Section 6

WATER RESOURCES

6. Water Resources

6.1 Surface Water

This Section describes the existing environment for water resources that may be affected by the Project in the context of the environmental values as defined in such documents referred to in the EP Act, the *Environmental Protection (Water) Policy 1997* and the *National Water Quality Management Strategy* (Australian and New Zealand Environment and Conservation Council, 2000).

Information within this Section has been divided into two sections "Surface Water" and "Groundwater".

6.1.1 Methodology

This Section discusses the existing environment in terms of the characteristics and water quality of the watercourses intersected by the study area. This includes the potential impacts of the Project and presents proposed mitigation measures to reduce any potential impacts on the receiving waters during the construction and operational phases of the Project. It also provides comment on monitoring requirements for the Project and identifies various permits and licences that may be required.

An assessment of the existing conditions and the potential impacts that the construction and operation of the Project may have on the surface water environment is provided. The assessment of existing conditions was limited to a review of previous studies and databases, which included:

- Department of Natural Resources and Water (DNRW) watershed database;
- State of the Rivers – Dawson River and Major Tributaries (Telfer, 1995); and
- SunWater Online.

A site visit was also undertaken to assess stream conditions. No field sampling was undertaken.

The DNRW watershed database was accessed to determine the nature of the surface waterways intersected by the preferred alignment in the study area. Information searches were conducted for all streams intersected by the study area.

The DNRW watershed database provided information on catchment size, water quality and flow for some streams, identifying specific stream gauging and water quality sampling locations. Water quality information has been compared with the Queensland Water Quality Guidelines (EPA, 2006) and Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000).

Detailed information regarding flooding is not available for the majority of local creeks and waterways that cross the alignment. Flood information for the Dawson River at Taroom, Theodore and Moura was sourced from the BOM and is shown in Appendix F.

SunWater Online and Fitzroy Water Resources Plan were used to obtained information on customers and off-takes in the Dawson catchment area as well as transfers of water licences that have occurred recently.

Drainage lines to be intercepted were identified, and catchments delineated. The rational method and RORB modelling were used to determine peak floods in each catchment depending on the size of the subject catchment. Culvert design to convey flood events was undertaken in accordance with the Road Drainage Design Manual (DMR, 2002).

In assessing surface water resources within the study area, consideration was given to the following legislation:

- *Water Act* 2000;
- *Fisheries Act* 1994; and
- *Integrated Planning* Act 1997.

A site inspection was undertaken with information collected on soil type, vegetation cover, geomorphlogical conditions and evidence of recent flows at the time of survey.

6.1.2 Description of Environmental Values

The Project is located in the Dawson River sub-catchment of the Fitzroy River drainage basin (Australian Water Resource Council (AWRC) 130) in the Central Coast Region of Queensland (see Map 21 – Dawson River Catchments in the Map Folio). The Fitzroy River basin has an approximate area of 150,000 km^2, making it the second largest catchment in Australia. The Fitzroy River is formed by the confluence of the Dawson River and the MacKenzie River just north of Duaringa. The Fitzroy River discharges eastwards into Keppel Bay (Coral Sea) north of Rockhampton.

The Project intersects a number of small creeks and drainage lines which are tributaries of the Dawson River. This including Juandah, Roche, Bullock, Bungaban, Cockatoo, Cabbage Tree, Downfall, Ross, Cracow, Delusion, Oxtrack, Boam, Castle, Lonesome, Banana, Orange, Pigeon, Kianga, Spring, Bottle Tree and Stakeyard Creeks. A description of the ecological values of the riparian ecology of these watercourses is provided in Section 5.2 of this EIS. All of the watercourses intersected by the Project either drain from south to north or east to west towards the Dawson River. All watercourses within the Dawson River catchment are ephemeral with the exception of the Dawson River which has a perennial flow. Catchment and geomorphological information is provided below on the larger catchments intersected by the Project and additional information (such as creek name and catchment size) is provided where known.

Being ephemeral systems, major flow within these watercourses is experienced only during times of heavy rainfall and is often associated with overbank flooding. Water quality information has been collected by DNRW for a number of the streams in the Dawson River catchment, with more specific details provided below.

Dawson River

Catchment Characteristics

Dawson River catchment encompasses an area of 50,800 km^2 and has a stream length of 640 km. The river is bounded by the Lynd and Exhibition Ranges to the west, the Great Dividing Range to the south, and the Auburn, Calliope, Ulam, and Dee Ranges to the east. The direction of flow is initially to the east but is generally from the south to the north.

The Dawson River drains into the MacKenzie River just north of Duaringa, and ultimately into the Fitzroy River, meeting the Coral Sea downstream of Rockhampton.

There are approximately 15 controls on the Dawson River and its tributaries, including a number of water storage facilities and weirs. This impounded water supports surrounding agriculture, industry and urban communities. Of the tributaries to the Dawson River that are intersected by the Project, only Orange Creek has a weir which impounds water for irrigation usage.

Land use within the catchment predominantly consists of cattle grazing, although forestry, rain fed and irrigated cropping activities cover considerable tracts of land (Telfer, 1995).

Geomorphological Conditions

According to Telfer (1995), there is little written information about the fluvial geomorphology of the Dawson River catchment at the beginning of European settlement. However, it is likely that most streams within the Dawson River catchment would have had a prominent summer flow regime as a result of rainfall patterns in the area.

In more recent times there have been changes in stream morphology and decreased diversity in stream habitat as a consequence of stream regulation and agricultural/industrial use, clearing of large tracts of vegetation, cropping and grazing influences.

There has been extensive clearing of native vegetation throughout the catchment, for both agricultural and grazing purposes. This has resulted in land degradation. This degradation is most extensive in locations where suitable management practices have not been utilised.

Where roadside structures have been poorly sited or have not been maintained, road side erosion has occurred, especially where dispersive clay soils are present in the area. Erosion of the stream banks occurs downstream of road crossing where appropriate battering and stabilisation work has not been undertaken or maintained (Telfer, 1995).

Water erosion in the form of sheet, rill and gully erosion, is found on approximately 80% of cultivated slopes within the catchment despite soil management practices being implemented on approximately half of cropping lands in the district (Shields and Gillespie, 1991, cited in Telfer (1995)). Soil losses after major runoff events on unprotected land have been recorded in the range of 90 - 100 t/ha (Telfer, 1995).

As a consequence of increased erosion of both cultivated and grazed areas in the catchment, significant quantities of soil has been removed and deposited in natural drainage lines and streams downstream and on the floodplain as alluvium. Reduced stream capacity results in increased over bank flooding and promotes further erosion damage on the floodplains. Moreover, aggradation of stream beds results in a loss of channel habitat and diversity reducing the ability of the system to support a diverse range of aquatic and terrestrial organisms. This in turn inhibits the natural function of the riverine system and eventually leads to an unhealthy river system (Koehn and O'Connor, 1990, cited in Telfer (1995)).

Juandah Creek

Catchment Characteristics

The catchment of Juandah Creek originates to the east of the Project in the foothills of the Great Dividing Range and flows north west towards the Dawson River through a primarily rural landscape. Juandah Creek is situated near the southern end of the Project near Wandoan. The creek occupies a catchment area of 1,678 km^2 and has a length of 62.8 km. The main land use surrounding Juandah Creek is cattle grazing. The creek is ephemeral, consists of a defined channel, some intact riparian vegetation and a wide floodplain. An inspection of this creek was undertaken as part of the EIS at which time the creek was flowing due to recent heavy rainfall (refer Photo 6-1).

Photo 6-1: Juandah Creek

Geomorphological Conditions

Evidence of erosion processes were observed during EIS field inspections on the bank of the creek, possibly as a result of recent flooding. This was supported by the observation of material recently deposited on the stream bank. The bank consists of a clay soil.

Roche Creek

Catchment Characteristics

Roche Creek also has its origins in the Great Dividing Range and flows west towards Juandah Creek. The main land use surrounding Roche Creek is cattle grazing. The creek is ephemeral and consists of a defined channel with some intact riparian vegetation and also has a wide floodplain. At the time of inspection the creek was flowing gently following recent rainfall (refer Photo 6-2).

Photo 6-2: Roche Creek

Geomorphological Conditions

Evidence of erosion processes were observed in the form of rill erosion. The bank consisted of a clay soil.

Cabbage Tree Creek

Catchment Characteristics

Cabbage Tree Creek is situated near the middle of the rail corridor. Land use upstream of the study area is dominated by grazing activities on cleared land, while downstream the creek flows through a forested area that is also grazed.

Cabbage Tree Creek consists of a well defined channel, incised approximately 4 m into the surrounding land surface. At the time of inspection, there was some water in the creek, however, it did not appear to be flowing (refer Photo 6-3).


Photo 6-3: Cabbage Tree Creek

Geomorphological Conditions

At the time of inspection the creek banks were characterised by a considerable amount of vegetative ground cover (i.e. long grass) providing protection to the banks. As such, there were no obvious signs of stream erosion noted. Soil at the site consisted of a silty sand.

Castle Creek

Catchment Characteristics

Castle Creek is situated in the middle of the upper half of the rail corridor. The creek occupies a catchment area of 683 km^2 and is 19.5 km long. The creek has a well defined channel and was flowing at the time of inspection. The riparian zone is in reasonable condition with some understorey riparian vegetation in amongst some taller, canopy type vegetation (refer Photo 6-4).


Photo 6-4: Castle Creek

Geomorphological Conditions

At the time of inspection, erosion around the creek was evident with sign of stream bed aggradation and terraces possibly created by sheet erosion. The soils are best described as a gravely sand.

Lonesome Creek

Catchment Characteristics

Lonesome Creek is situated towards the northern end of the study area. Lonesome Creek originates in a state forest on the Banana Ranges. The catchment area of the creek is 165 km^2 with a length of 30.6 km.

The creek has a well defined channel and was flowing at the time of inspection. As with Castle Creek, the riparian zone has significant vegetation, with some understorey vegetation in amongst some taller, canopy type vegetation (refer Photo 6-5).


Photo 6-5: Lonesome Creek

Geomorphological Conditions

Although well covered, there were signs of bank erosion as a result of recent high flows. The soil at the site consisted of gravely sand.

Cracow Creek

Catchment Characteristics

Cracow Creek is located approximately in the centre of the Project study area. Cracow Creek occupies a catchment area of 459 km^2 and has a length of 16.9 km.

Cracow Creek has a well defined channel, however, the creek was dry at the time of the EIS field inspection. Riparian vegetation consists of long grass to the bank edge and some upper canopy vegetation surrounding the creek (refer Photo 6-6).


Photo 6-6: Cracow Creek

Geomorphological Conditions

Adjacent soils appear to be silty clay. The stream substrate is dominated by sand, indicative of a depositional zone. There is some evidence of bank erosion at this location.

Other Surface Water Drainage

Other creeks and drainage lines intersected by the Project include Bullock, Bungaban, Cockatoo, Downfall, Ross, Orange, Delusion, Oxtrack, Boam, Banana, Pigeon, Kianga, Spring, Bottle Tree and Stakeyard Creeks. Table 6-1 below provides details of waterway characteristics, including observed flow at the time of a site inspection, the soil type, vegetation characteristics and geomorphological conditions.

Of note, despite recent heavy rainfall in the area, the majority of these creeks were dry at the time of inspection.

Table 6-1: Characteristics of other Watercourses

Creek	Geomorphological Conditions
Bullock 	Some rill erosion Dispersive clays
Bungaban 	Some evidence of erosion Some clay and weathered rock

Creek	Geomorphological Conditions
Cockatoo 	Minimal erosion Black dispersive soil
Downfall 	Minimal erosion Sand
Ross 	Erosion evident Black soil with some loose rock
Orange	Black soil, clay

Creek	Geomorphological Conditions
Delusion 	Some erosion Stiff clay/sand
Boam 	Some erosion Black soil
Banana 	Some erosion Black soil, gravely sand

In addition to the above, approximately 61 drainage lines will be intersected by the Project based on modelling undertaken to date.

6.1.3 History of Flooding

Detailed information regarding flooding on the many local creeks and waterways that cross the alignment is not available. However, all of these waterways drain into the Dawson River and would contribute to flood events on this river system. Data on flooding in the Dawson River is contained in Appendix F. The BOM has a flood warning network on the Fitzroy River system, including flood gauges on the Dawson River at Taroom, Theodore and Moura. The flood classifications for these gauges are presented in Table 6-2 and recorded flood level information for a number of historical flood events is presented in Table 6-3.

Table 6-3 indicates that the May 1983 flood event was the highest recorded event in the Dawson River catchment along the length of river between Taroom and Moura. This event was classified as a major flood event at all three locations, indicating that there was widespread inundation, isolation of towns and disruption to road and rail links. In more recent times the January 2008 event was also considered a major flood event at Taroom but was only considered a minor event at Moura.

The preferred alignment does not cross the Dawson River and the identified waterway crossings are far enough upstream of the Dawson River to be unaffected by river flooding. However, during the historical Dawson River flood events, it is probable that rainfall occurred across some or all of the individual waterway catchments and also caused flooding within these waterways themselves.

Table 6-2: Flood Classifications along the Dawson River

Gauge	Minor flood level (m AHD)	Moderate Flood Level (m AHD)	Major Flood Level (m AHD)
Taroom	183.82	184.82	186.82
Theodore	135.65	138.65	139.65
Moura	103.19	108.19	109.19

Table 6-3: Historical Flood Events along the Dawson River

Flood Event	Historical Peak Flood Level (m AHD)		
	Taroom	Theodore	Moura
Feb 1954	188.97	141.29	-
Jan/Feb 1978	184.90	138.92	107.65
May 1983	188.28	140.89	109.28
Mar 1988	184.77	-	-
Jan 1991	-	135.63	103.79
Jan 2008	186.89	-	103.99
Feb 2008	184.67	-	-

6.1.4 Current Water Licenses and Uses for Surface Water

Water Use

Surface water use in the Dawson River catchment includes irrigation water supply for cotton, fodder, cereal and crops such as wheat, barley, oats, maize, mung beans, soybeans, sunflowers, sorghum and peanuts (SunWater, 2007). Surface water is also used for urban water supplies for the towns of Theodore, Moura, Baralaba and Duaringa. Coal mines and an ammonium nitrate plant in the Moura-Kianga area, and a gold mining venture at Cracow are also supplied from the Dawson River catchment.

There are a number of major water storage sites within the catchment, including: Theodore weir constructed in 1930, Orange Creek weir constructed in 1932, Moura weir constructed in 1946, Glebe weir constructed in 1971, Neville Hewitt weir constructed in 1976, and Gyranda weir constructed in 1987.

Water Licenses

Water allocations (managed through Water Licences) are issued with a priority depending on the use of the allocation. An allocation can either have a high, medium or medium A priority. A water allocation with a high priority has a relatively high level of performance when compared to medium priority water allocations. A high level of performance in this context means that a holder of a high priority allocation would have a greater level of access to their allocated water relative to medium or medium A allocations (i.e. performance can be used to describe the reliability of accessing the allocation). High priority water allocations are mostly used for urban and industrial purposes. High priority allocations can occasionally be used to irrigate high value crops. Medium priority allocations have a lower level of performance compared to high priority allocations.

There are 151 registered Water License holders in the Dawson River catchment, with 371 off takes. The total water quantity for the Dawson Valley is 61,937 ML. For the current water year (2008[1]) 44,069.280 ML has been allocated of which only 8,779 ML has been used (SunWater Online, 2008). Eleven transfers have been undertaken this water year (October 2007-September 2008) totalling 706 ML. In the Water Resources Plan (WRP) Annual report produced by the DNRW, there were five permanent transfers between July 2006 and June 2007.

6.1.5 Environmental Values and Water Quality

This Section of the EIS addresses the environmental values and water quality of aquatic systems identified within or intersected by the Project and the downstream receiving environment.

The assessment is descriptive and it is based on existing literature and observations during site visits undertaken in February 2008. Given the limited water quality information held by DNRW for each of the watercourses there is only minimal data available to describe baseline conditions.

Description of Environmental Values

The *Environmental Protection (Water) Policy 1997* (EPP(Water)) under the EP Act identifies environmental values and water quality objectives (WQO's) for waters within Queensland.

[1] The water year starts every 1st of October

The EPP serves to protect Queensland's environment while allowing for ecologically sustainable development. This is achieved through the policy by providing a framework for:

a) identifying environmental values for Queensland waters; and

b) deciding and stating water quality guidelines and objectives to enhance or protect the environmental values; and

c) making consistent and equitable decisions about Queensland waters that promote efficient use of resources and best practice environmental management; and

d) involving the community through consultation and education, and promoting community responsibility.

Part 3, Section 7 of the policy states that:

1. The "environmental values" of waters to be enhanced or protected under this policy are:

   a) for a water in schedule 1, column 1—the environmental values stated in the document opposite the water in schedule 1, column 2; or

   b) for another water—the qualities in Subsection (2). 2 Under Section 3 of the Act, the object of the Act is to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development). s 8 7 s 8 Environmental Protection (Water) Policy 1997.

2. The qualities are:

   a) if the water:

      1. is a pristine water—biological integrity of a pristine aquatic ecosystem; or
      2. is not a pristine water—biological integrity of a modified aquatic ecosystem; and

   b) suitability for recreational use; and

   c) suitability for minimal treatment before supply as drinking water; 3 and

   d) suitability for agricultural use; and

   e) suitability for industrial use.

3. However, if a natural property of the water precludes enhancement or protection of a particular environmental value, subsection (1)(b) does not apply to the value.

4. For subsection (1)(a), a document is taken to state environmental values for a water if it states 1 or more values (however described) that are equivalent to a quality or qualities in subsection (2).

Watercourses impacted by the Project fit the definition of "modified aquatic ecosystem" under EPP (Water). In the absence of specific WQO's for these watercourses environmental values have been determined from the *Queensland Water Quality Guidelines 2006* (QWQG). The environmental values for the watercourses and receiving environment of the study area are as follows:

- Aquatic ecosystem – slightly to moderately disturbed ecosystem;
- Primary industries – irrigation, farm water supply, stock watering, aquaculture, human consumers of aquatic food;
- Recreation and aesthetics – primary recreation, secondary recreation, visual recreation;

- Industrial uses; and
- Cultural and spiritual values.

Water Quality Guidelines

The *Australian and New Zealand Conservation Council Guidelines 2000* (ANZECC) provide trigger values or descriptive statements for different indicators of water quality to protect aquatic ecosystems and human uses of water (e.g. primary recreation, human drinking water, agriculture, stock watering). The ANZECC Guidelines are a broad scale assessment and it is recommended that, where applicable, locally relevant guidelines are adopted.

The Queensland EPA's QWQG are intended to address the need identified in the ANZECC Guidelines by:

- Providing guidance values (numbers) that are tailored to Queensland regions and water types; and
- Providing a process/framework for deriving and applying local guidelines for waters in Queensland (i.e. more specific guidelines than those in the ANZECC Guidelines).

For the purpose of determining appropriate WQO's for the study area, the East Coast – Central (Basins 117-136) region has been adopted from QWQG (refer Table 6-4). The Fitzroy River is identified as Basin 130.

Freshwater creeks within the study area are considered to be upland freshwaters, although, a number of the streams have substrate that consists of material (sand and silt) more commonly found in lowland freshwater streams as defined by the ANZECC Guidelines. For comparison purposes, lowland freshwater values are also provided (refer Table 6-4).

In the ANZECC Guidelines lowland freshwater streams are defined as all freshwater streams or stream sections below 150 m. As outlined above, there are potential limitations with this surrogate, and a more broadly applicable definition is:

> *"Larger (third, fourth and fifth order or greater), slow-flowing and meandering streams and rivers. Gradient very slight. Substrates rarely cobble and gravel, more often sand, silt or mud." (DIBM 2001)*

In the ANZECC Guidelines upland freshwater streams are defined as all (freshwater) streams or stream sections above 150 m. This arbitrary altitude-based definition may not be appropriate for many areas. For example, some small streams below 150 m may be more appropriately identified as upland streams even though they fall outside this category. Similarly some waters above 150 m may exhibit characteristics more reflective of lowland freshwaters. A more broadly applicable definition is:

> *"Small (first, second and third order) upland streams. Moderate to fast flowing due to steep gradients. Substrate usually cobbles, gravel or sand — rarely mud." (DIBM 2001).*

Table 6-4: Water Quality Objectives for the Fitzroy Basin (derived from the QWQG and ANZECC Guidelines)

Parameter		Units	Freshwater Lowland	Freshwater Upland
Temperature		°C	N/A	N/A
pH	Upper		8	7.5
	Lower		6.5	6.5
Conductivity		μS/cm	200	200
DO	Upper	% sat	110	110
	Lower	% sat	85	90
Turbidity		NTU	50	25
Suspended Solids		mg/L	10	-
Total Nitrogen		μg/L	500	250
Organic N		μg/L	420	225
Oxidised N		μg/L	60	15
Ammonia N		μg/L	20	10
Total Phosphorus		μg/L	50	30
Filterable Reactive Phosphate		μg/L	20	15
Chlorophyll-a		μg/L	5	N/A

For parameters where QWQG provides no guideline value, ANZECC Guidelines have been adopted as the best practice. It is acknowledged that the application of QWQG to ephemeral and intermittently flowing streams is questionable, however, in the absence of appropriate guidelines for such environments, the default WQO's have been adopted. Compliance or otherwise with the guideline values will be discussed in terms of local conditions.

QWQG states that for "slightly to moderately disturbed" waters, compliance against the guideline values should be assessed using the median value of the data set for each site.

Water Quality Monitoring and Analysis

Results of water quality monitoring for several watercourses in the study area have been obtained from the DNRW Watershed Database (refer Table 6-6). Map 21 – Dawson Rivers Catchments in the Map Folio shows the locations of water quality monitoring sites. A review of background information revealed that there is very little data on water quality of the creeks identified within the study area. Limited historic water quality data is available for Juandah, Cracow, Castle and Lonesome Creeks.

The majority of the DNRW data for creeks in this area is not likely to be indicative of current water quality as it is over 10 years old (i.e. Cracow Creek 1983, Castle Creek 1963-1984 and Lonesome Creek was sampled once in 1997). Of the records that are less than 10 years old, Juandah Creek has data collected between 1985 and 2000. Table 6-5 summarises the data attributes for the DNRW sites.

Table 6-5: Summary of Data Attributes for DNRW sites

	DNRW Sites					
	1030302A	**130350B**	**130344A**	**130340A**	**130318A**	**1303220**
Station name	Dawson River @ Taroom	Dawson River @ Moura Weir Headwater	Juandah Creek @ Windamere	Cracow Creek @ AMTD 16.9 km	Castle Creek @ Old Walloon	Lonesome Creek @ Theodore Moura Rd
Location (easting, northing)	780152, 7161490	795351, 7276202	788431, 7118180	222205, 7185752	217398, 7244841	203555, 7247137
Catchment area (km^2)	15,846	29,010	1,678	459	683	165
Flow gauging	3	3	3	3	3	3
Water quality	3	3	3	3	3	N/A
Flow data range	1910-2006	1997-2002*	1973-2005	1982-1988*	1956-1984	N/A
Water quality data range	1963-2006	1997-2000	1985-2005	1983-1987	1963-1985	1997

Note: Mean monthly stream discharges statistics have not been calculated.

Water Quality Monitoring Results

This Section outlines the results obtained from the water quality monitoring conducted by DNRW for six relevant creeks. Median water quality results for a range of parameters recorded at each of these watercourses are presented in Table 6-6. Location of water quality monitoring sites in context of the study area and the overall Dawson River catchment are illustrated in Map 21 – Dawson River Catchments in the Map Folio.

Table 6-6: Water Quality Monitoring Results (median values)

Parameter	Water Quality Objectives	Dawson River (Taroom)	Dawson River (Moura)	Juandah Creek	Cracow Creek	Castle Creek	Lonesome Creek
Turbidity (NTU)	25	**59**	***403***	**100**	*7.67*	***30.33***	*21.9*
Chlorophyll – *a* (µg/L)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
pH	7.5-6.5	*7.7*	*7.3*	7.3	***8.3***	**8.0**	***7.9***
Conductivity (µS/m)	200	**265**	**264**	**205**	***1,468***	**845**	***375***
Suspended Solids (mg/L)	0	**46**	***171***	**391**	***10***	**10**	***34***
Dissolved Oxygen (% sat)	110-90	**5.0**	***6.6***	***9.2***	N/A	N/A	***4.9***
Total Nitrogen (µg/L)	250	**670**	***865***	***1,300***	N/A	N/A	N/A

Parameter	Water Quality Objectives	Dawson River (Taroom)	Dawson River (Moura)	Juandah Creek	Cracow Creek	Castle Creek	Lonesome Creek
Ammonia Nitrogen (μg/L)	10	**30**	N/A	***20***	N/A	N/A	N/A
Oxidised Nitrogen (μg/L)	15	N/A	N/A	N/A	N/A	N/A	N/A
Total Phosphorus (μg/L)	30	**140**	***230***	***380***	N/A	N/A	***96.5***
Filterable Reactive Phosphorus (μg/L)	15	**45**	N/A	N/A	N/A	N/A	N/A

Notes:

- **Bold** indicates exceedance of water quality objective
- *Italics* indicates single values (spot measurements) have been used as there are insufficient measurements to derive a reliable median value

QWQG values are currently exceeded at all sites, for the majority of parameters (with the exception of pH). The results indicate that these creeks are subject to anthropogenic influences, including grazing, land clearing and agriculture, and possibly in some instances industry and urban based activities.

Stream Discharge Monitoring

Stream discharge monitoring has been undertaken on a number of the streams that are intersected by the Project and the Dawson River. Table 6-7 shows details of mean monthly discharge calculated for four locations within the catchment. The data indicates that while some flow can occur during any month, the largest flows generally occur over the wetter summer months within the catchment.

Table 6-7: Summary of Mean Monthly Stream Discharge Statistics

Location / Month	Dawson River @ Taroom flow (ML)	Juandah Creek @ Windamere flow (ML)	Castle Creek @ Old Walloon flow (ML)
January	51,849	5,488	2,605
February	95,120	5,954	2,109
March	35,780	1,904	5,351
April	26,672	3,686	1,655
May	26,705	6,085	3,044
June	16,361	2,961	466
July	15,197	1,738	148
August	7,426	2,541	51
September	8,559	3,376	25
October	9,441	1,605	33

Location / Month	Dawson River @ Taroom flow (ML)	Juandah Creek @ Windamere flow (ML)	Castle Creek @ Old Walloon flow (ML)
November	26,826	5,074	1,861
December	45,776	5,129	6,045

6.1.6 *Surface Water Legislative Requirements*

Water Act 2000

Under the *Water Act 2000*, a watercourse is defined as:

- A river, creek or stream in which water flows permanently or intermittently in a natural channel, whether artificially improved or not;
- Or in an artificial channel that has changed the course of the watercourse. It also includes the bed and banks and any other element of a river, creek or stream confining or containing water.

Based on this definition, all surface water confined within a channel within the study area that will be crossed with either a culvert or a bridge would fall under this definition. Water licences will be required for any activity that interferes with the course of flow of water under Section 206 of the *Water Act 2000*. This is likely to include the construction of bridges and culverts within watercourses along the alignment.

Under this legislation, the DNRW Chief Executive may grant water licenses for taking water and interfering with the flow of water.

The words “diverting” or “changing “ in the context of this licence application does not refer to an action where water is taken from the watercourse, lake or spring by mechanical means and used on land. Any increase to, or reduction of the flow that occurs between the upstream and downstream extent of the diversion must solely be as a result of changes in the characteristics of the water course, lake or spring.

Approval of this type of licence application does not authorise construction or installation of the works or any associated development. Where required, an application must be lodged for a development permit under the IP Act as discussed below.

A water permit will be required in accordance with the *Water Act 2000* if it is proposed to take surface water for use in construction of the Project.

Under Section 237 of the *Water Act 2000*, an applicant can apply for a water permit for taking water for an activity. At the time of the application the activity must have a reasonably foreseeable conclusion date. The application must be in the approved form and supported by sufficient information so a decision can be made. A fee is also required to be submitted by the applicant with the application.

A riverine protection permit will be required for any activity that involves destroying native vegetation, placing fill or excavation within a watercourse, lake or spring in accordance with Section 266 of the *Water Act 2000* unless undertaken by a relevant authority.

A person may apply to the chief executive for a permit to do any or all of the following activities:

- Destroy vegetation in a watercourse, lake or spring
- Excavate in a watercourse, lake or spring
- Place fill in a watercourse, lake or spring

Integrated Planning Act 1997

Development Approval

Depending on the design and installation of culverts and bridges along the alignment, an application may need to be lodged for development approval under the IP Act and *Water Act 2000* for *Operational Works* involving *taking, or interfering with, water*.

Schedule 8, Part 1, Table 4, Item 3 of the IP Act specifies that operational work for the purposes of taking or interfering with the flow of water under it is assessable development, which includes:

- All work in a watercourse (e.g. a pump, gravity diversion, stream re-direction, weir or dam);
- All artesian bores anywhere in the State, no matter what their use;
- Sub artesian bores in declared sub artesian areas, under certain wild river declarations and under certain water resource plans, used for purposes other than stock and/or domestic use; and
- Sub artesian bores in certain declared sub artesian areas and under certain water resource plans that are used for stock and/or domestic purposes.

Development approval may also be required under the IP Act for *Operational Works* involving *constructing or raising waterway barrier works*. This application would be assessed against the *Fisheries Act 1994*.

The construction or raising any waterway barrier across a watercourse (freshwater or tidal) requires a development approval under the IP Act. The Chief Executive of the DPIF approves a development application for construction or raising a waterway barrier only if the proposal addresses movement of fish across the proposed barrier. The purpose of this part of the Act is to provide a balance between the need to construct dams and weirs and the need to maintain fish movement.

Development approval would be required if dredging within watercourses was necessary. It would be assessed as an Environmentally Relevant Activity 19 (b) under the IP Act. Dredging is defined as dredging material from the bed of any waters (other than dredging by a port authority) of material for which a royalty or similar charge is not payable.

6.1.7 *Potential Water Quality Impacts*

During the construction and operational phases of the Project direct and indirect impacts may occur in watercourses within and downstream of the Project, which may reduce the environmental values and WQO's described earlier. These include:

- Changes or alterations to environmental flows and overland runoff;
- Impacts to the water quality of the overland runoff or riverine waters;
- Loss or disturbance of threatened and migratory aquatic species; and
- Loss of habitat and biodiversity.

Potential Construction Impacts

A number of potential impacts to the water quality from construction works were identified and include:

- Sedimentation and runoff;
- Hydrocarbon and chemical spills;
- Stormwater discharge and flow redirection;
- Release of weed seeds and pathogens; and
- Construction Phase Water Supply.

Sedimentation and Runoff

Construction phase activities include clearing of vegetation, cut and fill, drainage and other earthworks and the construction of waterway crossings (i.e. installation of culverts and/or bridges). These activities, by their nature, will disturb the soil surface and increase the potential for erosion to occur. Uncontrolled erosion has implications for both stream health and engineering aspects.

Once soil is destabilised, erosive processes (i.e. water and wind) have the potential to strip, mobilise and transport sediment from the work area via overland flow and surface runoff into the drainage network, receiving waters and adjacent properties.

The Project requires cut and fill activities. These activities have the potential to impact on water quality through mobilisation of sediment in runoff and by altering the flow path either temporarily or permanently. Construction activities taking place in the vicinity of a watercourse also have the potential to impact on the quality of the downstream receiving environment and may result in infilling of pools.

Trapping and redirection of overland runoff may alter the functioning of downstream ecosystems. Overland flow may also transport nutrients and other contaminants into the downstream environments. An increase in nutrients can impact on the health of the system through growth of nuisance macrophytes and algae. This has potential to impact on the environmental values of the waterway, including ecosystem health, agricultural use, recreational and aesthetic values.

Bridge or culvert construction, may result in alteration to or removal of in-stream habitats and riparian vegetation which will affect bank and bed stability. Potentially high risk activities during the construction phase include any works within the bed and banks of watercourses. Works undertaken in these areas have the potential to create instability and erosion. This increases the risk of sedimentation and erosion and may result in the re-suspension of any toxicants and nutrients. It also reduces the buffering capacity of the area to cope with environmental flows and overland runoff (i.e. flow velocity and water quality).

Stormwater Discharge and Flow Redirection

Changes to the hydrology of the area, including temporary and permanent alterations to the existing watercourses, may impact on the quantity and quality of freshwater influx and hence the health of aquatic ecosystems and riparian zones within and downstream of the study area. Due to the ephemeral nature of the creeks in the study area, freshwater influx is important to the health of ecosystems, including the vegetation communities and fauna assemblages reliant on pool habitats. Changes to drainage channels may also impact on fauna assemblages, fauna movement, dispersal and reproduction.

Alteration or impediment to flow through the creation of a temporary impoundment during the construction phase of the Project will alter the physical dynamics of an aquatic system, which in turn will have implications for its ecology. In most cases the impacts are likely to be short-term (e.g. the creation of temporary impoundments during bridging works). The development of infrastructure may also impede water movement under base flow and/or flooding events. This includes pooling within watercourses, diversion of overland flow, and changes to frequency, quantity and quality of environmental flows.

Hydrocarbon and Chemical Spills

Potential pollutants can include hazardous and chemical substances (such as hydrocarbons from oil spills, asphalt plumes, solvents, cement slurry and wash water) and litter if not properly managed through appropriate storage and bunding. Stockpiling of materials and soils during construction activities, disturbance of soils and substrates during excavation activities and accidental chemical spills or leakages if not prevented can result in the release of potential sources of contaminants to the aquatic environment. The influx of contaminants such as hydrocarbons and heavy metals can impact on the aquatic biota through acute and chronic toxicity and bioaccumulating through the food web. This can impact on the environmental, commercial and recreational value of the area.

Release of Weed Seeds and Pathogens

The release of viable weed seeds and pathogens into the watercourses from vehicles and machinery traversing the watercourses or riparian zones can potentially occur from runoff from wash down areas has the potential to impact on watercourses through direct transportation of turbid water and weed seeds to adjacent watercourses. Also the source of water used for wash down has the potential to impact on surface water quality (i.e. salinity if bore water is being used or nutrients if recycled water is being used).

Construction Water Supply

This Section is covered in Section 6.2.5 of this report.

Potential Operational Impacts

The key locations where potential impacts may occur from operational activities are areas where runoff and/or discharge waters from the Project can enter watercourses and drainage lines. The potential impacts of the Project on water quality during the operational phase are considered to include:

- Sedimentation and runoff;
- Hydrocarbon and chemical spills;
- Stormwater discharge and flow direction; and
- Potential hydraulic impacts.

Sedimentation and Runoff

Bridge spans are likely to be used to cross major watercourses (refer Table 6-8). However, culverts will be installed in minor ephemeral watercourses to allow flow to pass under the rail line. The installation of bridges and culverts within watercourses has the potential to destabilise the bed and banks causing scouring and erosion around the structures. This has the potential to cause impacts on the engineered infrastructure (e.g. undermining, failure) as well as impacts on the downstream receiving environment (e.g. elevated turbidity levels resulting in clogging of fish gills, infilling of stream bed substrate and loss of in-stream biota, smothering aquatic plants and filling in of permanent pools/waterholes which act as refuges for aquatic fauna during dry periods).

Culverts have the potential to create a grade change in the stream bed and can cause alterations to stream flow velocities, resulting in erosion on the downstream side of the culvert. Maintenance activities to remove or control weeds (e.g. Typha and Paragrass) upstream of the culvert could cause over excavation of the bed resulting in shallow ponding which may provide habitat for mosquito breeding.

Hydrocarbon and Chemical Spills

Runoff from the roads, rail lines and maintenance areas may contain elevated levels of sediment and coal, heavy metals, petroleum hydrocarbons, polynuclear aromatic hydrocarbons (PAH's) and herbicides. These potential contaminants may result from a combination of the breakdown, spillage and normal operational emission of automotive components. These include tyres, clutch and brake linings, hydraulic fluids, automotive fuels or lubricants, particulates from exhaust emissions and materials from the vehicles themselves.

Chemical/fuel spills have the potential to cause significant damage to the terrestrial and downstream watercourses and to public health if inadequately contained on site. The potential environmental damage from a spill may be long term and has the potential to be significant, depending on the type and quantity of the contaminant spilt the proximity to a drainage line or waterway and the opportunity to intercept and contain the spill.

Accidents/spills resulting from the contents of the train leaving the carriage (i.e. derailment) have potential impacts on watercourses. The majority of the cargo being transported will be coal for export and is not considered a serious contaminant as it is practically inert in its natural state and can be readily cleaned up using mechanical techniques. Coal is unlikely to cause serious and/or permanent environmental harm.

The ephemeral nature of creeks within the study area means that if a spill event occurs during dry conditions, clean up can be undertaken before any contaminants are transported downstream.

Table 6-8: Construction Potential Impacts and Mitigation Measures of Hydrocarbon and Chemical Spills

Potential Impact	Mitigation Measures
Cement discharges to land or water	• Careful handling of unhydrated cement material and wet cement to avoid spills to marine environment. Cement must be stored in sealed containers.
	• No deliberate discharge of unhydrated cement material to surrounding soils or freshwater environment.
	• Immediately contain contaminated material in such a way that prevents contamination of surrounding soils and waterways. • Immediately inform site management of spills.
	• For any cement batching site, all stormwater generated from this area (including wash-off) from concrete trucks) to be directed to a sediment pond.

Potential Impact	Mitigation Measures
	• pH needs to be measured prior to discharges from the cement pond and adjusted if it falls outside an accepted pH range of 6.5-8.5. Clean water is then to be decanted from the top of the pond and disposed off to ground
	• Sediment from the pond will be excavated as required and disposed appropriately

Cement Spills

As described in Section 2.4.12 the bridge construction at Downfall Creek may require a concrete batching plant. Whilst concrete batching plants have a number of potential impacts such as dust and noise and waste (see Sections 7, 8 and 9 respectively), the most significant potential impact to water resources is the potential spillage of cement or concrete to waterways. Given the typical low flow conditions of the local streams and waterways, potential pH impact as a result of accidental discharges of cement would be exasperated. A number of mitigation measures are suggested in Section 6.1.9 to manage the production of concrete.

Stormwater Discharge and Flow Redirection

Drainage impacts have the potential to affect the quantity and the quality of the runoff water. Increased velocities as a result of constriction of flow by bridges and culverts will increase the potential for erosion, particularly during peak flows after storm events.

6.1.8 Potential Hydraulic Impacts

A drainage assessment study was undertaken and included the following:

- Location and identification of drainage routes intercepting the rail alignment;
- Delineation of catchments for each drainage route;
- Determination of peak flood discharges in each waterway at the rail alignment using:
  a) Rational method calculations; and
  b) RORB hydrologic modelling.
- Hydraulic analysis of culvert requirements;
- Hydraulic analysis of larger crossing using simplified HEC-RAS analysis;
- Review of hydraulic analysis outcomes; and
- Recommendations for drainage design.

For the purpose of preliminary hydrologic analysis catchments were differentiated into two groups based on catchment size. Peak discharges were estimated for catchments using two methods according to the catchment area:

- The Rational Method for catchments with areas less than 5,000 ha; and
- RORB modelling for catchments with areas exceeding 5,000 ha.

Culvert design was undertaken in accordance with the Road Drainage Design Manual (DMR, 2002), and considered:

- Ability to convey the peak discharge for the 1% annual exceedance probability (AEP) event;
- Determination of inlet or outlet controlling peak water levels; and
- Locating structures in the natural drainage channels delineated during catchment analysis.

RORB modelling was used for all catchment areas larger than 5,000 ha with flows exceeding 250 m^3/s being generated. The hydraulic analysis was based on shuttle radar topography mission (SRTM) derived topographical data and simple HEC-RAS models. See Table 6-9 for hydraulic analysis results for a selection of bridge openings.

Preliminary design indicates there will be a total of 47 bridges and 52 major culverts constructed or improved along the corridor. This is subject to change during the detailed design. The locations of proposed major culverts and bridges are shown in Map 23 – Road and River Crossings in the Map Folio. Bridges have generally been proposed as the preferred crossing method where 1% AEP flow exceeds 250 m^3/s.

Table 6-9: Proposed Bridge Crossings and Potential Hydraulic Impacts

Crossing	Proposed Infrastructure	100 year ARI water surface level (m AHD) – immediately upstream		Afflux (m)	Flow velocity at bridge opening during 1% AEP (m/s)
		Existing Case	Developed Case		
Juandah Creek	Bridge	239.04	239.47	+0.43	2.6
Roche Creek	Bridge	250.12	250.79	+0.67	2.1
Cabbage Tree Creek	Bridge	252.20	252.35	+0.15	1.9
Castle Creek	Bridge	169.19	171.25	+2.06	3.0
Lonesome Creek	Bridge	168.99	170.10	+1.11	3.1
Cracow Creek	Bridge	247.92	248.17	+0.25	2.3
Bullock Creek	Bridge	249.04	249.19	+0.15	1.7
Bungaban Creek	Bridge	242.17	242.44	+0.27	2.2
Cockatoo Creek	Bridge	204.67	205.13	+0.46	3.0
Ross Creek	Bridge	245.67	246.32	+0.65	3.1
Orange Creek	Bridge	206.59	207.38	+0.79	3.1
Delusion Creek	Bridge	174.38	174.78	+0.40	2.5
Boam Creek	Bridge	186.64	187.60	+0.96	2.1
Banana Creek	Bridge	156.44	156.68	+0.24	2.9

Note: Afflux is defined as the maximum increase in water surface elevation above that of an undisturbed stream, due to the presence of a structure such as a bridge or a culvert.

The acceptability of the above increases in peak water levels and potential changes to peak channel velocities, will need to be considered during detailed design when more detailed survey information is available to improve the accuracy of the hydraulic modelling. For example at this stage the higher levels of afflux associated with the Castle Creek and Lonesome Creek bridges can possibly be attributed to limits in the 1-dimensional hydraulic analysis. As part of the next design stage, it is anticipated that the afflux levels will be refined.

Identification of any nearby properties, buildings or infrastructure that may be impacted will also need to be undertaken during detailed design.

6.1.9 Mitigation Measures

Construction Phase

Potential water quality impacts during the construction phase will be managed primarily through the Erosion and Sediment Control Plan and the implementation of appropriate mitigation measures such as those outlined in Table 6-10.

Table 6-10: Construction Phase Mitigation Measures

Potential Impact	Mitigation Measure
Sedimentation and runoff	• Stockpile materials (i.e. cement) and soils away from watercourses and overland flow paths/drainage lines/low points. • Slow and/or prevent overland runoff using grass filter strips and artificial structures (e.g. diversion bunds and rock check dams along drainage lines). • Where practical, undertake the major earthworks during the dry season and install temporary bunding or sediment traps. • Where possible minimise the amount of actual work required within the bed or banks of a watercourse or within a riparian zone and establish "no go" zones to avoid accidental removal of vegetation. • Install erosion and sediment control measures in accordance with the Soil Erosion and Sediment Control – Engineering Guidelines for Queensland Construction Sites prior to the commencement of any construction activity and inspect regularly and repair or replace if necessary. This will be managed through the EMP(C). • Stabilise disturbed areas as soon as possible using appropriate treatment (e.g. hydromulch and seed batters) and stabilise any stockpiles to be left exposed for any period longer than two weeks duration. • Isolate and remediate areas of existing erosion and/or identified dispersive soils to prevent further damage. • Where practical, control access points to riparian areas to minimise the area of disturbance (e.g. existing tracks or disturbed areas) and locate the access point at the most optimal location (i.e. not on an unstable outer bank or a stream bend). • Utilise existing disturbed areas (e.g. stock crossings/tracks) wherever possible.

Potential Impact	Mitigation Measure
Hydrocarbon and chemical spills	• Implement drainage controls to separate "clean" and "dirty" water on site. • Educate relevant employees in appropriate chemical handling techniques and appropriate response to the identification of a spill or leak. • Chemical spill kits will be located within vehicles carrying chemicals and near chemical storage areas. • Temporary chemical storage areas and wash down facilities are to be located away from watercourses and drainage channels and will be appropriately bunded in accordance with relevant Australian Standards. Provisions are to be in place to ensure an abductor truck can access the site to pump out the bunded area if required. • Install oil and grit separators in areas of vehicle or plant maintenance/repairs. • Refuelling of equipment away from any watercourses. • Adopt weed management strategies which have a minimal impact on aquatic habitats (e.g. type herbicide used and application rate)
Stormwater discharge and flow redirection	• No filling, draining, damming or alteration of any waterway, excluding that necessary for the construction activities and for which approval has been given (i.e. installation of culverts or bridge footings). • Water quality monitoring will be undertaken following rain events significant enough to cause preventative and containment measures to become defective and visual inspections reveal discolouration (e.g. turbidity, oil) in receiving waters. • A Stormwater Management Plan will be developed for the construction phase of the Project.
Release of weeds and pathogens	• Care should be taken when using earthmoving equipment so that soil disturbance is kept to a minimum. • A Weed Management Plan will be developed to control the release of weed and pathogens.
Flooding of project work sites causing numerous discharges	• Measures will be implemented to avoid impacts from the Project associated with flood events by timing of certain works to fall outside of weather risk periods. This should be consistent with those techniques outlined in Soil Erosion and Sediment Control-Engineering Guidelines for Queensland Construction Sites (1996). Where possible, high risk works (i.e. major earthworks in watercourses) will be staged to avoid periods of expected seasonal rainfall.

Operation Phase

Potential impacts to water quality during the operational phase will be managed through the implementation of appropriate mitigation measures such as those outlined in Table 6-11.

Table 6-11: Operational Phase Mitigation Measures

Potential Impact	Mitigation Measure
Hydrocarbon and chemical spills	• Emergency response procedures will be implemented which will document how environmental cleanup following a derailment is to be undertaken; • All chemicals/fuels/contaminants will be stored in an appropriately bunded restricted area and clearly signposted; • All persons with access to chemicals/fuels/contaminants will be trained in spill management; • Adopt weed management strategies which have a minimal impact on aquatic habitats (e.g. type herbicide used and application rate); • Vehicles will be maintained according to manufacturer's specifications, with regular checks undertaken to ensure fuel, chemical and oil leaks are minimised; • Spills will be managed under the Waste Management Plan and hazardous substances Australian Standard AS 1940B1993.
Scouring	• Detailed hydraulic modelling and scour analysis will be undertaken during subsequent design stages of the Project; • Based on hydraulic assessment analysis undertaken to date, scour protection will be utilised for abutments, piers and channels of all watercourses except for the channels of Bullock, Cabbage Tree and Banana Creeks which are modelled as having lower velocities. Detailed scour analysis will be undertaken during subsequent stages of the Project; • All permanent erosion and sediment control structures will be regularly inspected and they will have a schedule for inspection and maintenance; • The risk to watercourses will be minimised (e.g. sedimentation and pooling of water) through the routine maintenance of culverts and bridges structures; • The design of the bridges or culverts should, where possible, endeavour to retain the natural morphology of the watercourse to maintain the natural flow and water quality conditions; • Bridges have been proposed for watercourses where a 1% AEP flood event flow exceeds 250 m^3/s based on hydraulic modelling undertaken to date; • Structures have been designed for drainage that can accommodate a 1 in 100 year flood event. Bridges have been designed to AS:5100.

Potential Impact	Mitigation Measure
Sedimentation and runoff	• Riparian vegetation, flow dependent ecosystems and wetlands will be left undisturbed wherever possible; • Stormwater management measures should be designed to capture and filter runoff without significantly compromising overland flows; • The Project design will include various stormwater drainage systems to convey stormwater from the site. Drainage systems will be required for road and rail cross drainage; • During the design phase, issues relating to transport of sediment from exposed and disturbed land entering into runoff and drainage lines will be considered. This will include the preparation of a number of management plans and adoption of mitigation measures, including: – Erosion and Sediment Control Plan – Waste Management Plan.
Existing users water users	• Bridges and culverts will be used to convey flows under the proposed rail line.
Increased flooding height	• Further hydraulic modelling will be undertaken at the detailed design stage to assist with minimising the effects of increased flood heights as a result of new bridges and culverts within the study area.

Note: Section 4.4 contains further mitigation measures relating to hydrocarbon and hazardous materials.

6.2 Groundwater

6.2.1 Methodology

This Section discusses the existing groundwater environment in terms of water quantity and quality in the area and identifies potential impacts of the Project on groundwater resources. Mitigation measures are also proposed to reduce any potential impacts on the groundwater resources during the construction and operational phases of the Project.

An assessment of the existing conditions and the potential impacts that the construction and operation of the Project may have on the groundwater resources is provided. The assessment of existing conditions was limited to a review of previous studies and databases, which included:

- DNRW groundwater database;
- Hydrogeology, Hydrochemistry and Isotope Hydrology of the Great Artesian Basin, GABFEST: A Resource Under Pressure (Habermehl, 2002); and
- Australian Natural Resource Atlas.

The DNRW groundwater database was accessed to determine the nature of the groundwater system throughout the study area. Searches were conducted on bores which were located on properties adjacent to the study area.

As the study area is within the Great Artesian Basin Declared Sub artesian Area, legislative requirements for the registration and reporting of groundwater bore locations and construction details specified within *Schedule 11* of the *Water Regulation 2002* have been considered in relation to the requirement for a development permit to be obtained prior to constructing or installing works that will take sub artesian water for the Project.

The DNRW groundwater database provided information on groundwater levels both on a seasonal and long-term scale within the study area as well as water quality information. Water quality information has been compared with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000).

Groundwater flow direction information was determined using a combination of Habermehl (2002) and existing knowledge of local and regional groundwater system behaviour in the region.

In assessing groundwater resources within the study area, consideration was given to the following legislation and policy documents:

- Water Resource (Great Artesian Basin) Plan 2006 (WRP);
- *Water Act 2000*;
- *Water Regulation 2002*;
- IP Act;
- GAB Resource Operations Plan; and
- Fitzroy Basin Water Resource Plan (WRP) and Resource Operations Plan (ROP).

6.2.2 *Description of Environmental Values*

The following provides a brief description of the environmental values associated with the groundwater environment. As discussed with the DNRW, a more detailed description of the existing groundwater environment, potential impacts of the project on the groundwater environment and proposed management/mitigation/monitoring options and requirements will be provided as part of the application process for water licenses and permits to utilise existing allocated or unallocated water resources in the study area.

Groundwater resources in the study area are an integral part of the overall existing water resource system that are utilised by a number of existing users. Groundwater has the potential of being a significant resource for the construction and operation of the Project, therefore the protection and monitoring of this resource is relevant. The sections below address the groundwater resources of the area based on current available information.

Groundwater Resources

Groundwater resources in the study area are typically associated with artesian/sub artesian aquifers of the Great Artesian Basin or with alluvial aquifers.

Groundwater in the study area is from the Great Artesian Basin (GAB) and is defined under the *Water Act 2000* as either artesian or sub artesian. The main GAB aquifers present in the study area comprise the Precipice Sandstone, the Evergreen Formation and the Hutton Sandstone.

The Hutton Sandstone aquifer is an inter-bedded sandstone, siltstone/mudstone formation with siltstone and mudstone generally being the dominant lithologies. It is a major confined aquifer; however, due to the predominance of mudstone/siltstone and variable lithology, yields are generally moderate and in the order of 6 to 13 L/s (200 to 400 ML/year) per bore.

The depth of the Hutton Sandstone varies from 240 to 500 metres below ground level (mbgl). With a thickness of approximately 200 metres in the study area. Due to its shallowness and good yields, the aquifer is used substantially for stock water supply.

The Precipice Sandstone aquifer is divided into an upper shaly unit and a lower, fine to medium grained sandstone, The formation is lithologically consistent and the sandstone has a relatively high permeability. The Precipice Sandstone has recorded yields of 20 to 30 L/s (630 to 945 ML/year) per bore.

The main alluvial aquifer is the study area is the Dawson River Alluvium, which is crossed by the rail from chainage 140 to 160 km. The alluvial deposits of the Dawson River are shallow and poorly developed and in some locations occur only superficially. North of Taroom the thickness of the alluvium is up to 20 m with sand and gravel aquifers supported by the significant catchments of the creek. Between Nathan Gorge and Theodore it was found that the water bearing sand and gravel beds appear to extend across the full width of the alluvium which is up to 24 m thick.

Although there are not many existing bores in the area, potential yields range from 10 to 60 L/s, but do to the reliance of rainfall recharge, the yields are not reliable/sustainable,

Existing Groundwater Bores

A review of the DNRW Groundwater Database indicates that there are 21 monitoring bores (14 listed as existing and 7 as abandoned), 145 sub artesian bores and 20 artesian bores recorded within a radius of approximately 5 km from the Project. Of these, 115 sub artesian bores and 19 artesian bores are currently operational, with the balance being destroyed or decommissioned. Data from these bores has been analysed to provide some relevant information on the groundwater resources within the study area. Of the bores that are still monitored, the monitoring frequency for standing water level measurement varies between approximately one and four measurements per annum.

Water Levels

Currently groundwater level data from the sub artesian bores in the study area indicate water levels between 0.29 m below ground level (bgl) and 92.96 m bgl. No groundwater levels of the artesian bores are reported within the database for the study area.

As discussed above, the monitoring frequency varies between approximately one and four times per annum as part of the DNRW ambient groundwater level monitoring network.

Groundwater Flow Directions

Localised groundwater flow paths can generally be assumed to be a reflection of topographical variations such as surface drainage patterns. The regional sub artesian groundwater flow system is assumed to be in a general direction towards the Dawson River. Localised flow paths will be controlled within the confines of the various sub catchments of the study area. Generally flow will be towards the local minor and major watercourses which will act as groundwater sinks. Regionally, groundwater flow will be directed towards the Dawson River across the extent of the study area.

Groundwater in the GAB generally flows to the south over much of the basin, however areas in the north flow in a northerly direction (refer to Figure 6-1).

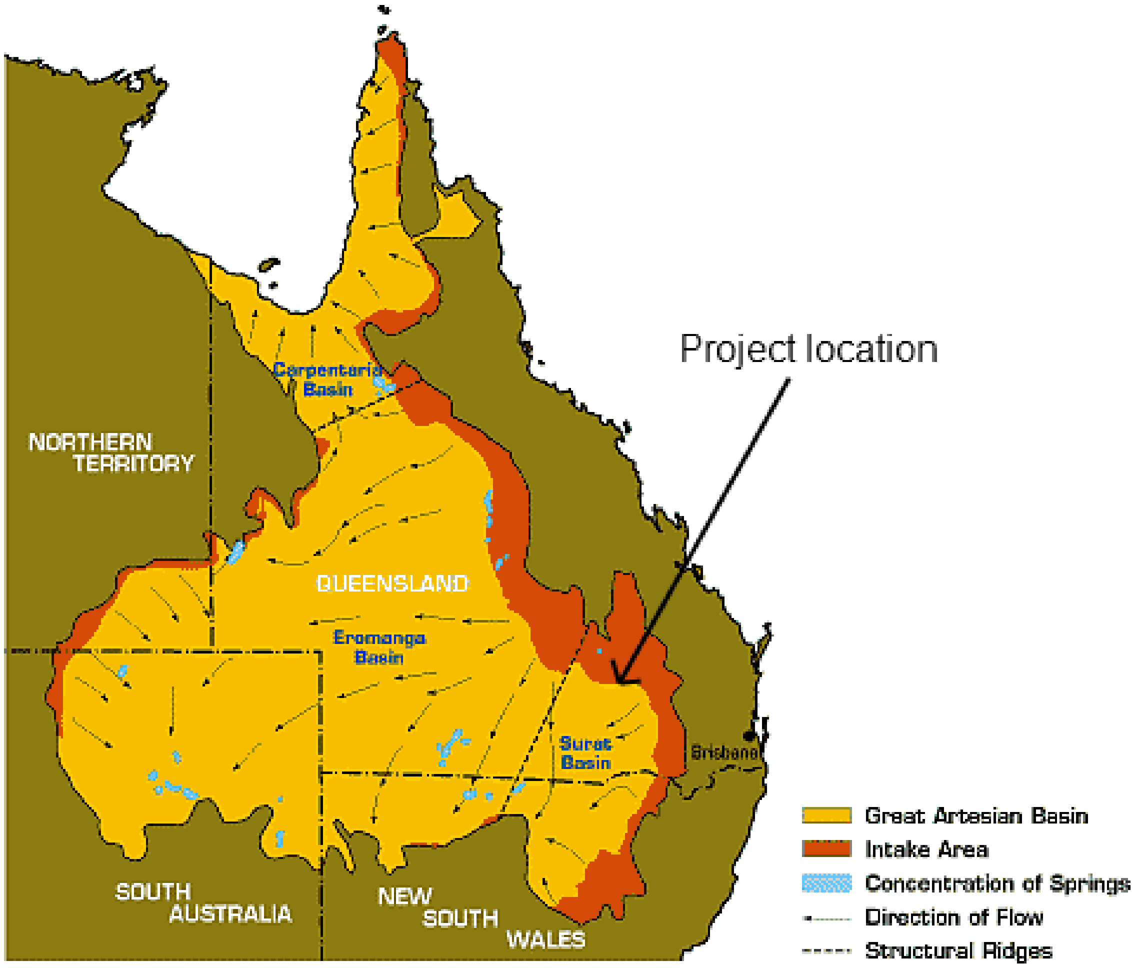

Figure 6-1: Distribution of the GAB showing Intake Areas and Flow Directions

Natural discharge of artesian water in the GAB occurs through mound springs in the south-western areas. Mound springs are found within the Dawson River catchment and are discussed in Section 5.2. These springs are usually associated with structural impediments, such as folds, faults, monoclines and intersecting lineaments, or occur at abutment of aquifers against bedrock to where confining beds thin near the discharge margins (Habermehl, 2002).

Seasonal Variations

As water level records for the sub artesian bores within the study area are limited, one monitoring bore located within the same sub catchment has been selected to determine the water level behaviour of the area. The seasonal variations of groundwater in the immediate study area have been calculated through the use of the representative monitoring bore 13030430 (refer Figure 6-2). This bore is assumed to be representative of the area and all assumptions have been based on this data only. Further analysis would be required to confirm this assumption and this information is therefore indicative only.

Records for bore 13030430 extend from 26 January, 1973 to 15 January, 2008. A graph of standing water levels for bore 13030430 is presented as Figure 6-2.

Water level measurements were recorded quarterly for the duration of monitoring. It should be noted that this sampling pattern is most likely to miss short duration extreme highs and lows. The records should however provide sufficient information to determine a steady state aquifer sample. This bore was observed to have a seasonal variation on average of 0.36 m/y, a maximum of 1.72 m in a calendar year and a minimum seasonal fluctuation of 0.04 m/y. Also, since 1997 it appears that the water level in the aquifer is tending downwards.

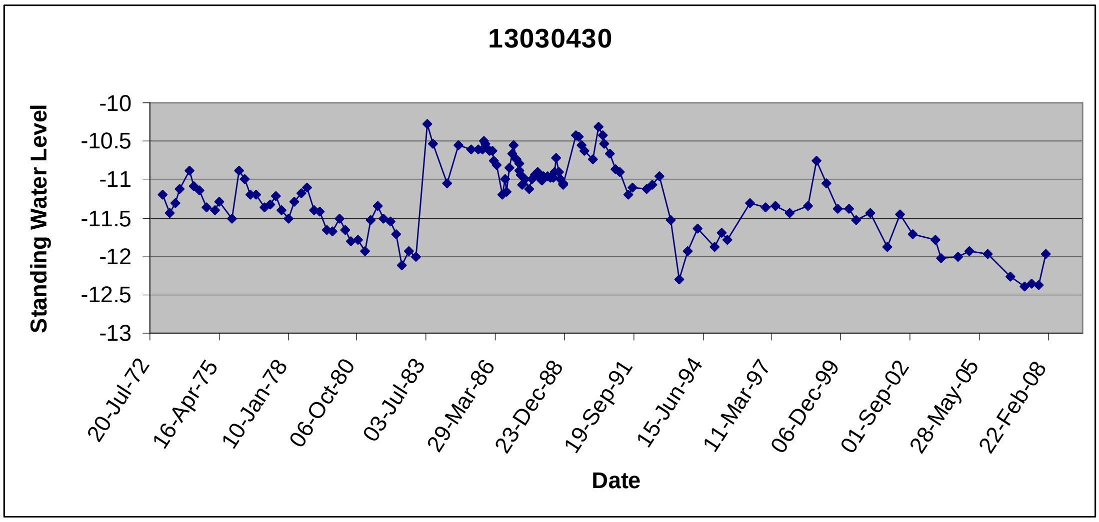

Figure 6-2: Water Levels – Bore 13030430

There are reported artesian aquifers within the study area, however, with minimal water level data available, the variation to be expected within the artesian aquifers has not been determined.

Hydraulic Parameters

The transmissive and storage properties determine the rate and amount of water that can be extracted from an aquifer. The two properties, hydraulic conductivity and storativity are important in characterising the groundwater flow system. These aquifer properties are most reliable when interpreted from pump test data. Other sources such as the interpretation from lithological logs provide data more representative of the site or bore than the aquifer. No data was available at the time of writing to determine the hydraulic parameters of the aquifers within the study area, although generalised data is available for the hydraulic parameters of the GAB. The Dawson River alluvial aquifer has sands and gravels that are highly transmissive with a transmissivity ranging from 400-3,000 m^2/day.

Hydraulic conductivity values of the aquifers range from 0.1 to 10 m/day with the majority being in the lower range. Storage coefficient values range from 10^{-4} to 10^{-5}. Groundwater movement is slow and based of the hydraulic parameters ranges from approximately 1 to 5 m per year.

Groundwater Quality

The ANZECC Guidelines provide guideline values or descriptive statements for different indicators to protect aquatic ecosystems and human uses of waters (e.g. primary recreation, human drinking water, agriculture, stock watering). The EPP (Water) also provides environmental value guidelines that are required to be protected or enhanced under the EPP policy. This policy outlines the protection of the following Environmental values for groundwater in Queensland:

- If the water:
  a) Is a pristine water—biological integrity of a pristine aquatic ecosystem
  b) Is not a pristine water—biological integrity of a modified aquatic ecosystem
- Suitability for recreational use;
- Suitability for minimal treatment before supply as drinking water;
- Suitability for agricultural use; and
- Suitability for industrial use.

The WQO's for the region are not defined under the EPP (Water). However, reference is made regarding the use of water guidelines that protect all environmental values of the water. Therefore, the ANZECC Guidelines have been used for comparison of groundwater quality in all cases.

A total of 55 analytical results for sub artesian bores were available from the DNRW Groundwater Database for groundwater samples obtained from bores within an approximate 5 km radius of the study area. Sample results from the individual bores were recorded between March 1953 and December 1998.

Water quality was found to be variable across the study area with electrical conductivities (EC's) ranging from 115 µS/cm to 35,000 µS/cm. The recorded pH for waters sampled was between 5.9 and 9.0 which exceed the recommended drinking water guideline range of between 6.5 and 8.5. These guidelines are based on the need to reduce corrosion and encrustation in pipes and fittings.

Sodium levels were recorded between 7.6 mg/L and 6,400 mg/L with 34 samples exceeding the drinking water guidelines of 180 mg/L. Two bores exceeded the guidelines for sulfate of 250 mg/L. Sample levels were reported to range between 1.0 mg/L and 1,120 mg/L.

The palatability of drinking water has been rated according to Total Dissolved Solids (TDS) concentrations by a scale developed by Bruvold and Daniels (1990) and as such ten samples were rated as good (> 80 mg/L and < 500 mg/L), eight as poor (> 500 mg/L and <1,000 mg/L) and the remainder (30) as unacceptable for drinking water purposes (> 1,000 mg/L).

Existing Water Uses

The majority of groundwater use in the study area is to provide water for stock (cattle, sheep) and domestic purposes. Groundwater is sourced from either the artesian or sub artesian aquifers with the better quality water being from the artesian sandstone aquifers.

Wandoan and Taroom townships rely on artesian water from the GAB for water supplies.

Groundwater resources are limited from the area between Cracow and Banana with the poor water quality limiting the extent of development and use of the resource. Currently groundwater is utilised in the Theodore Irrigation Area (TIA) located near the township of Theodore providing alternative irrigation supplies to surface water. The majority of irrigation in Theodore is for crops such as wheat and cotton.

6.2.3 *Groundwater Legislative Requirements*

In Queensland a number of areas have been declared as sub artesian areas (declared areas) under the *Water Act 2000* and the subordinate legislation (i.e. *Water Regulation* 2002 and Water Resource Plans) for individual catchments.

The southern part of the study area is located within the GAB declared artesian and sub artesian areas and is regulated by the Water Resource (Great Artesian Basin) Plan 2006. Surface water is overseen by the Water Resource (Fitzroy) Plan as discussed in Section 6.1. As such, water within the study area is subject to general conditions as required under the *Water Act 2000*, *Water Regulation 2002*, IP Act, Water Resource (Fitzroy) Plan 1999, Water Resource (Great Artesian Basin) Plan 2006, Fitzroy River Basin Resource Operations Plan and the GAB Resource Operations Plan.

The *Water Act 2000* requires that a water licence is obtained for taking or interfering with artesian water anywhere in the state. A water licence is also required to take or interfere with sub artesian water in declared sub artesian areas or in areas defined in a water resource plan. Generally, sub artesian water can be taken for non-intensive stock and domestic purposes without a licence within a declared sub artesian area. It is however, necessary to contact the local office of DNRW, prior to the development of any groundwater resource to ensure that no additional restrictions or requirements have been instigated.

Schedule 8 of the IP Act specifies the operational works that are assessable development. Assessable development includes:

- All work in a watercourse (e.g. pump, gravity diversion, stream redirection, weir or dam);
- All artesian bores anywhere in the state, no matter what their use;
- Sub artesian bores in declared groundwater areas used for purposes other than stock an/or domestic purposes; and
- Sub artesian bores in certain declared groundwater areas that are used for stock and/or domestic purposes.

It is a requirement of the *Water Act 2000* that all water bores in Queensland are to be constructed by a licensed water bore driller to meet the "*Minimum Construction Requirements for Water Bores in Australia*".

There are a number of options for accessing GAB water in the Surat Basin based on the limited resource and a number of legislative requirements that need to be adhered to. The legislative means of entitlements to this water are:

- Unallocated state reserve water;
- Unallocated general reserve water;
- Water licence;
- Water permit; and
- Private agreement.

The southern part of the study area is within the Surat North management area of the GAB. The Surat North management area is managed under the GAB Resource Operation Plan (ROP), which was released in December 2006, and implements the water planning objectives outlined in the Water Resource (GAB) Plan (WRP).

Under the provisions of the WRP and implemented by the ROP, a total of 10,000 ML of state reserve water is available at any one time for projects, for the following purposes:

- A project of state significance;
- A project of regional significance; and
- For water granted to a local government – town water supply purposes.

Water granted for a project is only granted for the life of the project and the right to take water is returned to the state after the conclusion of the project.

It has been determined that GAB water would be required for the Project, based on the area where the water would be required, under the ROP this water could only be taken from the following aquifers:

- Hutton Sandstone;
- Evergreen Formation; and
- Precipice Sandstone.

Unallocated water that is available as part of the state reserve is purchased using the fixed price process.

The EPP (Water) also contains measures for the protection of groundwater. These legislative measures attempt to prevent the contamination of groundwater through placing restrictions on the release of waste water. These restrictions ensure that any direct release of waste water into an aquifer is limited to meeting a number of strict conditions to protect groundwater sources and other groundwater users. It places the responsibility of managing Queensland's groundwater resources back onto DNRW under the *Water Resources Plan* process.

6.2.4 *Groundwater Monitoring Requirements*

As discussed with the DNRW, detailed groundwater impact assessments will be undertaken as part of the application process for water licenses and permits to utilise existing allocated or unallocated water resources in the study area. As part of this detailed assessment, groundwater monitoring requirements will be determined and a monitoring program developed and implemented, to the satisfaction of DNRW.

It is anticipated that as part of any future work for the Project that pre-construction groundwater monitoring in alluvial aquifers may be undertaken.

A series of monitoring bores would be installed along the preferred alignment targeting areas of significant groundwater resources, with emphasis on alluvial areas and intersections with the groundwater table. Special attention will need to be applied to intersections of potential artesian water bearing layers. Groundwater monitoring in these areas will be commenced as part of the detailed groundwater impact assessment, which should be undertaken at the earliest possible convenience to allow effective accumulation and continuity of data.

Groundwater monitoring should be undertaken in areas of cuts and excavations. Placement of these monitoring bores could potentially be undertaken during the geotechnical investigation phase.

Information on hydraulic parameters in the area will be collected by undertaking a series of aquifer tests. The areas where it is most important to collect hydraulic parameter information will be in geotechnical investigation areas for cut dewatering and construction activities that will occur below the water table.

6.2.5 Potential Groundwater Impacts

Potential impacts on the groundwater resource relating to the construction and operational phase of the Project include:

- Contamination through physical interaction with the underlying groundwater by extraction, excavation and construction and operation; and
- Reduced groundwater levels due to over extraction, during construction and operation of the Project, if groundwater is used as major water supply source (as proposed).

Potential groundwater impacting contaminants on construction sites include petroleum hydrocarbons, heavy metals, pesticides, phenyls, polychlorinated biphenyls, and non-metallics including arsenic, cyanide, sulphur, sulphides and sulfates.

Over extraction of groundwater during the development and operation of the Project could lead to a reduction in groundwater levels in the vicinity of the study area.

The potential for contamination and over extraction could impact on:

- Groundwater dependent vegetation such as Boggomosses; and
- Other groundwater users.

Construction Phase

Potential groundwater impacts during the construction phase include:

- The potential for groundwater contamination from fuel and chemical storage and use;
- Contamination of the exposed groundwater through spills, leaks and surface runoff entering the excavations;
- Infiltration of impacted leachate from stockpiled soil originating from the excavations;
- The intersection or interaction with the groundwater table of cut and fill earth works and embankments; and
- The extraction of groundwater for the provision of water for site works. This is addressed in more detail below.

Construction Water Supply

Water will be required for the following onsite construction activities:

- Moisture conditioning earthworks;
- Concrete batching;
- Dust suppression;
- Construction campsite and offices; and
- Vehicle wash down.

Preliminary water requirement estimates have been listed in Table 6-12.

Table 6-12: Estimated Water Requirements for Construction

Description	Min Water Required (ML)	Max Water Required (ML)
Bulk Earthworks	2,700	3,290
Concrete	10	18
Pavement	160	250
Dust Suppression	3,200	4,300
Miscellaneous	130	130
Construction Camps	50	80
Subtotal	**6,250**	**8,100**
Contingency	-	1,500
Total	**6,250**	**9,600**

Note: That these estimates are based on a broad construction plan with some assumptions. These water requirements need to be revised by the construction contractor throughout the Project

The different options available for the sourcing of water supply for the project are description in Section 2.8.2.

Water quality requirements for construction include:

- Potable water for construction site offices;
- Water with medium quality suitable for concrete; and
- Water of reduced quality suitable for earthworks.

A salinity of 1,000 mg/L TDS is generally palatable to most tastes, but up to 1,500 mg/L TDS can be acceptable in areas where better quality water is not available. Salinities above 1,500 mg/L TDS, generally render the water unacceptable for human consumption. The *Australian Drinking Water Guidelines* published by the National Health and Medical Research Council and Agriculture and Resource Management Council of Australia and New Zealand (NHMRC, 1996) recommend a maximum TDS level for drinking water of 500 mg/L.

Water to be used in concrete needs to be clean and free from injurious amounts of oils, acids, alkalis, salts, organic materials and substances harmful to concrete, reinforcement or embedded items. In accordance with AS1379, the pH value of the water needs to be higher than 5. The chloride-ion content of the water needs to be less than 500 mg/L and seawater shall not be used in the concrete mix.

According to the EPA, water for dust suppression requires levels of TDS below 2,000 mg/L and a pH between 6 and 9 for beneficial use approval.

Operational Phase

Ongoing work will be undertaken to determine a viable water source for the construction phase of the Project whilst ensuring sustainable levels for other users in the catchment area. Alternatives for sourcing water will be addressed in ongoing discussions with landowners and as part of the next Project stages.

The potential operational phase impacts of the Project may include:

- The use of pesticides and herbicides for weed and vermin control;
- The use of chemicals for the cleaning and maintenance of trains on site;
- The extraction of minor amounts of groundwater for the provision of facility water (if required); and
- The design and placement of infrastructure.

6.2.6 *Mitigation Measures*

Construction Phase

Potential impacts to the groundwater during the construction phase of the Project can be managed through the implementation of the measures outlined in Table 6-13.

Table 6-13: Construction Phase Mitigation Measures

Potential Impact	Mitigation Measures
Hydrocarbon and chemical spills	• All fuels and chemicals used during the construction phase of the Project stored in bunded facilities that prevent spills, leakage, or over topping of the facility. The facility should prevent any migration of fuels or chemicals to surface water bodies or the underlying groundwater; • Excavations that will remain open for any considerable time and that intercept the groundwater will be bunded to prevent any impact on the exposed groundwater through ingress of potentially contaminated surface water runoff from surrounding areas.
Water supply	• Mitigation measures will be identified during the impact assessment studies to be undertaken as part of the application process for allocated and unallocated water resources in the study area.

Operation Phase

Potential impacts to the groundwater during the operation phase of the Project can be managed through the implementation of the measures outlined in Table 6-14.

Table 6-14: Operation Phase Mitigation Measures

Potential Impact	Mitigation Measure
Hydrocarbons and chemical spills	• Vehicles will be maintained according to manufacturer's specifications, with regular checks undertaken to ensure fuel, chemical and oil leaks are minimised.

Potential Impact	Mitigation Measure
Pesticide and herbicide use and storage	• Adopt weed management strategies which have a minimal impact on aquatic habitats (e.g. type herbicide used and application rate).
Infrastructure	• Site structures should account for the presence of groundwater on the site with respect to potential embankment stability, floor heave, and corrosive water issues.