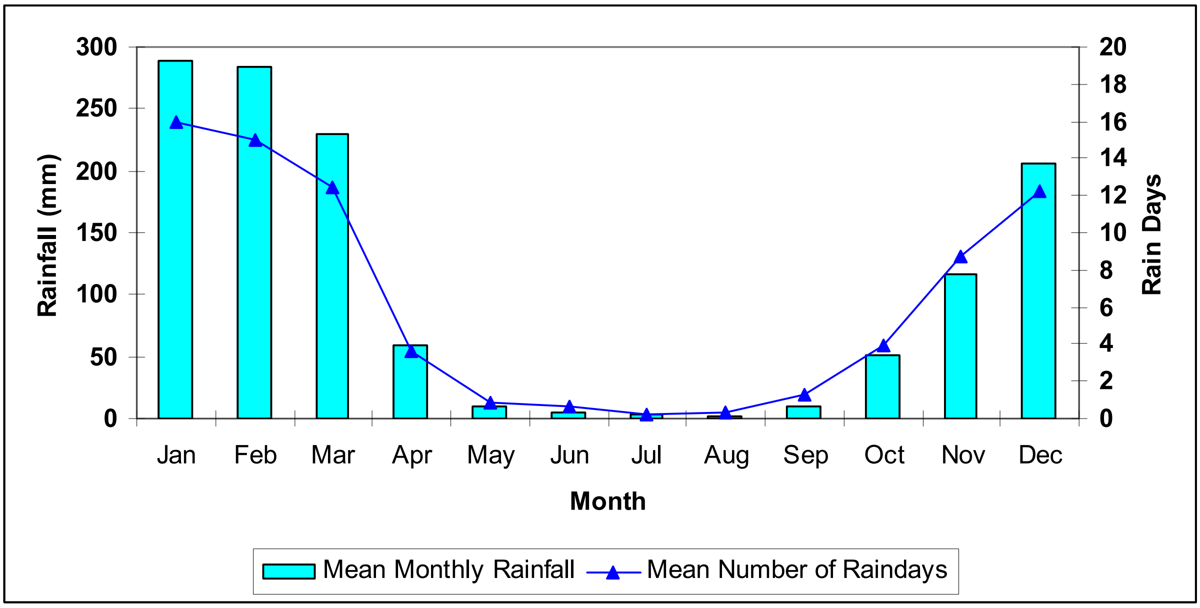
6. EXISTING BIO-PHYSICAL ENVIRONMENT

6.1 CLIMATE

The Frances Creek area has a tropical monsoonal climate. A pronounced wet season consists of a hot, high rainfall, humid summer from November to March. Conditions are typically cooler and dry from May to September. October and April are transitional months with some rainfall. Chart 2 shows the average rainfall pattern occurring in the region.

Chart 2: Burrundie Railway Station Monthly Rainfall Data (1889-1974)



Average rainfall in the region is 1,100 to 1,300 millimetres and falls between October and April. Most rain falls during the January to March period when the area is subject to tropical cyclones and associated tropical low pressure systems and monsoon troughs. The nearest long-term rainfall records available are from Burrundie Railway Station (15 kilometres west of the project area). Averages from this location are shown in Chart 2. Mean annual average rainfall for Burrundie Railway Station is 1,263 millimetres. More than 98% of this rain falls between October and April. Peak average monthly rainfall is in January (288 millimetres). Pine Creek, 25 kilometres south of the project area, has slightly lower rainfall, with an average annual rainfall of 1,149 millimetres for the period 1874 to 2000.

Air temperatures are relatively high and consistent from year to year. During the coolest time of the year (June to July), the mean monthly temperature for Pine Creek ranges from a minimum of 10 to 13 degrees Celsius to a maximum 20 to 32 degrees Celsius. In the hottest part of the year (October to November), mean monthly temperature ranges from a minimum of 24 to 27 degrees Celsius to a maximum of 37 to 41 degrees Celsius. The lowest recorded overnight temperatures are below five degrees Celsius.

Humidity measured at Pine Creek averaged 49% in September 2004 and 79% in February 2005 (Bureau of Meteorology, 2006). Evaporation at Pine Creek is estimated at 2,775 millimetres per year (Bureau of Meteorology, 2003). Therefore, evaporation exceeds rainfall by a factor of 2.2 (based on an average year for Burrundie).

6.2 GEOLOGY

The Frances Creek project area is on the Pine Creek Orogen, a Lower Proterozoic sequence of sediments.

Frances Creek deposits occur in the Proterozoic sequence which unconformably overlies Archaean intrusive and metamorphic rocks. The basal unit of the Pine Creek Orogen is the Namoona Group. This is represented in the area by the Masson Formation comprising phyllite, slate, siltstone, sandstone, conglomerate and sandy siltstone with subordinate haematite and limonite ironstone (pelitic rocks are commonly carbonaceous).

Unconformably overlying the Masson Formation is the Mount Partridge Group that is represented by Mundogie Sandstone and Wildman Siltstone. The Mundogie Sandstone is predominantly feldspathic quartzite with conglomerate, phyllite and siltstone. The lower part of Wildman Siltstone consists of carbonaceous phyllite, ironstone and minor siltstone overlaid by fine grained sediments with minor sandstone and carbonate units. The area of interest for mining is close to the interface of these two formations.

The South Alligator Group unconformably overlies the Mount Partridge Group and contains three types of formations. From the base are the Koolpin Formation (of carbonaceous and pyritic fine grained sediments and ironstones); the Gerowie Tuff (of fine grained sediments and tuff); and at the top of the sequence the Mount Bonnie Formation of generally fine grained sediments (Australian Groundwater Technologies (AGT), 2006).

The Lower Proterozoic sedimentary sequence is intruded by sills of the Zamu Dolerite. The sequence is also intruded by Lower Proterozoic granitoids of which a number of different phases have been recognised. Granitoid intrusives of this type are present in outcrop along the Frances Creek property southern boundary and in the southern part of Exploration Licence 24040. They have been interpreted to underlie much of the Proterozoic rocks at depth.

Overlying the Pine Creek Orogen rock sequence are remnants of Jurassic to Cretaceous sediments consisting of coarse sandstones with ferruginous material in the vicinity of iron deposits.

The Pine Creek geosyncline is intruded by igneous rocks including pre-tectonic dolerite sills and syn-to post-tectonic granite plutons (Cullen Batholith) with metamorphic contact aureoles in the adjacent meta-sediments and meta-dolerites and dolerite dykes (Bureau of Mineral Resources (BMR), 1987).

Iron deposits in the project area occur as semi-continuous lenses. They are haematitic ironstones with isoclinal folds in the lower member of the Wildman Siltstone. The deposits crop out as prominent, discontinuous ironstone ridges up to 50 metres high over a strike length of 15 kilometres (AGT, 2006). The largest bodies of ore occur from south to north being Helene, Thelma 2, Ochre Hill and Saddle deposits (BMR, 1987). The ironstone ridges thicken within fold hinges at the Helene pits and are continued within carbonaceous phyllite and siltstone (AGT 2006).

6.2.1 Waste Rock Geochemical Characterisation

Territory Iron commissioned MBS Environmental in January 2006 to conduct geochemical analysis of waste rock likely to be produced by mining operations. The complete report is in Appendix 4 and findings are summarised below.

Frances Creek iron ore lenses are hosted in carbonaceous weakly sulphidic siltstone, shale and finely laminated weakly sulphidic carbon-rich phyllite. Additional rock types are rare dolerite sills which generally follow the ore horizon footwall. Waste rock, both enclosing and interbedded with ore, is largely iron enriched, leached and free of visible sulphide and carbonate minerals. A prolonged period of surface exposure before the Cretaceous period, caused deep supergene iron enrichment of protore to ore grades after which the area was buried beneath Cretaceous continental sediments. Subsequent Cainozoic weathering and lateritisation re-exposed the buried ores and may have leached sulphides from the ores and enclosing rocks above the current water table.

6.2.1.1 Waste Rock Characterisation

Ten waste rock samples were taken for geochemical characterisation. Sampling covered the Ochre Hill, Helene 5, Helen 6/7, Jasmine East, Thelma Pit 2 and Thelma Rosemary deposits. Eight composite samples were taken from reverse circulation drill chips, one from open pit waste and one from cretaceous overburden. The sampled waste rock predominantly comprises oxidised siltstone and shales, with some dolerite as well as cretaceous sediments. All samples were analysed for Acid Neutralising Capacity, sulphur by LECO and sulphate-sulphur. Since no LECO sulphur analyses exceeded 0.2% total sulphur, none were analysed for Net Acid Generation. Results are shown in Table 10. From this it can be seen that all samples have a net acid producing potential of zero or less than zero and all are Non Acid Forming (NAF). Fizz rate (ANCEx/QUAL method) was zero for all samples and is not shown in Table 10.

The iron ore deposits are effectively free of sulphur and toxicants, but enclosing carbonaceous waste rocks contain trace amounts of uranium and chalcophile element – bearing sulphides. Sulphur contents are very low (maximum value recorded in ore is 0.025%, and in waste 0.103%) and the chance of acid development at these levels would normally be considered zero. However, waste rock is carbonate mineral free with no acid neutralising capacity. A Thelma 2 Pit waste rock sample had the highest sulphur value (0.103%S) with all sulphur already oxidised to sulphuric acid and a pH leachate value of 4.9. Adjacent pit water has a pH value of 3.5, which represents the sum of organic and sulphuric acids developed, then concentrated by 32 years of evaporation since former mining.

Based on results of analytical work and an understanding of the geology of the Frances Creek area, there is no likelihood of acid rock drainage development. Final open pit voids may develop low pH water within the aluminium hydroxy-sulphate buffer zone of pH 3.2 to 4.9 over a long time frame, but most acidity will be sourced from decomposing vegetation, not sulphides. Soluble organic – chalcophile element compounds derived from rotting vegetation and the enclosing siltstones may accumulate in final pit void waters to levels marginally higher than ANZECC fresh water ecosystem protection trigger values, but still below drinking water guideline values.

Traces of the chalcophile elements copper, lead, zinc and antimony plus arsenic, thallium and molybdenum will be largely concentrated in extremely carbonaceous footwall to the iron mineralisation and are likely to be at very low levels in the hanging wall rocks.

At the Thelma 2 Pit, previous mining has exposed a large amount of highly carbonaceous footwall material which is now below water level in the pit. This has resulted in chalcophile metals being leached and retained in solution in pit water. All sulphur in footwall waste rock has totally oxidised and current acidity in pit waters is dominated by organic acids from plant decomposition. The current values should be stable after 32 years and no further acidification is considered likely. The current level of sulphuric acid in Thelma 2 Pit is extremely low at less than 0.03% H_2SO_4. Further mining at this site will increase the chalcophile element concentrations.

6.2.1.2 Leachate Characterisation

As part of geochemical characterisation studies analysis determined, based on waste rock geochemical characteristics, the potential for trace element pollution of local groundwaters from long-term waste rock disposal and interaction of groundwater with final pits. Waste rock samples were leached with 1.0 molar acid to test for weak acid soluble metals. Six samples of surface soils and 11 waste rock samples were also water leached for comparative soluble metals data. Review of results indicates that:

- Helene and Ochre Hill areas will produce alkaline waste rock with negligible toxicants.
- Traces of arsenic, cadmium, nickel and molybdenum may leach from Ochre Hill waste rock, but only very slight dilution plus oxygenation will be needed to reduce concentrations for all of these elements to below fresh water trigger values.
- In the Jasmine–Thelma-Rosemary area, small amounts of cobalt, copper, lead, nickel, thallium and zinc are likely to leach from waste rock over time, but as for the Ochre Hill area, only slight dilution plus oxygenation will be needed to reduce all leachate results to below ANZECC fresh water ecosystem protection trigger values.

6.2.1.3 Uranium and Thorium Geochemistry

The proposed mining areas are immediately adjacent to and in places coincident with a regional stratiform zone of uranium enhancement within the Wildman Siltstone. Uranium and thorium are present in the ore and waste rock, but soluble levels are extremely low.

Uranium concentrations at individual sites varies considerably. At Helene, the median value is 10 parts per million, at Thelma-Rosemary 44 parts per million, Jasmine 29 parts per million and Ochre Hill 18 parts per million. These values seem to parallel the variation in chalcophile toxicants for the leachate analyses, suggesting a relationship between the sulphide and uranium, but not the thorium mineralisation.

Whilst the uranium median value is three times the expected shale background, these values are not unusual when compared with those in many mineralised areas. Many open pit and underground mines world-wide operate at comparable or higher levels.

Table 10: Geochemical Characterisation Results for Frances Creek Rock Samples

ELEMENTS	ANC	Total C	EC	Final pH	pH	Total S	SO_4-S	MPA	NAPP	CLASSIFICATION
UNITS	kg H_2SO_4/t	%	µS/cm	None	None	%	%	kg H_2SO_4/t	kg H_2SO_4/t	
DETECTION	1	0.01	10	0.01	0.1	0.005	0.03	1	1	
METHOD	ANCEx/ VOL	LECO	W/ MTR	ANCEx/ MTR	W/ MTR	LECO	ANCEx/ OES	Calc	Calc	
FC 01 Ochre Hill OHRC104, 09-14m IW	2	0.05	51	1.5	8.1	<0.005	<0.03	0	-2.0	NAF
FC 02 Ochre Hill OHRC109, 20-27m IW	2	0.04	57	1.5	7.7	<0.005	<0.03	0	-2.0	NAF
FC 03 Helene 5 FCRC054, 38-40m FW	0	0.05	46	1.5	6.6	<0.005	<0.03	0	0.0	NAF
FC 04 Helene 5 FCRC112, 19-24m IW	1	0.05	84	1.5	7.5	<0.005	<0.03	0	-1.0	NAF
FC 05 Helene 6/7 HERC010, 37-38m IW	1	0.02	36	1.5	7.6	<0.005	<0.03	0	-1.0	NAF
FC 06 Helene 6/7 HERC018, 09-11m HW	0	0.06	37	1.5	7.0	<0.005	<0.03	0	0.0	NAF
FC 07 Jasmine East JERC008, 26-30m ORE	1	0.06	56	1.5	6.0	<0.005	<0.03	0	-1.0	NAF
FC 08 Jasmine East JERC006, 35-39m IW	0	0.08	35	1.5	6.4	0.008	<0.03	0	0.0	NAF
FC 09 Thelma-Rosemary TRRC020, 06-08m FW	0	0.09	23	1.5	5.4	0.008	<0.03	0	0.0	NAF
T2 Thelma 2 Pit Carbonaceous Siltstone Waste	0	0.68	291	1.5	4.9	0.103	0.13	-0.8	-0.8	NAF
TRK Thelma-Rosemary Cretaceous Overburden	1	0.18	66	1.5	6.5	0.012	<0.03	0	-1.0	NAF

Sample Description Explanatory Notes:
OHRC104: Drill hole number followed by sample depth information
ORE: Marginal grade ore, Interval includes two metres analysing less than 60% Iron
HW, IW, FW: HW = Hanging Wall; IW = Internal Waste, possibly infolded HW; FW = Footwall Waste.

6.3 LANDFORM AND SOILS

Land Systems for the Katherine–Darwin Region have been described and mapped by Christian and Stewart (1953). The Frances Creek project area is located within the Brocks Creek Ridge Land System of the Katherine-Darwin Region (Christian and Stewart, 1953). A small section in the south-eastern area of the mineral lease is the Cullen Land System (Christian and Stewart, 1953), however no mining activity is proposed in this granitic area. The two land systems form part of the broader geomorphological unit referred to as the Elevated Backbone Country.

The Brocks Creek Ridge Land System is formed on strongly folded metamorphic of the Brocks Creek Group. Landforms consist of rocky north–south ridges and hills with slopes between 40 and 60 degrees moderating to gentle crests. Smaller convex hills, small alluvial flats and channels incised through sandy or loamy materials are also associated with this land system. The country is dissected by many watercourses and erosion is active (Reilly et al, 2006).

Active erosional process at work in the Brocks Creek Ridge Land System means little to no soil has accumulated on the steep slopes. Soils present are typically very gravelly sandy loams and skeletal soils (Christian and Stewart, 1953). Soils of the flat alluvial areas are typically heavier and darker than those found on slopes and contain higher levels of silt and clay. These soils are typically referred to as acid alluvial soils (Reilly et al, 2006).

The base rock of the Cullen Land System is Cullen Granite. The granite differs in structure, mineral composition and resistance to erosion spatially across the land system resulting in a highly variable topography. Typically the landforms of this group vary from rocky granite outcrops to gently undulating hills with small areas of flat land (Reilly et al, 2006).

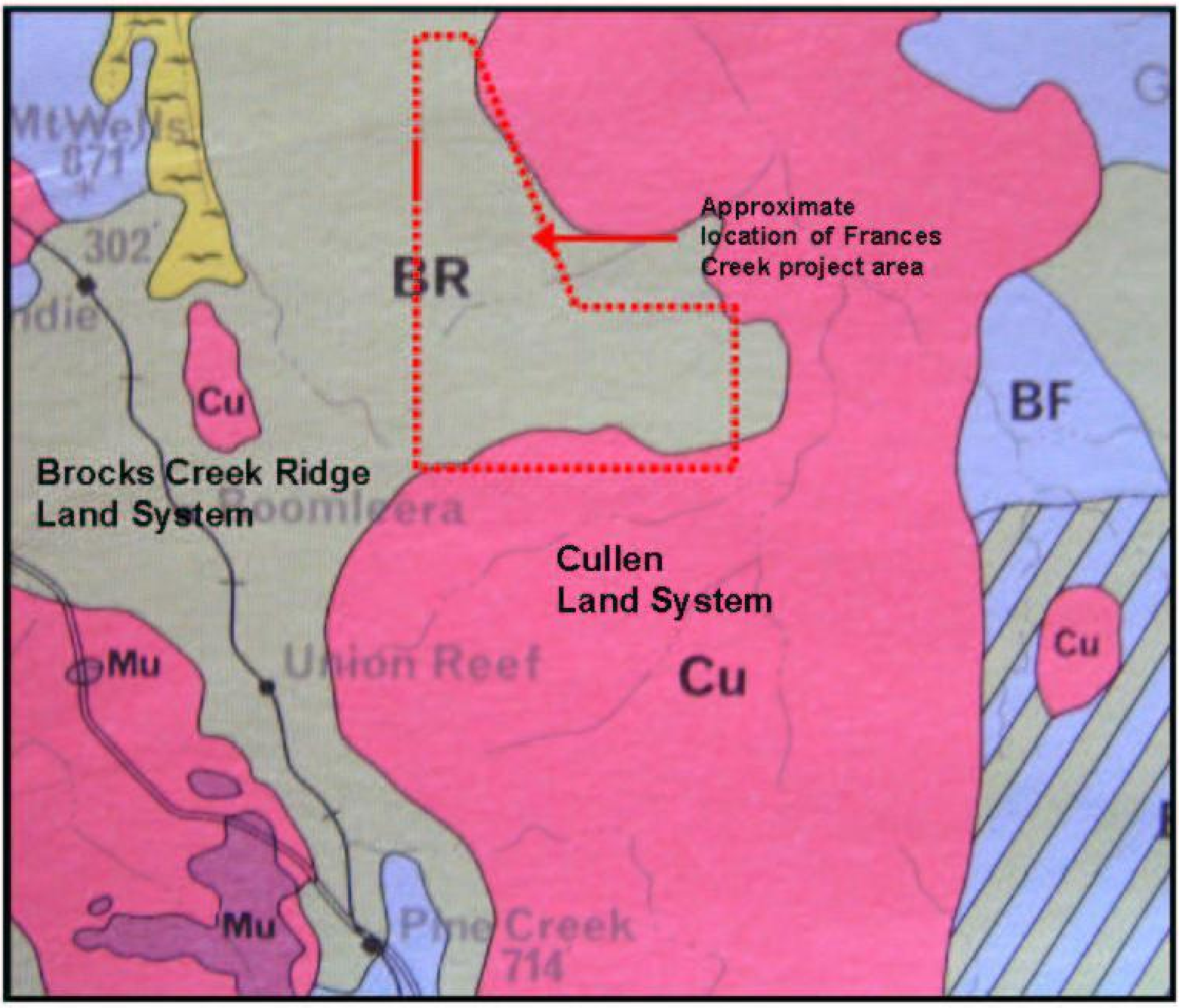
Soils of the steeper topography of the Cullen Land System are typically very gritty, sandy skeletal soils while the gently undulating hills have granitic sandy yellow podsolic soils (Reilly et al, 2006).

Reilly et al (2005; 2006) describe six land unit groups occurring across the lease area. These are:

- Brocks Creek Ridge Land System:
    - Ridge Crests and Slopes.
    - Low Hills.
    - Riparian.
    - Small Alluvial Flats.
- Cullen Land System
    - Low Undulating Plains.
    - Granite Hills.

Distribution of the land systems across the project area is shown in Figure 9.

Figure 9: Land Unit Distribution in the Frances Creek Area



The proposed haul road from the Frances Creek project area to the Alice Springs-Darwin Railway is in the Cullen Land System while all other mining development is in the Brocks Creek Ridge Land System, in particular within the Ridge Crest and Slopes and Low Hills land units.

Portions of the Frances Creek project area have been subject to disturbance from previous mining activities. Of the 172 hectares needed for the project, 78 hectares (45%) has been previously disturbed. This previously disturbed area includes 35.6 hectares out of a total of 81.6 hectares of Ridge Crests and Slopes, 30.9 hectares out of a total of 71.4 hectares of Low Hills, two hectares out of a total of nine hectares of Small Alluvial Flats and four hectares of Low Undulating Hills.

6.4 GROUNDWATER

Australian Groundwater Technologies completed a groundwater study of the project area in February 2006. The study area examined was bounded by Eastings 795,000 and 824,500, and Northings 8,490,000 and 8,505,900 Zones 52 and 53, MGA 94 (Pine Creek map sheet SD52-

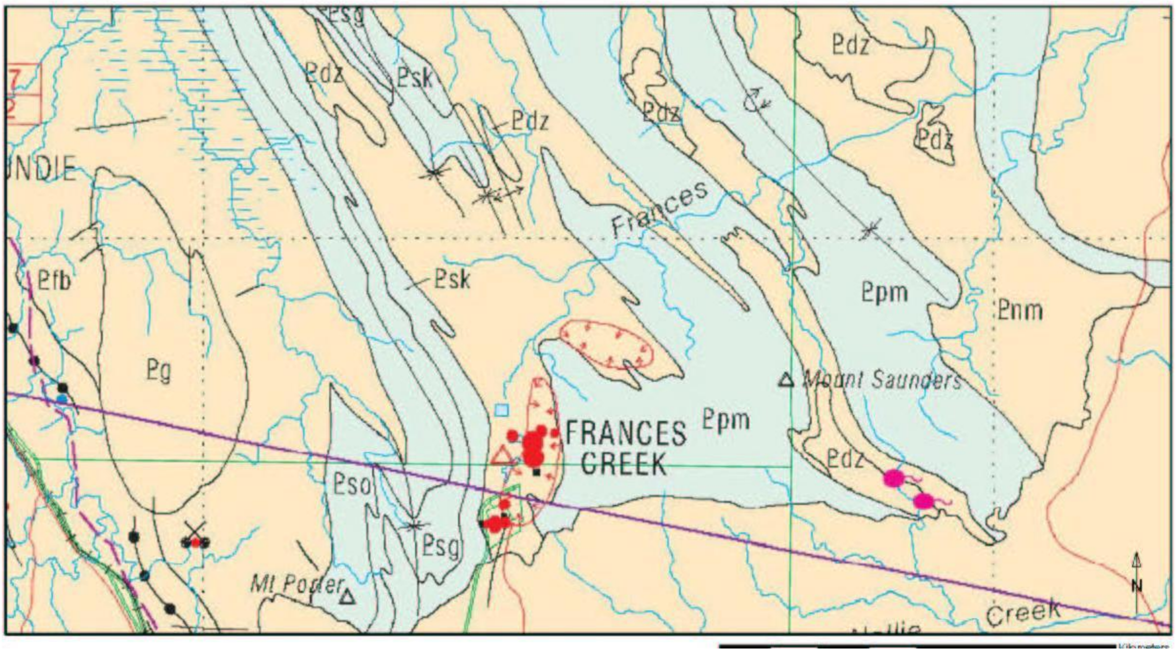
08, 1:50,000). A full copy of the report is provided in Appendix 5. Key details are summarised in Sections 6.4.1 to 6.4.3

6.4.1 Regional

The complex stratigraphic and structural geology of the Pine Creek region results in a rather complex hydro geological environment. Aquifer characteristics show extreme variation according to lithology, tectonic hiatus, and geomorphological history. Peneplanation, deep chemical weathering (including production of ironstones), weathering (to produce laterite profiles in the Cretaceous mesas), sheet-wash (in the Tertiary) and cyclic erosional and aggradational episodes (in the Quaternary) are geomorphological agents of the area's more recent geological history that may have influenced regional hydrogeology.

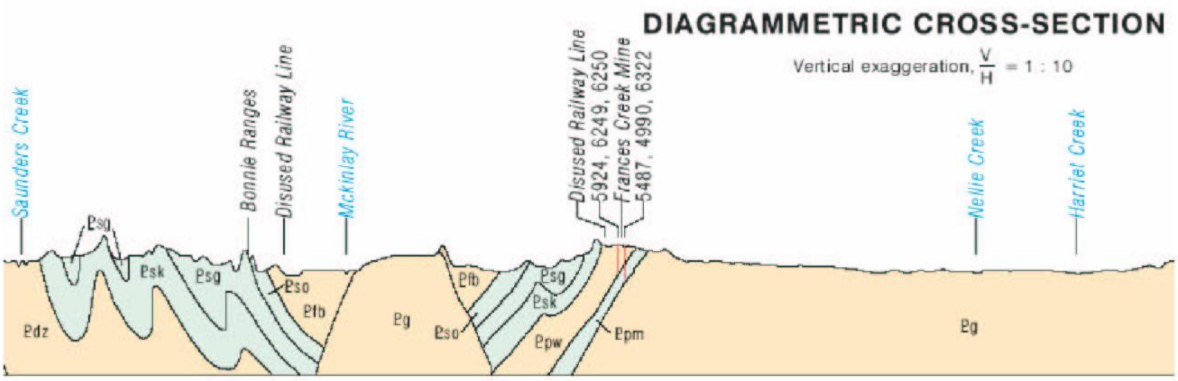
Dames and Moore (1989) produced a hydrogeological map covering parts of the 1:250,000 topographic sheets Pine Creek SD52-08, Mt Evelyn SD53-05, Katherine SD53-09, and Fergusson River SD52-12. Mining company water supply and dewatering investigations provided much of the information on groundwater resource exploration and development to produce this map. Figure 10 reproduces that part of the map covering the Pine Creek area, while Figure 11 presents a west to east section across this map and accompanying legend for the Pine Creek region.

Figure 10: Regional Hydro Geological Map



Source: AGT, 2006.

Figure 11: Hydro Geological Cross Section of Frances Creek Area



Source: AGT, 2006. Line of section marked in purple on Figure 10.

Hydraulic properties of lithological units shown on Figure 10 are heavily overwritten by structurally controlled features (fractures, joints shear zones faults) which tend to dominate over lithology in determining groundwater flow patterns. The Frances Creek area is believed to contain many local scale flow systems driven by topography and recharge/discharge processes.

Eastern and southern boundaries of the area examined in the AGT study are considered to form ‘no flow’ groundwater hydraulic boundaries, whilst the western boundary is a potential small groundwater province, and the northern boundary is a groundwater ‘sink’.

AGT could not determine regional groundwater flow directions owing to paucity of standing water level information as bores in the region are clustered in terrain with highly variable elevation. Groundwater velocities also cannot be determined with any credibility.

Regionally, groundwater is typically low salinity with high levels of bicarbonate and a pH that is slightly acid to slightly alkaline.

6.4.2 Project Area

The proposed mining areas, a series of ironstone lenses, follow a major fold structure which has resulted in a complex “Z” shaped pattern of outcrop. The Helene deposits are on the western limb of the structure where the township was also situated. Various Thelma/Rosemary deposits are on the diagonal or middle limb of the “Z” and Jasmine lies on the eastern limb. Ochre Hill is five kilometres north of Jasmine on the extended eastern limb of the structure.

Formations of interest in the Frances Creek area constitute fractured rock aquifers. They are the Wildman Siltstone, said by Dames and Moore (1989) to be low yielding (< 0.5 litres per second), and possibly the Mundogie Sandstone (< five litres per second) and Masson Formation (< 0.5 litres per second).

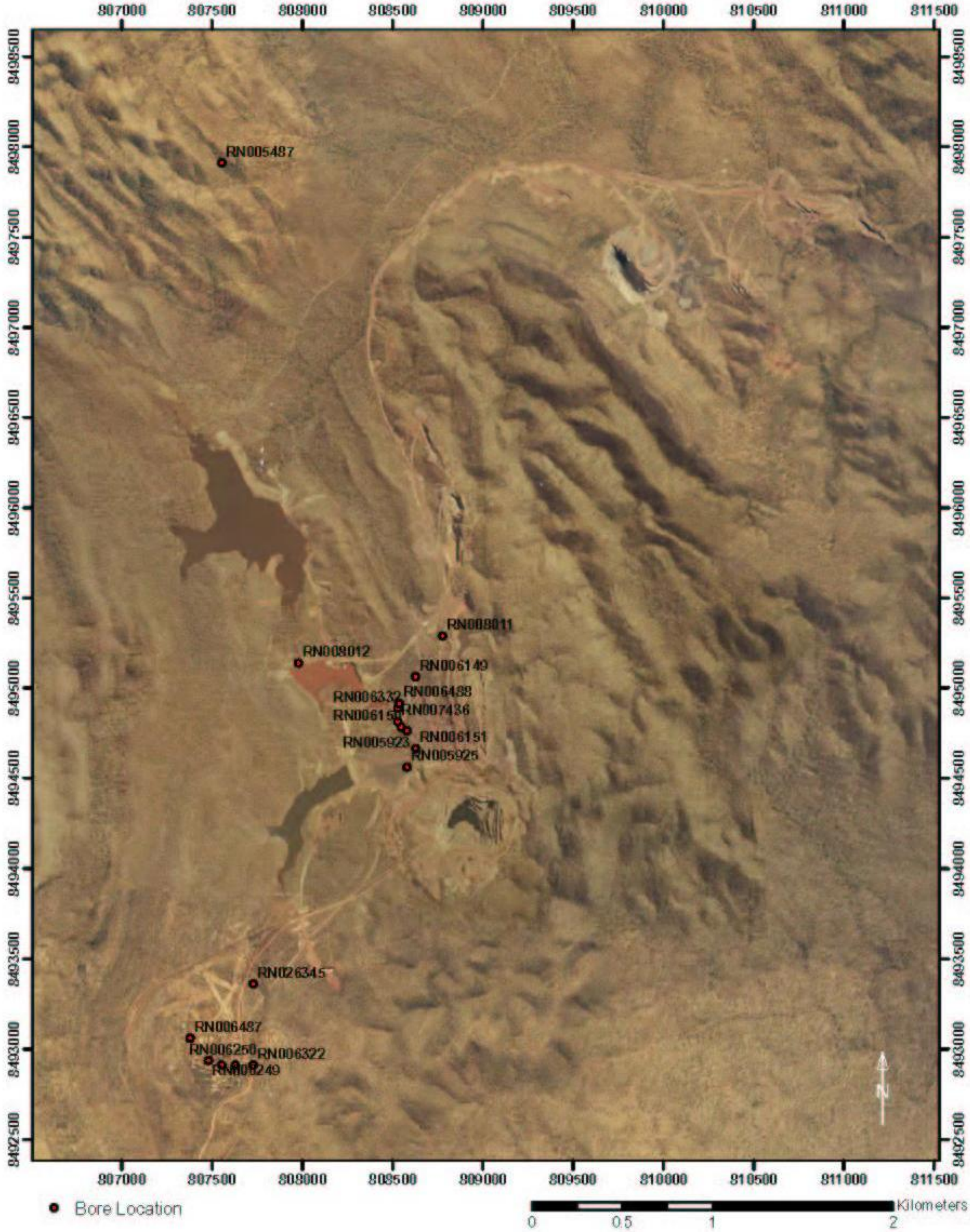
Reviewing database records indicates that 14 bores are in the Frances Creek project area. Geological logs of these water bores identified the fractured rock aquifers at the time of drilling (1965 to 1972) as the Masson Formation, but more recently published hydrogeological mapping (Dames and Moore, 1989) indicates the outcropping geological unit to be the Wildman Siltstone.

Around the Frances Creek mine site, brittle rocks are highly fractured and weathered producing much greater bore yields than suggested above. Virtually all of the higher yielding bores are sited in the previous mineral processing/stockpile/tailings area approximately 200 to 500 metres west of the ore body trend formerly exploited in the open pits at Helene 4, 5, and 6/7.

The yields listed in Dames and Moore (1989) of "usually 0.05 to 0.5 litres per second in water bearing zones" may well apply to the Wildman Siltstone/Masson Formation in structurally undisturbed areas. In the highly folded environment around the Frances Creek mine site, the more brittle rocks are highly fractured. Deep weathering combines with fracturing to produce bore yields which can be one to two orders of magnitude greater than suggested, especially in favourable situations near minor fold axes where tensile stresses can lead to open fractures.

Depth to water (SWL) historical data is available for five bores in the township area and seven bores in the mine-site (Figure 12). Monitoring data from the 1960s and 1970s, data collected during recent exploration activities and a site visit made by AGT in January 2006 suggests that average depth to water in the township area is approximately 24.66 metres and 28.95 metres for the mine area. Large differences in standing water levels recorded from the 1960s and 1970s to current results were observed. The groundwater has been relatively undisturbed by pumping for many years and, considering the area's high recharge potential it seems likely that groundwater levels could have recovered to within 10 to 15 metres of the surface since the site was vacated in 1976.

Figure 12: Location of Historic Water Bores in Frances Creek Area



Source: AGT, 2006.

6.4.2.1 Water Quality

Groundwater quality data from historic bores at the town and mine sites were extracted from the NT database. Data showed that the water is of good quality with a maximum TDS of 310 milligrams per litre, high bicarbonate content and generally slightly alkaline pH (AGT, 2006). Groundwater beneath the town and mine sites may be broadly characterised as a 'calcium-bicarbonate type' with relatively high hardness, but suitable for most purposes including for both human and livestock consumption.

High bicarbonate is an indicator of an actively recharging groundwater system, a process governed by high seasonal rainfall and relatively easy access for infiltration from the ground surface via frequent open joints (AGT, 2006).

Pit water quality is considered a reflection of groundwater plus varying amounts of rainwater accumulated in deeper pits that result in a low salinity signature. Samples were taken during a site visit in January 2006. Review of analytical results showed that:

- All samples have low TDS.
- All but one has pH values greater than six.
- All but one has generally low abundances of arsenic, cadmium, copper, lead and zinc.
- The one exception is a sample collected from Thelma 2 Pit in November 2005 which recorded a pH of 3.5. This sample is also reported to contain 25 milligrams per litre sulphur (equivalent to 75 milligrams per litre sulfate) which accounts for the very low pH. Copper and zinc exceed the ANZECC (2000) guideline values in this sample, but the other heavy metals are within acceptable limits.

The low salinity of pit waters suggests that the pits act as collectors and groundwater recharge points (groundwater sources) during the wet season. They are evaporative discharges (groundwater sinks) during the dry with very little through flow; presumably because local impact of the pit lake levels on groundwater flow is greater than that of the topographically dependant hydraulic gradients.

Native groundwater has low TDS, only three to four times that of the average pit water.

6.4.2.2 Hydrological Model

AGT developed a hydrogeological conceptual model that hypothesises a localised, rainfall-recharge-driven, groundwater flow system coupled with discharge to local creeks including Frances Creek. On this basis, all township/mine site runoff and groundwater throughflow would ultimately find its way into the Frances Creek headwaters and east into the Mary River.

Details of the model are fully described in Appendix 5.

6.4.3 Beneficial Uses

The sole town water supply (from the Burrell Creek Formation aquifer aligned along the Pine Creek Shear Zone) in the region is Pine Creek, 25 kilometres south of Frances Creek.

Agriculture in the vicinity consists of rangeland grazing of cattle on the Mary River West and Ban Ban Springs pastoral leases. It is low intensity with scattered watering points; dams, soaks and bores. Esmeralda Farm, 11 kilometres south of Frances Creek has no recorded water bores.

All other recorded users are historical (abandoned mines); and include:

- Union Extended Mine, eight kilometres west of Pine Creek.
- Spring Hill, 13 kilometres west of Pine Creek.
- McKeddes Gold Mine, 3.5 kilometres north east of Ochre Hill.
- Mt Wells Garden Lease, 13 kilometres west of Ochre Hill.

There are plans to reopen the Union Reef gold operation, 15 kilometres south south-west of Frances Creek, in 2006, the Burnside Project and to open the Mount Porter Mine, four kilometres south-west of Frances Creek.

6.5 SURFACE WATER

MBS Environmental completed a surface water study of the project area in August 2006 (MBS Environmental, August 2006). This report is attached in full in Appendix 6. Key details of the existing surface water environment are summarised in the following subsections.

6.5.1 Catchment Description

6.5.1.1 Regional Catchments

The Frances Creek project area is in the headwaters of the upper Mary River catchment (Figure 1). The Mary River catchment covers 8,000 square kilometres, draining north-west into the ocean at Van Diemen Gulf, about 100 kilometres east of Darwin. Approximately 1,987 square kilometres of the catchment is upstream of the confluence of Frances Creek and the Mary River. The upper catchment of Mary River is defined as that upstream of its major tributary, the McKinlay River, which joins Mary River about 100 kilometres from the ocean. The upper Mary River catchment is characterised by channel flow, while the lower catchment is dominated by sheet flow. Large areas of floodplain are seasonally inundated during the wet season, receding to a series of large pools of permanent water billabongs in the dry season.

Frances Creek is about 20 kilometres north of the Mary River catchment's southern boundary. The discharge point of Mary River to the ocean is 150 kilometres north of Frances Creek. The major drainage divide in the project area is between the Frances Creek and Maude Creek catchments. Frances Creek has a catchment area of 158 square kilometres. It arises in the project area and discharges into the Mary River some 20 kilometres downstream. Maude Creek is another tributary of the Mary River, about 20 kilometres north of and parallel to Frances Creek, with a catchment area of 223 square kilometres (Figure 2).

6.5.1.2 Project Area Catchments

Most of the Frances Creek project area lies in the Frances Creek catchment. The northern portion drains east into the Mary River via Maude Creek. Part of the haul route drains into Mary River via Nelly Creek and some drains west into McKinlay River (1,812 square kilometres total, 367 square kilometres at Watts Creek Confluence) either directly or via Watts Creek (80 square kilometres).

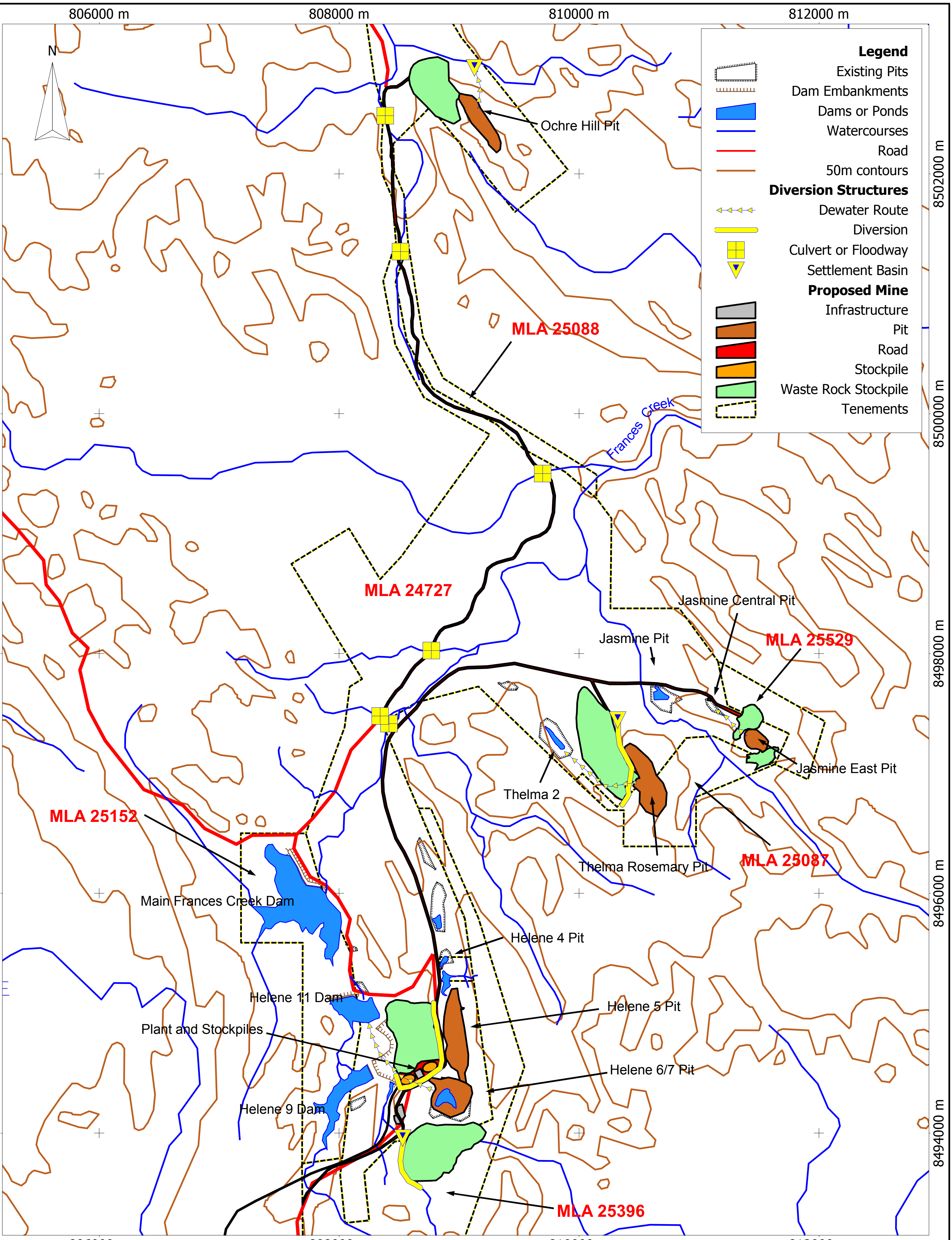
The highest point in the project area is about 292 metres AHD (Australian Height Datum) on the eastern edge of MLA 24727, the lowest point is around 150 metres AHD at the point where Frances Creek leaves the project area to the north-east.

Three large dams are on the upper part of Frances Creek. These were built for the previous Frances Creek mining operation and were completed in about 1971 (Barrie, 1999). The dam walls consist of an upper dam wall, which creates the Helene 9 Dam (dams are named after adjacent open pits) and an upstream embankment for the TSF. A lower TSF dam wall creates the Helene 11 Dam, which would have been a water recovery dam for the TSF. The lower dam wall creates the largest dam, Frances Creek Main Dam, downstream of the TSF (Figure 13). The Helene 9 Dam covers approximately 0.17 square kilometres and the main Frances Creek Dam covers 0.26 square kilometres. The maximum depth of all dams is about six to eight metres. They have catchment areas of 1.95 square kilometres (Helene 9), 2.55 square kilometres (Helene 11) and 2.40 square kilometres (Frances Creek Main) making a total of 6.9 square kilometres. Approximate volumetric capacity is 1,300 megalitres for the main Frances Creek Dam, 250 megalitres for the Helene 11 Dam and 450 megalitres for the Helene 9 Dam.

The Helene 9 Dam was created by damming the old TSF. The old TSF lies between the two dams, but the upper dam spillway is through a saddle allowing overflows to bypass the old TSF and Helene 11 Dam and flow directly to the main Frances Creek Dam.

The dam walls are all less than eight metres high so the dams are not classed as large by the Australian National Committee on Large Dams Inc. (ANCOLD, 2004). The spillway of the main Frances Creek Dam was eroded by record rainfall in early 2006 and requires maintenance before the 2006-07 wet season.

There are also two much smaller dams; Helene 6 Dam is created by the TSF blocking a small tributary, and covers an area of one hectare with a catchment of 0.78 square kilometres. Helene 4 Dam is created by the main haul road damming a catchment to the east and covers about 1.5 hectares with a catchment area of 0.44 square kilometres. These dams are likely to dry out during most dry seasons.



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info@mbsenvironmental.com.au

Scale: 1:40000
Original Size: A4
Datum: Australian Geocentric 1994 (GDA94)

0 1 km

Territory Iron
Frances Creek Mine

Location of Proposed Water Diversions, Culverts and Floodways

Figure 13

W:\Territory Iron\Frances Ck\PER\dwg\F13 Water Diversion.map 10/08/2006 A4

6.5.2 Average and Flood Flows

Watercourses in the project area are ephemeral and dry up during the dry season, but have regular flows during the wet season. Several seasonal and some semi-permanent natural waterholes are present in the Frances Creek project area. This is due to shallow groundwater levels in topographically low areas and the locally permeable nature of the bedrock (AGT, 2006).

A government flow monitoring station was operated on Frances Creek near the mine site from 1961 to 1967. Six years of water level data were collected, but a reliable rating curve is not available to translate the level measurements to flow measurements. It is likely the station was established to collect data for dam construction and was flooded when dams were completed. Two other gauging stations are within 20 kilometres of the project area. These are McKinlay River near Burrundie (G8180069) and Harriet Creek at downstream El Sherana Road (G8180252). Details of these stations are in Table 11 (data supplied by NT Water Resources).

Table 11: Stream Gauging Data Summary

Site	Distance (km)	Start Year	End Year	Period (Years)	Catchment Area (km^2)	Bad Records	Easting	Northing
G8180069 McKinlay River near Burrundie	16	1957	2005	48	352	12.4%	794186	8502406
G8180167 Frances Creek, Upstream Frances Creek Mine	0	1961	1967	6	7*	76.6%	278309	8497580
G8180252 Harriet Creek, Downstream El Sherana Road	17	1965	2005	40	122	40.3%	823159	8486119

* Estimated catchment area, no record of precise site location could be found.

Chart 3 shows flow statistics per square kilometre for the McKinlay River (Burrundie) and Harriet Creek (El Sharana) gauging stations. The units are megalitres per square kilometre, which are equivalent to millimetres of rainfall running off. It can be seen from this chart that very little runoff occurs between May and September. Runoff is consistently high in January and February in Harriet Creek and from January to March in the larger McKinlay catchment. Quite substantial runoff events can also occur in October, November, March and April, and the highest recorded flow on McKinlay River was in March. Since this data was extracted, a late cyclone in April 2006 created very high flows in the area for April.

Records available for Frances Creek indicate a closer match with the McKinlay River catchment, with flows extending into April and May. This is likely due to higher rainfall in the catchment, which is further north than Harriet Creek.

Table 12 shows estimated flows for catchments of existing dams in the project area and the Frances Creek crossing on the haul road to Ochre Hill. The figures in Table 12 were calculated by applying the average flows per square kilometre of catchment from McKinlay River at Burrundie to Frances Creek catchments.

Chart 3: Mean, Decile 9 and Maximum Monthly Runoff per Square Kilometre of Catchment for Harriet Creek (downstream El Sharana Road) and McKinlay River (Burrundie) Catchments

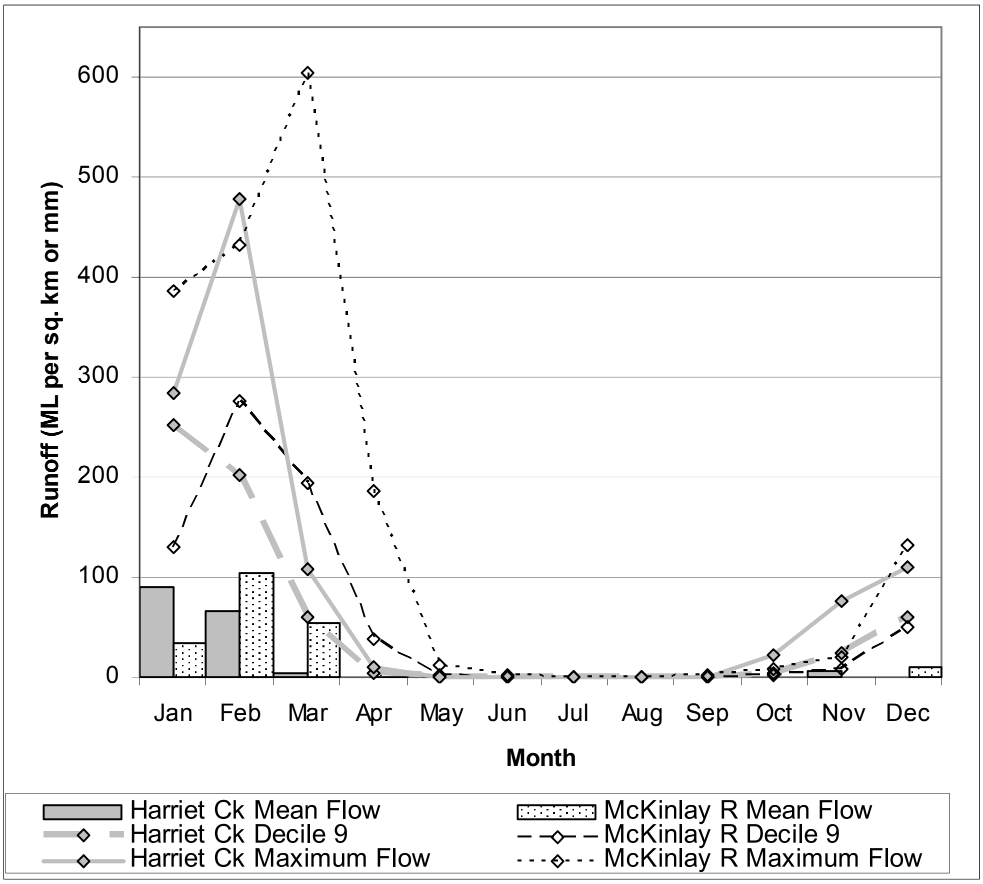

Table 12: Estimated Annual Flow Volumes for Frances Creek Catchments

	Catchment Area (km^2)	Dam Capacity (ML)	10th Percentile Annual Flow (ML)	Median Annual Flow (ML)	Mean Annual Flow (ML)	90th Percentile Annual Flow (ML)	Maximum Annual Flow (ML)
Helene 9 Dam	1.95	450	103.7	527.7	614.1	1137.8	2181.1
Helene 11 Dam	1.6	250	85.1	433.0	503.9	933.6	1789.7
Frances Ck Main Dam	2.4	1300	127.7	649.5	755.9	1400.4	2684.5
Helene 6 Dam	0.78	10	41.5	211.1	245.7	455.1	872.5
Helene 4 Dam	0.44	35	23.4	119.1	138.6	256.7	492.2
Ochre Hill Crossing Excluding Dams	4.08	0	217.1	1104.1	1285.0	2380.7	4563.6
Ochre Hill Crossing Including Dams	6.39	2045	339.9	1729.3	2012.5	3728.6	7147.4

It can be seen from Table 12 that the average annual stream flow for the dams in the project area is over half the storage capacity, and dams are likely to overflow most years.

6.5.3 Regional Water Quality

Table 13 presents a summary of water quality information for the Mary River catchment extracted from the report *"Water Quality of the Rivers and Streams of the Mary River Catchment (N.T.)* (Schultz et al, 2002). Water quality is compared to the ANZECC (2000) trigger values for protection of aquatic ecosystems (referred to as ANZECC trigger values in this report). These values are not intended by ANZECC to be used as a threshold value at which an environmental impact is inferred if exceeded. They are designed to be used with professional judgement as an initial assessment of potential risk. Exceeding trigger values should initiate further site specific investigation.

Table 13: Water Quality Characteristics of 40 sites in the Mary River Catchment

Element	Units	Number of Sites	Median	Range	10th Percentile	90th Percentile	ANZECC Trigger
pH		40	6.3	6.1 - 7.8	6.2	6.8	6.0-7.5
EC(2000)	µS/cm	40	53	12 - 342	32	119	20-250
Nitrate & Nitrite	mg/L	35	<0.001	<0.001-0.006	<0.001	0.004	0.030
NH_3 Nitrogen	mg/L	40	<0.01	<0.01-0.02	<0.01	0.01	na
Total Kjeldahl Nitrogen	mg/L	40	0.06	0.03 - 0.32	0.03	0.12	na
Total Nitrogen	mg/L	35	0.06	<0.03 - 0.32	0.03	0.13	0.15
Total Phosphorus	mg/L	40	0.007	0.004-0.013	0.005	0.011	0.01
Filterable Reactive Phosphorus	mg/L	35	0.001	<0.001-0.009	<0.001	0.003	0.005
Turbidity	NTU	40	5.7	0.7 - 15.0	3.8	13	2 - 15
Total Suspended Particulates	mg/L	40	1.95	0.40 - 8.76	0.85	4.46	na

Table 13 shows that the catchment in general has slightly low pH compared with relevant ANZECC (2000) default trigger values. The electrical conductivity is towards the upper end of the ANZECC trigger value range. Other studies confirm the upper Mary River catchment has elevated conductivity compared with the upper Katherine and East Alligator Rivers, (which have electrical conductivities of 38 and 22 micro siemens per centimetre respectively), but is low in comparison to other rivers in the top end of the NT such as the Daly and Roper Rivers (conductivities of approximately 600 and 1,000 microsiemens per centimetre respectively). The higher conductivity is likely to be due to different geology (Schultz et al, 2002). Nutrients (nitrogen and phosphorous) are low, generally below ANZECC (2000) trigger values. Turbidity is within the range of ANZECC (2000) trigger values.

Table 14 presents a summary of metal concentrations for the Mary River catchment extracted from the report *"Water Quality of the Rivers and Streams of the Mary River Catchment (N.T.)* (Schultz et al, 2002). Water samples were taken from 42 sites and a second sampling taken at five sites for a total of 47 samples. ANZECC (2000) specifies several levels of trigger values for toxicants. The values used for comparison in this report are those estimated to protect 95% of species, which are the recommended level for slightly to moderately disturbed ecosystems.

Table 14: Metal Concentrations (μg/L) at 42 sites in the Mary River Catchment

Element	% of Sites with Measurable Concentrations	Median	Range	10th Percentile	90th Percentile	ANZECC 95% Trigger
Aluminium	96	**60**	<5-**260**	12.6	150	55
Arsenic	55	1	<1-18	<1	3.32	37
Cadmium	6	<1	<1-**3**	<1	<1	0.2
Cobalt	4	<1	<1-5.9	<1	<1	ID
Chromium	0	<1	<1-<1	<1	<1	1
Copper	11	<1	<1-**12**	<1	0.44	1.4
Iron	100	620	44-1200	186	954	ID
Magnesium	100	2700	460-17,000	1048	8100	-
Manganese	100	27	3.8-390	9.6	119.4	1900
Molybdenum	2	<1	<1-15	<1	<1	ID
Nickel	30	<1	<1-**16**	<1	4.62	11
Lead	0	<1	<1-<1	<1	<1	3.4
Selenium	0	<1	<1-<1	<1	<1	ID
Uranium	2	<1	<1-1.3	<1	<1	ID
Vanadium	2	<1	<1-1.2	<1	<1	100
Zinc	60	1.6	<1-**200**	<1	**84.8**	8

Note: Bold text indicates values exceeding ANZECC 2000 trigger values.

It can be seen from Table 14 that median aluminium concentration is above the ANZECC trigger value. The median concentrations of all other metals analysed are below trigger values, but at least one sample exceeded the ANZECC trigger values for each of cadmium, copper, nickel and zinc.

Further analysis focusing on upper tributaries within the Pine Creek geosyncline indicates significant concentrations of metals in runoff from these areas, which include the Frances Creek catchment.

Widespread high concentrations of aluminium suggest that biota in the area has had an extended period to adapt to high aluminium concentrations (Schultz et al, 2002). The ANZECC trigger values are therefore likely to be too conservative to be applied to protect ecosystems in the Mary River catchment.

6.5.4 Project Area Water Quality

Surface water samples were taken in the project area during April, November, and December 2005. The Frances Creek Waste Characterisation Study (MBS Environmental, May 2006) includes a detailed analysis of all surface water samples in the project area.

Data available includes:

- EC, turbidity and pH data from the main Frances Creek, Helene 9 and Helene 11 Dams and Helene 6/7 open pit sourced from Territory Iron.
- Water quality data from the Helene 9 Dam (unaffected by dewatering) sourced from Territory Iron and the Helene 4 Dam (Sample F6) - sourced through MBS. This data is considered optimum as background surface water.
- Water quality data from the Helene 4 (sample F6), Jasmine (sample F2) and Thelma 2 (sample F3) open pits (unaffected by dewatering) - sourced through MBS Environmental (MBS).
- Surface ponds sourcing run-off water from un-mineralised Wildman Siltstone (sample F5) and pristine Mundogie Sandstone (sample F1) - sourced through MBS.
- Stream channel flow waters from basically un-mineralised ground (samples M2, M3, M5, M6) - sourced by MBS.
- Stream channel flow waters from mineralised ground (samples M4, M7, M8) - sourced by MBS.
- A stagnant pool on an old ore stockpile (sample M1) - sourced by MBS.

The most relevant surface water quality data is summarised in Table 15.

Table 15 shows that water quality in the project area is generally good, but with significantly enhanced metal content in some areas. All water is fresh, with some higher electrical conductivity observed in areas subject to evaporation over the dry season. All samples were taken early in the wet season (November to December 2005) with the exception of Helene 9 Dam (April - early dry season) and the Frances Creek Dam (July - dry season). It is expected that water during the wet season will more closely resemble rainwater with lower electrical conductivity. The highest concentrations of metals generally occurred in upper catchments without mining disturbances. Concentrations are lower in samples downstream. Aluminium is elevated in all samples, as it is in the upper Mary River catchment generally (Schultz et al, 2002). The highest recorded levels of metals were in sample F1, taken from an undisturbed mineralised catchment in a Territory Iron exploration area 7.5 kilometres north of the proposed project area.

High levels of some metals in natural runoff in the area means it will be important to monitor flows upstream of operations to distinguish natural levels of metals from any mining influence.

Table 15: Frances Creek Project Area Surface Water Quality

Sample	Location	EC (µS/cm)	pH	Other Characteristics (µg/L)
Frances Creek Tributaries				
F5	Helene 6 Dam upper Frances Creek Tributary Catchment includes old Helene waste rock stockpiles	306	4.8	Enhanced beryllium (0.35), cobalt (45), soluble iron (1800), nickel (**50**) and sulfate (105,000). Enhanced sodium (19,900) and chloride (17,300) indicates likely concentration through evaporation. Beryllium level is likely due to granite geology of upper catchment.
F4	Tailings Swamp, catchment includes tailings surface and old stockpile area	121	7.2	Trace of zinc (**30**).
Helene 4 Dam	Small tributary upstream of disturbances	34	6.6	No elements exceeding guidelines.
M3	Tributary undisturbed catchment between Helene 2 and Thelma	36	6.0	Slightly enhanced aluminium (500), reduced iron (340).
M7	Diversion around Jasmine Pit	50	6.4	Trace of reduced iron (200), sulfate (4,900) almost high enough to account for acidity
Frances Creek				
Helene 9 Dam	Upstream of all disturbances	26	6.7	Significant aluminium (**21,800**), little reduced iron (60), extremely low sulphate (400) and negligible contents of toxicants.
Main Frances Creek Dam*	Downstream of TSF and stockpile area. Handheld meter readings	100	8.1	Moderate EC. No analysis of toxicants. Higher pH likely due to hand held meter versus lab analysis.
M4	Downstream of Main Dam	596	7.5	High in nitrates (**75**) and highest in both calcium (37,600) and sulphate (172,000). Exceeds Uranium Trigger Value (0.66 vs 0.50).
M8	Upstream of Ochre Hill crossing	132	6.9	No enhanced elements, red colour from road runoff.
M6	Waterhole, not flowing, downstream of all except Jasmine Pit	36	6.9	Slightly enhanced aluminium (**600**), reduced iron (600)
Maude Creek Tributaries				
M5	3 km downstream of Ochre Hill	45	6.1	Slightly enhanced aluminium (**500**), reduced iron (400)
F1	7.5 km north of Ochre Hill, northern tributary of Maude Creek unaffected by project	45	6.6	Significantly enhanced soluble Aluminium (**10,200**), Beryllium (0.20), Cobalt (5), Copper (**10.0**) soluble Iron, Lead (**4,150**), Thallium (0.01), Uranium (0.005), Vanadium (**20**) and Zinc (**30**) when compared against Fresh Water Trigger Values.

Note: Bold text indicates values exceeding ANZECC 2000 trigger values (see Table14).

6.5.5 Downstream Water Users

Three main beneficial uses of surface water in the Mary River catchment have been declared under Beneficial Uses legislation under the *NT Water Act (1992)*. These are:

- Cultural use (including aesthetic and recreational).
- Environmental use (the maintenance of healthy aquatic ecosystems).
- Riparian use (public rights to extract water for domestic/stock purposes).

These uses are the basis for waste discharge licences and water quality planning – potential waste discharge or water extraction which detrimentally impacts on these Beneficial Uses will not be permitted under the *Water Act*.

The Mary River catchment has no townships. The resident population was estimated at less than 200 in 2002 (Armstrong et al, 2002). Some recreational use has been made of water on the main Frances Creek Dam, primarily water skiing and swimming. The main uses within the project area would be environmental. The area is not currently used for grazing, but as part of Ban Ban Springs pastoral lease has potential for riparian use for stock purposes.

Immediately downstream of the project area, Frances Creek passes through Ban Ban Springs and Mary River West pastoral leases. Major uses here would also be riparian (stock water) and environmental use. Frances Creek joins the Mary River next to Mary River Station and Mary River Roadhouse. This is the nearest residence downstream of the project area.

The Mary River forms a portion of the boundary of Kakadu National Park where Frances Creek joins it, about 20 kilometres downstream of the project area (Figure 2). The Kakadu National Park boundary diverges from the Mary River about 40 kilometres downstream. Mary River does not flow into the park so there is minimal use of water in Kakadu. Mary River National Park covers most of Mary River downstream of Kakadu. The final 40 kilometres before the ocean is pastoral and leasehold land. Fishing and boating are promoted as major recreational attractions of the National Park so recreation, as well as environmental uses, are significant in Mary River National Park.

6.6 VEGETATION AND FLORA

The Frances Creek project area lies in the Northern Territory's Pine Creek bioregion. This bioregion comprises foothills to the west of the Western Arnhem Land sandstone massive. The dominant vegetation types of the bioregion are tall open eucalypt forests of *Eucalyptus miniata* and *E. tetrodonta* and mixed *Eucalytptus* woodlands (NRETA, 2006b). Vegetation of the Pine Creek bioregion is considered to be in moderately good condition with some localised modification, mainly associated with mining, horticulture and improved pastures (NRETA, 2006b).

Vegetation communities of the Northern Territory have been mapped and described by Wilson et al (1990). The tropical woodland of the Frances Creek project area is mapped and described as vegetation type 21 – *Eucalyptus tintinans* with *Corymbia dichromophloia* and *Eucalyptus miniata*, over a tall *Sorghum* grassland understorey (Wilson et al, 1990).

Eucalyptus tetrodonta is also commonly associated with this vegetation community in the Frances Creek area. The surrounding area is mapped as vegetation type 15 – *Eucalyptus tectifica* and *Corymbia latifolia* with *Sorghum* grasses.

6.6.1 Land Units and Vegetation Types

Low Ecological Services completed an environmental survey of the project area between 11 and 15 November 2005 with a follow up survey between 17 and 21 May 2006. The surveys aimed to collect baseline data on flora, fauna, land systems and soils of the Frances Creek project area. The survey reports are included as Appendix 7.

Six land units were described during the November 2005 survey. The vegetation of these land units varied from patchy open woodland to open mixed *Eucalyptus* forest and riparian vegetation. The land units described were:

- Ridge Crests and Slopes.
- Low Hills.
- Riparian.
- Small Alluvial Flats.
- Granite Hills.
- Low Undulating Hills.

The Ridge Crests and Slopes consist of open mixed woodland/forest dominated by *Eucalyptus tetrodonta*, *E. minata* and *Corymbia dichromophloia* over sparse shrubs, a mid – tall mixed grassland and a sparse forbland.

The Low Hills consist of open mixed Eucalypt woodland dominated by *Corymbia dicromophloia*, *Erythrophleum chlorostachys* and *Eucalyptus miniata* over a mixed grass/herbland.

The Small Alluvial Flats consist of open mixed woodland over a mixed *Sorghum* species grassland. Dominant tree species of this land unit varied between sites and included *Eucalyptus minima*, *E. tetrodonta*, *E. alba* and *Erythrophleum chlorostachys*.

Vegetation of the Riparian land unit was denser and had thicker canopy cover than vegetation of other land units. The riparian land unit consisted of trees, shrubs and understorey species including *Acacia auriculiformis*, *Grevillea mimosoides*, *Ficus opposita*, *Livistona humilis*, *Terminalia ferdinandiana*, *Schefflera actinophylla*, *Alstonia actinophylla*, *Cyperus digitatus*, various forbs and grasses.

Granite Hills consist of low open woodland dominated by *Corymbia dicromophloia* and *Eucalyptus tinnitans* over a *Sorghum intrans* grassland.

Low Undulating Hills are characterised by open mixed Eucalypt woodland over a mixed grassland.

A full listing of flora species recorded can be found in Appendix 11.4 of Reilly et al. (2006) (Appendix 7 of this document). The vegetation types and flora species described during the

November 2005 and May 2006 surveys are widespread throughout appropriate habitat both within the Frances Creek project area and in the wider region. They are not considered to be threatened or significant (Reilly et al, 2006). The project area does not represent an area of significant endemism, but does retain areas of pristine habitat (Reilly et al, 2006).

6.6.2 Significant Flora and Threatened Ecological Communities

An isolated patch of Cycad (*Cycas armstrongii*) was located near the Ochre Hill Road. *Cycas armstrongii* is listed as Vulnerable under the *TPWC Act 2000*. The plants are located 50 metres from the road alignment and future road works should not disturb or remove any individual plants. No other flora species of conservation significance were recorded during the November 2005 and May 2006 surveys.

No Threatened Ecological Communities (TEC) are known to occur within the Frances Creek project area. The flora species and vegetation communities recorded during the November 2005 and May 2006 surveys are generally common and widespread throughout the region.

6.6.3 Vegetation Condition

Due to the historical mining activities at Frances Creek and current mining activities taking place at nearby locations, vegetation of the project area's southern portion is in a degraded condition.

Mining operations at Frances Creek were abandoned after flooding associated with Cyclone Tracey in 1974. The site was left to regenerate and rehabilitate under natural influences and processes. Many areas have since developed into healthy tropical woodlands (Reilly et al, 2005). Additionally, the old TSF has developed into a functioning wetland.

The November 2005 and May 2006 surveys identified a number of weed species in the Frances Creek project area. Weed species were recorded to varying densities and numbers across the project areas's southern portion with the old TSF recording most identified weed species in high densities, however weeds did appear to be confined to areas of previous disturbance (Reilly et al, 2005; 2006). Weed species recorded from the Frances Creek project area and surrounding areas are listed in Table 16. In addition to these species, Mission grass (*Pennisetum polystachion*), a Class B Declared Weed, and Gamba Grass (*Andropogon gayanus*) are known to be widespread throughout the Pine Creek Bioregion (NRETA, 2006b).

Table 16: Weed Species Identified in the Frances Creek Project Area and Nearby Areas

Species Name	Common Name	Recorded From	*Weeds Management Act 2001* Status
Cynodon dactylon	Couch Grass	Frances Creek	Not a Declared Weed
Pennisetum pedicellatum	African Feathergrass Annual Mission Grass	Frances Creek Mt Porter	Not a Declared Weed
Mimosa pudica	Common Sensitive Plant	Frances Creek	Class B/Class C Weed
Euphorbia heterophylla	Painted Spurge	Mt Porter	Not a Declared Weed
Calopogonium mucunoides	Calopo	Frances Creek	Not a Declared Weed
Crotalaria goreensis	Gambia Pea	Mt Porter	Not a Declared Weed
Passiflora foetida	Stinking Passion Vine	Frances Creek Mt Porter	Not a Declared Weed
Senna alata	Ringworm Scrub Candle Bush	Frances Creek	Class B/Class C Weed
Hyptis suaveolens	Hyptis Horehound	Frances Creek Mt Porter	Class B/Class C Weed

Source: Reilly et al. (2006) and NRETA (2006c)

6.7 FAUNA

Fauna of the Northern Territory is diverse with 400 species of birds, 150 species of mammals, 300 reptile species, 50 frog species, 60 species of freshwater fish and several hundred species of marine fish. Species richness declines from high rainfall areas of the northern monsoonal tropics to lower rainfall areas of the southern arid regions (NRETA, 2006a).

The Pine Creek Bioregion is considered to be in moderately good condition and provides habitat for populations of some threatened species including the Gouldian Finch (*Erythrura gouldiae*), the Partridge Pigeon (*Geophaps smithii*) and one of the largest known colonies of the Ghost Bat (*Macroderma gigas*) (NRETA, 2006b). Fauna of the Frances Creek project area is considered to be typical of the Pine Creek Bioregion (Reilly et al, 2006).

Low Ecological Services completed an environmental survey of the Frances Creek project area between 11 and 15 November 2005 with a follow up survey between 17 and 21 May 2006. These reports have been reproduced as Appendix 7 of this document.

A total of 149 species were identified during the two surveys. This included 30 mammals, 83 birds, 22 reptiles, six amphibians, eight fish and one crustacean. However, due to the short duration of the surveys and highly seasonal nature of the climate, the fauna species recorded does not represent the full suit of species expected to be present.

An above average wet season before the May 2006 survey ensured that aquatic fauna could be assessed. A total of eight fish, five frogs, two reptiles, one crustacean and two insects were identified. The cane toad was also observed in these areas.

A full list of fauna species recorded from the Frances Creek project area together with those species expected to occur in the area is in Appendices 11.5 to 11.8 of Reilly et al, (2006) (Appendix 7 of this document).

6.7.1 Species of Conservation Significance

A number of fauna species of conservation significance were recorded during the two surveys. This included six mammal, seven bird and one reptile species. A further 13 species (including seven migratory species) listed under the *EPBC Act 1999*, 15 species listed under the *TPWC Act 2000* and six species listed under both Acts are expected to occur in the region, but were not recorded during either the November 2005 or May 2006 surveys. Table 17 lists those species of conservation significance recorded from or expected to occur within the projected area with details of their threat status.

Table 17: Fauna Species of Conservation Significance Recorded and Potentially Occurring Within Frances Creek Area

Fauna Species	Recorded in Site Specific Surveys	NT Status	Federal Status	IUCN Status
Mammals				
Bare-rumped Sheathtail Bat (*Saccolaimus saccolaimus nudicuniatus*)		Data Deficient	Critically Endangered	Least Concern
Northern Quoll (*Dasyurus hallucatus*)		Vulnerable	Endangered	Near Threatened
Calaby's Pebble-mound Mouse (*Pseudomys calabyi*)	✓	Near Threatened		Rare
Nabarlek, Little Rock Wallaby (*Petrogale concinna*)		Near Threatened		Near Threatened
Brush-tailed Phascogale (*Phascogale tapoatafa*)		Vulnerable		Near Threatened
White-striped Sheathtail Bat Arnhem Sheathtail Bat (*Taphozous kapalgensis*)	✓	Near Threatened		Vulnerable
Ghost Bat (*Macroderma gigas)*	✓	Near Threatened		Vulnerable
Lesser Wart-nosed Horseshoe Bat (*Hipposideros stenotis*)		Near Threatened		Near Threatened
Western Chestnut Mouse (*Pseudomys nanus*)	✓	Near Threatened		Near Threatened
Pale Field-rat (*Rattus tunneyi*)	✓	Near Threatened		Near Threatened
Northern Nailtail Wallaby (*Onychogalea unguifera*)		Near Threatened		Least Concern

Fauna Species	Recorded in Site Specific Surveys	NT Status	Federal Status	IUCN Status
Orange Horseshoe-bat Orange Leaf-nosed Bat (*Rhinonicterus aurantius*)	✓	Near Threatened		
Reptiles				
Freshwater Crocodile (*Crocodylus johnstoni*)	✓		Listed Marine Species	Least Concern
Saltwater Crocodile (*Crocodylus porosus*)			Migratory Listed Marine Species	Least Concern
Oenpelli Python (*Morelia oenpelliensis*)		Vulnerable		
Chameleon Dragon (*Chelosania brunnea*)		Near Threatened		
Northern Death Adder (*Acanthopis praelongus*)		Near Threatened		
Yellow Spotted Monitor (*Varanus panoptes*)		Near Threatened		
Fish				
Freshwater Sawfish (*Pristis microdon*)			Vulnerable	Critically Endangered
Birds				
Gouldian Finch (*Erythrura gouldiae*)		Endangered	Endangered	Endangered
Red Goshawk (*Erythrotriorchis radiatus*)		Vulnerable	Vulnerable	Vulnerable
Partridge Pigeon (*Geophaps smithii*)	✓	Near Threatened	Vulnerable	Near Threatened
Masked Owl (*Tyto novaehollandiae*)		Near Threatened	Vulnerable	Least Concern
White-browed Robin (*Eopsaltria cucullata*)		Near Threatened	Migratory	
Cattle Egret (*Ardea ibis*)			Migratory	Least Concern
Fork-tailed Swift (*Apus pacificus*)			Migratory	Least Concern
Little Curlew (*Numenius minutus*)			Migratory	Least Concern
Melville Cicadabird (*Coracina tenuirostris melvillensis*)			Migratory	Least Concern
Oriental Plover (*Charadrius veredus*)			Migratory	Least Concern
Oriental Pratincole (*Glareola maldivarum*)			Migratory	Least Concern

Fauna Species	Recorded in Site Specific Surveys	NT Status	Federal Status	IUCN Status
Rainbow Bee-eater (*Merops ornatus*)	✓		Migratory	Least Concern
Rufous Fantail (*Rhipidura rufifrons*)			Migratory	Least Concern
White Egret (*Ardea alba*)	✓		Migratory	Least Concern
White-bellied Sea-Eagle (*Haliaetus leucogaster*)			Migratory	
Magpie Goose (*Anseranas semipalmata*)	✓		Listed Marine Species	Least Concern
Australian Bustard (*Ardeotis australis*)		Vulnerable		Near Threatened
Emu (*Dromaius novaehollandiae*)		Vulnerable		Least Concern
Bush Thick-knee (*Burhinus magnirostris*).	✓	Near Threatened		
Hooded Parrot (*Psephotus dissimilis*)		Near Threatened		Least Concern
Red-tailed Black Cockatoo (*Calyptorhynchus banksii*)	✓	Near Threatened		Least Concern
Square-tailed Kite (*Lophoictinia isura*)		Near Threatened		Least Concern
Star Finch (*Neochmia ruficauda*)	✓	Near Threatened		
Yellow-rumped Mannikin (*Lonchura flaviprymna*)		Near Threatened		Least Concern

With the exception of the Bare-rumped Sheathtail Bat (*Saccolaimus saccolaimus nudicuniatus*), all mammal species of conservation significance not recorded during the site specific surveys have been recorded in Kakadu National Park (Woinarski et al, 1989). The Northern Quoll (*Dasyurus hallucatus*) has also been recorded from Union Reef, Mt Todd, Pine Creek (NSR 1993) and Cosmo Howley (Davidson, 1985), however Low Ecological Services (Reilly, 2006) indicate that there is accumulating evidence that the Northern Quoll is largely disappearing from areas that cane toads have invaded.

The four terrestrial reptile species not recorded by Low Ecological Services during site specific surveys have been recorded by Woinarski et al. (1989) from Kakadu National Park. The Chameleon Dragon (*Chelosania brunnea*) and the Northern Death Adder (*Acanthopis praelongus*) have also been recorded from Mount Todd (NSR, 1993) and the Yellow Spotted Monitor has been recorded from Mount Todd and Union Reef (NSR, 1993). Neither the Saltwater Crocodile (*Crocodylus porosus*) nor the Freshwater Sawfish (*Pristis microdon*) have been recorded in the project area or from nearby surveys.

Of those bird species not observed during the site specific surveys, most have been recorded from Kakadu National Park (Woinarski et al, 1989), Pine Creek or Mt Todd (NSR, 1993).

Three species, the Masked Owl (*Tyto novaehollandiae*), Oriental Pratincole (*Glareola maldivarum*) and the White-bellied Sea Eagle (*Haliaetus leucogaster*), have not been recorded in the area. Two holes thought to be the inactive nest of the Hooded Parrot (*Psephotus dissimilis*) were recorded though no individuals of this species were observed.

The May 2006 survey also included a targeted search for the Gouldian Finch (*Erythrura gouldiae*). Habitat known to be preferred by Gouldian Finches was surveyed at several locations in the early morning and late afternoon. These locations included Frances Creek and other creeks, the old tailings storage facility swamp, alluvial areas dominated by Eucalypts and *Sorghum* grasses and low rocky hills dominated by Eucalypts and *Sorghum* grasses. Searches were also made of locations where other finch species were sighted. No Gouldian Finches were observed during either the November 2005 or May 2006 site specific surveys.

No aquatic fauna of conservation significance were observed. The Freshwater Crocodile (*Crocodylus johnstonii*) is a listed marine species under the *EPBC Act 1999* and is protected under the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) of which Australia is a member country.

6.7.2 Pest Species

Several introduced (pest) fauna species were recorded during the two surveys. These included feral cats (*Felis catus*), donkeys (*Equus asinus*), feral horses (*Equus caballus*) and feral pigs (*Sus scrofa*). Both the water buffalo (*Bubalus bubalus*) and feral cattle (*Bos taurus*) are known to be present in the region and have been recoded from nearby Kakadu National Park (Woinarski et al, 1989).

The cane toad (*Bufo marinus*) was also recoded during the two surveys. It is estimated that the cane toad arrived in the area during 2003 and may be responsible for disappearance of some native animals from the area, particularly the Northern Quoll, *Dasyurus hallucatus* (DEH, 2004).

6.8 AIR QUALITY

No ambient air quality data is available for the project area but air quality data for substance emissions is registered with the National Pollutant Inventory (NPI), for Pine Creek, located 30 kilometres away and the Anglo Gold Union Reef Mine 13 kilometres away. The only reporting facilities at Pine Creek are two electricity supply power stations. Emissions from the three facilities in the reporting year of 2004-05 (NPI, 2006) are shown in Table 18. Emissions for 2003-04 are shown for Union Reef because the mine was inactive in 2005. The mine is now being re-opened and the 2003-04 emissions are probably more representative of future emissions.

Table 18: 2004-2005 NPI Total Emissions to Air (kg) from Pine Creek Facilities

Substance	Union Reef 2003-2004	Union Reef 2004-2005	Power 2004-2005
Arsenic & compounds	6,900	2,400	0.15
Beryllium & compounds	0	0	0.009
Boron & compounds	310	110	0
Cadmium & compounds	43	15	0.81
Carbon monoxide	69,000	1,800	190,000
Chromium (III) compounds	0	0	0.99
Chromium (VI) compounds	530	180	0.053
Cobalt & compounds	120	41	0
Copper & compounds	270	89	0.64
Cyanide (inorganic) compounds	3,700	1,200	0
Fluoride compounds	4,900	1,700	0
Lead & compounds	3,400	1,200	0.42
Magnesium oxide fume	180	47	0
Manganese & compounds	3,400	1,200	0
Mercury & compounds	1	0	0.19
Nickel & compounds	330	110	1.6
Oxides of Nitrogen	120,000	4,700	290,000
Particulate Matter 10.0 um	370,000	39,000	5,100
Polychlorinated dioxins and furans	0	0	0.000011
Polycyclic aromatic hydrocarbons	0	0	1.4
Selenium & compounds	5	1	0
Sulfur dioxide	5,900	240	1,100
Total Volatile Organic Compounds	10,000	500	2,500
Zinc and compounds	7,600	2,600	0

Table 18 shows the major emissions to be characteristic of combustion and common to most populated areas. Emissions of all substances are characterised as low by the NPI (NPI, 2006).

Existing air quality in the project area is expected to be generally good given the lack of urban population or industry, and low emissions from the nearest industry and population centres. Suspended particulate levels are, however, expected to be elevated seasonally due to windblown dust, pastoral activities and bushfires.

6.9 NOISE AND VIBRATION

No quantitative baseline noise or vibration data is available for the project area. Subjective assessment from visits to site confirm that the current pastoral and mineral exploration land uses result in the project area having a relatively low background level of noise. Noise levels would increase slightly on the haul route and railway siding close to the railway and Stuart Highway. Occasional noise generated by recreational use of the dams for water skiing would also be present.

The nearest residence to the operations is at Union Extended Mine, approximately eight kilometres to the west, and greater than five kilometres from the nearest portion of the haul route. Esmeralda Farms homestead is 12 kilometres south of the mine and 3.5 kilometres from haul route 2. It is unoccupied but has potential to become occupied during the life of the mine. The nearest settlement is Pine Creek, approximately 23 kilometres to the south.

6.10 RADIOACTIVITY

The proposed mining areas are immediately adjacent to and sometimes coincident with a regional zone of above average uranium concentrations. Territory Iron analysed a batch of 131 samples of ore and waste rock for uranium and thorium. The results are displayed in Table 19 and are further described in Appendix 4. From this it can be seen that there are no correlations between uranium and thorium values.

Table 19: Uranium and Thorium Concentrations of Ore and Waste Rock

Type of Material	Uranium		Thorium	
	Range	Median	Range	Median
Iron Ore	5.3 - 74.8	12.3	0.1 - 4.8	1.5
Waste Rock	6.2 - 65.2	13.9	2.0 - 15.2	5.2

Median values of uranium in ore from the proposed pits are in the range of 10 to 44 parts per million. These levels are well below the recognised uranium ore grade of 200 parts per million. Many open pit and underground mines world-wide operate at comparable or higher levels.

Western Radiation Services provided advice on potential radiation levels. A letter from Western Radiation Services is attached as Appendix 8.

The recorded values of uranium and thorium would result in an estimated exposure effective dose rate of 0.057 milliSievert per annum (WRS, May 2006). Median concentration of uranium ore is more than an order of magnitude below the level where workers might receive the maximum recommended exposure to gamma radiation for members of the public. Additional exposure from potassium and thorium will be insignificant as these elements are present in the ore at or below normal background values (MBS Environmental, May 2006).

It is generally accepted that, for normal exposure situations, activity of materials to which personnel are exposed should be less than 1.0 Becquerel per gram (ARPANSA, 2005). The highest uranium value so far detected in the project area is 74.8 milligrams per kilogram uranium for which the calculated activity exclusive of the trace content of associated thorium is 0.93 Becquerel per gram.

Two samples of water were collected on 14 December 2005 and analysed for radioactive content by Western Radiation Services. The results are shown in Table 20. These results show normal levels of radium (WRS, May 2006).

Table 20: Radium 226 and 228 Analyses of Frances Creek Water Samples

Sample Location	Radium 226 (mBq/L)	Radium 228 (mBq/L)
Helene 6/7 Pit (groundwater)	6 ± 3	107 ± 42
Frances Creek Main Dam	<MDL	355 ±123

MDL (Method Detection Limit) = 3 for Radium 226, 100 for Radium 228

Western Radiation Services completed a background gamma radiation and radon survey of the project area between 18 and 23 May 2006. A copy of the survey report is attached as Appendix 9. The survey included a gamma radiation survey using a calibrated meter, targeted sampling using the meter results and electret monitoring for radon gas.

The survey area covered Ochre Hill, Helene 5, Helene 6/7, Thelma Rosemary, Thelma Rosemary (east) and Jasmine. Gamma radiation was also monitored in Pine Creek.

Data collected by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA, 2004) specify the mean natural background radiation within Australia is 2.3 millisieverts per annum. The world average for natural background radiation is about 3.5 millisieverts per annum. The calculated background gamma exposure rate for the Ochre Hill site (3.17 millisieverts per annum) is above Australian average levels, but below world levels. The calculated background gamma exposure rate for the Helene 5 site (3.50 millisieverts per annum) is above Australian average levels and the same as world levels. The calculated background gamma exposure rate of 2.63 millisieverts per annum for the Pine Creek township is above the Australian average, but less than the world levels. This information is summarised in Table 21.

Table 21: Comparison of Background Radiation Levels

Location	Background Radiation Levels (mSv per annum)
World Average	3.50
Australia Average	2.30
Pine Creek	2.63
Helene 5	3.50
Ochre Hill	3.17

The highest radon activity level found in the mine site survey was 300±18 Becquerels per metre at Ochre Hill, well below the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA, 2002) recommended limit of 1,000 Becquerels per cubic metre in the work place.

The gamma radiation measurements across the surveyed area are consistent with normal background measurements for the world and above the natural background for Australia.

To estimate the annual gamma exposure to workers at the proposed mine, the measured background gamma at Pine Creek was subtracted from the mean of the measured mine site data at Frances Creek. The difference value (microsieverts per hour) was multiplied by 2,000 hours (standard working year) to estimate mine workers' occupational gamma exposure. The highest mean gamma reading for the site was 0.41 microsieverts per hour at Ochre Hill. The estimated increased gamma exposure using this value was 0.22 millisieverts per annum which is below the one microsievert per annum recommended exposure limit for members of the public (ARPANSA, 2005).