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Dyno Nobel Asia Pacific Limited

Moranbah Ammonium Nitrate Project

Wastewater Management Report

August 2006

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

Contents

Table Index

Figure Index

Appendices

1. Introduction

1.1 Background

GHD were commissioned to investigate the feasibility of different wastewater management systems for a proposed ammonium nitrate plant at Moranbah. GHD understand that the proposed works will include an ammonium nitrate plant, emulsion plant, raw water reservoir, power generation facility and evaporation pond.

GHD understand that the proposed development will have access to municipal water supply on Goonyella Road, however wastewater is to be recycled and disposed of on-site.

This investigation considers the treatment and irrigation of **domestic** wastewater (namely wastewater sourced from toilets, laundry, basins, showers, kitchen facilities) on site. It does not consider either the treatment of wastewater from the ammonium nitrate plant or the design of the associated evaporation pond.

This desk-top assessment compares the viability of different wastewater treatment and management options to service both permanent staff at the facility, and the temporary accommodation units of construction staff.

1.2 General Development Description

Dyno Nobel Asia Pacific Limited (DN) is seeking to construct and operate a new ammonium nitrate plant and an emulsions manufacturing plant approximately 4 kilometres north-west of Moranbah. The combined plants would produce ammonium nitrate emulsion (a viscous liquid) and prill (a solid). The project would be an addition to its existing QNP facility at Moura.

1.3 Scope

This report only considers wastewater treatment/management options regarded as potentially appropriate at the site. Two different wastewater management systems will be considered:

Option 1	To manage wastewater from the temporary accommodation and from the permanent facilities in two separate systems. It is envisaged that wastewater from the temporary works will be treated by a package plant before irrigation of the recycled water to nearby land. Separate treatment would be provided for the permanent toilet facilities associated with the plant, and it is expected that this recycled water will be directed to the ammonium nitrate plant's evaporation ponds.
Option 2	To recycle water to irrigation from both permanent and temporary sources. While it is likely to be more efficient to still construct two separate wastewater treatment plants (one permanent and one temporary), recycled water from both sources would be irrigated. One advantage of irrigating recycled water from the evaporation pond is that it should allow the evaporation pond volume to be reduced.

The works undertaken in this report consist of:

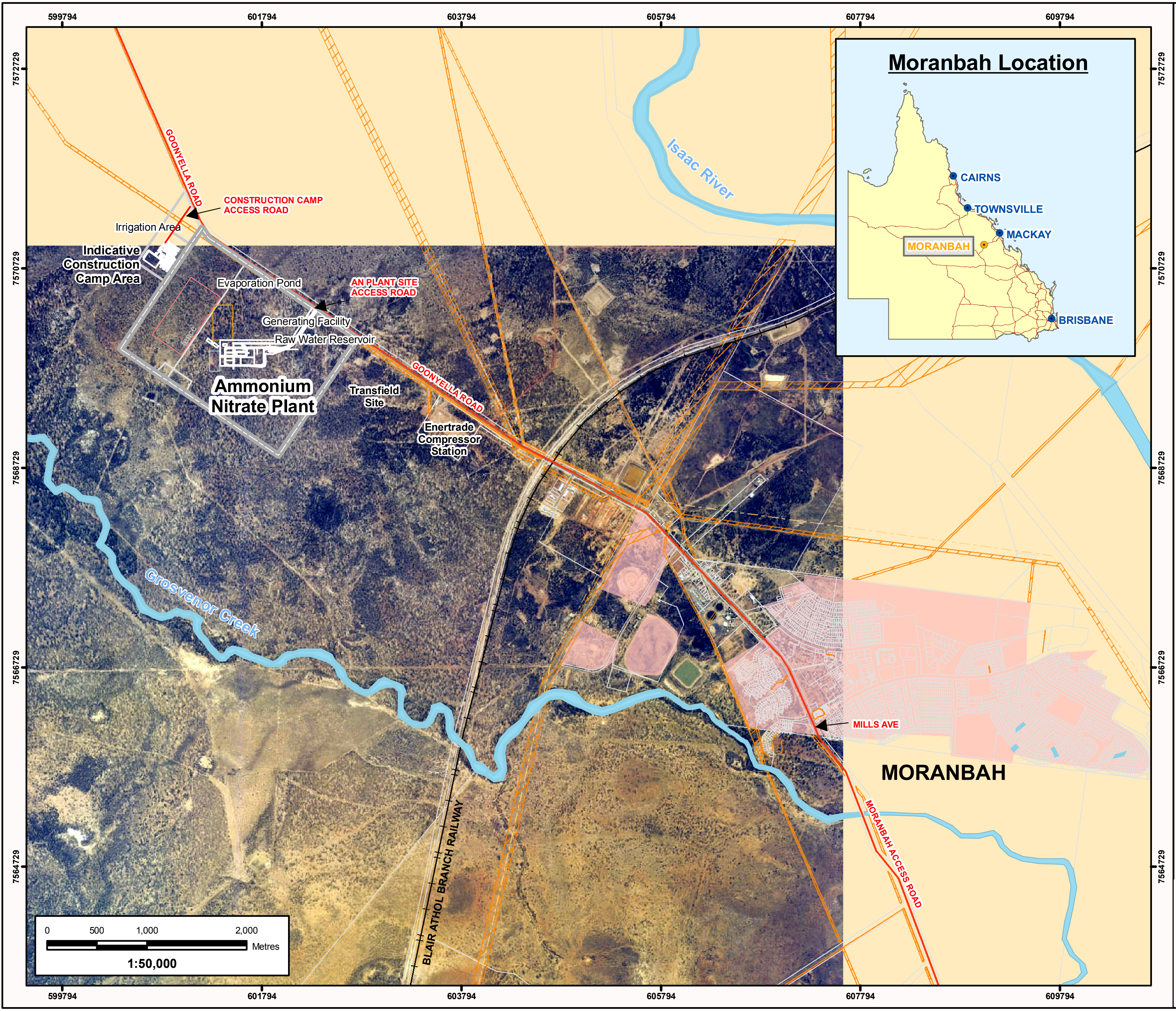
- Determining the wastewater flows expected from both temporary and permanent facilities;
- Outlining options for wastewater treatment;
- Determining (to a conceptual level of detail) expected nutrient concentrations in the effluent for the different treatment technologies;
- Using the design flows and nutrient concentrations to run MEDLI (Model for Effluent Disposal Using Land Irrigation) models. The MEDLI modelling will quantify the rates of sustainable irrigation of treated wastewater on site, and the irrigation areas required;
- Providing indicative cost estimates; and
- Identifying advantages and disadvantages of the different wastewater management options.

2. Description of Study Area

2.1 Location

The proposed ammonium nitrate plant location is shown in Figure 1.

Figure 1 illustrates the location of the ammonium nitrate plant site and the proposed temporary accommodation site. Please note that the 'irrigation area' shown adjacent to the accommodation camp is intended as a general indication of the area put aside for irrigation from the camp and it includes setback distances to roads and the camp. It is not proposed that the entire 7 hectare area is irrigated.



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Date: 02-10-06 Rev C
Datum: GDA94 (MGA) Zone 55
Source: Base data sourced from the State of Queensland, Department of Natural Resources, Mines. All other infrastructure supplied by Dyno Nobel Asia Pacific Ltd.
File: G:\41\15824\GIS\Maps\Final\MXD\fig1_Site_Location_RevC.mxd

Legend

- Ammonium Nitrate Plant Site
- Evaporation Pond
- Generating Facility*
- Raw Water Reservior
- Cadastre
- Easements
- Developed Area
- Watercourse
- Major Road
- Railway
- Powerlines

*Generating Facility location is subject to detailed engineering.

Moranbah Ammonium Nitrate Plant

Environmental Impact Statement

Figure 1
Site Location

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2.2 Geology

Coffey Geoscience Pty Ltd drilled a number of boreholes on the ammonium nitrate plant site as part of a separate investigation. Copies of the eleven borehole logs are included in Appendix A.

The majority of the borehole logs are clayey sand, with sandy clay, clay and gravely clayey sand also featured. The highest depth at which 'rock material' occurred was 4.5 m and generally rock material was not encountered til at least 10 m. The borehole closest to the proposed irrigation area for the temporary accommodation shows a clayey sand and it was assumed that this soil type represents all irrigation areas.

Clayey sand is not included in the standard MEDLI soil profiles. So to model the soil behaviour a new soil profile was created. The new soil profile was an amalgam of the standard "Sand" and standard "Grey Clay" profiles. The new soil characteristics were based more strongly on sand than grey clay, as sand was dominant in the soil classification. The upper and lower storage limits of the new soil profile were based on those for 'loamy clay' in Table 6.3 of the MEDLI Reference Manual[1]. Both the new and standard soil parameters used are included in Appendix B for reference.

2.3 Climate

Daily climate data (from 1957 to 2005) for Moranbah was sourced from the Department of Natural Resources, Mines and Water (DNRW). DNRW derived the data based on the location of the town (22^{o} 00' S and 148^{o} 05' E) in relation to the location of weather stations. The climate data used for the MEDLI analysis is summarised in Table 1.

The site has a dry climate with an average annual rainfall of only 964 mm. Pan evaporation consistently exceeds rainfall on an average monthly basis (Figure 2). The dry climate facilitates the use of on-site irrigation systems to dispose of treated wastewater.

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[1] GARDNER T., DAVIES (1998) *MEDLI Reference Manual.*

Table 1 Climate data for Moranbah

Monthly	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Rainfall (mm)	92	90	58	36	33	20	18	23	8	33	63	99	572
Pan Evap (mm)	233	188	197	153	120	97	108	136	181	226	234	246	2119
Ave Max Temp (^{O} C)	33	33	32	29	26	24	24	25	29	32	33	34	29
Ave Min Temp (^{O} C)	22	22	20	17	14	10	9	10	13	17	20	21	16
Rad (MJ/m^2/day)	22	21	20	18	15	15	16	19	22	24	24	24	19

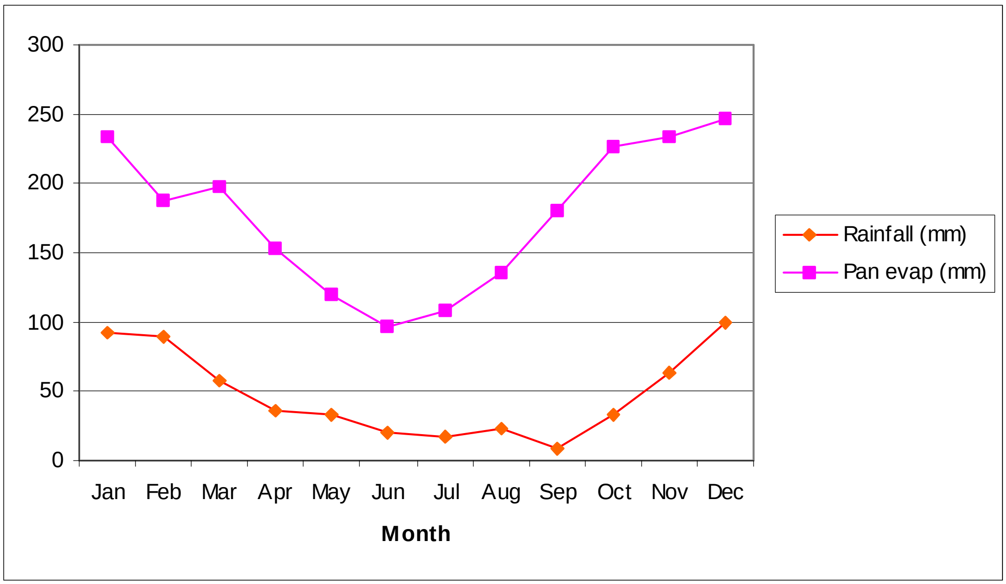

Figure 2: Plot of Rainfall vs Pan Evaporation for Moranbah

3. Design Wastewater Flows

3.1 Overview

This investigation considers wastewater flows generated from permanent and temporary facilities. Recycled water will be irrigated on site, so it was determined that the design wastewater generation rates included in *The On-site Domestic Wastewater Management Code (AS/NZS 1547:2000)* were the most appropriate to be adopted in this study.

The design loading rates for a dwelling with a reticulated water supply listed in Appendix 4.2D of *The On-site Domestic Wastewater Management Code* are:

- 180 L/EP/day for households with ‘ standard fixtures’ (ie without water conservation fittings);
- 145 L/EP/day for a dwelling with ‘standard’ water conservation fixtures; and
- 110 L/EP/day for a dwelling with full water-reduction fittings.

While the development will have at least standard water conservation fittings (such as dual flush toilets), 180 L/EP/day will be adopted in this investigation as representative of a dwelling with laundry, showers, kitchen facilities and flushing toilets. The additional flow allowance will act as a factor of safety.

The flow allowance of 180 L/EP/day is adjusted to account for which wastewater producing fixtures (eg toilets, showers etc) are being used for each facility. The basis for the adjustment is the typical proportion of wastewater source characteristics cited in DNRW’s *Planning Guidelines for Water Supply and Sewerage*[2] (Table 2).

Table 2 Typical Proportions of Wastewater Sources

Component	Usual Proportions in Wastewater
Toilets	26%
Bath/Shower	34%
Kitchen	13%
Laundry	22%
Other	5%

A description of both the temporary and permanent facilities and the design flows adopted are outlined in the following sections.

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[2] DEPARTMENT OF NATURAL RESOURCES AND MINES (March 2005) *Planning Guidelines for Water Supply and Sewerage*.

3.2 Temporary Facilities

Temporary accommodation will be provided at the site for construction staff. It is understood that accommodation for the site will include individual rooms with en-suite (i.e. showers and toilets). Communal laundry facilities will also be provided.

Wastewater management for temporary accommodation will be required for a peak of 550 construction staff from 18 months to 2 years. After this time, the temporary accommodation will be re-used and any wastewater management systems will be decommissioned. This advice was current when this report was prepared, although it is understood from recent advice that DN may consider making the construction accommodation a more permanent facility. For this report, it is assumed that the construction accommodation is temporary in nature.

It has been assumed that staff will build up to a peak of 550, and perhaps reduce back down to a lower level prior to commissioning of the ammonium nitrate plant. The wastewater treatment and management systems considered to a conceptual level in this report should be robust for this scheduling of variation in loads. Should the staff be expected to oscillate substantially over short periods of time (eg from 550 down to 200 then back to 550 etc) the use of biological treatment systems should be reconsidered. Biological systems which can cater for a progressive increase and reduction in loads are favoured in this report as they allow a good level of nutrient reduction, which in turn reduces the area (and costs) required for sustainable irrigation.

One of the wastewater management options considered in this investigation is the use of composting toilets for the temporary construction camp. The use of composting toilets will reduce the volume of wastewater to be irrigated and the total amount of nutrients in the wastewater. These factors act to reduce the area required for irrigation, and therefore to potentially reduce the investment in infrastructure that is expected to become redundant two years after establishment.

The treatment systems considered are outlined in more detail in Section 4 of this report.

3.3 Permanent Facilities

Wastewater management will be required for approximately 75 permanent staff. It is understood that the permanent workers will work on two 12 hour shifts, specifically that only 38 staff will be on-site at any one time.

The facilities to service the permanent staff are:

- A small kitchen facility;
- Toilets; and
- Showers.

3.4 Design Data

The flow rates have been based on a total possible per capita flow of 180 l/EP/d (AS/NZS 1547:2000). The design flow rates have been pro-rated from this value based on the following values in Table 3.

Table 3 Wastewater Proportions

Component	Usual Proportions in Wastewater	Permanent Facilities	Temporary Facilities	Temporary Facilities (with Composting Toilets)
Toilets	26%	26%	26%	4%
Bath/Shower	34%	17%	34%	34%
Kitchen	13%	13%	13%	13%
Laundry	22%	0%	22%	22%
Other	5%	5%	5%	5%

Please note the following:

- The permanent staff will not be resident at the process plant and are therefore assumed to use only 50% of the usual bath/shower use.
- The Temporary facilities are assumed to use the same proportion of flow as a ‘typical’ permanent dwelling.
- Permanent staff will use an off-site laundry, while temporary staff will share communal laundry facilities.
- Composting toilets are expected to result in a lower per capita flow than where more conventional flushing toilets are used.

The expected design characteristics of the wastewater based on the wastewater proportions are included in Appendix C and flow and nutrient quality of untreated wastewater are summarised in Table 4.

Table 4 Design Wastewater Characteristics

	Flow rate adopted (L/EP/day)	EP	Flow (kL)	TN (mg/L)	TP (mg/L)
Temporary	180	560	100.8	74	13
Permanent	110	38	4.18	120	21.5
Temporary - composting toilets option	140	550	77	96	16.9

4. Wastewater Treatment Technologies

4.1 Overview

A number of treatment technologies were considered for the two different situations - permanent staff and temporary staff. In both cases the option of using an Membrane Bioreactors (MBR), package activated sludge plant or Biolytix plant was investigated. In the case of the temporary staff combining one of these process options with composting toilet facilities was also investigated.

It was not considered beneficial to combine the wastewater from the permanent and temporary staff due to the problems that would be encountered when the high flow and load from the temporary staff was removed from the system after the two year construction phase.

The temporary construction staff are expected to reach a maximum of 550 EP and it is likely that there will be a staged increase in the number of staff present on site. A practical approach to the provision of wastewater treatment for any process would be to provide 3 stages of growth. Each stage could have a capacity of approximately 200 EP and would be brought on-line and decommissioned according to the population present on site.

4.2 Membrane Bioreactors (MBR)

MBRs have been developed overseas relatively recently (Canada, Japan, UK and Europe) and have been constructed in limited applications in Australia (GHD was involved in the design and commissioning of Australia's first membrane bioreactor at Picnic Bay on Magnetic Island). In MBRs, the concept is to amalgamate an activated sludge reactor with a membrane filtration plant to produce a hybrid reactor-separation step that does not require an intermediate secondary clarifier, thereby reducing the plant footprint. The membranes are immersed inside the activated sludge reactor. In order to minimise fouling of the membranes with the high solids concentration in the activated sludge reactor, the liquid surrounding the membranes is rapidly agitated, usually by coarse bubble aeration.

MBRs have the potential to produce very high effluent quality - the effective pore of the membranes is equivalent to ultrafiltration, which removes protozoa, bacteria and a significant fraction of viruses. The provision of an anoxic tank and recycle between the membrane tank and the anoxic tank allows for the removal of total nitrogen from the wastewater. The removal of total phosphorus is carried out using alum dosing.

The effluent quality from an MBR system in terms of nutrient quality is dependant on the sludge age of the biological process. With a low sludge age of approximately 5 days, the effluent nitrogen will be in the region of 11 mg/L (based on an anoxic zone and suitable recycles being included in the design). The effluent total phosphorous will be between 1 and 2 mg/L.

For the purposes of nutrient modelling, the MEDLI model will therefore assume the design effluent concentrations of 11 mg/L for nitrogen and 2 mg/L for phosphorous for both temporary and permanent facilities.[3]

4.3 Activated Sludge Package Plant

An activated sludge package plant could be used to provide a similar level of treatment, in terms of nutrient quality, to that produced by the MBR system. In addition to the activated sludge tank volume a final clarifier would be required to allow settlement of the mixed liquor. The waste mixed liquor would also have a lower concentration than that from the MBR therefore larger volumes of sludge would be produced and would probably require thickening before being transported off site.

The activated sludge process does not have the benefit of being equivalent to ultrafiltration therefore would be expected to have a much lower log removal of protozoa, bacteria and viruses than the MBR process.

For this investigation it was decided to look at the MBR process rather than the activated sludge process due to the improved performance in terms of disinfection and quantities of sludge produced. A cost/benefit comparison for the two processes could be compared at a later design stage to compare issues such as energy demand and maintenance requirements as well as capital costs.

4.4 Biolytix Filters

Biolytix™ Filters are a patented passive aerobic process. They are a relatively “natural” wastewater treatment system, primarily relying on biological treatment of wastes through vermiculture. Water that has been treated by the Biolytix filters is of better quality than that produced by septic tanks and it may be re-used via subsurface irrigation in gardens.

The filters consist of layered, flexible modular elements (as illustrated in Figure 3). The top layer of the filter system immediately separates solids from the raw sewage, which are broken down by worms and other organisms into a structured hummus. The organic matter particles then wash through and accumulate on the surface of a finely structured humus and coco-peat layer. The geotextile filters out remaining particles down to 90 micron. The biological filter unit requires only minimal maintenance as the organic processing of waste acts to maintain drainage pathways.

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[3] At the preliminary/ detailed design stages the design of the MBR will be adjusted to ensure these concentrations are achieved.

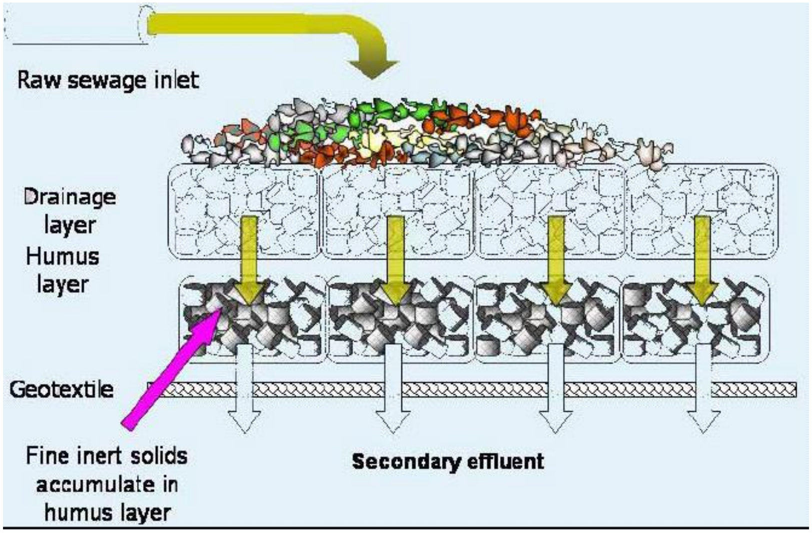

Figure 3: Cross-section of Biolytix™ Filter. Source: Biolytix Pty Ltd.

Biolytix™ Filters are typically applied in individual on-site systems, such as the BF6 filter. The treatment capabilities of Biolytix™ filters are telemetered and the effluent from BF6 filters is capable of being used for subsurface irrigation in gardens. An example of a BF6 treatment unit is shown in Figure 4.

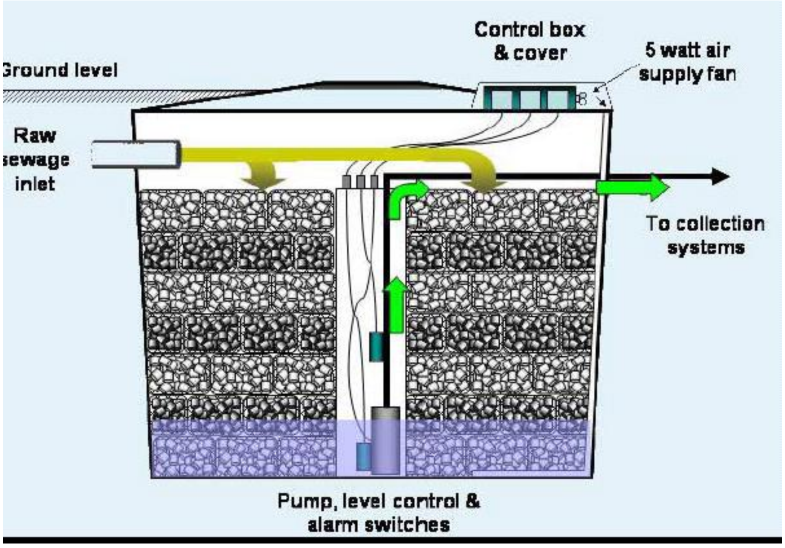

Figure 4: Biolytix™ Filter – BF6 treatment unit.

The individual Biolytix treatment units are available in a range of sizes appropriate to treat different flows, including 3.3 kL, 6.6 kL and 10 kL sizes. The treatment units can also be linked in what is termed a "Biowater™ Network", which links the individual treatment networks to a centralised storage and irrigation area.

The configuration of Biolytix filters can therefore be adapted (to an extent) to be compatible with the layout of the construction camp. For the purposes of this investigation, it is assumed that accommodation in the construction camp will be constructed in rows, and that the Biolytix filters will be placed between the rows. It is assumed that each Biolytix filters will receive waste from two units, and that separate Biolytix filters will be constructed for the laundry and the dining facilities. More detailed design will be possible when the layout of the camp is finalised and when topographical survey is completed.

Biolytix filters are certified for use in Queensland[4], but there is no associated cited nutrient quality data.[5] The Biolytix treatment filters achieved effluent concentrations of 50 mg/l TN and 9.1 mg/L for Macleay Island Biowater Scheme (Redlands Water), although the wastewater contained elevated levels of nutrients from the use of garbage grinder insinkerators. Allowing for this, the average removal of nitrogen is predicted to be 50% so concentrations of 60 mg/l effluent TN for permanent facilities, 37 mg/l for temporary facilities and 35 mg/l for temporary facilities with composting toilets are predicted.

4.5 Combination of Composting Toilets and Greywater Recycling

A composting toilet is an alternative on-site, sanitation system for treating human excreta without the use of water for flushing. Bulking material (fibrous organic matter like vegetable scraps, sawdust, etc.) can be used to optimise the composting process. The composting toilet has a similar arrangement to standard water closets, although composting toilets might incorporate a urine separation device in the bowl.

In contrast to common perception, (well-managed) composting toilets do not smell. Composting toilets have been used sustainably in permanent applications, but it's considered that their most useful application for the DN site would be for the temporary facility.

The composting process is dependent on moisture content and maintaining an aerobic environment in the compost heap. The presence of liquid, i.e. urine, leachate and grey water, can affect the composting process adversely. High moisture content in the heap can lower internal temperature leading to slower degradation, and can minimise air contact with the organic matter. Source separation can therefore improve the performance of composting toilets, making the compost more stable. It is proposed that urine would be managed with the greywater system, and treated before it was applied on site.

While urine separating toilets are potentially available, it is anticipated that the majority of employees on the industrial construction camp in a remote location would be men and that the more economical options of urinals is viable. Composting toilets can accommodate some urine as they are vented so it is not anticipated that use by a minority of females should be an issue.

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[4] Approval No 107, August 2003

[5] DLGPSR (17 March 2005) "Approved On-site Sewage Treatment Systems".

A number of different forms of composting toilets are available. The most appropriate form will depend on DN’s vision for the site. At the time this report was prepared, finalised layout plans for the construction site were not available, and it was assumed that Maxi Rota-Loo® composting toilets would be potentially appropriate. The Maxi Rota-Loo® composting toilets are a batch-type toilet with eight removable composting chambers mounted on a rotating disk base used for commercial areas.

It is assumed that the composting toilets would be provided in centralised toilet blocks and that individual toilets were not provided for each unit. The Maxi Rota-Loo® has a relatively large capacity which can service 25 permanent residents.

If the Maxi Rota-Loos® are constructed with 2 pedestals and a couple of urinals, the unit could be expected to service 40 people. This increases the cost effectiveness of the composting toilets. Fibreglass pedestals are recommended for the remote location as they are more robust.

The Maxi 2000's are constructed above ground and there should be 1.3m clearance from the ground to the structure above to facilitate maintenance. Each chamber of the Maxi 2000 normally last for 6-8 weeks use before you rotate it to the next one. By the time you get around to the first chamber again it should be about 10 months after its initial use. The compost in the chambers will be about a third of the initial volume and will be pathogen free. The wastes from composting toilets are typically buried under 8 inches of dirt[6].

Alternatively, the Biolet 200 module is a much smaller unit which can be accommodated into individual residences. This form of composting toilet would not be very cost-effective for the site as they typically cost $3200 each, and it is considered more economical to construct toilet blocks using the Maxi 2000 model.

4.6 Summary of Wastewater Treatment Options

Table 5 summarises the wastewater treatment options considered for the different source scenarios, and Table 6 summarises the design effluent flows and qualities.

Table 5 Wastewater Treatment Options

Option	Permanent	Temporary
1A	MBR / package plant	MBR / package plant
1B	Biolytix STP	Biolytix STP and/or Biolytix BF6 filters
1C	MBR / package plant/ Biolytix STP	Composting toilets + greywater recycling (with greywater treatment from either the Biolytix or MBR/ activated sludge package plant.

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[6] From conversation with the supplier, July 2006.

Table 6 Summary of Design Effluent Flows and Qualities

		MBR		Activated Sludge Package Plant		Biolytix	
	Flow (kL)	**TN (mg/L)**	**TP (mg/L)**	**TN (mg/L)**	**TP (mg/L)**	**TN (mg/L)**	**TP (mg/L)**
Temporary	100.8	11	2	11	2	37	8
Permanent	4.18	11	2	11	2	60	11
Temporary - composting toilets option	77	11	2	11	2	35	8

5. Separate Irrigation System Requirements

5.1 Overview

MEDLI (Model for Effluent Disposal Using Land Irrigation) was used to determine the feasibility of each treatment systems and the associated land required to dispose of 100% of average dry weather flows (ADWF).

This section outlines:

- The proposed irrigation areas;
- The results of the water and nutrient balances; and
- The proposed storage volumes.

5.2 Recycled Water System

Infrastructure required for the Recycled Water System include:

- A treatment system for the wastewater;
- A wet weather storage reservoir;
- Wastewater reticulation (ie pipelines to collect wastewater);
- Recycled Water reticulation (ie pumps and polyethylene pipelines to distribute and irrigate the treated wastewater).

It is expected that the relatively short lengths of pipeline and the use of materials such as polyethylene will minimise any inflow and infiltration[7] into the recycled water system. Due to the anticipated reduced inflow and infiltration, the costs for the MBR were derived on the basis of 2 x ADWF (rather than the factor of 5 which is normally adopted for more conventional sewerage collection networks).

5.3 Wet Weather Storage Sizing

Daily climate data (from 1957 until 2005) was analysed to determine how many days of wet weather storage would be appropriate. It should be noted that the climate in the area is dry, with only 572 mm per year.

97.2% of rainfall events greater than 2 mm are 4 days or less.

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[7] Inflow and infiltration are terms that refer to stormwater that enters the sewerage reticulation either through crack or joints in piplelines and manholes (after rainfall) or through illegal connections of stormwater pipelines. Sewerage networks with high inflow and infiltration are inherently less efficient than those that limit the influx of stormwater.

Table 7 Proposed Wet Weather Storage Volumes

	4 days Storage	Proposed Storage
Temporary Facility	400 kL	400 kL
Permanent Facility	17 kL	23 kL
Temporary Facility with Composting Toilets	300 kL	300 kL

Considering that the temporary facilities are only intended to be operational for two years, the likelihood of exceedance does not appear significant. It is proposed that the storage volume for the permanent facility is increased to 23 kL (which is a standard industrial tank size) to provide an additional factor of safety.

5.4 Nutrient Balance and Irrigation Area Sizing

MEDLI was used to iteratively determine an irrigation area, which would achieve balance with respect to hydraulic and nutrient loadings. The input data into the MEDLI model for each of the different scenarios is summarised in Appendix D.

The irrigation area was modelled on the basis of using kikuyu grass. Kikuyu grass was chosen as it has a relatively high rate uptake rate of nutrients for a grass.

The determination of the irrigation area was an iterative process, which started by considering the volume of recycled water to be irrigated and a practicable irrigation rate (5mm/day). The area was then adjusted so that the transpiration rate (ie the amount of water taken up by the vegetation) was at least within 10% of the irrigation rate and an approximate water balance was achieved over the site. The required irrigation area was adjusted further (where necessary) based on the performance (ie export of nutrients) over the irrigation area.

Table 8 Summary of MEDLI results

Treatment Technology	MBR	Biolytix	MBR	Biolytix	MBR	Biolytix
Scenario	permanent	permanent	temporary	temporary	temporary with composting toilets	temporary with composting toilets
Flow (ML/day)	0.10080	0.10080	0.00418	0.00418	0.07700	0.07700
Land available (ha)	2.5	3.5	0.11	0.25	1.8	4
Storage volume (ML)	0.40	0.40	0.017	0.017	0.31	0.31
TN Effluent	11	38	11	60	11	35
TP Effluent	2	8	2	11	2	8
% reuse	100%	100%	100%	100%	100%	100%

Treatment Technology	MBR	Biolytix	MBR	Biolytix	MBR	Biolytix
Scenario	permanent	permanent	temporary	temporary	temporary with composting toilets	temporary with composting toilets
N added in irrigation	134.1	330.5	116	278.3	130.4	186.7
N removed crop (kg/ha/yr)	169.1	365	151.1	312.4	165.4	221.3
P added irrigation (kg/ha/yr)	29.4	84.1	27.9	67.4	31.2	56.2
P removed crop (kg/ha/yr)	32	60.3	25.9	53.6	29	43.3
Change in adsorbed P	-2.9	23.8	1.9	13.8	2.1	12.9
Leached PO4-P (kg/ha/yr)		0.1	0.1	0	0.1	0

The MEDLI analyses showed the following:

- The irrigation land required is nutrient limited (ie the consideration of a sustainable rate of application of nutrients is more limiting than the consideration of application of water). This is generally the case with sustainable irrigation of recycled water and is particularly expected in dry climates.
- The land required to irrigate recycled water treated by an MBR or activated sludge packing plant is substantially less than that required for Biolytix. The lower concentration in the effluent from an MBR reduces the nutrient export risk and enables a smaller irrigation area.
- The assimilation rate of kikuyu for nitrogen is higher than the rate supplied by irrigation of the recycled water for all scenarios.
- Kikuyu is not predicted to assimilate all of the phosphorus applied through irrigation, except for the permanent MBR scenario. For the other scenarios, only minor amounts of phosphorus were leached (i.e. 0.1 kg/ha/yr or less) and the majority was adsorbed in to the soil profile.

Please note that a sensitivity analyses was completed for the soil type Clayey Sand, which is a non standard MEDLI soil (refer to Section 2.2). The sensitivity test considered the standard “Grey Clay’ soil type and ‘Sand’. The scenario analysed effluent from a Biolytix system (as this has the highest level of nutrients so should have the greatest level of modelling variability), considering wastewater sourced from the temporary accommodation.

The results of the soil sensitivity analyses are presented in Table 9. Clays have lower permeabilities and greater phosphorus adsorbing capabilities than sand, so predictably even less leaching is predicted to occur if the soil exhibits more clay-like properties. Even if this soil is sand, the majority of the difference between the phosphorus applied and that taken up by the plant is adsorbed.

Table 9 Soil Sensitivity Analyses

Treatment Technology	**Biolytix**	**Biolytix**	**Biolytix**
Flow (ML/day)	0.10080	0.10080	0.10080
Land available (ha)	3.5	3.5	3.5
Soil	Clayey sand	Sand	Grey clay
N added in irrigation	330.5	330.5	330.5
N removed crop (kg/ha/yr)	365	361	393.5
Leached NO_3-N (kg/ha/yr)	1	1.4	0.1
P added irrigation (kg/ha/yr)	84.1	84.1	84
P removed crop (kg/ha/yr)	60.3	60.6	62.5
Change in adsorbed P	23.8	23.1	21.4
Leached PO_4-P (kg/ha/yr)	0.1	0.4	0

6. Combined Irrigation System Requirements

6.1 Overview

GHD were asked to investigate the feasibility of having a combined irrigation system, which would irrigate recycled water from both the temporary and permanent sources, including the discharge from the ammonium nitrate processes.

The ammonium nitrate plant will require construction before it can produce any flows. Therefore there may be an opportunity to use the irrigation area which was constructed for the temporary accommodation plant to irrigate some of the wastewater from the ammonium nitrate plant. If feasible, this solution could utilise the existing irrigation infrastructure, maintaining the vegetation and decreasing the size of the evaporation pond required. The irrigation area could be enlarged to further minimise the evaporation pond size.

Flow quantity and quality data from DN was used in a MEDLI analysis to determine the feasibility of a combined irrigation system.

6.2 Wastewater Characteristics

Wastewater from operation of the ammonium nitrate plant is estimated to be a relatively constant flow of 15m^3/hr, or 130 ML/annum.[8]

DN has confirmed that the most appropriate nutrient concentration to characterise the wastewater from the plant is 1923 mg/L and 1.38 mg/L for nitrogen and phosphorus respectively.[9] This data is based on the concentrations from the first evaporation pond at Moura.

The nitrogen level in the plant's wastewater is far in excess of the concentrations in recycled water typically irrigated. While there will be some dilution from the domestic wastewater produced from the permanent facilities, this is not likely to have a significant dilution effect (the quantity of domestic wastewater expected from the permanent facility is only 1.5 ML/year, and therefore just 1% of the flows expected from the ammonium nitrate plant).

For the purposes of this analysis, concentrations of 1923 mg/L for nitrogen and 2 mg/L for phosphorus were assumed to be representative of the combined permanent sources.

6.3 MEDLI results

It is not sustainable to irrigate the wastewater from the ammonium nitrate plant. A number of iterations of the MEDLI model were run, including deficit irrigation scenarios and scenarios which irrigated a maximum of only 1 mm. In each there was a significant amount of NO3-N leaching, i.e. at least 2770 kg/ha/yr.

It is not considered appropriate to pursue this option further.

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[8] Email correspondence from Peter Etough dated 20th June 2006.

[9] Email correspondence from Peter Etough dated 24th July 2006.

7. Cost Estimates

7.1 Overview

The budget indicative costs presented in this section are typically developed based on the extrapolation of recent similar project pricing in Queensland, budget quotes for some equipment items, Australian Construction Handbook (Rawlinsons 2003), industry unit rates and GHD experience. Capital costs have been developed using estimated constructed costs and include 30% contingency for engineering and peripheral costs.

The budget cost estimates do not include reticulation costs (i.e. the pipelines and fittings required to transport wastewater from the wastewater source to the wastewater treatment system) as it is understood that the layout of the facility has not yet been provided and topographical data was not provided. However, they do include an allowance for irrigation costs.

The budget estimates are based on conceptual design only and are not warranted by GHD. The capital costs should be interpreted within the context of the inclusions and exclusions outlined in Section 7.3. Further design would be recommended to achieve greater accuracy for these figures.

7.2 Cost Estimates

Table 10, Table 11 and Table 12 present indicative capital costs for each option. Please note that all cost estimates included in this report are exclusive of GST.

On a small scale, such as the volumes of domestic wastewater requiring treatment at the permanent facility, MBRs are clearly not as cost effective as Biolytix units (Table 10).

Table 10 Indicative Capital Costs - Permanent Domestic Wastewater

	MBR	**Biolytix**
Treatment	$416,000	$55,000
Storages	$8,000	$8,000
Irrigation	$3,500	$5,000
TOTAL	$427,500	$68,000

However, as the volume of wastewater requiring treatment increases, MBRs (or activated sludge packing plants) become increasingly cost-effective. By coincidence, the volume of wastewater where MBRs are about as cost-effective as Biolytix units is approximately the volume of wastewater expected from the temporary construction accommodation. Therefore at this level of preliminary cost comparison it is not possible to distinguish between either a MBR or activated sludge package plant or a Biolytix system on the basis of capital cost to treat wastewater from the temporary construction facility.

Table 11 Indicative Capital Costs – Temporary Construction Accommodation

	MBR	**Biolytix**
Treatment	$1,482,000	$1,505,000
Storages	$230,000	$230,000
Irrigation	$30,000	$42,000
TOTAL	$1,742,000	$1,777,000

It appears that some savings in the wastewater management system would be plausible if the construction camp were to utilise composting toilets. The use of composting toilets decreases the treatment costs as there is a reduced volume of wastewater and it also reduces the cost of the irrigation area. This estimate for composting toilets is based on the concept of constructing toilet blocks with urinals and the provision of composting toilets to each single dwelling is likely to be prohibitively expensive. It is not certain if the provision of toilet blocks may not be consistent with DN's vision for the construction camp.

Table 12 Indicative Capital Costs – Temporary Construction Accommodation with Composting Toilets

	MBR assumed
	Capital costs
Composting toilets	$202,800
Treatment Plant (MBR)	$1,287,000
Storages	$200,000
Irrigation	$21,600
TOTAL	$1,711,400

At this stage, the responsibility for maintenance and operation of the treatment plant would be that of the developer, or a legal entity nominated by the developer (body corporate or similar).

7.3 Basis of Estimate – Capital Costs

7.3.1 Storages

The estimate for storage includes supply and delivery of tanks and fittings but does not include for construction of foundations. The estimate assumes the tanks are constructed above the ground on favourable ground conditions.

7.3.2 MBR Treatment

The following are included in the cost estimate for the MBR:

- Supply and fabrication of MBR tank, anoxic tank, walkways and handrails;
- Supply, clearance and installation of MBR modules;
- Supply of 3 mm screen, blowers, pumps, chemical dosing systems and mixers;
- Supply and installation of electrical equipment, MCC, PLC controller and operator interface plus cabling;
- Supply and installation of 20 m3 fibre glass permeate tank;
- Supply of valves, instrumentation and pipework;
- Provision of a UV system for disinfection (assumed this will be located after the recycled water tank);
- Civil costs for concrete slab for tanks plus control/blower building; and
- Provision of design, drafting, administration, commissioning and testing.

The cost estimate assumes favourable ground conditions and does not include costs for:

- Additional treatment and disposal of sludge;
- Separation of construction into 3 stages;
- Roads; and
- As-constructed drawings.

It is assumed that ground conditions are favourable, and no provision has been made for acid-sulphate soils, excavation in rock, naturally soft material, or for high water tables.

7.3.3 Biolytix

The costs for the Biolytix treatment systems are based on costs supplied by the supplier, with some allowances made for construction and contingencies. The Biolytix treatment units will require excavation and it is assumed that ground conditions are favourable, with no provision made for acid-sulphate soils, excavation in rock, naturally soft material, or for high water tables.

7.3.4 Composting Toilets

In costing the compost toilet facilities, it is assumed that 15 units consisting of one Maxi Rota Loo 2000 and two urinals are supplied and constructed.

The capital cost estimate does not include costs for:

- Construction of the toilet block building with 1.3 m clearance to the composting units;
- Provision of toilet pedestals (to make this option comparable with other options where toilet pedestals were also not included in costs).
- Disposal/reuse/transport of the compost material produced on site;
- Supplementary heating for the compost; and
- Roads.

7.3.5 Irrigation System

The irrigation system costs are based on the irrigation areas determined from the MEDLI analyses. The indicative costs consider subsurface irrigation, with laterals spaced 0.4 to 0.5m apart. The indicative costs do not include signage, earthworks, ground preparation, or any costs associated with seeding grass or supplying turf. The costs assume that ground conditions are favourable.

8. Discussion of Relative Merits

8.1 Overview

As the costs for the treatment of the wastewater from the temporary accommodation facility are comparable, the selection of the appropriate sewerage system will be heavily influenced by the preferences and perceptions of the developer and will depend on DN's vision for the development. Table 13 lists relative advantages and disadvantages of the different options.

Table 13 Advantages and Disadvantages of Each Option

Treatment process	Advantages	Disadvantages
MBR or activated sludge	Treats water to a very high standard, and removes significant proportion of nutrients. This reduces the size of the irrigation area required. Because of the very high quality of the water, garden irrigation could also use surface irrigation, which is easier to maintain.	A MBR treatment plant would require specialist labour to monitor the treatment plant and to chemically dose. Sourcing this specialist labour has practical implications for the site. Comparatively high operational costs, estimated at $40,000 for the permanent facility, and $76,000 for the temporary facility.[10] Separate sludge treatment required.
Biolytix units.	Biological system which will not require chemical dosing. If there were system failure it would be less likely to affect the whole camp. Modular units which can easily accommodate staging of the development. Less risk with maintenance - maintenance costs can easily be outsourced through Biolytix as part of a long-term service agreement.	Relatively high nutrient loading requires larger irrigation area. Garden irrigation must be subsurface. Irrigation from the Biolytix systems is more nutrient limited than from the MBRs and a much greater area was required. This decreases the water availability to the grass and it is predicted that the grass will show some signs of water stress. Grass irrigated from the MBR is expected to look greener.

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[10] Operational costs for the MBR include power; chemicals/cleaning agents; sludge transport and disposal; maintenance (civil structures, mechanical and electrical); membrane replacement; laboratory analysis; and operator input and labour.

Treatment process	Advantages	Disadvantages
Composting toilets	The use of composting toilets reduces the quantity of effluent that needs disposal. This in turn reduces the area required for disposal, and reduces the size and cost implications of the temporary facilities which will become redundant after construction has stopped. Reduces the water requirements for the site. Biosolids from the composting toilets could be used as fertiliser on site. Composting toilets are very robust to changing loads. Expected to be the most robust system to population fluctuations.	Would require construction of toilet blocks to be cost-effective. Costs of individual composting toilets for each unit would be prohibitive.

9. Conclusion and Recommendation

9.1 Conclusion

GHD were commissioned to complete a desk-top assessment of the viability of different wastewater systems for a proposed ammonium nitrate plant at Moranbah. GHD understand that the proposed works will include an ammonium nitrate plant, emulsion plant, raw water reservoir, power generation facility and evaporation pond. This investigation considers the treatment and irrigation of **domestic** wastewater (namely wastewater sourced from toilets, laundry, basins, showers, kitchen facilities) from the permanent staff at the facility, and the temporary accommodation units of construction staff. It does not consider either the treatment of wastewater from the ammonium nitrate plant or the design of the associated evaporation pond.

The conclusions from this report are:

- Wastewater sourced from either the temporary accommodation camp or the permanent domestic facility can be treated by either a MBR, activated sludge package plant or Biolytix unit and sustainably irrigated on site.
- Lower irrigation areas are possible with the MBR (or activated sludge package plant) because of the reduced nutrient loads in the effluent.
- Wastewater from the ammonium nitrate plant cannot be sustainably irrigated, at least without further treatment or dilution. Further treatment would require consideration of carbon and phosphorus supply and is outside the scope of this study.
- Biolytix units are the most cost-effective option for domestic wastewater from the permanent facility.
- Biolytix units, MBRs and activated sludge package plants have comparable capitals costs for the temporary accommodation.
- The use of composting toilets may reduce wastewater management costs for the temporary facility, but would require the construction of toilet blocks to be cost-effective.

9.2 Recommendations

GHD recommend that the way forward have the following steps:

- That a lot layout is consolidated, and that DN consider their treatment option preferences.
- It is preferable that some additional data is collected to characterise the geology on site (preferably constant head permeability tests and laboratory tests to characterise the chemical properties of the soil). The soil sensitivity tests completed in this analysis demonstrated that a sustainable system is achievable, but collecting the geological data and checking the irrigation system design will ensure that the system operates in an efficient, sustainable fashion.

- Complete a topographical survey of the site.
- Develop a concept design.
- Commission a suitably qualified quantity surveyor to prepare a cost estimate for a Biolytix system, an activated sludge package plant and a MBR.

All of the above should take into account that the ultimate design will be subject to the requirements of Council and other regulatory agencies such as the Environmental Protection Agency (EPA).

Appendix A

Borehole Logs

Coffey Geosciences Pty Ltd ACN 056 335 516

Coffey

Engineering Log - Borehole

Client:	*Technip Oceania Pty Ltd*
Principal:	*Dyno Knobel*
Project:	*Ammonium Nitrate Plant, Moranbah*
Borehole Location:	*Refer Figure 1*

Borehole No.	*BHA1*
Sheet	1 of 3
Office Job No.:	*P07342/02*
Date started:	*5.5.2006*
Date completed:	*6.5.2006*
Logged by:	*CP*
Checked by:	

drill model and mounting:	EDSON Truck Mounted	slope:	-90°	R.L. Surface:	
hole diameter:	100	bearing:		datum:	

drilling information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
WB		C				0		SC	**CLAYEY SAND:** Fine to medium grained sand, brown and pale orange with 10 - 20% low plasticity clay fines.	M	VD		
				SPT 12,18,22 N*=40		1							ALLUVIAL?
						2							
				SPT 21,R N*=R		3		SC	**CLAYEY SAND:** Fine to medium grained sand, pale orange, red and pale grey with 10 - 20% low plasticity clay fines.				SPT: R = 25 blows / 95mm
				SPT 27,R N*=R		4		CH	**CLAY:** High plasticity, pale grey.				SPT: R = 25 blows / 75mm XW(?) Mudstone
						5							
				SPT R N*=R		6		SC	**CLAYEY SAND:** Fine to coarse grained sand, pale grey with 15 - 25% medium plasticity clay fines.				SPT: R = 30 blows / 100mm
				SPT R N*=R		7							SPT: R = 33 blows / 150mm
						8							
						9							
						10							

PRELIMINARY

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support

T timbering N nil
C casing

penetration
1 2 3 4
no resistance ranging to refusal

water

▼ 10/1/98 water level on date shown
► water inflow
◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

BOREHOLE P07342-02.GPJ COFFEY GDT 23.06.06

Revision A

Coffey Geosciences Pty Ltd ACN 056 335 516

Borehole No. ***BHA1***

Sheet 2 of 3

Engineering Log - Borehole

Office Job No.: ***P07342/02***

Client:	*Technip Oceania Pty Ltd*	Date started:	*5.5.2006*
Principal:	*Dyno Knobel*	Date completed:	*6.5.2006*
Project:	*Ammonium Nitrate Plant, Moranbah*	Logged by:	*CP*
Borehole Location:	*Refer Figure 1*	Checked by:	

Coffey

drill model and mounting:	EDSON Truck Mounted	slope:	-90°	R.L. Surface:	
hole diameter:	100	bearing:		datum:	

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
				SPT R N*=R				SC	CLAYEY SAND:Fine to coarse grained sand, pale grey with 15 - 25% medium plasticity clay fines. *(continued)*	M	VD		SPT: R = 25 blows / 75mm
						11							
						12							
				SPT R N*=R		13							SPT: R = 25 blows / 50mm Basalt Layer
						14							
						15							
				SPT R N*=R		16							SPT: R = 25 blows / 90mm
						17							
				SPT R N*=R		18		CH	GRAVELLY CLAY:High plasticity, red and brown with some fine to medium grained gravel.				SPT: R = 25 blows / 75mm Basalt Layer
						19							
						20							

PRELIMINARY

BOREHOLE P07342-02.GPJ COFFEY.GDT 23.06.06

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support
T timbering N nil
C casing

penetration
1 2 3 4
no resistance ranging to refusal

water
10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Revision A

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering Log - Borehole

Borehole No. *BHA1*
Sheet 3 of 3
Office Job No.: *P07342/02*

Client: *Technip Oceania Pty Ltd*
Principal: *Dyno Knobel*
Project: *Ammonium Nitrate Plant, Moranbah*
Borehole Location: *Refer Figure 1*

Date started: *5.5.2006*
Date completed: *6.5.2006*
Logged by: *CP*
Checked by:

drill model and mounting: EDSON Truck Mounted
slope: -90°
R.L. Surface:
hole diameter: 100
bearing:
datum:

drilling information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetro-meter kPa 100 200 300 400	structure and additional observations
								CH	**GRAVELLY CLAY:** High plasticity, red and brown with some fine to medium grained gravel. *(continued)*	M	VD		
						21							
						22			ROCK MATERIAL - NOT YET LOGGED				Drill bit blocking, coring started
						23							
						24							
						25							
						26			Borehole BHA1 terminated at 26m				
						27							
						28							
						29							
						30							

PRELIMINARY

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support
T timbering N nil
C casing

penetration
1 2 3 4
no resistance ranging to refusal

water
▼ 10/1/98 water level on date shown
► water inflow
◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

BOREHOLE P07342-02.GPJ COFFEY.GDT 23.06.06

Revision A

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering Log - Borehole

Borehole No. **BHA3**
Sheet 1 of 2
Office Job No.: **P07342/02**
Date started: **7.5.2006**
Date completed: **7.5.2006**
Logged by: **CP**
Checked by:

Client: ***Technip Oceania Pty Ltd***
Principal: ***Dyno Knobel***
Project: ***Ammonium Nitrate Plant, Moranbah***
Borehole Location: ***Refer Figure 1***

drill model and mounting: EDSON Truck Mounted
slope: -90°
R.L. Surface:
hole diameter: 100
bearing:
datum:

PRELIMINARY

drilling information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetro-meter kPa 100 200 300 400	structure and additional observations
WB		C						SW	**GRAVELLY SAND:**Fine to coarse grained sand, pale brown and pale grey with 10 - 20% fine to coarse grained gravel and some medium plasticity clay fines.		VD		
				SPT 16,29,29 N*=58		1							ALLUVIAL?
						2							
				SPT 20,R N*=R		3							SPT: R = 33 blows / 150mm
				SPT 8,16,24 N*=40		4		SC	**CLAYEY SAND:**Fine to coarse grained sand, red and pale grey with 10 - 30% medium to high plasticity clay fines.				
						5							
				SPT 16,R N*=R		6		SP	**SILTY SAND:**Fine grained sand, red with 10 - 20% low plasticity silt fines.				SPT: R = 30 blows / 95mm XW Sandstone and with XW Ironstone seams?
				SPT R N*=R		7		SP	**SAND:**Fine to coarse grained, orange and pale grey with some medium plasticity clay fines.				SPT: R = 30 blows / 115mm
						8							
				SPT R N*=R		9		SP	**GRAVELLY SAND:** Fine to coarse grained sand, brown with 20 - 30% fine to coarse grained gravel.				SPT Bouncing, R = 25 blows / 90mm
						10							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support
T timbering N nil
C casing

penetration
1 2 3 4
no resistance ranging to refusal

water
10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

BOREHOLE P07342-02.GPJ COFFEY.GDT 23.06.06

Revision A

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering Log - Borehole

Borehole No. ***BHA3***
Sheet 2 of 2
Office Job No.: ***P07342/02***
Date started: ***7.5.2006***
Date completed: ***7.5.2006***
Logged by: ***CP***
Checked by:

Client: ***Technip Oceania Pty Ltd***
Principal: ***Dyno Knobel***
Project: ***Ammonium Nitrate Plant, Moranbah***
Borehole Location: ***Refer Figure 1***

drill model and mounting: EDSON Truck Mounted
slope: -90°
R.L. Surface:
hole diameter: 100
bearing:
datum:

drilling information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
WB				SPT R N*=R				SP	**SAND:** Fine to coarse grained sand, pale orange and white with some low plasticity clay fines.		VD		SPT: R = 25 blows / 80mm XW Sandstone
						11							
				SPT R N*=R				CH	**CLAY:**High plasticity, pale grey.				SPT: R = 25 blows / 65mm
						12							
						13			ROCK MATERIAL - NOT YET LOGGED				Drill rig loaded to 1000kPa - drilling progressing slowly. Coring Started
						14							
						15							
						16			Borehole BHA3 terminated at 16m				
						17							
						18							
						19							
						20							

PRELIMINARY

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support
T timbering N nil
C casing

penetration
1 2 3 4
no resistance ranging to refusal

water
10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

BOREHOLE P07342-02.GPJ COFFEY.GDT 23.06.06

Revision A

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering Log - Borehole

Client:	*Technip Oceania Pty Ltd*
Principal:	*Dyno Knobel*
Project:	*Ammonium Nitrate Plant, Moranbah*
Borehole Location:	*Refer Figure 1*

Borehole No.	*BHA5*
Sheet	1 of 3
Office Job No.:	*P07342/02*
Date started:	*13.5.2006*
Date completed:	*14.5.2006*
Logged by:	*CP*
Checked by:	

drill model and mounting:	EDSON Truck Mounted	slope:	-90°	R.L. Surface:	
hole diameter:	100	bearing:		datum:	

drilling information / **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetro-meter kPa 100 200 300 400	structure and additional observations
WB		C						SC	**GRAVELLY CLAYEY SAND:** Fine to coarse grained sand, brown with orange and red, with 20 - 30% medium plasticity clay fines and some fine to coarse grained gravel.		VD		
						1							
				SPT 19,26,27 N*=53									
						2							
				SPT 20,R N*=R				SC	**CLAYEY SAND:** Fine to coarse grained sand, pale orange, brown and pale grey with 20 - 30% medium plasticity clay fines and some fine to medium gravel.				
						3							
						4							
				SPT R N*=R				SC	**CLAYEY SAND:** Fine to coarse grained sand, orange, brown and pale grey with 20 - 30% medium plasticity clay fines and some fine to medium gravel.				
						5							
				SPT 33,R N*=R				CH	**SANDY CLAY:** High plasticity, pale grey with 25 - 35% fine grained sand and a trace of fine to medium grained gravel.				
						6							
						7							
				SPT R N*=R									
						8							
				SPT R N*=R				CH	**GRAVELLY SANDY CLAY:** High plasticity, purple and black with 20 - 30% fine to medium grained sand and some fine to medium grained gravel.				
						9							
						10							

PRELIMINARY

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support

T timbering N nil
C casing

penetration
1 2 3 4 no resistance ranging to refusal

water

▼ 10/1/98 water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

BOREHOLE P07342-02.GPJ COFFEY.GDT 23.06.06

Revision A

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering Log - Borehole

Borehole No.	*BHA5*
Sheet	2 of 3
Office Job No.:	*P07342/02*
Date started:	*13.5.2006*
Date completed:	*14.5.2006*
Logged by:	*CP*
Checked by:	

Client:	*Technip Oceania Pty Ltd*
Principal:	*Dyno Knobel*
Project:	*Ammonium Nitrate Plant, Moranbah*
Borehole Location:	*Refer Figure 1*

Coffey

drill model and mounting:	EDSON Truck Mounted	slope:	-90°	R.L. Surface:	
hole diameter:	100	bearing:		datum:	

drilling information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetro-meter kPa 100 200 300 400	structure and additional observations
				SPT R N*=R				CH	**GRAVELLY SANDY CLAY:** High plasticity, purple and black with 20 - 30% fine to medium grained sand and some fine to medium grained gravel. *(continued)*		VD		
						11							
				SPT R N*=R		12		CH	**SANDY GRAVELLY CLAY:** High plasticity, pale grey with 25 - 35% fine to coarse grained gravel and 15 - 20% fine to coarse grained sand.				
						13							
						14							
				SPT R N*=R		15		SC	**CLAYEY SAND:** Fine grained sand, pale grey with 30 - 40% high plasticity clay fines.				
						16							
						17							
						18							
						19							
						20							

PRELIMINARY

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix	
e.g.	ADT

support

T timbering N nil

C casing

penetration

1 2 3 4

no resistance ranging to refusal

water

▼ 10/1/98 water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

BOREHOLE P07342-02.GPJ COFFEY.GDT 23.06.06

Revision A

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering Log - Borehole

Borehole No.	*BHA5*
Sheet	3 of 3
Office Job No.:	*P07342/02*
Date started:	*13.5.2006*
Date completed:	*14.5.2006*
Logged by:	*CP*
Checked by:	

Client: *Technip Oceania Pty Ltd*

Principal: *Dyno Knobel*

Project: *Ammonium Nitrate Plant, Moranbah*

Borehole Location: *Refer Figure 1*

drill model and mounting:	EDSON Truck Mounted	slope:	-90°	R.L. Surface:	
hole diameter:	100	bearing:		datum:	

drilling information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetro-meter kPa 100 200 300 400	structure and additional observations
								SC	**CLAYEY SAND:**Fine grained sand, pale grey with 30 - 40% high plasticity clay fines. *(continued)*		VD		
						21		SP	**SAND:**Fine to coarse grained, brown.				
								CH	**CLAY:**High plasticity, yellow, purple and pale grey.				
									ROCK MATERIAL - NOT YET LOGGED				
						22							
						23							
						24			**PRELIMINARY**				
						25							
						26							
						27			Borehole BHA5 terminated at 27m				
						28							
						29							
						30							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support

T timbering N nil
C casing

penetration

1 2 3 4 no resistance ranging to refusal

water

▼ 10/1/98 water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

BOREHOLE P07342-02.GPJ COFFEY.GDT 23.06.06

Revision A

Coffey Geosciences Pty Ltd ACN 056 335 516

Coffey

Borehole No. *BHB1*

Sheet 1 of 2

Engineering Log - Borehole

Office Job No.: *P07342/02*

Client: *Technip Oceania Pty Ltd*

Principal: *Dyno Knobel*

Project: *Ammonium Nitrate Plant, Moranbah*

Borehole Location: *Refer Figure 1*

Date started: *3.5.2006*

Date completed: *4.5.2006*

Logged by: *CP*

Checked by:

drill model and mounting: EDSON Truck Mounted

slope: -90°

R.L. Surface:

hole diameter: 100

bearing:

datum:

drilling information / **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
WB		C						SP	**GRAVELLY SAND:** Fine to coarse grained sand, brown with 10 - 15% fine grained gravel.		VD		
				SPT 6,19,34 N*=53		1							
								SP	**GRAVELLY SAND:** Fine to coarse grained sand, brown with 20 - 25% fine grained gravel and some low plasticity clay fines.				
								CL	**GRAVELLY CLAY:** Medium plasticity, pale brown with some fine to medium grained gravel.				
				SPT 9,16,30 N*=46									
						2		CL	**CLAY:** Medium plasticity, pale brown with some fine to medium grained gravel.				
						3							
				D				CH	**CLAY:** High plasticity, pale grey.				
						4							
				D									
						5							
						6							
				D									
						7							
				D									
						8							
								CH	**CLAY:** High plasticity, pale grey with some red mottling.				
						9							
						10							

PRELIMINARY

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix

e.g. ADT

support

T timbering N nil

C casing

penetration

1 2 3 4

no resistance ranging to refusal

water

10/1/98 water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

BOREHOLE P07342-02.GPJ COFFEY.GDT 23.06.06

Revision A

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering Log - Borehole

Borehole No.	*BHB1*
Sheet	2 of 2
Office Job No.:	*P07342/02*
Date started:	*3.5.2006*
Date completed:	*4.5.2006*
Logged by:	*CP*
Checked by:	

Client:	*Technip Oceania Pty Ltd*
Principal:	*Dyno Knobel*
Project:	*Ammonium Nitrate Plant, Moranbah*
Borehole Location:	*Refer Figure 1*

drill model and mounting: EDSON Truck Mounted   slope: -90°   R.L. Surface:

hole diameter: 100   bearing: datum:

drilling information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetro-meter kPa 100 200 300 400	structure and additional observations
								CH	CLAY:High plasticity, pale grey with some red mottling. *(continued)*		VD		
				D		11							
						12			ROCK MATERIAL - NOT YET LOGGED				
						13							
						14							
						15			Borehole BHB1 terminated at 14.8m				
						16							
						17							
						18							
						19							
						20							

PRELIMINARY

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix	
e.g.	ADT

support

T timbering   N nil

C casing

penetration

1 2 3 4 — no resistance ranging to refusal

water

▼ 10/1/98 water level on date shown

◄— water inflow

—◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

BOREHOLE P07342-02.GPJ COFFEY.GDT 23.06.06

Revision A

Coffey Geosciences Pty Ltd ACN 056 335 516

Coffey

Engineering Log - Borehole

Borehole No.	*BHB3*
Sheet	1 of 2
Office Job No.:	*P07342/02*
Date started:	*8.5.2006*
Date completed:	*8.5.2006*
Logged by:	*CP*
Checked by:	

Client: *Technip Oceania Pty Ltd*
Principal: *Dyno Knobel*
Project: *Ammonium Nitrate Plant, Moranbah*
Borehole Location: *Refer Figure 1*

drill model and mounting:	EDSON Truck Mounted	slope:	-90°	R.L. Surface:	
hole diameter:	100	bearing:		datum:	

drilling information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetro-meter kPa 100 200 300 400	structure and additional observations
WB		C						CL	**SANDY CLAY:**Low plasticity, brown and pale grey matrix with 15 - 30% fine grained sand.		VD		
						1							
				D SPT R N*=R									
						2							
						3		SC	**CLAYEY SAND:**Fine to coarse grained sand, pale grey with 10 - 20% low plasticity clay fines.				
				SPT R N*=R									
						4							
				SPT 14,R N*=R				CH	**CLAY:**High plasticity, orange, red and pale grey.				
						5							
						6		CH	**CLAY:**High plasticity, pale grey.				
				SPT 17,R N*=R									
						7							
				SPT R N*=R									
						8							
						9							
						10							

PRELIMINARY

BOREHOLE P07342-02.GPJ COFFEY.GDT 23.06.06

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support
T timbering N nil
C casing

penetration
1 2 3 4
no resistance ranging to refusal

water
▼ 10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Revision A

Coffey Geosciences Pty Ltd ACN 056 335 516

Coffey

Engineering Log - Borehole

Borehole No.	*BHB3*
Sheet	2 of 2
Office Job No.:	*P07342/02*
Date started:	*8.5.2006*
Date completed:	*8.5.2006*
Logged by:	*CP*
Checked by:	

Client: *Technip Oceania Pty Ltd*
Principal: *Dyno Knobel*
Project: *Ammonium Nitrate Plant, Moranbah*
Borehole Location: *Refer Figure 1*

drill model and mounting: EDSON Truck Mounted
slope: -90°
R.L. Surface:
hole diameter: 100
bearing:
datum:

drilling information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
									ROCK MATERIAL - NOT YET LOGGED				
						11			**PRELIMINARY**				
						12							
						13			Borehole BHB3 terminated at 13m				
						14							
						15							
						16							
						17							
						18							
						19							
						20							

BOREHOLE P07342-02.GPJ COFFEY.GDT 23.06.06

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support
T timbering N nil
C casing

penetration
1 2 3 4
no resistance ranging to refusal

water
10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Revision A

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering Log - Borehole

Borehole No.	*BHB5*
Sheet	1 of 2
Office Job No.:	*P07342/02*
Date started:	*12.5.2006*
Date completed:	*12.5.2006*
Logged by:	*CP*
Checked by:	

Client: *Technip Oceania Pty Ltd*
Principal: *Dyno Knobel*
Project: *Ammonium Nitrate Plant, Moranbah*
Borehole Location: *Refer Figure 1*

drill model and mounting:	EDSON Truck Mounted	slope:	-90°	R.L. Surface:	
hole diameter:	100	bearing:		datum:	

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetro-meter kPa 100 200 300 400	structure and additional observations
WB		C					SC	CLAYEY SAND:Fine to medium grained sand, brown to dark brown with 30 - 40% high plasticity clay fines.		D		
						1						
				SPT 3,5,10 N*=15								
						2						
										VD		
				SPT R N*=R			GP	CLAYEY SANDY GRAVEL:Fine to coarse grained gravel, brown with 10 - 20% fine to coarse sand and some low plasticity clay fines.				
						3						
						4						
				SPT R N*=R			SC	CLAYEY SAND:Fine to coarse grained, pale orange and brown with 15 - 20% low plasticity clay fines.				
						5						
				SPT R N*=R			SC	CLAYEY SAND:Fine to coarse grained, pale grey, orange and red with 15 - 20% low plasticity clay fines.				
						6						
						7						
				SPT R N*=R			SC	GRAVELLY CLAYEY SAND:Fine to coarse grained sand, pale grey with 25 - 35% medium plasticity clay fines and some fine to coarse grained gravel.				
						8						
				SPT R N*=R								
						9						
						10						

PRELIMINARY

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix	
e.g.	ADT

support

T timbering N nil
C casing

penetration
1 2 3 4
no resistance ranging to refusal

water

▼ 10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Revision A

Borehole No.	BHB5
Sheet	2 of 2
Office Job No.:	P07342/02
Date started:	12.5.2006
Date completed:	12.5.2006
Logged by:	CP
Checked by:	

Engineering Log - Borehole

Client:	*Technip Oceania Pty Ltd*
Principal:	*Dyno Knobel*
Project:	*Ammonium Nitrate Plant, Moranbah*
Borehole Location:	*Refer Figure 1*

drill model and mounting: EDSON Truck Mounted

slope: -90°

R.L. Surface:

hole diameter: 100

bearing:

datum:

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetro-meter kPa 100 200 300 400	structure and additional observations
				SPT R N*=R				CH	CLAY: High plasticity, pale grey.		VD		
						11							
				SPT R N*=R		12		SC	CLAYEY SAND: Fine to coarse grained, pale grey with 20 - 40% high plasticity clay fines.				
						13							
						14							
				SPT R N*=R		15		CH	GRAVELLY SANDY CLAY: High plasticity, pale grey with 15 - 25% fine to coarse grained sand and 15 - 20% fine to coarse grained gravel.				
						16			ROCK MATERIAL - NOT YET LOGGED				
						17							
						18							
						19							
									Borehole BHB5 terminated at 19.5m				
						20							

PRELIMINARY

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support

T timbering N nil
C casing

penetration
1 2 3 4
no resistance ranging to refusal

water

10/1/98 water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

BOREHOLE P07342-02.GPJ COFFEY.GDT 23.06.06

Revision A

Coffey Geosciences Pty Ltd ACN 056 335 516

Coffey

Engineering Log - Borehole

Borehole No.	*BHC1*
Sheet	1 of 1
Office Job No.:	*P07342/02*
Date started:	*4.5.2006*
Date completed:	*4.5.2006*
Logged by:	*CP*
Checked by:	

Client: *Technip Oceania Pty Ltd*

Principal: *Dyno Knobel*

Project: *Ammonium Nitrate Plant, Moranbah*

Borehole Location: *Refer Figure 1*

drill model and mounting:	EDSON Truck Mounted	slope:	-90°	R.L. Surface:	
hole diameter:	100	bearing:		datum:	

drilling information / **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
WB		C						CH	**CLAY:**High plasticity, pale grey with a trace of medium to coarse grained gravel.		VD		
				D									
						1							
								SC	**CLAYEY SAND:**Fine grained, pale grey with 25 - 35% high plasticity clay fines.				
				SPT R N*=R		2							
						3		SC	**CLAYEY SAND:**Fine to medium grained, pale orange and red layering with 10 - 20% low plasticity clay fines.				
				SPT R N*=R									
						4							
									ROCK MATERIAL - NOT YET LOGGED				
						5							
						6			PRELIMINARY				
						7							
						8			Borehole BHC1 terminated at 8m				
						9							
						10							

BOREHOLE P07342-02.GPJ COFFEY.GDT 23.06.06

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support

T timbering N nil
C casing

penetration
1 2 3 4
no resistance ranging to refusal

water

▼ 10/1/98 water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Revision A

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering Log - Borehole

Borehole No. *BHC3*
Sheet 1 of 2
Office Job No.: *P07342/02*
Date started: *9.5.2006*
Date completed: *10.5.2006*
Logged by: *CP*
Checked by:

Client: *Technip Oceania Pty Ltd*
Principal: *Dyno Knobel*
Project: *Ammonium Nitrate Plant, Moranbah*
Borehole Location: *Refer Figure 1*

drill model and mounting: EDSON Truck Mounted
slope: -90°
R.L. Surface:
hole diameter: 100
bearing:
datum:

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetro-meter kPa 100 200 300 400	structure and additional observations
WB		C						SC	**CLAYEY SAND:** Fine to medium grained, pale brown and pale orange with 20 - 30% low plasticity clay fines.		VD		
						1							
				D									
				SPT 25,R N*=R									
						2							
						3							
				SPT 14,22,R N*=R									
						4							
				SPT R N*=R									
						5							
						6							
				SPT R N*=R									
						7							
				SPT R N*=R				CL	**SANDY CLAY:** Medium plasticity, pale grey with 15 - 30% fine grained sand.				
						8							
						9							
				SPT R N*=R									
						10							

PRELIMINARY

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support

T	timbering	N	nil
C	casing		

penetration
1 2 3 4
no resistance ranging to refusal

water

▼ 10/1/98 water level on date shown
► water inflow
◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

BOREHOLE P07342-02.GPJ COFFEY.GDT 23.06.06

Revision A

Coffey Geosciences Pty Ltd ACN 056 335 516

Coffey

Engineering Log - Borehole

Borehole No.	*BHC3*
Sheet	2 of 2
Office Job No.:	*P07342/02*
Date started:	*9.5.2006*
Date completed:	*10.5.2006*
Logged by:	*CP*
Checked by:	

Client: *Technip Oceania Pty Ltd*

Principal: *Dyno Knobel*

Project: *Ammonium Nitrate Plant, Moranbah*

Borehole Location: *Refer Figure 1*

drill model and mounting: EDSON Truck Mounted
slope: -90°
R.L. Surface:
hole diameter: 100
bearing:
datum:

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
								CL	**SANDY CLAY:**Medium plasticity, pale grey with 15 - 30% fine grained sand. *(continued)*		VD		
				SPT R N*=R		11		CH	**CLAY:**High plasticity, red, orange and brown.				
						12							
						13							
				SPT R N*=R		14		CH	**CLAY:**High plasticity, pale grey.				
						15			ROCK MATERIAL - NOT YET LOGGED				
						16							
						17							
						18			Borehole BHC3 terminated at 18m				
						19							
						20							

PRELIMINARY

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support

T	timbering	N	nil
C	casing		

penetration
1 2 3 4
no resistance ranging to refusal

water
10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Revision A

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering Log - Borehole

Borehole No.	**BHC5**
Sheet	1 of 2
Office Job No.:	*P07342/02*
Date started:	*12.5.2006*
Date completed:	*13.5.2006*
Logged by:	*CP*
Checked by:	

Client: *Technip Oceania Pty Ltd*
Principal: *Dyno Knobel*
Project: *Ammonium Nitrate Plant, Moranbah*
Borehole Location: *Refer Figure 1*

drill model and mounting: EDSON Truck Mounted
slope: -90°
R.L. Surface:
hole diameter: 100
bearing:
datum:

drilling information							**material substance**						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
WB		C						SC	**CLAYEY SAND:** Fine to medium grained sand, brown with 20 - 30% low plasticity clay fines and some fine to medium grained gravel.		VD		
				SPT 10,15,26 N*=41		1							
				SPT 15,24,35 N*=59		2		SC	**CLAYEY SAND:** Fine to medium grained, pale orange and brown with 20 - 30% low plasticity clay fines.				
				SPT 28,R N*=R		4		CH	**SANDY CLAY:** High plasticity, pale grey clay in a 25 - 35% fine to coarse grained, pale grey sand matrix.				
				SPT R N*=R		5		SC	**GRAVELLY CLAYEY SAND:** Fine to coarse grained, pale grey with 25 - 35% high plasticity clay fines and some medium to coarse grained gravel.				
				SPT R N*=R		7		CH	**CLAY:** High plasticity, pale grey.				
				SPT R N*=R		8		SC	**CLAYEY SAND:** Fine to medium grained, pale yellow and pale grey with 30 - 40% high plasticity clay fines.				
						10							

PRELIMINARY

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support
T timbering N nil
C casing

penetration
1 2 3 4
no resistance ranging to refusal

water
10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U₅₀	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Coffey Geosciences Pty Ltd ACN 056 335 516

Coffey

Engineering Log - Borehole

Client:	*Technip Oceania Pty Ltd*	Borehole No	*BHC5*
Principal:	*Dyno Knobel*	Sheet	2 of 2
Project:	*Ammonium Nitrate Plant, Moranbah*	Office Job No.:	*P07342/02*
Borehole Location:	*Refer Figure 1*	Date started:	*12.5.2006*
		Date completed:	*13.5.2006*
		Logged by:	*CP*
		Checked by:	

drill model and mounting:	EDSON Truck Mounted	slope:	-90°	R.L. Surface:	
hole diameter:	100	bearing:		datum:	

drilling information / **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
				SPT R N*=R		11		SC	CLAYEY SAND:Fine to coarse grained, pale grey with 20 - 30% high plasticitiy clay fines.		VD		
				SPT R N*=R		12 13 14		CH	CLAY:High plasticity, pale grey.				
						15 16 17			ROCK MATERIAL - NOT YET LOGGED				
						18 19 20			Borehole BHC5 terminated at 17.5m				

PRELIMINARY

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support

T timbering N nil
C casing

penetration
1 2 3 4
no resistance ranging to refusal

water

10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U$_{50}$	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

BOREHOLE P07342-02.GPJ COFFEY.GDT 23.06.06

Revision A

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering Log - Borehole

Borehole No. **BHD1**
Sheet 1 of 2
Office Job No.: *P07342/02*
Date started: *16.5.2006*
Date completed: *16.5.2006*
Logged by: *CP*
Checked by:

Client: *Technip Oceania Pty Ltd*
Principal: *Dyno Knobel*
Project: *Ammonium Nitrate Plant, Moranbah*
Borehole Location: *Refer Figure 1*

drill model and mounting: EDSON Truck Mounted
slope: -90°
R.L. Surface:
hole diameter: 100
bearing:
datum:

PRELIMINARY

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetro-meter kPa 100 200 300 400	structure and additional observations
WB		C				0	CH	**SANDY CLAY:**High plasticity, pale grey with 15 - 20% fine grained sand.		VD		
				SPT 22,R N*=R		1						
				SPT R N*=R		2.5	SC	**CLAYEY SAND:**Fine to coarse grained, pale grey with 20 - 30% high plasticity clay fines.				
				SPT R N*=R		4	SP	**SAND:**Fine to coarse grained sand, brown.				
				SPT R N*=R		5.5	SC	**CLAYEY SAND:**Fine to coarse grained, pale grey with 20 - 30% high plasticity clay fines.				
				SPT 26,R N*=R		7	CH	**CLAY:**High plasticity, pale grey.				
				SPT 29,R N*=R		8.5						
						10						

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix	
e.g.	ADT

support
T timbering N nil
C casing

penetration
1 2 3 4
no resistance ranging to refusal

water
▼ 10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

BOREHOLE P07342-02.GPJ COFFEY.GDT 23.06.06

Revision A

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering Log - Borehole

Borehole No. **BHD1**

Sheet 2 of 2

Office Job No.: *P07342/02*

Date started: *16.5.2006*

Date completed: *16.5.2006*

Logged by: *CP*

Checked by:

Client: *Technip Oceania Pty Ltd*

Principal: *Dyno Knobel*

Project: *Ammonium Nitrate Plant, Moranbah*

Borehole Location: *Refer Figure 1*

Coffey

drill model and mounting: EDSON Truck Mounted

slope: -90°

R.L. Surface:

hole diameter: 100

bearing:

datum:

drilling information							**material substance**						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetro-meter kPa 100 200 300 400	structure and additional observations
							▨	CH	**CLAY:** High plasticity, pale grey, *(continued)*		VD		
						11							
				SPT 21,R N*=R									
						12							
				SPT 24,R N*=R									
						13							
						14							
									ROCK MATERIAL - NOT YET LOGGED				
						15							
						16							
						17							
									Borehole BHD1 terminated at 17.5m				
						18							
						19							
						20							

PRELIMINARY

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix	
e.g.	ADT

support

T	timbering	N	nil
C	casing		

penetration

1 2 3 4

no resistance ranging to refusal

water

▼ 10/1/98 water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

BOREHOLE P07342-02.GPJ COFFEY.GDT 23.06.06

Revision A

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering Log - Borehole

Borehole No.	*BHD3*
Sheet	1 of 2
Office Job No.:	*P07342/02*
Date started:	*11.5.2006*
Date completed:	*11.5.2006*
Logged by:	*CP*
Checked by:	

Client: *Technip Oceania Pty Ltd*

Principal: *Dyno Knobel*

Project: *Ammonium Nitrate Plant, Moranbah*

Borehole Location: *Refer Figure 1*

drill model and mounting:	EDSON Truck Mounted	slope:	-90°	R.L. Surface:	
hole diameter:	100	bearing:		datum:	

drilling information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
WB		C						CL	**SANDY CLAY:**Low to medium plasticity, pale grey with 15 - 25% fine to medium grained sand and a trace of fine grained gravel.		VD		
						1							
				SPT 27,R N*=R									
						2							
				SPT R N*=R				CL	**SANDY GRAVELLY CLAY:**Medium plasticity, pale grey and pale orange matrix with 15 - 25% coarse grained gravel and some fine to medium grained sand.				
						3							
				SPT R N*=R		4		SC	**CLAYEY SAND:**Fine to coarse grained sand, pale grey with 20 - 30% medium plasticity clay.				
						5							
				SPT R N*=R									
						6							
						7							
				SPT R N*=R									
						8							
				SPT R N*=R				CH	**CLAY:**High plasticity, pale grey.				
						9							
						10							

PRELIMINARY

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support

T timbering N nil
C casing

penetration
1 2 3 4
no resistance ranging to refusal

water

▼ 10/1/98 water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

BOREHOLE P07342-02.GPJ COFFEY.GDT 23.06.06

Revision A

Coffey Geosciences Pty Ltd ACN 056 335 516

Coffey

Engineering Log - Borehole

Client:	*Technip Oceania Pty Ltd*	Borehole No.	*BHD3*
Principal:	*Dyno Knobel*	Sheet	2 of 2
Project:	*Ammonium Nitrate Plant, Moranbah*	Office Job No.:	*P07342/02*
Borehole Location:	*Refer Figure 1*	Date started:	*11.5.2006*
		Date completed:	*11.5.2006*
		Logged by:	*CP*
		Checked by:	

drill model and mounting:	EDSON Truck Mounted	slope:	-90°	R.L. Surface:	
hole diameter:	100	bearing:		datum:	

drilling information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
				SPT R N*=R				CH	**CLAY:**High plasticity, pale grey. *(continued)*		VD		
						11							
				SPT R N*=R				SC	**CLAYEY SAND:**Fine to coarse grained sand, pale grey with 20 - 30% low to medium plasticity clay fines.				
						12							
						13							
						14							
				SPT R N*=R					ROCK MATERIAL - NOT YET LOGGED				
						15							
						16							
						17							
									Borehole BHD3 terminated at 17.5m				
						18							
						19							
						20							

PRELIMINARY

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support
T timbering N nil
C casing

penetration
1 2 3 4
no resistance ranging to refusal

water
10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

BOREHOLE P07342-02.GPJ COFFEY.GDT 23.06.06

Revision A

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering Log - Borehole

Borehole No.	*BHD5*
Sheet	1 of 2
Office Job No.:	*P07342/02*
Date started:	*15.5.2006*
Date completed:	*16.5.2006*
Logged by:	*CP*
Checked by:	

Client: *Technip Oceania Pty Ltd*
Principal: *Dyno Knobel*
Project: *Ammonium Nitrate Plant, Moranbah*
Borehole Location: *Refer Figure 1*

Coffey

drill model and mounting: EDSON Truck Mounted slope: -90° R.L. Surface:
hole diameter: 100 bearing: datum:

drilling information							material substance					
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
WB		C				0	SP	**SAND:**Fine to coarse grained sand, brown with some low plasticity clay fines.		VD		
						1						
				SPT 10,8,12 N*=20								
							GP	**SANDY GRAVEL:**Fine to coarse grained gravel, brown with 20 - 30% fine to coarse grained sand.				
						2						
				SPT R N*=R			SP	**GRAVELLY SAND:**Fine to coarse grained sand, pale grey / pale brown with 15 - 25% fine to medium grained gravel.				
						3						
				SPT R N*=R		4	SC	**CLAYEY SAND:**Fine to medium grained sand, pale grey and pale orange with 20 - 30% low plasticity clay fines.				
						5						
				SPT R N*=R			SC	**CLAYEY SAND:**Fine to medium grained sand, pale grey with 20 - 30% low plasticity clay fines.				
						6						
				SPT R N*=R		7	SC	**CLAYEY SAND:**Fine to medium grained sand, pale grey with 30 - 40% low plasticity clay fines.				
						8						
				SPT R N*=R								
						9						
						10						

PRELIMINARY

BOREHOLE P07342-02.GPJ COFFEY.GDT 23.06.06

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support
T timbering N nil
C casing

penetration
1 2 3 4
no resistance
ranging to
refusal

water
10/1/93 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Revision A

Coffey Geosciences Pty Ltd ACN 056 335 516

Engineering Log - Borehole

Client:	*Technip Oceania Pty Ltd*	Borehole No.	*BHD5*
Principal:	*Dyno Knobel*	Sheet	2 of 2
Project:	*Ammonium Nitrate Plant, Moranbah*	Office Job No.:	*P07342/02*
Borehole Location:	*Refer Figure 1*	Date started:	*15.5.2006*
		Date completed:	*16.5.2006*
		Logged by:	*CP*
		Checked by:	

drill model and mounting: EDSON Truck Mounted
slope: -90°
R.L. Surface:
hole diameter: 100
bearing:
datum:

drilling information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
								SC	**CLAYEY SAND:**Fine to medium grained sand, pale grey with 30 - 40% low plasticity clay fines. *(continued)*		VD		
				SPT R N*=R		11		CH	**CLAY:**High plasticity, pale grey.				
						12							
						13							
				SPT R N*=R		14		SC	**CLAYEY SAND:**Fine to medium grained sand, pale grey with 25 - 35% high plasticity clay fines.				
						15							
						16							
				SPT R N*=R		17		CH	**CLAY:**High plasticity, pale grey. ROCK MATERIAL - NOT YET LOGGED				
						18							
						19							
						20							

PRELIMINARY

Borehole BHD5 terminated at 20m

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support

T timbering N nil
C casing

penetration
1 2 3 4
no resistance ranging to refusal

water
▼ 10/1/98 water level on date shown
► water inflow
◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressure meter
Bs	bulk sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

BOREHOLE P07342-02.GPJ COFFEY.GDT 23.06.06

Revision A

Appendix B

MEDLI soil profiles

Adopted and Standard

Table 14 Standard MEDLI Profile: Sand

Soil Water				
Layer	1	2	3	4
Soil Layer Thickness (mm)	100	500	600	300
Air Dry (%v)	4	0.1	0.1	0.1
Lower Storage Limit (theta at 15 bar)	4	6.4	7.5	6
Drained Upper Limit (theta at 0.3 bar)	10.9	13.6	13.8	9.1
Plant Available Water Content	6.9	36	37.8	9.3
Saturated Water Content (% v/v)	50.1	42.3	43.6	43.1
Bulk Density (g/cc)	1.31	1.52	1.48	1.5
Porosity (% v/v)	50.6	42.7	44	43.5
Saturated Conductivity (mm/hr)	50	50	20	10
Runoff Curve no	70		Lag	0.73
Stage 1 drying max (mm)	10		Wet Day	0.49
Slope of Stage 2 drying (mm/day ^ 0.5)	4.5		Albedo	0.23
Soil Nitrogen				
Initial Nitrate N (mg/kg)	7			
Initial Organic N (mg/kg)	350			
Ammonification of Soil Organic N	0.00035			
Denitrification	0.1			
Soil Phosphorus				
Design depth for Soil P Storage (mm)	1500			
Layer	1	2	3	4
Initial Soil Solution P (mg/L)	0.1	0.1	0.1	0.1
Adsorption Coefficient	75	75	75	75
Adsorption Exponent	0.33	0.33	0.33	0.33
Desorption Exponent	0.15	0.15	0.15	0.15

Table 15 Standard MEDLI Profile: Grey Clay

Soil Water				
Layer	1	2	3	4
Soil Layer Thickness (mm)	100	500	600	300
Air Dry (%v)	4.2	0.1	0.1	0.1
Lower Storage Limit (theta at 15 bar)	26.7	27.5	30.7	32.8
Drained Upper Limit (theta at 0.3 bar)	42	43.6	42.4	42.7
Plant Available Water Content	15.3	80.5	70.2	29.7
Saturated Water Content (% v/v)	47	48.6	47.4	48.2
Bulk Density (g/cc)	1.39	1.35	1.38	1.36
Porosity (% v/v)	47.5	49.1	47.9	48.7
Saturated Conductivity (mm/hr)	10	1	0.5	0.1
Runoff Curve no	75		Lag	0.73
Stage 1 drying max (mm)	6		Wet Day	0.49
Slope of Stage 2 drying (mm/day ^ 0.5)	3.5		Albedo	0.23
Soil Nitrogen				
Initial Nitrate N (mg/kg)	2.5			
Initial Organic N (mg/kg)	800			
Ammonification of Soil Organic N	0.00035			
Denitrification	0.1			
Soil Phosphorus				
Design depth for Soil P Storage (mm)	1500			
Layer	1	2	3	4
Initial Soil Solution P (mg/L)	0.1	0.1	0.1	0.1
Adsorption Coefficient	73	73	73	73
Adsorption Exponent	0.39	0.39	0.39	0.39
Desorption Exponent	0.25	0.25	0.25	0.25

Table 16 MEDLI Soil Profile Adopted to Represent “Clayey Sand”

Soil Water				
Layer	1	2	3	4
Soil Layer Thickness (mm)	100	500	600	300
Air Dry (%v)	4	0.1	0.1	0.1
Lower Storage Limit (theta at 15 bar)	7	7	7	7
Drained Upper Limit (theta at 0.3 bar)	18	18	18	18
Plant Available Water Content	11	55	66	33
Saturated Water Content (% v/v)	50.1	42.3	43.6	43.1
Bulk Density (g/cc)	1.31	1.52	1.48	1.5
Porosity (% v/v)	50.6	42.6	44	43.5
Saturated Conductivity (mm/hr)	40	40	10	5
Runoff Curve no	72		Lag	0.73
Stage 1 drying max (mm)	9		Wet Day	0.49
Slope of Stage 2 drying (mm/day ^ 0.5)	4.2		Albedo	0.23

Soil Nitrogen	
Initial Nitrate N (mg/kg)	6
Initial Organic N (mg/kg)	400
Ammonification of Soil Organic N	0.00035
Denitrification	0.1

Soil Phosphorus				
Design depth for Soil P Storage (mm)	1500			
Layer	1	2	3	4
Initial Soil Solution P (mg/L)	0.1	0.1	0.1	0.1
Adsorption Coefficient	74	74	74	74
Adsorption Exponent	0.35	0.35	0.35	0.35
Desorption Exponent	0.18	0.18	0.18	0.18

Appendix C

Wastewater Design Parameters

Table 17 Design Parameters

	Permanent Staff	Temporary Staff	Temporary Staff (Composting Toilets)
EP	38	550	550
% of Suggested Flow	61	100	78
Flow per Capita (l/EP/d)	110	180	140
Total Flow (kL/d)	4.2	100	77
Peak Flow (kL/d)[11]	12.6	300	231
BOD Load (kg/d)[12]	2.3	33	33
COD Load (kg/d)[13]	2.7	38.5	38.5
TSS Load (kg/d)	5.2	75.9	75.9
TN Load (kg/d)	0.5	7.4	7.4
TP Load (kg/d)	0.09	1.3	1.3
BOD Concentration (mg/l)[14]	550	330	429
COD Concentration (mg/l)	646	385	500
TSS Concentration (mg/l)	1244	759	986
TN Concentration (mg/l)	120	74	96
TP Concentration (mg/l)	21.5	13	16.9
Minimum Temperature (°C)	15	15	15
Maximum Temperature (°C)	25	25	25

---

[11] Based on a Peak to average flow of 3:1

[12] The following per capita loads were used – 60 g BOD, 70 g TSS, 13.5 g TN, 2.4 g TP

[13] Based on a COD:BOD of 2.3:1

[14] All concentrations based on average flow

Appendix D

MEDLI Input Data

Table 18 Summary of MEDLI Input Parameters – Temporary Accommodation

Category	Variable	Value
WASTE ESTIMATION	Type	“Other”
	Effluent Vol per day (ADWF)	100.8 kL/day
	TN (mg/L)	11 for MBR/Activated Sludge; 37 for Biolytix.
	TP (mg/L)	2 for MBR/Activated Sludge; 8 for Biolytix.
	Operating Period	7 days/week
CLIMATE	Site Name	Moranbah
	Latitude	22^{o} 00' S
	Longitude	148^{o} 05' E
	Start Date	1/1/1957
	End Date	31/12/2005
SOIL TYPE		Clayey Sand[15]
STORAGE		400 kL
PLANT		Kikuyu
IRRIGATION	Area Available	Variable – to be determined
	Trigger	Once every day
	Irrigate to:	5mm

---

[15] From borehole data from adjacent site. ‘Clayey sand’ is not a standard profile in MEDLI, so an amalgum of the standard profiles of ‘Sand’ and “Grey Clay” were used.

Table 19 Summary of MEDLI Input Parameters – Permanent Facilities

Category	Variable	Value
WASTE ESTIMATION	Type	"Other"
	Effluent Vol per day (ADWF)	4.2 kL/day
	TN (mg/L)	11 for MBR/Activated Sludge; 60 for Biolytix.
	TP (mg/L)	2 for MBR/Activated Sludge; 11 for Biolytix.
	Operating Period	7 days/week
CLIMATE	Site Name	Moranbah
	Latitude	22^{o} 00' S
	Longitude	148^{o} 05' E
	Start Date	1/1/1957
	End Date	31/12/2005
SOIL TYPE		Clayey Sand[16]
STORAGE		17 kL
PLANT		Kikuyu
IRRIGATION	Area Available	Variable – to be determined
	Trigger	Once every day
	Irrigate to:	5mm

---

[16] From borehole data from adjacent site. 'Clayey sand' is not a standard profile in MEDLI, so an amalgum of the standard profiles of 'Sand' and "Grey Clay" were used.

Table 20 Summary of MEDLI Input Parameters – Temporary Accommodation with Composting Toilets

Category	Variable	Value
WASTE ESTIMATION	Type	“Other”
	Effluent Vol per day (ADWF)	77 kL/day
	TN (mg/L)	11 for MBR/Activated Sludge; 35 for Biolytix.
	TP (mg/L)	2 for MBR/Activated Sludge; 8 for Biolytix.
	Operating Period	7 days/week
CLIMATE	Site Name	Moranbah
	Latitude	22^{o} 00' S
	Longitude	148^{o} 05' E
	Start Date	1/1/1957
	End Date	31/12/2005
SOIL TYPE		Clayey Sand[17]
STORAGE		308 kL
PLANT		Kikuyu
IRRIGATION	Area Available	Variable – to be determined
	Trigger	Once every day
	Irrigate to:	5mm

---

[17] From borehole data from adjacent site. ‘Clayey sand’ is not a standard profile in MEDLI, so an amalgam of the standard profiles of ‘Sand’ and “Grey Clay” were used.

Table 21 Summary of MEDLI Input Parameters – Temporary Accommodation with Composting Toilets

Category	Variable	Value
WASTE ESTIMATION	Type	“Other”
	Effluent Vol per day (ADWF)	77 kL/day
	TN (mg/L)	1923
	TP (mg/L)	2
	Operating Period	7 days/week
CLIMATE	Site Name	Moranbah
	Latitude	22° 00' S
	Longitude	148° 05' E
	Start Date	1/1/1957
	End Date	31/12/2005
SOIL TYPE		Clayey Sand[18]
STORAGE		400 kL
PLANT		Kikuyu
IRRIGATION	Area Available	Variable – to be determined
	Trigger	Once every day
	Irrigate to:	1 - 5mm considered

---

[18] From borehole data from adjacent site. ‘Clayey sand’ is not a standard profile in MEDLI, so an amalgum of the standard profiles of ‘Sand’ and “Grey Clay” were used.

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