# Technical Note

| | | | |
|---|---|---|---|
| **Subject** | **Copperstring-2 High-Level Flood Risk Assessment** | **Project Name** | UGL CS_2 Flood Risk Analysis |
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| **Date** | June 2021 | | |
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## 1. Introduction

Jacobs has been engaged by UGL to undertake a desktop study to assess the existing flood conditions of the UGL Copperstring_2 (CS-2) Powerline. The main powerline alignment is between Mount Isa and Mulgrave and includes two spurs between Chumvale to Selwyn and from Mt James to Hughenden as shown in **Figure 1-1**.

Detailed CS-2 alignment maps are shown in **Appendix A**, including chainages and proposed tower locations.

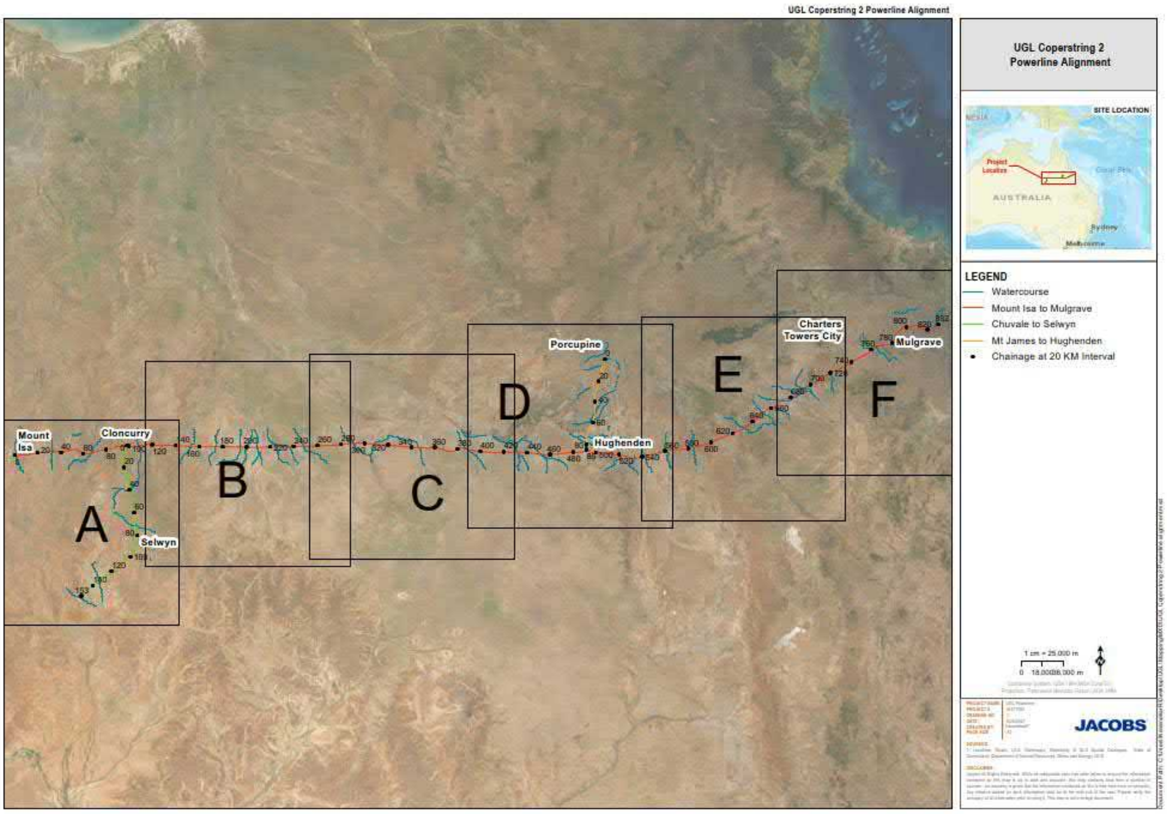


**Figure 1-1: UGL Coperstring-2 Powerline alignment**

- The proposed main Powerline alignment from Mount Isa to Mulgrave is approximately parallel to the Flinders Highway and crosses several major and minor waterways. The length of this section is about 914 km.

- The Chumvale to Selwyn spur starts near Phosphate Hill and joins the Mt Isa to Mulgrave line at Chainage 98 km. This alignment covers a length of about 85 km.

- The Mt James to Hughenden spur starts near Porcupine and joins the main line at Chainage 491 km. This alignment covers and length of about 153 km.

The proposed powerline alignments traverse major floodplains, including the Leichardt River, Flinders River and Burdekin River basin floodplains.

This high-level assessment of existing flood risk is based on existing and publicly available data, in combination with simplified regional methods. The outputs of this study include approximate flood extents and hydraulic parameters such as peak flood depth and velocity for the 1% and 0.5% Annual Exceedance Probability (AEP) along the proposed alignment.

### 1.1 Hydraulic Limitations/ Assumptions

The desktop study has the following limitations and assumptions:

- The assessment is a high-level, desktop study based on regional relationships. The estimations of peak flows and resulting peak levels therefore carry significant uncertainty.
- The study uses the relatively course topographic data (SRTM 1 Sec DEM), which limits the accuracy of the estimation of peak flood depths and flow velocities.
- No hydrological and hydraulic modelling has been undertaken as part of this assessment.

### 1.2 Available information

Data used for this assessment is listed in **Table 1-1**.

**Table 1-1: Available data**

| No. | Data type | Description |
|---|---|---|
| 1 | 30m DEM | Publicly available data, downloaded from ELVIS<br>This was used to delineate catchments boundaries |
| 2 | SRTM Hydro_Enforced_1_Second | Publicly available, downloaded from AusMap |
| 3 | Legacy XYZ LiDAR data | Provided by UGL as XYZ data. That can be used to extract the river/creek cross-sections for hydraulic parameter calculations. This data was provided after the hydraulic calcs has been finalised. |
| 4 | Powerline Alignment | Provided by UGL, that included the alignment and the proposed powerline tower locations. |
| 5 | Streamflow Data | Extracted from QLD Government website (https://water-monitoring.information.qld.gov.au/) to undertake flood frequency analysis. |
| 6 | QLD Globe Aerial Imagery 2019 | Used to derive the Manning's for each river crossing |
| 6 | Flood Maps | Queensland Recovery Authority (QRA) flood risk mapping |

# 2. Hydrological Assessment

## 2.1 General

A high-level hydrological assessment was undertaken to generate an approximate estimate of peak flood flows for 1%AEP and 0.5%AEP flood events.

## 2.2 Catchment Delineation

The proposed powerline alignment crosses numerous watercourses with a large range in catchment area upstream of the proposed crossing. The relevant waterway catchments were delineated based on 30m DEM obtained from Elevation Information System (ELVIS) data. An automated GIS technique was used to delineate the catchment boundaries, with some minor manual adjustments.

The waterway crossings were parametrised with catchment areas, river stream slopes at the location of the proposed crossing, and Manning's n roughness values. The relevant waterway catchment areas, ranging from 2km$^2$ up to approximately 36,000km$^2$, and the locations of major waterway streams are shown in **Figure 2-1**. The catchment details are summarised in **Table 2-1** for Mt Isa to Mulgrave Powerline alignment. **Table 2-2** shows the catchment parameters for Chumvale to Selwyn Powerline alignment, and **Table 2-3** shows the catchment parameters for Mt James to Hughenden Powerline alignment.

**Table 2-1: Catchment parameters for Mt Isa to Mulgrave Powerline waterway crossings**

| No | Powerline Chainage (m) | Waterway Name | Total Area (km$^2$) | Stream Slope (%) | Manning's n |
|---|---|---|---|---|---|
| 1 | 900 | Creek Crossing | 66 | 0.36 | 0.04 |
| 2 | 1,400 | Leichhardt River | 432 | 0.23 | 0.04 |
| 3 | 4,800 | Creek Crossing | 15 | 0.50 | 0.04 |
| 4 | 6,700 | Creek Crossing | 5 | 1.43 | 0.04 |
| 5 | 7,600 | Creek Crossing | 2 | 1.83 | 0.04 |
| 6 | 32,900 | Leichhardt River (East Branch) | 572 | 0.45 | 0.04 |
| 7 | 64,900 | Creek Crossing | 15 | 0.97 | 0.04 |
| 8 | 67,200 | Corella River | 475 | 0.28 | 0.04 |
| 9 | 101,500 | Creek Crossing | 4 | 0.38 | 0.04 |
| 10 | 108,500 | Cloncurry River | 1,431 | 0.10 | 0.04 |
| 11 | 148,300 | Creek Crossing | 290 | 0.05 | 0.04 - 0.05 |
| 12 | 152,500 | Williams River | 503 | 0.17 | 0.04 |
| 13 | 160,500 | Creek Crossing | 333 | 0.12 | 0.04 - 0.05 |
| 14 | 173,400 | Fullarton River | 683 | 0.12 | 0.04 |
| 15 | 184,100 | Creek Crossing | 50 | 0.18 | 0.04 - 0.05 |
| 16 | 194,700 | Holy Joe Creek | 363 | 0.12 | 0.04 |
| 17 | 199,800 | Gidya Creek | 1,535 | 0.08 | 0.04 |
| 18 | 208,700 | Gilliat River | 5,813 | 0.08 | 0.04 |
| 19 | 224,800 | Sadowa Creek | 909 | 0.02 | 0.04 |
| 20 | 235,200 | Eastern Creek | 2,090 | 0.04 | 0.04 |

| No | Powerline Chainage (m) | Waterway Name | Total Area ($km^2$) | Stream Slope (%) | Manning's n |
|---|---|---|---|---|---|
| 21 | 248,000 | Julia Creek | 842 | 0.04 | 0.04 |
| 22 | 253,700 | Floodplain | 20 | 0.17 | 0.04 - 0.05 |
| 23 | 290,665 | Alick Creek | 6,587 | 0.04 | 0.04 - 0.05 |
| 24 | 308,473 | Alick Creek | 1,224 | 0.04 | 0.04 - 0.05 |
| 25 | 346,810 | Alick Creek | 2,378 | 0.04 | 0.04 - 0.05 |
| 26 | 386,088 | O'Connell Creek | 1,269 | 0.08 | 0.04 - 0.05 |
| 27 | 428,600 | Tributary Creek Crossing | 42 | 0.18 | 0.04 - 0.05 |
| 28 | 431,714 | Sloane Creek | 784 | 0.06 | 0.04 - 0.05 |
| 29 | 450,861 | Warianna Creek | 1,252 | 0.06 | 0.04 |
| 30 | 451,098 | Walker Creek | 1,489 | 0.07 | 0.04 |
| 31 | 465,300 | Tributary Creek Crossing | 186 | 0.13 | 0.04 - 0.05 |
| 32 | 468,300 | Tributary Creek Crossing | 57 | 0.02 | 0.04 - 0.05 |
| 33 | 533,688 | Skeleton Creek | 51 | 0.10 | 0.04 |
| 34 | 542,557 | Prairie Creek | 120 | 0.13 | 0.04 |
| 35 | 560,714 | Bullock Creek | 964 | 0.13 | 0.04 |
| 36 | 584,802 | Torrens Creek | 755 | 0.18 | 0.04 |
| 37 | 620,200 | Tributary Creek Crossing | 416 | 0.25 | 0.04 |
| 38 | 626,000 | Tributary Creek Crossing | 547 | 0.25 | 0.04 |
| 39 | 631,143 | Warrigal Ck | 367 | 0.15 | 0.04 |
| 40 | 651,828 | Cape River | 1,242 | 0.14 | 0.04 - 0.05 |
| 41 | 670,918 | Campaspe River | 570 | 0.16 | 0.04 - 0.05 |
| 42 | 693,736 | Homestead Creek | 1,995 | 0.08 | 0.04 - 0.05 |
| 43 | 693,976 | Balfe Creek | 1,995 | 0.06 | 0.04 - 0.05 |
| 44 | 707,200 | Creek Crossing | 23 | 0.75 | 0.04 - 0.05 |
| 45 | 708,000 | Creek Crossing | 178 | 0.29 | 0.04 - 0.05 |
| 46 | 760,475 | Burdekin River | 36,381 | 0.02 | 0.04 - 0.05 |

**Table 2-2: Catchment parameters for Chumvale to Selwyn Powerline waterway crossings**

| No | Powerline Chainage (m) | Waterway Name | Total Area ($km^2$) | Stream Slope (%) | Manning's n |
|---|---|---|---|---|---|
| 1 | 16,000 | Floodplain | - | - | - |
| 2 | 17,100 | Creek Crossing | 213 | 0.26 | 0.04 - 0.05 |
| 3 | 21,500 | Creek Crossing | 43 | 0.31 | 0.04 - 0.05 |
| 4 | 24,400 | Creek Crossing | 11 | 0.43 | 0.04 |
| 5 | 32,300 | Creek Crossing | 6 | 1.00 | 0.04 |
| 6 | 39,712 | Cloncurry River | 3,255 | 0.13 | 0.04 - 0.05 |
| 7 | 49,800 | Creek Crossing | 254 | 0.20 | 0.04 - 0.05 |
| 8 | 68,700 | Creek Crossing | 77 | 0.18 | 0.04 - 0.05 |

| No | Powerline Chainage (m) | Waterway Name | Total Area ($km^2$) | Stream Slope (%) | Manning's n |
|---|---|---|---|---|---|
| 9 | 71,169 | Cloncurry River | 969 | 0.16 | 0.04 |
| 10 | 124,900 | Creek Crossing | 93 | 0.25 | 0.04 - 0.05 |
| 11 | 133,883 | Burke River | 2,584 | 0.10 | 0.04 - 0.05 |
| 12 | 149,100 | Creek Crossing | 13 | 0.28 | 0.04 |

**Table 2-3: Catchment parameters for Mt James to Hughenden Powerline waterway crossings**

| No | Powerline Chainage (m) | Waterway Name | Total Area ($km^2$) | Stream Slope (%) | Manning's n |
|---|---|---|---|---|---|
| 1 | 5,473 | Dutton River | 123 | 0.56 | 0.045 |
| 2 | 50,220 | Betts Gorge Creek | 714 | 0.30 | 0.045 |
| 3 | 56,792 | Horse Creek | 122 | 0.28 | 0.045 |
| 4 | 73,825 | Porcupine Creek | 2,144 | 0.09 | 0.045 |
| 5 | 78,704 | Flinders River | 2,543 | 0.15 | 0.045 |

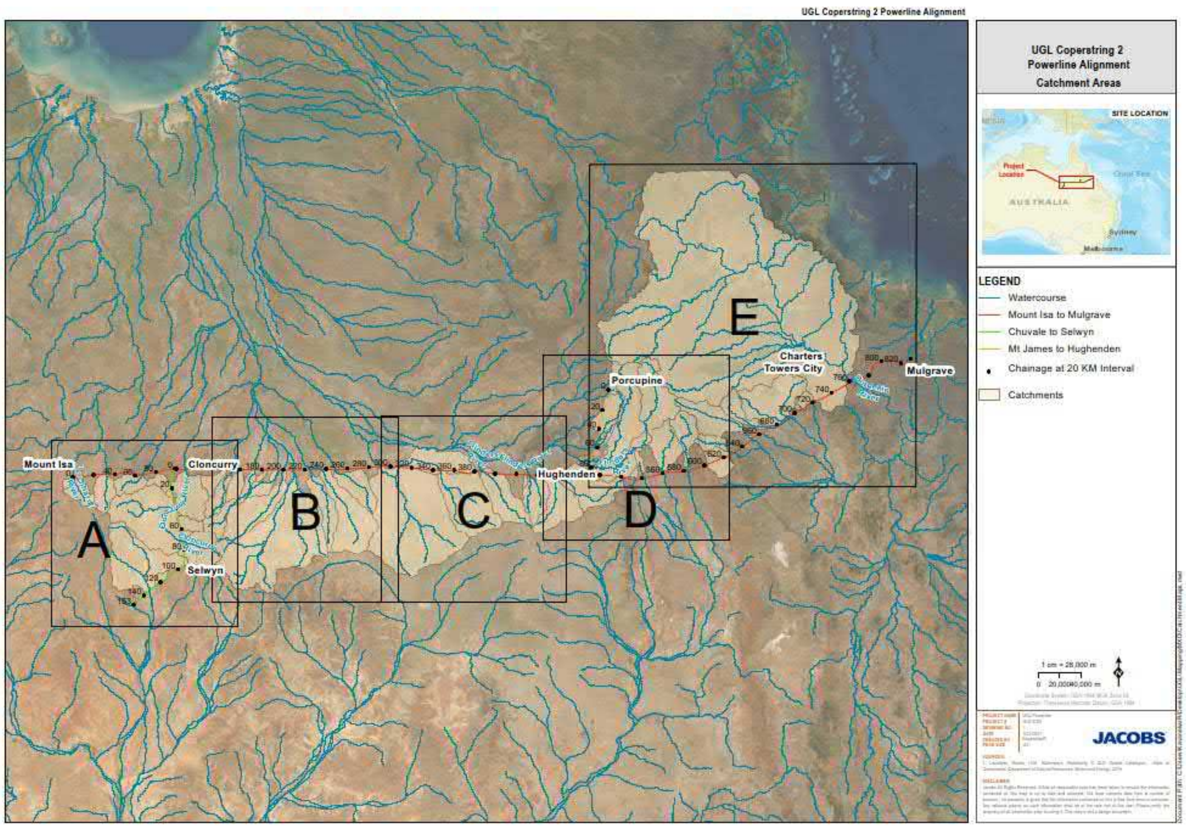


Figure 2-1: UGL Coperstring_2 Powerline alignment Catchment areas

Detailed catchment maps by segments are shown in **Appendix B**.

## 2.3 Design rainfall

The Intensity-Frequency-Duration (IFD) rainfall intensities (ARR2019) were extracted from the ARR Data Hub for the project area at several locations along the SC-2 Powerline alignment as this will vary with the catchment geographic location. **Appendix E** shows the design rainfall intensities (mm/hr) for comparison at three locations along the CS-2 alignment.

The **Appendix E** tables show that the design rainfall intensities vary greatly along the CS-2 Powerline alignment; therefore it is recommended to extract the design rainfall parameters for each specific location, when the design rainfall IFD is required for power tower pad stormwater drainage design.

## 2.4 Design Discharge Estimation

Taking into consideration the high-level nature of this flood risk assessment, a regional method has been used to estimate the design peak discharges for the 1%AEP and 0.5%AEP flood events. The 1%AEP flood peak was estimated using the Bill Weeks (Jan 2011) 1%AEP regional flood frequency estimate. This method correlates the catchment area and the peak discharge for 1%AEP flood event as shown in **Figure 2-2.**

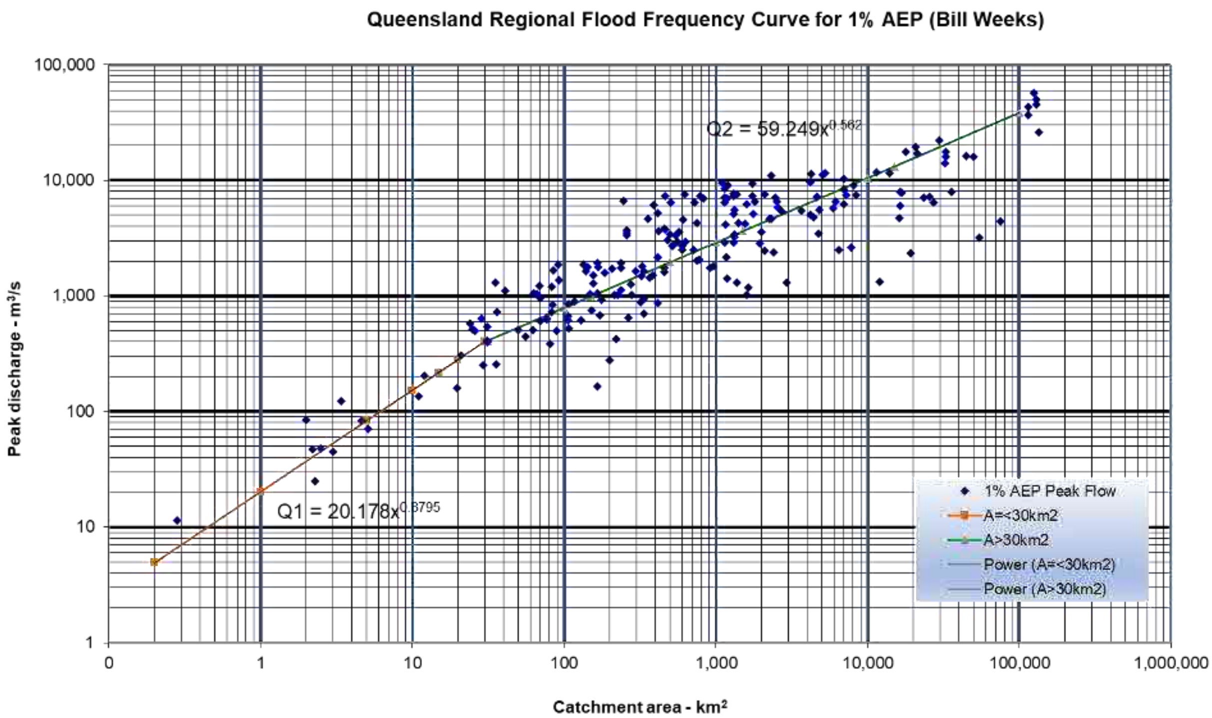


Figure 2-2: Queensland Regional flood frequency curve for 1%AEP event

The 0.5%AEP flood peak was estimated by factoring the 1%AEP flood peak by 1.2. This growth factor was estimated by comparing the 0.5%AEP flood peak to 1%AEP flood peak from the flood frequency analysis of recorded long-term annual flood peak data within the Cloncurry River, Flinders River and Burdekin River basins. However, it is strongly recommended that the design flood events should be estimated with proper hydrological model to reduce the uncertainty due to regional relationships.

**Table 2-4** shows the design peak discharge estimates for the river basins along the Mt Isa to Mulgrave Powerline alignment.

**Table 2-4: Design Flood Peaks for Mt Isa to Mulgrave CS-2 powerline alignment**

| No | Chainage | Waterway Name | Catchment Area | Peak Flow ($m^3/s$) | |
|---|---|---|---|---|---|
| | (m) | | ($km^2$) | 1% AEP | 0.5% AEP |
| 1 | 900 | Creek Crossing | 66 | 624 | 749 |
| 2 | 1,400 | Leichhardt River | 432 | 1,793 | 2,152 |
| 3 | 4,800 | Creek Crossing | 15 | 218 | 262 |
| 4 | 6,700 | Creek Crossing | 5 | 83 | 100 |
| 5 | 7,600 | Creek Crossing | 2 | 37 | 45 |
| 6 | 32,900 | Leichhardt River (East Branch) | 572 | 2,101 | 2,521 |
| 7 | 64,900 | Creek Crossing | 15 | 218 | 262 |
| 8 | 67,200 | Corella River | 475 | 1,892 | 2,271 |
| 9 | 101,500 | Creek Crossing | 4 | 68 | 82 |
| 10 | 108,500 | Cloncurry River | 1,431 | 3,517 | 4,220 |
| 11 | 148,300 | Creek Crossing | 290 | 1,434 | 1,721 |
| 12 | 152,500 | Williams River | 503 | 1,954 | 2,345 |
| 13 | 160,500 | Creek Crossing | 333 | 1,550 | 1,860 |
| 14 | 173,400 | Fullarton River | 683 | 2,321 | 2,785 |
| 15 | 184,100 | Creek Crossing | 50 | 534 | 641 |
| 16 | 194,700 | Holy Joe Creek | 363 | 1,626 | 1,951 |
| 17 | 199,800 | Gidya Creek | 1,535 | 3,658 | 4,390 |
| 18 | 208,700 | Gilliat River | 5,813 | 7,732 | 9,278 |
| 19 | 224,800 | Sadowa Creek | 909 | 2,725 | 3,269 |
| 20 | 235,200 | Eastern Creek | 2,090 | 4,351 | 5,221 |
| 21 | 248,000 | Julia Creek | 842 | 2,610 | 3,133 |
| 22 | 253,700 | Floodplain | 20 | 281 | 338 |
| 23 | 290,665 | Alick Creek | 6,587 | 8,295 | 9,953 |
| 24 | 308,473 | Alick Creek | 1,224 | 3,222 | 3,866 |
| 25 | 346,810 | Alick Creek | 2,378 | 4,679 | 5,614 |
| 26 | 386,088 | O'Connell Creek | 1,269 | 3,288 | 3,945 |
| 27 | 428,600 | Tributary Creek Crossing | 42 | 484 | 581 |
| 28 | 431,714 | Sloane Creek | 784 | 2,507 | 3,009 |
| 29 | 450,861 | Warianna Creek | 1,252 | 3,263 | 3,916 |
| 30 | 451,098 | Walker Creek | 1,489 | 3,596 | 4,315 |
| 31 | 465,300 | Tributary Creek Crossing | 186 | 1,117 | 1,341 |
| 32 | 468,300 | Tributary Creek Crossing | 57 | 575 | 690 |
| 33 | 533,688 | Skeleton Creek | 51 | 542 | 651 |
| 34 | 542,557 | Prairie Creek | 120 | 872 | 1,047 |
| 35 | 560,714 | Bullock Creek | 964 | 2,817 | 3,380 |
| 36 | 584,802 | Torrens Creek | 755 | 2,455 | 2,946 |

| No | Chainage | Waterway Name | Catchment Area | Peak Flow (m³/s) | |
|---|---|---|---|---|---|
| | (m) | | (km²) | 1% AEP | 0.5% AEP |
| 37 | 620,200 | Tributary Creek Crossing | 416 | 1,756 | 2,108 |
| 38 | 626,000 | Tributary Creek Crossing | 547 | 2,048 | 2,458 |
| 39 | 631,143 | Warrigal Ck | 367 | 1,638 | 1,966 |
| 40 | 651,828 | Cape River | 1242 | 3,247 | 3,897 |
| 41 | 670,918 | Campaspe River | 570 | 2,097 | 2,516 |
| 42 | 693,736 | Homestead Creek | 1995 | 4,239 | 5,087 |
| 43 | 693,976 | Balfe Creek | 1995 | 4,239 | 5,087 |
| 44 | 707,200 | Creek Crossing | 23 | 318 | 382 |
| 45 | 708,000 | Creek Crossing | 178 | 1,090 | 1,308 |
| 46 | 760,475 | Burdekin River | 36,381 | 21,672 | 26,006 |

**Table 2-5** shows the design peak discharge estimates for the river basins along the Chumvale to Selwyn Powerline alignment.

**Table 2-5: Design Flood Peaks for Chumvale to Selwyn CS-2 powerline alignment**

| No | Chainage | Waterway Name | Catchment Area | Peak Flow (m³/s) | |
|---|---|---|---|---|---|
| | (m) | | (km²) | 1% AEP | 0.5% AEP |
| 1 | 16,000 | Floodplain | - | - | - |
| 2 | 17,100 | Creek Crossing | 213 | 1,206 | 1,447 |
| 3 | 21,500 | Creek Crossing | 43 | 491 | 589 |
| 4 | 24,400 | Creek Crossing | 11 | 166 | 200 |
| 5 | 32,300 | Creek Crossing | 6 | 98 | 117 |
| 6 | 39,712 | Cloncurry River | 3,255 | 5,581 | 6,697 |
| 7 | 49,800 | Creek Crossing | 254 | 1,331 | 1,597 |
| 8 | 68,700 | Creek Crossing | 77 | 681 | 817 |
| 9 | 71,169 | Cloncurry River | 969 | 2,825 | 3,390 |
| 10 | 124,900 | Creek Crossing | 93 | 757 | 908 |
| 11 | 133,883 | Burke River | 2,584 | 4,903 | 5,883 |
| 12 | 149,100 | Creek Crossing | 13 | 193 | 231 |

**Table 2-6** shows the design peak discharge estimates for the river basins along the Chumvale to Selwyn Powerline alignment.

**Table 2-6: Design Flood Peaks for Mt James to Hughenden CS-2 powerline alignment**

| No | Chainage | Waterway Name | Catchment Area | Peak Flow (m³/s) | |
|---|---|---|---|---|---|
| | (m) | | (km²) | 1% AEP | 0.5% AEP |
| 1 | 5,473 | Dutton River | 123 | 885 | 1,062 |

| No | Chainage | Waterway Name | Catchment Area | Peak Flow ($m^3/s$) | |
|---|---|---|---|---|---|
| | (m) | | ($km^2$) | 1% AEP | 0.5% AEP |
| 2 | 50,220 | Betts Gorge Creek | 714 | 2,379 | 2,854 |
| 3 | 56,792 | Horse Creek | 122 | 880 | 1,056 |
| 4 | 73,825 | Porcupine Creek | 2,144 | 4,415 | 5,297 |
| 5 | 78,704 | Flinders River | 2,543 | 4,858 | 5,830 |

# 3. Flood Risk Assessment

## 3.1 General

The flood risk assessment for the CS-2 powerline alignment was based on existing flood maps of the river systems that traverse the proposed power line and by estimating the flood depths and flow velocities for river/creek crossings along the powerline alignment.

The hydraulic analysis for the river crossings was undertaken to provide an indication of key flood parameters such as peak depth and peak velocity. However, it should be noted that there is significant uncertainty within these estimates, and more detailed hydrological and hydraulic modelling works are recommended for areas where increased accuracy is required.

## 3.2 Existing flood maps

QRA flood risk mapping was readily available for major rivers across the project area. The flood risks presented in these maps are in some locations based on flood modelling studies, such as the Burdekin River. However, the majority of the data presented in the mapping is based on anecdotal flood marks and satellite images of historical flood events. It should be noted that the flood risks presented in these maps have not been assigned a statistical likelihood (i.e. an AEP). Therefore, limited reliance should be placed on these maps. For the purpose of this assessment, the following has been used:

- For the SC-2 Powerline alignment across the Burdekin River floodplain, the Burdekin River 1% AEP flood map was used.
- For crossings outside the Burdekin River floodplain, anecdotal and/or GIS based flood maps without AEP was used. These included the floodplains of Flinders River, Suttor River and Leichhardt Rivers.

**Figure 3-1** shows the QRA flood risk maps (https://www.business.qld.gov.au/running-business/support-assistance/mapping-data-imagery/maps/flood-mapping) for each major river/creek crossing along the powerline crossing. These are presented by segments in **Appendix C** to show with more detailed the flood extents.

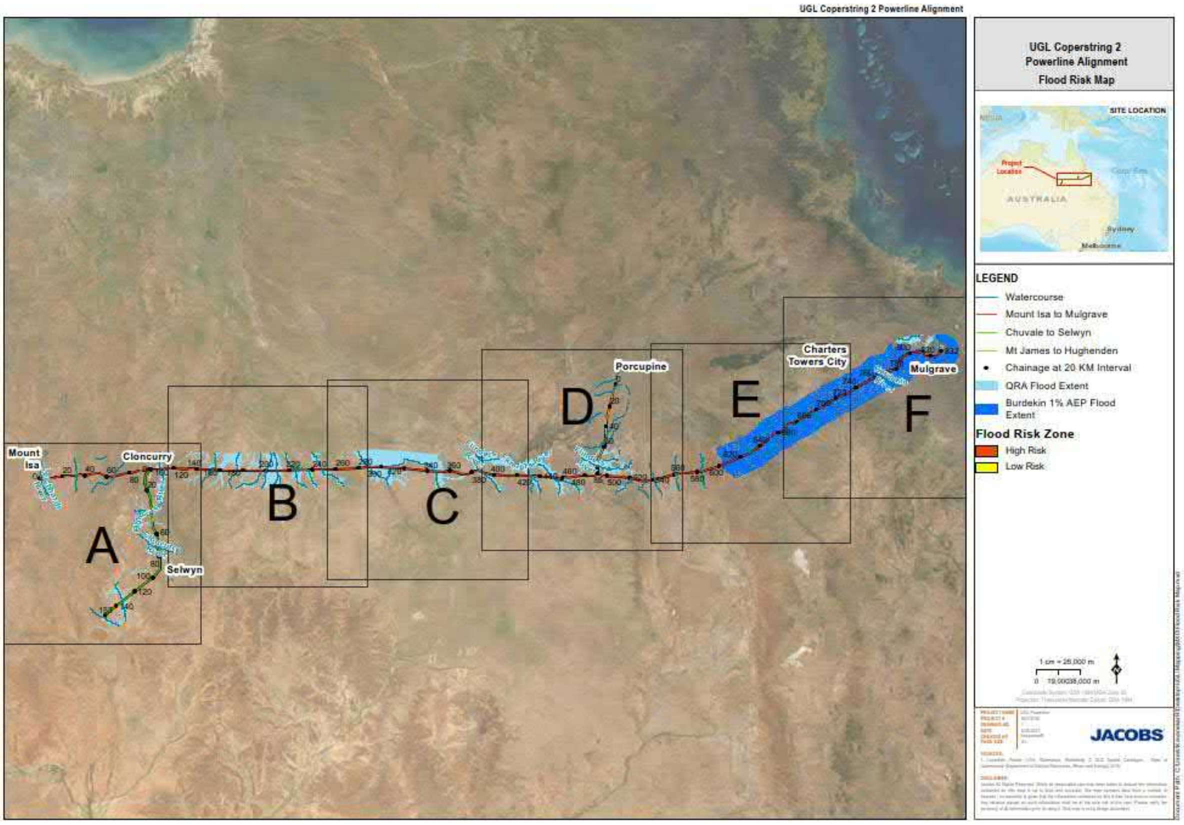


**Figure 3-1: QRA flood risk maps along the CS-2 powerline alignment**

## 3.3 Hydraulic parameter calculations

The project scope required to estimate the hydraulic parameters including the water depth, average flow velocity and critical flow depth for 1%AEP and 0.5%AEP flood events. This was undertaken with the USA Federal Highways Administration (FMA) Hydraulic Toolbox Ver 5.1.1.0, Channel Analysis module. The critical depth is the depth of flow where energy is at a minimum for a particular discharge.

This module is the Manning Equation solver using as input data the river channel cross-section geometry, river reach slope at crossing, the channel and floodplain Manning's n values and the design discharges for required AEPs.

### 3.3.1 River Cross-section

The river cross-sections were extracted using the best available LiDAR data provided by UGL. **Figure 3-2** shows an example of river cross-section extracted for Burdekin River at CS-2 Powerline crossing.

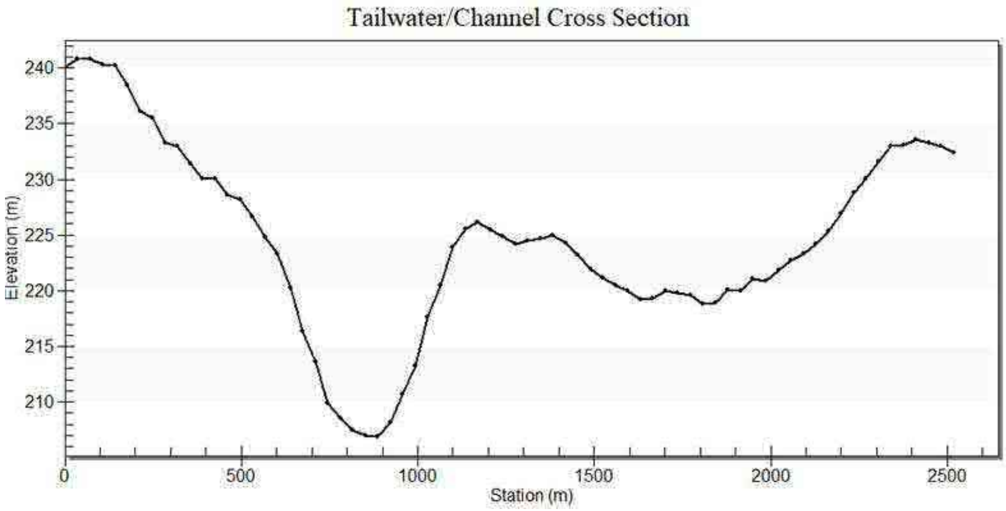


Figure 3-2: River Cross-section for Burdekin River at Powerline crossing

#### 3.3.2 Manning's n Roughness

The Manning's 'n' roughness values were based upon land use in the area. The aerial photography from Queensland government (2019) was used to visually estimate the Manning's n values for each river/creek crossing. These varied usually between 0.04 in the river channel and 0.05 to 0.06 in the floodplain or overbank areas.

**Table 3-1** shows the roughness "n" applied to each land use. The chosen Manning's (n) value for the watercourse was based on Brisbane City Council's Natural Channel Design guidelines.

**Table 3-1: Manning's n surface roughness values**

| No | Manning's n | Description |
|---|---|---|
| 1 | 0.035 | Kept grass / Parkland / Cleared |
| 2 | 0.045 | Unkept grass / Cleared / Very sporadic shrubs |
| 3 | 0.06 | Waterways / channels – minimal vegetation |
| 4 | 0.07 | Open pervious areas, minimal vegetation (grassed) |
| 5 | 0.09 | Heavy density vegetation |
| 6 | 0.05 | Roadside open drains |

### 3.4 Hydraulic analysis results

#### 3.4.1 Hydraulic Toolbox results

**Figure 3-3** shows the Hydraulic calculations results as an example for Burdekin River crossing. **Figure 3-3** shows the hydraulic analysis calculation example for Burdekin River crossing for 1%AEP flood event.

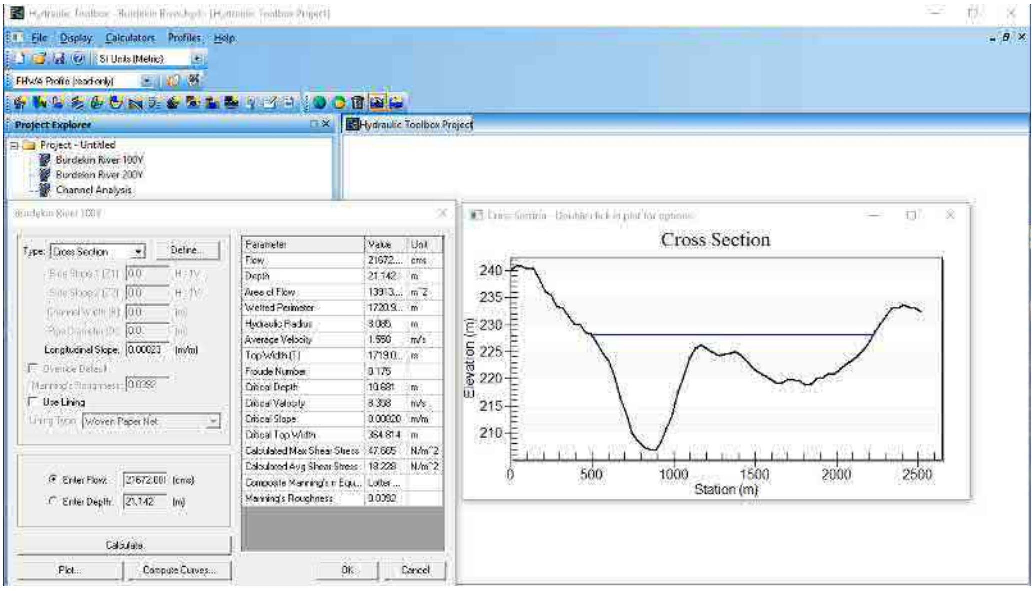


Figure 3-3: Hydraulic analysis results for Burdekin River at Powerline crossing

### 3.4.2 Hydraulic analysis results for CS-2 Powerline alignment

**Table 3-2** below shows the hydraulic analysis results for the CS-2 Powerline alignment from Mt Isa to Mulgrave.

**Table 3-2: Hydraulic parameters for CS-2 Power Alignment from Mt Isa to Mulgrave**

| No | Chainage | Waterway Name | Water Depth (m) | | Average flow velocity (m/s) | | Critical Depth (m) | | Flood Extent | Number of Affected Towers |
|---|---|---|---|---|---|---|---|---|---|---|
| | (m) | | 1% AEP | 0.5% AEP | 1% AEP | 0.5% AEP | 1% AEP | 0.5% AEP | (m) | (-) |
| 1 | 900 | Creek Crossing | 1.8 | 1.9 | 1.7 | 1.8 | 1.2 | 1.4 | 400 | 1 |
| 2 | 1,400 | Leichhardt River | 3.4 | 3.6 | 1.6 | 1.8 | 2.4 | 2.6 | 500 | 2 |
| 3 | 4,800 | Creek Crossing | 1.2 | 1.3 | 1.3 | 1.4 | 1.0 | 1.0 | 800 | 2 |
| 4 | 6,700 | Creek Crossing | 0.6 | 0.7 | 1.7 | 1.8 | 0.5 | 0.6 | 900 | 2 |
| 5 | 7,600 | Creek Crossing | 0.7 | 0.8 | 1.8 | 1.8 | 0.7 | 0.8 | 300 | 1 |
| 6 | 32,900 | Leichhardt River (East Branch) | 5.0 | 5.2 | 2.5 | 2.6 | 4.4 | 4.6 | 500 | 1 |
| 7 | 64,900 | Creek Crossing | 1.5 | 1.7 | 2.2 | 2.3 | 1.4 | 1.5 | 800 | 1 |
| 8 | 67,200 | Corella River | 3.7 | 4.0 | 2.1 | 2.2 | 2.6 | 2.8 | 800 | 3 |
| 9 | 101,500 | Creek Crossing | 0.6 | 0.6 | 0.8 | 0.9 | 0.4 | 0.4 | 2,500 | 5 |
| 10 | 108,500 | Cloncurry River | 6.6 | 7.1 | 1.8 | 1.9 | 4.0 | 4.3 | 6,900 | 13 |
| 11 | 148,300 | Creek Crossing | 3.1 | 3.3 | 0.8 | 0.8 | 1.6 | 1.8 | 2,600 | 6 |
| 12 | 152,500 | Williams River | 4.1 | 4.2 | 1.0 | 1.1 | 3.0 | 3.2 | 1,500 | 4 |

| No | Chainage | Waterway Name | Water Depth (m) | | Average flow velocity (m/s) | | Critical Depth (m) | | Flood Extent | Number of Affected Towers |
|---|---|---|---|---|---|---|---|---|---|---|
| | (m) | | 1% AEP | 0.5% AEP | 1% AEP | 0.5% AEP | 1% AEP | 0.5% AEP | (m) | (-) |
| 13 | 160,500 | Creek Crossing | 3.0 | 3.2 | 0.9 | 0.9 | 2.2 | 2.3 | 1,800 | 4 |
| 14 | 173,400 | Fullarton River | 2.7 | 2.8 | 0.9 | 1.0 | 1.9 | 1.9 | 3,500 | 6 |
| 15 | 184,100 | Creek Crossing | 1.6 | 1.8 | 1.0 | 1.0 | 1.2 | 1.2 | 1,700 | 4 |
| 16 | 194,700 | Holy Joe Creek | 2.5 | 2.6 | 1.0 | 1.1 | 1.7 | 1.8 | 1,400 | 3 |
| 17 | 199,800 | Gidya Creek | 2.6 | 2.7 | 0.7 | 0.7 | 1.7 | 1.8 | 7,100 | 13 |
| 18 | 208,700 | Gilliat River | 3.5 | 3.7 | 1.1 | 1.1 | 2.0 | 2.1 | 8,000 | 14 |
| 19 | 224,800 | Sadowa Creek | 3.8 | 4.0 | 0.5 | 0.5 | 1.9 | 2.1 | 9,700 | 16 |
| 20 | 235,200 | Eastern Creek | 4.3 | 4.6 | 0.8 | 0.9 | 2.3 | 2.5 | 4,300 | 10 |
| 21 | 248,000 | Julia Creek | 3.3 | 3.4 | 0.7 | 0.7 | 1.8 | 2.0 | 3,200 | 6 |
| 22 | 253,700 | Floodplain | 1.6 | 1.7 | 0.8 | 0.8 | 1.1 | 1.2 | 2,400 | 4 |
| 23 | 290,665 | Alick Creek | 4.7 | 4.9 | 0.8 | 0.8 | 2.6 | 2.8 | 20,300 | 29 |
| 24 | 308,473 | Alick Creek | 0.6 | 2.9 | 0.6 | 0.6 | 1.6 | 1.7 | 2,100 | 10 |
| 25 | 346,810 | Alick Creek | 3.9 | 4.1 | 0.8 | 0.8 | 2.1 | 2.2 | 8,200 | 15 |
| 26 | 386,088 | O'Connell Creek | 4.2 | 4.4 | 1.0 | 1.1 | 2.9 | 3.0 | 12,100 | 14 |
| 27 | 428,600 | Tributary Creek Crossing | 1.5 | 1.6 | 0.8 | 0.9 | 1.1 | 1.1 | 600 | 1 |
| 28 | 431,714 | Sloane Creek | 3.5 | 3.7 | 0.8 | 0.8 | 2.4 | 2.4 | 3,200 | 5 |
| 29 | 450,861 | Warianna Creek | 3.5 | 3.6 | 0.8 | 0.9 | 2.2 | 2.3 | 2,700 | 5 |
| 30 | 451,098 | Walker Creek | 3.4 | 3.7 | 0.9 | 0.9 | 2.3 | 2.4 | 8,300 | 15 |
| 31 | 465,300 | Tributary Creek Crossing | 2.7 | 2.9 | 1.2 | 1.3 | 1.6 | 1.7 | 600 | 2 |
| 32 | 468,300 | Tributary Creek Crossing | 2.8 | 3.0 | 0.5 | 0.5 | 1.2 | 1.3 | 2,700 | 6 |
| 33 | 533,688 | Skeleton Creek | 2.3 | 2.5 | 0.8 | 0.9 | 1.2 | 1.3 | 400 | 2 |
| 34 | 542,557 | Prairie Creek | 1.7 | 1.8 | 0.8 | 0.8 | 1.1 | 1.1 | 1,640 | 4 |
| 35 | 560,714 | Bullock Creek | 6.1 | 6.6 | 1.9 | 2.0 | 3.9 | 4.2 | 500 | 1 |
| 36 | 584,802 | Torrens Creek | 5.8 | 6.1 | 1.9 | 2.0 | 3.7 | 4.0 | 1,400 | 1 |
| 37 | 620,200 | Tributary Creek Crossing | 4.0 | 4.4 | 2.2 | 4.2 | 2.9 | 3.1 | 1,800 | 2 |
| 38 | 626,000 | Tributary Creek Crossing | 3.9 | 4.3 | 2.2 | 2.3 | 2.7 | 3.0 | 2,500 | 4 |
| 39 | 631,143 | Warrigal Ck | 4.1 | 4.2 | 1.3 | 1.3 | 3.0 | 3.1 | 2,100 | 5 |
| 40 | 651,828 | Cape River | 4.1 | 4.3 | 1.3 | 1.4 | 3.0 | 3.2 | 2,400 | 5 |
| 41 | 670,918 | Campaspe River | 2.6 | 2.7 | 1.2 | 1.2 | 1.8 | 1.9 | 1,800 | 6 |
| 42 | 693,736 | Homestead Creek | 2.8 | 3.0 | 0.9 | 0.9 | 1.7 | 1.8 | 8,900 | 17 |
| 43 | 693,976 | Balfe Creek | 2.9 | 3.1 | 0.8 | 0.8 | 1.7 | 1.8 | 2,900 | 6 |

| No | Chainage | Waterway Name | Water Depth (m) | | Average flow velocity (m/s) | | Critical Depth (m) | | Flood Extent | Number of Affected Towers |
|---|---|---|---|---|---|---|---|---|---|---|
| | (m) | | 1% AEP | 0.5% AEP | 1% AEP | 0.5% AEP | 1% AEP | 0.5% AEP | (m) | (-) |
| 44 | 707,200 | Creek Crossing | 1.2 | 1.2 | 1.5 | 1.6 | 1.0 | 1.0 | 600 | 2 |
| 45 | 708,000 | Creek Crossing | 3.2 | 3.4 | 1.6 | 1.7 | 2.6 | 2.8 | 2,100 | 3 |
| 46 | 760,475 | Burdekin River | 21.1 | 22.3 | 1.6 | 1.6 | 10.7 | 11.7 | 12,400 | 90 |

**Table 3-3** below shows the hydraulic analysis results for the CS-2 Powerline alignment from Chumvale to Selwyn.

**Table 3-3: Hydraulic parameters for CS-2 Power Alignment from Chumvale to Selwyn**

| No | Chainage | Waterway Name | Water Depth (m) | | Average Water Depth (m/s) | | Critical Depth (m) | | Flood Extent | Affected Towers |
|---|---|---|---|---|---|---|---|---|---|---|
| (-) | (m) | | 1% AEP | 0.5% AEP | 1% AEP | 0.5% AEP | (-) | 0.5% AEP | (m) | (-) |
| 1 | 16,000 | Floodplain | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 400 | 1 |
| 2 | 17,100 | Creek Crossing | 3.4 | 3.6 | 1.8 | 1.9 | 2.4 | 2.8 | 500 | 1 |
| 3 | 21,500 | Creek Crossing | 1.8 | 1.9 | 1.4 | 1.5 | 1.3 | 1.4 | 370 | 1 |
| 4 | 24,400 | Creek Crossing | 1.6 | 1.7 | 1.4 | 1.4 | 1.2 | 1.3 | 170 | 1 |
| 5 | 32,300 | Creek Crossing | 0.8 | 0.9 | 1.5 | 1.6 | 0.7 | 0.8 | 140 | 1 |
| 6 | 39,712 | Cloncurry River | 6.6 | 7.1 | 2.1 | 2.2 | 4.5 | 4.8 | 4,200 | 7 |
| 7 | 49,800 | Creek Crossing | 4.4 | 4.7 | 1.9 | 2.0 | 3.1 | 3.3 | 400 | 1 |
| 8 | 68,700 | Creek Crossing | 1.5 | 1.6 | 1.0 | 1.0 | 0.9 | 1.0 | 3,000 | 4 |
| 9 | 71,169 | Cloncurry River | 4.0 | 4.4 | 2.0 | 2.1 | 2.4 | 2.7 | 1,600 | 2 |
| 10 | 124,900 | Creek Crossing | 1.7 | 1.9 | 1.3 | 1.4 | 1.2 | 1.3 | 590 | 2 |
| 11 | 133,883 | Burke River | 4.0 | 4.2 | 1.0 | 1.0 | 2.9 | 3.0 | 3,900 | 8 |
| 12 | 149,100 | Creek Crossing | 1.1 | 1.2 | 0.9 | 0.9 | 0.7 | 0.8 | 422 | 1 |

**Table 3-4** below shows the hydraulic analysis results for the CS-2 Powerline alignment from Mt James to Hughenden.

**Table 3-4: Hydraulic parameters for CS-2 Power Alignment from Mt James to Hughenden**

| No | Chainage | Waterway Name | Water Depth (m) | | Average Water Depth (m/s) | | Critical Depth (m) | | Flood Extent | Affected Towers |
|---|---|---|---|---|---|---|---|---|---|---|
| (-) | (m) | | 1% AEP | 0.5% AEP | 1% AEP | 0.5% AEP | 1% AEP | 0.5% AEP | (m) | (-) |
| 1 | 16,000 | Floodplain | 2.9 | 3.1 | 2.2 | 2.3 | 2.3 | 2.5 | 550 | 1 |
| 2 | 17,100 | Creek Crossing | 6.9 | 7.2 | 2.4 | 2.5 | 5.3 | 5.6 | 400 | 2 |
| 3 | 21,500 | Creek Crossing | 2.3 | 2.6 | 1.6 | 1.7 | 1.5 | 1.6 | 350 | 2 |
| 4 | 24,400 | Creek Crossing | 3.3 | 3.4 | 2.0 | 2.1 | 2.8 | 3.0 | 1,710 | 6 |
| 5 | 32,300 | Creek Crossing | 4.0 | 4.1 | 1.0 | 1.1 | 2.9 | 3.1 | 3,890 | 15 |

# 4. Flood risk analysis

## 4.1 General

The flood risk for specific infrastructure is quantified by considering both peak flood depth and velocity. It is important to understand the relative degree of hazard and the underlaying flood behaviour causing the hazard (e.g. high depth, high velocity, depth and velocity combined), as these may require different mitigation management approaches and applicable design standards. **Table 4-1** shows the risk categories based on flow velocities (Australian Institute for Disaster Resilience, 2014). This table is indicative only for flood risk matrix assessment and cannot be used for design.

**Table 4-1: Flood risk categories**

| No | Velocity Range (m/s) | Risk Category |
|---|---|---|
| 1 | 0 - 1 | Low |
| 2 | 1 - 2 | Medium |
| 3 | 2 - 3 | High |
| 4 | >3 | Very high |

ARR 2019 recommends considering constructing a purpose-built structure that is an appropriately engineered structure specifically designed to withstand the full range of anticipated flood forces including:

- **Hydrostatic forces**: resulting from standing water or slow-moving flow around the structure.
- **Buoyant forces**: due to displaced volume of water.
- **Hydrodynamic forces**: arising from moderate-to-high-velocity water flow around the structure.
- **Impulsive Forces**: caused by the leading edge of the water impacting the structure.

- **Uplift forces**: on elevated floors of a structure that are submerged during a flood event.
- **Debris Impact Forces**: generated by floating debris colliding with the structure.
- **Damming of Waterborne Debris**: due to the accumulation of debris on the upstream side of the structure, which results in an increase in the hydrodynamic force.
- **Wave actions**: from wind and waves; and
- **Erosion and Scour**: due to flood actions such as flow velocities and shear stresses.

### 4.2 CS-2 powerline towers flood risk assessment

A vast area along the study corridor is inundated by overland flows even during the frequent flood events. A typical flood extent for the study area is presented in Figure 4-1, for 1% AEP flood event for the Burdekin River. The flood extents for the existing conditions from QRA are provided in Appendix D in several segments to appreciate better the flood risk areas.

The results of hydraulic analysis show that the average flow velocities for 1%AEP event can vary from less than 1m/s to 2.5m/s whereas for the 0.5%AEP event can vary up to 4.2m/s. The highest average flow velocities are localised in the main river channels whereas in the floodplain/overbank velocities are generally less than 1m/s.

To undertake a proper flood risk analysis for the powerline towers a flood modelling work is required using 1d/2d models such as TUFLOW. At this stage the nominated flood risk areas were defined taking into consideration the flood extent across the floodplains. For example, the powerline corridor across the Burdekin River floodplain is considered as high flood risk area as show in **Figure 4-1**.

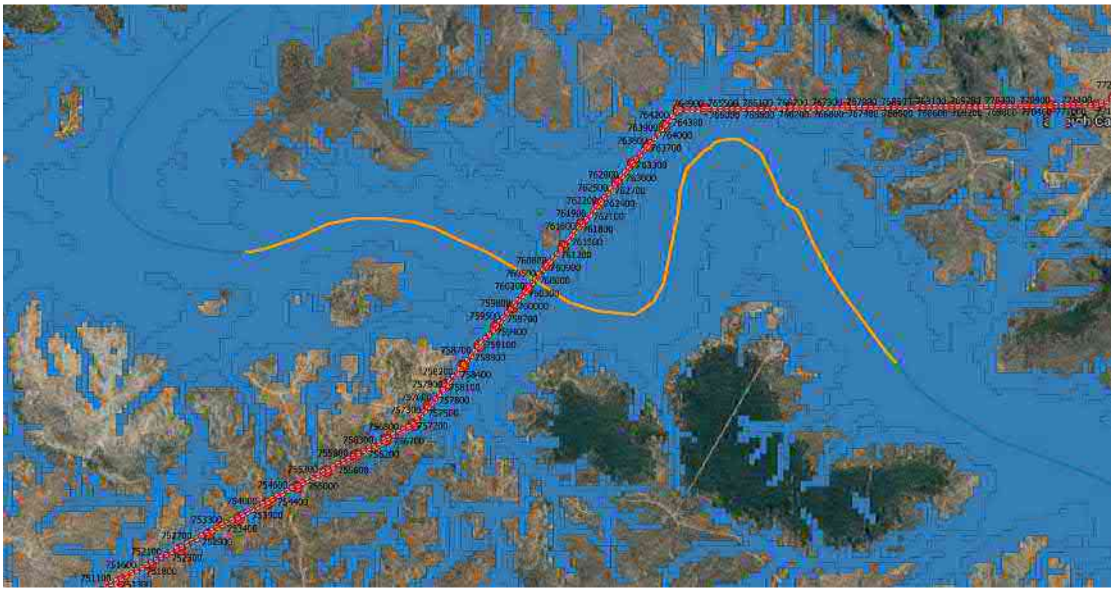

**Figure 4-1: 1% AEP flood extent for the Burdekin River (QRA)**

The areas in between the flood extents has been classified as low flood risk areas, the flood risk maps are shown in **Appendix D**.

This flood risk classification will identify locations with a higher flood risk which may benefit from a detailed flood risk investigation. More detailed flood modelling study would also allow to assess the flooding impact of the proposed CS-2 Powerline tower impact on the existing conditions. The results may be required for the environmental impact assessment and the relevant government approvals.

# 5. Conclusion and Recommendations

## 5.1 Conclusions

The UGL Copperstring-2 Powerline project traverses major river basin floodplain including the Leichhardt River, Cloncurry River, Flinders River and Burdekin River.

- The proposed main Powerline alignment from Mount Isa to Mulgrave is approximately parallel to the Flinders Highway and crosses about 46 major and medium size waterways. The number of affected towers is about 371.

- The Chumvale to Selwyn section starts near Phosphate Hill and joins the Mt Isa to Mulgrave line at Chainage 98 km and crosses about 12 major and medium size waterways. The number of affected towers is about 30.

- The Mt James to Hughenden section starts near Porcupine and joins the main line at Chainage 491 km and crosses about 5 major and medium size waterways. The number of affect towers are about 26.

The high-level hydraulic analysis identified about 63 major and medium size watercourse crossings and provided indicative flood depths and average flow velocities for each crossing.

Due to the significant uncertainty around the provided estimate, all river crossings have been classified to fall within the high-risk area, and the areas in between those to be within the low risk area. The current level of study does not permit to identify areas that are at no risk of flooding.

This report is a high-level flood risk assessment only that can be used to assess the relative risks and safety matrix of powerline towers located within the floodplain areas.

## 5.2 Recommendations

The following are the recommendations for next stage:

- Update the high-level assessment hydraulic calculations (Table 3-2, Table 3-3 and Table 3-4) using the UGL latest LiDAR data.

- Review the existing TMR Flinders Highway flood models to assess the model area of coverage that can be used in the next stage of the project.

- Undertake targeted hydrological and 2d hydraulic modelling for high flood risk areas.

- Assess the scour depts for each tower located within the high flood risk area. This task can only be completed when the flood modelling works are commissioned.

- Assess the flooding impacts of the proposed powerline towers for environmental approvals. This task can only be completed when the flood modelling works are commissioned.

## 6. References


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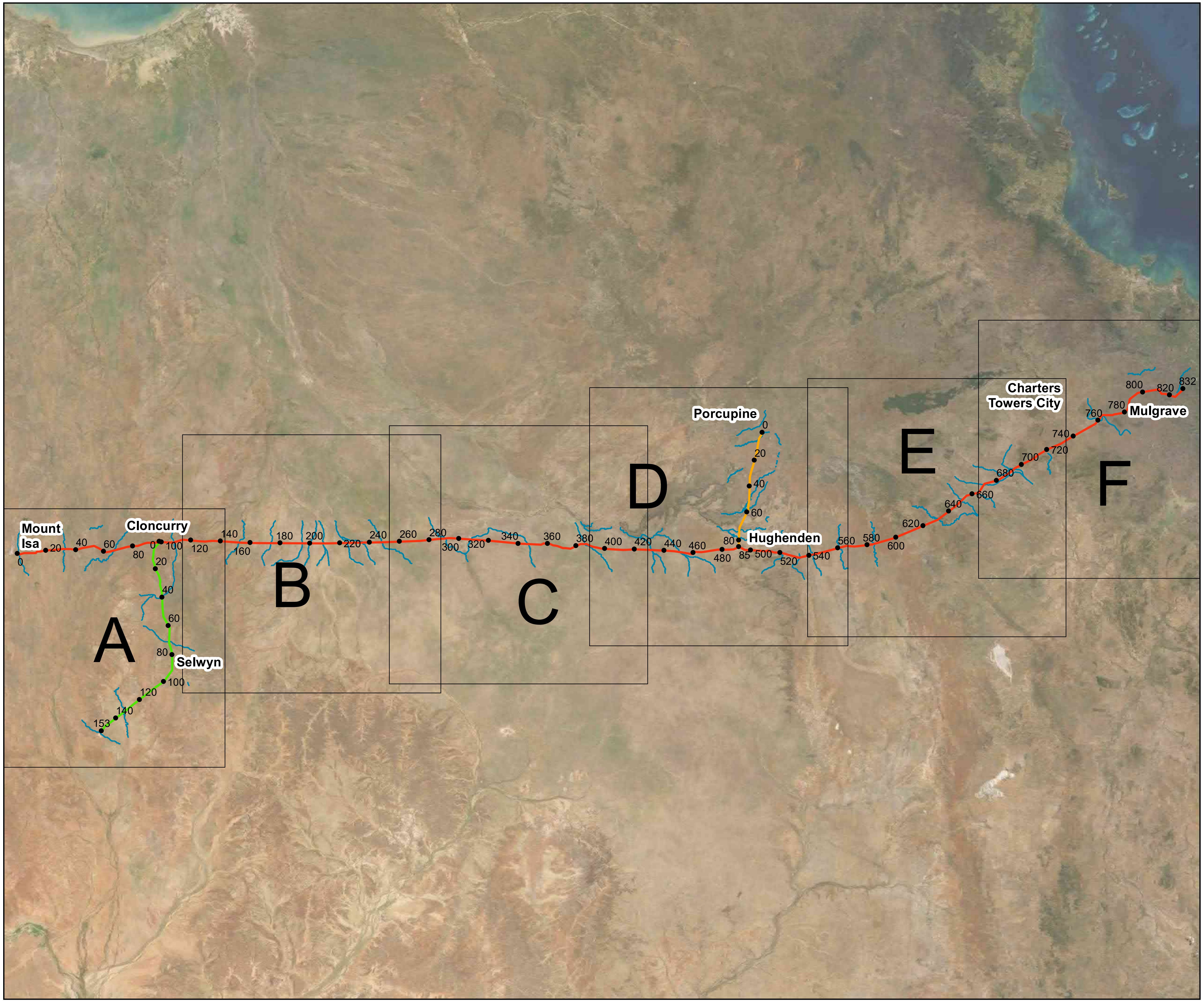
## Appendix A: UGL CS-2 Powerline Alignment




## UGL Coperstring 2 Powerline Alignment


LEGEND

- Watercourse
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval

1 cm = 25,000 m

0 18,000 36,000 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

| | |
|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
| DATE | 5/26/2021 |
| CREATED BY | KavanekarR |
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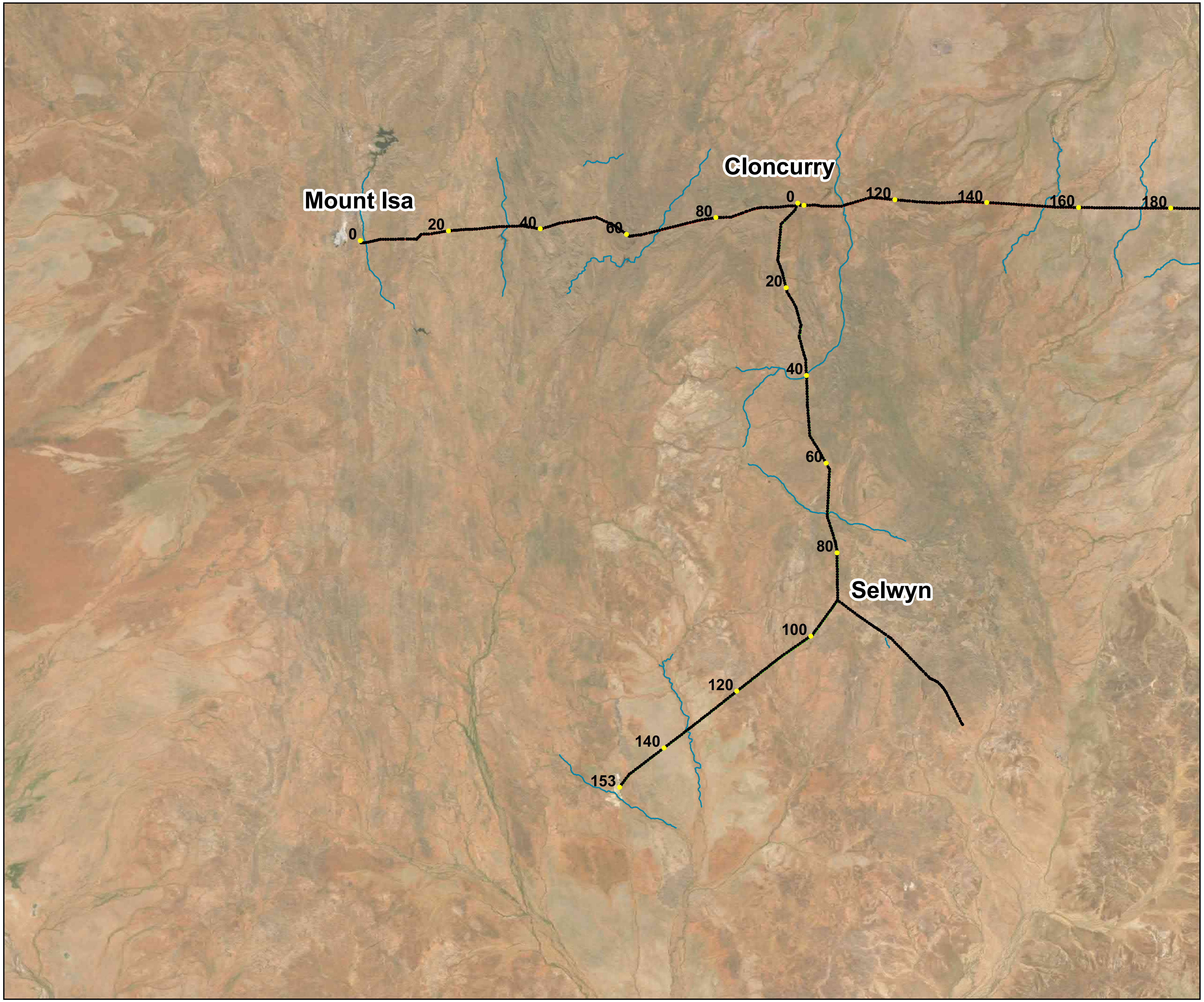


A

# UGL Coperstring 2 Powerline Alignment


## LEGEND

- Watercourse
- Tower Locations
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval

1 cm = 8,110 m

0 6,000 12,000 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

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|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
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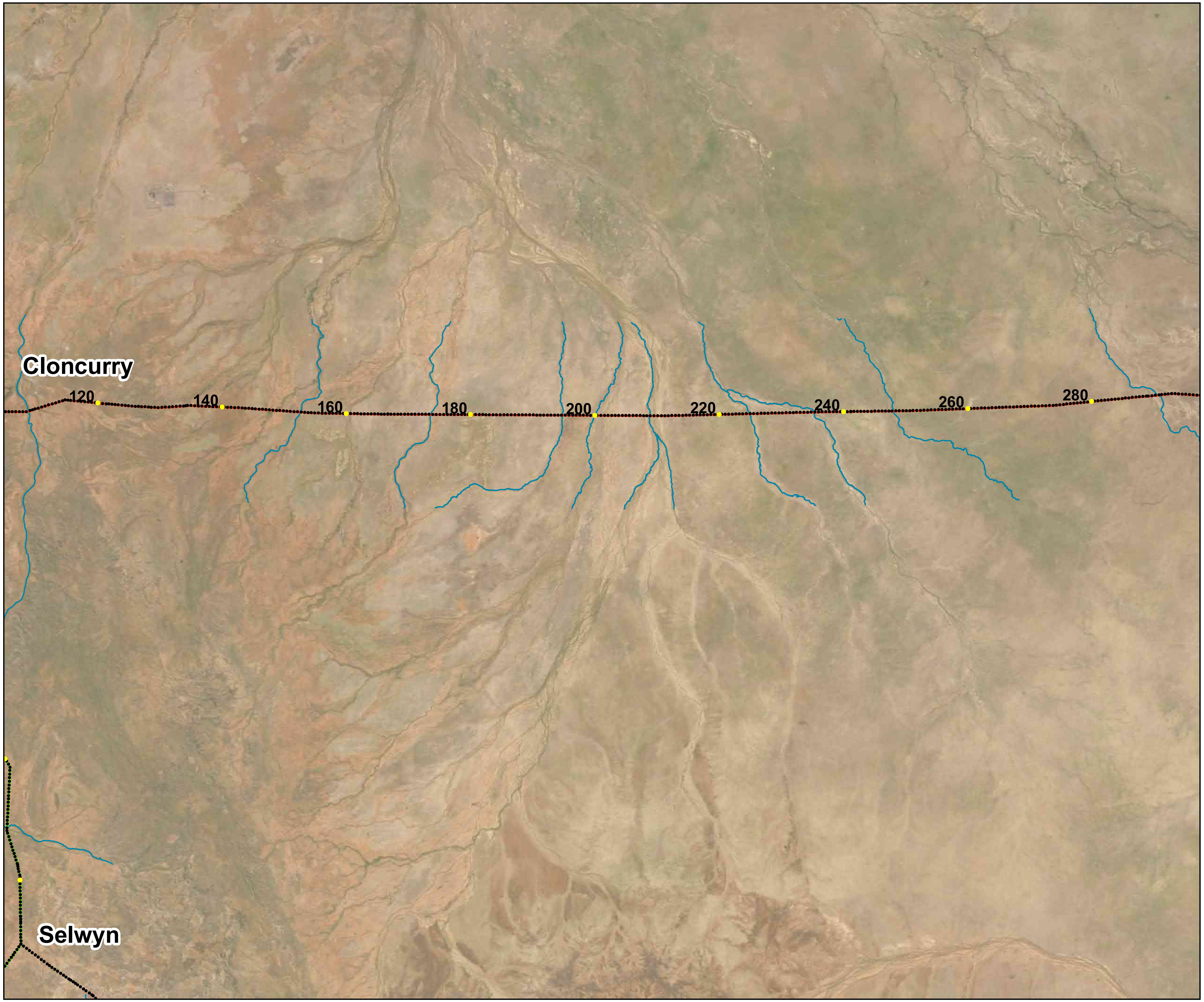


B

# UGL Coperstring 2 Powerline Alignment


## LEGEND

- Watercourse
- Tower Locations
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval

1 cm = 6,000 m

0 4,600 9,200 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

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|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
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C

# UGL Coperstring 2 Powerline Alignment


## LEGEND

- Watercourse
- Tower Locations
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval

1 cm = 6,000 m

0 4,600 9,200 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

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|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
| DATE | 5/26/2021 |
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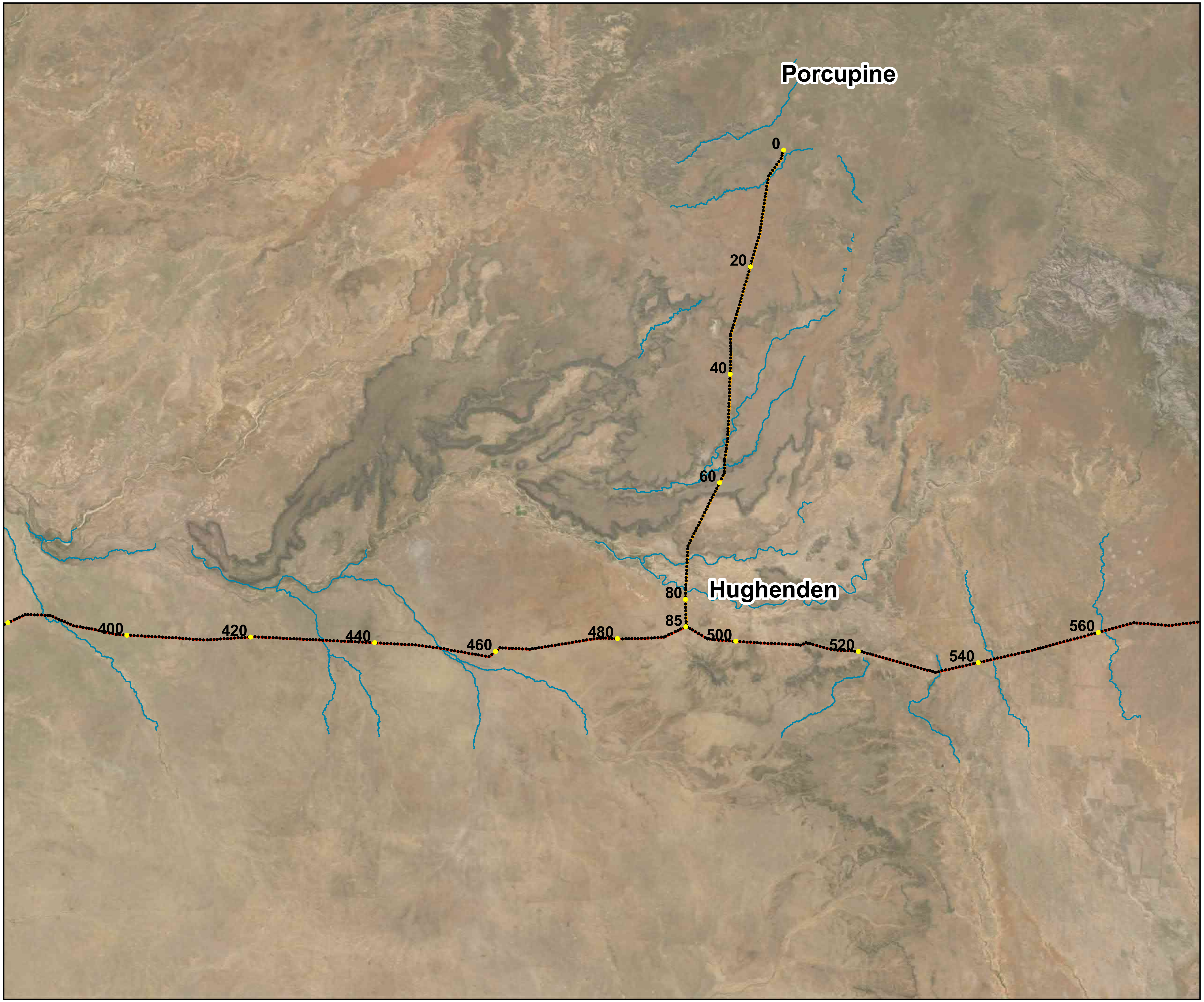
UGL Coperstring 2 Powerline Alignment




D

# UGL Coperstring 2 Powerline Alignment


## LEGEND

- Watercourse
- Tower Locations
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval

1 cm = 6,000 m

0 4,600 9,200 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

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|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
| DATE | 5/26/2021 |
| CREATED BY | KavanekarR |
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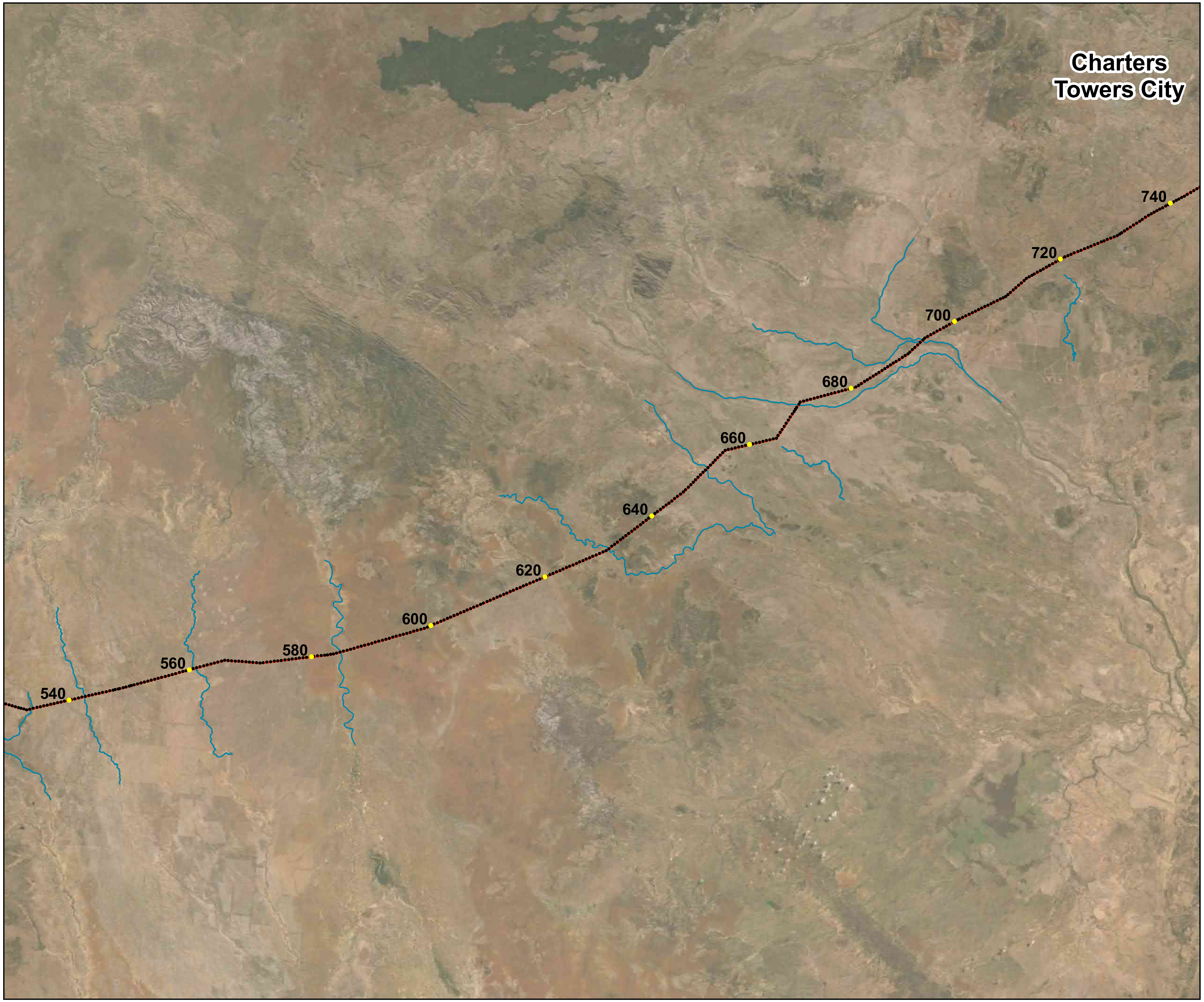
UGL Coperstring 2 Powerline Alignment




E

## UGL Coperstring 2 Powerline Alignment


## LEGEND

- Watercourse
- Tower Locations
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval

1 cm = 6,000 m

0 4,600 9,200 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

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|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
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F

## UGL Coperstring 2 Powerline Alignment

SITE LOCATION


## LEGEND

- Watercourse
- Tower Locations
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval

1 cm = 6,000 m

0 4,600 9,200 m

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

| | |
|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
| DATE | 5/26/2021 |
| CREATED BY | KavanekarR |
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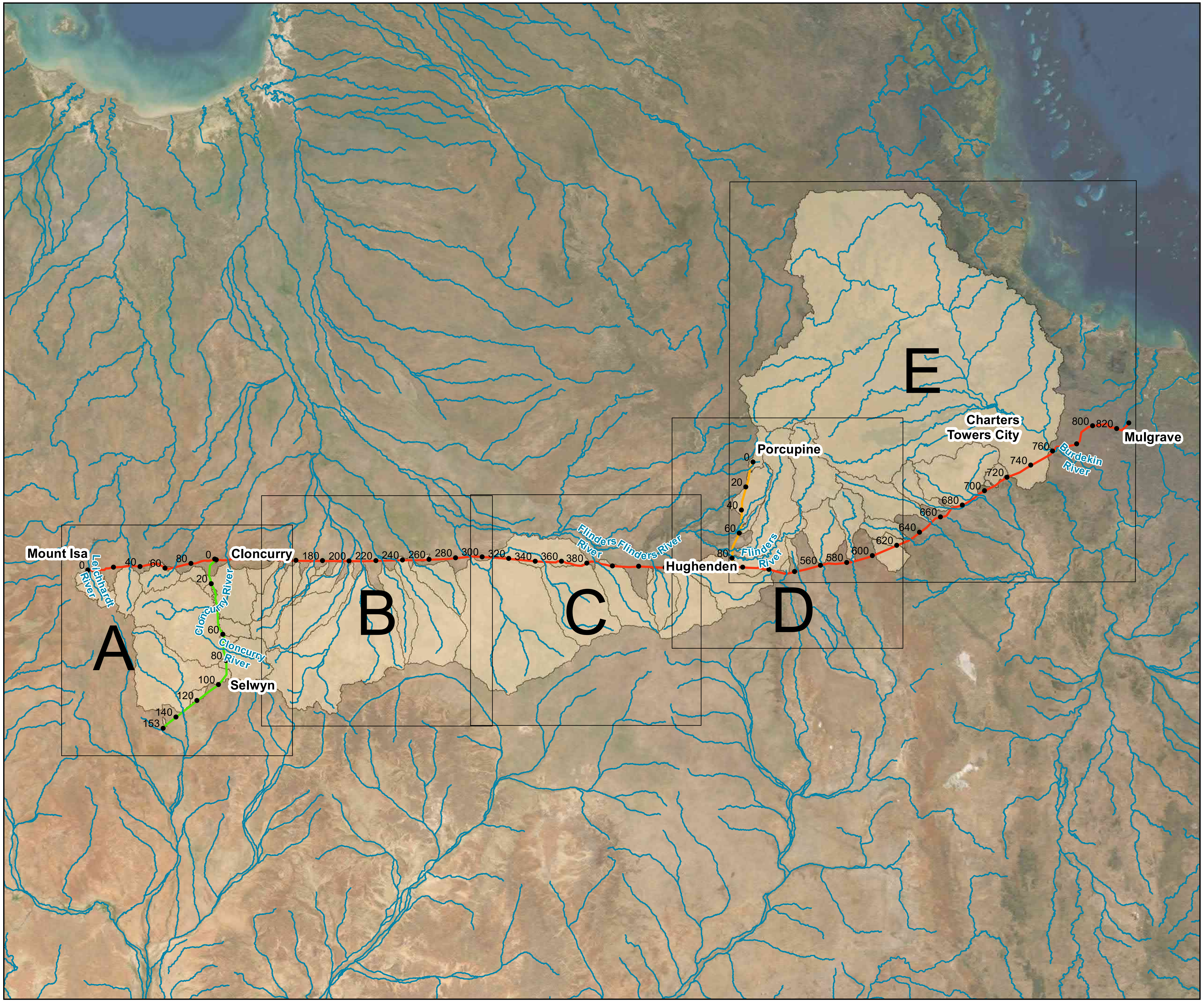
## Appendix B: UGL CS-2 Powerline – Catchment Maps




# UGL Coperstring 2 Powerline Alignment Catchment Areas


## LEGEND

- Watercourse
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval
- Catchments

1 cm = 28,000 m

0 20,000 40,000 m

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

| | |
|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
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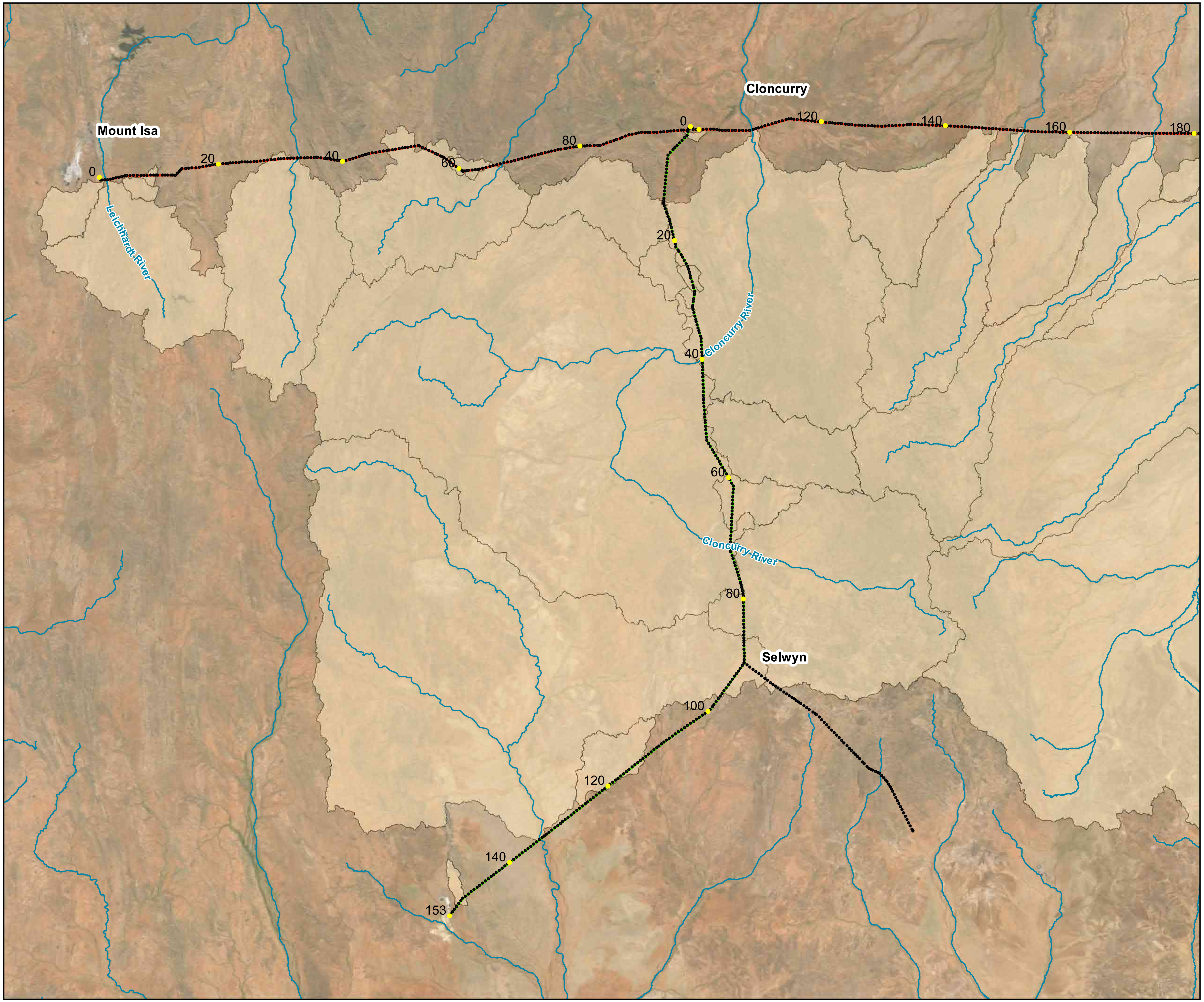


A

## UGL Coperstring 2 Powerline Alignment Catchment Maps


LEGEND

- Watercourse
- Tower Locations
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval
- Catchments

1 cm = 6,000 m

0 4,600 9,200 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

| | |
|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
| DATE | 5/26/2021 |
| CREATED BY | KavanekarR |
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B

## UGL Coperstring 2 Powerline Alignment Catchment Maps


LEGEND

- Watercourse
- Tower Locations
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval
- Catchments

1 cm = 6,000 m

0 4,600 9,200 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

| | |
|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
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| DATE | 5/26/2021 |
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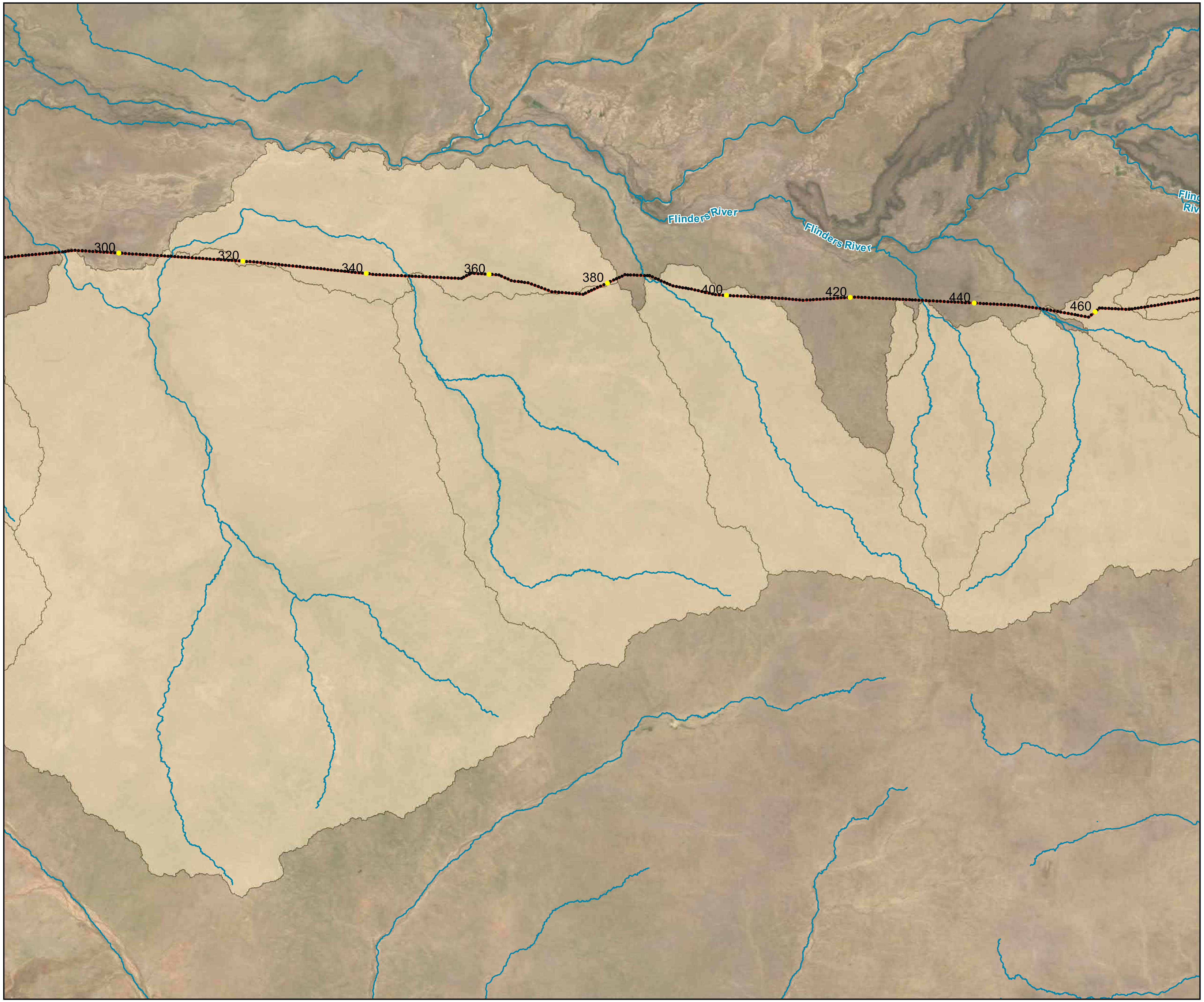
UGL Coperstring 2 Powerline Alignment




C

# UGL Coperstring 2 Powerline Alignment Catchment Maps


LEGEND

- Watercourse
- Tower Locations
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval
- Catchments

1 cm = 6,000 m

0 4,600 9,200 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

| | |
|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
| DATE | 5/26/2021 |
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SOURCES:
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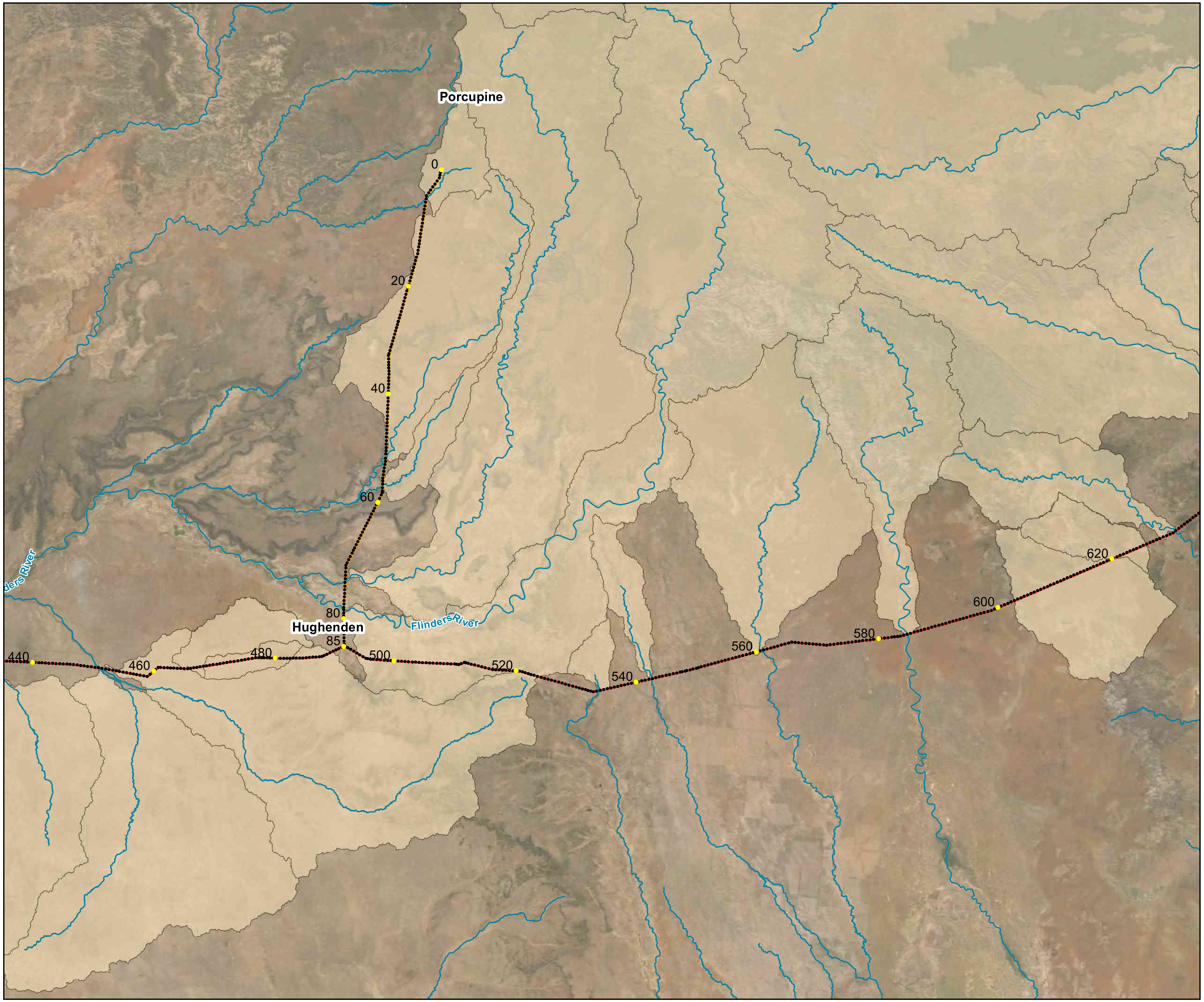
Document Path: C:\Users\KavanekarR\Desktop\UGL\Mapping\MXD\Catchment Areas_C.mxd




D

# UGL Coperstring 2 Powerline Alignment Catchment Maps


LEGEND

- Watercourse
- Tower Locations
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval
- Catchments

1 cm = 6,000 m

0 4,600 9,200 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

| | |
|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
| DATE | 5/26/2021 |
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E

# UGL Coperstring 2 Powerline Alignment Catchment Maps


LEGEND

- Watercourse
- Tower Locations
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval
- Catchments

1 cm = 10,000 m

0 7,400 14,800 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

| | |
|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
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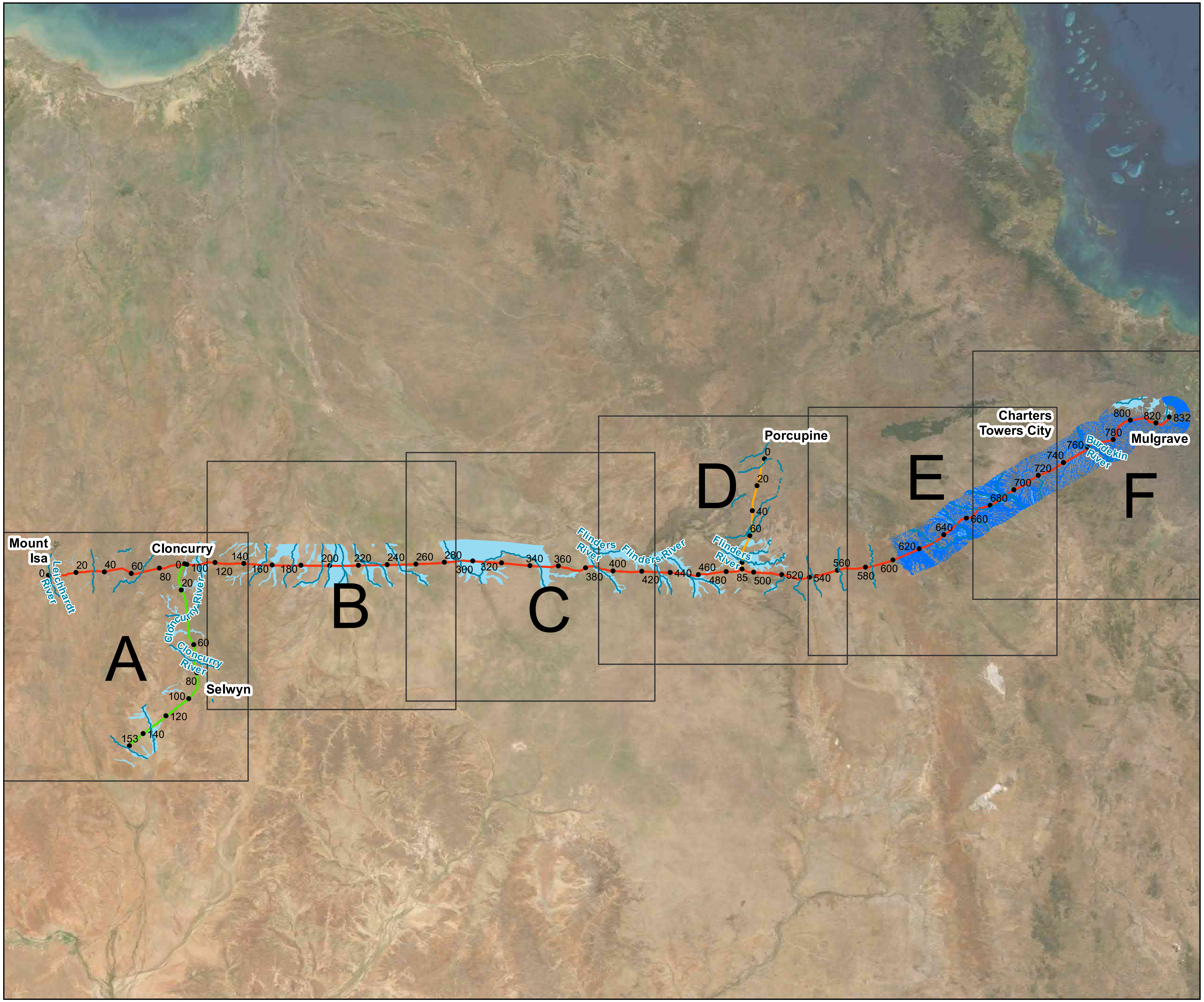
## Appendix C: UGL CS-2 Powerline – QRA Flood Maps

UGL Coperstring 2 Powerline Alignment




# UGL Coperstring 2 Powerline Alignment
## QRA Flood Maps


LEGEND

- Watercourse
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval
- QRA Flood Extent
- Burdekin 1% AEP Flood Extent

1 cm = 26,000 m

0 19,000 38,000 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

| | |
|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
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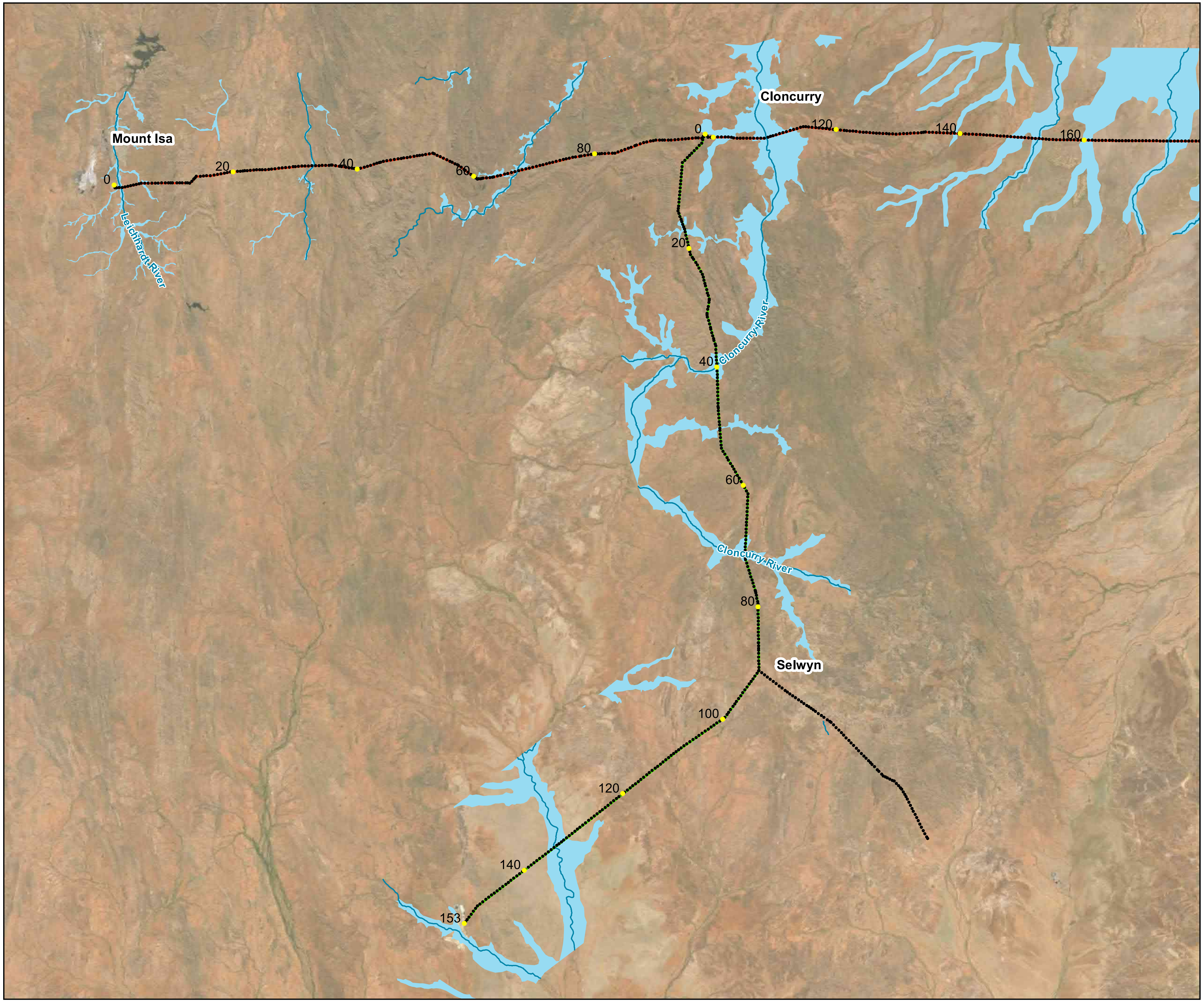
UGL Coperstring 2 Powerline Alignment




A

## UGL Coperstring 2 Powerline Alignment

QRA Flood Maps

SITE LOCATION


LEGEND

- Watercourse
- Tower Locations
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval
- QRA Flood Extent
- Burdekin 1% AEP Flood Extent

1 cm = 6,000 m

0 4,600 9,200 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

| | |
|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
| DATE | 5/26/2021 |
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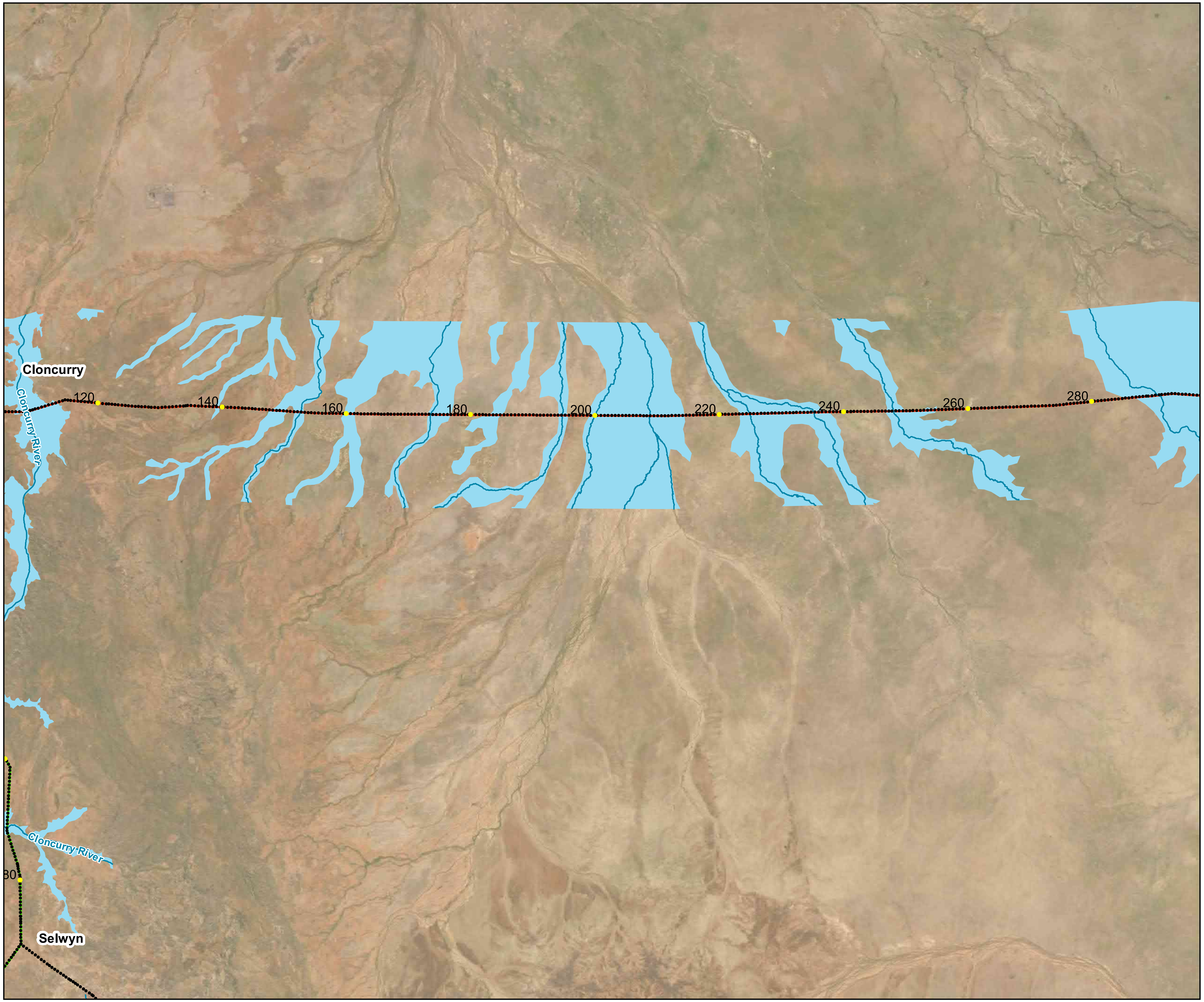


B

# UGL Coperstring 2 Powerline Alignment

## QRA Flood Maps


LEGEND

- Watercourse
- Tower Locations
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval
- QRA Flood Extent
- Burdekin 1% AEP Flood Extent

1 cm = 6,000 m

0 4,600 9,200 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

| | |
|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
| DATE | 5/26/2021 |
| CREATED BY | KavanekarR |
| PAGE SIZE | A3 |

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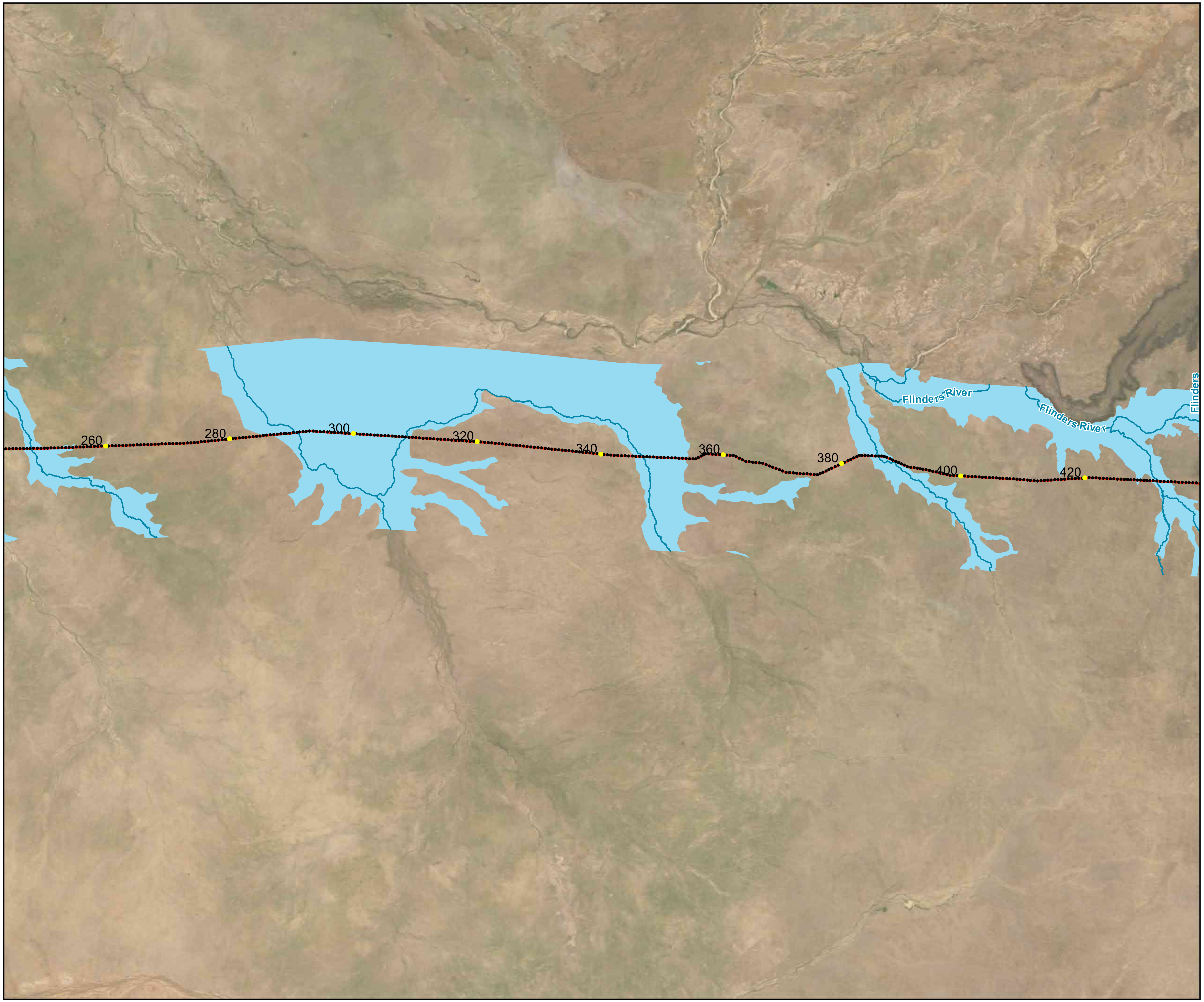


C

# UGL Coperstring 2 Powerline Alignment

## QRA Flood Maps


LEGEND

- Watercourse
- Tower Locations
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval
- QRA Flood Extent
- Burdekin 1% AEP Flood Extent

1 cm = 6,000 m

0 4,600 9,200 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

| | |
|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
| DATE | 5/26/2021 |
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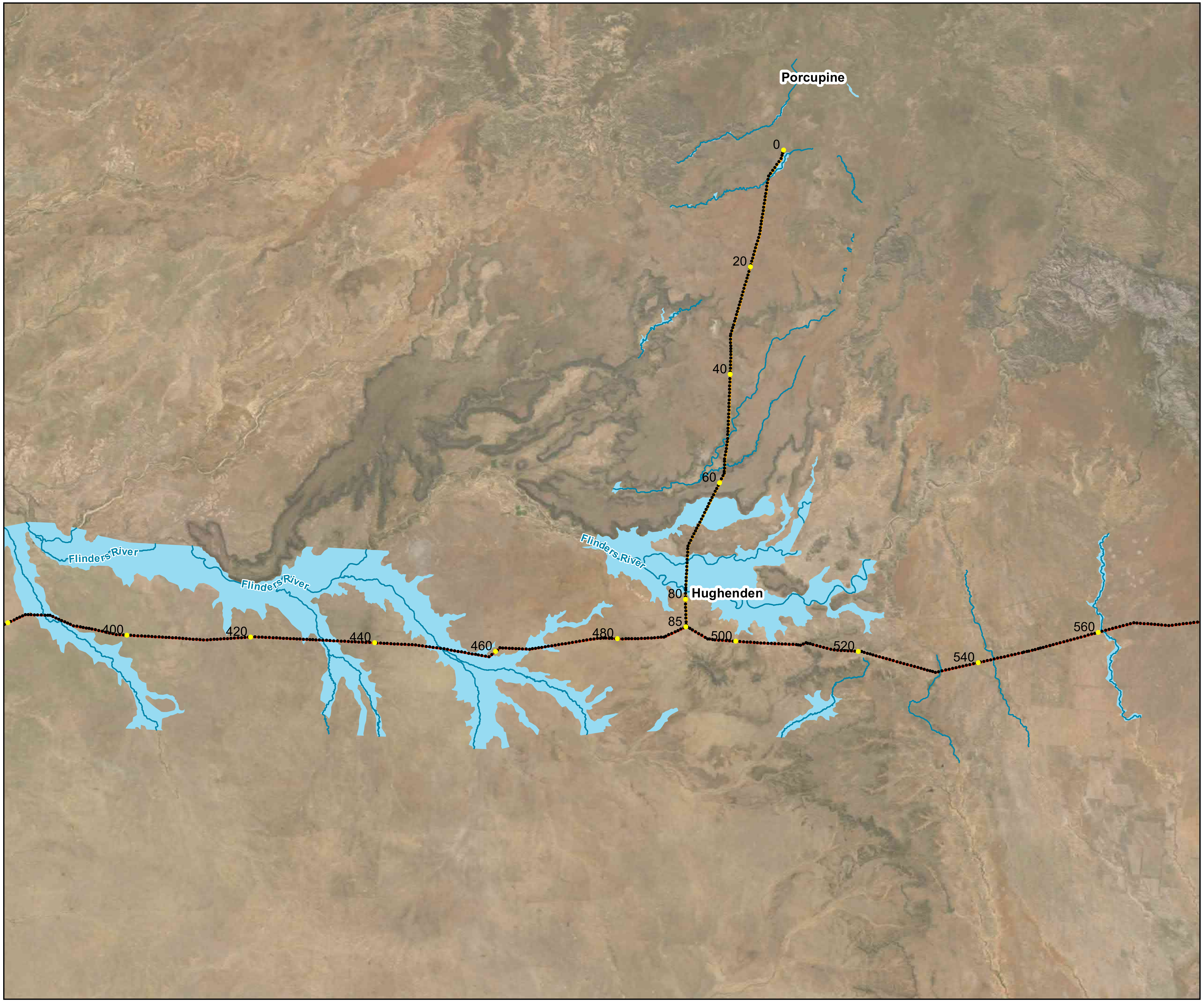


D

# UGL Coperstring 2 Powerline Alignment

## QRA Flood Maps


LEGEND

- Watercourse
- Tower Locations
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval
- QRA Flood Extent
- Burdekin 1% AEP Flood Extent

1 cm = 6,000 m

0 4,600 9,200 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

| | |
|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
| DATE | 5/26/2021 |
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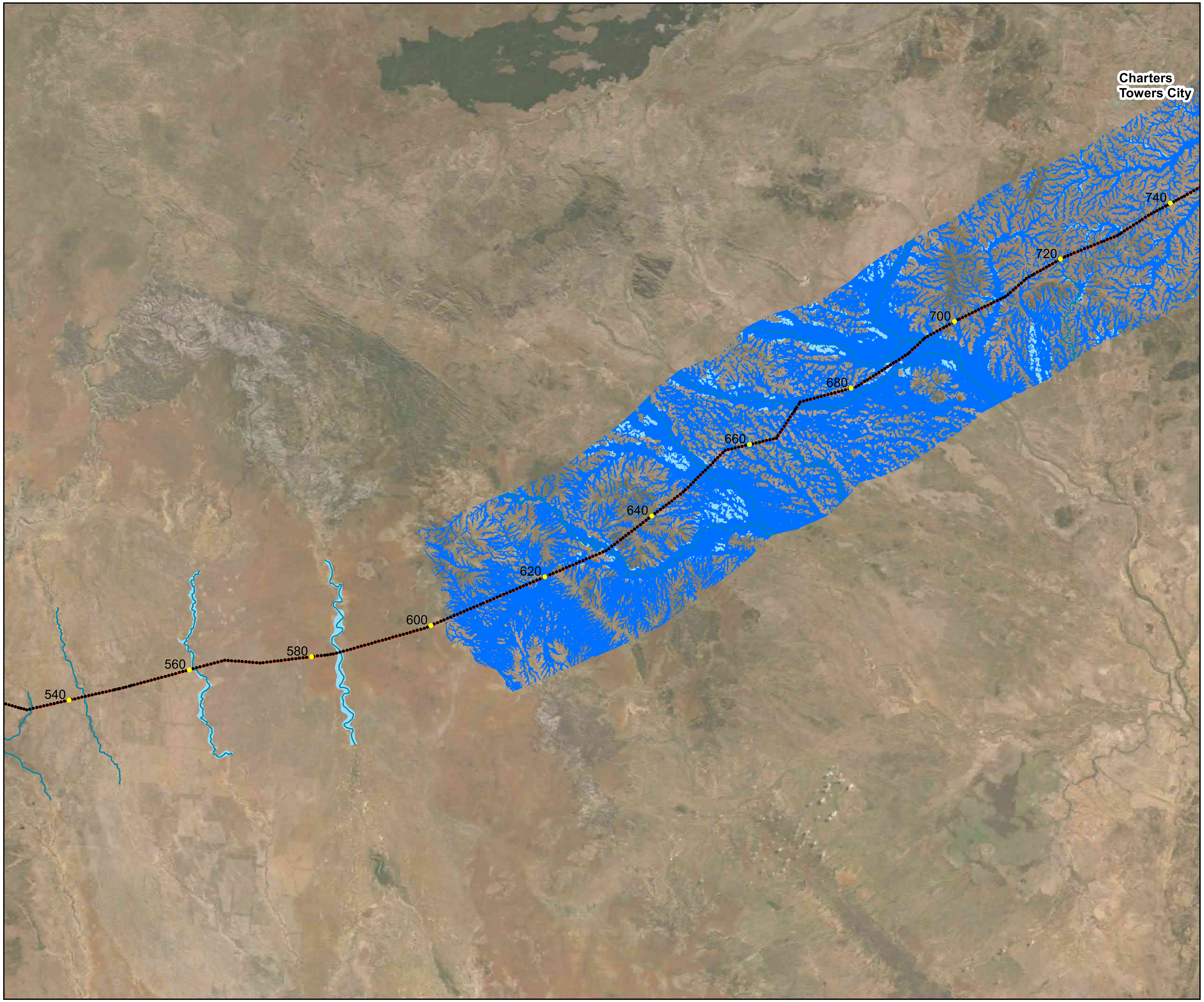


E

## UGL Coperstring 2 Powerline Alignment

## QRA Flood Maps


LEGEND

- Watercourse
- Tower Locations
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval
- QRA Flood Extent
- Burdekin 1% AEP Flood Extent

1 cm = 6,000 m

0 4,600 9,200 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

| | |
|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
| DATE | 5/26/2021 |
| CREATED BY | KavanekarR |
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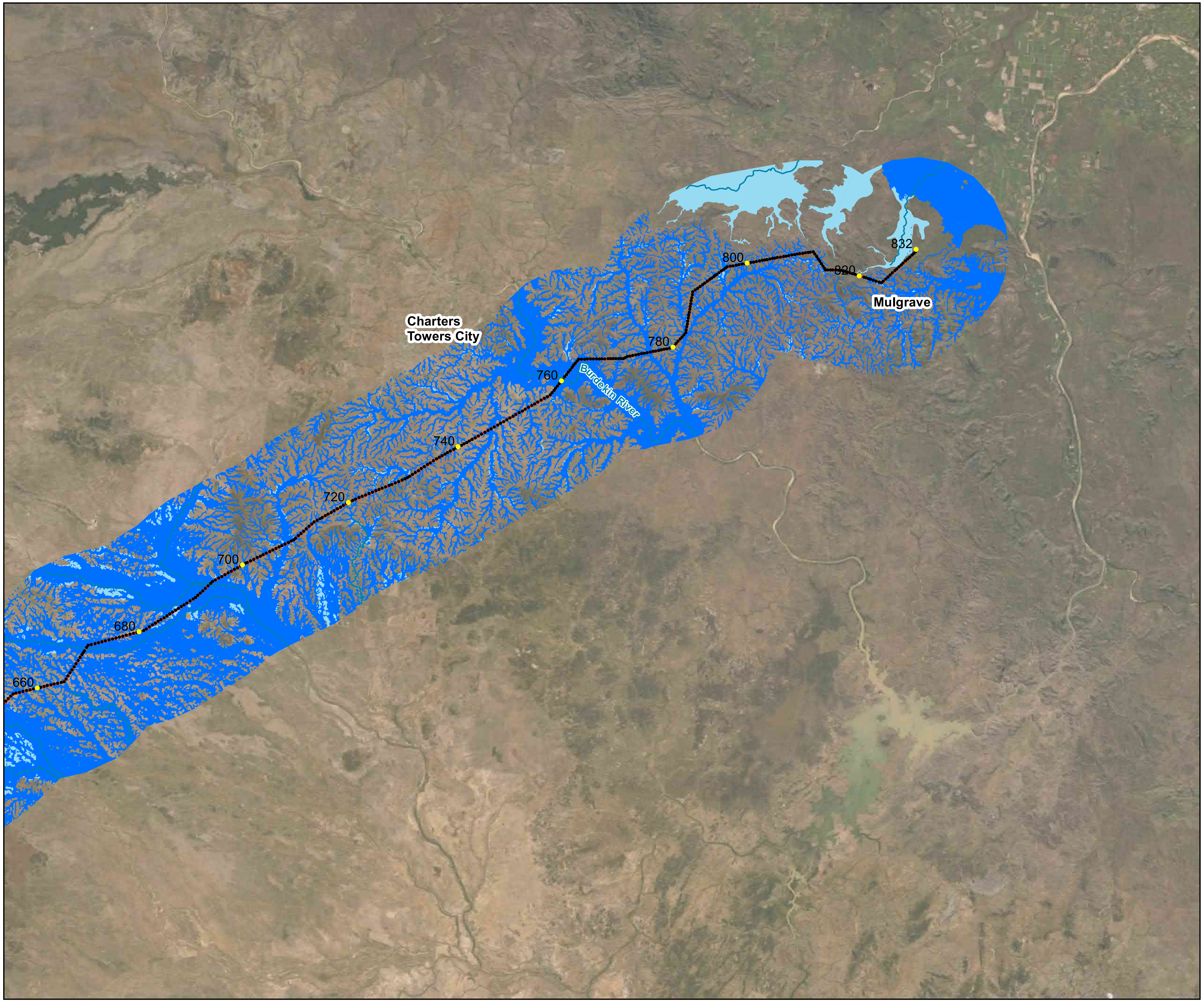


F

# UGL Coperstring 2 Powerline Alignment

## QRA Flood Maps


LEGEND

- Watercourse
- Tower Locations
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval
- QRA Flood Extent
- Burdekin 1% AEP Flood Extent

1 cm = 6,000 m

0 4,600 9,200 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

| | |
|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
| DATE | 5/26/2021 |
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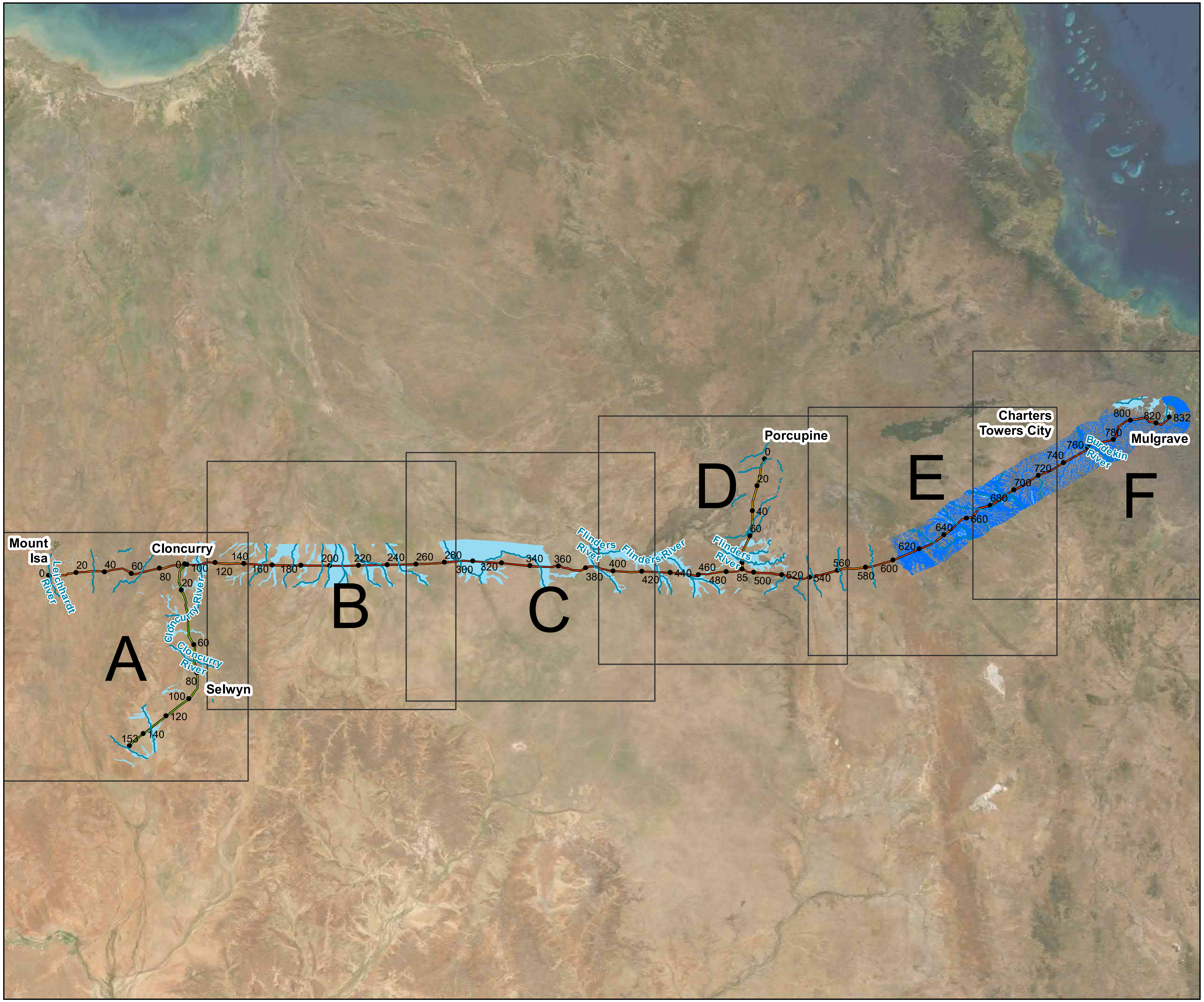
## Appendix D: UGL CS-2 Powerline – Flood Risk Map




# UGL Coperstring 2 Powerline Alignment Flood Risk Map

SITE LOCATION


## LEGEND

- Watercourse
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval
- QRA Flood Extent
- Burdekin 1% AEP Flood Extent

## Flood Risk Zone

- High Risk
- Low Risk

1 cm = 26,000 m

0 19,000 38,000 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

| | |
|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
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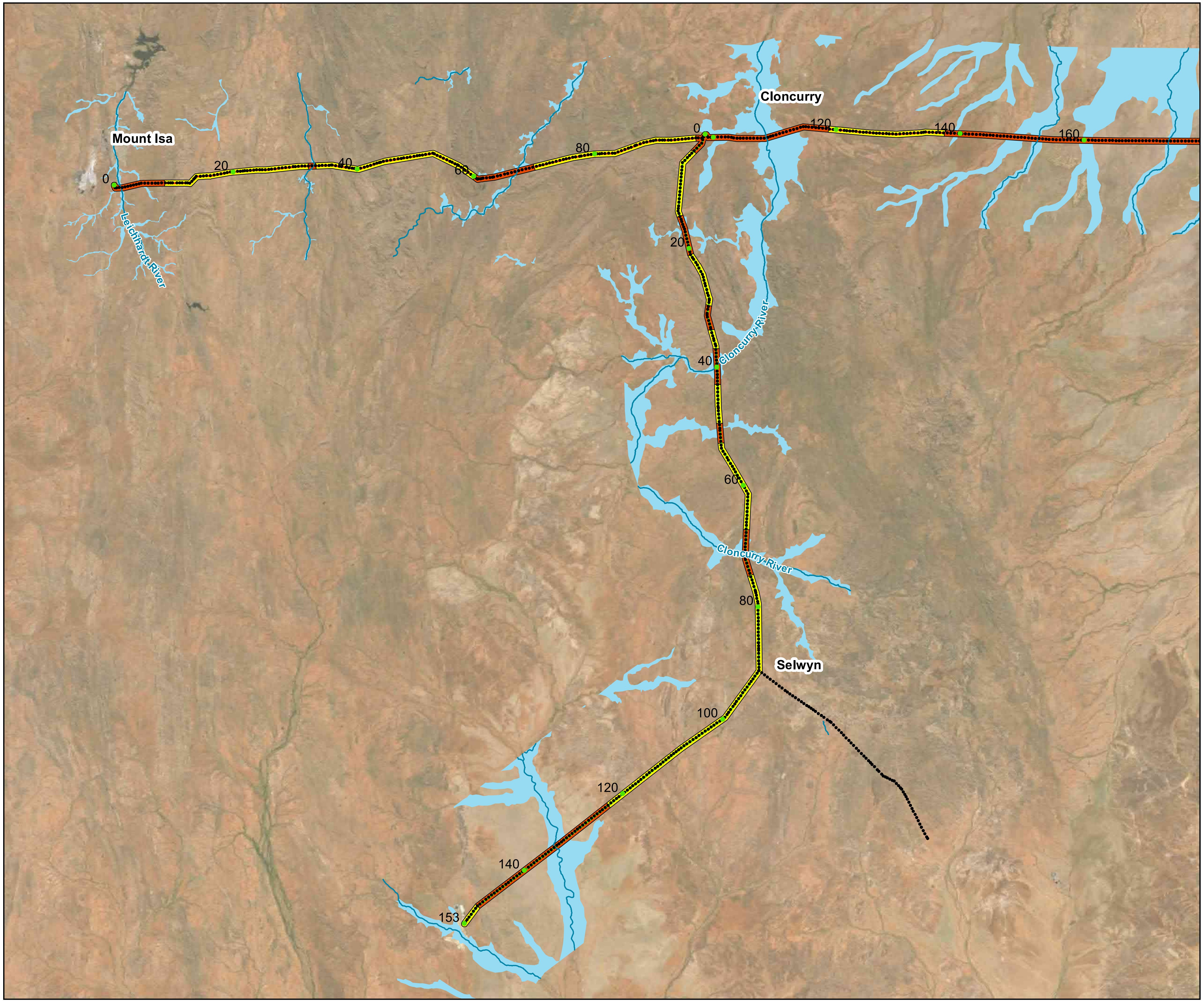
## UGL Coperstring 2 Powerline Alignment




A

# UGL Coperstring 2 Powerline Alignment Flood Risk Map


- Watercourse
- Tower Locations
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval
- QRA Flood Extent
- Burdekin 1% AEP Flood Extent

### Flood Risk Zones

- High Risk
- Low Risk

1 cm = 6,000 m

0 4,600 9,200 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

| | |
|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
| DATE | 5/26/2021 |
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B

# UGL Coperstring 2 Powerline Alignment Flood Risk Map


- Watercourse
- Tower Locations
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval
- QRA Flood Extent
- Burdekin 1% AEP Flood Extent

## Flood Risk Zones

- High Risk
- Low Risk

1 cm = 6,000 m

0 4,600 9,200 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

| | |
|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
| DATE | 5/26/2021 |
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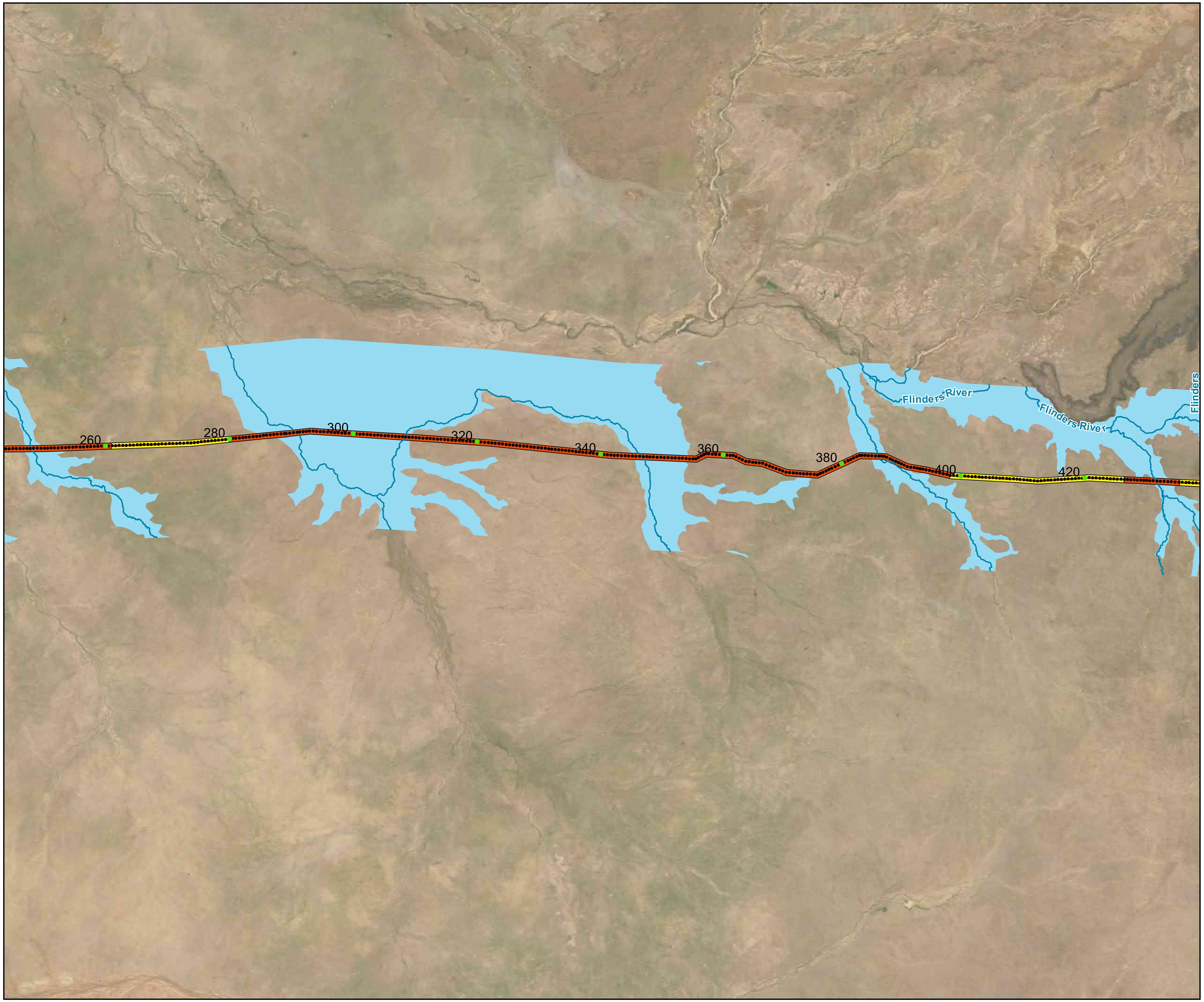


C

# UGL Coperstring 2 Powerline Alignment Flood Risk Map


- Watercourse
- Tower Locations
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval
- QRA Flood Extent
- Burdekin 1% AEP Flood Extent

## Flood Risk Zones

- High Risk
- Low Risk

1 cm = 6,000 m

0 4,600 9,200 m

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

| | |
|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
| DATE | 5/26/2021 |
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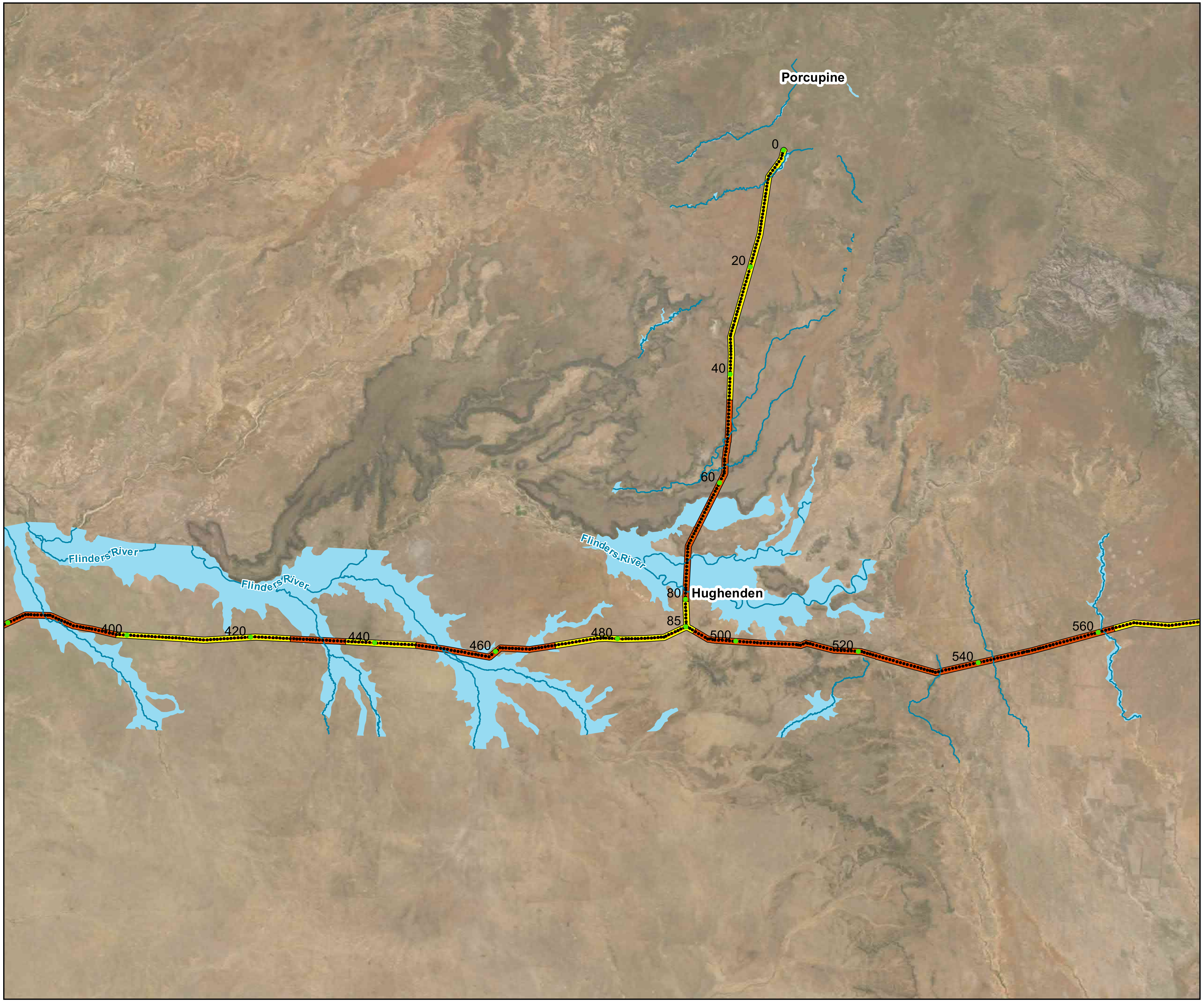


D

## UGL Coperstring 2 Powerline Alignment Flood Risk Map


Watercourse
Tower Locations
Mount Isa to Mulgrave
Chuvale to Selwyn
Mt James to Hughenden
Chainage at 20 KM Interval
QRA Flood Extent
Burdekin 1% AEP Flood Extent

**Flood Risk Zones**

High Risk
Low Risk

1 cm = 6,000 m

0 4,600 9,200 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

| | |
|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
| DATE | 5/26/2021 |
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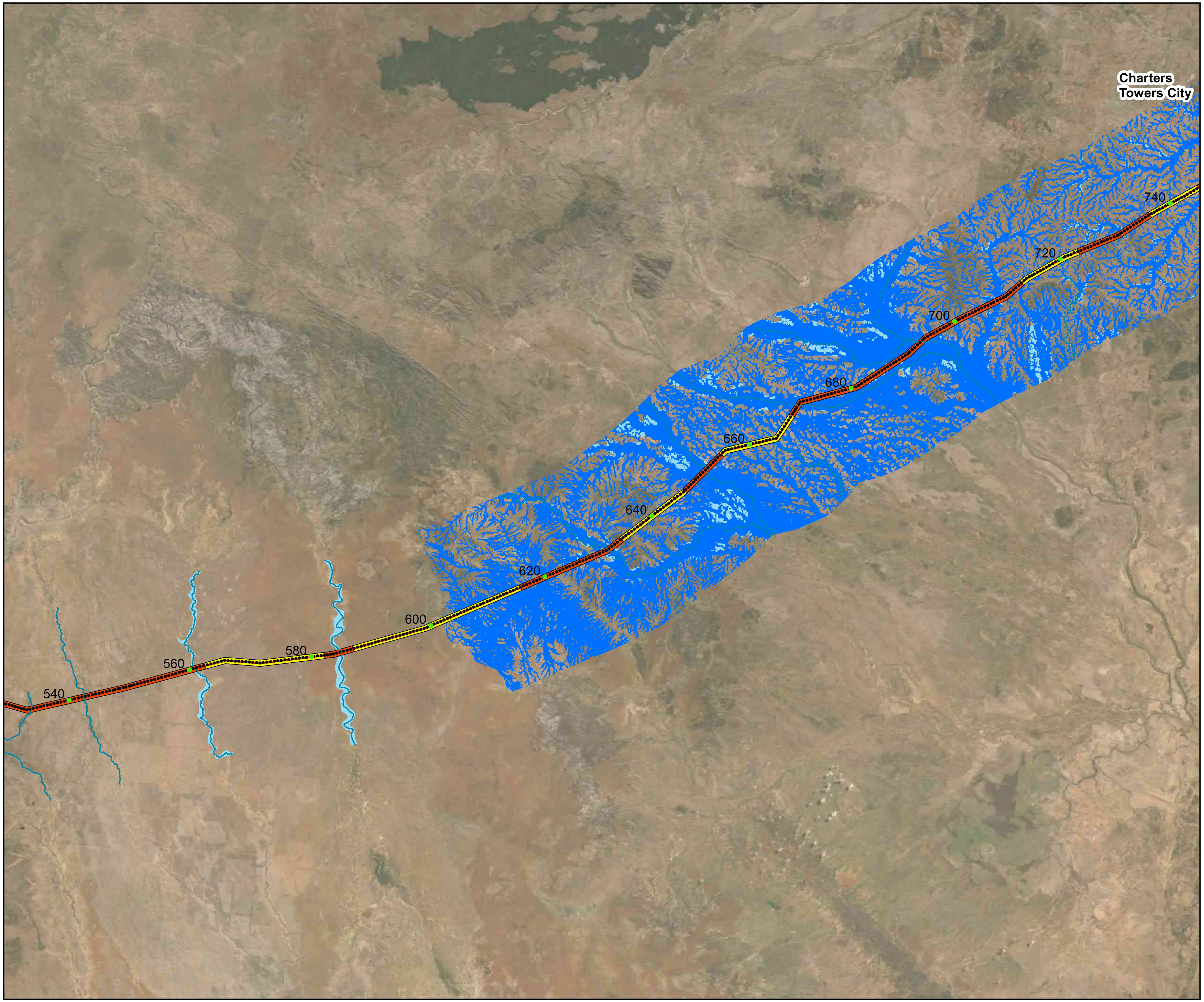


E

# UGL Coperstring 2 Powerline Alignment Flood Risk Map


- Watercourse
- Tower Locations
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval
- QRA Flood Extent
- Burdekin 1% AEP Flood Extent

**Flood Risk Zones**

- High Risk
- Low Risk

1 cm = 6,000 m

0 4,600 9,200 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

| | |
|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
| DATE | 5/26/2021 |
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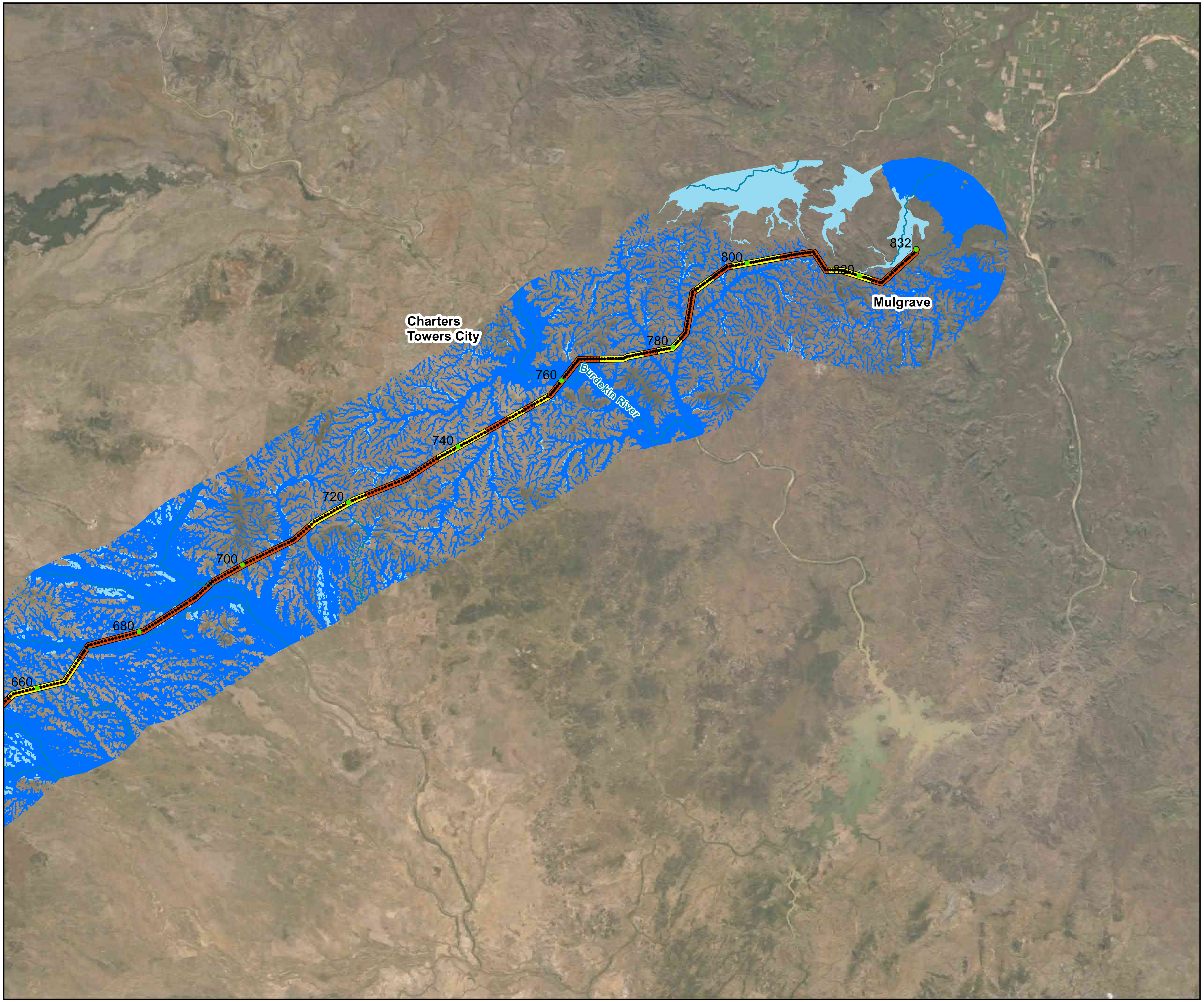


F

## UGL Coperstring 2 Powerline Alignment Flood Risk Map


- Watercourse
- Tower Locations
- Mount Isa to Mulgrave
- Chuvale to Selwyn
- Mt James to Hughenden
- Chainage at 20 KM Interval
- QRA Flood Extent
- Burdekin 1% AEP Flood Extent

**Flood Risk Zones**

- High Risk
- Low Risk

1 cm = 6,000 m

0 4,600 9,200 m

N

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator Datum: GDA 1994

| | |
|---|---|
| PROJECT NAME | UGL Powerline |
| PROJECT # | IS373700 |
| DRAWING NO | 1 |
| DATE | 5/26/2021 |
| CREATED BY | KavanekarR |
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Jacobs

## Appendix E: Design Rainfall IFDs

### Table E1: Design IFDs for Mt Isa area (mm/hr)

| Duration | Annual Exceedance Probability (AEP) | | | | | | |
|---|---|---|---|---|---|---|---|
| (-) | 63.20% | 50% | 20% | 10% | 5% | 2% | 1% |
| 1 min | 117 | 136 | 195 | 233 | 271 | 319 | 356 |
| 2 min | 99 | 116 | 166 | 199 | 230 | 268 | 297 |
| 3 min | 93.2 | 109 | 156 | 187 | 216 | 253 | 280 |
| 4 min | 89.2 | 104 | 149 | 178 | 206 | 242 | 269 |
| 5 min | 85.7 | 99.8 | 143 | 171 | 198 | 233 | 260 |
| 10 min | 72.0 | 83.6 | 120 | 144 | 167 | 197 | 220 |
| 15 min | 62.0 | 72 | 103 | 124 | 144 | 170 | 189 |
| 20 min | 54.4 | 63.3 | 90.6 | 109 | 126 | 149 | 166 |
| 25 min | 48.6 | 56.5 | 80.9 | 97.2 | 113 | 133 | 148 |
| 30 min | 43.9 | 51.1 | 73.2 | 87.9 | 102 | 120 | 134 |
| 45 min | 34.3 | 39.9 | 57.1 | 68.6 | 79.6 | 93.8 | 104 |
| 1 hour | 28.2 | 32.8 | 47.1 | 56.5 | 65.5 | 77.2 | 85.9 |
| 1.5 hour | 21.1 | 24.5 | 35 | 42.1 | 48.8 | 57.6 | 64.1 |
| 2 hour | 16.9 | 19.6 | 28.1 | 33.8 | 39.2 | 46.3 | 51.6 |
| 3 hour | 12.3 | 14.3 | 20.4 | 24.5 | 28.5 | 33.8 | 37.7 |
| 4.5 hour | 8.93 | 10.3 | 14.7 | 17.7 | 20.7 | 24.6 | 27.6 |
| 6 hour | 7.11 | 8.21 | 11.7 | 14.1 | 16.5 | 19.7 | 22.1 |
| 9 hour | 5.18 | 5.98 | 8.53 | 10.3 | 12 | 14.5 | 16.3 |
| 12 hour | 4.16 | 4.8 | 6.85 | 8.28 | 9.7 | 11.7 | 13.3 |
| 18 hour | 3.07 | 3.55 | 5.09 | 6.16 | 7.23 | 8.78 | 10 |
| 24 hour | 2.49 | 2.89 | 4.16 | 5.04 | 5.92 | 7.2 | 8.22 |
| 30 hour | 2.12 | 2.47 | 3.56 | 4.32 | 5.08 | 6.2 | 7.08 |
| 36 hour | 1.86 | 2.17 | 3.14 | 3.82 | 4.49 | 5.48 | 6.28 |
| 48 hour | 1.52 | 1.77 | 2.58 | 3.14 | 3.69 | 4.52 | 5.18 |
| 72 hour | 1.12 | 1.32 | 1.94 | 2.36 | 2.78 | 3.41 | 3.91 |
| 96 hour | 0.895 | 1.06 | 1.56 | 1.91 | 2.24 | 2.75 | 3.16 |
| 120 hour | 0.742 | 0.876 | 1.3 | 1.59 | 1.87 | 2.3 | 2.64 |
| 144 hour | 0.63 | 0.744 | 1.1 | 1.35 | 1.6 | 1.97 | 2.26 |
| 168 hour | 0.544 | 0.641 | 0.952 | 1.17 | 1.38 | 1.71 | 1.96 |

### Table E2 Design IFDs for Cloncurry area (mm/hr)

| Duration | Annual Exceedance Probability (AEP) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 63.20% | 50%# | 20%* | 10% | 5% | 2% | 1% |
| 1 min | 131 | 151 | 214 | 254 | 292 | 340 | 375 |
| 2 min | 114 | 133 | 190 | 226 | 259 | 298 | 325 |
| 3 min | 107 | 125 | 178 | 211 | 242 | 279 | 305 |
| 4 min | 102 | 119 | 168 | 200 | 229 | 265 | 291 |
| 5 min | 97.5 | 113 | 160 | 190 | 218 | 253 | 278 |

| Duration | Annual Exceedance Probability (AEP) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 63.20% | 50%# | 20%* | 10% | 5% | 2% | 1% |
| 10 min | 80.3 | 92.9 | 131 | 155 | 178 | 208 | 230 |
| 15 min | 68.8 | 79.5 | 112 | 133 | 153 | 178 | 197 |
| 20 min | 60.5 | 70 | 98.7 | 117 | 135 | 157 | 174 |
| 25 min | 54.2 | 62.7 | 88.5 | 105 | 121 | 141 | 156 |
| 30 min | 49.2 | 57 | 80.6 | 95.8 | 110 | 128 | 142 |
| 45 min | 39 | 45.3 | 64.1 | 76.3 | 87.8 | 102 | 113 |
| 1 hour | 32.6 | 37.9 | 53.8 | 64.1 | 73.7 | 85.7 | 94.5 |
| 1.5 hour | 24.9 | 29 | 41.3 | 49.3 | 56.7 | 66.1 | 72.9 |
| 2 hour | 20.4 | 23.8 | 33.9 | 40.5 | 46.7 | 54.5 | 60.2 |
| 3 hour | 15.2 | 17.8 | 25.5 | 30.4 | 35.2 | 41.2 | 45.7 |
| 4.5 hour | 11.3 | 13.2 | 18.9 | 22.7 | 26.3 | 31.1 | 34.7 |
| 6 hour | 9.08 | 10.6 | 15.3 | 18.4 | 21.4 | 25.4 | 28.5 |
| 9 hour | 6.66 | 7.78 | 11.3 | 13.7 | 16 | 19.2 | 21.6 |
| 12 hour | 5.34 | 6.24 | 9.12 | 11.1 | 13.1 | 15.7 | 17.8 |
| 18 hour | 3.9 | 4.56 | 6.74 | 8.3 | 9.89 | 11.9 | 13.5 |
| 24 hour | 3.11 | 3.65 | 5.45 | 6.76 | 8.12 | 9.81 | 11.1 |
| 30 hour | 2.61 | 3.07 | 4.62 | 5.77 | 6.98 | 8.43 | 9.56 |
| 36 hour | 2.26 | 2.67 | 4.04 | 5.08 | 6.17 | 7.45 | 8.44 |
| 48 hour | 1.8 | 2.13 | 3.27 | 4.14 | 5.08 | 6.12 | 6.92 |
| 72 hour | 1.3 | 1.55 | 2.42 | 3.09 | 3.83 | 4.60 | 5.19 |
| 96 hour | 1.03 | 1.23 | 1.94 | 2.49 | 3.1 | 3.73 | 4.20 |
| 120 hour | 0.861 | 1.03 | 1.63 | 2.1 | 2.61 | 3.14 | 3.55 |
| 144 hour | 0.742 | 0.89 | 1.41 | 1.81 | 2.25 | 2.72 | 3.08 |
| 168 hour | 0.655 | 0.786 | 1.24 | 1.59 | 1.97 | 2.39 | 2.72 |

Table E3 Design IFDs for Hughenden area (mm/hr)

| Duration | Annual Exceedance Probability (AEP) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 63.20% | 50% | 20% | 10% | 5% | 2% | 1% |
| 1 min | 126 | 146 | 205 | 244 | 280 | 326 | 360 |
| 2 min | 109 | 126 | 178 | 212 | 244 | 285 | 314 |
| 3 min | 102 | 118 | 166 | 198 | 228 | 265 | 292 |
| 4 min | 96.9 | 112 | 158 | 188 | 216 | 251 | 277 |
| 5 min | 92.8 | 107 | 151 | 179 | 206 | 240 | 264 |
| 10 min | 77.3 | 89.3 | 126 | 149 | 171 | 199 | 220 |
| 15 min | 66.6 | 77 | 108 | 128 | 147 | 172 | 190 |
| 20 min | 58.7 | 67.8 | 95.4 | 113 | 130 | 152 | 168 |
| 25 min | 52.5 | 60.7 | 85.5 | 102 | 117 | 136 | 150 |
| 30 min | 47.6 | 55.1 | 77.6 | 92.1 | 106 | 123 | 136 |
| 45 min | 37.4 | 43.3 | 60.9 | 72.4 | 83.3 | 97.1 | 107 |
| 1 hour | 31 | 35.8 | 50.4 | 59.9 | 68.9 | 80.3 | 88.7 |
| 1.5 hour | 23.3 | 26.9 | 37.7 | 44.8 | 51.5 | 60 | 66.2 |
| 2 hour | 18.8 | 21.6 | 30.3 | 36 | 41.4 | 48.1 | 53.1 |
| 3 hour | 13.7 | 15.8 | 22 | 26.1 | 30 | 34.8 | 38.4 |

| Duration | Annual Exceedance Probability (AEP) | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | 63.20% | 50% | 20% | 10% | 5% | 2% | 1% |
| **4.5 hour** | 9.95 | 11.4 | 15.9 | 18.8 | 21.5 | 25 | 27.6 |
| **6 hour** | 7.91 | 9.07 | 12.6 | 14.9 | 17 | 19.8 | 21.9 |
| **9 hour** | 5.75 | 6.58 | 9.1 | 10.7 | 12.3 | 14.4 | 15.9 |
| **12 hour** | 4.6 | 5.26 | 7.28 | 8.6 | 9.87 | 11.5 | 12.8 |
| **18 hour** | 3.38 | 3.87 | 5.38 | 6.37 | 7.32 | 8.61 | 9.59 |
| **24 hour** | 2.74 | 3.14 | 4.38 | 5.2 | 6 | 7.08 | 7.92 |
| **30 hour** | 2.33 | 2.67 | 3.75 | 4.47 | 5.17 | 6.13 | 6.87 |
| **36 hour** | 2.04 | 2.35 | 3.31 | 3.96 | 4.59 | 5.46 | 6.14 |
| **48 hour** | 1.66 | 1.92 | 2.73 | 3.28 | 3.82 | 4.57 | 5.16 |
| **72 hour** | 1.24 | 1.44 | 2.08 | 2.52 | 2.95 | 3.55 | 4.02 |
| **96 hour** | 0.998 | 1.17 | 1.7 | 2.07 | 2.43 | 2.93 | 3.32 |
| **120 hour** | 0.835 | 0.98 | 1.44 | 1.75 | 2.06 | 2.48 | 2.81 |
| **144 hour** | 0.716 | 0.842 | 1.24 | 1.51 | 1.78 | 2.13 | 2.41 |
| **168 hour** | 0.624 | 0.735 | 1.08 | 1.32 | 1.55 | 1.85 | 2.08 |