Section 6 Surface water

6.1 Introduction

The notice of intent (NOI) for Maud Creek mine identified a diversion of Gold Creek, depending on further flood risk analysis. Subsequently, a detailed mine plan and detailed flood study was undertaken that showed the proposed Gold Creek diversion was unnecessary.

Consequently, all details relating to the diversion of the creek have been removed. The section now assesses surface water issues within the mine operational area, i.e. the pit, ROM pad, office, workshops, waste rock stockpile, mine water dam and irrigation area.

6.2 Regional Surface Water Systems

Rivers, creeks and catchments in the vicinity of the mine are shown in Figure 6-1. The project area is located on Gold Creek, a tributary of Maud Creek, which flows into the Katherine River below the Katherine Gorge and upstream of Katherine Township and the Donkey camp water supply extraction point.

Beneficial use of surface waters in the project area is limited to small stock water supply dams. However, runoff from the Gold Creek and Maud Creek catchments contribute to flow in the Katherine River. The larger Katherine River catchment provides potable water supply to the town of Katherine via a water extraction point at Donkey Camp 30 km downstream from the mine site (shown as Pumping Station on Figure 6-1).

Stream flow gauging is not available for Gold Creek and Maud Creek. However, the stream hydrographs that were obtained for tributaries of the Katherine River and depicted in Figure 6-2 indicate a stream flow period from November to May with a stream flow maximum in February - March.

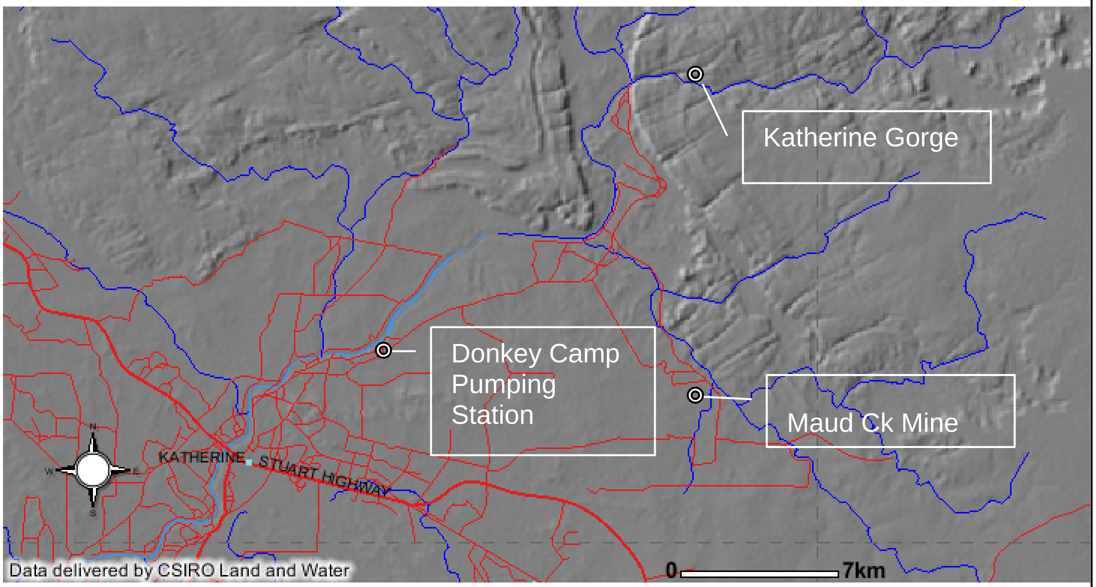
Similarly, both Gold Creek and Maud Creek are ephemeral creeks, which cease to flow during the dry season, although remnant pools remain. The creeks have steep, well vegetated banks and there is evidence of bank erosion associated with high flow rates in the wet season.

The Gold Creek catchment is approximately 23.5 km^2 in area, or 0.27% of the catchment area of the Katherine River, above the Donkey Camp pumping station (Figure 6-3). The time taken for flow from the Gold Creek catchment to reach the downstream end of the proposed development is estimated to be four hours. Given the topography and size of the catchment, the discharge rates in Gold Creek can fluctuate rapidly over a period of hours during and after a significant rainfall event.

Hydrological calculations indicate that several rainfall events in an average year are likely to produce flows that exceed the capacity of Gold Creek channel, and in those situations over-bank flow spreads across the valley flat. This over-bank flow also occurs along Maud Creek, although given the larger size of the catchment, the time response is considerably slower.

Section 6 Surface water

Figure 6-1 Regional topographic information, hill shade and topographic maps



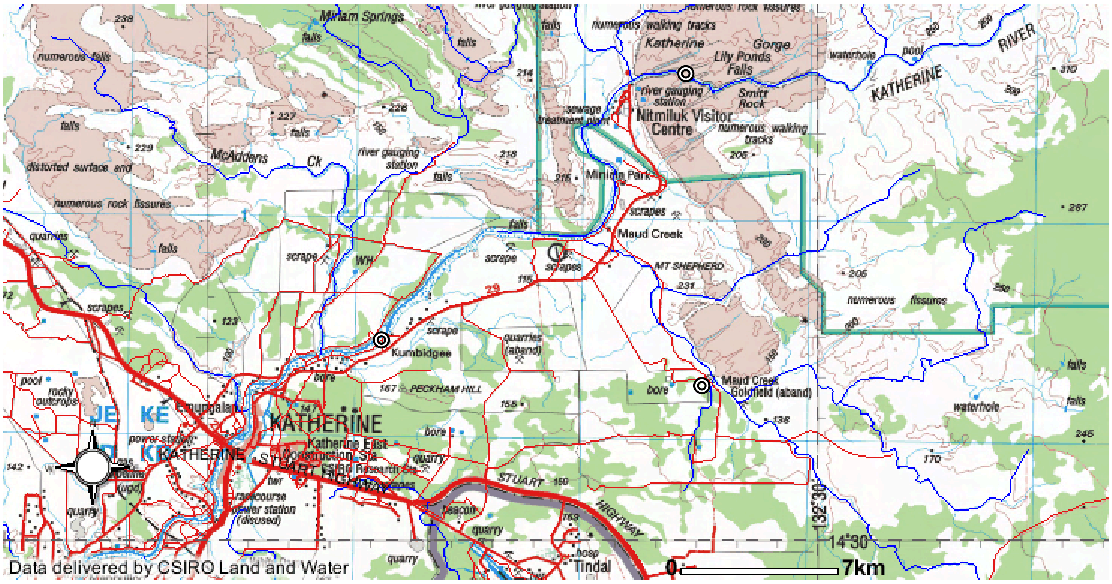


Figure 6-2 Mean monthly discharges for the Katherine River tributaries indicating period of stream flow (from Zaar *et al*. 2003)

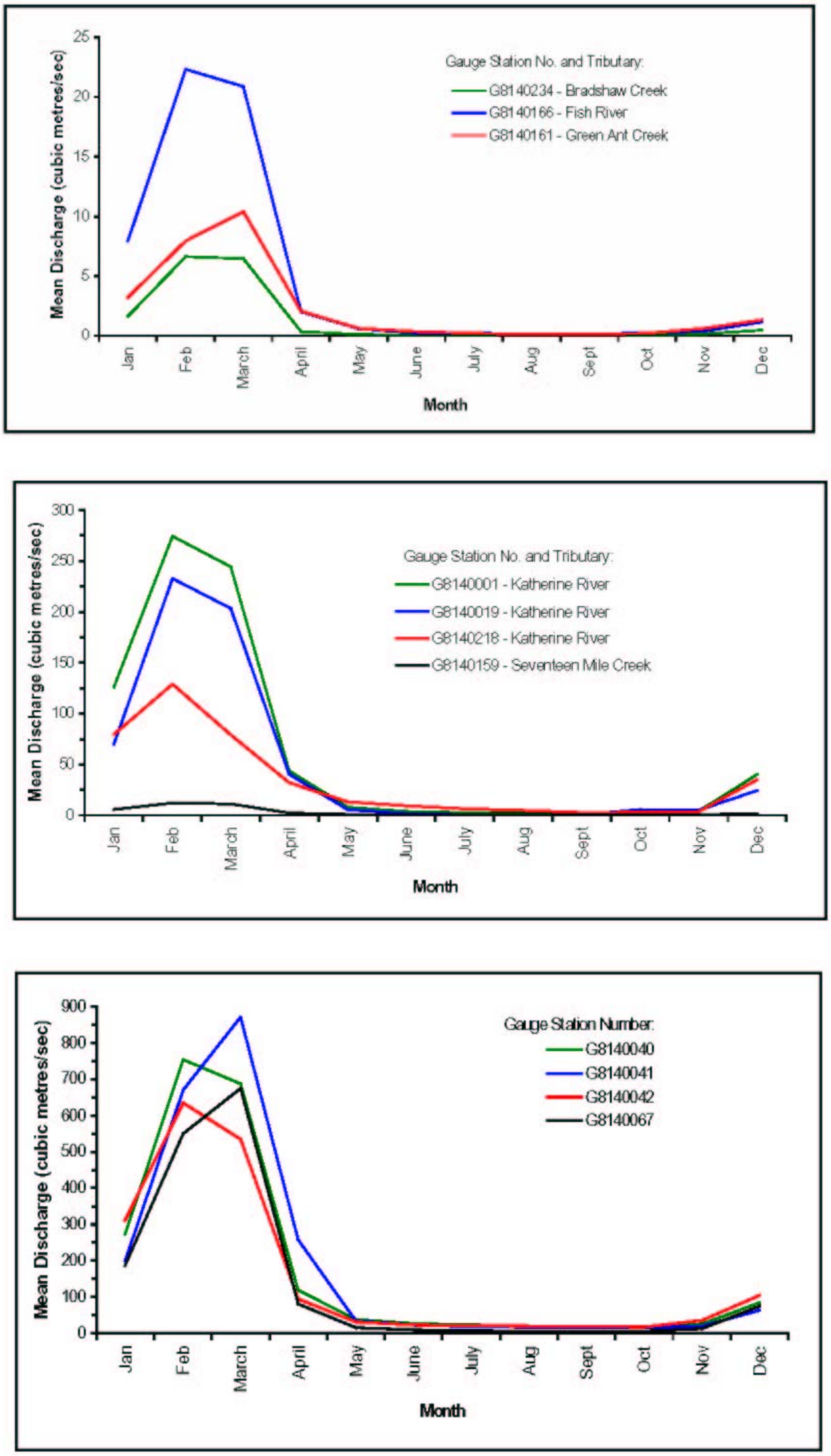
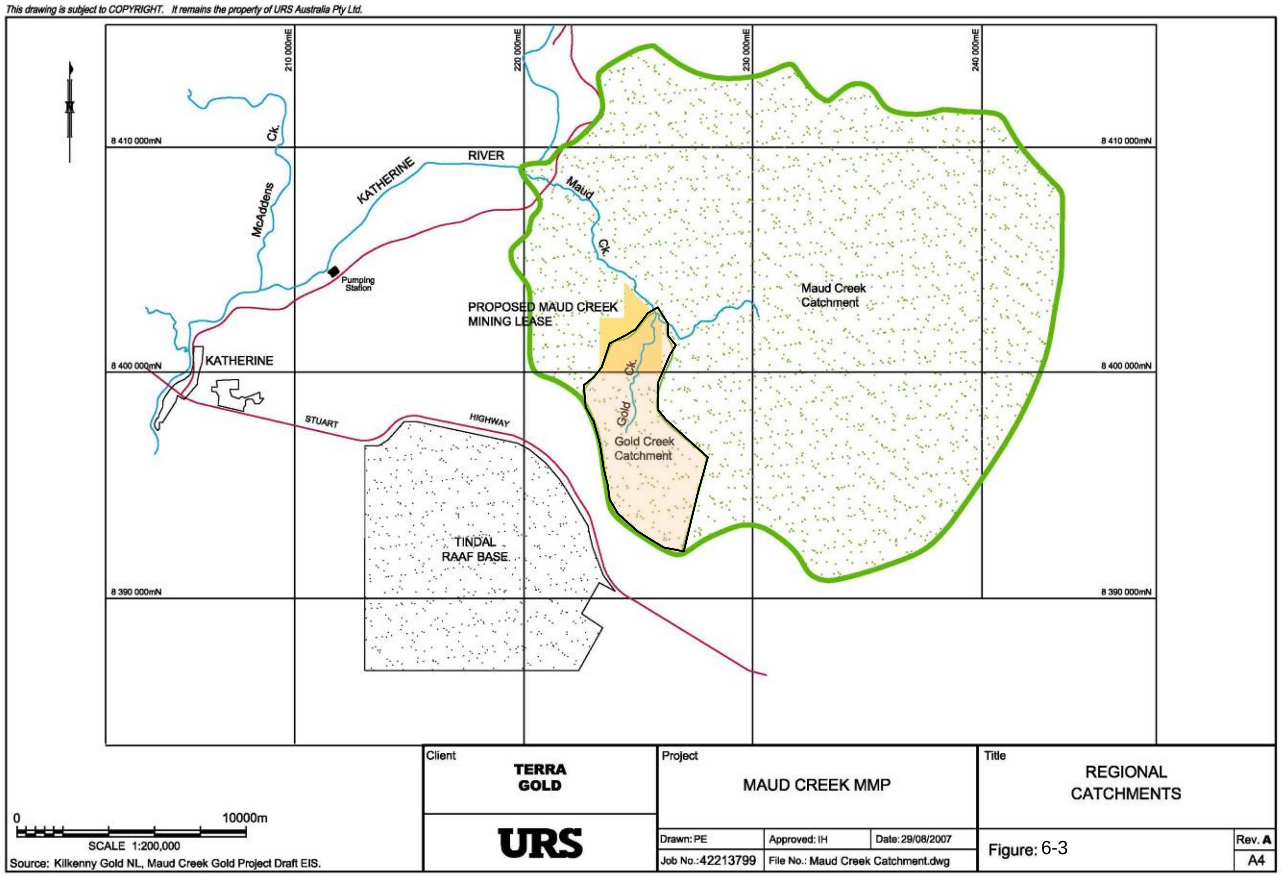


Figure 6-3 Regional surface water catchments



6.3 Operational Area

The operational area (pit, ROM pad, office, workshops, waste stockpile, etc) has a catchment size of approximately 12 ha. This represents about 0.5% of the Gold Creek Catchment of approximately 23.5 km^2 (Figure 6-3).

The operational area contains the following infrastructure (Table 2-2):

- existing open pit void 2.7 ha;
- ROM pad 1.6 ha;
- boxcut for decline portal 0.7 ha;
- miscellaneous infrastructure (office/workshop/internal roads etc) 2.4 ha; and
- mine water dam (existing waste rock stockpile) 4.6 ha.

A risk of hydrocarbon spillage exists within the workshop area. Onsite hydrocarbon storage will be restricted to limit this risk, and appropriate bunded areas will be provided to contain possible hydrocarbon spillage, in accordance with Australian Standard AS1940 (Section 16).

6.4 Flood Risk from Extreme Rainfall Events

The hazard to the quality of the municipal water supply is low given the distance between the mine site and the municipal water supply point, and given the small fraction of the operational area relative to the catchment areas (about 0.5% of the Gold Creek catchment area, which is in turn 0.27% of the Katherine River catchment area therefore 0.001 % of the Katherine river catchment area – refer also Figure 6-3).

However, taking a precautionary approach consistent with mining industry best practice, Terra Gold plans to install a flood protection bund to isolate the mine area runoff from stream flow, and to dispose of mine area runoff and mine dewatering to an irrigated land application area, which is remote from the creeks.

The flood protection bund has been designed following a detailed study of the 500 year flood level and will be constructed to protect operational infrastructure. The bund will surround the operational area and will be constructed to protect the mine area from a 1 in 500 year flood event. The flood risk analysis is presented in Appendix C - Maud Creek Mine Site Flood Study.

6.5 Site Water Balance

The site water balance was investigated with the aim of optimising the size and operation of the irrigated land application system in relation to the size of the mine water dam storage.

Potentially significant risks to downstream public infrastructure during mining operations and after closure are outlined in Section 17; these are associated with engineered containment structures such as the mine water dam. These risks have been addressed in the mine design.

Increasing the size of the mine water dam to contain mine water production with a high degree of confidence also increases the hazard associated with the structure failing. Also, reducing the size of the mine water dam will increase reliance on wet season disposal by irrigated land application.

Consequently, environmental performance of the water management system was optimised to trade-off the volume needed in the mine water dam to contain catchment runoff and mine dewatering during the wet season, and water disposal by irrigated land application during the wet season. The water balance makes the following assumptions:

- no water is discharged to either Gold or Maud Creeks (surface runoff and groundwater from mine dewatering);
- all water is transferred to the mine water dam and discharged using the irrigation system;
- a four-year rainfall sequence that includes three average rainfall years and one 90 percentile wet season. (1100mm/yr average and 1660mm/yr 90 percentile);
- the mine water dam is 4.5m deep (comprising 2.5m operational depth, 1.45m direct rainfall and 0.55m freeboard);
- the operational catchment area covers 12 ha, including 2.7 ha for the existing open pit;
- the runoff co-efficient over the pit area is 1.0, and over the remainder of the operational area is 0.7;
- irrigation rate and water quality is sustainable not leading to soil degradation due to water logging or unacceptable short-term accumulation of heavy metals with respect to guidelines for irrigated agriculture (ANZECC 2000, volume 3 section 9.2); or surface discharge to the receiving environment;
- a minimum of 42 ha has been identified for irrigated land application using a single centre pivot irrigation system, with the capacity to enlarge to 62 ha or 84 ha using two centre pivot irrigation systems installed on existing, cleared pasture land.

6.5.1 Water management system optimisation

Table 6-1 summarises the results of the water balance analysis incorporating the effects of varying dry season and wet season irrigation rates and irrigation area on the size and volume of the mine water dam, for three sizes of irrigation area.

Table 6-1 Sensitivity of mine water dam size to irrigation system design[1]

Irrigation Area (ha)	Irrigation Rate		Dam Size (assumed square)		Mine Water Dam Storage Volume Depth = 2.5m (ML)
	Dry Season (mm/day)	Wet season (mm/day)	Side length (m)	Area (ha)	
Option1. (42)	10	4	390	15.2	380
Option 2. (42)	14.5	0	510	26.0	650
Option3. (42)	10	10	60	0.36	9
Option4. (62)	10	0	510	26.0	650
Option5. (62)	6	3	360	13.0	325
Option6. (62)	5	5	220	4.8	120
Option7. (**84**)	**5**	**5**	**0**	**0**	**0**
Option8. (84)	5	4.25	42	0.18	4.5
Option9. (84)	5	4	80	0.64	16

[1] shaded cells indicate optimal configuration

Option 1 in Table 6-1 represents a base case, incorporating wet season irrigation at reduced rates to manage inventory. Option 2 in Table 6-1 demonstrates the sensitivity of the size of the mine water dam to wet season irrigation. Subsequent options investigate the sensitivity of mine water dam sizing to irrigation area and wet season rates of irrigated application. Irrigation during the wet season is the critical issue for reducing the size of the mine water dam.

The analysis in Table 6-1 indicates that irrigated disposal of mine water during the wet season and increasing the size of the irrigation area to 84 ha can potentially eliminate the need for a mine water dam. This is because the capacity to discharge water to irrigated agricultural land replaces the storage capacity needed to contain runoff from the mine area and mine dewatering during the wet season.

In Option 7 in Table 6-1 the irrigation system applies water at 5mm/day during the wet season (and the dry season) over an 84 ha irrigation area (two 42 ha centre pivot systems) no dam storage would be required for inventory. This is sensitive to the irrigation rate; for example if the wet season irrigation rate were reduced by one millimetre per day an 80m x 80m mine water dam (or equivalent area) is required to manage wet season inventory (Table 6-1).

Option 6 in Table 6-1 has the irrigation system applying water at 5mm/day during the wet season (and the dry season) over a 62 ha irrigation area (one 42 ha centre pivot system and one smaller 20 ha system). This option requires inventory management in the wet season which can be contained in a 4.8 ha storage dam with 2.5 m of storage depth. A mine water dam of this size could be constructed on the existing waste rock stockpile area.

Option 7 removes the need for a mine water dam to manage wet season inventory. However, providing emergency storage for peak wet season events becomes the critical issue for mine water dam sizing in this case. The calculated monthly emergency storage capacities for a mine water dam of 4.8 ha in area and 2.5 or 4 m operating depths are presented in Table 6-2. In peak wet season conditions a minimum of 15 days emergency storage could be provided and the mine water dam could be constructed on the existing waste rock stock pile.

Reducing the size of the mine water dam will have significant environmental benefits. The need to clear 26 ha of land to build a mine water dam with the capacity to store the entire wet season inventory is removed, and also the reduced footprint can be accommodated in existing disturbed areas. An irrigation area up to 84 ha in area would be accommodated in existing cleared agricultural land and the resulting risk to the surface drainage system would not be increased (Section 6.7.4).

In addition, the potential hazard to downstream public infrastructure and water quality values associated with failure of a mine water dam is removed. With year round irrigation the inventory is effectively disposed of according to Table 6-1.

If GBS uses irrigated land application to manage wet season pond water inventory, then emergency storage requirements only are necessary to determine the size of the mine water dam (taking the irrigation option of 84 ha at 5 mm per day throughout the year).

The current quality of the irrigation water does not present a risk to land or groundwater contamination. However, the water management system needs to incorporate a review process and monitor water quality over time so that appropriate management responses are triggered if there is significant deterioration.

Table 6-2 Storage Capacity of the Mine Water Dam - Emergency

Month	Rainfall, Runoff[1] & Pit Dewatering (Largest Volumes of a Wet Year) (kL)	Capacity of Mine Water Dam, Depth = 2.5m (kL)	Emergency Storage	Capacity of Mine Water Dam Depth = 4m (kL)	Emergency Storage
Jan	111,550	35,200	9 days	63,340	15 days
Apr	53,835	35,200	19 days	63,340	31 days
July	44,990	35,200	23 days	63,340	37 days
Oct	53,558	35,200	19 days	63,340	31 days

[1] For operational area of 12 ha (Table 2-2)

Option 7 in Table 6-1 (incorporating year round irrigation) is the recommended option. From Table 6-2, Constructing a mine water dam (4.8 ha area and 2.5 m storage depth) would contain estimated mine area water inventory for a 15 day period during the wet season. The size of the mine water dam in this scenario is capable of being constructed using the existing waste rock stockpile footprint. This strategy for irrigated disposal and mine water dam sizing and construction lessens the environmental footprint of the project, reduces the potential hazard to downstream water quality values and reduces closure liabilities for Terra Gold.

6.6 Impacts on Surface Water Quality and Quantity

The operational area is only 12 ha of the overall catchment area of 23.5 km^2 (representing about 0.5% of the Gold Creek catchment size, which is in turn 0.27% of the Katherine River catchment area), and impacts from the underground extraction project represent a proportionally low hazard to the quality of the Katherine town water supply.

Although reliable stream flow records are not available for the Gold Creek and Maud Creek catchments, the relatively small area impacted by the Maud Creek mine and separation of the mine water management system from the creek system will ensure that flow rates and levels in the creeks will not change appreciably during mining operations or after mining ceases.

6.7 Water Management

The mine water management system is designed to isolate overland flow in the mine area from Gold and Maud Creeks, and to dispose of the mine water in a sustainable way. The operational area will be fully bunded, with sumps to collect surface water for transfer to a Mine Water Dam and then to irrigation (refer Figure 2-3).

These measures reduce the potential risk to drinking water supply in the Katherine River and ecological values in Gold and Maud Creeks (Section 17). The strategy also minimises the operational footprint and separates the operational area catchment from the surface drainage system.

Consistent with best practice, the water management plan is for zero direct discharge of operation area water from the mine area to the creek. This represents a precautionary approach to environmental design that is consistent with best practice in the mining industry (DITR 2006b).

6.7.1 Water quality and beneficial use

Currently, the baseline aquatic environment is in a moderately disturbed condition from pastoral land use and previous mining activity. Historical water quality monitoring results for the Maud Creek catchments shown in Table 6-3 are typical of relatively hard waters, dominated by magnesium and calcium sulphate. The additional dry season water chemistry data shown specifically in Table 6-4 reinforces this assessment. The guidelines for protection of mildly disturbed ecosystems (ANZECC 2000) are also shown for comparison.

The ANZECC guidelines presented in Table 6-3 are proposed to be the operational focus levels to be used to trigger management response. Shaded cells indicate monitoring results in Table 6-3 that exceed guideline values. At present, livestock and feral animals foul the water during the dry season months. Apart from copper (Cu) and lead (Pb), the dry season results in Table 6-3 (for Maud Creek Remnant Pools September 1994) were within the range of the ANZECC guideline values.

Although no statistical inference is possible from the sampling, the metal levels for the 1998 dry season monitoring (shown in Table 6-4) are within the ANZECC guidelines.

Table 6-3 Historical surface water chemistry and ecosystem protection guidelines for Maud Creek

Parameter	Units	January 1968 - April 1969	Remnant Pools November 1977[1]	Remnant Pools September 1994[2]	Wet season February 1996[2]	Guidelines[7]
pH		6.5 - 7.5	6.1	6.2 - 7.2	5.8 - 6.3	6.5 - 9.0
Conductivity	(µS/cm)	30 - 80	3	157 - 997	31 - 87	<1,500
TSS [5]	(mg/L)	-	-	23 - 120	Nov-65	-
Total Alkalinity	(mg $CaCO_3$/L)	14 - 80	5	-	12 - 42	-
Hardness	(mg/L)	12 - 86	-	77 - 651	11 - 46	-
TDS[6]	(mg/L)	30 - 96	-	87 - 644	25 - 66	-
CO_3	(mg/L)	-	-	-	<1	-
HCO_2	(mg/L)	9 - 49	6	78.1 - 690.1	15 - 51	-
NO_2	(mg/L)	0.8 - 1.0	-	0.4 - 31.4	0.2 - 3.3	-
Cl	(mg/L)	2 - 8	3	Nov-25	2.4 - 2.5	-
Cl as NaCl	(mg/L)	-	5	-	-	-
SO_3	(mg/L)	2 - 8	-	0.1 - 0.3	0.1 - 0.9	-
Na	(mg/L)	2 - 4	-	10.0 - 33.3	1.2 - 2.1	-
K	(mg/L)	1 - 4	-	4 - 20.5	0.4 - 4.3	-
Mg	(mg/L)	2 - 11	-	12.3 - 111	1.9 - 6.6	-
Ca	(mg/L)	2 - 11	-	10.5 - 77.9	1.4 - 9.7	-
F	(mg/L)	0.1	-	-	-	-
Fe	(mg/L)	0.2 - 0.7	-	-	-	1
Si	(mg/L)	1 - 14	-	-	-	-
As	(µg/L)	-	-	1 - 5.6	<0.6	50
Ba	(µg/L)	-	-	36 - 168	10 - 26	-
Cd	(µg/L)	-	-	<0.5	-	0.2 - 2.0[3]
Hg	(µg/L)	-	-	-	-	0.1
Pb	(µg/L)	-	-	9 – 21[4]	10 - 19	1 – 5[3]
Cu	(µg/L)	-	-	14 - 20	13 - 37	2 – 5[3]
Zn	(µg/L)	-	-	6.9 - 19	40 - 98	5 – 50[3]

Notes:

1: Data supplied by NT Power and Water Authority; exact sampling dates and locations were not supplied.

2: Data by Kalmet Resources NL from seven sites along the length of Maud Creek.

3: Limit dependant on hardness or iron content.

4: Shading indicates values exceeding ANZECC guidelines.

5: TSS – Total Suspended Solids

6: TDS – Total Dissolved Solids

7: ANZEC C guideline values for Protection of Aquatic Ecosystems

Table 6-4 1998 Dry season surface water major ions and metals results (Maud Creek Project Area)

Parameter Analysis	Units	Site SW1		Site SW2	Site SW3		Site SW5
		June	July	June	June	July	June
Cl (titration)	mg/L	9	IS	13	5	IS	5
SO_4	µg/L	500	7100	<100	<100	700	<100
Total N	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ca - total	µg/L	49200	28200	52800	14100	13500	23700
K - total	µg/L	400	5100	4500	1700	2000	2200
Mg - total	µg/L	92300	95800	116300	21300	19700	26300
Na - total	µg/L	19800	25000	33800	10200	9700	10700
Si - total	µg/L	19100	19800	17800	10900	11900	8810
Al - total	µg/L	101.22	19.38	28.69	20.81	17.88	26.05
As - total	µg/L	1.7	54.03	5.18	1.18	1.14	0.68
Ba - total	µg/L	58.59	154.17	87.26	30.5	30.88	49.58
Be - total	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Bi - total	µg/L	0.01	<0.01	0.02	<0.01	<0.01	0.01
Ca - total	µg/L	0.14	0.06	1.51	0.03	<0.02	0.01
Co - total	µg/L	0.331	0.312	0.546	0.597	0.495	0.476
Cr - total	µg/L	0.6	0.1	0.2	0.2	<0.1	0.2
Cu - total	µg/L	1.61	1.81	3.04	0.67	0.47	0.77
Fe - total	µg/L	150	25	125	408	319	335
Mn - total	µg/L	15.37	17.48	71.02	126.35	151.97	349.45
Mo - total	µg/L	0.16	1.80	0.18	0.13	0.08	0.14
Ni - total	µg/L	1.22	3.01	1.22	0.83	0.79	1.18
Pb - total	µg/L	0.15	0.27	0.23	0.11	0.21	0.09
Sb - total	µg/L	<0.1	13.3	<0.1	<0.1	<0.1	<0.1
Se - total	µg/L	<0.2	0.5	0.2	<0.2	<0.2	<0.2
Th - total	µg/L	0.023	0.023	0.014	0.003	0.007	0.006
U - total	µg/L	1.461	1.505	1.319	0.132	0.100	0.255
Va - total	µg/L	20.24	25.50	15.2	1.07	1.34	1.10
Zn - total	µg/L	9.5	2.2	9.5	4.2	1.7	5.9

Note: IS denotes insufficient sample. Unfiltered samples

6.7.2 Pit water quality

A detailed investigation of water quality in the existing mine open pit was undertaken in October 2005. Follow up investigation of pit water quality that was conducted in 2007 was consistent with the 2005 report. The report of this investigation is given in Appendix B. The report is also summarised below.

The 2005 pit water quality investigation indicated that the pit water is fresh with a salinity that ranges between 420 and 470 mg/L TDS. Magnesium and sulphate are the dominant ions. The water is alkaline with a pH range of 8.0 to 8.6. Arsenic concentrations are elevated, ranging from 185 to 201 µg/L. The composition of all samples is relatively uniform with depth and along the sample transects. This implies that water within the pit is well mixed with little evidence of vertical stratification in the water body that could cause concern.

Table 6-5 presents the pit water quality data, and compares these data against the ANZECC guidelines for protecting moderately disturbed freshwater aquatic systems (ANZECC 2000 Guidelines for Fresh and Marine Water Quality).

Compared with environmental guidelines, the parameters for pH, Total Dissolved Salts (TDS) and arsenic (As) are elevated. It is noted, however, that this is consistent with the type of geological mineralisation found at the Maud Creek site.

Table 6-5 Pit water quality assessment[1]

Chemical	95% Trigger Value	80% Trigger Value	Pit Sample Min	Pit Sample Max	Above Trigger Value
pH	6.5 - 7.5	6.5 - 7.5	8.0	8.6	Yes
TDS (mg/L)	20-180	20-180	420	470	Yes
As (µg/L)	13	140	185	201	Yes
Cd (µg/L)	0.2	0.8	<0.02	<0.02	No
Cu (µg/L)	1.4	2.5	0.5	0.82	No
Mn (µg/L)	1900	3600	0.008	14.9	No
Pb (µg/L)	3.4	9.4	0.01	0.02	No
Se (µg/L)	11	34	<0.02	0.02	No
Zn (µg/L)	8.0	31	0.4	1.3	No

[1]Against ANZECC 2000 Guidelines for Fresh and Marine Water Quality

The data in Table 6-5 indicated some risk if the pit water were to be discharged to Maud Creek. However, it is not proposed that the pit water would discharge to any water way. As described above, the water management system is designed to contain all water from the operational area, and to dispose of this water to an agricultural irrigation system. Consequently, the relevant guidelines for water management relate to the ANZECC (2000a) guidelines for agricultural irrigation.

Based on the assessment presented in Table 6-6, the pit water is suited for irrigated agriculture, and this is the preferred mine water disposal option. It is noted that the minor elevation of pH may indicate bicarbonate in the water. Bicarbonate ion is significant in that it can adversely affect the operation of irrigation equipment leading to fouling; also it can affect plant uptake of certain nutrients.

Table 6-6 Pit water chemistry and selected ANZECC 2000 water quality guidelines for agricultural irrigation

Chemical	Long Term Use Up to 100 Years	Short Term Use Up to 20 Years	Pit Sample Min	Pit Sample Max	Above Short-Term Trigger Value
pH	6 - 8.5	6 – 8.5	8.0	8.6	Yes
TDS (mg/L)	600 (for clay)*	600 (for clay)*	420	470	No
As (µg/L)	100	2000	185	201	No
Cd (µg/L)	10	50	<0.02	<0.02	No
Cu (µg/L)	200	5000	0.5	0.82	No
Mn (µg/L)	200	10000	0.008	14.9	No
Pb (µg/L)	2000	5000	0.01	0.02	No
Se (µg/L)	20	50	<0.02	0.02	No
Zn (µg/L)	2000	5000	0.4	1.3	No

*Lowest average root zone salinity for all crops

6.7.3 Operational water management system

The plan view of the bund wall and water management infrastructure is depicted in Figure 6-4. Flood modelling undertaken by Terra Gold identified where the flood protection bunds are required so as to reduce the risk to facilities from extreme flooding events (1:500 year flood line).

The mine water dam will be built on top of the reshaped waste rock dump/stockpile shown in Figure 6-4. The design sections A and B on Figure 6-4 for the mine water dam are shown in Figure 6-5.

6.7.4 Irrigated land application

The criteria used to select the location of the irrigated water disposal system are:

- suitable soil, i.e. deep, well drained irrigable soils, minimising the risk of surface discharge;
- agricultural operational specifications;
- existing land cleared for agricultural use; and
- distance from receiving water bodies, maximising flow path lengths.

Irrigation system design

Maintaining irrigation application rates and irrigation water quality criteria that are consistent with acceptable agricultural practice will set the context for an environmentally sustainable approach to water disposal. Terra Gold has chosen to install a centre pivot system for cost efficiency and also because there is demonstrated experience in the Katherine area with use of these systems for irrigated crops and pastures.

Figure 6-4 Bund area and mine infrastructure

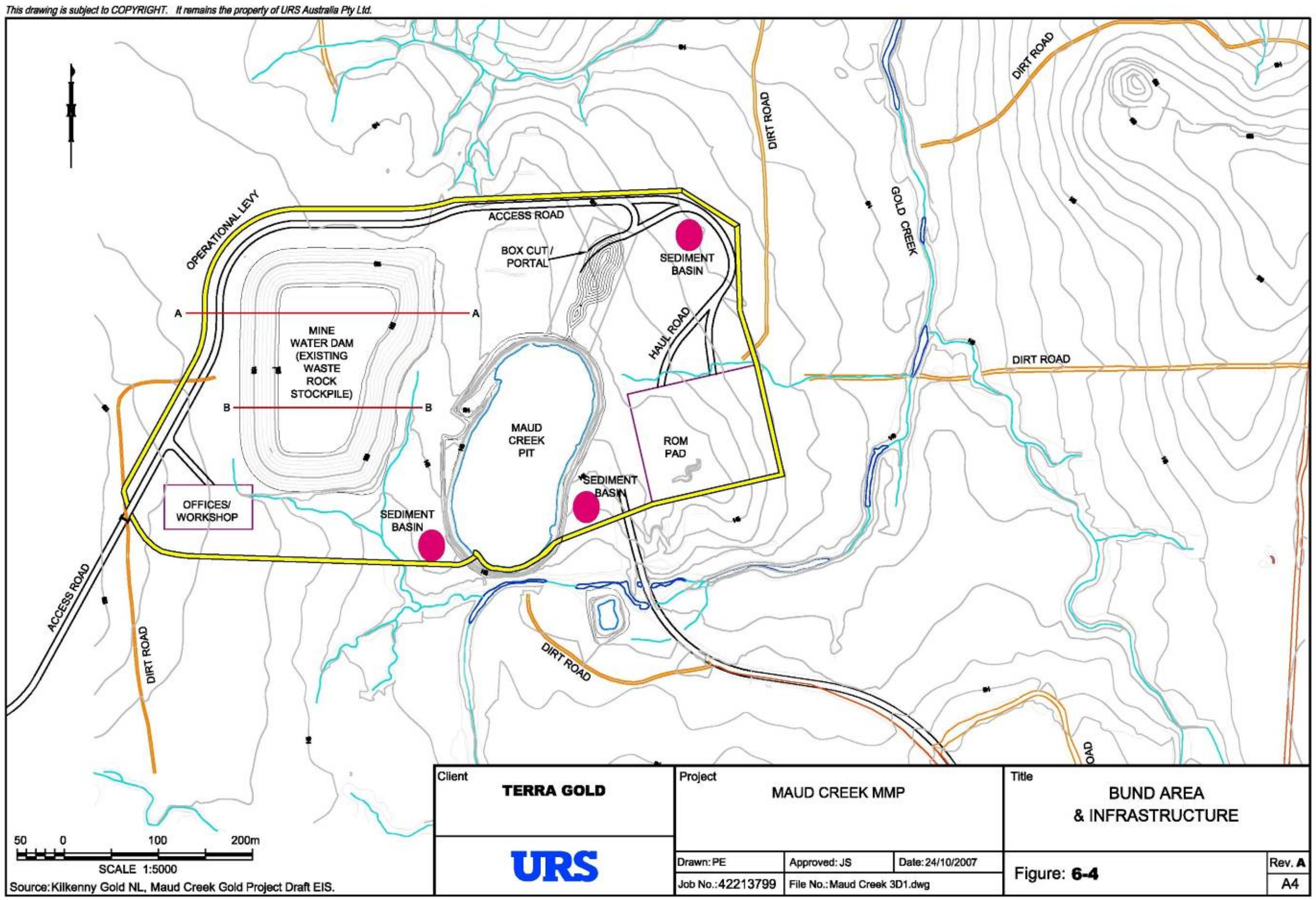
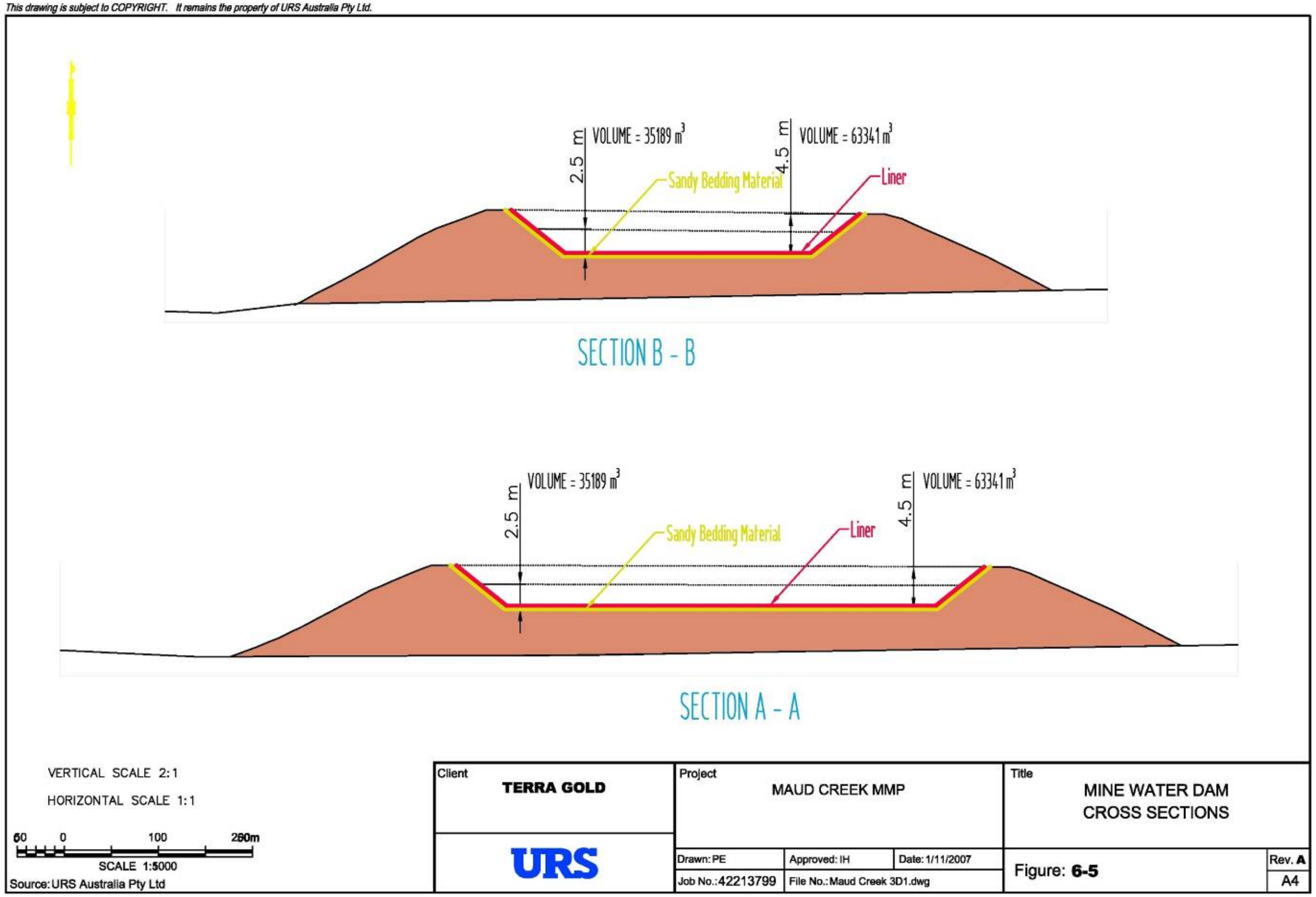


Figure 6-5 Mine water dam located within the waste rock stockpile



The optimum irrigation rate is one that:

- minimises the risk of over irrigation leading to groundwater discharge outside the application area; and
- is consistent with best practice irrigated agriculture in the district.

The volume of water produced prior to construction and during mining is critical to the design of the irrigation system. As of August 2007 there was 0.3 GL in the existing pit, which needs to be disposed of before mine construction can begin. This water meets the quality criteria for irrigation (20-year irrigation application criteria in Table 6-6).

Subsequently, the mining operation is expected to produce (on average) approximately 1 GL of water to be disposed of annually, both from rainfall caught over the site and aquifer inflow into the underground workings (Section 5). The water management plan also needs to accommodate extreme rainfall events. A centre pivot irrigation unit will irrigate 42 ha. It is proposed that two 42 ha units could be accommodated at the proposed site (Figure 2-2).

Cumulative Contaminant Load

ANZECC (2000) sets limits for applying contaminated water to soil based on the cumulative contaminant load (CCL) for chemicals of concern. These guidelines for irrigated soil and water quality are presented in Table 6-7. The CCL guideline in the soil is defined in gravimetric units (kg/ha) and represents the cumulative amount of a contaminant added before a site specific risk assessment is recommended, if irrigation and contaminant addition is continued.

Site based assessments in this situation would involve measurement of animal and human health risks due to uptake of arsenic dissolved in the irrigation stream. Based on the results in Table 6-6 for surface water and Table 5-1 for groundwater, the critical chemical of concern in the irrigation stream is dissolved arsenic.

A precautionary approach was taken to assess the CCL for arsenic. In the event that the concentration of arsenic in the irrigation stream increases over the life of the mine, the arsenic concentration used to assess the CCL was increased by a factor of two on current concentrations in the pit lake (Table 6-6). Consequently, a projected arsenic concentration of 0.05 mg/L was used. This is also at least a factor of two more than the measured concentration of arsenic in groundwater (Table 5-1).

The projected arsenic load equates to 50 kg As/GL of irrigation water. The CCL guideline for arsenic is 20 kg/ha (ANZECC 2000). As noted above the mining operation is expected to produce (on average) approximately 1 GL of water to be disposed of annually. At most, it is expected that 1.4 GL/year will need to be disposed of, i.e. a total of 10 to 14 GL of water will be irrigated over the life of the mine. Consequently, the estimated mass of arsenic to be applied in the irrigation area ranges from 500 kg to 700 kg.

Applying the projected amount of arsenic using one 42 ha centre pivot system produces a CCL of 11.9 to 16.6 kg As/ha. The projected range is within the CCL guideline. This guideline is conservative. Consequently, a site based risk assessment for arsenic is not considered to be required. This recommendation would need to be reviewed if cumulative contaminant loads were to increase substantially over the life of the mining operation.

Table 6-7 ANZECC soil and water guidelines for irrigation (Long Term and Short Term)

Element	Suggested soil CCL[b] (kg/ha)	Long-term irrigation water (long-term use - up to 100yrs)[a] (mg/L)	STV in irrigation water (short term use - up to 20yrs)[a] (mg/L)
Aluminium	ND[c]	5	20
Arsenic	20	0.1	2
Beryllium	ND	0.1	0.5
Boron	ND	0.5	Refer to table 9.2.18 (Volume 3)
Cadmium	2	0.01	0.05
Chromium	ND	0.1	1
Cobalt	ND	0.05	0.1
Copper	140	0.2	5
Fluoride	ND	1	2
Iron	ND	0.2	10
Lead	260	2	5
Lithium	ND	2.5 (0.075 Citrus crops)	2.5 (0.075 Citrus crops)
Manganese	ND	0.2	10
Mercury	2	0.002	0.002
Molybdenum	ND	0.01	0.05
Nickel	85	0.2	2
Selenium	10	0.02	0.05
Uranium	ND	0.01	0.1
Vanadium	ND	0.1	0.5
Zinc	300	2	5

a Trigger values should only be used in conjunction with information on each individual element and the potential for off-site transport of contaminants

b CCL - Cumulative contaminant loading is the maximum contaminant loading in the soil defined in gravimetric units (kg/ha) and represents the cumulative amount of contaminant added before a site specific risk assessment is recommended if irrigation and contaminant addition is continued.

c ND = Not Determined; insufficient background data to calculate CCL

Irrigation area properties

Terra Gold intends to irrigate existing cleared paddocks on its lease. The soils in the cleared paddocks are deep (≥ 3 m to regolith), free draining, gradational sandy clay loams, with a sandy surface and clay content increasing to a sandy clay loam at approximately 750 mm depth (Blain Sandy Loam; findings of six excavated soil pits made 19th July 2007).

The depth of the soil and free drainage means that the water table is unlikely to discharge at the land surface, even in cleared situations and during the wet season. The cleared land surface and deep well drained soil profile in the irrigation area is shown in Plate 6-1. Six pit profile logs were taken to support the irrigation modelling, and are provided in Appendix D.

Plate 6-1 Irrigation area land surface and soil profile (Blaine Sandy Loam, Red Kandosol)

The critical issues for sustainability of the irrigation area are irrigation rate, the water quality criteria for agricultural use (Table 6-6) and the capacity of the soil to adsorb heavy metal chemicals of concern over the life of the mining operation. Arsenic is the principle chemical of concern for the protection of water supplies and animal health.

Arsenic is very widespread in most aquifers at low concentrations, resulting in aqueous concentrations which can be beneficial. The chemistry of arsenic is complex, and there are few generalisations except that the trivalent form, As^{3+}, is much more toxic than the pentavalent form, As^{5+}.

The type of mineralisation in the outcropping ore body causes naturally elevated arsenic concentrations in the soils of the Maud Creek project area (Appendix L). This mineralisation is associated with arsenopyrite. Weathering processes further concentrate Arsenic and other metals from the underlying rocks in the soil zone. In particular, laterisation processes result in the dissolution of silica leading to mass wasting in the solum (soil profile) and relative concentration of meta-stable iron and aluminium oxyhydroxides, which bind Arsenic.

The soils in the irrigation area are deep sandy Red Earths (Red Kandosols) formed from lateritisation of the underling rocks. Lateritic soils effectively remove both arsenite and arsenate from aqueous solution (irrigation water) by adsorption. In practice, iron oxide coated sandy media have been used to polish arsenic contamination in groundwater (Gupta & Vaishya, 2006).

Arsenic removal assessment

Maji *et al.* (2007) measured removal of up to 98% of arsenite and 95% of arsenate in batch adsorption experiments conducted at 0.5 mg/L initial concentration of arsenic. Total arsenic concentrations at Maud Creek ranged from 0.037 mg/L in the pit lake to 0.003 mg/L in selected bores (Dames & Moore, 1998).

Although these concentrations are well below those used in the published study (Maji *et al.* 2007) there is a risk that arsenic concentrations in the dewatering stream may vary. However, there is assurance from the published adsorption figures that declining water quality is unlikely to be a critical issue affecting adsorption to the soil (see section 5.1.1).

Groundwater contamination is the main consequence of the applied arsenic moving below the soil zone. The groundwater table is separated from the soil zone by an unsaturated zone some 40 m thick (Section 5), which would lead to a lag time between the irrigation activity and groundwater impact being detected.

Also, the massive and earthy fabric of the soils in the irrigation area will promote matrix flow and diffusion films, which the adsorption reaction relies on. Consequently, the risk that water flow paths could by-pass the adsorption surface provided in the soil matrix and move rapidly to groundwater without time to adsorb is insignificant.

An analytical assessment of the capacity of the soils to adsorb the arsenic in the irrigation water (the chemical of concern) over the life of the mine was used to assess the level of containment of arsenic in the soil zone from irrigated mine water disposal.

The assessment of the soil depth needed to adsorb applied arsenic in the irrigated groundwater over the life of the mine is based on the following assumptions:

- The centre pivot irrigation unit irrigates 42 ha;
- Soil bulk density assumed to be 1,400 kg/ m^3;
- Maximum desirable arsenic concentration of 100 mg As/kg soil is required (=140 g/m^3: Category A Health investigation level suitable for standard residential soil NEPC, 1999);
- 0.3 GL (300,000,000 L) pit water to be irrigated;
- Assume arsenic concentration in groundwater is 250 µg/L;
- Total load of arsenic is 0.3 GL x 250 µg/L = 75 kg; and
- Application of 75 kg As to 42 ha will theoretically yield only 1.33 mm of soil profile with arsenic concentration of up to 100mg/L; and

In practice, the depth of soil with some adsorbed arsenic may differ (shallower if the arsenic is taken up at a greater rate and deeper if it is removed at a lesser rate), but these calculations demonstrate that the depth of soil contamination will be very minor. This assessment indicates that adsorbed arsenic applied in irrigation water will be contained in the top 1.3 mm of the soil. Based on this assessment, the risk of arsenic contamination to the underlying groundwater aquifer from the irrigation area operation is negligible. However, considering the high human health hazard associated with arsenic and extreme negative public perception of potential for water contamination from mining land use, a commitment to demonstrating containment of arsenic in the soil via a monitoring program is justified.

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Irrigation modelling

CSIRO Sustainable Ecosystems (under contract to GBS) assessed the capacity of a sustainable pasture irrigation strategy to dispose of mine water. The CSIRO agricultural productions systems group based in Toowoomba were engaged to model the soil water balance based on 107 years of Katherine daily rainfall data using the APSIM modelling suite (Verburg & Bond 2003).

The APSIM modelling suite was originally developed by CSIRO using data from the Katherine region; it is the premier soil water – crop growth modelling suite for northern Australia. The CSIRO study findings (Poulton & Dalgleish 2007) are attached as Appendix D. The Katherine Bureau of Meteorology (BoM) station (#014903: Katherine Aero) from the SILO patched point database was selected as the nearest long-term climate record (1900 to 2007) with a mean annual rainfall of 978mm.

The CSIRO study calibrated the APSIM model for a particular forage grass pasture (Bambatsi panic) and a clay soil and a sandy loam soil (Blain Sandy Loam) identified at two different locations at site. Only the results for the Blain Sandy Loam soil are presented here. The results for calibrations on both soil types are presented in Appendix D.

The sandy loam (Blain Sandy Loam) was preferred because this soil was free draining, presenting no risk of overland flow or waterlogging and while the area was three kilometres from the mine, it has already been cleared for agriculture. The clay soil was adjacent to the mine site, however the site needed to be cleared and control of runoff to the creek was not assured.

CSIRO used existing model calibration data for a Blain Sandy Loam located seven kilometres from the proposed irrigation site (Plant Available Water Content of 40-75 mm/m). Bambatsi panic (*Panicum coloratum* var. mararikariense) is a subtropical pasture species that will grow in the cool temperatures of the Katherine dry season. Bambatsi panic was used as a surrogate for a mixed weedy pasture currently at the site. A key requirement for this modelling assessment was to have actively growing (and hence actively transpiring) leaf area year round.

The soil depth to which water was extracted (i.e. rooting depth) was set to 2.5 m. The simulated pasture management was 150 kg/ha nitrogen applied at establishment, and reapplied on 1st May each year, and the above-ground biomass was cut and removed at the end of September each year.

Results represent a long-term mean of each four-year cycle as influenced by the climate record (Oct: year 1 to Sep: year 5). Monthly and annual totals for water use, drainage beneath the rooting zone, surface run-off and biomass production were simulated from 1900 to 2007. Potential evaporation (Eo), soil evaporation (Es), biomass transpiration (Ep) and irrigation amounts were recorded.

Surface residue cover of 2000 kg/ha of pasture material is reinitialised at the start of the four-year production cycle. Seasonal climatic variability affects annual pasture production, surface runoff and drainage with results captured by long-term simulation. Four-year production cycles of perennial bambatsi pasture were simulated using 107 years of climate record with soil water, soil nitrogen and surface cover reset in October at the end of each cycle.

Simulated drainage and runoff from a pasture grown under rainfed conditions in Table 6-8 forms the benchmark for assessing impact from additional irrigation. An additional simulation scenario without an actively growing pasture has been included for comparison. Runoff and drainage levels from a pasture system grown without supplementary irrigation can account for 30% to 46% of annual rainfall dependant on soil type.

Table 6-8 Simulated mean annual runoff and drainage rates under rainfed conditions[1]

Cover	Soil type	Mean annual rates of:				10% chance of exceeding:	
		GL/100ha	Irrigation (mm)	Runoff (mm)	Drainage (mm)	Runoff (mm)	Drainage (mm)
Bambatsi	**Sandy loam**	0	0	80	372	157	619
Bambatsi	**Clay**	0	0	259	34	456	120
Bare soil	**Sandy loam**	0	0	153	477	250	688
Bare soil	**Clay**	0	0	279	231	448	365

[1]Note: sandy loam and black clay soil from a bare soil paddock and a bambatsi pasture. Bare soil treatment is initialised with 2000 kg/ha of surface residue at the start of the 4 year simulation period. No weeds are considered. Values representing a 10% chance of exceeding the 90th percentile for runoff and drainage are presented for comparison with mean values.

A range of irrigation rates were selected from preliminary analysis and discussion of application capacity and current commercial experience with centre pivots in the Katherine region, for testing in this analysis. Irrigation rates of 2.5 to 20mm applied at 2 to 4 day intervals over 5 (May-Sep), 7 (Mar-Sep), 9 (Jan-Sep) and 12 (Oct-Sep) month periods were evaluated for impact on additional excess water over that of natural occurring drainage and runoff.

The irrigation scenarios that were modelled are shown in Table 6-9. Irrigation treatments of 2.5, 5, 10 and 20 mm per day were applied at 2 and 4 day intervals under non water limiting conditions to evaluate the optimal water application rate to minimise potential for runoff and deep drainage. Since it is not practical to apply small daily amounts, the daily rates were obtained by larger irrigations every few days, as shown.

Table 6-9 Irrigation modelling scenarios

Mean daily application	Irrigation period
Nil (i.e., natural rainfall)	Oct-Sep (i.e., year round)
2.5 mm (10mm every 4 days)	May-Sep; Mar-Sep; Jan-Sep; Oct-Sep
5 mm (20 mm every 4 days)	May-Sep; Mar-Sep; Jan-Sep; Oct-Sep
10 mm (20 mm every 2 days)	May-Sep; Mar-Sep; Jan-Sep; Oct-Sep
20 mm (40 mm every 2 days)	May-Sep; Mar-Sep; Jan-Sep; Oct-Sep

Application rates of 40mm applied every 2 days (20mm /day), 20mm applied every 2 days (10mm /day), 20mm applied every 4 days (5mm /day) and 10mm applied every 4 days (2.5mm /day) were simulated for both the clay and sandy loam soils.

Daily irrigation rates were applied for periods of 5, 7, 9 and 12 months. Aquifer inflow was not included. Water supply and pumping capacity were not limiting. No overland flow onto the irrigation area from the adjacent catchment was considered

Note that the irrigation rates in Table 6-9 are for water that is applied to the land surface. The discharge from the sprinklers can exceed this amount due to evaporation of spray between the sprinkler and the ground. The May-September period is the dry-season proper; under this scenario only natural rainfall was applied outside this period.

The October - September period is year-round irrigation i.e. throughout the wet and dry seasons. The other two periods are intermediate. For each of the irrigation scenarios shown in Table 6-9, monthly and annual totals for water use, drainage beneath the crop root zone, surface run-off and biomass production were simulated from 1900 to 2007. As described above, potential evaporation (Eo), soil evaporation (Es), biomass transpiration (Ep) and irrigation amounts were reported for comparison, which showed that the simulated values were realistic.

Evaporation and Rainfall

The range in simulated potential evaporation rate (Eo) used in the analysis and presented in Figure 6-6 is comparable to measured mean monthly pan evaporation rates (145-245mm) for Katherine. Under normal environmental conditions any irrigation applied over this potential rate can increase drainage or runoff flows. There is a net surplus of rainfall over evaporation in the first three months of the year, marking the peak of the monsoonal wet season.

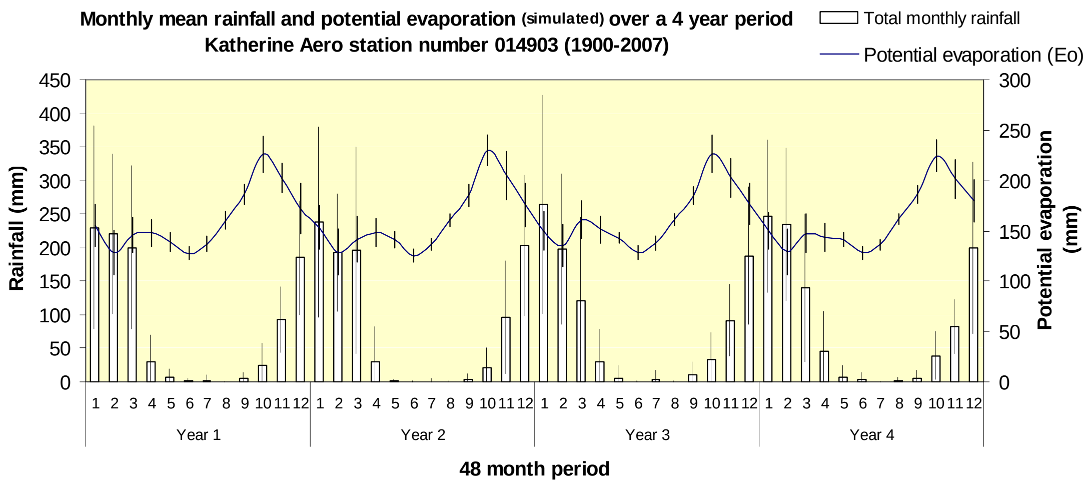
Runoff

Little change in mean annual runoff on the lighter sandy loam for irrigation rates <20mm per day was observed in the simulations (Table 6-10). There was a 10% chance of exceeding 158.4 mm/yr (rainfall only) and 1167.6 mm/yr (20 mm/day irrigation year-round). Mean total yearly run-off ranged from 60.0 mm/yr (rainfall only) to 80.4 mm/yr (20 mm/day irrigation year-round). Run-off from this site will be negligible, even under irrigation, a consequence of the high infiltration rate of the sandy soil.

Drainage

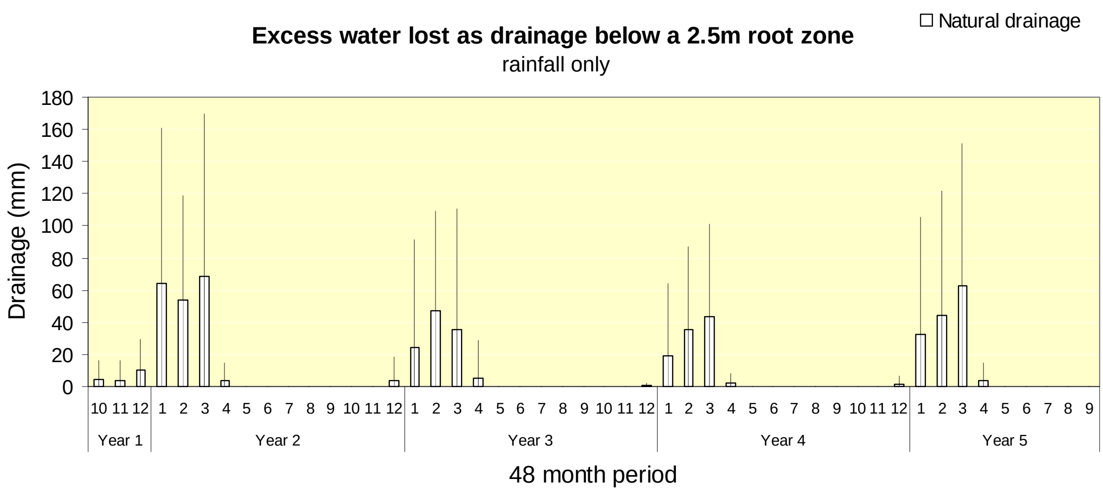
Figure 6-7 depicts drainage occurring during the wet season (December-March) under rainfed conditions in this environment. The actual rate depends on vegetation management and seasonal climate variability. Additional irrigation applied, particularly during the wet season period will add to drainage rates.

Figure 6-6 Mean monthly rainfall totals and potential evaporation[1].



[1] Values result from 26 periods of 48 months between 1900 and 2007, based on the Katherine Met Bureau station 014903. Error bars represent standard deviations from the mean.

Figure 6-7 Simulated distribution of mean monthly drainage[1]



[1] For a bambatsi pasture grown under rainfed conditions on a sandy loam soil. Error bars represent standard deviations from the mean

The results of the irrigation rate and duration scenario simulations are summarised in Table 6-10. The tactical management of applying irrigation to a dry soil will maximise water use during the dry season and minimise potential runoff or drainage during the wet season.

Applying low irrigation rates of 10mm irrigation every 4 days (2.5mm/day) to a sandy loam soil amounts to over 900mm irrigation per year with a mean annual drainage of 516mm. This drainage rate is not appreciably higher than the rainfed condition shown in Table 6-8.

Increasing irrigation rates on sandy loam soils to 10 mm/day is consistent with irrigation management in the Katherine area and does not increase the risk of runoff. The 90th percentile values for drainage and runoff are referred to as "10 % chance of exceeding" in Table 6-10. This is consistent with a 1:10 year design guideline used for civil works such as the mine water dam.

Table 6-10 Sandy loam soil - Simulated mean annual irrigation, runoff and drainage

Sandy loam soil			Mean annual rates of:			10% chance of exceeding:	
Irrigation	Period	GL/100ha	Irrigation (mm)	Runoff (mm)	Drainage (mm)	Runoff (mm)	Drainage (mm)
2.5mm	May-Sep	0.4	383	69	264	142	561
2.5mm	Mar-Sep	0.5	535	71	317	140	614
2.5mm	Jan-Sep	0.7	683	76	435	147	737
2.5mm	Oct-Sep	0.9	913	78	516	144	821
5mm	May-Sep	0.8	765	71	386	140	747
5mm	Mar-Sep	1.1	1070	79	586	158	1019
5mm	Jan-Sep	1.4	1365	85	861	166	1287
5mm	Oct-Sep	1.8	1826	93	1178	172	1516
10mm	May-Sep	1.5	1530	79	1126	157	1503
10mm	Mar-Sep	2.1	2140	85	1684	171	2078
10mm	Jan-Sep	2.7	2730	92	2258	177	2654
10mm	Oct-Sep	3.7	3653	107	3054	195	3384
20mm	May-Sep	3.1	3060	90	2695	177	2985
20mm	Mar-Sep	4.3	4280	95	3869	188	159
20mm	Jan-Sep	5.5	5460	104	5034	199	5310
20mm	Oct-Sep	7.3	7305	123	6706	225	6970

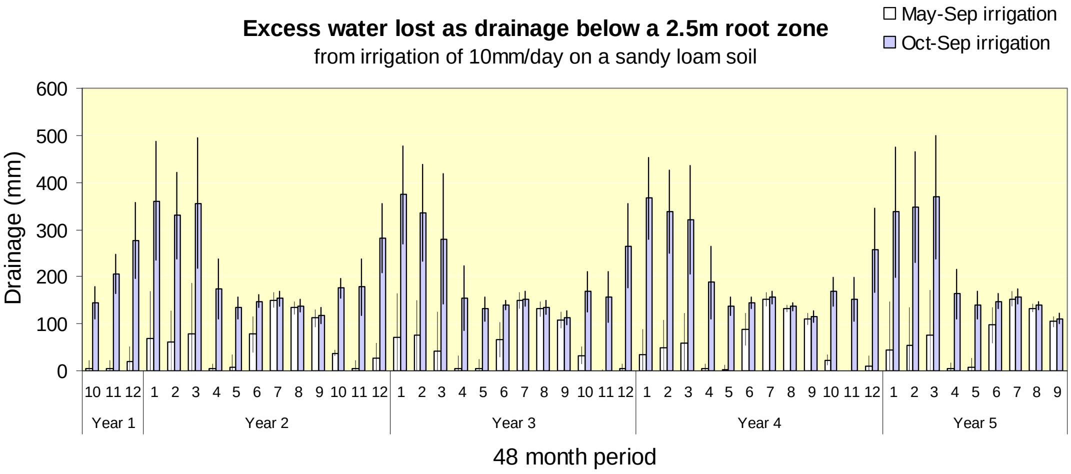
[1] Values are the mean of excess water occurring annually as a result of four irrigation management strategies. Water applied as irrigation is given in GL per 100ha. Values representing a 10% chance of exceeding the 90th percentile for runoff and drainage are presented for comparison with mean values.

Figure 6-8 compares irrigation applied at an effective rate of 10mm/day over a 12 month period with irrigation applied during the dry season (May-Sep) only. From Table 6-10, applying irrigation continually at a rate of 10 mm/day over 12 months increases the amount of water applied by 2123mm (> 2.1GL /100ha).

This also potentially doubles the drainage rate from a mean of 1126mm to 3054mm per annum on a sandy loam and is an order of magnitude higher than the estimated 372 mm of drainage below pasture grown under rainfed conditions (Table 6-8).

The monthly drainage distributions depicted in Figure 6-7 (rainfed) and Figure 6-8 (irrigated 10 mm per day) identify that drainage occurs predominantly in the first three months of the year under rainfed conditions and continuously through the year under irrigation.

Figure 6-8 Simulated distribution of mean monthly drainage over a 48 month period at 10 mm/day irrigation



[1] Values include rainfall and irrigation for a bambatsi pasture grown on sandy loam soil with irrigation applied for 5 and 12 month periods each year. Error bars represent standard deviations from the mean.

The dry season drainage rate under irrigation is of the same order as the wet season drainage rate under rainfed conditions, while the wet season drainage rate is approximately twice the rate under rainfed.

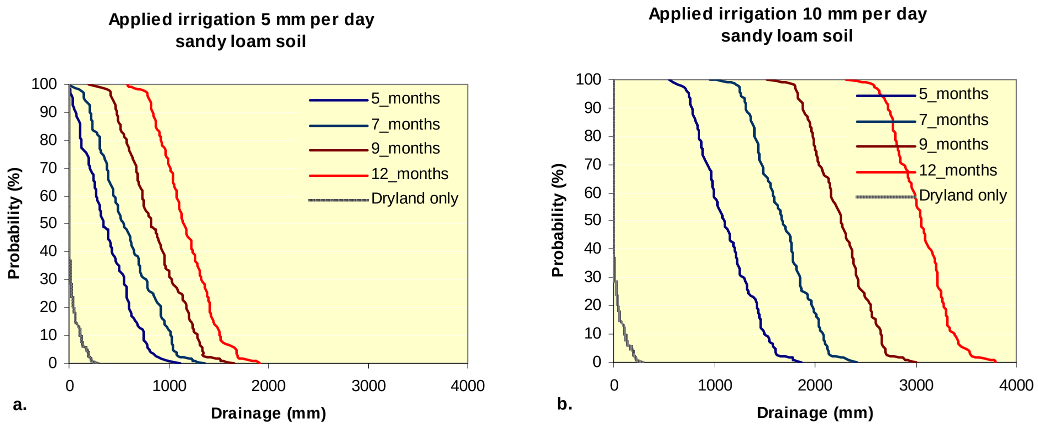
The undesirable situation where drainage induces groundwater rise into the root zone is unlikely in this situation due to the depth of the groundwater table at this site (Section 5). Consequently, the predicted perturbations in drainage rate during the life of the mine are unlikely to lead to environmental impact at the land surface from waterlogging.

The potential for rising groundwater tables due to increased drainage needs to be monitored. The simulation analysis presents a range of possible outcomes (within the limits of model parameters) that provide a guide to relative differences between irrigation scenarios. Absolute values may vary due to differences between the simulated and actual site conditions but the relative change between treatments should be consistent.

Figure 6-9 shows that at an agricultural application rate of 10 mm/day the length of the irrigation season can be varied to manage cumulative drainage. The drainage produced at an irrigation rate of 10 mm/day reflects the recharge enhancement likely to occur under irrigated agriculture.

The disposal of the 0.3 GL of water inventory in the mine pit is an opportunity to adjust and monitor the irrigation system to ensure optimal irrigation management procedures are in place before the 1 GL annual water disposal program is implemented while the mine is operational.

Figure 6-9 Cumulative probability curves of annual drainage for Sandy loam soil over 4 periods of 5 to 12 months under (a) 5 mm per day irrigation rate; (b) 10mm per day irrigation rate.



[1] Annual drainage from a rainfed bambatsi (dryland only) pasture is included for comparison with irrigated conditions. Values represent the probability of exceeding a particular level of drainage (mm).

Agronomy

The proposed paddock to be irrigated has a high cover of pasture grass and an existing centre pivot, which is not in working condition. The existing pasture cover should provide adequate transpiring leaf area. However, over sowing the paddock with Fine Cut Rhodes grass (*Chloris gayana*), a subtropical perennial grass species tolerant of the cool conditions of the Katherine dry season would greatly increase pasture growth and hence water use.

Fine Cut Rhodes grass is also productive in the wet season. This pasture grass is already being grown in the Katherine region for feedlots at Aust-Asia Cattle Depot, Florina Road (the former Rowlands Dairy) where they have four centre-pivots operating (Fergal O'Gara, NT DPIFM Berrimah Farm, personal communication). Rhodes grass forms strong bunch-type stools; its runners rapidly cover the ground surface, anchoring at the nodes and producing plantlets.

The Fine Cut cultivar is a particularly productive strain selected from the Katambora cultivar, which is more cool-tolerant and shoots earlier in spring than common Rhodes grass (Partridge 2003 in www.tropicalgrasslands.asn.au /pastures/rhodes.htm).

While this variety is persistent under irrigation it will not persist at Katherine without irrigation in the dry season, so it is benign as a weed hazard (Fergal O'Gara, NT DPIFM Berrimah Farm, pers. comm.). As a back-up, the spread of Rhodes grass will be contained by monitoring the paddock border sump and killing any runners by spraying with glyphosate.

Fertiliser will need to be applied (NPK blend at establishment, and nitrogen at each harvest) to promote vigorous pasture growth needed to maximise transpiration water use. It is anticipated this pasture will have similar water use characteristics to Bambatsi panic (if not superior for the present purposes). Periodically cutting or grazing the pasture is also needed to keep it growing vigorously, to maximise transpiring leaf area.

6.7.5 Post mining water management

The mine area will be rehabilitated once mining operations have ceased at Maud Creek. Following the cessation of mining, Terra Gold will seal the access to the underground mine with concrete and the pit will be allowed to fill with water from both direct rainfall and from the ground water inflow.

Over time, any pressure differential between the pit and the underground will equilibrate. The walls of the pit have a very high shear strength, which makes them inherently stable and unlikely to fail. Consequently, Terra Gold will leave the pit walls intact.

The irrigation area will be decommissioned when mining ceases. The spray rigs will remain the property of Terra Gold. Within the mine operational area smaller sediment dams will be filled in or breached, as appropriate. The bund that surrounds the mining operations will be breached at the lowest point, enabling the surface waters to flow into Gold Creek.

6.7.6 Protection of water courses

The creeks are ephemeral, running only during the wet season and typically for up to two months into the dry season. No routine discharge from the mine operational area to Gold Creek or Maud Creek is proposed. This will ensure a high level of protection to the waterways and downstream water supply infrastructure. The environmental management system will prioritise remediation of any breach that compromises the integrity of mine water management.

To protect water courses, water management infrastructure such as bunds and ponds will be designed to exclude a 1 in 500 year flood event from the operational mine area and will be installed and maintained prior to the commencement of mining. The bunds will be constructed from compacted fill.

To protect water courses, drainage discharge along the access/haul roads will be directed away from creek lines and on to stable vegetated areas. Also, sediment control structures will be constructed according to established guidelines where they are needed to protect water courses from sediment laden drainage.

6.7.7 Monitoring

Terra Gold will monitor operational components of the water management system, and conditions in the receiving environments. The monitoring program is presented in Table 6-11. The results will be kept by Terra Gold in a database, and will be supplied upon request to Government bodies.

Annual water and solute application and the accumulation of chemicals of concern (principally arsenic) in the soil will be monitored to assess the degree of containment and control over discharge from the irrigation system.

Also, monitoring soil water chemistry in the unsaturated zone below the crop root zone will determine the effectiveness of the soil zone as an absorption medium for the solutes of concern, principally dissolved metals. Unsaturated zone sampling using readily installed suction water samplers are recommended.

Table 6-11 Monitoring Programme

pH	EC	Total Suspended Solids	Alkalinity	Total Sulphate	Anions: Sulphate (filtered)	Aluminium	Arsenic	Cobalt	Manganese	Nickel	Zinc	Copper	Flow and/or level
Water													
Mine Water Dam													
M	M	M	M	M	M	M	M	M	M	M	M	M	M
Upstream (control -Gold Creek)													
W	W	W	M	M	M	M	M	M	M	M	M	M	W
Downstream (Maud Creek)													
W	W	W	M	M	M	M	M	M	M	M	M	M	W
Irrigation													
M	M	M	M	M	M	M	M	M	M	M	M	M	W
Irrigation area - below root zone (>1 m)													
M	M	M	M	M	M	M	M	M	M	M	M	M	M
Soil													
Irrigation area -root zone													
A	A	A	A	A	A	A	A	A	A	A	A	A	A

A = Annually
M = Monthly (when flowing)
W = Weekly (when flowing)

6.8 Commitments

Terra Gold commits to implementing a water management system that does not directly discharge to the creek system.

Terra Gold commits to monitoring to detect surface water quality impacts on Maud Creek.

Terra Gold commits to monitoring and inspecting the irrigation system to demonstrate sustainable operation.

Terra Gold commits to inspecting and completing any maintenance required for bunds that surround the operational area and the creek systems.

Terra Gold commits to giving high priority to remediating any breach that compromises the integrity of the mine water management system.