately with any contaminated sediment removed; and
- The riparian zone will be rehabilitated through stabilisation once construction has been completed.

The potential impacts to the downstream environment from potential sedimentation and potential contaminants from construction activities are expected to be negligible and restricted to the immediate area surrounding the working area. Appropriately applied best practice environmental management practices will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values.

7.6 Fluvial Geomorphology Impact Assessment

Construction phase releases will be made at the same release ratio as the operational phase (0.5%) and therefore any potential changes to key hydraulic are expected to be similar to those presented in Section 6.5.1. As previously noted, the modelling showed negligible changes to the key drivers of channel shape and floodplain morphology (e.g. velocity, depth, shear stress and stream power). Results for flows with and without the proposed releases are noted be significantly lower than the DRNR 2014 guideline values for stream power, velocity and shear stress (Table 81) which is indicative of the broad channel and downstream of the proposed release location.

It is not therefore expected that proposed construction phase releases of water will result in any changes to sediment transport and loads or channel stability – baseline critical shear stress thresholds will not be exceeded more frequently, or for longer, than would otherwise have been the case for a ‘no release’ scenario.

Design and construction of the release infrastructure will consider the potential risk of scouring which may cause localised erosion resulting in increased sedimentation further downstream. This may increase the sediment coarse fraction, which may impact the downstream environment by affecting turbidity and potentially impacting aquatic communities as discussed in Section 7.5. According to Section 5.12, the coarse fraction does not exceed trigger values and appears not to have been significantly affected by historic mining activities.

Design and construction of the release infrastructure is planned as part of an early works programme. Should commissioning of the release infrastructure be delayed beyond the commencement of the construction phase the releases may be made via the proposed temporary outfall structure (Section 4.1.2). During this period visual inspections of the outlet structure and surrounds will be undertaken following each release until such time that the final diffuser structure is in place. Thereafter ongoing regular (quarterly) visual inspections will be undertaken. Sedimentation potential will be monitored through regular sediment monitoring. Further detail regarding monitoring is presented in Section 9.2.

7.7 Hydrogeology Impact Assessment

During construction the predictive groundwater modelling (Appendix H) indicates that the water levels in the Eldridge Pit will be at their lowest and that the pit will continue to act as a groundwater sink, reducing seepage migration risks to the north of the Project (and downstream in the Copperfield River). During construction the water discharged from the Project will contribute a maximum of 4.2% of the flow volume to the Copperfield River and only occur during medium and high flow events. The scale and timing of these discharges is therefore not expected to materially influence the groundwater regime. Further groundwater impact considerations are provided in Table 105 below.

Table 105 Potential Impacts of Project Water Discharges

Potential Impact	Construction
Impacts on water levels affecting GDEs and licensed groundwater users	None
Water quality alteration of groundwater resources (including alluvial groundwater)	Discharge of water into the Copperfield River is not expected to significantly influence groundwater quality (recharge during high flow events). It is anticipated that by the time that the flow in the Copperfield River has reached the trigger level required prior to discharges commencing that the stream alluvial beds have been largely saturated. The concentrations of key contaminants will be monitored during both construction and operational discharges as part of the additional monitoring. The post discharge flushing will aim to return the water quality in any standing water to baseline condition, monitoring will be undertaken to confirm the efficacy of the discharge flushing.
Change in groundwater flow, including throughflow impacting on down gradient users	Limited increased groundwater recharge during high flow (discharge) events
Water quality alteration of surface water resources	Potential for migration between former mine area and Copperfield River where a hydraulic connection between the fault system and river is present, impacting water quality in semi-permanent pools

As discussed in Section 5.11.8, it is considered that in the instance a hydraulic connection between the fault system and the river is present, there is potential for migration between the former mine area and the Copperfield River. In order to ensure that impacts are not occurring as a result of potential migration between the former mine area and the Copperfield River, ongoing water and sediment quality monitoring is proposed at the following semi-permanent waterhole locations (refer to Section 5.14 for detail regarding these waterholes):

- Pond 3 (approximately 1.4 km upstream of the proposed release location);
- Pond 5 (approximately 5.8 km downstream of the proposed release location).

Furthermore, potential impacts to groundwater will be assessed through ongoing monitoring at bores BA06 and BA07. Further detail regarding monitoring is presented in Section 9.2.

8.0 Risk Assessment

8.1 Methodology

The risk assessment methodology set out in (AS/NZS) ISO 31000:2009 *Risk Management – Principles and Guidelines* (2009) was adopted for this report. Criteria used to rank the likelihood and consequences of potential impacts and how they are combined to determine the level of impact are set out in Table 106 to Table 108 below.

The classifications (major, high, moderate, low or negligible) for significance of an impact are as follows:

- **Major** significance of impact - arises when an impact will potentially cause irreversible or widespread harm to an EV that is irreplaceable because of its uniqueness or rarity. Avoidance through appropriate design responses is the only effective mitigation.
- **High** significance of impact - occurs when the proposed activities are likely to exacerbate threatening processes affecting the intrinsic characteristics and structural elements of the EV. While replacement of unavoidable losses is possible, avoidance through appropriate design responses is preferred to preserve its intactness or conservation status.
- **Moderate** significance of impact - although reasonably resilient to change, the EV would be further degraded due to the scale of the impact or its susceptibility to further change. The abundance of the EV ensures it is adequately represented in the region, and that replacement, if required, is achievable.
- **Low** significance of impact - occurs where an EV is of local importance and temporary and transient changes will not adversely affect its viability provided standard environmental management controls are implemented.
- **Negligible** significance of impact - impact on the EV will not result in any noticeable change in its intrinsic value and hence the proposed activities will have negligible effect on its viability. This typically occurs where the activities occur in industrial or highly disturbed areas.

Table 106 Description of Sensitivity Criteria

Sensitivity	Description
High	• The EV is listed on a recognised or statutory state, national or international register as being of conservation significance. • The EV is intact and retains its intrinsic value. • The EV is unique to the environment in which it occurs. It is isolated to the affected system/area which is poorly represented in the region, territory, country or the world. • It has not been exposed to threatening processes, or they have not had a noticeable impact on the integrity of the EV. Project activities would have an adverse effect on the value.
Moderate	• The EV is recorded as being important at a regional level, and may have been nominated for listing on recognised or statutory registers. • The EV is in a moderate to good condition despite it being exposed to threatening processes. It retains many of its intrinsic characteristics and structural elements. • It is relatively well represented in the systems/areas in which it occurs but its abundance and distribution are limited by threatening processes. • Threatening processes have reduced its resilience to change. Consequently, changes resulting from project activities may lead to degradation of the prescribed value. • Replacement of unavoidable losses is possible due to its abundance and distribution.

Sensitivity	Description
Low	• The EV is not listed on any recognised or statutory register. It might be recognised locally by relevant suitably qualified experts or organisations e.g., historical societies. • It is in a poor to moderate condition as a result of threatening processes which have degraded its intrinsic value. • It is not unique or rare and numerous representative examples exist throughout the system / area. • It is abundant and widely distributed throughout the host systems / areas. • There is no detectable response to change or change does not result in further degradation of the EV. • The abundance and wide distribution of the EV ensures replacement of unavoidable losses is achievable.

Table 107 Description of Magnitude Criteria

Magnitude	Description
High	An impact that is widespread, long lasting and results in substantial and possibly irreversible change to the EV. Avoidance through appropriate design responses or the implementation of site-specific environmental management controls are required to address the impact.
Moderate	An impact that extends beyond the area of disturbance to the surrounding area but is contained within the region where the project is being developed. The impacts are short term and result in changes that can be ameliorated with specific environmental management controls.
Low	A localised impact that is temporary or short term and either unlikely to be detectable or could be effectively mitigated through standard environmental management controls.

Table 108 Significance Assessment Matrix

Magnitude of Impact	Sensitivity of Environmental Value		
	High	Moderate	Low
High	Major	High	Moderate
Moderate	High	Moderate	Low
Low	Moderate	Low	Negligible

8.2 Project Risk Assessment

Table 109 below summarises the potential pre-mitigation risks associated with the release of water at the proposed Copperfield River release location. As discussed in Section 4.0 above, the aquatic ecosystem EV is considered to be the most relevant in the case of the proposed Copperfield River release.

Table 109 Risk Assessment and Mitigation Measures

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
Changes in water quality								
Increased water temperature and reducing natural thermal variability	Aquatic ecosystems	The Copperfield River is an ephemeral waterway with high naturally occurring variability in water temperature. Temperatures during a single sampling campaign ranged from approximately 21°C to 25.7°C. Temperatures within the reservoirs are unlikely to change significantly and are therefore highly unlikely to exceed the natural variability in the receiving environment. As discharges are limited to flow periods in the Copperfield River, and only make up a relatively small proportion of the flows the change is likely to be negligible.	Moderate	Low	Low (2C)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Implementation of REMP. • Continuous real-time monitoring of flow and other physical parameters such as temperature, EC, pH, etc. in the receiving environment upstream and downstream of the proposed release location.	Low (2C)	• Adjustments would be made to the release ratio as required. • Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger. • Modification of the REMP.
Increased toxicant loads in Copperfield River due to construction releases resulting in adverse impacts to aquatic ecosystems.	Aquatic ecosystems	Far-field mass balance modelling has indicated that WQOs may be exceeded for dissolved zinc and total nitrogen during the construction phase. However at a dilution ratio of 200:1, the simulated releases are well in excess of the minimum dilution ratio determined through DTA (9:1) required to meet 95% species protection. This indicates that the proposed releases will not result in toxicity-related impacts to aquatic ecosystems.	Moderate	Moderate	Moderate (2B)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d. • Implementation of REMP,	Low (2C)	• Adjustments to the release ratio as required. • Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger. • Modification of the REMP. • Other adaptive management strategies such as those outlined in Section 9.3 will be implemented where monitoring indicates that an unacceptable post-mitigation impact may be occurring. This may require cessation of further discharges until additional controls can be
	Stock watering	The maximum mixed pit concentrations scenario identified that the cattle	Low	Low	Negligible (3C)		Negligible (3C)	

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
		drinking water WQOs will not be exceeded at the point of discharge, or further downstream.				including aquatic ecology monitoring to determine whether impacts may be occurring. • Appropriate design and management of the diffuser will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values from scour. Further, photographic monitoring of the release point over time will document and monitor the rate of erosion and deposition occurring at and downstream of the release point. •		effectively implemented
	Recreational	The WQO for total manganese is specific to the protection of the recreation EV. Modelling has shown that the WQO for total manganese will not be exceeded post-mixing in the receiving environment.	Low	Moderate	Low (3B)		Negligible (3C)	
	Irrigation	Impacts to short term and long term irrigation during the construction phase are not anticipated, as concentrations of relevant constituents post releases are modelled to be below the WQO at the release point and all downstream locations.	Low	Moderate	Low (3B)		Negligible (3C)	
	Drinking water	The WQOs for sulfate and total arsenic are specific to the protection of the drinking water EV (sulfate for aesthetics and arsenic for health). Modelling has shown that the WQO for these parameters will not be exceeded post-mixing in the receiving environment.	High	Low	Moderate (1C)		Low (2C)	
Increased toxicant loads in Copperfield River due to operational releases resulting in adverse impacts to aquatic ecosystems.	Aquatic ecosystems	Parameters relevant to the aquatic ecosystem EV are below the WQO at all locations, with the exception of total nitrogen and dissolved zinc. The concentration of total nitrogen is above the WQO at all modelled locations, partly due to the elevated baseline concentrations (also above the	Moderate	Moderate	Moderate (1C)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Verification that the releases	Low (2C)	• Adjustments to the release ratio as required. • Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger. • Modification of the REMP. • Other adaptive management

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
		WQO).. Under a worst case scenario, there may be rare and very minor exceedances of the default 95% species protection WQO for dissolved zinc from Charles Creek to Chinaman Creek. For the scenarios assessed, the 90% species protection WQO will not be exceeded at any location in the receiving environment. The mass balance assessment indicates that the HMTV will not be exceeded in either of the two semi-permanent pools (Pond 4 and Pond 5) located downstream of the release location, therefore impacts to these pools are therefore anticipated to be negligible. At a dilution ratio of 200:1, the simulated releases are well in excess of the minimum dilution ratio determined through DTA (9:1) required to meet 95% species protection. This indicates that the proposed releases will not result in toxicity-related impacts to aquatic ecosystems.				are supporting downstream WQOs can be undertaken by collection of water quality samples at the downstream monitoring location(s) downstream of the proposed release point during the release event to demonstrate that the sustainable load objective is being met and environmental outcomes achieved. • Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d. • Appropriate design and management of the diffuser will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values associated with scour. Further, photographic monitoring of the release point over time will document and monitor the rate of erosion and deposition occurring at and downstream of the release point. • Implementation of REMP.		strategies such as those outlined in Section 9.3 will be implemented where monitoring indicates that an unacceptable post-mitigation impact may be occurring.
	Stock watering	The worst case concentrations in the receiving environment based on maximum concentrations indicates that WQOs for stock watering will not be exceeded. It therefore concluded that the Project is unlikely to result in impacts to the stock watering EV during the operations period.	Low	Low	Negligible (3C)		Negligible (3C)	

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
	Recreational	Impacts to recreation during the operations phase are not anticipated, as concentrations of total manganese post releases are modelled to be below the relevant WQO for recreation at all downstream locations.	Moderate	Low	Low (2C)		Low (2C)	
	Irrigation	Impacts to short term and long term irrigation during the operations phase are not anticipated, as concentrations of relevant constituents post releases are modelled to be below the WQO at the release point and all downstream locations.	Low	Low	Negligible (3C)		Negligible (3C)	
	Drinking water	Impacts to drinking water during the operations phase are not anticipated, as concentrations of sulfate and total arsenic post releases are modelled to be below the relevant WQO for drinking water at all downstream locations.	High	Low	Moderate (1C)		Low (2C)	
Visual impact at Einasleigh Gorge, through precipitation of dissolved contaminants during construction.	Recreation	Visual aesthetics may be impaired by precipitation of minerals from release water at Einasleigh Gorge. Hydrogeochemical modelling of the predicted water quality at the Gorge suggests, however, that mineral precipitation is not expected beyond that already associated with the (pre-release) Copperfield River.	Low	Moderate	Low (3B)	• Verification that the releases are supporting downstream WQOs can be undertaken by collection of water quality samples at the downstream monitoring location(s) downstream of the proposed release point during the release event to demonstrate that the sustainable load objective is being met and environmental outcomes achieved. • Implementation of REMP.	Negligible (3C)	• Modification of the REMP. • Other adaptive management strategies such as those outlined in Section 9.3 will be implemented where monitoring indicates that an unacceptable post-mitigation impact may be occurring.
	Cultural and spiritual value		Low	Moderate	Low (3B)		Negligible (3C)	

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
Visual impact at Einasleigh Gorge, through precipitation of dissolved contaminants during operations.	Recreation	The median post-release flush ratio shows continual reduction as distance from the proposed release point increases such that by Einasleigh, the flush ratio has reduced from 3.5% at the proposed release point to 0.6%. For 95% of releases, the post release flush at Einasleigh is estimated to exceed 41 times the release volume. Hydrogeochemical modelling of precipitation of minerals from the water reaching Einasleigh indicates that precipitation is not expected beyond that already associated with the (pre-release) river water.	Low	Moderate	Low (3B)	• Verification that the releases are supporting downstream WQOs can be undertaken by collection of water quality samples at the downstream monitoring location(s) downstream of the proposed release point during the release event to demonstrate that the sustainable load objective is being met and environmental outcomes achieved. • Implementation of REMP.	Negligible (3C)	• Modification of the REMP. • Other adaptive management strategies such as those outlined in Section 9.3 will be implemented where monitoring indicates that an unacceptable post-mitigation impact may be occurring.
	Cultural and spiritual value		Low	Moderate	Low (3B)		Negligible (3C)	
Residual water quality changes following discharge events, pooling in Copperfield River during construction.	Aquatic ecosystems	The mass balance assessment indicates that the HMTV will not be exceeded in either of the two semi-permanent pools (Pond 4 and Pond 5) located downstream of the release location, therefore impacts to these pools are therefore anticipated to be negligible. Ongoing streamflow following cessation of each release (post-release flush) will provide the means to facilitate the ongoing dilution and down-system transport of released water. This will aid in ensuring that pooled water is representative of upstream quality. The median post-release flush ratio (ratio of volume released to volume of post-release flush) is estimated	Moderate	Moderate	Moderate (2B)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Verification that the releases are supporting downstream WQOs can be undertaken by collection of water quality samples at the downstream monitoring location(s) downstream of the proposed release point during the release event to demonstrate that the sustainable load objective is being met and environmental outcomes achieved.	Low (2C)	• Adjustments to the release ratio as required. • Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger. • Modification of the REMP. • Other adaptive management strategies such as those outlined in Section 9.3 will be implemented where monitoring indicates that an unacceptable post-mitigation impact may be occurring.

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
		to be 5.6% at the proposed release point. However, continued tributary inflows downstream of the release will progressively contribute additional dilutionary flow adding to the post-release flush volume. Consequently, the median flush ratio at Eldridge is estimated to reduce significantly to 0.9%. For 95% of releases, the post release flush at the proposed release point is estimated to exceed 29 times the release volume.				• Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d. • Implementation of REMP. •		
	Recreation	The WQO for total manganese is specific to the protection of the recreation EV. Modelling has shown that the WQO for total manganese will not be exceeded post-mixing in the receiving environment.	Low	Moderate	Low (3B)		Negligible (3C)	
Residual water quality changes following discharge events, pooling in Copperfield River during operations.	Aquatic ecosystems	The mass balance assessment indicates that the HMTV will not be exceeded in either of the two semi-permanent pools (Pond 4 and Pond 5) located downstream of the release location, therefore impacts to these pools are therefore anticipated to be negligible. The median post-release flush ratio (ratio of volume released to volume of post-release flush) is estimated to be 3.5% at the proposed release point i.e. a flush volume approximately 28 times the volume released. Continued tributary inflows downstream of the release will provide additional dilutionary	Moderate	High	High (2A)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Verification that the releases are supporting downstream WQOs can be undertaken by collection of water quality samples at the downstream monitoring location(s) downstream of the proposed release point during the release event to demonstrate that the sustainable load	Low (2C)	• Adjustments to the release ratio as required. • Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger. • Modification of the REMP. • Other adaptive management strategies such as those outlined in Section 9.3 will be implemented where monitoring indicates that an unacceptable post-mitigation impact may be occurring.

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
		inflow and progressively add to the post-release flush volume. Consequently, the median flush ratio at Eldridge is estimated to be 0.6%.				objective is being met and environmental outcomes achieved. • Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d. • Implementation of REMP.		
Accumulation of contaminants in sediment	Aquatic ecosystems	Low likelihood, given times of discharges being high flow / high energy events. Ongoing monitoring will be undertaken as part of the REMP. Any observed increases in contaminants in sediments will be managed accordingly.	Moderate	Low	Low (2C)	• Implementation of REMP.	Low (2C)	• Modification of the REMP. • Other adaptive management strategies such as those outlined in Section 9.3 will be implemented where monitoring indicates that an unacceptable post-mitigation impact may be occurring.
Water quality changes in Pit water as level in Eldridge Pit falls and exposes pit walls	Aquatic ecosystems Cultural and spiritual value	The wall wash study suggests that the deterioration in water quality is relatively minor.	Moderate	Low	Low (2C)	• Ongoing monitoring and additional testing (kinetic testing). • Pit water quality will be monitored and compositional trends will be assessed.	Low (2C)	• Modification of the REMP.
Changes in stream hydrology								
Alteration of flow regime leading to changing cues of flow sensitive species (e.g. for migration and spawning) - Construction	Aquatic ecosystems	The contribution of flow during the construction phase is expected to be the same as during operation (0.503%).. Temporary construction releases are unlikely to materially impact on the existing flow regime in terms of the timing, frequency, duration	Moderate	Low	Low (2C)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Releases can be gradually	Low (2C)	• Adjustments to the release ratio as required. • Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger. • Other adaptive management strategies such as those

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
		and magnitude of flows. Releases will coincide with naturally occurring streamflow events in the Copperfield River at the proposed release point and cease as streamflow recesses below the proposed 400 ML/d trigger.				reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d.		outlined in Section 9.3 will be implemented where monitoring indicates that an unacceptable post-mitigation impact may be occurring.
Alteration of flow regime leading to changing cues of flow sensitive species (e.g. for migration and spawning) - Operation	Aquatic ecosystems	Operational releases are unlikely to materially impact on the existing flow regime in terms of the timing, frequency, duration and magnitude of flows. Releases will coincide with naturally occurring streamflow events in the Copperfield River at the proposed release point and cease as streamflow recesses below the proposed 400 ML/d trigger.. The base-case hydraulic model confirmed that the release into the channel at a ratio of 200:1 does not have a significant impact on the hydraulic characteristics of the Copperfield River.	Low	Low	Negligible (3C)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d.	Negligible (3C)	• Adjustments to the release ratio as required. • Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger.
Biota with critical life history links to flow having insufficient time to complete life cycle in an altered flow regime - Construction	Aquatic ecosystems	Many of the fish species that occur in the Copperfield River migrate upstream during the wet season to spawn. Furthermore, macroinvertebrate communities are highly seasonal with water availability and stage in the flow cycle is a defining factor on their community composition. The extension of flows and/or the permanency of water in the system will allow	Moderate	Low	Low (2C)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is	Low (2C)	• Adjustments to the release ratio as required. • Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger.
Biota with critical life history links to flow having insufficient time to complete life cycle in an altered flow regime - Operation			Low	Low	Negligible (3C)		Negligible (3C)	

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
		aquatic flora and fauna to utilise more of the watercourse for a longer period of time each year.				approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d.		
Increased hydrological connectivity affecting migration of invasive species - Construction	Aquatic ecosystems	If the permanency of water is increased upstream of the Project site, new refuges for aquatic flora and fauna may be developed. This may allow fish to access further upstream (on the Copperfield River or associated tributaries) during subsequent flow events which will last up to an additional nine days. It is currently unclear if any permanent pools already exist and provide this ability at, or upstream of, the Project site. While, if this occurs, it would be considered a change in natural conditions it may not be considered an adverse impact. Fish passage will not be reduced by this minor increase in flow.	Moderate	Low	Low (2C)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d.	Low (2C)	• Adjustments to the release ratio as required. • Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger.
Increased hydrological connectivity affecting migration of invasive species - Operation			Low	Low	Negligible (3C)		Negligible (3C)	
Increased flow rates selecting against species which inhabit low flow areas of boundary layers - Construction	Aquatic ecosystems	As the releases are to be managed to occur as event-based, no changes to key temporal indicators (timing, frequency and duration of flow events) are expected. While some minor increases to the rates of rise and fall are expected, they are not considered to be of sufficient magnitude to result in any adverse impacts to the aquatic ecology values of the system.	Moderate	Low	Low (2C)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed	Low (2C)	• Adjustments to the release ratio as required. • Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger.
Increased flow rates selecting against species which inhabit low flow areas of boundary layers - Operation			Low	Low	Negligible (3C)		Negligible (3C)	

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
						release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d.		
Changes in stream hydraulics and geomorphology								
Increased flow rates leading to bank and/or bed erosion and subsequent reduction of habitat - Construction	Aquatic ecosystems	Releases have the potential to increase erosion and sedimentation through physical processes/forces. Modelling suggests that the increased flow from the releases will not have any significant effect on the hydraulics of the natural system. The potential impacts to the downstream environment from increased erosion and sedimentation associated with the release point are expected to be minimal as construction of this component will be strictly limited to the dry season. During operation, impacts are anticipated to be restricted to the immediate area surrounding and downstream of the release point.	Moderate	Low	Low (2C)	• Detailed design and construction will need to take into consideration the potential for erosion, and ensure that engineering solutions appropriately mitigate this impact to avoid downstream impacts. • A diffuser will be employed for all releases (except in the event that commissioning of the release infrastructure is delayed) to ensure the mixing rate is maximised. Diffusers also reduce the potential for erosion to occur as a result of the release. • Photographic monitoring of the release point over time will document and monitor the rate of erosion and deposition occurring at and downstream of the release point. Until such time as a permanent diffuser is in place, visual inspections of the release point will be undertaken following each release to ensure that no adverse geomorphological impacts are occurring.	Low (2C)	• Other adaptive management strategies such as those outlined in Section 9.3 will be implemented where monitoring indicates that an unacceptable post-mitigation impact may be occurring.
Increased flow rates leading to bank and/or bed erosion and subsequent reduction of habitat - Operation			Moderate	Low	Low (2C)		Low (2C)	

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
Increased water levels leading to waterlogging of fringing and riparian vegetation that provide habitat for biota	Aquatic ecosystems	The proposed release ratio of 0.5% has a negligible impact on the hydraulic characteristics of the channel, with a maximum change in water depth of 0.35%.	Moderate	Low	Low (2C)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d.	Low (2C)	• Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger.
Increased flow rates leading to bank and/or bed erosion and subsequent reduction of habitat			Moderate	Low	Low (2C)		Low (2C)	
Increased flow altering the suspended particle size distribution, which could affect light penetration and subsequently affect productivity in the water body	Aquatic ecosystems	The proposed release ratio of 0.5% has a negligible impact on the hydraulic characteristics of the channel, with a maximum increase to channel velocity of 0.31%.	Moderate	Low	Low (2C)	• The location of the actual release point will be confirmed during detailed design. • Key criteria for site selection will include not only consideration of geomorphic stability but additional factors such as riparian vegetation, constructability, accessibility (construction and operation) and the Kidston cultural heritage area.	Low (2C)	• Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger.

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
Changes in hydrogeology								
Potential discharges to the Copperfield River affecting groundwater regime (including alluvial groundwater)	Aquatic ecosystems Farm water supply Stock watering Cultural and spiritual value	The Pit is understood to continue to function as a groundwater 'sink', during both construction and operation. The water discharged from the Project (during both construction and operations) will contribute a maximum of 0.5% additional flow volume to the Copperfield River and only occur during medium and high flow events. The scale and timing of these discharges is therefore not expected to materially influence the groundwater regime	Moderate	Low	Low (2C)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d. • The concentrations of key contaminants will be monitored during both construction and operational discharges as part of the additional monitoring. The post discharge flushing will aim to return the water quality in any standing water to baseline condition, monitoring will be undertaken to confirm the efficacy of the discharge flushing.	Low (2C)	• Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger.

This page has been left blank intentionally.

Step 4 – Circumstances, Limits and Monitoring Conditions

9.0 Release Criteria and Monitoring

9.1 Summary of Proposed Release Criteria

The proposed controlled release of water from the Project is governed by the availability of a release opportunity in the Copperfield River at the proposed release point; the amount of water released is dependent on the release ratio and discharge capacity. Table 110 summarises the key proposed release criteria that is required.

Table 110 Proposed Project Release Criteria

Aspect	Construction	Operations	Comment
Controlled Release Triggers	400 ML/d	400 ML/d	No releases into receiving environment when flows are equalled or less than 400 ML/d.
Dilution Ratio	200 to 1	200 to 1	
Release Ratio	0.5%	0.5%	Operational release ratio is based on a 69% utilisation of the available assimilative capacity for the contaminant of most concern, dissolved zinc which results in an effective total dilution ratio of 200:1. During construction, the utilisation of available assimilative capacity may increase to 76% due to the higher concentration of dissolved zone in the Eldridge Pit.
Maximum controlled release capacity	86.4 ML/d (1.0 m^3/s)	86.4 ML/d (1.0 m^3/s)	

It is important to note that the proposed release ratio (i.e. the ratio of the release flow to the receiving flow) is dependent on assumptions regarding:

- Concentration of the contaminant of most concern in the potential release water;
- Concentration of the contaminant of most concern in the receiving environment; and
- Adopted utilisation of the available assimilative capacity for the contaminant of most concern.

However, real time monitoring in the receiving environment and the Eldridge and Wises Pits for some key contaminants such as metalloids is not practical. Potential changes to the concentration of contaminants in either the release water or the receiving environment can influence the effective assimilative capacity utilisation. The proposed release ratio of 0.5% for the operational phase of the Project has been based on:

- A conservatively high release concentration of 1.5874 mg/L for dissolved zinc (based on the maximum values observed in the Wises and Eldridge Pits)
- A median (monitoring point W2) receiving environment concentration of 0.0025 mg/L for dissolved zinc
- A conservative adoption of a 69% utilisation of the dissolved zinc available assimilative capacity; and
- Maintenance of the same release ratio (0.5%) during the construction phase may result in a slightly greater use of the available assimilative capacity (76%) when water is released solely from the Eldridge pit where the observed maximum concentration of dissolved zine is 1.75 mg/L.

Consequently, at the proposed release ratio of 0.5%, these assumptions provide additional contingency to allow for possible increases to either the receiving environment or release concentrations releases to continue to meet the dissolved zinc HMTV.

Referring to Figure 73 and Figure 74 below:

- Sufficient contingency exists within the proposed release criteria (specifically a 69% utilisation of the available dissolved zinc assimilative capacity) that releases made at the proposed release ratio of 0.503% will continue to meet the total dissolved zinc HMTV up to:
  - A receiving environment concentration of 0.00613 mg/L. This represents a more than doubling of the concentration when compared to the median W2 concentration of 0.0025 mg/L (Figure 73); or
  - An end of pipe release concertation of 2.3 mg/L. This represents a potential increase of approximately 45% compared to the assumed concentration of 1.5874 mg/L (Figure 74).

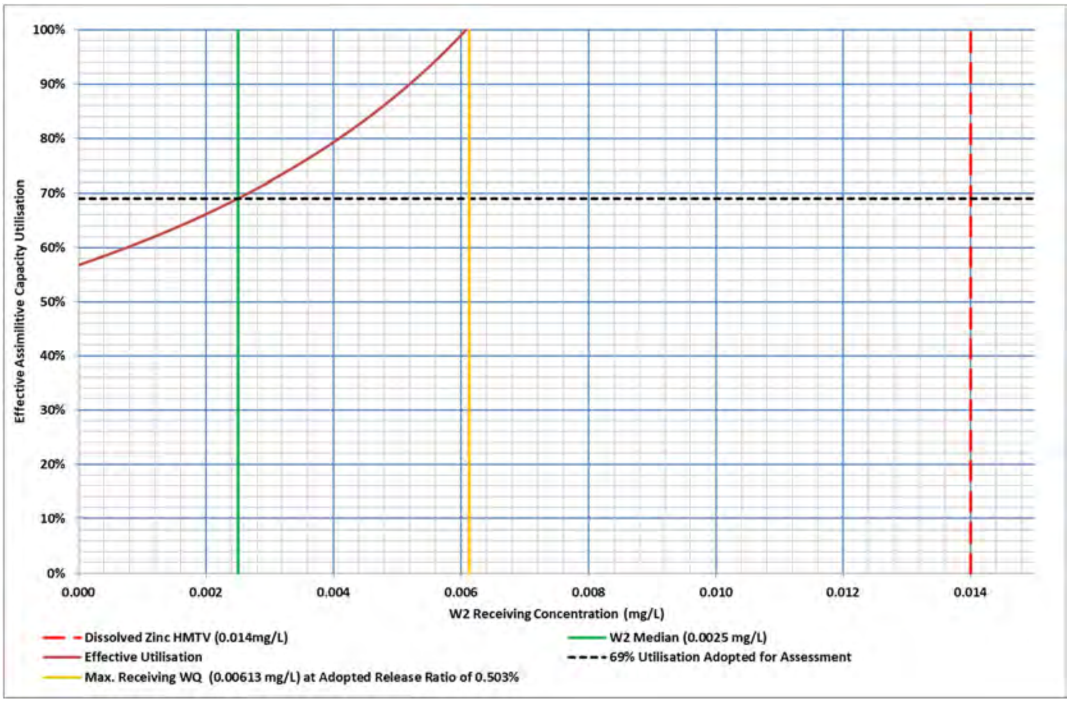


Figure 73 Effective Utilisation of Dissolved Zinc Assimilative Capacity Utilisation with Changing Receiving Environment Concentration (0.503% Release Ratio)

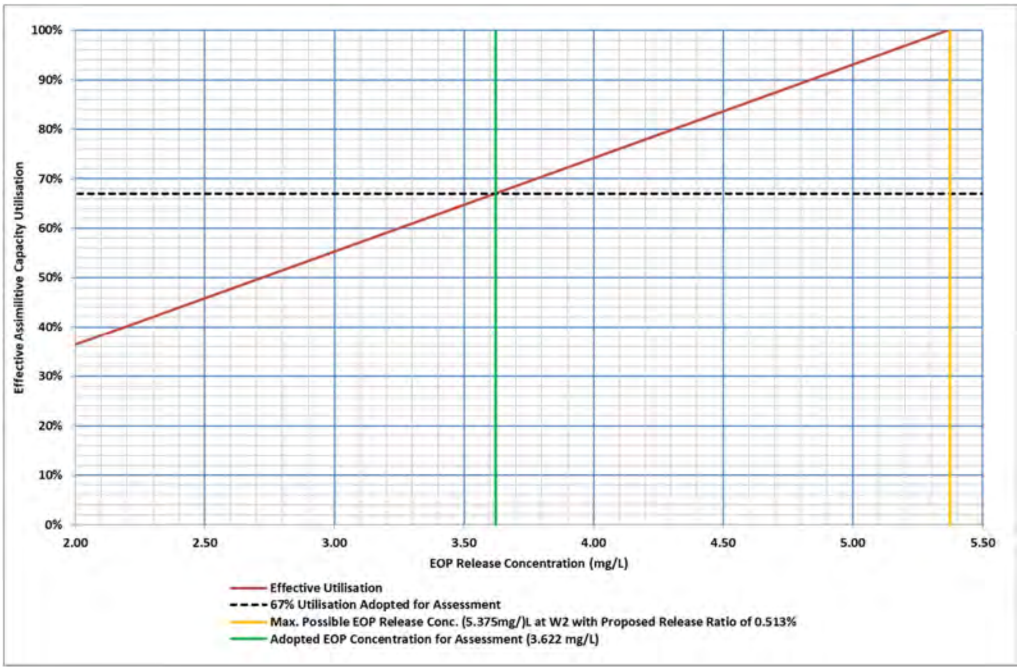


Figure 74 Effective Utilisation of Dissolved Zinc Assimilative Capacity Utilisation with Changing EOP Release Concentration (0.503% Release Ratio)

Ongoing monitoring of both water in the pits and the receiving environment will be used to inform the release ratio. Dynamic adjustment of the release ratio during release events is not practical or intended. The proposed release conditions have been based on conservative, maximum values for dissolved zinc and as long as ongoing monitoring continues to indicate that current concentrations are lower than this, the proposed release conditions will result in significantly less utilisation of the available assimilative capacity. In the event that monitoring indicates that concentrations of key contaminants in the pits significantly increase to the point that exceedance of the maximum values used to determine the proposed release ratio is likely, the release ratio can be adjusted (prior to a release) to ensure utilisation of available assimilative capacity is maintained at an appropriate level.

9.1.1 Approach to Releases

Definition of the proposed release operation is subject to ongoing refinement through detailed design however an indicative approach of the proposed release strategy would likely include the following key steps:

1. Continuous real-time monitoring of flow and other physical parameters such as temperature, electrical conductivity, pH, etc. in the receiving environment upstream and downstream of the proposed release location.
2. Continuous monitoring of flow in Copperfield River upstream of the proposed release location will provide an indication of when the proposed flow release trigger of 400 ML/d has been exceeded and a potential release opportunity is available.
3. The maximum release rate can be determined by multiplying the upstream monitored flow rate by the release ratio and could be adjusted based on real time data from the upstream stream gauge.
4. Verification that the releases are supporting downstream WQOs can be undertaken by collection of water quality samples at the downstream monitoring location(s) downstream of the proposed release point during the release event to demonstrate that the sustainable load objective is being met and environmental outcomes achieved.
5. Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d.
6. On the basis of ongoing monitoring of the receiving environment, water in the pits and collection of samples during release events, adjustments would be made to the release ratio as required.

9.2 Monitoring

A draft REMP for the Project has been prepared (refer to Appendix I) and will be finalised following the approvals process. The following types of monitoring are proposed:

1. Surface water quality
2. Sediment
3. Biological
4. Flow; and
5. Groundwater quality and level.

An overview of the monitoring program for the Project, including monitoring locations and frequencies is presented in Table 111 and Figure 75.

The monitoring set out below will be supplemented with existing monitoring programs currently being undertaken for the mine site (for example, groundwater monitoring). In addition, should commissioning of the release infrastructure be delayed, the temporary release location infrastructure will be monitored visually for signs of erosion and channel/bank scouring following each release, until the final diffuser structure is in place. Thereafter, visual inspections should be undertaken quarterly. Photographic monitoring of the release point over time will document and monitor the rate of erosion and deposition occurring at and downstream of the release point. Inspections will look for signs of:

- Localised changes to channel bed and stream bank morphology such as undercutting, slumping or rotation
- localised changes, loss or damage to riparian vegetation
- Localised downstream sedimentation visible through the development of new lateral depositional features
- Notable changes to instream water clarity (turbidity) immediately downstream of the release point.

Notable damage to any hydraulic structures In the instance that signs of erosion or sedimentation are noted the following would be undertaken:

- Record, report and assess for severity and determine any requirement for mitigation.
- If required, suitable measures including (but not limited to) placement of appropriately dimensioned hard rock material, gabions, etc. could be employed to prevent further worsening.
- Issues not requiring immediate action will be subject to additional monitoring to determine the rate of, or potential for, ongoing propagation and any requirement for future mitigation (noting that the dynamic nature of bed material transport is to some extent, a natural part of fluvial process at the proposed release point).

Table 111 Overview of Receiving Environment Monitoring Program

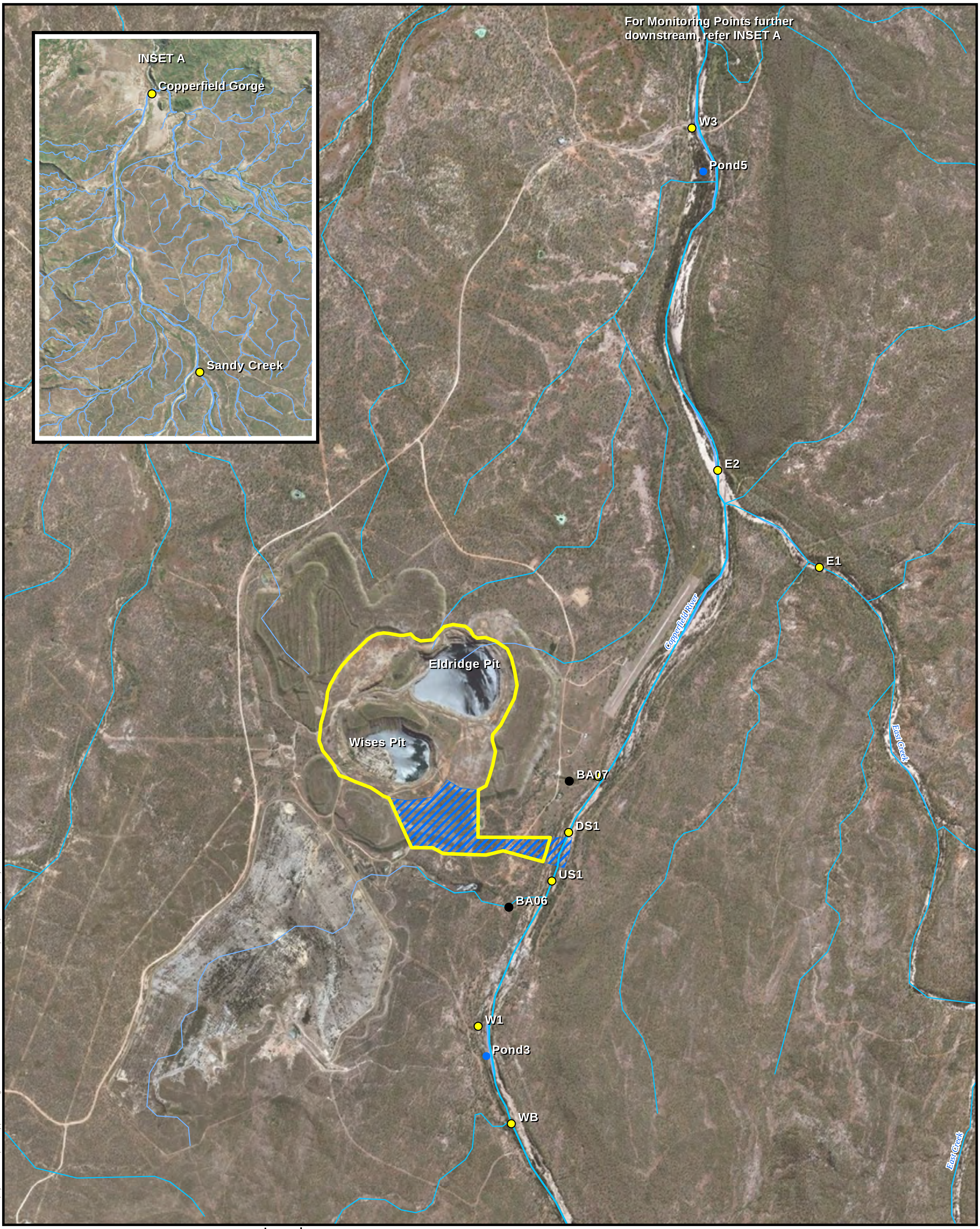
Group	Site	Easting	Northing	Description	Monitoring Frequency			
					Water Quality	Sediment Quality	Biological	Flow
Regional Monitoring – Background Sites	WB	201087	7907273	Upstream of all influences on the Copperfield River	**Baseline Monitoring** • Within 1 week of the commencement of flow • Monthly thereafter for as long as water persists	**Initial Sediment Study** • Dry Season 2019 • 5x replicates from each site **Thereafter** • 3x replicates from each site[2] • At the end of the Wet Season after releases have ceased	• At least six weeks after flows recede to <1000 ML/d towards the end of the wet season (March – May) • Early wet season sampling if possible (i.e. 6 weeks following flows receding to <1000ML/d) typically during November – February	N/A
	Pond 3	200868	7907862	Pool situated 1.4km upstream				
	E1	203774	7912124	East Creek upstream of the confluence with the Copperfield River				
Regional Monitoring – Impact Sites	W1	200799	7908133	Downstream of the Tailings Storage Facility on the Copperfield River	**Baseline Monitoring** • Within 1 week of the commencement of flow • Monthly thereafter for as long as water persists **During Releases** • Within the first 24 hours of the commencement of release • Every 3 days thereafter until seven days after the release ceases	**Initial Sediment Study** • Dry Season 2019 • 5x replicates from each site **Thereafter** • 3x replicates from each site[2] • At the end of the Wet Season after releases have ceased	• At least six weeks after flows recede to <1000 ML/d towards the end of the wet season (March – May) • Early wet season sampling if possible (i.e. 6 weeks following flows receding to <1000ML/d) typically during November – February	N/A
	W2	201851	7910299	Downstream of Manager's Creek Dam on the Copperfield River				
	W3	202667	7915973	At the causeway entrance to the Kidston Project on the Copperfield River. Most downstream monitoring point.				
	E2	202887	7912971	East Creek downstream of the confluence with the Copperfield River			N/A	
	Pond 5	202761	7915578	Pool situated 7.0km downstream		N/A	N/A	
	Copperfield River at the confluence with Sandy Creek (waterhole)	197509	7929897	Pool situated 20km downstream		N/A	• At least six weeks after flows recede to <1000 ML/d towards the end of the wet season (March – May) • Early wet season sampling if possible (i.e. 6 weeks following flows receding to <1000ML/d) typically during November – February	
	CG1	TBA[1]	TBA[1]	Copperfield Gorge		**Initial Sediment Study** • Dry Season 2019 • 5x replicates from each site **Thereafter** • 3x replicates from each site[2] At the end of the Wet Season after releases have ceased	N/A	

Group	Site	Easting	Northing	Description	Monitoring Frequency			
					Water Quality	**Sediment Quality**	**Biological**	**Flow**
Near-field monitoring - Mixing Zone	US1	TBA[#]	TBA[#]	Immediately upstream of release location	**Baseline Monitoring** • Within 1 week of the commencement of flow • Monthly thereafter for as long as water persists **During Releases** • Within the first 24 hours of the commencement of release • Every 3 days thereafter until seven days after the release ceases	**Initial Sediment Study** • Dry Season 2019 • 5x replicates from each site **Thereafter** • 3x replicates from each site[2] • At the end of the Wet Season after releases have ceased	N/A	Continuous
	DS1	TBA[#]	TBA[#]	Immediately downstream of mixing zone for releases from the K2H Project			N/A	Continuous
Release Water	Eldridge Pit	TBA[#]	TBA[#]	Eldridge Pit at the Ramp	**Baseline Monitoring** • Monthly for the first 24 months of Operation • Quarterly thereafter	N/A	N/A	N/A
	Wises Pit	TBA[#]	TBA[#]	Wises Pit at the Ramp				N/A
	Release Water	TBA[#]	TBA[#]	Sample of waters at the Release Point into the Copperfield River	• Within 24 hours of commencement of release • Every day thereafter while releases are occurring.			N/A
Groundwater Monitoring	BA06	201067	7909160	6.0m deep well installed in river loam and sand.	**Construction Phase** • Monthly **Operational Phase** • Quarterly	N/A	N/A	**WATER LEVEL:** **Construction Phase** • Monthly **Operational Phase** • Monthly
	BA07	201595	7910262	5.0m deep well installed in river loam and sand.				

[1] The most suitable location for monitoring at the Copperfield Gorge to be defined prior to the first release. Location is to be suitable for access in wet-weather events and suitable for water quality monitoring. NOTE: the sediment monitoring location may be different than the water quality sampling location as it would be ideal to capture sediment just upstream of the gorge in the dry river bed

[#] Location to be determined after installation of appropriate infrastructure.

[2] The initial sediment study is to determine whether replicates are required at each site for ongoing monitoring.



AECOM
www.aecom.com

N

DATUM GDA 1994, PROJECTION MGA ZONE 56

0 250 500 1,000
metres

1:30,000 (when printed at A3)

Legend

- Groundwater Bore
- Monitoring Point
- Pond
- Watercourse - Major
- Watercourse - Minor
- Key Project Infrastructure Footprint
- Spillway Options Corridor

KIDSTON PUMPED STORAGE HYDRO PROJECT
IMPACT ASSESSMENT REPORT

REMP Monitoring Points

PROJECT ID	60544566
CREATED BY	RF
LAST MODIFIED	FraserR2I - 11 Jan 2019
VERSION:	2

Figure
75

Filename: P:\605X\60544566\4. Tech Work Area\4.99 GIS\04_Outgoing\20190108_RF_K2H_MPs\20190108_RF_K2H_MPs.mxd

A3 size

9.3 Adaptive Mitigation Strategies

A number of strategies have been identified to provide further mitigation strategies. These strategies are adaptive in their nature and can be applied if found to be necessary based on feedback from the downstream monitoring programme outlined in the REMP (Appendix I). Each strategy is discussed below:

9.3.1 Extending the Flushing Period through Asymmetrical Release Triggers

The use of asymmetrical release triggers has the potential to increase the duration and volume of the post release flushing. By increasing the receiving flow rate trigger at which releases stop potential release events are curtailed at an earlier point in the flow event's recessional flow period thus extending the post-release flush. This is illustrated in Figure 76 which employs a cease to release trigger of 700 ML/d as an example. An advantage of this strategy is the potential for seasonal variability such that the cease to release trigger could be altered near the end of the wet season to ensure that any residual water remaining in the system during the dryer month benefits from further flushing. This mitigation measure would only be required if the monitoring undertaken as part of the proposed release program identifies that the flushing that is currently proposed is shown to be insufficient to adequately flush construction releases.

9.3.2 Extended Flushing using Releases from the Copperfield Dam

A controlled release of water from the Copperfield Dam could provide a means of diluting, flushing and assisting in the downstream movement of water contained within the pools and waterholes downstream of the proposed release point. Possible causative scenarios could be:

- Unexpectedly rapid flow recession leading to insufficient flushing; or
- Insufficient mixing of flush water through downstream waterholes and pools.

In the instance that monitoring identifies potential stranding of released water then a release of water from the Copperfield Dam could be employed to assist in the dilution and downstream movement of water by extending the natural flushing of the Copperfield River.

9.3.3 Cessation of Releases during the Dry Season

Complete cessation of releases during the dry season or a defined period within the dry season could be utilised as a measure to exclude the potential for stranding of released water in downstream pools and waterholes. This mitigation measure would only be required if the monitoring undertaken as part of the proposed release program identifies that the flushing that is currently proposed is shown to be insufficient to flush construction water releases during the dry season.

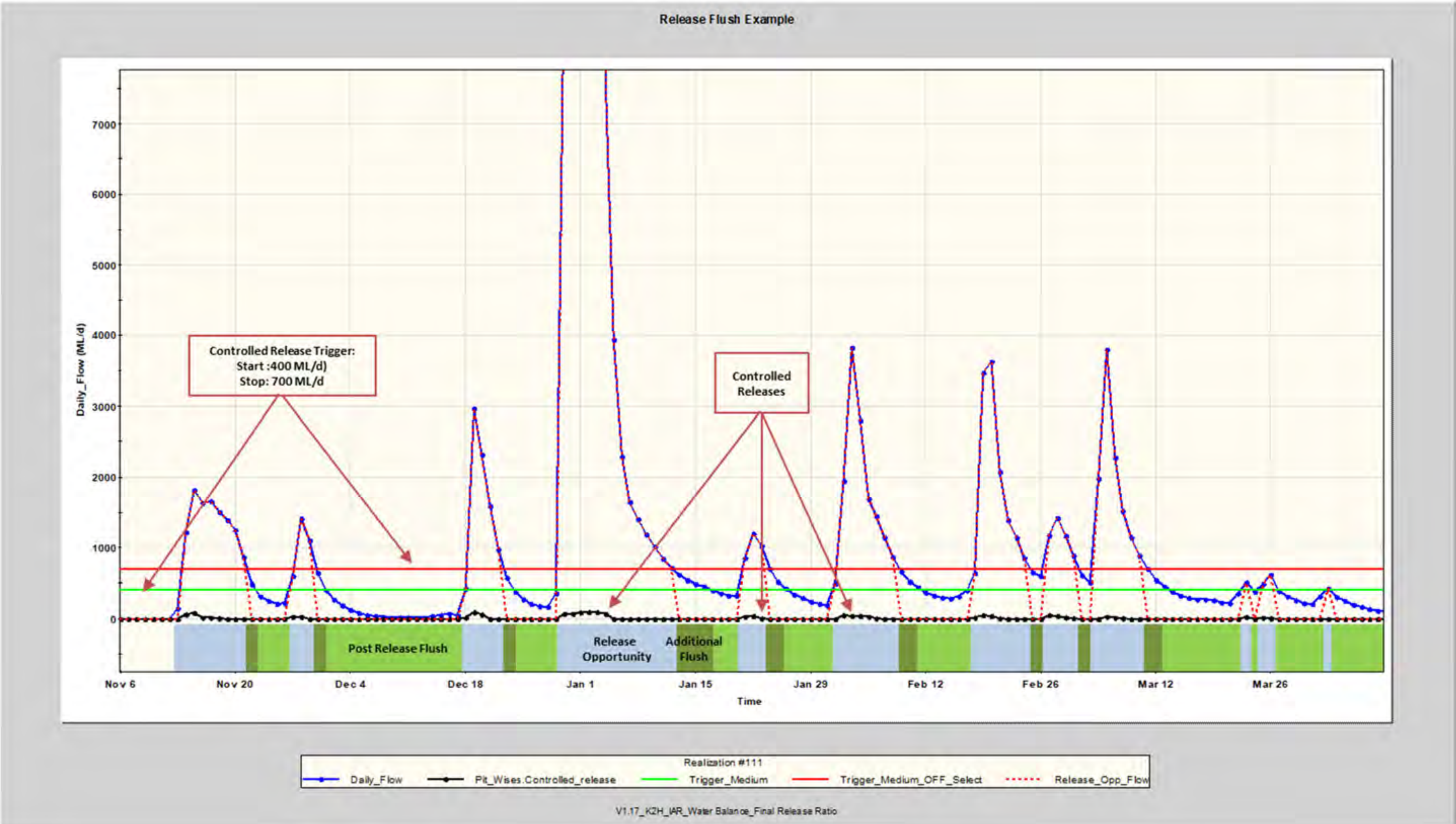


Figure 76 Example of Controlled Releases and Post-Release Flushes with use of Asymmetrical Release Triggers

10.0 Summary

Operational Releases

The operational releases will continue to be required throughout the life of the Project and the development of appropriate discharge limits has been used as a primary mitigation measure to ensure that environmental impacts are appropriately minimised. For operational releases, it is proposed that a maximum of 69% of the assimilative capacity of the receiving environment be utilised (this equates to an effective dilution ratio of 200 parts receiving environment to one part release water). By limiting the use of assimilative capacity to 69%, this allows for preservation of a portion of the capacity for future development. The assumptions behind calculating effective dilution ratios are highly conservative (based on maximum pit water qualities). In reality the actual assimilative capacity usage will be lower than 69% in most cases.

A comprehensive assessment has been undertaken to develop an understanding of the potential impacts of operational releases on the EVs of the receiving environment including potential impacts on water quality, hydrology, geomorphology, hydrogeology and ecology of the receiving environment. Key findings are summarised below.

Water Quality Impacts for Operational Releases

An assessment of near-field and far-field water quality modelling and DTA results indicates no significant adverse impacts to EVs relevant to the Project area resulting from operational releases. This is evidenced by the following:

- Parameters relevant to the aquatic ecosystem EV are below the WQO at all locations, with the exception of total nitrogen and dissolved zinc.
- Proposed releases are subject to initial mixing within the near field and predicted water quality within the mixing zone reaches the HMTV for dissolved zinc (the constituent of most concern), within a maximum (worst-case) distance of 625 m. Other modelled scenarios indicate a much smaller mixing zone of between 50 and 70 m downstream.
- The concentration of total nitrogen is modelled to drop below the WQO by Einasleigh. Nitrogen does not have many toxicological impacts on aquatic organisms; rather it is a nuisance nutrient that promotes algal growth. It is noted however that there is no evidence of algal growth currently and phosphorus concentrations (required to trigger algal growth) in the Copperfield River are low.
- Under a worst case scenario, there may be rare and very minor exceedances of the default 95% species protection WQO for dissolved zinc from Charles Creek to Chinaman Creek (95 concentrations). In addition, the exceedances are within the likely margin of error of the various methods used in the assessment. For the scenarios assessed, the 90% species protection WQO will not be exceeded at any location in the receiving environment.
- The mass balance assessment indicates that the HMTV will not be exceeded in either of the two semi-permanent pools (Pond 4 and Pond 5) located downstream of the release location, therefore impacts to these pools are therefore anticipated to be negligible.
- During the operations phase, the simulated releases are well in excess (200:1) of the minimum dilution ratio for toxicity-related impacts in the receiving environment (9:1).
- Concentrations of parameters relevant to other EVs are all modelled to be below the specified WQO.

Hydrology Impacts for Operational Releases

As a result of the proposed release of water from the Project, some minor changes are expected to the magnitude of flows that are a direct result of the additional water added during releases. The magnitude of the increases is however small and is not expected to be of material impact to the existing flow regime.

Due to the event-based nature of the proposed releases, no changes to key temporal indicators (timing, frequency and duration of flow events) were noted as a result of the proposed releases. Some minor increases to the rates of rise and fall were noted; however, they are not considered to be of sufficient magnitude to result in any adverse impacts.

Confirming that sufficient streamflow continues in the Copperfield River after cessation of any potential releases is required to ensure that potential releases continue to move downstream, are subject to ongoing dilutionary inflows and do not become stranded due to natural streamflow recession. The median duration of each post release flush at the proposed release point is 32 days with a volume of 1,758 ML.

Aquatic Ecology Impacts for Operational Releases

It is suggested that the adoption and application of appropriate release management strategies for operational releases will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values for the following reasons:

- The proposed controlled releases will only be undertaken during flow events within the receiving environment with a minimum flow trigger stipulated and the cessation of the release occurring prior to natural flows subsiding to allow for an additional flushing effect.
- The proposed release ratio during the operational phase is 200:1, well above that required to achieve 95% species protection determined through DTA.
- Mixing zone modelling has indicated that the use of a diffused discharge outlet structure will facilitate near field mixing at the outlet such that the WQO for the contaminant of most concern (dissolved zinc) will be met within 625m for the range of scenarios and outlet configurations assessed (most modelled scenarios suggest a mixing zone of between 50 and 70 m downstream).
- All fish species found to be occurring within the Copperfield River display relatively broad tolerances to a wide range of water quality characteristics, however, the macroinvertebrate communities were comprised of families sensitive to environmental change.
- As the releases are to be managed to occur as event-based, no changes to key temporal indicators (timing, frequency and duration of flow events) are expected. While some minor increases to the rates of rise and fall are expected, they are not considered to be of sufficient magnitude to result in any adverse impacts to the aquatic ecology values of the system. Fish passage will not be reduced by the minor increases in flow.
- The potential impacts to the downstream environment from increased erosion and sedimentation during the operation are anticipated to be restricted to the immediate area surrounding and downstream of the release point. Appropriate design and management of the diffuser will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values.

Hydraulics and Fluvial Geomorphology Impacts for Operational Releases

The base-case hydraulic model confirmed that the release into the channel at a ratio of 200:1 does not have a significant impact on the hydraulic characteristics of the Copperfield River. Minor increases to main channel depth of up to 0.01m were predicted, however this did not alter the overall water surface elevation for the river reach. The velocity for the high flow events did not change, and minor increases of 2% were noted in the medium flow scenario. With shear stress values increasing by only minor values (less than 2%) for the 'with releases' scenario, there is unlikely to be any increase in sediment transport as a result of Project releases.

Hydrogeology Impacts for Operational Releases

During the operational phase of the Project, the predictive groundwater modelling indicates that the Eldridge Pit will continue to act as a groundwater sink, reducing seepage migration risks to the north of the Project (and downstream in the Copperfield River). During operations the water discharged from the Project will contribute a maximum of 0.5% additional flow volume to the Copperfield River and only occur during medium and high flow events. The scale and timing of these discharges is therefore not expected to materially influence the groundwater regime.

Temporary Construction Releases

Temporary construction releases are anticipated to be required for a duration of approximately 2.15 years. For temporary construction releases, it is proposed that a maximum of 76.3% of the assimilative capacity of the receiving environment be utilised (this equates to an effective dilution ratio of 200 parts receiving environment to one part release water from the Eldridge Pit). By limiting the use of assimilative capacity to 76.3%, this allows for preservation of a portion of the capacity for future development. The assumptions behind calculating effective dilution ratios are highly conservative (based on the maximum pit water quality for Eldridge Pit). In reality the actual assimilative capacity usage will be lower than 76.3% in most cases.

A comprehensive assessment has been undertaken to develop an understanding of the potential impacts of temporary construction releases on the EVs of the receiving environment including potential impacts on water quality, hydrology, geomorphology, hydrogeology and ecology of the receiving environment. Key findings are summarised below.

Water Quality Impacts for Temporary Construction Releases

An assessment of far-field water quality modelling and DTA results indicates that any impacts occurring as a result of construction releases are temporary and reversible. This is evidenced by the following:

- Parameters relevant to the aquatic ecosystem EV are below WQOs at all locations, with the exception of total nitrogen and dissolved zinc. Concentrations of parameters relevant to other EVs are all modelled to be below the specified WQO.
- Under a worst case scenario, there may be rare and very minor exceedances of the default 95% species protection WQO for dissolved zinc from Charles Creek to Chinaman Creek. Given that these exceedances represent a ‘maximum’ modelled value, the likelihood of these concentrations being released is very low. In addition, the exceedances are within the likely margin of error of the various methods used in the assessment. For the scenarios assessed, the 90% species protection WQO will not be exceeded at any of the modelled location in the receiving environment.
- The mass balance assessment indicates that the HMTV will not be exceeded in either of the two semi-permanent pools (Pond 4 and Pond 5) located downstream of the release location, therefore impacts to these pools are therefore anticipated to be negligible.
- During the construction phase, the simulated releases are well in excess (200:1) of the minimum dilution ratio for toxicity-related impacts in the receiving environment (9:1).

Hydrology Impacts for Temporary Construction Releases.

Construction phase releases are proposed to utilise the same release conditions (including a release trigger of 400 ML/d) as operational phase releases. This is unlikely to materially impact on the existing flow regime in terms of the timing, frequency, duration and magnitude of flows. Releases will coincide with naturally occurring streamflow events in the Copperfield River at the proposed release point and cease as streamflow recesses below the proposed 400 ML/d trigger. The use of the same dilution ratio (200 to 1) during the construction phase as the operational phase dilution ratio will result in a similar contaminant mass loading per release event. Possible stranding of releases in downstream pools and waterholes is however considered unlikely due to the significant post release flush volumes following each release event.

Ongoing tributary inflows downstream of the proposed release point provide significant additional flushing such that the median mean flush ratio of 5.6 % at the release point is reduced to 0.9 % by Einasleigh.

Aquatic Ecology Impacts for Temporary Construction Releases

It is suggested that the adoption and application of appropriate release management strategies for temporary construction releases will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values for the following reasons:

- The proposed controlled releases will only be undertaken during flow events within the receiving environment with a minimum flow trigger stipulated and the cessation of the release occurring prior to natural flows subsiding to allow for an additional flushing effect.
- The proposed release ratio during the operational phase is 200:1, well above that required to achieve 95% species protection determined through DTA.
- Mixing zone modelling has indicated that the use of a diffused discharge outlet structure will facilitate near field mixing at the outlet such that the WQO for the contaminant of most concern (dissolved zinc) will be met within 625m for the range of scenarios and outlet configurations assessed (most modelled scenarios suggest a mixing zone of between 50 and 70 m downstream).
- All fish species found to be occurring within the Copperfield River display relatively broad tolerances to a wide range of water quality characteristics, however, the macroinvertebrate communities were comprised of families sensitive to environmental change.
- As the releases are to be managed to occur as event-based, no changes to key temporal indicators (timing, frequency and duration of flow events) are expected. While some minor increases to the rates of rise and fall are expected, they are not considered to be of sufficient magnitude to result in any adverse impacts to the aquatic ecology values of the system. Fish passage will not be reduced by the minor increases in flow.
- The potential impacts to the downstream environment from increased erosion and sedimentation during the construction phase are anticipated to be restricted to the immediate area surrounding and downstream of the release point. This is particularly relevant to the first wet season discharges when a temporary outfall structure may be utilised for a short period of time. Stabilisation of banks where discharge is proposed may be necessary to minimise these impacts. This will be further considered during detailed design.

Hydraulics and Fluvial Geomorphology Impacts for Temporary Construction Releases

The base-case hydraulic model confirmed that the release into the channel at a ratio of 200:1 does not have a significant impact on the hydraulic characteristics of the Copperfield River. Minor increases to main channel depth of up to 0.01m were predicted, however this did not alter the overall water surface elevation for the river reach. The velocity for the high flow events did not change, and minor increases of 2% were noted in the medium flow scenario. With shear stress values increasing by only minor values (less than 2%) for the ‘with releases’ scenario, there is unlikely to be any increase in sediment transport as a result of Project releases.

The discharge release infrastructure design will consider the potential risk of scouring as a result of the construction discharges which may cause localised erosion resulting in increased sedimentation. This may increase the sediment coarse fraction, which may impact the downstream environment by affecting turbidity. In order to ensure that erosion and scouring impacts are not occurring as a result of temporary construction releases, it is proposed that visual inspections of the outlet structure and surrounds are undertaken at appropriate times during the construction of the Project.

Hydrogeology Impacts for Temporary Construction Releases

During the construction phase of the Project, the predictive groundwater modelling indicates that the Eldridge Pit will continue to act as a groundwater sink, reducing seepage migration risks to the north of the Project (and downstream in the Copperfield River). During construction, the water discharged from the Project will contribute a maximum of 0.5% additional flow volume to the Copperfield River and only occur during medium and high flow events. The scale and timing of these discharges is therefore not expected to materially influence the groundwater regime.

Hydrogeology Impacts for Temporary Construction Releases

During construction the predictive groundwater modelling indicates that the water levels in the Eldridge Pit will be at their lowest and that the pit will continue to act as a groundwater sink, reducing seepage migration risks to the north of the Project (and downstream in the Copperfield River). During construction the water discharged from the Project will contribute a maximum of 4.2% of the flow volume to the Copperfield River and only occur during medium and high flow events. The scale and timing of these discharges is therefore not expected to materially influence the groundwater regime.

Conclusions

This impact assessment has investigated the implications of the Project on the identified receiving environment receptors (e.g., ecosystems, hydrology etc.). The assessment has been largely desktop-based, with some supplementary testing and analysis completed, and as such is subject to limitations of the largely historical database. In addition, model outcomes are determined by the assumptions made, which are based on the information available.

The assessment first determined a set of WQOs, supported by the DTA, with which to design the modelled operational and temporary construction releases. These models were used to simulate the likely Project regimes. Available information was used to assess the impacts of the Project regimes on the receptors.

Outcomes of the assessment indicate that operational releases are likely to result in relatively low impacts on the receptors in the receiving environment. During temporary construction releases, some impacts are predicted; however, these are expected to be temporary and reversible.

A Project REMP will be developed and implemented as part of the Project (refer to draft REMP contained in Appendix I). The Project REMP includes monitoring of water quality, sediment, biology and stream flow. The main objectives of the Project REMP are to verify assumptions presented in this assessment and report against relevant WQOs in order to monitor whether impacts to the receiving environment and associated EVs are potentially occurring and if further refinement of the release program is required to achieve acceptable environmental outcomes.

11.0 References

DNRM. (2014). *Guideline: Works that interfere with water in a watercourse—watercourse diversions.* QLD Department of Natural Resources and Mines.

ACARP . (2015, March 31). *Using Science to Determine Optimal Mine Water Management Practices.* Retrieved March 26, 2018, from Australian Coal Association Research Program: https://www.acarp.com.au/Media/ACARPMatters_31_C21043.pdf

AECOM Australia. (21 December 2017). *Surface Water Technical Report.* Brisbane: AECOM Australia.

ANZECC. (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.* Australian and New Zealand Environment and Conservation Council (ANZECC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ).

Association, A. N. (date not stated). *ANGFA Aquatic Survey Database*. Retrieved July 7, 2018, from http://db.angfa.org.au/index.php?option=search

Australasian Groundwater & Enviornmental Consultants, Gilbert & Associates, Dobos & Associates. (2001). *Kidston Gold Mine - Eldridge Pit Final Void Hydrology.* Kidston Gold Mines Limited.

Baker, L., & Walden, D. (1984). *Acute Toxicity of Copper and Zinc to Three Fish Species from the Alligator Rivers Region.* Canberra: Australian Government Publishing Service.

Barrick Australia. (2013). *Receiving Environment Monitoring Program .* Barrick Australia.

Bishop, K. A., Allen, S. A., Pollard, D. A., & Cook, M. G. (2001). *Ecological studies on the freshwater fishes of the Alligator Rivers Region, Northern Territory: Austecology.* Darwin: Supervising Scientist Report 145, Supervising Scientist.

CGQ. (2015). *Etheridge Shire.* Queensland Places - Centre for the Government of Queensland, University of Queensland.

Claus, S., Dunlop, J., & Ramsay, I. (2017). *Using Monitoring Data to Assess Groundwater Quality and Potential Environmental Impacts.* Brisbane, Queensland: Department of Science, Information Technology and Innovation.

DEHP. (2016). *Manual for assessing consequence categories and hydraulioc performance of structures.*

Departmnet of Resources Energy and Tourism. (2008). *Leading Practice Sustianable Development Program for the Mining Industry: Cyanide Management.* Canberra.

Doneker, R. L., & Jirka, G. H. (2017). *CORMIX User Manual.* MixZon Inc.

Dunlop, J. E., Mann, R. M., Hobbs, D., Smith, R., Nanjappa, V., Vardy, S., et al. (2016). Considering Background Ionic Proportions in the Development of Sulfate Guidlines for the Fitzroy River Basin. *Australasian Bulletin of Ecotoxicology & Environmental Chemistry, Volume 3*, 1-10.

Dunlop, J., Hobbs, D., Mann, R., Nanjappa, V., Smith, R., & Vink, S. (2011). *ACARP Project C18033 - Development of Ecosystem Protection Trigger Values for Sodium Sulphate in Seasonally Flowing Streams of the Fitzroy River Basin.* Australian Coal Association Research Program.

Dunlop, J., McGregor, G., & Horrigan, N. (2005). *Characterisation of impoacts and a discussion of regional target setting for riverine ecosystems in Queensland .* Brisbane: State of Queensland.

EHP. (09 June 2015). *Receiving Environment Monitoring Program Guideline.* EM1260 Version 2.00.

EHP. (12 September 2016). *Technical Guideline - Wastewater Release to Queensland Waters.* ESR/2015/1654 Version 2.00.

EHP. (2013). *Queensland Water Quality Guidelines.* Environment Policy and Planning, Department of Environment and Heritage Protection.

EHP. (2016). *Technical Guideline - Wastewater Release to Queensland Waters.* ESR/2015/1654 Version 2.00.

Einasleigh Progress Association . (2018). *Easter @ Einasleigh: Program*. Retrieved May 10, 2018, from Easter @ Einasleigh: http://easter.einasleigh.com.au/p/program-of-events.html

Entura. (2016). *Kidston PSP Bankable Feasibility Report - Water Quality and Dewatering Report - ENTURA-C4030.*

Entura. (2016). *Kidston Pumped Storage Project Bankable Feasbility Study - Hydological Report.*

Fischenich, C. (2001). *Stability Thresholds for Stream Restoration Materials.*

Genex Power. (2015). *Receiving Environment Monitoring Program.* Genex Power.

GHD. (2014). *Mt Todd Discharge - Surface Water Report.* GHD for Vista Gold Australia Pty Ltd.

Harford, A. J., & van Dam, R. A. (date not specified). *Ecotoxicological assessments of discharge waters from Cosmo Howley, Pine Creek, Tom's Gully and Brocks Creek Project Areas.* Environmental Research Institute of the Supervising Scientist.

Harford, A. J., Trenfield, M. A., Cheng, K. L., & van Dam, R. A. (2014). *Ecotoxicological assessment of manganese.* Australian Government Department of the Supervising Scientist.

Hickey, C. (2002, September 30). Nitrate Guideline Values in ANZECC 2000.

Hydrobiology. (2012). *Sulphate Trigger Value for MRM Mine.* Brisbane, Queensland: Hydrobiology Pty Ltd.

Hydro-Electric Corporation. (2018). *Investigating Tasmania's pumped hydro potential*. Retrieved 06 2018, from Hydro Tasmania: https://www.hydro.com.au/clean-energy/battery-of-the-nation/pumped-hydro

Jolly, I., Taylor, A. R., Rassam, D., Knight, J., Davies, P., & Harrington, G. (2013). *Surface Water - Groundwater Connectivity: A technical report to the Australian Government from teh CSIRO Flinders and Gilbert Agricultural Resource Assessment, part of hte Northern Queensland Irrigated Agriculture Strategy.* Australia: CSIRO Waer for a Healthy Country and Sustainable Agriculture Flagships.

Kidston Gold Mine. (8 January 2014). *Transitional Environmental Program - Kidston Gold Mine - Surface Water Discharge to Copperfield River.*

Lead, J. R., & Wilkinson, K. J. (2006). Aquatic Colloids and Nanoparticles: Current Knowledge and Future Trends. *Environ. Chem. Volume 3*, 159-171.

McConnell Dowel - John Holland JV. (2018). *Kidston Pumped Storage Project ECI Design Water Management.*

McGregor, G., Marshall, J., & Takahashi, E. (2011). Stream ecosystem health response to coal seam gas water release: Guidelines for managing flow regimes. *Brisbane: Queensland Department of Natural Resources and Mines.*

Metago Environmental Engineers. (2008). *Kidston Mine Project - Closure Planning - Pit Lake Hydrogeological Appraisal.* Perth, Western Australia.

Moreno, P., Aral, H., & Vecchio-Sadus, A. (2009). Environmental Impact and Toxicology of Sulphate. *Enviromine.* Santiago, Chile: Universidad Diego Portales and CSIRO Minerals.

Murray Darling Basin Authority. (2009). *Native Fish Strategy: Fish Factsheet: Hyrtl's Tandan.* Canberra: Murray Darling Basin Authority.

Nanson, C. G., Jones, G. B., Price, M. D., & Pietsch, J. T. (2005). Rivers turned to rock: Late Quaternary alluvial induration influencing the behaviour and morphology of an anabranching river in the Australian monsoon tropics. *Geomorphology*, 398-420.

NOAA. (2008). *Screening Quick Reference Tables*. Retrieved 2018, from SQuiRT Cards: https://response.restoration.noaa.gov/environmental-restoration/environmental-assessment-tools/squirt-cards.html

Norconsult. (2018). *Kidston Pumped Storage Project ECI Design - water Management.*

Pain, C., Gregory, L., Wilson, P., & McKenzie, N. (2011). *The Physiographic Regions of Australia.* ACLEP - Australian Collaborative Land Evaluation Program .

Petheram, C., Watson, I., & Stone, P. (2013). *Agricultural Resource Assessment for the Gilbert Catchment - A report to the Australian Government from the CSIRO Flinders and Gilbert Agricultural Resource Assessment part of the North Queensland Irrigated Agriculture Strategy.* Australia: CSIRO Water for a Healthy Country and Sustinable Agriculture Flagships.

Pusey, B., Kennard, M. J., & Arthington, A. (2004). *Freshwater Fishes of North-Eastern Australia.* Collingwood: CSIRO Publishing.

Reinier, M. M., Vink, S., Micevska, T., Hobbs, D., & Smith, R. E. (2014). Are Variatinos in Ionic Proportions Important for the Derivation of Trigger Values for Saline Mine Discharge Waters. *Australasian Bulletin of Ecotoxicology & Environmental Chemistry, Volume 1*, 1-11.

Riethmuller, N. (2000). *The effect of true water hardness and alkalinity on the toxicity of Cu and U to two tropical Australian freshwater organisms.* Northern Territory University.

Simpson, S. L., Graeme, B. E., & Chariton, A. A. (2013). *Revision of the ANZECC/ARMCANZ Sediment Quality Guidelines.* CSIRO Water for a Healthy Country.

Tait, J. (1998). *Einasleigh Water Resource Development Proposal Ecological Issues.* Townsville: Australian Centre for Tropical Freshwater Research - James Cook University.

Tait, J., Rizvi, S., & Waller, N. (2015). *Northern Gulf Inland waters Regional NRM Assessment.* Northern Gulf Resource Management Group.

Tappin, A. (2013, May). *Melanotaenia splendida subsp. inornata*. Retrieved July 4, 2018, from Rainbowfish: http://rainbowfish.angfaqld.org.au/Inornata.htm

Tomkiins, K. (2013). *Estimated sediment infilling rates for dams in northern Australia based on a review of previous literature.* Canberra, ACT: CSIRO Land and Water.

Tomkins, K. (2013). *Estimated sediment infilling rates for dams in Northern Australia based on a review of previous literature.* Canberra: CSIRO Flinders and Gilbert Agricultural Resource Assessment.

Torres, A. (n.d.). *Fishbase*. Retrieved July 7, 2018, from Mogurnda mogurnda (Richardson, 1844): https://www.fishbase.de/summary/22759

van Dam, R., Harford, A., Lunn, S., & Gagnon, M. (2014). Identifying the Cause of Toxicity of a Saline Mine Water. *PLoS One, V9(9)*.

Water Quality and Investigation, Department of Environment and Science. (2018). *Monitoring and Sampling Manual - Environmental Protection (Water) Policy 2009.* Queensland Government.

Wood, P.J. & Armitage, P.D. (1997). Biological Effects of Fine Sediment in the Lotic Environment. *Environmental Management,* **21(2):** 203-217.

12.0 Standard Limitations

AECOM has prepared this Report in accordance with the usual care and thoroughness of the consulting profession for the use of Genex Power Ltd and is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this Report.

This Report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This Report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

The development and use of the GoldSim water balance model utilised for this assessment has included information that has been provided to AECOM by third parties. Where this data has been utilised, AECOM has made no independent verification of this information except as expressly stated in the Report. AECOM assumes no liability for any inaccuracies in or omissions to that information.

Model results are based on historical climate data (SILO Data Drill) obtained from the Qld Department of Environment and Science. While this data is derived from the Bureau of Meteorology's weather station network, the algorithms used to produce a data Drill are occasionally revised which may result in minor changes to future Data Drills derived for the same location.

Modelling of the Project has been based on a number of simplified operational rules dictating operations such as when releases or topups of water from the Copperfield dam can be made. These rules are subject to ongoing refinement as the Project progresses through detailed design and subsequent operation.

To the extent permitted by law, AECOM expressly disclaims and excludes liability for any loss, damage, cost or expenses suffered by any third party relating to or resulting from the use of, or reliance on, any information contained in this Report. AECOM does not admit that any action, liability or claim may exist or be available to any third party. It is the responsibility of third parties to independently make inquiries or seek advice in relation to their particular requirements and proposed use of the site.

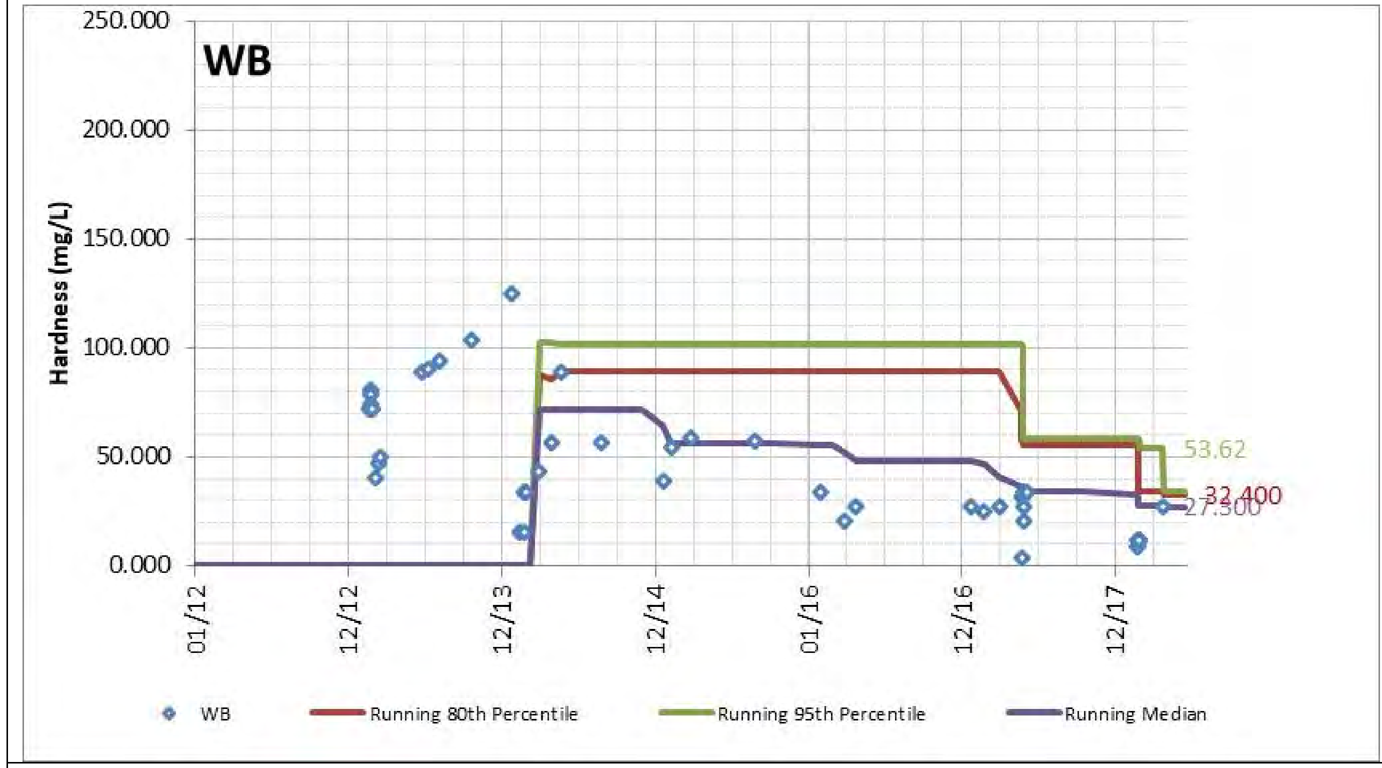
Any estimates of potential costs which have been provided are presented as estimates only as at the date of the Report. Any cost estimates that have been provided may therefore vary from actual costs at the time of expenditure.

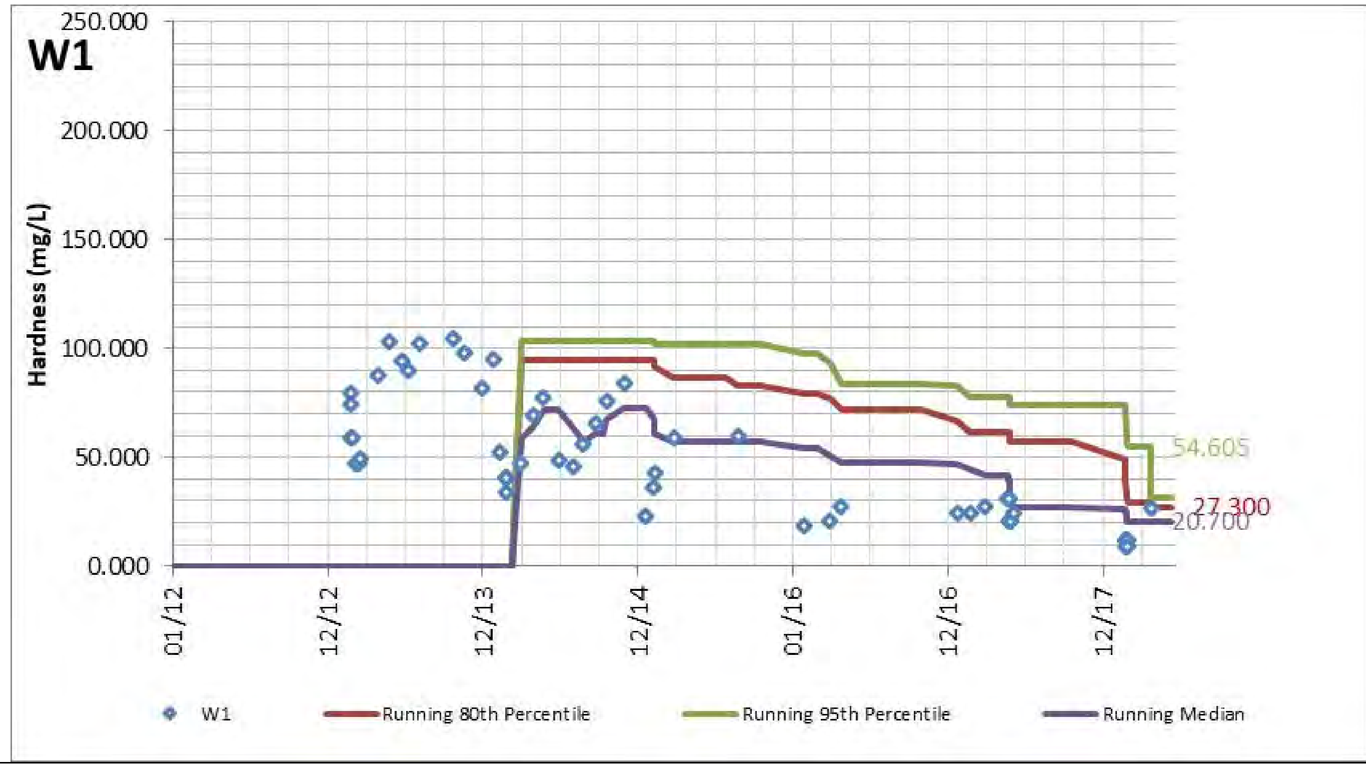
Appendix A

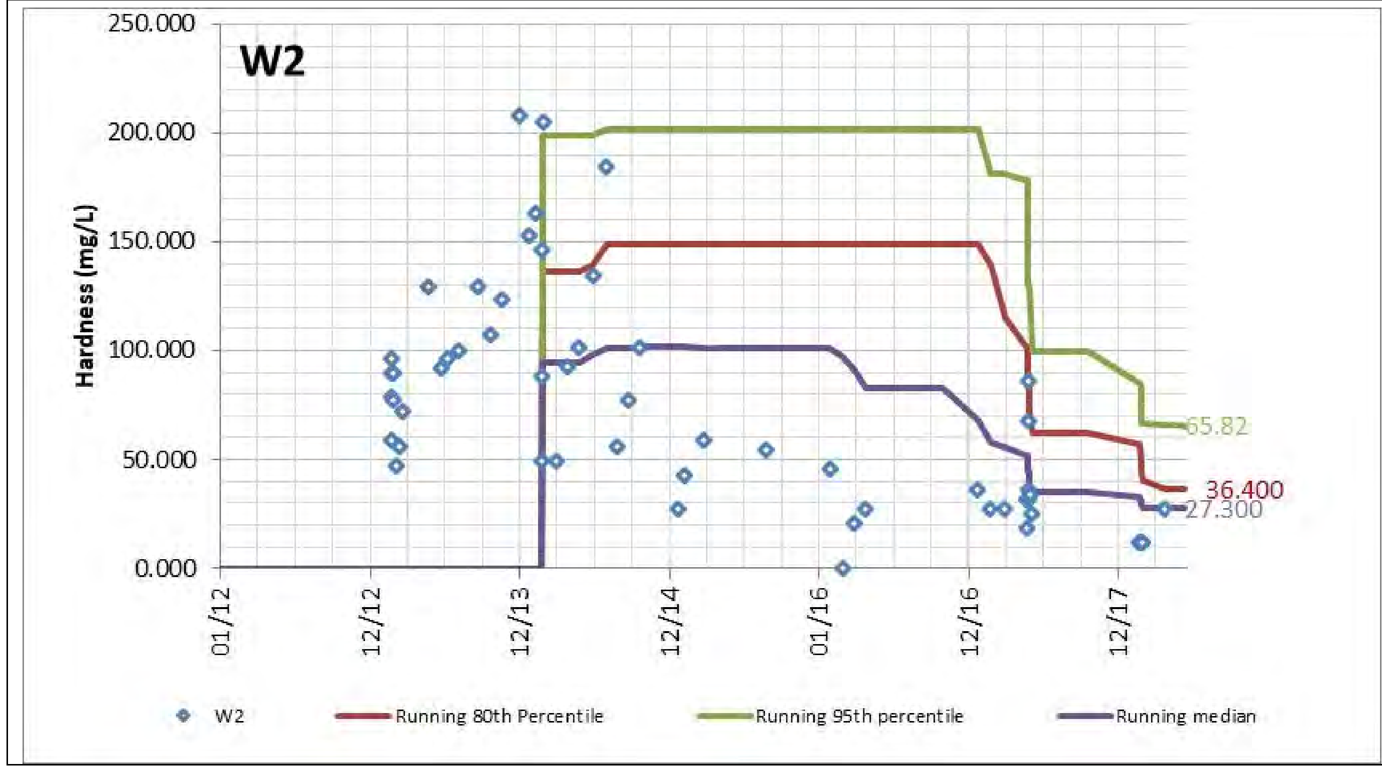
Receiving Environment Water Quality Charts

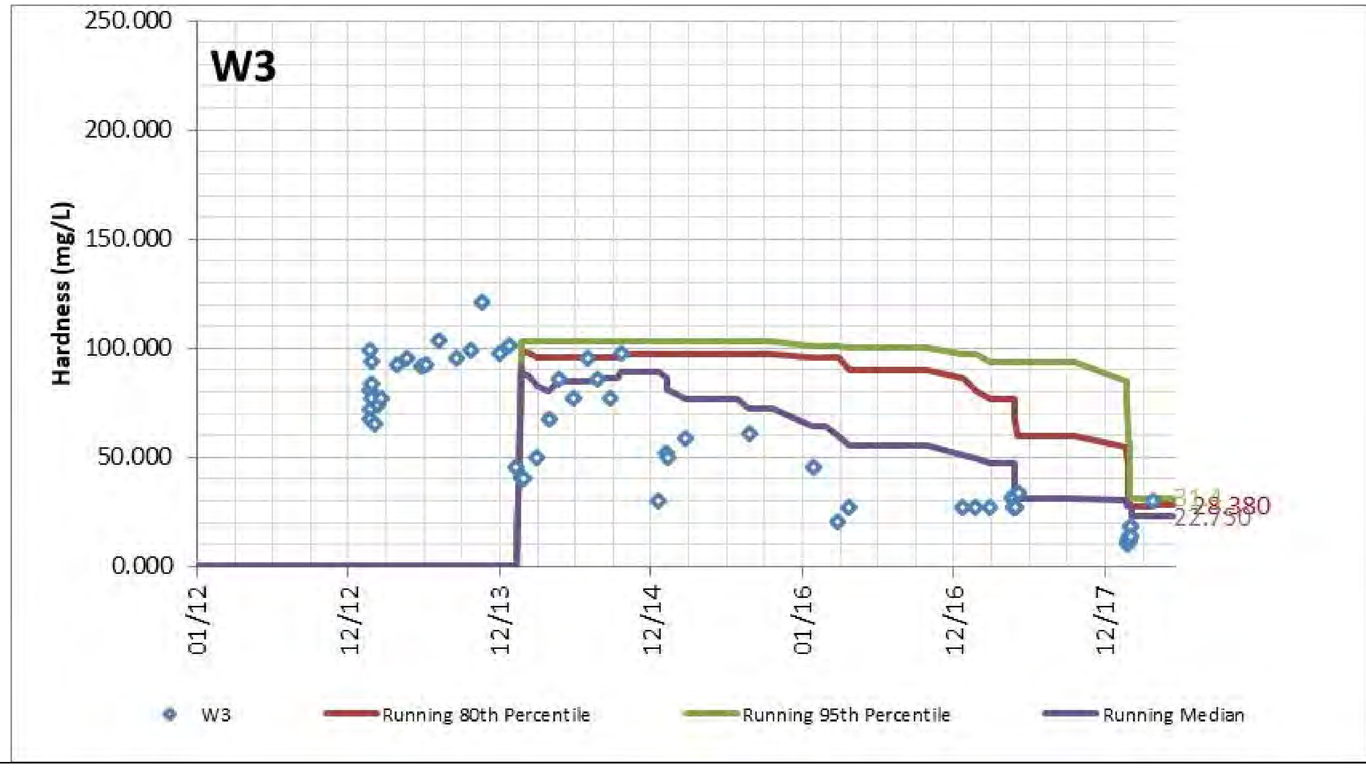
Appendix A Receiving Environment Water Quality Charts

Hardness

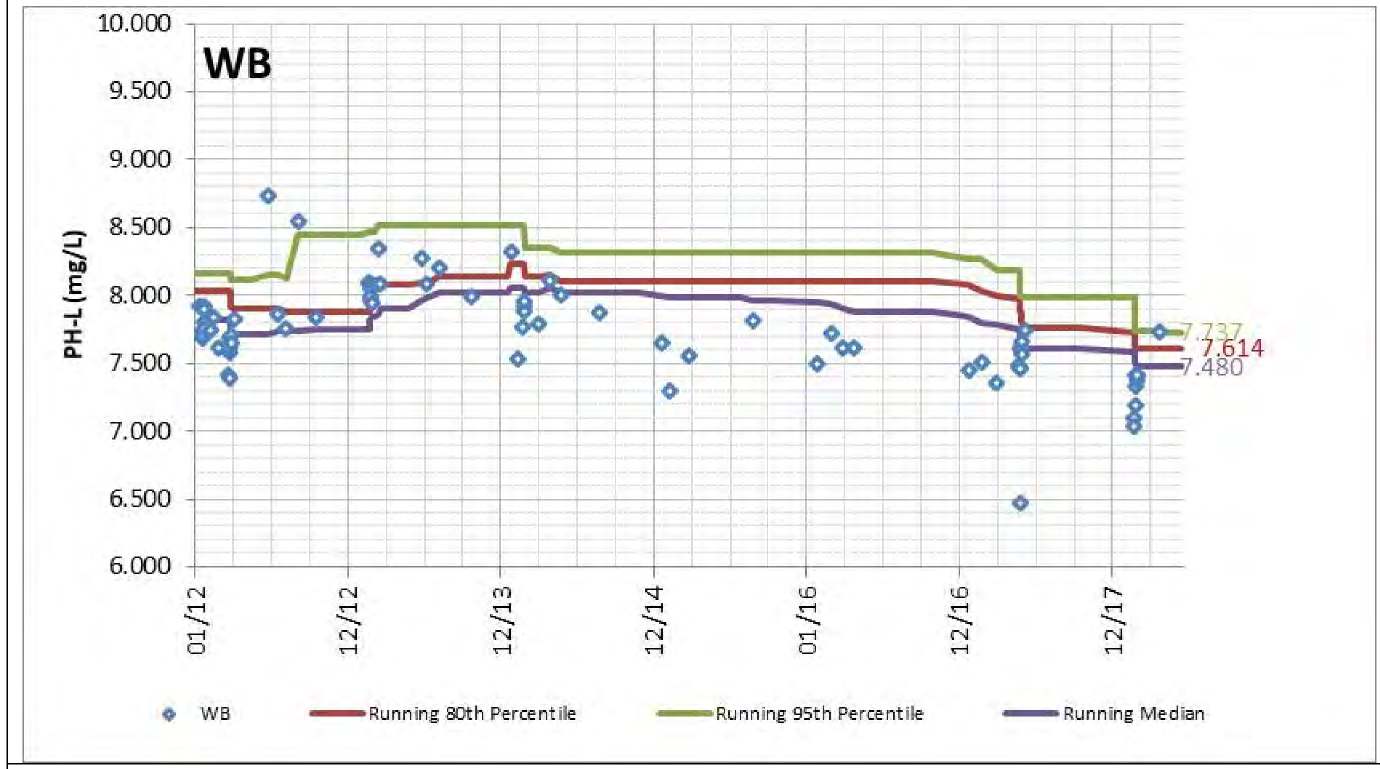


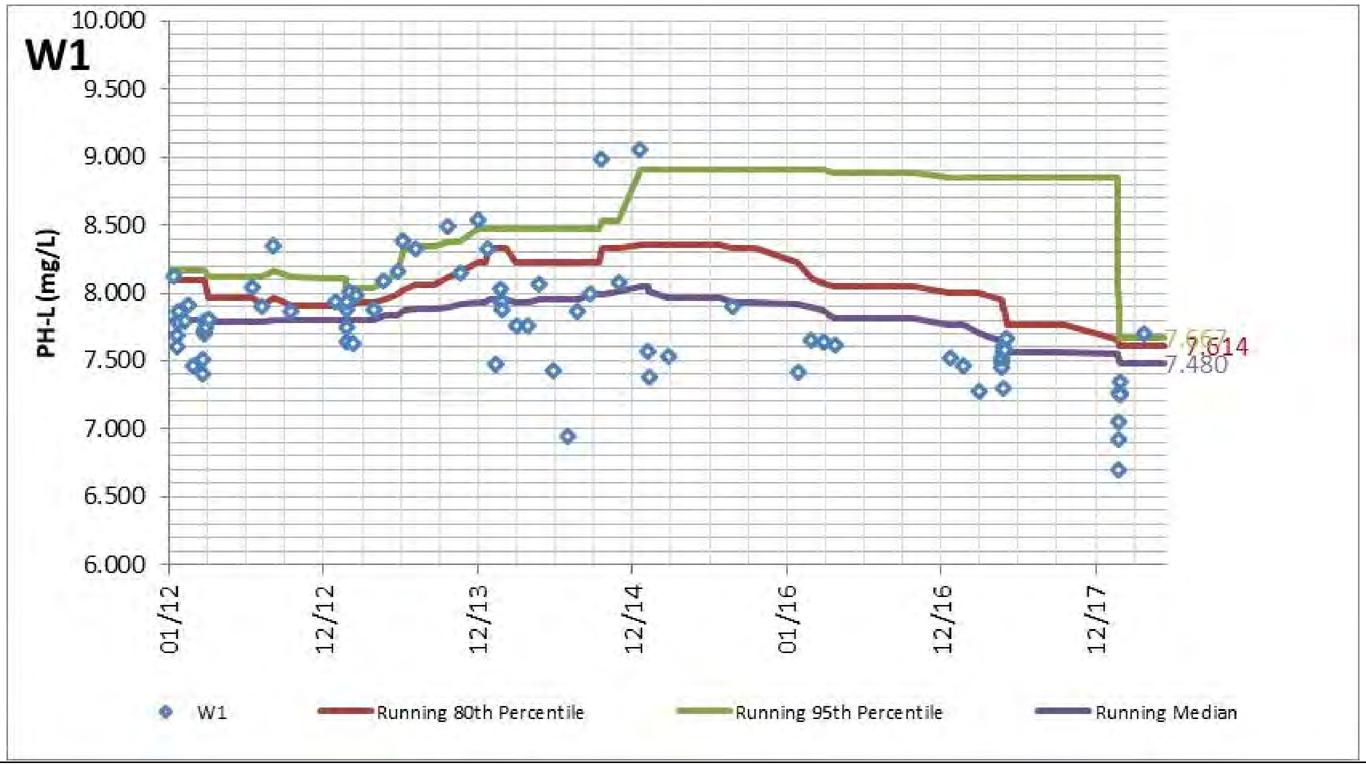


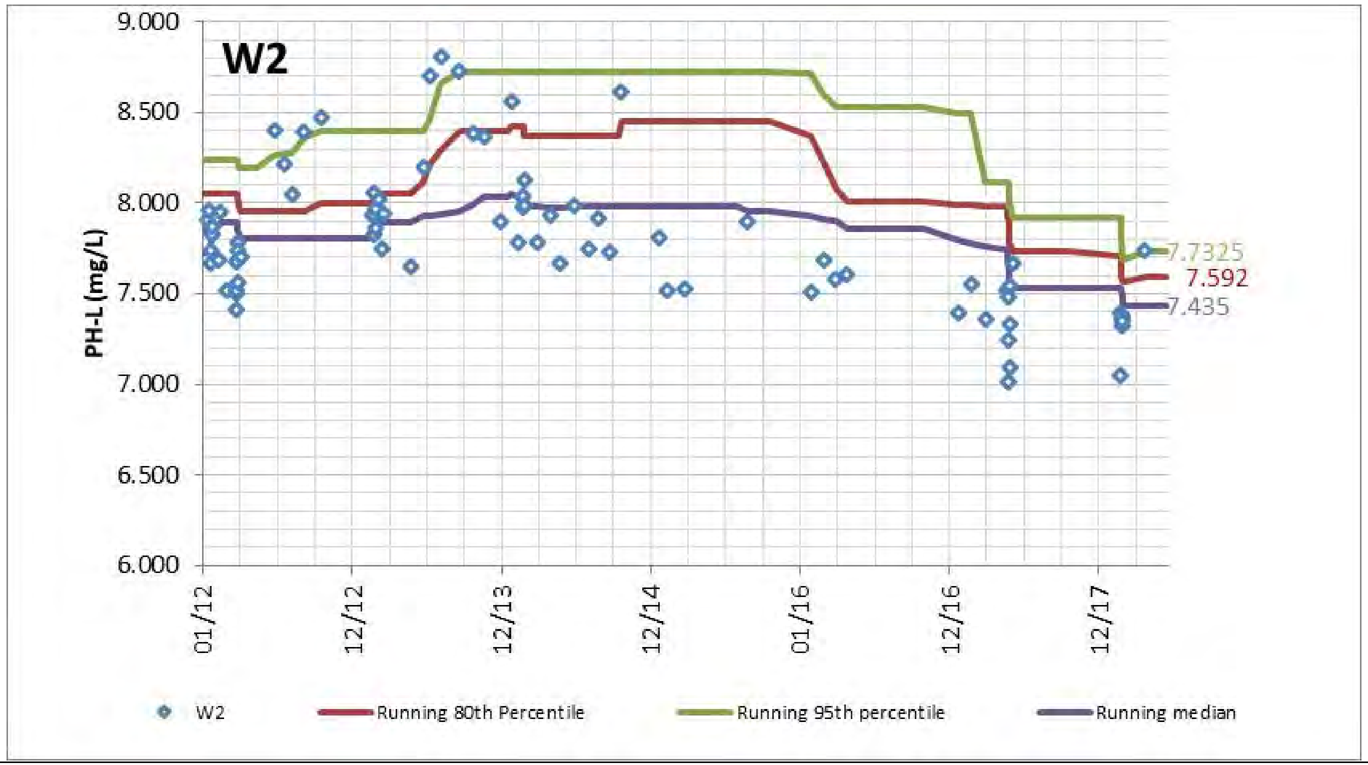


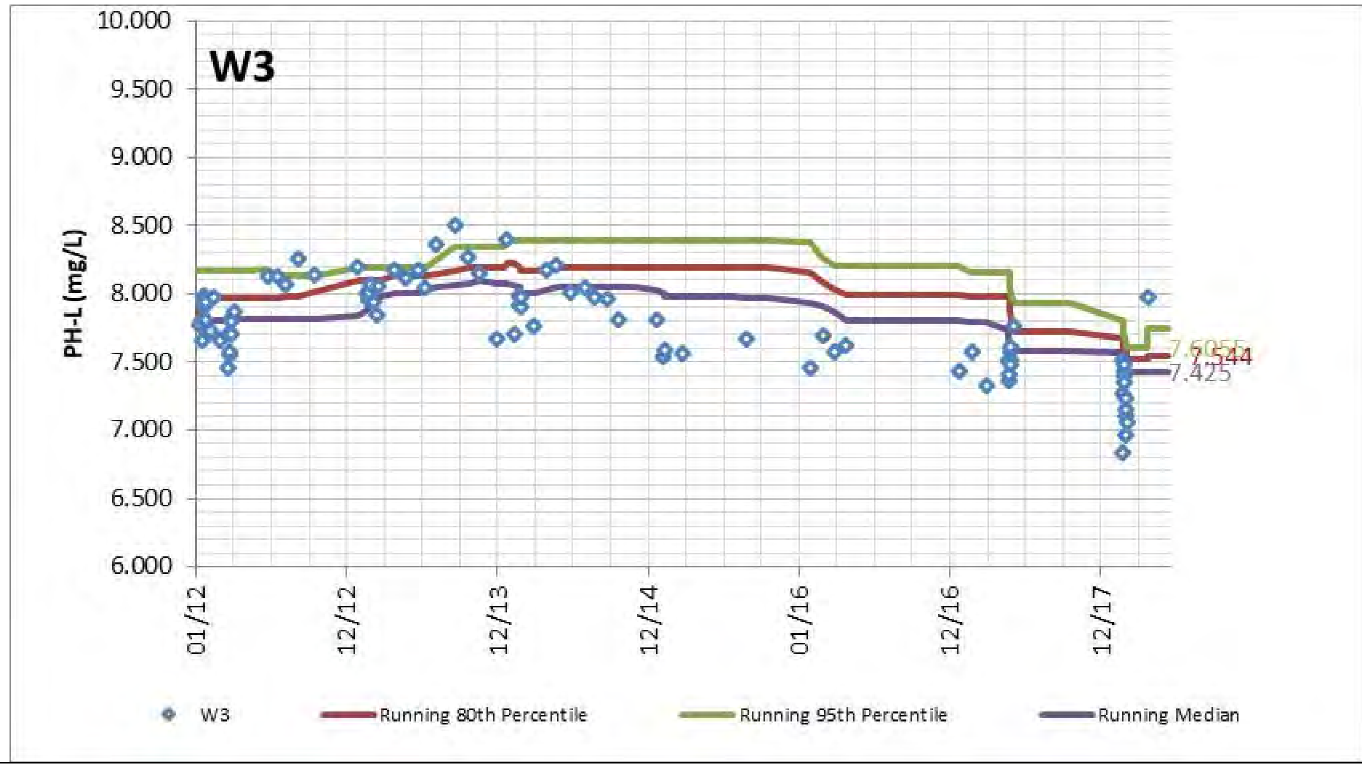


pH

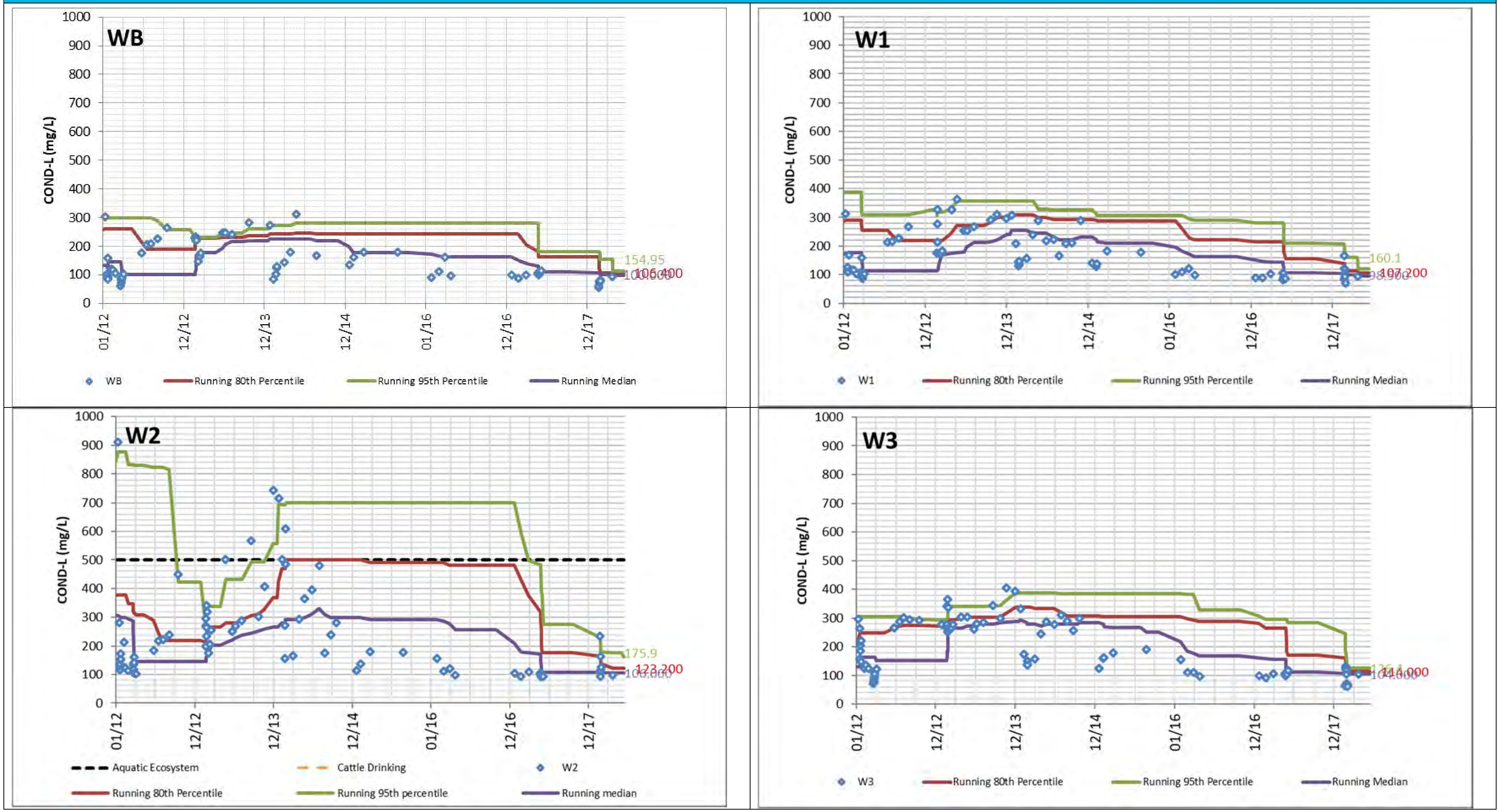

WB
PH-L (mg/L)
10.000
9.500
9.000
8.500
8.000
7.500
7.000
6.500
6.000
01/12
12/12
12/13
12/14
01/16
12/16
12/17
7.737
7.614
7.480
WB
Running 80th Percentile
Running 95th Percentile
Running Median


W1
PH-L (mg/L)
10.000
9.500
9.000
8.500
8.000
7.500
7.000
6.500
6.000
01/12
12/12
12/13
12/14
01/16
12/16
12/17
7.614
7.480
W1
Running 80th Percentile
Running 95th Percentile
Running Median

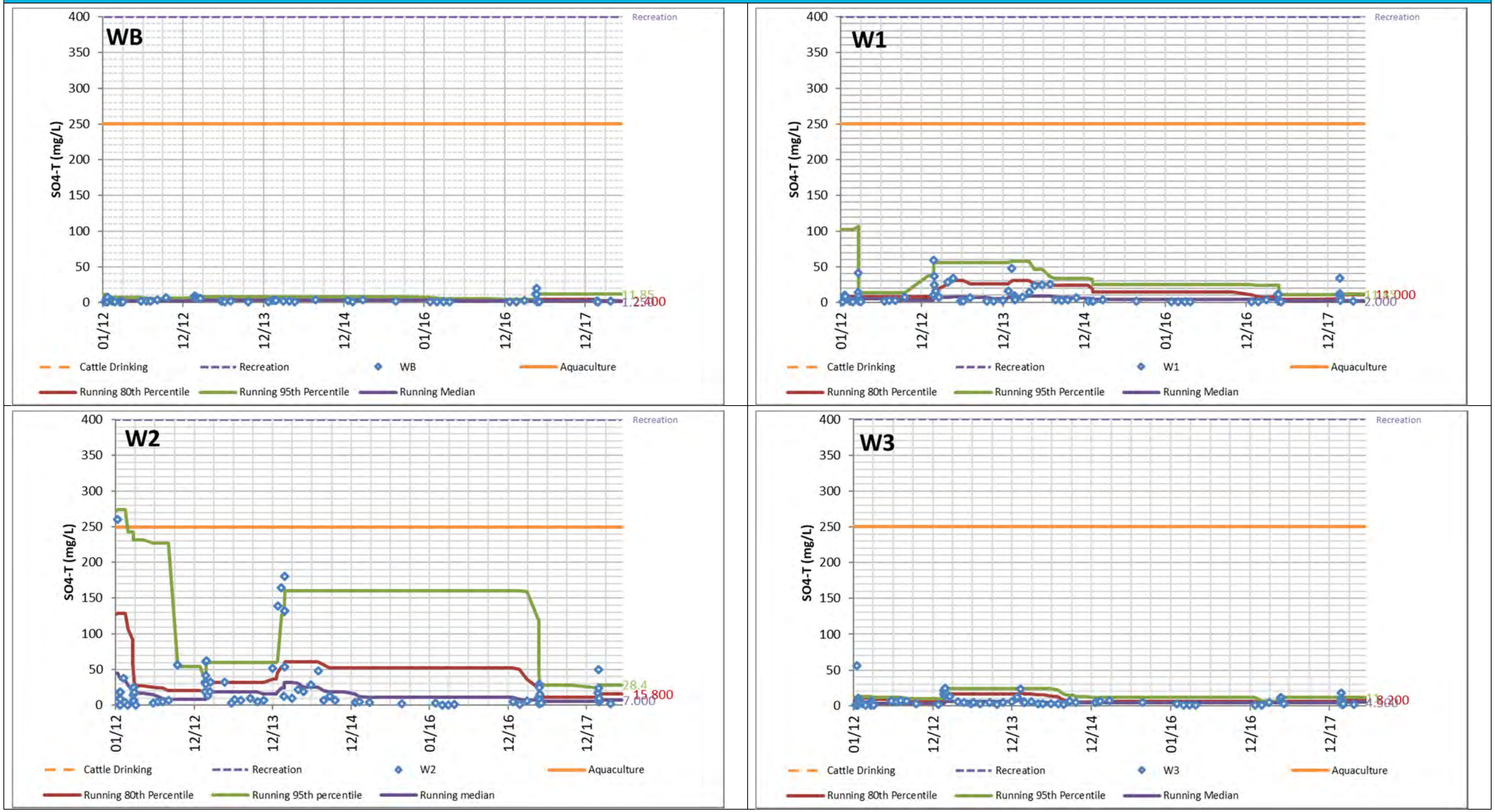

W2
PH-L (mg/L)
9.000
8.500
8.000
7.500
7.000
6.500
6.000
01/12
12/12
12/13
12/14
01/16
12/16
12/17
7.7325
7.592
7.435
W2
Running 80th Percentile
Running 95th percentile
Running median


W3
PH-L (mg/L)
10.000
9.500
9.000
8.500
8.000
7.500
7.000
6.500
6.000
01/12
12/12
12/13
12/14
01/16
12/16
12/17
7.425
W3
Running 80th Percentile
Running 95th Percentile
Running Median

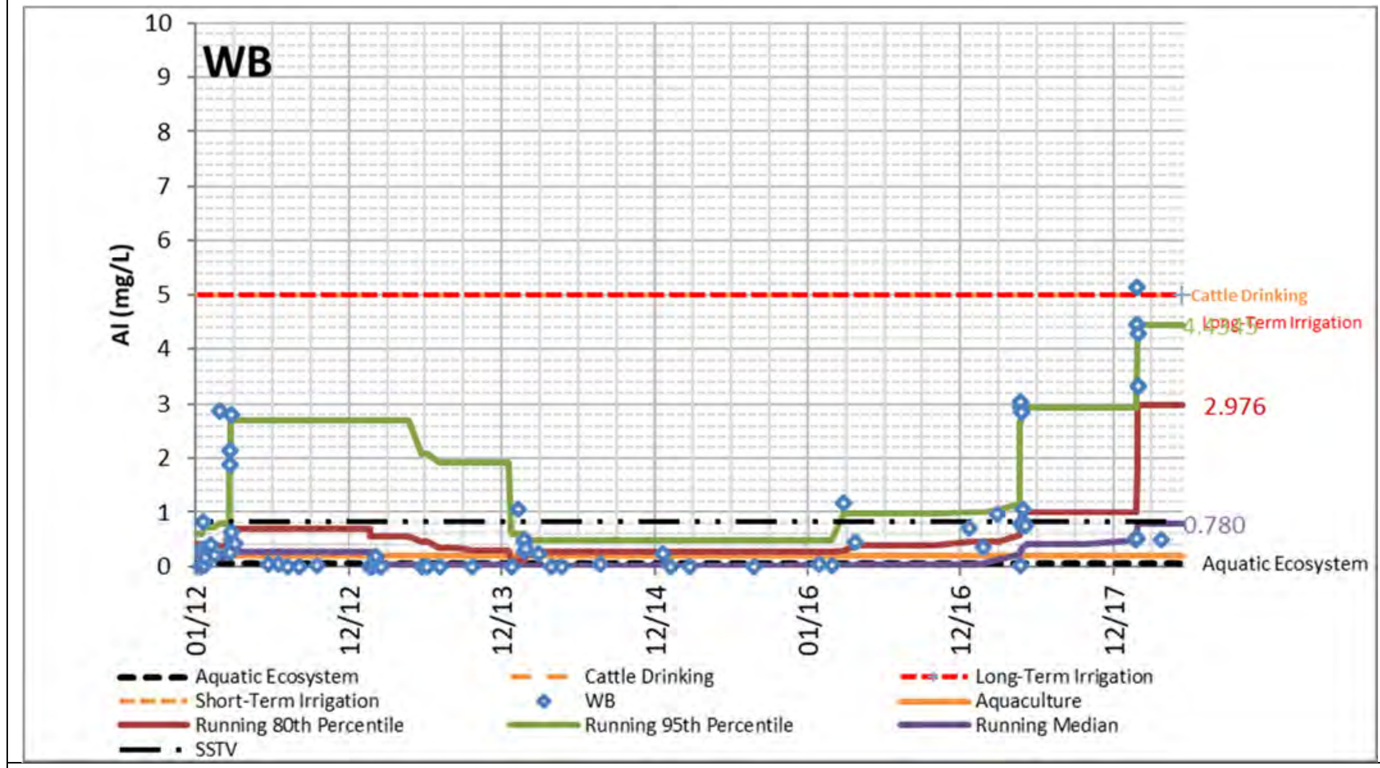
EC

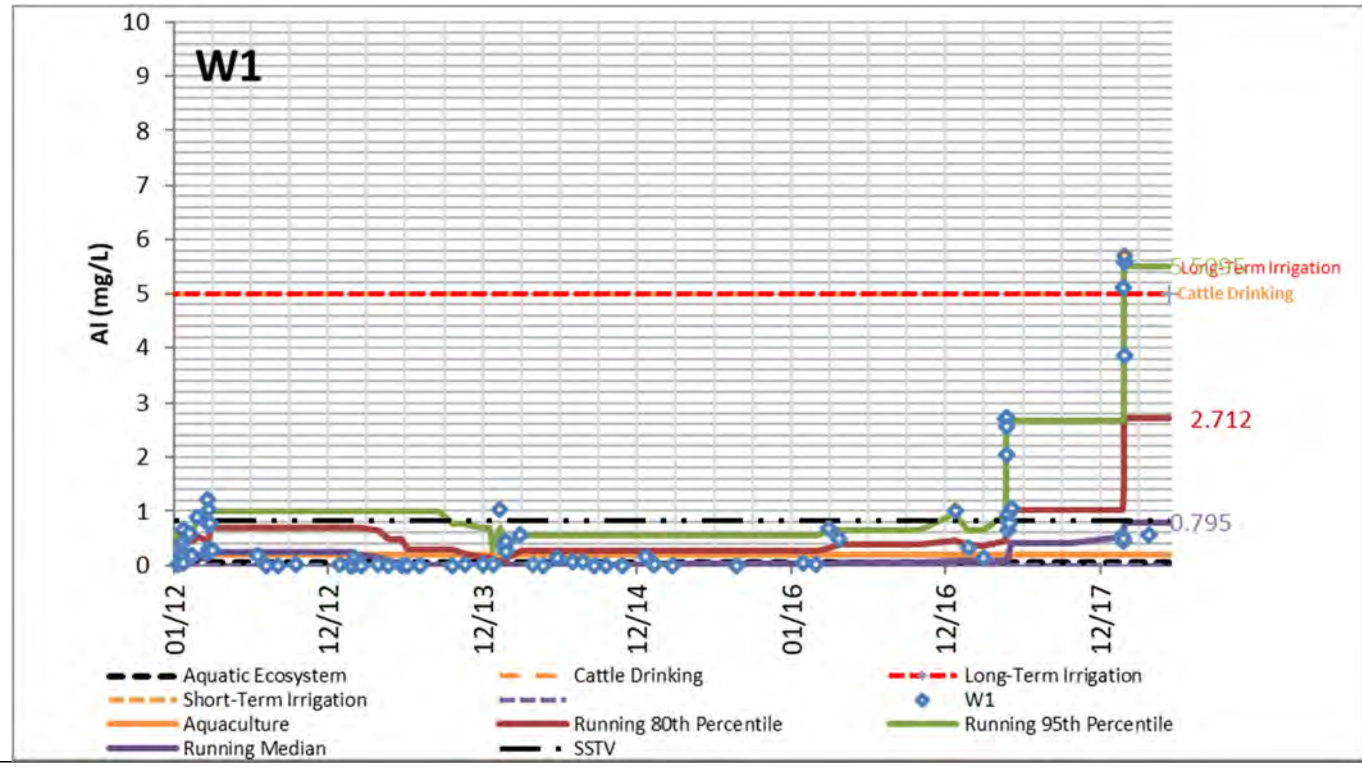

WB
W1
W2
W3
COND-L (mg/L)
1000
900
800
700
600
500
400
300
200
100
0
01/12
12/12
12/13
12/14
01/16
12/16
12/17
154.95
160.1
175.9
WB
W1
W2
W3
Running 80th Percentile
Running 95th Percentile
Running Median
Aquatic Ecosystem
Cattle Drinking
Running 95th percentile
Running median

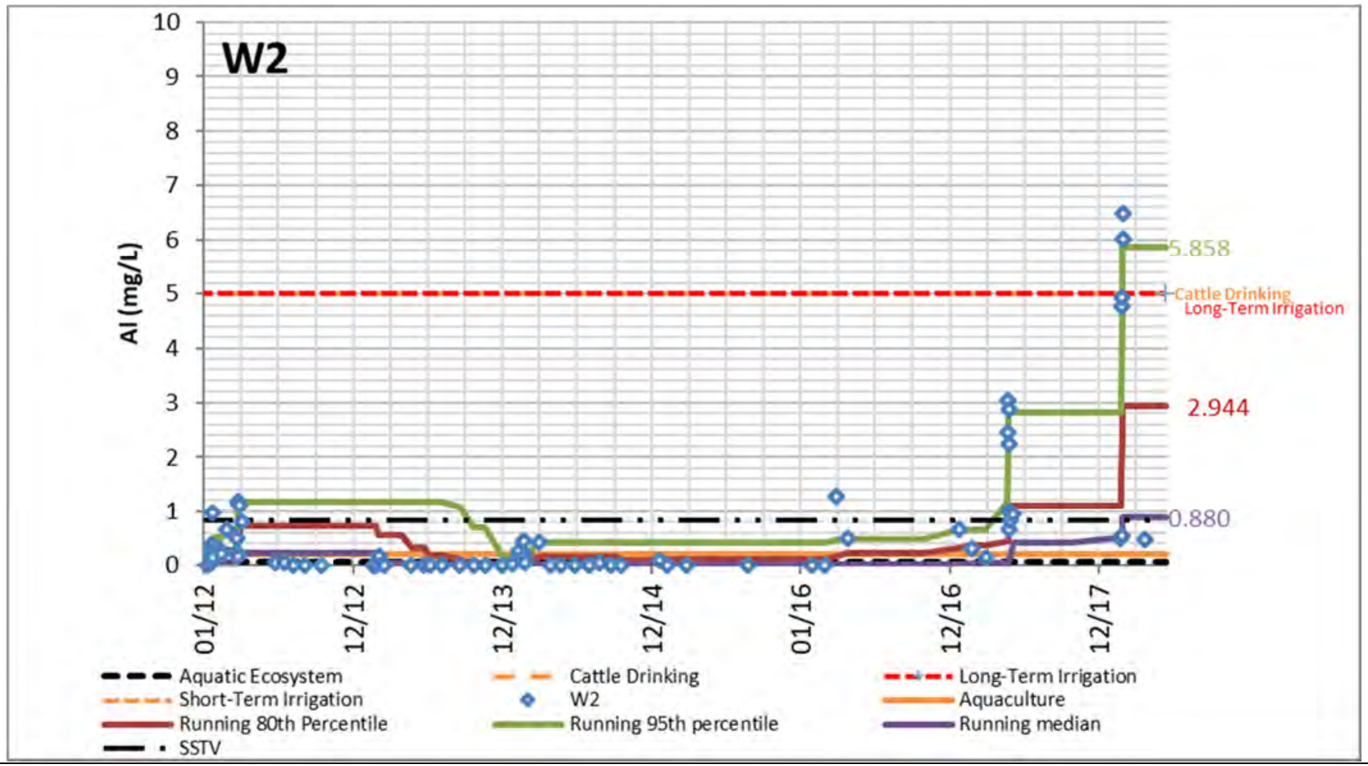
Sulfate as SO4

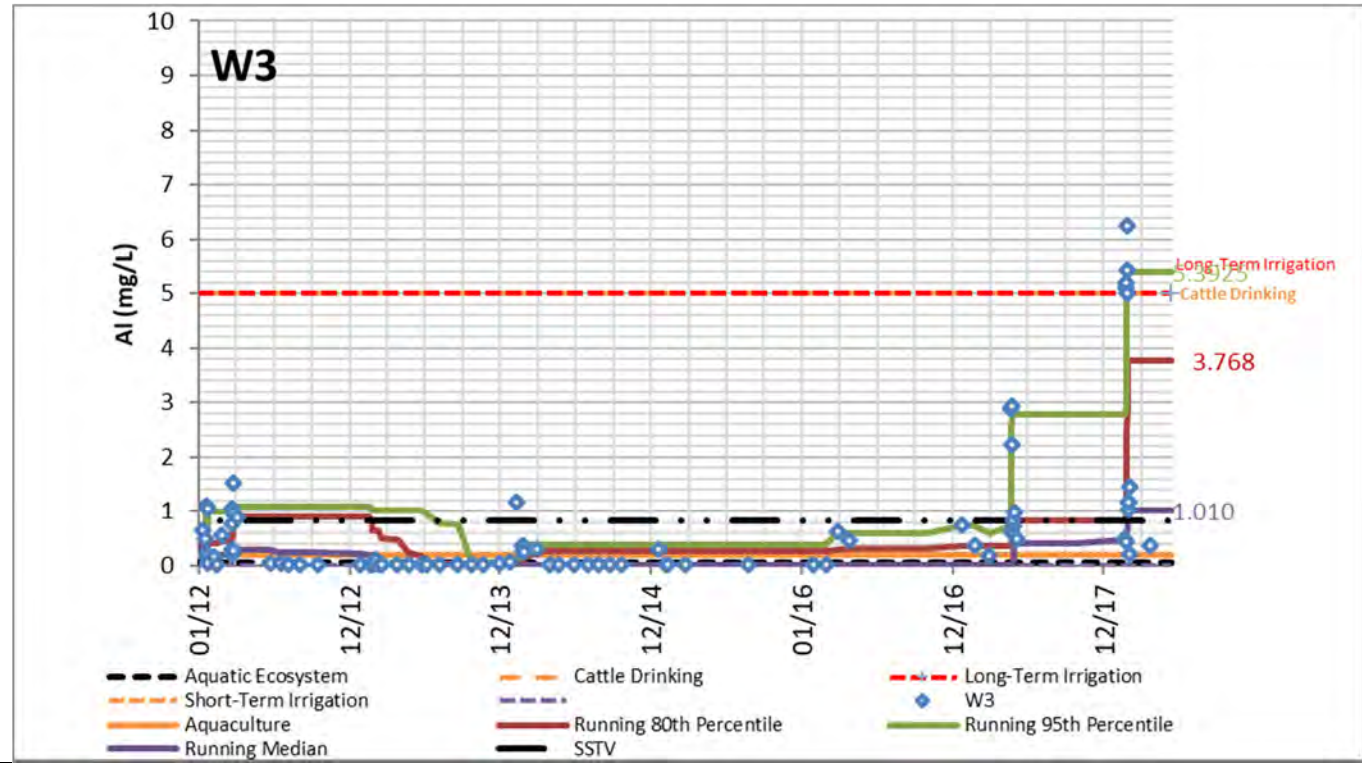


Dissolved Aluminium

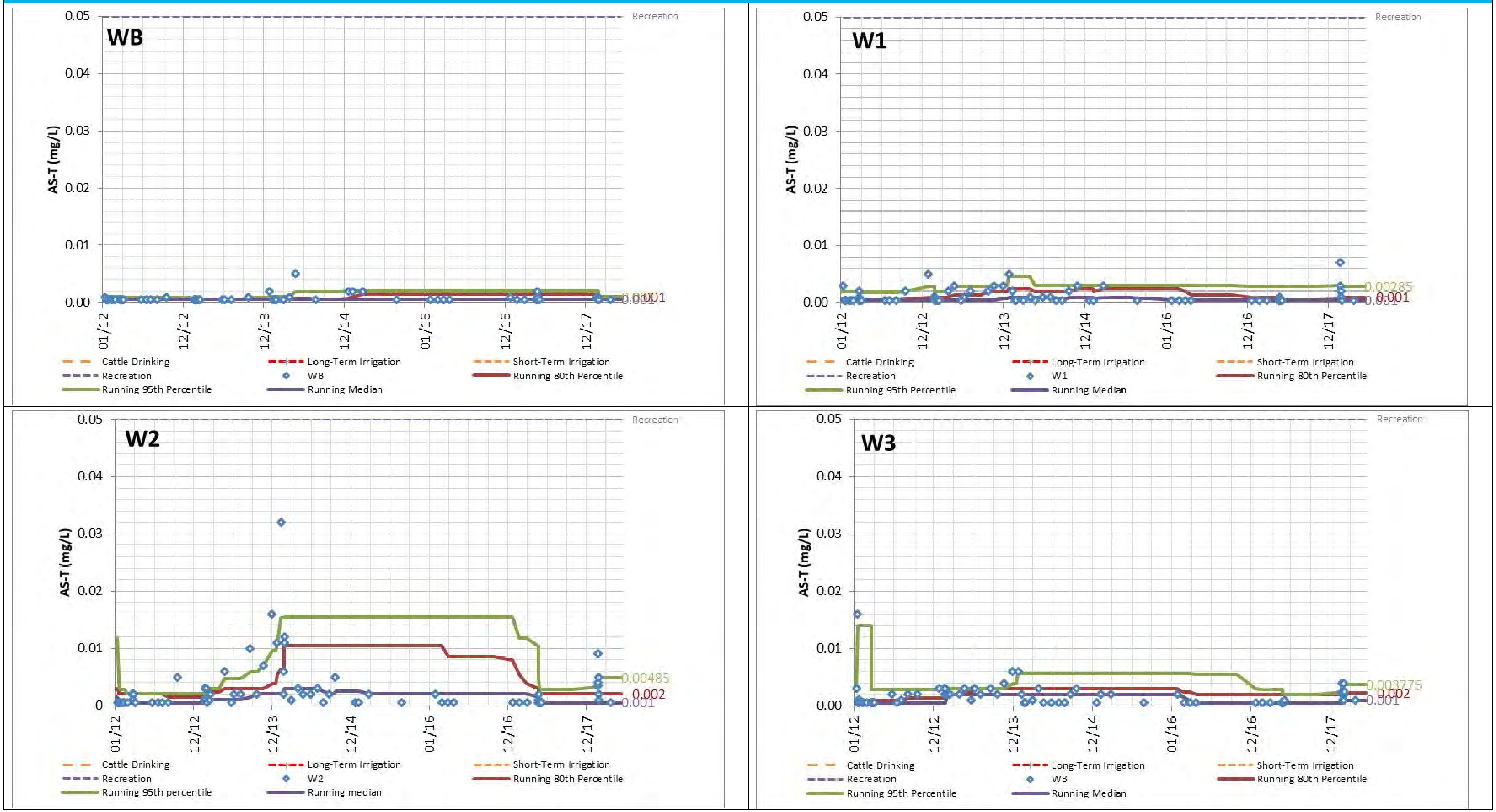




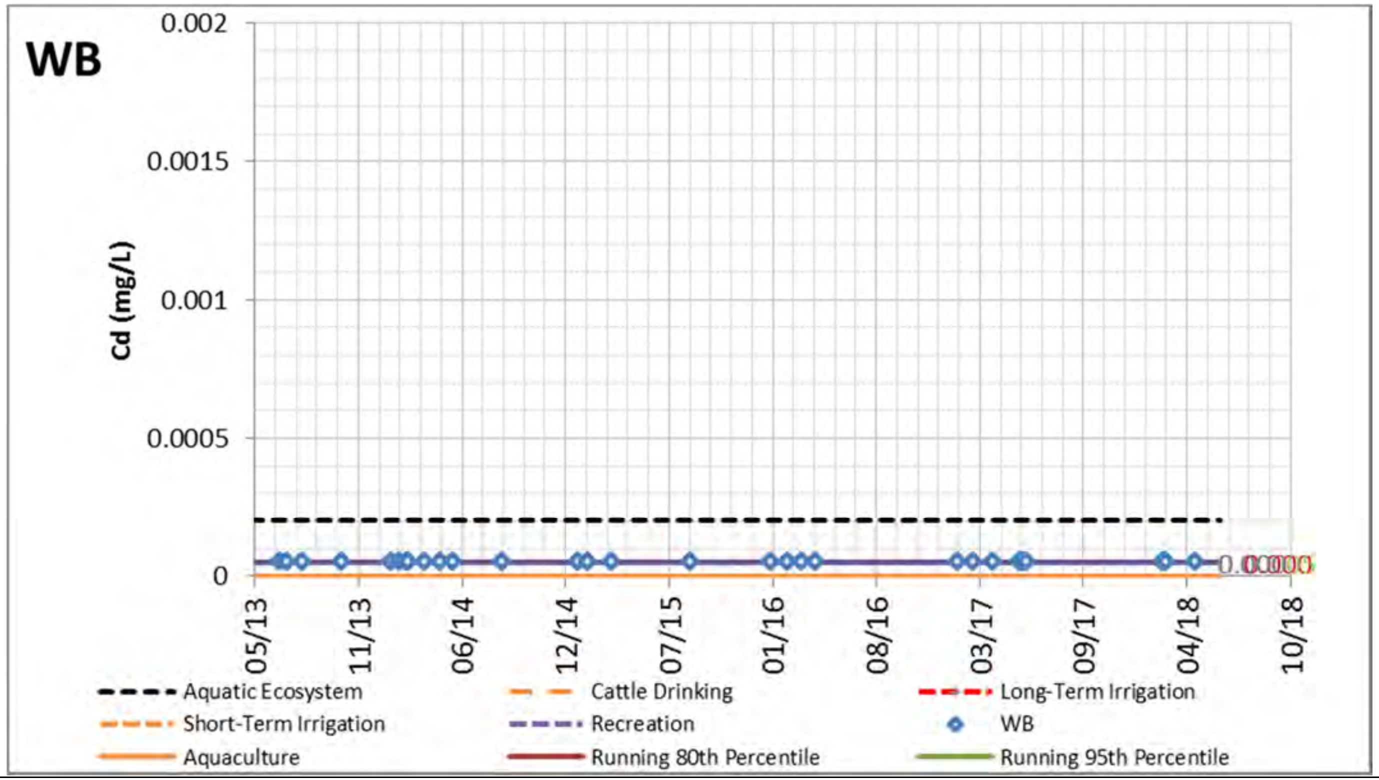


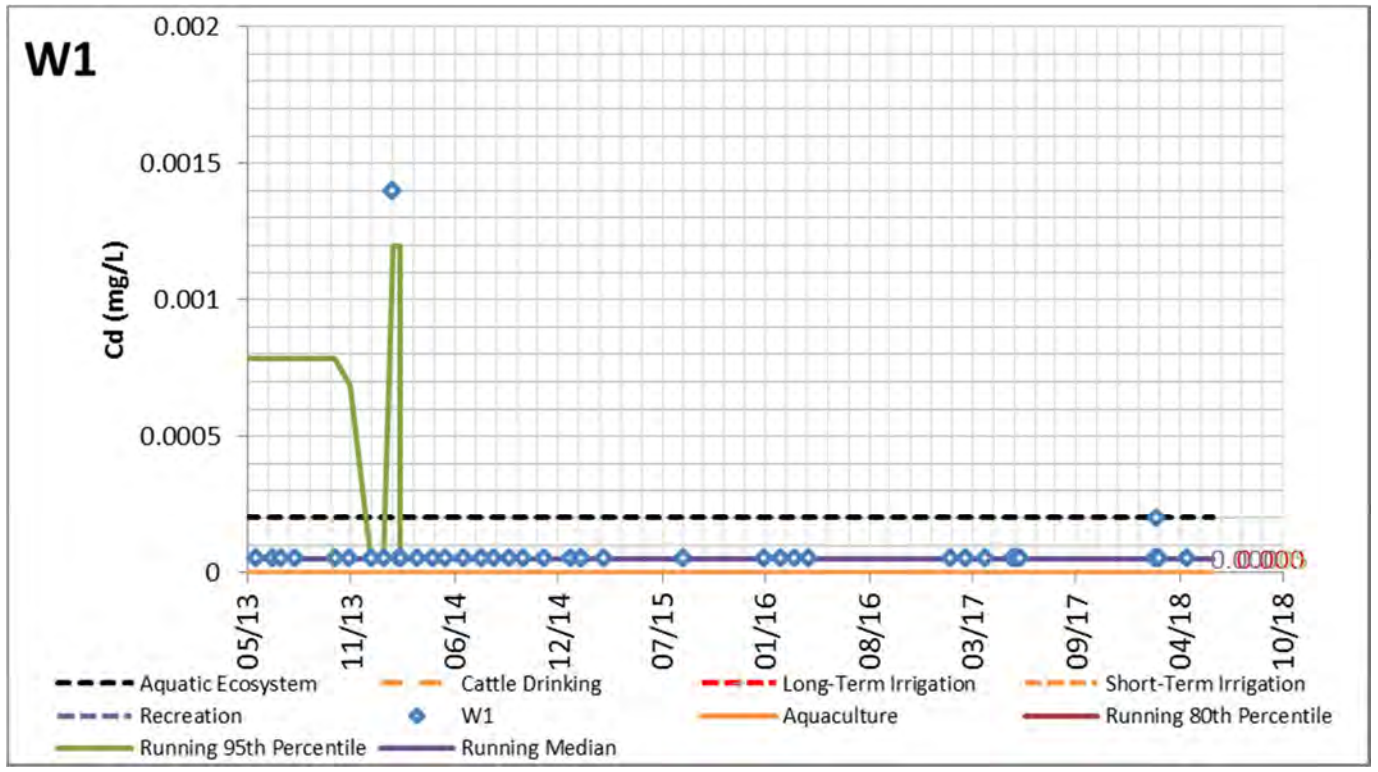


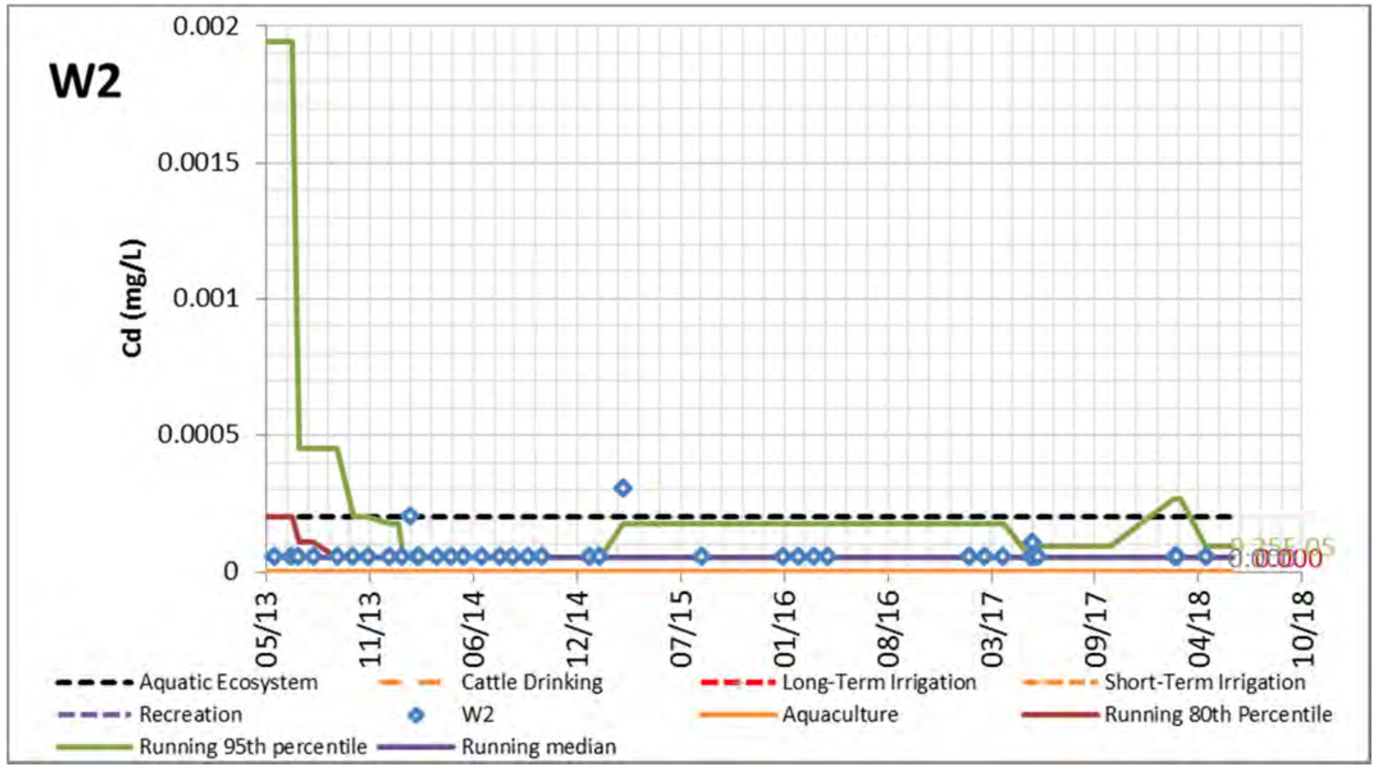
Total Arsenic



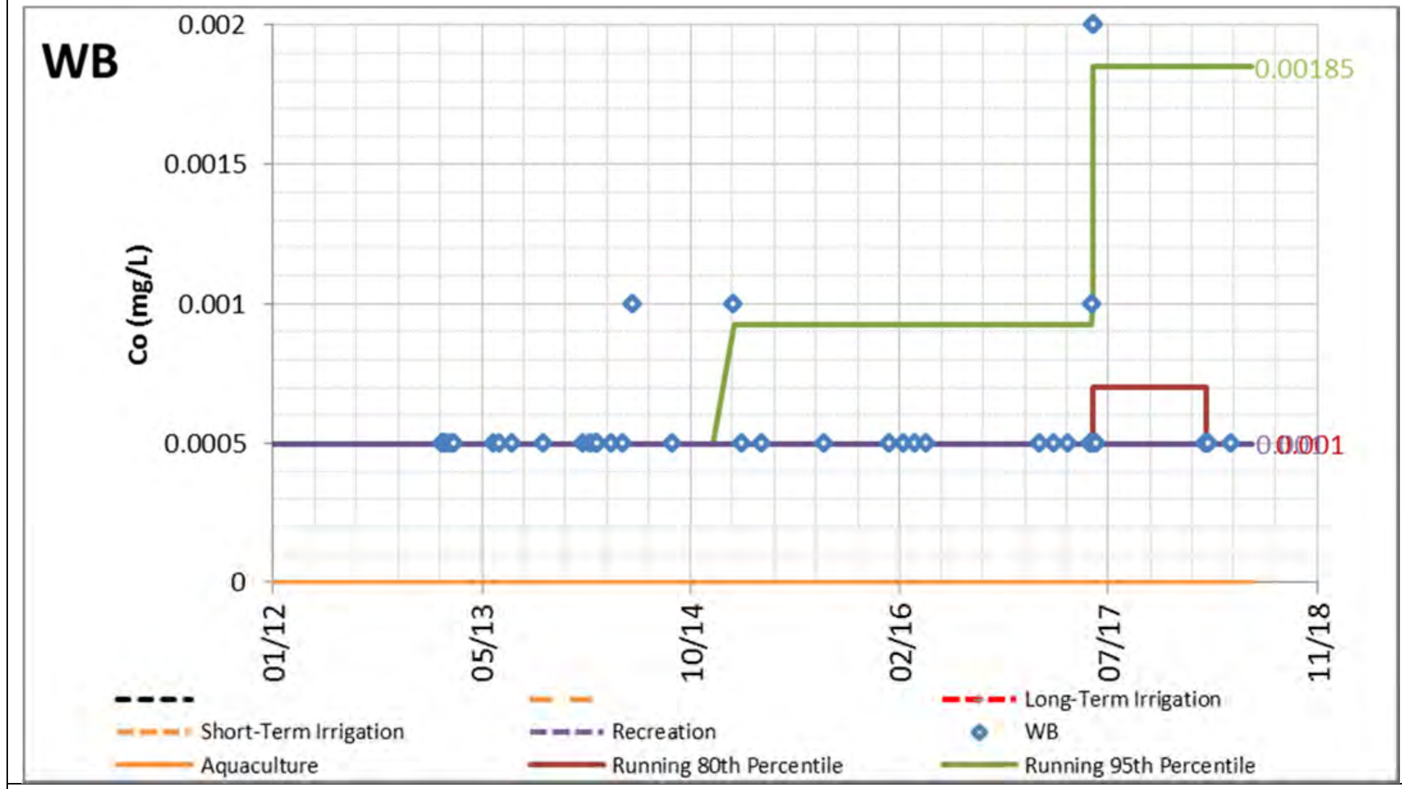
Dissolved Cadmium

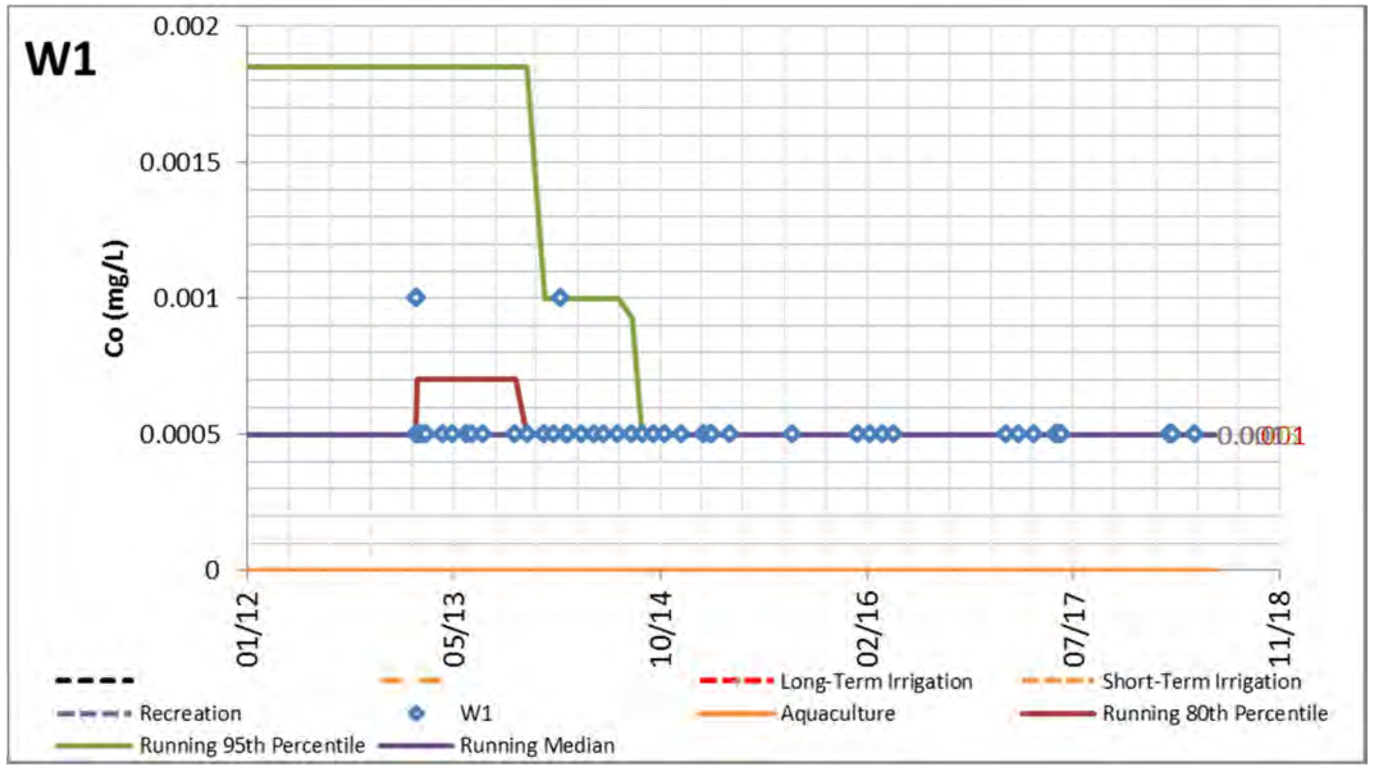


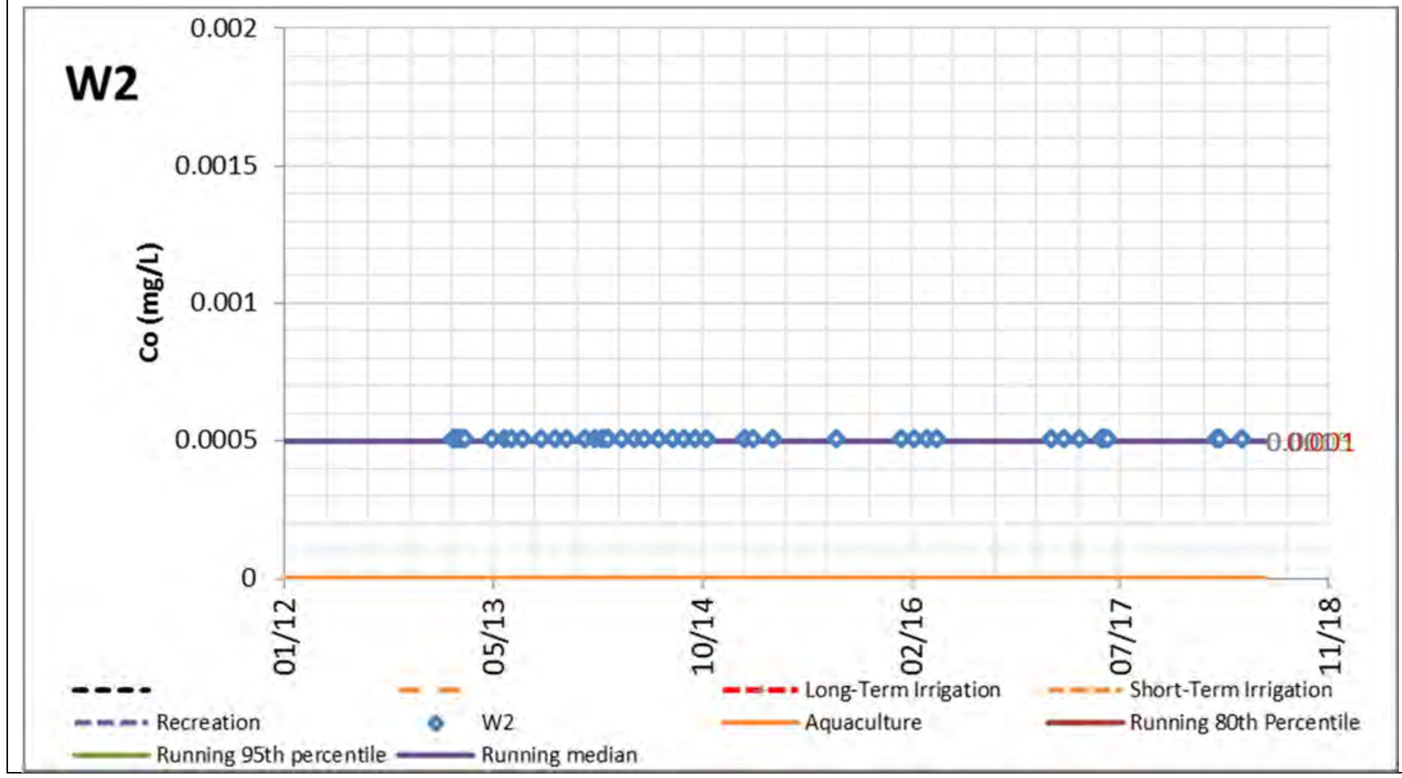


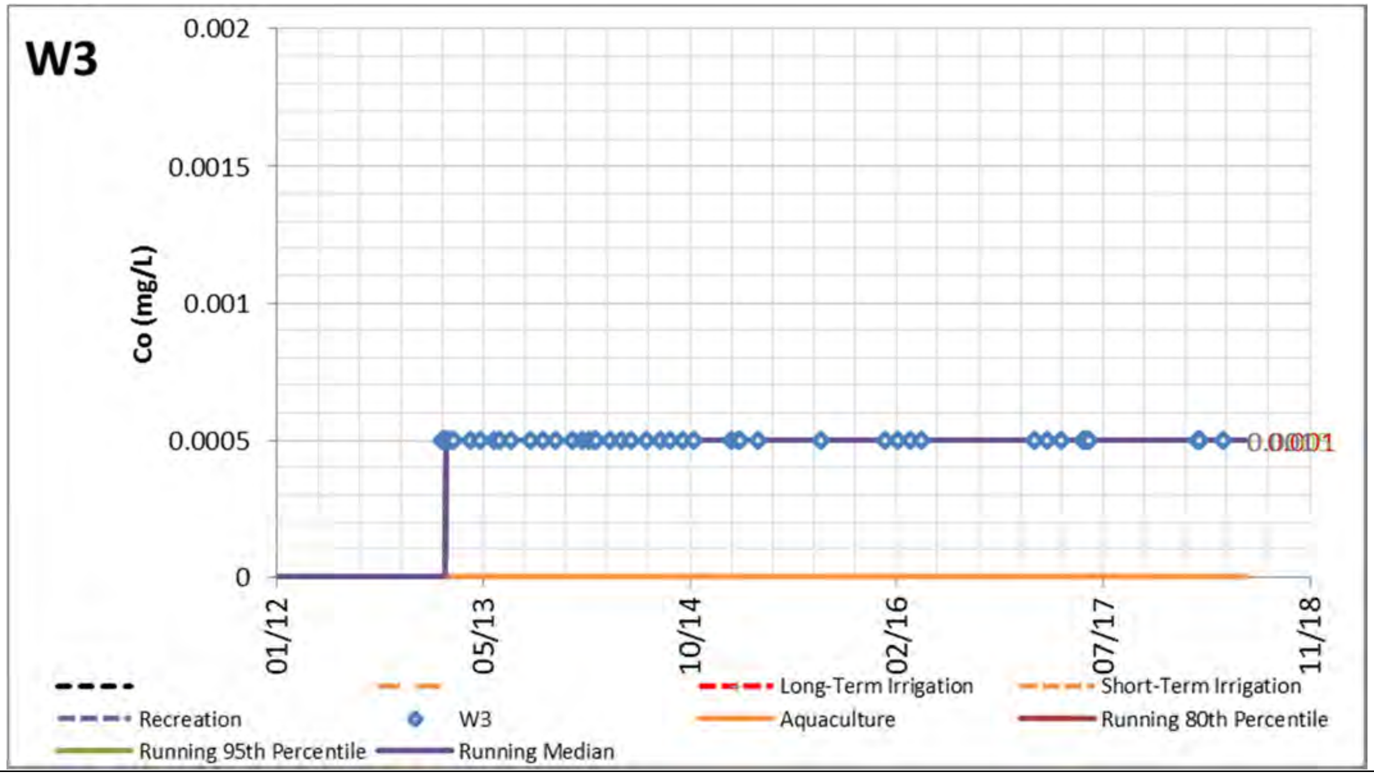


Dissolved Cobalt

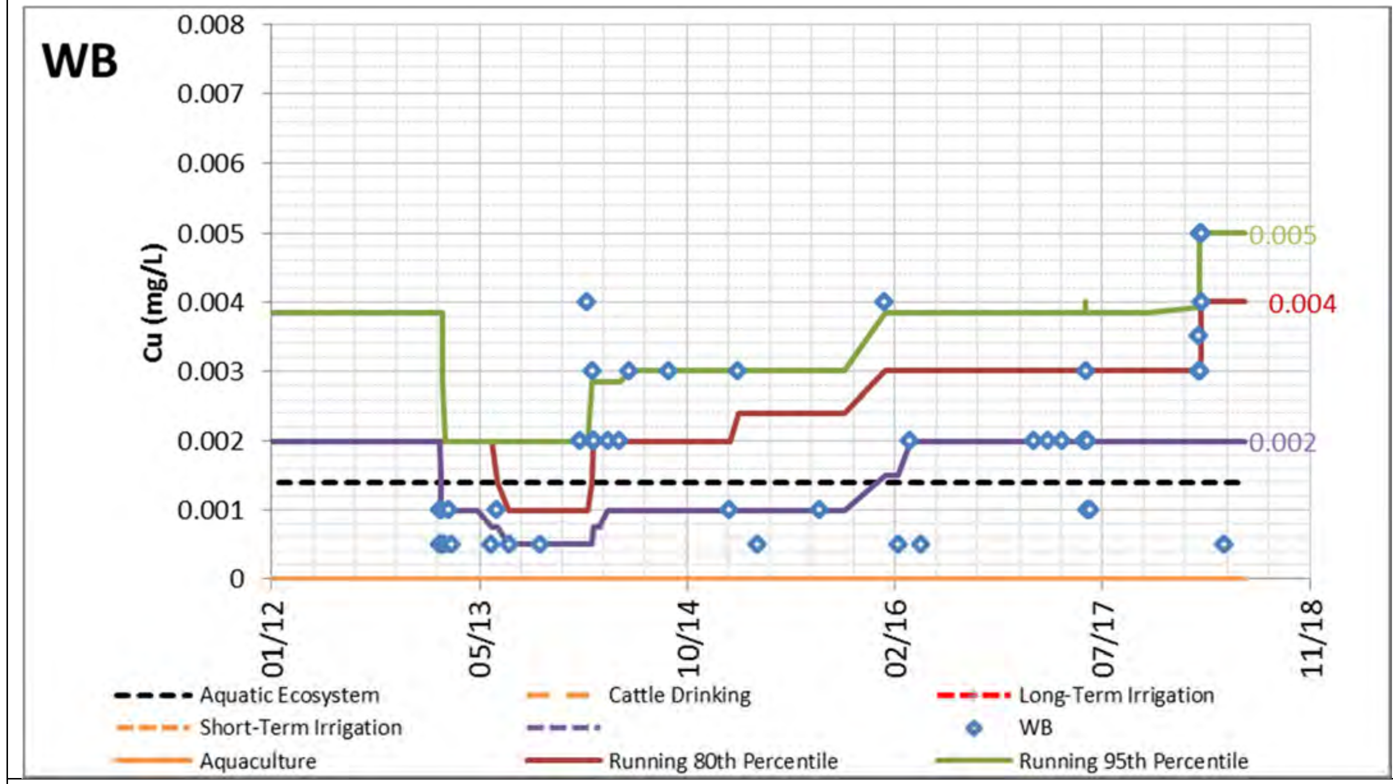


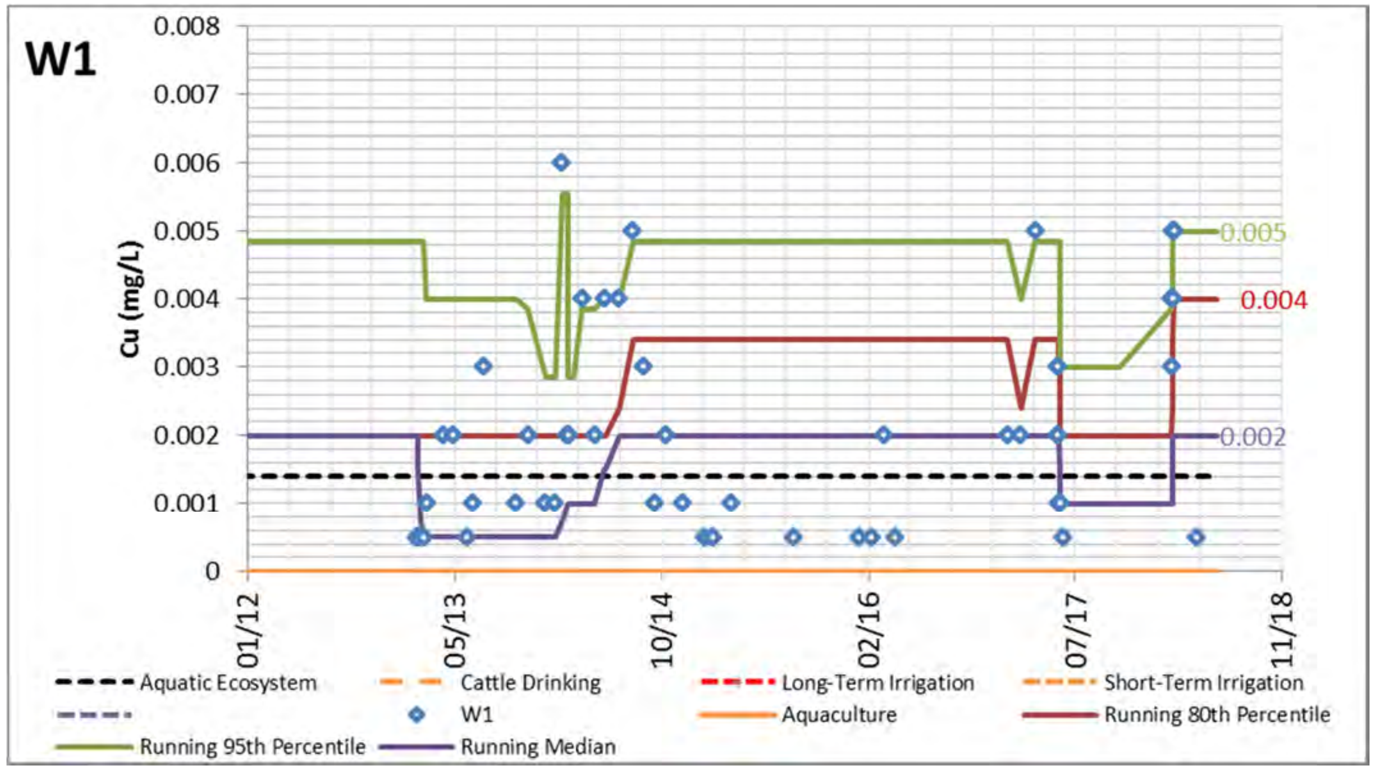


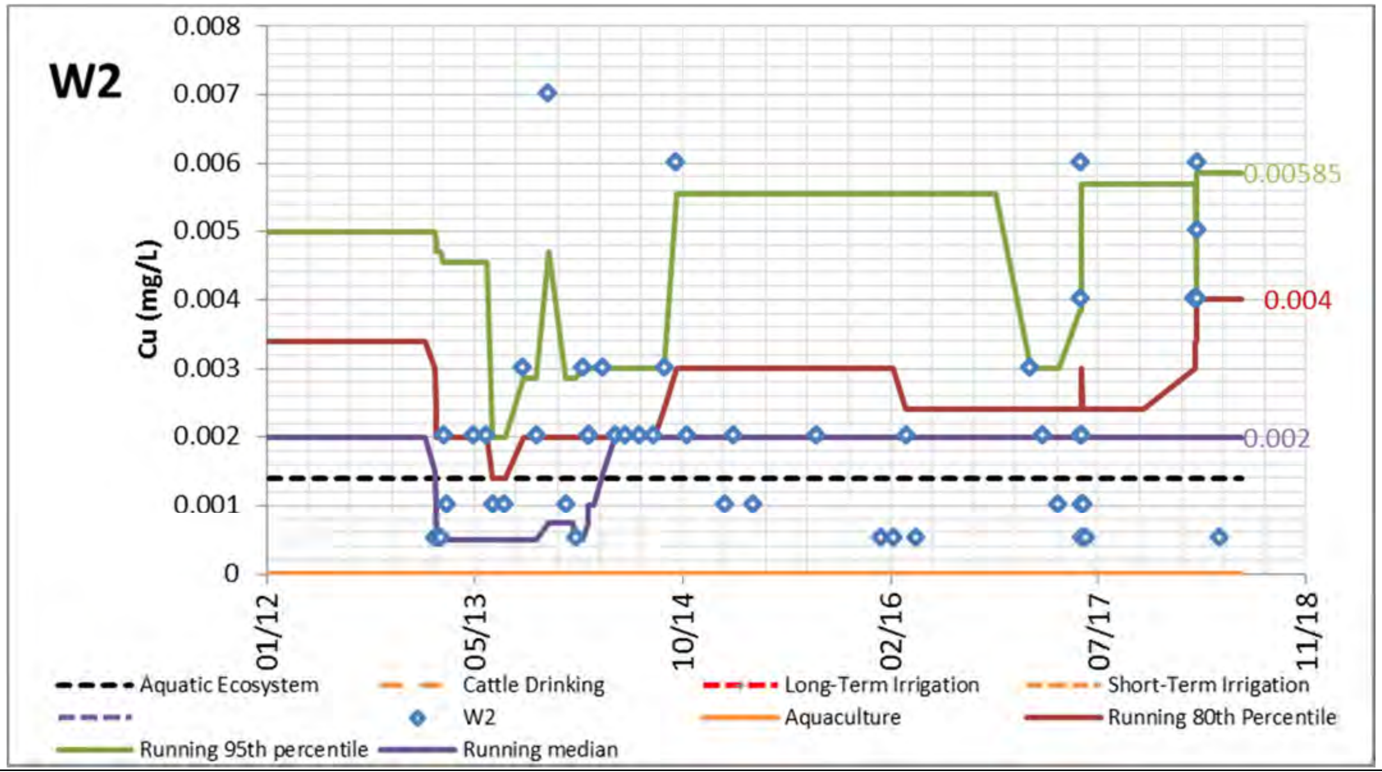


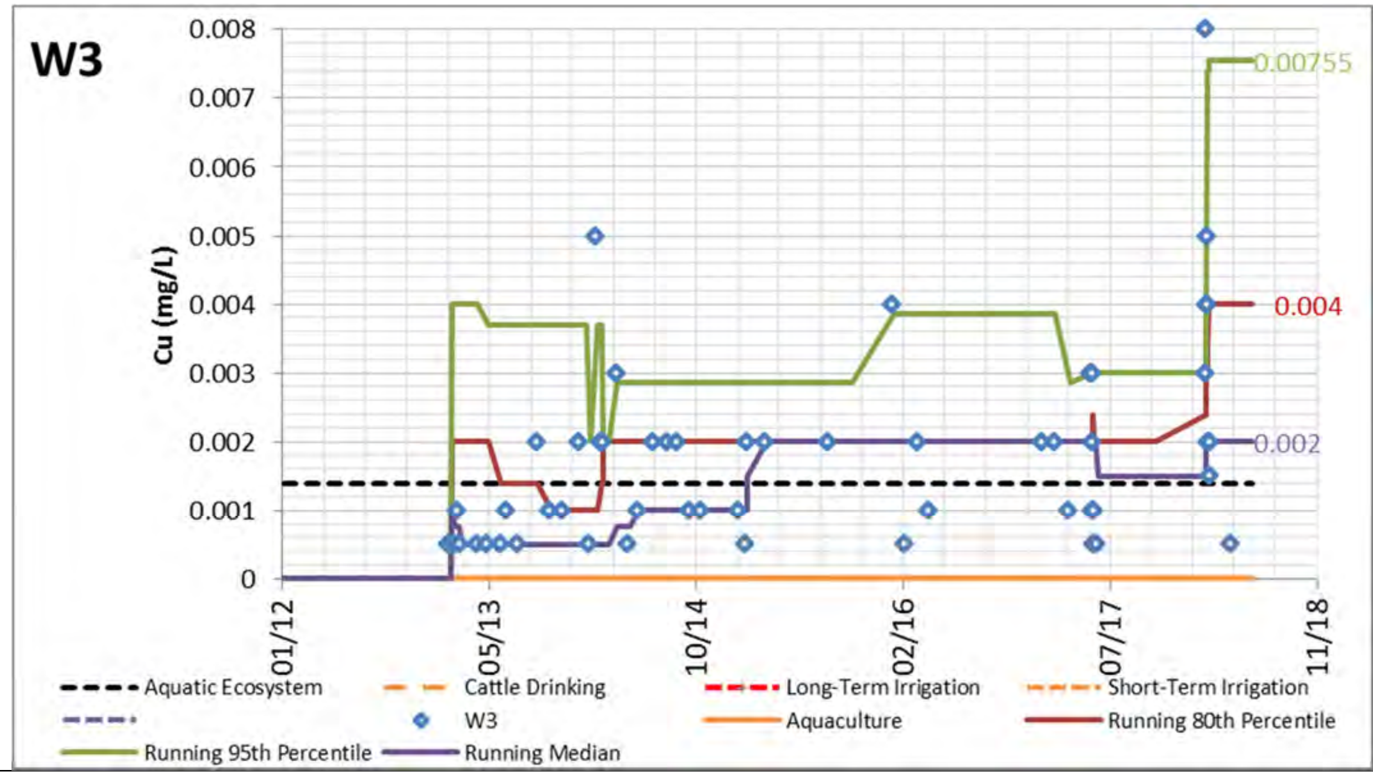


Dissolved Copper

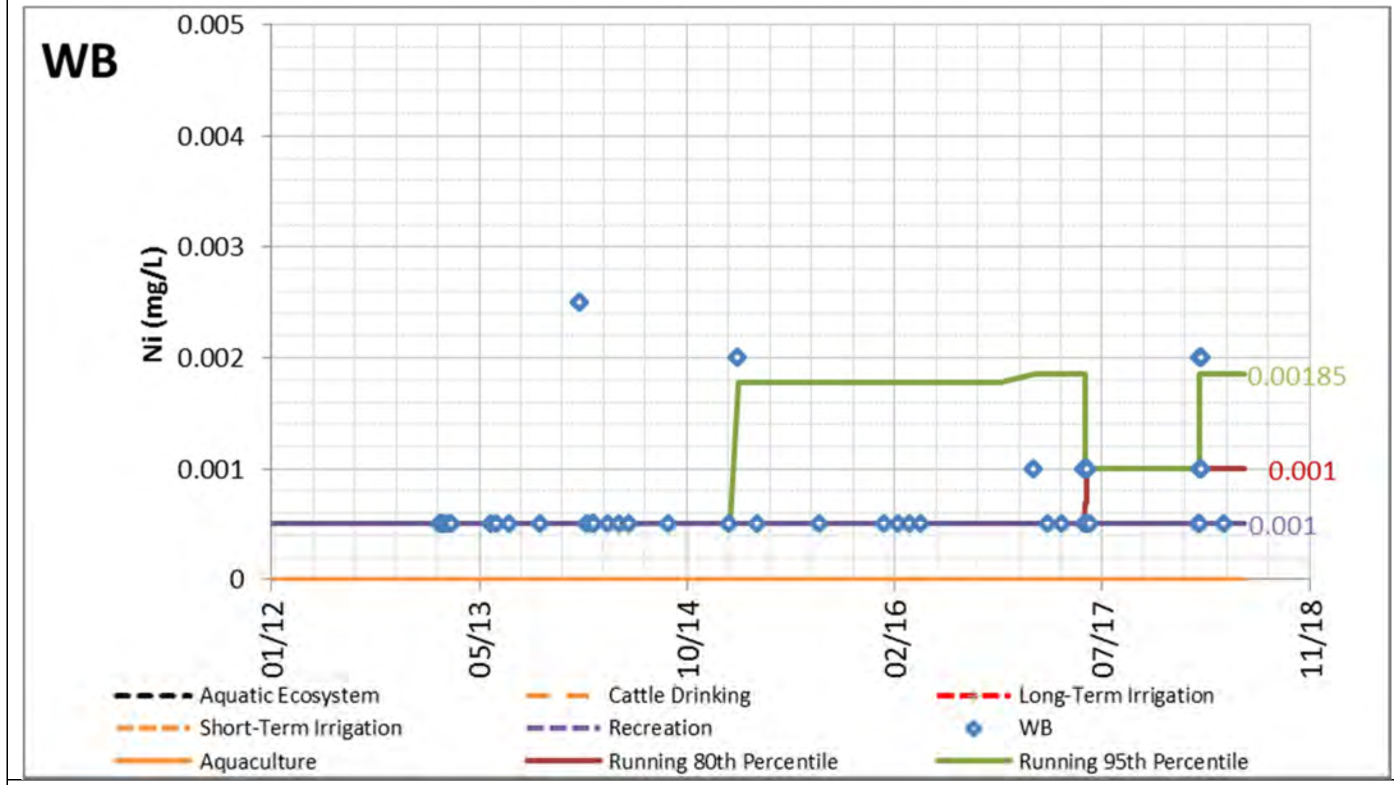


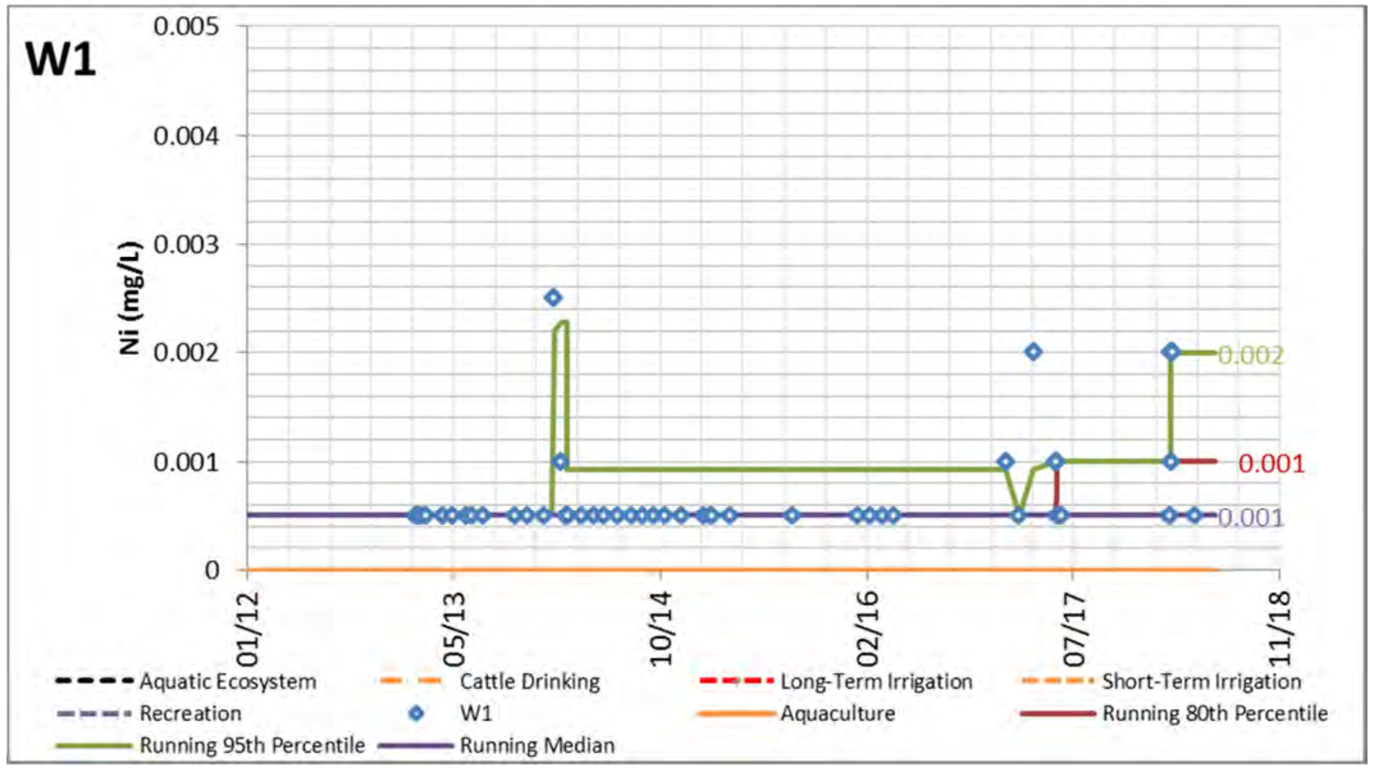


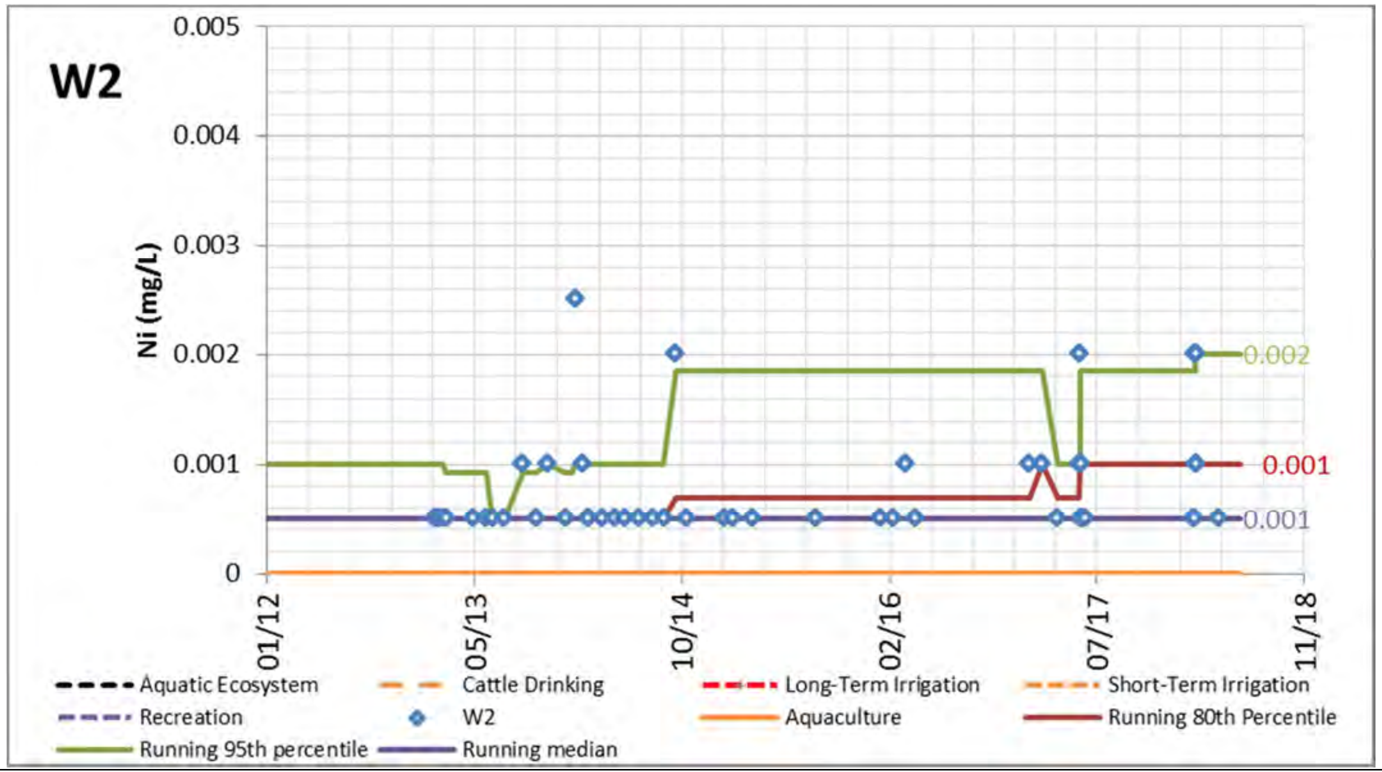


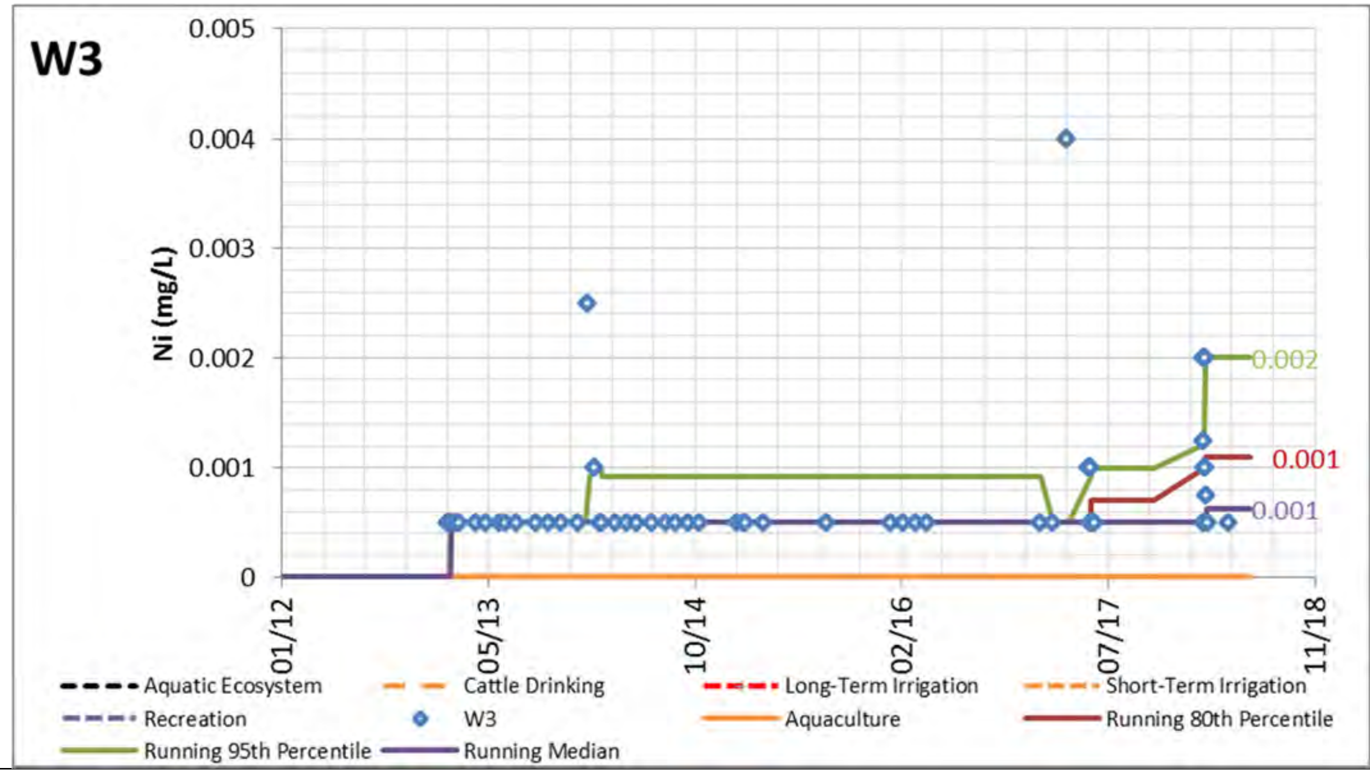


Dissolved Nickel

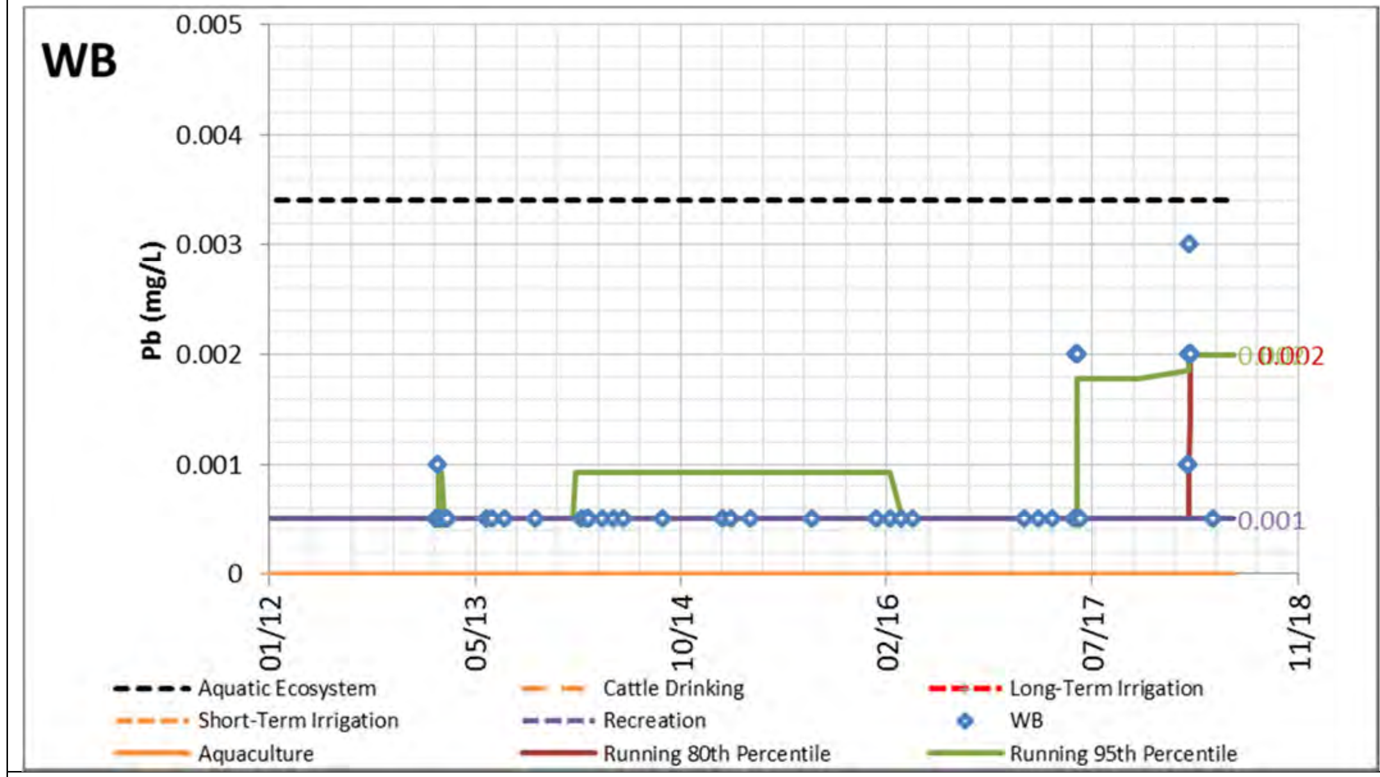


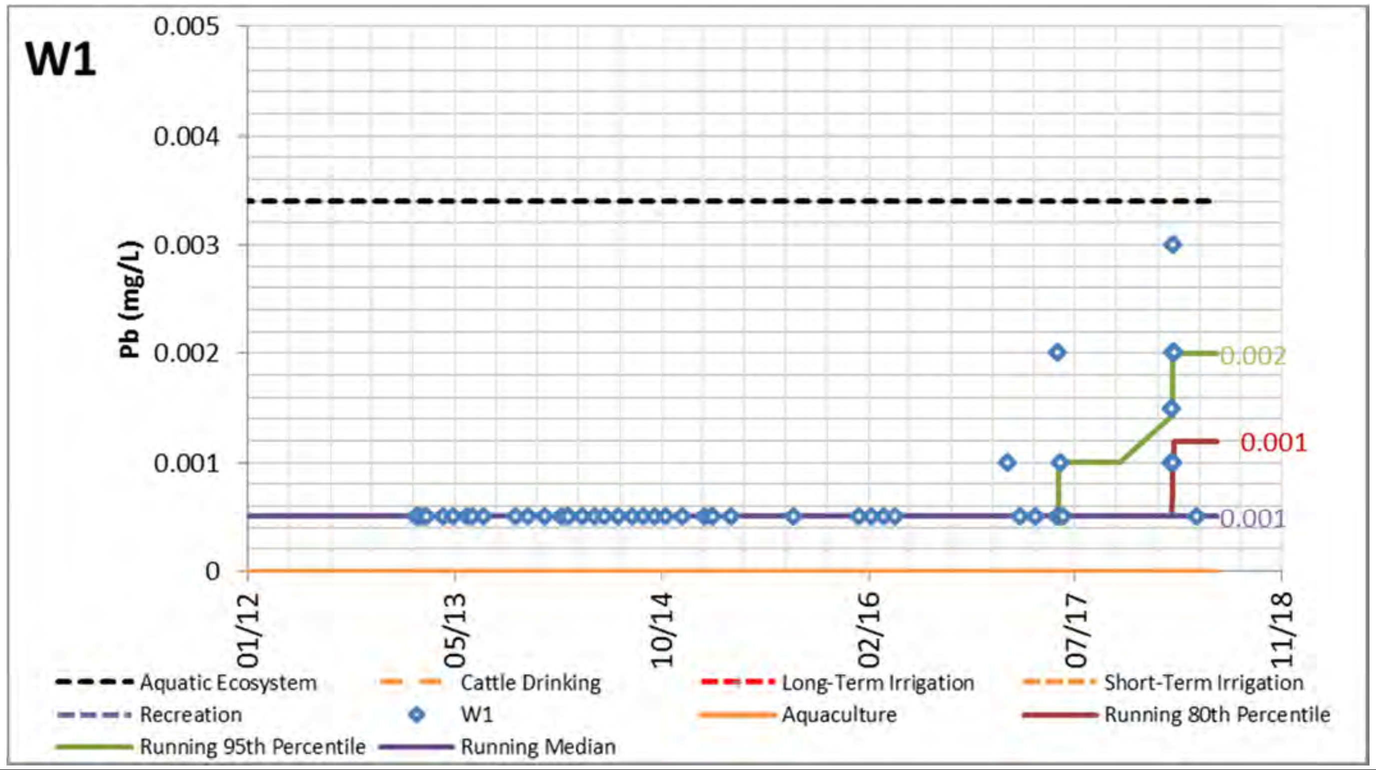


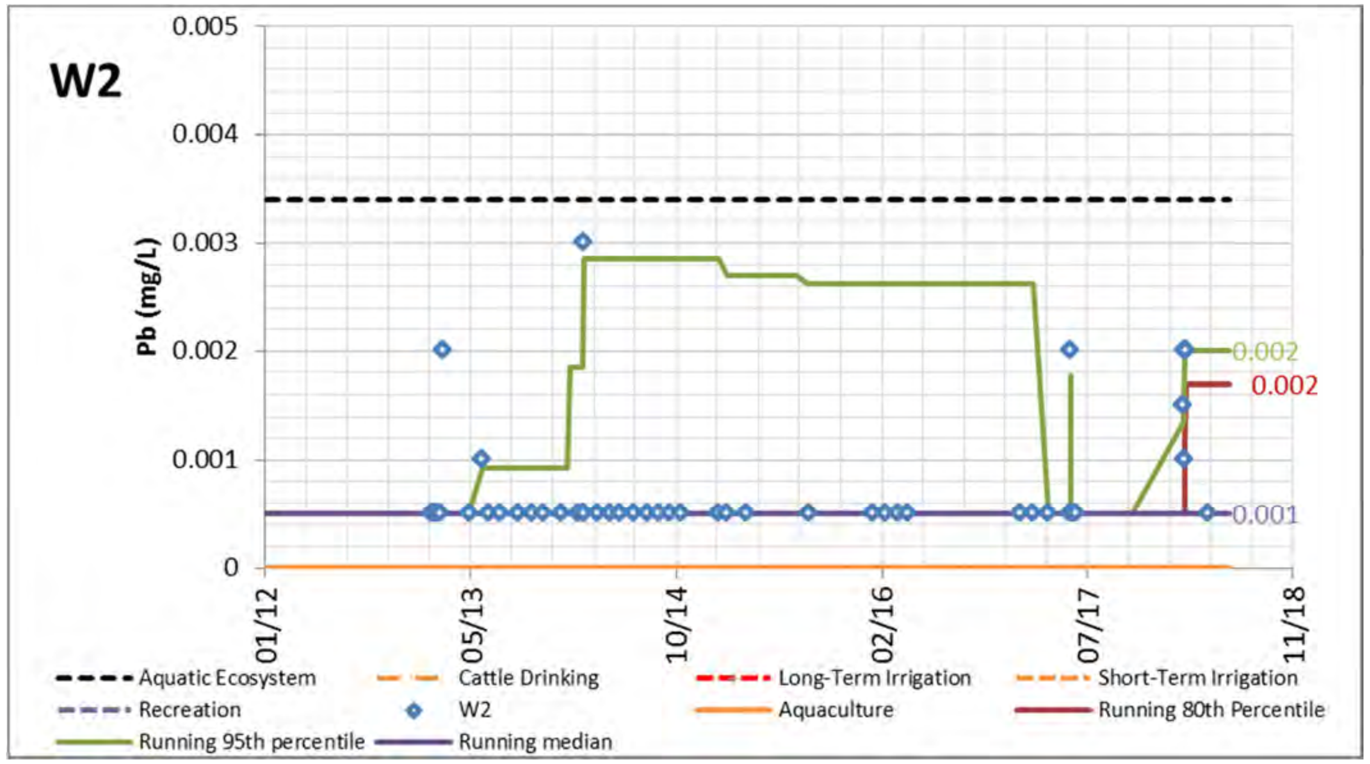


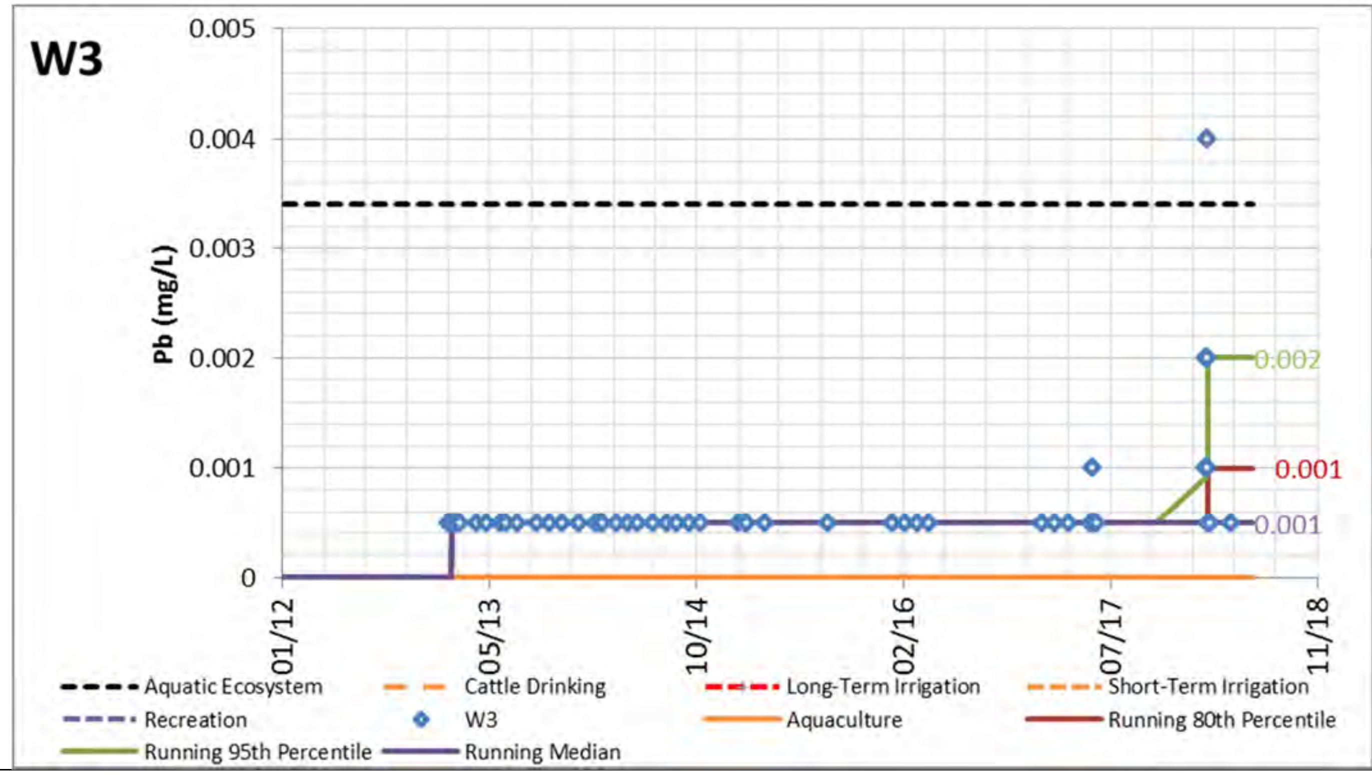


Dissolved Lead

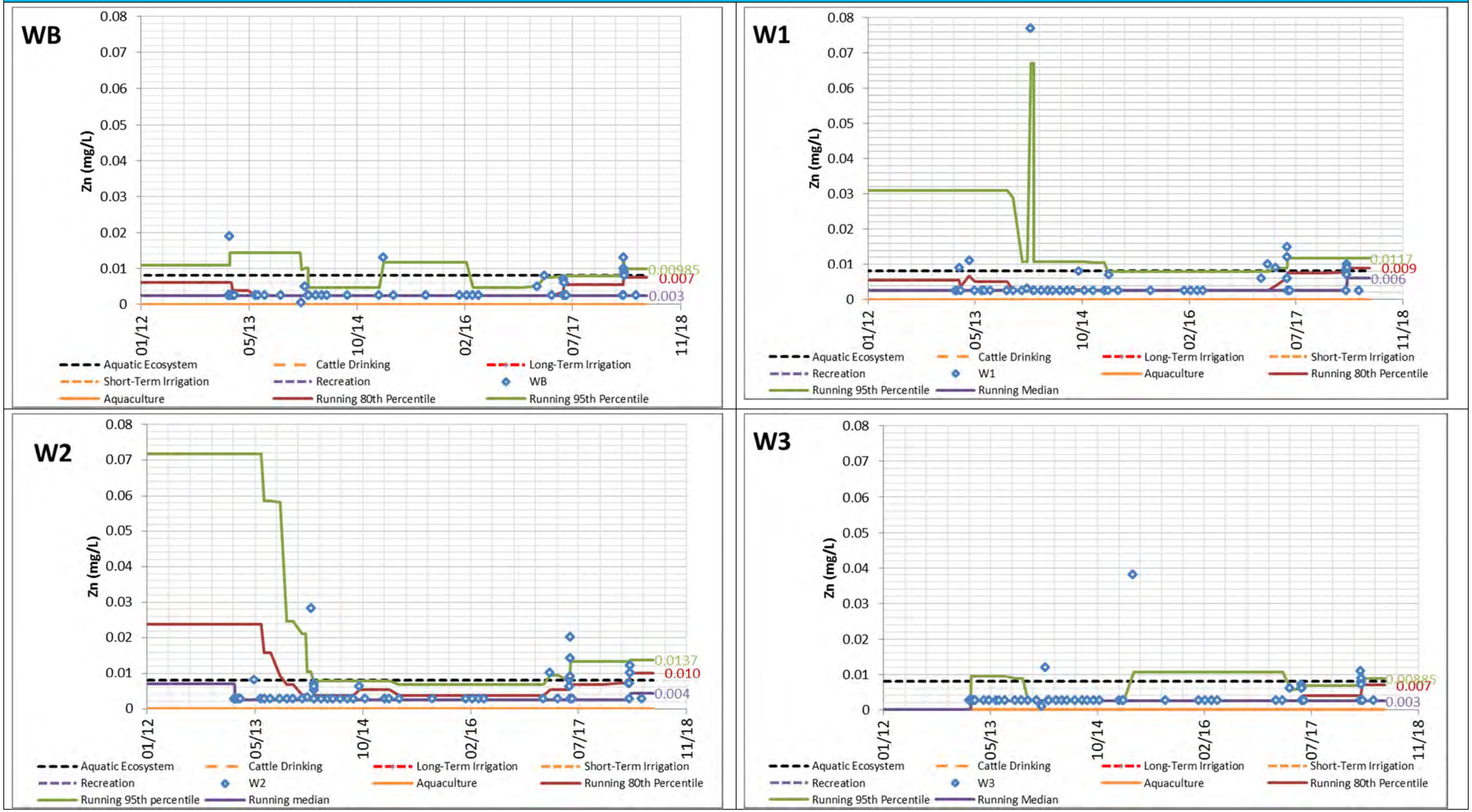




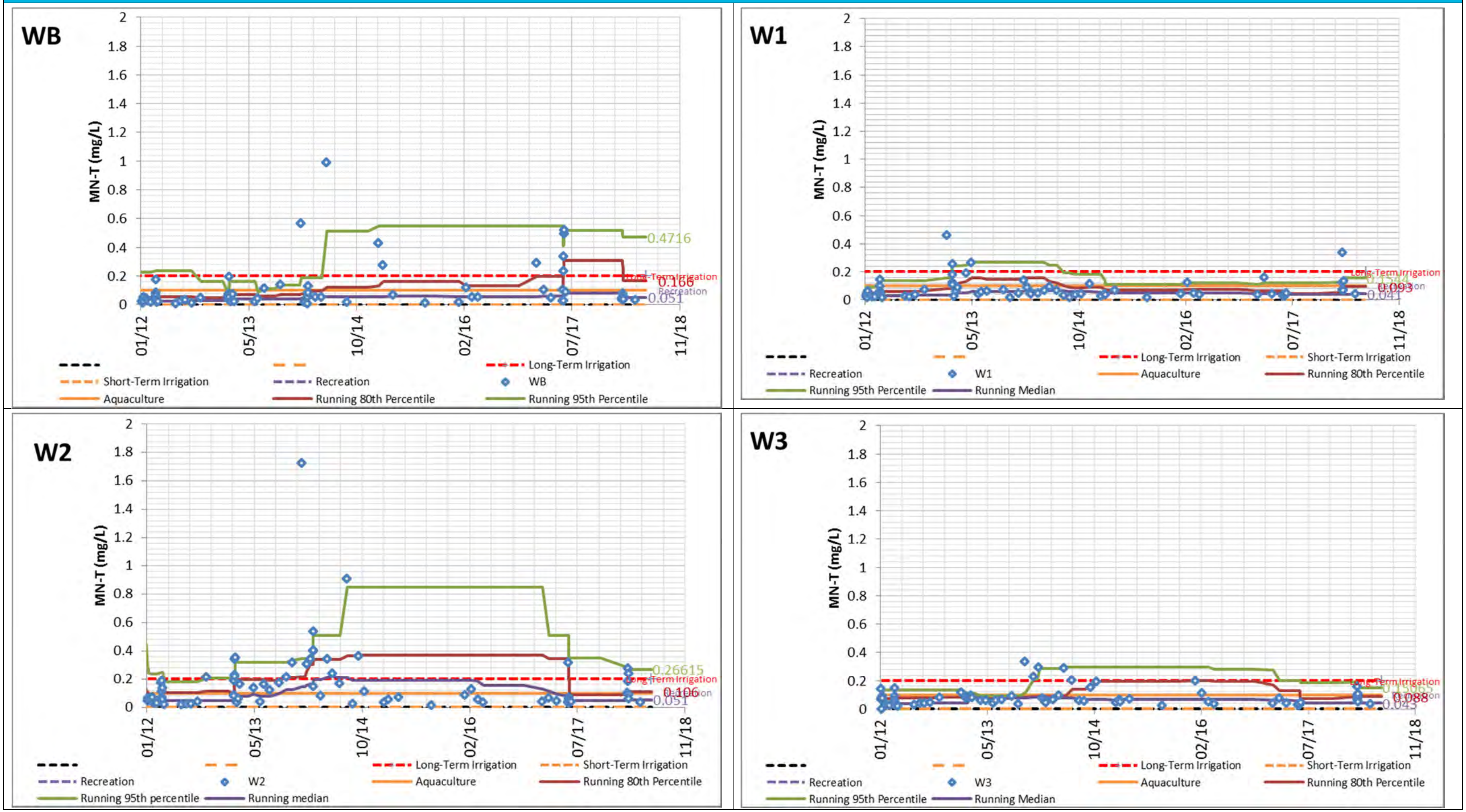




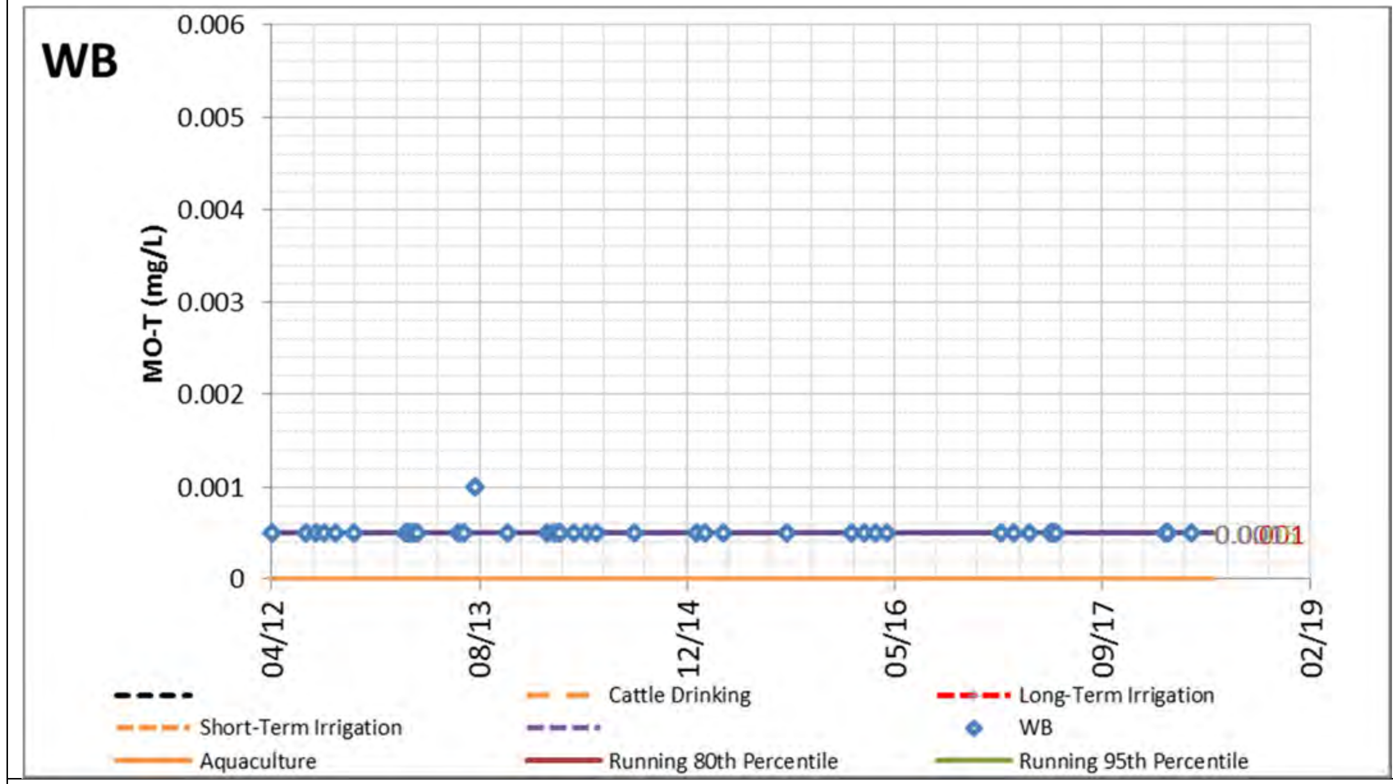
Dissolved Zinc

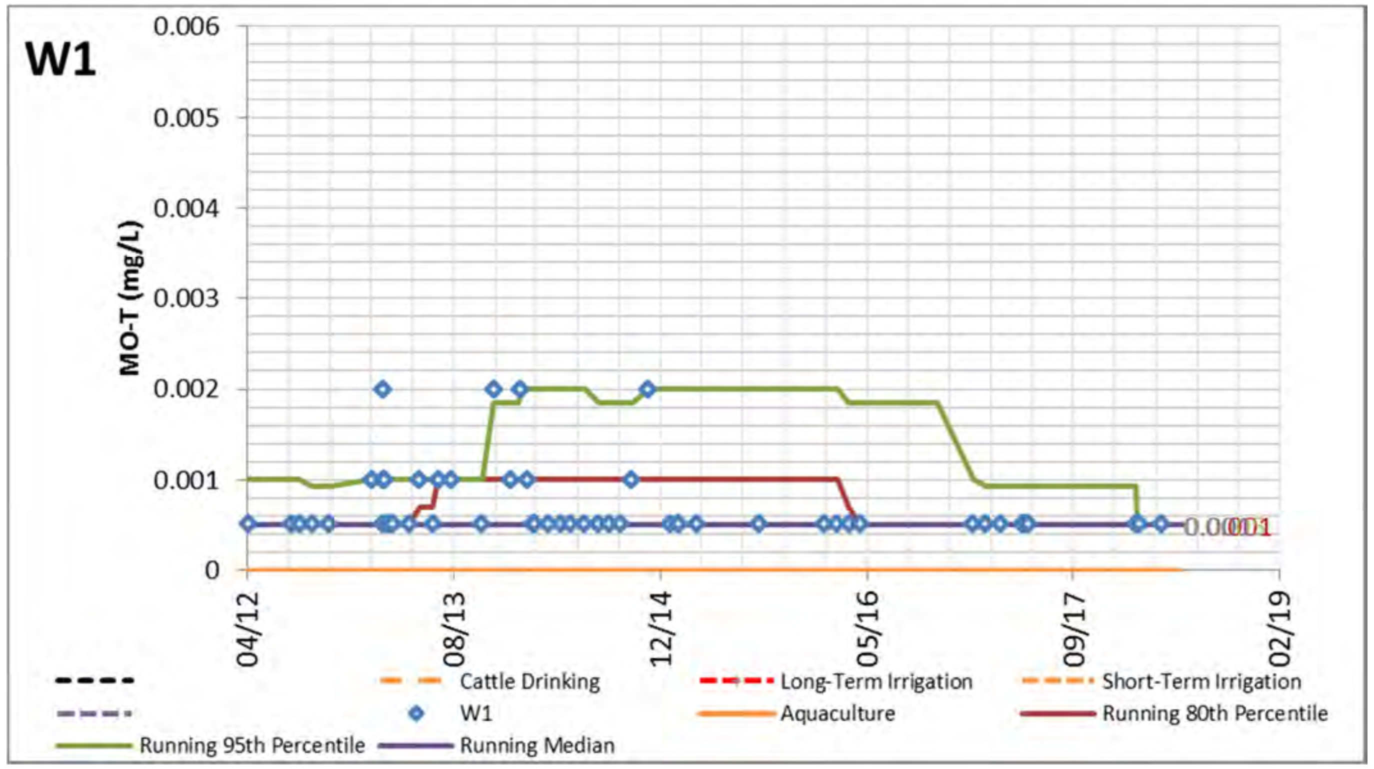


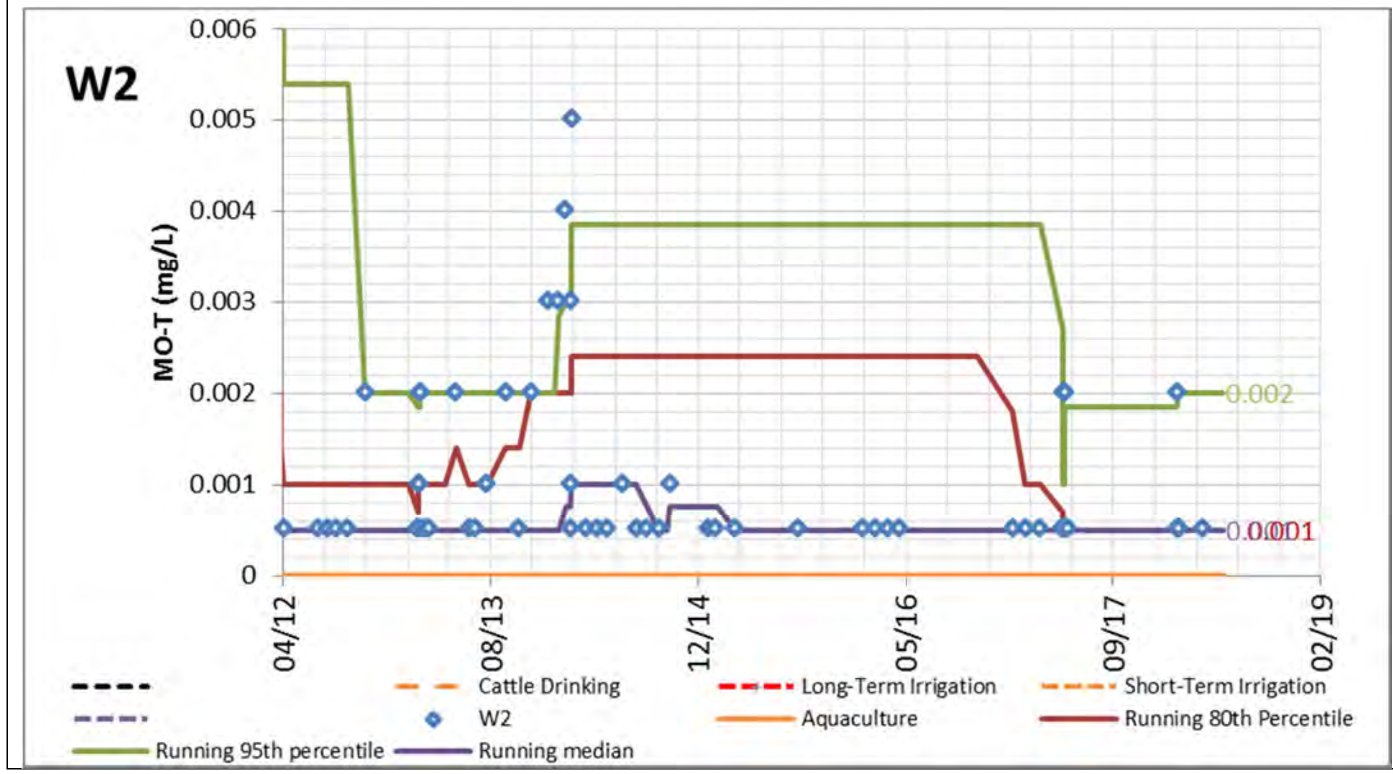
Total Manganese

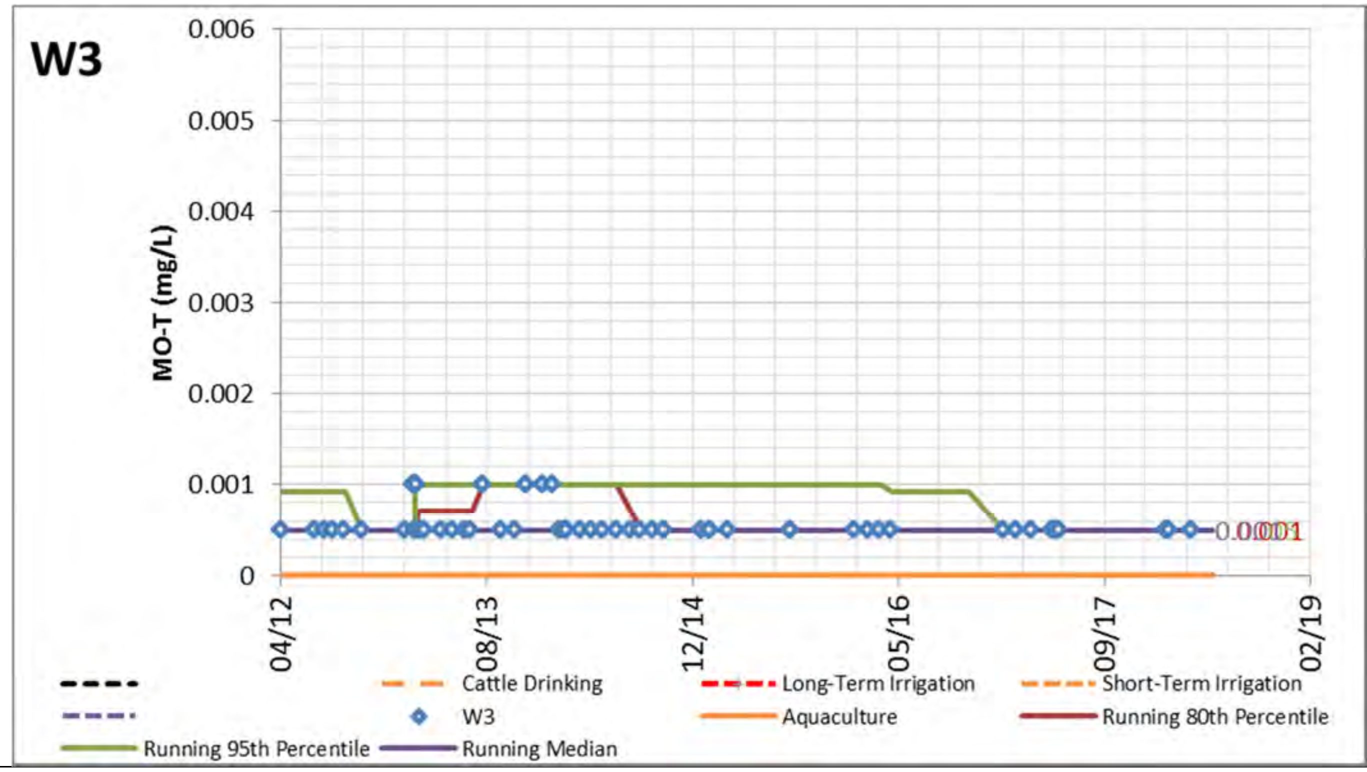


Total Molybdenum









Appendix B

Water Quality Statistics Table

Appendix B Water Quality Statistics Table

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
PH-L	pH Units	E1	1	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	N/A
		E2	1	7.64	7.64	7.64	7.64	7.64	7.64	7.64	7.64	7.64	7.64	7.64	7.64	N/A
		Pit1	19	7.42	7.572	7.6	7.7	7.89	7.9	7.904	7.944	8	8	8	7.802	0.172
		Pit2	18	7.4	7.7	7.824	7.863	7.915	8.188	8.2	8.26	8.43	8.566	8.6	7.989	0.278
		W1	83	6.7	7.276	7.464	7.505	7.75	7.93	8.002	8.158	8.377	8.993	9.05	7.744	0.406
		W2	85	6.89	7.36	7.518	7.53	7.78	7.97	8.024	8.376	8.542	8.743	8.81	7.796	0.383
		W3	95	6.81	7.294	7.476	7.52	7.8	8	8.05	8.162	8.225	8.407	8.51	7.749	0.357
		W4	17	7.37	7.542	7.576	7.6	7.86	8.07	8.142	8.218	8.282	8.352	8.37	7.861	0.287
		W5	11	7.33	7.36	7.38	7.42	7.64	8.115	8.27	8.42	8.425	8.429	8.43	7.788	0.426
		WA	19	7.37	7.456	7.466	7.505	7.63	7.665	7.726	7.956	8.034	8.135	8.16	7.645	0.206
		WB	77	6.47	7.372	7.474	7.53	7.73	7.95	7.99	8.094	8.288	8.586	8.73	7.733	0.351
COND-L	µS/cm	E1	1	181	181	181	181	181	181	181	181	181	181	181	181	N/A
		E2	1	100	100	100	100	100	100	100	100	100	100	100	100	N/A
		Pit1	19	2000	2200	2300	2305	2950	3285	3576	4110	4214	4675	4790	2995	786.5
		Pit2	18	3800	4168	4560	4705	5240	6563	7240	8060	8470	9694	10000	5821	1676
		W1	83	70	88	95.8	102.5	135	214	235	290.8	312.8	912.4	3420	202.1	365.6
		W2	85	68	98	106	114	167	273	294.4	466.6	552.8	769.7	910	227.6	162.8
		W3	95	60	71	98.8	105	150	277	285.4	302.2	338.5	392.7	404	183.4	94.83
		W4	17	100	103.6	138.2	163	233	275	275.8	327.6	374	418.8	430	220.9	93.32
		W5	11	97	101	142	149.5	234	283.5	295	374	627	829.4	880	274.5	217.9
		WA	19	60	81.4	88.8	90	108	151.5	173.6	212.8	260.9	469	521	143.7	102.6
		WB	77	55	79	88.2	94	111	180	218	236	266	304.6	313	141.6	66.1
SO4-T	mg/L	E1	1	2	2	2	2	2	2	2	2	2	2	2	2	N/A
		E2	1	2	2	2	2	2	2	2	2	2	2	2	2	N/A

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		Pit1	19	240	998	1160	1200	1500	1990	2126	2240	2410	2482	2500	1574	571.7
		Pit2	18	2300	2401	2640	2728	3205	3950	4000	4151	4290	4378	4400	3281	683.2
		W1	83	0.5	1	2	2	4	11	11.6	24.8	36.7	162.5	634	16.54	69.54
		W2	85	0.5	2	4	5	10	26	31.2	53.2	118	192.8	260	25.18	42.17
		W3	95	0.5	0.5	2	2.25	4	6	10	15.2	18.9	25.92	56	6.337	7.542
		W4	17	0.5	2	3	3	11	18	27.6	42.8	50.4	51.68	52	16.15	16.7
		W5	11	0.5	2	2.5	2.75	7	17.5	26	125	178.5	221.3	232	38.36	73.62
		WA	19	0.5	0.5	1	1	2	3	3.4	4.4	24.3	156.1	189	11.97	42.89
		WB	77	0.5	0.5	1	1	2	4	4.8	8	8.6	13.92	20	3.143	3.376
AL-T	mg/L	E1	1	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	N/A
		E2	1	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	N/A
		Pit1	18	0.01	0.01	0.022	0.025	0.025	0.0385	0.07	0.148	0.193	0.207	0.21	0.0524	0.0614
		Pit2	17	0.0038	0.005	0.005	0.005	0.025	0.025	0.085	0.33	0.402	0.44	0.45	0.0855	0.144
		W1	83	0.005	0.02	0.054	0.095	0.55	1.41	1.512	2.054	2.817	4.585	5.11	0.925	1.091
		W2	85	0.005	0.005	0.02	0.03	0.45	1.2	1.368	1.868	2.02	3.483	3.92	0.724	0.833
		W3	95	0.005	0.005	0.01	0.03	0.52	1.52	1.642	3.218	5.849	9.796	16	1.366	2.446
		W4	17	0.02	0.026	0.068	0.1	0.16	1.4	1.448	1.54	1.628	1.718	1.74	0.62	0.685
		W5	11	0.005	0.005	0.02	0.02	0.36	1.26	1.38	1.44	1.77	2.034	2.1	0.658	0.747
		WA	19	0.005	0.286	0.622	0.705	1.67	2.665	2.854	3.51	3.869	4.726	4.94	1.831	1.359
		WB	77	0.005	0.01	0.02	0.04	0.54	1.54	2.066	3.026	3.802	5.486	5.57	1.095	1.35
AS-T	mg/L	E1	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		E2	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		Pit1	19	0.012	0.0174	0.0202	0.0215	0.026	0.043	0.0592	0.086	0.125	0.233	0.26	0.0478	0.0576
		Pit2	17	0.007	0.0223	0.05	0.05	0.072	0.2	0.208	0.247	0.486	1.169	1.34	0.172	0.311
		W1	83	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.002	0.003	0.003	0.00536	0.007	0.00116	0.00122
		W2	85	0.0005	0.0005	0.0005	0.0005	0.001	0.002	0.003	0.006	0.0108	0.0186	0.032	0.00265	0.00441

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		W3	95	0.0005	0.0005	0.0005	0.0005	0.001	0.002	0.0022	0.003	0.004	0.0066	0.016	0.00171	0.00191
		W4	17	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.002	0.0022	0.00284	0.003	0.00091	0.00073
		W5	11	0.0005	0.0005	0.0005	0.0005	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.00114	0.00071
		WA	19	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0006	0.0011	0.00182	0.002	0.00061	0.00036
		WB	77	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.002	0.00272	0.005	0.00074	0.00063
CD-T	mg/L	E1	1	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	N/A
		E2	1	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	N/A
		Pit1	16	0.0018	0.0114	0.015	0.015	0.0221	0.0261	0.0291	0.0383	0.0417	0.0451	0.046	0.0226	0.0115
		Pit2	17	0.0004	0.0005	0.00052	0.0006	0.001	0.0016	0.00288	0.00382	0.00412	0.0045	0.0046	0.0016	0.00137
		W1	83	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.0002	0.00058	0.00191	0.0024	0.00014	0.00034
		W2	85	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.0001	0.00018	0.00071	0.0013	8.2E-05	0.00015
		W3	95	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.0002	0.0005	0.0005	0.0005	9.4E-05	0.00012
		W4	17	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	1.4E-20
		W5	11	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.0007	0.00265	0.00421	0.0046	0.00052	0.00137
		WA	19	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00012	0.00058	0.0007	8.4E-05	0.00015
		WB	77	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00006	0.00029	0.0009	6.3E-05	9.7E-05
CO-T	mg/L	E1	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		E2	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		Pit1	18	0.005	0.005	0.005	0.00525	0.025	0.025	0.0298	0.0541	0.644	3.201	3.84	0.234	0.9
		Pit2	16	0.002	0.002	0.002	0.002	0.0055	0.025	0.025	0.213	0.448	0.562	0.591	0.0714	0.169
		W1	83	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.002	0.002	0.00418	0.005	0.00081	0.00081
		W2	85	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0016	0.002	0.00216	0.003	0.0007	0.00051
		W3	88	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.00313	0.004	0.00064	0.00051
		W4	17	0.0005	0.0005	0.0005	0.0005	0.0005	0.002	0.002	0.0024	0.0032	0.00384	0.004	0.00132	0.00107
		W5	11	0.0005	0.0005	0.0005	0.0005	0.0005	0.00075	0.001	0.002	0.002	0.002	0.002	0.00082	0.0006
		WA	19	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00055	0.00091	0.001	0.00053	0.00011

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		WB	77	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.002	0.003	0.003	0.00071	0.00054
Cr-T	mg/L	E1	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		E2	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		Pit1	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		Pit2	1	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	N/A
		W1	83	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.002	0.0029	0.00518	0.006	0.00093	0.00106
		W2	85	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.002	0.00416	0.005	0.00076	0.00071
		W3	95	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.002	0.0053	0.0117	0.022	0.00137	0.00268
		W4	17	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.001	0.0012	0.00184	0.002	0.00071	0.0004
		W5	11	0.0005	0.0005	0.0005	0.0005	0.0005	0.00075	0.001	0.001	0.0015	0.0019	0.002	0.00073	0.00047
		WA	19	0.0005	0.0005	0.0005	0.0005	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.00134	0.00073
		WB	77	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.002	0.002	0.003	0.005	0.005	0.00104	0.00103
CU-T	mg/L	E1	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		E2	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		Pit1	18	0.001	0.002	0.002	0.002	0.005	0.01	0.0118	0.0253	0.043	0.0566	0.06	0.0106	0.0155
		Pit2	17	0.002	0.002	0.0022	0.003	0.005	0.006	0.006	0.0128	0.0276	0.0615	0.07	0.00906	0.0161
		W1	83	0.0005	0.0005	0.001	0.001	0.002	0.003	0.004	0.006	0.0107	0.0435	0.114	0.00455	0.013
		W2	85	0.0005	0.0005	0.0005	0.0005	0.002	0.003	0.003	0.004	0.0058	0.013	0.018	0.0022	0.00256
		W3	95	0.0005	0.0005	0.0005	0.001	0.002	0.003	0.004	0.006	0.0096	0.0212	0.024	0.00302	0.0039
		W4	17	0.0005	0.0005	0.0006	0.001	0.002	0.002	0.0028	0.003	0.0032	0.00384	0.004	0.00182	0.00104
		W5	11	0.0005	0.0005	0.001	0.0015	0.002	0.003	0.003	0.003	0.0045	0.0057	0.006	0.00227	0.00154
		WA	19	0.0005	0.0018	0.002	0.002	0.003	0.004	0.004	0.004	0.0047	0.00974	0.011	0.00324	0.00214
		WB	77	0.0005	0.0005	0.0005	0.0005	0.002	0.004	0.004	0.007	0.0082	0.01	0.01	0.0027	0.00261
MN-T	mg/L	E1	1	0.272	0.272	0.272	0.272	0.272	0.272	0.272	0.272	0.272	0.272	0.272	0.272	N/A
		E2	1	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	N/A
		Pit1	13	0.455	0.493	0.756	1.1	1.34	1.7	2.24	3.112	3.452	3.706	3.77	1.593	1.029

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		Pit2	12	0.025	0.025	0.025	0.025	0.0675	0.0953	0.107	0.217	1.156	2.063	2.29	0.257	0.643
		W1	83	0.016	0.0242	0.0284	0.031	0.046	0.0785	0.102	0.144	0.191	0.359	0.459	0.0731	0.0731
		W2	85	0.0005	0.026	0.032	0.038	0.073	0.184	0.224	0.335	0.387	1.034	1.72	0.151	0.223
		W3	88	0.0005	0.0277	0.0328	0.038	0.064	0.085	0.0958	0.149	0.2	0.3	0.333	0.0781	0.0618
		W4	17	0.008	0.0308	0.0388	0.042	0.064	0.096	0.109	0.127	0.153	0.192	0.202	0.0742	0.0482
		W5	11	0.006	0.025	0.028	0.029	0.063	0.128	0.141	0.158	0.275	0.369	0.392	0.0986	0.11
		WA	19	0.009	0.0128	0.015	0.0155	0.026	0.0725	0.0944	0.115	0.133	0.208	0.227	0.0521	0.0566
		WB	77	0.009	0.0166	0.024	0.027	0.047	0.085	0.111	0.261	0.443	0.669	0.988	0.101	0.157
MO-T	mg/L	E1	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		E2	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		Pit1	18	0.012	0.025	0.0338	0.0478	0.0515	0.0633	0.0652	0.0682	0.0754	0.0951	0.1	0.0518	0.0206
		Pit2	16	0.025	0.0415	0.051	0.0548	0.075	0.245	0.29	0.3	0.305	0.317	0.32	0.138	0.111
		W1	83	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.0019	0.002	0.002	0.00064	0.00038
		W2	85	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.002	0.003	0.00516	0.006	0.00098	0.00102
		W3	88	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.00113	0.002	0.00057	0.00022
		W4	17	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	2.2E-19
		W5	11	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00275	0.00455	0.005	0.00091	0.00136
		WA	19	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00095	0.00419	0.005	0.00074	0.00103
		WB	77	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00244	0.007	0.0006	0.00074
NI-T	mg/L	E1	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		E2	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		Pit1	17	0.01	0.0186	0.0216	0.024	0.025	0.036	0.04	0.0428	0.0442	0.0448	0.045	0.0281	0.00999
		Pit2	16	0.002	0.002	0.002	0.00238	0.00275	0.0175	0.025	0.025	0.0438	0.0888	0.1	0.0141	0.0246
		W1	83	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.002	0.003	0.00418	0.005	0.00101	0.00094
		W2	85	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.002	0.002	0.00316	0.004	0.00091	0.00072
		W3	95	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.002	0.003	0.004	0.00642	0.013	0.00125	0.00165

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		W4	17	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.0014	0.0022	0.00284	0.003	0.00085	0.00068
		W5	11	0.0005	0.0005	0.0005	0.0005	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.00114	0.00071
		WA	19	0.0005	0.0005	0.0005	0.0005	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.00116	0.00062
		WB	77	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.002	0.002	0.003	0.00324	0.004	0.001	0.00081
PB-T	mg/L	E1	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		E2	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		Pit1	18	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.0046	0.0395	0.16	0.19	0.0118	0.0446
		Pit2	16	0.0005	0.0005	0.0005	0.0005	0.002	0.0025	0.0025	0.0085	0.0108	0.0126	0.013	0.00303	0.00372
		W1	83	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.003	0.0086	0.012	0.012	0.00142	0.00248
		W2	85	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.002	0.003	0.00648	0.009	0.00104	0.00133
		W3	95	0.0005	0.0005	0.0005	0.0005	0.0005	0.002	0.002	0.003	0.006	0.0105	0.018	0.00152	0.00244
		W4	17	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0009	0.002	0.0022	0.00284	0.003	0.00085	0.00075
		W5	11	0.0005	0.0005	0.0005	0.0005	0.0005	0.00125	0.002	0.002	0.002	0.002	0.002	0.00091	0.0007
		WA	19	0.0005	0.0005	0.0005	0.0005	0.002	0.002	0.002	0.002	0.0021	0.00282	0.003	0.00142	0.00079
		WB	77	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.002	0.004	0.006	0.007	0.007	0.0014	0.00173
ZN-T	mg/L	E1	1	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	N/A
		E2	1	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	N/A
		Pit1	19	0.006	0.014	0.028	0.0335	0.152	0.887	1.033	1.936	2.1	2.244	2.28	0.594	0.761
		Pit2	17	0.011	0.034	0.0462	0.047	0.128	0.152	0.174	0.304	0.861	2.572	3	0.283	0.706
		W1	83	0.0025	0.0025	0.0025	0.0025	0.0025	0.008	0.009	0.023	0.0893	0.128	0.177	0.0131	0.0292
		W2	85	0.0025	0.0025	0.0025	0.0025	0.0025	0.009	0.0104	0.0216	0.0292	0.0957	0.115	0.00955	0.0173
		W3	95	0.0025	0.0025	0.0025	0.0025	0.0025	0.008	0.012	0.0172	0.0414	0.0599	0.09	0.00888	0.0141
		W4	17	0.0025	0.0025	0.0025	0.0025	0.0025	0.005	0.005	0.0092	0.013	0.0194	0.021	0.00471	0.00484
		W5	11	0.0025	0.0025	0.0025	0.00425	0.007	0.008	0.008	0.052	0.201	0.32	0.35	0.0411	0.103
		WA	19	0.0025	0.0025	0.0046	0.0065	0.008	0.0105	0.0136	0.0242	0.0278	0.048	0.053	0.0116	0.0119
		WB	77	0.0025	0.0025	0.0025	0.0025	0.0025	0.007	0.0108	0.018	0.028	0.0542	0.074	0.00781	0.0117

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
CN-T	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	3	0.002	0.002	0.002	0.002	0.002	1.111	1.333	1.776	1.998	2.176	2.22	0.741	1.281
		Pit2	3	0.002	0.002	0.002	0.002	0.002	0.188	0.225	0.3	0.337	0.367	0.374	0.126	0.215
		W1	59	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.00326	0.005	0.00205	0.00039
		W2	59	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.00742	0.008	0.00219	0.00101
		W3	69	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	1.3E-18
		W4	12	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	4.5E-19
		W5	10	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	4.6E-19
		WA	11	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.0035	0.0047	0.005	0.00227	0.0009
		WB	52	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	1.3E-18
CN-WAD	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	13	0.002	0.002	0.002	0.002	0.0025	0.0025	0.0025	0.0189	0.0258	0.0292	0.03	0.006	0.00921
		Pit2	12	0.002	0.002	0.002	0.002	0.0025	0.0025	0.0025	0.0111	0.0341	0.0556	0.061	0.008	0.0169
		W1	23	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.0098	0.012	0.00243	0.00209
		W2	24	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.0243	0.031	0.00321	0.00592
		W3	32	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.0199	0.028	0.00281	0.0046
		W4	5	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0
		W5	1	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	N/A
		WA	8	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0
		WB	24	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	1.3E-18
Alkalinity	mg/L	E1	1	76	76	76	76	76	76	76	76	76	76	76	76	N/A
		E2	1	44	44	44	44	44	44	44	44	44	44	44	44	N/A
		Pit1	2	45	57.5	70	76.25	107.5	138.8	145	157.5	163.8	168.8	170	107.5	88.39
		Pit2	3	28	40.2	52.4	58.5	89	90	90.2	90.6	90.8	90.96	91	69.33	35.81

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		W1	1	43	43	43	43	43	43	43	43	43	43	43	43	N/A
		W2	2	43	44.7	46.4	47.25	51.5	55.75	56.6	58.3	59.15	59.83	60	51.5	12.02
		W3	8	24	25.4	27.2	28.25	30	32	32	37.4	43.7	48.74	50	31.63	7.927
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	1	45	45	45	45	45	45	45	45	45	45	45	45	N/A
FE-T	mg/L	E1	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	N/A
		E2	0.5	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	N/A
		Pit1	2	0.105	0.116	0.127	0.1325	0.16	0.1925	0.199	0.212	0.2185	0.2235	0.225	0.1635	0.12
		Pit2	2	0.5325	0.553	0.5735	0.584	0.635	0.8375	0.878	0.959	0.9995	1.032	1.04	0.736	0.537
		W1	0.5	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	N/A
		W2	1.5	0.16	0.1875	0.215	0.229	0.2975	0.3665	0.38	0.4075	0.4215	0.4325	0.435	0.2975	0.389
		W3	4.5	0.65	1.1365	1.357	1.3675	1.985	2.9915	3.651	5.52	6.825	7.865	8.125	2.799	4.867
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0.5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	N/A
Ca	mg/L	E1	1	10	10	10	10	10	10	10	10	10	10	10	10	N/A
		E2	1	6	6	6	6	6	6	6	6	6	6	6	6	N/A
		Pit1	7	302	317	330	334.5	349	405	408	444	469.5	489.9	495	375	65.38
		Pit2	7	452	459.2	474.4	490	580	595.5	598.8	605.8	609.4	612.3	613	545.1	67.16
		W1	59	2	3	5	5	8	13	13	17.2	18.1	20	20	8.898	5.175
		W2	60	3	3	6	6	12	19	19.2	26.3	34	38.05	41	13.9	9.214
		W3	69	2	3	4	6	8	16	18	20	20.6	24	24	10.77	6.463
		W4	11	6	6	6	7	10	13.5	14	14	14.5	14.9	15	10.09	3.506

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		W5	9	6	6	6	6	12	26	26.8	29.2	31.6	33.52	34	15.67	10.89
		WA	10	6	6	6	6	8	15.5	17.8	23.5	34.75	43.75	46	13.5	12.55
		WB	52	0.5	3	3.4	5	7	13.25	14	16	18.9	22.98	24	8.933	5.638
Mg	mg/L	E1	1	7	7	7	7	7	7	7	7	7	7	7	7	N/A
		E2	1	3	3	3	3	3	3	3	3	3	3	3	3	N/A
		Pit1	7	90	90.6	92.4	94.5	98	100	100	110.4	118.2	124.4	126	100.4	12
		Pit2	7	130	134.2	137.2	137.5	138	141.5	142.4	161.8	175.9	187.2	190	145.1	20.17
		W1	60	1	1	2	2	5	9	10	12	14	15.41	16	5.95	4.156
		W2	61	1	1	3	4	7	12	12	18	20	27	30	8.705	6.611
		W3	70	1	1	2	3	5	9.75	10	11	12	13.62	15	5.971	3.978
		W4	12	3	3	3.2	3.75	4	7	7	7	11.05	15.01	16	5.75	3.646
		W5	10	3	3	3	3	5.5	6.75	8.8	16.6	19.3	21.46	22	7.4	6.45
		WA	11	2	2	2	2.5	4	5.5	6	16	23	28.6	30	7	8.602
		WB	53	0.5	1	2	3	4	7	9	10	12	14.92	17	5.255	3.723
Na	mg/L	E1	1	20	20	20	20	20	20	20	20	20	20	20	20	N/A
		E2	1	11	11	11	11	11	11	11	11	11	11	11	11	N/A
		Pit1	1	287	287	287	287	287	287	287	287	287	287	287	287	N/A
		Pit2	2	591	592	593	593.5	596	598.5	599	600	600.5	600.9	601	596	7.071
		W1	1	11	11	11	11	11	11	11	11	11	11	11	11	N/A
		W2	2	10	10	10	10	10	10	10	10	10	10	10	10	0
		W3	8	4	4	4	4	4	4.25	4.6	6.8	8.9	10.58	11	5	2.449
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	1	10	10	10	10	10	10	10	10	10	10	10	10	N/A
K	mg/L	E1	1	2	2	2	2	2	2	2	2	2	2	2	2	N/A

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		E2	1	2	2	2	2	2	2	2	2	2	2	2	2	N/A
		Pit1	1	44	44	44	44	44	44	44	44	44	44	44	44	N/A
		Pit2	2	116	116.1	116.2	116.3	116.5	116.8	116.8	116.9	117	117	117	116.5	0.707
		W1	1	2	2	2	2	2	2	2	2	2	2	2	2	N/A
		W2	2	2	2	2	2	2	2	2	2	2	2	2	2	0
		W3	8	1	1.7	2	2	2	2	2	2	2	2	2	1.875	0.354
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	1	2	2	2	2	2	2	2	2	2	2	2	2	N/A
Cl	mg/L	E1	1	12	12	12	12	12	12	12	12	12	12	12	12	N/A
		E2	1	6	6	6	6	6	6	6	6	6	6	6	6	N/A
		Pit1	1	91	91	91	91	91	91	91	91	91	91	91	91	N/A
		Pit2	2	181	181	181	181	181	181	181	181	181	181	181	181	0
		W1	1	5	5	5	5	5	5	5	5	5	5	5	5	N/A
		W2	2	6	6.2	6.4	6.5	7	7.5	7.6	7.8	7.9	7.98	8	7	1.414
		W3	8	3	3	3.4	3.75	4	4.25	4.6	5.3	5.65	5.93	6	4.125	0.991
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	1	6	6	6	6	6	6	6	6	6	6	6	6	N/A
F	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	1	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	N/A
		Pit2	2	4.3	4.38	4.46	4.5	4.7	4.9	4.94	5.02	5.06	5.092	5.1	4.7	0.566
		W1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		W2	1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	N/A
		W3	7	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	7.5E-18
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Al-F	mg/L	E1	1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	N/A
		E2	1	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	N/A
		Pit1	8	0.005	0.005	0.005	0.005	0.005	0.00875	0.014	0.02	0.02	0.02	0.02	0.00875	0.00694
		Pit2	6	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0
		W1	72	0.005	0.005	0.005	0.00875	0.15	0.515	0.578	0.807	1.015	1.979	3.86	0.335	0.534
		W2	69	0.005	0.005	0.005	0.005	0.05	0.38	0.474	0.804	0.982	1.529	2.25	0.255	0.399
		W3	82	0.005	0.005	0.005	0.005	0.125	0.488	0.644	1.026	1.166	1.588	2.09	0.331	0.442
		W4	16	0.005	0.0075	0.01	0.01	0.045	0.32	0.41	1.07	1.3	1.54	1.6	0.311	0.494
		W5	10	0.005	0.005	0.005	0.005	0.0775	0.54	0.622	0.876	1.083	1.249	1.29	0.332	0.448
		WA	16	0.005	0.125	0.18	0.188	0.645	1.225	1.36	1.765	1.815	1.875	1.89	0.81	0.639
		WB	66	0.005	0.005	0.005	0.005	0.21	0.48	0.52	0.815	1.058	2.979	3.33	0.37	0.598
As-F	mg/L	E1	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		E2	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		Pit1	7	0.01	0.01	0.0104	0.011	0.013	0.041	0.05	0.056	0.056	0.056	0.056	0.0261	0.0211
		Pit2	6	0.0226	0.0253	0.028	0.029	0.038	0.195	0.245	0.718	0.954	1.143	1.19	0.26	0.463
		W1	58	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.002	0.003	0.00386	0.005	0.0009	0.0009
		W2	59	0.0005	0.0005	0.0005	0.0005	0.0005	0.002	0.002	0.005	0.0091	0.0156	0.022	0.00204	0.00351
		W3	69	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.002	0.002	0.0026	0.006	0.006	0.00109	0.00113
		W4	12	0.0005	0.0005	0.0005	0.0005	0.0005	0.00125	0.0018	0.002	0.00245	0.00289	0.003	0.001	0.00085
		W5	10	0.0005	0.0005	0.0005	0.0005	0.0005	0.00163	0.002	0.002	0.002	0.002	0.002	0.00095	0.00072

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		WA	11	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.0015	0.0019	0.002	0.00068	0.00046
		WB	53	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.002	0.00296	0.004	0.00071	0.00059
Cd-F	mg/L	E1	1	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	N/A
		E2	1	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	N/A
		Pit1	7	0.0011	0.00812	0.0131	0.0135	0.0203	0.0233	0.0235	0.027	0.0296	0.0316	0.0321	0.0182	0.00989
		Pit2	6	0.0002	0.00035	0.0005	0.0005	0.00055	0.0006	0.0006	0.0009	0.00105	0.00117	0.0012	0.0006	0.00033
		W1	60	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00069	0.0014	7.5E-05	0.00018
		W2	59	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00014	0.0002	5.3E-05	2E-05
		W3	69	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00006	0.0005	0.0005	0.0005	9E-05	0.00013
		W4	12	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	1.4E-20
		W5	10	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	8.5E-05	0.00024	0.00037	0.0004	8.5E-05	0.00011
		WA	11	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00038	0.00064	0.0007	0.00011	0.0002
		WB	53	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	6.8E-21
Co-F	mg/L	E1	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		E2	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		Pit1	7	0.003	0.0036	0.004	0.004	0.005	0.005	0.005	0.0146	0.0218	0.0276	0.029	0.00786	0.00935
		Pit2	6	0.0005	0.0005	0.0005	0.00088	0.002	0.002	0.002	0.012	0.017	0.021	0.022	0.00483	0.00844
		W1	60	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00053	0.001	0.001	0.00053	0.00011
		W2	61	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	3.3E-19
		W3	63	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	3.3E-19
		W4	12	0.0005	0.0005	0.0005	0.0005	0.0005	0.002	0.002	0.002	0.002	0.002	0.002	0.00104	0.00072
		W5	10	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00055	0.00078	0.00096	0.001	0.00055	0.00016
		WA	11	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	1.1E-19
		WB	53	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.002	0.002	0.00058	0.00031
Cr-F	mg/L	E1	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		E2	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		Pit1	7	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0
		Pit2	6	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0
		W1	56	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.00145	0.002	0.00056	0.00023
		W2	55	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00065	0.001	0.001	0.00053	0.00011
		W3	65	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.00136	0.002	0.00055	0.00022
		W4	12	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	1.1E-19
		W5	10	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	1.1E-19
		WA	11	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	1.1E-19
		WB	53	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0009	0.001	0.002	0.002	0.00059	0.00031
Cu-F	mg/L	E1	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		E2	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		Pit1	7	0.0005	0.0008	0.001	0.001	0.002	0.002	0.002	0.0032	0.0041	0.00482	0.005	0.00193	0.00148
		Pit2	6	0.0005	0.00075	0.001	0.001	0.001	0.001	0.001	0.0015	0.00175	0.00195	0.002	0.00108	0.00049
		W1	49	0.0005	0.0005	0.0005	0.0005	0.001	0.002	0.0024	0.004	0.005	0.00552	0.006	0.0018	0.0015
		W2	42	0.0005	0.0005	0.0005	0.0005	0.001	0.002	0.002	0.003	0.004	0.004	0.004	0.00155	0.00113
		W3	58	0.0005	0.0005	0.0005	0.0005	0.0015	0.002	0.002	0.003	0.00415	0.00629	0.008	0.00169	0.00142
		W4	11	0.0005	0.0005	0.0005	0.0005	0.001	0.002	0.002	0.002	0.003	0.0038	0.004	0.00145	0.00108
		W5	9	0.0005	0.0005	0.0005	0.0005	0.001	0.002	0.002	0.0022	0.0026	0.00292	0.003	0.00128	0.00087
		WA	9	0.0005	0.0009	0.001	0.001	0.002	0.002	0.0024	0.0032	0.0036	0.00392	0.004	0.00194	0.00107
		WB	43	0.0005	0.0005	0.0005	0.0005	0.002	0.0025	0.003	0.004	0.0049	0.005	0.005	0.00187	0.00137
Mn-F	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	1	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	N/A
		Pit1	7	0.091	0.247	0.378	0.418	1.21	1.335	1.38	1.99	2.425	2.773	2.86	1.095	0.93
		Pit2	5	0.002	0.002	0.002	0.002	0.003	0.061	0.0744	0.101	0.115	0.125	0.128	0.0392	0.0558
		W1	58	0.0005	0.0037	0.007	0.008	0.016	0.0238	0.026	0.0351	0.0464	0.0749	0.1	0.0184	0.0168
		W2	57	0.001	0.008	0.0162	0.018	0.035	0.094	0.113	0.185	0.248	0.299	0.309	0.0685	0.0777

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		W3	62	0.0005	0.009	0.013	0.0143	0.023	0.0388	0.0438	0.0683	0.105	0.176	0.182	0.034	0.0349
		W4	12	0.006	0.0171	0.018	0.018	0.0295	0.054	0.0628	0.0669	0.0994	0.131	0.139	0.0418	0.0363
		W5	10	0.002	0.0047	0.0154	0.0185	0.0425	0.0633	0.0668	0.0758	0.0839	0.0904	0.092	0.0419	0.0313
		WA	10	0.005	0.0068	0.0166	0.0195	0.0285	0.056	0.0682	0.106	0.127	0.144	0.148	0.0462	0.0458
		WB	51	0.0005	0.005	0.01	0.012	0.029	0.058	0.108	0.224	0.375	0.698	0.877	0.0826	0.157
Mo-F	mg/L	E1	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		E2	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		Pit1	6	0.05	0.05	0.05	0.0508	0.0565	0.06	0.06	0.06	0.06	0.06	0.06	0.0555	0.00505
		Pit2	5	0.045	0.0454	0.0458	0.046	0.054	0.058	0.063	0.073	0.078	0.082	0.083	0.0572	0.0154
		W1	58	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00065	0.001	0.00143	0.002	0.00057	0.00024
		W2	55	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.002	0.002	0.00292	0.004	0.00075	0.00065
		W3	61	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.00052	9E-05
		W4	12	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	1.1E-19
		W5	10	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00095	0.00298	0.0046	0.005	0.00095	0.00142
		WA	9	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0
		WB	53	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	3.3E-19
Ni-F	mg/L	E1	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		E2	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		Pit1	7	0.002	0.0134	0.0214	0.022	0.025	0.027	0.0276	0.032	0.035	0.0374	0.038	0.0233	0.0109
		Pit2	6	0.0005	0.0005	0.0005	0.00088	0.002	0.00275	0.003	0.0065	0.00825	0.00965	0.01	0.003	0.00356
		W1	56	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.00145	0.002	0.00059	0.00025
		W2	54	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.00147	0.002	0.0006	0.00026
		W3	64	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.00137	0.002	0.00058	0.00024
		W4	12	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00095	0.001	0.001	0.001	0.00058	0.00019
		W5	9	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0
		WA	9	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0007	0.001	0.001	0.001	0.001	0.00061	0.00022

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		WB	50	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.002	0.002	0.00063	0.00033
Pb-F	mg/L	E1	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		E2	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		Pit1	7	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0
		Pit2	6	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0
		W1	56	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.002	0.00245	0.003	0.00066	0.00048
		W2	57	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0014	0.002	0.002	0.002	0.00068	0.00047
		W3	68	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	0.001	0.00266	0.004	0.00063	0.0005
		W4	12	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	1.1E-19
		W5	10	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	1.1E-19
		WA	11	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	1.1E-19
		WB	50	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.002	0.002	0.00251	0.003	0.00073	0.00056
Zn-F	mg/L	E1	1	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	N/A
		E2	1	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	N/A
		Pit1	7	0.097	0.111	0.122	0.125	0.688	0.976	1.08	1.39	1.57	1.714	1.75	0.677	0.624
		Pit2	5	0.023	0.0382	0.0534	0.061	0.106	0.115	0.117	0.12	0.122	0.124	0.124	0.0858	0.0427
		W1	50	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.003	0.009	0.01	0.0451	0.077	0.00508	0.0107
		W2	54	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.006	0.0077	0.01	0.0185	0.028	0.00408	0.00401
		W3	65	0.001	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0078	0.0114	0.012	0.00306	0.00197
		W4	10	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	4.6E-19
		W5	8	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.00325	0.00413	0.00483	0.005	0.00281	0.00088
		WA	9	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.003	0.004	0.0048	0.005	0.00278	0.00083
		WB	47	0.0005	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0062	0.0087	0.0116	0.013	0.00327	0.00234
HCO3	mg/L	E1	1	92.72	92.72	92.72	92.72	92.72	92.72	92.72	92.72	92.72	92.72	92.72	92.72	N/A
		E2	1	53.68	53.68	53.68	53.68	53.68	53.68	53.68	53.68	53.68	53.68	53.68	53.68	N/A
		Pit1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		Pit2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W1	1	52.46	52.46	52.46	52.46	52.46	52.46	52.46	52.46	52.46	52.46	52.46	52.46	N/A
		W2	6	0.0025	0.00375	0.005	0.00525	0.0065	0.00775	0.008	26.23	39.35	49.84	52.46	8.748	21.41
		W3	8	29.28	30.99	33.18	34.47	36.6	39.04	39.04	45.63	53.31	59.46	61	38.58	9.671
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	1	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	N/A
Hydroxide Alkalinitya sCaCO3	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W2	7	0.5	0.8	1.2	1.5	2	11	14	30	40.5	48.9	51	11.21	18.36
		W3	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Carbonat eAlkalinity asCaCO3	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W2	3	0.188	0.251	0.313	0.344	0.5	0.55	0.56	0.58	0.59	0.598	0.6	0.429	0.215
		W3	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TDS	mg/L	E1	1	118	118	118	118	118	118	118	118	118	118	118	118	N/A
		E2	1	65	65	65	65	65	65	65	65	65	65	65	65	N/A
		Pit1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W1	1	61	61	61	61	61	61	61	61	61	61	61	61	N/A
		W2	2	64	67.5	71	72.75	81.5	90.25	92	95.5	97.25	98.65	99	81.5	24.75
		W3	1	68	68	68	68	68	68	68	68	68	68	68	68	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	1	62	62	62	62	62	62	62	62	62	62	62	62	N/A
Hardness	mg/L	E1	1	54	54	54	54	54	54	54	54	54	54	54	54	N/A
		E2	1	27	27	27	27	27	27	27	27	27	27	27	27	N/A
		Pit1	7	1130	1184	1228	1242	1274	1402	1422	1563	1658	1735	1754	1350	203.8
		Pit2	7	1700	1712	1747	1788	2008	2056	2076	2178	2245	2298	2312	1958	217
		W1	59	9.1	11.6	20.7	21.95	40.5	67.35	76.64	90.92	98.53	104	104.9	46.63	28.67
		W2	61	0	11.6	27.3	27.3	56.2	96.7	101.7	134.7	162.9	206.2	208	69.4	50.26
		W3	69	10.35	11.6	18.2	27.3	40.5	81	88.28	95.6	99.2	109.1	121.5	51.34	32.4
		W4	11	27.3	27.3	31.4	33.9	39.8	62.45	63.7	63.7	64.95	65.95	66.2	44.98	15.53
		W5	9	27.3	27.3	27.3	27.3	50.5	89.6	91.6	110.7	143	168.8	175.2	65.59	48.95
		WA	10	23.2	23.2	25.2	26.1	33.1	58.23	65.82	93.19	165.6	223.5	238	58.76	65.57
		WB	52	3.3	11.6	16.7	23.78	33.9	62	71.9	87.93	91.95	113.8	124.7	43.73	28.97

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
Be-F	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		Pit2	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		W1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W2	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		W3	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ba-F	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	1	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	N/A
		Pit2	1	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	N/A
		W1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W2	1	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	N/A
		W3	1	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Se-F	mg/L	E1	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
		E2	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
		Pit1	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
		Pit2	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		W1	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
		W2	2	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0
		W3	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
V-F	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
		Pit2	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
		W1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W2	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
		W3	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
B-F	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	1	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	N/A
		Pit2	1	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	N/A
		W1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W2	1	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	N/A
		W3	1	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Fe-F	mg/L	E1	1	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	N/A
		E2	1	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	N/A
		Pit1	1	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	N/A
		Pit2	1	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	N/A
		W1	1	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	N/A
		W2	2	0.025	0.0425	0.06	0.0688	0.113	0.156	0.165	0.183	0.191	0.198	0.2	0.113	0.124
		W3	1	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	1	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	N/A
Be-T	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		Pit2	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		W1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W2	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		W3	1	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ba-T	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	1	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	N/A
		Pit2	1	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	N/A
		W1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W2	1	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	N/A
		W3	1	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Se-T	mg/L	E1	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
		E2	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
		Pit1	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
		Pit2	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
		W1	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
		W2	2	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0
		W3	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
V-T	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
		Pit2	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
		W1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		W2	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
		W3	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
B-T	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	1	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	N/A
		Pit2	1	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	N/A
		W1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W2	1	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	N/A
		W3	1	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Fe-T	mg/L	E1	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	N/A
		E2	0.5	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	N/A
		Pit1	2	0.105	0.116	0.127	0.1325	0.16	0.1925	0.199	0.212	0.2185	0.2235	0.225	0.1635	0.12
		Pit2	2	0.5325	0.553	0.5735	0.584	0.635	0.8375	0.878	0.959	0.9995	1.032	1.04	0.736	0.537
		W1	0.5	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	N/A
		W2	1.5	0.16	0.1875	0.215	0.229	0.2975	0.3665	0.38	0.4075	0.4215	0.4325	0.435	0.2975	0.389
		W3	4.5	0.65	1.1365	1.357	1.3675	1.985	2.9915	3.651	5.52	6.825	7.865	8.125	2.799	4.867
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0.5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	N/A
Hg-F	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	1	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	N/A
		Pit2	1	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	N/A
		W1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W2	1	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	N/A
		W3	1	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Hg-T	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	1	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	N/A
		Pit2	1	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	N/A
		W1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W2	1	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	N/A
		W3	1	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
U-F	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		Pit1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W3	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
U-T	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W3	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ammonia	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	N/A
		Pit2	1	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	N/A
		W1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W2	2	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		W3	1	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrite	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
		Pit2	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
		W1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W2	2	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0
		W3	1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrate	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	1	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	N/A
		Pit2	1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	N/A
		W1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W2	2	0.005	0.0105	0.016	0.0188	0.0325	0.0463	0.049	0.0545	0.0573	0.0595	0.06	0.0325	0.0389
		W3	1	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		WB	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrite+Nitrate	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W2	2	0.005	0.0105	0.016	0.0188	0.0325	0.0463	0.049	0.0545	0.0573	0.0595	0.06	0.0325	0.0389
		W3	1	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TKN	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	N/A
		Pit2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W2	2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0
		W3	1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total N	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	1	7	7	7	7	7	7	7	7	7	7	7	7	N/A

Variable	Units	Site	Num Obs	Minimum	10%ile	20%ile	25%ile (Q1)	50%ile (Q2)	75%ile (Q3)	80%ile	90%ile	95%ile	99%ile	Maximum	Mean	SD
		Pit2	1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	N/A
		W1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W2	2	0.2	0.21	0.22	0.225	0.25	0.275	0.28	0.29	0.295	0.299	0.3	0.25	0.0707
		W3	1	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total P	mg/L	E1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		E2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Pit1	1	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	N/A
		Pit2	1	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	N/A
		W1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W2	2	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0
		W3	1	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	N/A
		W4	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		W5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WA	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		WB	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Appendix C

Pit Profiling

Appendix C Pit Profiling

The Eldridge Pit contains approximately 240m depth of water. Given its considerable depth it is not likely that the water column will be uniform throughout. Generally in lakes and other deep bodies of water, the water column will separate into a number of distinct layers based on temperature, salinity and other parameters. This is known as stratification. The concentration of water quality parameters in the Eldridge Pit may change with depth. Given the volume of water contained in the Eldridge Pit these changes need to be understood and known.

Contrary to the Eldridge Pit, the Wises Pit contains approximately 10m depth of water and the water column is expected to be relatively uniform. Even if the Wises Pit is stratified, the volumes of water held in the pit that may have different concentrations than at the surface are minimal compared to the total volume of water that will be redistributed internally as part of the Project.

The Kidston Pumped Storage project Bankable Feasibility Study undertook depth profiling of the Eldridge Pit in October 2016 (Entura, 2016). Profiles were taken for in-situ parameters at 10m intervals to a total depth of 200m. Discrete samples for laboratory analysis were taken at 10m intervals to 50m, and then every 50m to 200m and a final sample taken at a depth of 230m (Table 112). This work found only two discrete layers of water, one from the surface down to approximately 20-30m depth and the remainder of the water column below 20-30m. Marginally higher concentrations of sulfate and some metal/metalloid substances were found at the surface of the Eldridge Pit (0-30m) compared to deeper intervals (Entura, 2016). However higher concentrations of arsenic and manganese were found at depth (230m) compared to concentrations in the remainder of the water column (Entura, 2016).

Table 112 Existing Eldridge Pit Water Quality Profiling (Entura, 2016)

Parameter Suite	Depth Intervals	Parameters*
In-situ parameters	Every 10m to 200m	pH, turbidity, DO, EC, temperature
Discrete interval water samples	Every 10m to 50m Every 50m from 50m to 200m 230m	• Al • Sb • As • B • Cd • Cr • Co • Cu • Fe • Pb • Mn • Mo • Ni • Se • Ag • SO4 • Cl • Ca • Mg • Na • K • total cyanide

*Metals analysed for total and filtered fraction

Overall metal concentrations showed a trend of having slightly higher concentrations at depths below 20m and a relatively uniform water quality profile throughout the majority of the water column (Figure 77).

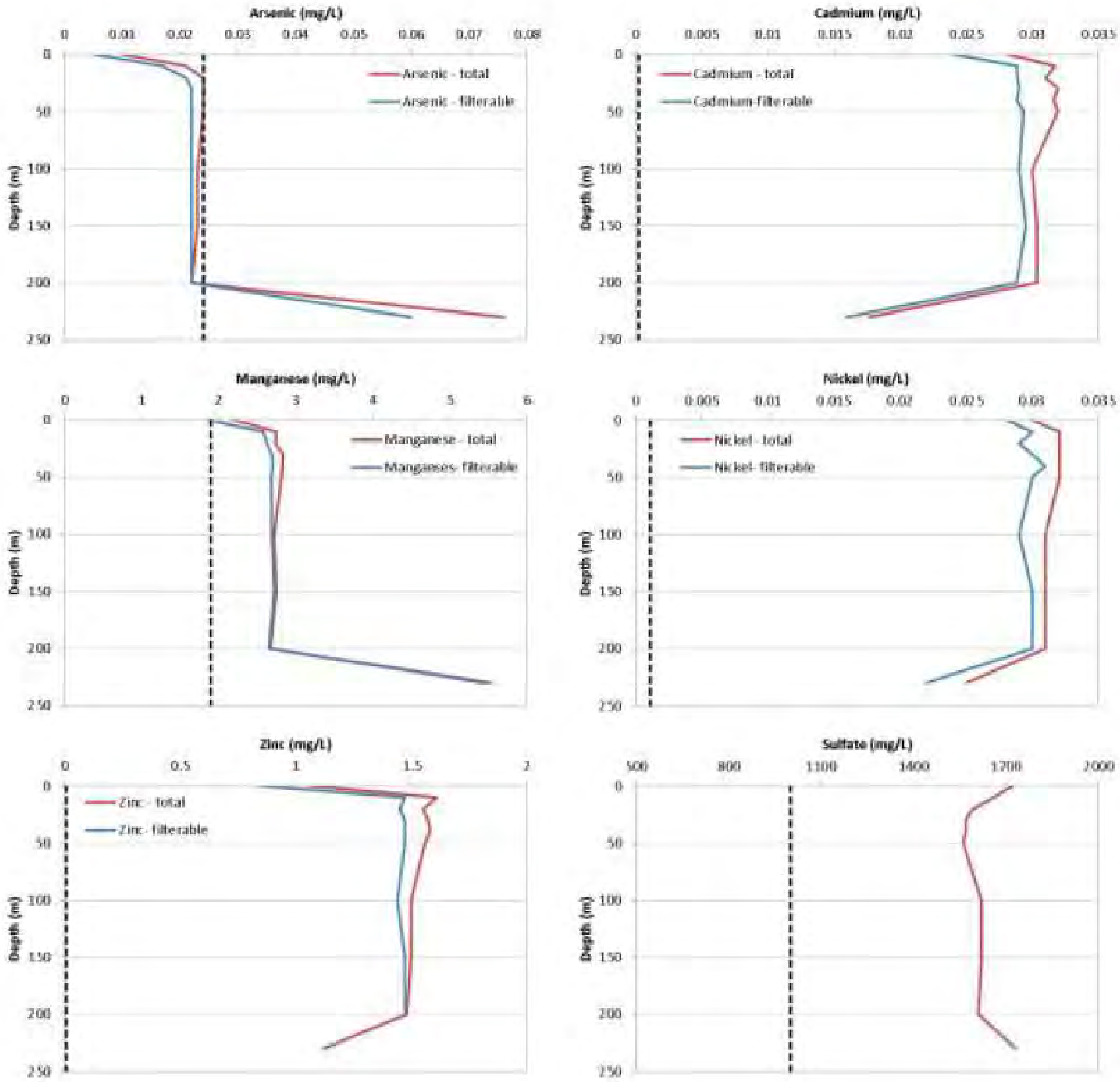


Figure 77 Metal concentrations with depth in the Eldridge Pit (Entura, 2016)

Sulphide oxidation could result in the generation of anaerobic water which could be found in a thick lens at the base of the pit, or a thinner lens near the edges. Oxygen diffusion in still water is approximately 8000 times lower than in air (Australasian Groundwater & Enviornmental Consultants, Gilbert & Associates, Dobos & Associates, 2001). As a consequence, sulphide minerals in contact with oxygenated water will deoxygenate the water in the immediate vicinity. Following this deoxygenation, anaerobic water found in this location could hinder further oxygenation of sulphides by reducing the mobility of oxygenated water into the surrounding pit wall rock. Significant water level fluctuations in the order of 40-50m as part of the Project could expose the pit wall rock to oxygen, causing acid rock drainage and the oxidation of sulphides or pyrite minerals that may be present. Since the depth profiling by Entura (2016) did not reach the base of the pit, AECOM undertook additional depth profiling with the express purpose of:

- Assessing consistency with the findings of Entura (2016).
- Specifically searching for anaerobic water in the pit (<1mg/L DO).
- Profiling the Eldridge Pit to the base (approximately 240m).

- Searching for acidic, saline and/or sub-oxic water that could settle at the base of the pit. The presence of this water would indicate acidic and/or metalliferous drainage may be occurring.

The remainder of this section presents the findings of the 2018 depth profiling.

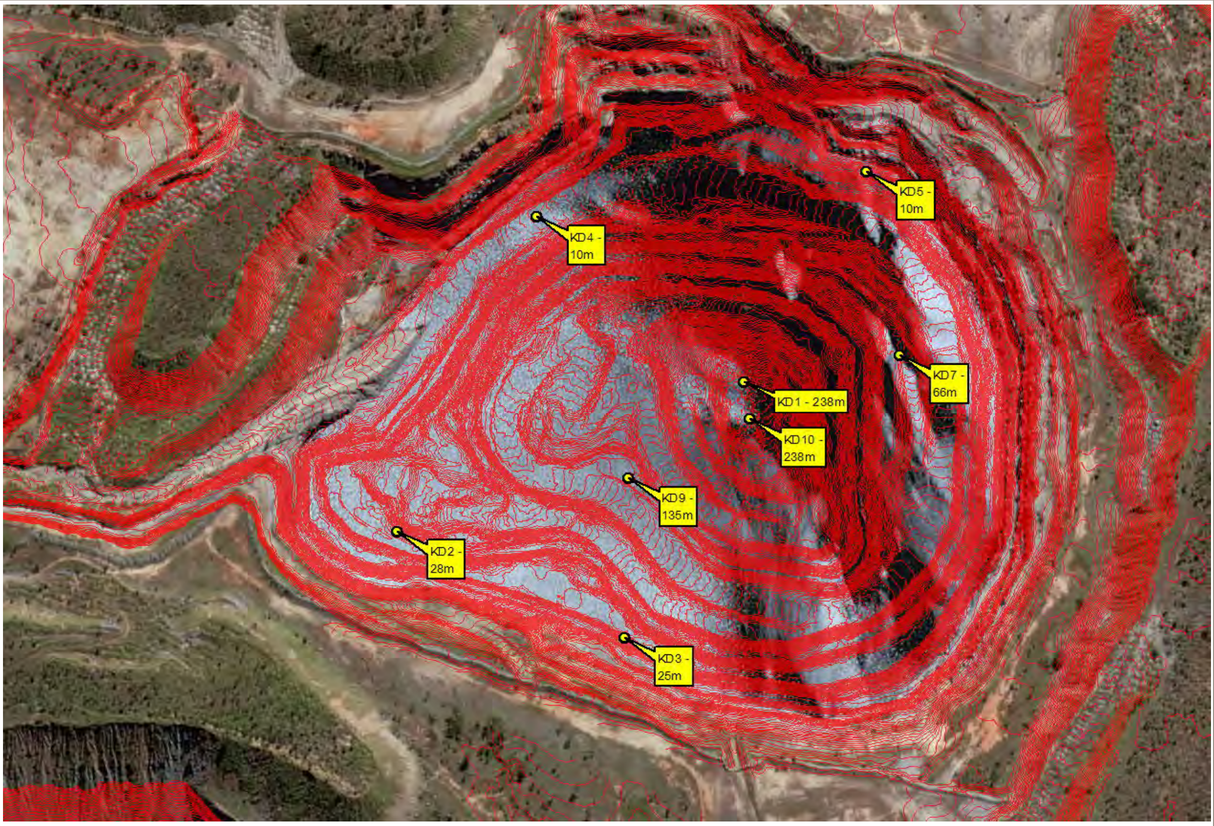
Methods

Eight profiles of the Eldridge Pit were conducted using a YSI Exo2 water quality sonde on 1 March 2018. The sonde is the only water quality meter that is rated to 250m available in Queensland. The sonde is capable of reading and logging the following parameters to an on-board data logger in real-time:

- pH
- EC
- Turbidity
- Oxidation Reduction Potential (ORP)
- DO
- Temperature
- Depth.

For each profile, the Exo2 water quality sonde was lowered slowly and held stationary at 10m depth intervals in order to ensure that the in-situ parameters had stabilised before descending another 10m interval. During the field investigation it was noted that this was not required as there was negligible lag for all parameters; nevertheless the approach was maintained for all profiles.

Profiles were conducted in the deepest parts of the pit that could be found with a depth-sounder attached to a 6m boat launched from the pit's ramp, as well as around the outer perimeter of the pit near the pit wall. Locations and depths of profiles of the Eldridge Pit are shown below in Figure 78. Note that pit bathymetry was not available at the time of sampling. The deepest part of the pit is profiled in KD1 and KD10. KD9 is also a relatively deep profile as well.



Profile	Easting (MGA Zone 55)	Northing (MGA Zone 55)	Maximum Depth (m)
KD1	200694	7911169	238
KD2	200342	7911017	28
KD3	200573	7910909	25
KD4	200484	7911336	10
KD5	200818	7911382	10
KD7	200852	7911196	66
KD9	200577	7911071	135
KD10	200700	7911131	238

Figure 78 Location and depths of water quality pit profiles

Results

Vertical Water Quality Changes

The deepest profiles are KD1 and KD10. Both profiles were commenced after undertaking multiple transects of the pit with the depth sounder and have a depth of 238m. KD9 is also a relatively deep profile with a depth of 135m.

Depth profiles show that the pit is stratified into two distinct layers. One layer extends from the surface to between 20 to 50m, depending on the parameter. The second layer extends from 20-50m to the base of the profile (Figure 79 to Figure 81). The upper layer has a range of values, extending typically from the highest reading to lower readings, while the lower layer is quite stable, with almost no variability in parameter measurements. This agrees with the findings of Entura (2016) which found a sharp change in parameters at 20m with little variation at greater depths. The only parameter that does not show this trend is ORP, which displays variability for different profiles. This likely reflects the instability of ORP measurements in general.

Lack of Water Indicating Sulfide Oxidation

There was no low oxygen water (<1mg/L) found in any of the profiles (Figure 79). DO concentrations were approximately 7mg/L at the surface and declined to 3.6-3.9mg/L by a depth of 40m. Concentrations remained constant at greater depths (Figure 79). A few readings found DO concentrations that decreased from 3.8 to 3.5mg/L at the greatest depths. These also correspond with high turbidity readings and it is evident from the data that the Exo3 sonde had settled in sediment at the base of the Pit (Figure 79).

There is no evidence of anaerobic water held within the Eldridge Pit based on ORP readings (Figure 79). Field ORP readings plotted on Figure 80 range from 180 to 270 mV. Translated to standard hydrogen electrode (SHE) values (typically used for comparison with geochemical data), the ORP ranges from about 380 to 470 mV, indicating oxidising conditions throughout the pit profiles. Differences between individual profiles are likely due to inherent difficulties in obtaining quantitative ORP readings in all but acid water. Since the pH of pit water ranges from about 7 to 8 (Figure 81), and is stable below 50m, there is no evidence of acidic conditions in pit water. ORP results and filtered oxygen readings indicate an oxidising environment within the entire water column for every depth profile.

Any leachable material found in inundated areas of the Pit is exposed to aerobic processes in its current environment. Therefore flushing of acidic or metalliferous drainage products as a result of the proposed hydro scheme will not be as high as what might occur if anaerobic water were present.

Horizontal Water Quality Changes

There are negligible changes to water quality horizontally within the Pit. Figure 79 to Figure 81 show all results from each profile stacked on top of each other. All of the results (except for ORP) show that water quality results at the surface of the pit are relatively similar for each profile. As discussed below ORP results are relative in nature and are not expected to be similar for each profile.

Discussion

Stratification

The presence of a single thermocline/chemocline within the pit is slightly unusual given its depth of 240m. Typical conceptual models of deep lakes and mine pit lakes would suggest that there should be additional thermoclines or chemoclines that form. A layer of denser water (hypolimnium) is not evident at the base of the pit, given the uniformity of the EC plot below about 40m (Figure 81).

Waters at depth appear uniform. Comparison between the deepest profiles (KD1, KD9 and KD10) shows that values for pH, EC, DO, temperature and turbidity fall within a narrow range between profiles at depths greater than approximately 50m (100m for pH) (Figure 81).

The uniform nature of the pit water could be a result of the accelerated flooding of the pit. A large volume of water was pumped into the pit to raise the water level to the estimated long-term equilibrium in 2001. This water would have been of a reasonably good quality, sourced from the Copperfield Dam. Therefore the majority of water held within the Eldridge Pit would still comprise water sourced for the accelerated flooding, explaining the relative uniformity pit profile. The reactivity of the pit walls is expected to be relatively low, otherwise changes to water quality throughout the water column would have occurred.

Temperature and wind only affects the top 40m of the water column as evidenced by the plots in Figure 80; however, all water beneath this level is relatively static. In addition, a number of pump-back systems operate around the mine. These systems pump excess water collected by the site’s seepage interception system back to the Eldridge Pit. Water from these pump-back systems is allowed to free-fall over the crest of the pit wall into the void in waterfalls. This will add additional DO and play a small role in promoting mixing within the upper part of the water column.

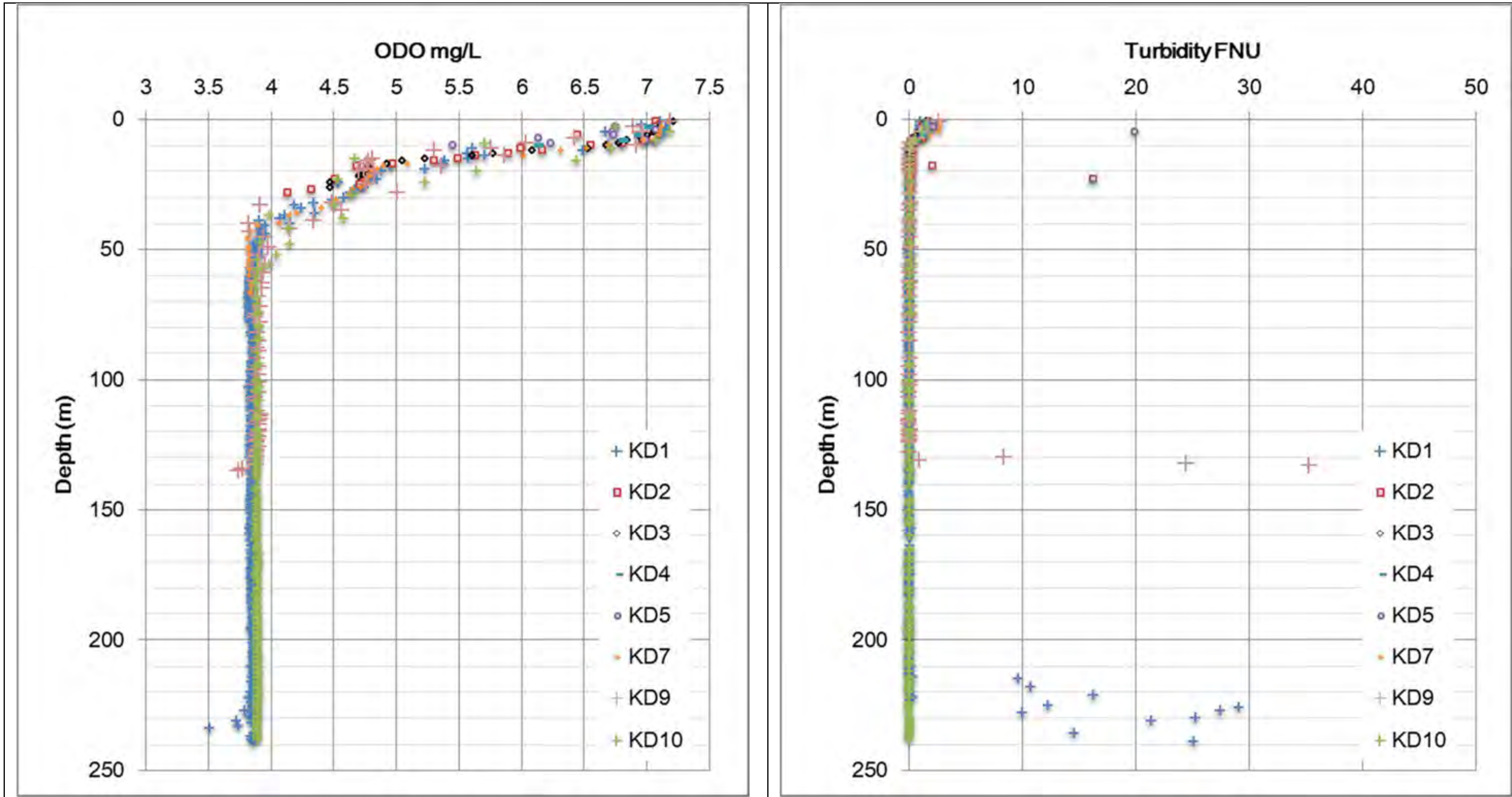


Figure 79 Depth Profiles for Filtered Oxygen and Turbidity

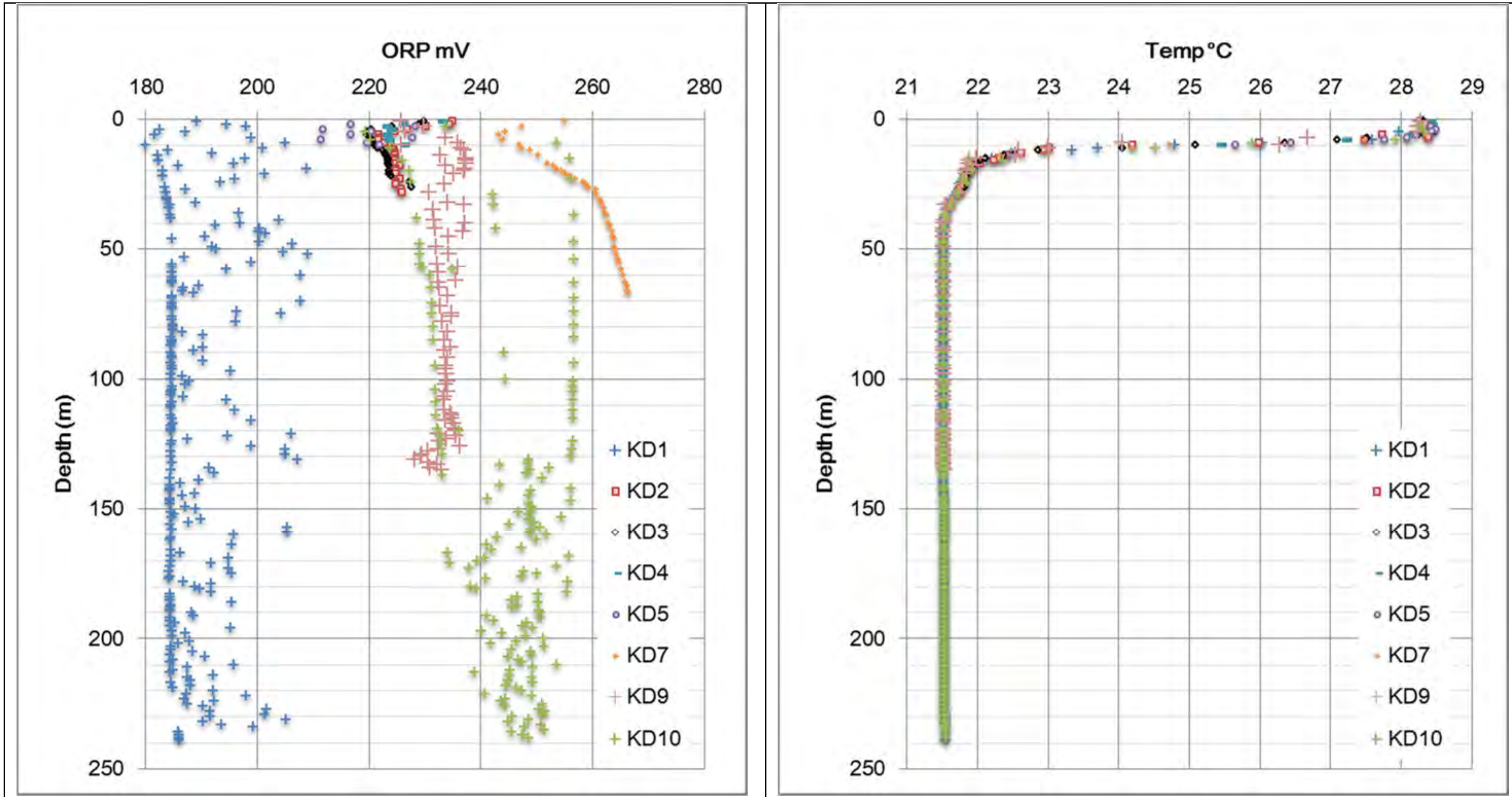
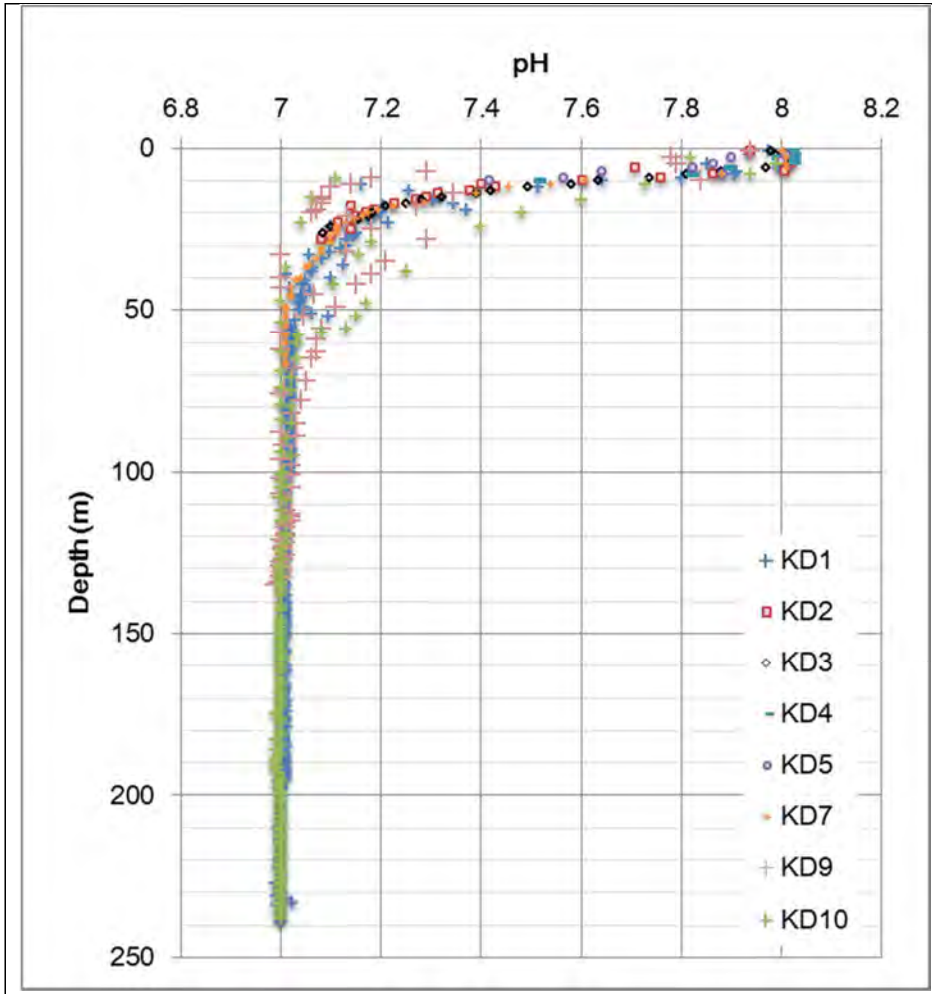


Figure 80 Depth Profiles for ORP and Temperature



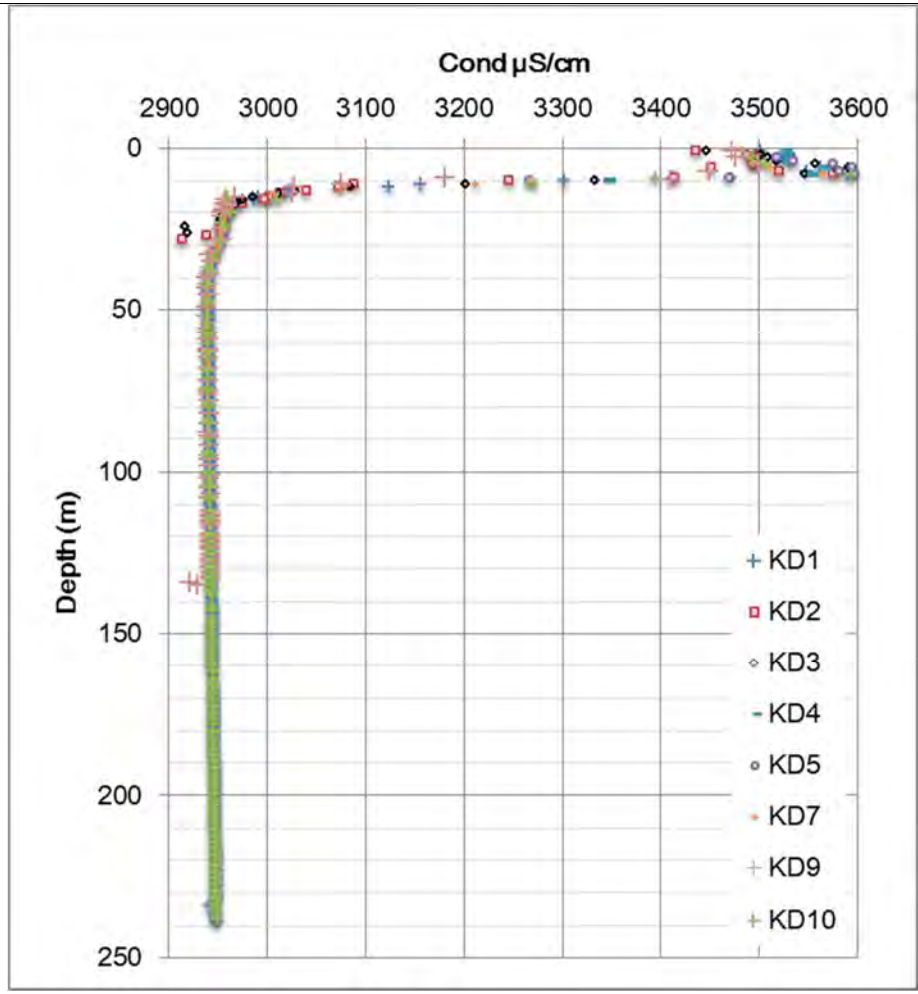


Figure 81 Depth Profiles for pH and EC

Changes with Depth

It is slightly unusual that there are waters with a higher EC at the surface of the Pit profile compared to deeper layers. Typically higher EC waters have a higher density (higher concentrations of dissolved minerals) and will sink to the base of the Pit. The EC of waters at the surface in all profiles is approximately 3400µS/cm to 3600µS/cm and is accompanied by water with a DO concentration of 5.5mg/L to 7.0mg/L and waters with a higher turbidity.

As mentioned earlier, the site's seepage pump-back system was operational during Pit profiling exercises. This seepage pump back system collects water that has emanated from the toes of waste rock dumps around the site and delivers it to the Wises Pit and Eldridge Pit to reduce the chances of uncontrolled discharges of the seepage collection dams. EC information for the seepage pump back system collected between 2012 and 2015 indicates that the average EC of seepage water is between 3,500µS/cm and 4,000µS/cm.

Therefore it is theorised that at the time of Pit profiling, water with a higher EC was being input into the Eldridge Pit from the seepage pump back system (and possibly runoff from the waste rock dumps, but this is unlikely). This water likely had an EC between 3,500µS/cm and 4,000µS/cm. This water would have delivered relatively high dissolved oxygen levels to the surface of the Pit as it cascades over waste rock before entering the water column. This explains the high EC and dissolved oxygen readings at the surface of the Pit. As the difference in EC between the seepage pump back water (3,500µS/cm) and the overall water column (approx. 2,950µS/cm) is not large, the seepage pump back water would not quickly sink below the lower EC water of the water column (i.e. a larger EC difference, such as that between seawater (60,000µS/cm) and freshwater (200µS/cm) would result in more rapid mixing). Therefore the seepage pump back water is, in general terms, sitting on 'top' of the water column in the Eldridge Pit (and likely the Wises Pit with a much shallower water column).

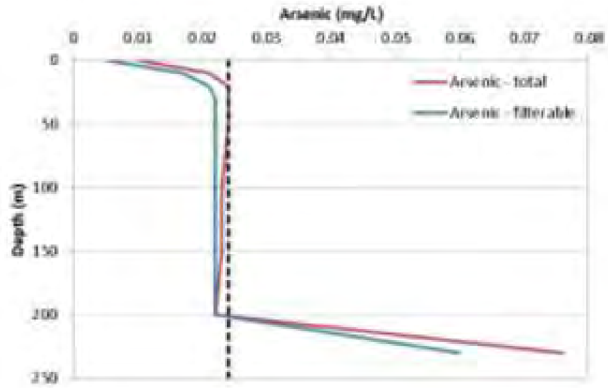
Samples collected over time in both Pits *could* be skewed towards the quality of the seepage pump back water. Sensitivity analysis has been incorporated into the dilution ratio to account for potential vertical changes in metal concentrations down the pit profile as encountered by Entura (2016).

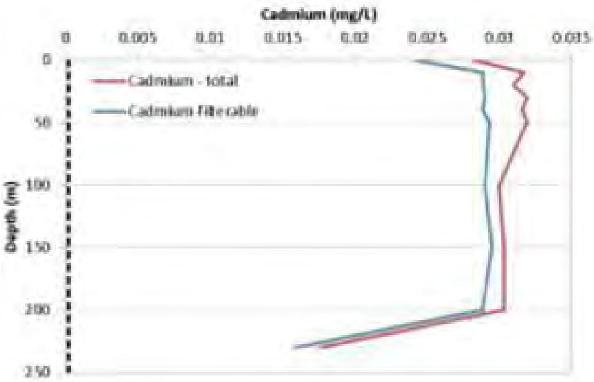
Addendum – August 2018 Pit Profiling

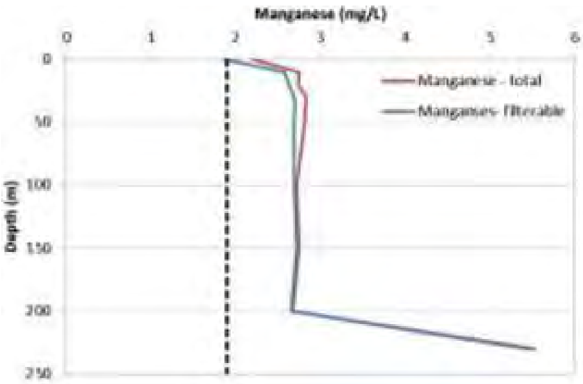
In August 2018, Genex undertook an additional round of water quality sampling within Eldridge Pit. Samples were collected from the same depths as previously sampled and analysed by the laboratory for the same parameters. The purpose of the additional sampling was to assess whether similar trends in water quality with depth were observed. Results are compared against the Entura pit profiling undertaken in 2016 (refer to Figure 82 below).

Overall, the August 2018 results are comparable to the 2016 Entura profiles: in general, dissolved metal/metalloid concentrations reported from the August 2018 profile sampling are slightly lower than those recorded in 2016. The August 2018 results also indicate an apparent homogeneity along the pit profile. The differences may be due to the different sampling methods (a Niskin bottle was used in the 2016 study, whereas HydraSleeves were employed in the 2018 work) and/or may reflect seasonal variations (the 2016 study was completed in the wet season, whereas the 2018 study was conducted in the dry season). The 2016 study reported variations in water quality both at the top and the base of the pit profile, which are not observed (or not observed in the same magnitude) in the 2018 investigation: differences in surface water quality may reflect seasonal variations. The 2016 study may have perturbed the base of the pit leading to marked variations in water quality in the lowest section of the profile; these were not observed in the 2018 study. August 2018 dissolved nickel concentrations are reportedly higher than total nickel concentrations; however, total suspended solids are recorded at or below limits of detection for most of the 2018 profile. In addition, repeat analysis of profile samples indicates that the total and dissolved concentrations are within analytical precision. It is suggested, therefore, that there were very little suspended solids entrained in the water column during sampling and that the total and dissolved concentrations are equivalent.

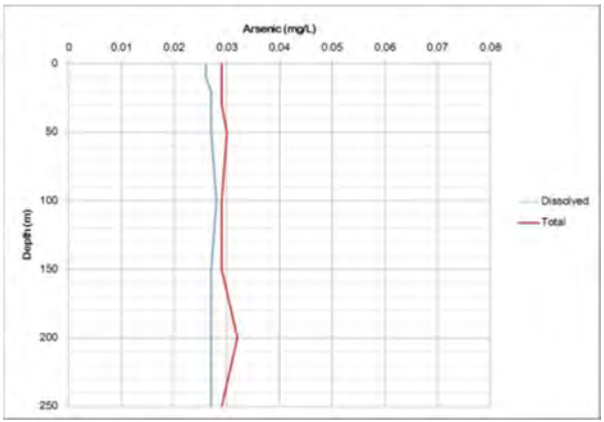
ENTURA 2016

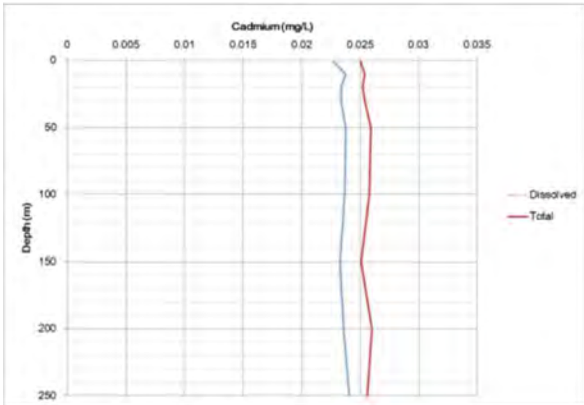


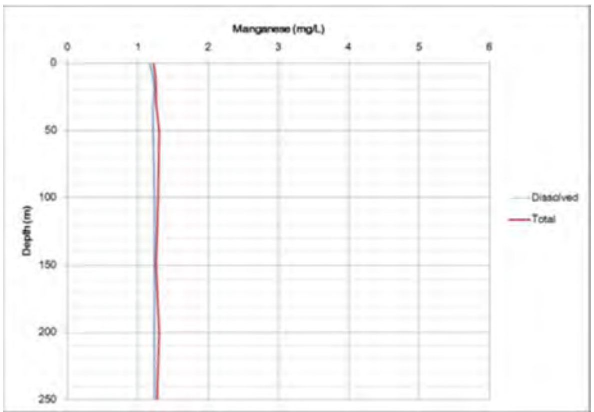


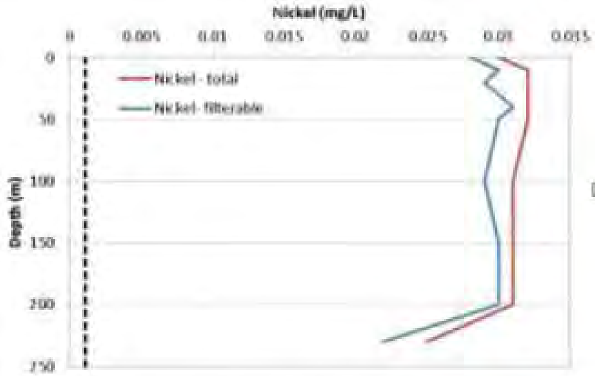


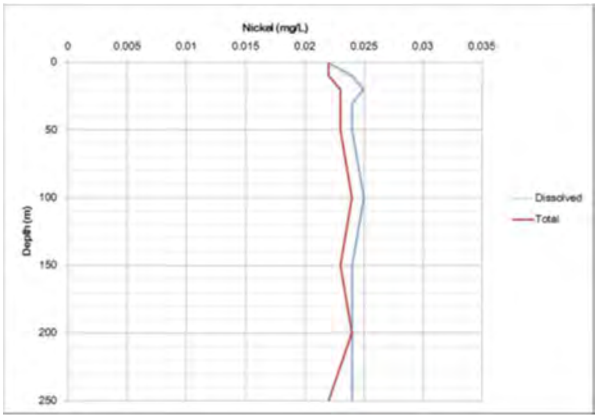
GENEX August 2018

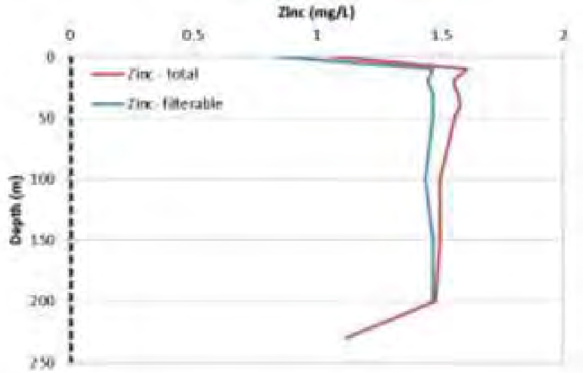


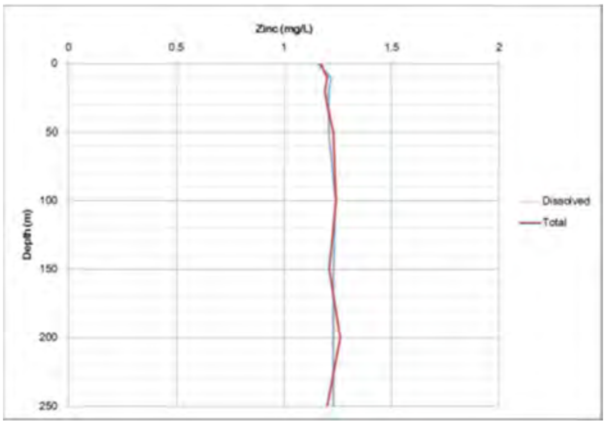


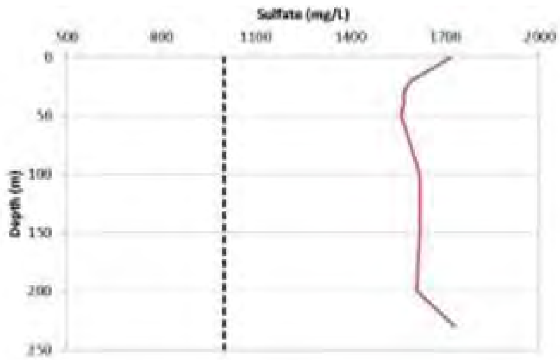


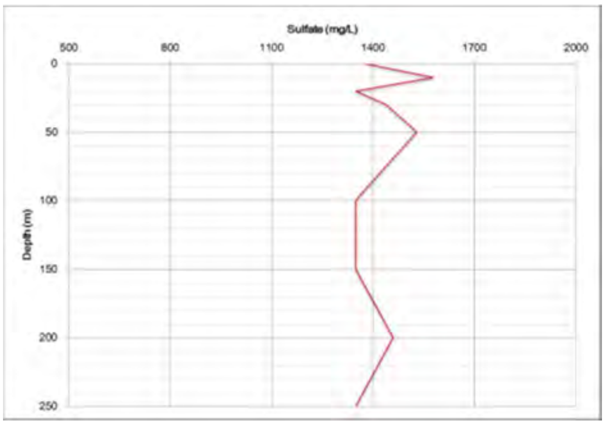

Nickel (mg/L)
Nickel - total
Nickel- filterable
Depth (m)


Nickel (mg/L)
Dissolved
Total
Depth (m)


Zinc (mg/L)
Zinc - total
Zinc- filterable
Depth (m)


Zinc (mg/L)
Dissolved
Total
Depth (m)


Sulfate (mg/L)
Depth (m)


Sulfate (mg/L)
Depth (m)

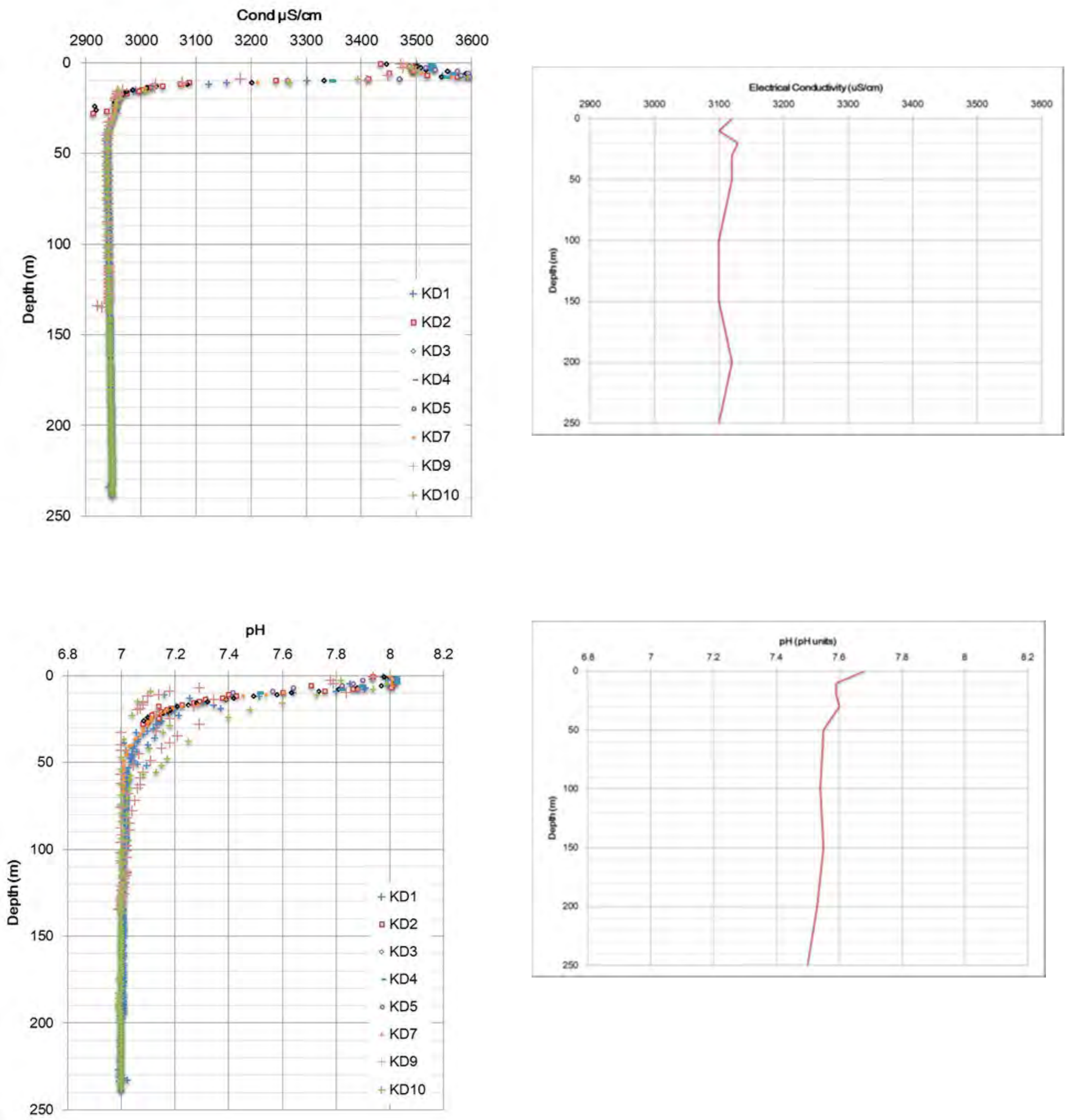


Figure 82 August 2018 Depth Profiles

Appendix D

Pit Water Quality Time Series

Appendix D Pit Water Quality Time Series

Yearly grab samples have been taken of the Wises and Eldridge Pits since 2003 and sent for analysis at a NATA accredited laboratory. Grab samples have been obtained at the surface (approx. 30cm below the surface) and represent the surface water quality. Further discussion on changes in water quality with depth in the Eldridge Pit are provided in Section 4.3. The majority of samples have been obtained in October of each year, corresponding to the peak of the dry season when evapo-concentration would have increased the concentration of filtered minerals in each pit. Samples have been analysed for total metal concentrations since 2003. Samples have only been passed through a 0.45µm filter and analysed for total as well as filtered metal concentrations within each of the pits since 2013.

Water quality in the pits is compared to the default WQOs. WQOs are designed to apply to receiving waters following mixing of any discharges; therefore an exceedance of a WQO in pit waters does not indicate a potential impact to the EVs of the receiving environment. Water quality of the pits is also compared in Appendix C and Appendix D for convenience. Overall the following parameters exceed the default WQOs in the Eldridge or Wises Pits, where an exceedance is taken to be the 95th percentile of the data.

- EC
- Sulfate as SO_4
- Total aluminium (however filtered aluminium is below all WQOs)
- Filtered and total arsenic
- Filtered and total cadmium
- Total cobalt (however filtered cobalt is below all WQOs)
- Filtered and total copper
- Filtered and total manganese
- Filtered and total molybdenum
- Filtered and total nickel
- Filtered and total zinc
- Total cyanide (occasionally).

These parameters were plotted as time series in Figure 83 to Figure 94 below to indicate variability throughout time as well as the concentrations of the most recent samples. A discussion on each of these parameters is outlined below.

The water quality results from a composite sample which is representative of the operational water quality for the Project (a mixture of Eldridge Pit water and Wises Pit water as outlined the main report) are also shown and discussed in the sections below.

Parameters which do not exceed WQOs are not discussed further in this Section.

Electrical Conductivity and Sulfate

EC is relatively elevated in both pits compared to the default WQO. The long-term record shows the highest values between the end of 2006 and the end of 2011 in Wises Pit (Figure 83). These levels decreased to a concentration that is more fitting with the long-term trend following 2011. In Eldridge pit the values show a relatively steady but slightly increasing trend over time (Figure 83). EC values for the representative sample is 4,600µS/cm which is above the Aquatic Ecosystem WQO.

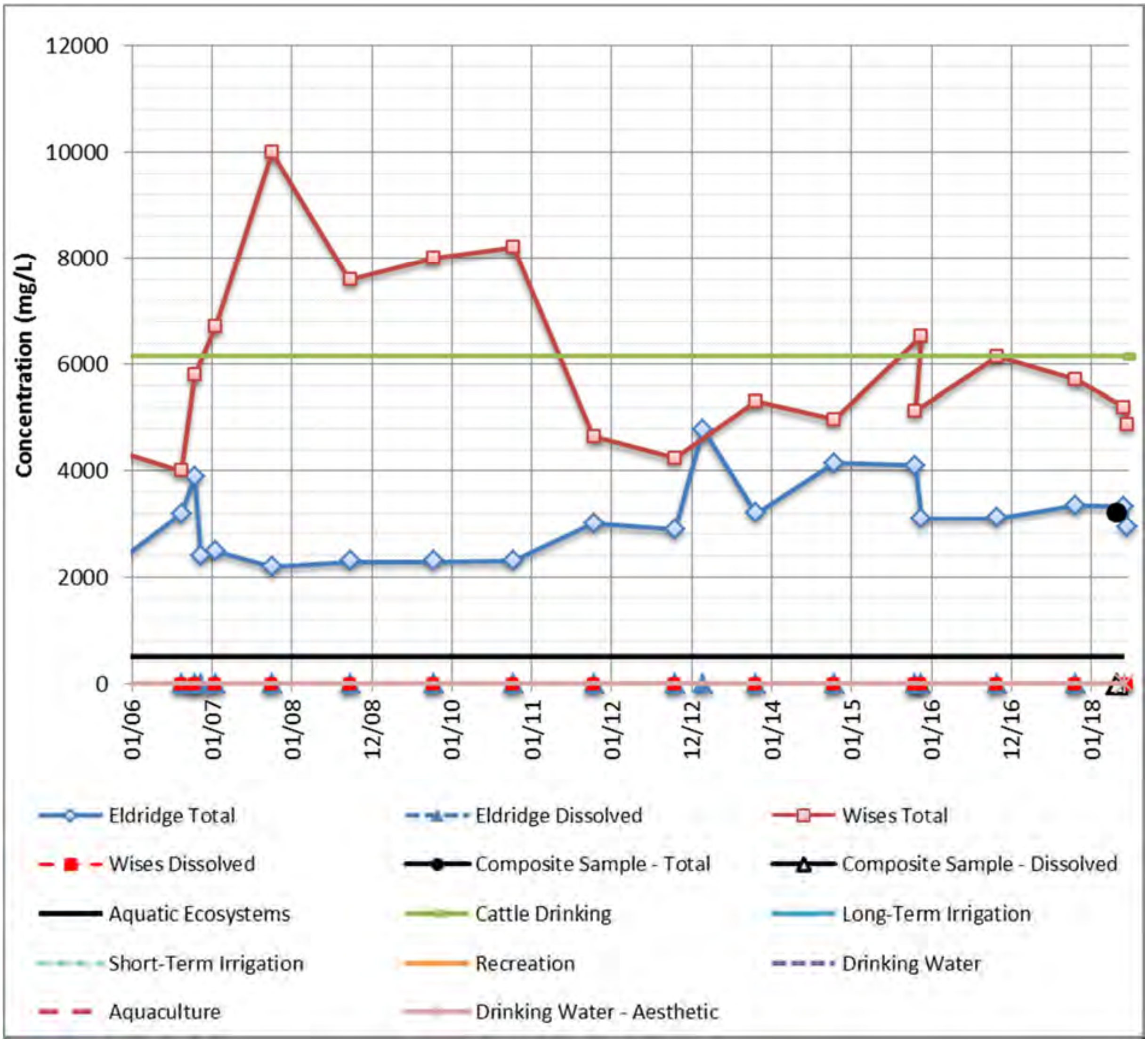


Figure 83 EC time series for Eldridge and Wises Pits

Sulfate concentrations (Figure 84) show similar trends to EC. Sulfate concentrations in both pits are generally above the WQO for Recreation, Drinking Water and Cattle Drinking for almost the entire record. A sample taken in 2008 for the Eldridge Pit shows an unusually low sulfate concentration and is generally considered an outlier (Figure 84).

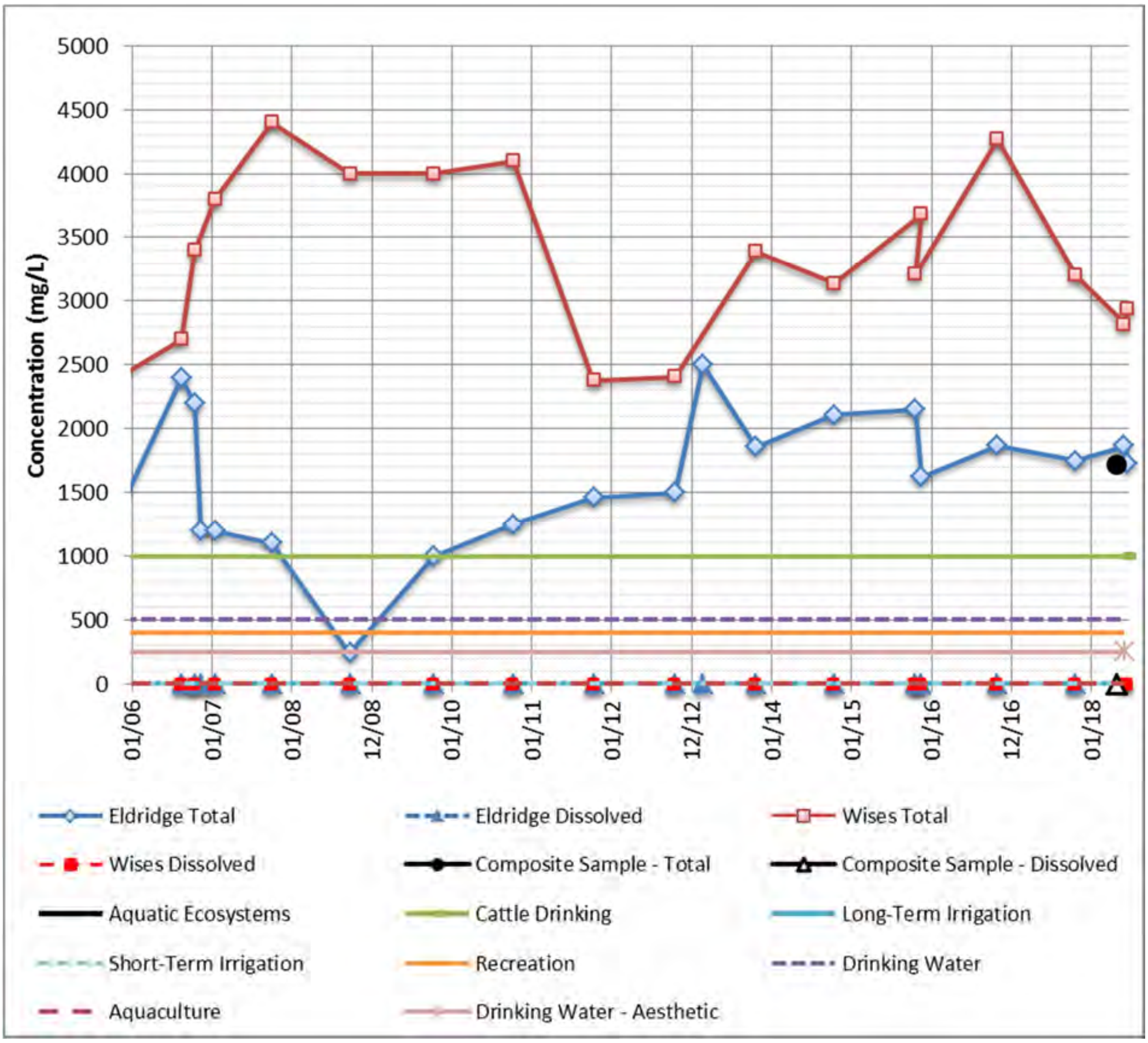


Figure 84 Sulfate time series concentration

There is a good relationship between EC and sulfate in the waters in both pits (Figure 85). A logarithmic relationship is plotted through each sample with an R^2 value of 0.9175 which is very good. This shows that the sulfate concentration can be estimated based on real-time in-situ measurement of EC. The strength of the relationship indicates that variations in EC values with depth in the pit can be used to estimate sulfate concentrations. There are negligible relationships between any other in-situ parameters and laboratory parameters that have been measured to date.

Pit profiling exercises show that the Eldridge Pit is only separated into two layers via vertical stratification. Using the EC results from in-situ profiling exercises it is estimated that sulfate will decrease from approximately 2150mg/L at the surface to a value of 1620mg/L at 30m depth. This concentration (approximately 1620mg/L) is expected to be relatively uniform throughout the rest of the water column.

Time-series graphs of surface concentrations (Figure 83) show that sulfate concentrations in the Eldridge pit have been relatively uniform over time and are generally not increasing. Therefore the likelihood of sulfate concentrations within the pit being sourced from the oxidation of pyrite within the pit walls is very low.

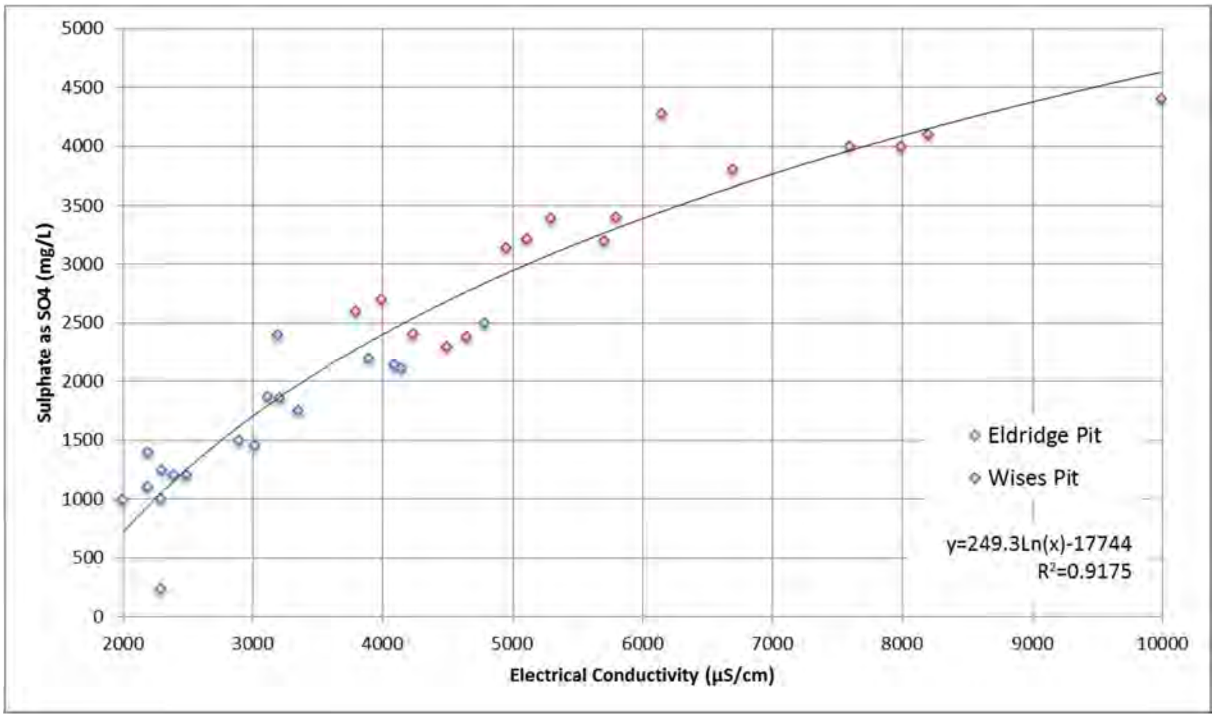


Figure 85 Relationship between EC and SO4 in the pit water.

Aluminium

Aluminium concentrations in the Pits are relatively low compared to the concentrations in the receiving environment. Overall the levels of total aluminium in the Eldridge and Wises Pits are below all WQOs for the majority of samples (Figure 86). There was an increase in aluminium concentrations in the Eldridge Pit in December 2012 (Figure 86). Total aluminium concentrations in the Wises Pit have been increasing since the end of 2016. Concentrations of total aluminium in the 2017 samples exceed the WQO for Aquatic Ecosystems and Recreation. However the dissolved aluminium concentrations are still very low in both Pits and are compliant with all WQOs. This indicates that results reported as total aluminium concentrations may be a result of aluminium attaching to colloidal material rather than as aluminium within the water column.

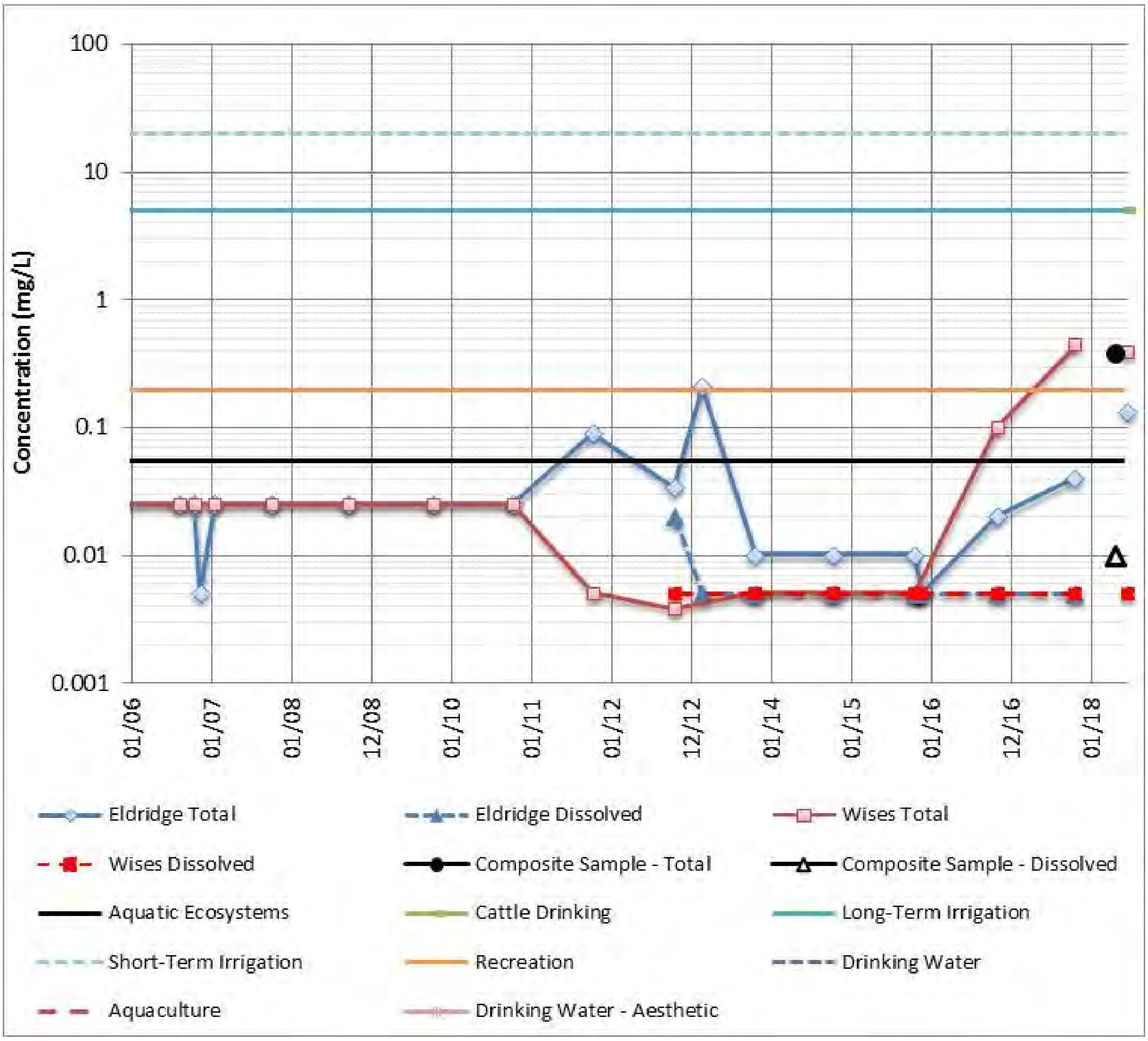


Figure 86 Aluminium concentrations in the Eldridge and Wises Pits

The composite sample shows a high concentration of total aluminium, generally above the historical concentrations in the Wises and Eldridge Pits. However the dissolved aluminium concentration is relatively low, fitting with the historical baseline. Overall the composite sample is representative of aluminium concentrations that may be expected once the waters it the two pits is mixed.

Arsenic

The majority of samples show total and filtered arsenic within both pits above the Drinking Water and Aquatic Ecosystem WQO for the majority of the record. Concentrations in the Wises Pit are consistently above concentrations in the Eldridge Pit. This is likely as a result of the Wises Pit being backfilled with tailings which are more geochemically reactive than the pit wall rock. In the most recent samples, the concentration of total and filtered arsenic is above the Cattle Drinking WQO but below the Short-Term Irrigation WQO. The composite sample representing the mixture of Eldridge Pit water and Wises Pit water expected during operations is above the Drinking Water, Aquatic Ecosystems, Recreation and Long-Term Irrigation WQOs but below the Cattle Drinking and Short-Term Irrigation WQOs.

Increases in pH values can increase the filtered arsenic concentration as the particle desorbs from iron mineral surfaces. At the pH values found within the pit waters, the majority of arsenic is filtered. There was a large increase in filtered and total arsenic in both pits between the 2016 and the 2017 samples. This could be a result of the relatively large wet season compared to relatively dry wet seasons experienced beforehand. In 2017, the relatively large wet season caused increased operation of the seepage pump back system, whereby seepage interception dams are dewatered back to the pits. This could have been the cause of an increase arsenic levels within both pits.

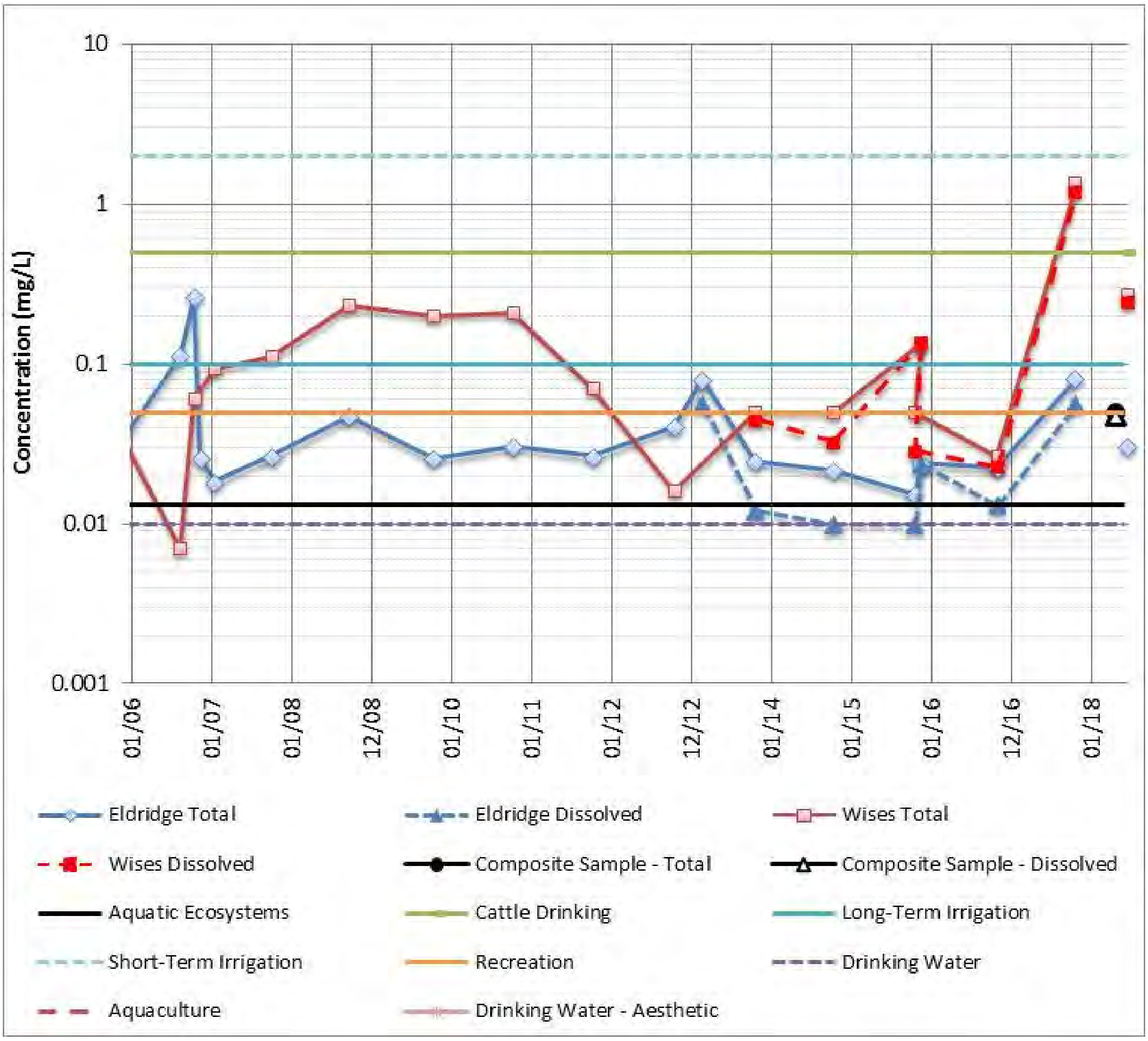


Figure 87 Arsenic Concentrations in the Eldridge and Wises Pits

The composite sample is more representative of water quality conditions within the Eldridge Pit than the Wises Pit. This is considered appropriate given that the majority of water in the operation will be sourced from the Eldridge Pit. Total arsenic within the composite sample represents approximately the 80th percentile of arsenic concentrations in the water quality history of the Eldridge Pit. The concentration of arsenic in the composite sample is above the WQO for Drinking Water and Aquatic Ecosystems.

Cadmium

Total and filtered cadmium time series graphs show that concentrations in the Eldridge Pit are almost constantly elevated above the all WQOs (Figure 88). Concentrations in the Eldridge Pit are much higher than the Wises Pit as found with manganese and nickel. An anomalous low concentration is found in late 2012, which also corresponds to low concentrations of manganese and nickel in the Eldridge Pit (Figure 88). Concentrations in the Eldridge Pit are only below the Short Term Irrigation WQO while concentrations in the Wises Pit are only above the Aquatic Ecosystem WQO.

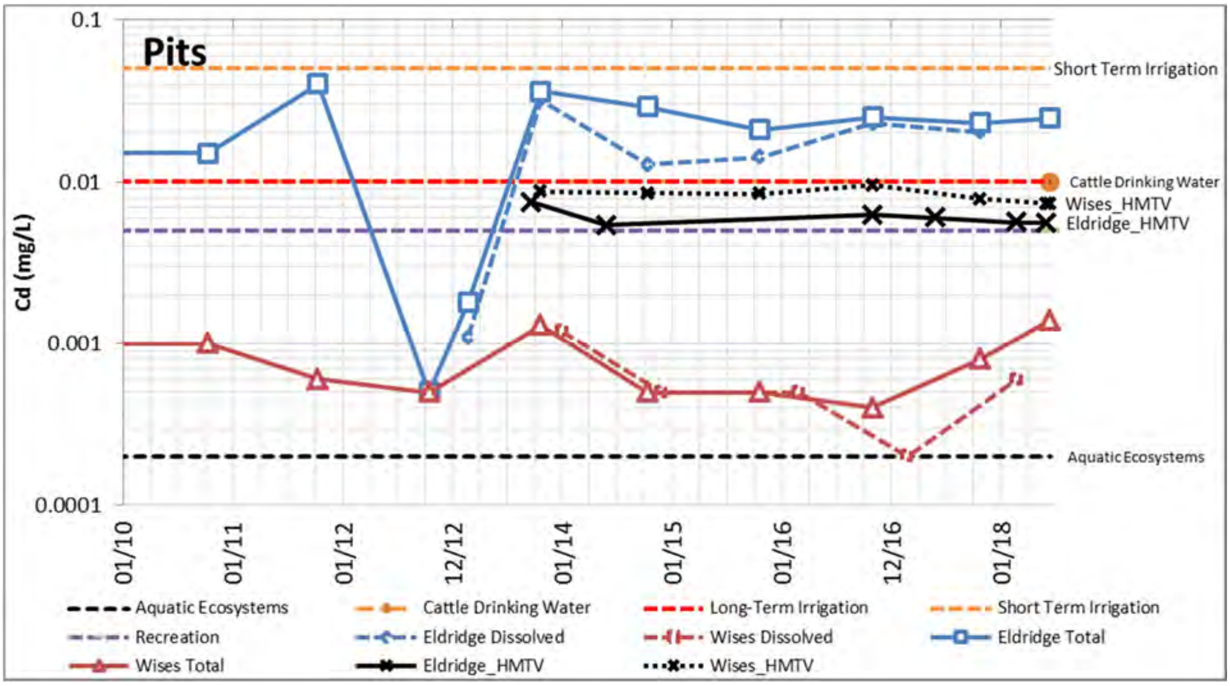


Figure 88 Cadmium Concentrations in the Eldridge and Wises Pits

The composite sample shows cadmium concentrations almost wholly representative of the Eldridge Pit (Figure 88). These concentrations are relatively high. The concentration of total cadmium in the composite sample (0.0222mg/L) is approximately equivalent to the 60th percentile value of the Eldridge Pit.

Comparison to Hardness Modified Trigger Values

Although the majority of samples for dissolved cadmium are above the Aquatic Ecosystem WQO of 0.0002mg/L, the toxicity of cadmium is related to water hardness. As discussed previously the water in the Eldridge Pit and Wises Pit is relatively hard (median of 1270mg/L and 2008mg/L respectively). In contrast the default WQO for dissolved cadmium has been developed for waters with a hardness of 30mg/L.

Consequently a hardness modified trigger value was developed on a sample by sample basis for the waters in both Pits in accordance with Table 3.4.3 of the ANZECC (2000) guidelines whereby the WQO for dissolved cadmium is calculated based on the hardness of the sample.

Figure 88 also shows a comparison between the HMTV and concentrations of dissolved cadmium within the Eldridge and Wises Pits. Almost all values within the Eldridge Pit are elevated above the HMTV for cadmium whereas all samples in the Wises Pit are below the HMTV.

Cobalt

Total and filtered cobalt concentrations in both the Eldridge and Wises Pits are generally below all WQO values except for a major spike occurring in 2012 and early values recorded in 2006 (Figure 88). This high spike in cobalt also corresponds to unusually low concentrations of manganese and cadmium. There is an increasing trend in total and filtered cobalt in the Wises Pit. This is likely a result of the operation of the seepage pump back system and the tailings stored within the pit. The composite sample which is taken to represent the operational water quality of the Project shows filtered (0.004mg/L) and total cobalt (0.005mg/L) concentrations are above the low reliability Aquatic Ecosystem WQO for cobalt (0.0028mg/L) (Figure 89).

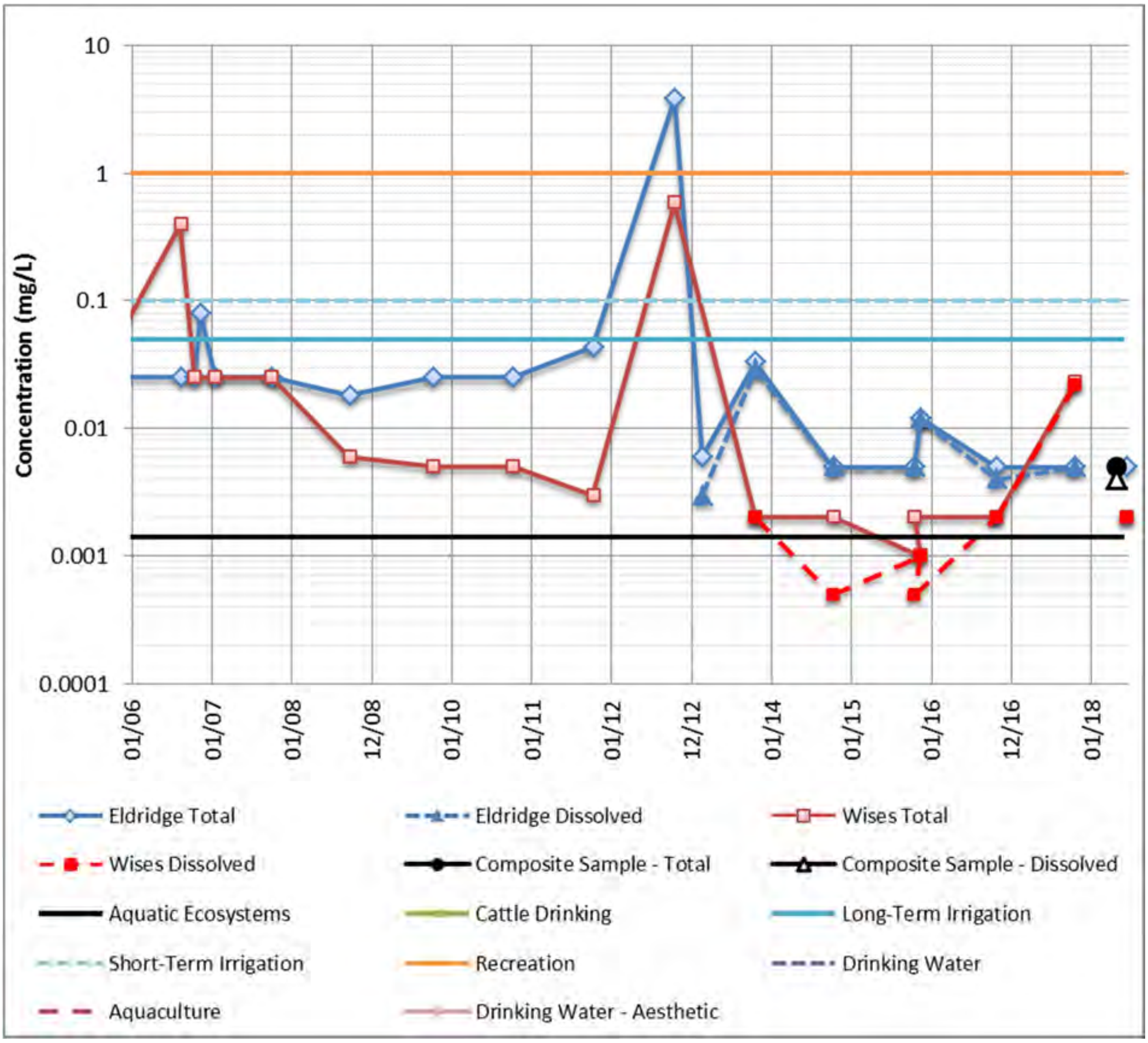


Figure 89 Cobalt Concentrations in the Eldridge and Wises Pits

Cobalt concentrations are relatively low compared to the historical water quality time series of the Pits. Dissolved cobalt concentrations would need to increase to 0.42mg/L to affect the Contaminant of Potential Concern (COPC) and dilution ratio equations used in Section 6.1.1.1 of the main report. This concentration is considerably above the concentrations of dissolved cobalt evident in 6 samples taken each from the Eldridge Pit and Wises Pits since 2013. However the concentration of dissolved cobalt is close to the concentration of total cobalt. Therefore total cobalt concentrations can be assumed approximately represent the concentrations of dissolved cobalt. Total cobalt has been analysed for a longer period than dissolved cobalt samples. Subsequently the concentrations of dissolved cobalt required to affect the COPC calculations (0.42mg/L) fall somewhere between the 90th percentile and 95th percentile of total cobalt concentrations historically measured in the Wises and Eldridge Pits between 17 samples taken since 2004.

Copper

Copper values in the Pits are variable with historically high concentrations of total copper experienced in the Eldridge Pit in late 2012. However concentrations have generally decreased since this date and only begun rising in the previous few months (Figure 90).

Compared to default WQOs for Aquatic Ecosystems the concentrations of Copper in both pits are elevated. However the toxicity of copper, like cadmium and chromium, is dependent on the hardness of the water. As discussed previously the Pits have a hardness of approximately 1500mg/L and

2000mg/L respectively, compared to a hardness of 30mg/L which has been used to develop the Aquatic Ecosystems WQO.

Dissolved copper concentrations are relatively low compared to the HMTV (Figure 90) for both pits. The HMTV is an order of magnitude greater than copper concentrations between 2014 and 2016 (Figure 90).

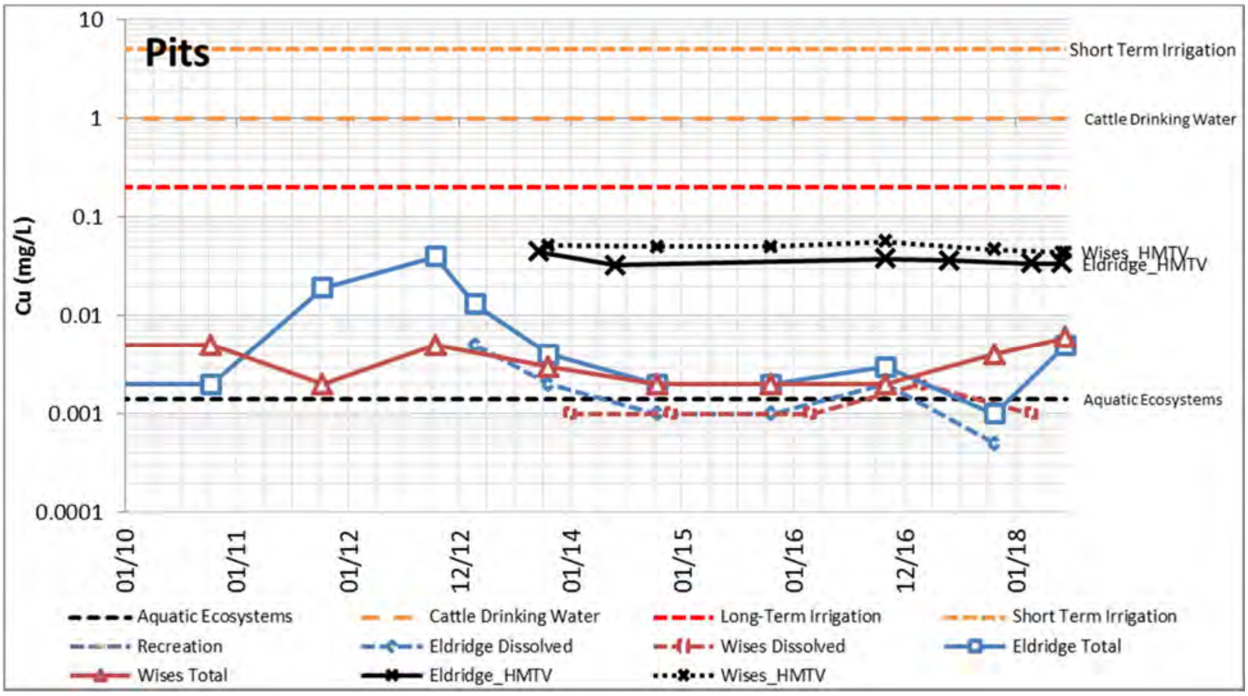


Figure 90 Copper concentrations in the Pits over time

Manganese

Historically, manganese concentrations in the Eldridge Pit are significantly higher than in the Wises Pit (Figure 91). The majority of manganese in both pits exists as filtered manganese, given the small difference between the total and filtered concentrations (Figure 91). Overall manganese concentrations in the Eldridge Pit are relatively constant between 1 and 4mg/L except for two exceptions in late 2006 and late 2012 where a relatively low concentration was recorded. Concentrations of manganese in the Wises Pit have been increasing since late 2015 and the concentration now exceeds the Eldridge Pit. This is likely a result of the tailings currently stored in the pit as well as the operation of the pump back system.

The relatively low anomalies in the data from the Eldridge Pit consist of the only two samples that contain concentrations below all WQOs (Figure 91).

The composite sample analysed for the purposes of this study also exceeds the default WQOs for Recreation and Long-Term Irrigation and Drinking Water but are below the WQO for Aquatic Ecosystems (Figure 91). The composite sample is fairly representative of concentrations found historically in the Eldridge Pit.

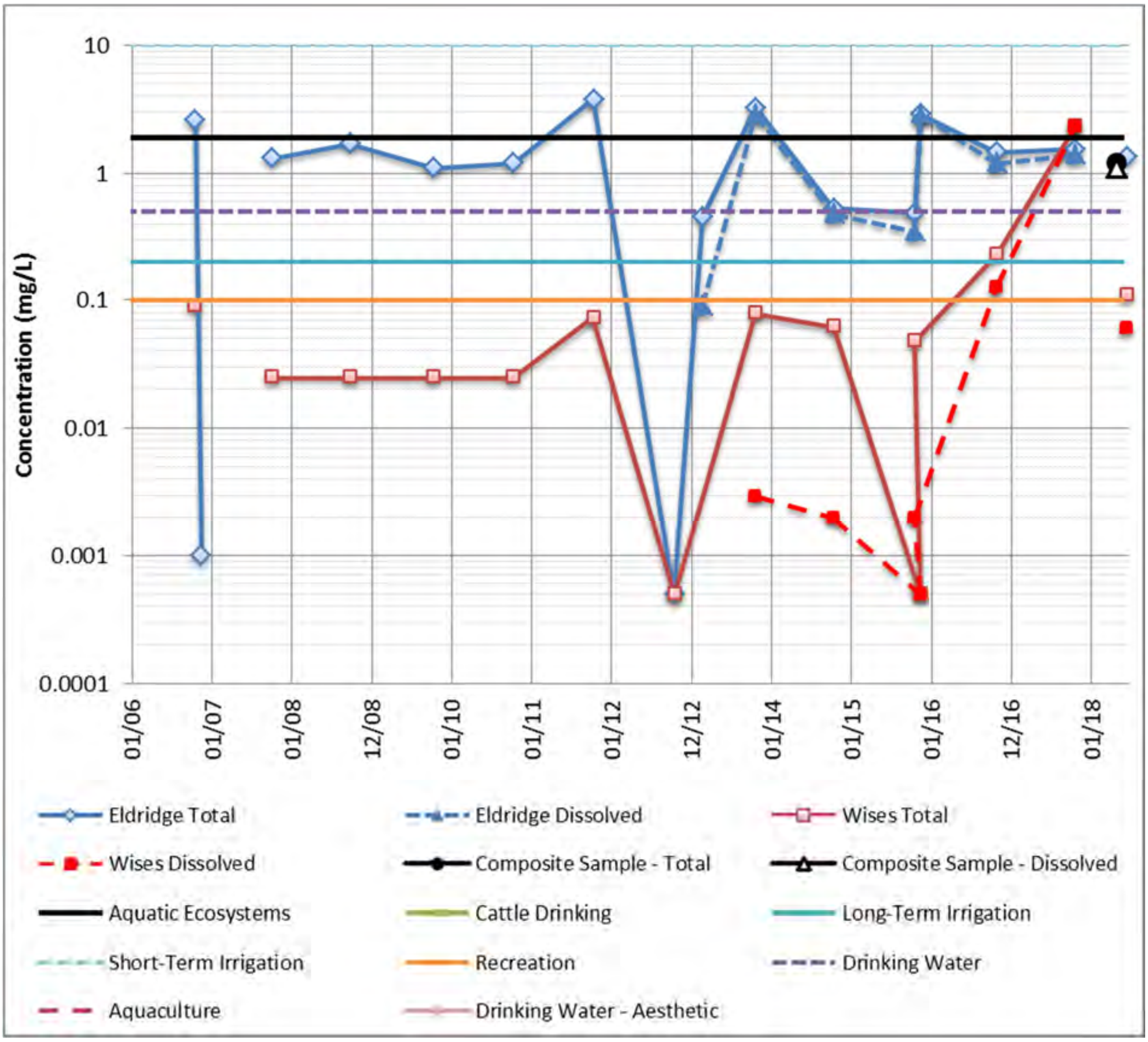


Figure 91 Manganese Concentrations in the Eldridge and Wises Pits

Molybdenum

The concentrations of filtered molybdenum in the Eldridge and Wises Pits have been relatively stable since the end of 2012. Concentrations fluctuate from being above or below the Drinking Water WQO (Figure 92). However concentrations are generally above the low reliability Aquatic Ecosystem WQO for molybdenum (Figure 92).

Concentrations of total molybdenum were historically elevated in the Wises Pit between 2007 and 2011 (Figure 92). The composite sample shows a concentration of total concentration of molybdenum above the Drinking Water and Aquatic Ecosystems WQO and is generally representative of water quality of both pits since 2012. Concentrations of molybdenum are significantly elevated compared to concentrations in the receiving environment (Appendix B).

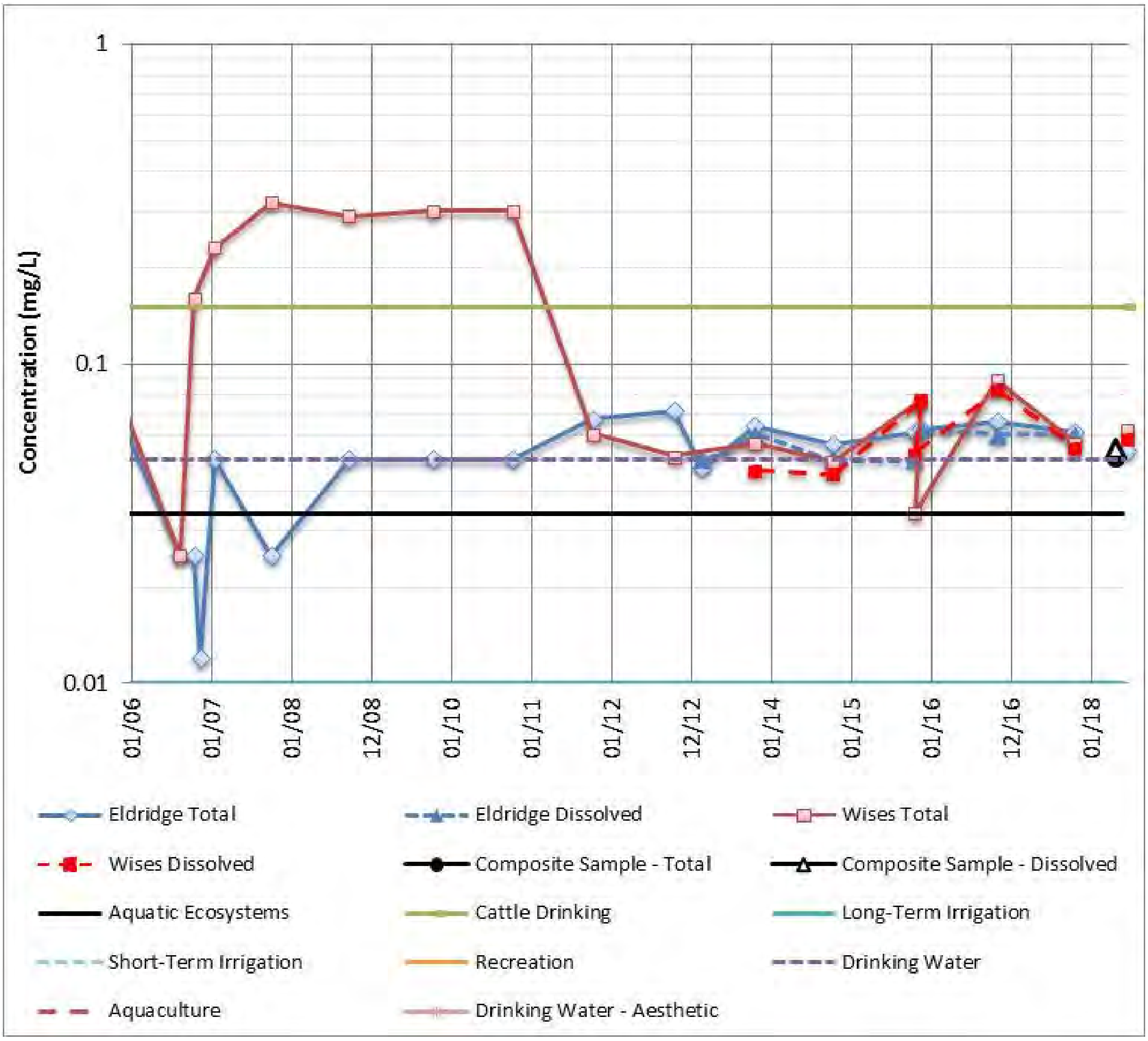


Figure 92 Molybdenum Concentrations in the Eldridge and Wises Pits

Nickel

Nickel concentrations are consistently higher in the Eldridge Pit compared to the Wises Pit (Figure 93). There have only been two samples of nickel (total) in the Eldridge Pit that show concentrations below all WQOs (Figure 93). Although concentrations are raised above Aquatic Ecosystem and Drinking Water WQOs in the Eldridge Pit there is no overall increase in the concentration of filtered or total nickel. Concentrations are relatively stable between 0.01 and 0.05mg/L except for one outlier in December 2012. Concentrations in the Wises Pit appear to be on an upwards trend since 2015. Concentrations in the composite sample (0.022mg/L) are above the Aquatic Ecosystem WQO and are generally consistent with concentrations in the Eldridge Pit.

Concentrations of dissolved nickel are well below the HMTVs provided for each pit (Figure 93). This is because the hardness values in the Pits are several orders of magnitude (i.e. between 1500mg/L and 2000mg/L) compared to the hardness values used to develop Aquatic Ecosystem WQOs (30mg/L).

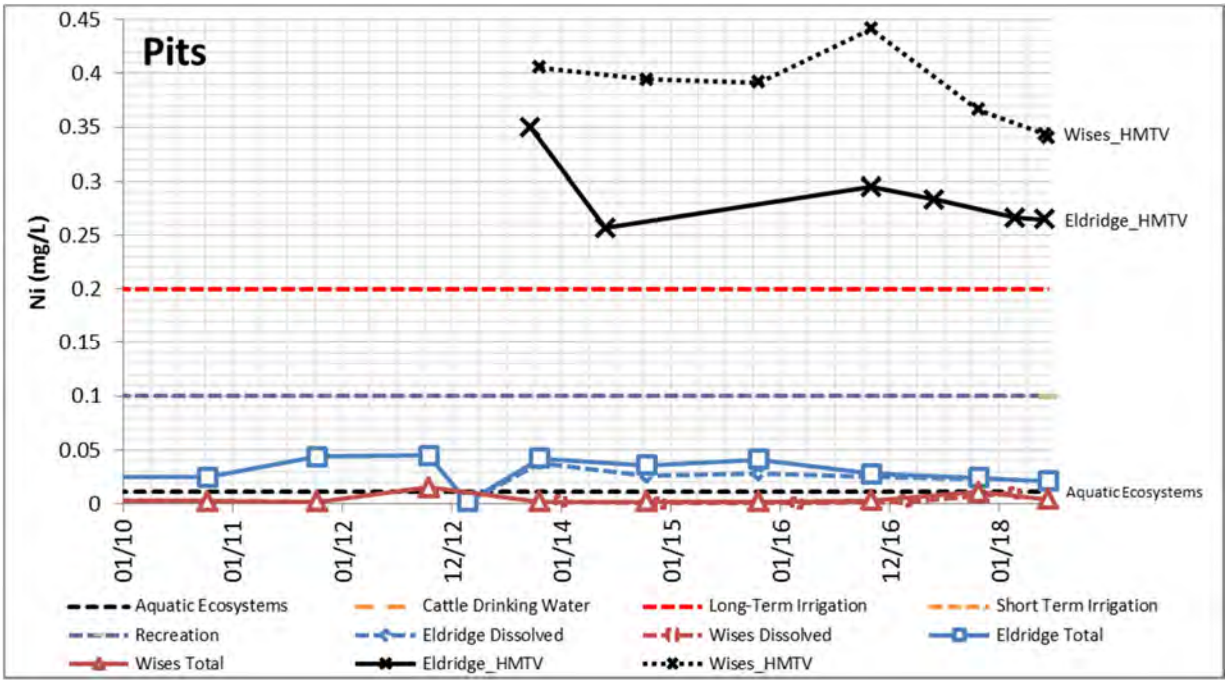


Figure 93 Nickel Concentrations in the Eldridge and Wises Pits

Zinc

Dissolved and total zinc concentrations in the Eldridge Pit are subject to high fluctuations (Figure 94) between 0.006mg/L to 2mg/L. There is sometimes an order of magnitude difference in the concentration of zinc within the Eldridge pit in consecutive samples and the concentrations do not correlate well with any other parameters that are currently analysed. Zinc concentrations in the Wises Pit are a little more stable than concentrations in the Eldridge Pit and are generally lower. Zinc concentrations in both pits were consistently above the WQO for Aquatic Ecosystems, with the exception of two samples from the Eldridge Pit in 2008 and 2009. The composite sample shows a concentration (approximately 1.04mg/L) above the Aquatic Ecosystem WQOs.

The toxicity of zinc is dependant on hardness. Higher hardness values will see higher competition between calcium and magnesium ions with zinc, therefore lowering toxicity. Subsequently a HMTV for zinc was calculated on a sample by sample basis in accordance with table 3.4.3 of the ANZECC (2000) Guidelines. These values are designed for Aquatic Ecosystem protection and over-ride the default WQO where they are larger. As discussed previously the Pits have a significantly higher hardness (1500-2000mg/L) compared to the values used to calculate the default WQO (30mg/L).

Subsequently it is only recent samples in the Wises Pit which have exceeded the HMTV for zinc (Figure 94). This sample was collected in early 2018. However the concentration of dissolved zinc in the Wises Pit decreased to below the HMTV in the June 2018 sample. Samples from the Eldridge Pit have exceeded the HMTV for dissolved zinc since late 2016. Concentrations of dissolved zinc in the Eldridge Pit (0.8-1.2mg/L) are roughly an order of magnitude above the HMTVs for the same period (approximately 0.2mg/L).

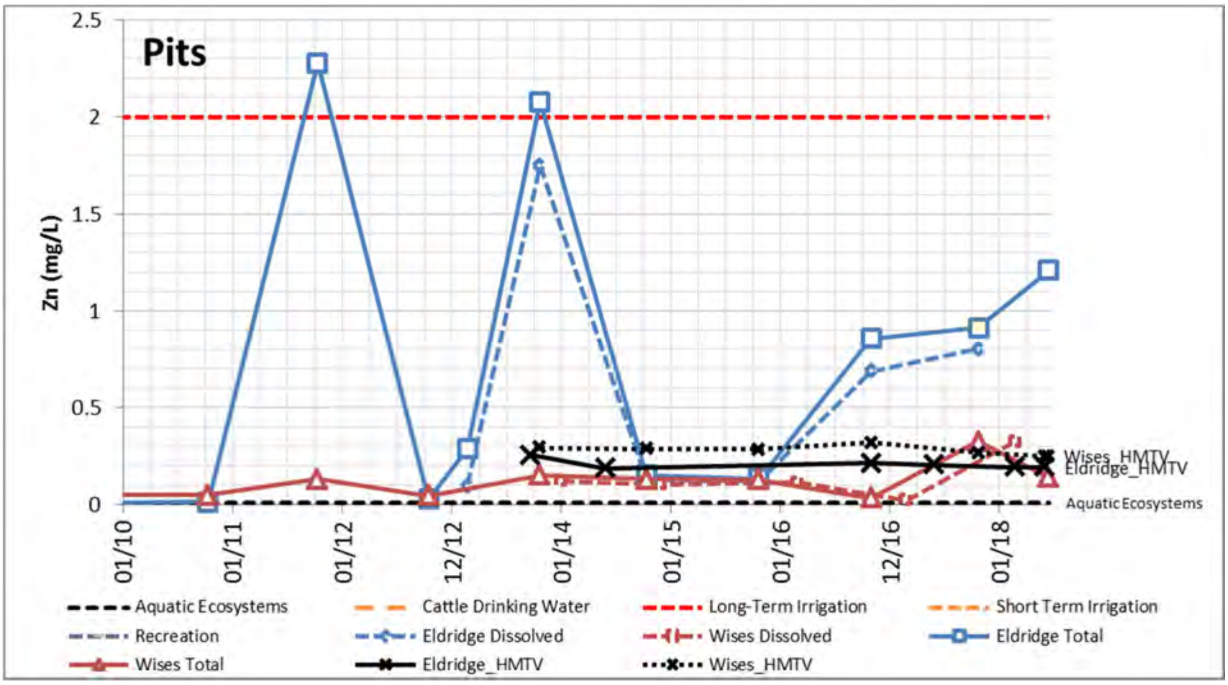


Figure 94 Zinc Concentrations in the Eldridge and Wises Pits

Cyanide

There have only been three samples collected from the Eldridge and Wises Pits which have been analysed for total cyanide. These concentrations are plotted below in Figure 95 Historical samples taken in 2012 show total cyanide concentrations above WQOs for both pits. However recent samples, as well as the composite sample are well below WQOs, and show concentrations which are below the LOR (<0.004mg/L). Therefore cyanide is not considered a contaminant of concern since it has not been detected in any samples since 2012.

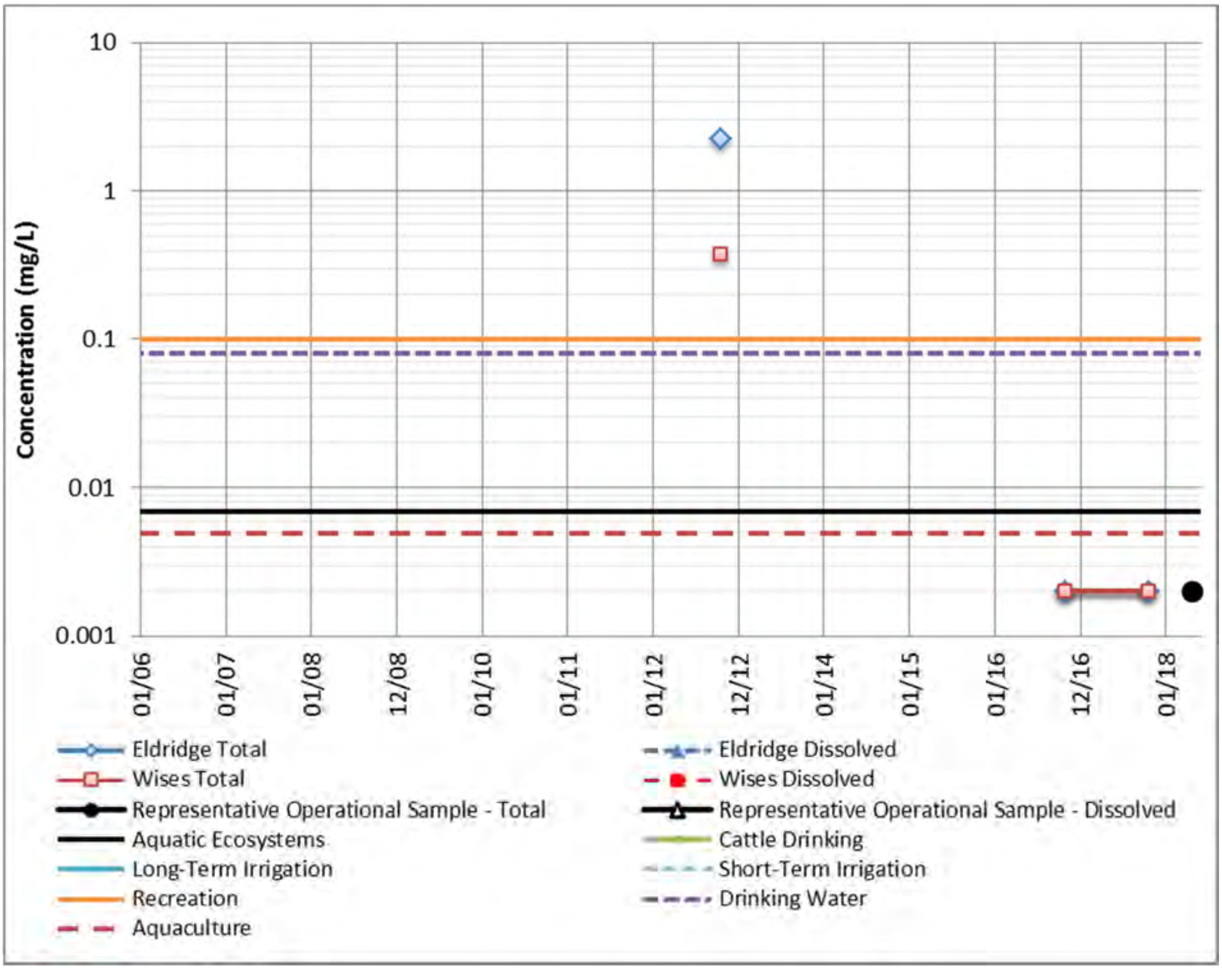


Figure 95 Total Cyanide Concentrations in the Wises and Eldridge Pits

Appendix E

Wet Season Aquatic Ecology Survey - 2018

C&R CONSULTING
Geochemical & Hydrobiological Solutions Pty Ltd
ABN 72 077 518 784

Underground Coal Gasification / Coal Seam Gas Investigations
Mineralogical, Geological, Petrographic and Soils Services
Hydrogeomorphic and Palaeogeomorphic Evaluations
Terrestrial and Aquatic Fauna and Flora Surveys
Climate History and Extreme Events Analysis
Contaminated Site and Mine Water Analysis
Environmental Compliance and Monitoring
Estuarine and Marine Water Assessments
Surface and Groundwater Investigations

PO Box 1777
Thuringowa, Qld, 4817, AUSTRALIA
Tel: +61 (0) 7 4725 3751
Mob: +61 (0) 417 635 032
info@candrconsulting.com.au
www.candrconsulting.com.au

KIDSTON PUMPED STORAGE HYDRO PROJECT

AQUATIC ECOLOGY SURVEY REPORT

REPORT PREPARED FOR:
AECOM Pty Ltd

Date:
June 2018

IMPORTANT NOTE

Christopher Cuff

Dr Chris Cuff
Director

20 June 2018

Date

Cecily Rasmussen

Dr Cecily Rasmussen
Director

20 June 2018

Date

SUMMARY OF RELEVANT INFORMATION

Project Title	Kidston Pumped Storage Hydro Project
Property Location	Kidston, North Queensland
Project Purpose	Aquatic Ecology Survey Report
Client Details	
Company	AECOM Pty Ltd
Nominated Representative	Reece Fraser
Title/Position	Senior Water Resources Scientist
Postal Address	GPO Box 5423 Townsville QLD 4810
Telephone	(07) 4729 5500
Fax:	(07) 4729 5599
Email	Reece.Fraser@aecom.com
Survey undertaken by:	Mr. M. Knott Mr. D. Buchanan

TABLE OF CONTENTS

1. INTRODUCTION 1

2. METHODS 2
- 2.1 Database Searches 2
- 2.2 Aquatic Ecology Field Surveys 2
  - 2.2.1 Timing 2
  - 2.2.2 Site Selection 2
  - 2.2.3 Aquatic Habitat 4
  - 2.2.4 Water Quality 5
  - 2.2.5 Aquatic Flora Communities 5
  - 2.2.6 Aquatic Macroinvertebrate Communities 5
  - 2.2.7 Fish Communities 8
  - 2.2.8 Turtle Communities 9
  - 2.2.9 Other Aquatic Vertebrates 9

3. RESULTS 11
- 3.1 Habitat Assessment 11
  - 3.1.1 Habitat Condition 11
- 3.2 Water Quality 15
- 3.3 Macroinvertebrate Communities 16
  - 3.3.1 Taxonomic Richness 16
  - 3.3.2 PET Richness 17
  - 3.3.3 Signal 2/Family Bi-Plots 18
  - 3.3.4 AusRivAS Modelling 20
  - 3.3.5 Baited Traps 21
  - 3.3.6 Summary 22
- 3.4 Fish Communities 22
  - 3.4.1 Species Richness 22
  - 3.4.2 Total Abundance 23
  - 3.4.3 Regional Context 23
- 3.5 Aquatic Flora 24
- 3.6 Turtle Community and Other Aquatic Vertebrates 24
  - 3.6.1 Turtle Communities Present 24
  - 3.6.2 Other Aquatic Vertebrates 24

4. REFERENCES 26

LIST OF FIGURES

Figure 1: Site map 3
Figure 2: SIGNAL 2 Bi-plot quadrants 8
Figure 3: Habitat condition observed at each site 15
Figure 4: Taxonomic richness within the bed habitats at all sites compared to the QWQG (2009) Central Queensland guideline values 16
Figure 5: Taxonomic richness within the edge habitats at all sites compared to the QWQG (2009) Central Queensland guideline values 17
Figure 6: PET richness within the bed habitats at all sites compared to the QWQG (2009) Central Queensland guideline values 18
Figure 7: PET richness within the edge habitats at all sites compared to the QWQG (2009) Central Queensland guideline values 18

Figure 8: SIGNAL 2 Bi-plot displaying the bed results from each site compared against guideline values from the Central Queensland region (QWQG, 2009)....19
Figure 9: SIGNAL 2 Bi-plot displaying the edge results from each site compared against guideline values from the Central Queensland region (QWQG, 2009)....20
Figure 10: Fish species richness at each site....23
Figure 11: Total fish abundance at each site....24

LIST OF TABLES

Table 1: Rating system used to determine Habitat Bioassessment Scores (DNRM 2001)....4
Table 2: Fishing settings and effort employed at each site....10
Table 3: Site descriptions, sampling limitations and site pictures....12
Table 4: In-situ water quality results....15
Table 5: Observed taxa results for each habitat at each site with greater than 50% probability of occurrence....20
Table 6: Overall site results and macroinvertebrate taxa information relevant to each site....21
Table 7: Invertebrate species caught in baited traps....22

LIST OF APPENDICES

Appendix 1 – Raw Macroinvertebrate and Fish Data....27
Appendix 2 – Search Results....31

1. INTRODUCTION

C&R Consulting Pty Ltd were contracted by AECOM Pty Ltd to undertake aquatic ecology sampling of the Copperfield River reaches associated with the Kidston Pump Storage Hydro Project and provide a report detailing the methods employed, the results, and an assessment of any significant findings. Therefore, this brief includes:

- Section 2 – An overview of the methods used to determine the aquatic flora and fauna communities inhabiting the site, including a literature review and detailed field surveys.
- Section 3 – Details the results of field work including the habitats present as well as describing their condition and the macroinvertebrate, fish, turtle, aquatic flora species identified occurring across the project site.

2. METHODS

2.1 DATABASE SEARCHES

Database searches for this study targeted listed aquatic flora, fauna and communities previously documented in the area (within a 20km radius of the project site). Databases searched included the EPBC Protected Matters Tool (2018) targeting EPBC Act species and communities, and Wildlife Online (2018) targeting NC Act species.

2.2 AQUATIC ECOLOGY FIELD SURVEYS

2.2.1 TIMING

The aquatic ecology field surveys were conducted at the end of the 2017-2018 wet season (23rd – 26th of April 2018), approximately six weeks after significant rain had fallen within the region (pers. comm. AECOM) and the major flows had receded (in accordance with AusRivAS methods; DNRM, 2001). The highly ephemeral nature of the majority of the watercourses within the region, indicates that end of wet season sampling is the most appropriate timing for identification of greatest biodiversity potential. This is also the most appropriate period for determining any potential impacts from upstream influences.

2.2.2 SITE SELECTION

Aquatic ecology sampling site locations were provided by the client and are shown in Figure 1. The six (6) sites were based on historic monitoring locations (WB, W1, W2 and W3) with additional sites (E1 and E2) incorporated to provide further information on the influence of East Creek.

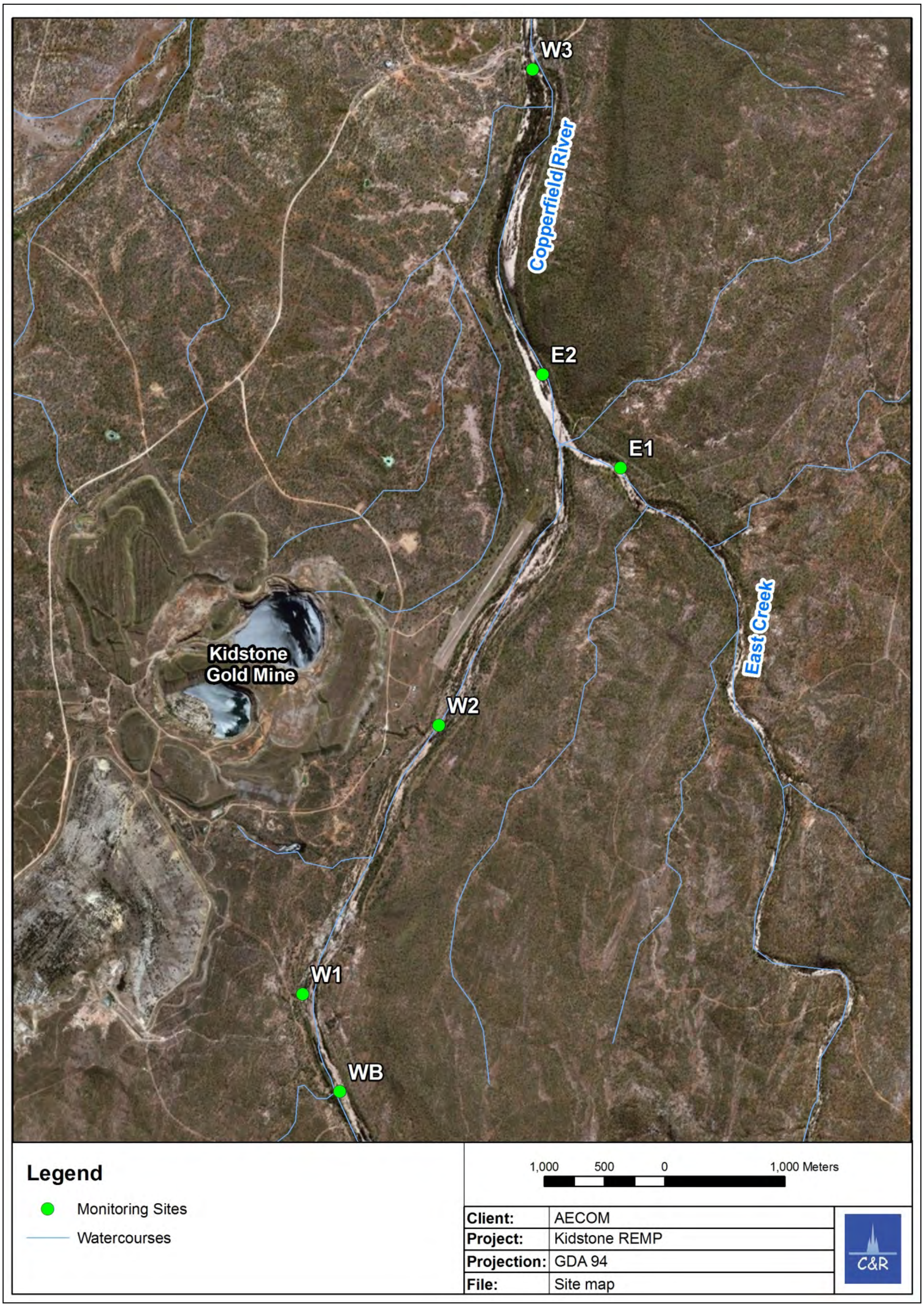


Figure 1: Site map

2.2.3 AQUATIC HABITAT

Habitat Characteristics and Condition

Habitat condition was assessed at each sampling site in accordance with the methods outlined within the *Queensland AUSRIVAS Sampling and Processing Manual* (DNRM, 2001). Under this manual, the following nine key physical habitat characteristics were assessed:

- Bottom substrate/available cover;
- Embeddedness;
- Velocity/depth cover;
- Channel alteration;
- Bottom scouring and deposition;
- Pool/riffle, run/bend ratio;
- Bank stability;
- Bank vegetative stability; and
- Streamside cover.

Habitat characteristics are given a rating based on their condition, with the overall habitat bioassessment score for a site (the sum of all the possible ratings) then allocated to one of four categories signifying habitat condition present at the site (Table 1). The four allocated categories are:

- Excellent (>110);
- Good (75 – 110);
- Fair / moderate (39 – 74); and
- Poor (≤38) (Table 1).

Table 1: Rating system used to determine Habitat Bioassessment Scores (DNRM 2001)

Number	Habitat Variable	Habitat condition rating ranges			
		Poor	Fair	Good	Excellent
1.	Bottom substrate / available cover	0 – 5	6 – 10	11 – 15	16 – 20
2.	Embeddedness	0 – 5	6 – 10	11 – 15	16 – 20
3.	Velocity / depth category	0 – 5	6 – 10	11 – 15	16 – 20
4.	Channel alteration	0 – 3	4 – 7	8 – 11	12 – 15
5.	Bottom scouring and deposition	0 – 3	4 – 7	8 – 11	12 – 15
6.	Pool / riffle, run / bend ratio	0 – 3	4 – 7	8 – 11	12 – 15
7.	Bank stability	0 – 2	3 – 5	6 – 8	9 & 10
8.	Bank vegetative stability	0 – 2	3 – 5	6 – 8	9 & 10
9.	Streamside cover	0 – 2	3 – 5	6 – 8	9 & 10
-	Total Habitat Bioassessment Score	0 – 38	39 – 74	75 – 110	111 – 135

Photos were taken to document habitat variability at each site. This habitat assessment provides a detailed overview of existing habitat condition at each sampling site. It also provides a baseline for each site against which future change can be monitored.

2.2.4 WATER QUALITY

Basic water quality analysis was undertaken at each site to assist in the interpretation of the biological data. Water quality at each site was tested using an Eureka Manta Sub-2 in-situ field meter. The following parameters were measured:

- Water temperature (°C);
- Electrical conductivity (µS/cm);
- pH (Units); and
- Dissolved oxygen (mg/L and %sat).

Water samples were also collected from each site and analysed at a NATA accredited laboratory for a range of parameters discussed further within AECOM's report.

2.2.5 AQUATIC FLORA COMMUNITIES

Aquatic flora can have many different forms, including:

- Submerged macrophytes: Growth is predominantly beneath the water surface although flowers and or leaves of some species protrude the surface of the water;
- Floating macrophytes: Can be either attached or free floating (Sainty & Jacobs, 2003). For example, the introduced water hyacinth floats freely around waterways being moved across the surface by wind or currents, while the waterlilies are rooted to the substrate but the mature leaves float on the surface;
- Emergent macrophytes: Generally grow in the shallower waters and are rooted to the substrate with the majority of the plant (stems, flowers and leaves) protruding above the surface of the water (Sainty & Jacobs, 2003); and,
- Algae: Generally need to be fully submerged to survive.

Aquatic flora surveys were conducted at each site along a 100m reach, with species inhabiting the reach identified. This assessment detailed the presence/absence of all native and exotic aquatic flora and their form (from the four categories listed above) as well as the percent cover of each species within a 50m sub-section at each site. Transects cannot be effectively surveyed in turbid and/or deep habitats, therefore transects generally targeted shallower waters.

Photographs of different macrophyte species present at each site were taken. Specimens of any species that could not be identified in the field were collected for identification purposes within the C&R laboratory.

The data collected provides an indication of the existing condition of aquatic macrophyte communities present within the watercourses of the project site.

2.2.6 AQUATIC MACROINVERTEBRATE COMMUNITIES

At each site both the bed and edge habitats were sampled for macroinvertebrates. Sampling methods followed the procedures set out in the Queensland AusRivAS Sampling Manual (DNRM, 2001). This involves the use of a standard triangular mouthed frame fitted with a 250µm mesh size net to collect all samples. Run habitats were sampled by holding the macroinvertebrate net downstream of the samplers position with the open end facing the sampler. The sampler then disturbs the substrate by kicking the feet and slowly walking upstream while dragging the net through the disturbed plume. This ensures that organisms inhabiting the benthos are collected. Edge habitat samples were taken by selecting the appropriate section (e.g. backwater with leaf litter, exposed tree roots and some trailing vegetation, if available) and vigorously sweeping the net in short upward movements perpendicular to the bank to ensure the substrate is disturbed and then sweep through any suspended material. For both habitats a maximum distance of 10m was sampled.

Samples taken were live picked in the field for a minimum of 30 minutes using tweezers and pipettes. The first 5 minutes of picking targeted the common and most abundant taxa. After the first 5 minutes, the majority of the picking effort focused on the less common, conspicuous taxa. If at the end of the 30 minutes less than 200 animals had been found the samples were picked for a further 10 minutes. Picked specimens from each sample were stored in a vial of 70% alcohol and sent to the C&R laboratory for detailed family identification. Organisms were counted and identified to the lowest practical taxonomic level (in most instances family) to comply with AusRivAS standards. Macroinvertebrate samples for this project were initially identified by a suitably qualified Aquatic Ecologist, with 10% (or greater) of samples randomly chosen for verification by C&R's Senior Aquatic Ecologist to ensure QA/QC.

Data Analysis

The QWQG (2009) are generally used by regulators to assess macroinvertebrate community health within freshwater systems specific to each Queensland region. However, the QWQG (2009) do not provide any guideline values for the region to assess biological communities. Instead, analysis of macroinvertebrate data was undertaken with upstream and downstream sites compared for the following indices:

- **Taxonomic richness** – This represents the total number of different macroinvertebrate taxa collected at each site. This is to determine the diversity of the macroinvertebrate community present at each site. Healthier sites will have a greater diversity.
- **PET Taxa richness –** Indicates the number of families collected from three specific orders; Plecoptera (stoneflies), Ephemeroptera (mayflies) and Trichoptera (caddisflies). These macroinvertebrate orders are considered sensitive to changes within their environment. Therefore, a low number of families collected from these orders (compared to the guidelines values) may suggest habitat degradation.
- **SIGNAL 2 index –** The SIGNAL index (Stream Invertebrate Grade Number – Average Level) was developed by Chessman (1995) to assist in the bioassessment of water quality in Australia. Chessmen (1995) determined sensitivity grade numbers (between 1 and 10) for most freshwater macroinvertebrate families in Australia based on how sensitive each was to various pollutants and other physical and chemical factors. In 2003 Chessman devised a weighted system for analysing SIGNAL indices to provide an overall SIGNAL 2 score for the site. This weighted system of analysis takes into consideration relative family abundance and therefore community composition. The overall SIGNAL 2 score is calculated using the following steps:
    - Determine SIGNAL grade for each different taxa present;
    - Determine weighting of each taxa present based on the number of individuals collected using the categories outlined in Chessman (2003);
    - Multiply the weight value by the SIGNAL grade for each taxa; and,
    - Divide the total weight determined for a site (add up all the weights) by the total SIGNAL grade x weight determined (add up all the values determined in the previous step) to provide an overall SIGNAL 2 score for the site.

    SIGNAL 2 scores are then interpreted using bi-plots and compared against the number of families recorded at each site. The bi-plots can then be divided into quadrants with each separate quadrant identifying the particular conditions occurring within a site (Figure 2). The boundaries that determine the quadrants are generally based on background assessments from the region. However, stream specific boundaries can be identified if sufficient reliable data are available. To date, all previous monitoring undertaken within the region has applied the boundaries for each quadrant based on a whole of Australia assessment undertaken Chessman (2003) (designated interim boundaries). The current study will adopt interim boundaries based on the Central Queensland regional guidelines as these appear most relevant (QWQG, 2009).

Further assessment of the data was also undertaken using the AusRivAS modelling programme to compare collected data against reference sites within the region and provide a level of macroinvertebrate community condition for each site. Data were analysed using the AusRivAS Queensland-Autumn-Western Regional- Edge and Run models. For a full description of how these models function please refer to the *AusRivAS Predictive Modelling Software Version 3.1 Users Manual (2004)* and the *AusRivAS Macroinvertebrate Bioassessment Predictive Modelling Manual (2000).* The results of these models provide an indication of the level of biological impairment experienced at the targeted sites. The Observed/Expected (O/E) score (50%) provides a measure of biological impairment for each habitat within a site. The O/E score (50%) indicates the number of collected taxa that were predicted (expected) to occur with equal to or greater than 50% probability. Each O/E score (50%) occurs within the range of one of five Bands (X, A, B, C or D). The Band provides the description of biological impairment. The habitat that provides the lowest O/E score (50%) (e.g. the most biologically impaired) for a site provides the level of biological impairment for that particular site. This provides a conservative approach to management.

The levels of biological impairment a site can be categorised as include:

- **Band X:** Indicates the site is richer than reference sites within the region. This means that more families were found than expected and can suggest that the site is either a potential biodiversity “hotspot” or has mild organic enrichment.
- **Band A:** Infers the site is similar to reference sites. Suggesting that the site is similar to the determined natural state of creeks in the region.
- **Band B:** Indicates the site is significantly impacted. Fewer families were collected than were predicted to occur. This suggests there is potential mild impact to water quality and/or sampled habitat.
- **Band C:** Indicates the site is severely impacted. Many families were not collected that were predicted to occur. Severely impacted water quality and/or habitat are present that has resulted in a loss of families.
- **Band D:** Indicates the site is impoverished. This infers that very few families were collected, indicating that the site is highly degraded with very poor water and/or habitat quality.

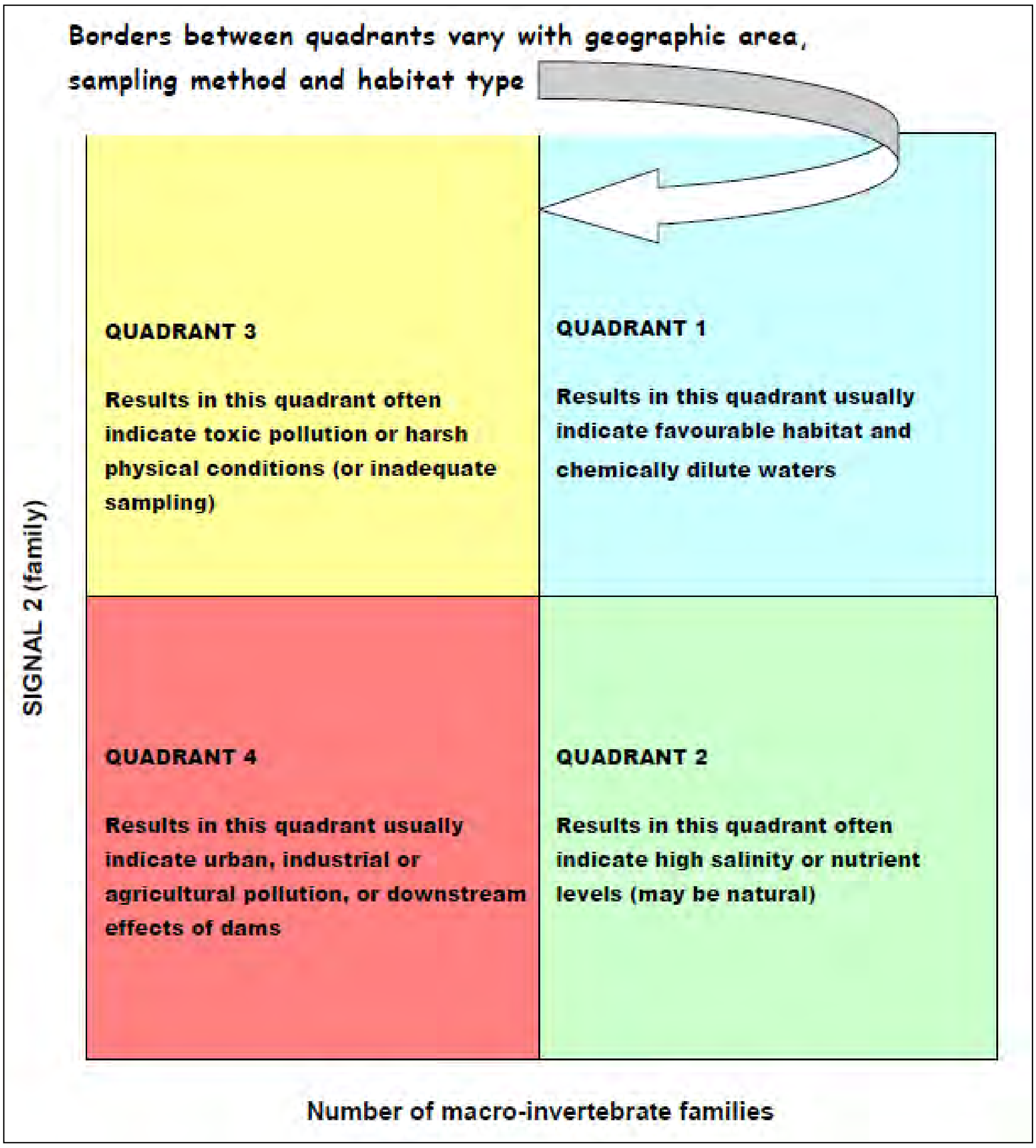


Figure 2: SIGNAL 2 Bi-plot quadrants

2.2.7 FISH COMMUNITIES

Fish communities were surveyed using a combination of backpack electrofishing, baited traps, seine nets, tangle nets and dip nets dependent on habitat type (e.g. deep pool, shallow run, etc.).

Backpack electrofishing (using a Smith-Root LR-24) was the preferred sampling technique (Table 2). Baited traps were employed at each site to target both fish and crustaceans. This included replicate samples of collapsible box traps (2mm mesh) and opera house traps (1.5" mesh) at each site. Table 2 outlines the fishing techniques and effort utilised at each particular site during the field assessment.

Fish collected were counted, identified, measured (to determine life history stage) and photographed. A general assessment of fish health was also noted for each surveyed site. Any specimens unable to be identified within the field were euthanised and brought back to the C&R laboratory (as voucher specimens) for identification.

Freshwater fish surveys were conducted in accordance with methods developed for the Northern Australian Freshwater Fish Atlas project (NAFF 2007, a collaboration between the National Centre for Tropical Wetland Research and Griffith University) and in accordance with the *Australian Code of Electrofishing Practice 1997*.

Data Analysis

Species richness, total abundance, abundance of listed aquatic species, abundance of exotic species, and abundance of each life history stage present (e.g. juvenile, intermediate or adult) were determined for each assessed site.

2.2.8 TURTLE COMMUNITIES

A turtle survey was conducted to identify any turtle species that may be present within the project site. Turtle communities at each site were assessed via visual surveys and baited cathedral traps dependent on habitat targeted and access (e.g. depth, macrophyte beds, etc.). However, the shallow nature of the majority of sites meant cathedral traps could only be utilised at W1 with one being deployed for a total of 15hrs. As the water was clear and relatively shallow at most sites, walk through visual surveys were employed to target freshwater turtles potentially inhabiting the area.

Turtles are also regularly seen during electrofishing surveys for fish communities. When noticed, the electrofisher was shut down to prevent injury to the animal. The turtle was then caught for identification purposes, and subsequently released.

Captured turtles were measured, identified to a species level and photographed. All results were tabulated for species presence and abundance at each sampling site.

All turtle surveys were conducted under Animal Ethics Approval No. CA 2016-02-942.

2.2.9 OTHER AQUATIC VERTEBRATES

The potential presence of other aquatic vertebrates in the region was assessed through the completion of database searches, specifically the Commonwealth's *Protected Matters Search Tool* and the Queensland Government's *Wildlife Online* database.

However, by undertaking the methods outlined for fish and turtle surveys, any other aquatic vertebrates observed inhabiting the area were noted with presence/absence data recorded.

Table 2: Fishing settings and effort employed at each site

	Date	Habitat sampled	Average Depth	Method	Fishing Settings			Total Effort
WB	25/04/2018	Shallow runs with deeper erosional banks and woody debris	0.75m	Baited box traps	2 deployed	2mm mesh		33 hrs
				Baited opera traps	2 deployed	1” mesh		33 hrs
				Backpack Electrofisher	240V	60Hz	25% Duty	487 secs
W1	25/04/2018	Deep pools with some shallower runs and backwater	>1m	Baited box traps	2 deployed	2mm mesh		31 hrs
				Baited opera traps	3 deployed	1” mesh		46.5 hrs
				Tangle net	1 deployed	1.5” mesh x 10m		1.5 hrs
				Backpack Electrofisher	240V	60Hz	25% Duty	205 secs
W2	24/04/2018	Shallow and deep riffles and runs with an some backwater	1m	Baited box traps	2 deployed	2mm mesh		31 hrs
				Baited opera traps	2 deployed	1” mesh		31 hrs
				Backpack Electrofisher	260V	60Hz	25% Duty	298 secs
W3	23/04/2018	Shallow runs and riffles and deeper riffles with deep undercut banks	1m	Baited box traps	3 deployed	2mm mesh		48 hrs
				Baited opera traps	3 deployed	1” mesh		48 hrs
				Tangle net	1 deployed	1.5” mesh x 10m		2 hrs
				Backpack Electrofisher	200V	60Hz	25% Duty	430 secs
E1	24/04/2018	Shallow run and small riffle, extensive backwater	0.75m	Baited box traps	2 deployed	2mm mesh		35 hrs
				Baited opera traps	2 deployed	1” mesh		35 hrs
				Backpack Electrofisher	200V	60Hz	25% Duty	415 secs
E2	24/04/2018	Isolated pool with only base flow remaining	0.5m	Baited box traps	3 deployed	2mm mesh		48 hrs
				Baited opera traps	3 deployed	1” mesh		48 hrs
				Backpack Electrofisher	360V	60Hz	25% Duty	248 secs

3. RESULTS

3.1 HABITAT ASSESSMENT

Field surveys were undertaken at the end of April 2018, at the end of the 2017-2018 wet season, and approximately six weeks after a significant rainfall event/flows, to allow aquatic flora and fauna assemblages to be at peak family richness.

Above ground flows were still present in Copperfield River, while East Creek was reduced to a series of pools connected by subsurface flows at the time of sampling. The study is considered to have adequately determined aquatic habitats that occur within the project site, including:

- Run;
- Riffle;
- Deep pool;
- Shallow pool;
- Undercut/eroded bank;
- Bedrock; and
- Complex woody debris (Table 3).

Table 3 outlines the sampling sites and portrays their status at time of sampling.

3.1.1 HABITAT CONDITION

The AusRivAS habitat condition assessment was determined for each sample site and the results are presented in Figure 3. These results indicate that the majority of sites were in a similar condition (good), with only E1 observed in moderate condition. This is a direct result of the relatively uniform flowing habitats, displaying riffles and runs within Copperfield River at time of sampling (Table 3). E1 scored slightly less because of the lack of flows and subsequent reduced diversity of habitats (Table 3).

Table 3: Site descriptions, sampling limitations and site pictures

Site	Upstream view	Downstream view	Description
WB			WB incorporated a long, shallow run habitat with a deep pool associated with a large fallen tree and other woody debris. There was also a large backwater pool that contained a large amount of leaf litter. The water was relatively clear with an average depth of 0.75m. The substrate was comprised of sand and gravel. The riparian vegetation was dominated by Acacia and Melaleuca, with aquatic vegetation limited to sedges. Exposed roots, sedges and trailing vegetation provided structurally complex habitat along the banks. ***Limitations –*** The shallow nature and high flows limited the effectiveness of nets and traps.
W1			W1 consisted of a deep turbid pool with some shallow run sections and backwater also present. Structural complexity was provided by exposed roots, some trailing vegetation and bedrock. The riparian vegetation was dominated by Melaleuca, with minimal aquatic vegetation noted. The substrate was dominated by sand and bedrock with an average depth of >1m. ***Limitations –*** The depth of water and turbidity limited the ability to utilise electrofishing at this site.

Site	Upstream view	Downstream view	Description
W2			This site consisted of one large straight run section with bedrock and woody debris creating some riffles. The water was relatively turbid and an average depth of ~1m. No aquatic vegetation was noted at this site. The riparian vegetation was again dominated by Melaleuca and the substrate dominated by coarse sand. ***Limitations*** **–** Turbidity limited the ability to utilise electrofishing at this site while the flows limited the use of nets.
E1			E1 was situated at the downstream end of East Creek immediately prior the confluence with Copperfield Creek. This site is to act as a reference site for flows at downstream sites to provide an indication of the influence flows from East Creek may have on downstream environments. The site was a large pool on a bend, with significant amounts of trailing vegetation. The water clarity at the site was good although the depth of water along the erosional restricted vision. The riparian zone was dominated by Melaleuca and Forest Blue Gums. Little erosion and moderate sediment deposition were noted. The substrate was dominated by sand. ***Limitations*** **–** The depth of the water along the erosional bank limited the ability to electrofish.

Site	Upstream view	Downstream view	Description
E2			This site was one long straight run habitat with a shallow backwater section and exposed roots providing some structural complexity. The substrate was dominated by sand. The aquatic vegetation community was limited to intermittent sedges along the banks. The riparian vegetation was again dominated by Melaleuca and Acacia. ***Limitations*** – Flow was too strong to utilise nets. However, all other sampling techniques were performed effectively.
W3			W3 provided the most diverse range of habitats including substantial riffle zones, shallow pools, runs and deeper pools. The site is located downstream of all historic mining operations at the main access road crossing. The substrate was dominated by sand, cobble and bedrock. The water was relatively clear, although it was opaque in deeper sections. The riparian vegetation was dominated by Melaleuca. ***Limitations*** – Sampling of deeper waters (>1.2m) was limited to traps as water was too deep and flowing too fast for electrofishing and nets.

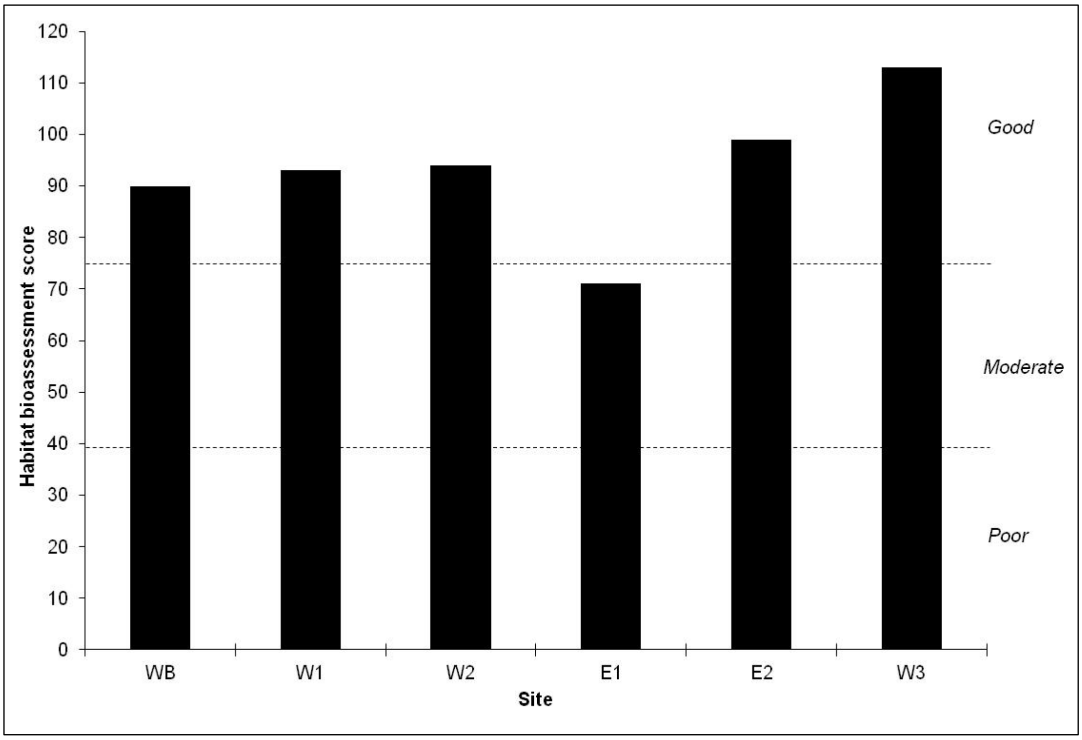


Figure 3: Habitat condition observed at each site

3.2 WATER QUALITY

In-situ water quality results displayed a relatively well mixed system with stable electrical conductivity, pH and dissolved oxygen across all sample sites (Table 4). The variability observed within the temperature data is simply a product of time of sampling during each day (e.g. morning or afternoon; Table 4).

Table 4: In-situ water quality results

Site	Temperature (ºC)	Electrical conductivity (µS/cm)	pH (pH units)	Dissolved oxygen (%Saturation)
WB	23.23	107	7.75	N/A
W1	20.99	113	7.75	91.7
W2	25.67	108	7.81	100.9
E1	22.5	116	7.78	105.9
E2	22.2	112	7.9	100.9
W3	25.00	115	7.63	99.2

3.3 MACROINVERTEBRATE COMMUNITIES

3.3.1 TAXONOMIC RICHNESS

Fifty one (51) different macroinvertebrate taxa were collected during the field survey compared to 41 in 2012, 39 in 2011, 35 in 2010 and 33 in 2009 (Genex 2015; refer to raw macroinvertebrate data in Appendix 1). As no guideline values are available for Gulf Rivers, the Central Coast Guideline Values (QWQG, 2009) were adopted as these are the most relevant in terms of the nature of flows within the targeted watercourses. Therefore, these guidelines simply provide guidance on the results, not definitive conclusions.

The majority of bed habitats were greater than the 20th percentile value set by the Queensland Water Quality Guidelines (QWQG) (2009), with only E2 recorded below this guideline value (Figure 4). All sites were well below the 80th percentile guideline value (Figure 4). The bed habitat at E2 was almost entirely comprised of sand with only a minor amount of cobble and gravel. This lack of structural complexity may have influenced the results.

Edge habitats at only W1 and E1 were compliant with the QWQG (2009) 20th percentile value (Figure 5). All other sites were non-compliant. Such results usually suggest a lack of diversity within the edge habitat. However, as these guideline values are not developed for this region it may simply be a regional trend. Edge habitats were predominantly exposed roots with a large amount of scouring associated with the relatively large and consistent flows experienced six weeks prior. This scouring may have reduced the diversity of fauna able to inhabit the areas.

Edge habitats are generally more structurally diverse and exhibit higher rates of primary production compared to bed habitats, resulting in greater diversity of macroinvertebrate communities than bed habitats (Choy *et al.,* 2002). This was the case in the current study. However, the presence of riffles within the bed habitats at most sites limited the overall differences in taxonomic richness between habitat types.

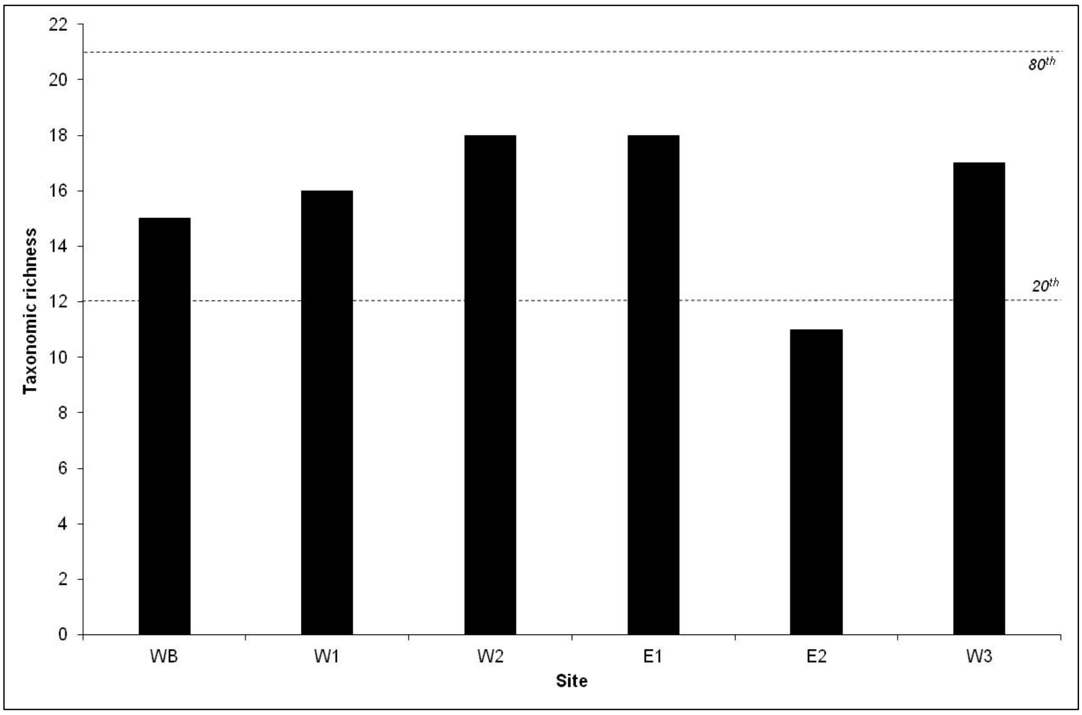


Figure 4: Taxonomic richness within the bed habitats at all sites compared to the QWQG (2009) Central Queensland guideline values

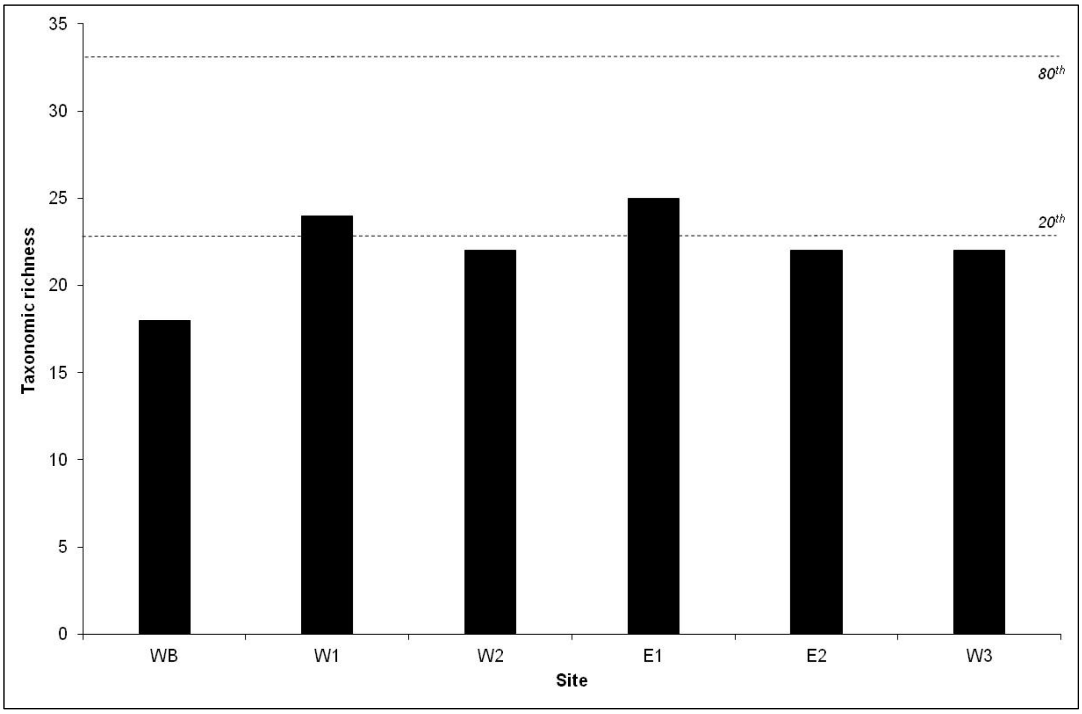


Figure 5: Taxonomic richness within the edge habitats at all sites compared to the QWQG (2009) Central Queensland guideline values

3.3.2 PET Richness

All sites recorded PET richness within the bed habitat well above the 20th percentile guideline value and often equal to the 80th percentile guideline value for Central Queensland (Figure 6). Similar trends were observed in the edge habitat at each site (Figure 7). These PET richness results suggest that either the communities are in excellent condition, or the guideline values are not relevant to the region.

Interestingly, the far afield downstream site (W3) recorded the highest levels of PET richness of any site in both habitats. This is likely a result of the variety of habitats observed at the site and extensive riffle zones encountered.

Seven of the nine PET families identified occurring within the receiving environment are allocated SIGNAL Grades of ≥5, with these seven families accounting for over 70% of PET individuals recorded. Therefore, the PET richness results also suggest that the macroinvertebrate communities within the receiving environment are comprised of a high number of taxa that are sensitive to environmental change. As the PET richness values recorded at downstream sites are similar to those recorded at upstream sites it is suggested that historic mining operations have had little residual effect on the concentrations of sensitive organisms inhabiting the various reaches of the receiving environment or an overarching disturbance is influencing the results from all sites. Comparison with raw historic data, if available, may provide further insight on these results.

Note; an Odonata family with a SIGNAL Grade of 10 was recorded in the edge habitat at several sites including downstream sites (refer to raw data in Appendix 1).

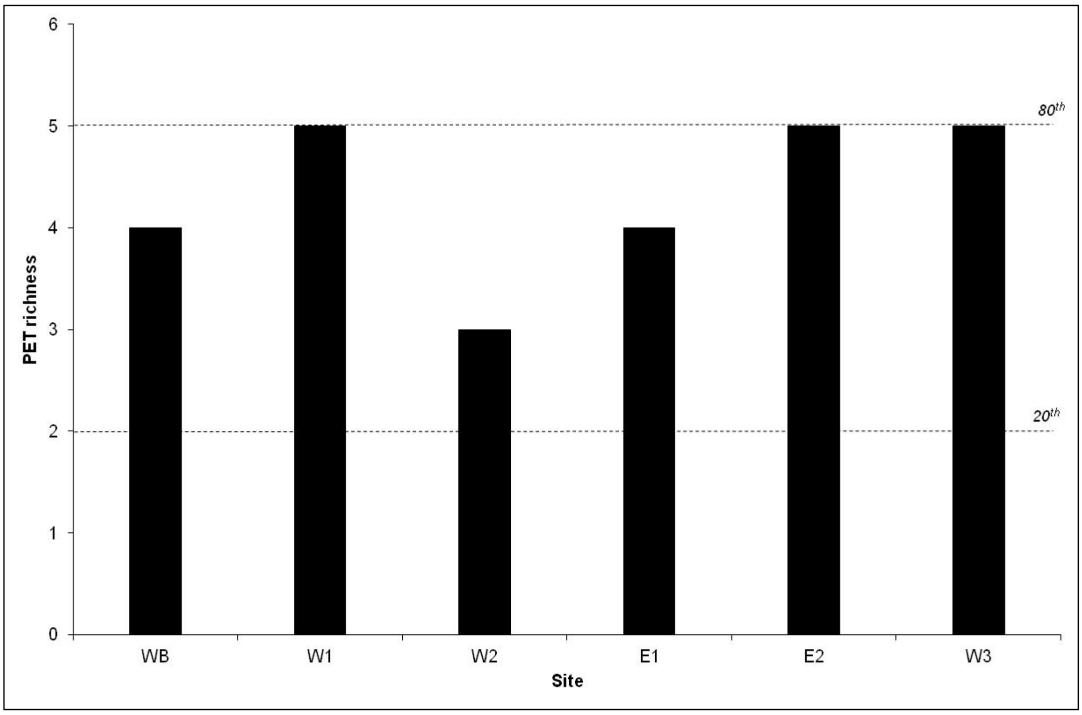


Figure 6: PET richness within the bed habitats at all sites compared to the QWQG (2009) Central Queensland guideline values

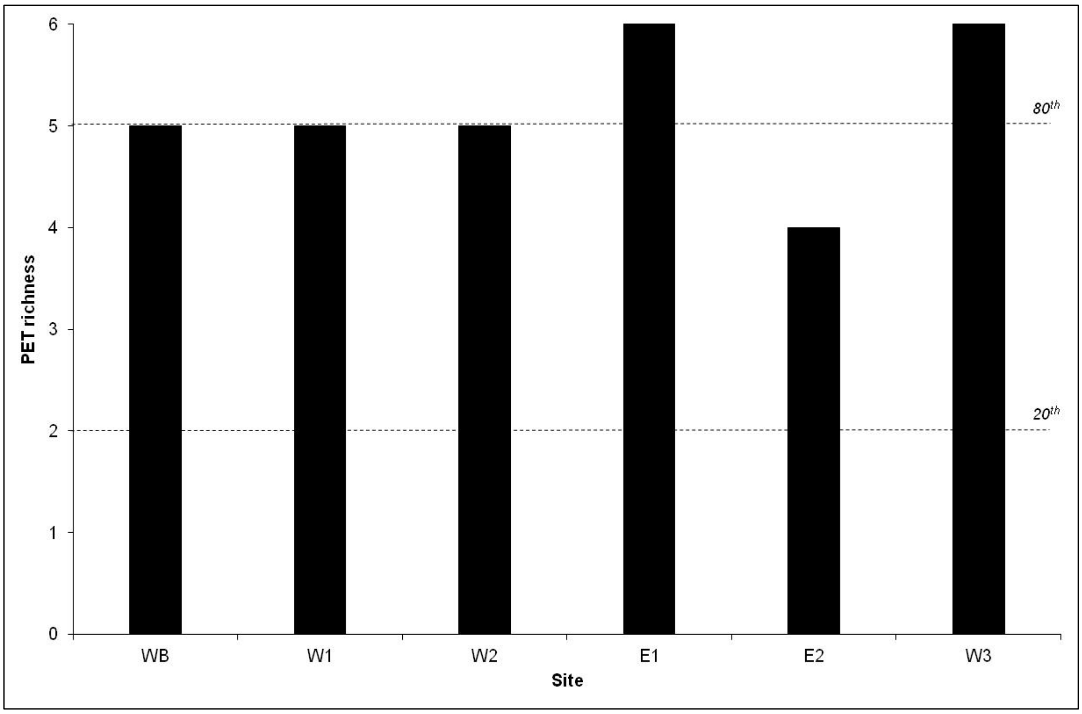


Figure 7: PET richness within the edge habitats at all sites compared to the QWQG (2009) Central Queensland guideline values

3.3.3 SIGNAL 2/FAMILY BI-PLOTS

SIGNAL 2/Family bi-plots provide an indication of the major environmental and anthropogenic factors influencing the structure (both diversity and tolerance) of the macroinvertebrate communities occurring at a particular site. For this assessment interim quadrant boundaries for edge and bed habitats were drawn from the QWQG (2009) 20th percentile values for taxonomic richness and SIGNAL Index Values allocated to the Central Queensland region.

Figure 8 shows that only E2 was outside quadrant one within the bed habitat. E2 occupied quadrant 3 suggesting the site is experiencing toxic pollution or harsh environmental conditions (Chessman 2003a). Water quality results for the system show lower concentrations at E2 than E1 for all parameters tested. All parameters from E2 were compliant with the default ANZECC & ARMCANZ (2000) WQOs for 95% Species Protection Level, except for dissolved aluminium. Concentrations at E2, 0.46mg/L, are not outside the range experienced in the system naturally where the 80th percentile at WB is 0.56mg/L (Pers. Comm. AECOM). Therefore the quadrant position of E2 is likely a result of the harsh environmental conditions experienced throughout the region naturally. The sites bed habitat was primarily made up of one extensive run habitat with a sandy substrate. The lack of habitat complexity and the high flow rates with the potential to shift the substrate are the likely contributing factors influencing this result.

Figure 9 shows that both upstream and downstream sites fall into quadrant three for the edge habitat. Again, this is likely the result of the higher flow rates experienced in the previous month (flooding flows were received in early March 2018) limiting the ability for some families to utilise the habitat with the potential for increased scouring. Since the results are wide spread across the study area (including upstream; WB) they are not likely a result of activities associated with the Kidston Gold Mine.

The sensitivity scores displayed in Figure 8 and Figure 9 provide further evidence of the highly sensitive communities inhabiting the area, as discussed with the PET richness results (refer to Section 3.3.2).

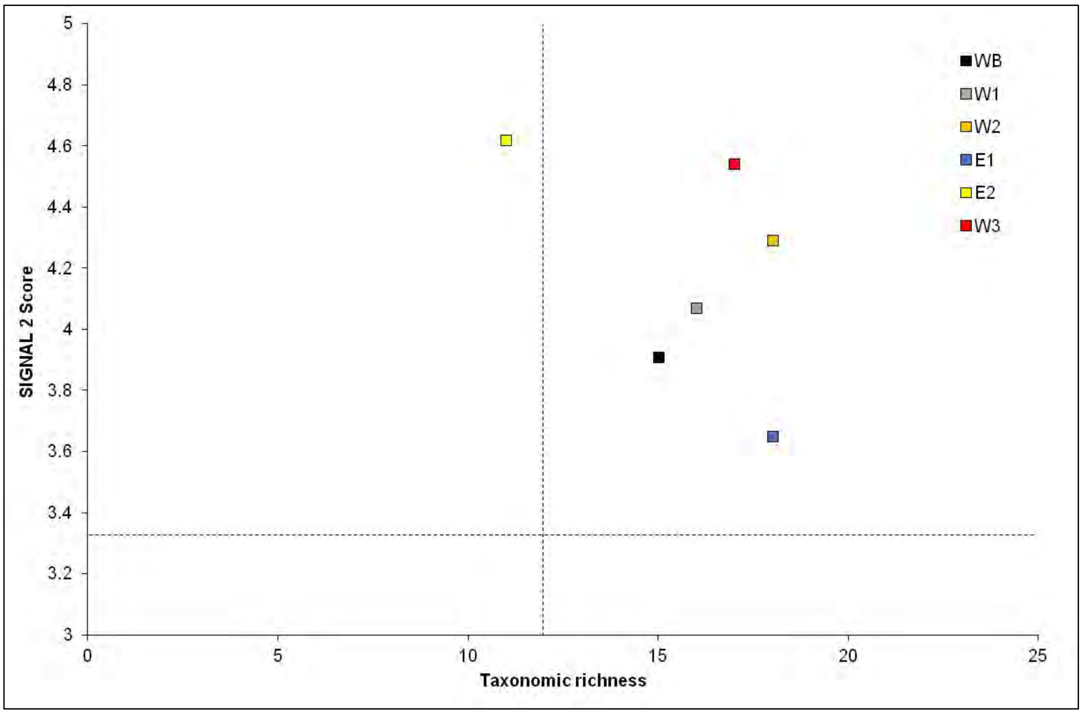


Figure 8: SIGNAL 2 Bi-plot displaying the bed results from each site compared against guideline values from the Central Queensland region (QWQG, 2009)

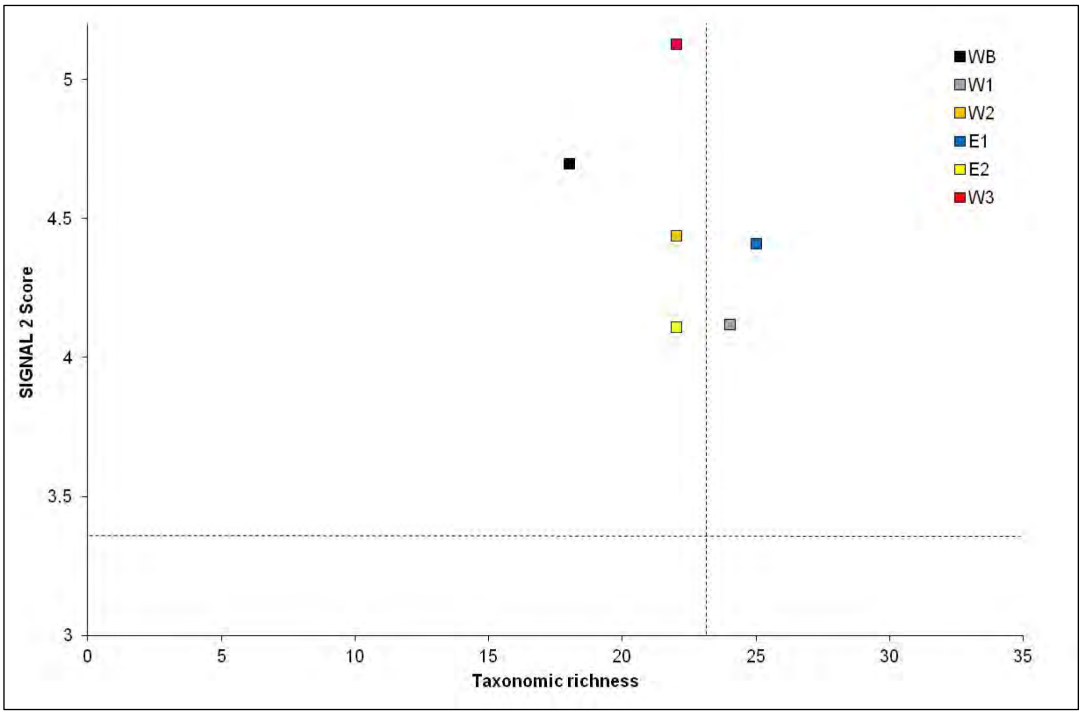


Figure 9: SIGNAL 2 Bi-plot displaying the edge results from each site compared against guideline values from the Central Queensland region (QWQG, 2009)

3.3.4 AusRivAS Modelling

AusRivAS modelling of the macroinvertebrate data indicates that the bed habitat at all sites was more biologically impaired than edge habitats (Table 5). The Band for all sites within the bed habitat was evaluated to be B, while the Band for various edge habitats (at W1, W2, E1 and E2) in the edge habitat was an A (Table 5). The Band provides the description of the level of biological impairment with:

- Band A classed as *similar to reference sites*; and,
- Band B classed as *significantly impaired*.

These results are consistent with PET and taxonomic richness data which indicated that the bed habitat at all sites were the least favourable for macroinvertebrate communities. Genex (2015) REMP Assessment suggests that historic sampling found all sites to be allocated as a Band A, but provides no actual data to compare these results.

Table 5: Observed taxa results for each habitat at each site with greater than 50% probability of occurrence

Site	Number of families collected (50%)		O/E score (50%)		O/E SIGNAL score (50%)		Band	
	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed
WB	12	10	0.80	0.60	1.13	0.89	B	B
W1	14	11	0.85	0.66	0.99	1.04	A	B
W2	13	11	0.86	0.66	0.98	1.02	A	B
E1	15	9	0.96	0.54	0.96	0.90	A	B
E2	14	9	0.93	0.54	0.94	1.06	A	B
W3	12	12	0.80	0.72	1.06	1.00	B	B

The O/E SIGNAL score (50%) results show that within both habitats the observed SIGNAL scores (with >50% probability of occurring) were generally similar to those expected (a value of 1.00 signifies the scores are equal) and sometimes better (i.e. a value >1.00; Table 5). Note; the macroinvertebrate assemblages inhabiting both habitats at W3 (the downstream site) were comprised of as sensitive or more sensitive families than the reference sites utilised by the model. This is likely a result of the diversity of structure/habitats identified at this site.

The bandwidth in Table 6 shows the upper O/E score (50%) for each Band allocated. When compared against the results in Table 5 it can be seen that the majority of bed habitats occurred within the middle of Band C (range 0.78 – 0.36).

Table 6: Overall site results and macroinvertebrate taxa information relevant to each site

Site	Overall site assessment Band	Upper O/E score for the allocated Band	Number of taxa predicted to occur (with >50% probability) but not collected	Most sensitive taxa recorded (including SIGNAL grade)
WB	B (bed habitat)	0.78	10	Hydracarina & Leptoceridae (S.G. – 6)
W1	B (bed habitat)	0.78	9	Leptophlebiidae (S.G. – 8)
W2	B (bed habitat)	0.78	9	Leptophlebiidae (S.G. – 8)
E1	B (bed habitat)	0.78	11	Hydracarina & Leptoceridae (S.G. – 6)
E2	B (bed habitat)	0.78	11	Philopotamidae (S.G. – 8)
W3	B (bed habitat)	0.78	8	Philopotamidae (S.G. – 8)

The number of families and/or sub-families expected with over 50% probability of occurring and not collected at the sites ranged from 8 to 11 (Table 6). The families and/or sub-families missing from the bed habitats at most sites were comprised of both sensitive (S.G. ≥5) and tolerant (S.G. <5) taxa. The highest sensitivity taxa, based on SIGNAL grades, collected within the bed habitat at any site were Leptophlebiidae and Philopotamidae with a SIGNAL grade of 8 collected at all sites downstream of historic mining operations (Table 6).

These AusRivAS results suggest that all watercourses within the project site are influenced by an overarching disturbance as both background and downstream sites are in similar condition.

3.3.5 Baited Traps

Three larger freshwater decapod species were caught using baited traps. These included one species of freshwater yabby, a species of freshwater prawn and a species of freshwater crab. Table 7 indicates the sites from which these invertebrates were recorded and their abundance.

Unlike the other two species, the freshwater crab had limited range within the study area and was only found at W2 (Table 7). It is unclear why this species was not wider spread within the project site (Table 7).

Table 7: Invertebrate species caught in baited traps

Site	*Cherax quadricarinatus* (Redclaw)	*Macrobrachium australiense* (Freshwater prawn)	*Austrothelphusa transversa* (Freshwater crab)
WB	23	2	
W1	9		
W2	20		2
E1			
E2	4	4	
W3	11	5	

3.3.6 SUMMARY

Despite the AusRivAS modelling determining the assemblages are significantly impacted, the relatively high percentage of sensitive macroinvertebrates inhabiting the receiving environment across the project site suggests the targeted watercourses (East Creek and Copperfield River) are in relatively good condition. This corresponds to past findings which have also suggested the macroinvertebrate communities inhabiting Copperfield River are in good condition (Genex, 2015).

None of the species of macroinvertebrates identified during field assessments, database searches, literature reviews, are listed under the EPBC Act or the NC Act.

3.4 FISH COMMUNITIES

3.4.1 SPECIES RICHNESS

Seven (7) species of freshwater fish were identified within the project site during the field survey, including:

- Checkered Rainbowfish (*Melanotaenia splendida inornata*);
- Northern Trout Gudgeon (*Mogurnda mogurnda*);
- Hyrtl's Tandan (*Neosuluris hyrtlii*);
- Spangled Perch (*Leioptherapon unicolor*);
- Sooty Grunter (*Hepthaestus fuliginosus*);
- Bony Bream (*Nematolosa erebi*); and
- Barred Grunter (*Amniataba percoides*).

No species listed under the EPBC Act or the NC Act were found during the field surveys.

W3 was the most diverse site recording a total of six species, closely followed by W1 with five species (Figure 10). W3 displayed the greatest diversity of habitats compared to all other sites and was also one of the only sites where all fish sampling procedures could be conducted.

W2 and E1 recorded the lowest diversity, with only three species of freshwater fish found at both sites (Figure 10). W2 and E1 both displayed relatively uniform habitats throughout their reaches, potentially a controlling factor on the results.

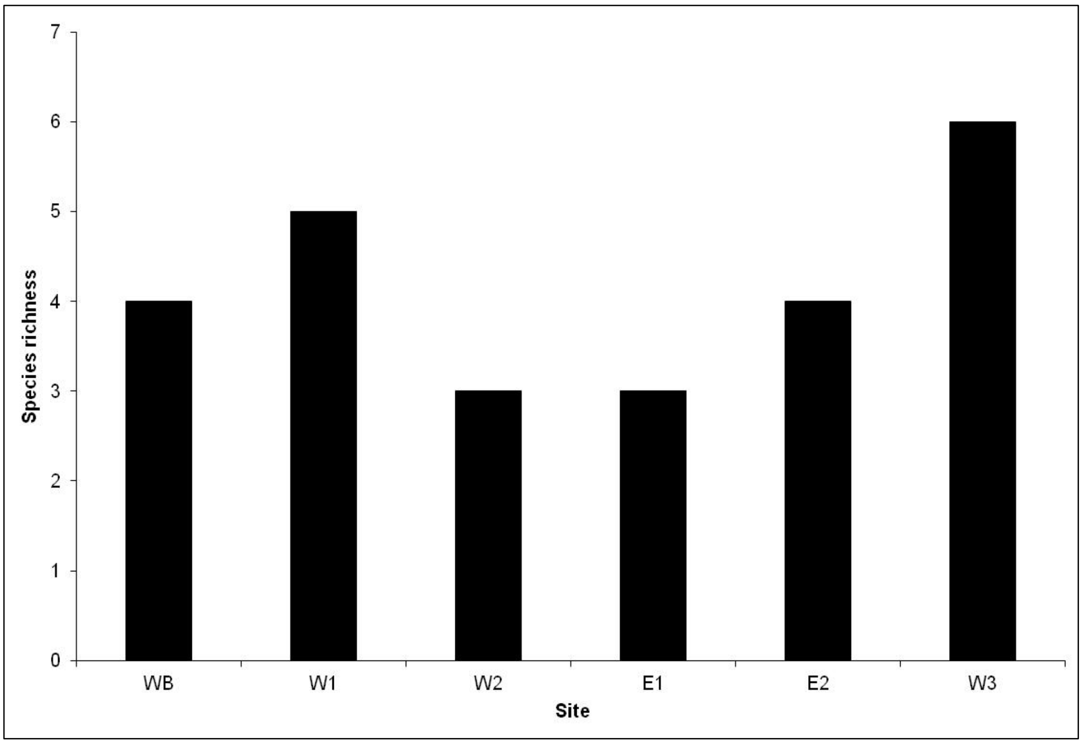


Figure 10: Fish species richness at each site

3.4.2 TOTAL ABUNDANCE

Similar to species richness, W3 recorded the highest total abundance and, despite being relatively species poor for the system, E1 recorded the second highest abundance (Figure 11). W2 was the least abundant. However, this site was difficult to survey with turbid, flowing waters and slippery bedrock (refer to Table 3).

Please refer to Appendix 1 for all the raw fish data collected in April 2018.

3.4.3 REGIONAL CONTEXT

Several of the fish species identified during the field survey are known to occur in the greater Copperfield River catchment (Wildlife Online, 2018; Appendix 2). An additional three species have previously been recorded within the system but were not found during the current study, including:

- Blackbanded gudgeon (*Oxyeleotris selheimi*);
- Sleepy cod (*Oxyeleotris lineolata*); and
- Hardy head (*Craterocephalus stercusmuscarum*).

No fish species listed under the EPBC Act or the NC Act occur within the project site or surrounding areas.

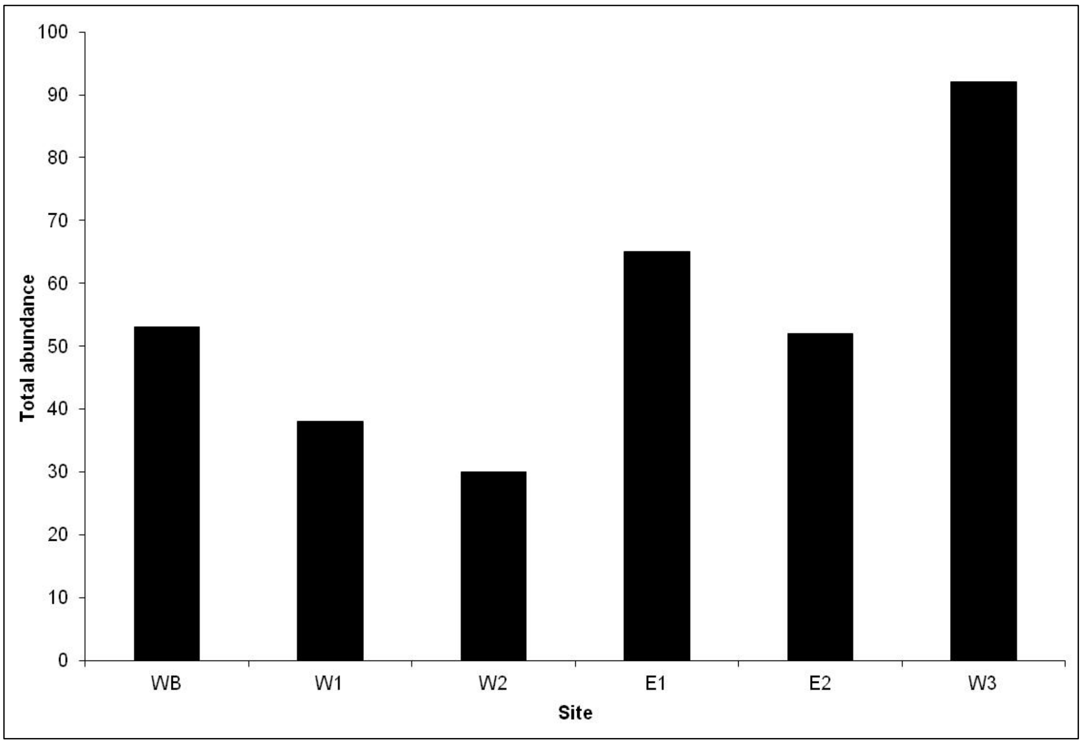


Figure 11: Total fish abundance at each site

3.5 AQUATIC FLORA

Only two species of macrophytes were recorded inhabiting the Copperfield River and East Creek (both sedges), Rice Sedge (*Cyperus difformis*) and *Cyperus species.* The reduced species assemblage is possibly a response to the ephemeral nature of the watercourses combined with high flow rates. Rice sedge is an emergent macrophyte that quickly establishes within shallow waters, allowing it to successfully inhabit flowing watercourse sites (Sainty & Jacobs, 2003).

No aquatic Weeds of National Significance (WONS) or aquatic weeds as classified under State legislation, were observed. Further, none of the aquatic flora species identified within the project site are listed under the EPBC Act or the NC Act.

3.6 TURTLE COMMUNITY AND OTHER AQUATIC VERTEBRATES

3.6.1 TURTLE COMMUNITIES PRESENT

No freshwater turtles were caught or observed within the Copperfield River or East Creek during the field studies. However, there is anecdotal evidence that the common Krefft's Turtle (*Emydura Macquari Krefftii*) possibly inhabits farm dams and more permanent waterholes within the area (i.e. conversation with local residents).

3.6.2 OTHER AQUATIC VERTEBRATES

Database searches identified the potential for the Freshwater Crocodile (*Crocodylus johnstoni*) to inhabit the area. While they were not found during field surveys of the Copperfield River or East Creek the species was observed inhabiting the Einasleigh River upstream of the confluence with the Copperfield River. Therefore, it is highly likely that the species utilises the lower reaches of the Copperfield River with the potential to push further upstream during flow events. There has been anecdotal evidence of Freshwater Crocodiles inhabiting the Copperfield River and Copperfield Dam in the past (i.e. conversations with local residents). This species is listed as Least Concern under the *Nature Conservation Act (1994)*.

4. REFERENCES

Allen, G.R., Midgley, S.H. and Allen, M. (2002). *Field Guide to the Freshwater Fishes of Australia.* Western Australian Museum.

ANZECC (Australian and New Zealand Environment and Conservation Council) and ARMCANZ (Agricultural and Resource Management Council of Australia and New Zealand) (2000). *Australian and New Zealand guidelines for fresh and marine water quality. National Water Quality Management Strategy.* Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

Chessman, B.C. (1995). *SIGNAL 2 – A scoring system for macro-invertebrates ('water bugs') in Australian rivers – User manual Version 2.* National River Health Program.

Chessman, B.C. (2003). New sensitivity grades for Australian river macroinvertebrates. *Marine and Freshwater Research*. **54:** 95-103.

Chessman, B.C. (2003a). *SIGNAL 2 – A Scoring System for Macro-invertebrate ('Water Bugs') in Australian Rivers. Monitoring River Health Initiative Technical Report No. 31,* Commonwealth of Australia, Canberra.

Choy, S.C., Thomson, C.B. and Marshall, J.C. (2002). Ecological condition of central Australian arid-zone rivers. *Water Science and Technology,* **45(11):** 225-232.

EPBC (2018). *EPBC Act Protected Matters Report*. Department of Sustainability, Environment, Water, Population and Communities. Commonwealth of Australia. ACT, Australia.

Genex (2015). Kidston: Receiving Environment Monitoring Program, Revision No.: R01. Report prepared by Genex Power.

Jones, D.S. and Morgan, G.J. (2002). *A Field Guide to Crustaceans of Australian Waters*. Western Australian Museum.

Pusey, B., Kennard, M. and Arthington, A. (2004). *Freshwater Fishes of North-Eastern Australia.* CSIRO Publishing, Victoria.

QWQG (2009). *Queensland Water Quality Guidelines, Version 3*. Department of Environment and Resource Management (DERM), Queensland.

Sainty, G.R. and Jacobs, S.W.L. (2003). W*aterplants in Australia: A Field Guide, 4th Edition*. Sainty and Associates, Potts Point, NSW.

Wildlife Online (2018). *Wildlife Online Extract*. Department of Environment and Resource Management, Queensland Government, Australia.

APPENDIX 1 – RAW MACROINVERTEBRATE AND FISH DATA

Table A1.1: Raw macroinvertebrate data during the April 2018 sampling round

Order	Family/sub-family	AusRivAS Code	SIGNAL Grade	WB		W1		W2		E1		E2		W3	
				Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge
Nematoda		II999999	3											2	
Oligochaeta		LO999999	2	2				2				4		1	
Gastropoda	Planorbidae	KG079999	2					1			1				
Cladocera	Cladocera	OG999999	5.5		1										
Copepoda	Copepoda	OJ999999	5.5				1				1				
Ostracoda	Ostracoda	OH999999	5.5		1	1				1					1
Decapoda	Atyidae	OT019999	3										1		5
	Parastacidae	OV019999	4						1						3
Acarina	Hydracarina	MM999999	6	7	13	39	25	23	27	22	19	14	30	16	20
Coleoptera	Dytiscidae	QC099999	2		5		7	5	9	8	4	2	5	12	8
	Hydrophilidae	QC119999	2							11	2				1
	Hydrochidae	QCAO9999	4		3		3				15				
	Elmidae	QC349999	7			1		1							1
	Hydraenidae	QC139999	3		1		2		1					1	
	Haliplidae	QC069999	2				1	1		2	5				
	Staphylinidae	QC189999	3												1
Diptera	Unidentified	QDZZ9999	3	1	1			1		1					
	Chironomidae														
	Chironominae	QDAJ9999	3	20	11	10	5	9	11	1	3	4	7	2	2
	Tanypodiinae	QDAE9999	4	1			2		1	3	1		1		1
	Orthocladiinae	QDAF9999	4	5	1	1		1					1	3	
	Podonominae	QDAD9999	6	3				1	1						
	Ceratopogonidae	QD099999	4	1	1	1		1	2	4	1	2		4	1
	Simuliidae	QD109999	5						1					22	
	Tabanidae	QD239999	3			1				1				2	
	Muscidae	QD899999	1	6		17		3		3		9		15	
	Culicidae	QD079999	1										2		

Order	Family/sub-family	AusRivAS Code	SIGNAL Grade	WB		W1		W2		E1		E2		W3	
				Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge	Bed	Edge
Ephemeroptera	Baetidae	QE029999	5	15	23	26	23	7	10	20	10	58	18	47	39
	Caenidae	QE089999	4	41	7	41	12	22	26	24	16	15	7	25	8
	Leptophlebiidae	QE069999	8		1	1		4	1			3		3	1
Hemiptera	Micronectidae	N/A	2	3		7	9		1	6			1		
	Corixidae	QH659999	2			1	3								
	Gerridae	QH579999	4				3		1		2		1		3
	Nepidae	QH619999	3										1		
	Notonectidae	QH679999	1		1		3				1				1
	Pleidae	QH689999	2								6		1		
	Veliidae	QH569999	3				2		3	1	1		4		
	Belastomatidae	QH629999	1										1		
Odonata	Gomphidae	QO139999	5	1	8	2	9	3	1				5		1
	Corduliidae	QO169999	5				2								
	Libellulidae	QO179999	4		1		10		4	12	15		3		2
	Austrocorduliidae	QO279999	10						2		6		1		1
	Platycnemidae	QO049999	4				1				4		2		
	Coenagrionidae	QO029999	2				7		6		12		3		
	Isostictidae	QO039999	3				3		1		1				
Trichoptera	Leptoceridae	QT259999	6	1	10	2	10	2	3	1	10		1		3
	Calocidae	QT189999	9		3		4		3		4		2		63
	Ecnomidae	QT089999	4	3		1		1		1					
	Helicophidae	QT199999	10				1				1				
	Philopotamidae	QT049999	8									4		33	1
	Hydropsychidae	QT069999	6								1	7		15	
Lepidoptera	Crambidae	QL999999	2											1	

Table A1.2: Raw fish data collected during the April 2018 sampling round

Species	WB	W1	W2	E1	E2	W3
Melanotaenia splendida inornata	26	26	22	53	26	53
Mogurnda mogurnda	14	1		2	11	4
Neosuluris hyrtlii	9		2		1	1
Leioptherapon unicolor	4	9	6	10	14	31
Hepthaestus fuliginosus		1				
Nematolosa erebi		1				1
Amniataba percoides						2

APPENDIX 2 – SEARCH RESULTS

Australian Government

Department of the Environment and Energy

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 20/05/18 20:03:30

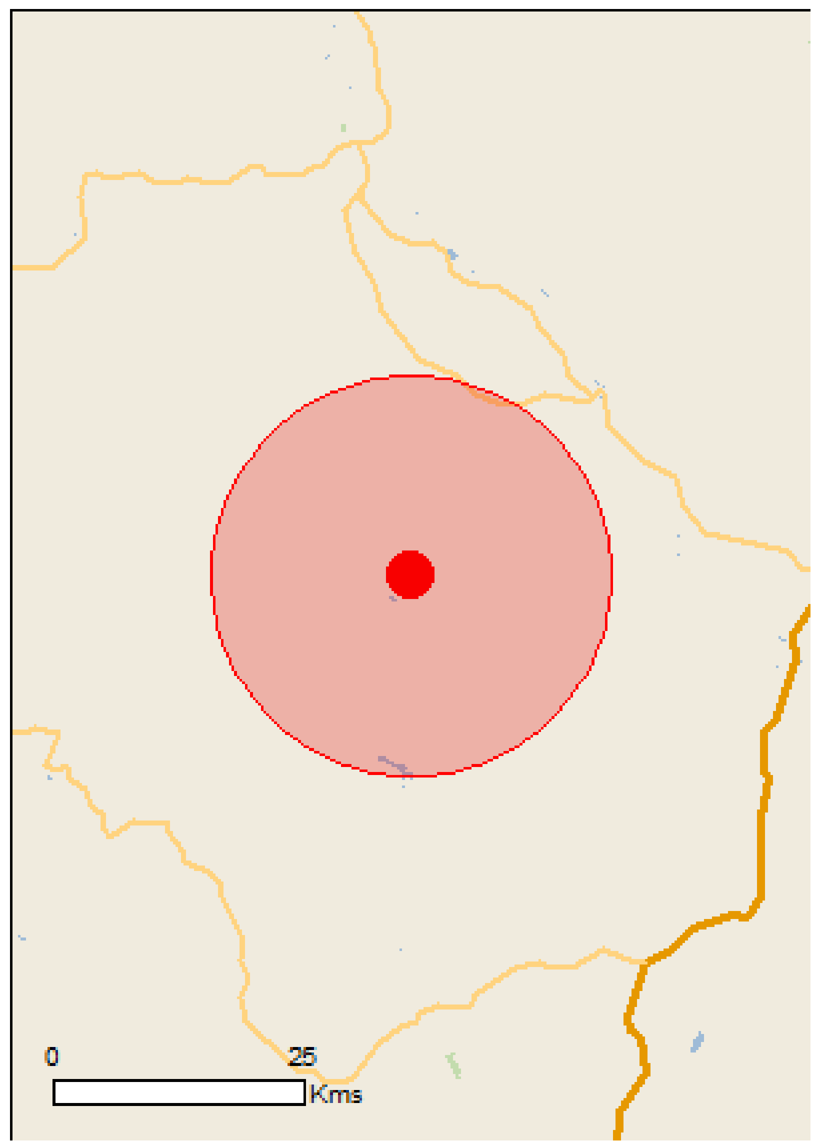
Summary

Details

- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

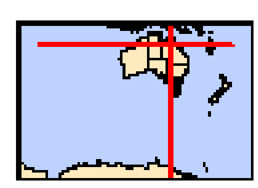
Caveat

Acknowledgements



Coordinates

Buffer: 20.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	17
Listed Migratory Species:	12

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	19
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	1
Regional Forest Agreements:	None
Invasive Species:	16
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
[Calidris ferruginea]		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
[Erythrotriorchis radiatus]		
Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
[Erythrura gouldiae]		
Gouldian Finch [413]	Endangered	Species or species habitat likely to occur within area
[Poephila cincta cincta]		
Southern Black-throated Finch [64447]	Endangered	Species or species habitat likely to occur within area
[Rostratula australis]		
Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
[Tyto novaehollandiae kimberli]		
Masked Owl (northern) [26048]	Vulnerable	Species or species habitat may occur within area
Mammals		
[Dasyurus hallucatus]		
Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat may occur within area
[Macroderma gigas]		
Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area
[Mesembriomys gouldii rattoides]		
Black-footed Tree-rat (north Queensland), Shaggy Rabbit-rat [87620]	Vulnerable	Species or species habitat may occur within area
[Petauroides volans]		
Greater Glider [254]	Vulnerable	Species or species habitat may occur within area
[Phascolarctos cinereus (combined populations of Qld, NSW and the ACT)]		
Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat may occur within area
[Rhinolophus robertsi]		
Large-eared Horseshoe Bat, Greater Large-eared Horseshoe Bat [87639]	Vulnerable	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Saccolaimus saccolaimus nudicluniatus Bare-rumped Sheath-tailed Bat, Bare-rumped Sheathtail Bat [66889]	Vulnerable	Species or species habitat may occur within area
Plants		
Cajanus mareebensis [8635]	Endangered	Species or species habitat likely to occur within area
Cycas cairnsiana a cycad [5780]	Vulnerable	Species or species habitat likely to occur within area
Dichanthium setosum bluegrass [14159]	Vulnerable	Species or species habitat likely to occur within area
Reptiles		
Egernia rugosa Yakka Skink [1420]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat likely to occur

Name	Threatened	Type of Presence
		within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species

[Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Cuculus saturatus Oriental Cuckoo, Himalayan Cuckoo [710]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat likely to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat may occur within area
Reptiles		
Crocodylus johnstoni Freshwater Crocodile, Johnston's Crocodile, Johnston's River Crocodile [1773]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Newcastle Range-The Oaks	QLD

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Plants		
Acacia nilotica subsp. indica Prickly Acacia [6196]		Species or species habitat may occur within area
Cryptostegia grandiflora Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913]		Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Parthenium hysterophorus Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-18.8828 144.1488

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

Department of the Environment
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

Wildlife Online Extract

Search Criteria: Species List for a Specified Point
Species: All
Type: All
Status: All
Records: All
Date: All
Latitude: -18.8722
Longitude: 144.1550
Distance: 20
Email: matt@candrconsulting.com.au
Date submitted: Sunday 20 May 2018 21:22:03
Date extracted: Sunday 20 May 2018 21:30:02

The number of records retrieved = 355

Disclaimer

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	amphibians	Bufonidae	*Rhinella marina*	cane toad	Y			1
animals	birds	Acanthizidae	*Gerygone olivacea*	white-throated gerygone		C		2
animals	birds	Acanthizidae	*Smicrornis brevirostris*	weebill		C		2
animals	birds	Accipitridae	*Milvus migrans*	black kite		C		4
animals	birds	Accipitridae	*Hieraaetus morphnoides*	little eagle		C		1
animals	birds	Accipitridae	*Haliastur sphenurus*	whistling kite		C		2
animals	birds	Accipitridae	*Aquila audax*	wedge-tailed eagle		C		1
animals	birds	Alaudidae	*Mirafra javanica*	Horsfield's bushlark		C		1
animals	birds	Anatidae	*Anas superciliosa*	Pacific black duck		C		3
animals	birds	Anhingidae	*Anhinga novaehollandiae*	Australasian darter		C		2
animals	birds	Ardeidae	*Ardea alba modesta*	eastern great egret		C		2
animals	birds	Ardeidae	*Egretta novaehollandiae*	white-faced heron		C		7
animals	birds	Artamidae	*Cracticus nigrogularis*	pied butcherbird		C		12
animals	birds	Artamidae	*Strepera graculina*	pied currawong		C		2
animals	birds	Artamidae	*Cracticus tibicen*	Australian magpie		C		19
animals	birds	Artamidae	*Artamus cinereus*	black-faced woodswallow		C		5
animals	birds	Artamidae	*Cracticus torquatus*	grey butcherbird		C		4
animals	birds	Cacatuidae	*Eolophus roseicapilla*	galah		C		16
animals	birds	Campephagidae	*Coracina novaehollandiae*	black-faced cuckoo-shrike		C		7
animals	birds	Campephagidae	*Coracina papuensis*	white-bellied cuckoo-shrike		C		3
animals	birds	Campephagidae	*Lalage tricolor*	white-winged triller		C		2
animals	birds	Casuariidae	*Dromaius novaehollandiae*	emu		C		1
animals	birds	Charadriidae	*Vanellus miles miles*	masked lapwing (northern subspecies)		C		3
animals	birds	Charadriidae	*Vanellus miles*	masked lapwing		C		1
animals	birds	Charadriidae	*Elseyornis melanops*	black-fronted dotterel		C		1
animals	birds	Climacteridae	*Climacteris picumnus*	brown treecreeper		C		5
animals	birds	Columbidae	*Geophaps scripta*	squatter pigeon		C		1
animals	birds	Columbidae	*Geopelia striata*	peaceful dove		C		4
animals	birds	Columbidae	*Ocyphaps lophotes*	crested pigeon		C		5
animals	birds	Coraciidae	*Eurystomus orientalis*	dollarbird		C		3
animals	birds	Corcoracidae	*Struthidea cinerea*	apostlebird		C		6
animals	birds	Corvidae	*Corvus sp.*					5
animals	birds	Corvidae	*Corvus orru*	Torresian crow		C		5
animals	birds	Cuculidae	*Eudynamys orientalis*	eastern koel		C		1
animals	birds	Estrildidae	*Poephila cincta atropygialis*	black-throated finch (black-rumped subspecies)		C		2
animals	birds	Estrildidae	*Poephila cincta cincta*	black-throated finch (white-rumped subspecies)		E	E	1
animals	birds	Estrildidae	*Taeniopygia bichenovii*	double-barred finch		C		2
animals	birds	Falconidae	*Falco cenchroides*	nankeen kestrel		C		3
animals	birds	Falconidae	*Falco berigora*	brown falcon		C		2
animals	birds	Falconidae	*Falco longipennis*	Australian hobby		C		1
animals	birds	Gruidae	*Grus antigone*	sarus crane		C		1
animals	birds	Gruidae	*Grus rubicunda*	brolga		C		2
animals	birds	Halcyonidae	*Todiramphus macleayii*	forest kingfisher		C		1
animals	birds	Halcyonidae	*Todiramphus pyrrhopygius*	red-backed kingfisher		C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Halcyonidae	*Todiramphus sanctus*	sacred kingfisher		C		2
animals	birds	Halcyonidae	*Dacelo novaeguineae*	laughing kookaburra		C		7
animals	birds	Halcyonidae	*Dacelo leachii*	blue-winged kookaburra		C		4
animals	birds	Maluridae	*Malurus melanocephalus*	red-backed fairy-wren		C		2
animals	birds	Meliphagidae	*Plectorhyncha lanceolata*	striped honeyeater		C		3
animals	birds	Meliphagidae	*Melithreptus albogularis*	white-throated honeyeater		C		4
animals	birds	Meliphagidae	*Philemon citreogularis*	little friarbird		C		3
animals	birds	Meliphagidae	*Manorina melanocephala*	noisy miner		C		1
animals	birds	Meliphagidae	*Philemon corniculatus*	noisy friarbird		C		1
animals	birds	Meliphagidae	*Lichmera indistincta*	brown honeyeater		C		2
animals	birds	Meliphagidae	*Entomyzon cyanotis*	blue-faced honeyeater		C		6
animals	birds	Meropidae	*Merops ornatus*	rainbow bee-eater		C		6
animals	birds	Monarchidae	*Grallina cyanoleuca*	magpie-lark		C		8
animals	birds	Monarchidae	*Myiagra rubecula*	leaden flycatcher		C		1
animals	birds	Nectariniidae	*Dicaeum hirundinaceum*	mistletoebird		C		1
animals	birds	Neosittidae	*Daphoenositta chrysoptera*	varied sittella		C		1
animals	birds	Otididae	*Ardeotis australis*	Australian bustard		C		2
animals	birds	Pachycephalidae	*Pachycephala rufiventris*	rufous whistler		C		4
animals	birds	Pardalotidae	*Pardalotus striatus*	striated pardalote		C		7
animals	birds	Petroicidae	*Microeca fascinans*	jacky winter		C		2
animals	birds	Phalacrocoracidae	*Phalacrocorax sulcirostris*	little black cormorant		C		2
animals	birds	Phalacrocoracidae	*Microcarbo melanoleucos*	little pied cormorant		C		2
animals	birds	Podicipedidae	*Tachybaptus novaehollandiae*	Australasian grebe		C		1
animals	birds	Pomatostomidae	*Pomatostomus temporalis*	grey-crowned babbler		C		4
animals	birds	Psittacidae	*Trichoglossus haematodus moluccanus*	rainbow lorikeet		C		6
animals	birds	Psittacidae	*Platycercus adscitus adscitus*	pale-headed rosella (northern form)		C		4
animals	birds	Psittacidae	*Aprosmictus erythropterus*	red-winged parrot		C		1
animals	birds	Psittacidae	*Platycercus adscitus*	pale-headed rosella		C		2
animals	birds	Ptilonorhynchidae	*Ptilonorhynchus nuchalis*	great bowerbird		C		2
animals	birds	Rallidae	*Gallinula tenebrosa*	dusky moorhen		C		1
animals	birds	Rallidae	*Fulica atra*	Eurasian coot		C		1
animals	birds	Rhipiduridae	*Rhipidura leucophrys*	willie wagtail		C		5
animals	birds	Rhipiduridae	*Rhipidura albiscapa*	grey fantail		C		1
animals	birds	Threskiornithidae	*Platalea flavipes*	yellow-billed spoonbill		C		1
animals	birds	Threskiornithidae	*Threskiornis spinicollis*	straw-necked ibis		C		2
animals	mammals	Bovidae	*Bos taurus*	European cattle	Y			1
animals	mammals	Canidae	*Canis lupus dingo*	dingo				1
animals	mammals	Suidae	*Sus scrofa*	pig	Y			1
animals	ray-finned fishes	Atherinidae	*Craterocephalus stercusmuscarum*	flyspecked hardyhead				1
animals	ray-finned fishes	Clupeidae	*Nematalosa erebi*	bony bream				1
animals	ray-finned fishes	Eleotridae	*Oxyeleotris lineolata*	sleepy cod				1
animals	ray-finned fishes	Eleotridae	*Oxyeleotris selheimi*	blackbanded gudgeon				1
animals	ray-finned fishes	Melanotaeniidae	*Melanotaenia splendida inornata*	checkered rainbowfish				2
animals	ray-finned fishes	Terapontidae	*Leiopotherapon unicolor*	spangled perch				2
animals	ray-finned fishes	Terapontidae	*Hephaestus fuliginosus*	sooty grunter				1
animals	ray-finned fishes	Terapontidae	*Amniataba percoides*	barred grunter				1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	reptiles	Crocodylidae	*Crocodylus johnstoni*	Australian freshwater crocodile		C		1
animals	reptiles	Elapidae	*Acanthophis praelongus*	northern death adder		C		1
animals	reptiles	Scincidae	*Carlia pectoralis sensu lato*			C		1
animals	reptiles	Scincidae	*Morethia taeniopleura*	fire-tailed skink		C		1
animals	reptiles	Scincidae	*Cryptoblepharus virgatus sensu lato*			C		1
animals	uncertain	Indeterminate	*Indeterminate*	Unknown or Code Pending		C		1
plants	conifers	Cupressaceae	*Callitris intratropica*	coast cypress pine		C		1/1
plants	cycads	Cycadaceae	*Cycas cairnsiana*			V	V	5/5
plants	ferns	Adiantaceae	*Cheilanthes brownii*			C		2/2
plants	ferns	Adiantaceae	*Paraceterach muelleri*			C		1/1
plants	ferns	Marsileaceae	*Marsilea exarata*	sway-back nardoo		C		1/1
plants	higher dicots	Acanthaceae	*Rostellularia adscendens subsp. glaucoviolacea*			C		1/1
plants	higher dicots	Acanthaceae	*Rostellularia adscendens*			C		1/1
plants	higher dicots	Amaranthaceae	*Gomphrena lanata*			C		1/1
plants	higher dicots	Amaranthaceae	*Ptilotus capensis*			C		1/1
plants	higher dicots	Amaranthaceae	*Achyranthes aspera*			C		1/1
plants	higher dicots	Amaranthaceae	*Amaranthus interruptus*			C		1/1
plants	higher dicots	Anacardiaceae	*Pleiogynium timorense*	Burdekin plum		C		1/1
plants	higher dicots	Araliaceae	*Trachymene bivestita var. bivestita*			C		2/2
plants	higher dicots	Asteraceae	*Pterocaulon serrulatum var. serrulatum*			C		1/1
plants	higher dicots	Asteraceae	*Bidens subalternans var. simulans*		Y			1/1
plants	higher dicots	Asteraceae	*Centipeda minima subsp. minima*			C		1/1
plants	higher dicots	Asteraceae	*Acanthospermum hispidum*	star burr	Y			1/1
plants	higher dicots	Asteraceae	*Olearia xerophila*			C		1/1
plants	higher dicots	Asteraceae	*Cyanthillium cinereum*			C		1/1
plants	higher dicots	Bignoniaceae	*Dolichandrone alternifolia*			C		1/1
plants	higher dicots	Burseraceae	*Canarium australianum var. glabrum*			C		1/1
plants	higher dicots	Byttneriaceae	*Waltheria indica*			C		1/1
plants	higher dicots	Caesalpiniaceae	*Labichea nitida*			C		1/1
plants	higher dicots	Caesalpiniaceae	*Senna magnifolia*			C		1/1
plants	higher dicots	Caesalpiniaceae	*Lysiphyllum hookeri*	Queensland ebony		C		1/1
plants	higher dicots	Caryophyllaceae	*Polycarpaea spirostylis*			C		1/1
plants	higher dicots	Casuarinaceae	*Casuarina cunninghamiana*			C		1/1
plants	higher dicots	Cleomaceae	*Cleome viscosa*	tick-weed		C		1/1
plants	higher dicots	Cochlospermaceae	*Cochlospermum gregorii*			C		1/1
plants	higher dicots	Combretaceae	*Terminalia aridicola subsp. aridicola*			C		1/1
plants	higher dicots	Cucurbitaceae	*Cucumis queenslandicus*			C		1/1
plants	higher dicots	Dilleniaceae	*Hibbertia stelligera*			C		1/1
plants	higher dicots	Ebenaceae	*Diospyros humilis*	small-leaved ebony		C		1/1
plants	higher dicots	Erythroxylaceae	*Erythroxylum ellipticum*			C		1/1
plants	higher dicots	Euphorbiaceae	*Euphorbia tannensis subsp. eremophila*			C		1/1
plants	higher dicots	Euphorbiaceae	*Euphorbia macdonaldii var. macdonaldii*			C		1/1
plants	higher dicots	Euphorbiaceae	*Microstachys chamaelea*			C		1/1
plants	higher dicots	Euphorbiaceae	*Euphorbia dallachyana*			C		1/1
plants	higher dicots	Euphorbiaceae	*Ricinus communis*	castor oil bush	Y			1/1
plants	higher dicots	Euphorbiaceae	*Euphorbia schultzii var. schultzii*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Fabaceae	*Zornia*			C		1/1
plants	higher dicots	Fabaceae	*Clitoria ternatea*	butterfly pea	Y			1/1
plants	higher dicots	Fabaceae	*Tephrosia varians*			C		1/1
plants	higher dicots	Fabaceae	*Desmodium muelleri*			C		1/1
plants	higher dicots	Fabaceae	*Indigofera colutea*	sticky indigo		C		1/1
plants	higher dicots	Fabaceae	*Indigofera hirsuta*	hairy indigo		C		1/1
plants	higher dicots	Fabaceae	*Sesbania cannabina*			C		1
plants	higher dicots	Fabaceae	*Cajanus acutifolius*			C		3/3
plants	higher dicots	Fabaceae	*Stylosanthes scabra*		Y			1/1
plants	higher dicots	Fabaceae	*Crotalaria verrucosa*			C		1/1
plants	higher dicots	Fabaceae	*Indigofera brevidens*			C		1/1
plants	higher dicots	Fabaceae	*Indigofera linifolia*			C		1/1
plants	higher dicots	Fabaceae	*Indigofera pratensis*			C		1/1
plants	higher dicots	Fabaceae	*Tephrosia macrostachya*			C		1/1
plants	higher dicots	Fabaceae	*Crotalaria laburnifolia*		Y			1/1
plants	higher dicots	Fabaceae	*Tephrosia astragaloides*			C		1/1
plants	higher dicots	Fabaceae	*Tephrosia gaudium-solis*			C		3/3
plants	higher dicots	Fabaceae	*Aphyllodium biarticulatum*			C		2/2
plants	higher dicots	Fabaceae	*Gastrolobium grandiflorum*			C		1/1
plants	higher dicots	Fabaceae	*Tephrosia filipes forma vestita*			C		1/1
plants	higher dicots	Fabaceae	*Zornia muriculata subsp. angustata*			C		1/1
plants	higher dicots	Fabaceae	*Crotalaria aridicola subsp. aridicola*			C		1/1
plants	higher dicots	Fabaceae	*Indigofera australis subsp. australis*			C		1/1
plants	higher dicots	Fabaceae	*Phyllodium pulchellum var. pulchellum*			C		1/1
plants	higher dicots	Fabaceae	*Zornia muelleriana subsp. muelleriana*			C		1/1
plants	higher dicots	Fabaceae	*Tephrosia sp. (Cobbold Gorge B.S.Wannan 1167)*			C		1/1
plants	higher dicots	Fabaceae	*Tephrosia sp. (Georgetown G.N.Batianoff+ 900402H)*			C		2/2
plants	higher dicots	Fabaceae	*Crotalaria novae-hollandiae subsp. novae-hollandiae*			C		1/1
plants	higher dicots	Fabaceae	*Tephrosia sp. (Copperfield River P.I.Forster PIF14768)*			C		1/1
plants	higher dicots	Goodeniaceae	*Goodenia armitiana*			C		3/3
plants	higher dicots	Goodeniaceae	*Goodenia grandiflora*			C		1/1
plants	higher dicots	Goodeniaceae	*Goodenia effusa*			C		2/2
plants	higher dicots	Haloragaceae	*Haloragis heterophylla*	rough raspweed		C		1
plants	higher dicots	Lentibulariaceae	*Utricularia gibba*	floating bladderwort		C		1/1
plants	higher dicots	Loranthaceae	*Amyema villiflora subsp. villiflora*			C		1/1
plants	higher dicots	Loranthaceae	*Amyema congener subsp. rotundifolia*			C		2/2
plants	higher dicots	Lythraceae	*Ammannia multiflora*	jerry-jerry		C		2/1
plants	higher dicots	Lythraceae	*Rotala mexicana*			C		1/1
plants	higher dicots	Lythraceae	*Rotala tripartita*			C		2/1
plants	higher dicots	Malvaceae	*Hibiscus meraukensis*	Merauke hibiscus		C		1/1
plants	higher dicots	Malvaceae	*Sida hackettiana*			C		1/1
plants	higher dicots	Malvaceae	*Abutilon hannii*			C		1/1
plants	higher dicots	Malvaceae	*Sida magnifica*			C		1/1
plants	higher dicots	Martyniaceae	*Martynia annua*	small-fruited devil's claw	Y			1/1
plants	higher dicots	Mimosaceae	*Acacia hemignosta*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Mimosaceae	*Acacia umbellata*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia nesophila*			C		2/2
plants	higher dicots	Mimosaceae	*Acacia lazaridis*			C		2/2
plants	higher dicots	Mimosaceae	*Acacia hammondii*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia longispicata*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia multisiliqua*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia colei var. colei*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia galioides*			C		2/2
plants	higher dicots	Mimosaceae	*Acacia*			C		2/2
plants	higher dicots	Mimosaceae	*Acacia victoriae subsp. fasciaria*			C		1/1
plants	higher dicots	Molluginaceae	*Glinus oppositifolius*			C		1/1
plants	higher dicots	Molluginaceae	*Glinus lotoides*	hairy carpet weed		C		1/1
plants	higher dicots	Moraceae	*Ficus opposita*			C		1/1
plants	higher dicots	Moraceae	*Ficus rubiginosa forma rubiginosa*			C		1/1
plants	higher dicots	Myrsinaceae	*Lysimachia ovalis*			C		1/1
plants	higher dicots	Myrtaceae	*Melaleuca viridiflora var. attenuata*			C		1/1
plants	higher dicots	Myrtaceae	*Eucalyptus camaldulensis subsp. acuta*			C		1/1
plants	higher dicots	Myrtaceae	*Lophostemon grandiflorus subsp. riparius*			C		1/1
plants	higher dicots	Myrtaceae	*Melaleuca leucadendra*	broad-leaved tea-tree		C		1
plants	higher dicots	Myrtaceae	*Melaleuca fluviatilis*			C		1/1
plants	higher dicots	Myrtaceae	*Eucalyptus microneura*	Gilbert River box		C		1/1
plants	higher dicots	Myrtaceae	*Calytrix leptophylla*			C		2/2
plants	higher dicots	Myrtaceae	*Melaleuca bracteata*			C		2/1
plants	higher dicots	Myrtaceae	*Eucalyptus shirleyi*			C		1/1
plants	higher dicots	Myrtaceae	*Eucalyptus coolabah*	coolabah		C		1/1
plants	higher dicots	Myrtaceae	*Corymbia peltata*	yellowjacket		C		1/1
plants	higher dicots	Myrtaceae	*Eucalyptus camaldulensis*			C		1
plants	higher dicots	Myrtaceae	*Corymbia erythrophloia*	variable-barked bloodwood		C		1/1
plants	higher dicots	Myrtaceae	*Eucalyptus leptophleba*	Molloy red box		C		1/1
plants	higher dicots	Myrtaceae	*Melaleuca trichostachya*			C		2/2
plants	higher dicots	Nyctaginaceae	*Boerhavia pubescens*			C		1/1
plants	higher dicots	Oleaceae	*Jasminum didymum subsp. racemosum*			C		1/1
plants	higher dicots	Onagraceae	*Ludwigia octovalvis*	willow primrose		C		4/2
plants	higher dicots	Orobanchaceae	*Striga squamigera*			C		1/1
plants	higher dicots	Passifloraceae	*Passiflora aurantia var. aurantia*			C		1/1
plants	higher dicots	Pentapetaceae	*Melhania brachycarpa*			C		1/1
plants	higher dicots	Pentapetaceae	*Melhania oblongifolia*			C		1/1
plants	higher dicots	Phyllanthaceae	*Antidesma parvifolium*			C		1/1
plants	higher dicots	Phyllanthaceae	*Flueggea virosa subsp. melanthesoides*			C		1/1
plants	higher dicots	Phyllanthaceae	*Phyllanthus hebecarpus*			C		1/1
plants	higher dicots	Phyllanthaceae	*Margaritaria dubium-traceyi*			C		1/1
plants	higher dicots	Phyllanthaceae	*Breynia oblongifolia*			C		1/1
plants	higher dicots	Phyllanthaceae	*Phyllanthus collinus*			C		2/2
plants	higher dicots	Phyllanthaceae	*Phyllanthus virgatus*			C		2/2
plants	higher dicots	Picrodendraceae	*Petalostigma pubescens*	quinine tree		C		1/1
plants	higher dicots	Polygonaceae	*Persicaria barbata*			C		2/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Polygonaceae	*Persicaria subsessilis*	hairy knotweed		C		1/1
plants	higher dicots	Portulacaceae	*Portulaca*			C		1/1
plants	higher dicots	Portulacaceae	*Portulaca filifolia*			C		1/1
plants	higher dicots	Proteaceae	*Grevillea pteridifolia*	golden parrot tree		C		1/1
plants	higher dicots	Proteaceae	*Grevillea glauca*	bushy's clothes peg		C		1/1
plants	higher dicots	Proteaceae	*Hakea arborescens*			C		1/1
plants	higher dicots	Proteaceae	*Grevillea mimosoides*			C		1/1
plants	higher dicots	Putranjivaceae	*Drypetes deplanchei*	grey boxwood		C		1/1
plants	higher dicots	Rhamnaceae	*Alphitonia excelsa*	soap tree		C		2/2
plants	higher dicots	Rubiaceae	*Pavetta granitica*			C		1/1
plants	higher dicots	Rubiaceae	*Larsenaikia ochreata*			C		1/1
plants	higher dicots	Rubiaceae	*Dentella repens*	dentella		C		1/1
plants	higher dicots	Rubiaceae	*Spermacoce cristulata*			C		1/1
plants	higher dicots	Rubiaceae	*Spermacoce brachystema*			C		2/2
plants	higher dicots	Rubiaceae	*Coelospermum reticulatum*			C		1/1
plants	higher dicots	Rubiaceae	*Psychotria daphnoides var. angustifolia*			C		1/1
plants	higher dicots	Rubiaceae	*Oldenlandia mitrasacmoides subsp. nigricans*			C		1/1
plants	higher dicots	Rutaceae	*Geijera salicifolia*	brush wilga		C		1/1
plants	higher dicots	Salicaceae	*Homalium brachybotrys*			C		1/1
plants	higher dicots	Santalaceae	*Exocarpos latifolius*			C		1/1
plants	higher dicots	Santalaceae	*Santalum lanceolatum*			C		1/1
plants	higher dicots	Sapindaceae	*Dodonaea lanceolata var. subsessilifolia*			C		1/1
plants	higher dicots	Sapindaceae	*Dodonaea dodecandra*			C		1/1
plants	higher dicots	Sapotaceae	*Sersalisia sericea*			C		1/1
plants	higher dicots	Sparrmanniaceae	*Triumfetta pentandra*		Y			1/1
plants	higher dicots	Sparrmanniaceae	*Grewia retusifolia*			C		1/1
plants	higher dicots	Sparrmanniaceae	*Grewia mesomischa*			C		1/1
plants	higher dicots	Sparrmanniaceae	*Corchorus*			C		1/1
plants	higher dicots	Sparrmanniaceae	*Triumfetta micracantha*			C		1/1
plants	higher dicots	Sterculiaceae	*Brachychiton chillagoensis*			C		1/1
plants	higher dicots	Sterculiaceae	*Brachychiton diversifolius subsp. orientalis*			C		1/1
plants	higher dicots	Ulmaceae	*Celtis paniculata*	native celtis		C		1/1
plants	higher dicots	Ulmaceae	*Trema tomentosa*			C		1/1
plants	higher dicots	Viscaceae	*Notothixos cornifolius*	kurrajong mistletoe		C		1/1
plants	higher dicots	Vitaceae	*Cayratia trifolia*			C		1/1
plants	higher dicots	Vitaceae	*Cissus cardiophylla*			C		1/1
plants	lower dicots	Apocynaceae	*Tylophora erecta*			C		2/2
plants	lower dicots	Apocynaceae	*Alyxia spicata*			C		1/1
plants	lower dicots	Apocynaceae	*Parsonsia lanceolata*	northern silkpod		C		1/1
plants	lower dicots	Apocynaceae	*Marsdenia microlepis*			C		1/1
plants	lower dicots	Apocynaceae	*Carissa lanceolata*			C		1/1
plants	lower dicots	Apocynaceae	*Cynanchum viminale subsp. brunonianum*			C		1/1
plants	lower dicots	Aristolochiaceae	*Aristolochia pubera var. pubera*			C		1/1
plants	lower dicots	Boraginaceae	*Heliotropium peninsulare*			C		1/1
plants	lower dicots	Boraginaceae	*Heliotropium cunninghamii*			C		3/3
plants	lower dicots	Boraginaceae	*Trichodesma zeylanicum var. zeylanicum*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	lower dicots	Boraginaceae	*Heliotropium collinum*			C		2/2
plants	lower dicots	Convolvulaceae	*Polymeria*			C		1/1
plants	lower dicots	Convolvulaceae	*Jacquemontia sp. (Fairview R.W.Johnson 4026)*			C		2/2
plants	lower dicots	Convolvulaceae	*Jacquemontia paniculata var. tomentosa*			C		1/1
plants	lower dicots	Convolvulaceae	*Evolvulus alsinoides var. decumbens*			C		1/1
plants	lower dicots	Convolvulaceae	*Evolvulus alsinoides var. sericeus*			C		1/1
plants	lower dicots	Convolvulaceae	*Ipomoea polymorpha*			C		1/1
plants	lower dicots	Convolvulaceae	*Ipomoea costata*			C		1/1
plants	lower dicots	Convolvulaceae	*Bonamia media*			C		1/1
plants	lower dicots	Hernandiaceae	*Gyrocarpus americanus*			C		1/1
plants	lower dicots	Lamiaceae	*Anisomeles lappa*			C		1/1
plants	lower dicots	Lamiaceae	*Premna acuminata*			C		1/1
plants	lower dicots	Lamiaceae	*Ocimum caryophyllinum*			C		1/1
plants	lower dicots	Lauraceae	*Cassytha filiformis*	dodder laurel		C		1/1
plants	lower dicots	Linderniaceae	*Lindernia lobelioides*			C		1/1
plants	lower dicots	Menyanthaceae	*Nymphoides indica*	water snowflake		C		1/1
plants	lower dicots	Solanaceae	*Solanum crebrispinum*			C		1/1
plants	monocots	Commelinaceae	*Commelina ensifolia*	scurvy grass		C		1/1
plants	monocots	Commelinaceae	*Aneilema siliculosum*			C		1/1
plants	monocots	Cyperaceae	*Cyperus distans*			C		1/1
plants	monocots	Cyperaceae	*Scleria brownii*			C		3/3
plants	monocots	Cyperaceae	*Fuirena ciliaris*			C		1
plants	monocots	Cyperaceae	*Baumea rubiginosa*	soft twigrush		C		1
plants	monocots	Cyperaceae	*Cyperus difformis*	rice sedge		C		1/1
plants	monocots	Cyperaceae	*Cyperus exaltatus*	tall flatsedge		C		1
plants	monocots	Cyperaceae	*Cyperus javanicus*			C		1/1
plants	monocots	Cyperaceae	*Cyperus brevifolius*	Mullumbimby couch	Y			2/1
plants	monocots	Cyperaceae	*Cyperus polystachyos*			C		3/1
plants	monocots	Cyperaceae	*Eleocharis geniculata*			C		1
plants	monocots	Cyperaceae	*Fimbristylis dichotoma*	common fringe-rush		C		2/1
plants	monocots	Cyperaceae	*Fimbristylis littoralis*			C		1/1
plants	monocots	Cyperaceae	*Lipocarpha microcephala*			C		1
plants	monocots	Cyperaceae	*Schoenoplectiella mucronata*			C		1/1
plants	monocots	Cyperaceae	*Cyperus conicus var. conicus*			C		1/1
plants	monocots	Cyperaceae	*Cyperus dietrichiae var. dietrichiae*			C		1/1
plants	monocots	Cyperaceae	*Cyperus conicus*			C		1/1
plants	monocots	Cyperaceae	*Cyperus iria*			C		1/1
plants	monocots	Cyperaceae	*Cyperus haspan*			C		1
plants	monocots	Laxmanniaceae	*Lomandra decomposita*			C		1/1
plants	monocots	Laxmanniaceae	*Thysanotus banksii*			C		1/1
plants	monocots	Orchidaceae	*Cymbidium canaliculatum*			C		1/1
plants	monocots	Poaceae	*Melinis repens*	red natal grass	Y			1/1
plants	monocots	Poaceae	*Sarga plumosum*			C		1/1
plants	monocots	Poaceae	*Aristida spuria*			C		1/1
plants	monocots	Poaceae	*Cynodon dactylon*		Y			2
plants	monocots	Poaceae	*Eriachne ciliata*			C		2/2

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	monocots	Poaceae	*Leersia hexandra*	swamp rice grass		C		1
plants	monocots	Poaceae	*Themeda avenacea*			C		1/1
plants	monocots	Poaceae	*Aristida pruinosa*			C		2/2
plants	monocots	Poaceae	*Eragrostis fallax*			C		1/1
plants	monocots	Poaceae	*Thellungia advena*	coolibah grass		C		1/1
plants	monocots	Poaceae	*Echinochloa colona*	awnless barnyard grass	Y			2
plants	monocots	Poaceae	*Ectrosia gulliveri*			C		1/1
plants	monocots	Poaceae	*Eragrostis sororia*			C		1/1
plants	monocots	Poaceae	*Perotis clarksonii*			C		1/1
plants	monocots	Poaceae	*Sacciolepis indica*	Indian cupscale grass		C		1
plants	monocots	Poaceae	*Eragrostis speciosa*			C		1/1
plants	monocots	Poaceae	*Oxychloris scariosa*	winged chloris		C		1/1
plants	monocots	Poaceae	*Paspalidium gracile*	slender panic		C		1/1
plants	monocots	Poaceae	*Tragus australianus*	small burr grass		C		1/1
plants	monocots	Poaceae	*Bothriochloa pertusa*		Y			1/1
plants	monocots	Poaceae	*Eragrostis schultzii*			C		1/1
plants	monocots	Poaceae	*Triodia stenostachya*			C		2/2
plants	monocots	Poaceae	*Urochloa holosericea*			C		2/2
plants	monocots	Poaceae	*Cymbopogon bombycinus*	silky oilgrass		C		2/2
plants	monocots	Poaceae	*Digitaria breviglumis*			C		1/1
plants	monocots	Poaceae	*Heteropogon contortus*	black speargrass		C		1/1
plants	monocots	Poaceae	*Aristida inaequiglumis*			C		1/1
plants	monocots	Poaceae	*Enneapogon lindleyanus*			C		1/1
plants	monocots	Poaceae	*Enneapogon polyphyllus*	leafy nineawn		C		3/3
plants	monocots	Poaceae	*Paspalum scrobiculatum*	ditch millet		C		1
plants	monocots	Poaceae	*Dactyloctenium radulans*	button grass		C		1/1
plants	monocots	Poaceae	*Eragrostis spartinoides*			C		1/1
plants	monocots	Poaceae	*Enneapogon robustissimus*			C		1/1
plants	monocots	Poaceae	*Aristida calycina var. praealta*			C		1/1
plants	monocots	Poaceae	*Eragrostiella bifaria var. bifaria*			C		2/2
plants	monocots	Poaceae	*Panicum seminudum var. cairnsianum*			C		2/2
plants	monocots	Poaceae	*Eriachne pallescens var. pallescens*			C		1/1
plants	monocots	Poaceae	*Aristida queenslandica var. dissimilis*			C		1/1
plants	monocots	Poaceae	*Aristida jerichoensis var. subspinulifera*			C		1/1
plants	monocots	Typhaceae	*Typha domingensis*			C		2
plants	monocots	Xanthorrhoeaceae	*Xanthorrhoea johnsonii*			C		1/1

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992.* The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999.* The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens). This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon. This number is output as 999 if it equals or exceeds this value.

Appendix F

DTA - May 2018

Hydrobiology

DTA OF POTENTIAL RELEASE WATER FROM THE KIDSTON PUMPED STORAGE HYDRO PROJECT

BRISBANE | PERTH | SINGAPORE | PAPUA NEW GUINEA

PREPARED FOR AECOM

DRAFT

AEC1701

—

JUNE 2018

THIS COMPANY IS REGISTERED FOR GST.

STREET
27 / 43 Lang Parade
Auchenflower 4066
QUEENSLAND

REGISTERED
c/- de Blonk Smith and
Young Accountants
GPO 119, Brisbane 4001
QUEENSLAND

POSTAL
PO Box 2151
Toowong 4066
QUEENSLAND

CONTACT
+61 (0)7 3721 0100 P
info@hydrobiology.biz

ABN 26 096 574 659

www.hydrobiology.biz

DOCUMENT CONTROL INFORMATION

DATE PRINTED	JOB NUMBER	REPORT NUMBER
14/06/2018	AEC1701	1

PROJECT TITLE	DIRECT TOXICITY ASSESSMENT OF WISES AND ELDRIDGE PITS
PROJECT SUBTITLE	Prepared for AECOM
PROJECT MANAGER	Dustin Hobbs
FILENAME	AEC1701_R_1_v2-0

STATUS	ORIGINATOR/S	REVIEWED	AUTHORISED	DATE
V0-3	Marie Bigot	Dustin Hobbs	Dustin Hobbs	12/06/2018

DISTRIBUTION

FILENAME	DESCRIPTION	ISSUED TO	ISSUED BY
V1-0	Draft	Reece Fraser Rouven Lau	Marie Bigot
V2-0	Draft	Reece Fraser Rouven Lau	Marie Bigot

EXECUTIVE SUMMARY

This Direct Toxicity Assessment (DTA) aimed to determine effluent release rates for the Kidston pumped storage Hydro project in the slightly to moderately disturbed Gilbert Basin.

Waters from Wises Pit and Eldridge Pit at the former Kidston gold mine were mixed to produce a representative composite sample of the proposed discharge into the Copperfield River. Ecotoxicity testing was performed by the NATA accredited laboratories at Ecotox Services Australasia (ESA) on the composite water sample using Copperfield River water as diluent.

The following sub-chronic to chronic toxicity tests were selected for this DTA and satisfied the minimum data requirement of ANZECC & ARMCANZ (2000):

- 96hr growth inhabitation of the freshwater duckweed *Lemna aequinoctialis* based on OECD method 221 (OECD, 2006)
- 72hr microalgal growth inhibition (cell yield) test using the freshwater alga *Chlorella vulgaris* (based on US EPA method 1003.0, (US EPA, 2002))
- 96hr population growth toxicity test using *Hydra viridissima* (based on Riethmuller et al. (2003))
- Fish embryonic development and post-hatch survival toxicity test using the rainbowfish *Melanotaenia splendida splendida* (based on US EPA (2002))
- 7 day reproductive impairment toxicity test using the freshwater cladoceran *Ceriodaphnia cf dubia* (based on US EPA (2002) and Bailey et al. (2000))

The results obtained from these ecotoxicity tests were used to create a species sensitivity distribution (SSD) to predict the concentrations that would protect specified percentages of species in the receiving Copperfield River ecosystem. Trigger values (TVs) were derived using the BurrliOZ software package (Campbell et al., 2000), provided as part of ANZECC and ARMCANZ (2000) package. BurrliOZ fits a log-

logistic distribution to estimate the concentrations of discharges such that a given percentage of species will be protected. The TV for the protection of 95 % of the receiving ecosystem species corresponded to a concentration of 10 % of the composite pit sample tested. This corresponded to a safe dilution factor of 9.

Based on the outcomes of this DTA, it is recommended that the proposed discharge water (composed of a mixture of Eldridge and Wises pit water) be diluted at least 10 times to achieve a minimum protection level of 95% of species in the receiving Copperfield River.

contents

1. BACKGROUND AND OBJECTIVES 11

2. METHODS 12

2.1 Sample collection 12

2.2 Water quality 12

2.3 Ecotoxicity testing 16

2.4 Statistical analysis 17

2.5 Derivation of protective concentrations 17

2.6 QA/QC 17

3. RESULTS AND DISCUSSION 18

4. CONCLUSION 21

5. REFERENCES 22

APPENDIX A. LABORATORY TOXICITY RESULTS

tables

Table 2-1 Water quality results for the composite and river water samples used in the DTA 14

Table 3-1 Summary of toxicity test results 19

Table 3-2 Calculated safe dilution factors for each level of protection 20

figures

Figure 2-1 Map of river sampling locations along the Copperfield River and proposed release points 13

Figure 3-1 Species sensitivity distribution (SSD) 19

Glossary of Terms and Acronyms

The following glossary is based on that provided by *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC and ARMCANZ 2000) and Environment Canada (1999) except where otherwise indicated.

Chronic toxicity – A biological response to exposure to a toxicant that takes a prolonged period to appear and persists for a prolonged period. The term can be used to define either the exposure of an aquatic species or its response to an exposure (effect). The ANZECC & ARMCANZ (2000) define chronic exposure as being greater than 96 hours duration for multi-celled organisms and being equal to or greater than 72 hours duration for single-celled organisms.

Control (control treatment) – In toxicity tests, the control is that treatment in which the test organisms are not subjected to the test substance. The control is used as a standard comparison, to check that the outcome of the experiment is a reflection of the test conditions and not some unknown factor.

Direct toxicity assessment (DTA) – The use of toxicity tests to determine the acute and/or chronic toxicity of effluents and other mixtures of potential toxicants.

EC – Electrical Conductivity, which is an estimate of the amount of total dissolved salts (TDS).

EC_{10} – The concentration of a chemical that is estimated to cause a response in 10% of the test organisms or causes the mean response of the organisms to differ from the control by 10%. The EC10 is usually expressed as a time-dependent value, e.g. 24-hour EC_{10} is the concentration estimated to cause an effect on 10% of the test organisms after 24 hours of exposure.

EC_{50} – The concentration of chemical that is estimated to cause a response in 50% of the test organisms or causes the mean response of the organisms to differ from the control by 50%. The EC50 is usually expressed as a time-dependent value, e.g. 24-hour EC_{50} is the concentration estimated to be cause an effect on 50% of the test organisms after 24 hours of exposure.

Endpoint – The biological response of test organisms in toxicity tests that is measured (e.g. lethality, immobilisation).

ESA – Ecotox Services Australasia.

Ecosystem trigger values – These are the concentration (or loads) of the key performance indicators measured for the ecosystem, below which there exists a low risk that adverse biological (ecological) effects will occur. They indicate a risk of impact if exceeded and should 'trigger' some action, either further ecosystem-specific investigations or implementation of management/remedial actions.

Goodness of Fit – A statistical measure of how well a set of observations fit the predicted pattern of a probability distribution function.

ICp – The concentration that inhibits an endpoint by 'p' percent (e.g. the $IC50_{(reprod)}$ is the concentration that inhibits reproduction by 50%). It represents a point estimate of a concentration of test material that causes a designated percent inhibition (p) compared to the control. The ICp is usually expressed as a time-dependent value, e.g. 24-hour IC_{50} is the concentration estimated to cause an effect on 50% of the test organisms after 24 hours of exposure.

LC_{50} – The concentration of material in water that is estimated to be lethal to 50% of the test organisms. The LC_{50} is usually expressed as a time-dependent value, e.g. 24-hour or 96-hour LC_{50}, the concentration estimated to be lethal to 50% of the test organisms after 24 or 96 hours of exposure.

Level of protection – The ANZECC & ARMCANZ (2000) provide three levels of protection depending on the current status of the ecosystem being considered. The levels are (1) high conservation ecosystems where the default is to protect 99% of species (i.e. PC_{99} values apply), (2) slightly to moderately modified ecosystems where the default is to protect 95% of species (i.e. PC_{95} values apply) and (3) highly modified ecosystems where the default is to protect between 80 to 90% of species (i.e. PC_{80} to PC_{90} values apply).

LOEC – The lowest observed concentration of a toxicant used in a toxicity test that has a statistically significant ($P \leq 0.05$) adverse effect on the exposed population of test organisms compared with the controls. This is estimated by hypothesis-based statistical methods and is therefore not a point estimate.

Mixing zones – An explicitly defined area around a discharge point where discharge concentrations may exceed guideline values and therefore result in certain environmental values not being protected. The size of the mixing zone is site specific.

NATA – National Association of Testing Authorities.

NOEC – The highest observed concentration of a toxicant used in a toxicity test that does not exert a statistically significant adverse effect ($P > 0.05$) on the exposed population of test organisms compared to the controls. This is estimated by hypothesis based statistical methods and is therefore not a point estimate.

Protective concentrations (PC) – The concentration predicted by species sensitivity distribution methods that will protect a chosen percentage of species from experiencing toxic effects. For example, the PC_{99} should protect 99% of species in the ecosystem being considered. The toxic effects that are being prevented will depend on the type of toxicity data used to derive the PC values. Thus, if sub-lethal EC_{10} data are used to generate a PC_{95} – it will protect 95% of species from experiencing sub-lethal EC_{10} effects.

Safe dilution factors – The concentration that a chemical or discharge must be diluted by in order to meet a selected PC value. The lower the PC value the higher the dilution factor must be to protect the selected percentage of species.

Species Sensitivity Distribution (SSD) – SSD is a statistical approach for predicting the threshold concentrations of a contaminant or effluent that will protect a specific proportion of aquatic species with a predetermined level of confidence.

Sub-lethal – A biological response that is less severe than death. Examples of sub-lethal effects include inhibition of reproduction, reduction in growth, reduction in population growth, inhibition of fertilisation and inhibition of development.

Toxicity – The inherent potential or capacity of a chemical to cause adverse effects in a living organism.

Toxicity test – A test that exposes living organisms to several concentrations of a substance that is under investigation, and evaluates the organism's responses.

Trigger Value (TV) – The numerical limit for the aqueous concentration of a toxicant which if exceeded leads to further investigation or action to remediate the site or to reduce the concentration of the toxicant.

1. BACKGROUND AND OBJECTIVES

AECOM has commissioned Hydrobiology and Ecotox Services Australia Pty Ltd (ESA) to perform a Direct Toxicity Assessment (DTA) of a mixture of water from Wises Pit and Eldridge Pit at Kidston which is being proposed to be discharged into the Copperfield River (Gilbert Basin, North Queensland). The major contaminants of concern identified in the effluent release were sulphate (as SO4), arsenic, zinc and nickel.

The scope of this work was to determine acceptable safe dilution factors in the Gilbert Basin which has been assessed as a slightly to moderately disturbed upland freshwater system that will achieve the prescribed level of aquatic ecosystem protection of 95% of species in the receiving environment.

The specific objectives of this study were to:

- Use the results obtained in ecotoxicity testing performed by ESA to create a species sensitivity distribution (SSD);
- Use the SSD to predict the concentrations that would protect specified percentages of species in the receiving Copperfield River ecosystem; and
- Derive safe dilution factors for protecting this ecosystem.

2. METHODS

2.1 SAMPLE COLLECTION

All water samples used for this investigation were collected by the AECOM aquatic ecology team in April 2018. Two test water samples were provided from the Wises and Eldridge pits. Diluent water was also collected from the Copperfield River. The river sample was collected at site W2, as indicated in Figure 2-1. This point was located directly downstream of the proposed release point and represents the most likely river water quality that will mix with the proposed discharge.

2.2 WATER QUALITY

The two test waters from Eldridge and Wises pits were mixed in-house at ESA. The DTA was undertaken using this composite sample serially diluted using Copperfield River water. Both the Copperfield River and composite pit samples were characterised at Australian Laboratory Services (ALS). Parameters analysed included:

- Physico-chemical parameters
- Cations/Anions
- Metals (total and dissolved)
- Nutrients
- Cyanide

Water quality results for the composite sample and the river water sample used in this DTA are presented in Table 2-1.

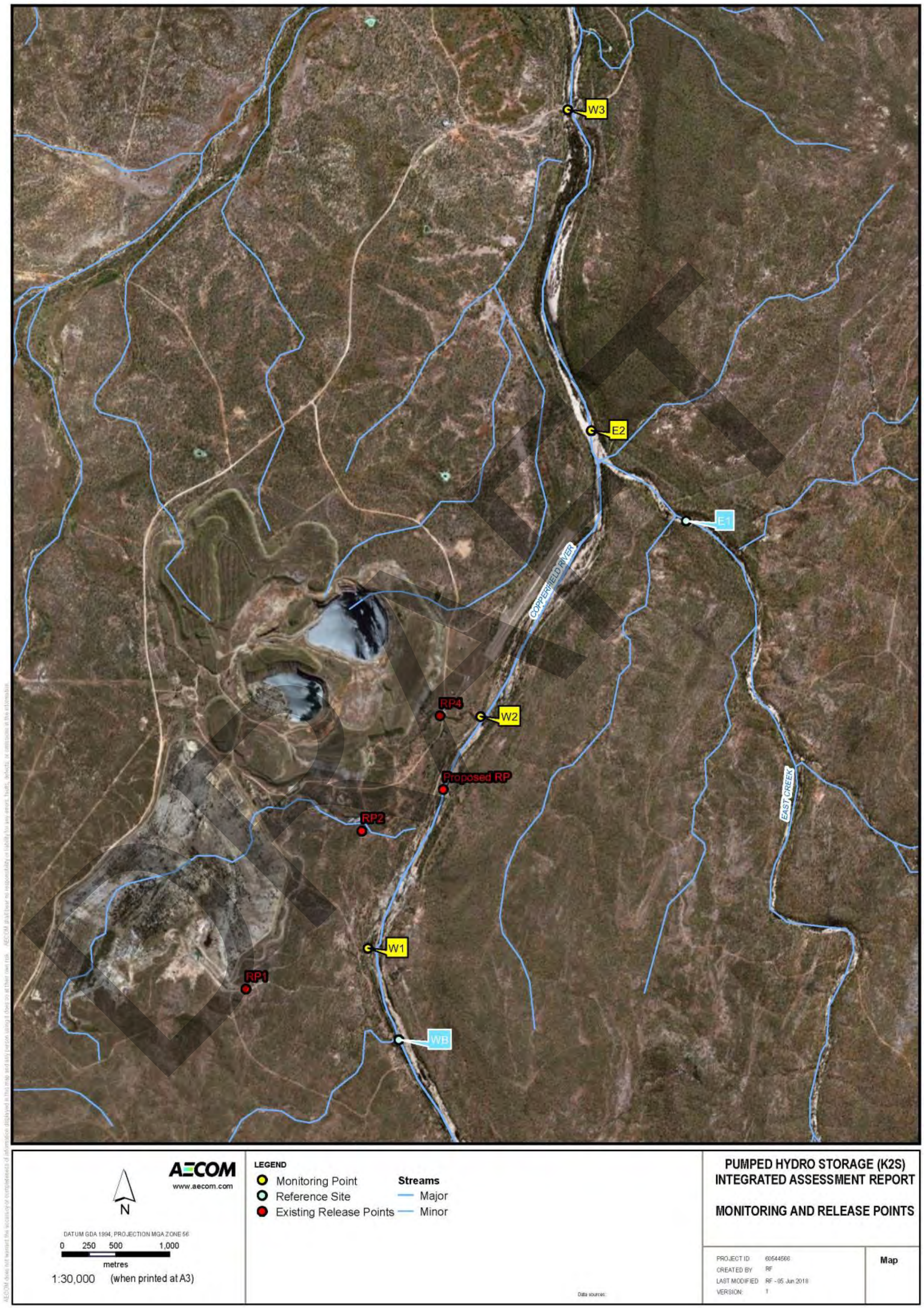


Figure 2-1 Map of river sampling locations along the Copperfield River and proposed release points

Table 2-1 Water quality results for the composite and river water samples used in the DTA

Parameter	Unit	Composite pit sample	Copperfield River sample (W2)
pH	-	7.82	7.74
EC (at 25˚C)	µS/cm	4600	98
Total Hardness (as $CaCO_3$)	mg/L	1530	27
Sodium adsorption ratio (SAR)	-	6.04	0.83
Total Alkalinity (as $CaCO_3$)	mg/L	84	43
Sulphate (SO42-)	mg/L	2630	2
Chloride	mg/L	161	6
Calcium	mg/L	410	6
Magnesium	mg/L	124	3
Sodium	mg/L	544	10
Potassium	mg/L	110	2
Fluoride	mg/L	4.9	0.1
Total Anions	meq/L	61.0	1.07
Total Cations	meq/L	57.1	1.03
Ionic Balance	%	3.25	-
Ammonia as N	mg/L	0.35	0.02
Nitrite as N	mg/L	0.01	<0.01
Nitrate as N	mg/L	0.31	0.06
Total Kjeldahl Nitrogen as N	mg/L	0.4	0.2
Total Phosphorous as P	mg/L	0.09	<0.01
Reactive Phosphorous as P	mg/L	0.04	<0.01
Aluminium	mg/L	<0.01 (D), 0.14 (T)	0.47 (D), 0.69 (T)

Parameter	Unit	Composite pit sample	Copperfield River sample (W2)
Arsenic	mg/L	0.247 (D), 0.250 (T)	<0.001 (D), <0.001 (T)
Beryllium	mg/L	<0.001 (D), <0.001 (T)	-
Barium	mg/L	0.042 (D), 0.043 (T)	-
Cadmium	mg/L	0.0012 (D), 0.0015 (T)	<0.0001 (D), <0.0001 (T)
Chromium	mg/L	<0.001 (D), <0.001 (T)	<0.001 (D), <0.001 (T)
Cobalt	mg/L	0.002 (D), 0.003 (T)	<0.001 (D), <0.001 (T)
Copper	mg/L	0.002 (D), 0.002 (T)	<0.001 (D), <0.001 (T)
Lead	mg/L	<0.001 (D), <0.001 (T)	<0.001 (D), <0.001 (T)
Manganese	mg/L	0.236 (D), 0.256 (T)	0.020 (D), 0.028 (T)
Mercury	mg/L	<0.0001 (D), <0.0001 (T)	<0.0001 (D), <0.0001 (T)
Molybdenum	mg/L	0.042 (D), 0.56 (T)	<0.001 (D), <0.001 (T)
Nickel	mg/L	0.003 (D), 0.003 (T)	<0.001 (D), <0.001 (T)
Selenium	mg/L	<0.01 (D), <0.01 (T)	<0.01 (D), <0.01 (T)
Uranium	mg/L	0.006 (D), 0.007 (T)	-
Vanadium	mg/L	<0.01 (D), <0.01 (T)	-
Zinc	mg/L	0.080 (D), 0.081 (T)	<0.005 (D), <0.005 (T)
Boron	mg/L	0.08 (D), 0.09 (T)	-
Iron	mg/L	<0.05 (D), 0.08 (T)	0.20 (D), 0.71 (T)
Free cyanide	mg/L	<0.004	<0.004
Total cyanide	mg/L	<0.004	<0.004
Cyanide (WAD)	mg/L	<0.004	<0.004

Notes: (D) denotes dissolved concentrations, (T) denotes total concentrations

2.3 ECOTOXICITY TESTING

A minimum of five tests on species from four taxonomic groups are required to enable the derivation of "safe" dilutions of discharges using an SSD approach (ANZECC & ARMCANZ, 2000). The following chronic and sub-chronic tests were selected for this DTA:

- 96hr growth inhabitation of the freshwater duckweed *Lemna aequinoctialis* based on OECD method 221 (OECD, 2006)

  Two species of macrophytes were found in the Copperfield river aquatic ecology survey performed in April 2018 (C&R Consulting, 2018). The test species *L. aequinoctialis*, is a small aquatic, flowering macrophyte commonly known as duckweed. Unlike many other evolutionary more complex plants, their small size and fast growth rates make them ideal for testing in the laboratory. This test was based on the OECD protocol method 221 (OECD, 2006). A standard number of vegetatively reproducing *lemna* plants were exposed to dilution series of the test solution over 96 hours under controlled conditions. The number of fronds was counted at the end of the test and from this, the degree of plant growth was calculated and compared with an appropriate control to determine the percentage inhibition of growth for each treatment.

- 72hr microalgal growth inhibition (cell yield) test using the freshwater alga *Chlorella vulgaris* (based on US EPA method 1003.0, (US EPA, 2002))

  Chlorella vulgaris (Chlorophyceae) is a unicellular freshwater green alga. Exponentially growing cells of *C. vulgaris* were exposed to dilution series of the test toxicant over several generations under defined conditions. The test was conducted over 72 hours with cell counts undertaken at both 48 and 72 h. From these counts, cell division rates were calculated. The test solution was considered toxic when a statistically significant ($P \leq 0.05$) concentration-dependent inhibition of algal growth occurred. Development of this method is described by Franklin et al. (1998).

- 96hr population growth toxicity test using *Hydra viridissima* (based on Riethmuller et al. (2003))

  Hydra viridissima is referred to as 'green' hydra because of its green colouration resulting from the presence of a symbiotic green alga in the gastrodermal cells of the animal. Although the precise distribution of this species has not been mapped, it has been found in a variety of aquatic habitats in northern Australia. Asexually reproducing (budding) test hydra were exposed to a dilution series of the test toxicant for 96 hours. Observations of any changes to the hydra population (i.e. changes in the number of intact hydroids, where one hydroid equals one animal plus any attached buds) were recorded at 24 h intervals. The method is based on the hydra population growth test described by Hyne et al. (1996) and Riethmuller et al. (2003).

- Fish embryonic development and post-hatch survival toxicity test using the rainbowfish *Melanotaenia splendida splendida* (based on US EPA (2002))

  Rainbowfish were chosen as they are common in freshwater areas of the Copperfield River and other north Queensland catchments. The Copperfield River aquatic ecology survey performed in April 2018 reported the presence of checkered rainbowfish (*Melanotaenia splendida inornata*) (C&R Consulting, 2018). The methods adopted by ESA for this test were based on US EPA (2002), but adapted for use with native rainbowfish. The embryo development and post-hatch survival test method covers the first 6 days of embryonic development and 4-days post hatch period (10-day exposure period in total).

- 7 day reproductive impairment toxicity test using the freshwater cladoceran, *Ceriodaphnia* cf. *dubia* (based on US EPA (2002) and Bailey et al. (2000))

  The *Ceriodaphnia* cf. *dubia* freshwater cladoceran (water flea) is the most commonly used test organism to assess the potential harm a toxicant poses to freshwater aquatic ecosystems around the world. Cladocera species were found in the Copperfield River aquatic ecology survey performed in April 2018 (C&R Consulting, 2018), therefore this test is highly relevant to the study area. The reproductive impairment toxicity test measures chronic toxicity using less than 24 h old neonates during a three-brood (seven-day), static renewal test. The test began with asexually reproducing female freshwater cladocera (waterfleas) that were less than six hours old (i.e. neonates). These neonate females were exposed to a dilution series of the test substance, an effluent or reference toxicant under 'static-renewal' conditions. These females were transferred daily to fresh solutions of the same concentration. Each day, observations were made on the survival of each female, the number of neonates produced and neonate survival. Each female was accounted for as alive, dead or missing, rather than assuming missing animals were dead. The test was terminated when three broods were produced by each surviving control female (normally over a 5 to 7 day period). The method is based on the Ceriodaphnia Survival and Reproduction Test developed by the US EPA (2002).

All tests were performed by ESA which is a NATA endorsed toxicity testing facility.

2.4 STATISTICAL ANALYSIS

The EC_{10} (the effective concentration giving 10% reduction in the endpoint compared with the controls) was calculated by ESA using Trimmed Spearman-Karber analysis (Hamilton, Russo and Thurston, 1977), Maximum Likelihood Probit analysis (Finney, 1971) or Log-Logit Interpolations (US EPA, 2002), depending on which method was appropriate.

2.5 DERIVATION OF PROTECTIVE CONCENTRATIONS

Trigger values (TVs) were derived for the protection of aquatic freshwater species using the SSD method. The TVs were derived using the BurrliOZ software package (Campbell *et al.*, 2000), provided as part of ANZECC and ARMCANZ (2000) package. BurrliOZ fits a log-logistic distribution to estimate the concentrations of discharges such that a given percentage of species will be protected. The EC_{10} data from the DTA was input to the SSD to derive the protective concentrations. The TVs for the 80%, 90%, 95% and 99% protective concentrations were derived as per ANZECC and ARMCANZ (2000).

Safe dilution factors (i.e. the dilution needed for the discharge to have little to no effect on the receiving ecosystem) were extrapolated from the data to ensure protection of 95% of species in the aquatic ecosystem of the receiving environment.

2.6 QA/QC

Specific procedures for undertaking toxicity testing activities, procurement and culturing of test organisms, maintenance and calibration of instruments, cleaning, chain-of-custody and sample handling procedures are carried out by ESA as per their Procedures Manual. Quality assurance procedures were undertaken for all toxicity tests.

Quality assurance and quality control of all NATA accredited tests were satisfied. In the case of the *Ceriodaphnia* cf. *dubia* test (not NATA accredited), the control results were satisfactory.

3. RESULTS AND DISCUSSION

A summary of ecotoxicity testing results received from ESA is presented in Table 3-1. The most sensitive species of the testing suite was the microalgae *C. vulgaris* for which the EC_{10} was estimated at 11.8 %.

The five chronic EC_{10} data points were taken forward into the derivation of TVs for the protection of freshwater species using the BurrliOZ program by producing an SSD (Figure 3-1). The SSD was then used to derive ecosystem TVs corresponding to different levels of protection from 80 to 99% of species. These TVs are presented in Table 3-2.

The TV for the protection of 95 % of the receiving ecosystem species corresponded to a concentration of 10 % of the composite pit sample tested (Table 3-2). This result allowed the calculation of the dilution ratio that provides a 95% species protection level for the contaminant mixture proposed to be discharged to the Copperfield River. A safe dilution factor of 9 was calculated to achieve a mixing of 10% composite pit water in the river. Hydrobiology recommends using a conservative 10 times dilution of the composite pit water at the edge of the designated mixing zone in the Copperfield River.

Table 3-1 Summary of toxicity test results

Test	NOEC	LOEC	EC10 (95% confidence interval)	EC50 (95% confidence interval)
96-hr Growth inhibition of *Lemna aequinoctialis*	50%	100%	74.9%	>100%
96-hr acute toxicity test using *Hydra viridissima*	25%	50%	31.4 (25.8-34.9)%	63.9 (57.9-67.6)%
Fish embryo hatching test using *Melanotaenia splendida splendida*	100%	>100%	>100%	>100%
72-hr microalgal growth inhibition test using *Chlorella vulgaris*	6.3%	12.5%	11.8%	>100%
7-day reproduction test using *Ceriodaphnia* cf. *dubia*	25%	50%	30.9 (25.4-35.3)%	79.1 (73.3-84.3)%

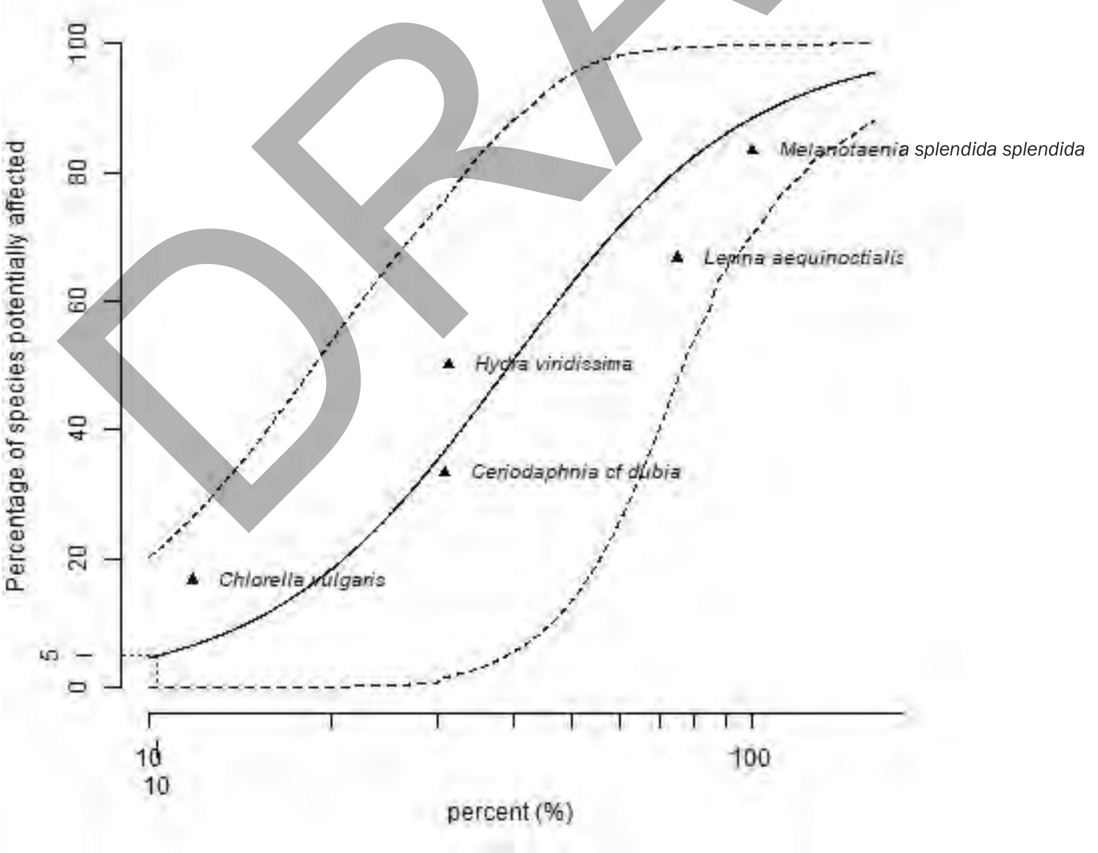


Figure 3-1 Species sensitivity distribution (SSD)

Table 3-2 Calculated safe dilution factors for each level of protection

Solution	Level of protection	Trigger value (TV) [95% confidence interval]	Safe dilution factor estimate
Composite sample Eldridge + Wises	99% species	4.9 % [2.1 – 30.5 %]	19.4
	95% species	**10 % [4.6 – 40.8 %]**	**9.0**
	90% species	15 % [6.6 – 48.7 %]	5.7
	80% species	21 % [10 – 55 %]	3.8

4. CONCLUSION

Based on the composite sample used in this DTA (mixture of pit water from Eldridge and Wises), it is recommended that the proposed discharge water be diluted at least 10 times to achieve a minimum protection level of 95% of species in the receiving Copperfield River.

5. REFERENCES

ANZECC & ARMCANZ (2000) 'Australian and New Zealand Guidelines for Fresh and Marine Water Quality - The Guidelines', *National Water Quality Management Strategy*, 1(4), p. 314.

Bailey, H. C. *et al.* (2000) 'Application of Ceriodaphnia cf. dubia for whole effluent toxicity tests in the Hawkesbury-Nepean watershed, New South Wales, Australia: method development and validation.', *Environmental Toxicology and Chemistry*, 19, pp. 88–93.

C&R Consulting (2018) 'Kidston pumped storage Hydro Project - Aquatic Ecology Survey Report', *report prepared by Geochemical & Hydrobiological Solutions Pty Ltd for AECOM Pty Ltd*.

Campbell, E. *et al.* (2000) *BurrliOZ: A computer program for calculating toxicant trigger values for the ANZECC and ARMCANZ water quality guidelines.* Perth, Australia.

Finney, D. J. (1971) *Probit Analysis (3rd edition)*. Cambridge. Cambridge.

Franklin, N., Australia. Environment Australia. and Australia. Supervising Scientist. (1998) 'A new tropical algal test to assess the toxicity of metals in freshwaters', *Supervising scientist report, 133.*, p. viii, 83.

Hamilton, M. A., Russo, R. C. and Thurston, R. V. (1977) 'Trimmed Spearman-Karber method for estimating median lethal concentrations in toxicity bioassays', *Environmental Science & Technology*, 11(7), pp. 714–719.

Hyne, R. V. *et al.* (1996) 'Procedures for the biological toxicity testing of mine waste waters using freshwater organisms', *Supervising scientist report 110*.

OECD (2006) 'Lemna sp. Growth Inhibition Test. Method 221. OECD Guideline for the Testing of Chemicals.', *Organisation for Economic Cooperation and Development, Paris*.

Riethmuller, N. *et al.* (2003) 'Ecotoxicological testing protocols for Australian tropical freshwater ecosystems', *Supervising Scientist Report 173, Supervising Scientist, Darwin NT*, p. 145.

US EPA (2002) 'Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms. 4th Ed.', *United States Environmental Protection Agency, Office of Water, Washington DC.*

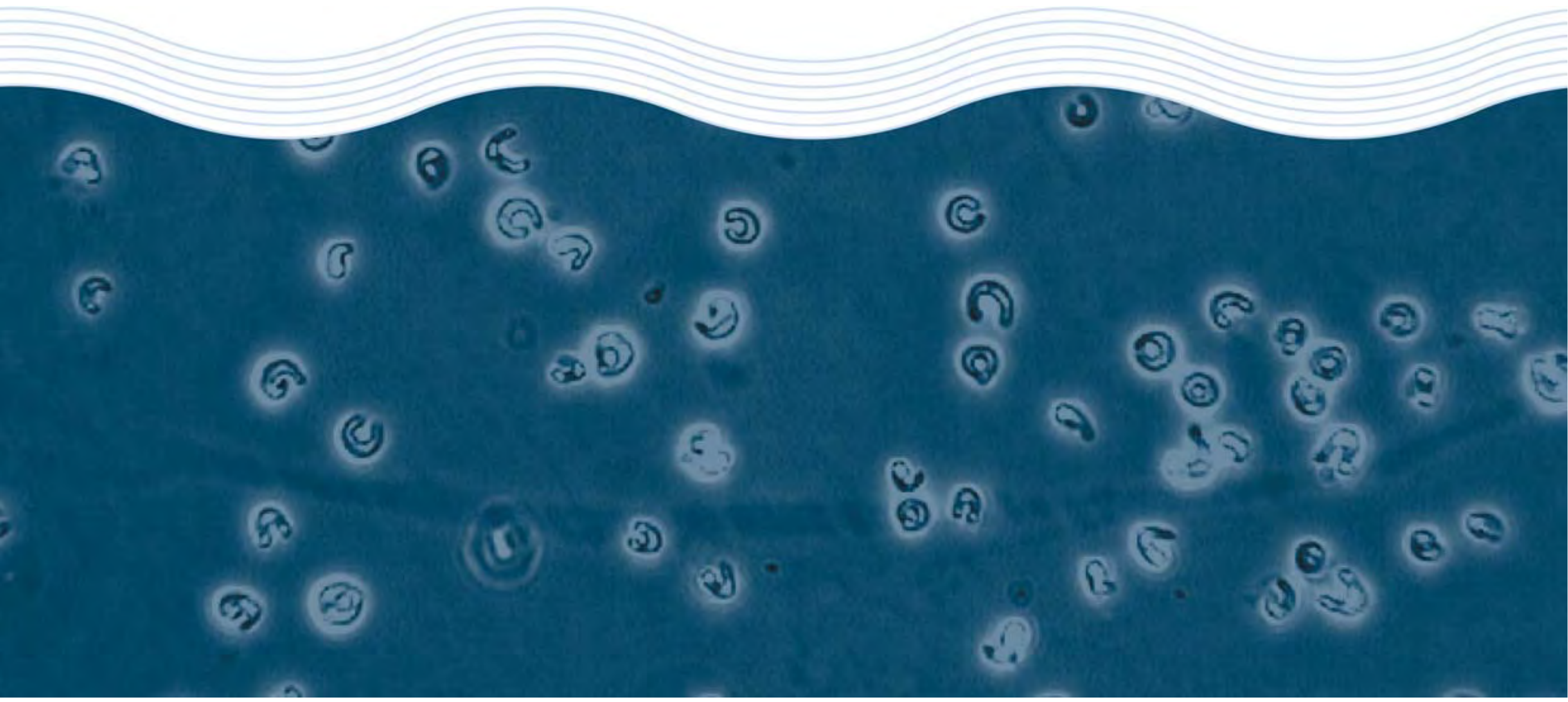
APPENDIX A. LABORATORY TOXICITY RESULTS

Ecotoxicity of a Blend of Eldridge and Wises Samples to a suite of Tropical Freshwater Test Species

Aecom

Test Report

May 2018



Toxicity Test Report: TR1552/1

Accredited for compliance with ISO/IEC 17025

Client:	Aecom PO Box 5423 Townsville QLD 4810	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1552 24 April 2018 30 April 2018
Attention:	Reece Fraser	**Sampled By:**	Client
Client Ref:	60544566	**ESA Quote #:**	PR1552_02

Lab ID No.:	Sample Name:	Sample Description:
8649	Eldridge	Aqueous sample, pH 8.0, conductivity 3310 µS/cm, total ammonia <2.0mg/L. Sample received at 15 ºC in apparent good condition.
8650	Wises	Aqueous sample, pH 8.3, conductivity 5120 µS/cm, total ammonia <2.0 mg/L. Sample received at 15ºC in apparent good condition.
8651	W2	Aqueous sample, pH 8.1, conductivity 106 µS/cm, total ammonia <2.0mg/L. Sample received at 15ºC in apparent good condition.

*NATA accreditation does not cover the performance of this service

Test Performed:	Partial life-cycle toxicity test using the freshwater cladoceran *Ceriodaphnia cf dubia*
Test Protocol:	ESA SOP 102 (ESA 2016), based on USEPA (2002) and Bailey *et al.* (2000)
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The test solution was prepared as a mixture comprising of 10% Wises (sample 8650) and 90% Eldridge (sample 8649) as per the clients instructions. This *Mixture* was serially diluted with W2 (sample 8651) to achieve the final test concentrations. A Dilute Mineral Water (DMW-culture water) control was tested concurrently with the samples.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	11 May 2018 at 1730h

Mixture diluted with W2 (Lab ID 8651):

Concentration (%)	% Unaffected at 7 days (Mean ± SD)
DMW Control	100 ± 0.0
W2 Diluent	100 ± 0.0
6.3	100 ± 0.0
12.5	100 ± 0.0
25	100 ± 0.0
50	100 ± 0.0
100	100 ± 0.0

7 day EC10 (unaffected) = >100%
7 day EC50 (unaffected) = >100%
NOEC = 100%
LOEC = >100%

Mixture diluted with W2 (Lab ID 8651):

Concentration (%)	Number of Young (Mean ± SD)
DMW Control	16.3 ± 1.0
W2 Diluent	12.4 ± 1.1
6.3	16.3 ± 0.7
12.5	16.8 ± 1.5
25	14.5 ± 1.4
50	10.9 ± 2.2*
100	5.2 ± 1.3*

7 day IC10 (reproduction) = 30.9 (25.4-35.3)%
7 day IC50 (reproduction) = 79.1 (73.3-84.3)%
NOEC = 25%
LOEC = 50%

* Significantly lower number of young compared with the W2 Diluent (Dunnett's Test, 1-tailed, P=0.05)

QA/QC Parameter	Criterion	This Test	Criterion met?
DMW Control mean % unaffected	≥80.0%	100%	Yes
Control mean number of young per surviving adult	≥15.0	16.3	Yes
Reference Toxicant within cusum chart limits	192.4-242.9 mgKCl/L	209.6 mgKCl/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 6 June 2018

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

Citations:

Bailey, H.C., Krassoi, R., Elphick, J.R., Mulhall, A., Hunt, P., Tedmanson, L. and Lovell, A. (2000) Application of *Ceriodaphnia cf. dubia* for whole effluent toxicity tests in the Hawkesbury-Nepean watershed, New South Wales, Australia: method development and validation. *Environmental Toxicology and Chemistry* 19:88-93.

ESA (2016) ESA SOP 102 – *Acute Toxicity Test Using Ceriodaphnia dubia.* Issue No 11. Ecotox Services Australasia, Sydney, NSW.

USEPA (2002) *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms.4th Ed.* United States Environmental Protection Agency, Office of Water, Washington DC.

ecotox
SERVICES AUSTRALIA

Toxicity Test Report: TR1552/2

Performed in compliance with ISO/IEC 17025

Client:	Aecom PO Box 5423 Townsville QLD 4810	**ESA Job #:**	PR1552
		Date Sampled:	24 April 2018
		Date Received:	30 April 2018
Attention:	Reece Fraser	**Sampled By:**	Client
Client Ref:	60544566	**ESA Quote #:**	PR1552_02

Lab ID No.:	**Sample Name:**	**Sample Description:**
8649	Eldridge	Aqueous sample, pH 8.0, conductivity 3310 µS/cm, total ammonia <2.0mg/L. Sample received at 15 ºC in apparent good condition.
8650	Wises	Aqueous sample, pH 8.3, conductivity 5120 µS/cm, total ammonia <2.0 mg/L. Sample received at 15ºC in apparent good condition.
8651	W2	Aqueous sample, pH 8.1, conductivity 106 µS/cm, total ammonia <2.0mg/L. Sample received at 15ºC in apparent good condition.

Test Performed:	96-hr Growth inhibition of the freshwater aquatic duckweed *Lemna aequinoctialis*
Test Protocol:	ESA SOP 112 (ESA 2016), based on ASTM (2012)
Test Temperature:	The test was performed at 29±2°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The test solution was prepared as a mixture comprising of 10% Wises (sample 8650) and 90% Eldridge (sample 8649) as per the clients instructions. This *Mixture* was serially diluted with W2 (sample 8651) to achieve the final test concentrations. A CAAC control was tested concurrently with the samples..
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	11 May 2018 at 1700h

Mixture diluted with W2 (Lab ID 8651):

Concentration (%)	**Specific Growth Rate (Mean ± SD)**
CAAC Control	0.33 ± 0.03
W2 Diluent	0.33 ± 0.03
6.3	0.33 ± 0.02
12.5	0.32 ± 0.03
25	0.34 ± 0.02
50	0.33 ± 0.01
100	0.27 ± 0.05

96-h IC10 = 74.9%
96-h IC50 = >100%
NOEC = 50%
LOEC = 100%

Vacant

* Significantly lower growth rate compared with the W2 Diluent (Dunnett's Test, 1-tailed, P=0.05)

ecotox SERVICES AUSTRALIA

Toxicity Test Report: TR1552/2

QA/QC Parameter	Criterion	This Test	Criterion met?
CAAC Control Specific Growth rate	>0.231	0.33	Yes
Reference Toxicant within cusum chart limits	5.6-58.6mg Mg/L	13.8 mg Mg/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 6 June 2018

Results are based on the samples in the condition as received by ESA.
This document shall not be reproduced except in full.

Citations:

ESA (2016) *SOP 112 – Duckweed Growth Inhibition Test.* Issue No. 7. Ecotox Services Australasia, Sydney NSW

OECD (2006) *Lemna sp*. Growth Inhibition Test. Method 221. OECD Guideline for the Testing of Chemicals. Organisation for Economic Cooperation and Development, Paris

ecotox SERVICES AUSTRALIA

Toxicity Test Report: TR1552/3

Performed in compliance with ISO/IEC 17025

Client:	Aecom PO Box 5423 Townsville QLD 4810	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1552 24 April 2018 30 April 2018
Attention:	Reece Fraser	**Sampled By:**	Client
Client Ref:	60544566	**ESA Quote #:**	PR1552_02

Lab ID No.:	Sample Name:	Sample Description:
8649	Eldridge	Aqueous sample, pH 8.0, conductivity 3310 µS/cm, total ammonia <2.0mg/L. Sample received at 15 ºC in apparent good condition.
8650	Wises	Aqueous sample, pH 8.3, conductivity 5120 µS/cm, total ammonia <2.0 mg/L. Sample received at 15ºC in apparent good condition.
8651	W2	Aqueous sample, pH 8.1, conductivity 106 µS/cm, total ammonia <2.0mg/L. Sample received at 15ºC in apparent good condition.

Test Performed:	96-hr acute toxicity test using the freshwater hydra *hydra viridissima*
Test Protocol:	ESA SOP 125 (2016), based on Riethmuller et al. (2003)
Test Temperature:	The test was performed at 28±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The test solution was prepared as a mixture comprising of 10% Wises (sample 8650) and 90% Eldridge (sample 8649) as per the clients instructions. This *Mixture* was serially diluted with W2 (sample 8651) to achieve the final test concentrations. A LC control (culture water) was tested concurrently with the samples.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	11 May 2018 at 1530h

Mixture diluted with W2 (Lab ID 8651):

Concentration (%)	Population Growth Rate (Mean ± SD)
LC Control	0.37 ± 0.02
W2 Diluent	0.36 ± 0.02
6.3	0.36 ± 0.02
12.5	0.36 ± 0.02
25	0.35 ± 0.01
50	0.25 ±0.02*
100	0.00 ± 0.00

96-h IC10 = 31.4 (25.8-34.9)%
96-h IC50 = 63.9 (57.9-67.6)%
NOEC = 25%
LOEC = 50%

Vacant

* Significantly lower growth rate compared with the W2 Diluent (Dunnett's Test, 1-tailed, P=0.05)

Toxicity Test Report: TR1552/3

QA/QC Parameter	Criterion	This Test	Criterion met?
LC Control mean population growth rate	≥0.259	0.37	Yes
Reference Toxicant within cusum chart limits	2.61-10.30µg Cu/L	3.80µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 6 June 2018

Results are based on the samples in the condition as received by ESA.

Citations:

ESA (2016) SOP 125 –*Hydra Population Growth Test.* Issue No 5. Ecotox Services Australasia, Sydney, NSW

Riethmuller N, Camilleri C, Franklin N, Hogan A, King A, Koch A, Markich SJ, Turley C and van Dam R (2003).

Green Hydra Population Growth Test. In: *Ecotoxicological testing protocols for Australian tropical freshwater ecosystems*. Supervising Scientist Report 173, Supervising Scientist, Darwin NT.

Toxicity Test Report: TR1552/4

Performed in compliance with ISO/IEC 17025

Client:	Aecom PO Box 5423 Townsville QLD 4810	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1552 24 April 2018 30 April 2018
Attention:	Reece Fraser	**Sampled By:**	Client
Client Ref:	60544566	**ESA Quote #:**	PR1552_02

Lab ID No.:	**Sample Name:**	**Sample Description:**
8649	Eldridge	Aqueous sample, pH 8.0, conductivity 3310 µS/cm, total ammonia <2.0mg/L. Sample received at 15 ºC in apparent good condition.
8650	Wises	Aqueous sample, pH 8.3, conductivity 5120 µS/cm, total ammonia <2.0 mg/L. Sample received at 15ºC in apparent good condition.
8651	W2	Aqueous sample, pH 8.1, conductivity 106 µS/cm, total ammonia <2.0mg/L. Sample received at 15ºC in apparent good condition.

Test Performed:	Rainbowfish embryo hatching test using *Melanotaenia splendida splendida*
Test Protocol:	ESA SOP 126 (2016), based on USEPA (2002), but adapted for use with native rainbowfish
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The test solution was prepared as a mixture comprising of 10% Wises (sample 8650) and 90% Eldridge (sample 8649) as per the clients instructions. This *Mixture* was serially diluted with W2 (sample 8651) to achieve the final test concentrations. A Dilute Mineral Water (DMW) control (culture water) was tested concurrently with the samples.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	11 May 2018 at 1830h

Mixture diluted with W2 (Lab ID 8651):

Concentration (%)	**% Unaffected (Mean ± SD)**
DMW Control	90.0 ± 11.6
W2 Diluent	95.0 ± 10.0
6.3	85.0 ± 19.2
12.5	100 ± 0.0
25	95.0 ± 10.0
50	100.0 ± 0.0
100	90.0 ± 11.6

12-d EC10 = >100 %
12-d EC50 = >100 %
NOEC = 100%
LOEC = >100%

Vacant

Toxicity Test Report: TR1552/4

QA/QC Parameter	Criterion	This Test	Criterion met?
DMW Control mean % unaffected	$\geq$80.0%	90.0%	Yes
Reference Toxicant within cusum chart limit	14.8-106.7µg Cu/L	87.4µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 6 June 2018

Results are based on the samples in the condition as received by ESA.

This document shall not be reproduced except in full.

Citations:

ESA (2016) *SOP 126- Rainbowfish Embryo Hatching Test*. Issue N°6. Ecotox Services Australasia, Sydney NSW

USEPA (2002) *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms.4th Ed.* United States Environmental Protection Agency, Office of Water, Washington DC.

Toxicity Test Report: TR1552/5

Performed in compliance with ISO/IEC 17025

Client:	Aecom PO Box 5423 Townsville QLD 4810	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1552 24 April 2018 30 April 2018
Attention:	Reece Fraser	**Sampled By:**	Client
Client Ref:	60544566	**ESA Quote #:**	PR1552_02

Lab ID No.:	**Sample Name:**	**Sample Description:**
8649	Eldridge	Aqueous sample, pH 8.0, conductivity 3310 µS/cm, total ammonia <2.0mg/L. Sample received at 15 ºC in apparent good condition.
8650	Wises	Aqueous sample, pH 8.3, conductivity 5120 µS/cm, total ammonia <2.0 mg/L. Sample received at 15ºC in apparent good condition.
8651	W2	Aqueous sample, pH 8.1, conductivity 106 µS/cm, total ammonia <2.0mg/L. Sample received at 15ºC in apparent good condition.

Test Performed:	72-hr microalgal growth inhibition test using the green alga *Chlorella vulgaris*
Test Protocol:	ESA SOP 103 (ESA 2016), based on USEPA (2002)
Test Temperature:	The test was performed at 29±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The test solution was prepared as a mixture comprising of 10% Wises (sample 8650) and 90% Eldridge (sample 8649) as per the clients instructions. This *Mixture* was serially diluted with W2 (sample 8651) to achieve the final test concentrations. A USEPA control was tested concurrently with the samples.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	11 May 2018 at 1730h

Mixture diluted with W2 (Lab ID 8651):

Concentration (%)	**Cell Yield $x10^4$ cells/mL (Mean ± SD)**
USEPA Control	26.0 ± 0.9
W2 Diluent	29.0 ± 2.2
6.3	27.4 ± 0.8
12.5	25.9 ± 1.2*
25	25.7 ± 1.0*
50	24.9 ± 1.4*
100	25.2 ± 1.3*

96-h IC10 = 11.8%
96-h IC50 = >100%
NOEC = 6.3%
LOEC = 12.5%

Vacant

* Significantly lower cell yield compared with the W2 Diluent (Dunnett's Test, 1-tailed, P=0.05)

ecotox
SERVICES AUSTRALIA

Toxicity Test Report: TR1552/5

QA/QC Parameter	Criterion	This Test	Criterion met?
USEPA Control mean cell density	≥16.0x10^4 cells/mL	26.0 x10^4 cells/mL	Yes
Control coefficient of variation	<20%	7.4 %	Yes
Reference Toxicant within cusum chart limits	447-3843mg KCl/L	3465mg KCl/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 6 June 2018

Results are based on the samples in the condition as received by ESA.
This document shall not be reproduced except in full.

Citations:

ESA (2016) *ESA SOP 103 – Green Alga, Selenastrum capricornutum, Growth Test*. Issue No 11. Ecotox Services Australasia, Sydney, NSW.

USEPA (2002) *Short-term methods for estimating the chronic toxicity of effluents and receiving waters to freshwater organisms*. Fourth Edition. EPA-821-R-02-013. United States Environmental Protection Agency, Office of Research and Development, Washington DC, USA,

Chain-of-Custody Documentation

Chain-of-Custody / Service Request Form

Datasheet ID: 601.1
Last Revised: 15 July 2014

ecotox
SERVICES AUSTRALASIA

Customer: AECOM AUSTRALIA
Ship To:
Contact Name: ROUVEN LAU
Attention:
Phone: 0450617847 Email: rouven.lau@aecom.com (please provide an email address for sample receipt notification)
Sampled by: Matthew Knott

Sample Date (day/month /year)	Sample Time	Sample Name (exactly as written on the sample vessel)	Sample Method (eg. Grab, composite etc.)	Number and Volume of Containers (eg 2 x 1L)	Tests Requested (See reverse for guidance): Algal Growth Sc	Duckweed Ltd	Hydra	Embryo Fish	chronic Cerio		Comments / Instructions
25/4/18		W2	Grab	4x4L	✓	✓	✓	✓	✓		Pilvent

Note that testing will be delayed if an incomplete chain of custody is received

- Additional treatment of samples (i.e. spiking)
- Sub-contracted services (i.e. chemical analyses)
- Dilutions required (if different than 100% down to 6.25%)
- Sample holding time restriction (if applicable)
- Sample used for litigation (if applicable)

Note: An MSDS must be attached if Available

ESA Project Number: PR 60544566

1) Released By:	Date:	2) Received By: Claire	Date: 30/4/18	3) Released By:	Date:	4) Received By:	Date:
Of:	Time:	Of: ESA	Time: 10:15am	Of:	Time:	Of:	Time:

Note that the chain-of-custody documentation will provide definitive information on the tests to be performed.

Ecotox Services Australasia . Unit 27, 2 Chaplin Drive, Lane Cove NSW 2066 AUSTRALIA
Phone: 61 2 9420-9481 Fax 61 2 9420-9484 info@ecotox.com.au

Datasheet ID: 601.1
Last Revised: 15 July 2014

Chain-of-Custody / Service Request Form

ecotox
SERVICES AUSTRALASIA

Customer: AECOM AUSTRALIA
Contact Name: ROUVEN LAU
Phone: 0450617847 Email: rouven.lau@aecom.com (please provide an email address for sample receipt notification)
Sampled by: Matthew Knott

Ship To:
Attention:

Sample Date (day/month /year)	Sample Time	Sample Name (exactly as written on the sample vessel)	Sample Method (eg. Grab, composite etc.)	Number and Volume of Containers (eg 2 x 1L)	Tests Requested (See reverse for guidance): Algal Growth Sc	Duckweed Ltd	Hydra	Embryo Fish	Chronic Cerio		Comments / Instructions
25/4/18		Eldridge	Grab	3x4L	✓	✓	✓	✓	✓		Note: The Ecotox
25/4/18		Wises	Grab	1x4L							is to prepare a
											composite sample of
											Eldridge + Wises.
											Please contact me
											as soon as you receive
											for dilution Ratio.

Comments / Instructions:

Note that testing will be delayed if an incomplete chain of custody is received

- Additional treatment of samples (i.e. spiking)
- Sub-contracted services (i.e. chemical analyses)
- Dilutions required (if different than 100% down to 6.25%)
- Sample holding time restriction (if applicable)
- Sample used for litigation (if applicable)

Note: An MSDS must be attached if Available

ESA Project Number: PR 6054456

1) Released By:	Date:	2) Received By: Claire	Date: 30/4/18	3) Released By:	Date:	4) Received By:	Date:
Of:	Time:	Of: ESA	Time: 10.15am	Of:	Time:	Of:	Time:

Note that the chain-of-custody documentation will provide definitive information on the tests to be performed.

Ecotox Services Australasia . Unit 27, 2 Chaplin Drive, Lane Cove NSW 2066 AUSTRALIA
Phone: 61 2 9420-9481 Fax 61 2 9420-9484 info@ecotox.com.au

Statistical Printouts for the 3-brood Partial Life Cycle Test with *Ceriodaphnia dubia*

Ceriodaphnia Partial Life-Cycle Test-Reproduction					
Start Date:	11/05/2018 14:30	Test ID:	PR1552/01	Sample ID:	Mixture
End Date:	18/05/2018 14:30	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:	Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)				

Conc-%	1	2	3	4	5	6	7	8	9	10
W2 Diluent	11.000	13.000	13.000	12.000	13.000	13.000	13.000	13.000	10.000	13.000
DMW Control	17.000	17.000	16.000	15.000	16.000	16.000	16.000	15.000	17.000	18.000
6.3	15.000	16.000	17.000	16.000	17.000	17.000	17.000	16.000	16.000	16.000
12.5	19.000	14.000	18.000	18.000	17.000	17.000	15.000	17.000	16.000	17.000
25	13.000	15.000	13.000	15.000	13.000	14.000	17.000	16.000	14.000	15.000
50	10.000	8.000	9.000	11.000	11.000	13.000	13.000	9.000	15.000	10.000
100	4.000	3.000	5.000	6.000	4.000	5.000	5.000	6.000	7.000	7.000

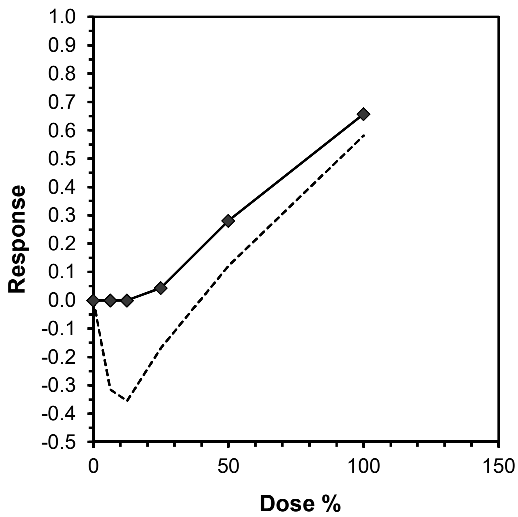
			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
W2 Diluent	12.400	0.7607	12.400	10.000	13.000	8.669	10	*			15.167	1.0000
DMW Control	16.300	1.0000	16.300	15.000	18.000	5.820	10					
6.3	16.300	1.0000	16.300	15.000	17.000	4.141	10	-6.135	2.287	1.454	15.167	1.0000
12.5	16.800	1.0307	16.800	14.000	19.000	8.784	10	-6.922	2.287	1.454	15.167	1.0000
25	14.500	0.8896	14.500	13.000	17.000	9.338	10	-3.304	2.287	1.454	14.500	0.9560
*50	10.900	0.6687	10.900	8.000	15.000	20.030	10	2.360	2.287	1.454	10.900	0.7187
*100	5.200	0.3190	5.200	3.000	7.000	25.318	10	11.327	2.287	1.454	5.200	0.3429

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Kolmogorov D Test indicates normal distribution (p > 0.05)	0.874769	0.895	0.175717	0.519824
Bartlett's Test indicates equal variances (p = 0.04)	11.77794	15.08627		
The control means are significantly different (p = 8.59E-08)	8.602011	2.100922		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	25	50	35.35534	4	1.453561	0.117223	185.1767	2.02037	4.0E-25	5, 54
Treatments vs W2 Diluent										

Linear Interpolation (200 Resamples)

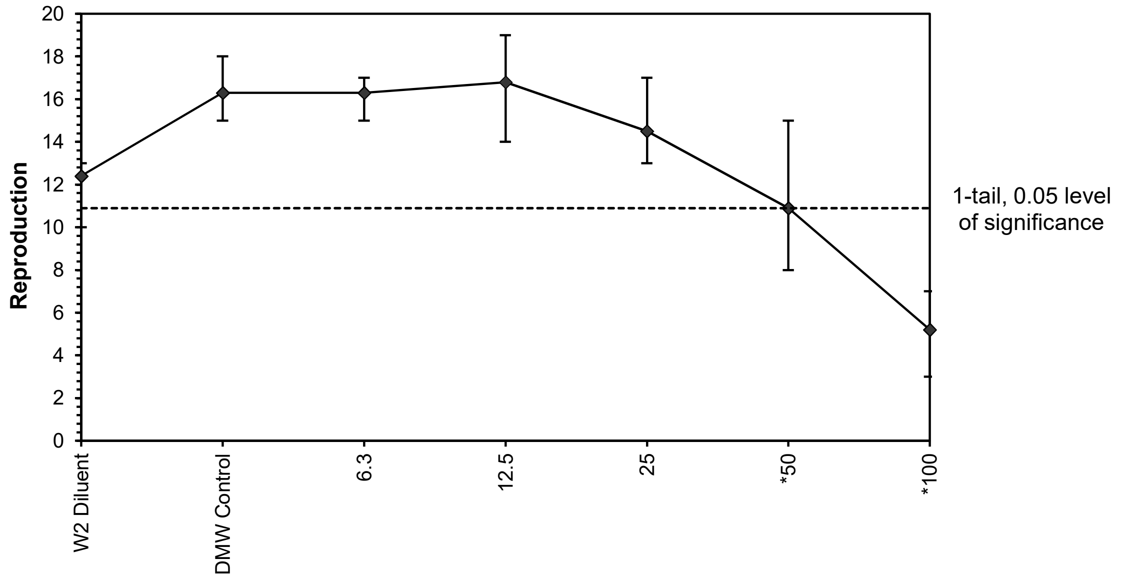
Point	%	SD	95% CL		Skew
IC05	25.637	3.393	18.873	29.824	-0.2499
IC10	30.903	2.718	25.238	35.256	-0.1293
IC15	36.169	2.674	31.041	41.259	0.4592
IC20	41.435	3.084	36.262	48.246	0.8132
IC25	46.701	3.536	41.043	54.313	0.6444
IC40	65.789	3.996	55.672	72.062	-0.4693
IC50	79.094	3.001	73.324	84.287	-0.0796



Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	11/05/2018 14:30	Test ID:	PR1552/01	Sample ID:	Mixture
End Date:	18/05/2018 14:30	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:	Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)				

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	11/05/2018 14:30	Test ID:	PR1552/01	Sample ID:	Mixture
End Date:	18/05/2018 14:30	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia

Comments: Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
W2 Diluent	No of Young	12.40	10.00	13.00	1.07	8.36	10
DMW Control		16.30	15.00	18.00	0.95	5.98	10
6.3		16.30	15.00	17.00	0.67	5.04	10
12.5		16.80	14.00	19.00	1.48	7.23	10
25		14.50	13.00	17.00	1.35	8.02	10
50		10.90	8.00	15.00	2.18	13.56	10
100		5.20	3.00	7.00	1.32	22.07	10
W2 Diluent	% unaffected	100.00	100.00	100.00	0.00	0.00	10
DMW Control		100.00	100.00	100.00	0.00	0.00	10
6.3		100.00	100.00	100.00	0.00	0.00	10
12.5		100.00	100.00	100.00	0.00	0.00	10
25		100.00	100.00	100.00	0.00	0.00	10
50		100.00	100.00	100.00	0.00	0.00	10
100		100.00	100.00	100.00	0.00	0.00	10
W2 Diluent	pH	8.10	8.10	8.10	0.00	0.00	1
DMW Control		8.10	8.10	8.10	0.00	0.00	1
6.3		8.30	8.30	8.30	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.10	8.10	8.10	0.00	0.00	1
100		8.00	8.00	8.00	0.00	0.00	1
W2 Diluent	DO %	98.00	98.00	98.00	0.00	0.00	1
DMW Control		96.30	96.30	96.30	0.00	0.00	1
6.3		99.30	99.30	99.30	0.00	0.00	1
12.5		98.40	98.40	98.40	0.00	0.00	1
25		97.90	97.90	97.90	0.00	0.00	1
50		98.20	98.20	98.20	0.00	0.00	1
100		8.00	8.00	8.00	0.00	0.00	1
W2 Diluent	Cond uS/cm	106.00	106.00	106.00	0.00	0.00	1
DMW Control		186.00	186.00	186.00	0.00	0.00	1
6.3		511.00	511.00	511.00	0.00	0.00	1
12.5		867.00	867.00	867.00	0.00	0.00	1
25		1475.00	1475.00	1475.00	0.00	0.00	1
50		2590.00	2590.00	2590.00	0.00	0.00	1
100		4660.00	4660.00	4660.00	0.00	0.00	1

ecotox
SERVICES AUSTRALIA

Statistical Printouts for the Duckweed Growth Inhibition Tests

Duckweed Growth Inhibtion Test-Specific Growth Rate

Start Date:	11/05/2018 17:00	Test ID:	PR1552/04	Sample ID:	Mixture
End Date:	15/05/2018 17:00	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 112	Test Species:	LA-Lemna aequinoctialis
Comments:	Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)				

Conc-%	1	2	3	4
W2 Diluent	0.3466	0.3666	0.3010	0.3132
CAAC Control	0.3666	0.3359	0.2882	0.3248
6.3	0.3248	0.3010	0.3466	0.3359
12.5	0.3666	0.3010	0.2882	0.3248
25	0.3359	0.3132	0.3359	0.3666
50	0.3359	0.3132	0.3466	0.3359
100	0.2452	0.2118	0.3248	0.2882

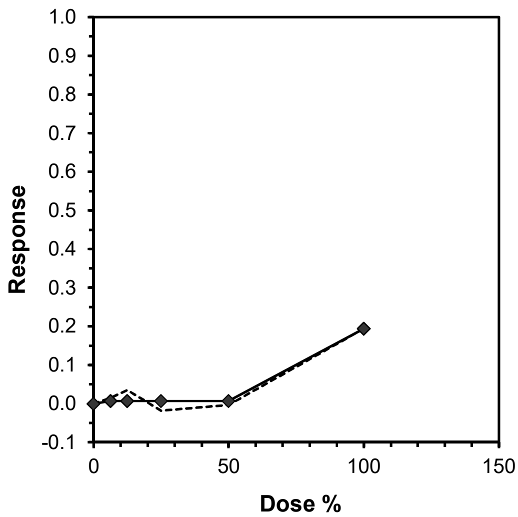
			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
W2 Diluent	0.3318	1.0090	0.3318	0.3010	0.3666	9.080	4	*			0.3318	1.0000
CAAC Control	0.3289	1.0000	0.3289	0.2882	0.3666	9.845	4					
6.3	0.3271	0.9945	0.3271	0.3010	0.3466	5.970	4	0.220	2.410	0.0520	0.3295	0.9930
12.5	0.3201	0.9734	0.3201	0.2882	0.3666	10.772	4	0.542	2.410	0.0520	0.3295	0.9930
25	0.3379	1.0275	0.3379	0.3132	0.3666	6.486	4	-0.281	2.410	0.0520	0.3295	0.9930
50	0.3329	1.0123	0.3329	0.3132	0.3466	4.226	4	-0.050	2.410	0.0520	0.3295	0.9930
*100	0.2675	0.8134	0.2675	0.2118	0.3248	18.452	4	2.980	2.410	0.0520	0.2675	0.8061

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.981457	0.916	0.185402	-0.14152
Bartlett's Test indicates equal variances (p = 0.40)	5.122074	15.08627		
The control means are not significantly different (p = 0.90)	0.133771	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	50	100	70.71068	2	0.052031	0.156796	0.002746	0.000932	0.040917	5, 18
Treatments vs W2 Diluent										

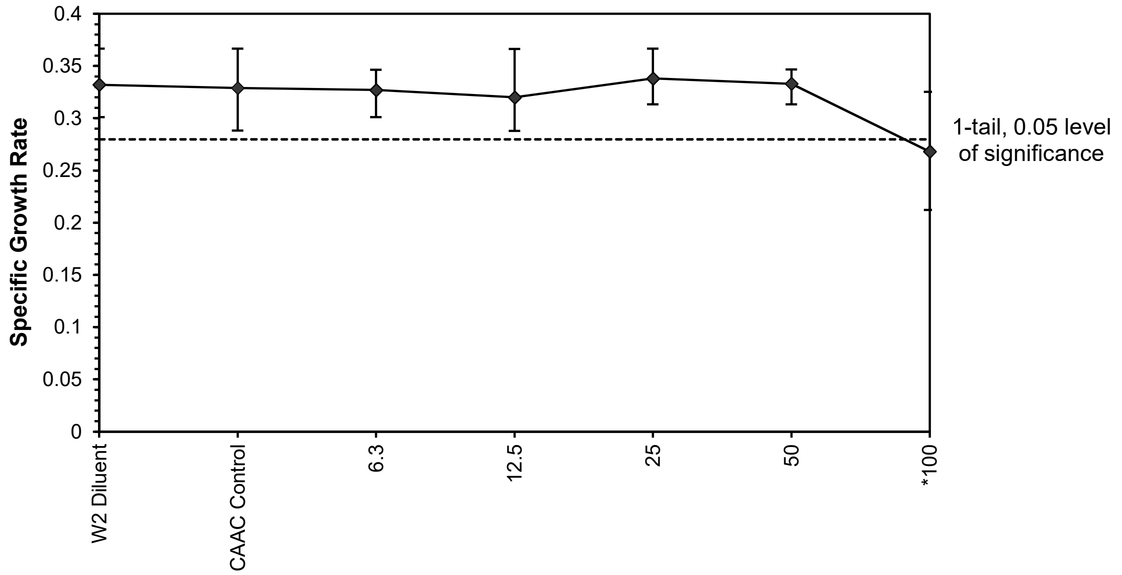
Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	61.504	21.929	0.000	98.580	-1.2313
IC10	74.884				
IC15	88.263				
IC20	>100				
IC25	>100				
IC40	>100				
IC50	>100				



Duckweed Growth Inhibtion Test-Specific Growth Rate					
Start Date:	11/05/2018 17:00	Test ID:	PR1552/04	Sample ID:	Mixture
End Date:	15/05/2018 17:00	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 112	Test Species:	LA-Lemna aequinoctialis
Comments:	Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)				

Dose-Response Plot



Duckweed Growth Inhibtion Test-Specific Growth Rate

Start Date:	11/05/2018 17:00	Test ID:	PR1552/04	Sample ID:	Mixture
End Date:	15/05/2018 17:00	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 112	Test Species:	LA-Lemna aequinoctialis

Comments: Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
W2 Diluent	Specific growth rate	0.33	0.30	0.37	0.03	52.31	4
CAAC Control		0.33	0.29	0.37	0.03	54.71	4
6.3		0.33	0.30	0.35	0.02	42.72	4
12.5		0.32	0.29	0.37	0.03	58.01	4
25		0.34	0.31	0.37	0.02	43.81	4
50		0.33	0.31	0.35	0.01	35.63	4
100		0.27	0.21	0.32	0.05	83.05	4
W2 Diluent	pH	8.10	8.10	8.10	0.00	0.00	1
CAAC Control		6.20	6.20	6.20	0.00	0.00	1
6.3		8.30	8.30	8.30	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.10	8.10	8.10	0.00	0.00	1
100		8.00	8.00	8.00	0.00	0.00	1
W2 Diluent	Cond uS/cm	106.00	106.00	106.00	0.00	0.00	1
CAAC Control		186.00	186.00	186.00	0.00	0.00	1
6.3		511.00	511.00	511.00	0.00	0.00	1
12.5		867.00	867.00	867.00	0.00	0.00	1
25		1475.00	1475.00	1475.00	0.00	0.00	1
50		2590.00	2590.00	2590.00	0.00	0.00	1
100		4660.00	4660.00	4660.00	0.00	0.00	1

Statistical Printouts for *Hydra* Population Growth Tests

Hydra Population Growth Test-Growth Rate

Start Date:	11/05/2018 15:30	Test ID:	PR1552/06	Sample ID:	Mixture
End Date:	15/05/2018 15:30	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 125	Test Species:	HV-Hydra viridissima
Comments:	Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)				

Conc-%	1	2	3	4
W2 Diluent	0.3527	0.3815	0.3647	0.3466
LC Diluent	0.3815	0.3527	0.3922	0.3704
6.3	0.3527	0.3588	0.3466	0.3815
12.5	0.3647	0.3402	0.3466	0.3815
25	0.3402	0.3527	0.3588	0.3527
50	0.2389	0.2291	0.2574	0.2747
100	0.0000	0.0000	0.0000	0.0000

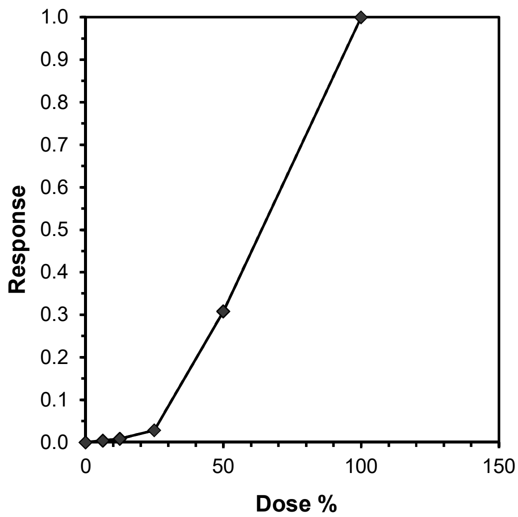
			Transform: Untransformed					1-Tailed			Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
W2 Diluent	0.3614	0.9657	0.3614	0.3466	0.3815	4.257	4	*			0.3614	1.0000
LC Diluent	0.3742	1.0000	0.3742	0.3527	0.3922	4.500	4					
6.3	0.3599	0.9618	0.3599	0.3466	0.3815	4.236	4	0.130	2.360	0.0268	0.3599	0.9959
12.5	0.3582	0.9574	0.3582	0.3402	0.3815	5.204	4	0.276	2.360	0.0268	0.3582	0.9914
25	0.3511	0.9383	0.3511	0.3402	0.3588	2.219	4	0.904	2.360	0.0268	0.3511	0.9717
*50	0.2500	0.6681	0.2500	0.2291	0.2747	8.080	4	9.823	2.360	0.0268	0.2500	0.6918
100	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	4				0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.929908	0.905	0.427296	-0.93344
Bartlett's Test indicates equal variances (p = 0.68)	2.285716	13.2767		
The control means are not significantly different (p = 0.30)	1.1253	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	25	50	35.35534	4	0.026757	0.074042	0.009334	0.000257	1.5E-07	4, 15
Treatments vs W2 Diluent										

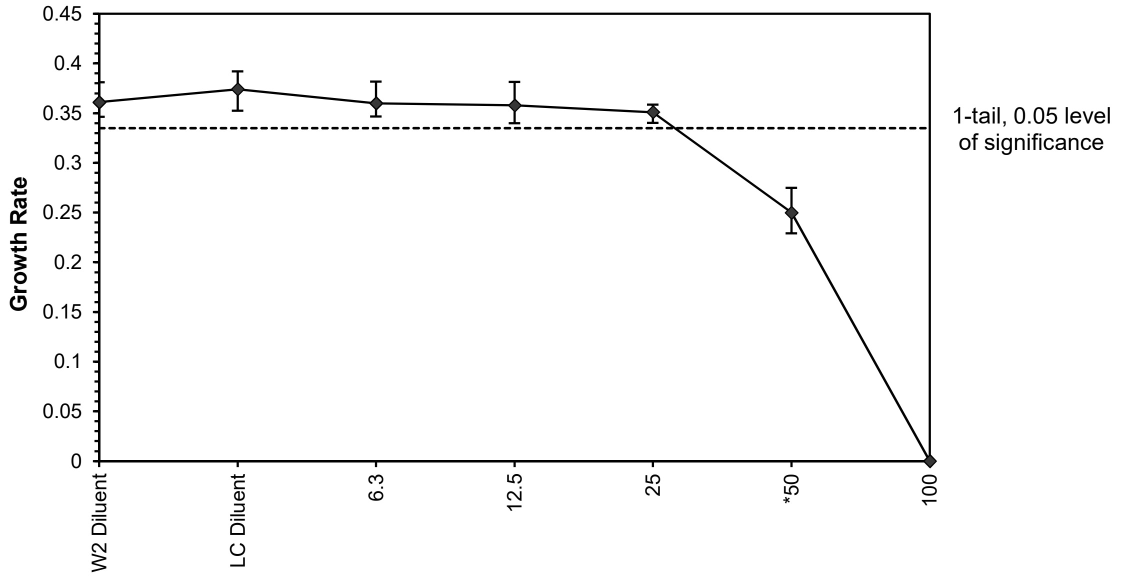
Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	26.934	4.399	1.878	30.047	-3.0698
IC10	31.401	1.455	25.818	34.888	-0.0822
IC15	35.868	1.563	30.498	40.538	0.1354
IC20	40.335	1.790	34.607	46.558	0.3252
IC25	44.802	2.075	38.061	51.583	0.3791
IC40	56.636	1.754	49.477	61.156	-0.1969
IC50	63.863	1.461	57.898	67.630	-0.1969



Hydra Population Growth Test-Growth Rate					
Start Date:	11/05/2018 15:30	Test ID:	PR1552/06	Sample ID:	Mixture
End Date:	15/05/2018 15:30	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 125	Test Species:	HV-Hydra viridissima
Comments:	Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)				

Dose-Response Plot



 ToxCalc v5.0.23 Reviewed by:_____

Hydra Population Growth Test-Growth Rate					
Start Date:	11/05/2018 15:30	Test ID:	PR1552/06	Sample ID:	Mixture
End Date:	15/05/2018 15:30	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 125	Test Species:	HV-Hydra viridissima
Comments:	Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)				

		Auxiliary Data Summary					
Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
W2 Diluent	Specific growth rate	0.36	0.35	0.38	0.02	34.32	4
LC Diluent		0.37	0.35	0.39	0.02	34.68	4
6.3		0.36	0.35	0.38	0.02	34.31	4
12.5		0.36	0.34	0.38	0.02	38.11	4
25		0.35	0.34	0.36	0.01	25.14	4
50		0.25	0.23	0.27	0.02	56.85	4
100		0.00	0.00	0.00	0.00		4
W2 Diluent	pH	8.10	8.10	8.10	0.00	0.00	1
LC Diluent		7.60	7.60	7.60	0.00	0.00	1
6.3		8.30	8.30	8.30	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.10	8.10	8.10	0.00	0.00	1
100		8.00	8.00	8.00	0.00	0.00	1
W2 Diluent	Cond uS/cm	106.00	106.00	106.00	0.00	0.00	1
LC Diluent		32.00	32.00	32.00	0.00	0.00	1
6.3		511.00	511.00	511.00	0.00	0.00	1
12.5		867.00	867.00	867.00	0.00	0.00	1
25		1475.00	1475.00	1475.00	0.00	0.00	1
50		2590.00	2590.00	2590.00	0.00	0.00	1
100		4660.00	4660.00	4660.00	0.00	0.00	1

Statistical Printouts for the Larval Fish Imbalance Tests

Fish Embryonic Development-% Unaffected					
Start Date:	11/05/2018 18:30	Test ID:	PR1552/02	Sample ID:	Mixture
End Date:	23/05/2018 18:30	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 126	Test Species:	MS-Melanotaenia splendida
Comments:	Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)				

Conc-%	1	2	3	4
W2 Diluent	1.0000	1.0000	1.0000	0.8000
DMW Control	1.0000	0.8000	0.8000	1.0000
6.3	1.0000	0.8000	0.6000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000
25	1.0000	1.0000	0.8000	1.0000
50	1.0000	1.0000	1.0000	1.0000
100	0.8000	0.8000	1.0000	1.0000

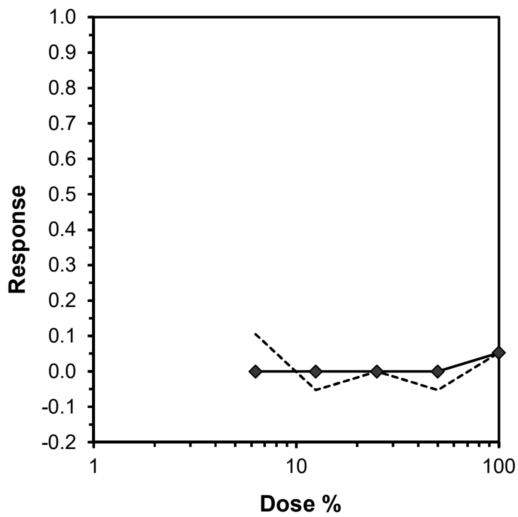
			Transform: Arcsin Square Root					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
W2 Diluent	0.9500	1.0556	1.2857	1.1071	1.3453	9.261	4	*		0.9500	1.0000
DMW Control	0.9000	1.0000	1.2262	1.1071	1.3453	11.212	4				
6.3	0.8500	0.9444	1.1709	0.8861	1.3453	18.840	4	15.50	10.00	0.9500	1.0000
12.5	1.0000	1.1111	1.3453	1.3453	1.3453	0.000	4	20.00	10.00	0.9500	1.0000
25	0.9500	1.0556	1.2857	1.1071	1.3453	9.261	4	18.00	10.00	0.9500	1.0000
50	1.0000	1.1111	1.3453	1.3453	1.3453	0.000	4	20.00	10.00	0.9500	1.0000
100	0.9000	1.0000	1.2262	1.1071	1.3453	11.212	4	16.00	10.00	0.9000	0.9474

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.920884	0.916	-0.77636	0.66368
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 0.54)	0.654654	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1
Treatments vs W2 Diluent				

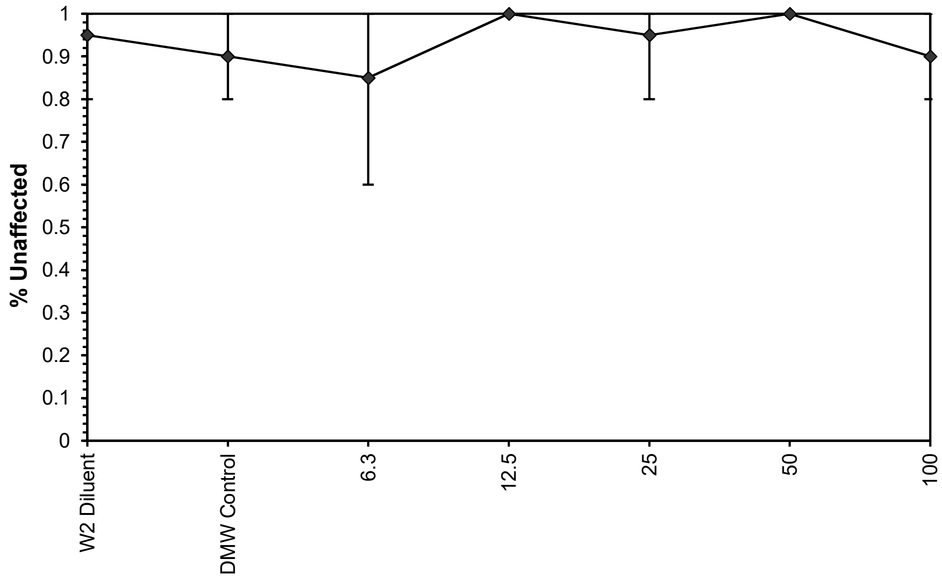
Log-Logit Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	97.438			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Fish Embryonic Development-% Unaffected					
Start Date:	11/05/2018 18:30	Test ID:	PR1552/02	Sample ID:	Mixture
End Date:	23/05/2018 18:30	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 126	Test Species:	MS-Melanotaenia splendida
Comments:	Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)				

Dose-Response Plot



Fish Embryonic Development-% Unaffected

Start Date:	11/05/2018 18:30	Test ID:	PR1552/02	Sample ID:	Mixture
End Date:	23/05/2018 18:30	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 126	Test Species:	MS-Melanotaenia splendida

Comments: Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
W2 Diluent	% Unaffected	95.00	80.00	100.00	10.00	3.33	4
DMW Control		90.00	80.00	100.00	11.55	3.78	4
6.3		85.00	60.00	100.00	19.15	5.15	4
12.5		100.00	100.00	100.00	0.00	0.00	4
25		95.00	80.00	100.00	10.00	3.33	4
50		100.00	100.00	100.00	0.00	0.00	4
100		90.00	80.00	100.00	11.55	3.78	4
W2 Diluent	pH	8.10	8.10	8.10	0.00	0.00	1
DMW Control		8.10	8.10	8.10	0.00	0.00	1
6.3		8.30	8.30	8.30	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.10	8.10	8.10	0.00	0.00	1
100		8.00	8.00	8.00	0.00	0.00	1
W2 Diluent	Conductivity (uS/cm)	106.00	106.00	106.00	0.00	0.00	1
DMW Control		186.00	186.00	186.00	0.00	0.00	1
6.3		511.00	511.00	511.00	0.00	0.00	1
12.5		867.00	867.00	867.00	0.00	0.00	1
25		1475.00	1475.00	1475.00	0.00	0.00	1
50		2590.00	2590.00	2590.00	0.00	0.00	1
100		4660.00	4660.00	4660.00	0.00	0.00	1
W2 Diluent	DO (% sat)	98.00	98.00	98.00	0.00	0.00	1
DMW Control		96.30	96.30	96.30	0.00	0.00	1
6.3		99.30	99.30	99.30	0.00	0.00	1
12.5		98.40	98.40	98.40	0.00	0.00	1
25		97.90	97.90	97.90	0.00	0.00	1
50		98.20	98.20	98.20	0.00	0.00	1
100		8.00	8.00	8.00	0.00	0.00	1

 Reviewed by:_____

Statistical Printouts for the *Chlorella* Growth Inhibition Tests

Microalgal Cell Yield-Cell Yield					
Start Date:	11/05/2018 17:30	Test ID:	PR1552/08	Sample ID:	Mixture
End Date:	14/05/2018 17:30	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 103	Test Species:	CV-Chlorella vulgaris
Comments:	Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)				

Conc-%	1	2	3	4
W2 Diluent	31.800	27.200	29.600	27.200
USEPA Diluent	25.600	24.800	26.600	26.800
6.3	28.200	26.600	26.800	27.800
12.5	26.600	25.200	24.600	27.200
25	26.200	26.800	25.000	24.600
50	23.000	26.200	25.600	24.800
100	23.800	25.600	26.800	24.400

			Transform: Untransformed					1-Tailed			Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
W2 Diluent	28.950	1.1156	28.950	27.200	31.800	7.638	4	*			28.950	1.0000
USEPA Diluent	25.950	1.0000	25.950	24.800	26.800	3.581	4					
6.3	27.350	1.0539	27.350	26.600	28.200	2.824	4	1.621	2.410	2.379	27.350	0.9447
*12.5	25.900	0.9981	25.900	24.600	27.200	4.655	4	3.090	2.410	2.379	25.900	0.8946
*25	25.650	0.9884	25.650	24.600	26.800	3.995	4	3.343	2.410	2.379	25.650	0.8860
*50	24.900	0.9595	24.900	23.000	26.200	5.584	4	4.103	2.410	2.379	25.025	0.8644
*100	25.150	0.9692	25.150	23.800	26.800	5.290	4	3.850	2.410	2.379	25.025	0.8644

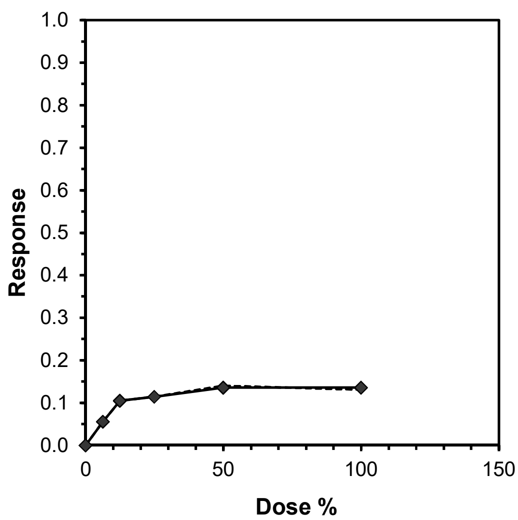
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.957556	0.916	0.263337	-0.46097
Bartlett's Test indicates equal variances (p = 0.64)	3.399041	15.08627		
The control means are significantly different (p = 0.05)	2.501448	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	6.3	12.5	8.87412	15.87302	2.379006	0.082176	9.590667	1.948889	0.005168	5, 18
Treatments vs W2 Diluent										

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05*	5.700	3.610	0.929	22.732	1.6698
IC10	11.837				
IC15	>100				
IC20	>100				
IC25	>100				
IC40	>100				
IC50	>100				

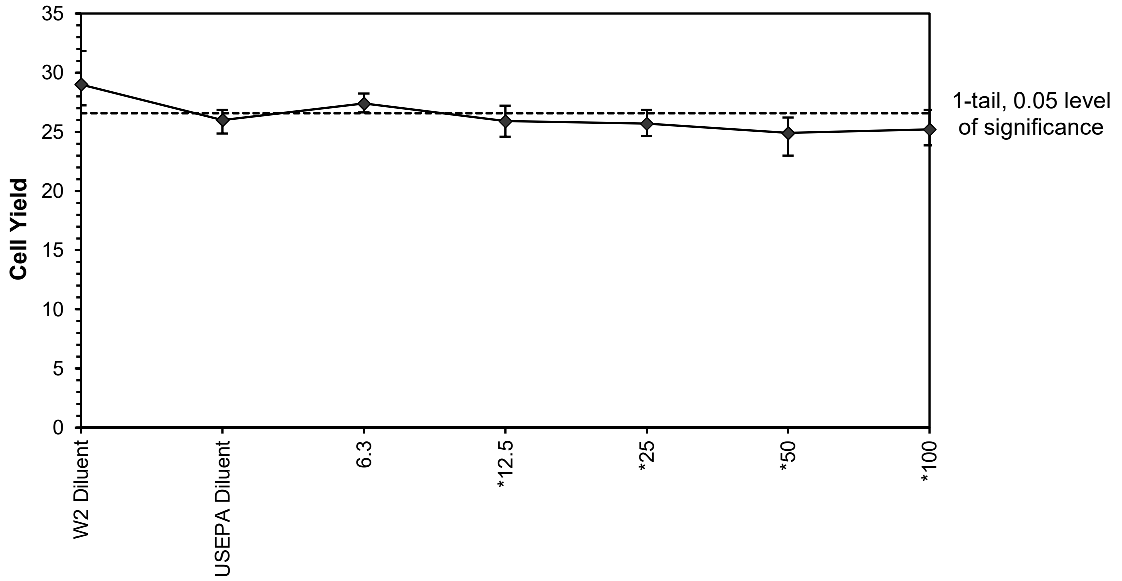
* indicates IC estimate less than the lowest concentration



Microalgal Cell Yield-Cell Yield

Start Date:	11/05/2018 17:30	Test ID:	PR1552/08	Sample ID:	Mixture
End Date:	14/05/2018 17:30	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 103	Test Species:	CV-Chlorella vulgaris
Comments:	Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)				

Dose-Response Plot



Microalgal Cell Yield-Cell Yield

Start Date:	11/05/2018 17:30	Test ID:	PR1552/08	Sample ID:	Mixture
End Date:	14/05/2018 17:30	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 103	Test Species:	CV-Chlorella vulgaris

Comments: Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
W2 Diluent	Cell Yield	28.95	27.20	31.80	2.21	5.14	4
USEPA Diluent		25.95	24.80	26.80	0.93	3.71	4
6.3		27.35	26.60	28.20	0.77	3.21	4
12.5		25.90	24.60	27.20	1.21	4.24	4
25		25.65	24.60	26.80	1.02	3.95	4
50		24.90	23.00	26.20	1.39	4.74	4
100		25.15	23.80	26.80	1.33	4.59	4
W2 Diluent	pH	8.10	8.10	8.10	0.00	0.00	1
USEPA Diluent		7.60	7.60	7.60	0.00	0.00	1
6.3		8.30	8.30	8.30	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.10	8.10	8.10	0.00	0.00	1
100		8.00	8.00	8.00	0.00	0.00	1
W2 Diluent	Conductivity uS/cm	106.00	106.00	106.00	0.00	0.00	1
USEPA Diluent		99.00	99.00	99.00	0.00	0.00	1
6.3		511.00	511.00	511.00	0.00	0.00	1
12.5		867.00	867.00	867.00	0.00	0.00	1
25		1475.00	1475.00	1475.00	0.00	0.00	1
50		2590.00	2590.00	2590.00	0.00	0.00	1
100		4660.00	4660.00	4660.00	0.00	0.00	1

Hydrobiology

STREET
27 / 43 Lang Parade
Auchenflower 4066
QUEENSLAND

POSTAL
PO Box 2151
Toowong 4066
QUEENSLAND

CONTACT
+61 (0)7 3721 0100 P
info@hydrobiology.biz

ABN 26 096 574 659

www.hydrobiology.biz

Appendix G

DTA - June 2018

DTA OF POTENTIAL RELEASE WATER FROM THE KIDSTON PUMPED STORAGE HYDRO PROJECT

BRISBANE | PERTH | SINGAPORE |
PAPUA NEW GUINEA

PREPARED FOR AECOM

AEC1701

—

JULY 2018

THIS COMPANY IS REGISTERED FOR GST.

STREET
27 / 43 Lang Parade
Auchenflower 4066
QUEENSLAND

REGISTERED
c/- de Blonk Smith and
Young Accountants
GPO 119, Brisbane 4001
QUEENSLAND

POSTAL
PO Box 2151
Toowong 4066
QUEENSLAND

CONTACT
+61 (0)7 3721 0100 P
info@hydrobiology.biz

ABN 26 096 574 659

www.hydrobiology.biz

DOCUMENT CONTROL INFORMATION

DATE PRINTED	JOB NUMBER	REPORT NUMBER
17/07/2018	AEC1701	2

PROJECT TITLE	DTA OF POTENTIAL RELEASE WATER FROM THE KIDSTON PUMPED STORAGE HYDRO PROJECT
PROJECT SUBTITLE	Prepared for AECOM
PROJECT MANAGER	Dustin Hobbs
FILENAME	AEC1701_R_2_v1-0

STATUS	ORIGINATOR/S	REVIEWED	AUTHORISED	DATE
V1-1	Marie Bigot	Dustin Hobbs	Dustin Hobbs	17/07/2018

DISTRIBUTION

FILENAME	DESCRIPTION	ISSUED TO	ISSUED BY
V1-0	Draft	Reece Fraser Rouven Lau	Marie Bigot
V2-0	Final	Reece Fraser Rouven Lau	Marie Bigot

EXECUTIVE SUMMARY

This Direct Toxicity Assessment (DTA) aimed to determine effluent release rates for the Kidston pumped storage Hydro project.

Waters from Wises Pit and Eldridge Pit at the former Kidston gold mine were mixed at a volumetric ratio of 10% to 90% (respectively) to produce a representative composite sample of the proposed discharge into the Copperfield River (Gilbert Basin). Ecotoxicity testing was performed by the NATA accredited laboratories at Ecotox Services Australasia (ESA) on the composite water sample using Copperfield River water as diluent.

The following sub-chronic to chronic toxicity tests were selected for this DTA and satisfied the minimum data requirement of ANZECC & ARMCANZ (2000):

- 96hr growth inhabitation of the freshwater duckweed *Lemna aequinoctialis* based on OECD method 221 (OECD, 2006)
- 72hr microalgal growth inhibition (cell yield) test using the freshwater alga *Chlorella vulgaris* (based on US EPA method 1003.0, (US EPA, 2002))
- 96hr population growth toxicity test using *Hydra viridissima* (based on Riethmuller et al. (2003))
- Fish embryonic development and post-hatch survival toxicity test using the rainbowfish *Melanotaenia splendida splendida* (based on US EPA (2002))
- 7 day reproductive impairment toxicity test using the freshwater cladoceran *Ceriodaphnia cf dubia* (based on US EPA (2002) and Bailey et al. (2000))

The results obtained from these ecotoxicity tests were used to create a species sensitivity distribution (SSD) to predict the concentrations that would protect specified percentages of species in the receiving Copperfield River ecosystem. Trigger values (TVs) were derived in accordance with ANZECC and

ARMCANZ (2000) methods using the BurrliOZ 2.0 software package (Barry and Henderson, 2014) provided by CSIRO. BurrliOZ fits a log-logistic distribution to estimate the concentrations of discharges such that a given percentage of species will be protected. The TV for the protection of 95 % of the receiving ecosystem species corresponded to a concentration of 49 % of the composite pit sample tested. This corresponded to a safe dilution factor of 1.1.

Based on the outcomes of this DTA, it is recommended that the proposed discharge water (composed of 90% Eldridge to 10% Wises pit water) be diluted at least 1.1 times to achieve a minimum protection level of 95% of species in the receiving Copperfield River. A conservative dilution factor of 2 should protect >99% of species.

It is important to note that there appears to be some temporal variability in the composition of Eldridge and Wises pit water. The results from this study apply for a representative mixture as described in Table 2-1. In the case where the composition of the mixture varies (in particular EC levels), the dilution factor may need to be adjusted. The DTA performed in May 2018 (HB 2018) could be considered a worst case scenario.

contents

1. BACKGROUND AND OBJECTIVES 11

2. METHODS 12

2.1 Sample collection 12

2.2 Water quality 12

2.3 Ecotoxicity testing 16

2.4 Statistical analysis 17

2.5 Derivation of protective concentrations 17

2.6 QA/QC 18

3. RESULTS AND DISCUSSION 19

4. CONCLUSION 22

5. REFERENCES 23

APPENDIX A. LABORATORY TOXICITY RESULTS

tables

Table 2-1 Water quality results for the composite and river water samples used in the DTA 14

Table 3-1 Summary of toxicity test results 20

Table 3-2 Calculated safe dilution factors for each level of protection 21

figures

Figure 2-1 Map of river sampling locations along the Copperfield River and proposed release points (provided by AECOM) 13

Figure 3-1 Species sensitivity distribution (SSD) 20

Glossary of Terms and Acronyms

The following glossary is based on that provided by *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC and ARMCANZ 2000) and Environment Canada (1999) except where otherwise indicated.

Chronic toxicity – A biological response to exposure to a toxicant that takes a prolonged period to appear and persists for a prolonged period. The term can be used to define either the exposure of an aquatic species or its response to an exposure (effect). The ANZECC & ARMCANZ (2000) define chronic exposure as being greater than 96 hours duration for multi-celled organisms and being equal to or greater than 72 hours duration for single-celled organisms.

Control (control treatment) – In toxicity tests, the control is that treatment in which the test organisms are not subjected to the test substance. The control is used as a standard comparison, to check that the outcome of the experiment is a reflection of the test conditions and not some unknown factor.

Direct toxicity assessment (DTA) – The use of toxicity tests to determine the acute and/or chronic toxicity of effluents and other mixtures of potential toxicants.

EC – Electrical Conductivity, which is an estimate of the amount of total dissolved salts (TDS).

EC_{10} – The concentration of a chemical that is estimated to cause a response in 10% of the test organisms or causes the mean response of the organisms to differ from the control by 10%. The EC10 is usually expressed as a time-dependent value, e.g. 24-hour EC_{10} is the concentration estimated to cause an effect on 10% of the test organisms after 24 hours of exposure.

EC_{50} – The concentration of chemical that is estimated to cause a response in 50% of the test organisms or causes the mean response of the organisms to differ from the control by 50%. The EC50 is usually expressed as a time-dependent value, e.g. 24-hour EC_{50} is the concentration estimated to be cause an effect on 50% of the test organisms after 24 hours of exposure.

Endpoint – The biological response of test organisms in toxicity tests that is measured (e.g. lethality, immobilisation).

ESA – Ecotox Services Australasia.

Ecosystem trigger values – These are the concentration (or loads) of the key performance indicators measured for the ecosystem, below which there exists a low risk that adverse biological (ecological) effects will occur. They indicate a risk of impact if exceeded and should 'trigger' some action, either further ecosystem-specific investigations or implementation of management/remedial actions.

Goodness of Fit – A statistical measure of how well a set of observations fit the predicted pattern of a probability distribution function.

ICp – The concentration that inhibits an endpoint by 'p' percent (e.g. the $IC50_{(reprod)}$ is the concentration that inhibits reproduction by 50%). It represents a point estimate of a concentration of test material that causes a designated percent inhibition (p) compared to the control. The ICp is usually expressed as a time-dependent value, e.g. 24-hour IC_{50} is the concentration estimated to cause an effect on 50% of the test organisms after 24 hours of exposure.

LC_{50} – The concentration of material in water that is estimated to be lethal to 50% of the test organisms. The LC_{50} is usually expressed as a time-dependent value, e.g. 24-hour or 96-hour LC_{50}, the concentration estimated to be lethal to 50% of the test organisms after 24 or 96 hours of exposure.

Level of protection – The ANZECC & ARMCANZ (2000) provide three levels of protection depending on the current status of the ecosystem being considered. The levels are (1) high conservation ecosystems where the default is to protect 99% of species (i.e. PC_{99} values apply), (2) slightly to moderately modified ecosystems where the default is to protect 95% of species (i.e. PC_{95} values apply) and (3) highly modified ecosystems where the default is to protect between 80 to 90% of species (i.e. PC_{80} to PC_{90} values apply).

LOEC – The lowest observed concentration of a toxicant used in a toxicity test that has a statistically significant ($P \leq 0.05$) adverse effect on the exposed population of test organisms compared with the controls. This is estimated by hypothesis-based statistical methods and is therefore not a point estimate.

Mixing zones – An explicitly defined area around a discharge point where discharge concentrations may exceed guideline values and therefore result in certain environmental values not being protected. The size of the mixing zone is site specific.

NATA – National Association of Testing Authorities.

NOEC – The highest observed concentration of a toxicant used in a toxicity test that does not exert a statistically significant adverse effect ($P > 0.05$) on the exposed population of test organisms compared to the controls. This is estimated by hypothesis based statistical methods and is therefore not a point estimate.

Protective concentrations (PC) – The concentration predicted by species sensitivity distribution methods that will protect a chosen percentage of species from experiencing toxic effects. For example, the PC_{99} should protect 99% of species in the ecosystem being considered. The toxic effects that are being prevented will depend on the type of toxicity data used to derive the PC values. Thus, if sub-lethal EC_{10} data are used to generate a PC_{95} – it will protect 95% of species from experiencing sub-lethal EC_{10} effects.

Safe dilution factors – The concentration that a chemical or discharge must be diluted by in order to meet a selected PC value. The lower the PC value the higher the dilution factor must be to protect the selected percentage of species.

Species Sensitivity Distribution (SSD) – SSD is a statistical approach for predicting the threshold concentrations of a contaminant or effluent that will protect a specific proportion of aquatic species with a predetermined level of confidence.

Sub-lethal – A biological response that is less severe than death. Examples of sub-lethal effects include inhibition of reproduction, reduction in growth, reduction in population growth, inhibition of fertilisation and inhibition of development.

Toxicity – The inherent potential or capacity of a chemical to cause adverse effects in a living organism.

Toxicity test – A test that exposes living organisms to several concentrations of a substance that is under investigation, and evaluates the organism's responses.

Trigger Value (TV) – The numerical limit for the aqueous concentration of a toxicant which if exceeded leads to further investigation or action to remediate the site or to reduce the concentration of the toxicant.

1. BACKGROUND AND OBJECTIVES

AECOM has commissioned Hydrobiology and Ecotox Services Australia Pty Ltd (ESA) to perform a Direct Toxicity Assessment (DTA) of a mixture of water from Wises Pit and Eldridge Pit at Kidston which is being proposed to be discharged into the Copperfield River (Gilbert Basin, North Queensland). The major contaminants of concern identified in the effluent release were sulphate (as SO_4), arsenic, zinc and nickel.

The scope of this work was to determine acceptable safe dilution factors for discharge of a mixture of pit waters in the Copperfield River which is part of Gilbert Basin. The aim was to achieve a level of aquatic ecosystem protection of 95% of species in the receiving environment corresponding to a slightly to moderately disturbed upland freshwater system.

The specific objectives of this study were to:

- Use the results obtained in ecotoxicity testing performed by ESA to create a species sensitivity distribution (SSD);
- Use the SSD to predict the concentrations that would protect specified percentages of species in the receiving Copperfield River ecosystem; and
- Derive safe dilution factors for protecting this ecosystem.

2. METHODS

2.1 SAMPLE COLLECTION

All water samples used for this investigation were collected by AECOM in June 2018. Two test water samples were provided from the Wises and Eldridge pits. Diluent water was also collected from the Copperfield River. The river sample was collected at site W2, as indicated in Figure 2-1. This point was located directly downstream of the proposed release point and represents the most likely river water quality that will mix with the proposed discharge.

2.2 WATER QUALITY

The two test waters from Eldridge and Wises pits were mixed by AECOM at a ratio of 90% Eldridge to 10% Wises. The DTA was undertaken using this composite sample which was serially diluted using Copperfield River water. Both the Copperfield River and composite pit samples were characterised at Australian Laboratory Services (ALS). Parameters analysed included:

- Physico-chemical parameters
- Cations/Anions
- Metals (total and dissolved)
- Nutrients
- Cyanide

Water quality results for the composite sample and the river water sample used in this DTA are presented in Table 2-1.

Figure 2-1 Map of river sampling locations along the Copperfield River and proposed release points (provided by AECOM)

Table 2-1 Water quality results for the composite and river water samples used in the DTA

Parameter	Unit	Copperfield River sample (June 2018)	Composite pit sample (90% Eldridge+10% Wises) (June 2018)	Composite pit sample (May 2018) used for previous DTA (HB, 2018)
pH	-	8.10	7.78	7.82
EC (at 25˚C)	µS/cm	153	3210	4600
Total Hardness (as $CaCO_3$)	mg/L	50	1230	1530
Sodium adsorption ratio (SAR)	-	0.83	4.02	6.04
Total Alkalinity (as $CaCO_3$)	mg/L	60	48	84
Sulphate (SO_4^{2-})	mg/L	7	1720	2630
Chloride	mg/L	8	107	161
Calcium	mg/L	10	338	410
Magnesium	mg/L	6	94	124
Sodium	mg/L	10	324	544
Potassium	mg/L	2	52	110
Fluoride	mg/L	0.2	2.8	4.9
Total Anions	meq/L	1.57	39.8	61.0
Total Cations	meq/L	1.48	40.0	57.1
Ionic Balance	%	-	0.3	3.25
Ammonia as N	mg/L	0.02	0.16	0.35
Nitrite as N	mg/L	<0.01	<0.01	0.01
Nitrate as N	mg/L	<0.01	5.19	0.31
Total Kjeldahl Nitrogen as N	mg/L	0.2	0.6	0.4

Parameter	Unit	Copperfield River sample (June 2018)	Composite pit sample (90% Eldridge+10% Wises) (June 2018)	Composite pit sample (May 2018) used for previous DTA (HB, 2018)
Total Phosphorous as P	mg/L	<0.01	0.03	0.09
Reactive Phosphorous as P	mg/L	<0.01	0.01	0.04
Arsenic	mg/L	<0.001 (D), <0.001 (T)	0.047 (D), 0.050 (T)	0.247 (D), 0.250 (T)
Beryllium	mg/L	<0.001 (D), <0.001 (T)	<0.001 (D), <0.001 (T)	<0.001 (D), <0.001 (T)
Barium	mg/L	0.023 (D), 0.027 (T)	0.037 (D), 0.050 (T)	0.042 (D), 0.043 (T)
Cadmium	mg/L	<0.0001 (D), <0.0001 (T)	0.0221 (D), 0.0222 (T)	0.0012 (D), 0.0015 (T)
Chromium	mg/L	<0.001 (D), <0.001 (T)	<0.001 (D), <0.001 (T)	<0.001 (D), <0.001 (T)
Cobalt	mg/L	<0.001 (D), <0.001 (T)	0.004 (D), 0.005 (T)	0.002 (D), 0.003 (T)
Copper	mg/L	<0.001 (D), <0.001 (T)	0.003 (D), 0.007 (T)	0.002 (D), 0.002 (T)
Lead	mg/L	<0.001 (D), <0.001 (T)	<0.001 (D), <0.001 (T)	<0.001 (D), <0.001 (T)
Manganese	mg/L	0.004 (D), 0.053 (T)	1.11 (D), 1.21 (T)	0.236 (D), 0.256 (T)
Mercury	mg/L	<0.0001 (D), <0.0001 (T)	<0.0001 (D), <0.0001 (T)	<0.0001 (D), <0.0001 (T)
Nickel	mg/L	<0.001 (D), <0.001 (T)	0.021 (D), 0.022 (T)	0.003 (D), 0.003 (T)
Selenium	mg/L	<0.01 (D), <0.01 (T)	<0.01 (D), <0.01 (T)	<0.01 (D), <0.01 (T)
Vanadium	mg/L	<0.01 (D), <0.01 (T)	<0.01 (D), <0.01 (T)	<0.01 (D), <0.01 (T)
Zinc	mg/L	<0.005 (D), <0.005 (T)	1.09 (D), 1.10 (T)	0.080 (D), 0.081 (T)

Parameter	Unit	Copperfield River sample (June 2018)	Composite pit sample (90% Eldridge+10% Wises) (June 2018)	Composite pit sample (May 2018) used for previous DTA (HB, 2018)
Boron	mg/L	<0.05 (D), <0.05 (T)	0.05 (D), 0.05 (T)	0.08 (D), 0.09 (T)

Notes: (D) denotes dissolved concentrations, (T) denotes total concentrations

Also presented in Table 2-1 are the water quality analysis results of a composite sample that was used in DTA testing in May 2018. We note that water quality of the mixture tested for this DTA (i.e. 90% Eldridge to 10% Wises pit water) was different when compared with the previous mixture tested in May 2018 (which was an unknown mixture ratio). It is important to note that the composition of each pit varied considerably between the two sampling dates. In particular, EC was considerably lower in June (Eldridge sample was 3340 and 2950 µS/cm in May and June, respectively, and Wises sample was 6180 and 4870 µS/cm, respectively) which resulted in a lower EC for the June composite sample compared with the previous (3210 µS/cm compared with 4600 µS/cm in May 2018). The concentrations of major ions (including Ca, Cl, Mg, Na and K), alkalinity and hardness were also lower. In terms of metal contaminants, many were found at higher concentrations in June compared with the mixture from May 2018, these included Cd, Co, Cu, Mn, Ni and Zn, which were found at concentrations above their respective trigger values for freshwater ecosystems in ANZECC & ARMCANZ (2000). Arsenic and boron were found in lower concentrations in June compared with May.

2.3 ECOTOXICITY TESTING

A minimum of five tests on species from four taxonomic groups are required to enable the derivation of "safe" dilutions of discharges using an SSD approach (ANZECC & ARMCANZ, 2000). The following chronic and sub-chronic tests were selected for this DTA:

- 96hr growth inhabitation of the freshwater duckweed *Lemna aequinoctialis* based on OECD method 221 (OECD, 2006)

  Two species of macrophytes were found in the Copperfield River aquatic ecology survey undertaken in April 2018 (C&R Consulting, 2018). The test species, *L. aequinoctialis*, is a small aquatic, flowering macrophyte, commonly known as duckweed. Unlike many other evolutionary more complex plants, their small size and fast growth rates make them ideal for testing in the laboratory. This test was based on the OECD protocol method 221 (OECD, 2006). A standard number of vegetatively reproducing *Lemna* plants were exposed to dilution series of the test solution over 96 hours under controlled conditions. The number of fronds was counted at the end of the test and from this, the degree of plant growth was calculated and compared with an appropriate control to determine the percentage inhibition of growth for each treatment.

- 72hr microalgal growth inhibition (cell yield) test using the freshwater alga *Chlorella vulgaris* (based on US EPA method 1003.0, (US EPA, 2002))

  Chlorella vulgaris (Chlorophyceae) is a unicellular freshwater green alga. Exponentially growing cells of *C. vulgaris* were exposed to dilution series of the test toxicant over several generations under defined conditions. The test was conducted over 72 hours with cell counts undertaken at both 48 and 72 h. From these counts, cell division rates were calculated. The test solution was considered toxic when a statistically significant ($P \leq 0.05$) concentration-dependent inhibition of algal growth occurred. Development of this method is described by Franklin et al. (1998).

- 96hr population growth toxicity test using *Hydra viridissima* (based on Riethmuller et al. (2003))

Hydra viridissima is referred to as 'green' hydra because of its green colouration resulting from the presence of a symbiotic green alga in the gastrodermal cells of the animal. Although the precise distribution of this species has not been mapped, it has been found in a variety of aquatic habitats in northern Australia. Asexually reproducing (budding) test hydra were exposed to a dilution series of the test toxicant for 96 hours. Observations of any changes to the hydra population (i.e. changes in the number of intact hydroids, where one hydroid equals one animal plus any attached buds) were recorded at 24 h intervals. The method is based on the hydra population growth test described by Hyne et al. (1996) and Riethmuller et al. (2003).

- Fish embryonic development and post-hatch survival toxicity test using the rainbowfish *Melanotaenia splendida splendida* (based on US EPA (2002))

  Rainbowfish were chosen as they are common in freshwater areas of the Copperfield River and other north Queensland catchments. The Copperfield River aquatic ecology survey performed in April 2018 reported the presence of checkered rainbowfish (*Melanotaenia splendida inornata*) (C&R Consulting, 2018). The methods adopted by ESA for this test were based on US EPA (2002), but adapted for use with native rainbowfish. The embryo development and post-hatch survival test method covers the first 6 days of embryonic development and 4-days post hatch period (10-day exposure period in total).

- 7 day reproductive impairment toxicity test using the freshwater cladoceran, *Ceriodaphnia* cf. *dubia* (based on US EPA (2002) and Bailey et al. (2000))

  The *Ceriodaphnia* cf. *dubia* freshwater cladoceran (water flea) is the most commonly used test organism to assess the potential harm a toxicant may pose to freshwater aquatic ecosystems around the world. Cladocera species were found in the Copperfield River aquatic ecology survey performed in April 2018 (C&R Consulting, 2018), therefore this test is highly relevant to the study area. The reproductive impairment toxicity test measures chronic toxicity using less than 24 h old neonates during a three-brood (seven-day), static renewal test. The test began with asexually reproducing female freshwater cladocera (waterfleas) that were less than six hours old (i.e. neonates). These neonate females were exposed to a dilution series of the test substance, an effluent or reference toxicant under 'static-renewal' conditions. These females were transferred daily to fresh solutions of the same concentration. Each day, observations were made on the survival of each female, the number of neonates produced and neonate survival. Each female was accounted for as alive, dead or missing, rather than assuming missing animals were dead. The test was terminated when three broods were produced by each surviving control female (normally over a 5 to 7 day period). The method is based on the Ceriodaphnia Survival and Reproduction Test developed by the US EPA (2002).

All tests were performed by ESA which is a NATA endorsed toxicity testing facility.

2.4 STATISTICAL ANALYSIS

The EC_{10} (the effective concentration giving 10% reduction in the endpoint compared with the controls) was calculated by ESA using Trimmed Spearman-Karber analysis (Hamilton, Russo and Thurston, 1977), Maximum Likelihood Probit analysis (Finney, 1971) or Log-Logit Interpolations (US EPA, 2002), depending on which method was appropriate.

2.5 DERIVATION OF PROTECTIVE CONCENTRATIONS

Trigger values (TVs) were derived for the protection of aquatic freshwater species using the SSD method. The TVs were derived in accordance with ANZECC and ARMCANZ (2000) using the BurrliOZ 2.0 software package (Barry and Henderson, 2014) provided by CSIRO. BurrliOZ fits a log-logistic distribution to estimate the concentrations of discharges such that a given percentage of species will be protected. The EC_{10} data from the DTA was input to the SSD to derive the protective concentrations. The TVs for the 80%, 90%, 95% and 99% protective concentrations were derived as per ANZECC and ARMCANZ (2000).

Safe dilution factors (i.e. the dilution needed for the discharge to have little to no effect on the receiving ecosystem) were extrapolated from the data to ensure protection of 80%, 90%, 95% and 99% species in the aquatic ecosystem of the receiving environment.

2.6 QA/QC

Specific procedures for undertaking toxicity testing activities, procurement and culturing of test organisms, maintenance and calibration of instruments, cleaning, chain-of-custody and sample handling procedures are carried out by ESA as per their Procedures Manual. Quality assurance procedures were undertaken for all toxicity tests.

Quality assurance and quality control of all NATA accredited tests were satisfied. In the case of the *Ceriodaphnia* cf. *dubia* test (not NATA accredited), the control results were satisfactory.

3. RESULTS AND DISCUSSION

A summary of ecotoxicity testing results received from ESA is presented in Table 3-1. The most sensitive species of the testing suite was the freshwater cladoceran, *Ceriodaphnia* cf. *dubia* for which the EC_{10} was estimated at 54.3 %. This is much higher compared with the previous DTA performed on the May 2018 mixture, where the EC_{10} for *C.* cf *dubia* was estimated at 30.9 %, and the most sensitive species of the testing suite was the microalgae *C. vulgaris* with an EC_{10} estimated at 11.8 % (HB, 2018). It is likely that the difference in toxicity observed between the two mixtures was associated with the reduced EC in the mixture prepared in June 2018. It appears that the higher concentrations of metals (Cd, Co, Cu, Mn, Ni and Zn) did not cause further adverse effects.

The five chronic EC_{10} data points were taken forward into the derivation of TVs for the protection of freshwater species using the BurrliOZ program by producing an SSD (Figure 3-1). The SSD was then used to derive ecosystem TVs corresponding to different levels of protection from 80 to 99% of species. These TVs are presented in Table 3-2.

The TV for the protection of 95 % of the receiving ecosystem species corresponded to a concentration of 49 % of the composite pit sample tested (Table 3-2). This result allowed the calculation of the dilution ratio that provides a 95% species protection level for the contaminant mixture proposed to be discharged to the Copperfield River. A safe dilution factor of 1.1 was calculated to achieve the 95% species protection level for the composite pit water in the river. Hydrobiology recommends using a conservative dilution factor of 2 at the edge of the designated mixing zone to ensure adequate protection of the aquatic ecosystem in the Copperfield River.

Table 3-1 Summary of toxicity test results

Test	NOEC	LOEC	EC10 (95% confidence interval)	EC50 (95% confidence interval)
96-hr Growth inhibition of *Lemna aequinoctialis*	50%	100%	64.3 (52.9-78.5)%	>100%
96-hr acute toxicity test using *Hydra viridissima*	50%	100%	74.6 (49.6-93.9)%	>100%
Fish embryo hatching test using *Melanotaenia splendida splendida*	100%	>100%	>100%	>100%
72-hr microalgal growth inhibition test using *Chlorella vulgaris*	100%	>100%	>100%	>100%
7-day reproduction test using *Ceriodaphnia* cf. *dubia*	50%	100%	54.3 (43.0-58.6)%	99.3 %**

** 95% confidence interval limits not determinable

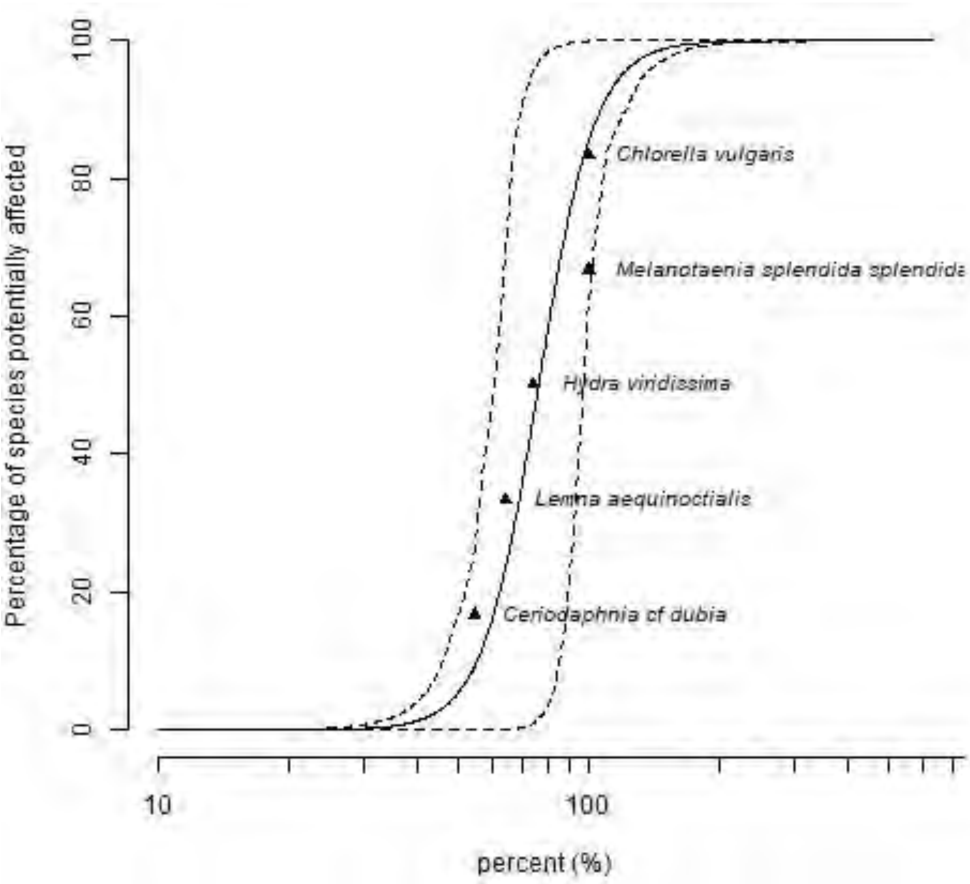


Figure 3-1 Species sensitivity distribution (SSD)

Table 3-2 Calculated safe dilution factors for each level of protection

Solution	Level of protection	Trigger value (TV) [95% confidence interval]	Safe dilution factor estimate
Composite sample 90% Eldridge + 10% Wises	99% species	38 % [31 – 75 %]	1.63
	95% species	**49 % [42 – 82 %]**	**1.1**
	90% species	55 % [46 – 86 %]	0.82
	80% species	62 % [52 – 90 %]	0.61

4. CONCLUSION

Based on the composite sample used in this DTA (mixture of 90% Eldridge and 10% Wises pit waters), the proposed discharge water should be diluted at least 1.1 times to achieve a minimum protection level of 95% of species in the receiving Copperfield River. It is recommended that a conservative dilution factor of 2 be applied, which should ensure the protection of >99% of species.

It is important to note that there appears to be some temporal variability in the composition of Eldridge and Wises pit water. The results from this study apply for a representative mixture as described in Table 2-1. In the case where the composition of the mixture varies (in particular EC levels), the dilution factor may need to be adjusted. The DTA performed in May 2018 (HB 2018) could be considered a worst case scenario.

5. REFERENCES

ANZECC & ARMCANZ (2000) 'Australian and New Zealand Guidelines for Fresh and Marine Water Quality - The Guidelines', *National Water Quality Management Strategy*, 1(4), p. 314.

Bailey, H. C. *et al.* (2000) 'Application of Ceriodaphnia cf. dubia for whole effluent toxicity tests in the Hawkesbury-Nepean watershed, New South Wales, Australia: method development and validation.', *Environmental Toxicology and Chemistry*, 19, pp. 88–93.

Barry, S. and Henderson, B. (2014) *Burrlioz 2.0.*, *Canberra (AU): Commonwealth Science and Industrial Research Organisation.*

C&R Consulting (2018) 'Kidston pumped storage Hydro Project - Aquatic Ecology Survey Report', *report prepared by Geochemical & Hydrobiological Solutions Pty Ltd for AECOM Pty Ltd*.

Finney, D. J. (1971) *Probit Analysis (3rd edition)*. Cambridge. Cambridge.

Franklin, N., Australia. Environment Australia. and Australia. Supervising Scientist. (1998) 'A new tropical algal test to assess the toxicity of metals in freshwaters', *Supervising scientist report, 133.*, p. viii, 83.

Hamilton, M. A., Russo, R. C. and Thurston, R. V. (1977) 'Trimmed Spearman-Karber method for estimating median lethal concentrations in toxicity bioassays', *Environmental Science & Technology*, 11(7), pp. 714–719.

HB (2018) 'DTA of potential release water from the Kidston pumped storage Hydro Project - June 2018', *Hydrobiology Pty Ltd prepared for AECOM*.

Hyne, R. V. *et al.* (1996) 'Procedures for the biological toxicity testing of mine waste waters using freshwater organisms', *Supervising scientist report 110*.

OECD (2006) ‘Lemna sp. Growth Inhibition Test. Method 221. OECD Guideline for the Testing of Chemicals.’, *Organisation for Economic Cooperation and Development, Paris*.

Riethmuller, N. *et al.* (2003) ‘Ecotoxicological testing protocols for Australian tropical freshwater ecosystems’, *Supervising Scientist Report 173, Supervising Scientist, Darwin NT*, p. 145.

US EPA (2002) ‘Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms. 4th Ed.’, *United States Environmental Protection Agency, Office of Water, Washington DC.*

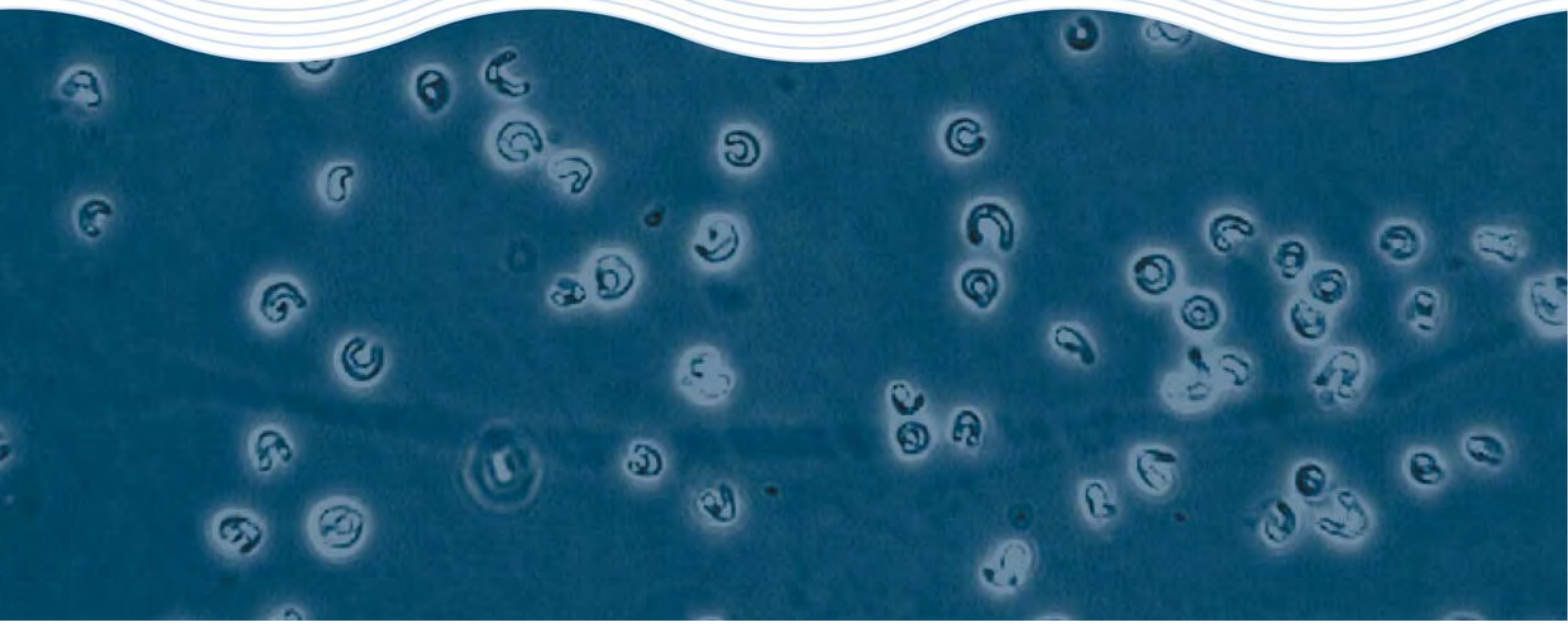
APPENDIX A. LABORATORY TOXICITY RESULTS

Ecotoxicity of a Composite of Eldridge and Wises Waters to a Suite of Tropical Freshwater Test Species

Aecom

Test Report

June 2018



Toxicity Test Report: TR1552/6

Accredited for compliance with ISO/IEC 17025

Client:	Aecom PO Box 5423 Townsville QLD 4810	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1552 13 June 2018 15 June 2018
Attention:	Reece Fraser	**Sampled By:**	Client
Client Ref:	60544566	**ESA Quote #:**	PR1552_02

Lab ID No.:	**Sample Name:**	**Sample Description:**
8666	Composite	Aqueous sample, pH 7.7, conductivity 3370 µS/cm, total ammonia <2.0mg/L. Sample received at 8 ºC in apparent good condition.
8667	W2	Aqueous sample, pH 7.8, conductivity 258 µS/cm, total ammonia <2.0mg/L. Sample received at 8ºC in apparent good condition.

*NATA accreditation does not cover the performance of this service

Test Performed:	Partial life-cycle toxicity test using the freshwater cladoceran *Ceriodaphnia cf dubia*
Test Protocol:	ESA SOP 102 (ESA 2016), based on USEPA (2002) and Bailey *et al.* (2000)
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The *Composite* sample (8666) was serially diluted with W2 (sample 8667) to achieve the final test concentrations. A Dilute Mineral Water (DMW- culture water) control was tested concurrently with the samples.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	15 June 2018 at 1730h

Composite diluted with W2 (Lab ID 8667):

Concentration (%)	**% Unaffected at 7 days (Mean ± SD)**
DMW Control	100 ± 0.0
W2 Diluent	100 ± 0.0
6.3	100 ± 0.0
12.5	100 ± 0.0
25	100 ± 0.0
50	100 ± 0.0
100	90.0 ± 31.6

7 day EC10 (unaffected) = >100%
7 day EC50 (unaffected) = >100%
NOEC = 100%
LOEC = >100%

Composite diluted with W2 (Lab ID 8667):

Concentration (%)	**Number of Young (Mean ± SD)**
DMW Control	15.9 ± 1.5
W2 Diluent	16.2 ± 1.3
6.3	15.8 ± 1.3
12.5	16.4 ± 1.4
25	16.0 ± 1.4
50	15.2 ± 1.1
100	8.0 ± 3.3*

7 day IC10 (reproduction) = 54.3 (43.0-58.6)%
7 day IC50 (reproduction) = 99.3%**
NOEC = 50%
LOEC = 100%

* Significantly lower number of young compared with the W2 Diluent (Steels Many-One Rank Test, 1-tailed, P=0.05)
** 95% Confidence Limits not determinable

Toxicity Test Report: TR1552/6

QA/QC Parameter	Criterion	This Test	Criterion met?
DMW Control mean % unaffected	≥80.0%	100%	Yes
Control mean number of young per surviving adult	≥15.0	15.9	Yes
Reference Toxicant within cusum chart limits	192.4-242.9 mgKCl/L	197.2 mgKCl/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 10 July 2018

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

Citations:

Bailey, H.C., Krassoi, R., Elphick, J.R., Mulhall, A., Hunt, P., Tedmanson, L. and Lovell, A. (2000) Application of *Ceriodaphnia cf. dubia* for whole effluent toxicity tests in the Hawkesbury-Nepean watershed, New South Wales, Australia: method development and validation. *Environmental Toxicology and Chemistry* 19:88-93.

ESA (2016) ESA SOP 102 – *Acute Toxicity Test Using Ceriodaphnia dubia.* Issue No 11. Ecotox Services Australasia, Sydney, NSW.

USEPA (2002) *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms.4th Ed.* United States Environmental Protection Agency, Office of Water, Washington DC.

ecotox
SERVICES AUSTRALIA

Toxicity Test Report: TR1552/7

Performed in compliance with ISO/IEC 17025

Client:	Aecom PO Box 5423 Townsville QLD 4810	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1552 13 June 2018 15 June 2018
Attention:	Reece Fraser	**Sampled By:**	Client
Client Ref:	60544566	**ESA Quote #:**	PR1552_02

Lab ID No.:	**Sample Name:**	**Sample Description:**
8666	Composite	Aqueous sample, pH 7.7, conductivity 3370 µS/cm, total ammonia <2.0mg/L. Sample received at 8 ºC in apparent good condition.
8667	W2	Aqueous sample, pH 7.8, conductivity 258 µS/cm, total ammonia <2.0mg/L. Sample received at 8ºC in apparent good condition.

Test Performed:	96-hr Growth inhibition of the freshwater aquatic duckweed *Lemna aequinoctialis*
Test Protocol:	ESA SOP 112 (ESA 2016), based on ASTM (2012)
Test Temperature:	The test was performed at 29±2°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The *Composite* sample (8666) was serially diluted with W2 (sample 8667) to achieve the final test concentrations. A CAAC control was tested concurrently with the samples.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	15 June 2018 at 1700h

Composite diluted with W2 (Lab ID 8667):

Concentration (%)	**Specific Growth Rate (Mean ± SD)**
CAAC Control	0.23 ± 0.01
W2 Diluent	0.23 ± 0.01
6.3	0.22 ± 0.01
12.5	0.24 ± 0.02
25	0.23 ± 0.01
50	0.24 ± 0.02
100	0.15 ± 0.05

96-h IC10 = 64.3 (52.9-78.5)%
96-h IC50 = >100%
NOEC = 50%
LOEC = 100%

Vacant

* Significantly lower growth rate compared with the W2 Diluent (Dunnett's Test, 1-tailed, P=0.05)

Toxicity Test Report: TR1552/7

QA/QC Parameter	Criterion	This Test	Criterion met?
CAAC Control Specific Growth rate	>0.231	0.23	Yes
Reference Toxicant within cusum chart limits	5.6-58.6mg Mg/L	13.8 mg Mg/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 10 July 2018

Results are based on the samples in the condition as received by ESA.
This document shall not be reproduced except in full.

Citations:

ESA (2016) *SOP 112 – Duckweed Growth Inhibition Test.* Issue No. 7. Ecotox Services Australasia, Sydney NSW

OECD (2006) *Lemna sp*. Growth Inhibition Test. Method 221. OECD Guideline for the Testing of Chemicals. Organisation for Economic Cooperation and Development, Paris

Toxicity Test Report: TR1552/8

Performed in compliance with ISO/IEC 17025

Client:	Aecom PO Box 5423 Townsville QLD 4810	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1552 13 June 2018 15 June 2018
Attention:	Reece Fraser	**Sampled By:**	Client
Client Ref:	60544566	**ESA Quote #:**	PR1552_02

Lab ID No.:	**Sample Name:**	**Sample Description:**
8666	Composite	Aqueous sample, pH 7.7, conductivity 3370 µS/cm, total ammonia <2.0mg/L. Sample received at 8 ºC in apparent good condition.
8667	W2	Aqueous sample, pH 7.8, conductivity 258 µS/cm, total ammonia <2.0mg/L. Sample received at 8ºC in apparent good condition.

Test Performed:	96-hr acute toxicity test using the freshwater hydra *hydra viridissima*
Test Protocol:	ESA SOP 125 (2016), based on Riethmuller et al. (2003)
Test Temperature:	The test was performed at 28±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The *Composite* sample (8666) was serially diluted with W2 (sample 8667) to achieve the final test concentrations. A LC control (culture water) was tested concurrently with the samples.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	15 June 2018 at 1830h

Composite diluted with W2 (Lab ID 8667):

Concentration (%)	**Population Growth Rate (Mean ± SD)**
LC Control	0.34 ± 0.01
W2 Diluent	0.35 ± 0.01
6.3	0.34 ± 0.01
12.5	0.35 ± 0.02
25	0.35 ± 0.01
50	0.34 ± 0.01
100	0.29 ±0.02*

96-h IC10 = 74.6 (49.6-93.9)%
96-h IC50 = >100%
NOEC = 50%
LOEC = 100%

Vacant

* Significantly lower growth rate compared with the W2 Diluent (Dunnett's Test, 1-tailed, P=0.05)

ecotox
SERVICES AUSTRALIA

Toxicity Test Report: TR1552/8

QA/QC Parameter	Criterion	This Test	Criterion met?
LC Control mean population growth rate	≥0.259	0.34	Yes
Reference Toxicant within cusum chart limits	2.61-10.30µg Cu/L	3.80 µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 10 July 2018

Results are based on the samples in the condition as received by ESA.

This document shall not be reproduced except in full.

Citations:

ESA (2016) SOP 125 –*Hydra Population Growth Test.* Issue No 5. Ecotox Services Australasia, Sydney, NSW

Riethmuller N, Camilleri C, Franklin N, Hogan A, King A, Koch A, Markich SJ, Turley C and van Dam R (2003).

Green Hydra Population Growth Test. In: *Ecotoxicological testing protocols for Australian tropical freshwater ecosystems*. Supervising Scientist Report 173, Supervising Scientist, Darwin NT.

ecotox
SERVICES AUSTRALIA

Toxicity Test Report: TR1552/9

Performed in compliance with ISO/IEC 17025

Client:	Aecom PO Box 5423 Townsville QLD 4810	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1552 13 June 2018 15 June 2018
Attention:	Reece Fraser	**Sampled By:**	Client
Client Ref:	60544566	**ESA Quote #:**	PR1552_02

Lab ID No.:	Sample Name:	Sample Description:
8666	Composite	Aqueous sample, pH 7.7, conductivity 3370 µS/cm, total ammonia <2.0mg/L. Sample received at 8 ºC in apparent good condition.
8667	W2	Aqueous sample, pH 7.8, conductivity 258 µS/cm, total ammonia <2.0mg/L. Sample received at 8ºC in apparent good condition.

Test Performed:	Rainbowfish embryo hatching test using *Melanotaenia splendida splendida*
Test Protocol:	ESA SOP 126 (2016), based on USEPA (2002), but adapted for use with native rainbowfish
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The *Composite* sample (8666) was serially diluted with W2 (sample 8667) to achieve the final test concentrations. A Dilute Mineral Water (DMW) control (culture water) was tested concurrently with the samples.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	15 June 2018 at 1900h

Composite diluted with W2 (Lab ID 8667):

Concentration (%)	% Unaffected (Mean ± SD)
DMW Control	95.0 ± 10.0
W2 Diluent	95.0 ± 10.0
6.3	90.0 ± 20.0
12.5	95.0 ± 10.0
25	100.0 ± 0.0
50	95.0 ± 10.0
100	100.0 ± 0.0

12-d EC10 = >100 %
12-d EC50 = >100 %
NOEC = 100%
LOEC = >100%

Vacant

Toxicity Test Report: TR1552/9

QA/QC Parameter	Criterion	This Test	Criterion met?
DMW Control mean % unaffected	≥80.0%	95.0%	Yes
Reference Toxicant within cusum chart limit	14.8-106.7µg Cu/L	87.4µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 10 July 2018

Results are based on the samples in the condition as received by ESA.

This document shall not be reproduced except in full.

Citations:

ESA (2016) *SOP 126- Rainbowfish Embryo Hatching Test*. Issue N°6. Ecotox Services Australasia, Sydney NSW

USEPA (2002) *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms.4th Ed.* United States Environmental Protection Agency, Office of Water, Washington DC.

ecotox SERVICES AUSTRALIA

Toxicity Test Report: TR1552/10

Performed in compliance with ISO/IEC 17025

Client:	Aecom PO Box 5423 Townsville QLD 4810	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1552 13 June 2018 15 June 2018
Attention:	Reece Fraser	**Sampled By:**	Client
Client Ref:	60544566	**ESA Quote #:**	PR1552_02

Lab ID No.:	**Sample Name:**	**Sample Description:**
8666	Composite	Aqueous sample, pH 7.7, conductivity 3370 µS/cm, total ammonia <2.0mg/L. Sample received at 8 ºC in apparent good condition.
8667	W2	Aqueous sample, pH 7.8, conductivity 258 µS/cm, total ammonia <2.0mg/L. Sample received at 8ºC in apparent good condition.

Test Performed:	72-hr microalgal growth inhibition test using the green alga *Chlorella vulgaris*
Test Protocol:	ESA SOP 103 (ESA 2016), based on USEPA (2002)
Test Temperature:	The test was performed at 29±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The *Composite* sample (8666) was serially diluted with W2 (sample 8667) to achieve the final test concentrations. A USEPA control was tested concurrently with the samples.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	15 June 2018 at 1730h

Composite diluted with W2 (Lab ID 8667):

Concentration (%)	**Cell Yield $x10^4$ cells/mL (Mean ± SD)**
USEPA Control	23.1 ± 0.8
W2 Diluent	23.2 ± 0.7
6.3	22.8 ± 0.8
12.5	23.0 ± 0.2
25	22.8 ± 1.0
50	23.5 ± 0.6
100	23.3 ± 0.8

96-h IC10 = >100%
96-h IC50 = >100%
NOEC = 100%
LOEC = >100%

Vacant

ecotox
SERVICES AUSTRALIA

Toxicity Test Report: TR1552/10

QA/QC Parameter	Criterion	This Test	Criterion met?
USEPA Control mean cell density	$\geq$16.0x10^4 cells/mL	23.1 x10^4 cells/mL	Yes
Control coefficient of variation	<20%	3.4 %	Yes
Reference Toxicant within cusum chart limits	447-3843mg KCl/L	3809 mg KCl/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 10 July 2018

Results are based on the samples in the condition as received by ESA.
This document shall not be reproduced except in full.

Citations:

ESA (2016) *ESA SOP 103 – Green Alga, Selenastrum capricornutum, Growth Test*. Issue No 11. Ecotox Services Australasia, Sydney, NSW.

USEPA (2002) *Short-term methods for estimating the chronic toxicity of effluents and receiving waters to freshwater organisms*. Fourth Edition. EPA-821-R-02-013. United States Environmental Protection Agency, Office of Research and Development, Washington DC, USA,

Chain-of-Custody Documentation

Datasheet ID: 601.1
Last Revised: 15 July 2014

Chain-of-Custody / Service Request Form

ecotox SERVICES AUSTRALASIA

Customer: AECOM AUSTRALIA PTY LTD   Ship To: ESA
Contact Name: Reece Fraser   Attention: Rick
Phone: 0747201674   Email: reece.fraser@aecom.com (please provide an email address for sample receipt notification)
Sampled by: Genex

Sample Date (day/month /year)	Sample Time	Sample Name (exactly as written on the sample vessel)	Sample Method (eg. Grab, composite etc.)	Number and Volume of Containers (eg 2 x 1L)	Tests Requested (See reverse for guidance): Algal growth Sc	Duckweed Ltd	Hydra	Embryo Fish	Chronic Cerio		Comments / Instructions
											Note that testing will be delayed if an incomplete chain of custody is received • Additional treatment of samples (i.e. spiking) • Sub-contracted services (i.e. chemical analyses) • Dilutions required (if different than 100% down to 6.25%) • Sample holding time restriction (if applicable) • Sample used for litigation (if applicable) *Note: An MSDS must be attached if Available* **ESA Project Number: PR** 1552
~~W2~~											
~~COMPOSITE~~											
8666 13/06/2018		Composite	Composite	2×5L	✓	✓	✓	✓	✓		
8667 13/06/2018		W2	Grab	3×5L	✓	✓	✓	✓	✓		

8°C

1) Released By: Reece Fraser	Date: 14/06/2018	2) Received By: RK	Date: 15/6/18	3) Released By:	Date:	4) Received By:	Date:
Of: AECOM	Time: 16:00	Of: ESA	Time: 1130	Of:	Time:	Of:	Time:

Note that the chain-of-custody documentation will provide definitive information on the tests to be performed.

Ecotox Services Australasia . Unit 27, 2 Chaplin Drive, Lane Cove NSW 2066 AUSTRALIA
Phone: 61 2 9420-9481 Fax 61 2 9420-9484 info@ecotox.com.au

Statistical Printouts for the 3-brood Partial Life Cycle Test with *Ceriodaphnia dubia*

Ceriodaphnia Partial Life-Cycle Test-7 Day Unaffected					
Start Date:	15/06/2018 17:30	Test ID:	PR1552/21	Sample ID:	Composite
End Date:	22/06/2018 17:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:	Diluted with W2 (sample 8667)				

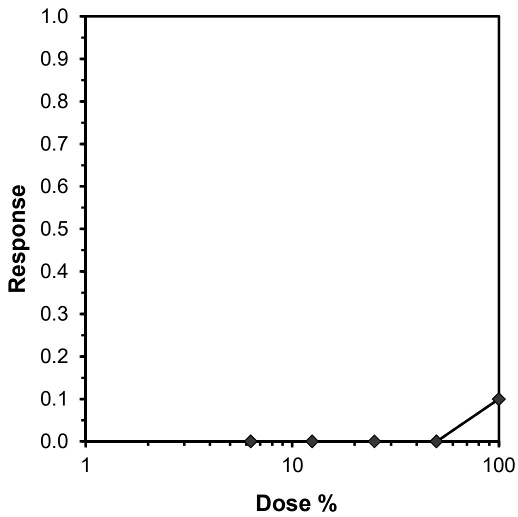
Conc-%	1	2	3	4	5	6	7	8	9	10
DMW	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
W2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6.3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
25	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
50	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
100	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Conc-%	Mean	N-Mean	Resp	Not Resp	Total	N	Fisher's Exact P	1-Tailed Critical	Isotonic Mean	Isotonic N-Mean
DMW	1.0000	1.0000	0	10	10	10	0.6238			
W2	1.0000	1.0000	0	10	10	10	*		1.0000	1.0000
6.3	1.0000	1.0000	0	10	10	10	1.0000	0.0500	1.0000	1.0000
12.5	1.0000	1.0000	0	10	10	10	1.0000	0.0500	1.0000	1.0000
25	1.0000	1.0000	0	10	10	10	1.0000	0.0500	1.0000	1.0000
50	1.0000	1.0000	0	10	10	10	1.0000	0.0500	1.0000	1.0000
100	0.9000	0.9000	1	9	10	10	0.5000	0.0500	0.9000	0.9000

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Fisher's Exact Test	100	>100		1
Treatments vs W2				

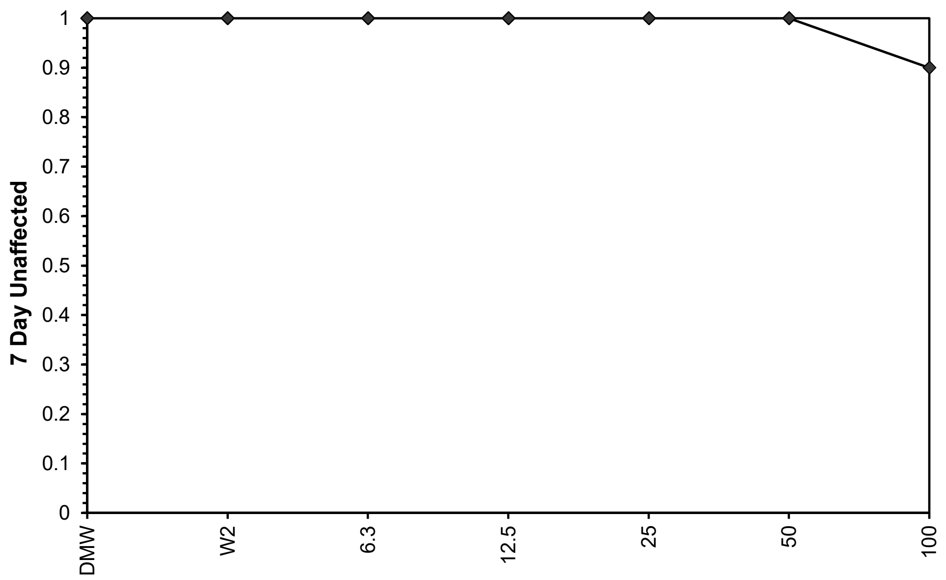
Log-Logit Interpolation (200 Resamples)

Point	%	SD	95% CL	Skew
IC05	92.908			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Ceriodaphnia Partial Life-Cycle Test-7 Day Unaffected					
Start Date:	15/06/2018 17:30	Test ID:	PR1552/21	Sample ID:	Composite
End Date:	22/06/2018 17:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:	Diluted with W2 (sample 8667)				

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-7 Day Unaffected					
Start Date:	15/06/2018 17:30	Test ID:	PR1552/21	Sample ID:	Composite
End Date:	22/06/2018 17:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:	Diluted with W2 (sample 8667)				

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
DMW	No of Young	15.90	13.00	18.00	1.45	7.57	10
W2		16.20	14.00	18.00	1.32	7.08	10
6.3		15.80	14.00	18.00	1.32	7.26	10
12.5		16.40	14.00	19.00	1.35	7.08	10
25		16.00	14.00	18.00	1.41	7.43	10
50		15.20	13.00	17.00	1.14	7.01	10
100		8.00	2.00	12.00	3.33	22.82	10
DMW	% unaffected	100.00	100.00	100.00	0.00	0.00	10
W2		100.00	100.00	100.00	0.00	0.00	10
6.3		100.00	100.00	100.00	0.00	0.00	10
12.5		100.00	100.00	100.00	0.00	0.00	10
25		100.00	100.00	100.00	0.00	0.00	10
50		100.00	100.00	100.00	0.00	0.00	10
100		90.00	0.00	100.00	31.62	6.25	10
DMW	pH	8.10	8.10	8.10	0.00	0.00	1
W2		7.90	7.90	7.90	0.00	0.00	1
6.3		7.80	7.80	7.80	0.00	0.00	1
12.5		7.80	7.80	7.80	0.00	0.00	1
25		7.80	7.80	7.80	0.00	0.00	1
50		7.80	7.80	7.80	0.00	0.00	1
100		7.70	7.70	7.70	0.00	0.00	1
DMW	DO %	96.80	96.80	96.80	0.00	0.00	1
W2		97.90	97.90	97.90	0.00	0.00	1
6.3		993.00	993.00	993.00	0.00	0.00	1
12.5		98.90	98.90	98.90	0.00	0.00	1
25		99.10	99.10	99.10	0.00	0.00	1
50		99.10	99.10	99.10	0.00	0.00	1
100		98.90	98.90	98.90	0.00	0.00	1
DMW	Cond uS/cm	187.00	187.00	187.00	0.00	0.00	1
W2		258.00	258.00	258.00	0.00	0.00	1
6.3		428.00	428.00	428.00	0.00	0.00	1
12.5		663.00	663.00	663.00	0.00	0.00	1
25		1104.00	1104.00	1104.00	0.00	0.00	1
50		1912.00	1912.00	1912.00	0.00	0.00	1
100		3370.00	3370.00	3370.00	0.00	0.00	1

Ceriodaphnia Partial Life-Cycle Test-Reproduction					
Start Date:	15/06/2018 17:30	Test ID:	PR1552/21	Sample ID:	Composite
End Date:	22/06/2018 17:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:	Diluted with W2 (sample 8667)				

Conc-%	1	2	3	4	5	6	7	8	9	10
DMW	17.000	17.000	15.000	15.000	15.000	17.000	13.000	16.000	18.000	16.000
W2	18.000	16.000	14.000	18.000	15.000	16.000	17.000	17.000	15.000	16.000
6.3	18.000	16.000	16.000	17.000	14.000	14.000	16.000	15.000	15.000	17.000
12.5	19.000	17.000	14.000	17.000	16.000	17.000	16.000	15.000	16.000	17.000
25	18.000	16.000	15.000	16.000	14.000	16.000	16.000	18.000	14.000	17.000
50	17.000	16.000	15.000	15.000	15.000	16.000	16.000	14.000	13.000	15.000
100	12.000	8.000	11.000	12.000	10.000	7.000	2.000	7.000	7.000	4.000

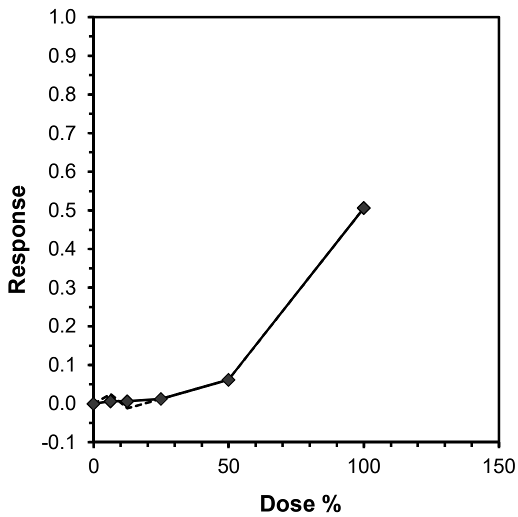
			Transform: Untransformed					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
DMW	15.900	0.9815	15.900	13.000	18.000	9.114	10				
W2	16.200	1.0000	16.200	14.000	18.000	8.127	10	*		16.200	1.0000
6.3	15.800	0.9753	15.800	14.000	18.000	8.333	10	96.50	75.00	16.100	0.9938
12.5	16.400	1.0123	16.400	14.000	19.000	8.231	10	109.00	75.00	16.100	0.9938
25	16.000	0.9877	16.000	14.000	18.000	8.839	10	101.00	75.00	16.000	0.9877
50	15.200	0.9383	15.200	13.000	17.000	7.469	10	84.00	75.00	15.200	0.9383
*100	8.000	0.4938	8.000	2.000	12.000	41.667	10	55.00	75.00	8.000	0.4938

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Kolmogorov D Test indicates normal distribution (p > 0.05)	0.722312	0.895	-0.41555	1.936263
Bartlett's Test indicates unequal variances (p = 3.08E-03)	17.8993	15.08627		
The control means are not significantly different (p = 0.63)	0.484544	2.100922		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	50	100	70.71068	2
Treatments vs W2				

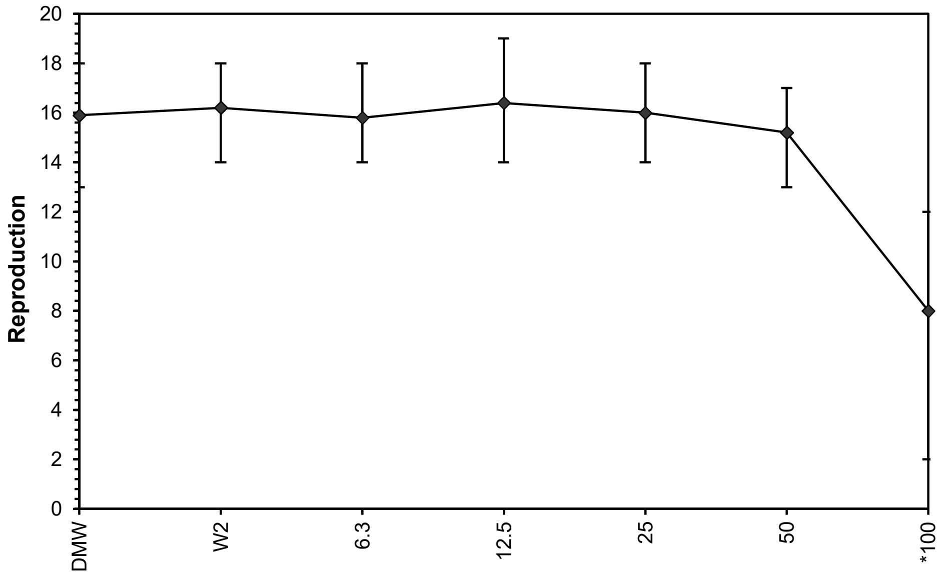
Linear Interpolation (200 Resamples)

Point	%	SD	95% CL		Skew
IC05	44.063	12.182	10.253	52.722	-0.6631
IC10	54.306	3.762	42.961	58.560	-1.6877
IC15	59.931	2.795	53.641	64.650	0.1689
IC20	65.556	3.084	59.529	71.161	0.5567
IC25	71.181	3.560	64.580	77.981	0.8430
IC40	88.056				
IC50	99.306				



Ceriodaphnia Partial Life-Cycle Test-Reproduction					
Start Date:	15/06/2018 17:30	Test ID:	PR1552/21	Sample ID:	Composite
End Date:	22/06/2018 17:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:	Diluted with W2 (sample 8667)				

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	15/06/2018 17:30	Test ID:	PR1552/21	Sample ID:	Composite
End Date:	22/06/2018 17:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:	Diluted with W2 (sample 8667)				

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
DMW	No of Young	15.90	13.00	18.00	1.45	7.57	10
W2		16.20	14.00	18.00	1.32	7.08	10
6.3		15.80	14.00	18.00	1.32	7.26	10
12.5		16.40	14.00	19.00	1.35	7.08	10
25		16.00	14.00	18.00	1.41	7.43	10
50		15.20	13.00	17.00	1.14	7.01	10
100		8.00	2.00	12.00	3.33	22.82	10
DMW	% unaffected	100.00	100.00	100.00	0.00	0.00	10
W2		100.00	100.00	100.00	0.00	0.00	10
6.3		100.00	100.00	100.00	0.00	0.00	10
12.5		100.00	100.00	100.00	0.00	0.00	10
25		100.00	100.00	100.00	0.00	0.00	10
50		100.00	100.00	100.00	0.00	0.00	10
100		90.00	0.00	100.00	31.62	6.25	10
DMW	pH	8.10	8.10	8.10	0.00	0.00	1
W2		7.90	7.90	7.90	0.00	0.00	1
6.3		7.80	7.80	7.80	0.00	0.00	1
12.5		7.80	7.80	7.80	0.00	0.00	1
25		7.80	7.80	7.80	0.00	0.00	1
50		7.80	7.80	7.80	0.00	0.00	1
100		7.70	7.70	7.70	0.00	0.00	1
DMW	DO %	96.80	96.80	96.80	0.00	0.00	1
W2		97.90	97.90	97.90	0.00	0.00	1
6.3		993.00	993.00	993.00	0.00	0.00	1
12.5		98.90	98.90	98.90	0.00	0.00	1
25		99.10	99.10	99.10	0.00	0.00	1
50		99.10	99.10	99.10	0.00	0.00	1
100		98.90	98.90	98.90	0.00	0.00	1
DMW	Cond uS/cm	187.00	187.00	187.00	0.00	0.00	1
W2		258.00	258.00	258.00	0.00	0.00	1
6.3		428.00	428.00	428.00	0.00	0.00	1
12.5		663.00	663.00	663.00	0.00	0.00	1
25		1104.00	1104.00	1104.00	0.00	0.00	1
50		1912.00	1912.00	1912.00	0.00	0.00	1
100		3370.00	3370.00	3370.00	0.00	0.00	1

 Reviewed by:_____

Statistical Printouts for the Duckweed Growth Inhibition Tests

Duckweed Growth Inhibtion Test-Specific Growth Rate

Start Date:	15/06/2018 17:00	Test ID:	PR1552/25	Sample ID:	Composite
End Date:	23/06/2018 17:00	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 112	Test Species:	LA-Lemna aequinoctialis
Comments:	Diluted with W2 (sample 8667)				

Conc-%	1	2	3	4
LC	0.2483	0.2389	0.2189	0.2189
W2	0.2082	0.2389	0.2291	0.2389
6.3	0.2189	0.2082	0.2389	0.2291
12.5	0.2574	0.2189	0.2483	0.2291
25	0.2389	0.2189	0.2291	0.2389
50	0.2189	0.2389	0.2291	0.2574
100	0.0841	0.1971	0.1469	0.1733

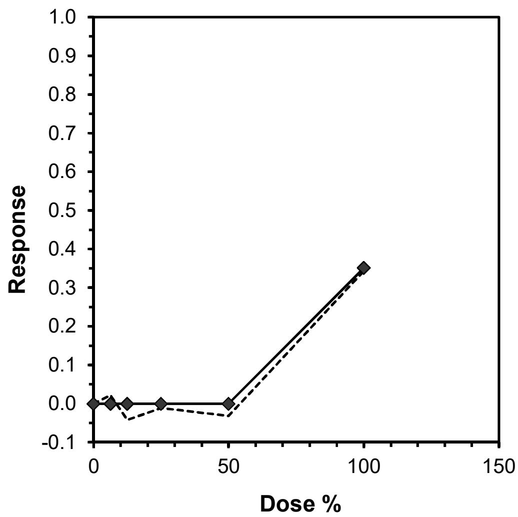
			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
LC	0.2312	1.0108	0.2312	0.2189	0.2483	6.395	4					
W2	0.2288	1.0000	0.2288	0.2082	0.2389	6.317	4	*			0.2317	1.0000
6.3	0.2238	0.9781	0.2238	0.2082	0.2389	5.895	4	0.296	2.410	0.0407	0.2317	1.0000
12.5	0.2384	1.0422	0.2384	0.2189	0.2574	7.377	4	-0.571	2.410	0.0407	0.2317	1.0000
25	0.2314	1.0116	0.2314	0.2189	0.2389	4.132	4	-0.157	2.410	0.0407	0.2317	1.0000
50	0.2361	1.0319	0.2361	0.2189	0.2574	6.952	4	-0.432	2.410	0.0407	0.2317	1.0000
*100	0.1504	0.6573	0.1504	0.0841	0.1971	32.379	4	4.642	2.410	0.0407	0.1504	0.6490

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.922065	0.916	-0.90857	3.714862
Bartlett's Test indicates equal variances (p = 0.06)	10.523	15.08627		
The control means are not significantly different (p = 0.82)	0.238676	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	50	100	70.71068	2	0.040705	0.177935	0.004517	0.000571	4.3E-04	5, 18
Treatments vs W2										

Linear Interpolation (200 Resamples)

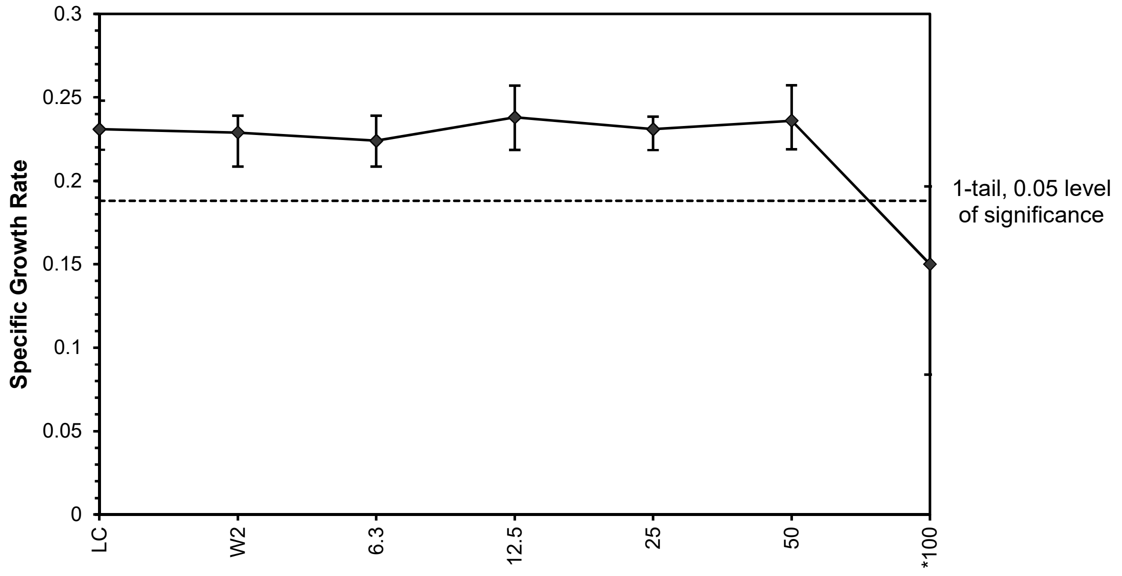
Point	%	SD	95% CL(Exp)		Skew
IC05	57.123	3.452	47.418	64.096	-2.1823
IC10	64.246	4.459	52.883	78.448	0.5617
IC15	71.368	6.448	56.433	94.177	0.7694
IC20	78.491				
IC25	85.614				
IC40	>100				
IC50	>100				



Duckweed Growth Inhibtion Test-Specific Growth Rate

Start Date:	15/06/2018 17:00	Test ID:	PR1552/25	Sample ID:	Composite
End Date:	23/06/2018 17:00	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 112	Test Species:	LA-Lemna aequinoctialis
Comments:	Diluted with W2 (sample 8667)				

Dose-Response Plot



Duckweed Growth Inhibtion Test-Specific Growth Rate

Start Date:	15/06/2018 17:00	Test ID:	PR1552/25	Sample ID:	Composite
End Date:	23/06/2018 17:00	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 112	Test Species:	LA-Lemna aequinoctialis
Comments:	Diluted with W2 (sample 8667)				

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
LC	Specific growth rate	0.23	0.22	0.25	0.01	52.59	4
W2		0.23	0.21	0.24	0.01	52.55	4
6.3		0.22	0.21	0.24	0.01	51.33	4
12.5		0.24	0.22	0.26	0.02	55.63	4
25		0.23	0.22	0.24	0.01	42.25	4
50		0.24	0.22	0.26	0.02	54.27	4
100		0.15	0.08	0.20	0.05	146.74	4
LC	pH	8.10	8.10	8.10	0.00	0.00	1
W2		7.90	7.90	7.90	0.00	0.00	1
6.3		7.80	7.80	7.80	0.00	0.00	1
12.5		7.80	7.80	7.80	0.00	0.00	1
25		7.80	7.80	7.80	0.00	0.00	1
50		7.80	7.80	7.80	0.00	0.00	1
100		7.90	7.90	7.90	0.00	0.00	1
LC	Cond uS/cm	103.00	103.00	103.00	0.00	0.00	1
W2		258.00	258.00	258.00	0.00	0.00	1
6.3		428.00	428.00	428.00	0.00	0.00	1
12.5		663.00	663.00	663.00	0.00	0.00	1
25		1104.00	1104.00	1104.00	0.00	0.00	1
50		1912.00	1912.00	1912.00	0.00	0.00	1
100		3370.00	3370.00	3370.00	0.00	0.00	1

Statistical Printouts for *Hydra* Population Growth Tests

Hydra Population Growth Test-Growth Rate

Start Date:	15/06/2018 18:30	Test ID:	PR1552/26	Sample ID:	Composite
End Date:	23/06/2018 18:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 125	Test Species:	HV-Hydra viridissima
Comments:	Diluted with W2 (sample 8667)				

Conc-%	1	2	3	4
LC	0.3588	0.3338	0.3466	0.3402
W2	0.3402	0.3527	0.3647	0.3338
6.3	0.3402	0.3202	0.3527	0.3402
12.5	0.3588	0.3704	0.3466	0.3338
25	0.3527	0.3466	0.3647	0.3402
50	0.3338	0.3202	0.3338	0.3527
100	0.2908	0.2662	0.3059	0.2985

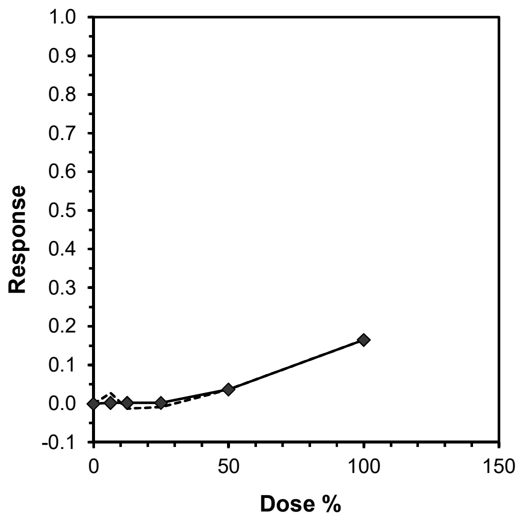
			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
LC	0.3448	0.9913	0.3448	0.3338	0.3588	3.093	4					
W2	0.3478	1.0000	0.3478	0.3338	0.3647	3.938	4	*			0.3478	1.0000
6.3	0.3384	0.9727	0.3384	0.3202	0.3527	3.975	4	0.947	2.410	0.0241	0.3473	0.9983
12.5	0.3524	1.0130	0.3524	0.3338	0.3704	4.476	4	-0.452	2.410	0.0241	0.3473	0.9983
25	0.3511	1.0092	0.3511	0.3402	0.3647	2.964	4	-0.320	2.410	0.0241	0.3473	0.9983
50	0.3351	0.9634	0.3351	0.3202	0.3527	3.989	4	1.272	2.410	0.0241	0.3351	0.9634
*100	0.2903	0.8347	0.2903	0.2662	0.3059	5.945	4	5.745	2.410	0.0241	0.2903	0.8347

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.954494	0.916	-0.20141	-0.90554
Bartlett's Test indicates equal variances (p = 0.98)	0.75652	15.08627		
The control means are not significantly different (p = 0.74)	0.347215	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	50	100	70.71068	2	0.024122	0.069347	0.00218	0.0002	6.1E-05	5, 18
Treatments vs W2										

Linear Interpolation (200 Resamples)

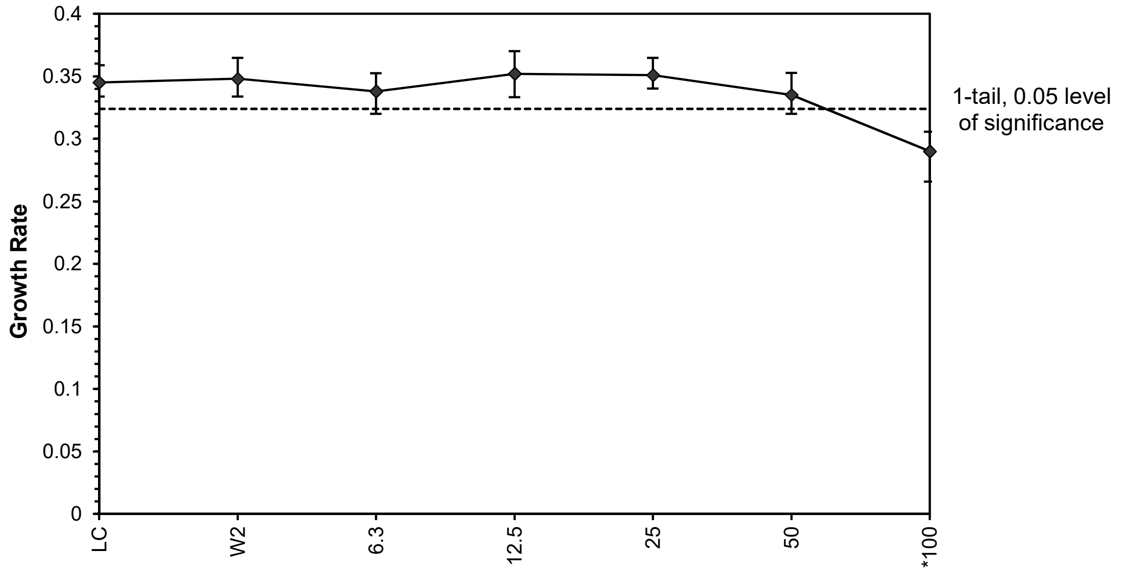
Point	%	SD	95% CL(Exp)		Skew
IC05	55.208	9.464	18.411	73.908	-1.4073
IC10	74.631	7.316	49.633	93.870	0.0588
IC15	94.054				
IC20	>100				
IC25	>100				
IC40	>100				
IC50	>100				



Hydra Population Growth Test-Growth Rate

Start Date:	15/06/2018 18:30	Test ID:	PR1552/26	Sample ID:	Composite
End Date:	23/06/2018 18:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 125	Test Species:	HV-Hydra viridissima
Comments:	Diluted with W2 (sample 8667)				

Dose-Response Plot



Hydra Population Growth Test-Growth Rate

Start Date:	15/06/2018 18:30	Test ID:	PR1552/26	Sample ID:	Composite
End Date:	23/06/2018 18:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 125	Test Species:	HV-Hydra viridissima
Comments:	Diluted with W2 (sample 8667)				

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
LC	Growth Rate	0.34	0.33	0.36	0.01	29.95	4
W2		0.35	0.33	0.36	0.01	33.65	4
6.3		0.34	0.32	0.35	0.01	34.27	4
12.5		0.35	0.33	0.37	0.02	35.64	4
25		0.35	0.34	0.36	0.01	29.06	4
50		0.34	0.32	0.35	0.01	34.50	4
100		0.29	0.27	0.31	0.02	45.25	4
LC	Conductivity	0.00	0.00	0.00	0.00		0
W2		0.00	0.00	0.00	0.00		0
6.3		0.00	0.00	0.00	0.00		0
12.5		0.00	0.00	0.00	0.00		0
25		0.00	0.00	0.00	0.00		0
50		0.00	0.00	0.00	0.00		0
100		0.00	0.00	0.00	0.00		0
LC	pH	0.00	0.00	0.00	0.00		0
W2		0.00	0.00	0.00	0.00		0
6.3		0.00	0.00	0.00	0.00		0
12.5		0.00	0.00	0.00	0.00		0
25		0.00	0.00	0.00	0.00		0
50		0.00	0.00	0.00	0.00		0
100		0.00	0.00	0.00	0.00		0
LC	DO, % sat	0.00	0.00	0.00	0.00		0
W2		0.00	0.00	0.00	0.00		0
6.3		0.00	0.00	0.00	0.00		0
12.5		0.00	0.00	0.00	0.00		0
25		0.00	0.00	0.00	0.00		0
50		0.00	0.00	0.00	0.00		0
100		0.00	0.00	0.00	0.00		0

Statistical Printouts for the Rainbowfish Embryonic Development and Post-hatch Survival Tests

Fish Embryonic Development-% Unaffected

Start Date:	15/06/2018 19:00	Test ID:	PR1552/27	Sample ID:	Composite
End Date:	27/06/2018 19:00	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 126	Test Species:	MS-Melanotaenia splendida
Comments:	Diluted with W2 (sample 8667)				

Conc-%	1	2	3	4
DMW	1.0000	1.0000	1.0000	0.8000
W2	1.0000	1.0000	0.8000	1.0000
6.3	1.0000	1.0000	0.6000	1.0000
12.5	1.0000	1.0000	0.8000	1.0000
25	1.0000	1.0000	1.0000	1.0000
50	0.8000	1.0000	1.0000	1.0000
100	1.0000	1.0000	1.0000	1.0000

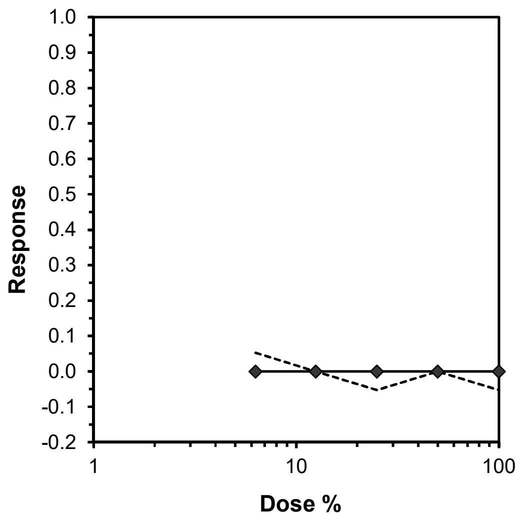
			Transform: Arcsin Square Root					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
DMW	0.9500	1.0000	1.2857	1.1071	1.3453	9.261	4				
W2	0.9500	1.0000	1.2857	1.1071	1.3453	9.261	4	*		0.9583	1.0000
6.3	0.9000	0.9474	1.2305	0.8861	1.3453	18.660	4	17.50	10.00	0.9583	1.0000
12.5	0.9500	1.0000	1.2857	1.1071	1.3453	9.261	4	18.00	10.00	0.9583	1.0000
25	1.0000	1.0526	1.3453	1.3453	1.3453	0.000	4	20.00	10.00	0.9583	1.0000
50	0.9500	1.0000	1.2857	1.1071	1.3453	9.261	4	18.00	10.00	0.9583	1.0000
100	1.0000	1.0526	1.3453	1.3453	1.3453	0.000	4	20.00	10.00	0.9583	1.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.762065	0.916	-1.76412	3.060606
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 1.00)	0	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1
Treatments vs W2				

Log-Logit Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			

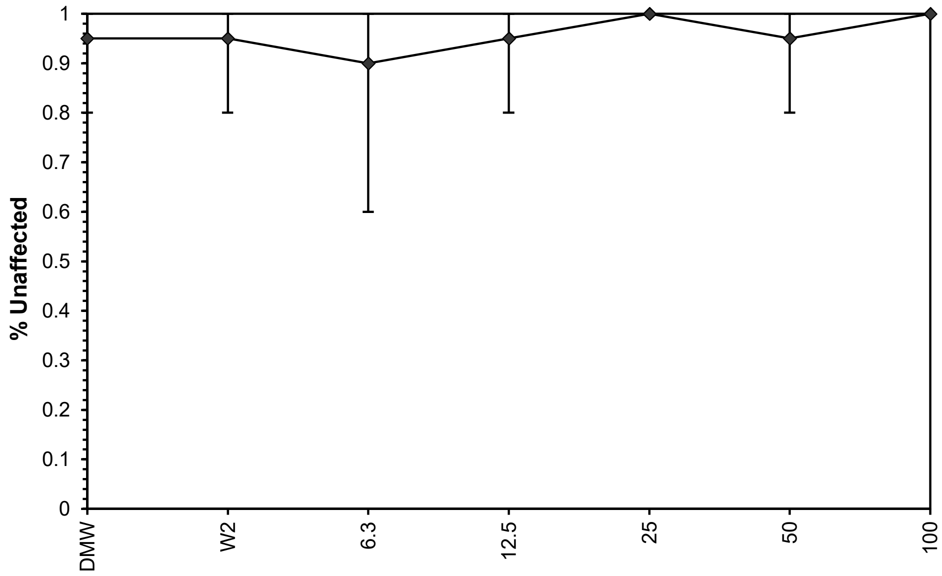


 ToxCalc v5.0.23 Reviewed by:_____

Fish Embryonic Development-% Unaffected

Start Date:	15/06/2018 19:00	Test ID:	PR1552/27	Sample ID:	Composite
End Date:	27/06/2018 19:00	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 126	Test Species:	MS-Melanotaenia splendida
Comments:	Diluted with W2 (sample 8667)				

Dose-Response Plot



Fish Embryonic Development-% Unaffected

Start Date:	15/06/2018 19:00	Test ID:	PR1552/27	Sample ID:	Composite
End Date:	27/06/2018 19:00	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 126	Test Species:	MS-Melanotaenia splendida
Comments:	Diluted with W2 (sample 8667)				

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
DMW	% Unaffected	95.00	80.00	100.00	10.00	3.33	4
W2		95.00	80.00	100.00	10.00	3.33	4
6.3		90.00	60.00	100.00	20.00	4.97	4
12.5		95.00	80.00	100.00	10.00	3.33	4
25		100.00	100.00	100.00	0.00	0.00	4
50		95.00	80.00	100.00	10.00	3.33	4
100		100.00	100.00	100.00	0.00	0.00	4
DMW	pH	8.10	8.10	8.10	0.00	0.00	1
W2		7.90	7.90	7.90	0.00	0.00	1
6.3		7.80	7.80	7.80	0.00	0.00	1
12.5		7.80	7.80	7.80	0.00	0.00	1
25		7.80	7.80	7.80	0.00	0.00	1
50		7.80	7.80	7.80	0.00	0.00	1
100		7.70	7.70	7.70	0.00	0.00	1
DMW	Conductivity (uS/cm)	187.00	187.00	187.00	0.00	0.00	1
W2		258.00	258.00	258.00	0.00	0.00	1
6.3		428.00	428.00	428.00	0.00	0.00	1
12.5		663.00	663.00	663.00	0.00	0.00	1
25		11047.00	11047.00	11047.00	0.00	0.00	1
50		1912.00	1912.00	1912.00	0.00	0.00	1
100		3370.00	3370.00	3370.00	0.00	0.00	1
DMW	DO (% sat)	96.80	96.80	96.80	0.00	0.00	1
W2		97.90	97.90	97.90	0.00	0.00	1
6.3		99.30	99.30	99.30	0.00	0.00	1
12.5		98.90	98.90	98.90	0.00	0.00	1
25		99.10	99.10	99.10	0.00	0.00	1
50		99.10	99.10	99.10	0.00	0.00	1
100		98.90	98.90	98.90	0.00	0.00	1

Statistical Printouts for the *Chlorella* Growth Inhibition Tests

Microalgal Cell Yield-Cell Yield

Start Date:	15/06/2018 17:30	Test ID:	PR1552/23	Sample ID:	Composite
End Date:	18/06/2018 17:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 103	Test Species:	CV-Chlorella vulgaris
Comments:	Diluted with W2 (sample 8667)				

Conc-%	1	2	3	4
USEPA	23.800	23.600	22.000	22.800
W2	22.800	24.200	23.000	22.600
6.3	22.400	23.800	22.800	22.000
12.5	22.800	23.000	23.200	22.800
25	24.200	22.600	22.400	22.000
50	22.800	24.200	23.200	23.600
100	24.400	23.000	22.600	23.200

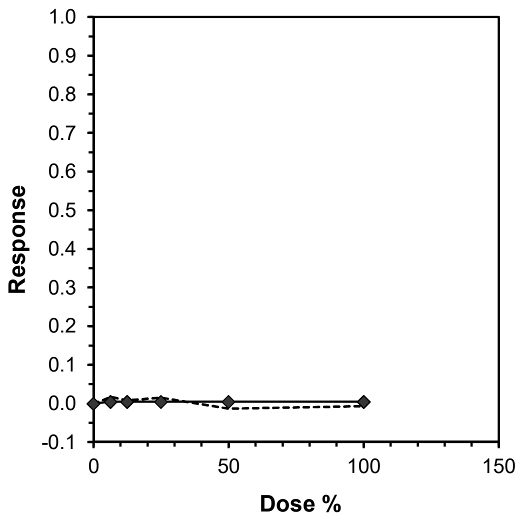
			Transform: Untransformed					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
USEPA	23.050	0.9957	23.050	22.000	23.800	3.569	4				
W2	23.150	1.0000	23.150	22.600	24.200	3.105	4	*		23.150	1.0000
6.3	22.750	0.9827	22.750	22.000	23.800	3.395	4	14.50	10.00	23.050	0.9957
12.5	22.950	0.9914	22.950	22.800	23.200	0.834	4	18.50	10.00	23.050	0.9957
25	22.800	0.9849	22.800	22.000	24.200	4.237	4	14.00	10.00	23.050	0.9957
50	23.450	1.0130	23.450	22.800	24.200	2.547	4	21.00	10.00	23.050	0.9957
100	23.300	1.0065	23.300	22.600	24.400	3.324	4	20.00	10.00	23.050	0.9957

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.887465	0.916	0.93118	-0.07202
Bartlett's Test indicates equal variances (p = 0.37)	5.34866	15.08627		
The control means are not significantly different (p = 0.86)	0.183083	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1
Treatments vs W2				

Linear Interpolation (200 Resamples)

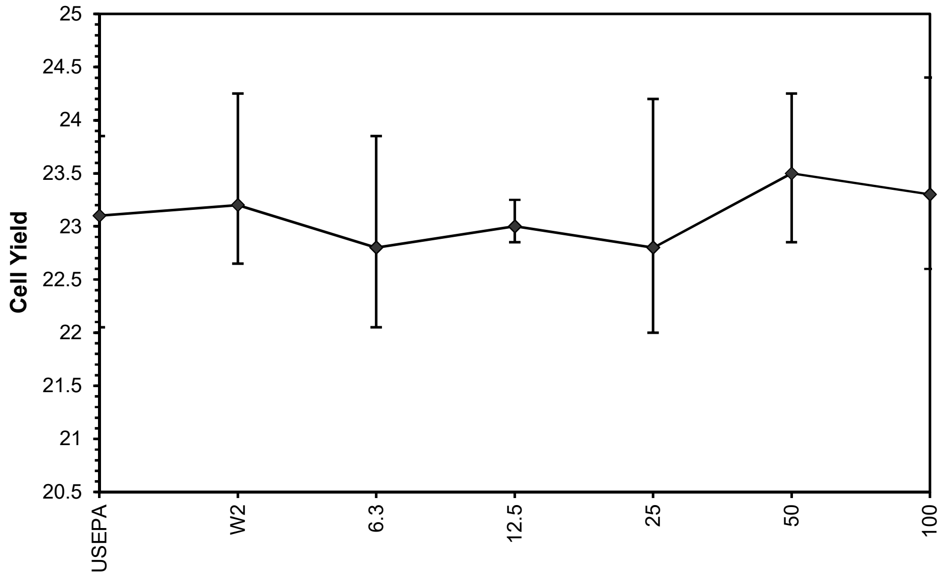
Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Microalgal Cell Yield-Cell Yield

Start Date:	15/06/2018 17:30	Test ID:	PR1552/23	Sample ID:	Composite
End Date:	18/06/2018 17:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 103	Test Species:	CV-Chlorella vulgaris
Comments:	Diluted with W2 (sample 8667)				

Dose-Response Plot



Microalgal Cell Yield-Cell Yield

Start Date:	15/06/2018 17:30	Test ID:	PR1552/23	Sample ID:	Composite
End Date:	18/06/2018 17:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 103	Test Species:	CV-Chlorella vulgaris
Comments:	Diluted with W2 (sample 8667)				

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
USEPA	Cell Yield	23.05	22.00	23.80	0.82	3.93	4
W2		23.15	22.60	24.20	0.72	3.66	4
6.3		22.75	22.00	23.80	0.77	3.86	4
12.5		22.95	22.80	23.20	0.19	1.91	4
25		22.80	22.00	24.20	0.97	4.31	4
50		23.45	22.80	24.20	0.60	3.30	4
100		23.30	22.60	24.40	0.77	3.78	4
USEPA	pH	8.10	8.10	8.10	0.00	0.00	1
W2		7.90	7.90	7.90	0.00	0.00	1
6.3		7.80	7.80	7.80	0.00	0.00	1
12.5		7.80	7.80	7.80	0.00	0.00	1
25		7.80	7.80	7.80	0.00	0.00	1
50		7.80	7.80	7.80	0.00	0.00	1
100		7.90	7.90	7.90	0.00	0.00	1
USEPA	Conductivity uS/cm	103.00	103.00	103.00	0.00	0.00	1
W2		258.00	258.00	258.00	0.00	0.00	1
6.3		428.00	428.00	428.00	0.00	0.00	1
12.5		663.00	663.00	663.00	0.00	0.00	1
25		1104.00	1104.00	1104.00	0.00	0.00	1
50		1912.00	1912.00	1912.00	0.00	0.00	1
100		3370.00	3370.00	3370.00	0.00	0.00	1

Hydrobiology

STREET
27 / 43 Lang Parade
Auchenflower 4066
QUEENSLAND

POSTAL
PO Box 2151
Toowong 4066
QUEENSLAND

CONTACT
+61 (0)7 3721 0100 P
info@hydrobiology.biz

ABN 26 096 574 659

www.hydrobiology.biz

Appendix H

AGE 2019 Groundwater Memorandum

Australasian Groundwater
and Environmental Consultants Pty Ltd
Level 2 / 15 Mallon Street
Bowen Hills, QLD 4006 Australia

ABN: 64 080 238 642
T. +61 7 3257 2055
F. +61 7 3257 2088
brisbane@ageconsultants.com.au
www.ageconsultants.com.au

AMD:kc
G1789C Kidston K2-Hydro
10 January 2019

Arran McGhie
Genex Power Limited

via email

Dear Arran,

RE: Kidston K2-Hydro – Groundwater Modelling

1 Introduction

Genex Power is assessing the potential groundwater impacts posed by the proposed hydropower scheme that uses the residual voids of the former Kidston Gold Mine. The optimised Kidston K2-Hydro operation will use the Wises pit as an upper storage and the Eldridge Pit as a receiving storage, and these pits will be connected by infrastructure that includes the hydropower plant.

The operation of the hydropower scheme will involve the variation of water levels within the existing pits (including increasing the storage volume and surface area of Wises Pit), and the water level changes will induce changes with how the pits control the regional groundwater levels. Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) were engaged by Genex Power to undertake an assessment of the potential changes to the groundwater regime resulting from the optimised K2-Hydro operation.

2 Goals and scope of work

Goal of this project was to assess the operational design of the K2-Hydro Project in terms of its potential to impact the surrounding groundwater environment.

3 Model development and calibration

AGE used a numerical model to assess the impact of the proposed K2-Hydro modification. A model was originally developed by AGE in 2001 to examine final void hydrology and this assessment has used this model as a basis.

3.1 Update of the 2001 AGE model

The following parts of the 2001 model were changed:

- model mesh – the refinement of the model mesh was changed to reflect the maximum increase ratio for neighbouring cells to be 1.5. The horizontal extent of the new mesh is slightly larger;
- model layers – increased from the previous three to 6 layers to better accommodate the depth of pits and simulate infrastructure;
- modelling code and solver – while the old model used then current version of MODFLOW (MODFLOW 88), the modelling code have been updated to MODFOW-SURFACT that is more suitable for conditions of steep hydraulic gradients with potential of unsaturated flow;
- extending the Wises Pit void to cover the updated area of the upper reservoir (in model layers 1 and 2); and
- implementing a horizontal flow barrier to account for the HDPE liner minimizing lateral seepage of water from the upper sections of the reservoir.

3.2 Current numerical model setup

The current numerical model setup is summarised below.

3.2.1 Model grid

The model covers area of 77.8 km^2 (9.0 km × 8.6 km) and is rotated by -22.35°. The model grid consists of 164 rows, 144 columns and 6 layers (141,696 active cells). The cell size varies from 300 m × 300 m in the areas around the edge of the model to 20 m × 20 m in the area covering the voids.

3.2.2 Model layers

The geotechnical investigations completed by Entura (2015) included seven fully cored diamond drill holes (KDDH series) around Wises Pit. The geotechnical report contains core photographs and logs which describe the degree of weathering, and include measurement of the rock quality designation (RQD) which indicates how fractured or jointed the rock mass is.

The information from the KDDH series holes indicates that the weathered/fractured zone, which is expected to enhance the movement of groundwater, is in the order of 10 m thick around Wises Pit. This is greater than the previously modelled thickness of 2 m to 3 m in the previous version of the model that utilised remote sensing data to estimate the thickness of the weathered zone. The thicknesses of Layer 1 and Layer 2 were therefore increased to a minimum of 5 m each.

The geological units were represented by six model layers:

- Layer 1 – weathered bedrock/topsoil or alluvium and spoil/tailings deposits where present;
- Layer 2 – weathered bedrock or alluvium where present;
- Layer 3 – fresh bedrock, base of layer at approximately 520 m AHD;
- Layer 4 – fresh bedrock, base of layer at approximately 498 m AHD (floor of Wises Pit);
- Layer 5 – fresh bedrock, base of layer at approximately 240 m AHD (floor of Eldridge Pit); and
- Layer 6 – fresh bedrock, base of the model at 30 m AHD.

3.2.3 Hydraulic properties

Based on previous studies and in-situ testing described in AGE (2001), the hydraulic conductivity of bedrock material is characterized as ‘tight’ and varies from 5×10^{-9} m to 9×10^{-7} m/day. The investigation undertaken by Entura (2015) describes in-situ tests on seven bores (KDDH01 to KDDH07) and shows hydraulic conductivities higher than described previously, varying from less than 8.6×10^{-4} m/day to more than 8.6×10^{-1} m/day with average of 4×10^{-2} m/day. The records indicate that packer tests were undertaken on both ‘fresh’ and ‘weathered’ intervals and their results are skewed upwards by testing of the weathered zone. The hydraulic conductivity values were used to constrain the calibration process.

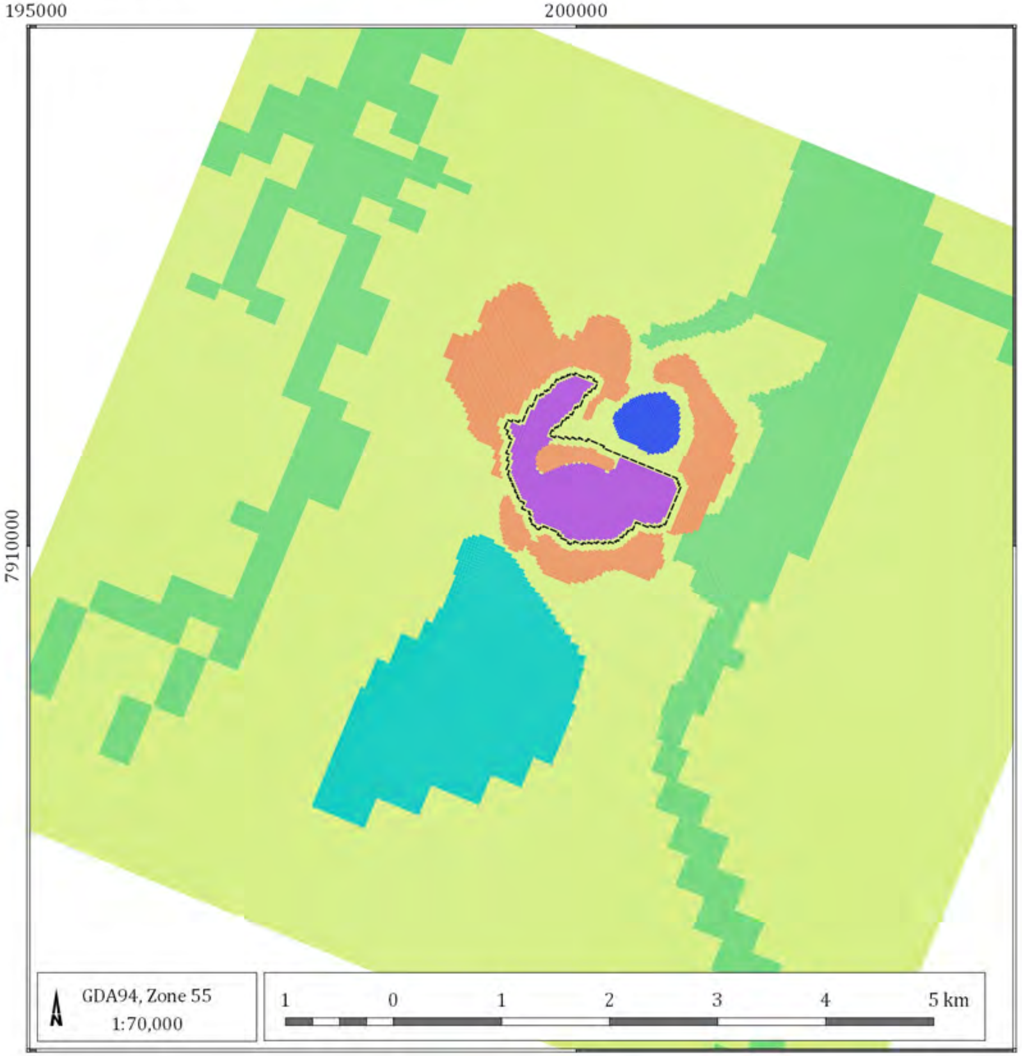
The weathered zone and fresh bedrock in the model were divided into four zones to represent the regionally extensive geological units. These zones represent Oak River granodiorite, Kennedy Province rhyolite, Einasleigh metamorphics and polymict breccias associated with the Kidston ore deposit mineralization. Zones were also created within the model to represent mine waste rock dumps, tailings deposits and alluvium aligned along surface streams.

The updated zonation of hydraulic properties is presented on Figure 1. The increased extent of Wises pit can be seen by the dashed line in the left panel of Figure 1, which represents the liner applied to the upper layers (Layer 1 to 2) in the model, and the purple coloured zone representing the void.

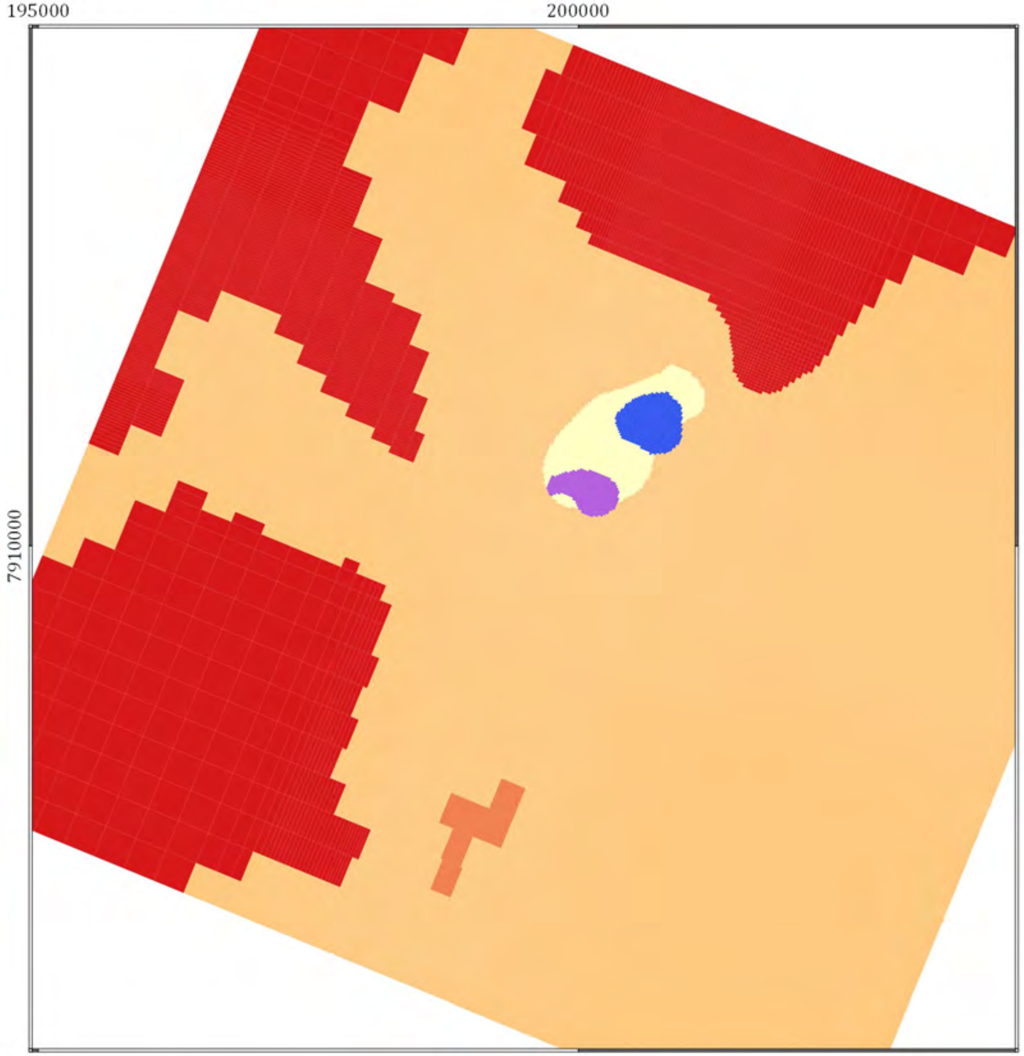
3.2.4 Recharge

Average annual rainfall ranges between 620 mm to 698 mm (AGE 2001) with much higher evaporation rates up to 1868 mm/year (CSIRO 2013) indicating a rainfall deficit. The actual effective recharge is estimated to be quite low – less than 5 mm/year (CSIRO 2013). Recharge within the model was varied using the geological zones described above to represent the potential variability due to geology.

Zones - hydraulic properties - L1-L2



Zones - hydraulic properties - L3-L6



LEGEND

----- horizontal flow barrier

- Topsoil, weathered regolith
- Alluvium
- Northern spoil
- Tailings dam
- Void – Wises Pit
- Void – Eldridge Pit
- Oak River granodiorite
- Kennedy Province rhyolite
- Einsleigh metamorphics
- Polymict breccia
- Void – Wises Pit
- Void – Eldridge Pit

Kidston K2-Hydro (G1789C)

Zonation of hydraulic properties in model layers 1-2 and 3-6

DATE
10/01/2019

FIGURE No:
1

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:/Projects/G1789B.Kidston K2-Hydro/3_GIS/Workspaces/001_Deliverable1/1_zones_hydraulic_properties.qgs

3.3 Model calibration

The model was calibrated against available groundwater level measurements from monitoring bores. Data from 61 observation bores were available, of which 38 sites were actually used during the calibration process (Figure 2). Many of the observed water levels are historical observations collected during periods of active mining and are not expected to accurately reflect current water levels across the site. These bores were therefore removed from the calibration dataset. The majority of recent water level measurements are from piezometers around the tailings dam to the south of the pits. Whilst this provides a high degree of control in this area of the site there are other areas of the model, such as around Eldridge pit, where current water levels are unknown.

Table 1 presents the simulated and the measured groundwater levels for the calibrated model and the difference between these levels (the residuals).

Table 2 summarises the hydraulic conductivity values adopted for each geological zone. The calibrated hydraulic conductivities for the bedrock units in this simulation were at the higher end of the measured ranges. This version of the model is therefore expected to allow groundwater to move more freely through the bedrock than if lower values were adopted.

The calibrated recharge across the undisturbed areas of the model was relatively low at <3 mm/yr, whilst higher rates were incorporated over the alluvium and the areas disturbed by mining (spoil and tailings). A review of water quality measurements indicates the groundwater generally has a low salinity that would suggest moderate recharge rates; the fact the numerical calibrated well to a low recharge indicates some uncertainty in this parameter within the model.

A post-calibration scatter diagram is shown in Figure 3, with the main statistical indicators of the calibration in Table 3.

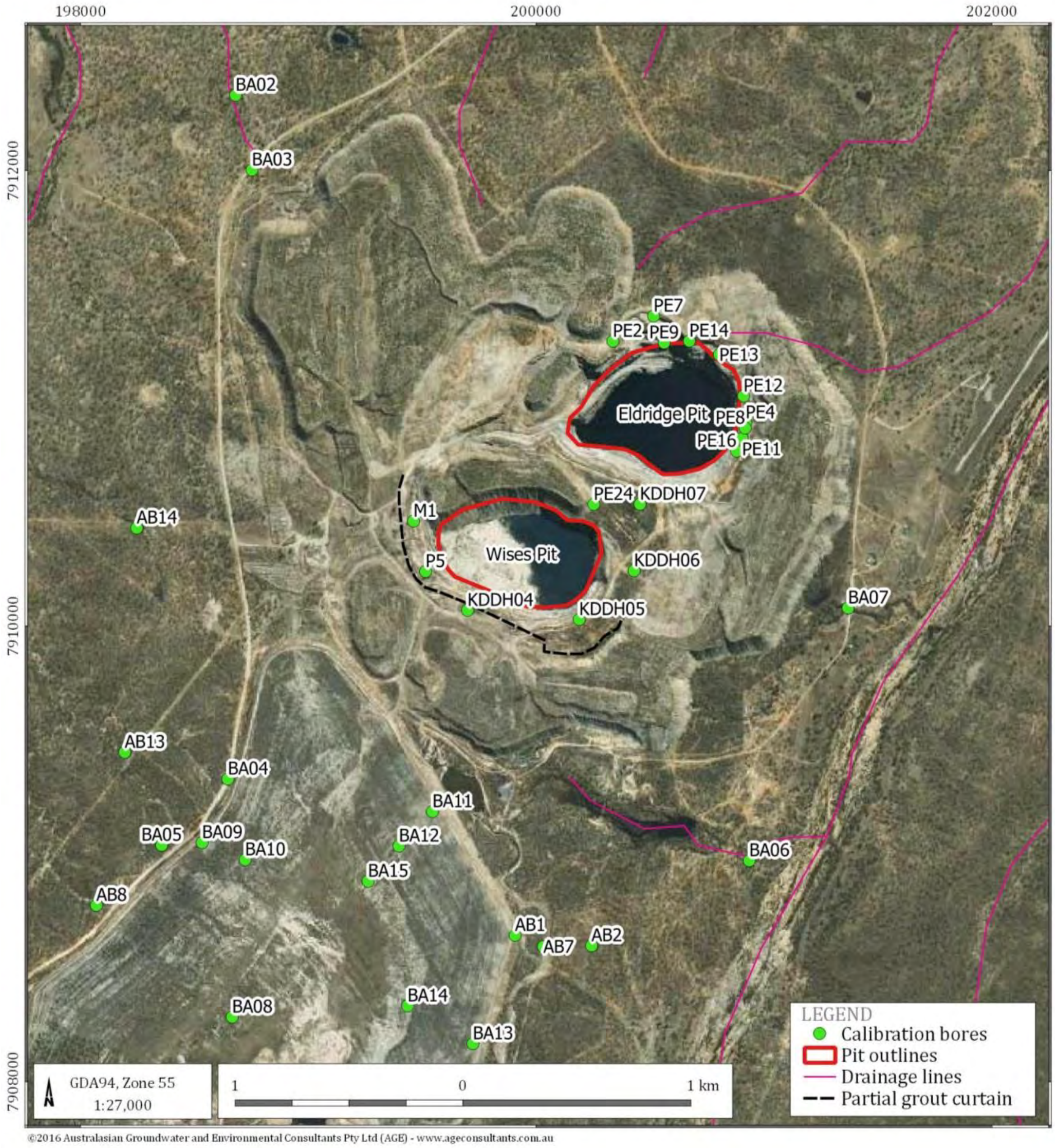


Figure 2 Calibration bore locations

Table 1 Steady state calibration - residuals

Bore ID	Easting (GDA94 Z55)	Northing (GDA94 Z55)	Observed head (m AHD)	Modelled head (m AHD)	Residual (m)
AB1	199908	7908642	544.6	540.3	4.3
AB2	198194	7909446	533.7	537.7	-3.9
AB7	198247	7910431	525.4	526.9	-1.5
AB8	200244	7908597	516.1	527.0	-11.0
AB13	200032	7908593	531.4	533.0	-1.6
AB14	198070	7908774	541.4	544.5	-3.2

Bore ID	Easting (GDA94 Z55)	Northing (GDA94 Z55)	Observed head (m AHD)	Modelled head (m AHD)	Residual (m)
BA02	198681	7912331	521.6	518.9	2.6
BA03	198753	7912003	526.0	517.7	8.2
BA04	198647	7909329	547.3	541.4	6.0
BA05	198357	7909039	545.0	544.0	1.1
BA06	200936	7908971	508.1	512.0	-4.0
BA07	201370	7910080	510.3	508.0	2.2
BA08	198666	7908284	545.8	548.4	-2.6
BA09	198534	7909050	544.2	544.9	-0.6
BA10	198723	7908974	549.4	544.8	4.6
BA11	199545	7909186	540.9	538.8	2.1
BA12	199398	7909035	544.0	540.1	3.9
BA13	199723	7908167	540.0	542.7	-2.7
BA14	199436	7908333	542.0	544.0	-2.0
BA15	199262	7908880	545.3	542.0	3.2
BA16	197379	7910486	524.4	526.5	-2.1
KDDH04	199699	7910069	527.9	513.6	14.3
KDDH05	200189	7910029	515.0	509.8	5.2
KDDH06	200430	7910243	527.3	506.9	20.4
KDDH07	200456	7910535	519.0	495.4	23.5
M1	199462	7910461	516.8	514.0	2.8
P5	199515	7910240	508.5	514.9	-6.4
PE2	200904	7910824	480.9	486.6	-5.7
PE4	200911	7911010	490.4	485.1	5.4
PE7	200804	7911192	503.6	486.9	16.6
PE8	200673	7911252	500.0	483.2	16.8
PE9	200880	7910769	496.0	487.3	8.6
PE11	200337	7911251	509.9	501.3	8.6
PE12	200253	7910535	500.2	498.6	1.6
PE13	200920	7910893	508.4	488.1	20.2
PE14	200516	7911361	531.4	509.2	22.2
PE16	200918	7910870	509.7	487.5	22.2
PE24	200562	7911244	481.2	482.0	-0.8

Table 2 Calibrated hydraulic properties

Matrix description		Hydraulic conductivity (m/day)	
		Horizontal (Kh)	Vertical (Kv)
Topsoil		0.1	0.02
Alluvium		0.5	0.025
Spoil		4.0	0.4
Tailings		0.7	0.0007
Weathered profile	Oak River granodiorite	0.08	0.004
	Kennedy Province rhyolite	0.005	0.005
	Einasleigh metamorphics	0.007	0.007
	Polymict breccia - ore mineralization	0.005	0.00025
Fresh bedrock	Oak River granodiorite	0.007	0.002
	Kennedy Province rhyolite	0.008	0.008
	Einasleigh metamorphics	0.002	0.002
	Polymict breccia - ore mineralization	0.0001	0.0001

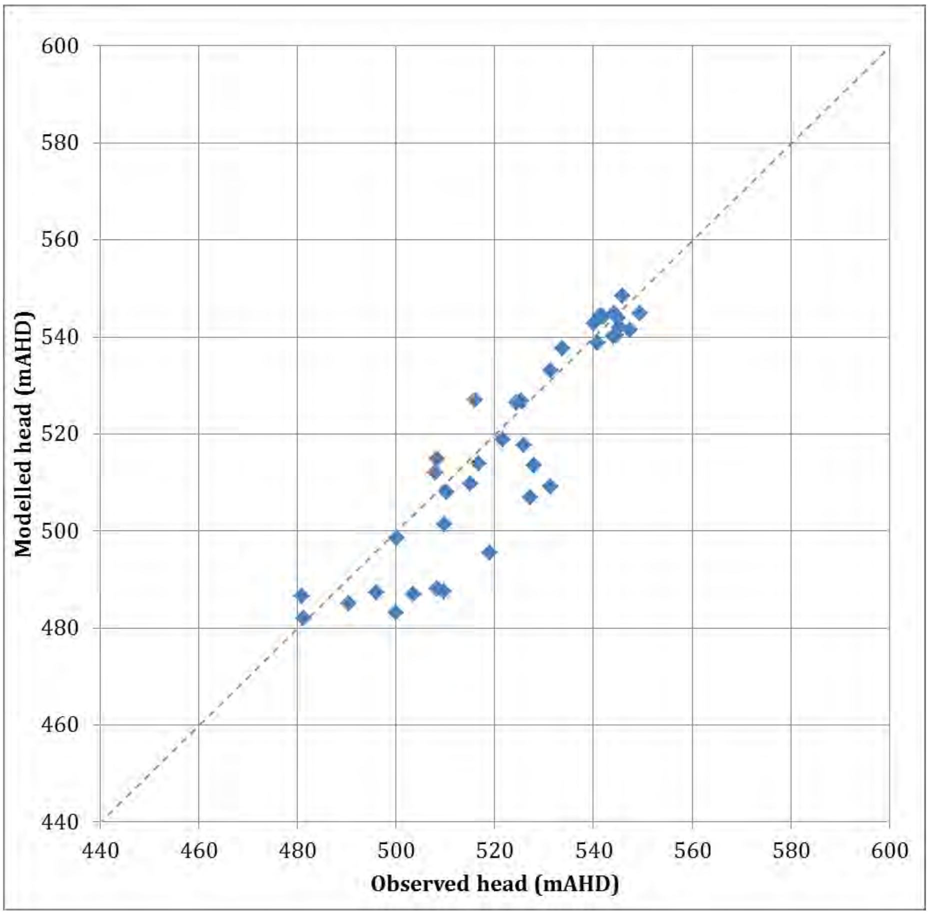


Figure 3 Steady state calibration – scatter diagram of modelled against observed heads

Table 3 Main statistical indicators of calibration process

Statistical indicator		Value	Units
SSQ	Sum of squared residuals	3793	(m^2)
RMS	Root mean square	9.99	(m)
SRMS	Scaled RMS	14.6	(%)

The SRMS is one of the main indicators of calibration fit and at 14.6% it is considered to be slightly poor. This indicates that some processes in the natural environment are not represented in the model. The model was calibrated to assumed steady state water levels, which are estimates of long term average water levels. The available monitoring data suggests the water levels within the mine pits have not reached equilibrium and are therefore not likely to represent the long term average level. The water level measurements within the monitoring bores are also sporadic and may not represent the full fluctuations that occur across the wet season and dry season climatic cycles. The model also assumes the hydraulic properties of the geologic units are uniform across large areas, which is of course not true within the natural environment. These aspects likely combine to result in the slightly poor calibration.

3.4 Model predictions

In order to assess the impact of the Project, each pit was assigned a water level that explores the maximum possible water level gradient between Wises and Eldridge pits. The setup of the model in terms of defined water levels is shown in Table 4.

Table 4 Modelled scenarios – pit water levels

Scenario	Simulated water level in reservoirs (mRL)	
	Wises Pit (upper, shallow)	Eldridge Pit (lower, deep)
Baseline	492.00	480.75
K2-Hydro	551.00 *	328.40

Note: * *This is a conservative level as the Maximum Operating Level for Wises Pit is 546 mRL. The MOL is achieved when the Eldridge Pit water level is at elevation 328.40 mRL.*

4 Modelling results

Two steady state models were run with the setups described in Table 4. The potential impacts of the K2-Hydro modification were determined through comparisons between these two model predictions. The key model outputs used to determine the impact were predicted groundwater table (groundwater mounding and drawdown analysis) and changes to water budgets for predicted pit inflow/outflow and flows to the Copperfield River. A simple particle tracking exercise was also undertaken to better understand the extent of the impacts in the context of the limitations of the steady state model with respect to the real-life duration of the Project (50 years).

4.1 Groundwater levels

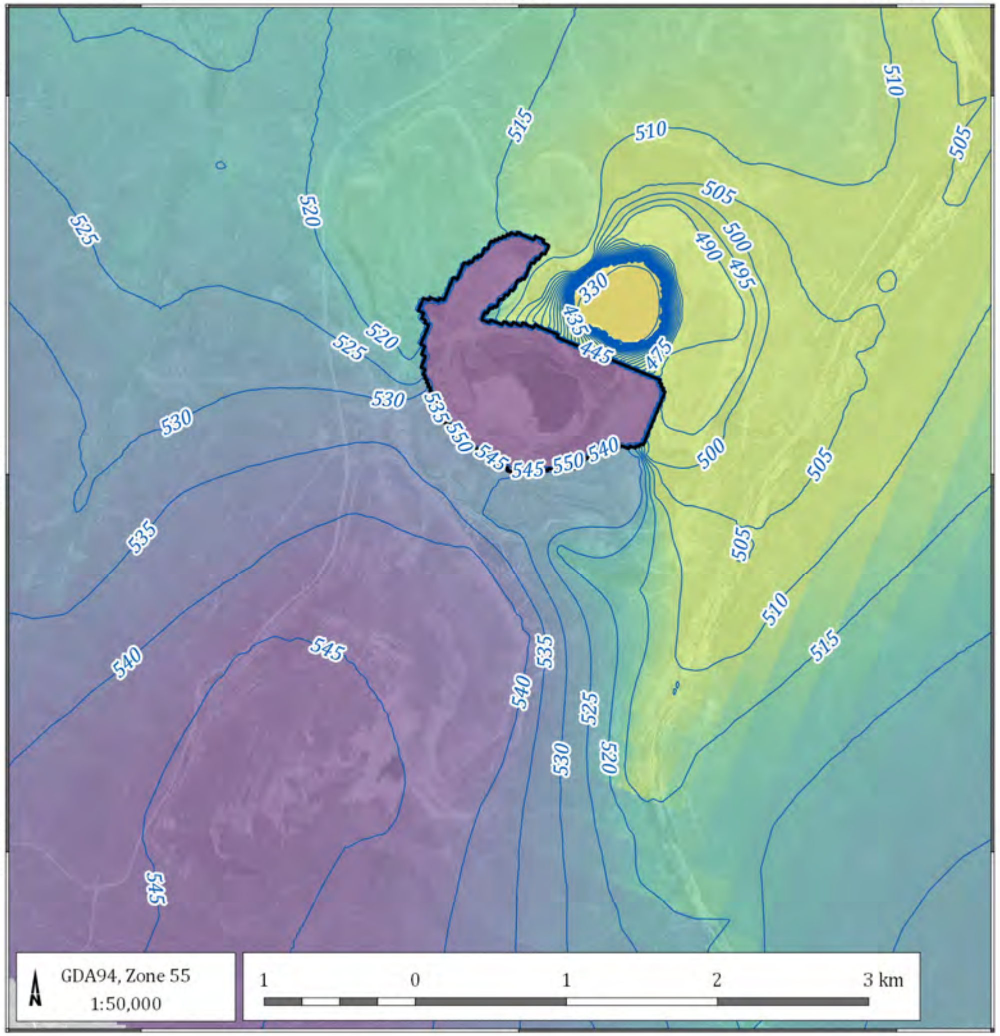
Figure 4 below shows predicted heads (left) and predicted difference to the baseline simulation (right) in model Layer 1 (representing the phreatic surface) for the K2-Hydro setup in Table 4. The predicted difference shows both drawdown (positive contours) and mounding (negative contours). Generally, the water seeps through the floor of the upper reservoir and travels down-gradient where it is either captured by the Eldridge Pit or remains in the groundwater system and results in a rise in the water table level. Because the water level in the Wises reservoir (551 m RL) is relatively high and above the existing water table, the model predicts an increased seepage and water level rise in the immediate vicinity of the pit towards the west, southwest and south. The elevated water table around Wises pit from this seepage 'dams' the regional flow towards the north and the backed up water results in additional mounding in the areas south and southwest from the Wises reservoir.

4.2 Particle tracking

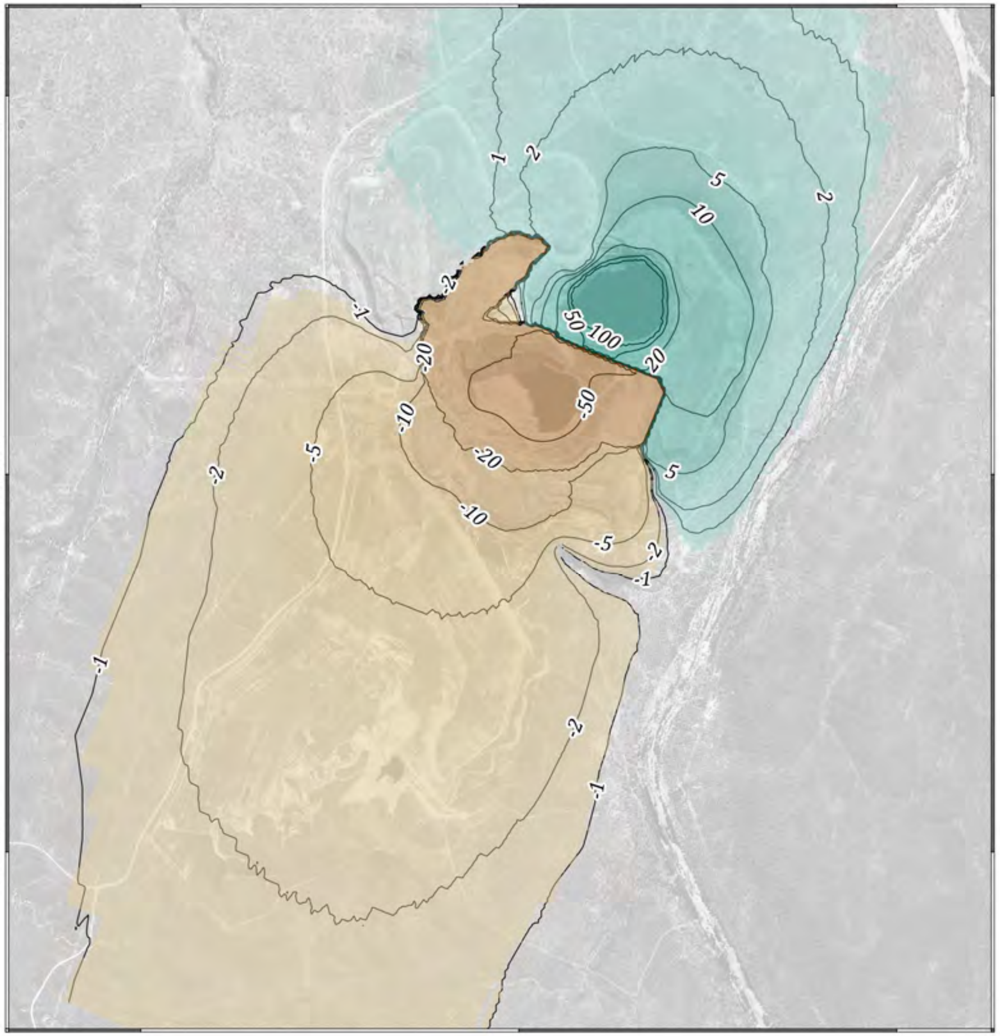
Particle tracking was used to identify the likely travel distances of water particles that start their journey in the Wises reservoir at the start of the Project. The distance of travel of particles indicates the spatial extent of the likely impacts from the Project over its operational phase. The pathlines for 100 years timeframe were generated, as these were comfortably past the expected lifetime of the Project (50 years).

Particles were started inside the lined pond (see Figure 5). Particles released on the north eastern side of Wises Pit generally migrate to the Eldridge pit. However, the particles released in other parts of the reservoir migrate in a west, south or south-west directions remain "active" in the groundwater system. During the 100 year timeframe run, only 4 (out of 54) particles ended up in the Eldridge Pit, all the other particles remained active after moving in the downwards direction through the bedrock units. Regardless of the length of the particle tracking timeframe, the travel of particles in south and southwest direction is limited. This is likely to be due to the northerly gradient being maintained from the tailings dam area towards the north. No particles made it to Copperfield River in the 100 year period.

K2-Hydro - predicted groundwater heads



K2-Hydro - predicted drawdowns



LEGEND

contour - heads

contour - drawdown

Kidston K2-Hydro (G1789C)

Heads and drawdowns

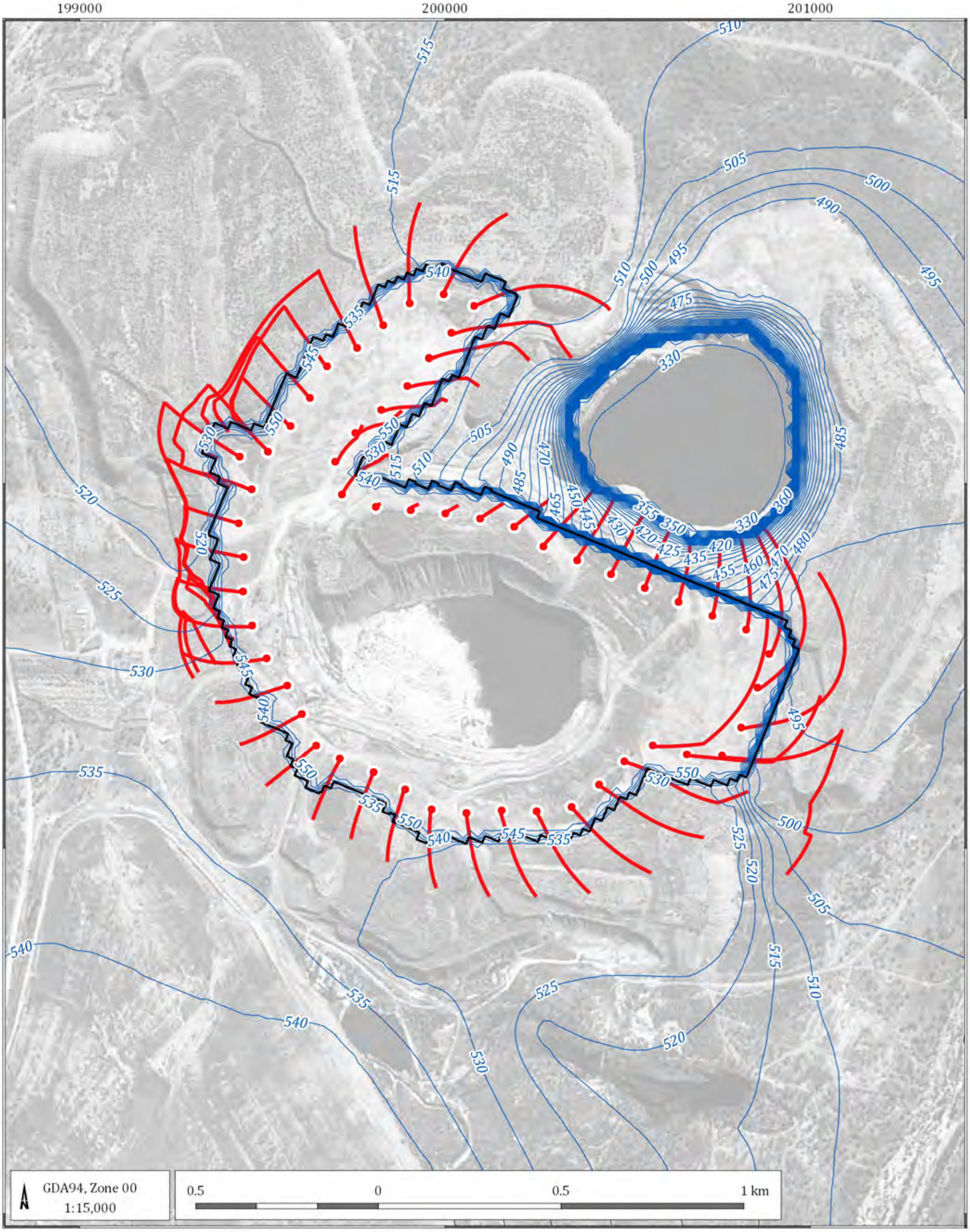
DATE

10/01/2019

FIGURE No:

4

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:/Projects/G1789B.Kidston K2-Hydro/3_GIS/Workspaces/001_Deliverable1/2_heads_drawdowns.qgs



LEGEND

horizontal flow barrier
contour - groundwater head
initial particle position
particle trace

Kidston K2-Hydro (G1789C)

Particle tracking - 100 years

DATE 10/01/2019

FIGURE No: **5**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:/Projects/G1789B.Kidston K2-Hydro/3_GIS/Workspaces/001_Deliverable1/3_particles.qgs

4.3 Predicted water balance for the pits

Under current conditions (pre-development baseline), both pits act as sinks because their water level sits slightly below the observed regional water table. Shallower Wises Pit receives approximately 19 m^3/day, while deeper Eldridge pit receives approximately 270 m^3/day (see Table 5). Under operating conditions (Scenario A), the water level in Wises Pit will be above regional groundwater table and becomes water source as the pit will be losing 350 m^3/day, while Eldridge Pit (lower reservoir) will remain sink with potential inflows of 770 m^3/day. In net terms, the operational conditions increase the inflow to pits from 290 m^3/day (pre-development baseline) up to 420 m^3/day (K2-Hydro project in place with maximum groundwater gradient).

Table 5 Water balance for Wises and Eldridge pits

Scenario	Predicted groundwater inflows (m^3/day)		
	Wises (upper, shallow)	Eldridge (lower, deep)	Net interception of groundwater
Baseline	19	271	290
K2-Hydro	-350	770	420

What has been demonstrated through pathline analysis and groundwater level change is that the increased inflow into Eldridge pit during the operational phase will be sourced from both Wises pit seepage and inflow from surrounding groundwater in all directions around the pit.

4.4 Predicted interaction with Copperfield River

The boundary condition representing Copperfield River was set up as a potential water source with capability to both remove water from the environment in the form of baseflow, as well as contribute to the groundwater system via river bed recharge.

In order to estimate the impact of the Project on the Copperfield River, the model domain was divided into water balance zones as presented in Figure 6. The water balances were calculated separately for the "northern" (red) and "southern" (green) sections of the river, as it is expected the impact will be different in these sections: the northern part will be more influenced by lowering the groundwater levels in the vicinity of Eldridge Pit, the southern part will be potentially impacted by additional baseflow from elevated groundwater levels due to Wises Pit and the tailings dam south of Wises Pit. The water balances (net flow rates) are presented in Table 6.

LEGEND

- bedrock - west
- bedrock - east
- river - north
- river - south

horizontal flow barrier

Kidston K2-Hydro (G1789C)

Water balance zones - Copperfield River

DATE 10/01/2019

FIGURE No: **6**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:/Projects/G1789B.Kidston K2-Hydro/3_GIS/Workspaces/001_Deliverable1/4_budget_zones_river.qgs

Table 6 Zone water balances for Copperfield River

Scenario		From west (m³/day)	From east (m³/day)	Net inflows (m³/day)
Baseline	Northern section	157	337	690
	Southern section	64	132	
K2-Hydro	Northern section	88	257	543
	Southern section	65	133	

The analysis of the zone water balance is showing that the Copperfield River is both losing water in the form of river bed recharge and gaining water in the form of baseflow, with the baseflow dominant of the two. The river generally acts as a conduit removing water from the groundwater system. The extreme operational conditions (low water level in Eldridge pit, high water level in Wises pit) impact on the groundwater system by the following way:

- Overall, the baseflow to the river will decrease by 150 m^3/day from 690 m^3/day (current baseline condition) to 540 m^3/day.
- The northern section of river within the model domain will see a decrease of baseflow due to the increased gradient towards the nearby Eldridge Pit. The decrease of baseflow impacts flows from both west and east. The decrease of baseflow from the western side of the river (Eldridge Pit) was estimated to be ~70 m^3/day (44% of the baseflow predicted to occur in the model domain).
- The southern section of the river is predicted to see a very slight increase of flow from the west (caused by increased gradient towards the Copperfield River due to the mounding in tailings dam area). The flows from the east remain more or less unchanged (increase of 1.1 m^3/day). The increase of baseflow from the western side (tailings dam) presents an additional 1 m^3/day, which is ~1.6% increase over the baseline predicted baseflow.

The reduced inflow (baseflow) for the western side of the northern zone is expected during the Project operation because of its proximity to Eldridge pit that draws the water table down increasing the groundwater inflow to the pit. There is also a reduced baseflow from the east of Copperfield River due to the cone of depression extending under the river immediately adjacent to the Eldridge Pit.

There is a relatively minor increase in the flow to the southern zone of the Copperfield River through the model domain. This slight increase of just under 2 m^3/day from the west, is due to slightly higher groundwater levels due to the damming effect of the Wises Pit on the regional groundwater flow.

4.5 Predicted impact on groundwater potentially associated with Groundwater Dependent Ecosystems (GDEs)

The National Atlas of Groundwater Dependent Ecosystems (BoM, 2018[1]) maps locations of potential terrestrial groundwater dependent ecosystems that rely on the subsurface presence of groundwater to meet all or some of their water requirements based on national scale mapping. The GDE atlas also includes potential areas of GDEs which use groundwater after it has been discharged to surface (aquatic GDEs).

---

[1] Bureau of Meteorology, 2018. Groundwater Dependent Ecosystem Atlas, Website: http://www.bom.gov.au/water/groundwater/gde/ downloaded November 2018.

Permanent springs are recorded in the Queensland Springs database (DES, 2018[2]). The database also includes details of non-permanent springs, although the information on these can be limited.

Figure 7 shows the location of the potential GDEs and identified springs around the Kidston site, along with the predicted changes in groundwater level resulting from the extreme operational limits of the K2 Hydro scheme. It is important to remember that water levels are predicted to rise around Wises Pit and fall around Eldridge Pit.

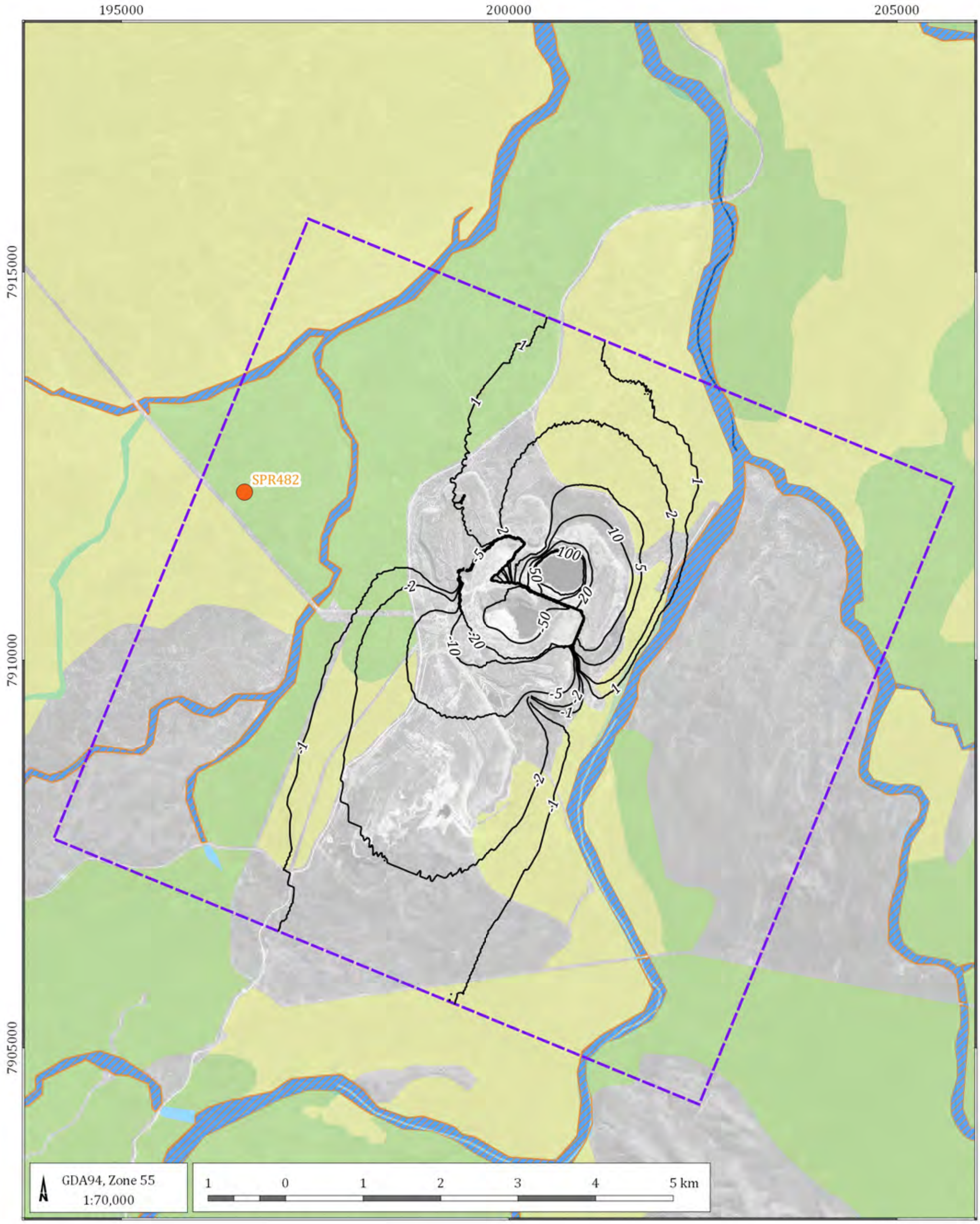
The figure indicates that terrestrial GDEs may be present over large areas of land close to the K2-Hydro Project. Areas of highest potential are located along the drainage lines. It is possible that high potential GDEs along the Copperfield River could see a reduction in groundwater as a result of the Project. The majority of the area predicted to draw down by more than 1 m is unclassified over the historically disturbed mining areas, or at low potential for terrestrial GDEs.

Potential aquatic GDEs are located along many of the nearby drainage lines, with the locations correlating strongly with the high potential terrestrial GDE mapping. The majority of aquatic GDEs are classified as moderate or low potential, with a small area of high potential along the Copperfield River to the northeast of the K2-Hydro Project. It is possible that GDEs along the Copperfield River could see a reduction in groundwater inputs as a result of the K2-Hydro Project.

Although there are potential changes in groundwater levels predicted in the vicinity of several potential GDEs additional work will be required to determine if the changes could result in a negative impact to the vegetation communities.

There is one permanent spring (SPR482 – Middle Spring), located approximately 4.8 km west-northwest of the Project. This is close to the edge of the model domain and is predicted to be impacted by less than 0.2 m from a very conservative steady state assessment.

[2] Department of Environment and Science, Queensland Government, 2018. Springs database, version 11/09/2018.



LEGEND

- Springs
- Drawdown contour
- Model extent

Terrestrial GDEs

- High potential GDE
- Moderate potential GDE
- Low potential GDE

Aquatic GDEs

- High potential GDE
- Moderate potential GDE
- Low potential GDE

Kidston K2-Hydro (G1789C)

Predicted drawdown and nearby GDEs

AGE

DATE
10/01/2019

FIGURE No:
7

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:/Projects/G1789C.Kidston K2H/3_GIS/Workspaces/001_Deliverable1/05.00_G1789C_Predicted drawdown and nearby GDEs.qgs

5 Conclusion

5.1 Impacts of the project

Impacts of the projects were described in terms of lowering or raising water levels in the groundwater system and changing the baseflow and recharge rates with respect to the surface drainage, namely Copperfield River.

If the increased groundwater gradient caused by the difference of water levels between Wises and Eldridge pits remained in place indefinitely, the groundwater regime would be altered in the following way: groundwater table below the tailings dam would rise by 2 m to 5 m due to Wises pit damming up and reducing regional groundwater movement to the north of the spoil, while groundwater levels surrounding the Eldridge pit would be lowered. The mounding in the southern tailings area would marginally increase the baseflow to the Copperfield River. The cone of depression developed around Eldridge pit would extend up to 3000 m in the north-eastern direction (from the Eldridge Pit) and approximately 1300 m towards the Copperfield River and decrease the baseflow contribution adjacent to the Eldridge Pit.

These predictions are however conservative as they are based on the steady state model. The particle tracking exercise demonstrated that in the short timeframe that spans the lifetime of the project, the drawdown and mounding impacts will not have time to develop to the same extent as the steady state model predictions indicate.

During the Project operation, the increased inflow of groundwater to Eldridge pit will reduce the baseflow occurring to Copperfield River. This water will be collected by the pit and become part of the operation. When an opportunity of increased flow in Copperfield River occurs (due to a rainfall event), the poorer quality water could be released back to the river (if required) and the dilution would result in better overall water quality in the river than it being baseflow in low flow conditions.

The flow to the west, south and southwest should be considered temporary during the Project life. This seepage from Wises pit is not predicted to travel far during the life of the Project as indicated by the conservative 100 year pathlines. At the end of the project, when the head in Wises is no longer maintained, the capture zone of Eldridge pit will increase and it is entirely likely that the drawdown cone of depression for Eldridge will be recharged by the water lost from Wises during the project operation. Water levels in both pits can be expected to return to their pre-project elevations.

5.2 Limitations of the model

The model in its current form (steady state) with its simplifying assumptions is satisfactory for understanding the conceptual issues surrounding the Project, however it is not capable of quantifying the impacts on the timescale of the project. In this sense, the model is very conservative when considering the extent of impacts.

6 References

AGE (2001) "*Kidston gold mine – Eldridge Pit final void hydrology*"; Project no. G1080; Brisbane, Queensland, January 2001.

AGE (2016) "*Kidston voids modelling – preliminary results*"; project no. G1789; Brisbane, Queensland, January 2016.

CSIRO (2013) "*Agricultural resource assessment for the Gilbert catchment*". An overview report to the Australian Government from the CSIRO Flinders and Gilbert Agricultural Resource Assessment, part of the North Queensland Irrigated Agriculture Strategy. CSIRO Water for a Healthy Country and Sustainable Agriculture flagships, Australia.

Entura (2015) "*Kidston pumped storage project – geology report 1*"; Cambridge, Tasmania, December 2015.

Queensland Government Water Monitoring Information Portal (2016) "*Station dataset for 917115A Copperfield River at Spanner Waterhole*". Accessed from: https://water-monitoring.information.qld.gov.au/, on 4th May 2016.

Appendix I

Draft REMP

Integrated Assessment Report
Genex Power Ltd
10-Jan-2019 DRAFT

Kidston Pumped Storage Hydro Project

Receiving Environment Monitoring Program

D R A F T

Kidston Pumped Storage Hydro Project

Receiving Environment Monitoring Program

Client: Genex Power Ltd

ABN: 18 152 098 854

Prepared by

AECOM Australia Pty Ltd
Level 5, 7 Tomlins Street, South Townsville Qld 4810, PO Box 5423, Townsville QLD 4810, Australia
T +61 7 4729 5500 F www.aecom.com
ABN 20 093 846 925

10-Jan-2019

Job No.: 60544566

AECOM in Australia and New Zealand is certified to ISO9001, ISO14001 AS/NZS4801 and OHSAS18001.

D R A F T

Quality Information

Document Kidston Pumped Storage Hydro Project

Ref 60544566

Date 10-Jan-2019

Prepared by Reece Fraser & Nicky Lee

Reviewed by James Tuff

Revision History

Rev	Revision Date	Details	Authorised	
			Name/Position	Signature
0	31-Aug-2018	For Client Review		
1	10-Jan-2019	Revised following OCG Comments - Issued for Client Review		

D R A F T

Table of Contents

1.0	Aims and Objectives		1
2.0	Activity Description		2
	2.1	Project Overview	2
	2.2	Water Releases	2
		2.2.1 Event-Based Discharge of Water to Maintain Water Levels and Quality	2
		2.2.2 Pass-Through Discharge	2
3.0	Receiving Environment Description		5
	3.1	Ecosystem Condition Classification	5
		3.1.1 Water Type	5
		3.1.2 Management Intent	5
	3.2	Environmental Values	6
	3.3	Guideline Values	8
		3.3.1 Default Water Quality Objectives	8
		3.3.2 Sediment Quality Guidelines	11
	3.4	Summary of Receiving Environment	12
4.0	Monitoring Program Design		14
	4.1	Water Quality Monitoring	14
		4.1.1 Routine Sampling Locations and Frequency	14
		4.1.2 Field Quality Control	14
		4.1.3 Sampling Equipment	14
		4.1.4 Water Quality Monitoring Parameters and Limits of Reporting	15
		4.1.5 Sampling Method	16
		4.1.6 Data Handling and Reporting	18
	4.2	Sediment Monitoring	19
		4.2.1 Initial Sediment Investigation	19
		4.2.2 Routine Sampling Locations and Frequency	19
		4.2.3 Sampling Method	19
		4.2.4 Field Quality Control	20
		4.2.5 Sediment Quality Monitoring Parameters and Limits of Reporting	20
	4.3	Biological Monitoring	21
		4.3.1 Routine Sampling Locations and Frequency	21
		4.3.2 Aquatic Habitat and Flora	21
		4.3.3 Macroinvertebrate monitoring	21
	4.4	Flow	23
	4.5	Groundwater	23
		4.5.1 Sampling Methods	24
		4.5.2 Sample Parameters	25
5.0	Data Interpretation		26
	5.1	Overview	26
	5.2	Water Quality	26
		5.2.1 Values below the Limit of Reporting	26
		5.2.2 Data Requirements for Background Data	26
		5.2.3 Assessing compliance with WQOs	26
		5.2.4 Dissolved and Total Metals	27
		5.2.5 Data Analysis	27
	5.3	Sediment Quality	27
		5.3.1 Values below the Limit of Reporting	27
		5.3.2 Site Variability	27
		5.3.3 Accumulation of Reference Site Data	28
		5.3.4 Assessment against guideline values	29
	5.4	Biological Monitoring	30
	5.5	Groundwater	31
6.0	Reporting and Review		32
7.0	33		
8.0	References		33

Appendix A
REMP Monitoring Locations and Frequencies A

1.0 Aims and Objectives

Genex Power Ltd (Genex) commissioned AECOM Australia Pty Ltd (AECOM) to prepare this Receiving Environment Monitoring Program (REMP) for the Kidston Pumped Storage Hydro Project (the Project), which proposes to develop the former Kidston Gold Mine pit voids to store water and use it to generate a form of gravitationally-driven hydroelectric power. The main objective of the REMP is to report against relevant water quality objectives (WQOs) for receiving waters potentially affected by controlled releases of pit water and to verify water quality assumptions presented in the Impact Assessment Report (IAR) for the Project (AECOM 2018).

Insert reference to relevant conditions of approval when available.

This document has been prepared in accordance with the requirements of the Queensland Government Department of Environment and Science (DES, formerly DEHP) technical guideline entitled '*Wastewater release to Queensland waters*' (ESR/2015/1654, Version 2, September 2015) and the '*Receiving environment monitoring program guideline*' (ESR/2016/2399, Version 2.01, June 2015) .

2.0 Activity Description

2.1 Project Overview

The Project involves storing water within an elevated upper reservoir, allowing energy to be stored in the form of gravitational potential energy. During periods of peak electrical demand, the water will be released from the upper reservoir into a lower reservoir via a turbine-generator system that produces electricity. At the end of the electricity-generating cycle, the turbines will be reversed and, powered by electricity from the nearby Kidston Solar Farm, will be used to pump the water from the lower reservoir back to the upper reservoir to begin the electricity generation cycle again. The Project proposes to utilise two existing mining pits, Wises (upper reservoir) and Eldridge (lower reservoir), at the decommissioned Kidston Gold Mine. The Wises Pit will be modified via the construction of a perimeter dam to increase its storage volume.

The Project generation capability is 250 MW with a storage capacity of 1,870 MWh. The Project forms a component of the wider Kidston Renewable Energy Hub. Once completed, the Project will be the first in the world to utilise two disused mine pits for hydroelectric power generation, and the first hybrid large-scale solar photovoltaic and pumped hydro storage plant.

A major component of the Project is the ability to control the stored water, both in the initial phase of construction of site infrastructure (e.g., the power generating facilities, access tunnels etc.), and during operations, when water will be transferred from the upper reservoir (the Wises Pit) to the lower reservoir (the Eldridge Pit). Crucial to this control will be the potential to release additional volumes of water that may arise following periods of high water ingress, such as wet season rainfall events and storms. Water release may be required to maintain operations during power generation.

2.2 Water Releases

As described above, the Project may need to release water in order to maintain reservoir levels during the power generation cycle, to prevent inundation of key infrastructure, and/or to mitigate possible water quality deterioration. It is proposed that water will be released from the Project via one of two different strategies depending on the nature of the causal event. These two release strategies are described as follows:

2.2.1 Event-Based Discharge of Water to Maintain Water Levels and Quality

Additional water added to the reservoirs through rainfall/runoff ingress during either critical construction stages or normal operations may, at times need to be released. The preferred method is via the controlled release of Project water during periods of naturally-occurring streamflow in the Copperfield River (herein referred to as an event-release). This type of release has a number of advantages, including:

- Releases are conducted within a set of licenced conditions and under pre-determined operating rules to ensure potential impacts are appropriately mitigated.
- Releases are independent of the normal operation of the Project (e.g., the power generation and pump-back phases).

By limiting event-releases to periods of medium to high flow and appropriately managing the release, relevant environmental values (EVs) will be protected.

2.2.2 Pass-Through Discharge

In the event of the forecast of a significant rainfall event (e.g. cyclonic or regional monsoonal trough[1]), Project operations may opt to conduct a pass-through discharge of event-induced incident rainfall, either during specific phases of construction, or during normal operations. This would be achieved by maintaining the upper reservoir at spillway elevation such that any incident rainfall would simply pass through the reservoir and discharge to the Copperfield River via the spillway chute. Depending on the

[1] The Australian BOM estimates that ~ 4.7 cyclones per year affect the Queensland Tropical Cyclone Warning Centre Area of Responsibility (http://www.bom.gov.au/cyclone/about/eastern.shtml)

duration and timing of the event, the power generation cycle may be required to cease in order to hold the upper reservoir at the required level.

This type of release is not the preferred approach to release water from the Project because:

- Total or partial cessation of power generation may be required.
- The rate of water released would be dependent on rainfall intensity and any attenuation provided by the upper reservoir.
- The water quality discharged during the event would be a function of the extent to which the fresh rainwater mixes with the existing upper reservoir water body.

It is noted however that during a pass-through discharge, Genex would still retain the ability to cease the release by lowering the level of water in the upper reservoir and allowing water to flow back into the lower reservoir.

For both types of releases the protection of EVs will be determined by assessment against:

- Any relevant local water quality objectives (WQOs).
- ANZECC/ARMCANZ 2000 (Australian and New Zealand Environment Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.*
- The Environmental Protection (Water) Policy 2009, and the National Water Quality management strategy.
- The hydrological characteristics of the receiving environment (e.g. flows regime, riparian structure etc.).

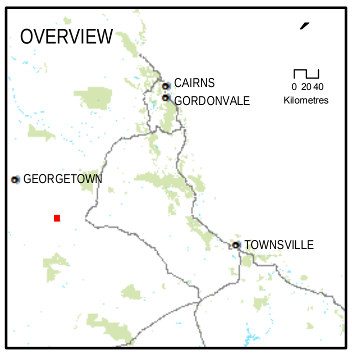
The Project layout including the release location is shown on Figure 1.

AECOM
www.aecom.com

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator

0 100 200 300 400
Meters
1:17,000 (when printed at A3)

Legend
- Boundary Points
- Watercourses
- Major Roads
- Minor Roads
- Water Intake Pipeline
- Key Project Infrastructure Footprint
- Spillway Options Corridor
- Mining Lease Boundary
- Cadastral Parcel



Data sources:
Roads and Tracks, Cadastre, Watercourses - DNRM 2017
Electrical Network - Ergon Energy 2017
SISP Imagery 2017

Disclaimer:
While every care is taken to ensure the accuracy of the Information Product, the Department of Natural Resources and Mines makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which you might incur as a result of the product being inaccurate or incomplete in any way and for any reason.

Kidston Solar Farm
Genex Power Limited

Indicative Project Area

PROJECT ID	60544566
CREATED BY	JR
LAST MODIFIED	LB - 13/06/2018
VERSION:	1

Figure 1

File Folder: Z:\605X\60544566\4. Tech Work Area\4.99 GIS\02_MXDs\Hydro\H60544566_002_Indicative_Project_Area_20180510_A3L_v2.mxd

A3 size

D R A F T

3.0 Receiving Environment Description

The Copperfield River is a large ephemeral, braided watercourse which runs through the Einasleigh Uplands bioregion in Far North Queensland, approximately 250km southwest of Cairns North. It is situated within the Gilbert River basin, draining towards the Gulf of Carpentaria. The Copperfield River forms the eastern boundary to the site, and is the receiving water body for pit water releases associated with the Project. There are various downstream inflows, including East Creek, Charles Creek, Oak River, Soda Creek and Chinaman Creek. The Copperfield River discharges to the Einasleigh River approximately 50 km downstream of the release location (Figure 1).

During the dry season the Copperfield River typically becomes a series of disconnected pools with reduced water quality. These pools experience large diurnal fluctuations which limit the diversity of remnant flora and fauna communities. The pools can be heavily impacted by cattle and feral pigs as they become the final refuges for these exotic species to water.

The high flow rates experienced in the Copperfield River over the wet season limits the establishment of aquatic flora and small bodied fauna communities. Successful recruitment in these systems can then occur once peak flows have subsided.

The Project area and surrounds consist predominately of agricultural land and are primarily used for grazing (AECOM Australia, 21 December 2017). The Project site, comprising of relatively flat terrain, adjoins lease land to the west and north and is bordered by the Gilberton Road to the south and east.

3.1 Ecosystem Condition Classification

3.1.1 Water Type

The ANZECC (2000) guidelines separate upland and lowland freshwaters at an elevation of 150m AHD. The guidelines also define upland freshwaters as small (first or second order) streams that are moderate to fast flowing as a result of steep gradients and which have cobble, gravel or sand beds. Lowland streams are defined as larger streams (greater than 3rd order) that meander with generally slower flows and beds comprised of sand, silt and mud. The Copperfield River falls into both of these classifications as it is above an elevation of 150m AHD but is a large 5th order stream with a bed of sand, silt, rock and mud. For the purposes of this REMP the Copperfield River in the vicinity of the project has been classified as upland freshwater.

3.1.2 Management Intent

Generally the condition of aquatic ecosystems in the vicinity of the proposed release falls within the category of “Slightly to Moderately Disturbed” as outlined in the ANZECC (2000) and QWQG (2009). However the EPP Water (2009) allows for the separation of slightly disturbed waters from moderately disturbed waters. As presented in the IAR, the macroinvertebrate data for the Project supports the distinction of a ‘Slightly Disturbed’ aquatic ecosystem condition. The definition of slightly disturbed waters is “*waters that have the biological integrity of high ecological value waters with slightly modified physical or chemical indicators but effectively unmodified biological indicators – the measures for the slightly modified physical or chemical indicators are progressively improved to achieve the water quality objectives for high ecological value water*”.

The management intent of slightly disturbed waters is to gradually improve water quality and to aim to achieve a HEV waterway classification, however it is noted that HEV WQOs may not be achievable in the Copperfield River as there are a number of regionally based negative influences on water quality, including:

- Large-scale historical clearing;
- Cattle grazing and direct access to the river by cattle; and
- Flow regulation by the Copperfield Dam.

DRAFT

3.2 Environmental Values

EVs are qualities designed to provide requirements to make water suitable for supporting aquatic ecosystems and human uses. They require protection from the effects of habitat alteration, waste releases, contaminated runoff and changed flows to ensure healthy aquatic ecosystems and waterways that are safe for community use. The EVs of waters are protected under EPP Water. The policy sets WQOs, which are physical and chemical measures of the water (i.e. pH, nutrients, salinity etc.) to achieve the EVs set for a particular waterway or water body. EVs define the suitable uses of the water (i.e. aquatic ecosystems, human consumption, industrial use etc.).

An evaluation of site specific EVs that are relevant to the proposed release regime and the local receiving environment is provided in Table 1 and is based on the mapping exercise undertaken as part of the IAR.

Table 1 Surface Water Environmental Values Relevant to the Project Site

Environmental Value	Relevance to Copperfield River	Justification
Aquatic ecosystems (incorporating Habitat value)	✓	The macroinvertebrate field survey and desktop assessment supports the definition of a 'Slightly Disturbed' aquatic ecosystem condition (waters that have the biological integrity of high ecological value waters with slightly modified physical or chemical indicators but effectively unmodified biological indicators) as discussed in Section 3.1.2
Irrigation (Short Term < 20 years)	✓	There are no known irrigation operations within the receiving environment. There are no current water allocations. However there is the potential for irrigation subject to economic feasibility (Petheram, Watson, & Stone, 2013). Therefore this EV is considered relevant.
Irrigation (Long Term ~100 years)	✓	There are no known established irrigation operations within the receiving environment, and there are no current water allocations. However, following an assessment of the feasibility of irrigation occurring in the catchment, economic factors were found to be the main limiting factor. These may change within the next 100 years, and may allow irrigation projects within the receiving environment, sourcing water from the Copperfield Dam, to become feasible. Subsequently this environmental value has been applied.
Farm supply (e.g. fruit washing, milking sheds, intensive livestock yards)	✓	There are no intensive farm uses within the downstream receiving environment, and there are no water allocations within the receiving environment. There are a number of farm dams that *could* obtain water via unlicensed extraction from the Copperfield River. Therefore this EV is considered applicable.
Stock watering (e.g. grazing cattle)	✓	The majority of the land use in the downstream receiving environment comprises cattle grazing. Cattle are able to directly access the river upstream and downstream of the proposed release location.

Environmental Value	Relevance to Copperfield River	Justification
Aquaculture	✓	Whilst this EV has been assessed and is potentially relevant to the larger catchment, it is not considered to be relevant to the receiving environment immediately downstream. The ephemeral nature of the Copperfield River catchment means that future use for aquaculture is highly unlikely.
Human consumption (e.g. of wild or stocked fish)	✓	As outlined in the site specific assessment contained in the IAR, there are a number of locations where the Copperfield River could be accessed.
Primary recreation (fully immersed in water e.g. swimming)	✓	As outlined in the site specific assessment contained in the IAR, there are a number of locations where the Copperfield River could be accessed. The most likely location for primary and secondary recreation is at the Einasleigh Gorge, approximately 44km downstream. Although outside the expected area of impact, this EV has been nominated as applicable to the receiving environment.
Secondary recreation (possibly splashed with water, e.g. sailing)	✓	
Visual appreciation (no contact with water, e.g. picnics)	✓	Visual appreciation is applicable downstream at Einasleigh in the Einasleigh Gorge. It could be applicable at possible access points.
Drinking water (raw water supplies taken for drinking)	✓	The closest location that could potentially extract water from the Copperfield River for potable supply is at the Oaks Homestead, 11.2km downstream from the proposed release point; however this has not been confirmed. There is no municipal water supply to Einasleigh township. Personal communications with Etheridge Shire Council on 16 May 2018 indicated that there are a number of unlicensed spears into the river in the vicinity of Einasleigh township; it is assumed that these could be used for domestic supply.
Industrial use (e.g. power generation, manufacturing, road maintenance)	✓	The only industrial user of water in the receiving environment is the Project and its co-located solar projects. There is a potential for industrial use in the Einasleigh township.
Cultural and spiritual values	✓	There are a large number of indigenous artefacts identified in the Copperfield River catchment. The Copperfield and Einasleigh Rivers were focuses of indigenous occupation of the area.

The EV for Aquaculture refers to commercial aquaculture operations that produce a multitude of aquatic species for human consumption. Currently there are no such ventures in the receiving environment for the operation, and the potential for such a venture is extremely low. Therefore parameters for Aquaculture will not be considered for the development of WQOs for the Project.

The ANZECC (2000) guidelines do not provide quantitative measures to protect cultural or spiritual values. Consideration is given to cultural and spiritual values of a watercourse by the development of site specific guideline values as recommended for aquatic ecosystem protection.

DRAFT

3.3 Guideline Values

3.3.1 Default Water Quality Objectives

The QWQG and EPP Water do not specify WQOs for the Gulf Rivers region or the Gilbert Basin. Instead they recommend the use of the ANZECC (2000) guidelines, cautioning that these values may not be appropriate for intermittent and ephemeral inland streams. In cases where more than one WQO is available for a particular parameter, the most stringent value from all EVs is applicable. As outlined above, the WQOs for Aquaculture (specifically referring to commercial aquaculture operations) have not been incorporated into the assessment of the lowest WQO from all EVs.

The simplified decision tree for assessing toxicants in ambient waters from the ANZECC (2000) guidelines was applied to select and refine WQO's for the Project. Figure 2 describes application of the decision tree.

Appropriate guidelines and trigger values (WQOs) were assembled for the applicable EVs that are outlined in Table 1. The default WQOs for the Project are provided below in Table 2.

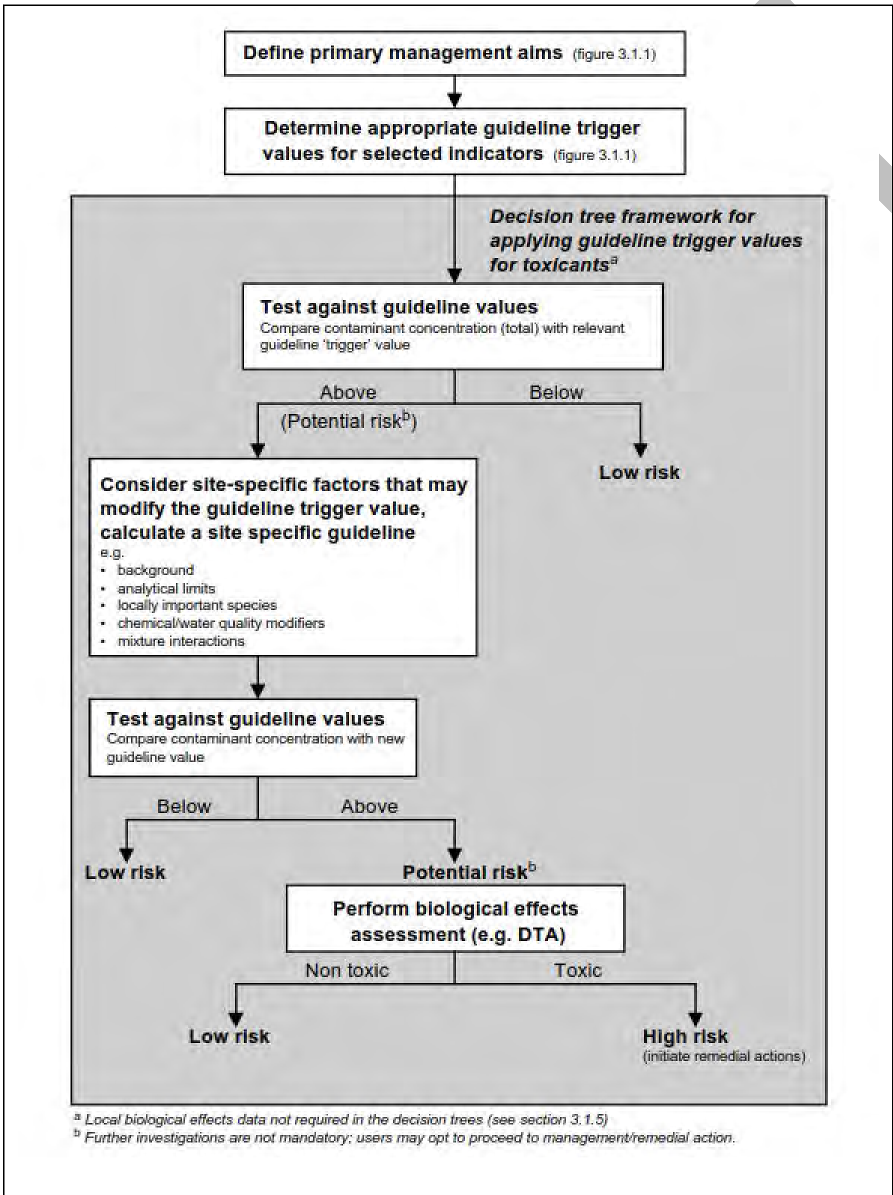


Figure 2 Simplified decision tree for assessing toxicants in ambient waters (from ANZECC (2000))

D R A F T

Table 2 WQOs adopted for the project

Parameter	Unit	LOR	Applicable WQO
pH value	pH unit	0.01	6.0 – 8.4*
Electrical Conductivity	(µS/cm)	1	500
Sulfate as SO_4^{2-}	mg/L	1	250
Aluminium (total)	mg/L	0.01	1.52*
Aluminium (dissolved)	mg/L	0.01	0.57*
Arsenic (total)	mg/L	0.001	0.01
Arsenic (dissolved)	mg/L	0.001	0.013
Cadmium (total)	mg/L	0.0001	0.002
Cadmium (dissolved)	mg/L	0.0001	0.0003*
Cobalt (total)	mg/L	0.001	0.05
Cobalt (dissolved)	mg/L	0.001	0.0028
Chromium (total)	mg/L	0.001	0.05
Chromium (dissolved)	mg/L	0.001	0.0017*
Copper (total)	mg/L	0.001	0.2
Copper (dissolved)	mg/L	0.001	0.003*
Manganese (total)	mg/L	0.001	0.1
Manganese (dissolved)	mg/L	0.001	1.9
Molybdenum (total)	mg/L	0.001	0.01
Nickel (total)	mg/L	0.001	0.02
Nickel (dissolved)	mg/L	0.001	0.019*
Lead (total)	mg/L	0.001	0.01
Lead (dissolved)	mg/L	0.001	0.0075*
Zinc (total)	mg/L	0.005	2*
Zinc (dissolved)	mg/L	0.005	0.014
Total Cyanide	mg/L	0.004	0.08
Iron (total)	mg/L	0.05	0.43*
Iron (dissolved)	mg/L	0.05	0.3
Chloride	mg/L	1	175*
Sodium	mg/L	1	115
Boron (total)	mg/L	0.05	0.5
Boron (dissolved)	mg/L	0.05	0.37
Barium (total)	mg/L	0.001	1.0
Beryllium (total)	mg/L	0.001	0.06
Beryllium (dissolved)	mg/L	0.001	0.00013
Mercury (total)	mg/L	0.00004	0.001

DRAFT

Parameter	Unit	LOR	Applicable WQO
Mercury (dissolved)	mg/L	0.00004	0.00005
Selenium (total)	mg/L	0.01	0.01
Selenium (dissolved)	mg/L	0.01	0.011
Uranium (total)	mg/L	0.001	0.01
Uranium (dissolved)	mg/L	0.001	0.0005
Vanadium (total)	mg/L	0.01	0.1
Vanadium (dissolved)	mg/L	0.01	0.006
Fluoride	mg/L	0.1	1
Ammonia as N	mg/L	0.005	0.5
Nitrate as N	mg/L	0.002	0.7
Nitrite as N	mg/L	0.002	1
Total N	mg/L	0.01	0.15
Total P	mg/L	0.005	0.01

[#] Low reliability trigger for 95% species protection as outlined in Volume 2 of ANZECC (2000)
* derived from a TDS concentration for cattle drinking water by using a conversion of EC to TDS = EC x 0.64
[1] Sourced from ANZECC (2000) Aquatic Ecosystem Guidelines for Upland & Lowland Rivers for Tropical Australia – Table 3.3.4
[2] Sourced from Table G.1 of the Queensland Water Quality Guidelines for the Gulf Rivers region (75th percentile value)
[3] A cyanide value of 0.007mg/L (as un-ionised hydrogen-cyanide) is recommended by the ANZECC (2000) guidelines. However the Leading Practice Sustainable Development Program for the Mining Industry publication on Cyanide Management (2008) states:

"Measurement of total cyanide values below 0.1 mg/L and Weak Acid Dissociable (WAD) cyanide below 0.05 mg/L present in mining related discharges may be unreliable and should be reported as 'less than' and not used for compliance purposes… The possible reasons for reporting measured levels of cyanide in surface waters or treated effluent needs to be taken into account when interpreting results of a monitoring program. The first is analytical error; the second is naturally produced cyanide excreted by plants, micro-organisms and insects; and the third is manufactured cyanide. Incorrect conclusions can easily be drawn, with potentially serious consequences if valid measurements are not used" pp 14

Following from these conclusions it is recommended that a total cyanide WQO of 0.1mg/L is set for the Project. If this value is exceeded further investigation may be warranted.

[4] The default WQO for beryllium (0.00013 mg/L) is below the standard LOR of 0.001 mg/L, therefore it is not possible to accurately assess concentrations against the WQO.

[5] There is no scheduled default physico-chemical stressor guideline value for nitrate in the Gulf Rivers region. There is currently insufficient data available to establish a site-specific value for nitrate and there is a lack of published data available for an adjacent similar catchment, therefore the ANZECC (2000) trigger value for the protection of 95% species is applied. Nitrate monitoring in the receiving environment will form part of the REMP in order to gather sufficient information to establish a site-specific WQO for nitrate.

3.3.1.1 Hardness Modified Trigger Values

The default trigger values outlined in Table 2 can be modified to account for water hardness. Hardness influences the biological uptake of toxicity of dissolved cadmium, chromium (III), copper, nickel, lead and zinc. Subsequently the above trigger values can be adjusted to allow for water hardness. Trigger values for these parameters should be adjusted for hardness based on the equations outlined in Table 3. HMTV's should only be calculated if the hardness in the water exceeds 25mg/L as $CaCO_3$.

Where a HMTV is calculated it should be recorded in the water quality database and an assessment on a sample by sample basis undertaken to determine if dissolved concentrations in the sample exceed the hardness modified trigger value.

Table 3 Equations to calculate hardness modified trigger values (from ANZECC, 2000)

Parameter	Equation
Cadmium	$TV * (Hardness / 30)^{0.89}$
Chromium (III)	$TV * (Hardness / 30)^{0.82}$
Copper	$TV * (Hardness / 30)^{0.85}$
Lead	$TV * (Hardness / 30)^{1.27}$
Nickel	$TV * (Hardness / 30)^{0.85}$
Zinc	$TV * (Hardness / 30)^{0.85}$

3.3.2 Sediment Quality Guidelines

Sediment trigger level and contaminant limits are based upon ANZECC/ARMCANZ (2013) Sediment Quality Guidelines and are presented, where present, for relevant parameters in Table 4. The recommended approach is to calculate the median background concentration and multiply this by a certain factor (typically two) (Simpson, Graeme, & Chariton, 2013). This approach is applied to EAs of mine sites throughout Queensland and allows site-specific concentrations of the above contaminants to be provided.

Where replicate samples are taken at a monitoring site, an exceedance is taken to be where the 95th percentile of the replicate samples exceeds the guideline value as outlined in Table 4. Where the replicate samples from an impact site are compared to replicate samples from a reference site, an exceedance is taken to be where the 95th percentile of the impact site exceeds the maximum at the reference site.

Table 4 Trigger levels and contaminant limits for stream sediments

	Units	Trigger Level~	Contaminant Limit
Arsenic	mg/kg	20[1]	70[2]
Cadmium		1.5[1]	10[2]
Chromium		80[1]	370[2]
Copper		65[1]	270[2]
Lead		50[1]	220[2]
Mercury		0.15[1]	1.0[2]
Nickel		21[1]	52[2]
Zinc		200[1]	410[2]
Other Parameters	As relevant	Where there is no guideline provided specifically, the trigger level is to be the value of the reference site and the contaminant level is to be three times the value at the reference site.	

~ Trigger values can be those found in this column or the value from the reference site, whichever is higher

Contaminant limits can be the values found in this column, or three times the reference value, whichever is higher

D R A F T

[1] Value from "Revision of the ANZECC/ARMCANZ Sediment Quality Guidelines (Simpson, Graeme, & Chariton, 2013) "Guideline Value"
[2] Value from "Revision of the ANZECC/ARMCANZ Sediment Quality Guidelines (Simpson, Graeme, & Chariton, 2013) "SQG-High"

3.4 Summary of Receiving Environment

The following summary of the receiving environment is presented from the IAR for the K2H Project:

Surface Water Quality

- EVs for the Gilbert River basin have not been defined under the EPP Water. In this instance, the EPP Water prescribes the application of all default EVs. EVs have been described for the Copperfield River over a 44km stretch downstream from the former Kidston mine site to the confluence of the Einasleigh River.
- Macroinvertebrate data supports the distinction of a 'Slightly Disturbed' aquatic ecosystem condition under the EPP Water. The management intent for this water type is to gradually improve water quality and to aim to achieve a HEV waterway classification, however HEV WQOs may not be achievable in the Copperfield River as there are a number of regionally based negative influences on water quality.
- The QWQG and EPP Water do not specify WQOs for the Gulf Rivers region or the Gilbert Basin. Instead they recommend the use of the ANZECC (2000) guidelines, cautioning that these values may not be appropriate for intermittent and ephemeral inland streams. In cases where more than one WQO is available for a particular parameter, the most stringent value from all EVs is applicable. Where applicable, site-specific trigger values were derived based on the upstream dataset for monitoring location WB. HMTVs were developed for the area in the immediate vicinity of the release point, using the median baseline hardness values at monitoring location W2.
- Some anomalies in the receiving environment water quality datasets were noted and led to the exclusion of samples collected prior to 2012 (providing an adequate dataset size for analysis of 40 to 60 samples). Ongoing monitoring is recommended for parameters with limited dataset sizes.
- The baseline assessment indicated that a number of parameters are elevated above WQOs in the receiving environment. Monitoring site W2 has indicated potential impacts from seepage.

Hydrology

- In the absence of stream gauging, hydrological modelling was used to undertake a flow spells analysis which showed a definite seasonal distribution with a distinct high flow season occurring from December through April.
- Cease to flow conditions (less than 1 ML/d) are present on approximately 55% of all days for any day and reduce to approximately 32% during the wet season (November through April).

Hydrogeology

- The groundwater flow regime of the Project has been modified by the construction of the tailings dam, interception drains, and by dewatering of the two pits. In their current state, Wises Pit and Eldridge Pit are both understood to function as groundwater 'sinks', as groundwater levels in the surrounds of both pits are higher than the surface water level in the pits.
- One confirmed wetland spring, Middle Spring, lies within the vicinity of the mine area. This spring is located west-northwest of the former mine and is not considered to be hydraulically connected to the groundwater regime of the proposed release area.

Sediment Quality

- The braided nature of the Copperfield River results in sediment transport that is limited to a few months per year during the wet season when discharge is high enough. Very little fine sediment is stored in the channel bed in the upper to mid catchments.

- Sediment samples have been collected annually between 2009 and 2013. No whole-sediment samples exceeded the SQG, indicating that sediment within the Copperfield River is considered to be unaffected by the historical mining processes. Although the <0.063 mm samples reported a number of SQG exceedances, this fraction is considered less useful for comparison to guideline values.
- For toxicants in the <0.063 mm fractions, exceedances reported around the potential release sites (e.g., W1 and W2) are also reported in the upstream and downstream monitoring sites (e.g., WB and W3, respectively) suggesting that there are no widespread impacts from historical mining activities evident within the Copperfield River and that the concentrations of metals found are a result of the overall catchment drainage. Additional sampling and monitoring is recommended in accordance with the REMP.

Aquatic Ecology

- The macroinvertebrate assessment determined that communities inhabiting the Copperfield River both upstream and within the receiving environment are in good condition. AusRivAS modelling determined that assemblages at some locations were considered to be significantly impacted. However these scores may be typical of the region and PET scores and taxa richness determined sensitive taxa were well represented.

Dry Season Survey

- Six semi-permanent waterholes were identified within the floodplain of the Copperfield River through a drone flyover in September 2018. These waterholes were sampled in late September 2018, along with monitoring locations W1 and W3.
- Previous significant rainfall in the catchment occurred in March 2018, therefore the water in the pools is assumed to have been standing for a long duration and were likely subjected to evapo-concentration.
- Total manganese, total iron, total nitrogen and total phosphorus recorded results above their respective WQOs both upstream and downstream of the proposed release point.
- A comparison against the long-term (post 2011) dataset for W1 and W3 did not indicate any clear trends with regards to water quality.

4.0 Monitoring Program Design

The aims of the monitoring program are to detect changes to the natural environment downstream of the K2H project as a result of controlled releases. The following sections outline requirements for the following types of monitoring to achieve this aim:

1. Water quality;
2. Sediment;
3. Biological,
4. Flow, and
5. Groundwater.

An overview of the monitoring program for the Project, including monitoring locations and frequencies is presented in Appendix A. Further detail regarding methodologies and parameters for water quality, sediment, biological monitoring and flow is presented in Sections 4.1, 4.2, 4.3, 4.4 and Section 4.5 respectively.

Monitoring locations and sampling regimes (Appendix A) have been designed to appropriately monitor environmental variables from areas upstream of any impact from historical mining activities, as well as near-field and far-field monitoring. Sample locations have been added downstream beyond the historical REMP monitoring locations to evaluate potential impacts to the Einasleigh River as a result of water releases from the Project. Water quality is to be monitored at the Einasleigh Gorge in order to record water quality trends in this location.

4.1 Water Quality Monitoring

4.1.1 Routine Sampling Locations and Frequency

Water quality sampling locations and frequencies are listed in Appendix A.

4.1.2 Field Quality Control

The collection of quality control samples is essential in order to provide confidence in the results of a sampling program, and is part of the overall quality assurance program. Quality control samples are listed in Table 5.

Table 5 Quality Control Samples

Quality Control Sample	Number of quality control samples to be collected	Notes
Rinsate/Equipment Blank	One per field team per trip	The equipment blank assesses the potential for cross contamination of samples due to insufficient decontamination of sampling equipment.
Duplicates	One per 10 samples	Assesse the precision of results within a laboratory and between laboratories.

Source: Adapted from DES 2018

4.1.3 Sampling Equipment

- Field meter capable of reading pH, EC, temperature, TDS, turbidity and dissolved oxygen. ORP is preferential but not required;
- Sample bottles;
- Extendable sampling pole;
- Field filters for metals;
- Laboratory equipment;

DRAFT

- Adequate field sheets;
- Rinsate for field blanks;
- Deionised water for decontamination;
- Disposable nitrile gloves.

4.1.4 Water Quality Monitoring Parameters and Limits of Reporting

Each water quality sample should be analysed for the parameters listed in Table 6 and at the Limit of Reporting (LOR) specified.

Table 6 Water quality monitoring parameters and limits of reporting

Parameter	Units	LOR
Physico-Chemical		
pH (field + laboratory)	pH	0.1 pH units
EC (field + laboratory)	µS/cm	1 µS/cm
Total Suspended Solids (laboratory)	mg/L	5 mg/L
Turbidity (field + laboratory)	NTU	0.1 NTU
Dissolved Oxygen (field)	mg/L and % saturation	
Redox Potential (field)	mV	0.1 mV
Temperature (field)	^{o}C	0.1 ^{o}C
Cations / Anions		
Calcium	mg/L	1 mg/L
Magnesium		1 mg/L
Sodium		1 mg/L
Potassium		1 mg/L
Sulfate as SO_4		2 mg/L
Chloride		1 mg/L
Alkalinity		1 mg/L
Hardness		1 mg/L as $CaCO_3$
Fluoride		0.1 mg/L
Metals (total and dissolved)		
Aluminium	mg/L	0.01 mg/L
Arsenic		0.001 mg/L
Barium		0.001 mg/L
Beryllium		0.001 mg/L
Boron		0.001 mg/L
Cadmium		0.0001 mg/L
Chromium		0.001 mg/L
Cobalt		0.001 mg/L
Copper		0.001 mg/L
Manganese		0.001 mg/L
Mercury#		**0.00006 mg/L#**

DRAFT

Parameter	Units	LOR
Nickel		0.001 mg/L
Lead		0.001 mg/L
Selenium		0.01 mg/L
Vanadium#		**0.006 mg/L**#
Uranium#		**0.0005 mg/L**#
Zinc#		**0.002 mg/L**#
Iron		0.05 mg/L
Nutrients		
Total Phosphorous	mg/L	0.01 mg/L
Organic Nitrogen as N		0.01 mg/L
Total Nitrogen		0.01 mg/L
Ammonia as N		0.01 mg/L
Nitrate		0.01 mg/L
Nitrite		0.01 mg/L
Other		
Dissolved Organic Carbon	mg/L	1 mg/L
Cyanide - Total		0.004 mg/L
Cyanide – Free		0.004 mg/L
Total Organic Carbon		1 mg/L
Chlorophyll a	mg/m^3	1 mg/m^3

These parameters require “ultra-trace” analysis to reach the recommended LOR. This will require larger sample containers and higher volumes of water and must be specifically marked on the Chain of Custody (COC) form.

4.1.5 Sampling Method

The following methodology should be employed to collect all in situ and grab water samples (Barrack Australia, 2013):

1. Ensure that the field meter is appropriately calibrated before starting fieldwork. Calibrate to manufacturer’s specifications and maintain a calibration record.
2. Upon arrival at a sample site, turn on the field meter and place the probes in the stream, pond etc. to be sampled. This will allow the probes to equilibrate with the sample conditions while performing the other sampling tasks. Once having completed all other sampling tasks and just prior to leaving the site, record the readings from the field meter.
3. Using a new pair of disposable nitrile gloves, open the zip-lock plastic bag containing the sample bottles and write the necessary details on the bottle label.
4. While still wearing the disposable nitrile gloves and using the green labelled 1L plastic sample bottle, without removing the lid submerge the bottle into the stream or pond to a depth of approximately 10-15 cm (half-way up the forearm). Facing upstream, to ensure the bottle is upstream of your body or any disturbance caused to the stream bottom by your presence. Open the lid with your free hand, allow the bottle to fill and then close the lid whilst still under water. Withdraw the sample from the water.

5. The same procedure in Step 3 is to be followed with the 50ml red/green bottle for “total” metal analysis. However, using a permanent ink marking pen, place a “tick” in the “Total Metals” box on the red/green sample bottle label.
6. The following sample bottle types contain preservative chemicals and or have been specially treated and must not be used as in Step 3:
   a) 50ml red/green sample bottle for “filtered” (dissolved) metal analysis;
   b) 250ml blue sample bottle for cyanide analysis;
   c) 50ml blue sample bottle for chromium analysis;
   d) 50ml clear sample bottle for arsenic analysis.
7. If one of the bottle types from (b) to (d) listed in Step 5 is required, while still wearing the disposable plastic gloves, remove the lid from the bottle and place it thread facing up on the ground (to avoid any soil/sediment etc. entering the bottle when the lid is later replaced). With the sample collected in the green labelled 1L plastic sample bottle from Step 3, carefully fill the bottle to nearly full but ensuring that the bottle does not overflow. Since bottle types from (b) to (d) listed in step 5 have various chemical preservatives added, if the lids from these bottles are swapped this will introduce gross contamination. Ensure that the correct lid from each bottle is used when being replaced.
8. After filling any necessary bottles, Step 3 is to be repeated with the green labelled 1L plastic sample bottle.
9. For “dissolved” (“filtered”) metal analysis , while still wearing the disposable nitrile gloves, with a new 50ml plastic syringe:
   a) Submerge the syringe into the stream or pond to a depth of approximately 10-15 cm (half-way up the forearm). While facing upstream, ensuring the syringe is upstream of your body or any disturbance caused to the stream bottom by your presence, draw back the plunger to fill the syringe. Remove the syringe from the stream or pond and dispose of the sample downstream.
   b) Repeat this twice to ensure the syringe has been thoroughly rinsed.
   c) With a syringe full of water sample as per step 7a, rinse the outside of the syringe and your gloved hands with rinse water. Then gently shake the syringe and your gloved hands to remove as much adhering water droplets as possible. This is to ensure no unfiltered droplets of water containing sediment/soil are accidently allowed to enter the 50ml red/green sample bottle for “filtered” metal analysis.
   d) Remove a 0.45μm filter disc from the wrapper and attach the filter disc to the bottom of the syringe prepared in step 7b. Press the plunger to filter the sample allowing the first approximately ten (10) drops to be discarded onto the ground. Filter the remaining volume in the syringe into the 50ml red/green sample bottle for “filtered” (dissolved) metal analysis. The syringe/filter disk is then discarded (do not reuse between sites).
   e) Using a permanent ink marking pen, place a “tick” in the “Dissolved Metals” box on the red/green sample bottle label.
10. Once all the necessary bottles have been filled, each is to be externally washed with rinse water to ensure any adhering soil or sediment is removed. Gently shake to remove as much adhering water as possible, and then return to the sample bottle to zip-lock plastic bag.
11. The samples are to be sent to a National Association Of Testing Authorities (NATA) Australia accredited laboratory in an iced plastic sample esky for analysis as soon as possible after collection.

For each sampling event, a photographic record of the following should be taken:

1. Upstream of the sample point;
2. Downstream of the sample point;

3. Any erosion present at the sample point;
4. Significant aquatic and riparian vegetation or noted changes in vegetation at the sample point; and
5. Anything else that is observed to potentially contribute to the water quality conditions at the site.

Once the parameter readings have stabilised they should be recorded on a field sheet, along with the following information:

- Site name;
- Brief site description (e.g. location and obvious environmental elements);
- Date and time of sampling;
- Weather at the time of and preceding sampling;
- General site observations including presence of weeds, animal tracks, site degradation and environmental health;
- The presence and / or state of any inflows or outflows to the site;
- Estimated maximum depth and width of the water body/watercourse at the point of sampling;
- Depth at which the parameters were recorded;
- Appearance of the water, including water clarity and colour;
- Water odour; and
- Substrate material at the site.

4.1.6 Data Handling and Reporting

Upon receipt of samples from the laboratory, the following methods should be employed:

1. If quality characteristics of any downstream samples exceed the WQOs specified in Table 2, compare downstream results to the upstream results, and:
   a. Where the downstream results are lower than the upstream results, no action is to be taken
   b. Where the downstream results are higher than the upstream results, notify the administering authority within 24 hours of receipt of the results; AND
   c. Complete an investigation into the potential for environmental harm and provide a written report to the administering authority within 90 days of receiving the result, outlining:
      i. Details of the investigation carried out;
      ii. Actions taken to prevent environmental harm.

4.2 Sediment Monitoring

4.2.1 Initial Sediment Investigation

Existing sediment quality data suggests that levels of zinc and arsenic in the <0.063mm fraction are elevated above trigger values in the receiving environment at W1 and W2, and that other metals are elevated at multiple sites including the upstream monitoring site (AECOM, 2018).

An initial stream sediment investigation is proposed to be undertaken prior to the commencement of the Project to characterise the metal concentrations and behaviour in the Copperfield River prior to the commencement of releases.

There is inherent variability in sediment sampling results, particularly in metals analyses. Subsequently the aims of this initial investigation are to:

- Undertake sufficient sediment sampling for suitable parameters and analyse the <0.063mm fraction;
- Undertake sufficient replication of samples to characterise a 'true' sediment level and remove uncertainty regarding variability of results arising from the nature of stream sediment sampling; and,
- Characterise elements that may be above trigger and contaminant limits from upstream sampling sites.

This initial study should collect at least five (5) replicate samples from each monitoring site using the collection methods outlined in Section 4.2.3. Sample locations are identified in Appendix A.

Each sample should be separated into a <0.063mm fraction and a <2mm fraction and each fraction analysed for the parameters outlined in Table 7 by a NATA accredited laboratory. Samples should be taken in the dry season prior to the onset of the wet season when the majority of waterholes have dried up.

The aim of the initial sediment study is to characterise variability of concentrations in sediment from replicate samples, to determine if there is a consistent trend found at each site, or whether there is inherent variability in the sediment results. The outcomes of the initial sediment study will govern whether replicate samples are required for ongoing sediment monitoring. In addition the replicate sediment study will also aim to determine the pre-existing concentrations in sediment along the Copperfield River before releases commence.

4.2.2 Routine Sampling Locations and Frequency

Sediment sampling locations and frequencies are listed in Appendix A. Samples should be taken from areas of fine sediment deposition. This can include scour holes or at the upstream or downstream end of naturally occurring waterholes. Sediment samples should always be targeted in the mobile-bed of the river in sediment has recently been deposited. Sediment samples should not be obtained from areas where there has been no sediment movement in years.

4.2.3 Sampling Method

Field sampling for sediments will be undertaken in accordance with the Sediment Quality Assessment Guidelines as well as the Australian Standard (AS/NZS 5667.12:1999). A plastic (HDPE or PTFE) sampling trowel will be used to scoop sediments into a suitable sample container ready for sieving. At least 2kg of sample will be collected prior to sieving.

There is significant risk that the samples submitted to the laboratory will not have enough volume to analyse the <0.063mm fraction. If the NATA accredited laboratory does not have enough volume to analyse the <0.063mm fraction, the laboratory LOR will be artificially raised. Instructions on handling laboratory results with artificially raised LORs are provided in Section 4.2.5.

Sediment samples are to be collected from the top 0.3m of sediment on the bed using a plastic trowel. Sediment sampling locations should target areas of fine sediment, such as at the downstream end of scour holes or depressions within the bed. Sampling is to target newly deposited sediment whereever possible. The location of the sediment sample should be recorded and photographed and effort should be made to take future samples from the same location in order to determine changes over time.

A photographic record of the monitoring location will be taken during each sampling event, including upstream, downstream and the actual sample site.

4.2.4 Field Quality Control

As specified in DES 2018, one duplicate sample should be collected per 20 samples (minimum of one per field trip).

4.2.5 Sediment Quality Monitoring Parameters and Limits of Reporting

As discussed above, each sample should be sieved to <0.063mm and <2mm fractions. Each fraction should be analysed for the parameters outlined in Table 7.

Following the collection of five years of sediment quality data post releases, the data will be evaluated. If any of the monitored parameters have not been recorded at levels above the LOR for more than 80% of the record, and the concentrations of those parameters do not exceed trigger levels, SQG-High or reference site concentrations, they can be removed from the analysis.

Table 7 Sediment quality monitoring parameters and limits of reporting

Parameter	Units	LOR (for both the <0.063mm fraction)
Physical Parameters		
Particle Size Distribution	%	1
pH	pH units	0.1
Cation Exchange Capacity (CEC) including exchangeable aluminium	mg/kg	1
Total fluoride	mg/kg	1
Sulfate – Total as SO4	mg/kg	1
Metals		
Aluminium	mg/kg	50
Arsenic	mg/kg	5
Barium	mg/kg	10
Beryllium	mg/kg	1
Boron	mg/kg	50
Cadmium	mg/kg	1
Chromium	mg/kg	2
Cobalt	mg/kg	2
Copper	mg/kg	5
Nickel	mg/kg	2
Manganese	mg/kg	5
Mercury	mg/kg	0.1
Lead	mg/kg	5
Selenium	mg/kg	5
Vanadium	mg/kg	5
Zinc	mg/kg	5

Parameter	Units	LOR (for both the <0.063mm fraction)
Other		
Cyanide - Total	mg/kg	1
Total Nitrogen	mg/kg	20
Total Phosphorous	mg/kg	2

4.3 Biological Monitoring

4.3.1 Routine Sampling Locations and Frequency

Biological monitoring locations and frequencies are listed in Appendix A.

4.3.2 Aquatic Habitat and Flora

Aquatic ecology can be greatly influenced by habitat factors at the time of sampling. For this reason a detailed habitat assessment will be undertaken at each site where macroinvertebrate sampling or sampling for higher-order aquatic fauna is undertaken. The habitat assessment will be undertaken in accordance with the AusRivas methodology (DNRM, 2001). Care must be maintained to sufficiently describe the bed and edge habitat separately as well as any gradients between the two.

The habitat assessment will focus on rating:

- Bottom substrate / available cover;
- Embeddedness;
- Velocity / depth category;
- Channel alteration;
- Bottom scouring and deposition;
- Pool / riffle, run/band ratio;
- Bank stability;
- Bank vegetative stability;
- Streamside cover.

The condition of the above elements is to be scored in accordance with the Queensland AusRivas Sampling and Processing Manual. For each site, each element above must be scored either as “Poor”, “Moderate”, “Good” or “Excellent” and provided a score in accordance with the AusRivas Sampling and Processing Manual. The score of each element is then added to provide an overall habitat assessment score for each site to allow comparison.

4.3.3 Macroinvertebrate monitoring

The composition and abundance of macroinvertebrates is a key indicator of the health of aquatic ecosystems. There are various methods to sample and analyse macroinvertebrates. In ephemeral environments the life-history strategies of aquatic fauna have evolved in response to seasonal flow regimes. Therefore the timing of rainfall, floods and the persistence of pools are the main driving forces for macroinvertebrate community composition and abundance.

There are two methods nationally used for collecting aquatic macroinvertebrates. Both methods involve sampling a defined length of habitat using a dip net. However the samples that are collected can be live picked, or stored for laboratory picking of the sample. This method has been used throughout Queensland to set WQOs for various macroinvertebrate indices and is suitable for comparison of sample results to these WQOs.

As outlined in the 2018 Aquatic Ecology Study (C&R Consulting, 2018) there are no WQOs defined for the Gilbert River catchment. Instead the initial aquatic ecology characterisation of the area compared macroinvertebrate indices to those from the Central Queensland region given that the geomorphology and aquatic habitats in the Copperfield River are similar to those in Central Queensland. This approach is not sufficient for ongoing monitoring of potential impacts from the Kidston project.

The approach for ongoing macroinvertebrate monitoring of the Kidston Project is to undertake quantitative analysis of macroinvertebrate samples. This involves field collection of macroinvertebrates in accordance with the AusRivas method but excludes live picking of macroinvertebrates in the field. Instead all macroinvertebrates collected are preserved and sent for laboratory analysis. This allows quantitative analysis of the sample and comparison between sample sites using multivariate analyses.

The field picking method as outlined by AusRivas is not quantitative as it does not identify and quantify all individuals in the sample; instead the results are used in a presence-absence AusRivas model to broadly indicate ecosystem health. Laboratory picking involves transport of the entire sample to a laboratory for identification of all collected macroinvertebrates. Mutlivariate analysis is then undertaken on the results and the similarity of sample sites can be quantitatively defined. This approach is preferred for the detection of impacts from point source pollution (Smith, Jeffree, John, & Clayton, 2004). Downstream sites are compared to upstream sites, rather than all sites being compared to regional WQOs (which, for the Kidston site, may not be representative as the WQOs are for Central Queensland).

4.3.3.1 Quantitative Macroinvertebrate Sampling Methodology

Three replicates of edge habitat and three replicates of bed habitat samples will be collected using the following methods which are broadly in accordance with AusRivas protocols, but modified for the quantitative macroinvertebrate analysis technique.

In areas of fast flowing water

- Use a surber sampler with an area of 0.3m by 0.3m and fitted with 250µm mesh.
- Disturb the 0.3m by 0.3m area to a depth of 5cm for a total of 5 seconds and then sweep the 250µm mesh through the disturbed area 5 times.

In areas of slow flowing water or still water

- Place a 0.3m by 0.3m quadrat and disturb the area to a depth of 5cm.
- Sweep a standard 250µm triangular mesh through the disturbed area 5 times.

Following Sample Collection

- Preferably wash all samples collected through nested sieves (8mm and 250mm) to remove excess organic matter and detritus. However this will be at the discretion of the sampler. It should be noted whether this was conducted within the reporting.
- Transfer the sample to screw top jars and preserve with 70% ethanol for laboratory analysis.
- Laboratory analysis is to identify all individuals to the family level taxonomic level consistent with AusRivas taxonomic resolution. The exception is the microcrustacean taxa (Cladocera, Copepoda, Ostracoda).

Each replicate should be collected from a homogenous macrophyte habitat with greater than 50% cover at all sites for edge habitat to reduce false positives in impact detection as a result of different habitat characteristics. Generally edge and bed habitat sample replicates should be taken from the same location each year. Variations can be added from year to year based on changing habitat conditions such as macrophyte cover. As the Copperfield River is braided, macroinvertebrate samples should be collected from the braid that is known to contain release waters in all near-field sites. Specific sample locations at upstream monitoring sites should target the braid which will receive release water. Far-field sites should be sampled in the same manner year after year (i.e. the same number of replicates should be collected from the same side of the bank as the previous year).

4.3.3.2 Coincident Macroinvertebrate and Water Quality Analysis

Water quality analysis should occur at the same time as macroinvertebrate monitoring. If scheduled, routine water quality samples (as scheduled in Appendix A) are not gathered at the same time as macroinvertebrate monitoring, water quality samples should be collected and analysed for the following parameters:

Table 8 Minimum water quality analyses to be undertaken with macroinvertebrate monitoring

Grouping	Parameter	Units
In-Situ water quality parameters (field meter)	pH	pH unit
	Electrical conductivity	μS/cm
	Turbidity	NTU
	Dissolved Oxygen	mg/L and % saturation
	Temperature	^{0}C
Cations/Anions (laboratory analysis)	Sulfate as SO_4	mg/L
	Calcium	mg/L
	Magnesium	mg/L
Total and dissolved metals	Aluminium	mg/L
	Copper	mg/L
	Iron	mg/L
	Manganese	mg/L
	Lead	mg/L
	Uranium	mg/L
	Zinc	mg/L

4.4 Flow

Continuous (i.e. 15 minute intervals) flow monitoring will be undertaken in the Copperfield River upstream (at monitoring site US1) and downstream of the proposed release location (at monitoring site DS1). The monitoring station and associated equipment will be maintained and calibrated in accordance with manufacturer's instructions. A rating curve for the gauge will be established and regularly updated. In situ water quality parameters including temperature, pH, EC and DO will also be continuously measured at the stations.

4.5 Groundwater

The Copperfield River, at the proposed release area, drains through Quaternary alluvial sediments which directly overlie the Einasleigh Metamorphics.

The alluvial sediments (comprising clay, silt, sand, and gravel) extend laterally from the river bed as flood-plain alluvium. Drilling indicates limited thickness of alluvial sediments within the Copperfield River, some 5 to 6 m. The Einasleigh Metamorphics, predominantly biotite gneisses, outcrop adjacent to, and in some sections within, the Copperfield River.

Regional groundwater flow within the alluvium is considered to mimic the topography of the Copperfield River and subsequent flow direction, generally north. The hydrological regime of the Copperfield River is ephemeral; flows are highly episodic and likely sustained only during and immediately after significant rainfall events and the wet season. The locations of semi-permanent waterholes within the floodplain of the Copperfield River were identified through flyover with a drone by Genex in September 2018. Six locations were identified. Standing water was present at long term monitoring points W1 and W3 as well.

The majority of waterholes found were minor remnant pools occurring in-channel. Only two substantial pools were noted downstream of the Project site (Pond 5 near W3 and the Sandy Creek site). These two pools have the potential to persist year round, providing refuge to aquatic fauna. The longevity of these pools would be highly correlated with the hydrology of the system on a yearly basis.

The presence of semi-permanent pools suggests the river is, at least for some parts of the year, fed by groundwater discharge. The fact that the pools do not persist throughout the year indicates that the

D R A F T

groundwater source aquifer (likely the alluvium in the surrounds of the river) has limited storage. Groundwater inflows to the river are potentially sourced from surface water that has infiltrated the alluvium when the river is in flood.

Limited hydrochemistry data for the alluvium associated with the Copperfield River is available. Groundwater quality monitoring data provided by Genex was assessed and bore reports from the DNRME registered GWBD were interrogated for groundwater quality data in proximity to the proposed release area.

Two registered bores are reported to be constructed to intersect the floodplain alluvial sediments of the Copperfield River, RN139937 (BA06) and RN139938 (BA07) located adjacent to the mine pits and north and south of the proposed release area.

The available groundwater quality data for these bores, provided by Genex, comprises monitoring from October 2008 through October 2017, which includes some seasonal variability (wet and dry season monitoring) and spatial variability.

- The available data from monitoring bore BA06 indicates magnesium/calcium-sulphate-rich water quality. Sulphate concentrations have varied throughout the monitoring period but generally ranged between ~ 2,500 and 3,000 mg/L, although a marked increase was observed in January 2017, to ~ 5,000 mg/L.
- The available quality data for monitoring bore BA07 indicates a greater proportion of dissolved sodium and chloride, and lower dissolved sulphate concentrations (< 1,000 mg/L) than bore BA06. The January 2017 sulphate ‘spike’ observed in BA06 was also observed in water quality from BA07 sampled on the same date; however, sulphate concentrations reported subsequently decreased in both bores (to < ~ 1,000 mg/L). Electrical conductivity trends mirror sulphate concentrations.

Samples from both bores record relatively high alkalinity (~ 200-500 mg/L) and pH has remained consistently between 7 - 8 for both bores throughout the monitoring period. Recorded dissolved metal concentrations are generally at or below laboratory LOR in samples from both monitoring bores.

The location of BA07 (just east and down topographic gradient from the former mine pits) and the marked variation in water quality from bore BA06, suggest that seepage from the former mine area may be acting as artificial recharge to the alluvial sediments in proximity to the proposed release area.

Monitoring of these two bores (BA06 and BA07) is to occur as part of the REMP to quantify any linkages between the pits and the Copperfield River. The locations of these bores as well as monitoring frequencies are found in Appendix A.

4.5.1 Sampling Methods

4.5.1.1 Water Level Monitoring

Sampling should be undertaken in accordance with the following method:

1. Assess the monument and/or casing and cap for any signs of damage or changes.
2. Open the monument or remove the casing and cap.
3. Use a water quality dipper such as a Solinst Water Level Meter. Turn it on and gently lower the probe into the water column. Take care to prevent the tape from rubbing on the edge of the casing or monument as this will make it fray and can disrupt the electrical signal used to indicate water.
4. Once the alarm sounds, gradually raise the probe again until the alarm stops. Lower again slowly until the alarm sounds to record the water level.
5. Enter the Standing Water Level from the reference location (top of casing) into the field sheet.
6. If no further monitoring is to take place, ensure the cap is placed tightly back on the bore casing.

This is to be undertaken prior to any groundwater sampling to record the standing water level prior to disturbance.

4.5.1.2 Groundwater quality sampling

Groundwater quality sampling is to be undertaken with *Groundwater Sampling and Analysis – A Field Guide* (Geoscience Australia, 2009). Generally there are two different methods to sample bores, including:

- Bore purge method;
- Low flow sampling.

Please refer to the latest copy of the above document for further information regarding sampling using these methods. The choice of method will be at the discretion of the sampler. However, once a bore is sampled using one method, future samples should also use the same method to provide as consistent results as possible.

Water quality samples cannot be collected using either method until field parameters have reached stabilisation limits. The stabilisation limits are provided in Table 9. Three consecutive samples, taken at least 2 minutes apart, must be within the tolerances outlined in Table 9 until sample bottles for laboratory analysis can be filled.

Table 9 Stabilisation parameters for low flow sampling

pH	ORP	EC	DO	Temperature
± 0.1	± 10mV	± 5%	± 10%	± 0.2 degree

4.5.2 Sample Parameters

All groundwater samples should be analysed for the parameters outlined in Appendix A to provide as consistent results as possible.

D R A F T

5.0 Data Interpretation

5.1 Overview

All data collected for the REMP is to be analysed and discussed in an annual REMP Assessment Report to be submitted in October of each year. The REMP Assessment Report will review all data collected for the receiving environment and assess against current triggers and guidelines. The REMP Assessment Report will also determine whether the current release regime is suitable and will outline what impacts are occurring in the receiving environment.

5.2 Water Quality

5.2.1 Values below the Limit of Reporting

Values that are returned from the laboratory below the LOR should be transformed to 50% of the LOR. For example, a value of <0.001 mg/L becomes 0.0005mg/L.

5.2.2 Data Requirements for Background Data

The QWQG 2009 provides a framework for developing locally relevant WQOs. Background data can be used if samples are collected from a suitable location and there are enough samples collected over a relevant time period. It is preferable to have 18 samples over 24 months. (Claus, Dunlop, & Ramsay, 2017). Until minimum data requirements have been established, comparison of test site medians should be made with reference to the default guidelines. A discussion of the water quality monitoring sites and data suitability is outlined below.

5.2.3 Assessing compliance with WQOs

Compliance assessment is not as simple as comparing individual water quality samples to the WQOs listed in Table 2,. The method to assess whether a WQO has been exceeded depends on the parameter type. These are summarised below (for Slightly to Moderately Disturbed waters):

- **Physical and chemical stressors**[2]

  Trigger values are exceeded when the median of at least 8 samples (preferably 24 collected over a 2 year period) at a test site exceed the WQO. Or if suitable background data exist, when the median of the 8 to 24 samples exceeds the 80th percentile of the reference site (from the same number of samples), the trigger investigation level is exceeded (ANZECC (2000) Guidelines, Section 7.4.4.1).

- **Toxicants**[3]

  A trigger value is exceeded when the 95th percentile of the test distribution exceeds the default value; no action is triggered if 95% of all values fall within the default WQO.

  If background data exists, compare the 80th percentile of background data (calculated over at least 10 to 24 samples gathered over the previous 24 months) to the default WQO. If the 80th percentile exceeds the WQO, then the 80th percentile becomes the new WQO and exceedance occurs if the running median (from the same period of samples) of the test site exceeds the running 80th percentile of background data. (EHP, 2013).

Statistical measures (medians, 80th percentiles, 95th percentiles) should be calculated from the most recent 10 to 24 samples. Where an exceedance of the default WQO applies, the entire dataset should be investigated in further detail.

With reference of comparison of site data to ANZECC (2000) WQOs for Aquatic Ecosystems it is important to note that Section 3.4.3.2 of the ANZECC (2000) guidelines states:

---

[2] Includes nutrients, biodegradable organic matter, dissolved oxygen, turbidity, suspended particulate matter, temperature, salinity, pH.
[3] Includes ammonia, heavy metals and other toxic compounds

D R A F T

"… Comparison of total concentrations will, at best, overestimate the fraction that is bio-available. The major toxic effect of metals comes from the dissolved fraction so it is valid to filter samples (e.g. to 0.45µm) and compare the filtered concentration against the trigger value" (pp 3.4-15)

Site data from 'filtered' samples are compared to default WQOs for Aquatic Ecosystems; however, if the WQO is sourced from an alternate EV (such as recreation or cattle drinking etc.) the 'total' concentration from site data is compared.

5.2.4 Dissolved and Total Metals

A comparison should be made between dissolved and total concentrations of metals in each sample. Where the dissolved concentration exceeds the total concentration, the laboratory should be queried for possible reasons.

If the dissolved concentration is greater than the total, the following checks will be undertaken:

1. Assess the precision of the method and compare concentrations in duplicate samples.
2. Check total suspended solids concentrations. If concentrations are low, this indicates that total and dissolved concentrations will be the same or very similar.
3. If the results of Steps 1 and 2 above are inconclusive, ask the laboratory to check their results.

5.2.5 Data Analysis

Water quality test site results will be compared with both WQOs and control site water quality. As a minimum, a condition assessment will be conducted over an annual cycle to allow sufficient time to gather data for statistical analysis over various flows (base flow and high flow) and to take into account seasonal periods. Any raw data used in the analysis will also be included in the reporting, along with suitable reporting statistics (e.g. 20th, 50th, 80th, 95th percentiles).

Potential causes for any exceedances of WQOs and potential effects on EVs will be assessed. Long-term trends will be assessed once sufficient data has been accumulated.

5.3 Sediment Quality

5.3.1 Values below the Limit of Reporting

Where the standard LOR is achieved, values that are returned from the laboratory below the LOR should be transformed to 50% of the LOR. For example, a value of <1 mg/kg becomes 0.5 mg/kg.

Since the <0.063mm fraction is being analysed, there is a significant risk that the volume of each sample <0.063mm is not sufficient for the laboratory to obtain suitable LORs. For example if there is not enough sediment volume, the sample in the <0.063mm fraction may show <10 mg/kg instead of <1 mg/kg. In these instances the following hierarchy should be followed:

1. If the value below the LOR is below SQG Trigger Levels or SQG High, transform the value to 50% of the LOR. For example, if the concentration of lead is returned as <40 mg/kg, transform the value to 20mg/kg.
2. If the value below the LOR is above SQG Trigger Levels and SQG High, record the sample as exceeding the SQG Trigger Level. For example, if the concentration of lead for a sample is returned as <60mg/kg (and the SQG Trigger Level is 50mg/kg), record the sample as exceeding the SQG Trigger Level.
3. If the value below the LOR is above the SQG-High, record the sample as possibly exceeding the SQG High. For example if the concentration of lead for a sample is returned as <300 mg/kg (and the SQG-High value is 220mg/kg), record the sample as possibly exceeding the SQG High value. Re-sampling may be required in this instance as there was a very low volume of sediment provided to the laboratory in the <0.063mm fraction.

5.3.2 Site Variability

The nature of stream sediment sampling means that there is a high degree of uncertainty regarding the composition of sediment and the subsequent results of metals analysis. Stream sediment is comprised of a number of different weathering products from a range of host geologies. Any given sample of sediment will have different relative compositions of mineral particles, potentially altering the results of subsequent metals analysis by a NATA accredited laboratory.

In addition the grain size distribution will affect results. Total sediment samples (comprising all grain sizes) as well as samples sieved to the <0.063mm fraction (clays and silts) were analysed between 2009 and 2013 at the former Kidston mine. The total samples recorded zinc concentrations in the order of 5 to 70mg/kg with the majority of values around 10 to 15mg/kg. The <0.063mm fraction recorded concentrations in the order of 100-300 mg/kg with one sample showing a value of 431 mg/kg. The higher values are a result of the higher surface area available for adsorption and desorption in the finer fraction of sediment. This fraction is also the most bio-available to aquatic organisms as it is often ingested with food or passed through gills.

The variability of sediment sampling for the <0.063mm fraction is shown below in Figure 3, which shows zinc concentrations over five sampling events from the former Kidston mine site. At WB, the upstream reference site, zinc concentrations fluctuated between 88 mg/kg to 188 mg/kg between successive sampling events (29/11/2014 and 28/05/2015). The 19/11/2013 sampling event appears to show higher concentrations than previous or successive events, while the 23/05/2013 event generally shows the second-highest levels of concentrations. These factors introduce a high degree of uncertainty when interpreting the results below in Figure 3.

Subsequently replication of sediment samples is required to more adequately detect the variability of sediment and metals at each site. Three replicates are proposed for each site of the <0.063mm fraction. However the initial sediment study will undertake 5x replicates at each site to characterise the nature of variability. The recommended number of replicates for ongoing monitoring will be provided as an outcome of the Initial Sediment Study.

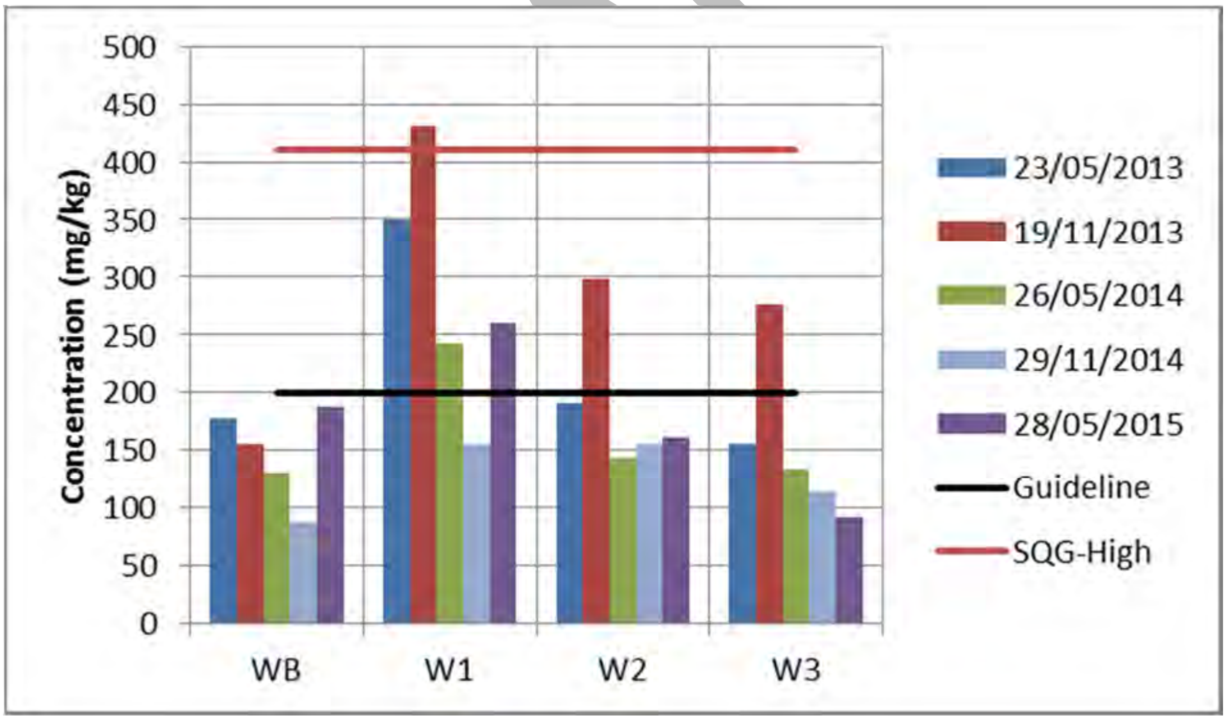


Figure 3 Results for zinc concentrations at monitoring sites form the former Kidston mine

5.3.3 Accumulation of Reference Site Data

The REMP recommends an initial sediment study (refer Section 4.2.1) be undertaken to quantify concentrations of parameters that are outlined in Table 7 in the receiving environment with sufficient replication to remove errors that may be present as a result of the inherent variability of targeted sediment sampling in a river system.

It is recommended that values from reference sites in the Copperfield River are accumulated over a number of years and used to calculate suitable statistics for comparison to impact sites. This will allow a measure of Before-After-Control-Impact (BACI) analysis as outlined in the ANZECC (2000) guidelines. In the case of ongoing sediment sampling, statistics from reference sites should contain preferably 15 replicates from each site. This is approximately 5 years' worth of data.

Statistics from impact sites, based on three replicate samples, will then be compared to the 15 replicates from the reference sites. The previous 15 replicates should always be chosen for the reference site, including the current sampling event.

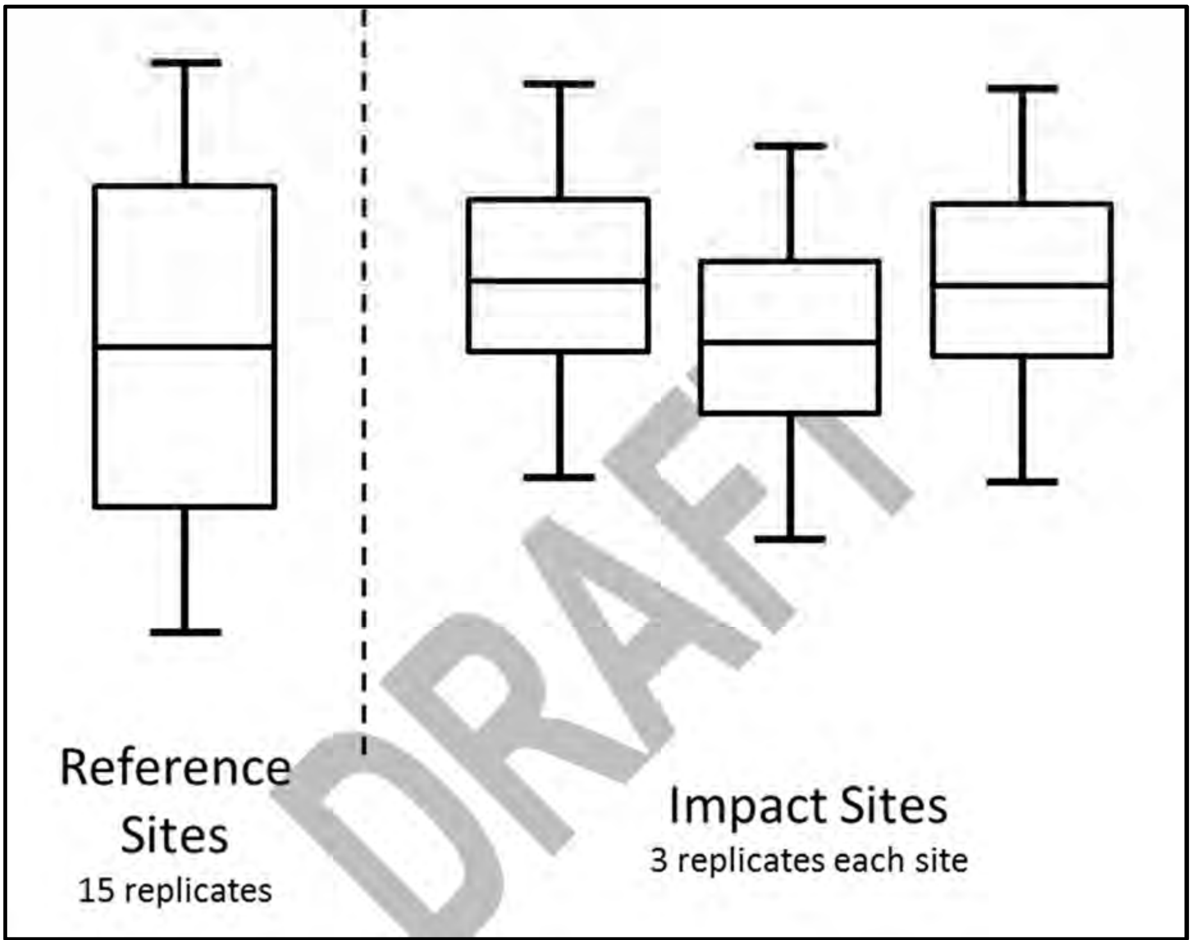


Figure 4 **Example box plot comparison of multi-year reference site dataset to single-year impact site data.**

5.3.4 Assessment against guideline values

As outlined in the ANZECC (2000) guidelines, a sediment trigger level or guideline is said to be exceeded when the 95th percentile of the dataset is above the trigger level or guideline value. Initially the sediment quality sample data is to be compared to the guidelines outlined in Table 4. If the sediment values exceed the trigger levels, then the data should be compared to upstream data.

The recommended approach is to calculate the median (background) concentration and multiply it by a certain factor (typically two) (Simpson, Graeme, & Chariton, 2013). This approach is applied to EAs of mine sites throughout Queensland and allows site-specific concentrations of the above contaminants to be provided.

Where replicate samples are taken at a monitoring site, an exceedance is taken to be where the 95th percentile of the replicate samples exceeds the guideline value as outlined in Table 4. Where the replicate samples from an impact site are compared to replicate samples from a reference site, an exceedance is taken to be where the 95th percentile of the impact site exceeds the maximum at the reference site.

D R A F T

5.4 Biological Monitoring

5.4.1 Aquatic Habitat

Aquatic habitat scores are to be compiled using methods outlined in the AusRivas Sampling Manual and an overall habitat score provided for each site. The overall habitat scores for all sites should be compared side by side to allow the relative condition of each site to be compared to all other sites.

Critical information that may affect the habitat score should be highlighted and discussed when interpreting the results.

5.4.2 Macroinvertebrates

Macroinvertebrate data is used to indicate ecosystem health in a number of indices. These indices are outlined below in Table 10. These indices will be used to compare upstream and downstream sites. Emphasis in reporting and analysis is to be placed on the difference between upstream and downstream sites and the factors contributing towards these differences rather than absolute values.

Table 10 Indices of environmental health based on macroinvertebrate data

Name	Description
Taxonomic Richness	Total number of families within a sample. Most unambiguous diversity measurements. However this is a presence / absence metric and the abundance is not incorporated. Subsequently rare taxa have the same weighting as common taxa. Typically healthier communities have greater diversity.
PET (Plecoptera, Ephemeroptera, Trichoptera) Taxa Richness	The number of taxa collected from stoneflies (Plecoptera), mayflies (Ephemeroptera) and caddisflies (Trichoptera) which are sensitive to environmental change. There are typically more PET families in sites with good habitat and water quality than in heavily impacted sites. PET taxa are often the first to disappear when water quality or environmental degradation occurs. Lower scores of PET taxa indicate higher values of degradation.
SIGNAL 2 Index (Stream Invertebrate Grade Number – Average Level)	SIGNAL 2 scores are a measure of the sensitivity of freshwater macroinvertebrate families to pollutants and other physical and chemical stressors. SIGNAL 2 scores consider the relative abundance of tolerant or sensitive taxa, rather than just the presence/absence of these families. Low SIGNAL 2 scores indicate poor habitat quality and/or impact, as a low value represents a high abundance of taxa tolerant to environmental change and a low abundance of taxa which are intolerant to environmental change. A high SIGNAL 2 score indicates a moderate to high abundance of taxa which are intolerant to environmental change, indicating good habitat quality. The SIGNAL 2 score also considers background assessments for the region or specific stream boundaries. There have been no such studies undertaken for the Gilbert River catchment and the SIGNAL 2 scores should adopt interim boundaries based on the Central Queensland guidelines for indicative comparison (C&R Consulting, 2018).

Multivariate Analysis

Quantitative macroinvertebrate analysis allows multivariate analysis to be undertaken and provide an indication of the relationship between upstream and downstream sample sites for a number of parameters. This multivariate analysis is widely undertaken in the ecology field. Table 11 provides a brief description of the multivariate analyses to perform for the assessment.

Table 11 Multivariate analyses for macroinvertebrate data

Name	Description
SIMPER	Determines which variables (i.e. composition of macroinvertebrates) contribute to dissimilarity between sites and may help to define potential 'indicator' species.
nMDS (non metric multidimensional scaling) and associated Ordination Plots	A graph where the proximity of data from each site to other sites indicates the similarities in macroinvertebrate. The graph is calculated from the Bray-Curtis similarity matrix which is calculated as part of the analysis.
ANOSIM	Compares the observed differences between groups with the differences amongst replicates within the groups. A global analysis is calculated to determine if there are differences between any of the samples. If there are differences, then comparisons between each combination of sites are undertaken. The results are indicated by an R statistic, whereby: • R > 0.75 = groups well separated • R > 0.50 = groups overlapping but clearly different • R < 0.25 = groups barely separated • Significance Level <5% = significant difference
RELATE (including BioEnv)	Used to correlate water, sediment and macroinvertebrate data to determine which water and sediment parameters are having the most impact.

It is recommended that the above analyses are undertaken in the PRIMER software package. This package has been developed specifically to undertake the above analyses and will provide consistent graphical outputs from year to year to allow easy comparison of data.

Comparison

For macroinvertebrate data, analysis results from upstream sites are to be compared to downstream sites to determine if there is any discernible difference. If there are no differences that are not attributable to other environmental factors (such as the percentage of macrophyte cover between sites), then an impact can have been said to occur.

5.5 Groundwater

Groundwater data should be analysed to determine if there are any correlations between pit water data and the receiving environment. This will involve examination of correlations between certain parameters (i.e. zinc) as well as examination of cation/anion compositions. Groundwater quality data are to be compared to trigger levels outlined in Table 2, but exceedances of groundwater quality samples with the trigger values in Table 2 should not trigger investigation. The purpose of groundwater monitoring is to identify any linkages between the pit water and the Copperfield River. The WQOs outlined in Table 2 were developed for surface water systems and are not meant to be applied to groundwater systems. The WQOs outlined in Table 2 are appropriate for SW quality and will not be used as GW trigger values; however, the WQOs will be used for comparison with GW water sampled from bores BA06 and BA07 to evaluate long-term trends in GW quality, which will aid in assessment of potential linkages between the pit water and the Copperfield River.

D R A F T

6.0 Reporting and Review

All data collected as part of the REMP must be compiled into an annual REMP Assessment Report by October each year. The report must include:

- An overview of the releases for that period, including start date/time, end date/time and the volume released.
- A description of monitoring undertaken for all parameters outlined in this report.
- Examination of the suitability of data for derivation of local WQOs. If data is suitable, derive local WQOs using data collected as part of the REMP.
- Comparison of data collected in this report to licence conditions, standards, WQOs and include upstream to downstream comparison.
- A review of the suitability of monitoring locations, methods, timing, frequencies and parameters.
- Provide a summary table of monitoring required for the next REMP period.

The outcomes of the REMP should be used to evaluate whether adjustments to release rates are required to minimise the chance of environmental harm occurring.

7.0 References

AECOM Australia. (21 December 2017). *Surface Water Technical Report.* Brisbane: AECOM Australia.

Barrack Australia. (2013). *Receiving Environment Monitoring Program .*

C&R Consulting . (2018). *Kidston Pumped Storage Hydro Project - Aquatic Ecology Survey Report.* Townsville, Queensland.

Chessman, B. (2003). *SIGNAL 2 - A Scoring System for Macroinvertebrates (Water Bugs) in Australian Rivers. .* Canberra: Monitoring River Health Initiative Technical Report No 31, Commonwealth of Australia.

Claus, S., Dunlop, J., & Ramsay, I. (2017). *Using Monitoring Data to Assess Groundwater Quality and Potential Environmental Impacts.* Brisbane, Queensland: Department of Science, Information Technology and Innovation.

DES. (2018). *Water Monitoring and Sampling Manual*. Retrieved from Department of Environment and Science: http://www.ehp.qld.gov.au/water/monitoring/sampling-manual/

DNRM. (2001). *Queensland Australian River Assessment System (AusRivas) Samplig and Processing Manual.* DNRM.

EHP. (2013). *Queensland Water Quality Guidelines.* Environment Policy and Planning, Department of Environment and Heritage Protection.

Geoscience Australia. (2009). *Groundwater Sampling and Analysis - A Field Guide.* Geoscience Australia.

Petheram, C., Watson, I., & Stone, P. (2013). *Agricultural Resource Assessment for the Gilbert Catchment - A report to the Australian Government from the CSIRO Flinders and Gilbert Agricultural Resource Assessment part of the North Queensland Irrigated Agriculture Strategy.* Australia: CSIRO Water for a Healthy Country and Sustinable Agriculture Flagships.

Simpson, S. L., Graeme, B. E., & Chariton, A. A. (2013). *Revision of the ANZECC/ARMCANZ Sediment Quality Guidelines.* CSIRO Water for a Healthy Country.

Smith, R., Jeffree, R., John, J., & Clayton, P. (2004). *Review of Methods for Water Quality Assessment of Temporary Stream and Lake Systems.* Kenmore: Australian Centre for Mining Environmental Research.

Appendix A

REMP Monitoring Locations and Frequencies

DRAFT

Appendix A REMP Monitoring Locations and Frequencies

<table>
<tr><th rowspan="2">Group</th><th rowspan="2">Site</th><th rowspan="2">Easting</th><th rowspan="2">Northing</th><th rowspan="2">Description</th><th colspan="4">Monitoring Frequency</th></tr>
<tr><th>Water Quality</th><th>Sediment Quality</th><th>Biological</th><th>Flow</th></tr>
<tr><td rowspan="3">Regional Monitoring – Background Sites</td><td>WB</td><td>201087</td><td>7907273</td><td>Upstream of all influences on the Copperfield River</td><td rowspan="3">Baseline Monitoring
• Within 1 week of the commencement of flow
• Monthly thereafter for as long as water persists</td><td rowspan="3">Initial Sediment Study
• Dry Season 2019
• 5x replicates from each site
Thereafter
• 3x replicates from each site[2]
• At the end of the Wet Season after releases have ceased</td><td rowspan="3">• At least six weeks after flows recede to <1000 ML/d towards the end of the wet season (March – May)
• Early wet season sampling if possible (i.e. 6 weeks following flows receding to <1000ML/d) typically during November – February</td><td rowspan="3">N/A</td></tr>
<tr><td>Pond 3</td><td>200868</td><td>7907862</td><td>Pool situated 1.4km upstream</td></tr>
<tr><td>E1</td><td>203774</td><td>7912124</td><td>East Creek upstream of the confluence with the Copperfield River</td></tr>
<tr><td rowspan="7">Regional Monitoring – Impact Sites</td><td>W1</td><td>200799</td><td>7908133</td><td>Downstream of the Tailings Storage Facility on the Copperfield River</td><td rowspan="7">Baseline Monitoring
• Within 1 week of the commencement of flow
• Monthly thereafter for as long as water persists
During Releases
• Within the first 24 hours of the commencement of release
• Every 3 days thereafter until seven days after the release ceases</td><td rowspan="4">Initial Sediment Study
• Dry Season 2019
• 5x replicates from each site
Thereafter
• 3x replicates from each site[2]
• At the end of the Wet Season after releases have ceased</td><td rowspan="3">• At least six weeks after flows recede to <1000 ML/d towards the end of the wet season (March – May)
• Early wet season sampling if possible (i.e. 6 weeks following flows receding to <1000ML/d) typically during November – February</td><td rowspan="7">N/A</td></tr>
<tr><td>W2</td><td>201851</td><td>7910299</td><td>Downstream of Manager’s Creek Dam on the Copperfield River</td></tr>
<tr><td>W3</td><td>202667</td><td>7915973</td><td>At the causeway entrance to the Kidston Project on the Copperfield River. Most downstream monitoring point.</td></tr>
<tr><td>E2</td><td>202887</td><td>7912971</td><td>East Creek downstream of the confluence with the Copperfield River</td><td>N/A</td></tr>
<tr><td>Pond 5</td><td>202761</td><td>7915578</td><td>Pool situated 7.0km downstream</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Copperfield River at the confluence with Sandy Creek (waterhole)</td><td>197509</td><td>7929897</td><td>Pool situated 20km downstream</td><td>N/A</td><td>• At least six weeks after flows recede to <1000 ML/d towards the end of the wet season (March – May)
• Early wet season sampling if possible (i.e. 6 weeks following flows receding to <1000ML/d) typically during November – February</td></tr>
<tr><td>CG1</td><td>TBA[1]</td><td>TBA[1]</td><td>Copperfield Gorge</td><td>Initial Sediment Study
• Dry Season 2019
• 5x replicates from each site
Thereafter
• 3x replicates from each site[2]
At the end of the Wet Season after releases have ceased</td><td>N/A</td></tr>
</table>

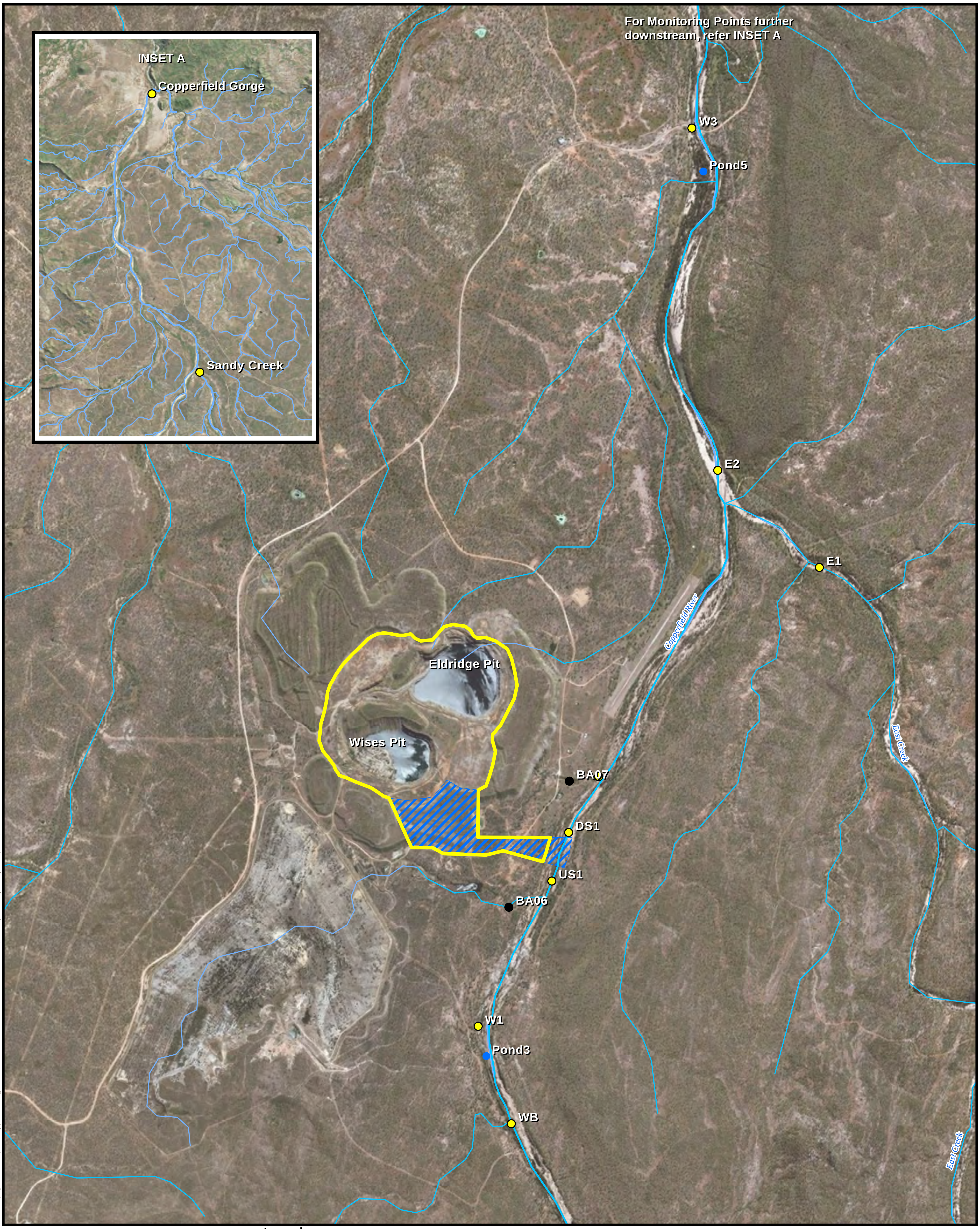
DRAFT

Group	Site	Easting	Northing	Description	Monitoring Frequency			
					Water Quality	Sediment Quality	Biological	Flow
Near-field monitoring - Mixing Zone	US1	TBA[#]	TBA[#]	Immediately upstream of release location	**Baseline Monitoring** • Within 1 week of the commencement of flow • Monthly thereafter for as long as water persists **During Releases** • Within the first 24 hours of the commencement of release • Every 3 days thereafter until seven days after the release ceases	**Initial Sediment Study** • Dry Season 2019 • 5x replicates from each site **Thereafter** • 3x replicates from each site[2] • At the end of the Wet Season after releases have ceased	N/A	Continuous
	DS1	TBA[#]	TBA[#]	Immediately downstream of mixing zone for releases from the K2H Project			N/A	Continuous
Release Water	Eldridge Pit	TBA[#]	TBA[#]	Eldridge Pit at the Ramp	**Baseline Monitoring** • Monthly for the first 24 months of Operation • Quarterly thereafter	N/A	N/A	N/A
	Wises Pit	TBA[#]	TBA[#]	Wises Pit at the Ramp				N/A
	Release Water	TBA[#]	TBA[#]	Sample of waters at the Release Point into the Copperfield River	• Within 24 hours of commencement of release • Every day thereafter while releases are occurring.			N/A
Groundwater Monitoring	BA06	201067	7909160	6.0m deep well installed in river loam and sand.	**Construction Phase** • Monthly **Operational Phase** • Quarterly	N/A	N/A	**WATER LEVEL:** **Construction Phase** • Monthly **Operational Phase** • Monthly
	BA07	201595	7910262	5.0m deep well installed in river loam and sand.				

[1] The most suitable location for monitoring at the Copperfield Gorge to be defined prior to the first release. Location is to be suitable for access in wet-weather events and suitable for water quality monitoring. NOTE: the sediment monitoring location may be different than the water quality sampling location as it would be ideal to capture sediment just upstream of the gorge in the dry river bed

[#] Location to be determined after installation of appropriate infrastructure.

[2] The initial sediment study is to determine whether replicates are required at each site for ongoing monitoring.



Legend

- Groundwater Bore
- Monitoring Point
- Pond
- Watercourse - Major
- Watercourse - Minor
- Key Project Infrastructure Footprint
- Spillway Options Corridor

AECOM
www.aecom.com

N

DATUM GDA 1994, PROJECTION MGA ZONE 56

0 250 500 1,000
metres

1:30,000 (when printed at A3)

KIDSTON PUMPED STORAGE HYDRO PROJECT
IMPACT ASSESSMENT REPORT

REMP Monitoring Points

PROJECT ID	60544566
CREATED BY	RF
LAST MODIFIED	FraserR2I - 11 Jan 2019
VERSION:	2

Figure
75

A3 size

Filename: P:\605X\60544566\4. Tech Work Area\4.99 GIS\04_Outgoing\20190108_RF_K2H_MPs\20190108_RF_K2H_MPs.mxd

Appendix J

Eldridge Pit Water Quality Data – August 2018

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ET1802030**	Page	: 1 of 32
Client	: **GENEX POWER LTD**	Laboratory	: Environmental Division Townsville
Contact	: A M	Contact	: Customer Services ET
Address	: Level 11, 2 Bligh Street, Sydney NSW 2000 PO Box R514, Royal Exchange, NSW 1225 Sydney NSW 2000	Address	: 13 Carlton Street, Kirwan Townsville QLD Australia 4814
Telephone	: +61 02 9993 4443	Telephone	: +61 7 4773 0000
Project	: Kidston	Date Samples Received	: 08-Aug-2018 13:20
Order number	:	Date Analysis Commenced	: 09-Aug-2018
C-O-C number	: ----	Issue Date	: 20-Aug-2018 21:27
Sampler	: JOHN LAWLER		
Site	: ----		
Quote number	: EN/222/17		
No. of samples received	: 13		
No. of samples analysed	: 13		

ilac-MRA NATA

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Diana Mesa	2IC Organic Chemist	Brisbane Organics, Stafford, QLD
Greg Vogel	Laboratory Manager	Brisbane Inorganics, Stafford, QLD
Hannah Beazley		Brisbane Microbiological, Stafford, QLD
Kim McCabe		Townsville Inorganics, Townsville, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	WB Water Lab Brisbane, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Tom Maloney		Townsville Inorganics, Townsville, QLD
Tom Maloney	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Tom Maloney	Senior Inorganic Chemist	WB Water Lab Brisbane, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- It is recognised that EK267PA-CM (Total Phosphorus) is less than EK271A-CM (Reactive Phosphorus) for sample Pit 2. However, the difference is within experimental variation of the methods.
- EG020-F (Dissolved Metals by ICP-MS) were found to be higher than EG020-T (Total Metals by ICP-MS) for sample ET1802030-002(Pit 2). This was confirmed by re-digestion and re-analysis.
- Results apply to sample(s) as submitted.
- EK067G (Total Phosphorous as P): Some samples were diluted due to matrix interference. LOR adjusted accordingly.
- EK058G, EA045, EA005-P, EA010-P, EA025H, ED037-P, ED041G, ED045G, EK040P, EK055G, EK057G, EK059G conducted by ALS Townsville, NATA accreditation no. 825, (Site no. 23313)
- KEY: PTP=Potential Toxin Producers
  ; ND=Not Detected; NS=Not Specified
  ; cf. = comparable from
- Samples were preserved with Lugols Iodine solution.
- It is recognised that EP005 (Total Organic Carbon) is less than EP002 (Dissolved Organic Carbon) for samples 'Pit 1' and 'Eldridge Ramp' . However, the difference is within experimental variation of the methods.
- EP002 (Dissolved Organic Carbon) was found to be higher than EP005 (Total Organic Carbon) for sample 'Eldridge 200m' . This has been confirmed by re-analysis.
- EK061G (Total Kjeldahl Nitrogen as N): Some samples were diluted due to matrix interference. LOR adjusted accordingly.
- It is recognised that EG094T (Total Metals in Fresh Water) is less than EG094F (Dissolved Metals in Fresh Water) for some samples. However, the difference is within experimental variation of the methods.
- It is recognised that EG020T (Total Metals) is less than EG020F (Dissolved Metals) for some samples. However, the difference is within experimental variation of the methods.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: **WATER**
(Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Pit 1	Pit 2	Eldridge Ramp	Wises Ramp	Eldridge 0m
Client sampling date / time				07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
				ET1802030-001	**ET1802030-002**	**ET1802030-003**	**ET1802030-004**	**ET1802030-005**
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.74**	**7.60**	**7.67**	**8.16**	**7.68**
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**3180**	**5120**	**3130**	**5160**	**3120**
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	**7**	<5	<5	<5
EA045: Turbidity								
Turbidity	----	0.1	NTU	**0.5**	**13.5**	**0.6**	**0.6**	**0.4**
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**44**	**98**	**45**	**93**	**45**
Total Alkalinity as CaCO3	----	1	mg/L	**44**	**98**	**45**	**93**	**45**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**1480**	**2400**	**1350**	**2410**	**1380**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**92**	**187**	**96**	**189**	**100**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**324**	**472**	**323**	**492**	**305**
Magnesium	7439-95-4	1	mg/L	**96**	**137**	**95**	**147**	**91**
Sodium	7440-23-5	1	mg/L	**303**	**563**	**301**	**616**	**288**
Potassium	7440-09-7	1	mg/L	**47**	**110**	**47**	**126**	**45**
ED093F: SAR and Hardness Calculations								
Total Hardness as CaCO3	----	1	mg/L	**1200**	**1740**	**1200**	**1830**	**1140**
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.02**	<0.01	**0.03**	<0.01	**0.02**
Arsenic	7440-38-2	0.001	mg/L	**0.028**	**0.517**	**0.028**	**0.234**	**0.026**
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	**0.040**	**0.036**	**0.039**	**0.040**	**0.038**
Cadmium	7440-43-9	0.0001	mg/L	**0.0237**	**0.0004**	**0.0238**	**0.0006**	**0.0227**
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	**0.004**	**0.010**	**0.005**	**0.002**	**0.004**
Copper	7440-50-8	0.001	mg/L	**0.002**	**0.001**	**0.003**	**0.002**	**0.002**
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	**1.22**	**0.943**	**1.21**	**0.100**	**1.17**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Pit 1	Pit 2	Eldridge Ramp	Wises Ramp	Eldridge 0m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ET1802030-001	ET1802030-002	ET1802030-003	ET1802030-004	ET1802030-005
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Molybdenum	7439-98-7	0.001	mg/L	**0.036**	**0.056**	**0.050**	**0.056**	**0.052**
Nickel	7440-02-0	0.001	mg/L	**0.023**	**0.006**	**0.024**	**0.003**	**0.022**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	7440-61-1	0.001	mg/L	**0.005**	**0.010**	**0.006**	**0.009**	**0.006**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	**1.21**	**0.163**	**1.23**	**0.072**	**1.16**
Boron	7440-42-8	0.05	mg/L	**0.09**	**0.09**	**0.07**	**0.09**	**0.07**
Iron	7439-89-6	0.05	mg/L	<0.05	**3.20**	<0.05	<0.05	<0.05
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.07**	**0.06**	**0.08**	<0.01	**0.04**
Arsenic	7440-38-2	0.001	mg/L	**0.030**	**0.466**	**0.032**	**0.237**	**0.029**
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	**0.035**	**0.038**	**0.036**	**0.037**	**0.036**
Cadmium	7440-43-9	0.0001	mg/L	**0.0243**	**0.0010**	**0.0246**	**0.0006**	**0.0250**
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	**0.004**	**0.005**	**0.004**	**0.002**	**0.004**
Copper	7440-50-8	0.001	mg/L	**0.006**	**0.005**	**0.005**	**0.001**	**0.004**
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	**1.22**	**0.577**	**1.23**	**0.098**	**1.22**
Molybdenum	7439-98-7	0.001	mg/L	**0.057**	**0.060**	**0.057**	**0.065**	**0.056**
Nickel	7440-02-0	0.001	mg/L	**0.022**	**0.004**	**0.022**	**0.002**	**0.022**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	7440-61-1	0.001	mg/L	**0.006**	**0.008**	**0.006**	**0.008**	**0.006**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	**1.14**	**0.138**	**1.17**	**0.075**	**1.17**
Boron	7440-42-8	0.05	mg/L	**0.06**	**0.07**	**0.06**	**0.07**	**0.05**
Iron	7439-89-6	0.05	mg/L	<0.05	**2.42**	**0.05**	<0.05	<0.05
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.00004	mg/L	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004
EG035T: Total Mercury by FIMS								
Mercury	7439-97-6	0.00004	mg/L	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS								

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Pit 1	Pit 2	Eldridge Ramp	Wises Ramp	Eldridge 0m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ET1802030-001	ET1802030-002	ET1802030-003	ET1802030-004	ET1802030-005
				Result	Result	Result	Result	Result
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS - Continued								
Uranium	7440-61-1	0.05	µg/L	**6.51**	**10.4**	----	----	----
Vanadium	7440-62-2	0.2	µg/L	**0.2**	**0.6**	----	----	----
Zinc	7440-66-6	1	µg/L	**1140**	**129**	----	----	----
EG094T: Total metals in Fresh water by ORC-ICPMS								
Uranium	7440-61-1	0.05	µg/L	**6.65**	**9.70**	----	----	----
Vanadium	7440-62-2	0.2	µg/L	<0.2	**0.6**	----	----	----
Zinc	7440-66-6	1	µg/L	**1220**	**111**	----	----	----
EK025SF: Free CN by Segmented Flow Analyser								
Free Cyanide	----	0.004	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**3.0**	**4.3**	**3.0**	**4.5**	**3.0**
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	----	----	**0.21**	**0.52**	**0.20**
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	----	----	**0.01**	<0.01	**0.01**
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	----	----	**5.14**	**0.41**	**5.08**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	----	----	**5.15**	**0.41**	**5.09**
EK060G:Organic Nitrogen as N (TKN-NH3) By Discrete Analyser								
Organic Nitrogen as N	----	0.1	mg/L	----	----	<0.5	**0.8**	<0.5
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	----	----	<0.5	**1.3**	<0.5
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ **Total Nitrogen as N**	----	0.1	mg/L	----	----	**5.2**	**1.7**	**5.1**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	----	----	<0.05	**0.09**	<0.05
EK255A: Ammonia								
Ammonia as N	7664-41-7	0.005	mg/L	**0.146**	**0.646**	----	----	----
EK257A: Nitrite								
Nitrite as N	14797-65-0	0.002	mg/L	**0.012**	**0.005**	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Pit 1	Pit 2	Eldridge Ramp	Wises Ramp	Eldridge 0m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ET1802030-001	ET1802030-002	ET1802030-003	ET1802030-004	ET1802030-005
				Result	Result	Result	Result	Result
EK258A: Nitrate								
Nitrate as N	14797-55-8	0.002	mg/L	3.51	0.451	----	----	----
EK259A: Nitrite and Nitrate (NOx)								
Nitrite + Nitrate as N	----	0.002	mg/L	3.52	0.456	----	----	----
EK260A: Organic Nitrogen								
Organic Nitrogen as N	----	0.01	mg/L	9.43	5.86	----	----	----
EK261A: Total Kjeldahl Nitrogen								
Total Kjeldahl Nitrogen as N	----	0.01	mg/L	9.58	6.50	----	----	----
EK262A: Total Nitrogen								
Total Nitrogen as N	----	0.01	mg/L	13.1	6.96	----	----	----
EK267A: Total Phosphorus (Persulfate Digestion)								
Total Phosphorus as P	----	0.005	mg/L	0.031	0.016	----	----	----
EK271A: Reactive Phosphorus								
Reactive Phosphorus as P	14265-44-2	0.001	mg/L	0.008	0.020	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	34.3	57.2	31.7	57.4	32.4
Total Cations	----	0.01	meq/L	38.4	62.1	38.2	66.7	36.4
Ionic Balance	----	0.01	%	5.72	4.13	9.32	7.50	5.72
EP002: Dissolved Organic Carbon (DOC)								
Dissolved Organic Carbon	----	1	mg/L	2	3	2	3	<1
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	1	3	1	3	<1
EP008: Chlorophyll a & Pheophytin a								
Chlorophyll a	----	1	mg/m³	----	----	<1	<1	<1
MW024: Bacillariophytes (Diatoms) - Centrales								
Acanthoceras spp.	----	5	cells/ml	----	----	----	----	<5
Aulacoseira spp.	----	5	cells/ml	----	----	----	----	<5
Chaetoceros spp.	----	5	cells/ml	----	----	----	----	<5
Coscinodiscus spp.	----	5	cells/ml	----	----	----	----	<5
Cyclotella spp.	----	5	cells/ml	----	----	----	----	<5
Melosira spp.	----	5	cells/ml	----	----	----	----	<5
Rhizosolenia spp.	----	5	cells/ml	----	----	----	----	<5
Skeletonema spp.	----	5	cells/ml	----	----	----	----	<5
Thalassioseira spp.	----	5	cells/ml	----	----	----	----	<5

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Pit 1	Pit 2	Eldridge Ramp	Wises Ramp	Eldridge 0m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ET1802030-001	ET1802030-002	ET1802030-003	ET1802030-004	ET1802030-005
				Result	Result	Result	Result	Result
MW024: Bacillariophytes (Diatoms) - Centrales - Continued								
Urosolenia spp.	----	5	cells/ml	----	----	----	----	<5
Other centrics	----	5	cells/ml	----	----	----	----	<5
Thalassiosira spp.	----	5	cells/ml	----	----	----	----	<5
MW024: Bacillariophytes (Diatoms) - Pennales								
Achnanthidium spp.	----	5	cells/ml	----	----	----	----	<5
Amphora spp.	----	5	cells/ml	----	----	----	----	<5
Asterionella spp.	----	5	cells/ml	----	----	----	----	<5
Bacillaria spp.	----	5	cells/ml	----	----	----	----	<5
Bacillariophytes	----	5	cells/ml	----	----	----	----	<5
Cocconeis spp.	----	5	cells/ml	----	----	----	----	<5
Cylindrotheca closterium	----	5	cells/ml	----	----	----	----	<5
Cymbella spp.	----	5	cells/ml	----	----	----	----	<5
Diatoma spp.	----	5	cells/ml	----	----	----	----	<5
Entomoneis spp.	----	5	cells/ml	----	----	----	----	<5
Eunotia spp.	----	5	cells/ml	----	----	----	----	<5
Fragilaria spp.	----	5	cells/ml	----	----	----	----	<5
Gomphonema spp.	----	5	cells/ml	----	----	----	----	<5
Gyrosigma spp.	----	5	cells/ml	----	----	----	----	<5
Hantzschia spp.	----	5	cells/ml	----	----	----	----	<5
Navicula spp.	----	5	cells/ml	----	----	----	----	<5
Nitzschia spp.	----	5	cells/ml	----	----	----	----	<5
Pinnularia spp.	----	5	cells/ml	----	----	----	----	<5
Pseudonitzschia spp.	----	5	cells/ml	----	----	----	----	<5
Rhoicosphenia spp.	----	5	cells/ml	----	----	----	----	<5
Rhopalodia spp.	----	5	cells/ml	----	----	----	----	<5
Surirella spp.	----	5	cells/ml	----	----	----	----	<5
Synedra spp.	----	5	cells/ml	----	----	----	----	<5
Tabellaria spp.	----	5	cells/ml	----	----	----	----	<5
Other Bacillariophytes	----	5	cells/ml	----	----	----	----	<5
Other pennates	----	5	cells/ml	----	----	----	----	<5
MW024: Bacillariophytes (Diatoms) - TOTAL BACILLARIOPHYTES								
Total Bacillariophytes	----	5	cells/ml	----	----	----	----	<5
MW024: Chlorophytes (Green Algae) - Chaetophorales								
Chaetophora spp.	----	5	cells/ml	----	----	----	----	<5

Analytical Results

Sub-Matrix: **WATER**
(Matrix: **WATER**)

			Client sample ID	Pit 1	Pit 2	Eldridge Ramp	Wises Ramp	Eldridge 0m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	*CAS Number*	*LOR*	*Unit*	**ET1802030-001**	**ET1802030-002**	**ET1802030-003**	**ET1802030-004**	**ET1802030-005**
				Result	Result	Result	Result	Result
MW024: Chlorophytes (Green Algae) - Chaetophorales - Continued								
Stigeoclonium spp.	----	5	cells/ml	----	----	----	----	<5
MW024: Chlorophytes (Green Algae) - Chlorococcales								
Actinastrum spp.	----	5	cells/ml	----	----	----	----	<5
Ankistrodesmus spp.	----	5	cells/ml	----	----	----	----	<5
Ankyra spp.	----	5	cells/ml	----	----	----	----	<5
Botryococcus spp.	----	5	cells/ml	----	----	----	----	<5
Chlorella spp.	----	5	cells/ml	----	----	----	----	<5
Closteridium spp.	----	5	cells/ml	----	----	----	----	<5
Closteriopsis spp.	----	5	cells/ml	----	----	----	----	<5
Coelastrum spp.	----	5	cells/ml	----	----	----	----	<5
Crucigenia spp.	----	5	cells/ml	----	----	----	----	<5
Cylindrocapsa spp.	----	5	cells/ml	----	----	----	----	<5
Dictyosphaerium spp.	----	5	cells/ml	----	----	----	----	<5
Didymocystis spp.	----	5	cells/ml	----	----	----	----	<5
Dimorphococcus spp.	----	5	cells/ml	----	----	----	----	<5
Elakatothrix spp.	----	5	cells/ml	----	----	----	----	<5
Golenkenia spp.	----	5	cells/ml	----	----	----	----	<5
Hydrodictyon spp.	----	5	cells/ml	----	----	----	----	<5
Kirchneriella spp.	----	5	cells/ml	----	----	----	----	<5
Lagerheimia spp.	----	5	cells/ml	----	----	----	----	<5
Micractinium spp.	----	5	cells/ml	----	----	----	----	<5
Microspora spp.	----	5	cells/ml	----	----	----	----	<5
Monoraphidium spp.	----	5	cells/ml	----	----	----	----	<5
Nephrocytium spp.	----	5	cells/ml	----	----	----	----	<5
Oocystis spp.	----	5	cells/ml	----	----	----	----	<5
Palmella spp.	----	5	cells/ml	----	----	----	----	<5
Pediastrum spp.	----	5	cells/ml	----	----	----	----	<5
Quadrigula spp.	----	5	cells/ml	----	----	----	----	<5
Scenedesmus spp.	----	5	cells/ml	----	----	----	----	<5
Schroederia spp.	----	5	cells/ml	----	----	----	----	<5
Selenastrum spp.	----	5	cells/ml	----	----	----	----	<5
Selenodictyum spp.	----	5	cells/ml	----	----	----	----	<5
Sphaerocystis spp.	----	5	cells/ml	----	----	----	----	<5
Tetradesmus spp.	----	5	cells/ml	----	----	----	----	<5
Tetraedron spp.	----	5	cells/ml	----	----	----	----	<5

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)

Compound	CAS Number	LOR	Unit	Pit 1	Pit 2	Eldridge Ramp	Wises Ramp	Eldridge 0m
Client sampling date / time				07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
				ET1802030-001	ET1802030-002	ET1802030-003	ET1802030-004	ET1802030-005
				Result	Result	Result	Result	Result
MW024: Chlorophytes (Green Algae) - Chlorococcales - Continued								
Tetrastrum spp.	----	5	cells/ml	----	----	----	----	<5
Treubaria spp.	----	5	cells/ml	----	----	----	----	<5
Crucigeniella spp.	----	5	cells/ml	----	----	----	----	<5
Dichotomochoccus spp.	----	5	cells/ml	----	----	----	----	<5
Westella spp.	----	5	cells/ml	----	----	----	----	<5
MW024: Chlorophytes (Green Algae) - Cladophorales								
Cladophora spp.	----	5	cells/ml	----	----	----	----	<5
Rhizoclonium spp.	----	5	cells/ml	----	----	----	----	<5
MW024: Chlorophytes (Green Algae) - Oedogoniales								
Bulbochaete spp.	----	5	cells/ml	----	----	----	----	<5
Oedogonium spp.	----	5	cells/ml	----	----	----	----	<5
MW024: Chlorophytes (Green Algae) - Tetrasporales								
Gloeocystis spp.	----	5	cells/ml	----	----	----	----	<5
Tetraspora spp.	----	5	cells/ml	----	----	----	----	<5
MW024: Chlorophytes (Green Algae) - TOTAL CHLOROPHYTES								
Total Chlorophytes	----	5	cells/ml	----	----	----	----	<5
MW024: Chlorophytes (Green Algae) - Ulotrichales								
Planktonema spp.	----	5	cells/ml	----	----	----	----	<5
Ulothrix spp.	----	5	cells/ml	----	----	----	----	<5
Planctonema spp.	----	5	cells/ml	----	----	----	----	<5
Koliella spp.	----	5	cells/ml	----	----	----	----	<5
MW024: Chlorophytes (Green Algae) - Volvocales								
Carteria spp.	----	5	cells/ml	----	----	----	----	<5
Chlamydomonas spp.	----	5	cells/ml	----	----	----	----	<5
Chlorogonium spp.	----	5	cells/ml	----	----	----	----	<5
Eudorina spp.	----	5	cells/ml	----	----	----	----	<5
Gonium spp.	----	5	cells/ml	----	----	----	----	<5
Haematococcus spp.	----	5	cells/ml	----	----	----	----	<5
Pandorina spp.	----	5	cells/ml	----	----	----	----	<5
Phacotus spp.	----	5	cells/ml	----	----	----	----	<5
Pleodorina spp.	----	5	cells/ml	----	----	----	----	<5
Pteromonas spp.	----	5	cells/ml	----	----	----	----	<5
Spermatozoopsis spp.	----	5	cells/ml	----	----	----	----	<5
Sphaerellopsis spp.	----	5	cells/ml	----	----	----	----	<5

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Pit 1	Pit 2	Eldridge Ramp	Wises Ramp	Eldridge 0m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ET1802030-001	ET1802030-002	ET1802030-003	ET1802030-004	ET1802030-005
				Result	Result	Result	Result	Result
MW024: Chlorophytes (Green Algae) - Volvocales - Continued								
Tetraselmis spp.	----	5	cells/ml	----	----	----	----	<5
Volvox spp.	----	5	cells/ml	----	----	----	----	<5
Unidentified Green algae	----	5	cells/ml	----	----	----	----	<5
Pyramimonas spp.	----	5	cells/ml	----	----	----	----	<5
Chlorophytes	----	5	cells/ml	----	----	----	----	<5
Other green cells	----	5	cells/ml	----	----	----	----	<5
Other green filaments	----	5	cells/ml	----	----	----	----	<5
Stichococcus spp.	----	5	cells/ml	----	----	----	----	<5
MW024: Chlorophytes (Green Algae) - Zygnematales								
Actinotaenium spp.	----	5	cells/ml	----	----	----	----	<5
Closterium spp.	----	5	cells/ml	----	----	----	----	<5
Cosmarium spp.	----	5	cells/ml	----	----	----	----	<5
Cosmocladium spp.	----	5	cells/ml	----	----	----	----	<5
Desmidium spp.	----	5	cells/ml	----	----	----	----	<5
Euastrum spp.	----	5	cells/ml	----	----	----	----	<5
Gonatozygon spp.	----	5	cells/ml	----	----	----	----	<5
Hyalotheca spp.	----	5	cells/ml	----	----	----	----	<5
Micrasterias spp.	----	5	cells/ml	----	----	----	----	<5
Mougeotia spp.	----	5	cells/ml	----	----	----	----	<5
Netrium spp.	----	5	cells/ml	----	----	----	----	<5
Penium spp.	----	5	cells/ml	----	----	----	----	<5
Pleurotaenium spp.	----	5	cells/ml	----	----	----	----	<5
Sirogonium spp.	----	5	cells/ml	----	----	----	----	<5
Sphaerozosma spp.	----	5	cells/ml	----	----	----	----	<5
Spirogyra spp.	----	5	cells/ml	----	----	----	----	<5
Spondylosium spp.	----	5	cells/ml	----	----	----	----	<5
Staurastrum spp.	----	5	cells/ml	----	----	----	----	<5
Straurodesmus spp.	----	5	cells/ml	----	----	----	----	<5
Tellingia spp.	----	5	cells/ml	----	----	----	----	<5
Triploceras spp.	----	5	cells/ml	----	----	----	----	<5
Xanthidium spp.	----	5	cells/ml	----	----	----	----	<5
Zygnema spp.	----	5	cells/ml	----	----	----	----	<5
Haplotaenium spp.	----	5	cells/ml	----	----	----	----	<5
MW024: Chrysophytes (Golden Algae)								

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Pit 1	Pit 2	Eldridge Ramp	Wises Ramp	Eldridge 0m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ET1802030-001	ET1802030-002	ET1802030-003	ET1802030-004	ET1802030-005
				Result	Result	Result	Result	Result
MW024: Chrysophytes (Golden Algae) - Continued								
Centritractus spp.	----	5	cells/ml	----	----	----	----	<5
Chrysophytes	----	5	cells/ml	----	----	----	----	<5
Chrysochromulina spp.	----	5	cells/ml	----	----	----	----	<5
Diceras spp.	----	5	cells/ml	----	----	----	----	<5
Dinobryon spp.	----	5	cells/ml	----	----	----	----	<5
Epipyxis spp.	----	5	cells/ml	----	----	----	----	<5
Isthmochloron spp.	----	5	cells/ml	----	----	----	----	<5
Mallomonas akrokomos	----	5	cells/ml	----	----	----	----	<5
Mallomonas splendidum	----	5	cells/ml	----	----	----	----	<5
Mallomonas spp.	----	5	cells/ml	----	----	----	----	<5
Synura spp.	----	5	cells/ml	----	----	----	----	<5
Tribonema spp.	----	5	cells/ml	----	----	----	----	<5
Uroglena spp.	----	5	cells/ml	----	----	----	----	<5
Unidentified Golden algae	----	5	cells/ml	----	----	----	----	<5
Other Chrysophytes	----	5	cells/ml	----	----	----	----	<5
MW024: Chrysophytes (Golden Algae) - TOTAL CHRYSOPHYTES								
Total Chrysophytes	----	5	cells/ml	----	----	----	----	<5
MW024: Cyanophytes (Blue Green Algae) - Chroococcales								
Aphanothece spp. <2 µm	----	5	cells/ml	----	----	----	----	<5
Aphanothece spp. >2 µm	----	5	cells/ml	----	----	----	----	<5
cf. Synechococcus spp.	----	5	cells/ml	----	----	----	----	<5
cf. Synechocystis spp.	----	5	cells/ml	----	----	----	----	<5
Coelomoron spp.	----	5	cells/ml	----	----	----	----	<5
Coelosphaerium spp.	----	5	cells/ml	----	----	----	----	<5
Chroococcus spp.	----	5	cells/ml	----	----	----	----	<5
Chroococcus minimus	----	5	cells/ml	----	----	----	----	<5
Chroococcus minutus	----	5	cells/ml	----	----	----	----	<5
Cyanocatena imperfecta	----	5	cells/ml	----	----	----	----	<5
Cyanocatena planctonica	----	5	cells/ml	----	----	----	----	<5
Cyanocatena spp.	----	5	cells/ml	----	----	----	----	<5
Cyanodictyon spp.	----	5	cells/ml	----	----	----	----	<5
Cyanogranis libera	----	5	cells/ml	----	----	----	----	<5
Cyanonephron spp.	----	5	cells/ml	----	----	----	----	<5
Cyanothece spp.	----	5	cells/ml	----	----	----	----	<5

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Pit 1	Pit 2	Eldridge Ramp	Wises Ramp	Eldridge 0m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ET1802030-001	ET1802030-002	ET1802030-003	ET1802030-004	ET1802030-005
				Result	Result	Result	Result	Result
MW024: Cyanophytes (Blue Green Algae) - Chroococcales - Continued								
Eucapsis spp.	----	5	cells/ml	----	----	----	----	<5
Gloeocapsa spp.	----	5	cells/ml	----	----	----	----	<5
Gloeothece spp.	----	5	cells/ml	----	----	----	----	<5
Gomphosphaeria spp.	----	5	cells/ml	----	----	----	----	<5
Limnococcus spp.	----	5	cells/ml	----	----	----	----	<5
Merismopedia spp.	----	5	cells/ml	----	----	----	----	<5
Merismopedia danubiana	----	5	cells/ml	----	----	----	----	<5
Merismopedia marsonii	----	5	cells/ml	----	----	----	----	<5
Merismopedia punctata	----	5	cells/ml	----	----	----	----	<5
Merismopedia tenuissima	----	5	cells/ml	----	----	----	----	<5
Microcystis spp.	----	5	cells/ml	----	----	----	----	<5
Microcystis aeruginosa (PTP)	----	5	cells/ml	----	----	----	----	<5
Microcystis cf. aeruginosa (PTP)	----	5	cells/ml	----	----	----	----	<5
Microcystis botrys	----	5	cells/ml	----	----	----	----	<5
Microcystis flos-aquae	----	5	cells/ml	----	----	----	----	<5
Microcystis wesenbergii	----	5	cells/ml	----	----	----	----	<5
Myxobaktron cf. spp.	----	5	cells/ml	----	----	----	----	<5
Myxobaktron spp.	----	5	cells/ml	----	----	----	----	<5
Pannus punctiferus	----	5	cells/ml	----	----	----	----	<5
Picoplanktic Chroococcales (<2µm)	----	5	cells/ml	----	----	----	----	<5
Rhabdoderma spp.	----	5	cells/ml	----	----	----	----	<5
Rhabdogloea spp.	----	5	cells/ml	----	----	----	----	<5
Radiocystis spp.	----	5	cells/ml	----	----	----	----	<5
Snowella spp.	----	5	cells/ml	----	----	----	----	<5
Synechococcus spp.	----	5	cells/ml	----	----	----	----	<5
Synechocystis spp.	----	5	cells/ml	----	----	----	----	<5
Woronichinia spp.	----	5	cells/ml	----	----	----	----	<5
Large Chroococcales	----	5	cells/ml	----	----	----	----	<5
Other Chroococcales	----	5	cells/ml	----	----	----	----	<5
Unidentified Chroococcales	----	5	cells/ml	----	----	----	----	<5
Total Chroococcales	----	5	cells/ml	----	----	----	----	<5
Aphanocapsa spp. < 2µm	----	5	cells/ml	----	----	----	----	<5
Aphanocapsa spp. > 2µm	----	5	cells/ml	----	----	----	----	<5
MW024: Cyanophytes (Blue Green Algae) - Nostocales								
Anabaena spp. (coiled)	----	5	cells/ml	----	----	----	----	<5

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Pit 1	Pit 2	Eldridge Ramp	Wises Ramp	Eldridge 0m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ET1802030-001	ET1802030-002	ET1802030-003	ET1802030-004	ET1802030-005
				Result	Result	Result	Result	Result
MW024: Cyanophytes (Blue Green Algae) - Nostocales - Continued								
Anabaena spp. (straight)	----	5	cells/ml	----	----	----	----	<5
Dolichospermum crassum	----	5	cells/ml	----	----	----	----	<5
Anabaena torulosa	----	5	cells/ml	----	----	----	----	<5
Aphanizomenon spp.	----	5	cells/ml	----	----	----	----	<5
Aphanizomenon gracile	----	5	cells/ml	----	----	----	----	<5
Cuspidothrix issatschenkoi	----	5	cells/ml	----	----	----	----	<5
Cylindrospermopsis raciborskii (PTP)	----	5	cells/ml	----	----	----	----	<5
Cylindrospermopsis cf. raciborskii (PTP)	----	5	cells/ml	----	----	----	----	<5
Cylindrospermum spp.	----	5	cells/ml	----	----	----	----	<5
Gloeotrichia spp.	----	5	cells/ml	----	----	----	----	<5
Nodularia spumigena (PTP)	----	5	cells/ml	----	----	----	----	<5
Nodularia cf. spumigena (PTP)	----	5	cells/ml	----	----	----	----	<5
Nostoc linckia (PTP)	----	5	cells/ml	----	----	----	----	<5
Nostoc cf. linckia (PTP)	----	5	cells/ml	----	----	----	----	<5
Nostoc spp.	----	5	cells/ml	----	----	----	----	<5
Raphidiopsis mediterranea (PTP)	----	5	cells/ml	----	----	----	----	<5
Raphidiopsis cf. mediterranea (PTP)	----	5	cells/ml	----	----	----	----	<5
Rivularia spp.	----	5	cells/ml	----	----	----	----	<5
Sphaerospermopsis aphanizomenoides	----	5	cells/ml	----	----	----	----	<5
Unidentified Nostocales	----	5	cells/ml	----	----	----	----	<5
Total Nostocales	----	5	cells/ml	----	----	----	----	<5
Anabaenopsis spp. (sphere)	----	5	cells/ml	----	----	----	----	<5
Anabaenopsis spp. (cylinder)	----	5	cells/ml	----	----	----	----	<5
Dolichospermum circinale (PTP)	----	5	cells/ml	----	----	----	----	<5
Dolichospermum cf. circinale (PTP)	----	5	cells/ml	----	----	----	----	<5
Chrysosporum bergii	----	5	cells/ml	----	----	----	----	<5
Chrysosporum ovalisporum (PTP)	----	5	cells/ml	----	----	----	----	<5
Chrysosporum cf. ovalisporum (PTP)	----	5	cells/ml	----	----	----	----	<5
Dolichospermum smithii	----	5	cells/ml	----	----	----	----	<5
Dolichospermum planctonicum	----	5	cells/ml	----	----	----	----	<5
Dolichospermum spp. (straight)	----	5	cells/ml	----	----	----	----	<5
Dolichospermum spp. (coiled)	----	5	cells/ml	----	----	----	----	<5
Other Nostocales	----	5	cells/ml	----	----	----	----	<5
Other Nostocales (possible PTP)	----	5	cells/ml	----	----	----	----	<5
MW024: Cyanophytes (Blue Green Algae) - Oscillatoriales								

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Pit 1	Pit 2	Eldridge Ramp	Wises Ramp	Eldridge 0m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ET1802030-001	ET1802030-002	ET1802030-003	ET1802030-004	ET1802030-005
				Result	Result	Result	Result	Result
MW024: Cyanophytes (Blue Green Algae) - Oscillatoriales - Continued								
Arthrospira spp.	----	5	cells/ml	----	----	----	----	<5
Geitlerinema spp.	----	5	cells/ml	----	----	----	----	<5
Komvophoron spp.	----	5	cells/ml	----	----	----	----	<5
Leptolyngbya spp.	----	5	cells/ml	----	----	----	----	<5
Limnothrix spp.	----	5	cells/ml	----	----	----	----	<5
Lyngbya spp.	----	5	cells/ml	----	----	----	----	<5
Lyngbya wollei (PTP)	----	5	cells/ml	----	----	----	----	<5
Lyngbya cf. wollei (PTP)	----	5	cells/ml	----	----	----	----	<5
Oscillatoria spp.	----	5	cells/ml	----	----	----	----	<5
Planktolyngbya minor	----	5	cells/ml	----	----	----	----	<5
Planktolyngbya limnetica	----	5	cells/ml	----	----	----	----	<5
Planktolyngbya microspira	----	5	cells/ml	----	----	----	----	<5
Pseudanabaena spp.	----	5	cells/ml	----	----	----	----	<5
Pseudanabaena galeata	----	5	cells/ml	----	----	----	----	<5
Pseudanabaena limnetica	----	5	cells/ml	----	----	----	----	<5
Pseudanabaena mucicola	----	5	cells/ml	----	----	----	----	<5
Plectonema spp.	----	5	cells/ml	----	----	----	----	<5
Romeria spp.	----	5	cells/ml	----	----	----	----	<5
Spirulina spp.	----	5	cells/ml	----	----	----	----	<5
Trichodesmium spp.	----	5	cells/ml	----	----	----	----	<5
Tychonema spp.	----	5	cells/ml	----	----	----	----	<5
Unidentified Oscillatoriales	----	5	cells/ml	----	----	----	----	<5
Total Oscillatoriales	----	5	cells/ml	----	----	----	----	<5
Phormidium spp. <5 µm	----	5	cells/ml	----	----	----	----	<5
Phormidium spp. >5 µm	----	5	cells/ml	----	----	----	----	<5
Planktothrix spp. <5 µm	----	5	cells/ml	----	----	----	----	<5
Planktothrix spp. >5 µm	----	5	cells/ml	----	----	----	----	<5
Fischerella sp. (PTP)	----	5	cells/ml	----	----	----	----	<5
Geitlerinema splendidum	----	5	cells/ml	----	----	----	----	<5
Glaucospira spp.	----	5	cells/ml	----	----	----	----	<5
Limnothrix spp. (possible PTP)	----	5	cells/ml	----	----	----	----	<5
Microseira wollei (PTP)	----	5	cells/ml	----	----	----	----	<5
Phormidium aff. amoenum (PTP)	----	5	cells/ml	----	----	----	----	<5
Phormidium aff. formosum (PTP)	----	5	cells/ml	----	----	----	----	<5
Phormidium spp. <5µm (possible PTP)	----	5	cells/ml	----	----	----	----	<5

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			Client sample ID	Pit 1	Pit 2	Eldridge Ramp	Wises Ramp	Eldridge 0m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	*CAS Number*	*LOR*	*Unit*	ET1802030-001	ET1802030-002	ET1802030-003	ET1802030-004	ET1802030-005
				Result	Result	Result	Result	Result
MW024: Cyanophytes (Blue Green Algae) - Oscillatoriales - Continued								
Phormidium spp. >5µm (possible PTP)	----	5	cells/ml	----	----	----	----	<5
Planktolyngbya spp.	----	5	cells/ml	----	----	----	----	<5
Other Oscillatoriales	----	5	cells/ml	----	----	----	----	<5
Other Oscillatoriales (possible PTP)	----	5	cells/ml	----	----	----	----	<5
MW024: Cyanophytes (Blue Green Algae) - Other Cyanophytes								
Other Cyanophytes	----	5	cells/ml	----	----	----	----	<5
MW024: Cyanophytes (Blue Green Algae) - Stigonematales								
Nostochopsis spp.	----	5	cells/ml	----	----	----	----	<5
Total Stigonematales	----	5	cells/ml	----	----	----	----	<5
Unidentified Cyanophytes	----	5	cells/ml	----	----	----	----	<5
Other Stigonmetales	----	5	cells/ml	----	----	----	----	<5
Other Stigonematales	----	5	cells/ml	----	----	----	----	<5
MW024: Cyanophytes (Blue Green Algae) - TOTAL CYANOPHYTES								
Total Cyanophytes	----	5	cells/ml	----	----	----	----	<5
MW024: Cyanophytes (Blue Green Algae) - TOTAL POTENTIALLY TOXIC CYANOPHYTES								
Total Potentially Toxic Cyanophytes	----	5	cells/ml	----	----	----	----	<5
MW024: Flagellates - Cryptophytes								
Chroomonas spp.	----	5	cells/ml	----	----	----	----	<5
Cryptomonas spp.	----	5	cells/ml	----	----	----	----	<5
Rhodomonas spp.	----	5	cells/ml	----	----	----	----	<5
Unidentified Flagellates	----	5	cells/ml	----	----	----	----	<5
Other Cryptophytes	----	5	cells/ml	----	----	----	----	<5
Flagellates	----	5	cells/ml	----	----	----	----	<5
MW024: Flagellates - Euglenophytes								
Encysted Euglenophytes	----	5	cells/ml	----	----	----	----	<5
Euglena spp.	----	5	cells/ml	----	----	----	----	<5
Eutreptia spp.	----	5	cells/ml	----	----	----	----	<5
Lepocinclis spp.	----	5	cells/ml	----	----	----	----	<5
Phacus spp.	----	5	cells/ml	----	----	----	----	<5
Strombomonas spp.	----	5	cells/ml	----	----	----	----	<5
Trachelomonas spp.	----	5	cells/ml	----	----	----	----	<5
MW024: Flagellates - Pyrrophytes								
Ceratium spp.	----	5	cells/ml	----	----	----	----	<5
Encysted Dinium	----	5	cells/ml	----	----	----	----	<5

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Pit 1	Pit 2	Eldridge Ramp	Wises Ramp	Eldridge 0m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ET1802030-001	ET1802030-002	ET1802030-003	ET1802030-004	ET1802030-005
				Result	Result	Result	Result	Result
MW024: Flagellates - Pyrrophytes - Continued								
Glenodinium spp.	----	5	cells/ml	----	----	----	----	<5
Gonyaulax spp.	----	5	cells/ml	----	----	----	----	<5
Gymnodinium spp.	----	5	cells/ml	----	----	----	----	<5
Gyrodinium spp.	----	5	cells/ml	----	----	----	----	<5
Katodinium spp.	----	5	cells/ml	----	----	----	----	<5
Peridinium spp.	----	5	cells/ml	----	----	----	----	<5
Prorocentrum minimum	----	5	cells/ml	----	----	----	----	<5
Prorocentrum spp.	----	5	cells/ml	----	----	----	----	<5
Other Dinoflagellates	----	5	cells/ml	----	----	----	----	<5
Unidentified Dinoflagellates	----	5	cells/ml	----	----	----	----	<5
Scrippsiella spp.	----	5	cells/ml	----	----	----	----	<5
Scerpsiella spp.	----	5	cells/ml	----	----	----	----	<5
MW024: Flagellates - TOTAL FLAGELLATES								
Total Flagellates	----	5	cells/ml	----	----	----	----	<5
MW024: Raphidophyte								
Gonyostomum spp.	----	5	cells/ml	----	----	----	----	<5
Heterosigma spp.	----	5	cells/ml	----	----	----	----	<5
Raphidophytes	----	5	cells/ml	----	----	----	----	<5
Other Raphidophytes	----	5	cells/ml	----	----	----	----	<5
MW024: Raphidophyte - TOTAL RAPHIDOPHYTE								
Total Raphidophytes	----	5	cells/ml	----	----	----	----	<5
MW024T: TOTAL ALGAE								
Total Algae Count	----	5	cells/ml	----	----	----	----	<5

Analytical Results

Sub-Matrix: **WATER**
(Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Eldridge 10m	Eldridge 20m	Eldridge 30m	Eldridge 50m	Eldridge 100m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
				ET1802030-006	ET1802030-007	ET1802030-008	ET1802030-009	ET1802030-010
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.59	7.59	7.60	7.55	7.54
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	3100	3130	3120	3120	3100
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	<5	<5	<5	<5
EA045: Turbidity								
Turbidity	----	0.1	NTU	0.3	0.4	0.3	0.3	0.3
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	44	44	43	43	45
Total Alkalinity as CaCO3	----	1	mg/L	44	44	43	43	45
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	1580	1350	1440	1530	1350
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	93	96	93	93	93
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	316	321	313	314	321
Magnesium	7439-95-4	1	mg/L	93	94	93	92	93
Sodium	7440-23-5	1	mg/L	297	297	298	295	295
Potassium	7440-09-7	1	mg/L	46	47	46	46	46
ED093F: SAR and Hardness Calculations								
Total Hardness as CaCO3	----	1	mg/L	1170	1190	1160	1160	1180
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.02	0.03	0.02	0.02	0.03
Arsenic	7440-38-2	0.001	mg/L	0.026	0.027	0.027	0.027	0.028
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	0.038	0.038	0.038	0.038	0.039
Cadmium	7440-43-9	0.0001	mg/L	0.0238	0.0234	0.0234	0.0238	0.0237
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	0.005	0.005	0.005	0.004	0.005
Copper	7440-50-8	0.001	mg/L	0.003	0.003	0.003	0.003	0.003
Lead	7439-92-1	0.001	mg/L	<0.001	0.002	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	1.22	1.23	1.22	1.22	1.23

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Eldridge 10m	Eldridge 20m	Eldridge 30m	Eldridge 50m	Eldridge 100m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ET1802030-006	ET1802030-007	ET1802030-008	ET1802030-009	ET1802030-010
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Molybdenum	7439-98-7	0.001	mg/L	**0.051**	**0.049**	**0.048**	**0.050**	**0.050**
Nickel	7440-02-0	0.001	mg/L	**0.024**	**0.025**	**0.024**	**0.024**	**0.025**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	7440-61-1	0.001	mg/L	**0.006**	**0.006**	**0.006**	**0.006**	**0.006**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	**1.22**	**1.21**	**1.21**	**1.21**	**1.24**
Boron	7440-42-8	0.05	mg/L	**0.07**	**0.06**	**0.06**	**0.06**	**0.06**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**
Arsenic	7440-38-2	0.001	mg/L	**0.029**	**0.029**	**0.029**	**0.030**	**0.029**
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	**0.036**	**0.035**	**0.034**	**0.036**	**0.035**
Cadmium	7440-43-9	0.0001	mg/L	**0.0254**	**0.0252**	**0.0254**	**0.0259**	**0.0258**
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	**0.004**	**0.004**	**0.004**	**0.004**	**0.004**
Copper	7440-50-8	0.001	mg/L	**0.004**	**0.004**	**0.004**	**0.004**	**0.004**
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	**1.25**	**1.26**	**1.26**	**1.30**	**1.29**
Molybdenum	7439-98-7	0.001	mg/L	**0.057**	**0.056**	**0.057**	**0.058**	**0.058**
Nickel	7440-02-0	0.001	mg/L	**0.022**	**0.023**	**0.023**	**0.023**	**0.024**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	7440-61-1	0.001	mg/L	**0.006**	**0.006**	**0.006**	**0.006**	**0.006**
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	**1.20**	**1.19**	**1.20**	**1.23**	**1.24**
Boron	7440-42-8	0.05	mg/L	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.00004	mg/L	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004
EG035T: Total Mercury by FIMS								
Mercury	7439-97-6	0.00004	mg/L	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004
EK025SF: Free CN by Segmented Flow Analyser								

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Eldridge 10m	Eldridge 20m	Eldridge 30m	Eldridge 50m	Eldridge 100m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ET1802030-006	ET1802030-007	ET1802030-008	ET1802030-009	ET1802030-010
				Result	Result	Result	Result	Result
EK025SF: Free CN by Segmented Flow Analyser - Continued								
Free Cyanide	----	0.004	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**3.0**	**2.9**	**2.9**	**3.0**	**3.0**
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.22**	**0.21**	**0.19**	**0.18**	**0.21**
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**5.02**	**5.01**	**5.02**	**4.96**	**4.99**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**5.02**	**5.01**	**5.02**	**4.96**	**4.99**
EK060G:Organic Nitrogen as N (TKN-NH3) By Discrete Analyser								
Organic Nitrogen as N	----	0.1	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.5	<0.5	<0.5	**0.5**	<0.5
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	**5.0**	**5.0**	**5.0**	**5.5**	**5.0**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**36.4**	**31.7**	**33.5**	**35.3**	**31.6**
Total Cations	----	0.01	meq/L	**37.5**	**37.9**	**37.4**	**37.2**	**37.7**
Ionic Balance	----	0.01	%	**1.51**	**8.88**	**5.57**	**2.63**	**8.73**
EP002: Dissolved Organic Carbon (DOC)								
Dissolved Organic Carbon	----	1	mg/L	<1	<1	<1	**1**	**1**
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	<1	<1	<1	**1**	**1**
EP008: Chlorophyll a & Pheophytin a								
Chlorophyll a	----	1	mg/m³	----	----	<1	----	----
MW024: Bacillariophytes (Diatoms) - Centrales								
Acanthoceras spp.	----	5	cells/ml	----	----	<5	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Eldridge 10m	Eldridge 20m	Eldridge 30m	Eldridge 50m	Eldridge 100m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ET1802030-006	ET1802030-007	ET1802030-008	ET1802030-009	ET1802030-010
				Result	Result	Result	Result	Result
MW024: Bacillariophytes (Diatoms) - Centrales - Continued								
Aulacoseira spp.	----	5	cells/ml	----	----	<5	----	----
Chaetoceros spp.	----	5	cells/ml	----	----	<5	----	----
Coscinodiscus spp.	----	5	cells/ml	----	----	<5	----	----
Cyclotella spp.	----	5	cells/ml	----	----	<5	----	----
Melosira spp.	----	5	cells/ml	----	----	<5	----	----
Rhizosolenia spp.	----	5	cells/ml	----	----	<5	----	----
Skeletonema spp.	----	5	cells/ml	----	----	<5	----	----
Thalassioseira spp.	----	5	cells/ml	----	----	<5	----	----
Urosolenia spp.	----	5	cells/ml	----	----	<5	----	----
Other centrics	----	5	cells/ml	----	----	<5	----	----
Thalassiosira spp.	----	5	cells/ml	----	----	<5	----	----
MW024: Bacillariophytes (Diatoms) - Pennales								
Achnanthidium spp.	----	5	cells/ml	----	----	<5	----	----
Amphora spp.	----	5	cells/ml	----	----	<5	----	----
Asterionella spp.	----	5	cells/ml	----	----	<5	----	----
Bacillaria spp.	----	5	cells/ml	----	----	<5	----	----
Bacillariophytes	----	5	cells/ml	----	----	<5	----	----
Cocconeis spp.	----	5	cells/ml	----	----	<5	----	----
Cylindrotheca closterium	----	5	cells/ml	----	----	<5	----	----
Cymbella spp.	----	5	cells/ml	----	----	<5	----	----
Diatoma spp.	----	5	cells/ml	----	----	<5	----	----
Entomoneis spp.	----	5	cells/ml	----	----	<5	----	----
Eunotia spp.	----	5	cells/ml	----	----	<5	----	----
Fragilaria spp.	----	5	cells/ml	----	----	<5	----	----
Gomphonema spp.	----	5	cells/ml	----	----	<5	----	----
Gyrosigma spp.	----	5	cells/ml	----	----	<5	----	----
Hantzschia spp.	----	5	cells/ml	----	----	<5	----	----
Navicula spp.	----	5	cells/ml	----	----	<5	----	----
Nitzschia spp.	----	5	cells/ml	----	----	<5	----	----
Pinnularia spp.	----	5	cells/ml	----	----	<5	----	----
Pseudonitzschia spp.	----	5	cells/ml	----	----	<5	----	----
Rhoicosphenia spp.	----	5	cells/ml	----	----	<5	----	----
Rhopalodia spp.	----	5	cells/ml	----	----	<5	----	----
Surirella spp.	----	5	cells/ml	----	----	<5	----	----
Synedra spp.	----	5	cells/ml	----	----	<5	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Eldridge 10m	Eldridge 20m	Eldridge 30m	Eldridge 50m	Eldridge 100m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ET1802030-006	ET1802030-007	ET1802030-008	ET1802030-009	ET1802030-010
				Result	Result	Result	Result	Result
MW024: Bacillariophytes (Diatoms) - Pennales - Continued								
Tabellaria spp.	----	5	cells/ml	----	----	<5	----	----
Other Bacillariophytes	----	5	cells/ml	----	----	<5	----	----
Other pennates	----	5	cells/ml	----	----	<5	----	----
MW024: Bacillariophytes (Diatoms) - TOTAL BACILLARIOPHYTES								
Total Bacillariophytes	----	5	cells/ml	----	----	<5	----	----
MW024: Chlorophytes (Green Algae) - Chaetophorales								
Chaetophora spp.	----	5	cells/ml	----	----	<5	----	----
Stigeoclonium spp.	----	5	cells/ml	----	----	<5	----	----
MW024: Chlorophytes (Green Algae) - Chlorococcales								
Actinastrum spp.	----	5	cells/ml	----	----	<5	----	----
Ankistrodesmus spp.	----	5	cells/ml	----	----	<5	----	----
Ankyra spp.	----	5	cells/ml	----	----	<5	----	----
Botryococcus spp.	----	5	cells/ml	----	----	<5	----	----
Chlorella spp.	----	5	cells/ml	----	----	<5	----	----
Closteridium spp.	----	5	cells/ml	----	----	<5	----	----
Closteriopsis spp.	----	5	cells/ml	----	----	<5	----	----
Coelastrum spp.	----	5	cells/ml	----	----	<5	----	----
Crucigenia spp.	----	5	cells/ml	----	----	<5	----	----
Cylindrocapsa spp.	----	5	cells/ml	----	----	<5	----	----
Dictyosphaerium spp.	----	5	cells/ml	----	----	<5	----	----
Didymocystis spp.	----	5	cells/ml	----	----	<5	----	----
Dimorphococcus spp.	----	5	cells/ml	----	----	<5	----	----
Elakatothrix spp.	----	5	cells/ml	----	----	<5	----	----
Golenkenia spp.	----	5	cells/ml	----	----	<5	----	----
Hydrodictyon spp.	----	5	cells/ml	----	----	<5	----	----
Kirchneriella spp.	----	5	cells/ml	----	----	<5	----	----
Lagerheimia spp.	----	5	cells/ml	----	----	<5	----	----
Micractinium spp.	----	5	cells/ml	----	----	<5	----	----
Microspora spp.	----	5	cells/ml	----	----	<5	----	----
Monoraphidium spp.	----	5	cells/ml	----	----	<5	----	----
Nephrocytium spp.	----	5	cells/ml	----	----	<5	----	----
Oocystis spp.	----	5	cells/ml	----	----	<5	----	----
Palmella spp.	----	5	cells/ml	----	----	<5	----	----
Pediastrum spp.	----	5	cells/ml	----	----	<5	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Eldridge 10m	Eldridge 20m	Eldridge 30m	Eldridge 50m	Eldridge 100m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ET1802030-006	ET1802030-007	ET1802030-008	ET1802030-009	ET1802030-010
				Result	Result	Result	Result	Result
MW024: Chlorophytes (Green Algae) - Chlorococcales - Continued								
Quadrigula spp.	----	5	cells/ml	----	----	<5	----	----
Scenedesmus spp.	----	5	cells/ml	----	----	<5	----	----
Schroederia spp.	----	5	cells/ml	----	----	<5	----	----
Selenastrum spp.	----	5	cells/ml	----	----	<5	----	----
Selenodictyum spp.	----	5	cells/ml	----	----	<5	----	----
Sphaerocystis spp.	----	5	cells/ml	----	----	<5	----	----
Tetradesmus spp.	----	5	cells/ml	----	----	<5	----	----
Tetraedron spp.	----	5	cells/ml	----	----	<5	----	----
Tetrastrum spp.	----	5	cells/ml	----	----	<5	----	----
Treubaria spp.	----	5	cells/ml	----	----	<5	----	----
Crucigeniella spp.	----	5	cells/ml	----	----	<5	----	----
Dichotomochoccus spp.	----	5	cells/ml	----	----	<5	----	----
Westella spp.	----	5	cells/ml	----	----	<5	----	----
MW024: Chlorophytes (Green Algae) - Cladophorales								
Cladophora spp.	----	5	cells/ml	----	----	<5	----	----
Rhizoclonium spp.	----	5	cells/ml	----	----	<5	----	----
MW024: Chlorophytes (Green Algae) - Oedogoniales								
Bulbochaete spp.	----	5	cells/ml	----	----	<5	----	----
Oedogonium spp.	----	5	cells/ml	----	----	<5	----	----
MW024: Chlorophytes (Green Algae) - Tetrasporales								
Gloeocystis spp.	----	5	cells/ml	----	----	<5	----	----
Tetraspora spp.	----	5	cells/ml	----	----	<5	----	----
MW024: Chlorophytes (Green Algae) - TOTAL CHLOROPHYTES								
Total Chlorophytes	----	5	cells/ml	----	----	<5	----	----
MW024: Chlorophytes (Green Algae) - Ulotrichales								
Planktonema spp.	----	5	cells/ml	----	----	<5	----	----
Ulothrix spp.	----	5	cells/ml	----	----	<5	----	----
Planctonema spp.	----	5	cells/ml	----	----	<5	----	----
Koliella spp.	----	5	cells/ml	----	----	<5	----	----
MW024: Chlorophytes (Green Algae) - Volvocales								
Carteria spp.	----	5	cells/ml	----	----	<5	----	----
Chlamydomonas spp.	----	5	cells/ml	----	----	<5	----	----
Chlorogonium spp.	----	5	cells/ml	----	----	<5	----	----
Eudorina spp.	----	5	cells/ml	----	----	<5	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Eldridge 10m	Eldridge 20m	Eldridge 30m	Eldridge 50m	Eldridge 100m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ET1802030-006	ET1802030-007	ET1802030-008	ET1802030-009	ET1802030-010
				Result	Result	Result	Result	Result
MW024: Chlorophytes (Green Algae) - Volvocales - Continued								
Gonium spp.	----	5	cells/ml	----	----	<5	----	----
Haematococcus spp.	----	5	cells/ml	----	----	<5	----	----
Pandorina spp.	----	5	cells/ml	----	----	<5	----	----
Phacotus spp.	----	5	cells/ml	----	----	<5	----	----
Pleodorina spp.	----	5	cells/ml	----	----	<5	----	----
Pteromonas spp.	----	5	cells/ml	----	----	<5	----	----
Spermatozoopsis spp.	----	5	cells/ml	----	----	<5	----	----
Sphaerellopsis spp.	----	5	cells/ml	----	----	<5	----	----
Tetraselmis spp.	----	5	cells/ml	----	----	<5	----	----
Volvox spp.	----	5	cells/ml	----	----	<5	----	----
Unidentified Green algae	----	5	cells/ml	----	----	<5	----	----
Pyramimonas spp.	----	5	cells/ml	----	----	<5	----	----
Chlorophytes	----	5	cells/ml	----	----	<5	----	----
Other green cells	----	5	cells/ml	----	----	<5	----	----
Other green filaments	----	5	cells/ml	----	----	<5	----	----
Stichococcus spp.	----	5	cells/ml	----	----	<5	----	----
MW024: Chlorophytes (Green Algae) - Zygnematales								
Actinotaenium spp.	----	5	cells/ml	----	----	<5	----	----
Closterium spp.	----	5	cells/ml	----	----	<5	----	----
Cosmarium spp.	----	5	cells/ml	----	----	<5	----	----
Cosmocladium spp.	----	5	cells/ml	----	----	<5	----	----
Desmidium spp.	----	5	cells/ml	----	----	<5	----	----
Euastrum spp.	----	5	cells/ml	----	----	<5	----	----
Gonatozygon spp.	----	5	cells/ml	----	----	<5	----	----
Hyalotheca spp.	----	5	cells/ml	----	----	<5	----	----
Micrasterias spp.	----	5	cells/ml	----	----	<5	----	----
Mougeotia spp.	----	5	cells/ml	----	----	<5	----	----
Netrium spp.	----	5	cells/ml	----	----	<5	----	----
Penium spp.	----	5	cells/ml	----	----	<5	----	----
Pleurotaenium spp.	----	5	cells/ml	----	----	<5	----	----
Sirogonium spp.	----	5	cells/ml	----	----	<5	----	----
Sphaerozosma spp.	----	5	cells/ml	----	----	<5	----	----
Spirogyra spp.	----	5	cells/ml	----	----	<5	----	----
Spondylosium spp.	----	5	cells/ml	----	----	<5	----	----
Staurastrum spp.	----	5	cells/ml	----	----	<5	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Eldridge 10m	Eldridge 20m	Eldridge 30m	Eldridge 50m	Eldridge 100m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ET1802030-006	ET1802030-007	ET1802030-008	ET1802030-009	ET1802030-010
				Result	Result	Result	Result	Result
MW024: Chlorophytes (Green Algae) - Zygnematales - Continued								
Staurodesmus spp.	----	5	cells/ml	----	----	<5	----	----
Tellingia spp.	----	5	cells/ml	----	----	<5	----	----
Triploceras spp.	----	5	cells/ml	----	----	<5	----	----
Xanthidium spp.	----	5	cells/ml	----	----	<5	----	----
Zygnema spp.	----	5	cells/ml	----	----	<5	----	----
Haplotaenium spp.	----	5	cells/ml	----	----	<5	----	----
MW024: Chrysophytes (Golden Algae)								
Centritractus spp.	----	5	cells/ml	----	----	<5	----	----
Chrysophytes	----	5	cells/ml	----	----	<5	----	----
Chrysochromulina spp.	----	5	cells/ml	----	----	<5	----	----
Diceras spp.	----	5	cells/ml	----	----	<5	----	----
Dinobryon spp.	----	5	cells/ml	----	----	<5	----	----
Epipyxis spp.	----	5	cells/ml	----	----	<5	----	----
Isthmochloron spp.	----	5	cells/ml	----	----	<5	----	----
Mallomonas akrokomos	----	5	cells/ml	----	----	<5	----	----
Mallomonas splendidum	----	5	cells/ml	----	----	<5	----	----
Mallomonas spp.	----	5	cells/ml	----	----	<5	----	----
Synura spp.	----	5	cells/ml	----	----	<5	----	----
Tribonema spp.	----	5	cells/ml	----	----	<5	----	----
Uroglena spp.	----	5	cells/ml	----	----	<5	----	----
Unidentified Golden algae	----	5	cells/ml	----	----	<5	----	----
Other Chrysophytes	----	5	cells/ml	----	----	<5	----	----
MW024: Chrysophytes (Golden Algae) - TOTAL CHRYSOPHYTES								
Total Chrysophytes	----	5	cells/ml	----	----	<5	----	----
MW024: Cyanophytes (Blue Green Algae) - Chroococcales								
Aphanothece spp. <2 µm	----	5	cells/ml	----	----	<5	----	----
Aphanothece spp. >2 µm	----	5	cells/ml	----	----	<5	----	----
cf. Synechococcus spp.	----	5	cells/ml	----	----	<5	----	----
cf. Synechocystis spp.	----	5	cells/ml	----	----	<5	----	----
Coelomoron spp.	----	5	cells/ml	----	----	<5	----	----
Coelosphaerium spp.	----	5	cells/ml	----	----	<5	----	----
Chroococcus spp.	----	5	cells/ml	----	----	<5	----	----
Chroococcus minimus	----	5	cells/ml	----	----	<5	----	----
Chroococcus minutus	----	5	cells/ml	----	----	<5	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Eldridge 10m	Eldridge 20m	Eldridge 30m	Eldridge 50m	Eldridge 100m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ET1802030-006	ET1802030-007	ET1802030-008	ET1802030-009	ET1802030-010
				Result	Result	Result	Result	Result
MW024: Cyanophytes (Blue Green Algae) - Chroococcales - Continued								
Cyanocatena imperfecta	----	5	cells/ml	----	----	<5	----	----
Cyanocatena planctonica	----	5	cells/ml	----	----	<5	----	----
Cyanocatena spp.	----	5	cells/ml	----	----	<5	----	----
Cyanodictyon spp.	----	5	cells/ml	----	----	<5	----	----
Cyanogranis libera	----	5	cells/ml	----	----	<5	----	----
Cyanonephron spp.	----	5	cells/ml	----	----	<5	----	----
Cyanothece spp.	----	5	cells/ml	----	----	<5	----	----
Eucapsis spp.	----	5	cells/ml	----	----	<5	----	----
Gloeocapsa spp.	----	5	cells/ml	----	----	<5	----	----
Gloeothece spp.	----	5	cells/ml	----	----	<5	----	----
Gomphosphaeria spp.	----	5	cells/ml	----	----	<5	----	----
Limnococcus spp.	----	5	cells/ml	----	----	<5	----	----
Merismopedia spp.	----	5	cells/ml	----	----	<5	----	----
Merismopedia danubiana	----	5	cells/ml	----	----	<5	----	----
Merismopedia marsonii	----	5	cells/ml	----	----	<5	----	----
Merismopedia punctata	----	5	cells/ml	----	----	<5	----	----
Merismopedia tenuissima	----	5	cells/ml	----	----	<5	----	----
Microcystis spp.	----	5	cells/ml	----	----	<5	----	----
Microcystis aeruginosa (PTP)	----	5	cells/ml	----	----	<5	----	----
Microcystis cf. aeruginosa (PTP)	----	5	cells/ml	----	----	<5	----	----
Microcystis botrys	----	5	cells/ml	----	----	<5	----	----
Microcystis flos-aquae	----	5	cells/ml	----	----	<5	----	----
Microcystis wesenbergii	----	5	cells/ml	----	----	<5	----	----
Myxobaktron cf. spp.	----	5	cells/ml	----	----	<5	----	----
Myxobaktron spp.	----	5	cells/ml	----	----	<5	----	----
Pannus punctiferus	----	5	cells/ml	----	----	<5	----	----
Picoplanktic Chroococcales (<2µm)	----	5	cells/ml	----	----	<5	----	----
Rhabdoderma spp.	----	5	cells/ml	----	----	<5	----	----
Rhabdogloea spp.	----	5	cells/ml	----	----	<5	----	----
Radiocystis spp.	----	5	cells/ml	----	----	<5	----	----
Snowella spp.	----	5	cells/ml	----	----	<5	----	----
Synechococcus spp.	----	5	cells/ml	----	----	<5	----	----
Synechocystis spp.	----	5	cells/ml	----	----	<5	----	----
Woronichinia spp.	----	5	cells/ml	----	----	<5	----	----
Large Chroococcales	----	5	cells/ml	----	----	<5	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Eldridge 10m	Eldridge 20m	Eldridge 30m	Eldridge 50m	Eldridge 100m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ET1802030-006	ET1802030-007	ET1802030-008	ET1802030-009	ET1802030-010
				Result	Result	Result	Result	Result
MW024: Cyanophytes (Blue Green Algae) - Chroococcales - Continued								
Other Chroococcales	----	5	cells/ml	----	----	<5	----	----
Unidentified Chroococcales	----	5	cells/ml	----	----	<5	----	----
Total Chroococcales	----	5	cells/ml	----	----	<5	----	----
Aphanocapsa spp. < 2µm	----	5	cells/ml	----	----	<5	----	----
Aphanocapsa spp. > 2µm	----	5	cells/ml	----	----	<5	----	----
MW024: Cyanophytes (Blue Green Algae) - Nostocales								
Anabaena spp. (coiled)	----	5	cells/ml	----	----	<5	----	----
Anabaena spp. (straight)	----	5	cells/ml	----	----	<5	----	----
Dolichospermum crassum	----	5	cells/ml	----	----	<5	----	----
Anabaena torulosa	----	5	cells/ml	----	----	<5	----	----
Aphanizomenon spp.	----	5	cells/ml	----	----	<5	----	----
Aphanizomenon gracile	----	5	cells/ml	----	----	<5	----	----
Cuspidothrix issatschenkoi	----	5	cells/ml	----	----	<5	----	----
Cylindrospermopsis raciborskii (PTP)	----	5	cells/ml	----	----	<5	----	----
Cylindrospermopsis cf. raciborskii (PTP)	----	5	cells/ml	----	----	<5	----	----
Cylindrospermum spp.	----	5	cells/ml	----	----	<5	----	----
Gloeotrichia spp.	----	5	cells/ml	----	----	<5	----	----
Nodularia spumigena (PTP)	----	5	cells/ml	----	----	<5	----	----
Nodularia cf. spumigena (PTP)	----	5	cells/ml	----	----	<5	----	----
Nostoc linckia (PTP)	----	5	cells/ml	----	----	<5	----	----
Nostoc cf. linckia (PTP)	----	5	cells/ml	----	----	<5	----	----
Nostoc spp.	----	5	cells/ml	----	----	<5	----	----
Raphidiopsis mediterranea (PTP)	----	5	cells/ml	----	----	<5	----	----
Raphidiopsis cf. mediterranea (PTP)	----	5	cells/ml	----	----	<5	----	----
Rivularia spp.	----	5	cells/ml	----	----	<5	----	----
Sphaerospermopsis aphanizomenoides	----	5	cells/ml	----	----	<5	----	----
Unidentified Nostocales	----	5	cells/ml	----	----	<5	----	----
Total Nostocales	----	5	cells/ml	----	----	<5	----	----
Anabaenopsis spp. (sphere)	----	5	cells/ml	----	----	<5	----	----
Anabaenopsis spp. (cylinder)	----	5	cells/ml	----	----	<5	----	----
Dolichospermum circinale (PTP)	----	5	cells/ml	----	----	<5	----	----
Dolichospermum cf. circinale (PTP)	----	5	cells/ml	----	----	<5	----	----
Chrysosporum bergii	----	5	cells/ml	----	----	<5	----	----
Chrysosporum ovalisporum (PTP)	----	5	cells/ml	----	----	<5	----	----
Chrysosporum cf. ovalisporum (PTP)	----	5	cells/ml	----	----	<5	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Eldridge 10m	Eldridge 20m	Eldridge 30m	Eldridge 50m	Eldridge 100m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ET1802030-006	ET1802030-007	ET1802030-008	ET1802030-009	ET1802030-010
				Result	Result	Result	Result	Result
MW024: Cyanophytes (Blue Green Algae) - Nostocales - Continued								
Dolichospermum smithii	----	5	cells/ml	----	----	<5	----	----
Dolichospermum planctonicum	----	5	cells/ml	----	----	<5	----	----
Dolichospermum spp. (straight)	----	5	cells/ml	----	----	<5	----	----
Dolichospermum spp. (coiled)	----	5	cells/ml	----	----	<5	----	----
Other Nostocales	----	5	cells/ml	----	----	<5	----	----
Other Nostocales (possible PTP)	----	5	cells/ml	----	----	<5	----	----
MW024: Cyanophytes (Blue Green Algae) - Oscillatoriales								
Arthrospira spp.	----	5	cells/ml	----	----	<5	----	----
Geitlerinema spp.	----	5	cells/ml	----	----	<5	----	----
Komvophoron spp.	----	5	cells/ml	----	----	<5	----	----
Leptolyngbya spp.	----	5	cells/ml	----	----	<5	----	----
Limnothrix spp.	----	5	cells/ml	----	----	<5	----	----
Lyngbya spp.	----	5	cells/ml	----	----	<5	----	----
Lyngbya wollei (PTP)	----	5	cells/ml	----	----	<5	----	----
Lyngbya cf. wollei (PTP)	----	5	cells/ml	----	----	<5	----	----
Oscillatoria spp.	----	5	cells/ml	----	----	<5	----	----
Planktolyngbya minor	----	5	cells/ml	----	----	<5	----	----
Planktolyngbya limnetica	----	5	cells/ml	----	----	<5	----	----
Planktolyngbya microspira	----	5	cells/ml	----	----	<5	----	----
Pseudanabaena spp.	----	5	cells/ml	----	----	<5	----	----
Pseudanabaena galeata	----	5	cells/ml	----	----	<5	----	----
Pseudanabaena limnetica	----	5	cells/ml	----	----	<5	----	----
Pseudanabaena mucicola	----	5	cells/ml	----	----	<5	----	----
Plectonema spp.	----	5	cells/ml	----	----	<5	----	----
Romeria spp.	----	5	cells/ml	----	----	<5	----	----
Spirulina spp.	----	5	cells/ml	----	----	<5	----	----
Trichodesmium spp.	----	5	cells/ml	----	----	<5	----	----
Tychonema spp.	----	5	cells/ml	----	----	<5	----	----
Unidentified Oscillatoriales	----	5	cells/ml	----	----	<5	----	----
Total Oscillatoriales	----	5	cells/ml	----	----	<5	----	----
Phormidium spp. <5 µm	----	5	cells/ml	----	----	<5	----	----
Phormidium spp. >5 µm	----	5	cells/ml	----	----	<5	----	----
Planktothrix spp. <5 µm	----	5	cells/ml	----	----	<5	----	----
Planktothrix spp. >5 µm	----	5	cells/ml	----	----	<5	----	----
Fischerella sp. (PTP)	----	5	cells/ml	----	----	<5	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Eldridge 10m	Eldridge 20m	Eldridge 30m	Eldridge 50m	Eldridge 100m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ET1802030-006	ET1802030-007	ET1802030-008	ET1802030-009	ET1802030-010
				Result	Result	Result	Result	Result
MW024: Cyanophytes (Blue Green Algae) - Oscillatoriales - Continued								
Geitlerinema splendidum	----	5	cells/ml	----	----	<5	----	----
Glaucospira spp.	----	5	cells/ml	----	----	<5	----	----
Limnothrix spp. (possible PTP)	----	5	cells/ml	----	----	<5	----	----
Microseira wollei (PTP)	----	5	cells/ml	----	----	<5	----	----
Phormidium aff. amoenum (PTP)	----	5	cells/ml	----	----	<5	----	----
Phormidium aff. formosum (PTP)	----	5	cells/ml	----	----	<5	----	----
Phormidium spp. <5µm (possible PTP)	----	5	cells/ml	----	----	<5	----	----
Phormidium spp. >5µm (possible PTP)	----	5	cells/ml	----	----	<5	----	----
Planktolyngbya spp.	----	5	cells/ml	----	----	<5	----	----
Other Oscillatoriales	----	5	cells/ml	----	----	<5	----	----
Other Oscillatoriales (possible PTP)	----	5	cells/ml	----	----	<5	----	----
MW024: Cyanophytes (Blue Green Algae) - Other Cyanophytes								
Other Cyanophytes	----	5	cells/ml	----	----	<5	----	----
MW024: Cyanophytes (Blue Green Algae) - Stigonematales								
Nostochopsis spp.	----	5	cells/ml	----	----	<5	----	----
Total Stigonematales	----	5	cells/ml	----	----	<5	----	----
Unidentified Cyanophytes	----	5	cells/ml	----	----	<5	----	----
Other Stigonmetales	----	5	cells/ml	----	----	<5	----	----
Other Stigonematales	----	5	cells/ml	----	----	<5	----	----
MW024: Cyanophytes (Blue Green Algae) - TOTAL CYANOPHYTES								
Total Cyanophytes	----	5	cells/ml	----	----	<5	----	----
MW024: Cyanophytes (Blue Green Algae) - TOTAL POTENTIALLY TOXIC CYANOPHYTES								
Total Potentially Toxic Cyanophytes	----	5	cells/ml	----	----	<5	----	----
MW024: Flagellates - Cryptophytes								
Chroomonas spp.	----	5	cells/ml	----	----	<5	----	----
Cryptomonas spp.	----	5	cells/ml	----	----	<5	----	----
Rhodomonas spp.	----	5	cells/ml	----	----	<5	----	----
Unidentified Flagellates	----	5	cells/ml	----	----	<5	----	----
Other Cryptophytes	----	5	cells/ml	----	----	<5	----	----
Flagellates	----	5	cells/ml	----	----	<5	----	----
MW024: Flagellates - Euglenophytes								
Encysted Euglenophytes	----	5	cells/ml	----	----	<5	----	----
Euglena spp.	----	5	cells/ml	----	----	<5	----	----
Eutreptia spp.	----	5	cells/ml	----	----	<5	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Eldridge 10m	Eldridge 20m	Eldridge 30m	Eldridge 50m	Eldridge 100m
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	ET1802030-006	ET1802030-007	ET1802030-008	ET1802030-009	ET1802030-010
				Result	Result	Result	Result	Result
MW024: Flagellates - Euglenophytes - Continued								
Lepocinclis spp.	----	5	cells/ml	----	----	<5	----	----
Phacus spp.	----	5	cells/ml	----	----	<5	----	----
Strombomonas spp.	----	5	cells/ml	----	----	<5	----	----
Trachelomonas spp.	----	5	cells/ml	----	----	<5	----	----
MW024: Flagellates - Pyrrophytes								
Ceratium spp.	----	5	cells/ml	----	----	<5	----	----
Encysted Dinium	----	5	cells/ml	----	----	<5	----	----
Glenodinium spp.	----	5	cells/ml	----	----	<5	----	----
Gonyaulax spp.	----	5	cells/ml	----	----	<5	----	----
Gymnodinium spp.	----	5	cells/ml	----	----	<5	----	----
Gyrodinium spp.	----	5	cells/ml	----	----	<5	----	----
Katodinium spp.	----	5	cells/ml	----	----	<5	----	----
Peridinium spp.	----	5	cells/ml	----	----	<5	----	----
Prorocentrum minimum	----	5	cells/ml	----	----	<5	----	----
Prorocentrum spp.	----	5	cells/ml	----	----	<5	----	----
Other Dinoflagellates	----	5	cells/ml	----	----	<5	----	----
Unidentified Dinoflagellates	----	5	cells/ml	----	----	<5	----	----
Scrippsiella spp.	----	5	cells/ml	----	----	<5	----	----
Scerpsiella spp.	----	5	cells/ml	----	----	<5	----	----
MW024: Flagellates - TOTAL FLAGELLATES								
Total Flagellates	----	5	cells/ml	----	----	<5	----	----
MW024: Raphidophyte								
Gonyostomum spp.	----	5	cells/ml	----	----	<5	----	----
Heterosigma spp.	----	5	cells/ml	----	----	<5	----	----
Raphidophytes	----	5	cells/ml	----	----	<5	----	----
Other Raphidophytes	----	5	cells/ml	----	----	<5	----	----
MW024: Raphidophyte - TOTAL RAPHIDOPHYTE								
Total Raphidophytes	----	5	cells/ml	----	----	<5	----	----
MW024T: TOTAL ALGAE								
Total Algae Count	----	5	cells/ml	----	----	<5	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Eldridge 150m	Eldridge 200m	Eldridge Bottom	----	----
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	----	----
Compound	CAS Number	LOR	Unit	ET1802030-011	ET1802030-012	ET1802030-013	--------	--------
				Result	Result	Result	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.55	7.53	7.50	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	3100	3120	3100	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	16	6	----	----
EA045: Turbidity								
Turbidity	----	0.1	NTU	0.4	6.1	0.4	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	43	44	44	----	----
Total Alkalinity as CaCO3	----	1	mg/L	43	44	44	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	1350	1460	1350	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	94	93	94	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	321	314	316	----	----
Magnesium	7439-95-4	1	mg/L	94	94	93	----	----
Sodium	7440-23-5	1	mg/L	300	299	300	----	----
Potassium	7440-09-7	1	mg/L	47	46	46	----	----
ED093F: SAR and Hardness Calculations								
Total Hardness as CaCO3	----	1	mg/L	1190	1170	1170	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.03	0.03	0.03	----	----
Arsenic	7440-38-2	0.001	mg/L	0.027	0.027	0.027	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Barium	7440-39-3	0.001	mg/L	0.038	0.038	0.038	----	----
Cadmium	7440-43-9	0.0001	mg/L	0.0233	0.0236	0.0241	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Cobalt	7440-48-4	0.001	mg/L	0.005	0.005	0.005	----	----
Copper	7440-50-8	0.001	mg/L	0.003	0.004	0.003	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Manganese	7439-96-5	0.001	mg/L	1.24	1.23	1.24	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Eldridge 150m	Eldridge 200m	Eldridge Bottom	----	----
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	----	----
Compound	CAS Number	LOR	Unit	ET1802030-011	ET1802030-012	ET1802030-013	--------	--------
				Result	Result	Result	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Molybdenum	7439-98-7	0.001	mg/L	**0.050**	**0.049**	**0.051**	----	----
Nickel	7440-02-0	0.001	mg/L	**0.024**	**0.024**	**0.024**	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Uranium	7440-61-1	0.001	mg/L	**0.006**	**0.006**	**0.006**	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	----	----
Zinc	7440-66-6	0.005	mg/L	**1.23**	**1.23**	**1.23**	----	----
Boron	7440-42-8	0.05	mg/L	**0.06**	**0.06**	**0.06**	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.04**	**0.25**	**0.04**	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.029**	**0.032**	**0.029**	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Barium	7440-39-3	0.001	mg/L	**0.035**	**0.038**	**0.036**	----	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0251**	**0.0260**	**0.0256**	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Cobalt	7440-48-4	0.001	mg/L	**0.004**	**0.005**	**0.004**	----	----
Copper	7440-50-8	0.001	mg/L	**0.004**	**0.008**	**0.004**	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Manganese	7439-96-5	0.001	mg/L	**1.26**	**1.30**	**1.27**	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.058**	**0.058**	**0.058**	----	----
Nickel	7440-02-0	0.001	mg/L	**0.023**	**0.024**	**0.022**	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Uranium	7440-61-1	0.001	mg/L	**0.006**	**0.006**	**0.006**	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	----	----
Zinc	7440-66-6	0.005	mg/L	**1.21**	**1.26**	**1.20**	----	----
Boron	7440-42-8	0.05	mg/L	**0.05**	**0.05**	**0.05**	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	**0.23**	<0.05	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.00004	mg/L	<0.00004	<0.00004	<0.00004	----	----
EG035T: Total Mercury by FIMS								
Mercury	7439-97-6	0.00004	mg/L	<0.00004	<0.00004	<0.00004	----	----
EK025SF: Free CN by Segmented Flow Analyser								

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Eldridge 150m	Eldridge 200m	Eldridge Bottom	----	----
			Client sampling date / time	07-Aug-2018 00:00	07-Aug-2018 00:00	07-Aug-2018 00:00	----	----
Compound	CAS Number	LOR	Unit	ET1802030-011	ET1802030-012	ET1802030-013	--------	--------
				Result	Result	Result	----	----
EK025SF: Free CN by Segmented Flow Analyser - Continued								
Free Cyanide	----	0.004	mg/L	<0.004	<0.004	<0.004	----	----
EK026SF: Total CN by Segmented Flow Analyser								
Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	<0.004	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**2.9**	**2.9**	**2.9**	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.20**	**0.21**	**0.18**	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**5.01**	**5.00**	**4.98**	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**5.01**	**5.00**	**4.98**	----	----
EK060G:Organic Nitrogen as N (TKN-NH3) By Discrete Analyser								
Organic Nitrogen as N	----	0.1	mg/L	<0.5	<0.5	<0.5	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.5	<0.5	<0.5	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	**5.0**	**5.0**	**5.0**	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	<0.05	<0.05	<0.05	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**31.6**	**33.9**	**31.6**	----	----
Total Cations	----	0.01	meq/L	**38.0**	**37.6**	**37.6**	----	----
Ionic Balance	----	0.01	%	**9.17**	**5.16**	**8.67**	----	----
EP002: Dissolved Organic Carbon (DOC)								
Dissolved Organic Carbon	----	1	mg/L	**1**	**1**	**1**	----	----
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	**1**	<1	**1**	----	----

ALS Environmental

QUALITY CONTROL REPORT

Work Order	: **ET1802030**	Page	: 1 of 16
Client	: **GENEX POWER LTD**	Laboratory	: Environmental Division Townsville
Contact	: A M	Contact	: Customer Services ET
Address	: Level 11, 2 Bligh Street, Sydney NSW 2000 PO Box R514, Royal Exchange, NSW 1225 Sydney NSW 2000	Address	: 13 Carlton Street, Kirwan Townsville QLD Australia 4814
Telephone	: +61 02 9993 4443	Telephone	: +61 7 4773 0000
Project	: Kidston	Date Samples Received	: 08-Aug-2018
Order number	:	Date Analysis Commenced	: 09-Aug-2018
C-O-C number	: ----	Issue Date	: 20-Aug-2018
Sampler	: JOHN LAWLER		
Site	: ----		
Quote number	: EN/222/17		
No. of samples received	: 13		
No. of samples analysed	: 13		

NATA

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Diana Mesa	2IC Organic Chemist	Brisbane Organics, Stafford, QLD
Greg Vogel	Laboratory Manager	Brisbane Inorganics, Stafford, QLD
Hannah Beazley		Brisbane Microbiological, Stafford, QLD
Kim McCabe		Townsville Inorganics, Townsville, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	WB Water Lab Brisbane, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Tom Maloney		Townsville Inorganics, Townsville, QLD
Tom Maloney	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Tom Maloney	Senior Inorganic Chemist	WB Water Lab Brisbane, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key :
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA005P: pH by PC Titrator (QC Lot: 1861927)									
ET1802030-001	Pit 1	EA005-P: pH Value	----	0.01	pH Unit	7.74	7.72	0.259	0% - 20%
ET1802030-011	Eldridge 150m	EA005-P: pH Value	----	0.01	pH Unit	7.55	7.52	0.398	0% - 20%
EA010P: Conductivity by PC Titrator (QC Lot: 1861928)									
ET1802030-001	Pit 1	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	3180	3140	1.26	0% - 20%
ET1802030-011	Eldridge 150m	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	3100	3110	0.322	0% - 20%
EA025: Total Suspended Solids dried at 104 ± 2°C (QC Lot: 1861949)									
ET1802012-001	Anonymous	EA025H: Suspended Solids (SS)	----	5	mg/L	<5	<5	0.00	No Limit
ET1802030-001	Pit 1	EA025H: Suspended Solids (SS)	----	5	mg/L	<5	<5	0.00	No Limit
EA025: Total Suspended Solids dried at 104 ± 2°C (QC Lot: 1861950)									
ET1802030-011	Eldridge 150m	EA025H: Suspended Solids (SS)	----	5	mg/L	<5	<5	0.00	No Limit
EA045: Turbidity (QC Lot: 1861964)									
ET1802030-001	Pit 1	EA045: Turbidity	----	0.1	NTU	0.5	0.5	0.00	No Limit
ET1802030-011	Eldridge 150m	EA045: Turbidity	----	0.1	NTU	0.4	0.4	0.00	No Limit
ED037P: Alkalinity by PC Titrator (QC Lot: 1861926)									
ET1802030-001	Pit 1	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	44	46	4.54	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	44	46	4.54	0% - 20%
ET1802030-011	Eldridge 150m	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	43	45	3.99	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	43	45	3.99	0% - 20%
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 1861937)									
ET1802030-001	Pit 1	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	1480	1370	7.45	0% - 20%

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 1861937) - continued									
ET1802030-011	Eldridge 150m	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	1350	1330	1.29	0% - 20%
ED045G: Chloride by Discrete Analyser (QC Lot: 1861938)									
ET1802030-001	Pit 1	ED045G: Chloride	16887-00-6	1	mg/L	92	95	2.63	0% - 20%
ET1802030-011	Eldridge 150m	ED045G: Chloride	16887-00-6	1	mg/L	94	93	0.00	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 1867612)									
EB1819443-019	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	23	23	0.00	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	24	24	0.00	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	68	68	0.00	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	6	6	0.00	No Limit
ET1802030-005	Eldridge 0m	ED093F: Calcium	7440-70-2	1	mg/L	305	320	5.01	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	91	94	3.64	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	288	300	4.29	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	45	47	4.58	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 1867613)									
ET1802030-007	Eldridge 20m	ED093F: Calcium	7440-70-2	1	mg/L	321	316	1.52	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	94	93	0.00	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	297	297	0.00	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	47	46	0.00	0% - 20%
EG020F: Dissolved Metals by ICP-MS (QC Lot: 1867608)									
ET1802030-005	Eldridge 0m	EG020B-F: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020B-F: Uranium	7440-61-1	0.001	mg/L	0.006	0.006	0.00	No Limit
EB1819443-006	Anonymous	EG020B-F: Silver	7440-22-4	0.001	mg/L	<1 µg/L	<0.001	0.00	No Limit
		EG020B-F: Uranium	7440-61-1	0.001	mg/L	<1 µg/L	<0.001	0.00	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 1867611)									
ET1802030-005	Eldridge 0m	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	0.0227	0.0243	6.85	0% - 20%
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.026	0.028	8.10	0% - 20%
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.038	0.039	0.00	0% - 20%
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	0.004	0.005	0.00	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	0.002	0.002	0.00	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	1.17	1.22	4.19	0% - 20%
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	0.052	0.050	3.47	0% - 20%
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.022	0.024	5.41	0% - 20%
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	1.16	1.20	2.82	0% - 20%
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	0.02	0.02	0.00	No Limit
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
EG020F: Dissolved Metals by ICP-MS (QC Lot: 1867611) - continued									
ET1802030-005	Eldridge 0m	EG020A-F: Boron	7440-42-8	0.05	mg/L	0.07	0.06	0.00	No Limit
		EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.00	No Limit
EB1819443-006	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.1 µg/L	<0.0001	0.00	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	3 µg/L	0.003	0.00	No Limit
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<1 µg/L	<0.001	0.00	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	142 µg/L	0.141	1.04	0% - 20%
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	<1 µg/L	<0.001	0.00	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<1 µg/L	<0.001	0.00	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	2 µg/L	0.002	0.00	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<1 µg/L	<0.001	0.00	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	141 µg/L	0.140	0.00	0% - 20%
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	2 µg/L	0.002	0.00	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	4 µg/L	0.004	0.00	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	<5 µg/L	<0.005	0.00	No Limit
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<10 µg/L	<0.01	0.00	No Limit
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<10 µg/L	<0.01	0.00	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<10 µg/L	<0.01	0.00	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	130 µg/L	0.13	0.00	No Limit
		EG020A-F: Iron	7439-89-6	0.05	mg/L	<50 µg/L	<0.05	0.00	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 1867614)									
ET1802030-012	Eldridge 200m	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	0.0236	0.0242	2.42	0% - 20%
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.027	0.028	4.09	0% - 20%
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.038	0.038	0.00	0% - 20%
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	0.005	0.004	0.00	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	0.004	0.004	0.00	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	1.23	1.25	1.52	0% - 20%
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	0.049	0.051	2.99	0% - 20%
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.024	0.025	4.21	0% - 20%
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	1.23	1.23	0.180	0% - 20%
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	0.03	0.03	0.00	No Limit
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	0.06	0.06	0.00	No Limit
		EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.00	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 1867926)									
ET1802030-008	Eldridge 30m	EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	0.006	0.006	0.00	No Limit

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
EG020T: Total Metals by ICP-MS (QC Lot: 1867926) - continued									
EB1819267-001	Anonymous	EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	0.020	0.021	0.00	0% - 50%
EG020T: Total Metals by ICP-MS (QC Lot: 1867928)									
ET1802030-001	Pit 1	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0243	0.0250	2.74	0% - 20%
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.030	0.031	0.00	0% - 20%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.035	0.036	0.00	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	0.004	0.004	0.00	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.006	0.005	0.00	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	1.22	1.25	1.83	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	0.057	0.057	0.00	0% - 20%
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.022	0.022	0.00	0% - 20%
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	1.14	1.17	1.90	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	0.07	0.06	0.00	No Limit
		EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	0.06	0.06	0.00	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.00	No Limit
EB1819267-001	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0001	<0.0001	0.00	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.004	0.004	0.00	No Limit
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.192	0.174	10.2	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	0.010	0.010	0.00	0% - 50%
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	0.006	0.006	0.00	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.014	0.012	10.1	0% - 50%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	0.010	0.010	0.00	No Limit
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	1.09	1.07	2.10	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	0.025	0.025	0.00	0% - 20%
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.013	0.013	0.00	0% - 50%
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.076	0.074	1.61	0% - 50%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	13.5	11.2	18.5	0% - 20%
		EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	0.02	0.02	0.00	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	0.98	0.97	1.03	0% - 50%
		EG020A-T: Iron	7439-89-6	0.05	mg/L	26.6	24.5	8.06	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 1867930)									
ET1802030-008	Eldridge 30m	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0254	0.0247	2.70	0% - 20%
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.029	0.028	0.00	0% - 20%

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
EG020T: Total Metals by ICP-MS (QC Lot: 1867930) - continued									
ET1802030-008	Eldridge 30m	EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.034	0.035	0.00	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	0.004	0.004	0.00	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.004	0.004	0.00	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	1.26	1.26	0.215	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	0.057	0.057	0.00	0% - 20%
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.023	0.023	0.00	0% - 20%
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	1.20	1.18	1.80	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	0.04	0.04	0.00	No Limit
		EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	0.05	0.05	0.00	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.00	No Limit
ET1802039-002	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.103	0.106	3.16	0% - 20%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.143	0.145	1.21	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	0.002	0.002	0.00	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.002	0.003	0.00	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	3.58	4.20	15.9	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	0.003	0.004	0.00	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.006	0.008	18.8	No Limit
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	0.34	0.30	11.6	0% - 20%
		EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	0.07	0.07	0.00	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	0.56	0.80	35.5	0% - 50%
EG035F: Dissolved Mercury by FIMS (QC Lot: 1867972)									
ET1802030-001	Pit 1	EG035F-LL: Mercury	7439-97-6	0.00004	mg/L	<0.00004	<0.00004	0.00	No Limit
ET1802030-011	Eldridge 150m	EG035F-LL: Mercury	7439-97-6	0.00004	mg/L	<0.00004	<0.00004	0.00	No Limit
EG035T: Total Mercury by FIMS (QC Lot: 1867932)									
ET1802030-001	Pit 1	EG035T-LL: Mercury	7439-97-6	0.00004	mg/L	<0.00004	<0.00004	0.00	No Limit
ET1802030-011	Eldridge 150m	EG035T-LL: Mercury	7439-97-6	0.00004	mg/L	<0.00004	<0.00004	0.00	No Limit
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS (QC Lot: 1867922)									
EB1819443-007	Anonymous	EG094A-F: Uranium	7440-61-1	0.05	µg/L	0.97	0.95	1.46	0% - 50%

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report					
				LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS (QC Lot: 1867922) - continued									
EB1819443-007	Anonymous	EG094A-F: Vanadium	7440-62-2	0.2	µg/L	1.5	1.5	0.00	No Limit
		EG094A-F: Zinc	7440-66-6	1	µg/L	<1	<1	0.00	No Limit
EG094T: Total metals in Fresh water by ORC-ICPMS (QC Lot: 1867872)									
ET1802030-001	Pit 1	EG094A-T: Uranium	7440-61-1	0.05	µg/L	6.65	6.58	1.000	0% - 20%
		EG094A-T: Vanadium	7440-62-2	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG094A-T: Zinc	7440-66-6	1	µg/L	1220	1170	3.88	0% - 20%
EB1819301-001	Anonymous	EG094A-T: Uranium	7440-61-1	0.05	µg/L	<0.05	<0.05	0.00	No Limit
		EG094A-T: Vanadium	7440-62-2	0.2	µg/L	0.8	0.8	0.00	No Limit
		EG094A-T: Zinc	7440-66-6	1	µg/L	2	1	0.00	No Limit
EK025SF: Free CN by Segmented Flow Analyser (QC Lot: 1867079)									
ET1802030-001	Pit 1	EK025SF: Free Cyanide	----	0.004	mg/L	<0.004	<0.004	0.00	No Limit
ET1802030-011	Eldridge 150m	EK025SF: Free Cyanide	----	0.004	mg/L	<0.004	<0.004	0.00	No Limit
EK026SF: Total CN by Segmented Flow Analyser (QC Lot: 1867080)									
ET1802030-001	Pit 1	EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	0.00	No Limit
ET1802030-011	Eldridge 150m	EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	<0.004	0.00	No Limit
EK040P: Fluoride by PC Titrator (QC Lot: 1861925)									
ET1802030-001	Pit 1	EK040P: Fluoride	16984-48-8	0.1	mg/L	3.0	3.0	0.00	0% - 20%
ET1802030-011	Eldridge 150m	EK040P: Fluoride	16984-48-8	0.1	mg/L	2.9	3.0	0.00	0% - 20%
EK055G: Ammonia as N by Discrete Analyser (QC Lot: 1861954)									
ET1802024-001	Anonymous	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	0.07	<0.01	151	No Limit
ET1802030-010	Eldridge 100m	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	0.21	0.20	0.00	0% - 20%
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 1861939)									
ET1802030-003	Eldridge Ramp	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	0.01	0.01	0.00	No Limit
ET1802030-013	Eldridge Bottom	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 1861955)									
ET1802024-001	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	1.49	1.48	0.00	0% - 20%
ET1802030-010	Eldridge 100m	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	4.99	4.97	0.484	0% - 20%
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 1867737)									
EB1819424-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.3	0.3	0.00	No Limit
ET1802030-008	Eldridge 30m	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.5	<0.5	0.00	No Limit
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 1867736)									
EB1819418-001	Anonymous	EK067G: Total Phosphorus as P	----	0.01	mg/L	0.16	0.14	16.5	No Limit
ET1802030-008	Eldridge 30m	EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.05	<0.05	0.00	No Limit
EK255A: Ammonia (QC Lot: 1862336)									
ET1802030-001	Pit 1	EK255A-CM: Ammonia as N	7664-41-7	0.005	mg/L	0.146	0.167	13.5	No Limit
EK257A: Nitrite (QC Lot: 1862337)									
ET1802030-001	Pit 1	EK257A-CM: Nitrite as N	14797-65-0	0.002	mg/L	0.012	0.012	0.00	No Limit
EK259A: Nitrite and Nitrate (NOx) (QC Lot: 1862335)									

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
EK259A: Nitrite and Nitrate (NOx) (QC Lot: 1862335) - continued									
ET1802030-001	Pit 1	EK259A-CM: Nitrite + Nitrate as N	----	0.002	mg/L	3.52	3.47	1.63	0% - 20%
EK262A: Total Nitrogen (QC Lot: 1864421)									
ET1802030-001	Pit 1	EK262PA-CM: Total Nitrogen as N	----	0.01	mg/L	13.1	13.0	0.922	0% - 20%
EK267A: Total Phosphorus (Persulfate Digestion) (QC Lot: 1864422)									
ET1802030-001	Pit 1	EK267PA-CM: Total Phosphorus as P	----	0.005	mg/L	0.031	0.018	51.4	No Limit
EK271A: Reactive Phosphorus (QC Lot: 1862338)									
ET1802030-001	Pit 1	EK271A-CM: Reactive Phosphorus as P	14265-44-2	0.001	mg/L	0.008	0.011	33.4	No Limit
EP002: Dissolved Organic Carbon (DOC) (QC Lot: 1867840)									
ET1802030-003	Eldridge Ramp	EP002: Dissolved Organic Carbon	----	1	mg/L	2	1	0.00	No Limit
ET1802030-010	Eldridge 100m	EP002: Dissolved Organic Carbon	----	1	mg/L	1	1	0.00	No Limit
EP005: Total Organic Carbon (TOC) (QC Lot: 1867837)									
ET1802030-001	Pit 1	EP005: Total Organic Carbon	----	1	mg/L	1	<1	0.00	No Limit
ET1802030-010	Eldridge 100m	EP005: Total Organic Carbon	----	1	mg/L	1	<1	0.00	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA005P: pH by PC Titrator (QCLot: 1861927)								
EA005-P: pH Value	----	----	pH Unit	----	4 pH Unit	101	98	102
				----	7 pH Unit	99.6	98	102
EA010P: Conductivity by PC Titrator (QCLot: 1861928)								
EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	147 µS/cm	100	91	107
				<1	12890 µS/cm	98.9	91	107
EA025: Total Suspended Solids dried at 104 ± 2°C (QCLot: 1861949)								
EA025H: Suspended Solids (SS)	----	5	mg/L	<5	150 mg/L	97.3	83	120
				<5	1000 mg/L	94.8	83	120
EA025: Total Suspended Solids dried at 104 ± 2°C (QCLot: 1861950)								
EA025H: Suspended Solids (SS)	----	5	mg/L	<5	150 mg/L	100	83	120
				<5	1000 mg/L	97.4	83	120
EA045: Turbidity (QCLot: 1861964)								
EA045: Turbidity	----	0.1	NTU	<0.1	4 NTU	100	87	113
				<0.1	40 NTU	101	95	105
				<0.1	400 NTU	100	97	103
ED037P: Alkalinity by PC Titrator (QCLot: 1861926)								
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	200 mg/L	89.2	87	112
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 1861937)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	100 mg/L	87.7	80	120
				<1	25 mg/L	114	80	120
ED045G: Chloride by Discrete Analyser (QCLot: 1861938)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	97.0	80	120
				<1	10 mg/L	89.2	80	120
ED093F: Dissolved Major Cations (QCLot: 1867612)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
ED093F: Dissolved Major Cations (QCLot: 1867613)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EG020F: Dissolved Metals by ICP-MS (QCLot: 1867608)								
EG020B-F: Silver	7440-22-4	0.001	mg/L	<0.001	0.1 mg/L	98.0	85	114
EG020B-F: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020F: Dissolved Metals by ICP-MS (QCLot: 1867611)								
EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	97.1	79	118
EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	101	88	116
EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.1 mg/L	96.5	81	117
EG020A-F: Barium	7440-39-3	0.001	mg/L	<0.001	0.5 mg/L	94.8	70	130
EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	93.8	88	108
EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	98.8	87	113
EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	100.0	86	112
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.2 mg/L	106	88	114
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	98.4	89	110
EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	98.7	89	120
EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.1 mg/L	98.9	89	112
EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	98.7	89	113
EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	99.0	83	112
EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	111	88	114
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.2 mg/L	97.5	87	113
EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	0.5 mg/L	101	81	125
EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	99.8	82	114
EG020F: Dissolved Metals by ICP-MS (QCLot: 1867614)								
EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	96.0	79	118
EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	103	88	116
EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.1 mg/L	94.0	81	117
EG020A-F: Barium	7440-39-3	0.001	mg/L	<0.001	0.5 mg/L	97.9	70	130
EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	94.2	88	108
EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	99.7	87	113
EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	99.9	86	112
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.2 mg/L	108	88	114
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	97.3	89	110
EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	97.9	89	120
EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.1 mg/L	96.9	89	112
EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	102	89	113
EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	93.9	83	112
EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	107	88	114
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.2 mg/L	97.4	87	113
EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	0.5 mg/L	106	81	125
EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	100	82	114

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 1867926)								
EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	0.1 mg/L	102	84	117
EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 1867928)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	110	80	114
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	108	88	112
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.1 mg/L	99.7	81	119
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	0.5 mg/L	103	70	130
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	101	88	111
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	98.3	89	115
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	99.5	89	115
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.2 mg/L	98.5	88	116
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	103	89	112
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	100	88	114
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.1 mg/L	106	90	114
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	105	88	116
EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	101	79	111
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	98.2	87	114
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.2 mg/L	104	84	114
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.5 mg/L	97.9	82	128
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	106	82	118
EG020T: Total Metals by ICP-MS (QCLot: 1867930)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	98.5	80	114
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	99.9	88	112
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.1 mg/L	92.7	81	119
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	0.5 mg/L	104	70	130
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	99.8	88	111
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	89.9	89	115
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	91.6	89	115
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.2 mg/L	90.9	88	116
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	104	89	112
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	91.9	88	114
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.1 mg/L	105	90	114
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	110	88	116
EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	90.2	79	111
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	90.3	87	114
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.2 mg/L	94.8	84	114
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.5 mg/L	87.2	82	128
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	97.0	82	118

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EG035F: Dissolved Mercury by FIMS (QCLot: 1867972)								
EG035F-LL: Mercury	7439-97-6	0.00004	mg/L	<0.00004	0.002 mg/L	112	85	118
EG035T: Total Mercury by FIMS (QCLot: 1867932)								
EG035T-LL: Mercury	7439-97-6	0.00004	mg/L	<0.00004	0.002 mg/L	95.0	84	114
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS (QCLot: 1867922)								
EG094A-F: Uranium	7440-61-1	0.05	µg/L	<0.05	----	----	----	----
EG094A-F: Vanadium	7440-62-2	0.2	µg/L	<0.2	10 µg/L	120	80	120
EG094A-F: Zinc	7440-66-6	1	µg/L	<1	20 µg/L	99.6	80	120
EG094T: Total metals in Fresh water by ORC-ICPMS (QCLot: 1867872)								
EG094A-T: Uranium	7440-61-1	0.05	µg/L	<0.05	----	----	----	----
EG094A-T: Vanadium	7440-62-2	0.2	µg/L	<0.2	10 µg/L	102	80	120
EG094A-T: Zinc	7440-66-6	1	µg/L	<1	20 µg/L	82.0	80	120
EK025SF: Free CN by Segmented Flow Analyser (QCLot: 1867079)								
EK025SF: Free Cyanide	----	0.004	mg/L	<0.004	0.2 mg/L	99.1	80	120
EK026SF: Total CN by Segmented Flow Analyser (QCLot: 1867080)								
EK026SF: Total Cyanide	57-12-5	0.004	mg/L	<0.004	0.2 mg/L	108	85	119
EK040P: Fluoride by PC Titrator (QCLot: 1861925)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	5 mg/L	98.6	80	120
EK055G: Ammonia as N by Discrete Analyser (QCLot: 1861954)								
EK055G: Ammonia as N	7664-41-7	0.01	mg/L	<0.01	0.5 mg/L	90.5	80	120
EK057G: Nitrite as N by Discrete Analyser (QCLot: 1861939)								
EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	0.5 mg/L	108	80	120
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 1861955)								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.5 mg/L	92.2	89	115
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 1867737)								
EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.1	10 mg/L	73.7	70	111
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 1867736)								
EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.01	0.442 mg/L	85.2	77	109
EK255A: Ammonia (QCLot: 1862336)								
EK255A-CM: Ammonia as N	7664-41-7	0.005	mg/L	<0.005	0.1 mg/L	116	80	120
EK257A: Nitrite (QCLot: 1862337)								
EK257A-CM: Nitrite as N	14797-65-0	0.002	mg/L	<0.002	0.1 mg/L	104	84	119
EK259A: Nitrite and Nitrate (NOx) (QCLot: 1862335)								
EK259A-CM: Nitrite + Nitrate as N	----	0.002	mg/L	<0.002	0.1 mg/L	110	80	120
EK262A: Total Nitrogen (QCLot: 1864421)								
EK262PA-CM: Total Nitrogen as N	----	0.01	mg/L	<0.01	1 mg/L	95.8	80	120
EK267A: Total Phosphorus (Persulfate Digestion) (QCLot: 1864422)								

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EK267A: Total Phosphorus (Persulfate Digestion) (QCLot: 1864422) - continued								
EK267PA-CM: Total Phosphorus as P	----	0.005	mg/L	<0.005	0.42 mg/L	100	80	120
EK271A: Reactive Phosphorus (QCLot: 1862338)								
EK271A-CM: Reactive Phosphorus as P	14265-44-2	0.001	mg/L	<0.001	0.1 mg/L	98.2	81	120
EP002: Dissolved Organic Carbon (DOC) (QCLot: 1867840)								
EP002: Dissolved Organic Carbon	----	1	mg/L	<1	10 mg/L	91.5	80	112
				<1	100 mg/L	98.1	80	112
EP005: Total Organic Carbon (TOC) (QCLot: 1867837)								
EP005: Total Organic Carbon	----	1	mg/L	<1	10 mg/L	93.7	79	113
				<1	100 mg/L	98.9	79	113
EP008: Chlorophyll (QCLot: 1862979)								
EP008: Chlorophyll a	----	1	mg/m^3	<1	12 mg/m^3	100	85	123

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
				Concentration	MS	Low	High
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 1861937)							
ET1802030-002	Pit 2	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	20 mg/L	# Not Determined	70	130
ED045G: Chloride by Discrete Analyser (QCLot: 1861938)							
ET1802030-002	Pit 2	ED045G: Chloride	16887-00-6	400 mg/L	93.6	70	130
EG020F: Dissolved Metals by ICP-MS (QCLot: 1867611)							
EB1819443-008	Anonymous	EG020A-F: Aluminium	7429-90-5	0.5 mg/L	94.8	70	130
		EG020A-F: Arsenic	7440-38-2	0.1 mg/L	98.3	70	130
		EG020A-F: Beryllium	7440-41-7	0.1 mg/L	92.7	70	130
		EG020A-F: Barium	7440-39-3	0.5 mg/L	98.8	70	130
		EG020A-F: Cadmium	7440-43-9	0.1 mg/L	95.8	70	130
		EG020A-F: Chromium	7440-47-3	0.1 mg/L	98.5	70	130
		EG020A-F: Cobalt	7440-48-4	0.1 mg/L	95.1	70	130
		EG020A-F: Copper	7440-50-8	0.2 mg/L	102	70	130
		EG020A-F: Lead	7439-92-1	0.1 mg/L	93.0	70	130
		EG020A-F: Manganese	7439-96-5	0.1 mg/L	93.8	70	130
		EG020A-F: Molybdenum	7439-98-7	0.1 mg/L	93.6	70	130
		EG020A-F: Nickel	7440-02-0	0.1 mg/L	94.1	70	130
		EG020A-F: Selenium	7782-49-2	0.1 mg/L	93.5	70	130

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report: Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%) Low	Recovery Limits (%) High
EG020F: Dissolved Metals by ICP-MS (QCLot: 1867611) - continued							
EB1819443-008	Anonymous	EG020A-F: Vanadium	7440-62-2	0.1 mg/L	88.9	70	130
		EG020A-F: Zinc	7440-66-6	0.2 mg/L	96.4	70	130
		EG020A-F: Boron	7440-42-8	0.5 mg/L	96.8	70	130
EG020F: Dissolved Metals by ICP-MS (QCLot: 1867614)							
ET1802030-013	Eldridge Bottom	EG020A-F: Aluminium	7429-90-5	0.5 mg/L	90.4	70	130
		EG020A-F: Arsenic	7440-38-2	0.1 mg/L	99.3	70	130
		EG020A-F: Beryllium	7440-41-7	0.1 mg/L	89.0	70	130
		EG020A-F: Barium	7440-39-3	0.5 mg/L	98.2	70	130
		EG020A-F: Cadmium	7440-43-9	0.1 mg/L	94.7	70	130
		EG020A-F: Chromium	7440-47-3	0.1 mg/L	94.3	70	130
		EG020A-F: Cobalt	7440-48-4	0.1 mg/L	94.1	70	130
		EG020A-F: Copper	7440-50-8	0.2 mg/L	99.5	70	130
		EG020A-F: Lead	7439-92-1	0.1 mg/L	95.3	70	130
		EG020A-F: Manganese	7439-96-5	0.1 mg/L	# Not Determined	70	130
		EG020A-F: Molybdenum	7439-98-7	0.1 mg/L	90.2	70	130
		EG020A-F: Nickel	7440-02-0	0.1 mg/L	91.3	70	130
		EG020A-F: Selenium	7782-49-2	0.1 mg/L	92.6	70	130
		EG020A-F: Vanadium	7440-62-2	0.1 mg/L	88.3	70	130
		EG020A-F: Zinc	7440-66-6	0.2 mg/L	# Not Determined	70	130
		EG020A-F: Boron	7440-42-8	0.5 mg/L	97.2	70	130
EG020T: Total Metals by ICP-MS (QCLot: 1867928)							
EB1819418-001	Anonymous	EG020A-T: Arsenic	7440-38-2	1 mg/L	99.1	70	130
		EG020A-T: Beryllium	7440-41-7	0.1 mg/L	101	70	130
		EG020A-T: Barium	7440-39-3	1 mg/L	108	70	130
		EG020A-T: Cadmium	7440-43-9	0.5 mg/L	100	70	130
		EG020A-T: Chromium	7440-47-3	1 mg/L	95.9	70	130
		EG020A-T: Cobalt	7440-48-4	1 mg/L	96.4	70	130
		EG020A-T: Copper	7440-50-8	1 mg/L	93.1	70	130
		EG020A-T: Lead	7439-92-1	1 mg/L	112	70	130
		EG020A-T: Manganese	7439-96-5	1 mg/L	97.0	70	130
		EG020A-T: Nickel	7440-02-0	1 mg/L	88.0	70	130
		EG020A-T: Vanadium	7440-62-2	1 mg/L	96.4	70	130
		EG020A-T: Zinc	7440-66-6	1 mg/L	90.0	70	130
EG020T: Total Metals by ICP-MS (QCLot: 1867930)							
ET1802030-009	Eldridge 50m	EG020A-T: Arsenic	7440-38-2	1 mg/L	100	70	130
		EG020A-T: Beryllium	7440-41-7	0.1 mg/L	94.6	70	130

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report: Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%) Low	Recovery Limits (%) High
EG020T: Total Metals by ICP-MS (QCLot: 1867930) - continued							
ET1802030-009	Eldridge 50m	EG020A-T: Barium	7440-39-3	1 mg/L	106	70	130
		EG020A-T: Cadmium	7440-43-9	0.5 mg/L	102	70	130
		EG020A-T: Chromium	7440-47-3	1 mg/L	96.4	70	130
		EG020A-T: Cobalt	7440-48-4	1 mg/L	99.6	70	130
		EG020A-T: Copper	7440-50-8	1 mg/L	97.9	70	130
		EG020A-T: Lead	7439-92-1	1 mg/L	116	70	130
		EG020A-T: Manganese	7439-96-5	1 mg/L	96.2	70	130
		EG020A-T: Nickel	7440-02-0	1 mg/L	91.8	70	130
		EG020A-T: Vanadium	7440-62-2	1 mg/L	97.6	70	130
		EG020A-T: Zinc	7440-66-6	1 mg/L	92.4	70	130
EG035F: Dissolved Mercury by FIMS (QCLot: 1867972)							
ET1802030-002	Pit 2	EG035F-LL: Mercury	7439-97-6	0.002 mg/L	125	70	130
EG035T: Total Mercury by FIMS (QCLot: 1867932)							
ET1802030-002	Pit 2	EG035T-LL: Mercury	7439-97-6	0.002 mg/L	115	70	130
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS (QCLot: 1867922)							
EB1819443-009	Anonymous	EG094A-F: Vanadium	7440-62-2	50 µg/L	101	70	130
		EG094A-F: Zinc	7440-66-6	100 µg/L	96.6	70	130
EG094T: Total metals in Fresh water by ORC-ICPMS (QCLot: 1867872)							
EB1819301-002	Anonymous	EG094A-T: Vanadium	7440-62-2	50 µg/L	90.6	70	130
		EG094A-T: Zinc	7440-66-6	100 µg/L	94.3	70	130
EK025SF: Free CN by Segmented Flow Analyser (QCLot: 1867079)							
ET1802030-002	Pit 2	EK025SF: Free Cyanide	----	0.4 mg/L	102	70	130
EK026SF: Total CN by Segmented Flow Analyser (QCLot: 1867080)							
ET1802030-002	Pit 2	EK026SF: Total Cyanide	57-12-5	0.4 mg/L	104	70	130
EK040P: Fluoride by PC Titrator (QCLot: 1861925)							
ET1802030-002	Pit 2	EK040P: Fluoride	16984-48-8	1.92 mg/L	100	80	120
EK055G: Ammonia as N by Discrete Analyser (QCLot: 1861954)							
ET1802024-002	Anonymous	EK055G: Ammonia as N	7664-41-7	0.4 mg/L	73.1	70	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 1861939)							
ET1802030-004	Wises Ramp	EK057G: Nitrite as N	14797-65-0	0.4 mg/L	120	70	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 1861955)							
ET1802024-002	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.4 mg/L	70.1	70	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 1867737)							
EB1819424-002	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	5 mg/L	88.5	70	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 1867736)							

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report: Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%) Low	Recovery Limits (%) High
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 1867736) - continued							
EB1819420-003	Anonymous	EK067G: Total Phosphorus as P	----	1 mg/L	95.0	70	130
EK255A: Ammonia (QCLot: 1862336)							
ET1802030-002	Pit 2	EK255A-CM: Ammonia as N	7664-41-7	0.566 mg/L	130	70	130
EK257A: Nitrite (QCLot: 1862337)							
EB1819229-002	Anonymous	EK257A-CM: Nitrite as N	14797-65-0	0.1 mg/L	92.1	70	130
EK259A: Nitrite and Nitrate (NOx) (QCLot: 1862335)							
ET1802030-002	Pit 2	EK259A-CM: Nitrite + Nitrate as N	----	0.566 mg/L	121	70	130
EK262A: Total Nitrogen (QCLot: 1864421)							
ET1802030-002	Pit 2	EK262PA-CM: Total Nitrogen as N	----	30 mg/L	101	70	130
EK267A: Total Phosphorus (Persulfate Digestion) (QCLot: 1864422)							
ET1802030-002	Pit 2	EK267PA-CM: Total Phosphorus as P	----	1 mg/L	96.2	70	130
EK271A: Reactive Phosphorus (QCLot: 1862338)							
ET1802030-002	Pit 2	EK271A-CM: Reactive Phosphorus as P	14265-44-2	0.4 mg/L	122	70	130
EP002: Dissolved Organic Carbon (DOC) (QCLot: 1867840)							
ET1802030-004	Wises Ramp	EP002: Dissolved Organic Carbon	----	100 mg/L	98.3	70	130
EP005: Total Organic Carbon (TOC) (QCLot: 1867837)							
ET1802030-002	Pit 2	EP005: Total Organic Carbon	----	100 mg/L	98.4	70	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **ET1802030**	Page	: 1 of 20
Client	: **GENEX POWER LTD**	Laboratory	: Environmental Division Townsville
Contact	: A M	Telephone	: +61 7 4773 0000
Project	: Kidston	Date Samples Received	: 08-Aug-2018
Site	: ----	Issue Date	: 20-Aug-2018
Sampler	: JOHN LAWLER	No. of samples received	: 13
Order number	:	No. of samples analysed	: 13

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **Matrix Spike outliers exist - please see following pages for full details.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **NO Quality Control Sample Frequency Outliers exist.**

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA	ET1802030--002	Pit 2	**Sulfate as SO4 - Turbidimetric**	14808-79-8	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG020F: Dissolved Metals by ICP-MS	ET1802030--013	Eldridge Bottom	**Manganese**	7439-96-5	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG020F: Dissolved Metals by ICP-MS	ET1802030--013	Eldridge Bottom	**Zinc**	7440-66-6	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method		Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		*Date extracted*	*Due for extraction*	***Days overdue***	*Date analysed*	*Due for analysis*	***Days overdue***
EA005P: pH by PC Titrator							
Clear Plastic Bottle - Natural							
Pit 1, Eldridge Ramp, Eldridge 0m, Eldridge 20m, Eldridge 50m, Eldridge 150m, Eldridge Bottom	Pit 2, Wises Ramp, Eldridge 10m, Eldridge 30m, Eldridge 100m, Eldridge 200m,	----	----	----	09-Aug-2018	07-Aug-2018	**2**
EK255A: Ammonia							
Clear Plastic - Filtered (AS/ISO) - for UT Nut.							
Pit 1,	Pit 2	----	----	----	09-Aug-2018	08-Aug-2018	**1**
EK262A: Total Nitrogen							
Clear Plastic Bottle - Natural							
Pit 1,	Pit 2	10-Aug-2018	08-Aug-2018	**2**	10-Aug-2018	08-Aug-2018	**2**
EK267A: Total Phosphorus (Persulfate Digestion)							
Clear Plastic Bottle - Natural							
Pit 1,	Pit 2	10-Aug-2018	08-Aug-2018	**2**	10-Aug-2018	08-Aug-2018	**2**
EK271A: Reactive Phosphorus							
Clear Plastic - Filtered (AS/ISO) - for UT Nut.							
Pit 1,	Pit 2	----	----	----	09-Aug-2018	08-Aug-2018	**1**

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: ✘ = Holding time breach ; ✓ = Within holding time.

Method	*Sample Date*	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)		*Date extracted*	*Due for extraction*	*Evaluation*	*Date analysed*	*Due for analysis*	*Evaluation*
EA005P: pH by PC Titrator							
Clear Plastic Bottle - Natural (EA005-P)							
Pit 1, Pit 2, Eldridge Ramp, Wises Ramp, Eldridge 0m, Eldridge 10m, Eldridge 20m, Eldridge 30m, Eldridge 50m, Eldridge 100m, Eldridge 150m, Eldridge 200m, Eldridge Bottom	**07-Aug-2018**	**----**	----	----	**09-Aug-2018**	07-Aug-2018	✘
EA010P: Conductivity by PC Titrator							
Clear Plastic Bottle - Natural (EA010-P)							
Pit 1, Pit 2, Eldridge Ramp, Wises Ramp, Eldridge 0m, Eldridge 10m, Eldridge 20m, Eldridge 30m, Eldridge 50m, Eldridge 100m, Eldridge 150m, Eldridge 200m, Eldridge Bottom	**07-Aug-2018**	**----**	----	----	**09-Aug-2018**	04-Sep-2018	✓
EA025: Total Suspended Solids dried at 104 ± 2°C							
Clear Plastic Bottle - Natural (EA025H)							
Pit 1, Pit 2, Eldridge Ramp, Wises Ramp, Eldridge 0m, Eldridge 10m, Eldridge 20m, Eldridge 30m, Eldridge 50m, Eldridge 100m, Eldridge 150m, Eldridge 200m, Eldridge Bottom	**07-Aug-2018**	**----**	----	----	**09-Aug-2018**	14-Aug-2018	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA045: Turbidity								
Clear Plastic Bottle - Natural (EA045)								
Pit 1, Eldridge Ramp, Eldridge 0m, Eldridge 20m, Eldridge 50m, Eldridge 150m, Eldridge Bottom	Pit 2, Wises Ramp, Eldridge 10m, Eldridge 30m, Eldridge 100m, Eldridge 200m,	**07-Aug-2018**	**----**	----	----	**09-Aug-2018**	09-Aug-2018	✓
ED037P: Alkalinity by PC Titrator								
Clear Plastic Bottle - Natural (ED037-P)								
Pit 1, Eldridge Ramp, Eldridge 0m, Eldridge 20m, Eldridge 50m, Eldridge 150m, Eldridge Bottom	Pit 2, Wises Ramp, Eldridge 10m, Eldridge 30m, Eldridge 100m, Eldridge 200m,	**07-Aug-2018**	**----**	----	----	**09-Aug-2018**	21-Aug-2018	✓
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Clear Plastic Bottle - Natural (ED041G)								
Pit 1, Eldridge Ramp, Eldridge 0m, Eldridge 20m, Eldridge 50m, Eldridge 150m, Eldridge Bottom	Pit 2, Wises Ramp, Eldridge 10m, Eldridge 30m, Eldridge 100m, Eldridge 200m,	**07-Aug-2018**	**----**	----	----	**09-Aug-2018**	04-Sep-2018	✓
ED045G: Chloride by Discrete Analyser								
Clear Plastic Bottle - Natural (ED045G)								
Pit 1, Eldridge Ramp, Eldridge 0m, Eldridge 20m, Eldridge 50m, Eldridge 150m, Eldridge Bottom	Pit 2, Wises Ramp, Eldridge 10m, Eldridge 30m, Eldridge 100m, Eldridge 200m,	**07-Aug-2018**	**----**	----	----	**09-Aug-2018**	04-Sep-2018	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
ED093F: Dissolved Major Cations								
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F)								
Pit 1,	Pit 2,	**07-Aug-2018**	**----**	----	----	**13-Aug-2018**	04-Sep-2018	✓
Eldridge Ramp,	Wises Ramp,							
Eldridge 0m,	Eldridge 10m,							
Eldridge 20m,	Eldridge 30m,							
Eldridge 50m,	Eldridge 100m,							
Eldridge 150m,	Eldridge 200m,							
Eldridge Bottom								
ED093F: SAR and Hardness Calculations								
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F)								
Pit 1,	Pit 2,	**07-Aug-2018**	**----**	----	----	**13-Aug-2018**	04-Sep-2018	✓
Eldridge Ramp,	Wises Ramp,							
Eldridge 0m,	Eldridge 10m,							
Eldridge 20m,	Eldridge 30m,							
Eldridge 50m,	Eldridge 100m,							
Eldridge 150m,	Eldridge 200m,							
Eldridge Bottom								
EG020F: Dissolved Metals by ICP-MS								
Clear Plastic Bottle - Filtered; Lab-acidified (EG020B-F)								
Pit 1,	Pit 2,	**07-Aug-2018**	**----**	----	----	**13-Aug-2018**	03-Feb-2019	✓
Eldridge Ramp,	Wises Ramp,							
Eldridge 0m,	Eldridge 10m,							
Eldridge 20m,	Eldridge 30m,							
Eldridge 50m,	Eldridge 100m,							
Eldridge 150m,	Eldridge 200m,							
Eldridge Bottom								
EG020T: Total Metals by ICP-MS								
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020B-T)								
Pit 1,	Pit 2,	**07-Aug-2018**	**14-Aug-2018**	03-Feb-2019	✓	**14-Aug-2018**	03-Feb-2019	✓
Eldridge Ramp,	Wises Ramp,							
Eldridge 0m,	Eldridge 10m,							
Eldridge 20m,	Eldridge 30m,							
Eldridge 50m,	Eldridge 100m,							
Eldridge 150m,	Eldridge 200m,							
Eldridge Bottom								

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG035F: Dissolved Mercury by FIMS								
Clear HDPE (U-T ORC) - Filtered; Lab-acidified (EG035F-LL)								
Pit 1,	Pit 2	**07-Aug-2018**	**----**	----	----	**13-Aug-2018**	04-Sep-2018	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F-LL)								
Eldridge Ramp, Eldridge 0m, Eldridge 20m, Eldridge 50m, Eldridge 150m, Eldridge Bottom	Wises Ramp, Eldridge 10m, Eldridge 30m, Eldridge 100m, Eldridge 200m,	**07-Aug-2018**	**----**	----	----	**13-Aug-2018**	04-Sep-2018	✓
EG035T: Total Mercury by FIMS								
Clear HDPE (U-T ORC) - Unfiltered; Lab-acidified (EG035T-LL)								
Pit 1,	Pit 2	**07-Aug-2018**	**----**	----	----	**14-Aug-2018**	04-Sep-2018	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T-LL)								
Eldridge Ramp, Eldridge 0m, Eldridge 20m, Eldridge 50m, Eldridge 150m, Eldridge Bottom	Wises Ramp, Eldridge 10m, Eldridge 30m, Eldridge 100m, Eldridge 200m,	**07-Aug-2018**	**----**	----	----	**14-Aug-2018**	04-Sep-2018	✓
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS								
Clear HDPE (U-T ORC) - Filtered; Lab-acidified (EG094A-F)								
Pit 1,	Pit 2	**07-Aug-2018**	**----**	----	----	**14-Aug-2018**	03-Feb-2019	✓
EG094T: Total metals in Fresh water by ORC-ICPMS								
Clear HDPE (U-T ORC) - Unfiltered; Lab-acidified (EG094A-T)								
Pit 1,	Pit 2	**07-Aug-2018**	**14-Aug-2018**	03-Feb-2019	✓	**14-Aug-2018**	03-Feb-2019	✓
EK025SF: Free CN by Segmented Flow Analyser								
White Plastic Bottle-NaOH - Pb Acetate (EK025SF)								
Pit 1, Eldridge Ramp, Eldridge 0m, Eldridge 20m, Eldridge 50m, Eldridge 150m, Eldridge Bottom	Pit 2, Wises Ramp, Eldridge 10m, Eldridge 30m, Eldridge 100m, Eldridge 200m,	**07-Aug-2018**	**----**	----	----	**11-Aug-2018**	21-Aug-2018	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation: Date extracted	Due for extraction	Evaluation	Analysis: Date analysed	Due for analysis	Evaluation
EK026SF: Total CN by Segmented Flow Analyser								
White Plastic Bottle-NaOH - Pb Acetate (EK026SF)								
Pit 1,	Pit 2,	**07-Aug-2018**	**----**	----	----	**11-Aug-2018**	21-Aug-2018	✓
Eldridge Ramp,	Wises Ramp,							
Eldridge 0m,	Eldridge 10m,							
Eldridge 20m,	Eldridge 30m,							
Eldridge 50m,	Eldridge 100m,							
Eldridge 150m,	Eldridge 200m,							
Eldridge Bottom								
EK040P: Fluoride by PC Titrator								
Clear Plastic Bottle - Natural (EK040P)								
Pit 1,	Pit 2,	**07-Aug-2018**	**----**	----	----	**09-Aug-2018**	04-Sep-2018	✓
Eldridge Ramp,	Wises Ramp,							
Eldridge 0m,	Eldridge 10m,							
Eldridge 20m,	Eldridge 30m,							
Eldridge 50m,	Eldridge 100m,							
Eldridge 150m,	Eldridge 200m,							
Eldridge Bottom								
EK055G: Ammonia as N by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK055G)								
Eldridge Ramp,	Wises Ramp,	**07-Aug-2018**	**----**	----	----	**09-Aug-2018**	04-Sep-2018	✓
Eldridge 0m,	Eldridge 10m,							
Eldridge 20m,	Eldridge 30m,							
Eldridge 50m,	Eldridge 100m,							
Eldridge 150m,	Eldridge 200m,							
Eldridge Bottom								
EK057G: Nitrite as N by Discrete Analyser								
Clear Plastic Bottle - Natural (EK057G)								
Eldridge Ramp,	Wises Ramp,	**07-Aug-2018**	**----**	----	----	**09-Aug-2018**	09-Aug-2018	✓
Eldridge 0m,	Eldridge 10m,							
Eldridge 20m,	Eldridge 30m,							
Eldridge 50m,	Eldridge 100m,							
Eldridge 150m,	Eldridge 200m,							
Eldridge Bottom								
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK059G)								
Eldridge Ramp,	Wises Ramp,	**07-Aug-2018**	**----**	----	----	**09-Aug-2018**	04-Sep-2018	✓
Eldridge 0m,	Eldridge 10m,							
Eldridge 20m,	Eldridge 30m,							
Eldridge 50m,	Eldridge 100m,							
Eldridge 150m,	Eldridge 200m,							
Eldridge Bottom								

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK061G)								
Eldridge Ramp, Eldridge 0m, Eldridge 20m, Eldridge 50m, Eldridge 150m, Eldridge Bottom	Wises Ramp, Eldridge 10m, Eldridge 30m, Eldridge 100m, Eldridge 200m,	**07-Aug-2018**	**13-Aug-2018**	04-Sep-2018	✓	**13-Aug-2018**	04-Sep-2018	✓
EK067G: Total Phosphorus as P by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK067G)								
Eldridge Ramp, Eldridge 0m, Eldridge 20m, Eldridge 50m, Eldridge 150m, Eldridge Bottom	Wises Ramp, Eldridge 10m, Eldridge 30m, Eldridge 100m, Eldridge 200m,	**07-Aug-2018**	**13-Aug-2018**	04-Sep-2018	✓	**13-Aug-2018**	04-Sep-2018	✓
EK255A: Ammonia								
Clear Plastic - Filtered (AS/ISO) - for UT Nut. (EK255A-CM)								
Pit 1,	Pit 2	**07-Aug-2018**	**----**	----	----	**09-Aug-2018**	08-Aug-2018	×
EK257A: Nitrite								
Clear Plastic - Filtered (AS/ISO) - for UT Nut. (EK257A-CM)								
Pit 1,	Pit 2	**07-Aug-2018**	**----**	----	----	**09-Aug-2018**	11-Aug-2018	✓
EK259A: Nitrite and Nitrate (NOx)								
Clear Plastic - Filtered (AS/ISO) - for UT Nut. (EK259A-CM)								
Pit 1,	Pit 2	**07-Aug-2018**	**----**	----	----	**09-Aug-2018**	11-Aug-2018	✓
EK262A: Total Nitrogen								
Clear Plastic Bottle - Natural (EK262PA-CM)								
Pit 1,	Pit 2	**07-Aug-2018**	**10-Aug-2018**	08-Aug-2018	×	**10-Aug-2018**	08-Aug-2018	×
EK267A: Total Phosphorus (Persulfate Digestion)								
Clear Plastic Bottle - Natural (EK267PA-CM)								
Pit 1,	Pit 2	**07-Aug-2018**	**10-Aug-2018**	08-Aug-2018	×	**10-Aug-2018**	08-Aug-2018	×
EK271A: Reactive Phosphorus								
Clear Plastic - Filtered (AS/ISO) - for UT Nut. (EK271A-CM)								
Pit 1,	Pit 2	**07-Aug-2018**	**----**	----	----	**09-Aug-2018**	08-Aug-2018	×

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation: Date extracted	Due for extraction	Evaluation	Analysis: Date analysed	Due for analysis	Evaluation
EP002: Dissolved Organic Carbon (DOC)							
Amber DOC Filtered- Sulfuric Preserved (EP002) Pit 1, Pit 2, Eldridge Ramp, Wises Ramp, Eldridge 0m, Eldridge 10m, Eldridge 20m, Eldridge 30m, Eldridge 50m, Eldridge 100m, Eldridge 150m, Eldridge 200m, Eldridge Bottom	07-Aug-2018	----	----	----	13-Aug-2018	04-Sep-2018	✓
EP005: Total Organic Carbon (TOC)							
Amber TOC Vial - Sulfuric Acid (EP005) Pit 1, Pit 2, Eldridge Ramp, Wises Ramp, Eldridge 0m, Eldridge 10m, Eldridge 20m, Eldridge 30m, Eldridge 50m, Eldridge 100m, Eldridge 150m, Eldridge 200m, Eldridge Bottom	07-Aug-2018	----	----	----	13-Aug-2018	04-Sep-2018	✓
EP008: Chlorophyll a & Pheophytin a							
White Plastic Bottle - Unpreserved (EP008) Eldridge Ramp, Wises Ramp, Eldridge 0m, Eldridge 30m	07-Aug-2018	----	----	----	09-Aug-2018	09-Aug-2018	✓
MW024: Bacillariophytes (Diatoms) - Centrales							
White Plastic Bottle-Lugols Iodine (MW024_TOT) Eldridge 0m, Eldridge 30m	07-Aug-2018	----	----	----	14-Aug-2018	03-Feb-2019	✓
MW024: Bacillariophytes (Diatoms) - Pennales							
White Plastic Bottle-Lugols Iodine (MW024_TOT) Eldridge 0m, Eldridge 30m	07-Aug-2018	----	----	----	14-Aug-2018	03-Feb-2019	✓
MW024: Bacillariophytes (Diatoms) - TOTAL BACILLARIOPHYTES							
White Plastic Bottle-Lugols Iodine (MW024_TOT) Eldridge 0m, Eldridge 30m	07-Aug-2018	----	----	----	14-Aug-2018	03-Feb-2019	✓
MW024: Chlorophytes (Green Algae) - Chaetophorales							
White Plastic Bottle-Lugols Iodine (MW024_TOT) Eldridge 0m, Eldridge 30m	07-Aug-2018	----	----	----	14-Aug-2018	03-Feb-2019	✓
MW024: Chlorophytes (Green Algae) - Chlorococcales							
White Plastic Bottle-Lugols Iodine (MW024_TOT) Eldridge 0m, Eldridge 30m	07-Aug-2018	----	----	----	14-Aug-2018	03-Feb-2019	✓
MW024: Chlorophytes (Green Algae) - Cladophorales							
White Plastic Bottle-Lugols Iodine (MW024_TOT) Eldridge 0m, Eldridge 30m	07-Aug-2018	----	----	----	14-Aug-2018	03-Feb-2019	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation: Date extracted	Due for extraction	Evaluation	Analysis: Date analysed	Due for analysis	Evaluation
MW024: Chlorophytes (Green Algae) - Oedogoniales								
White Plastic Bottle-Lugols Iodine (MW024_TOT)								
Eldridge 0m,	Eldridge 30m	**07-Aug-2018**	----	----	----	**14-Aug-2018**	03-Feb-2019	✓
MW024: Chlorophytes (Green Algae) - Tetrasporales								
White Plastic Bottle-Lugols Iodine (MW024_TOT)								
Eldridge 0m,	Eldridge 30m	**07-Aug-2018**	----	----	----	**14-Aug-2018**	03-Feb-2019	✓
MW024: Chlorophytes (Green Algae) - TOTAL CHLOROPHYTES								
White Plastic Bottle-Lugols Iodine (MW024_TOT)								
Eldridge 0m,	Eldridge 30m	**07-Aug-2018**	----	----	----	**14-Aug-2018**	03-Feb-2019	✓
MW024: Chlorophytes (Green Algae) - Ulotrichales								
White Plastic Bottle-Lugols Iodine (MW024_TOT)								
Eldridge 0m,	Eldridge 30m	**07-Aug-2018**	----	----	----	**14-Aug-2018**	03-Feb-2019	✓
MW024: Chlorophytes (Green Algae) - Volvocales								
White Plastic Bottle-Lugols Iodine (MW024_TOT)								
Eldridge 0m,	Eldridge 30m	**07-Aug-2018**	----	----	----	**14-Aug-2018**	03-Feb-2019	✓
MW024: Chlorophytes (Green Algae) - Zygnematales								
White Plastic Bottle-Lugols Iodine (MW024_TOT)								
Eldridge 0m,	Eldridge 30m	**07-Aug-2018**	----	----	----	**14-Aug-2018**	03-Feb-2019	✓
MW024: Chrysophytes (Golden Algae)								
White Plastic Bottle-Lugols Iodine (MW024_TOT)								
Eldridge 0m,	Eldridge 30m	**07-Aug-2018**	----	----	----	**14-Aug-2018**	03-Feb-2019	✓
MW024: Chrysophytes (Golden Algae) - TOTAL CHRYSOPHYTES								
White Plastic Bottle-Lugols Iodine (MW024_TOT)								
Eldridge 0m,	Eldridge 30m	**07-Aug-2018**	----	----	----	**14-Aug-2018**	03-Feb-2019	✓
MW024: Cyanophytes (Blue Green Algae) - Chroococcales								
White Plastic Bottle-Lugols Iodine (MW024_TOT)								
Eldridge 0m,	Eldridge 30m	**07-Aug-2018**	----	----	----	**14-Aug-2018**	03-Feb-2019	✓
MW024: Cyanophytes (Blue Green Algae) - Nostocales								
White Plastic Bottle-Lugols Iodine (MW024_TOT)								
Eldridge 0m,	Eldridge 30m	**07-Aug-2018**	----	----	----	**14-Aug-2018**	03-Feb-2019	✓
MW024: Cyanophytes (Blue Green Algae) - Oscillatoriales								
White Plastic Bottle-Lugols Iodine (MW024_TOT)								
Eldridge 0m,	Eldridge 30m	**07-Aug-2018**	----	----	----	**14-Aug-2018**	03-Feb-2019	✓
MW024: Cyanophytes (Blue Green Algae) - Other Cyanophytes								
White Plastic Bottle-Lugols Iodine (MW024_TOT)								
Eldridge 0m,	Eldridge 30m	**07-Aug-2018**	----	----	----	**14-Aug-2018**	03-Feb-2019	✓
MW024: Cyanophytes (Blue Green Algae) - Stigonematales								
White Plastic Bottle-Lugols Iodine (MW024_TOT)								
Eldridge 0m,	Eldridge 30m	**07-Aug-2018**	----	----	----	**14-Aug-2018**	03-Feb-2019	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
MW024: Cyanophytes (Blue Green Algae) - TOTAL CYANOPHYTES							
White Plastic Bottle-Lugols Iodine (MW024_TOT) Eldridge 0m, Eldridge 30m	07-Aug-2018	----	----	----	14-Aug-2018	03-Feb-2019	✓
MW024: Cyanophytes (Blue Green Algae) - TOTAL POTENTIALLY TOXIC CYANOPHYTES							
White Plastic Bottle-Lugols Iodine (MW024_TOT) Eldridge 0m, Eldridge 30m	07-Aug-2018	----	----	----	14-Aug-2018	03-Feb-2019	✓
MW024: Flagellates - Cryptophytes							
White Plastic Bottle-Lugols Iodine (MW024_TOT) Eldridge 0m, Eldridge 30m	07-Aug-2018	----	----	----	14-Aug-2018	03-Feb-2019	✓
MW024: Flagellates - Euglenophytes							
White Plastic Bottle-Lugols Iodine (MW024_TOT) Eldridge 0m, Eldridge 30m	07-Aug-2018	----	----	----	14-Aug-2018	03-Feb-2019	✓
MW024: Flagellates - Pyrrophytes							
White Plastic Bottle-Lugols Iodine (MW024_TOT) Eldridge 0m, Eldridge 30m	07-Aug-2018	----	----	----	14-Aug-2018	03-Feb-2019	✓
MW024: Flagellates - TOTAL FLAGELLATES							
White Plastic Bottle-Lugols Iodine (MW024_TOT) Eldridge 0m, Eldridge 30m	07-Aug-2018	----	----	----	14-Aug-2018	03-Feb-2019	✓
MW024: Raphidophyte							
White Plastic Bottle-Lugols Iodine (MW024_TOT) Eldridge 0m, Eldridge 30m	07-Aug-2018	----	----	----	14-Aug-2018	03-Feb-2019	✓
MW024: Raphidophyte - TOTAL RAPHIDOPHYTE							
White Plastic Bottle-Lugols Iodine (MW024_TOT) Eldridge 0m, Eldridge 30m	07-Aug-2018	----	----	----	14-Aug-2018	03-Feb-2019	✓
MW024T: TOTAL ALGAE							
White Plastic Bottle-Lugols Iodine (MW024_TOT) Eldridge 0m, Eldridge 30m	07-Aug-2018	----	----	----	14-Aug-2018	03-Feb-2019	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Alkalinity by PC Titrator	ED037-P	2	16	**12.50**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Ammonia as N - Ultra-Trace for Catchment Monitoring	EK255A-CM	1	3	**33.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Ammonia as N by Discrete analyser	EK055G	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS - Low Level	EG035F-LL	2	13	**15.38**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	3	24	**12.50**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite B	EG020B-F	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-F	1	2	**50.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Organic Carbon	EP002	2	13	**15.38**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	2	13	**15.38**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Free CN by Segmented Flow Analyser	EK025SF	2	13	**15.38**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	3	29	**10.34**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) - Ultra-Trace for Catchment M	EK259A-CM	1	3	**33.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Ultra-Trace for Catchment Monitoring	EK257A-CM	1	3	**33.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	2	14	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH by PC Titrator	EA005-P	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P - Ultra-Trace for Catchment M	EK271A-CM	1	2	**50.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	3	23	**13.04**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	2	13	**15.38**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS - Low Level	EG035T-LL	2	13	**15.38**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	4	35	**11.43**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	EG020B-T	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-T	2	2	**100.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Nitrogen as N (Persulfate digestion)-Ultra-Trace - CM	EK262PA-CM	1	5	**20.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	2	13	**15.38**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus(Persulfate Digestion) - Ultra-Trace for CM	EK267PA-CM	1	2	**50.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Turbidity	EA045	2	13	**15.38**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Alkalinity by PC Titrator	ED037-P	1	16	**6.25**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Control Samples (LCS) - Continued							
Ammonia as N - Ultra-Trace for Catchment Monitoring	EK255A-CM	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Ammonia as N by Discrete analyser	EK055G	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chlorophyll a and Pheophytin a	EP008	1	8	**12.50**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS - Low Level	EG035F-LL	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	24	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-F	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Organic Carbon	EP002	2	13	**15.38**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Free CN by Segmented Flow Analyser	EK025SF	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) - Ultra-Trace for Catchment M	EK259A-CM	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Ultra-Trace for Catchment Monitoring	EK257A-CM	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	14	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH by PC Titrator	EA005-P	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P - Ultra-Trace for Catchment M	EK271A-CM	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	4	23	**17.39**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS - Low Level	EG035T-LL	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	2	35	**5.71**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	EG020B-T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-T	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Nitrogen as N (Persulfate digestion)-Ultra-Trace - CM	EK262PA-CM	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	2	13	**15.38**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus(Persulfate Digestion) - Ultra-Trace for CM	EK267PA-CM	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Turbidity	EA045	3	13	**23.08**	**15.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Ammonia as N - Ultra-Trace for Catchment Monitoring	EK255A-CM	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Ammonia as N by Discrete analyser	EK055G	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chlorophyll a and Pheophytin a	EP008	1	8	**12.50**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS - Low Level	EG035F-LL	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: ✗ = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Method Blanks (MB) - Continued							
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	24	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-F	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Organic Carbon	EP002	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Free CN by Segmented Flow Analyser	EK025SF	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	2	29	**6.90**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) - Ultra-Trace for Catchment M	EK259A-CM	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Ultra-Trace for Catchment Monitoring	EK257A-CM	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	14	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P - Ultra-Trace for Catchment M	EK271A-CM	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	2	23	**8.70**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS - Low Level	EG035T-LL	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	2	35	**5.71**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	EG020B-T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-T	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Nitrogen as N (Persulfate digestion)-Ultra-Trace - CM	EK262PA-CM	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus(Persulfate Digestion) - Ultra-Trace for CM	EK267PA-CM	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Turbidity	EA045	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Ammonia as N - Ultra-Trace for Catchment Monitoring	EK255A-CM	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Ammonia as N by Discrete analyser	EK055G	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS - Low Level	EG035F-LL	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	24	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-F	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Organic Carbon	EP002	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Free CN by Segmented Flow Analyser	EK025SF	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) - Ultra-Trace for Catchment M	EK259A-CM	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		*Count*		*Rate (%)*			*Quality Control Specification*
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Matrix Spikes (MS) - Continued							
Nitrite as N - Ultra-Trace for Catchment Monitoring	EK257A-CM	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	14	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P - Ultra-Trace for Catchment M	EK271A-CM	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Cyanide by Segmented Flow Analyser	EK026SF	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS - Low Level	EG035T-LL	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	2	35	**5.71**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-T	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Nitrogen as N (Persulfate digestion)-Ultra-Trace - CM	EK262PA-CM	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus(Persulfate Digestion) - Ultra-Trace for CM	EK267PA-CM	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
pH by PC Titrator	EA005-P	WATER	In house: Referenced to APHA 4500 H+ B. This procedure determines pH of water samples by automated ISE. This method is compliant with NEPM (2013) Schedule B(3)
Conductivity by PC Titrator	EA010-P	WATER	In house: Referenced to APHA 2510 B. This procedure determines conductivity by automated ISE. This method is compliant with NEPM (2013) Schedule B(3)
Suspended Solids (High Level)	EA025H	WATER	In house: Referenced to APHA 2540D. A gravimetric procedure employed to determine the amount of \`non-filterable\` residue in a aqueous sample. The prescribed GFC (1.2um) filter is rinsed with deionised water, oven dried and weighed prior to analysis. A well-mixed sample is filtered through a glass fibre filter (1.2um). The residue on the filter paper is dried at 104+/-2C . This method is compliant with NEPM (2013) Schedule B(3)
Turbidity	EA045	WATER	In house: Referenced to APHA 2130 B. This method is compliant with NEPM (2013) Schedule B(3)
Alkalinity by PC Titrator	ED037-P	WATER	In house: Referenced to APHA 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (2013) Schedule B(3)
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	In house: Referenced to APHA 4500-SO4. Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (2013) Schedule B(3)
Chloride by Discrete Analyser	ED045G	WATER	In house: Referenced to APHA 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM (2013) Schedule B(3) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (2013) Schedule B(3) Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite A	EG020A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.

Analytical Methods	Method	Matrix	Method Descriptions
Dissolved Metals by ICP-MS - Suite B	EG020B-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite B	EG020B-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Mercury by FIMS - Low Level	EG035F-LL	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) Samples are 0.45µm filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Total Mercury by FIMS - Low Level	EG035T-LL	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the unfiltered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020 Samples are 0.45µm filtered prior to analysis. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM (2013) Schedule B(3)
Total Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM (2013) Schedule B(3)
Free CN by Segmented Flow Analyser	EK025SF	WATER	In house: Referenced to ASTM D7237: Using an automated segmented flow analyser, a sample at high pH (sodium hydroxide preserved) is buffered to pH 6.0. The hydrogen cyanide present passes across a gas dialysis membrane into an acceptor stream consisting of 0.01 M sodium hydroxide. The acceptor stream mixes with a buffer at pH 5.2 and reacts with chloramine-T to form cyanogen chloride. Cyanogen chloride reacts with 4-pyridine carboxylic acid and 1,3-dimethylbarbituric acid to give a red colour, measured at 600nm. This method is compliant with NEPM (2013) Schedule B(3)

Analytical Methods	Method	Matrix	Method Descriptions
Total Cyanide by Segmented Flow Analyser	EK026SF	WATER	In house: Referenced to APHA 4500-CN C / ASTM D7511. Sodium hydroxide preserved samples are introduced into an automated segmented flow analyser. Complex bound cyanide is decomposed in a continuously flowing stream, at a pH of 3.8, by the effect of UV light. A UV-B lamp (312 nm) and a decomposition spiral of borosilicate glass are used to filter out UV light with a wavelength of less than 290 nm thus preventing the conversion of thiocyanate into cyanide. The hydrogen cyanide present at a pH of 3.8 is separated by gas dialysis. The hydrogen cyanide is then determined photometrically, based on the reaction of cyanide with chloramine-T to form cyanogen chloride. This then reacts with 4-pyridine carboxylic acid and 1,3-dimethylbarbituric acid to give a red colour which is measured at 600 nm. This method is compliant with NEPM (2013) Schedule B(3)
Fluoride by PC Titrator	EK040P	WATER	In house: Referenced to APHA 4500-F C: CDTA is added to the sample to provide a uniform ionic strength background, adjust pH, and break up complexes. Fluoride concentration is determined by either manual or automatic ISE measurement. This method is compliant with NEPM (2013) Schedule B(3)
Ammonia as N by Discrete analyser	EK055G	WATER	In house: Referenced to APHA 4500-NH3 G Ammonia is determined by direct colorimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite as N by Discrete Analyser	EK057G	WATER	In house: Referenced to APHA 4500-NO2- B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrate as N by Discrete Analyser	EK058G	WATER	In house: Referenced to APHA 4500-NO3- F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	WATER	In house: Referenced to APHA 4500-NO3- F. Combined oxidised Nitrogen (NO2+NO3) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Organic Nitrogen as N (TKN - NH3) (discrete analyser)	EK060G	WATER	In house: Referenced to APHA 4500-Norg/4500-NH3. This method is compliant with NEPM (2013) Schedule B(3)
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	WATER	In house: Referenced to APHA 4500-Norg D (In house). An aliquot of sample is digested using a high temperature Kjeldahl digestion to convert nitrogenous compounds to ammonia. Ammonia is determined colorimetrically by discrete analyser. This method is compliant with NEPM (2013) Schedule B(3)
Total Nitrogen as N (TKN + Nox) By Discrete Analyser	EK062G	WATER	In house: Referenced to APHA 4500-Norg / 4500-NO3-. This method is compliant with NEPM (2013) Schedule B(3)
Total Phosphorus as P By Discrete Analyser	EK067G	WATER	In house: Referenced to APHA 4500-P H, Jirka et al (1976), Zhang et al (2006). This procedure involves sulphuric acid digestion of a sample aliquot to break phosphorus down to orthophosphate. The orthophosphate reacts with ammonium molybdate and antimony potassium tartrate to form a complex which is then reduced and its concentration measured at 880nm using discrete analyser. This method is compliant with NEPM (2013) Schedule B(3)
Ammonia as N - Ultra-Trace for Catchment Monitoring	EK255A-CM	WATER	In house: Referenced to APHA 4500-NH3 H. Ammonia is determined by direct colorimetry by FIA. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite as N - Ultra-Trace for Catchment Monitoring	EK257A-CM	WATER	In house: Referenced to APHA 4500-NO2- B. Nitrite is determined by direct colourimetry by FIA.
Nitrate as N - Ultra-Trace for Catchment Monitoring	EK258A-CM	WATER	In house: Referenced to APHA 4500-NO3- I Nitrate is reduced to nitrite by way of a cadmium reduction column followed by quantification by FIA. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results.

Analytical Methods	Method	Matrix	Method Descriptions
Nitrite and Nitrate as N (NOx) - Ultra-Trace for Catchment M	EK259A-CM	WATER	In house: Referenced to APHA 4500-NO3- I. Combined oxidised Nitrogen (NO2+NO3) is determined by Cadmium Reduction and direct colourimetry by FIA.
Organic Nitrogen as N (diss. TN - NH3-N - NOx-N) (FIA-UT)	EK260PA-CM	WATER	Calculated by difference from total Nitrogen and inorganic Nitrogen (Ammonia, Nitrate and Nitrite). Contributing method parameters are determined by FIA. APHA 4500-P J. Persulfate Method for Simultaneous Determination of Total Nitrogen, 4500 NO3- I. NOx and 4500 NH3+-H Ammonia. This method is compliant with NEPM (2013) Schedule B(3)
TKN (Total N - NOx-N). (FIA - UT) for Catchment Monitoring	EK261PA-CM	WATER	In house: Referenced to APHA 4500-P J. & 4500-NO3- I . Calculated by difference from total Nitrogen and NOx. Contributing method parameters are determined by FIA. This method is compliant with NEPM (2013) Schedule B(3)
Total Nitrogen as N (Persulfate digestion)-Ultra-Trace - CM	EK262PA-CM	WATER	In house: Referenced to APHA 4500-P J. Persulfate Method for Simultaneous Determination of Total Nitrogen and Total Phosphorus. As sample is digested with persulfate under alkaline conditions yielding orthophosphate and nitrate. Following digestion, analytes are determined by flow injection analysis. This method is compliant with NEPM (2013) Schedule B(3)
Total Phosphorus(Persulfate Digestion) - Ultra-Trace for CM	EK267PA-CM	WATER	In house: Referenced to APHA 4500-P J. Persulfate Method for Simultaneous Determination of Total Nitrogen and Total Phosphorus. As sample is digested with persulfate under alkaline conditions yielding orthophosphate and nitrate. Following digestion, analytes are determined by flow injection analysis. This method is compliant with NEPM (2013) Schedule B(3)
Reactive Phosphorus as P - Ultra-Trace for Catchment M	EK271A-CM	WATER	In house: Referenced to APHA 4500-P E Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with othophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by FIA. This method is compliant with NEPM (2013) Schedule B(3)
Ionic Balance by PCT DA and Turbi SO4 DA	EN055 - PG	WATER	In house: Referenced to APHA 1030F. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Organic Carbon	EP002	WATER	In house: Referenced to APHA 5310 B. This method is compliant with NEPM (2013) Schedule B(3) . Samples are combusted at high termperature in the presence of an oxidative catalyst. The evolved carbon dioxide is quantified using an IR detector.
Total Organic Carbon	EP005	WATER	In house: Referenced to APHA 5310 B, The automated TOC analyzer determines Total and Inorganic Carbon by IR cell. TOC is calculated as the difference. This method is compliant with NEPM (2013) Schedule B(3)
Chlorophyll a and Pheophytin a	EP008	WATER	In house: Referenced to APHA 10200 H. The pigments are extracted into aqueous acetone. The optical density of the extract before and after acidification at both 664 nm and 665 nm is determined spectrometrically.
Total Algae Count	MW024 TOT	WATER	In house: Referenced to Hotzel and Groome, 1999 and APHA 10200

Preparation Methods	Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	WATER	In house: Referenced to APHA 4500 Norg - D; APHA 4500 P - H. This method is compliant with NEPM (2013) Schedule B(3)
Persulfate Digestion for UT TN and TP for FIA finish.	EK262/267-PA Prep	WATER	In house: Referenced to APHA 4500 P - J. This method is compliant with NEPM (2013) Schedule B(3)
Digestion for Total Recoverable Metals	EN25	WATER	In house: Referenced to USEPA SW846-3005. Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (2013) Schedule B(3)

Preparation Methods	Method	Matrix	Method Descriptions
Digestion for Total Recoverable Metals - ORC	EN25-ORC	WATER	In house: Referenced to USEPA SW846-3005. This is an Ultrapure Nitric acid digestion procedure used to prepare surface and ground water samples for analysis by ORC- ICPMS. This method is compliant with NEPM (2013) Schedule B(3)

ALS Environmental

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ADELAIDE 21 Burma Road Pooraka SA 5095 Ph: 08 8359 0890 E: adelaide@alsglobal.com
☐BRISBANE 32 Shand Street Stafford QLD 4053 Ph: 07 3243 7222 E: samples.brisbane@alsglobal.com
☐GLADSTONE 46 Callemondah Drive Clinton QLD 4680 Ph: 07 7471 5600 E: gladstone@alsglobal.com
☐MACKAY 78 Harbour Road Mackay QLD 4740 Ph: 07 4944 0177 E: mackay@alsglobal.com
☐MELBOURNE 2-4 Westall Road Springvale VIC 3171 Ph: 03 8549 9600 E: samples.melbourne@alsglobal.com
☐MUDGEE 27 Sydney Road Mudgee NSW 2850 Ph: 02 6372 6735 E: mudgee.mail@alsglobal.com
☐NEWCASTLE 5/585 Maitland Rd Mayfield West NSW 2304 Ph: 02 4014 2500 E: samples.newcastle@alsglobal.com
☐NOWRA 4/13 Geary Place North Nowra NSW 2541 Ph: 024423 2063 E: nowra@alsglobal.com
☐PERTH 10 Hod Way Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsglobal.com
☐SYDNEY 277-289 Woodpark Road Smithfield NSW 2164 Ph: 02 8784 8555 E: samples.sydney@alsglobal.com
☐TOWNSVILLE 14-15 Desma Court Bohle QLD 4818 Ph: 07 4796 0600 E: townsville.environmental@alsglobal.com
☐WOLLONGONG 99 Kenny Street Wollongong NSW 2500 Ph: 02 4225 3125 E: portkembla@alsglobal.com

CLIENT: Genex
OFFICE:
PROJECT: KIDSTON
ORDER NUMBER:
PROJECT MANAGER: Reece Fraser
CONTACT PH:
SAMPLER: Genex - John Lawlor -
SAMPLER MOBILE:
COC emailed to ALS? NO
EDD FORMAT (or default):
Email Reports to (will default to PM if no other addresses are listed): reece.fraser@aecom.com; clm@genexpower.com.au
Email Invoice to (will default to PM if no other addresses are listed): rouven.lau@aecom.com; reece.fraser@aecom.com

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
Standard TAT (**List due date**):
ASAP - please provide prelim results when available.

ALS QUOTE NO.: As per Genex Quote
Task Number:

COC SEQUENCE NUMBER (Circle)
COC: 1
OF: 1

FOR LABORATORY USE ONLY (Circle) [illegible]

RELINQUISHED BY: *Reece Fraser*
DATE/TIME: 08/08/2018

RECEIVED BY: CM
DATE/TIME: 8/8/18 13:20

RELINQUISHED BY:
DATE/TIME:

RECEIVED BY:
DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE	SAMPLE DETAILS MATRIX: SOLID (S) WATER (W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).									Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL CONTAINERS	As per quote from Joy Morgan to Reece Fraser 3/8/18 - no Chlorophyll a	As per quote from Joy Morgan to Reece Fraser 3/8/18 - Including Chlorophyll a	Total and dissolved Silver							Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	Pit 1	7/8/2018	W		11	X		X							
2	Pit 2	7/8/2018	W		11	X		X							
3	Eldridge Ramp	7/8/2018	W		9		X	X							
4	Wises Ramp	7/8/2018	W		9		X	X							
5	Eldridge 0m	7/8/2018	W		9		X	X							
6	Eldridge 10m	7/8/2018	W		8	X		X							
7	Eldridge 20m	7/8/2018	W		8	X		X							
8	Eldridge 30m	7/8/2018	W		9		X	X							
9	Eldridge 50m	7/8/2018	W		8	X		X							
10	Eldridge 100m	7/8/2018	W		8	X		X							
11	Eldridge 150m	7/8/2018	W		8	X		X							
12	Eldridge 200m	7/8/2018	W		8	X		X							
13	Eldridge Bottom	7/8/2018	W		8	X		X							
				TOTAL	114	9	4	13							

Environmental Division
Townsville
Work Order Reference
ET1802030
Telephone : +61 7 4773 0000

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

Appendix K

Preliminary Construction Assessment

Memorandum

To		Page	1
CC			
Subject	Preliminary Construction Assessment [Revision 1]		
From			
File/Ref No.		Date	08/01/2019

1.0 Introduction

1.1 Relationship to Previous Assessment

This appendix presents the results of a number of modelling scenarios and sensitivities completed in order to assess the Kidston Pumped Storage Project (the Project) during the construction phase. Fundamentally, this revised assessment differs from the previous assessment (refer to Appendix 1) in that:

- The objective of the previous assessment (Appendix 1) was to determine a suitable release rate for the construction phase. It was found that a significantly lower dilution ratio and higher discharge capacity was required during the construction phase when compared to the operational phase.
- The current revised assessment focusses on identification of a number of additional strategies required for the design and temporary construction phase operation of the Project assuming adoption of the same proposed release regime as that nominated for the operational phase, namely:
  - A release trigger of 400 ML/d in the Copperfield River at the proposed release point (releases may be made at any time during the construction phase as long as the receiving flow is in excess of the trigger).
  - A maximum discharge capacity of 1 m^3/s (86.4 ML/d);
  - A minimum dilution ratio of 200 to 1 (0.5033% release ratio) which is based on the contaminant of most concern (dissolved zinc) and assumes the following:
    - End of pipe concentration of 1.5874 mg/L for dissolved zinc;
    - Receiving concentration of 0.0025 mg/L for dissolved zone; and
    - Water quality objective (WQO) of 0.014 mg/L (hardness modified) for dissolved zinc.
- Additional objectives for the assessment included:
  - Elimination of the reliance of releases of water from the Copperfield dam to augment discharge potential;
  - Potentially limiting releases to only the 2020/21 wet season; and
  - A reduction in the assumed water consumption (1 ML/d) of additional disposal options, including (but not limited to) construction activities such as bulk earthworks, dust suppression, etc.

In addition, the construction phase schedule has been subjected to a number changes including a later start data and reduced duration.

1.2 Construction Phase Activities

The dewatering of Eldridge Pit must be completed in order to facilitate access for the completion of the tailrace tunnel outlet and pit wall stabilisation works. At the approximate time of writing, current water levels in both Wises and Eldridge Pits indicate that the volume of water required to be pumped from Eldridge Pit exceeds both the current (undeveloped) and preliminary constructed capacity of Wises Pit ('excess construction water'). In order for the tailrace outlet works to commence in accordance with planned construction scheduling the Project water balance must achieve an overall net loss equivalent to the estimated excess construction water. However, the net loss is the balance of a number of inflows (rainfall, runoff, seepage interception system (SIS) and groundwater inflows) and outflows (controlled releases, evaporation).

1.3 Preliminary Construction Phase Assessment

The proposed operational phase controlled release assumptions (refer to Section 1.1above) provide sufficient release potential for the operational phase of the Project. However, when applied to the construction phase, do not allow for the release of the volume of water required to meet proposed construction scheduling. In order to determine additional strategies required for the design and temporary construction phase operation of the Project the following were completed:

- Detailed review of the revised construction and pit dewatering staging schedule in order to confirm and define:
  - Dewatering volumes and rates;
  - Critical dates;
  - Key schedule-based objectives; and
  - Model objective functions – i.e. key metrics with which to compare the relative efficacy of each model scenario.
- Review and develop model assumptions for the transition of Wises Pit from its existing condition as an open cut mine pit with an external (runoff) catchment to its constructed condition with an extensive water surface area and no external catchment.
- Assess the efficacy of proposed design and temporary construction phase operational strategies:
  - Creation of additional storage within the proposed Wises upper reservoir though the removal of additional waste rock material currently located within the proposed footprint;
  - Temporary storage of water in the construction Wises upper reservoir above both the operational phase full supply level (FSL) of RL 551 m AHD and the operational phase spillway elevation of 551.5 m AHD.

Additional sensitivity assessment of key assumptions (catchment area and runoff coefficient for Wises Pit) against adopted model objective functions was previously assessed as part of the previous assessment. Results indicated a relatively low sensitivity to both assumptions. Results are presented in Appendix A.

1.4 Modelled Construction and Dewatering Schedule

Modelling of the construction phase has considered three key stages associated with the dewatering of Eldridge Pit and construction of the power hall access tunnel, tailrace outlet works and the Wises upper reservoir embankment. Table 1 summarises the key construction stages, dates and durations.

Table 1 Key Construction Phase Stages

Stage	Description	Stage Schedule Details		
		Scheduled Stage Start	Scheduled Stage End	Scheduled Stage Duration (days)
1	Dewatering of Eldridge Pit for safe access to allow main access tunnel construction. Dewatering to continue up to the maximum allowable fill (RL 525m AHD) in the existing Wises Pit without impacting ongoing embankment works.	11/12/2019	16/04/2020	127
2	Final dewatering of Eldridge Pit to the completed Wises upper reservoir. Eldridge lowered to RL suitable for the safe construction of tailrace outlet works (305 m AHD).	18/11/2020	13/08/2021	268
3	Refill of Eldridge Pit to MOL RL (328.4 m AHD)	28/01/2022	11/02/2022	779 (total from start of stage 1 to end of stage 3)

It should be noted that this programme is indicative, is based on dewatering commencing in December 2019 and may be subject to change.

The key model objective function adopted was the scheduled duration of stage 2 dewatering as:

- On-time achievement of stage 2 completion is critical to the commencement of key construction activities associated with the tailrace tunnel outlet works.
- On-time completion of stage 2 is notably dependant on the availability of the constructed Wises upper reservoir to receive the remaining volume from Eldridge Pit.
- Current water levels in both Wises and Eldridge Pits imply insufficient capacity in the fully constructed Wises upper reservoir to receive all of the estimated stage 2 dewatering volume.

  On-time completion of stage 1 dewatering is not anticipated to be limited by the ability of the current Wises Pit to receive the estimated stage 1 dewatering volume (required to complete access tunnel works) and the total volume is effectively the balance of the current undeveloped Wises Pit less its current volume.

1.4.1 Adopted Model Performance Targets (Objective Function)

Reliability up to the 80^{th} percentile (P80) was adopted as the target for achieving the modelled stage 2 dewatering duration of 268 days. This was required to be achieved while adopting the operational phase release conditions (200 to 1 dilution ratio for dissolved zinc – refer to Section 1.1)

1.5 Estimated Dewatering Volumes, Excess Water and Adopted Pump Rates

Table 2 details the dewatering volumes associated with stages 1 and 2. Note that Stage 3 is simply the refilling of Eldridge Pit to MOL and is not considered to be of material interest to the assessment. From the table it can be seen that the end water RL for the constructed Wises upper reservoir upon completion of stage 2 is estimated to be 552.6 m AHD. This should be contrasted with the proposed spillway elevation of RL 551.5 m AHD and the proposed FSL of 551 m AHD. This effectively results in an excess construction volume of:

- Approximately 1.9 GL if Wises upper reservoir is filled to the spillway elevation (551.5 m AHD) at the end of stage 2; or
- Approximately 2.5 GL if Wises upper reservoir is filled to the FSL elevation (551 m AHD) at the end of stage 2.

These high excess water volumes were the primary driver in the previous assessment for the requirement to have a significantly lower dilution ration when compared to the operational phase.

Table 2 Construction Dewatering Volumes

Stage	Eldridge Pit				Pump Volume	Existing Wises Pit/Upper Reservoir			
	Start RL	Start Vol.	End RL	End Vol.	GL	Start RL	Start Vol.	End RL	End Vol.
	m	GL	m	GL		m	GL	m	GL
1	484.49	29.092	457.7	21.454	7.637	493.96	0.80	525	8.44
2	457.7	21.454	305	1.062	20.392	525	8.44	552.60[1]	28.83[2]
3	Refill Eldridge to MOL RL (328.4 m AHD)								

Based on the key construction stages in Table 1 and the estimated dewatering volumes in Table 2 the following preliminary pump rates have been adopted for the construction phase modelling:

- Stage 1 – 1,200 L/s (104 ML/d); and
- Stage 2 – 1,200 L/s (104 ML/d).
- Pumps were initially assumed to operate 20 hours per day however sensitivity analysis indicated that as the excess water volume was progressively reduced, the effective pump capacity (after consideration of duty) become a key driver and results were relatively insensitive to dilution ratio. The final scenarios (refer to Section 4.0) therefore increased the assumed duty to 22 hours.

1.6 Construction of Wises Upper Reservoir Embankment

The transition of the existing Wises open cut pit into the Wises upper reservoir will result in significant changes to its water balance throughout the duration of the construction phase. While detailed construction scheduling has not yet been completed, a number of high level assumptions have been adopted to reflect the proposed construction of the upper reservoir and its impact on the water balance. Referring to Figure 1:

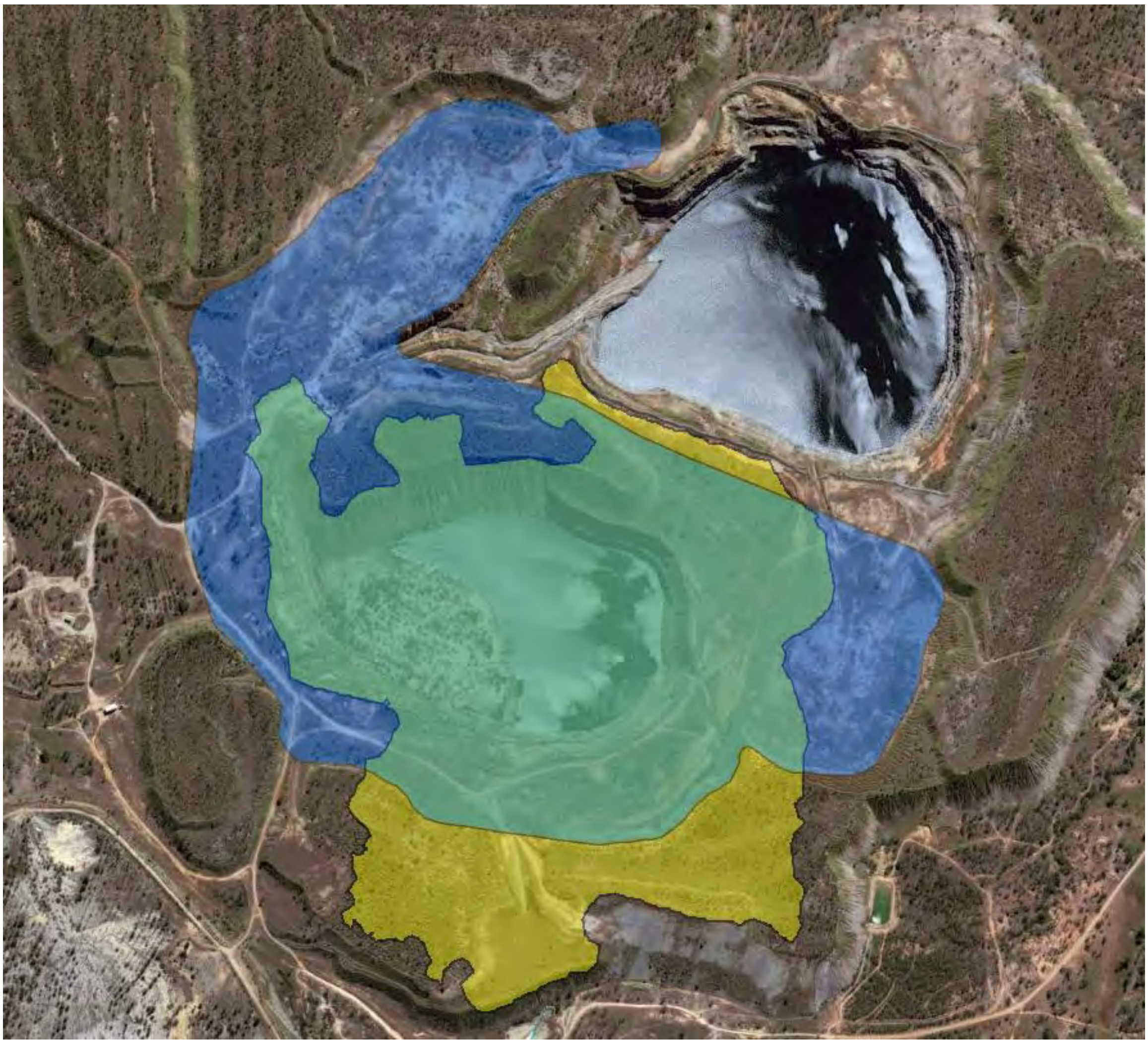
- The existing Wises Pit has an external catchment of approximately 105 Ha;
- The Wises upper reservoir will have an internally-draining catchment of approximately 125 Ha and no external catchment; and
- Approximately 75 ha of the existing Wises Pit external catchment lies within the proposed Wises upper reservoir, an internally-draining catchment.

[1] Indicates resultant water level is in excess of the FSL (551 m AHD) and spillway (551.5 m AHD) elevations.
[2] Indicates that the resultant water volume is in excess of the Wises upper reservoir storage capacity of 26.74 GL (at FSL) and 27.36 GL (at spillway elevation.)

Adopted catchment area assumptions for Wises Pit during the construction phase model simulation are summarised in Table 3. A runoff coefficient of 0.33 was adopted for the Wises Pit external catchment. This is consistent with that used for Eldridge Pit (McConnell Dowel - John Holland JV, 2018) and (Entura, 2016) but does not represent a calibrated value. Sensitivity to the runoff coefficient as well as assumed catchment areas are discussed in Appendix A.

Table 3 Adopted Wises Pit Catchment Area Assumptions for Construction Simulation

Date	Description	Wises Catchment		Comment
		Runoff	Internal (Direct Rainfall)	
1/21/2019	Start of model construction simulation and stage 1 dewatering (11/12/19)	75 Ha less the water surface area (calculated daily during model simulation)	Based on water surface area (calculated daily during model simulation)	Assumes existing external areas outside embankment diverted as early works. This assumption has been sensitivity tested (refer to 1.0)
1/05/2020	Existing drainage paths away from pit blocked by embankment earthworks	125 ha less the water surface area (calculated daily during model simulation)	Based on water surface area (calculated daily during model simulation)	7 months into critical construction period.
18/11/2020	Start of stage 2 dewatering	0 Ha	125 Ha	Conservative assumption that assumes immediate inundation of runoff catchment upon commencement of stage 3 dewatering.
28/01/2022	Commence refill of Eldridge	0 Ha	125 Ha	End of critical construction period/model simulation



Catchment	Area (Ha)	Ref.	Comment
Existing Wises Pit catchment (yellow and green areas)	105 (total – yellow and green areas) 30 (outside Wises upper reservoir footprint – yellow area)		Early works are assumed to divert any of the existing Wises Pit catchment that falls outside of the proposed Wises upper reservoir footprint (yellow area only) in order to reduce the volume of external runoff entering Wises Pit during construction. The resultant area of 75 ha (green area) assumed to be the un-divertible remaining external catchment at start of construction phase. This assumption has been sensitivity tested (refer to Section 1.0).
Wises upper reservoir footprint	125		Internally draining catchment for constructed Wises upper reservoir.
Area of overlap	75		Assumed remaining external catchment reporting to Wises Pit during initial construction period i.e. prior to stage 3 dewatering.

Figure 1 Assumed Wises Pit Catchments during Construction Phase

2.0 Revised Construction Phase Sensitivity Assessment Modelling

2.1 Construction Sensitivity Assessment Scenarios Assessed

A number of sensitivity scenarios were assessed for the construction phase simulation as summarised in Table 4 below:

- Scenario 1 utilises the previous construction phase dilution ratio (20 to 1) which was adopted as the base case with which to compare. Maximum allowed volume in Wises (FSL) is RL 551 m AHD and no additional excavation of waste rock material.
- Scenarios 1.1 to 1.5 assessed the impact of progressively reducing the potential freeboard in Wises upper reservoir (by increasing the FSL) during the construction phase. This was completed by progressively increasing the level at which water transferred from Eldridge Pit during stage 2 dewatering is halted (the FSL). Five scenarios considered incremental 100mm reductions in freeboard (difference between maximum allowable water level and spillway elevation).
- Scenarios 2.1 to 2.9 assessed the impact of progressive temporary increases to the spillway elevation. Nine scenarios considered incremental 100mm increases to the spillway elevation with a constant 100mm of freeboard maintained for all scenarios (i.e. FSL is maintained at 100mm below the spillway RL).
- Scenarios 3.1 to 3.5 assessed the potential impact of increasing the storage capacity of the completed Wises upper reservoir through the additional removal of waste rock material currently placed in the existing open cut pit. A total of five scenarios considered progressive 0.25 Mm^3 excavations from 0.5 Mm^3 to the maximum possible excavation volume of 1.5 Mm^3. For these scenarios the proposed operational spillway RL (551.5 m AHD) was maintained with 100mm of freeboard (i.e. FSL is maintained at 100mm below the spillway RL).

2.1.1 Simulation Parameters and Key Objectives Summary

Each scenario was run as a boot-strapped Monte Carlo simulation consisting of 127 realisations. The simulation duration used was as follows:

- Start – 1/12/2019; and
- End – 21/01/2022 (start of stage 3 and refill of Eldridge Pit).

The key objectives were to:

- Target the scheduled stage 2 dewatering duration of 268 days up to the 80^{th} percentile (P80); and
- Adopt operational phase release conditions (refer to Section 1.1) i.e. 400 ML/d day release trigger in the Copperfield River at the proposed release location, 200 to 1 dilution ratio for dissolved zinc (0.5033% release ratio) and a maximum release capacity of 1.0 m^3/s (86.4 ML/d).
- A number of additional secondary objectives included:
  - Elimination of the reliance of releases of water from the Copperfield dam to augment discharge potential;
  - Potentially limiting releases to only the 2020/21 wet season; and
  - A reduction in the assumed water consumption of additional disposal options, including (but not limited to) construction activities such as bulk earthworks, dust suppression, etc.

Table 4 Revised Construction Phase Sensitivity Assessment Scenarios Assessed

Scenario	Description	Wises Freeboard RL (m AHD)	Wises Freeboard Volume (ML)[3]	Wises Spillway RL (m AHD)	Wises Initial RL (m AHD)	Wises Initial Volume (GL)	Eldridge Initial RL (m AHD)	Eldridge Initial Volume (GL)	Excess Water (ML)	Comments
0	Base case	551	612.5	551.5	493.96	0.8077	484.49	29.203	2,458	Target Stage 2 dewatering duration achieved with a 25 to 1 dilution ratio
1.1	Freeboard capacity scenarios (no increase to spillway RL)	551.1	490.0	551.5	493.96	0.8077	484.49	29.2	2,336	-100mm reduction in freeboard[4]
1.2		551.2	367.5	551.5	493.96	0.8077	484.49	29.2	2,213	-200mm reduction in freeboard
1.3		551.3	245.0	551.5	493.96	0.8077	484.49	29.2	2,091	-300mm reduction in freeboard
1.4		551.4	122.5	551.5	493.96	0.8077	484.49	29.2	1,968	-400mm reduction in freeboard
1.5		551.5	0	551.5	493.96	0.8077	484.49	29.2	1,846	-500mm reduction in freeboard (no freeboard)
2.1	Increased spillway RL scenarios (freeboard maintained at 100mm)	551.5	123.5	551.6	493.96	0.8077	484.49	29.2	1,846	+100mm increase to spillway RL
2.2		551.6	123.5	551.7	493.96	0.8077	484.49	29.2	1,722	+200mm increase to spillway RL
2.3		551.7	123.5	551.8	493.96	0.8077	484.49	29.2	1,599	+300mm increase to spillway RL
2.4		551.8	123.5	551.9	493.96	0.8077	484.49	29.2	1,475	+400mm increase to spillway RL
2.5		551.9	123.5	552.0	493.96	0.8077	484.49	29.2	1,352	+500mm increase to spillway RL
2.6		552	124.4	552.1	493.96	0.8077	484.49	29.2	1,228	+600mm increase to spillway RL
2.7		552.1	124.4	552.2	493.96	0.8077	484.49	29.2	1,104	+700mm increase to spillway RL
2.8		552.2	124.4	552.3	493.96	0.8077	484.49	29.2	980	+800mm increase to spillway RL
2.9		552.3	124.4	552.4	493.96	0.8077	484.49	29.2	855	+900mm increase to spillway RL
3.1	Additional Wises storage only (no increase to spillway RL, freeboard maintained at 100mm)[5]	551.4	122.5	551.5	493.96	0.8077	482.89	28.704	1,469	~0.5 Mm^3 excavation
3.2		551.4	122.5	551.5	493.96	0.8077	482.27	28.454	1,220	~0.75 Mm^3 excavation
3.3		551.4	122.5	551.5	493.96	0.8077	481.43	28.205	971	~1.0 Mm^3 excavation
3.4		551.4	122.5	551.5	493.96	0.8077	480.68	27.953	717	~1.25 Mm^3 excavation
3.5		551.4	122.5	551.5	493.96	0.8077	479.87	27.706	472	~1.5 Mm^3 excavation
4.1	Reduced release capacity	551.4	122.5	551.5	493.96	0.8077	479.87	27.706	472	$1m^3/s$ release capacity
4.2	Delay releases	551.4	122.5	551.5	493.96	0.8077	479.87	27.706	472	No releases until start of '20/21 wet season
4.3	No dam releases	551.4	122.5	551.5	493.96	0.8077	479.87	27.706	472	Turn off Copperfield Dam releases.
4.4	No additional disposal	551.4	122.5	551.5	493.96	0.8077	479.87	27.706	472	No additional disposal options
4.5	Reduced additional disposal	551.4	122.5	551.5	493.96	0.8077	479.87	27.706	472	0.5 ML/d additional disposal

[3] Freeboard volumes presented here are prior to development of a revised storage curve for the constructed wises upper reservoir incorporating the full 1.5Mm^3 of waste rock excavation from the existing Wises open cut pit
[4] Differemnce between FSL and spillway RL
[5] The assessment of these scenarios was completed prior to development of a revised storage curve for the constructed wises upper reservoir. The additional storage volume provided by the waste rock excavation was simulated by removal of an equivalent volume of water from the Eldridge Pit starting volume.

Scenario	Description	Wises Freeboard RL (m AHD)	Wises Freeboard Volume (ML)[3]	Wises Spillway RL (m AHD)	Wises Initial RL (m AHD)	Wises Initial Volume (GL)	Eldridge Initial RL (m AHD)	Eldridge Initial Volume (GL)	Excess Water (ML)	Comments
4.6	Reduced release capacity + no dam releases	551.4	122.5	551.5	493.96	0.8077	479.87	27.706	472	• $1m^3/s$ release capacity • Turn off Copperfield Dam releases.
4.7	Reduced release capacity + no dam releases + reduced additional disposal	551.4	22.5	551.5	493.96	0.8077	479.87	27.706	472	• $1m^3/s$ release capacity • Turn off Copperfield Dam releases • 0.5 ML/d additional disposal

3.0 Revised Construction Phase Sensitivity Assessment Modelling Results

3.1 Freeboard Capacity Scenarios (Scenarios 1.1 to 1.5)

The requirement to maximise water storage in the Wises upper reservoir occurs towards to end of the stage 2 dewatering and must be maintained until the start of stage 3 when Eldridge lower reservoir is returned to its MOL (refer to Table 1). Table 5 below shows the results for scenarios 1.1 to 1.5 which considered potential reductions in the freeboard (achieved by increasing the FSL whilst maintaining the spillway RL) for Wises upper reservoir during the construction phase:

- While each progressive reduction in freeboard allows for some increases in dilution ratio, even when the freeboard is reduced to zero, the dilution ratio required to meet the stage 2 dewatering duration target is 34 to 1 which is still significantly lower than the target of 200 to 1.
- The results indicate that the minimum freeboard that could be temporarily applied during the construction phase to reduce the likelihood of an uncontrolled overflow is 100mm (scenario 1.4). This criterion was subsequently adopted for all further scenarios – i.e. FSL is 100m below the spillway RL.

Table 5 Required Dilution Ratios for Freeboard Capacity Scenarios

Scenario	Description	Required Dilution Ratio (Zinc (F))	P80 Stage 2 Duration (Target 268 Days)	Comments
0	Basecase (500mm freeboard)	25:1	271	Target Stage 2 dewatering duration achieved with a 25 to 1 dilution ratio
1.1	-100mm reduction in freeboard	27.5:1	272	
1.2	-200mm reduction in freeboard	29:1	273	
1.3	-300mm reduction in freeboard	31:1	274	
1.4	-400mm reduction in freeboard	32.5:1	273	Adopted for further assessment.
1.5	-500mm reduction in freeboard (no freeboard)	34:1	274	Uncontrolled (overflow) discharges noted at P5 result

3.2 Increased Spillway RL Scenarios (Scenarios 2.1 to 2.9)

Adopting scenario 1.4 as the basis for comparison (100mm of freeboard), results for the increased spillway RL scenarios (2.1 to 2.9) are shown below in Table 6:

- Initial increases to the spillway RL have only a limited impact on the required dilution ratio. For example, a 300mm increase (scenario 2.3) only results in a dilution ratio of 36 to 1.
- At the maximum possible spillway increase assessed (scenario 2.9, 900mm increase), the dilution ratio required to meet the stage 2 dewatering duration is 60 to 1. While this is a notable improvement on the base case (scenario 0) of 25 to 1, it still falls significantly short of the required 200 to 1 target. In addition, the embankment crest freeboard is reduced to only 300mm which could result in wave run up over the crest and potentially affect the embankment integrity.

Table 6 Required Dilution Ratios for Increased Spillway RL Scenarios

Scenario	Description	Required Dilution Ratio (Zinc (F))	P80 Stage 2 Duration (Target 268 Days)	Comments
1.4	**-400mm reduction in freeboard**	**32.5:1**	**273**	**Basis for comparison – adopted 100mm freeboard**
2.1	+100mm increase to spillway RL	32.5:1	273	Similar result to scenario 1.4
2.2	+200mm increase to spillway RL	34:1	274	
2.3	+300mm increase to spillway RL	36:1	272	
2.4	+400mm increase to spillway RL	38:1	270	
2.5	+500mm increase to spillway RL	41:1	270	
2.6	+600mm increase to spillway RL	45:1	271	
2.7	+700mm increase to spillway RL	50:1	272	
2.8	+800mm increase to spillway RL	55:1	272	
2.9	+900mm increase to spillway RL	60:1	272	Maximum possible spillway increase. At this point freeboard to the embankment crest is reduced to 300 mm.

3.3 Additional Wises Storage Scenarios (Scenarios 3.1 to 3.5)

Adopting scenario 1.4 as the basis for comparison (100mm of freeboard), results for the additional Wises storage scenarios (3.1 to 3.5) are shown below in Table 8:

- The progressive increases to the Wises upper reservoir capacity through the additional excavation of waste rock material provide a significant increase in the required dilution ratio such that at the maximum possible excavation volume of 1.5 Mm^3, the stage 2 dewatering target can be achieved with a 1 to 165 dilution ratio.
- Scenario 3.5 (1.5 Mm^3 excavation) was consequently adopted as the preferred solution and adopted for additional assessment (Sections 4.0 and 3.4).

Table 7 Required Dilution Ratios for Additional Wises Storage Scenarios

Scenario	Description	Required Dilution Ratio (Zinc (F))	P80 Stage 2 Duration (Target 268 Days)	Comments
1.4	-400mm reduction in freeboard	32.5:1	273	Basis for comparison – adopted 100mm freeboard
3.1	~0.5 Mm^3 excavation	45:1	270	
3.2	~0.75 Mm^3 excavation	55:1	269	
3.3	~1.0 Mm^3 excavation	70:1	267	
3.4	~1.25 Mm^3 excavation	100:1	268	
3.5	~1.5 Mm^3 excavation	165:1	271	Maximum possible excavation volume. Adopted for further assessment.

3.4 Additional Objectives Scenarios (Scenarios 4.1 to 4.7)

Adopting scenario 3.5 as the basis for comparison (1.5 Mm^3 excavation of waste rock for Wises and 100mm of freeboard), results for the additional objectives scenarios (4.1 to 4.9) are shown below in Table 8:

- A reduction in the maximum release capacity from 1.5 m^3/s to1.0 m^3/s only resulted in a minimal reduction in the required dilution ratio from165 to 1 to 150 to 1 (scenario 4.1). Consequently, in accordance with the objectives outlined in Section 2.1.1, a maximum release capacity of 1.0 m^3/s has been adopted for the construction phase (consistent with the operational phase).
- Delaying release until the commencement of the 2020/21 wet season resulted in a reduction of required dilution ratio to 25 to 1 (scenario 4.2) and has been discounted as a practical option.
- Scenario 4.3 considered turning off the use of water releases from the Copperfield Dam in order to augment potential release opportunity at the proposed release location. Based on small reduction in required dilution ratio it has been determined that Copperfield Dam releases will not be required as a means of enhancing discharge potential.
- Scenarios 4.4 and 4.5 considered changes to the assumed volume of water that could be disposed of via additional consumptive options. While reducing the volume to 0 ML/d (scenario 4.4) resulted in an unacceptable reduction in the required ratio, a reduction from 1.0 to 0.5 ML/d resulted in a reduction of required dilution ratio to 105 to 1 which is considered acceptable.
- In order to assess the impact on required dilution ratio all three options were combined (scenario 4.7). The overall reduction in required dilution ratio to 80 to 1 was considered acceptable and adopted for subsequent analysis to determine the additional temporary increase to the Wises spillway RL that would be required in order to meet the objective of a required dilution ratio of 200 to 1.

Table 8 Required Dilution Ratios for Additional Objectives Scenarios

Scenario	Description	Required Dilution Ratio (Zinc (F))	P80 Stage 2 Duration (Target 268 Days)	Comments
3.5	**~1.5 Mm^3 excavation and 100mm of freeboard**	**165:1**	**271**	**Basis for comparison**
4.1	1m^3/s max release capacity	150:1	271	Adopted
4.2	No releases until start of '20/21 wet season	25:1	272	Not practical
4.3	Turn off Copperfield Dam releases.	150:1	271	Adopted
4.4	No additional disposal options	70:1	274	Not practical
4.5	0.5 ML/d additional disposal (reduced from a baseline of 1.0 ML/d)	105:1	272	Adopted
4.6	• 1m^3/s release capacity • Turn off Copperfield Dam releases.	130:1	268	Moderate impact on dilution ratio
4.7	• 1m^3/s release capacity • Turn off Copperfield Dam releases • 0.5 ML/d additional disposal	80:1	272	Acceptable reduction in dilution ratio. Adopted.

4.0 Revised Construction Phase Assessment

4.1 Assumptions and Objectives

Based on the results of the initial sensitivity assessment (section 3.0), the following assumptions were made for the revised construction phase assessment:

- A maximum discharge capacity of 1.0 m^3/s;
- No releases from the Copperfield Dam ; and
- Additional disposal of 0.5 ML/d (such as bulk earthworks, dust suppression, etc.).

During sensitivity assessment it was noted that as the excess construction volume approached zero as a result of the additional measures employed to enhance the capacity of Wises upper reservoir model, results became increasingly sensitive to assumed effective (i.e. after duty consideration) pump capacity. Consequently, in order to ensure the results were not limited by pumping, the duty assumption was increased from 20 to 22 hours. In addition, the final modelling was also able to utilise a revised storage curve for the constructed Wises upper reservoir inclusive of the excavation of the additional 1.5 Mm^3 of waste rock material.

The key objective was, as previously noted:

- Achieve the stage 2 dewatering duration of 268 days whilst employing a release dilution ratio of 200 to 1 (0.5033% release ratio) which is based on the contaminant of most concern (dissolved zinc)

In order to achieve this, temporary increases to the RL of the Wises upper reservoir were considered. From Table 9 it can be seen that a temporary increase of the spillway RL by 300mm (and an increase in the FSL to 100m below the spillway) was sufficient to meet the key objective of meeting the stage 2 dewatering duration objective of 268 days at a 200 to 1 dilution ratio.

Table 9 Final Construction Phase Scenarios

Scenario	Description	Required Dilution Ratio (Zinc (F))	P80 Stage 2 Duration (Target 268 Days)	Comments
1	0mm increase to spillway RL	105:1	270	467 ML excess
2	+100mm increase to spillway RL	130:1	274	344 ML excess
3	+200mm increase to spillway RL	155:1	273	221 ML excess
4	+300mm increase to spillway RL	200:1	270	97 ML excess Adopted

5.0 Conclusions

A key requirement of the Project construction phase is the need to dewater the existing Eldridge Pit down to RL 305 m AHD in order to facilitate various construction works associated with both the access and tailrace tunnel construction. The revised dewatering programme will take place in two distinct phases – stage 1 which will transfer approximately 7.58 GL (the maximum volume able to be added to Wises Pit at its current capacity) from Eldridge Pit into the Existing Wises Pit. Upon completion of the proposed Wises upper reservoir embankment the remaining volume of water will be transferred from Eldridge Pit to the fully constructed Wises upper reservoir (stage 2). Based on the current water inventory in both pits, the stage 2 transfer could result in a final water level in the Wises upper reservoir of approximately 552.60 m AHD – approximately 1.1 m above the planned spillway elevation and 1.6m above the FSL. This results in an estimated construction phase water excess of 1.85 GL or 2.56 GL depending if spillway or FSL elevation was adopted as the maximum water level in the Wises upper reservoir.

Subsequent to the previous assessment (Appendix A), Genex has been able to employ additional design and water management measures to significantly reduce the volume of the excess construction water volume:

- Excavation of up to 1.5 Mm^3 of waste rock material from the existing wises pit to provide an additional 1.5 GL of additional storage in the constructed Wises upper reservoir; and
- The temporary storage of water in the Wises upper reservoir above the operational phase FSL and spillway elevation.

These combined measures have significantly reduced the excess construction water volume allowing for releases made during the construction phase to be at the same dilution ratio (200 to 1) and same maximum rate (1.0 m^3/s) as proposed for the operational phase. In addition, reliance on releases from the Copperfield Dam to augment release opportunity has been discarded and the rate of water disposed of via additional measures such as dust suppression and bulk earthworks has been reduced to 0.5 ML/d.

The proposed temporary release conditions and assumptions during the construction phase are summarised below in Table 10.

Table 10 Proposed Temporary Construction Phase Release Conditions

Aspect	Proposed Condition	Comment
Copperfield River release trigger	400 ML/d	As per operational phase. Releases may be made at any time during the construction phase as long as the receiving flow is in excess of the trigger.
Dilution ratio	200:1	As per operational phase
Release ratio	0.503%	As per operational phase
Release capacity	1 m^3/s	As per operational phase
Temporary spillway RL	551.8 m AHD	For construction phase only
Temporary FSL RL	551.7 m AHD	For construction phase only

6.0 References

Entura. (2016). *Kidston Pumped Storage Project Bankable Feasibility Study - Hydrological Report.*

McConnell Dowel - John Holland JV. (2018). *Kidston Pumped Storage Project ECI Design Water Management.*

Appendix A

Previous Preliminary Construction Phase Assessment

Memorandum

To		Page	1
CC			
Subject	Preliminary Construction Assessment		
From			
File/Ref No.		Date	25-Oct-2018

1.0 Introduction

This appendix presents the results of a number of modelling scenarios and sensitivities completed in order to define the rate of release required by the Kidston Pumped Storage Project (the Project) during the construction phase. During this period a rate of water release higher than during the operational phase is required. This appendix is

2.0 Construction Phase Scheduling and Assumptions

2.1 Introduction

The dewatering of Eldridge Pit must be completed in order to facilitate access for the completion of the tailrace tunnel outlet and pit wall stabilisation works. At the approximate time of writing, current water levels in both Wises and Eldridge Pits indicate that the volume of water required to be pumped from Eldridge Pit exceeds both the current (undeveloped) and constructed capacity of Wises Pit ('excess construction water'). In order for the tailrace outlet works to commence in accordance with planned construction scheduling the Project water balance must achieve an overall net loss equivalent to the estimated excess construction water. However, the net loss is the balance of a number of inflows (rainfall, runoff, seepage interception system (SIS) and groundwater inflows and topup water from the Copperfield Dam) and outflows (controlled releases, evaporation).

The proposed operational phase controlled release assumptions provide sufficient release potential for the operational phase of the Project but, when applied to the construction phase do not allow for the release of the volume of water required to meet proposed construction scheduling. In order to determine suitable temporary release conditions for the construction period the following were completed:

- Detailed review of the proposed construction and pit dewatering staging schedule in order to confirm and define:
    - Dewatering volumes and rates;
    - Critical dates;
    - Key schedule-based objectives; and
    - Model objective functions – i.e. key metrics with which to compare the relative efficacy of each model scenario.
- Review and develop model assumptions for the transition of Wises Pit from its existing condition as an open cut mine pit with an external (runoff) catchment to its constructed condition with an extensive water surface area and no external catchment.
- Complete a number of model simulations to test the sensitivity of key assumptions (dilution ratio, discharge capacity, catchment area and runoff coefficient for Wises Pit and additional water disposal) against adopted model objective functions.

2.2 Modelled Construction and Dewatering Schedule

Modelling of the construction phase has considered four key stages associated with the dewatering of Eldridge Pit and construction of the power hall access tunnel, tailrace outlet works and the Wises upper reservoir embankment. Table 1 summarises the key construction stages, dates and durations.

Table 1 Key Construction Phase Stages

Stage	Description	Stage Schedule Details		
		Scheduled Stage Start	Scheduled Stage End	Scheduled Stage Duration (days)
1	Initial dewatering of Eldridge Pit for safe access to allow main access tunnel construction	11/01/2019		
2	Continue dewatering of Eldridge Pit up to the maximum allowable fill (RL 525m AHD) in the existing Wises Pit without impacting ongoing embankment works.		4/03/2019 (stage 1 and 2)	52 (stage 1 and 2)
3	Final dewatering of Eldridge Pit to the completed Wises upper reservoir. Eldridge lowered to RL suitable for the safe construction of tailrace outlet works.	8/01/2020	14/07/2020	188
4	Refill of Eldridge Pit to MOL RL (328.4 m AHD)	11/10/2021	21/10/2021	1,004 (total from start of stage 1 to end of stage 4)

It should be noted that this timetable is illustrated only and based on construction commencing in January 2019 which is decided upon a number of factors, and may be subject to change.

The key model objective function adopted was the scheduled duration of stage 3 as:

- On-time achievement of stage 3 completion is critical to the commencement of key construction activities associated with the tailrace tunnel outlet works.
- On-time completion of stage 3 is notably dependant on the availability of the constructed Wises upper reservoir to receive the remaining volume from Eldridge Pit.
- Current water levels in both Wises and Eldridge Pits imply insufficient capacity in the fully constructed Wises upper reservoir to receive all of the estimated stage 3 dewatering volume.
- On-time completion of stage 1 dewatering is not anticipated to be limited by the ability of the current Wises Pit to receive the estimated stage 1 dewatering volume (required to complete access tunnel works).
- Completion of stage 2 dewatering is not required for construction accessibility in Eldridge Pit – the stage 2 volume is effectively the balance of the current undeveloped Wises Pit less its current volume and volume pumped from Eldridge during stage 1.

2.2.1 Adopted Model Performance Target (Objective Function)

Reliability up to the 80th percentile (P80) was adopted as the target for achieving the modelled stage 3 dewatering duration of 188 days.

2.3 Estimated Dewatering Volumes, Excess Water and Adopted Pump Rates

Table 2 details the dewatering volumes associated with stages 1 to 3. Note that Stage 4 is simply the refilling of Eldridge Pit to MOL and is not considered to be of material interest to the assessment. From the table it can be seen that the end water RL for the constructed Wises upper reservoir upon completion of stage 3 is estimated to be 552.6 m AHD. This should be contrasted with the proposed spillway elevation of RL 551.5 m AHD and the proposed FSL of 551 m AHD. This effectively results in an excess construction volume of:

- Approximately 1.85 GL if Wises upper reservoir is filled to the spillway elevation (551.5 m AHD) at the end of stage 3; or
- Approximately 2.56 GL if Wises upper reservoir is filled to the FSL elevation (551 m AHD) at the end of stage 3.

Genex is currently investigating measures to temporarily increase the storage capacity of the Wises upper reservoir during the dry season during construction however this has not yet been confirmed. Consequently, for the purpose of modelling the construction phase it has been assumed that the completion of stage 3 must be achieved without the Wises constructed reservoir exceeding the FSL of 551 m AHD as:

- Access to the Eldridge Pit tailrace construction works is required to be maintained from the scheduled end of stage 3 (14/07/2020) to the start of stage 4 (11/10/2021) (), a period which includes the 2020/2021 wet season when any temporary increase to the capacity of the Wises upper reservoir would likely have to be removed.
- Continued storage of water in Wises upper reservoir at the spillway elevation or the FSL (551.5 m AHD) would result in a significant increase in the likelihood of uncontrolled discharges particularly during the 2020/2021 wet season.

Table 2 Construction Dewatering Volumes

Stage	Eldridge Pit				Pump Volume	Existing Wises Pit/Upper Reservoir			
	Start RL	Start Vol.	End RL	End Vol.	GL	Start RL	Start Vol.	End RL	End Vol.
	m	GL	m	GL		m	GL	m	GL
1	484.49	29.092	465	23.414	5.678	493.96	0.80	518.50	6.48
2	465	23.414	458	21.509	1.905	518.50	6.48	524.80	8.38
3	458	21.509	305	1.062	20.447	524.80	8.38	552.60[1]	28.83[2]
4	Refill Eldridge to MOL RL (328.4 m AHD)								

Based on the key construction stages in Table 1 and the estimated dewatering volumes in Table 2 the following preliminary pump rates have been adopted for the construction phase modelling:

- Stage 1 and 2 – 2,040 L/s (176 ML/d); and
- Stage 3 – 1,507 L/s (130 ML/d).

2.4 Construction of Wises Upper Reservoir Embankment

The transition of the existing Wises open cut pit into the Wises upper reservoir will result in significant changes to its water balance throughout the duration of the construction phase. While detailed construction scheduling has not yet been completed, a number of high level assumptions have been adopted to reflect the proposed construction of the upper reservoir and its impact on the water balance. Referring to Figure 1:

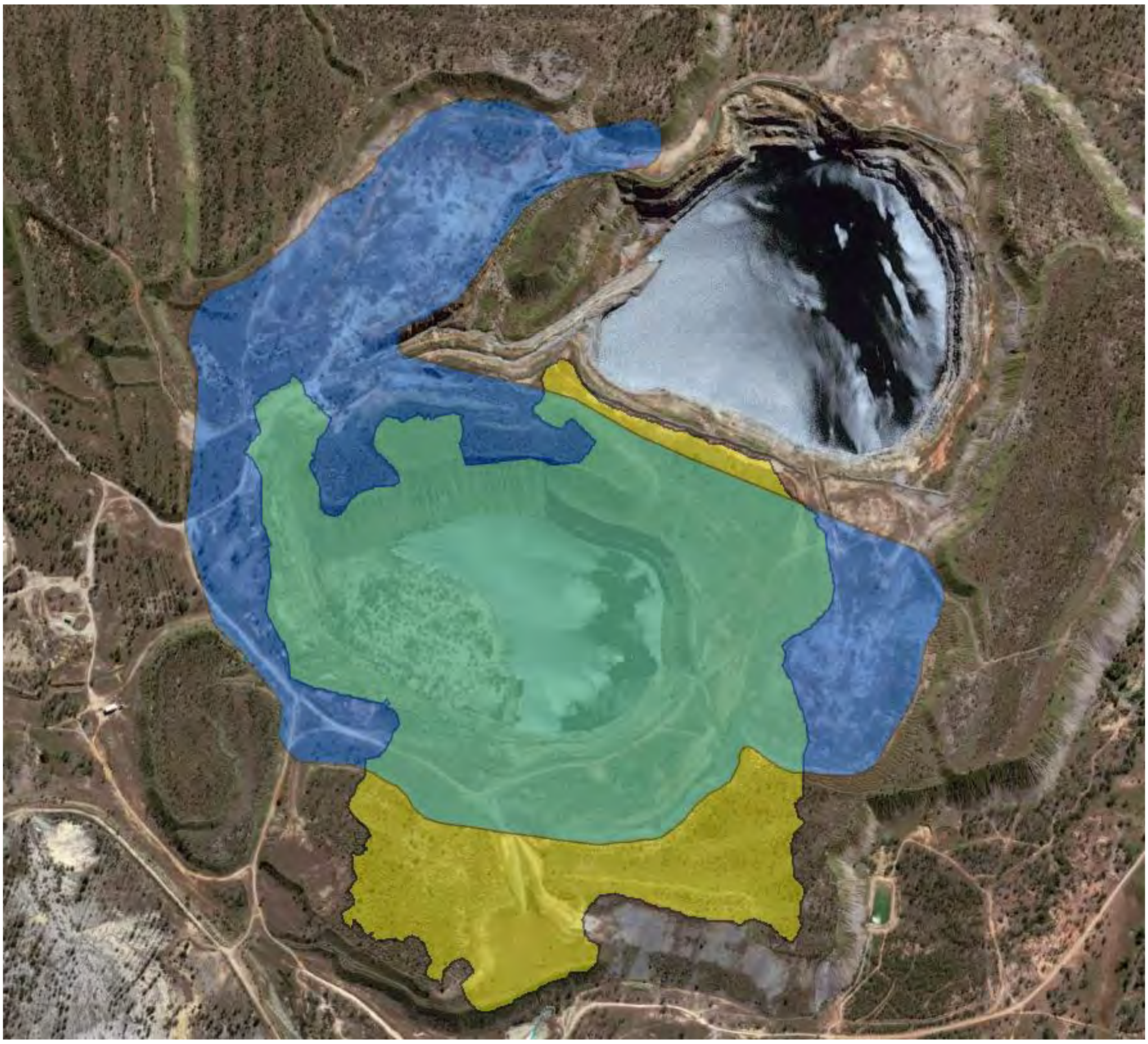
- The existing Wises Pit has an external catchment of approximately 105 Ha
- The Wises upper reservoir will have an internally-draining catchment of approximately 125 Ha and no external catchment; and
- Approximately 75 ha of the existing Wises Pit external catchment lies within the proposed Wises upper reservoir, an internally-draining catchment.

[1] Indicates resultant water level is in excess of the FSL (551 m AHD) and spillway (551.5 m AHD) elevations.
[2] Indicates that the resultant water volume is in excess of the Wises upper reservoir storage capacity of 26.74 GL (at FSL) and 27.36 GL (at spillway elevation.)

Adopted catchment area assumptions for Wises Pit during the construction phase model simulation are summarised in Table 3. A runoff coefficient of 0.33 was adopted for the Wises Pit external catchment. This is consistent with that used for Eldridge Pit (McConnell Dowell – John Holland JV, 2018) and (Entura, 2016) but does not represent a calibrated value. Sensitivity to the runoff coefficient as well as assumed catchment areas are discussed in Section 4.2.

Table 3 Adopted Wises Pit Catchment Area Assumptions for Construction Simulation

Date	Description	Wises Catchment		Comment
		Runoff	Internal (Direct Rainfall)	
11/01/2019	Start of model construction simulation and stage 1 dewatering	75 Ha less the water surface area (calculated daily during model simulation)	Based on water surface area (calculated daily during model simulation)	Assumes existing external areas outside embankment diverted as early works. This assumption has been sensitivity tested (refer to 4.2)
1/07/2019	Existing drainage paths away from pit blocked by embankment earthworks	125 ha less the water surface area (calculated daily during model simulation)	Based on water surface area (calculated daily during model simulation)	6 months into critical construction period.
08/01/2020	Start of stage 3 dewatering	0 Ha	125 Ha	Conservative assumption that assumes immediate inundation of runoff catchment upon commencement of stage 3 dewatering.
11/10/2021	Commence refill of Eldridge	0 Ha	125 Ha	End of critical construction period/model simulation



Catchment	Area (Ha)	Ref.	Comment
Existing Wises Pit catchment (yellow and green areas)	105 (total – yellow and green areas) 30 (outside Wises upper reservoir footprint – yellow area)		Early works are assumed to divert any of the existing Wises Pit catchment that falls outside of the proposed Wises upper reservoir footprint (yellow area only) in order to reduce the volume of external runoff entering Wises Pit during construction. The resultant area of 75 ha (green area) assumed to be the un-divertible remaining external catchment at start of construction phase. This assumption has been sensitivity tested (refer to Section 4.2).
Wises upper reservoir footprint	125		Internally draining catchment for constructed Wises upper reservoir.
Area of overlap	75		Assumed remaining external catchment reporting to Wises Pit during initial construction period i.e. prior to stage 3 dewatering.

Figure 1 Assumed Wises Pit Catchments during Construction Phase

3.0 Construction Phase Modelling

3.1 Construction Scenarios Assessed

A number of scenarios and sensitivities were assessed for the construction simulation as summarised in Table 4 below:

- Scenario 3.1 was the adopted operational phase dilution ratio which was adopted as the base case with which to compare.
- Scenarios 3.2 to 3.6 assessed a range of lower dilution ratios with the assumed operational release capacity of 1 m^3/s (86.4 ML/d).
- Scenarios 3.7 to 3.11 considered an increased release capacity of 1.5 m^3/s (129.6 ML/d).
- Scenario 3.12 adopted the base case dilution ratio for sensitivity assessment of key Wises Pit assumptions.
- Scenarios 3.13 to 3.16 assumed a large runoff catchment (no early catchment diversion works) and assessed the sensitivity of the Wises pit runoff coefficient.
- Scenarios 3.17 to 3.19 assessed the sensitivity of the Wises pit runoff coefficient only; and
- Scenarios 3.20 to 3.25 assessed the potential impact of releases from the Copperfield Dam as a method to augment flow in the Copperfield River (and increase the release potential) as well as the impact of additional water disposal (e.g. dust suppression, construction, etc.).

3.1.1 Simulation Parameters

Each scenario was run as a boot-strapped Monte Carlo simulation consisting of 127 realisations. The simulation duration used was as follows:

- Start – 1/01/2019
- End – 11/10/2021 (start of stage 4 and refill of Eldridge Pit).

The adopted key objective function was to achieve the scheduled stage 3 dewatering duration of 188 days up to the 80^{th} percentile (P80) result.

Table 4 Scenario 3 (Construction Phase) Sensitivities Assessed

Scenario 3 Sensitivity	Description	Wises Initial Catchment Area (Ha)	Wises Runoff Coeff.	Total Mn Dilution Ratio (1:xx)	Release Ratio (%)	Release Capacity (m3/s)	Additional Disposal (ML/d)	Copperfield Dam Release	Comment
3.1	Dilution Base case	75	0.33	200	0.513	1	N/A	N/A	Operational release conditions for comparison
3.2	Dilution sensitivities	75	0.33	100	1.038	1	N/A	N/A	Dilution Sensitivity
3.3		75	0.33	50	2.160	1	N/A	N/A	Dilution Sensitivity
3.4		75	0.33	35	3.195	1	N/A	N/A	Dilution Sensitivity
3.5		75	0.33	15	8.525	1	N/A	N/A	Dilution Sensitivity
3.6		75	0.33	10	15.880	1	N/A	N/A	Dilution Sensitivity
3.7		75	0.33	100	1.038	1.5	N/A	N/A	Release Cap. Sensitivity
3.8		75	0.33	50	2.160	1.5	N/A	N/A	Release Cap. Sensitivity
3.9		75	0.33	35	3.195	1.5	N/A	N/A	Release Cap. Sensitivity
3.10		75	0.33	15	8.525	1.5	N/A	N/A	Release Cap. Sensitivity
3.11		75	0.33	10	15.880	1.5	N/A	N/A	Release Cap. Sensitivity
3.12	Adopted dilution base case	75	0.33	25	4.696	1.5	N/A	N/A	Adopted base case to asses sensitivity of key Wises assumptions
3.13	Wises assumptions sensitivities	105	0.33	25	4.696	1.5	N/A	N/A	No early diversion works
3.14		105	0.2	25	4.696	1.5	N/A	N/A	No early diversion works/low runoff coeff
3.15		105	0.4	25	4.696	1.5	N/A	N/A	No early diversion works/higher runoff coeff
3.16		105	0.5	25	4.696	1.5	N/A	N/A	No early diversion works/higher runoff coeff
3.17		75	0.2	25	4.696	1.5	N/A	N/A	Low runoff coeff.
3.18		75	0.4	25	4.696	1.5	N/A	N/A	Higher runoff coeff.
3.19		75	0.5	25	4.696	1.5	N/A	N/A	Higher runoff coeff.
3.20	Additional disposal option/ Copperfield Dam release	75	0.33	100	1.038	1.5	1.0	4,654 ML @ 500ML/d	1.0 ML/d additional disposal capacity
3.21		75	0.33	50	2.160	1.5	1.0	4,654 ML @ 500ML/d	1.0 ML/d additional disposal capacity
3.22		75	0.33	35	3.195	1.5	1.0	4,654 ML @ 500ML/d	1.0 ML/d additional disposal capacity
3.23		75	0.33	25	4.696	1.5	1.0	4,654 ML @ 500ML/d	1.0 ML/d additional disposal capacity
3.24		75	0.33	15	8.525	1.5	1.0	4,654 ML @ 500ML/d	1.0 ML/d additional disposal capacity
3.25		75	0.33	10	15.880	1.5	1.0	4,654 ML @ 500ML/d	1.0 ML/d additional disposal capacity

4.0 Construction Period Modelling Results

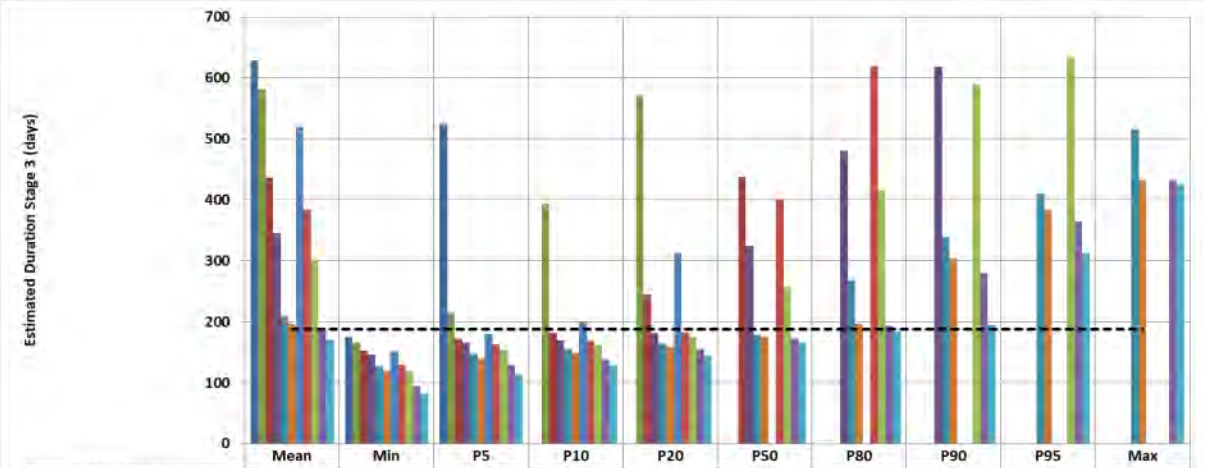
4.1 Dilution Ratio Assessment (Scenarios 3.1 to 3.11)

Figure 2 shows the estimated stage 3 dewatering duration for scenarios 3.1 to 3.11. Where no duration is recorded the scenario was unable to dewater the required volume from Eldridge Pit. These scenarios considered potential total manganese dilution ratios ranging from the operational phase 200:1 down to 10 to 1 (i.e. release ratios from 0.513% to 15.880%). A higher discharge capacity of 1.5 m^3/s was also assessed (scenarios 3.7 to 3.11). In summary:

- Only scenarios 3.6, 3.10 and 3.11 were able to approach or exceed the target duration of 188 days for the P80 result. These results however are achieved with the dilution ratios of 10 and 15 to 1 (release ratios of 8.525% and 15.880%) which were not considered too low as:
  - Dilution ratios of 10 to 1 and 15 to 1 both result in a mass balanced (including hardness modification where relevant) receiving environment concentration that could potentially temporally exceed 10 different WQOs during the proposed construction phase water release.
  - This is reduced to 6 contaminants at a dilution ratio of 35 to 1 (release ratio of 3.195%).
  - Dilution ratios of 10 to 1 and 15 to 1 which have release ratios of 8.525% and 15.880% respectively, would result in a significant increase of release volume to flush volume ratio. This could potentially increase the risk of stranding potential releases in downstream pools and waterholes.
- A notable reduction in overall duration is achieved thought the use of the higher discharge capacity (scenarios 3.2 to 3.6 compared to scenarios 3.7 to 3.11). For example, when comparing the P50 result for scenarios 3.4 and 3.9, the increased release capacity reduces the estimated stage 3 duration from 324 to 258 days respectively.
- The operational phase dilution ratio of 200:1 (scenario 3.1, release ratio of 0.513%) is unable to complete the stage 3 dewatering objective at all probabilities from P10 upwards and only the minimum result meets the 188 day objective.

Based on the initial assessment of dilution ratios and release capacity the optimum temporary release conditions for the construction phase:

- Requires a release capacity of 1.5 m3/s; and
- A total manganese dilution ratio lower than 35 to1 (release ratio of 3.195%) but greater than 15 to 1 (release ratio of 8.525%).
- Consequently, a total manganese dilution ratio of 25:1 (release ratio of 4.696%) was adopted for the purpose of additional sensitivity testing as:
  - The 25:1 dilution ratio provides the optimum combination of reduction to the estimated duration of stage 3 dewatering with the least number of additional WQO exceedances when comparing (a dilution ratio of 35 to 1) with the lower dilution ratios assessed of 15 to 1 and 10 to 1.
  - The 25:1 dilution ratio is higher than that required for 95% species protection for aquatic ecosystems as identified through both DTA assessments.
  - Compared to the lower dilution ratios of 15 to 1 and 10 to 1 examined above, a dilution ratio of 25:1 will reduce the likelihood of potential construction phase releases stranding in downstream pools and waterholes.



	Mean	Min	P5	P10	P20	P50	P80	P90	P95	Max
3.1 (200:1@1cumec)	628	175	524	-	-	-	-	-	-	-
3.2 (100:1@1cumec)	582	165	215	393	572	-	-	-	-	-
3.3 (50:1@1cumec)	436	152	172	181	245	438	-	-	-	-
3.4 (35:1@1cumec)	345	146	166	170	181	324	480	618	-	-
3.5 (15:1@1cumec)	210	127	147	155	164	179	268	339	410	516
3.6 (10:1@1cumec)	197	119	140	149	159	176	197	304	384	432
3.7 (100:1@1.5cumec)	519	151	180	201	312	-	-	-	-	-
3.8 (50:1@1.5cumec)	384	129	163	168	183	400	620	-	-	-
3.9 (35:1@1.5cumec)	302	119	154	162	175	258	415	589	634	-
3.10 (15:1@1.5cumec)	188	94	129	138	155	172	193	280	364	432
3.11 (10:1@1.5cumec)	171	82	114	128	144	166	184	195	313	426
Target (188 Days)	188	188	188	188	188	188	188	188	188	188

Figure 2 Estimated Stage 3 Dewatering Duration (Scenarios 3.1 to 3.11)

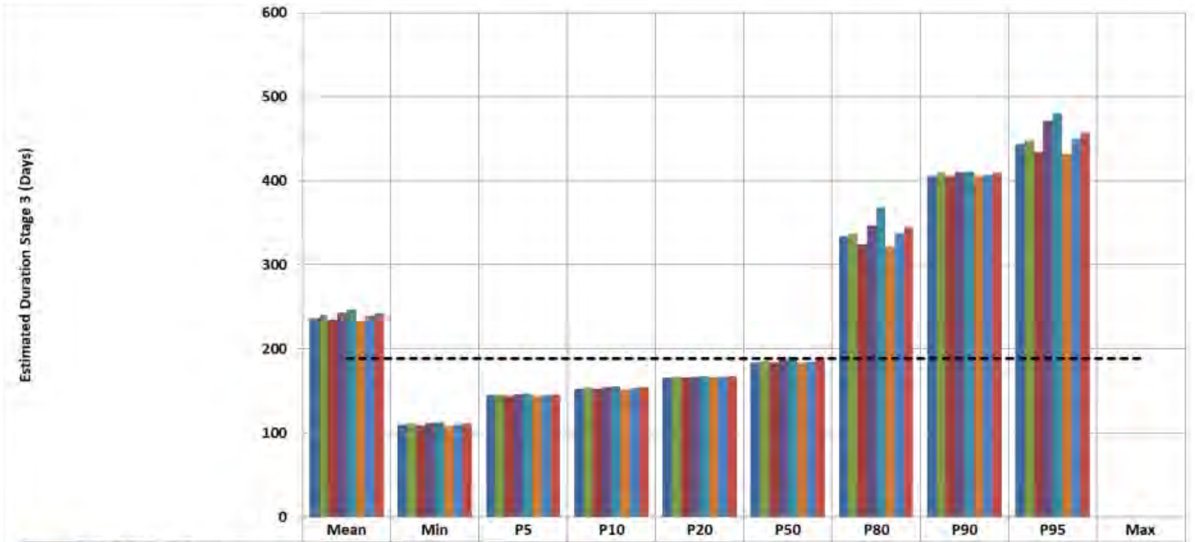
4.2 Wises Pit Assumptions Sensitivity Assessment (Scenarios 3.12 to 3.19)

Figure 3 shows the estimated stage 3 dewatering duration for scenarios 3.12 to 3.19.

- Generally the estimated stage 3 dewatering duration is relatively insensitive to the area of the runoff catchment or runoff coefficient as:
  - Wises Pit only has a runoff catchment for the first year of the simulation (after the start of stage 3 it is conservatively assumed to be 100% direct rainfall catchment.
  - The water surface area of Wises Pit at RL 525 m AHD (after completion of stage 2) is approximately 31 Ha. This is subtracted from the Wises Pit runoff catchment which leaves:
    - Approximately 44Ha of runoff catchment for the first 6 months or 69 Ha if the early works catchment diversion works are not achieved.
    - Approximately 93Ha for runoff for the next 6 months (most of which is during the dry season when rainfall and runoff are very low).

As a result of the sensitivity assessment a runoff coefficient of 0.33 was adopted for Wises Pit and it was additionally assumed the early works would achieve a partial diversion of some of the Wises Pit runoff catchment. However, as the results indicate, there is only a relatively small impact on the estimated duration of stage 3 dewatering as a result of changes to these assumptions.

AECOM Imagine it. Delivered.



	Mean	Min	P5	P10	P20	P50	P80	P90	P95	Max
3.12 (25:1 BaseCase)	237	110	145	153	166	184	334	406	443	-
3.13 (25:1/Wises@105Ha/0.33)	240	111	146	154	167	186	337	409	448	-
3.14 (25:1/Wises@105Ha/0.2)	235	109	144	153	166	184	324	406	434	-
3.15 (25:1/Wises@105Ha/0.4)	243	112	146	154	167	187	347	410	472	-
3.16 (25:1/Wises@105Ha/0.5)	247	113	147	155	168	190	369	411	480	-
3.17 (25:1/Wises@75Ha/0.2)	233	108	144	152	166	184	322	406	432	-
3.18 (25:1/Wises@75Ha/0.4)	239	110	145	153	167	185	338	407	450	-
3.19 (25:1/Wises@75Ha/0.5)	242	111	146	154	168	187	345	409	458	-
Target (188 Days)	188	188	188	188	188	188	188	188	188	188

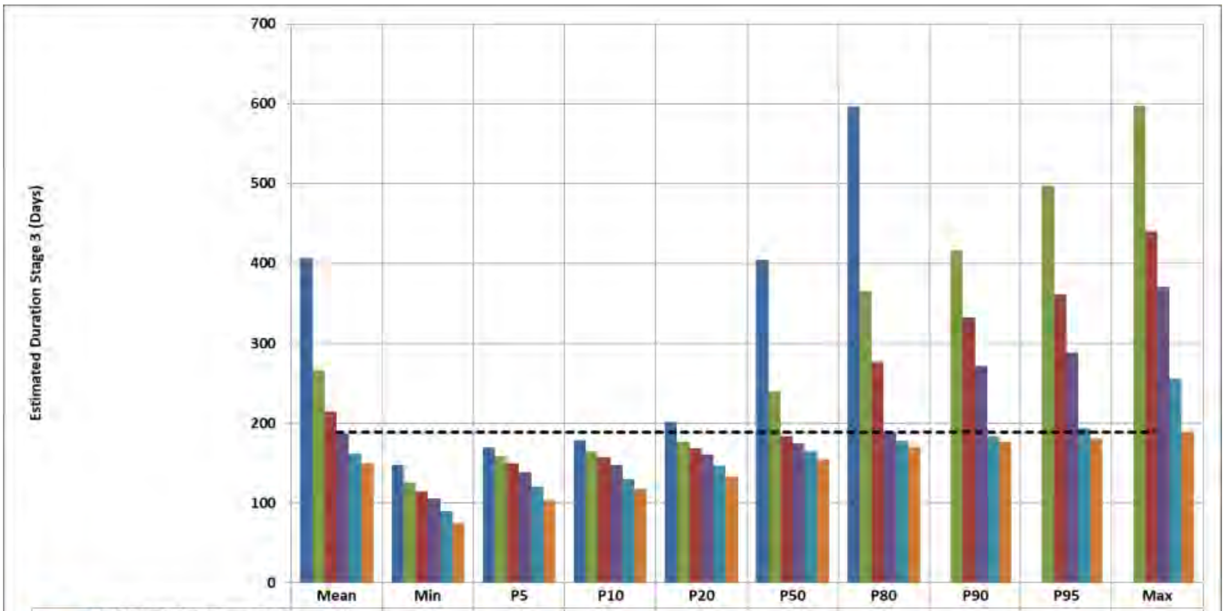
Figure 3 Estimated Stage 3 Dewatering Duration (Scenarios 3.12 to 3.19)

4.3 Additional Disposal Options and use of the Copperfield Dam (Scenarios 3.20 to 3.25)

While it can be seen from Figure 3 (scenario 3.12) that the adopted dilution ratio of 25:1 (release ratio of 4.696%) is able to meet the target stage 3 dewatering duration of 188 days this is only at the for the P50 result. In order to increase the likelihood of the estimated dewatering duration being met two additional strategies were also considered:

- Use of Genex's existing allocation (4,650 ML) from the Copperfield Dam:
  - The release of the water allocation was used to generate additional streamflow at the proposed release point in order to increase the potential release opportunity.
  - Releases were assumed to commence on 1st January each year and were modelled at 500 ML/d until exhaustion of the 4,.650 ML annual allocation.
- The impact of additional water disposal during the construction phase:
  - A combined 1 ML/d of water disposal was assumed.
  - The exact nature of water disposal options has yet to be determined however preliminary options include the use of pit water during construction for dust suppression and earthworks.

Figure 4 below shows the estimated stage 3 dewatering duration for scenarios 3.20 to 3.25. From the figure it can be seen that the adopted dilution ratio of 25:1 (release ratio of 4.696%, scenario 3.23) meets the stage 3 dewatering duration objective of 188 days. It is however reiterated that this assumes the use of Genex's water allocation from the Copperfield Dam as well as an additional disposal capacity of 1 ML/d (e.g. construction demand, dust suppression, etc.).



	Mean	Min	P5	P10	P20	P50	P80	P90	P95	Max
20 (100:1+1ML/d+Dam Rel.)	406	147	169	178	201	404	596	-	-	-
21 (50:1+1ML/d+Dam Rel.)	266	125	158	164	176	239	365	416	497	597
22 (35:1+1ML/d+Dam Rel.)	214	114	149	157	168	183	276	332	361	440
23 (25:1+1ML/d+Dam Rel.)	186	105	138	147	160	174	188	271	288	370
24 (15:1+1ML/d+Dam Rel.)	161	89	120	129	146	164	177	183	193	255
25 (10:1+1ML/d+Dam Rel.)	149	74	103	117	132	154	170	176	180	189
Target (188 Days)	188	188	188	188	188	188	188	188	188	188

Figure 4 Estimated Stage 3 Dewatering Duration (Scenarios 3.20 to 3.25)

5.0 Conclusions

A key requirement of the Project construction phase is the need to dewater the existing Eldridge Pit down to RL 305 m AHD in order to facilitate various construction works associated with both the access and tailrace tunnel construction. Dewatering will take place in two distinct phases – stages 1 and 2 which will transfer approximately 7.58 GL (the maximum volume able to be added to Wises Pit at its current capacity) from Eldridge Pit into the Existing Wises Pit. Upon completion of the proposed Wises upper reservoir embankment the remaining volume of water will be transferred from Eldridge Pit to the fully constructed Wises upper reservoir (stage 3). Based on the current water inventory in both pits, the stage 3 transfer would result in a final water level in the Wises upper reservoir of approximately 552.60 m AHD – approximately 1.1 m above the planned spillway elevation and 1.6m above the FSL. This results in an estimated construction phase water excess of 1.85 GL or 2.56 GL depending if spillway or FSL elevation was adopted as the maximum water level in the Wises upper reservoir.

In order to reduce the likelihood of uncontrolled discharges during the construction phase a conservative target of limiting water storage in the Wises upper reservoir to FSL was adopted and therefore results in an estimated construction phase excess water volume of up to 2.56 GL. Genex is currently investigating the possible temporary increase of the Wises upper reservoir FSL which would reduce this volume however for the purpose of this assessment it has been conservatively assumed that the current FSL of 551m AHD is the maximum permissible pumped water level during the construction phase.

Based on the proposed construction schedule, the 188 day duration of stage 3 dewatering of Eldridge Pit was adopted (at the P80 result) as the key assessment performance target (Section 3.1.1) with which to compare the efficacy of 25 different scenario sensitivities. As a result of completing a total of ten different dilution sensitivities (scenarios 3.2 to 3.11) it was determined that a total dilution ratio of 25:1 (release ratio of 4.696%) was the best compromise between the lower ratios (15 and 10 to 1) (release ratios of 8.525% and 15.880%) that were able to achieve the target stage 3 duration and limiting releases to a more acceptable mass loading. It was also found that a temporary increase in the release capacity to 1.5 m^3/s (129.6 ML/d) during the construction phase would also be required.

Key catchment area assumptions (runoff catchment area and coefficient) adopted for Wises Pit during the construction phase were tested for their overall sensitivity to the key objective function (stage 3 duration). The results indicated that these assumptions did not significantly impact the results due to the relatively small areas involved and the short duration during which the runoff catchment was active during the construction simulation (refer to Section 4.2).

In order to ensure that the estimated stage 3 dewatering duration of 188 days was met at not just the P50 (median) result bit also the target P80 result, two additional measures were adopted. The release of Genex's existing 4,650 ML allocation from the Copperfield Dam (to augment flows in the Copperfield River and increase release potential) as well as an additional water disposal of up to 1 ML/d. This would likely come from various consumptive water demands during the construction phase such as dust suppression and bulk earthworks.

Proposed temporary releases during the construction phase are summarised below in Table 5.

Table 5 Proposed Temporary Construction Phase Release Conditions

Aspect	Proposed Temporary Condition
Copperfield River release trigger	400 ML/d (as per operational phase)
Total dilution ratio	25:1
Release ratio	4.7%
Release capacity	1.5 m^3/s (129.6 ML/d)

Appendix L

Modelling Information

AECOM Imagine it. Delivered.

AECOM Australia Pty Ltd
Level 5, 7 Tomlins Street
South Townsville Qld 4810
PO Box 5423
Townsville QLD 4810
Australia
www.aecom.com

+61 7 4729 5500 tel

ABN 20 093 846 925

Memorandum

To		Page	1
CC			
Subject	Modelling Information		
From			
File/Ref No.		Date	25-Oct-2018

1.0 Introduction

This appendix provides additional supporting documentation relating to the development and parameterisation of the water balance model used for the Kidston Pumped Storage Hydro (the Project) Impact Assessment Report (IAR). An additional technical note regarding the derivation and use of dilution ratios and release ratios is also included.

2.0 Water Balance Model

2.1 Purpose

A dynamic water balance model (WBM) has been developed for the Project using Goldsim probabilistic modelling software. GoldSim is a Monte Carlo simulation software package that is commonly used in the mining, power and water resource industries for water balance modelling. The WBM was developed to provide the basis for a number of different assessments related to the Project IAR.

2.2 Initial Project Water Balance Model Development

The Project water balance model was initially developed for the operational phase of the Project (Norconsult, 2018) in order to develop an understanding of the Project water deficit and excess. The spread sheet-based model was developed to run on a daily timestep and was used to estimate the Project water balance using a 128 year deterministic simulation applying climate data obtained from the SILO Data Drill service (DES). In order to provide a suitable basis for assessment of the proposed operational and construction phase release conditions it was considered necessary to utilise a more suitable software platform – GoldSim. Goldsim is a Monte Carlo simulation software package that is commonly used in the mining and water resource industries for water balance modelling.

2.3 GoldSim Project Water Balance Model Key Assumptions and Input Data

All key assumptions and input data from the water balance developed by (Norconsult, 2018) were retained in development of the GoldSim model and are shown in Table 1.

Table 1 Key Water Balance Input Data and Assumptions

Aspect	Assumption or Input Data	Source	Comment
Climate data (rainfall and evaporation)	SILO data drill	Queensland Government (DES)	-18.8500 144.1500
Pan evaporation factor	0.9	(Norconsult, 2018)	Sensitivity tested by (Norconsult, 2018).

Aspect	Assumption or Input Data	Source	Comment
Storage curve data	Volume to area Volume to RL	12D analysis of site LiDAR and pit contour data as provided by the MCD-JH JV	
Eldridge Pit - runoff catchment	1,714,390 m^2	(Norconsult, 2018)	
Eldridge Pit – runoff coefficient	0.33	(Norconsult, 2018)	Sensitivity tested by (Norconsult, 2018)
Eldridge Pit – direct rainfall catchment	300,000 m^2	(Norconsult, 2018)	
Wises upper reservoir – direct rainfall catchment (constructed)	1,250,000 m^2	(Norconsult, 2018)	
Groundwater inflow	775 m^3/d steady state	(Norconsult, 2018)	Balance of Wises upper reservoir seepage loss and groundwater inflow to Eldridge Pit
Seepage interception system	300,000m^3/476 mm rainfall	(Norconsult, 2018)	Derived relationship from seepage pumping data and applied to rainfall for first 4 months of each year. Sensitivity tested by (Norconsult, 2018)
Copperfield Dam top up rate	200 L/s	Assumption	

2.3.1 Simulation Method

In order to validate the performance of the Project under a range of historical climatic conditions, multiple simulations (known as realisations) may be run (either annually or for the proposed 50 year duration of the Project). The only difference between each realisation is the input climate data (rainfall and evaporation) which consists of 127 years (1890 to 2017) of data from SILO Data Drill.

Taking simulation of the life of Project as an example; running on a daily timestep, the first model realisation simulates the proposed 50 year Project utilising climate data from 1890 to 1940. The second realisation then utilises climate data from the period 1891 to 1941, the third from 1892 to 1942, and so on. This process allows for a total of 127 model realisations (known as a boot-strapped Monte Carlo simulation) to be run from the available climate data allows for development of a greater understanding of the Project risk profile associated with the range of potential climatic extremes inherent in the historical climate record.

2.4 Key Model Objectives

The water balance model (WBM) includes the ability to simulate potential releases of water from the Project under a range of assumed operating and receiving environment conditions. Model functionality was developed in order to address a number of key assessment objectives as detailed in Table 2 below.

Table 2 Key Impact Assessment Objectives of the GoldSim WBM (Mass Balance)

Objective	Key Outputs	Comments
Assess the site water budget (balance of inputs and outputs to identify water excess or deficit	• Excess water • Water deficit (top up water) • Unmitigated (no releases) assessment	
Estimated controlled release volumes and frequency	• Release volumes • Number of release days • Number of release events	Potential changes to the existing hydrological flow regime in the Copperfield River have been assessed using the estimated flow at the proposed release point inclusive of potential releases.
Estimated release loadings	• Estimated loading of contaminant of most concern in estimated releases.	Load released based on the estimated volume and assumed concentration of the water released from the Project.
Understand cumulative impact (downstream catchment inflow dilution)	• Downstream mass balance assessment to assess far-field dilution effects from progressive downstream tributary inflows	Tributary and residual inflows based on IQQM model output
Estimate post-release event flushing	• Post-release receiving flow volume • Post-release receiving flow duration	Estimated receiving flow passing the proposed release point after cessation of any release event.
Estimate changes to Copperfield River streamflow at the proposed release point	• Streamflow inclusive of release water for the Copperfield River at the proposed release point.	Streamflow data inclusive of release water analysed using RAP to assess potential changes to flow regime

2.5 Additional IQQM Model Development

In order to assess the concentration of the contaminant of most concern downstream of the proposed release point during potential releases, a number of additional nodes were added to the IQQM model. Inflow nodes were added to the IQQM model to represent the impact of major tributary (headwater) and residual inflows on the Copperfield River downstream of the potential release point. Flows from the IQQM model for each inflow node were then added to the GoldSim model for estimation of downstream concentrations of the contaminant of most concern during potential releases. Inflow nodes added to the IQQM model and their total and cumulative catchment areas are shown in Table 3.

Table 3 IOQQM Copperfield River Inflow Nodes Downstream of Proposed Release Point

Inflow	Description	Distance Downstream from Proposed Release Point (km)	Catchment Area (km^2)	
			Total	Cumulative
East Creek	Headwater Inflow	3.5	248.5	248.5
Kidston (Gilberton Road)	Residual	6.9	10.7	259.1
Downstream of Kidston	Residual	19.6	30.7	289.8
Charles Creek	Headwater Inflow	19.6	142.1	431.9
Oak River	Headwater Inflow	23.4	525.7	957.7
Upstream of Soda Creek	Residual	30.4	113.5	1,071.1
Soda Creek	Headwater Inflow	30.4	129.4	1,200.5
Upstream of Chinaman Creek	Residual	35.7	51.8	1,252.3
Chinaman Creek	Headwater Inflow	35.7	112.3	1,364.6
Upstream of Einasleigh	Residual	48.3	86.3	1,450.9
Einasleigh River at Einasleigh	Headwater Inflow	48.3	5,183.7	6,634.6

Model Limitations

While every attempt has been made to ensure that the GoldSim WBM is a representative as possible the following limitations are noted:

- Model results are based on historical climate data (SILO Data Drill), assumed operational rules and a variety of input data and assumptions. While the degree of model complexity is commensurate to the current level of assessment it should be noted that results are presented primarily for the purpose of relative assessment and that absolute results are to be considered within the high level of the input data, assumptions and conceptual operating rules.
- A small number of conceptual operational rules (such as when topup water from the Copperfield Dam is added, at what water level controlled release can be made) have been adopted for the purpose of modelling. Ongoing refinement of the Project design and operational planning will further develop these rules and may not be consistent with the rules adopted for this assessment.
- Modelling has not taken into account potential changes to rainfall and evaporation as a result of climate change.
- Downstream tributary and residual inflows are based on IQQM output. All downstream flows are scaled from the same streamflow record which was calibrated to the Einasleigh stream gauge (917106A - Einasleigh River at Einasleigh). No routing of the inflows was conducted and all downstream inflows are therefore coincident.
- Concentrations (end of pipe (EOP) and receiving environment) are assumed to be fixed and therefore not subject to any temporal variation or variation with flow.

- Modelling is conducted at a daily timestep with release flows calculated daily based on receiving flow and assumed fixed for the duration of the timestep (day).
- The mass balance assumes contaminants are conserved i.e. advective transport is assumed as the only contaminant transport mechanism with no dispersion).
- Mixing is assumed to occur instantaneously i.e. per timestep (daily) at the point of release.

Inputs and Assumptions

Key model assumptions relevant to the impact assessment are provided in Table 4. Note that additional model assumptions related to the Project site balance are provided in 2.3. Estimated modelled releases are based on the release conditions shown in Table 4.

Table 4 Key Mass Balance Assumptions Adopted for use in the Water Balance Model (GoldSim)

Aspect	Assumption	Adopted Value	Comments
Release Conditions (Operations)	Release trigger	400 ML/d	10^{th} percentile daily flow at proposed release point
	End of pipe (EOP) concentration for contaminant of most concern (dissolved zinc)	1.5874 mg/L	Resultant concentration for maximum values of dissolved zinc in Wises and Eldridge pits when mixed at the assumed operational phase ratio of 1 to 9
	Proposed release point receiving environment concentration (dissolved zinc)	0.0025 mg/L	Median concentration, W2
	Proposed downstream tributary inflows concentration (dissolved zinc)	0.0025 mg/L	Median concentration, W3/W2
	Proposed release point water quality objective	0.014 mg/L	HMTV
	Assimilative capacity utilisation	69 %	Adopted to meet the administrative objective of a 200:1 dilution ratio
	Target water quality	0.0104 mg/L	Refer to eqn. [2] below
	Potential release ratio	0.503 %	Refer to eqn. [3] below.
	Dilution ratio	200:1	Refer to eqn. [1] below.
	Maximum release capacity	1 m^3/s (86.4 ML/d)	
Release Conditions (Construction)	Release trigger	400 ML/d	10^{th} percentile daily flow at proposed release point
	End of pipe (EOP) concentration for contaminant of most concern (dissolved zinc)	1.5874 mg/L	Resultant concentration for maximum values of dissolved zinc in Wises and Eldridge pits when mixed at the assumed operational phase ratio of 1 to 9
	Proposed release point receiving environment concentration (dissolved zinc)	0.0025 mg/L	Median concentration, W2

Aspect	Assumption	Adopted Value	Comments
	Proposed downstream tributary inflows concentration (dissolved zinc)	0.0025 mg/L	Median concentration, W3/W2
	Proposed release point water quality objective	0.014 mg/L	HMTV
	Target water quality	0.066 mg/L	Refer to eqn. [2] below
	Potential release ratio	4.174 %	Refer to eqn. [3] below.
	Dilution ratio	25:1	Refer to eqn. [1] below.
	Maximum release capacity	1.5 m^3/s (129.6 ML/d)	
Streamflow – release point (Copperfield River) and all tributary inflows and Einasleigh River	Based on IQQM output		
Project site release operations	Wises Pit release trigger (excess water trigger).	RL 550.575m AHD	Actual release dictated by receiving flow release trigger of 400 ML/d in the Copperfield River.
Simulation year	1st November through 31st October		Hydrological year
Simulation type	Deterministic (128 years) for input to RAP and assessment of changes to flow regime. Monte Carlo (boot strapped) for mass balance and assessment of releases and post release flushes		

2.6 Use of Release Ratios and the Difference to Dilution Ratio

Modelled releases of water from the Project during both operational and construction phases have been estimated using release ratios calculated for the contaminant of most concern. It is important to note that dilution ratios and release ratios are not the same; the following provides a detailed discussion of the calculation and difference between dilution and release ratios.

2.6.1 Dilution Ratio

The dilution ratio is the ratio of solute (concentration of a contaminant to be released) to solvent (concentration of the same contaminant in the receiving environment) and is calculated as per equations [1] and [2] below.

[1] Dilution ratio:

$$Dilution\ Ratio, DR = \frac{Conc._{EOP}}{Conc._{Tar.} - Conc._{Rec.}}$$

[2] Target water quality:

$$Conc._{Tar.} = Utilisation * \left(Conc._{WQO} - Conc._{Rec.}\right) + Conc._{Rec.}$$

Where:

- $Conc._{Tar.}$ = Target water quality after utilisation of available assimilative capacity taken into account
- $Conc._{WQO}$ = Water quality objective for contaminant of most concern
- $Conc._{Rec.}$ = Receiving environment concentration for contaminant of most concern
- $Conc._{EOP}$ = End of pipe (discharge) concentration for contaminant of most concern
- Utilisation = Adopted utilisation of available assimilative capacity (%)

As the concentration of the solute (i.e. the EOP concentration) increases, the dilution ratio will therefore increase assuming the target and receiving WQ remain constant – more solvent is required to dilute the solute. This is a linear increase and will approach infinity. Some dilution is always possible, no matter how large the ratio (Figure 1 below).

If the receiving concentration increases (EOP remains constant) the dilution ratio will increase exponentially until the point where the receiving concentration is the same as the WQO and then no dilution can be achieved as the denominator in equation [1] above is zero. Dilution is limited in this example, the WQO (or target water quality) being the limiting factor (Figure 2 below).

2.6.2 Release Ratio

The key advantage of using a release ratio is that is can be used directly to calculate the required rate of release by simply multiplying the receiving flow rate by the release ratio. In addition, two release ratios of the same value will result in identical estimates of release volume for a given flow regime whereas the same is not true for similar dilution ratios as shown in Table 5 below. Both scenarios result in the same dilution ratios (138 to 1 and 25 to 1) however actual rates of release (i.e. the release ratio) are different and would result in differences in the total volume of water released (almost 3% for scenario 2).

The release ratio is proportional to the difference between the target and receiving water quality to the difference between the EOP and target water quality remains constant i.e. the flow and concentration downstream of a potential release is the mass-balanced sum of the two flows and concentration and is calculated as shown in equation [3] below. Potential release rates can then be estimated simply by multiplying the release ratio by the receiving flow.

[3] Potential release ratio:

$$Potential\ Release\ Ratio, RR = \frac{Conc._{Tar.} - Conc._{Rec.}}{Conc._{EOP} - Conc._{Tar.}}$$

Table 5 Potential Difference in Release Ratio for Identical Dilution Ratios

Parameter	Scenario 1a	Scenario 1b	Scenario 2a	Scenario 2b
EOP (mg/L)	1.5874	0.276	0.5	1.5
WQO (mg/L)	0.014	0.014	0.1	0.1
Receiving (mg/L)	0.0025	0.012	0.08	0.04
Dilution ratio	138:1	138:1	25:1	25:1
Release ratio (%)	0.731	0.763	5.000%	4.286%

The release ratio however is not the same as dilution ratio and it is not simply the reciprocal of the dilution ratio. As the EOP concentration increases, the release ratio will therefore reduce assuming the target and receiving WQ remain constant – the rate of release must reduce. This is an exponential decay towards zero i.e. some dilution is always possible, just at an ever reducing rate chart. Release is, in theory always possible (Figure 1 below).

As the concentration of the receiving environment increases, the release ratio decreases in a linear way to the point when the difference between the WQO and receiving concentrations is zero and the release ratio is then zero. In this instance the WQO (or target water quality) is the limiting factor (Figure 2 below).

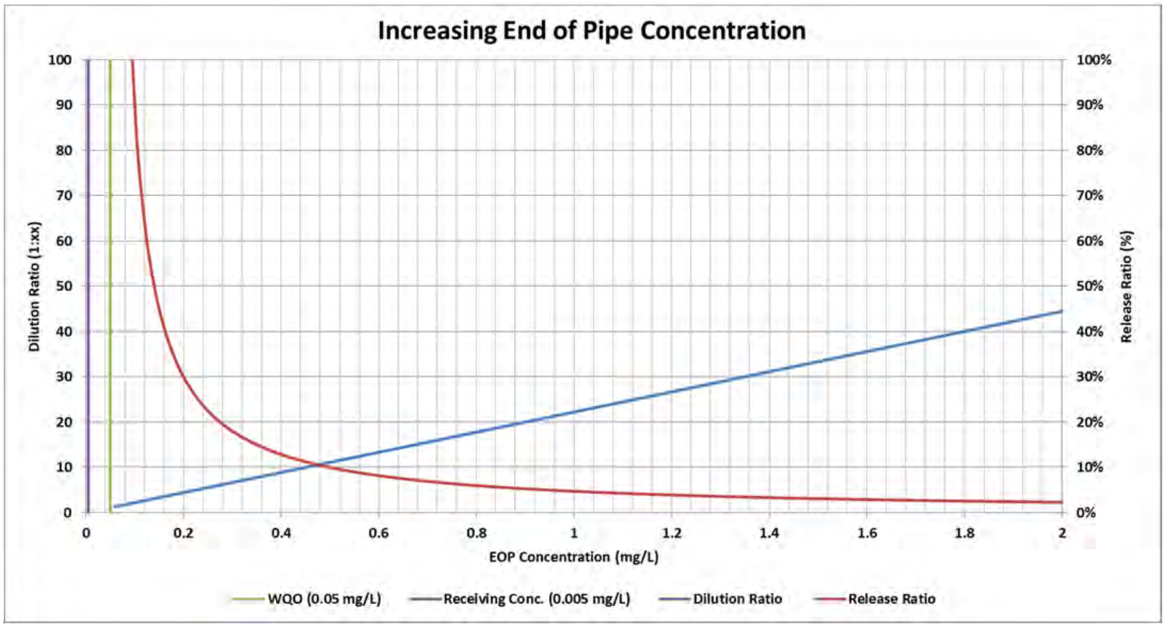


Figure 1 Effect of an Increasing End of Pipe Release Concentration on Release and Dilution Ratios

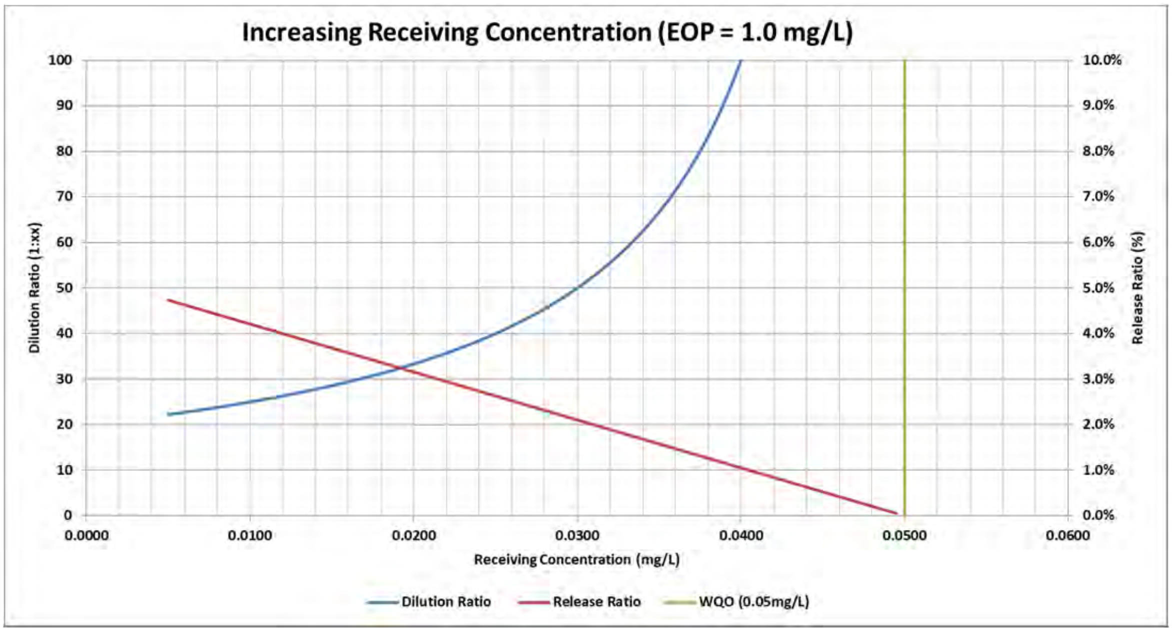


Figure 2 Effect of an Increasing Receiving Environment Concentration on Release and Dilution Ratios

It is recognised that use of ‘dilution ratio’ provides a more familiar term than ‘release ratio’ despite the inconsistency in comparing similar dilution ratios for different contaminants or water quality assumptions (as shown in Table 5 above). Therefore, to ensure the correct rate of release is estimated the release ratio may be calculated using the dilution ratio as shown in equation [4] below].

[4] Release ratio as a function of a given dilution ratio:

$$Potential\ Release\ Ratio, RR\ =\ \frac{Conc._{Tar.} - \ Conc._{Rec.}}{DR(Conc._{Tar.} - Conc._{Rec.}) - Conc._{Tar.}}$$

3.0 References

Doneker, R. L., & Jirka, G. H. (2017). *CORMIX User Manual.* MixZon Inc.

EHP. (2016). *Technical Guideline - Wastewater Release to Queensland Waters.* ESR/2015/1654 Version 2.00.

Norconsult. (2018). *Kidston Pumped Storage Project ECI Design - water Management.*

Appendix M

Decision Notice

ETHERIDGE SHIRE COUNCIL

41 St George Street, Georgetown QLD 4871 Australia
Phone: (07) 4079 9090 **Fax:** (07) 4062 1285 **Email:** info@etheridge.qld.gov.au

...The Golden Heart of the Gulf

ABN 57 665 238 857

Address all correspondence to:
The Chief Executive Officer
PO Box 12
GEORGETOWN QLD 4871

Our ref: DA2018-002/0918/DCM
Your ref:

When telephoning or calling
Please ask for: David Munro
Phone: (07) 4079 9007

19 September 2018

Genex Power Limited
c/ Aecom Australia Pty Ltd
Po Box 5423
TOWNSVILLE QLD 4810

Attention: Collette Hayes

Dear Collette,

RE: DEVELOPMENT APPLICATION FOR:

(A) MATERIAL CHANGE OF USE – CODE ASSESSMENT FOR COMMUNITY INFRASTRUCTURE (HYDRO STORAGE FACILITY AND ASSOCIATED INFRASTRUCTURE);
(B) OPERATIONAL WORKS – CODE ASSESSMENT (CLEARING NATIVE VEGETATION);
(C) OPERATIONAL WORKS – CODE ASSESSMENT (REFERRABLE DAM); AND
(D) OPERATIONAL WORKS – CODE ASSESSMENT (ELECTRICITY INFRASTRUCTURE)

ON LAND DESCRIBED AS LOT 1 ON SP289310 AND LOT 66 ON SP287774 (VIA GILBERTON ROAD, KIDSTON)

With reference to the above Development Application please find attached the relevant Decision Notice which was determined at the Council General Meeting held on 19th September 2018.

The Notice includes documents with respect to representations about conditions, negotiated decision, suspension of appeal period and lodging and appeal.

Should you have any queries in relation to this Decision Notice please contact David Munro on 07 4079 9007.

Yours Sincerely

N Garsden

Norman Garsden
CHIEF EXECUTIVE OFFICER

Enc. Decision Notice and Appendices

ETHERIDGE SHIRE COUNCIL

41 St George Street, Georgetown QLD 4871 Australia
Phone: (07) 4079 9090 **Fax:** (07) 4062 1285 **Email:** info@etheridge.qld.gov.au

...The Golden Heart of the Gulf

Decision Notice Approval

Planning Act Form 2 (version 1.0 effective 3 July 2017) made under Section 282 of the Planning Act 2016 for a decision notice (approval) under s63(2) Planning Act 2016

Application number:	DA2018-002	Contact:	David Munro
Notice Date:	19 September 2018	Contact Number:	07 4079 9007

APPLICANT DETAILS

Name: Genex Power Limited

Postal Address: C/- Aecom Australia Ltd
Po Box 5423
Townsville Qld 4810

Phone No: 07 4720 1730 Mobile No: Email: colette.hayes@aecom.com

I acknowledge receipt of the above application on 29th June 2018 and confirm the following:

DEVELOPMENT APPROVAL

Development Permit for Material Change of Use assessable against a Planning Scheme for a Hydro Storage Facility and Associated Ancillary Infrastructure.

PROPERTY DESCRIPTION

Address: Gilberton Road, Kidston Qld 4870

Real Property Description: Lot 1 on SP289310 and Lot 66 on SP287774

To, Genex Solar Limited, C/- Aecom Australia Ltd,

I advise that, on 19th September 2018 the above development application was:

☒ approved in full with conditions* (refer to the conditions contained in Attachment 1)

*Note: *The conditions show which conditions have been imposed by the assessment manager and which conditions have been imposed by a referral agency.*

1. DETAILS OF THE APPROVAL

	Planning Regulation 2017 reference	Development Permit	Preliminary Approval
Development assessable under the planning scheme, a temporary local planning instrument, a master plan or a preliminary approval which includes a variation approval		☒	☐

2. CONDITIONS

This approval is subject to the conditions in Attachment 1.

3. FURTHER DEVELOPMENT PERMITS REQUIRED

Please be advised that the following development permits are required to be obtained before the development can be carried out:

Type of development permit required	Subject of the required development permit
Carrying out building works; Carrying out drainage and plumbing works	

4. REFERRAL AGENCIES FOR THE APPLICATION

The referral agencies for this application for an application involving a Material Change of Use (Code Assessment) for Community Infrastructure (Hydro Storage Facility) and Associated Ancillary Infrastructure are:

Item	Trigger	Name of Technical Agency	Referral Agency Status	Referral Agency Address
1	Schedule 10, Part 9, Division 2, Table 1 under the Planning Regulations 2017 ☐ The purposes of the Electricity Act 1994 and the Electrical Safety Act 2002.	Ergon Energy	Referral	Ergon Energy Principal Town Planner P.O. Box 264 FORTITUDE VALLEY QLD 4006
2	Schedule 10, Part 3, Division 4, Table 3, of the Planning Regulation 2017: ☐ State Development Assessment Provisions – State Code 16, Native Vegetation Clearing.	State Assessment & Referral Agency	Referral	Department of State Development, Manufacturing, Infrastructure & Planning Ground Floor, Cairns Port Authority Building, Cnr Grafton and Lake Streets, Cairns QLD 4870 PO Box 2358, Cairns QLD 4870
3	Schedule 10, Part 19, Division 3, Table 1 of the Planning Regulation 2017: ☐ State Development Assessment Provisions – State Code 20: Referrable Dams	State Assessment & Referral Agency	Referral	Department of State Development, Manufacturing, Infrastructure & Planning Ground Floor, Cairns Port Authority Building, Cnr Grafton and Lake Streets, Cairns QLD 4870 PO Box 2358, Cairns QLD 4870

5. THE APPROVED PLANS

The approved development must be completed and maintained generally in accordance with the approved drawings and documents:

Plan / Document Name	Plan / Document Reference	Dated
Figure 1 – Indicative Project Area	Figure 1	29th June 2018
Clearing & Excavation Layout Plan	Drawing No. 91603592-KPSP04.01 DWG-2061	29th June 2018
Embankment Layout Plan	Drawing No. 91603592-KPSP04.03 DWG-2061	29th June 2018
Embankment	Drawing No. 91603592-KPSP04.03 DWG-2062	29th June 2018
Embankment	Drawing No. 91603592-KPSP04.03 DWG-2063	29th June 2018
Embankment Longitudinal Section	Drawing No. 91603592-KPSP04.03 DWG-2064	29th June 2018
Embankment Longitudinal Section	Drawing No. 91603592-KPSP04.03 DWG-2065	29th June 2018
Embankment Spillway	Drawing No. 91603592-KPSP04.03 DWG-2066	29th June 2018
General Arrangement	Drawing No. 377551-KST-FS-DWG-130	29th June 2018
General Arrangement	Drawing No. 377551-KST-FS-DWG-700	29th June 2018
General Arrangement	Drawing No. 377551-KST-FS-DWG-711	29th June 2018

6. CURRENCY PERIOD FOR THE APPROVAL (S.85)

The standard relevant periods stated in section 85 of *Planning Act 2016* apply to each aspect of development in this approval, if not stated in the conditions of approval attached.[1]

[1] S.85
Lapsing of approval at end of currency period
(1)A part of a development approval lapses at the end of the following period (the currency period)—
(a)for any part of the development approval relating to a material change of use—if the first change of use does not happen within—
(i)the period stated for that part of the approval; or
(ii)if no period is stated—6 years after the approval starts to have effect;

(b)for any part of the development approval relating to reconfiguring a lot—if a plan for the reconfiguration that, under the Land Title Act, is required to be given to a local government for approval is not given to the local government within—
(i)the period stated for that part of the approval; or
(ii)if no period is stated—4 years after the approval starts to have effect;

(c)for any other part of the development approval—if the development does not substantially start within—
(i)the period stated for that part of the approval; or
(ii)if no period is stated—2 years after the approval starts to take effect.

(2)If part of a development approval lapses, any monetary security given for that part of the approval must be released.

7. STATEMENT OF REASONS

Description of the development	The proposed development is for a Material Change of Use (Code Assessment) for Community Infrastructure (Hydro Storage Facility) and Associated Ancillary Infrastructure assessable against a Planning Scheme
Assessment Benchmarks	The proposed development was assessed against the following assessment benchmarks: ☐ Rural Zone ☐ General Development Code ☐ Community Infrastructure Zone Code ☐ Good Quality Agricultural Land Overlay Code ☐ Bushfire Management Overlay Code (Medium Bushfire Hazard)
Reasons for decision (list non-compliance items and how they were resolved)	The development was assessed against all of the assessment benchmarks listed above and complies with all of these.

8. RIGHTS OF APPEAL

The rights of an applicant to appeal to a tribunal or the Planning and Environment Court against a decision about a development application are set out in chapter 6, part 1 of the *Planning Act 2016*. For particular applications, there may also be a right to make an application for a declaration by a tribunal (see chapter 6, part 2 of the *Planning Act 2016*).

Appeal by an applicant

An applicant for a development application may appeal to the Planning and Environment Court against the following:

- the refusal of all or part of the development application
- a provision of the development approval
- the decision to give a preliminary approval when a development permit was applied for
- a deemed refusal of the development application.

An applicant may also have a right to appeal to the Development tribunal. For more information, see schedule 1 of the *Planning Act 2016*.

The timeframes for starting an appeal in the Planning and Environment Court are set out in section 229 of the *Planning Act 2016*.

Attachment 2 is an extract from the *Planning Act 2016* that sets down the applicant's appeal rights and the appeal rights of a submitter.

9. WHEN THE DEVELOPMENT APPROVAL TAKES EFFECT

This development approval takes effect:

- From the time the decision notice is given – if there is no submitter and the applicant does not appeal the decision to the court.

Or

- When the submitter's appeal period ends – if there is a submitter and the applicant does not appeal the decision to the court.

Or

- Subject to the decision of the court, when the appeal is finally decided – if an appeal is made to the court.

This approval will lapse unless substantially commenced within the above stated relevant periods (refer to sections 85 of *Planning Act 2016* for further details).

Etheridge Shire Council
Assessment Manager

CHIEF EXECUTIVE OFFICER

Attachment 1 – Conditions of the approval
Part 1 – Conditions imposed by the assessment manager [Note: where a condition is imposed about infrastructure under Chapter 4 of the *Planning Act 2016*, the relevant provision of the Act under which this condition was imposed must be specified.]
Part 2 – Conditions imposed by the referral agencies

Attachment 2—Extract on appeal rights

Attachment 1 – Part 1

Etheridge Shire Council Conditions

PLANNING ACT 2016

1. ADMINISTRATION

1.1 The Developer and his employee, agent, contractor or invitee is responsible for ensuring compliance with the conditions of this development approval.

1.2 Where these Conditions refer to "Council" in relation to requiring Council to approve or to be satisfied as to any matter, or conferring on the Council a function, power or discretion, that role may be fulfilled in whole or in part by a delegate appointed for that purpose by the Council.

1.3 All conditions, works, or requirements of this development approval must be undertaken and completed:
- 1.3.1 to Council's satisfaction;
- 1.3.2 at no cost to Council.

1.4 The following further Development Permits must be obtained prior to the commencement of any works associated with their purposes:
- 1.4.1 Building Works
- 1.4.2 Plumbing & Drainage Works

1.5 The development shall be undertaken substantially in accordance with the approved drawings and/or documents and in accordance with the specifications, facts and circumstances as set out in the application submitted to Council.

1.6 The conditions of the Development Permit must be affected prior to Commencement of Use, except where specified otherwise in these conditions of approval.

1.7 The developer shall be responsible for securing a permanent and ongoing water supply for the development.

1.8 The Applicant shall liaise with and comply with any requirements that the Civil Aviation Safety Authority (CASA) may require in relation to this development. The Applicant shall provide council copies of any agreements and/or conditions which CASA determine necessary for this development.

2. TIME AND EFFECT

2.1 The Development Approval shall lapse six (6) years after the date the Development Approval takes effect in accordance with the provisions of Section 85 of the *Planning Act 2016.*

3. APPROVED PLANS AND DOCUMENTS

3.1 The approved development must be completed and maintained generally in accordance with the approved plans and documents, except where amended by any condition of this development approval:

Plan / Document Name	Plan / Document Reference	Dated
Figure 1 – Indicative Project Area	Figure 1	29th June 2018
Clearing & Excavation Layout Plan	Drawing No. 91603592-KPSP04.01 DWG-2061	29th June 2018
Embankment Layout Plan	Drawing No. 91603592-KPSP04.03 DWG-2061	29th June 2018
Embankment	Drawing No. 91603592-KPSP04.03 DWG-2062	29th June 2018
Embankment	Drawing No. 91603592-KPSP04.03 DWG-2063	29th June 2018
Embankment Longitudinal Section	Drawing No. 91603592-KPSP04.03 DWG-2064	29th June 2018
Embankment Longitudinal Section	Drawing No. 91603592-KPSP04.03 DWG-2065	29th June 2018

Plan / Document Name	Plan / Document Reference	Dated
Embankment Spillway	Drawing No. 91603592-KPSP04.03 DWG-2066	29th June 2018
General Arrangement	Drawing No. 377551-KST-FS-DWG-130	29th June 2018
General Arrangement	Drawing No. 377551-KST-FS-DWG-700	29th June 2018
General Arrangement	Drawing No. 377551-KST-FS-DWG-711	29th June 2018

3.2 Where conditions require the above plans or documents to be amended, the revised document(s) must be submitted for approval by Council.

4. WASTE MANAGEMENT

4.1 Construction Waste[2] generated during the construction of the Project will be required to be transported to Townsville or to an alternative landfill site outside of the Etheridge Shire area that has the capacity to meet the volume of Construction Waste which is in line with the Applicants Development Report, page 17, Clause 5.2.2.5.

4.2 The Applicant will be required to transport and dispose of all Commercial Waste[3] from the Development Site as a result of the activities generated from this Development to an alternative Landfill Site outside of the Etheridge Shire area that has the capacity to meet the volume of Commercial Waste (i.e. Townsville) as the Waste Facility (landfill) located in the Township of Einasleigh does not have the capacity to meet the estimated increase in volume of Commercial Waste that is to be generated during the construction phase of this development and furthermore Councils current ERA Permit (EPR00239313) has limitations on Council as to the amount of the yearly volume of waste that can be disposed of within Council's four (4) licenced Landfill Facilities.

5. BUSHFIRE MANAGEMENT

5.1 The Applicant shall ensure the Hydro Storage Facility infrastructure will be designed and constructed to ensure that it is not susceptible to damage from bushfire.

5.2 A Bushfire Management Plan will be prepared in accordance with Part E (4) of State Planning Policy (July 2017) - Assessment Benchmarks – natural hazards, risk and resilience to the satisfaction of Council's Delegated officer.

5.3 The approved use shall comply with the requirements of the Bushfire Management Plan at all times.

5.4 The Applicant shall ensure that the development can be accessed by the Rural Fire Service & Emergency Management Personnel in the event of bushfire, to the satisfaction of that organisation

6. SERVICES

6.1 The Applicant shall be responsible for the cost of necessary alterations to existing public utility mains, services or installations required by works in relation to the proposed development or any works required by condition(s) of this approval.

7. ROADS – INTERNAL (ACCESS ROADS ON PRIVATE PROPERTY)

7.1 The Applicant shall ensure where practicable access and movement within the site/s shall be sited during the period of construction and for the life of the project. The design shall minimize cut and fill, road drainage and soil erosion and interference with natural drainage lines. Care should also be taken to minimise impacts on visual and landscape values and environmentally sensitive areas with final design to the satisfaction of Council's delegated officer.

---

[2] *"**Construction waste**" **means** any substance, matter or thing which is generated as a result of **construction** work and abandoned whether or not it has been processed or stockpiled before being abandoned.*

[3] ***Commercial waste** consists of **waste** from premises used mainly for the purposes of a **trade** or **business** or for the purpose of sport, recreation, education or entertainment, but excluding household, agricultural or industrial **waste**.*

8. ROADS – EXTERNAL (GILBERTON ROAD)

8.1 The Developer is to enter into a Road Use Deed of Agreement with Council whereby the Road Use Deed Agreement outlines the agreed activities pertaining to Road and Bridge Assessment requirements under Section 3 of the Agreement; Upgrades or Repairs to Roads and Bridges contained under Section 4 of the Agreement and Road Improvement Works as outlined under Section 5 of the Agreement.

8.2 The Road Use Deed Agreement may need to reviewed and or amended by Council (Assessment Manager) in the event that the Developer lodges any future Development Applications pertaining to the development and construction works associated with future Stages of the Kidston Renewable Energy Hub Project.

9. DECOMMISSIONING OF THE SITE

9.1 Prior to the commencement of decommissioning, the Applicant will provide a Decommissioning and Rehabilitation Plan to Council for approval.

Attachment 1 – Part 2

Referral Agencies Conditions

PLANNING ACT 2016

RA6-N

Queensland Government

Department of
State Development, Manufacturing, Infrastructure and Planning

Our reference: 1807-6382 SRA
Your reference: DA2018-002

22 August 2018

The Chief Executive Officer
Etheridge Shire Council
PO Box 12
Georgetown Qld 4871
info@etheridge.qld.gov.au

Attention: Mr Norman Garsden

Dear Norman

Referral agency response—with conditions
(Given under section 56 of the *Planning Act 2016*)

The development application described below was properly referred to the Department of State Development, Manufacturing, Infrastructure and Planning on 19 July 2018.

Referral triggers

The development application was referred to the department under the following provisions of the Planning Regulation 2017:

- 10.19.3.3.1.1 Water-related development - referable dams
- 10.3.4.3.1 Clearing native vegetation

Response

Date of response:	23 August 2018
Response details:	Referral agency response with conditions
Development details:	Development Permit for a Material change of use for Pumped storage hydro facility and operational work for native vegetation clearing
Conditions:	The conditions set out in Attachment 1 must be attached to any development approval

Location details

Real property description:	1SP289310; 66SP287774

Development Assessment Advisory Team
Level 13, 1 William Street
PO Box 15009, Brisbane East QLD 4002

Local government area:	Etheridge Shire Council

Applicant details

Applicant name:	Genex Power Limited
Applicant contact details:	PO Box 5423 Townsville QLD 4810 frances.mahlouzarides@aecom.com

A copy of this response has been sent to the applicant for their information.

For further information please contact Danielle Harris, Principal Planner, on 34527654 or via email DAAT@dsdmip.qld.gov.au who will be pleased to assist.

Yours sincerely

Tim O'Leary
Manager

cc Genex Power Limited - frances.mahlouzarides@aecom.com

enc Attachment 1—Referral agency conditions
Attachment 2—Statement of reasons
Attachment 3—Approved plans

Attachment 1—Referral agency conditions

No.	Conditions	Condition timing
Material Change of Use for a Pumped Storage Hydro Facility		
Referrable dams—The chief executive administering the *Planning Act 2016* nominates the Director-General of Department of Natural Resources, Mines and Energy to be the enforcement authority for the development to which this development approval relates for the administration and enforcement of any matter relating to the following condition(s):		
1.	(a) Report all incidents and failures (as defined in the *Queensland Dam Safety Management Guidelines* prepared by the Department of Natural Resources and Mines, dated February 2002) associated with the dam to the Dam Safety Regulator via damsafety@dnrme.qld.gov.au. (b) Provide a report on the incident or failure, including any remedial action taken, to the Dam Safety Regulator via damsafety@dnrme.qld.gov.au.	a) Within forty-eight (48) hours of becoming aware of the incident or failure b) Within one (1) month of the incident or failure occurring
2.	Provide a comprehensive Design Report for the dam prepared in accordance with the *Queensland Dam Safety Management Guidelines* prepared by the Department of Natural Resources and Mines, dated February 2002 to the Dam Safety Regulator via damsafety@dnrme.qld.gov.au. The Design Report must be prepared by a Registered Professional Engineer of Queensland (RPEQ) and include: i. adopted design criteria ii. foundation properties and treatment iii. construction material sources and properties iv. structural capacity of principal elements v. spillway adequacy vi. outlet works, vii. surveillance requirements viii. construction specification including construction drawings.	Forty (40) days prior to the commencement of construction
3.	(a) Provide written notice to the Dam Safety Regulator via damsafety@dnrme.qld.gov.au advising of the completion of the construction of the dam. (b) Provide "As Constructed" documentation to the Dam Safety Regulator via damsafety@dnrme.qld.gov.au. The "As Constructed" documentation must include: i. a record of any decisions to adapt the nominated design to suit actual field conditions ii. 'as constructed' drawings indicating the actual lines, levels and dimensions to which the structure is built iii. a description of the construction process iv. systematically compiled and comprehensive photographs of the construction v. foundation surface mapping of rock defects vi. a summary of material test results vii. a summary of construction inspection reports viii. a certification by a RPEQ that the works have been	a) Within seven (7) business days of the completion of the works b) Within three (3) months of the completion of works

	constructed in accordance with relevant engineering standards.	
4.	(a) Prepare a Data Book in accordance with the *Queensland Dam Safety Management Guidelines* prepared by the Department of Natural Resources and Mines, dated February 2002. The Data Book must include all information as required in the Queensland Dam Safety Management Guidelines in particular: i. all pertinent records and history relating to the dam ii. documentation of investigation, design, construction, operation, maintenance, surveillance, monitoring measurements and any remedial action taken during construction and subsequent operation of the dam. (b) Provide a written notification to the Dam Safety Regulator via damsafety@dnrme.qld.gov.au, confirming the Data Book has been reviewed by the dam owner and, if necessary, updated to incorporate any new dam safety information developed since the previous review.	a) Within three months (3) months of the completion of construction of the works b) By the 1st July each year following the completion of the works
5.	(a) Prepare an Operations and Maintenance Manual for the dam. The Operations and Maintenance Manual must be prepared in accordance with the *Queensland Dam Safety Management Guidelines* prepared by the Department of Natural Resources and Mines, dated February 2002. (b) Implement the Operations and Maintenance Manual prepared in accordance with part (a) of this condition. (c) Review and update where required the Operations and Maintenance Manual prepared in accordance with part (a) of this condition.	a) within sixty (60) business days of the completion of construction of the works b) at all times c) By the 1st July each year following the completion of the works
6.	(a) Carry out a Comprehensive Inspection of the dam in accordance with the *Queensland Dam Safety Management Guidelines*. (b) Advise the Dam Safety Regulator via damsafety@dnrme.qld.gov.au of the Comprehensive Inspection occurring and if required allow the Dam Safety Regulator to observe any or all procedures involved in the inspection process. (c) Submit a copy of the report detailing the findings of the Comprehensive Inspection to the Dam Safety Regulator via damsafety@dnrme.qld.gov.au.	a) by the 1st July of the year following completion of works and then every five (5) years b) at least five (5) business days prior to the date of the comprehensive inspection c) within sixty (60) business days after completion of the inspection.
7.	(a) Carry out a Safety Review of the dam in accordance with the *Queensland Dam Safety Management Guidelines*. The Safety Review must be done under the supervision of a Registered Professional Engineer of Queensland (RPEQ). (b) Provide a copy of a report detailing the findings of this Safety Review to the Dam Safety Regulator via damsafety@dnrme.qld.gov.au.	a) Within twenty (20) years of the initial comprehensive inspection and every twenty (20) years thereafter b) Within sixty (60) business days after completion of the review.

8.	(a) Prepare a Decommissioning Plan for the dam in accordance with the *Queensland Dam Safety Management Guidelines,* prepared by the Department of Natural Resources and Mines, dated February 2002. (b) Provide a copy of the Decommissioning Plan to the Dam Safety Regulator via damsafety@dnrme.qld.gov.au.	Prior to decommissioning occurring
Operational Work for Native Vegetation Clearing		
Native vegetation clearing—The chief executive administering the *Planning Act 2016* nominates the Director-General of Department of Natural Resources, Mines and Energy to be the enforcement authority for the development to which this development approval relates for the administration and enforcement of any matter relating to the following condition(s):		
9.	The clearing of vegetation under this development approval is limited to the areas identified as Area A (A1-A3) as shown on attached Technical Agency Response (Vegetation) Plan TARP 1807-6382 SRA, Sheet 1 of 1, dated 16 August 2018.	At all times
10.	Clearing within any watercourse or drainage feature, or within 50 metres of the defining bank of any watercourse or drainage feature must: a) not exceed 20 metres in width b) not occur within five metres of the defining bank, unless clearing is required into or across the watercourse or drainage feature.	At all times
11.	Any person(s) engaged or employed to carry out the clearing of vegetation under this development approval must be provided with a full copy of this development approval and must be made aware of the full extent of clearing authorised by this development approval.	Prior to clearing

Attachment 2—Statement of Reasons

GE78-N

Queensland Government

Department of
State Development, Manufacturing, Infrastructure and Planning

Department of State Development, Manufacturing, Infrastructure and Planning
Statement of reasons for application 1807-6382 SRA
(Given under section 56 of the *Planning Act 2016*)

Departmental role: Referral agency

Response

Date of response:	23 August 2018
Response details:	Referral agency response with conditions
Development details:	Development Permit for a Material change of use for Pumped storage hydro facility and operational work for vegetation clearing
Conditions:	The conditions set out in Attachment 1 must be attached to any development approval

Location details

Real property description:	1SP289310; 66SP287774
Local government area:	Etheridge Shire Council

Applicant details

Applicant name:	Genex Power Limited
Applicant contact details:	PO Box 5423 Townsville QLD 4810 frances.mahlouzarides@aecom.com

Assessment matters

Aspect of development requiring code assessment	Applicable codes
1. Material change of use for Pumped storage hydro facility	State Code 20: Referable dams
2. Operational work for vegetation clearing	State Code 16: Native vegetation clearing

Reasons for the department's decision

The reasons for the decision are:

- the proposal complies with the applicable performance outcomes of State Code 20: Referable dams
- the proposal will be designed and constructed in accordance with appropriated dam engineering practices and standards

Development Assessment Advisory Team
Level 13, 1 William Street
PO Box 15009, Brisbane East QLD 4002

- the proposal is appropriate for the site conditions where the dam is located
- the proposal complies with the performance outcomes of State Code 16: Native vegetation clearing
- the project footprint avoids and minimises impacts on native vegetation

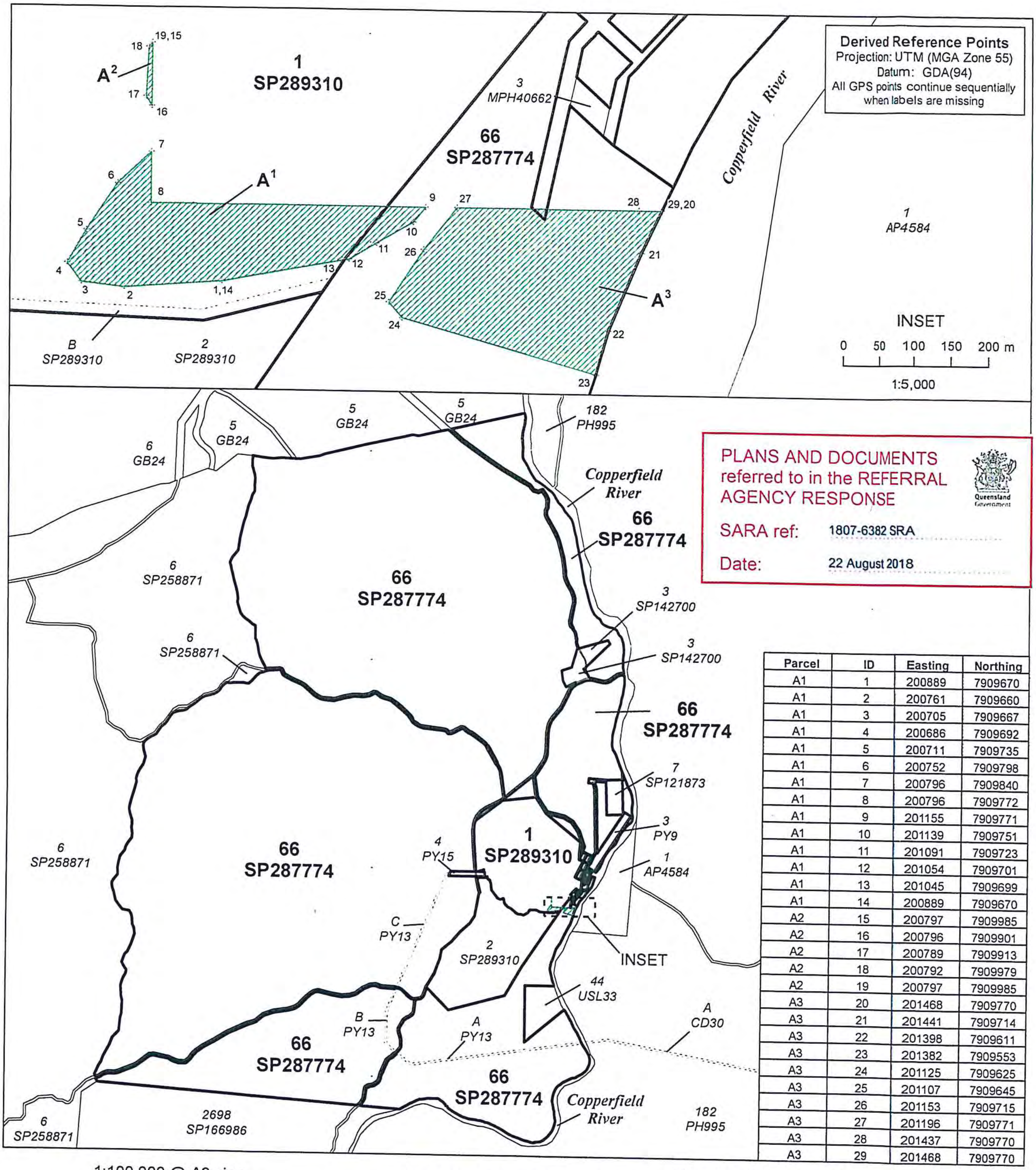
Response

Nature of Approval	Nature of Response	Date of Response
Development permit	Referral agency response – with conditions	22 August 2018

Relevant material

- State Development Assessment Provisions, published by the Department of State Development, Manufacturing, Infrastructure and Planning
- *Planning Act 2016*
- *Planning Regulation 2017*
- *DA Rules*
- Common application material

Attachment 3—Approved Plans



Parcel	ID	Easting	Northing
A1	1	200889	7909670
A1	2	200761	7909660
A1	3	200705	7909667
A1	4	200686	7909692
A1	5	200711	7909735
A1	6	200752	7909798
A1	7	200796	7909840
A1	8	200796	7909772
A1	9	201155	7909771
A1	10	201139	7909751
A1	11	201091	7909723
A1	12	201054	7909701
A1	13	201045	7909699
A1	14	200889	7909670
A2	15	200797	7909985
A2	16	200796	7909901
A2	17	200789	7909913
A2	18	200792	7909979
A2	19	200797	7909985
A3	20	201468	7909770
A3	21	201441	7909714
A3	22	201398	7909611
A3	23	201382	7909553
A3	24	201125	7909625
A3	25	201107	7909645
A3	26	201153	7909715
A3	27	201196	7909771
A3	28	201437	7909770
A3	29	201468	7909770

1:100,000 @ A3 size

0 1 2 3 4 5 6 7 8 km

Projection: UTM (MGA Zone 55) **Datum: GDA94**

Note: Derived Reference Points are provided to assist in the location of the Technical Agency Response boundaries. Responsibility for locating these boundaries lies solely with the landholder and delegated contractor(s).

The property boundaries shown on this plan are APPROXIMATE ONLY. They are NOT an accurate representation of the legal boundaries.

LEGEND

- Derived Reference Points for GPS
- Subject Lot(s)
- Area A (Parts A¹ - A³)

Technical Agency Response (Vegetation) Plan

Plan of Area A (Parts A^1 - A^3) in Lot 1 on SP289310 and Lot 66 on SP287774

Elvas Case. 2018/004727

N

Queensland Government

CENTRE: MAREEBA
LOCALITY OF EINASLEIGH

REGION: NORTH
LOCAL GOVT: ETHERIDGE SHIRE

Map Reference: 7660,7760

Compiled from: DCDB, PVMP & VMO Notes

File Reference: eDOCS - 082/0003090

Prepared by: PJB - J5462 Date: 16 August 2018

TARP
1807-6382 SRA
Sheet 1 of 1

420 Flinders Street, Townsville QLD 4810
PO Box 1090, Townsville QLD 4810

ergon.com.au

23 August 2018

Etheridge Shire Council
info@etheridge.qld.gov.au

Attention: David Munro

cc Genex Power Limited
c/- Aecom
Frances.Mahlouzarides@aecom.com.

Attention: Frances Mahlouzarides

Dear David,

Development Application – Material Change of Use for Community Infrastructure (Kidston Pumped Storage hydro) located at Gilberton Road, Einasleigh, described as L66 on SP258871 and L66 on SP287796.
Council Ref: DA2018-002
Our Ref: HBD6300439

We refer to the above reference Development Application which has been referred to Ergon Energy in accordance with the *Planning Act 2016*.

In accordance with Schedule 10, Part 9, Division 2 of the *Planning Regulation 2017*, the application has been assessed against the purposes of the *Electricity Act 1994* and *Electrical Safety Act 2002*. The below response is provided in accordance with section 56(1) of the *Planning Act 2016*.

Connection of the proposed infrastructure to Ergon Energy's network is subject to negotiation. The negotiations are commercial and technical in nature and are not considered to be critically relevant for Council's assessment or decision regarding the proposed Material Change of Use.

This correspondence does not constitute approval for connection.

Ergon Energy has no objection to the proposed development, subject to the following conditions being applied to any approval:

1. Development is carried out generally in accordance with the plans and reports provided as part of the application.

2. The water inlet pipe shown on the indicative project area plan (Figure 1) is not approved, as it is shown within the substation area. It is understood this is indicative only the pipe will run along the substation boundary.
3. GENEX will be required to protect or relocate our assets entering and exiting the Kidston Zone Substation during construction of the pipeline.
4. All easement condition must be maintained.
5. Access to our infrastructure must be available at all times.
6. Any proposed earth works do not result in an increase in ponding or run off to stormwater onto existing electricity infrastructure.
7. Should changes to Ergon Energy infrastructure be proposed or required as part of the development, those changes are made with Ergon Energy's consent and at the developer/owners expense.

Should you require any further information on the above matter, please contact the undersigned on (07) 3664 4815.

Yours faithfully

Kirsten Sellers
Senior Town Planner

Attachment 2 – Part 1

Appeal Rights

PLANNING ACT 2016

The following is an extract from the *Planning Act 2016* (Chapter 6)

Appeal rights

229Appeals to tribunal or P&E Court

(1) Schedule 1 states—
  (a) matters that may be appealed to—
    (i) either a tribunal or the P&E Court; or
    (ii) only a tribunal; or
    (iii) only the P&E Court; and
  (b) the person—
    (i) who may appeal a matter (the ***appellant***); and
    (ii)who is a respondent in an appeal of the matter;
    (iii) who is a co-respondent in an appeal of the matter; and
    (iv) who may elect to be a co-respondent in an appeal of the matter.

(2) An appellant may start an appeal within the appeal period.

(3)The ***appeal period*** is—
  (a) for an appeal by a building advisory agency—10 business days after a decision notice for the decision is given to the agency; or
  (b) for an appeal against a deemed refusal—at any time after the deemed refusal happens; or
  (c) for an appeal against a decision of the Minister, under chapter 7 , part 4 , to register premises or to renew the registration of premises—20 business days after a notice is published under section 269 (3)(a) or (4); or
  (d) for an appeal against an infrastructure charges notice—20 business days after the infrastructure charges notice is given to the person; or
  (e) for an appeal about a deemed approval of a development application for which a decision notice has not been given—30 business days after the applicant gives the deemed approval notice to the assessment manager; or
  (f) for any other appeal—20 business days after a notice of the decision for the matter, including an enforcement notice, is given to the person.

Note -
See the P&E Court Act for the court's power to extend the appeal period.

(4) Each respondent and co-respondent for an appeal may be heard in the appeal.

(5) If an appeal is only about a referral agency's response, the assessment manager may apply to the tribunal or P&E Court to withdraw from the appeal.

(6) To remove any doubt, it is declared that an appeal against an infrastructure charges notice must not be about—
  (a) the adopted charge itself; or
  (b) for a decision about an offset or refund—
    (i) the establishment cost of trunk infrastructure identified in a LGIP; or
    (ii) the cost of infrastructure decided using the method included in the local government's charges resolution.

230 Notice of appeal

(1) An appellant starts an appeal by lodging, with the registrar of the tribunal or P&E Court, a notice of appeal that—
  (a) is in the approved form; and
  (b) succinctly states the grounds of the appeal.

(2) The notice of appeal must be accompanied by the required fee.

(3) The appellant or, for an appeal to a tribunal, the registrar, must, within the service period, give a copy of the notice of appeal to—
  (a) the respondent for the appeal; and
  (b) each co-respondent for the appeal; and
  (c) for an appeal about a development application under schedule 1 , table 1, item 1—each principal submitter for the development application; and
  (d) for an appeal about a change application under schedule 1 , table 1, item 2—each principal submitter for the change application; and
  (e) each person who may elect to become a co-respondent for the appeal, other than an eligible submitter who is not a principal submitter in an appeal under paragraph (c) or (d); and
  (f) for an appeal to the P&E Court—the chief executive;
  (g) for an appeal to a tribunal under another Act—any other person who the registrar considers appropriate.

(4)The ***service period*** is—
  (a) if a submitter or advice agency started the appeal in the P&E Court—2 business days after the appeal is started; or
  (b) otherwise—10 business days after the appeal is started.

(5) A notice of appeal given to a person who may elect to be a co-respondent must state the effect of subsection (6).

(6) A person elects to be a co-respondent by filing a notice of election, in the approved form, within 10 business days after the notice of appeal is given to the person.

(7) Despite any other Act or rules of court to the contrary, a copy of a notice of appeal may be given to the chief executive by emailing the copy to the chief executive at the email address stated on the department's website for this purpose.

231 Other appeals

(1) Subject to this chapter, schedule 1 and the P&E Court Act, unless the Supreme Court decides a decision or other matter under this Act is affected by jurisdictional error, the decision or matter is non-appealable.

(2) The *Judicial Review Act 1991* , part 5 applies to the decision or matter to the extent it is affected by jurisdictional error.

(3) A person who, but for subsection (1) could have made an application under the *Judicial Review Act 1991* in relation to the decision or matter, may apply under part 4 of that Act for a statement of reasons in relation to the decision or matter.

232Rules of the P&E Court

(1) A person who is appealing to the P&E Court must comply with the rules of the court that apply to the appeal.

(2) However, the P&E Court may hear and decide an appeal even if the person has not complied with rules of the P&E Court.

Attachment 2 – Part 2

Appeal Rights

PLANNING ACT 2016

Schedule 1
Appeals Section 229

1. Appeal rights and parties to appeals

(1)Table 1 states the matters that may be appealed to—
(a)the P&E court; or
(b)a tribunal.

(2)However, table 1 applies to a tribunal only if the matter involves—
(a)the refusal, or deemed refusal of a development application, for—
(i)a material change of use for a classified building; or
(ii)operational work associated with building work, a retaining wall, or a tennis court; or
(b)a provision of a development approval for—
(i)a material change of use for a classified building; or
(ii)operational work associated with building work, a retaining wall, or a tennis court; or
(c)if a development permit was applied for—the decision to give a preliminary approval for—
(i)a material change of use for a classified building; or
(ii)operational work associated with building work, a retaining wall, or a tennis court; or
(d)a development condition if—
(i)the development approval is only for a material change of use that involves the use of a building classified under the Building Code as a class 2 building; and
(ii)the building is, or is proposed to be, not more than 3 storeys; and
(iii)the proposed development is for not more than 60 sole-occupancy units; or
(e)a decision for, or a deemed refusal of, an extension application for a development approval that is only for a material change of use of a classified building; or
(f)a decision for, or a deemed refusal of, a change application for a development approval that is only for a material change of use of a classified building; or
(g)a matter under this Act, to the extent the matter relates to the Building Act, other than a matter under that Act that may or must be decided by the Queensland Building and Construction Commission; or
(h)a decision to give an enforcement notice—
(i)in relation to a matter under paragraphs (a) to (g); or
(ii)under the Plumbing and Drainage Act; or
(i)an infrastructure charges notice; or
(j)the refusal, or deemed refusal, of a conversion application; or
(l)a matter prescribed by regulation.

(3)Also, table 1 does not apply to a tribunal if the matter involves—
(a)for a matter in subsection (2)(a) to (d)—
(i)a development approval for which the development application required impact assessment; and
(ii)a development approval in relation to which the assessment manager received a properly made submission for the development application; or
(b)a provision of a development approval about the identification or inclusion, under a variation approval, of a matter for the development.

(4)Table 2 states the matters that may be appealed only to the P&E Court.

(5)Table 3 states the matters that may be appealed only to the tribunal.

(6)In each table—
(a)column 1 states the appellant in the appeal; and
(b)column 2 states the respondent in the appeal; and
(c)column 3 states the co-respondent (if any) in the appeal; and
(d)column 4 states the co-respondents by election (if any) in the appeal.

(7)If the chief executive receives a notice of appeal under section 230 (3)(f), the chief executive may elect to be a co-respondent in the appeal.

Attachment 3 – Part 1

Development Plans

PLANNING ACT 2016

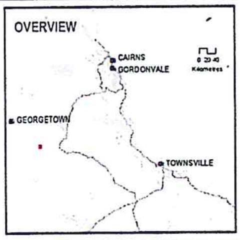
AECOM
www.aecom.com

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator

0 100 200 300 400
Meters
1:17,000 (when printed at A3)

Legend

- Boundary Points
- Watercourses
- Major Roads
- Minor Roads
- Water Intake Pipeline
- Key Project Infrastructure Footprint
- Spillway Options Corridor
- Mining Lease Boundary
- Cadastral Parcel



Data sources:
Roads and Tracks, Cadastre, Watercourses - DNRM 2017
Electrical Network - Ergon Energy 2017
SISP Imagery 2017

Disclaimer:
While every care is taken to ensure the accuracy of the Information Product, the Department of Natural Resources and Mines makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which you might incur as a result of the product being inaccurate or incomplete in any way and for any reason.

Kidston Solar Farm
Genex Power Limited

Indicative Project Area

PROJECT ID	60544566
CREATED BY	JR
LAST MODIFIED	13 - 13/06/2018
VERSION	1

Figure 1

A3 size

Appendix N

Other Matters

Appendix N Other Matters

Consideration of other planning and environmental matters

Aspect	Assessment Summary
Land Use	The Project site is largely surrounded by pastoral leases. Oaks Rush Station borders the mine site to the North, West and South and the Kimberly Station borders the township to the East. The township area of Kidston is between the border of the Mining Lease and the Copperfield River. There are some freehold land parcels and the remaining are land leases, State land and some Council owned reserves (i.e. Kidston Airport and Airstrip). The existing surrounding land uses include agricultural grazing land and renewable energy facilities. The lot adjoining the site to the south (Lot 2 SP289310) contains a solar farm (KS1). The township area was created for the purpose of servicing the mine. Since the closure of the mine the residential population of the town has significantly decreased leaving a small permanent population in the township. The permanent residential population is estimated at 10 residents in total. The residents are either employed by local council; Oaks Rush accommodation facility; maintenance or monitoring of the Kidston mine site; associated with the Kidston Renewable Energy Hub and grazing business in the area. The majority of the buildings and houses in the old township have been destroyed and depleted due to either natural disasters (i.e. cyclonic weather) or failure in the foundations of the buildings likely due to the age of the buildings. The Project area and surrounding land is zoned as rural under the Etheridge Shire Planning Scheme 2005. The planning scheme identified the Project area as containing good quality agricultural land and low and medium bushfire hazard (Etheridge Shire Council, 2005). The surrounding pastoral leases have previously co-existed with the former Kidston Gold Mine site during its long-term operation. Similarly, the Kidston Township has historically co-existed with the mine site directly adjacent, however given the mine has been closed for a number of years, residents present may not be accustomed to potential amenity impacts associated with the construction and operation of the Project. The wider Project has largely been contained within the Mining Lease, with the exception of the specific infrastructure associated with the required water discharges for the Project.

Aspect	Assessment Summary
Native Title	A search of the National Native Title Tribunal database on 8 May 2018 indicates that there are no current claims or determinations over the bulk of the Project area (lot 66 SP287774, lot 1 SP289310 and 2 SP289310). The Ewamian People #2 and Ewamian People #3 have been determined as holding Native Title (QCD2013/006, QCD2013/007) over parcels of land that abut the southern extent of the proposed spillway (lot 66 SP287774). The area over which Native Title has been determined includes the Copperfield River and its northern banks. Depending on the extent of works intended for the end of the spillway, this area of Native Title may be impacted and will be managed at the time. As part of the detailed design of this component of the Project, it is the intention of Genex to avoid any impacts to Native Title where possible.
Cultural Heritage	Genex and the Ewamian People signed a Cultural Heritage Management Agreement (CHMA) for the Kidston Renewable Energy Project in May 2018. The CHMA identifies roles and responsibilities, the organisation and arrangement of fieldwork and inductions, clear processes for the identification of unexpected heritage and a dispute resolution process. A cultural heritage assessment was completed for the areas which extend from the historical mining lease area. The proposed spillway is located immediately south of the Kidston Township, which is listed on the State Heritage Register (SHR#600506) for its historical, rarity, research, and technical significance in representing early 20th century goldmining. The survey did not identify evidence of either Aboriginal heritage sites or areas with potential for subsurface remains. Given the extent of historical ground disturbance in the area, the Ewamian People consider it unlikely that Project works will have an impact on Aboriginal archaeological values. However, should Aboriginal heritage objects be identified during Project works, the relevant procedures under the CHMA should be implemented. Given the proximity to the Kidston township, there is potential for archaeological sites to be present. Results of the cultural heritage assessment will be provided to Department of Environment and Science for discussion at completion of the survey report. Any places which are deemed to be of heritage significance will be avoided.
Contaminated Land	The Project site is included on the Environmental Management Register (EMR) due to historical mining activities on the site. A search of the EMR was undertaken in October 2017. The search identified that the site has been included on the EMR due to the following notifiable activities or hazardous contaminates: • abrasive blasting • chemical manufacturing or formulation • chemical storage • engine reconditioning works • explosive production or storage • landfill

Aspect	Assessment Summary
	• metal treatment or coating • mine wastes • petroleum product or oil storage • smelting or refining. Waste rock from the former Kidston mine is stored within the north, east, south and south east waste rock dumps and tailings stored within the tailings dam storage facility. Containment of seepage from the waste rock dumps and Tailings Dam is provided in onsite seepage containment structures (i.e. North Dump Seepage Dam, East Dump Seepage Dam, South East Dump Seepage Dam, Reclaim Dam, Butchers Creek Dam and Managers Creek Dam) (Barrick Australia, 2015). The Kidston mine was rehabilitated following strategies detailed in the Plan of Operations (February 2005 to December 2006) and the Closure Plan (Kidston Gold Mines Limited, 2000). The Closure Plan was implemented following completion of the major rehabilitation works, including the tailings storage facility, waste rock dump capping and completion of a Contaminated Lands Assessment (Stage 2) and remedial actions. The Contaminated Lands Assessment identified the primary contaminants present at the site as arsenic, which occurs naturally at the site as arsenopyrite in the ore and waste rock; hydrocarbons from spillage of oil and diesel fuels; and cyanide which is present in the South Pond sediments. Construction activities will consider the management of ground breaking activities through the Construction Environmental Management Plan, and, where required, address residual contamination issues. During operation, potential for impacts from contaminated land are considered to remain unchanged. The site will continue to be managed in accordance with the approved Plan of Operations and Environmental Authority.
Waste Management	Construction waste will be generated in high volumes throughout the construction of the Project. Waste will be transported back to Townsville on the vehicle that delivered the material to site. This was successfully undertaken as part of the KS1 Project and will form part of the construction program for this Project. Waste from operations will be generated mainly from the operations and maintenance building and is expected to be minimal. Waste will be general rubbish including putrescible waste, and recyclable material which will be placed into bins and disposed of at the waste facilities in Einasleigh.
Failure Impact Assessment	A Failure Impact Assessment has been completed for the proposed Wises Dam. The Failure Impact Assessment considered both Sunny Day and Dam Crest Failure flood of the Wises Dam. Evaluation of the population at risk varied for either a Sunny Day or Dam Crest Failure. The potential populations at risk was determined to be with the category of “two to 100 people”, and therefore defined as a Category 1 dam. The Failure Impact Assessment has been approved by the Chief Executive administering the *Water Supply (Safety and Reliability) Act 2008* under section 350 of the Act. This assessment also formed part of the development application process under the *Planning Act 2016*.

Aspect	Assessment Summary
Traffic	A Traffic Impact Assessment was undertaken as a part of the Development Application process under the *Planning Act 2016*. The estimated increase in traffic volumes along Gilberton Road during the construction phase will peak at 68 vehicles per day during month 14 of the construction works due to the construction phase coinciding with the Stage 2 Solar Farm Project. While no data is currently available to establish the exact traffic volumes currently on Gilberton Road it is expected that these volumes are relatively low based on current site observations. It is anticipated that the total traffic (including the construction traffic from the Project) would still be well below the limits of operation for a two way, two lane rural road. It is expected that there will be adequate "capacity" in the existing road network to cater for the additional trips generated by the Project. The operational phase of the Project is anticipated to have a peak traffic generation of 20 light vehicle movements for staff per day and at most 8 heavy vehicle movements per day (i.e. an AADT increase of 28). Staff movements are expected to be undertaken in 4WD vehicles and body trucks are the most likely vehicle to be used for deliveries. These traffic volumes are much lower than the construction phase of the Project and are also anticipated to have minimal impact on the existing road network. The Project site will be accessed from the external road network via Gilberton Road. The access locations will be confirmed during the detailed design stage. The final location of the access points will be based on achieving adequate sight distances for vehicles entering and exiting the intersections to ensure that safe operation of the accesses is achievable for all vehicles.
Noise and Vibration	Existing noise levels in the Project area are likely to be low, and dominated by typical rural activity, road usage and environmental contributors. The maintenance of the Kidston mine site may contribute a level of noise, however this is unlikely to be significant. The nearest sensitive receptor for noise is the Kidston Township, directly adjacent the site to the east. The regional meteorological data identifies the predominant wind patterns at the site are easterly. The Project has the potential to impact on the immediate area, and surrounding area during both construction and operation. No detailed noise and vibration impact assessments have been undertaken during this assessment, however both construction and operational activities have been considered. Construction activities that are likely to contribute to noise emissions include: • earthworks • blasting • drilling • rock stabilisation • concrete batching

Aspect	Assessment Summary
	• underground excavation works • increased vehicular movements • other general construction activities. During the operational stage, the noise and vibration impacts are likely to be less than those during construction. Operational equipment that may contribute to noise and vibration include: • operation of pumps • general operational activities • low level transport. Noise impacts associated with the water release at the Copperfield River are expected to be minor. The discharges will be occurring whilst the Copperfield River is already flowing, and the discharge site is more than 500m away from the closest residence, being the Kidston site manager's office.
Air Quality	The principal pollutant of concern for the Project in regard to potential impact on air quality is particulate matter from construction activities (dust). The Project's construction activities are likely to contribute to elevated levels of particulate include the following: • earthworks to raise the dam wall height • construction of concrete plinths to secure a high-density polyethylene liner • rock bolt stabilization works to batters • underground excavation works in hard rock to construct access tunnels • powerhouse cavern concrete and building works. The following data examines the prevailing meteorology and examines the constraints and risks likely to be associated with the dam construction activities. Regional meteorological data has been sourced from the Bureau of Meteorology (BOM) station located at Georgetown, approximately 100 kilometres north west of Kidston. The local area generally consists of slightly undulating terrain sloping to the north. The local relief of the surrounding area is minor and is not expected to influence air quality dispersion. No major industrial pollution sources are located in the area with road and aviation traffic (Kidston airport is located approximately one kilometre east of the site) the only potential pollution sources (although limited usage).

Aspect	Assessment Summary
	As the site is a decommissioned mine, there exists the potential for elevated levels of hazardous contaminants within the site, resulting in the potential for those pollutants to be within airborne dust generated during construction activities. The nearest sensitive receptors are located approximately 600m to the east of the site. It should be noted that the predominant wind patterns at the site are easterly suggesting that any pollution generated at the site would migrate to the west and is unlikely to affect the receptor locations. Given the lack of any complex terrain, major sources of pollution and given that the nearest sensitive receptors are positioned upwind of the site, with the implementation of appropriate management and mitigation measures there are only minor air quality issues requiring consideration in regard to the proposed works. The water discharge will be via diffusers into the Copperfield River during high flow periods. No air drift is anticipated and the discharge site is more than 500m away from the closest residence, being the Kidston site manager's office. Air quality impacts are not proposed to be further considered in the IAR.
Fisheries Waterways	Any structure located within the Copperfield River with a potential impact to fish passage, is anticipated to require a Development Permit for Waterway Barrier Works under the *Planning Act 2016*. Detailed design of the structure as it is positioned within the Copperfield River is not yet determined, however during the detailed design process, consideration will be given to existing and resulting fish passage, with the intent of minimising impacts where they may occur. It is also anticipated that where any significant residual impact to fish passage in the Copperfield River, resulting from the structure, will be subject to potential offset implications under the development approval process. Prior to lodging any development applications to obtained the before mentioned Development Permit, consultation will be undertaken with relevant State government departments, through the State Assessment and Referral Agency, pre-lodgement forum. The Department of Agriculture and Fisheries (DAF) mapping identified four low waterways to the northern section of the site. Of the four waterways only one had the potential to be relevant to the Project. The waterway is situated between the lower reservoir and the sloped area adjacent (to the immediate west of the lower reservoir). However the upper extent of the waterway is mapped a being below ground. Advice received from DAF stated no approval would be required for works in this area.