APPENDIX D

Response to Submissions/Preferred Project Report (including Surface Water Routing and Flood Analysis)

20 December 2012

WHYTES GULLY NEW LANDFILL CELL

Response to Submissions/Preferred Project Report

Submitted to:
NSW Department of Planning and Infrastructure

REPORT

Report Number. 117625003

Golder Associates

Table of Contents

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

1.1 Overview and Background

Wollongong City Council (WCC) own and operate the Whytes Gully Resource Recovery Park (RRP), which currently receives all of the municipal solid waste within the Wollongong local government area. With existing landfill airspace at Whytes Gully RRP projected to expire in late 2013, WCC is proposing a staged new landfill cell at this location (the Project).

An Environmental Assessment (EA) supporting the proposed new landfill cell at Whytes Gully RRP has been prepared by Golder Associates Pty Ltd (Golder) in accordance with the assessment requirements of transitional Part 3A (Schedule 6A) of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The EA addresses the Director Generals' Requirements for the Project, which were issued 11 August 2011.

The EA was exhibited from 6 August 2012 to 7 September 2012 by the NSW Department of Planning and Infrastructure (DPI). During the exhibition period, DPI received eight submissions from government agencies and one further submission from the public.

In accordance with the EP&A Act, the Director General of the DPI requires WCC to respond to the issues identified during the exhibition period, in addition to identifying and assessing proposed minor changes to the Project as a result of responding to submissions. As such, a combined Response to Submissions and Preferred Project Report (the Report) has been prepared by Golder for the Project.

1.2 Structure of the Report

The structure of the Report is as follows:

- Section 2.0 presents a summary of submissions received;
- Section 3.0 presents the response to submissions;
- Section 4.0 presents modifications to the Project; and
- Section 5.0 presents the Revised Draft Statement of Commitments for the Project.

2.0 SUMMARY OF SUBMISSIONS

A total of nine submissions were received in relation to the Project, comprising eight submissions from government bodies and one submission from the public. No submissions were received from individuals. Submissions were received from the following stakeholders:

- The NSW Department of Planning and Infrastructure (DPI)
- Sydney Water
- The NSW Office of Water (NOW)
- The Environment Protection Authority (EPA)
- The Roads and Maritime Services (RMS)
- The Office of Environment and Heritage (OEH)
- Wollongong City Council (WCC); and
- Asciano Pty Ltd.

The stakeholder, issue, and the sections of the Report in which each issue is addressed are summarised in Table 1.

Table 1: Summary of Submissions

Submission Issue/ Discipline	Stakeholder	Report Section
Project Description	DPI	Section 3.1
Planning	WCC	Section 3.2
Design	DPI	Section 3.3
Noise	EPA DPI Asciano	Section 3.4
Greenhouse Gas	Asciano	Section 3.5
Contamination	Asciano	Section 3.6
Groundwater	OEH WCC NOW Sydney Water Asciano	Section 3.7
Surface Water, Drainage and Flooding	OEH WCC DPI Asciano	Section 3.8
Leachate	DPI Asciano	Section 3.9
Flora and Fauna and Heritage	OEH NOW Asciano	Section 3.10
Dust and Odour	EPA Asciano	Section 3.11
Traffic	RMS	Section 3.12

Submission Issue/ Discipline	Stakeholder	Report Section
	DPI WCC Asciano	
Socio-economic	Asciano	Section 3.13
Visual Assessment	Asciano	Section 3.14
Bushfire Risks	Asciano	Section 3.15

3.0 RESPONSE TO SUBMISSIONS

3.1 Project Description

The submission by DPI states:

1) *The Department requires more detailed information about the staging of the project.*

2) *The Department wishes to clarify and summarise exactly what components of the project are scheduled to occur and when. This may be achieved by providing an amended. More detailed version of Table 10.5 in the EA. This table must include all components of the proposed project (eg surface water and leachate pond reconfiguration, landfill gas management system construction, ancillary infrastructure and demolition components).*

Response

Staging is assessed in Chapter 8 of the EA. Further detail on the staging of components of the Project is provided in the staging plans for the Whytes Gully New Landfill Cell, presented in the Landfill Master Plan, located within Appendix P Draft Landfill Environmental Management Plan (LEMP). Appendix A, Figures 1 to 11 of the Landfill Master Plan show the staging plans, and surface water staging is shown in Figure 5 of the Landfill Master Plan.

Table 3 of the Landfill Master Plan provides details of the New Landfill Cell Works staging for components of the Project including areas of cell construction and lining, landfilling and capping, permanent stormwater infrastructure, leachate management infrastructure, easements and services relocation, temporary and permanent access roads, excavation and other associated infrastructure including progressive construction of landfill gas management system and relocation of site amenities. This table has been reproduced in this Report as Table 2.

Table 2: New Landfill Cell Works Staging

Stage 1-1: Approximately 2012 – 2013 (Appendix A Figure 1 of the Landfill Master Plan)	
Cell Construction	Stage 1-1 (Cell 1 and lower portion PB 1)
Landfilling	Complete filling on Eastern Gully Landfill Platform.
Capping and Rehabilitation	Not required.
Access Road	Construction of new access road A - B, going across the existing Green Waste Processing Centre prior to the construction of liner in Cell 1. Construction of temporary access road C - D on Western Gully Landfill along western side of Stage 1.
Permanent Surface Water	Construction of diversion channel for surface water drainage from Central Ridge (C-D) connected with existing drainage system to discharge to surface water pond.
Excavation	Excavation of existing material on Eastern Gully Landfill to average 1.5 m depth to form subgrade surface; for use as daily cover material.

Other	Relocation of existing amenities to Old SWERT building. Demolishing of existing infrastructure and removal of services with Cell 1 footprint. Construction of new leachate drainage system for the existing leachate collection systems in the existing Western and Eastern Gully Landfill (beneath the Cell 1 liner system). Construction of active landfill gas extraction on existing Western and Eastern Gully landfill areas in 2012.
Stage 1-1 and 1-2: Approx. 2013 – 2015 (Appendix A Figure 2 of the Landfill Master Plan)	
Cell Construction	Stage 1-2 (upper portion PB 1)
Landfilling	Stage 1-1 (Cell 1 and lower portion PB 1)
Capping and Rehabilitation	Not required
Access Road	Construction of permanent access road E – E1. Forming access road E1 - F on waste during the filling of Stage 1-1.
Permanent Surface Water	Not required
Excavation	Complete excavation of material in Cell 2A prior to the construction of Stage 2A.
Staging 1-2 and 2A: Approx. 2015 – 2018 (Appendix A Figure 3 of the Landfill Master Plan)	
Cell Construction	Stage 2A (Cell 2A and PB 2A)
Landfilling	Stage 1-2 (Cell 1 and PB 1) Waste Cutback on Eastern Gully Landfill (Waste relocation to Stage 1-1)
Capping and Rehabilitation	not required
Access Roads	Construction of temporary access road D - D1 during filling of Stage 1-2. Removal of access road within Stage 2A footprint (refer Appendix A Figure 2 of the Landfill Master Plan for location). Construction access road E1 - F during capping Stage 1-1.
Permanent Surface Water	Construction of swale drain along eastern boundary of the waste cutback and perimeter drain along southern edge of Cell 1, to discharge into the existing surface stormwater pond.
Excavation	Not required
Other	Progressive construction of active landfill gas extraction in new waste.

Stage 2A and 2B-1: Approx. 2018 – 2021 (Appendix A Figure 4 of the Landfill Master Plan)	
Cell Construction	Stage 2B-1 (Cell 2 and PB2B)
Landfilling	Stage 2A (PB 2A and Cell 2A)
Capping and Rehabilitation	Progressive Stage 1
Access Road	Construction access road G - H - I for filling of Stage 2A. Construction of access road I – J on waste during the filling of Stage 2A. Removal of access roads B - C and C - C1 located within Stage 2B-1 footprint.
Permanent Surface Water Drain	Construction drainage channel to discharge clean stormwater from northern site catchment and Stage 1 cap area off site.
Excavation of On-Site Materials	Not required
Other	Relocation of services (Telstra and Power) to along old Reddalls Road. Progressive construction of active landfill gas extraction in new waste.

Stage 2B-1 and 2B-2: Approx. 2021 – 2026 (Appendix A Figure 5 of the Landfill Master Plan)	
Cell Construction	Stage 2B-2 (PB2B)
Landfilling	Stage 2B-1 (Cell2 and PB2B)
Capping and Rehabilitation	Progressive Stage 1, Stage 2A
Access Road	Construction of permanent landfill access road I - J, during capping Stage 2A. Construction of temporary access road B - K adjacent to Stage 2B. Forming access road F – B on waste during the filling of Stage 2B-1. Road surface to be constructed during/after capping.
Permanent Surface Water	Construction of perimeter drain along the edge of Stage 2A, discharged to the clean water drain along eastern cell boundary. Construction of clean drainage channel along north western and western boundary of the site.
Excavation of On-Site Materials	Complete excavation of Cell 2B prior to the construction of Stage 2B-3.
Other	Progressive construction of active landfill gas extraction in new waste.

Stage 2B-2 and 2B-3: Approx. 2026 – 2031 (Appendix A Figure 6 of the Landfill Master Plan)	
Cell Construction	Stage 2B-3 (Cell 2B and PB2B)
Landfilling	Stage 2B-2 (PB2B)
Capping and Rehabilitation	Progressive Stage 1, Stage 2A, Stage 2B-1
Access Road	Removal of access road K - D located within Stage 2B-3 footprint. Construction of access road F – B for Stage 2B-3 during capping Stage 2B-1.
Permanent Surface Water	Not required
Other	Progressive construction of active landfill gas extraction in new waste.

Stage 2B-3 and 3-1: Approx. 2031 – 2035 (Appendix A Figure 7 of the Landfill Master Plan)	
Cell Construction	Stage 3-1 (Cell3 and PB3)
Landfilling	Stage 2B3
Capping and Rehabilitation	Progressive Stage 1, Stage 2A, Stage 2B-1, Stage 2B-2
Access Road	Removal of access road A - B - B1 located within Stage 3-1 footprint (refer Figure 6 of Landfill Master Plan for location of access road). Construction of temporary access road H – H1 during the filling of Stage 2B-3. Removal of access road B – N at end of Stage 2B-3.
Permanent Surface Water Drain	Not required
Excavation	Excavation of borrow materials within PB3-1 footprint completed prior to the construction of Stage 3–1.
Other	Progressive construction of active landfill gas extraction in new waste. Removal of private powerlines prior to construction of Stage 3-2.

Stage 3-1 and 3-2: Approx. 2035 – 2041 (Appendix A Figure 8 of the Landfill Master Plan)	
Cell Construction	Stage 3-2 (PB3)
Landfilling	Stage 3-2 (Cell3 and PB3)
Capping and Rehabilitation	Progressive Stage 1, Stage 2A, Stage 2B-1, Stage 2B-2, Stage 2B-3

Access Road	Construction of access roads A - M - N on waste during the filling of Stage 3-1 and access road G - L - H for the filling of Stage 3-2. Removal of access roads G - H and G - K located within Stage 3-2 footprint.(refer Figure 7 of Landfill Master Plan for location)
Permanent Surface Water	Connecting perimeter drain along Cell 2 boundary to the clean water channel discharged off site.
Excavation of On-Site Materials	Excavation of borrow materials within Stage 4-1 footprint completed prior to Stage 4-1 cell construction.
Others	Progressive construction of active landfill gas extraction in new waste. Relocation of leachate pond(s) prior to Cell 4 construction 2045. Downsizing of surface water pond(s) prior to leachate pond relocation.
Stage 3-2 and 4-1: Approx. 2041 – 2047 (Appendix A Figure 9 of the Landfill Master Plan)	
Cell Construction	Stage 4-1 (Cell 4)
Landfilling	Stage 3-2 (PB3)
Capping and Rehabilitation	Progressive Stage 1, Stage 2A, Stage 2B-1, Stage 2B-2, Stage 2B-3, Stage 3-1, Stage 3- 2
Access Road	Construction of temporary access road Z – Z1 during the filling of Stage 3-2.
Permanent Surface Water	Construction of perimeter drain along Cell 3 and Cell 2B boundary, discharged to the existing stormwater ponds.
Excavation of On-Site Materials	Excavation of Cell 4A completed prior to Stage 4-2.
Other	Progressive construction of active landfill gas extraction in new waste.
Stage 4-1 and 4-2: Approx. 2047 – 2050 (Appendix A Figure 10 of the Landfill Master Plan)	
Cell Construction	Stage 4-2 (Cell 4A)
Landfilling	Stage 4-1 (Cell 4)
Capping and Rehabilitation	Progressive Stage 1, Stage 2A, Stage 2B-1, Stage 2B-2, Stage 2B-3, Stage 3-1, Stage 3- 2
Access Road	Removal of access road (M-N-G-L) located within Stage 4-2 footprint during Cell 4A construction.
Permanent Surface Water Drain	Connecting perimeter drain along Cell 3 boundary to the clean water channel discharged off site.
Excavation of On-Site Materials	Not required

Others	Progressive construction of active landfill gas extraction in new waste.

Stage 4-2 : Approximately 2050 – 2054 (Appendix A Figure 11 of the Landfill Master Plan)	
Cell Construction	None
Landfilling	Stage 4-2
Capping and Rehabilitation	Stage 4
Access Road	Forming access road M – O and P – Q on waste during the filling of Stage 4-2. Construction of access road O – P for the filling of Stage 4-2. Completing the permanent access road for final landform during capping of Stage 4-2.
Permanent Surface Water Drain	Completing the perimeter drain around the final landform.
Excavation of On-Site Materials	Not required
Others	Not required Progressive construction of active landfill gas extraction in new waste.

3.2 Planning

WCC provided the following comment in relation to Land Use Strategy:

1) *"..it is considered that the applicant should provide comment on Part 6 of Wollongong LEP (West Dapto) 2010 within Section 2.1.3 of the EA."*

Response

The Project addresses the objectives of Part 6 of *Wollongong LEP (West Dapto) 2010* in considering and contributing to the appropriate infrastructure for development of urban release areas. Comment on Part 6 of the LEP is provided in the last paragraph of Section 18.1 of the EA.

3.3 Design

The submission by DPI states the following in relation to the landfill liner and contingency measures:

1) *The Department requires more detailed information on how the design of the new landfill cells (eg. liner) and leachate pond would ensure that local water sources are not further impacted upon by leachate. Contingency measures and/or remedial actions in the event that the liner/s fail should also be detailed.*

Response

As described in Section 8.4 of the EA, cell design features to protect groundwater and surface water from leachate impacts would include measures to limit the volume of leachate generated at the Whytes Gully RRP site, barriers to leachate migration, separation of surface water and monitoring and managing the impacts.

In order to limit leachate generation, the cell capping would include a barrier to limit infiltration of water into the waste. The capping would be sloped to promote runoff. The surface water design would include measures to collect and control runoff such that clean waters are diverted away from waste filling areas.

The cell design also includes measures to protect groundwater from leachate impact such as the leachate barrier and leachate collection system. To limit impact of leachate on groundwater, the cell base liner would include a low permeability liner and a leachate collection system. Detailed discussion of these design features is provided in Section 4.0 of the Preliminary Design Report (refer to Appendix O of the EA). To provide a barrier to migration of leachate into groundwater from the leachate ponds, the existing ponds are lined with a HDPE liner, and future ponds would be lined with a composite liner.

Measures to protect surface water include separation of surface water from 'dirty' water and leachate water, such as diversion of 'clean' runoff away from disturbed areas, capture of sediment laden 'dirty' water in swale drains and diversion to the surface water ponds, and managing all surface water that falls on the exposed working face of the landfill as leachate. The staged separation of waters is described in the Draft LEMP (Appendix P of the EA).

Measures to protect surface waters from leachate impact include the separation of surface water and leachate and management of the leachate ponds. Measures to prevent overtopping of leachate ponds include the provision of freeboard and the use of shutoff valves on leachate lines to shut off flow to the ponds when capacity is reached.

Contingency measures to manage potential of leachate impact on surface waters from overtopping of the ponds are presented in Section 12.5 of the EA and include discharge directly to sewer from leachate ponds, reinjection into waste, provision of temporary 'package' treatment plants, upgrade of the treatment plant, construction of a cover over leachate ponds, trucking of leachate to sewage treatment plant for disposal and use of the old leachate ponds for contingency storage until the end of Stage 1.

Monitoring of groundwater quality and trends at the Whytes Gully RRP site is detailed in the groundwater sampling and assessment program in the Draft LEMP (Appendix P of the EA). The Draft LEMP sets out the remedial actions for liner or leachate collection system failure in Section 7.3, which comprises detection of water pollution through a sampling and assessment program, development of a groundwater assessment program in the event of a possible failure of the leachate containment system, and development of a water contamination remediation plan if groundwater contamination is confirmed by the assessment program. General options for remediation of groundwater contamination in an aquifer are also provided in Section 7.4 Water Contamination Remediation Plan of the Draft LEMP (Appendix P of the EA).

3.4 Noise

Reponses to submissions relating to potential noise impacts of the Project have been arranged under the following main themes.

- Noise Criteria
- Offsite Impacts
- Mitigation

3.4.1 Noise Criteria

The DPI submission states the following in relation to noise criteria:

1) *The Department does not agree the use of the Interim Construction Noise Guideline (ICNG) criteria for the evaluation of the cumulative noise impacts of the project but notes that there would be an on-going component of construction noise associated with the project.*

2) *The Department recognises the historical use of the site which has been operating since 1983 and considers the site and its surrounds represent a rural/industrial interface.*

3) *The Department therefore considers that it would be more appropriate to apply the Industrial Noise Policy (INP) amenity criteria (Table 2.1) for rural residences to the project (i.e. A maximum recommended Level $_{(11\ hour)}$ noise level of 50dBA during standard day-time hours).*

The EPA submission states the following in relation to noise criteria.

4) *The Noise Impact Assessment (NIA) in the Environmental Assessment includes the subject premises in the background noise monitoring, which is not in accordance with the guidance in the Industrial Noise Policy (INP). The EPA will therefore assume that the minimum background level of 30dBA applies to the surrounding residential receivers.*

5) *The EPA does not agree with the proponent that cumulative noise levels should be assessed against the construction noise criteria. The EPA considers that the INP applies to the entire process on site, that is both the construction and operation stages.*

Response

In response to comments 1, 2, 3 and 5 and in accordance with the recommendations of the DPI, given the historical use of the site, it is considered reasonable to adopt the suggested INP amenity daytime criteria for rural residences of 50 dB $_{LAeq\ (11\ hour)}$.

It is also proposed that Wollongong City Council would enter into discussions on negotiated agreements of affected locations of the Project in accordance with Chapter 8 of the INP. Golder considers this to be a suitable planning outcome given the purpose the Project, the proposed activity (i.e. construction and operational activities overlapping and running concurrently throughout the life of the Project), the number of residences potentially affected by noise generated as a result of the Project and the potential complication in maintaining two sets of noise limits where construction and operational activities consistently occur throughout the life of the Project.

In response to comment 4 ,it is considered that it would be unreasonable to adopt a minimum background level of 30 dBA to all surrounding residential receivers, as all the residential receivers are also affected by other extraneous noise such as road traffic and other industrial uses in the vicinity. Furthermore a background level of 30 dBA would not be consistent with the recommended licence conditions noise limits as identified by EPA and would not be consistent with the recommended INP noise limit of 50 dB $_{LAeq\ (11\ hour)}$.

3.4.2 Offsite Impacts

The submission by DPI states the following in relation to noise impacts upon the surrounding area:

1) *The Department needs to be satisfied that the project would achieve an acceptable acoustic environment for local residents.*

2) *As discussed at our on-site meeting on 21/9/2012, the Department suggests that you consult with the EPA and consider reducing the footprint of landfilled waste in Stage 4 to increase the buffer distance between N1 and reduce noise levels to comply with the INP amenity criteria. In this regard, a preferred project report which addresses this issue should be submitted to the Department as part of your response to submissions report.*

The submission by EPA states the following in relation to noise impacts:

3) *The cumulative (ie construction and operation) predicted noise levels at receivers N1 and N2 are significantly greater than the Project Specific Noise Level (PSNL) – up to 54 dBA at N1 and 45 dBA at N2. The proponent has not provided any description of feasible and reasonable mitigation measures to reduce the predicted levels. The EPA advises that it does not normally Licence to levels significantly greater than the PSNLs.-*

4) *The EPA has not included receivers N1 and N2 in the noise limits table in the attached recommended licence conditions, on the assumption that Planning will advise the proponent that the negotiated agreements process in Chapter 8 of the INP is available to them, and that Planning will require the proponent to provide evidence of negotiated agreements being in place with N1 and N2 before any Project Approval can be issued.*

The submission by Asciano identified:

5) *Proposed activities associated with the construction & operation of the project generate noise the* (sic) *amenity of the surrounding area.*

Response

In response to comments 1, 2 and 3, to further reduce the potential cumulative effects of the construction and operational activities at Receiver N1, the final Stage (4-2) of the Project has been broken into two parts (Stage 4-2A and Stage 4-2B) (refer Figure 1). Stage 4-2B would be the final stage of the Project to be constructed. The division of the stages as shown in Figure 1 is such that all activity up to and including Stage 4-2A occurs behind the existing north-east ridgeline, and at a greater distance from Receiver N1 than for Stage 4-2B .(refer Figures 2). It is proposed that approval of Stage 4-2B would be conditional on further noise modelling and assessment of mitigation measures to be conducted prior to construction. This has been reflected in the revised draft Statement of Commitments in Section 5.0 of the Report. Further details of the revised staging including proposed volumes and timelines are provided in Section 4.0 of the Report.

The breaking of Stage 4-2 into two parts allows a greater level of detail in modelling the level and duration of noise exposure to Receiver N1. The reduced duration of exposure is discussed in Section 4.0, and shows that for construction and operation activity nearest to Receiver N1 (in Stage 4-2B) is approximately six years, which is less than the nine years presented in the EA for the whole of Stage 4-2.

The assumptions adopted in the NIA report have been used in predicting the noise associated with the construction and operational activities for Stage 4-2A. Table 3 below sets out the predicted Stage 4-2A construction noise levels at Receiver N1, taking into account site layout, distance separation, screening from existing topography and ground and atmospheric absorption, without the implementation of any mitigation measures except that all plant and equipment are assumed to be fitted with appropriate silencers and broadband reversing alarms.

Table 3: Predicted construction noise levels (dB L_{Aeq}) – plant and equipment located within Stage 4-2A

Receivers	Stage 4-2A
N1	37

Similarly, Table 4 sets out the predicted Stages 4-2A operational noise levels at Receiver N1, taking into account site layout, distance separation, screening from existing topography and ground and atmospheric absorption, without the implementation of any mitigation measures except that all plant and equipment are assumed to be fitted with appropriate silencers and broadband reversing alarms. In accordance with the recommendations of the DPI, given the historical use of the site, the INP amenity daytime criteria for rural residences is considered to be the applicable criteria for the Project.

Table 4: Predicted operational noise levels (dB L_{Aeq}) – plant and equipment located within Stage 4-2A

Receivers	INP Amenity Criteria ($L_{Aeq, 11\text{-}hour}$)	Stage 4-2A
N1	50	45

Noise from the operational activities is predicted to comply with the INP amenity limit at Receiver N1 during all operation phases. By breaking down the staging of the landfill and considering Stage 4-2B separately, the predicted operational noise levels at N1 have been reduced by 9 dB(A) to 45 dB $_{LAeq}$.

It should also be noted that the predicted noise levels are considered to be conservative as all plant and equipment have been assumed to operate concurrently and continuously on the Project site, which is unlikely to be the case under normal operational conditions.

As discussed in section 6.1.2 of the NIA report, construction and operational activities are expected to be undertaken concurrently at the Whytes Gully RRP. To assess the cumulative effects of the construction and operational activities, all the plant and equipment are assumed to operate simultaneously and continuously. Table 5 sets out the cumulative predicted Stage 4-2A noise levels at the closest receivers to the proposed

Project assuming all plant and equipment are located at the northern part of each stage (i.e. closest to the Receiver N1).

Table 5: Predicted cumulative noise levels (dB L_{Aeq}) – plant and equipment located within Stage 4-2A

Receivers	INP Amenity Criteria ($L_{Aeq,\ 11\text{-}hour}$)	Stage 4-2A
N1	50	47

By breaking down the staging of the landfill, compliance of the construction noise criteria are predicted at N1 and during stage 4-2A when all plant and equipment are located at the northern part of each stage. This assessment indicates that based on the information currently available, that “highly noise affected” levels are not expected at any residential receivers and therefore respite periods are not proposed.

Over the life of the landfill receiver noise levels will vary over the range of the predicted levels depending upon the relative locations of plant and equipment. In addition, at other times when the plant and equipment are further from the receivers, lower noise levels are predicted.

In response to comment 4, as identified within the NIA and the draft statement of commitments within the EA, it is proposed that Wollongong City Council enter into discussions on negotiated agreements of affected locations of the Project in accordance with Chapter 8 of the INP.

In response to comment 5, it is considered that the noise impacts of construction and operation of the Project upon the amenity of the surrounding area has been assessed appropriately within the Report and the EA including the Noise Impact Assessment report located in Appendix D of the EA.

3.4.3 Mitigation

The submission by DPI states the following in relation to noise impacts:

1) *The Department needs to be satisfied that all reasonable and feasible noise management and mitigation measures have been implemented to minimise noise impacts on surrounding receivers (eg. committing to the installation of 'smart alarms' on equipment once replaced).*

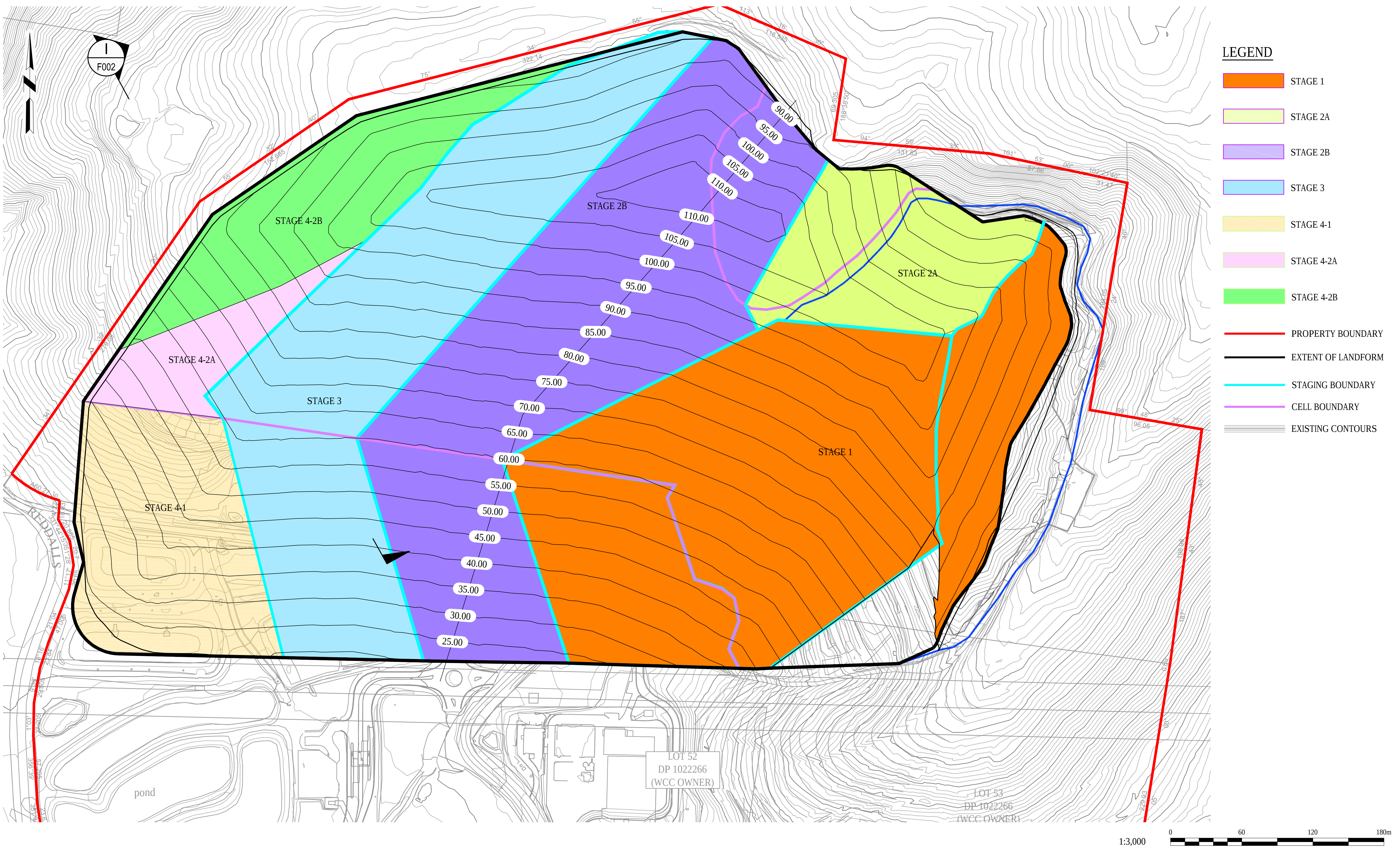
The submission by DPI states the following in relation to noise impacts:

2) *The EPA has recommended noise limits for receivers N3 to N5 based on the predicted cumulative noise levels in Tables 15 and 16 in the NIA. Where the levels are more than 2dBA above the PSNLs, the EPA recommends that the proponent implement a noise management plan (NMP) to minimize noise from the site over the life of the landfill. The EPA does not and will not approve or endorse a NMP and does not need to review such a plan.*

Response

The proposed splitting of Stage 4-2 of the Project into Stage 4-2A and 4-2B has reduced the construction and operation noise levels at Receiver N1 to below their respective calculated noise limits (refer modelling results in Table 3 to Table 5). In addition mitigation measures have been incorporated to reduce the noise generated by the Project upon the site and surrounding area. This includes the fitting of all plant and equipment with appropriate silencers and broadband reversing alarms.

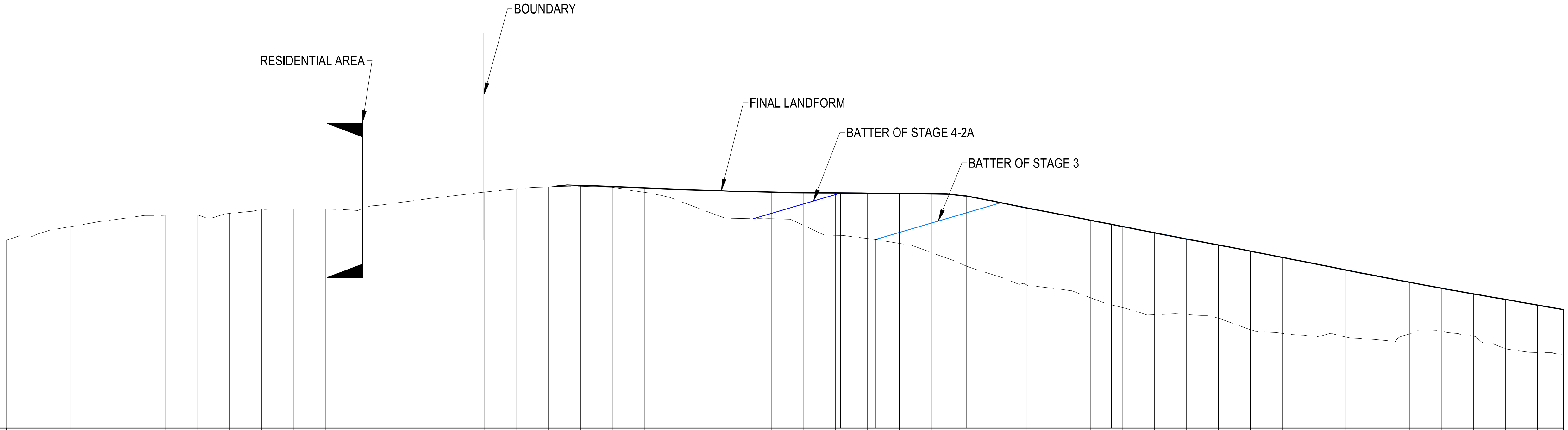
WCC are committed to reducing noise limits of the Project and propose to draft and implement a noise management plan to manage noise generated at the Whytes Gully RRP site over the life of the proposed Project.



CLIENT		PROJECT					
WOLLONGONG CITY COUNCIL		PRELIMINARY CONCEPT - WHYTES GULLY LANDFILL					
DRAWN BY: EJ JEET	DATE: 18 DEC 2012	DRAWING TITLE: Revised Staging Plan					
CHECKED BY: K DOHLE	DATE: 18 DEC 2012						
SCALE: 1:3,000	SHEET SIZE: A3	PROJECT No: 117625003	DOC No: 207	DOC TYPE: R	FIGURE No: F001	REVISION: 0	FIGURE 1

Golder Associates
www.golder.com
GOLDER ASSOCIATES PTY. LTD.

Plot Date: 19 December 2012 Time:1:17:50 PM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\FIGURES - File Name:117625003-207-R-F001-REV0.dwg
Xref: 117625003-XREF-EXISTING BREAKLINES.dwg; GAP_LOGO-A3.dwg; 117625003-XREF-LANDFORM FINAL AS OF 120116.dwg;



CHAINAGE	NATURAL SURFACE	DESIGN SURFACE	STAGE 3	STAGE 4-2A
0.00	59.00			
10.00	61.00			
20.00	63.28			
30.00	64.96			
40.00	66.34			
50.00	66.85			
60.00	66.93			
70.00	67.46			
80.00	68.70			
90.00	68.92			
100.00	68.84			
110.00	68.38			
120.00	70.43			
130.00	71.76			
140.00	73.00			
150.00	74.12			
160.00	75.16			
170.00	75.77			
180.00	75.92	76.22		
190.00	75.60	75.84		
200.00	74.07	75.45		
210.00	71.74	75.01		
220.00	67.94	74.72		
230.00	65.88	74.35		
240.00	65.75	74.10		67.50
250.00	63.68	73.92		70.44
260.00	60.58	73.84		73.38
270.00	59.53	73.77		73.76
280.00	58.06	73.69	61.44	73.68
290.00	55.17	73.61	64.38	73.60
300.00	51.34	73.03	67.32	73.03
310.00	47.96	71.18	70.27	71.16
320.00	44.94	69.16	69.20	
330.00	43.70	67.23	67.24	
340.00	40.92	65.28	65.27	
350.00	37.88	63.31	63.32	
360.00	35.68	61.34	61.39	
370.00	35.72	59.39	59.46	
380.00	34.54	57.53	57.53	
390.00	30.96	55.60	55.58	
400.00	29.80	53.64	53.64	
410.00	28.71	51.67	51.69	
420.00	28.62	49.67	49.75	
430.00	27.78	47.73	47.81	
440.00	29.63	45.84	45.86	
450.00	30.45	43.95	44.02	
460.00	28.90	42.18	42.25	
470.00	24.94	40.43	40.47	
480.00	23.84	38.68	38.70	
488.15	23.26	37.26	37.26	

SECTION 1 F001 TYPICAL SECTION

SCALE 1:1,500

1:1,500 0 30 60 90m

Golder Associates
www.golder.com
GOLDER ASSOCIATES PTY. LTD.

CLIENT: WOLLONGONG CITY COUNCIL		PROJECT: PRELIMINARY CONCEPT - WHYTES GULLY LANDFILL	
DRAWN BY: EJ JEET	DATE: 18 DEC 2012	DRAWING TITLE: Revised Staging Plan Section 1	
CHECKED BY: K DOHLE	DATE: 18 DEC 2012		
SCALE: 1:1,500	SHEET SIZE: A3	PROJECT No: 117625003	DOC No: 207 · DOC TYPE: R · FIGURE No: F002 · REVISION: 0 · FIGURE 2

Plot Date: 19 December 2012 Time:1:18:32 PM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\FIGURES - File Name:117625003-207-R-F002-REV0.dwg
Xref: GAP_LOGO-A3.dwg;

3.5 Greenhouse Gas

The submission from Asciano commented that "a high level of greenhouse gas may be generated as a result of this project".

Response

The greenhouse gas impact is assessed in Chapter 11 of the EA.

Estimated peak Project annual net emissions of greenhouse gas (in 2053) are less than 0.03 percent of the NSW total state emissions (based on 2009 data). Energy efficiency mitigation measures for the Project include reduced emissions from increased resource recovery and recycling, and capture and combustion of landfill gas.

3.6 Contamination

The submission from Asciano identified potential issues associated with contamination.

Response

The contamination impacts in relation to soil, groundwater and surface water are assessed in Chapter 12 of the EA. As a part of the EA, groundwater and surface water sampling and analysis was conducted and sampling, field screening and laboratory analysis of pond sediments and surface soils was undertaken.

3.7 Groundwater

Reponses to submissions have been arranged under the following main themes:

- Groundwater Beneficial Uses
- Groundwater Dependent Ecosystems
- Licences
- Use of Historical Data
- Water Quality Analytical Results
- Interpretation of Borehole core samples
- Impact on Dapto Creek and Groundwater Quality

3.7.1 Groundwater Beneficial Uses

The submission by DPI states the following in relation to groundwater beneficial reuse:

- *Section 12.2.2 of the environmental assessment (EA) states there is a "moratorium on new entitlements under the Greater Metropolitan Water Sharing Plan" (pages 159, volume 1). Under the Water Sharing Plan (WSP), entitlements will be released in the future under a controlled allocation order. The mechanism for controlled allocation is yet to be communicated by the NSW government but there is a not a moratorium on new entitlements.*

Response

The correction is noted. The original advice was based on a phone conversation with Office of Water when the hydrogeological assessment was being prepared. The description should have read "*no new entitlements are currently being granted under the Water Act 1912, pending commencement of the Greater Metropolitan Water Sharing Plan*".

3.7.2 Groundwater Dependent Ecosystems

The submission by DPI states the following in relation to groundwater dependent ecosystems:

1) *The EA provides insufficient details on Groundwater Dependent Ecosystems (GDEs) to assess the potential impact of the proposal on GDEs. Section 12.2.2 of the EA indicates a number of actions have been undertaken to assess the potential presence of high value GDE's in the vicinity of the site. The EA notes the actions include a review of high value GOEs presented in the WSP for the Greater Metropolitan Region and the review found there are no known high value GOEs within at least 10 km of the site (page 159). The section on GDE's contradicts with the Groundwater Beneficial Uses section which indicates Dapto Creek "may receive baseflow from groundwater in the alluvial deposits" (page 159).*

2) *The assessment of GDEs should not be limited to high value GDEs. The EA should have given consideration to all GDEs that may occur at the local scale. There is a strong likelihood that GDEs occur downstream of the site in association with surface water flow. The EA needs to demonstrate a sound understanding of surface water and groundwater interaction particularly as Dapto Creek is located down gradient of the site and may receive baseflow from groundwater. An assessment at the local scale needs to be undertaken in the surrounding area.*

The submission by NOW states the following in relation to groundwater dependent ecosystems:

3) *The 14th dot point under Flora and Fauna (page 256) to extend the current water quality monitoring program on Dapto Creek should reflect that there is to be a combined surface water and groundwater monitoring program to gain an understanding of surface water and groundwater interaction and to assess potential impacts on the downstream environment including Dapto Creek and GDEs.*

Response

Dapto Creek and its minor tributaries are the only natural surface water courses located close enough to the site to be reasonably considered as a potential receiving environment for discharge of shallow groundwater from the site. The depth to the water table as measured in the shallow boundary monitoring wells located close to Dapto Creek is approximately 3m below ground level, however the creek bed elevation is currently not known so a comparison of water table elevation to creek bed elevation (as a rough indicator of potential for surface water – groundwater interaction) could not be made. This would be assessed in the future for future assessment of impact on Dapto Creek.

There are considered to be a sufficient number of shallow monitoring wells installed along the south-western (downgradient) boundary of the site to identify groundwater quality issues along the downgradient site boundary, and surface water quality is monitored from Dapto Creek upstream and downstream from the landfill such that potential correlations can be made between shallow groundwater and creek water quality.

It is confirmed there is to be a combined surface water and groundwater monitoring program to gain an understanding of surface water and groundwater interaction and to assess potential impacts on the downstream environment including Dapto Creek and GDEs. Refer revised draft statement of commitments Section 5.0.

3.7.3 Licences

The submission by DPI states the following in relation to licences:

1) *Table 2.1 in the EA notes the project would involve the installation of bores on the site to enable monitoring of groundwater quality (page 18). The table notes licences as prescribed under Section 112 have been received. The licences may be subject to a conversion process to convert them to Water Management Act authorisation.*

Response

It is noted that if additional wells are required as a consent condition to the Project approval, that the wells may qualify as exempt bores within the meaning of Cl 3 and Cl 36(1)(c) of the Water Management (General) Regulation 2011, and therefore not require a water supply works approval.

3.7.4 Use of Historical Data

The submission by WCC states the following in relation to use of historical data:

1) *In relation to the impact of tip leachate on surface and groundwater contamination, the entire document is based on the results of three sampling events conducted during August 2011, November 2011 and January 2012. However, a reliable and solid data base reflecting nearly 20 years of data collection is available with Wollongong Council Waste Management Services. The Council database reflects fluctuation in leachate composition, surface water, and groundwater chemistry in extreme weather conditions over an extended period of time interval.*

2) *Since the early 1990's, the Whytes Gully waste disposal depot was operating under an EPA licence. Under the licence requirements, leachate, surface water, groundwater samples were collected regularly and analysed by NATA accredited analytical laboratories. In the opinion of Council's Environment Section, the information from this data base should have been assessed and used for the design of future cells at Whytes Gully.*

Response

During the preparation of the hydrogeological assessment, multiple requests were made with WCC for access to all available environmental monitoring data associated with Whytes Gully RRP. A number of older investigation reports were made available dating back to 1981, as described under “Summary of Previous Hydrogeological Investigations” (refer Section 12.2.2 of the EA and Section 2.5 of Appendix G3 of the EA). In addition, a spreadsheet of groundwater monitoring results dating back to 1996 was reviewed, which included:

- pH and ammonia results for two wells (1 and 3) between 1996 and 2003;
- pH and ammonia results for five wells (1, 3, 4a, 5a, 6a) from 2004 to 2009; and
- pH, ammonia, major ions, TDS and TOC for eight wells (1, 3, 4, 5, 6, 4a, 5a, 6a) from 2009 to 2011.

Using pH and ammonia concentrations as a proxy for leachate impact assessment, the average pH values during this monitoring period ranged from 6.2 to 7.0, and the average ammonia concentrations ranged from 0.05 to 0.7 mg/L (based on detect ammonia concentrations only; approximately 50% of the ammonia analyses were below the laboratory limit of reporting). Only nine of the 461 ammonia results were above the ANZECC (2000) criterion of 0.91 mg/L (not adjusted for pH), and in each case were discrete spikes in the monitoring record.

While the previous monitoring data were considered, well construction details were not available for the monitoring network and therefore the data were not extensively relied upon for interpretive purposes. It is noted that the monitoring wells installed as part of the new cell design investigation provide more extensive spatial coverage than the previous monitoring network. Some of the new well locations represent similar locations to the previous wells, and the analytical results from these wells are consistent with the historical data set. Hence the conclusions regarding the local hydrogeological setting and groundwater quality in the hydrogeological assessment are consistent with the historical monitoring data.

With isolated exceptions, groundwater monitoring between August 2011 and August 2012 has confirmed these results.

3.7.5 Water Quality Analytical Results

The submission by WCC states the following in relation to water quality analytical results:

1) *In various chapters and sections of the report (volume 1, page 158, table 12.3, volume 2, appendix G, page 48, table 22, volume 2, appendix G3) the ammonia concentration of the leachate is reported as 0.69 mg/L., while long term data indicates that the ammonia concentrations in the Whytes Gully leachate is well over 100 to 150 mg/L. Fluctuations in ammonia concentrations up to 280 mg/L was also recorded, depending on weather conditions.*

2) *In the Fauna and Flora report prepared by Biosis (volume 2, page 140, and table 12, appendix S) inaccurate data reporting was also observed. A conductivity of 0.1 us/cm in the Whytes Gully stormwater pond is reported. The conductivity of the stormwater pond is usually over 400 to 470 uS/cm. Whilst it is noted that this inaccuracy would have no great bearing on interpretation of the habitat value, it should be further reviewed to ensure that the reported values are correct and not contradictory to other values reported in the other chapters of the document.*

Response

The reported leachate ammonia concentration of 0.69 mg/L, for a leachate pond influent sample collected in December 2011, was identified as being unusual at the time; however the result was verified by the laboratory and was reported as it appeared on the laboratory report. It is still considered that this may have been an analytical or transcription error on the lab report, and should probably have been qualified as such in the report. However more extensive leachate monitoring data was not made available until after the completion of the hydrogeological assessment. The leachate monitoring data indicate ammonia concentrations closer to the expected range (over 1000 mg/L ammonia-N). Whilst it would have been preferable to include this data in the assessment, it does not affect the conclusions of the hydrogeological assessment as the impact assessment focused primarily on shallow and deep groundwater across the site as an indication of historical leachate impact, and potential groundwater exposure pathways in the event of future leachate impacts.

The Biosis report represented the only available recent water quality data for Dapto Creek at the time of preparation of the hydrogeological assessment, which was important for comparison to previous results reported in a regional surface water quality study (Beardsmore and Ganjayia, 2006). The unusually low EC value reported in the Biosis is noted, but as mentioned does not have a material impact on the assessment results as EC was only one of nine leachate indicator parameters considered during review of the surface water quality data.

The data set in the hydrogeological assessment was subject to a data validation process and multiple levels of peer review. Whilst the unusual leachate ammonia concentration was correctly challenged, it was reported as it appeared in the laboratory report. We are confident that this does not reflect a systematic data reporting error throughout the hydrogeological assessment.

3.7.6 Interpretation of Borehole core samples

The submission by WCC states the following in relation to interpretation of the boreholes:

1) *In the current study, 13 newly drilled bores were cored and the photographs of the core samples show signs of discoloration along the fractures and joints. This discoloration often results from vertical movement of leachate or contaminated water toward the deeper horizons. In the early 1990s, when the eastern gully waste cell was under construction, the core samples extracted from the bed of the gully were examined by a UoW Honours student and the samples from the discoloured joints were analysed using XRF. Analytical results confirmed the impact of the leachate in the joints. In the current report, discoloration along the joints and fractures is observable in BH01 (1 - 4m depth), BH03 (12m depth), BH OS (13m depth), GWM 101 (in 4-7 m interval) GWM 103 (5-7 m interval) ... etc.*

The comment is noted. Whilst discolouration in fractures can potentially be an indication of contamination, it is also commonly associated with natural mineral deposits related to the water-rock interactions. In particular, orange iron-stained fractures are very commonly encountered in water bearing fractures in areas of little or no contamination potential, simply from oxidation of iron-bearing minerals in the rock matrix.

In addition, if the staining in the fractures from the well installation cores was attributable to the presence of landfill leachate, then it should have been detected in the groundwater samples collected from those wells.

Staining in fractures was one of the criteria for deciding where to set the well screens (as an indicator of potential water-bearing fracture zones), hence the fractures in question would be represented in the monitoring data. With minor exceptions, limited evidence of leachate impact to groundwater was noted at the site.

3.7.7 Impact on Dapto Creek and Groundwater Quality

The WCC submission states the following in relation to impacts on Dapto Creek:

1) *Water quality monitoring conducted by Wollongong City Council in Dapto Creek just downstream of the Whytes Gully stormwater detention pond has revealed high concentrations of nitrogen species, especially ammonia. Water quality data from borehole GMW09D indicated high levels of ammonia and nitrogen species. Information from this borehole indicated that the contaminated groundwater from Whytes Gully is discharging into the Dapto Creek. Lake Illawarra's receiving waterbody is a nitrogen limited system, discharge of nitrogen rich groundwater is potentially detrimental to the water quality of the lake. Interception of polluted groundwater through a permeable reactive barrier at the down gradient of ground water flow can reduce the negative impacts on the water quality Lake Illawarra.*

The DPI submission states the following in relation to impacts on Groundwater Quality:

2) *It is evident to the Department from past environmental performance monitoring and information provided by Wollongong City Council that groundwater quality at the site may have been impacted upon by leachate from previous landfilling activities.*

3) *Given the above, the Department wishes to understand what (if any) remedial actions have occurred (or are planned) to explore and/or rectify the potential groundwater leachate contamination issue at the site?*

The Sydney Water submission states the following in relation to impacts on Groundwater Quality:

4) *The proponent should enquire through the Environmental Protection Authority and take appropriate precautions to manage contamination. In addition, they should protect all Sydney Water infrastructure affected by their development including taking any precautions to protect our infrastructure from all potential contamination issues, including acidic groundwater.*

Response

Isolated cases of leachate impact to groundwater were noted in certain historical reports for the site (e.g. WCC, 1991; Maunsell, 1992), which were generally “one-off” results reported for samples collected from boreholes or temporary wells later destroyed during cell development.

Recent groundwater baseline monitoring results from the current robust monitoring network, as well as the monitoring data available from WCC since 1996 indicates very limited evidence of leachate impact to groundwater at the site.

An elevated ammonia concentration has been reported for shallow boundary monitoring well MW109S during the recent groundwater monitoring program (August 2011 to August 2012). The source of the ammonia is uncertain as it does not appear in any other wells in the monitoring network, including wells located upgradient from MW109S, and is not characteristic of water quality in the stormwater pond adjacent to the well. It is noted that MW109S is located close to a sewer main in the Reddalls Rd alignment, which could be a possible alternative source of contamination.

Irrespective of the source, it is noted that recent baseline surface water quality monitoring in Dapto Creek both upstream and downstream of MW109S, carried out in conjunction with the groundwater monitoring, has not indicated an increasing (or even elevated) ammonia concentration, which suggests that the creek is not being adversely affected by the presence of elevated ammonia concentrations in shallow groundwater adjacent to the creek. The issue would be considered further in the annual evaluation of the baseline monitoring data.

Based on review of the groundwater quality monitoring results for the past 15 years, and especially the recent detailed monitoring, there is limited evidence to suggest significant leachate impact to groundwater has occurred at the site. Isolated cases of elevated leachate-indicator parameters have been noted at specific wells, and would be considered further in the annual review of the baseline monitoring results. It would be premature to consider remedial action at this stage.

3.8 Surface Water, Drainage and Flooding

The response to surface water and flooding comments has been arranged by the following main themes:

- Floodplain risk management
- Flood impact
- Catchment Area
- Drainage
- Surface water management
- Surface water pond sizing
- Surface Water pond reconfiguration

3.8.1 Flood Impact

The submission by OEH states the following in relation to flood impacts:

1) *With regard to floodplain risk management, the proposal should be considered in accordance with the NSW Government's Flood Prone Land Policy as set out in the Floodplain Development Manual, 2005 as areas of the project are located on a floodplain with the potential to be adversely affected by or to impact on flooding in the catchment. Consideration should be given to the impact of flooding on the proposal, the impact of the proposal on flood behaviour and the impact flooding to the safety of people over the full range of possible floods up to the probable maximum flood.*

2) *OEH notes the EA has limited its consideration to the impact of flooding to the 1% AEP event. While flooding has been identified in the EA as a 'Potential Hazardous Scenario' (vol.1, p.234), it is unclear whether adequate consideration has been made to issues associated with the impacts of flooding (and associated risks) over the full range of potential floods. Issues relating to the integrity of the water treatment ponds (i.e. risk of failure or overtopping), hydrologic impacts, flood damages and environmental risks of floods exceeding the design event on water quality. In addition, major flooding may restrict access to and from the site potentially affecting operational management during a flood event and the safety of people on site. These issues are potentially compounded if flooding causes a loss power and/or communications.*

The submission by WCC states the following in relation to flood impacts:

3) *The methodology used to determine the Permissible Site Discharge (PSD) and Site Storage Requirement (SSR) values for catchments larger than 2 ha need to be determined using pre and post development runoff routing analysis, inclusive of any existing on-site detention storage (OSD) on site.*

4) *The PSD/SSR calculations use a pre development impervious area percentage of 20% (based on a land use of Public Recreation Area). As the nature of the pre development catchment is known, the actual pre development impervious area should be used in this instance. This should be reflected in the pre-development runoff routing modelling used to determine the site PSD/SSR values (as above)*

5) *Runoff routing modelling should be undertaken for each stage of the development (including final landform) demonstrating that the total site discharge to Dapto Creek including OSD bypass flows will not exceed the PSD values. The modelling for each stage must take into account any additional*

impervious area and changes to the hydrology of the catchment, including increases in surface stormwater generation resulting from the infiltration barrier in the capping profile.

The submission by Asciano states the following in relation to flood impacts:

6) *Contribution and adverse impact upon local flooding of the site and surrounding area. The Whytes Gully surface water ponds drain into a creek that crosses the Autocare site. If flooding occurs:*

- *What is the impact on our site?*
- *What measures will be in place to minimise the flood risk?*
- *Key concerns: (i) Vehicle water damaged due to flooding. (ii) facility may need to resurface vehicle storage areas due to flooding (iii) repair facility fencing (electric) due to flooding.*

Response

Subsequent to submission of the EA an extension to the Mullet Creek, West Dapto flood model has been made available in the form of the Bewsher Consulting Pty Ltd report (Bewsher 2011). Based on this report, and in particular the revised 100 year ARI flood levels , flood water appears to have been generated on the existing Whytes Gully landfill site. The depth of water shown on the Bewsher model plans shows that the water upstream of the Reddall's road is significantly greater than the depth downstream (by more than several meters), suggesting that the model is showing flood water on site is not caused by backwater., suggesting that flood water is overtopping Reddalls Road before discharging into Dapto Creek (refer Figure 3). This is opposed to the 100 year floodplain reaching the Whytes Gully RRP and inundating the site with flood water.

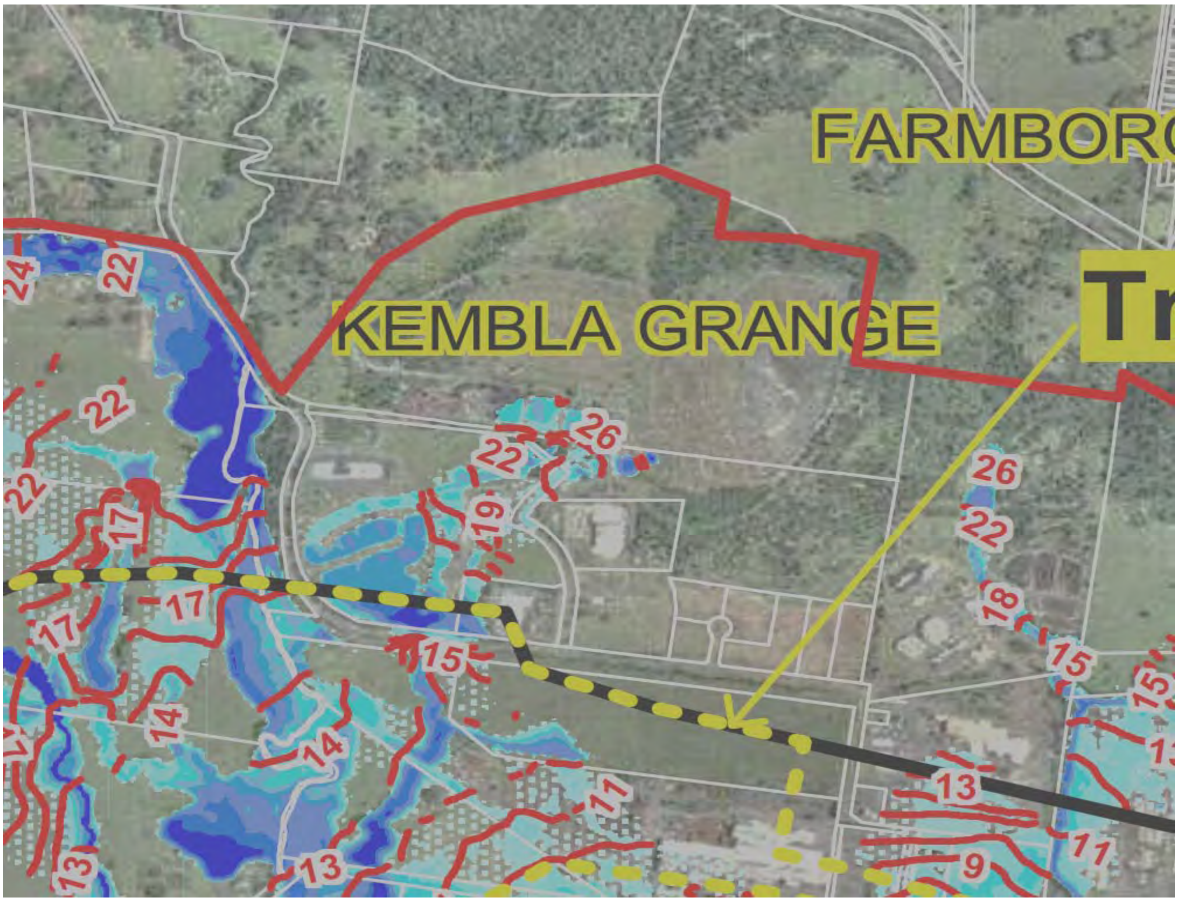


Figure 3: An extract from Bewsher's extended flood model (figure 7) completed December 2011

It is therefore our opinion that the culverts under the Reddalls Road have not been modelled within Bewsher's extended flood model as these would be classed as minor structures for the intent of the overall model. To confirm whether or not the existing landfill site is within the 100 year floodplain (as shown on the Bewsher model), a runoff routing analysis was completed to include the culverts under Reddalls Road. The results from this analysis have been presented in the Surface Water Routing and Flood Analysis Report (Golder 2012) in Appendix A of this Report.

In summary, it is believed that flood water from the 100 year event would not reach the site and therefore not impact the proposal, and therefore affect the integrity of the ponds or human safety.

A pre-development runoff routing analysis has been completed. A summary of pre-development PSD results have been listed in Table 1 below which have been modelled going through the twin 2500 mm diameter culverts under Reddalls Road before discharging into Dapto Creek.

Table 6: Summary of pre-development PSD values

ARI	PSD (m^3/s)
5 yr. Minor (2 hour critical storm)	7.04
100 yr. Major (2 hour critical storm)	18.1

The philosophy for the post-development runoff from site is to mimic to that of the pre-development runoff, therefore it is envisaged that there would not be a change to the existing flood behaviour. The runoff from site would be managed onsite through the attenuation of flows using storage ponds and outflow controls (i.e. orifices and high level spill ways) throughout the construction of the landfill to ensure that that PSD's would not be exceeded. It is proposed that all post development runoff would be restricted to the existing runoff for the 5 year and 100 year ARI critical storm in accordance with WCC DCP chapter E14 (WCC 2004).

A runoff routing analysis would be completed as part of the detailed design for each stage of the Project and would be presented within the detailed design report for each Stage of the landfill development. The post-development peak flow rates off site would be restricted to the pre-development PSD rates. Therefore the proposed works would not affect downstream flood behaviour and human safety.

3.8.2 Catchment Area

The submission by WCC states the following in relation to catchment area:

1) *The information submitted with the development indicates that the catchment area of the site is approximately 50 ha. However, based on Council's ALS contour data it appears that the total site catchment area (incl. surface water ponds) is in excess of 60 ha. A catchment plan should be provided showing the total catchment area and sub-catchment breakdown for pre development conditions and each respective stage of the development (including landform).*

Response

The submission by WCC notes that the total site catchment in is in excess of the 60 ha; 10 ha greater than the area given in the EA. The additional 10 ha consists of land unaffected by the development of the new landfill cell. This additional 10 ha is located to the south of the landfill catchment, labelled as Area 10 on Figure 1 (Existing Catchment Boundaries and Surface Water Management).. This area would remain undisturbed and the water would continue to be conveyed offsite via existing controls.

3.8.2.1 Drainage structure design

The WCC submission states the following in relation to drainage structure design:

1) *The surface drainage for the landfill area (i.e. bench and drop structures) should have sufficient capacity to convey a 100 year ARI storm event in a controlled manner without scouring or eroding the landfill surface. It is unclear whether these drains achieve this.*

2) *The documentation provided with the application indicates that a 2 hour duration storm has been used to size the drainage system. However, this may not be the critical storm duration for all parts of the surface water drainage network. Where the contributing catchment area is small, shorter storm durations may produce higher localised peak flows. The critical storm duration at each location in the drainage network should be used to size the drainage system.*

3) *The proposed grassed surface drains are contrary to section 10.3.6 of chapter E14 of the Wollongong DCP2009. Side slopes of grassed channels should be relatively flat for safe access/maintenance purposes. The desirable batter slope must not be greater than 1 vertical to 6 horizontal. However in difficult circumstances a 1 vertical to 4 horizontal may be considered.*

Response

Drainage details provided to date have been designed for up to a 100 year storm event (refer to section 4.4.1.2 of the EA appendix G4) including the benching and drop structures.

With respect to the comment on use of a 2 hour storm duration, it has been noted that other storm durations could present themselves as a critical duration for each catchment area. Critical duration would be ascertained as part of detailed design for each Stage of the Project.

The design criteria for the grassed channels have been noted and the channel sections would be updated to suit as part of the detailed design for each Stage of the Project.

3.8.3 Surface Water Pond Design

The submission by DPI states the following in relation to stormwater pond size:

1) *The Department notes from the EA that the existing surface water ponds would be used to capture sediment laden water for stages 1 to 3 of the project and would have a storage volume of 29,000 m^3. The Department wishes to clarify whether the existing sediment ponds would be able to contain up to a 100 year ARI peak flow event and/or satisfy Council's DCP (or Landcom's Bluebook) requirements for Permissible Site Discharge values and Site Storage Requirements*

Response

The volume of the surface water ponds is 40,000 m^3, of which 29,000 m^3 is provided for sediment storage in accordance with the Blue Book (Landcom) methodology. This pond volume will be sufficient to hold a 100 yr ARI storm event.

It is proposed that the existing ponds are maintained to be able to contain a 5 day duration (90^{th} percentile) rainfall depth in accordance with the Landcom Blue book. The offsite discharge from site would be restricted to the WCC DCP requirements for PSD and SSR for a minor storm 5 yr ARI and major storm 100 yr ARI.

3.8.4 Surface Water Management

The submission by DPI states the following in relation to surface water management:

1) *Department requires more information on how clean, dirty and waste affected (leachate) surface water would be separated at all stages of the project to prevent cross contamination. A figure similar to drawing 'D051" (Appendix A of Appendix O) with more labels may be useful in illustrating how bunds, swales, drains and other diversion devices are currently (and would be) used to keep water sources separate.*

2) *The Department also requires more information on how 'dirty' surface water that has not come into contact with waste (i.e. not considered leachate) is currently (and would be) managed and treated before discharging to Dapto Creek (including frequency of discharge) at all stages of the project in accordance with the relevant guidelines (i.e. for both treatment and water quality).*

3) *It is unclear if the proposed 'clean drain' to be constructed at the end of Stage 2B to bypass the sediment ponds and discharge directly to Dapto Creek would be able to convey a 100 year ARI storm event in a controlled manner. Further, it is unclear if it is proposed to solely use this drain to discharge*

the entire anticipated 30 hectare 'clean' catchment by stage 4. Measures to monitor the quality of this surface water from 2 B and beyond prior to discharging into Dapto Creek should be detailed.

4) *Clean & Dirty (sediment laden) stormwater leaving the site may not meet discharge criteria. Flows are discharged at a rate that do not protect downstream environments.*

The submission by Asciano states the following in relation to surface water management:

5) *Patrick AutoCare require confirmation that the creek that flows from the landfill site across our facility will not fill with sediments over time. Given our site is downhill from the landfill, we need assurance that sediment or dirty water will be controlled in such a manner that will not impact our facility.*

Response

Management and separation of surface waters is described in Section 7.3.2 of the of the EA. Surface water is described as either "clean", "dirty" or "leachate" as follows:

- "clean" stormwater: runoff from areas of the site where soil and vegetation have not been disturbed or vegetation has been established is considered to be "clean";
- "dirty" stormwater: runoff from areas of the site where soils have been disturbed and are likely to generate sediment are considered to be "dirty", including areas of intermediate cover or areas of final capping that have not yet been vegetated; and
- "leachate": comprises runoff from areas of waste or daily cover material as well as leachate generated by the landfill.

Existing and future management of "dirty" stormwater throughout the stages of the Project is described in the Draft LEMP (refer Section 7.2.3 in Appendix P of the EA). The existing catchment boundaries and surface water management is shown in Figure 4. Stormwater runoff is captured in swale drains and directed to the surface water treatment system comprising a series of reed beds and surface water polishing ponds. Discharge of the ponds is to Dapto Creek. Details of how 'dirty' surface water is managed prior to discharge to Dapto Creek throughout Project staging are also provided in Section 7.2.3 of Appendix P of the EA.

Drawing D051 showing the surface water management concept has been revised to provide clearer annotation of the separation of clean and dirty water throughout each stage construction. For the separation of leachate at each stage refer to drawing D041 (Leachate Collection System) located in Appendix O of the EA.

The proposal is to convey the entire 30 ha clean catchment (once the 30 ha catchment has been fully capped) off site, via the 'clean' drain. This drain would be used solely for this purpose. This drain would be designed for up to a 100 year ARI.

The outfall for this drain, in combination with the outfall from the treated water from the sediment ponds, would be restricted to PSD restrictions at the Dapto Creek outfall as per the WCC's DCP requirements for a 5 year ARI minor storm and 100 year ARI major storm.

Water quality monitoring would be conducted before and/or after the clean drain is constructed in accordance with the site management plan to ensure water quality criterion have been met in accordance with the EPL licence. Surface water monitoring would be taking place throughout the construction and operation of the landfill site to ensure sediment laden surface water is kept below permissible criteria (refer draft LEMP in Appendix P of the EA).

Sediment migration would be managed on site through the use of erosion controls and sediment ponds to collect migrating silts prior to discharging off site (refer draft LEMP in Appendix P of the EA).

LEGEND

CATCHMENT AREAS	HECTARES
AREA 1A	3.00 Ha
AREA 1B	2.20 Ha
AREA 1C	2.00 Ha
AREA 2	2.00 Ha
AREA 3	8.60 Ha
AREA 4	2.00 Ha
AREA 5	4.00 Ha
AREA 6	10.30 Ha
AREA 7	10.00 Ha
AREA 8	1.90 Ha
AREA 9	0.80 Ha
AREA 10	9.00 Ha
AREA 11	4.60 Ha

CATCHMENT BOUNDARIES

SITE BOUNDARY

DRAINAGE AND FLOW DIRECTION

LEACHATE PONDS

SURFACEWATER PONDS

SOURCE:

- BASE DRAWING TAKEN FROM K F WILLIAMS & ASSOCIATES WHYTES PHOTOGRAMMETRY AND GROUND SURVEY 20-07-11
- GRID COORDINATES ARE MGA 94, ZONE 56

nearmap IMAGE DATED 06.11.2012 SOURCED WITH PERMISSION FROM NEARMAP ON 21.11.2012 IMAGE GEOREFERENCED BY GOLDER AND INTENDED FOR INDICATIVE PURPOSES ONLY www.nearmap.com.au

ISSUED FOR

PRELIMINARY

NOT FOR CONSTRUCTION

1:4,000

0 80 160 240m

Golder Associates

www.golder.com
GOLDER ASSOCIATES PTY. LTD.

CLIENT	WOLLONGONG CITY COUNCIL		
DRAWN BY	HC	DATE	21.11.2012
CHECKED BY	MN	DATE	30.11.2012
SCALE	1:4,000	SHEET SIZE	A3

PROJECT: STAGE I PROPOSED WORKS
WHYTES GULLY LANDFILL GAS COLLECTION SYSTEM

DRAWING TITLE: EXISTING CATCHMENT BOUNDARIES AND SURFACE WATER MANAGEMENT

PROJECT No	DOC No	DOC TYPE	FIGURE No	REVISION	
117625003	207	R	F008	0	FIGURE 4

Plot Date: 20 December 2012 Time:10:21:47 AM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\FIGURES - File Name:117625003-208-R-F008-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-WHYTES PHOTOGRAMMETRY AND GOUND SURVEY 20-07-11.dwg; 117625003-XREFAERIAL 06_11_2012.dwg; Nearmap_Logo.jpg; WGCoords.jpg; 1-1.jpg;

3.8.5 Surface Water Pond Reconfiguration

The submission by DPI states the following in relation to surface water ponds:

1) *The Department notes that it is proposed to reconfigure existing surface water ponds that are located on flood affected land. The Department wishes to clarify if the reconfigured ponds would have the same capacity and bund level height/s as the existing ponds.*

2) *The Department requires more information on the potential impacts of this reconfiguration on the available flood storage area and flooding behaviour.*

3) *The Department also requires a discussion of what the potential environmental and downstream impacts would be if the surface water ponds were inundated during the 100 year ARI flood event.*

Response

The surface water ponds are not to be reconfigured, rather the reed bed ponds will cease being used and the polishing pond used as the surface water pond as the size of the catchment decreases substantially (approximately 60 per cent) between Stage 3 and 4 of the project.

Furthermore, based on the results of the surface water routing and flood analysis (refer Appendix A), the 100 year flood would not reach the site, and as such the ponds would not impact the 100 year flood event.

3.9 Leachate

The response to leachate comments has been arranged by the following main themes:

- Leachate Treatment Plant Augmentation
- Leachate Pond Capacity
- Sewer Capacity

3.9.1 Leachate Treatment Plant Augmentation

The submission by DPI states the following in relation to the leachate treatment plant augmentation:

1) *The Department notes from the EA that it is proposed to 'augment the existing landfill leachate biological treatment plant required to treat leachate for disposal to the sewer system' (p. 50) as part of the project. The Department requires more detailed information on what this entails and when?*

Response

As discussed in Section 12.5.2 of the EA, WCC would log and review the leachate generation volumes and rainfall amounts during 2014 and reassess the water balance model assumptions for infiltration rates and continue to liaise with Sydney Water on timing for sewer capacity upgrade and quantify and assess the need to upgrade the leachate treatment plant.

3.9.2 Leachate Pond Capacity

The submission by DPI states the following in relation to leachate pond capacity:

1) *The EA states that the existing leachate ponds would cater for worst-case leachate volumes generated for stages 1 to 3 of the project (ie 18 000 m^3). However, it is unclear if the existing leachate ponds would have (reserve) additional capacity for high rainfall events (eg. As a minimum, a 1 in 25 year storm event) and appropriate freeboard for wave action.*

2) *The department needs to be satisfied that the existing leachate ponds have sufficient capacity to cater for worst-case leachate generation during high rainfall events and/or long wet periods. Additional contingency actions for reducing leachate volumes during high rainfall event/periods should be detailed.*

Response

The freeboard provided on the leachate ponds is approximately 300 mm which is provided for wave action, and also is able to receive approximately a 1 in 25 year, 24hr ARI storm event.

Of greater significance to the pond's capacity is the worst case wet weather period modelling. Modelling of required leachate pond capacity is presented in Section 4.5 of Appendix G5 of the EA (Leachate Generation and Water Balance Modelling). To determine the required capacity of the leachate ponds in stages 1 to 3 a worst case wet weather period was modelled using two consecutive years of 90th percentile annual rainfall data as recommended in the EPA Victoria's *Best Practice Environmental Management – Siting, Design, Operation and Rehabilitation of Landfills* (2010). The modelling showed that the ponds have sufficient capacity to store leachate during two consecutive wet years, with a peak cumulative leachate storage requirement occurring during the third month of the Project (during Stage 1A), and the volume of leachate storage required generally decreasing as the Project progresses.

Contingency measures for leachate storage and/or treatment include discharge directly to sewer from leachate ponds, reinjection into waste, provision of temporary 'package' treatment plants, upgrade treatment plant, construct a cover over leachate ponds, trucking of leachate to sewage treatment plant for disposal and use of the old leachate ponds until the end of Stage 1. These contingency measures are presented in Section 12.5 of the EA and Section 5.0 of Appendix G5.

Additional measures to prevent overtopping of leachate ponds include the provision of freeboard and the use of shutoff valves on leachate lines to shut off flow to the ponds when capacity is reached.

3.9.3 Sewer Capacity

The submission from Asciano stated:

1) *Sydney Water have denied our Reddalls Road site access to the same sewer on the basis that the sewer line is at 100% capacity. Given that they are expanding the landfill I assume that the leachate discharge will increase. If the sewer is already at 100% capacity how can it handle this additional volume from the landfill? Has the landfill 'reserved' some additional sewer capacity or have they been given preferential treatment regarding access to the sewer system?*

Response

The calculations for future discharges to sewer are in accordance with the limits set in the existing Sydney Water Trade Waste Agreement for the site for discharge to sewer, reference is made to Section 12.5 of the EA.

This approach is considered to be conservative, as a future upgrade to the capacity of the West Dapto sewer main is planned, as detailed in a recent Sydney Water Booklet titled *West Dapto Urban Release Area and Adjacent Growth Areas, Proposed water and wastewater services* (September 2012, available http://www.sydneywater.com.au/majorprojects/South/WestDaptoUrbanReleaseArea/index.cfm).

3.10 Flora and Fauna and Heritage

Reponses to submissions with regard to flora, fauna and heritage have been arranged under the following themes:

- Biodiversity
- Riparian Land
- Flora and Fauna
- Heritage

3.10.1 Biodiversity

The submission by OEH states the following in relation to biodiversity:

1) *Impacts of vegetation may occur as a result of the 'construction phase of the project' and the future operation of the expanded landfill. To offset these losses, measures including a weed control program in the remaining 0.55ha (or 0.48ha) of ISTR (and an unknown area of other native vegetation communities) and the revegetation of an unknown disturbed areas are proposed. These measures are to be undertaken in accordance with a Landscape Strategy (appendix N) which contains little detail on how existing native vegetated areas proposed to be retained will be restored and/or managed.*

2) *To realise the proponent's commitment 'to ensure the proposal maintains or improves the biodiversity values of the region', OEH recommends the offsetting measures be assessed against the 'Principles for the use of biodiversity offsets in NSW' (Offsetting Principles). In accordance with the first of these principles, OEH recommends DPI seek from the proponent justification on why the proposed clearing of the 0.49 ha of good condition native vegetation cannot be avoided. OEH also recommends any approval include a requirement for the proponent to prepare a biodiversity offset strategy detailing the proposed offset measures to be implemented and secured and how they will be protected managed, funded and monitored over the duration of the project. The offset strategy should also reference best management guidelines for restoring and managing the vegetation communities proposed for protection.*

Response

Reference is made to Chapter 13 of the EA and the Flora and Fauna Assessment Report in Appendix F of the EA.

Table 9 in Section 4.1 of Appendix F documents 0.49 ha of native vegetation mapped as Forest-Redgum Open Forest/Closed Woodland (0.48ha) and ISTR (0.01ha) to be cleared as a direct impact of the Project. The Forest Redgum community is described as being in poor condition due to dominance of exotic species in the midstorey and ground layer and the ISTR proposed to be removed is described as being in moderate to poor condition due to woody weeds throughout the midstorey.

Works recommended to offset native vegetation removal include regeneration of native vegetation communities to improve quality, as well as re-vegetation of cleared and disturbed areas. WCC commit to providing a Vegetation Management Plan (VMP) to address restoration works.

An assessment of proposed offsetting measures against the thirteen Offsetting Principles is outlined below:

1) *Impacts must be avoided first by using prevention and mitigation measures*

The new landfill cell has been significantly redesigned to retain majority of the ISTR. and other vegetation communities.

2) *All regulatory requirements must be met*

All offsetting provisions outlined in the Biosis report are to offset residual losses of native vegetation, following all efforts to avoid and minimise losses of native vegetation. All regulatory requirements will be met through the approvals process.

3) *Offsets must never reward on-going poor performance*

All efforts have been taken to avoid and minimise impact to native vegetation. The measures proposed to offset native vegetation losses include improvements to the quality of retained native vegetation.

4) *Offsets will complement other government programs*

The areas where offsetting measures are proposed are not currently managed for biodiversity conservation.

5) *Offsets must be underpinned by sound ecological principles*

The majority of works are proposed in areas of retained ISTR, an endangered ecological community, as well as restoration of areas of other native vegetation communities. These areas are not currently managed for conservation, and would assist in retention and improvement of vegetation in the local area, and at a regional scale.

6) *Offsets should aim to result in a net improvement in biodiversity over time*

Offsetting measures include restoration of ISTR and Forest Red Gum Community, as well as re-vegetation of disturbed areas. These measures would result in an increase in areas of native vegetation across the site as well as improvements in the quality of retained vegetation.

7) *Offsets must be enduring - they must offset the impact of the development for the period that the impact occurs*

Offsetting measures are proposed through the life of the Whytes Gully Landfill site. All areas proposed for restoration or re-vegetation are outside of the operational areas of the landfill site.

8) *Offsets should be agreed prior to the impact occurring*

Regeneration and re-vegetation works would be outlined in a VMP. This VMP would be prepared prior to the removal of native vegetation.

9) *Offsets must be quantifiable - the impacts and benefits must be reliably estimated*

The VMP would specify hectares of vegetation to be restored, as well as management actions, planting lists, maintenance program and a timeframe for the works, setting out the works program.

10) *Offsets must be targeted*

Offsets are proposed for the two vegetation communities proposed to be impacted, namely the Forest Red Gum Community and ISTR.

11) *Offsets must be located appropriately*

Offsetting measures are proposed for on-site. If suitable offsets were not available off-site offsets in immediate proximity to the local area are available.

12) *Offsets must be supplementary*

The areas proposed for restoration works are not currently managed for conservation or funded under any conservation scheme.

13) *Offsets and their actions must be enforceable through development consent conditions, licence conditions, conservation agreements or a contract*

Offsetting measures, and measures to monitor the success of these offsets, would propose to be provided in a VMP.

Restoration works are to follow the guiding principles set out in DEC (2005) *Recovering Bushland on the Cumberland Plain: Best practice guidelines for the management and restoration of bushland*.

- **Retain** – Retain remnant indigenous vegetation. Conserving existing native vegetation should be the highest priority;
- **Regenerate** – Where bushland remains but is degraded, regeneration should be the primary objective;
- **Revegetate** – Where there is no regeneration potential, revegetation is then an option.

The design of the new landfill cell has been significantly redesigned to retain the majority of the ISTR. Regeneration is recommended in the ISTR patch as this area has regeneration potential and an increase in native species diversity is expected following regeneration works in this area. Revegetation is recommended in disturbed areas. Briefly this would include the revegetation of areas that would not be disturbed by the ongoing operations of the recovery centre and would be restricted to the northern portion and the north western boundary of the site. This area would be planted with a diversity of species of local provenance to re-establish the Forest Red Gum Community over this area.

The draft Statement of Commitments within the EA outlines a number of mitigation measures in relation to Flora and Fauna and offsetting and the VMP would provide further detail of an offset strategy and would be developed in accordance with the Principles for the use of Biodiversity Offsets in NSW as outlined above.

Offsetting measures, and measures to monitor the success of these offsets, would be outlined in the VMP.

3.10.2 Riparian Land

The NOW submission states the following in relation to riparian land:

1) *Section 3.5.4 of the Terrestrial and Aquatic Flora and Fauna Assessment (TAFFA) in Appendix F refers to the RCMS riparian buffer widths to be considered in the planning and design of the proposal. The EA (Section 13.3) and Section 4.2 of the TAFFA recommends as a mitigation measure to maintain suitable buffer distances from nearby waterways based on the stream orders of waterways and the subsequent categories identified within the Wollongong DCP (2009). It should be noted the riparian land management section in Wollongong DCP 2009 (Chapter E23) is not based on stream order but on the DIPNR (2004) Riparian Corridor Management Study. Map 7 in DIPNR (2004) is the relevant riparian map for the Whytes Gully site. It is not clear how the recommended buffer distances shown on Figure 9 in Appendix F have been derived.*

2) *The 12th dot point under Flora and Fauna (page 256, Volume 1) refers to maintaining suitable buffer distances from nearby waterways and it notes these buffer distances are based on stream orders of waterways and the subsequent categories identified within the Wollongong City Council Development Control Plan 2009. The riparian land management section in Wollongong DCP 2009 (Chapter E23) is not based on stream order but on the DIPNR (2004) Riparian Corridor Management Study (RCMS).*

Response

Generic advice sought from NOW and WCC as a part of this response to submissions indicates that the new *Guidelines for riparian corridors on waterfront land* (NSW Office of Water, July 2012) have replaced the RCMS method and would be the minimum that is required from NOW and WCC when assessing riparian buffer widths.

Outcomes from discussions with NOW specifically relating to the Project's potential impact on buffer widths were completed. NOW identified they agree to the usage of buffer widths identified within Map 7 of DIPNR (2004) and a merit based assessment for the historic stream within the resource recovery park boundary as completed in the EA and Appendix F.

Figure 9 of the Biosis report has been amended to further define the buffer widths of the merit based assessment, as well as the usage of Map 7 of the DIPNR (2004) Riparian Corridor Management Study (refer Figure 5 below). All proposed buffer zones are outside of the Resource Recovery Park boundary.

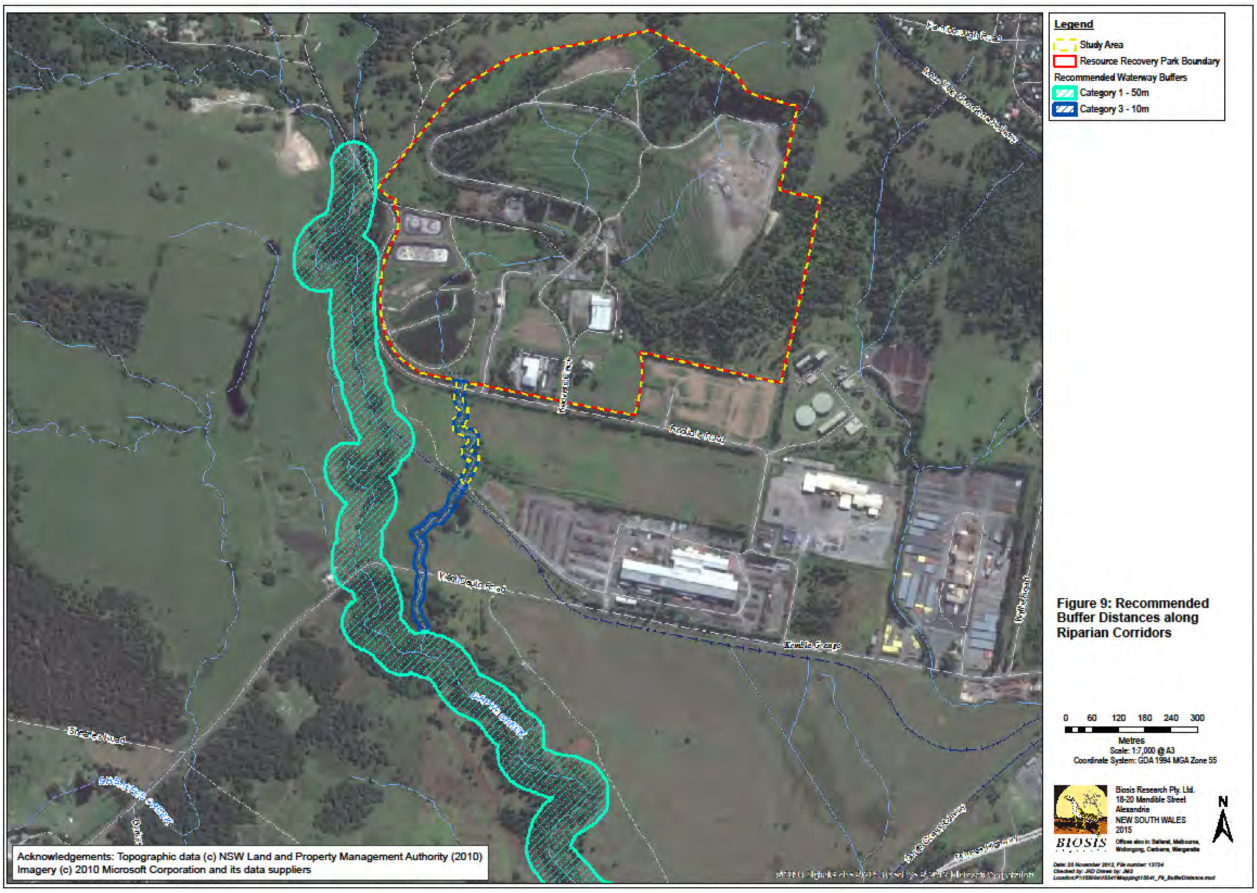


Figure 5: Recommended Buffer Distances along Riparian Corridors

3.10.3 Flora and Fauna

The WCC submission states the following in relation to flora and fauna:

1) *The report would have benefited from:*

- *Page 18 - Reference to the Illawarra Biodiversity Strategy (2011) rather than the draft Illawarra Biodiversity Strategy.*
- *Page 32- Reference to the current requirements for Lantana under the NSW Noxious' Weeds' Act 1993 for the Wollongong LGA, i.e. The growth of the plant must be managed in a manner that reduces its numbers, spread and incidence and continuously inhibits its reproduction and the plant must not be sold propagated or knowingly distributed.*
- *Reference to the current requirements for African Lovegrass under the NSW Noxious' Weeds' Act 1993 for the Wollongong LGA, i.e. the growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction.*
- *Page 54 - Reference to the Water Management Act 2000 rather than the Rivers and Foreshores Improvement Act 1948.*
- *Page 140 - Replacement of the unrealistic result of 0.1 J-ls/cm conductivity for Whytes Gully surface water ponds with an actual realistic result.*

The Asciano submission states:

2) *Will the new cells attract / increase new/existing wildlife to the site? What is in place to ensure the site does not attract excessive wildlife to the area with the accompanying fall out. In some cases the acid in bird faeces can etch vehicle paintwork within 48 hours if it is not removed.*

Response

WCC comments are noted.

The Project is unlikely to substantially change the current diversity of species in the site, and the intensity of operations is not increasing. Issues associated with vermin, pests and litter are addressed in the Section 9 of the Draft LEMP (Appendix P of the EA). This includes measures such as daily covering of waste and minimising the size of the operating tipping face.

3.10.4 Heritage

The Asciano submission noted:

1) *Adverse impacts upon existing heritage on site and surrounding area*

Response

Aboriginal and non-Aboriginal heritage impacts of the Project were assessed in Chapter 16 of the EA finding it would have negligible impacts upon known heritage sites on the site or surrounding area.

3.11 Dust and Odour

The EPA submission states:

1) *The issue of PM10 24-hour average exceedances requires some clarification. The proponent should confirm the cumulative 24-hour average PM10 assessment results. If the results shown in Figure 7.12 are correct, the proponent should provide a revised assessment including additional controls to ensure no exceedances are predicted to occur due to project operations. If the assessment does not predict exceedances of impact assessment criteria for PM10, the EPA recommends conditions of approval.*

The Asciano submission states:

2) *Patrick Autocare will be storing vehicles within 250 m of the proposed expansion cells. We require surety that the proposed expansion does not increase the amount of dust/dirt in the air that may settle on the vehicles in storage and affect the health and safety of our staff. Key concerns: (i) vehicle paint damage caused by dust with metallic content settling on new vehicles in storage. (ii) increase the need to perform vehicle washing due to increase amount of dust/dirt (iii) employee's health and safety may be affected (breathing issues) due to increase gasses/odours/dust/dirt in the area.*

Response

3.11.1 Dust

The NSW EPA was correct that the text and Figure 7.12 were conflicting. Figure 7.12 was correct and did show one additional cumulative exceedance of the 24-hour average PM10 criterion at R1 during Stage 4. It is noted however, that this was a conservative assessment and the exceedance was less than 2 $\mu g/m^3$ above the criterion, on a single occasion.

Notwithstanding this, dust control measures have been applied to dozer activity and then Stages 1 and 4 were remodelled. Emissions from dozer activity are estimated make up more than half of the total emissions from the site.

Katestone (2011) suggests that a 50% reduction in emissions can be achieved by keeping travel routes moist. This factor was applied to the Stage 1 and 4 emissions inventories and the results and assessment report updated.

Figure 6 shows the updated time series (measured and modelled incremental increase) for the nearest residence (R1) during Stage 4, assuming that dozer travel routes are kept moist. This results in no predicted additional exceedances above the 24-hour PM10 criterion.

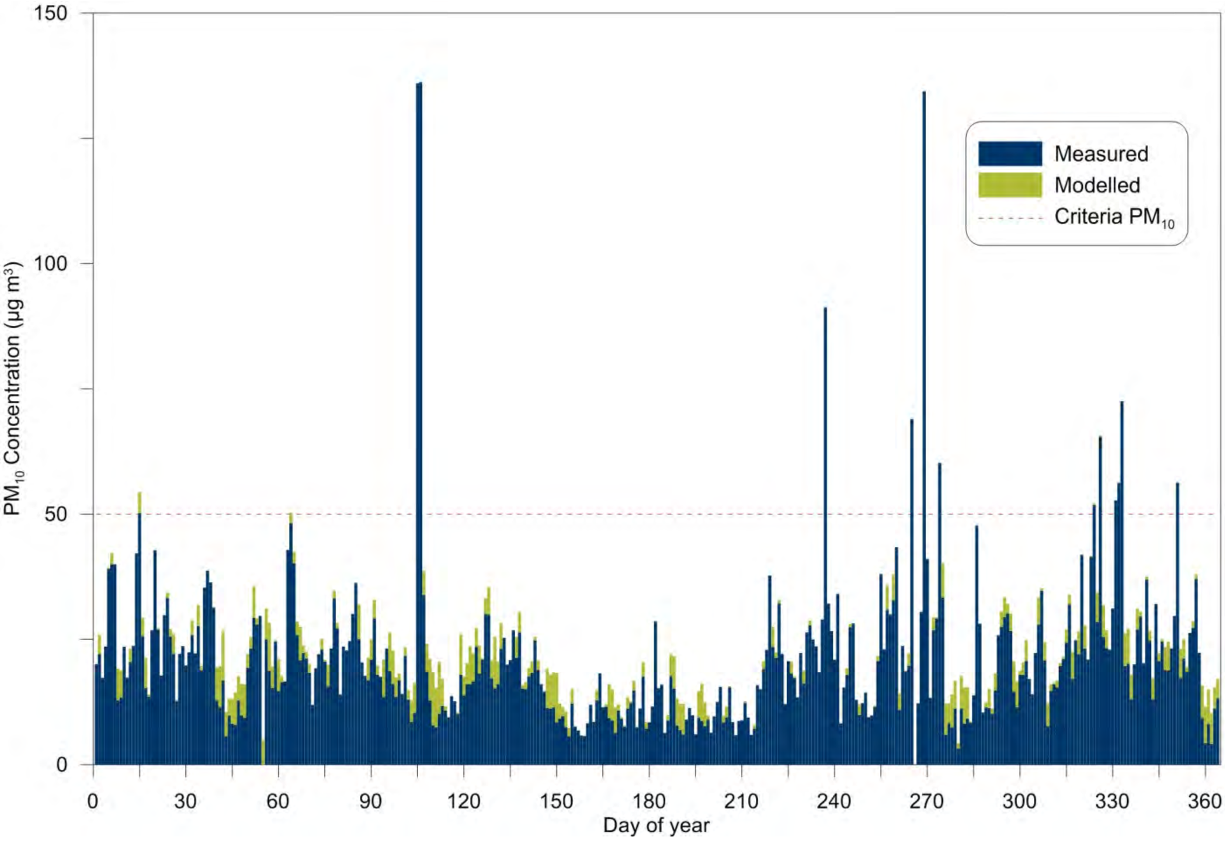


Figure 6: Time series of measured and modelled 24-hour average PM_{10} concentrations at R1 (Stage 4).

Figure 7 shows the predicted annual average dust deposition levels in Stage 1, likely to be the worst case for Asciano (Patrick Autocare site). These are the remodelled results with dust controls on dozers.

The levels at the Patrick site are predicted to be less than 0.1 g/m^2/month which is well below both the incremental and cumulative criteria for nuisance impacts. These criteria are set to protect public amenity (i.e. dust nuisance), including visible dust on cars, and predictions indicate that the contribution from Whytes Gully is likely to be less than four times below the incremental criterion of 2 g/m^2/month.

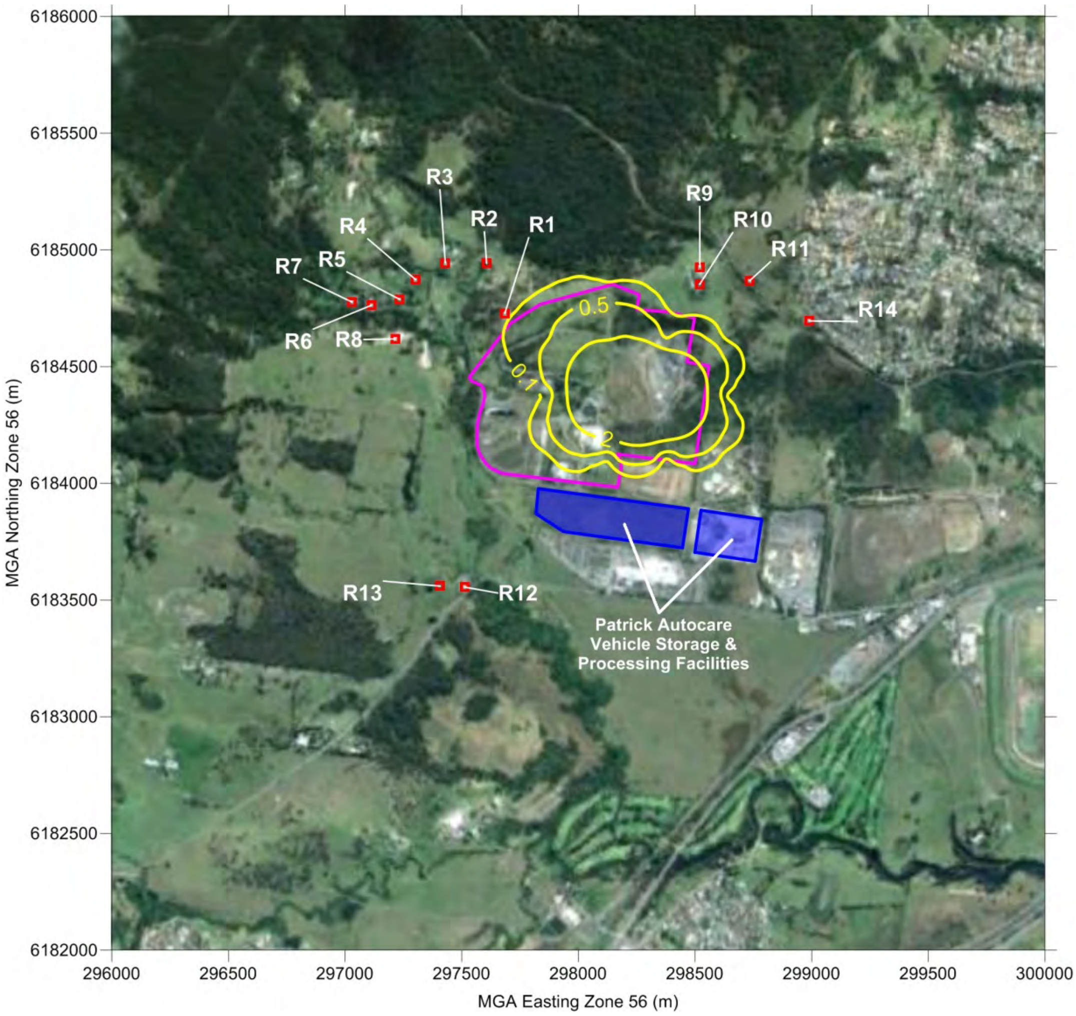


Figure 7: Predicted annual average dust deposition levels due to Stage 1 operations (g/m2/month)

Figure 8 shows the 24-hour average PM10 concentrations predicted at the Patrick site and surrounding land, due to proposed Stage 1 operations. Maximum incremental increases in 24-hour PM10 are predicted to be of the order of 2 µg/m^3, significantly below the health-based criterion of 50 µg/m^3.

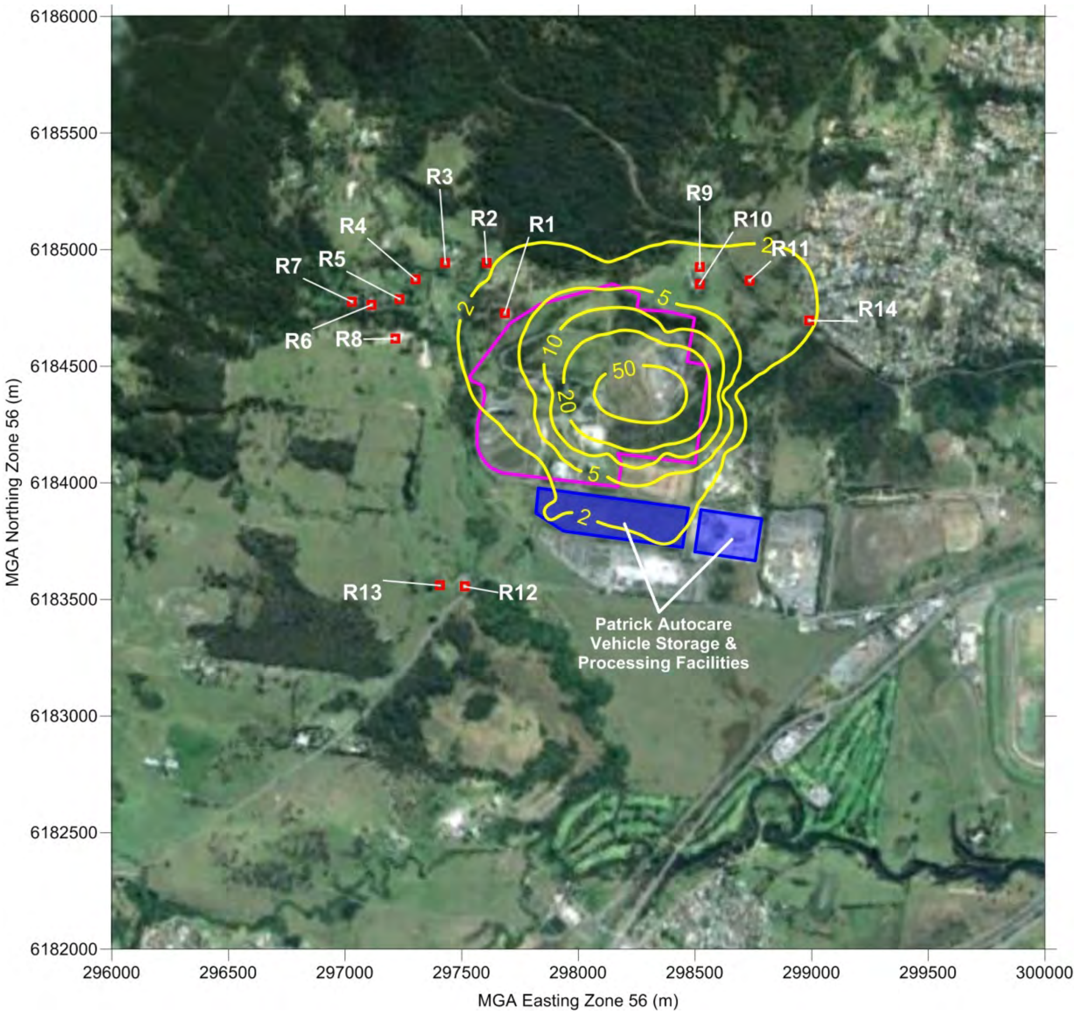


Figure 8: Predicted 24-hour average PM10 concentrations due to Stage 1 operations (µg/m3)

In relation to the "key concerns" raised by Asciano, the following points are made:

- Predicted annual average dust deposition levels at the Patrick site do not indicate that vehicles in storage are likely to be adversely impacted with respect to additional dust loads. Levels are well below the criterion set to protect amenity, including dust on cars.
- Predicted 24-hour and annual average predictions due to operations at the Whytes Gully landfill are not predicted to be at levels that would exceed health-based air quality criteria.

3.11.2 Odour

Odour assessment criteria are designed to take into account the range in sensitivities to odours within the community, and provide additional protection for individuals with a heightened response to odours. The EPA suggests that an odour criterion of 7 odour units (ou) is likely to represent the level below which offensive odours should not occur for an individual with a standard sensitivity. The EPA therefore recommends that no individual be exposed to odour levels greater than 7 ou (99th percentile) in its Technical Framework for odour assessment and management (EPA, 2006).

Stage 1 is likely to represent the worst case period with respect to odour, as previously buried waste would be uncovered briefly during excavation operations. The odour impact assessment predicted that levels of approximately 5 ou (99th percentile) are anticipated at the Patrick site during Stage 1 operations. This does not mean that odour levels above 5 ou would never be experienced at that location, but rather they are not anticipated to occur for more than 1% of the time (88 hours per year), in line with the EPA criterion.

In relation to odour, levels are not predicted to exceed 7 ou (99th percentile) at the Patrick site, an appropriate level for this site.

3.12 Traffic

The submission by DPI states:

1) *The Department notes that construction and operation of the project would be undertaken concurrently.*

2) *The Department therefore considers that the traffic impact assessment should consider the worst-case scenario of cumulative traffic impacts (ie. Adding the predicted worst-case construction and operation traffic numbers and assessing the impact of this on the safety and capacity (ie. Level of service) of the surrounding street networks). Any inconsistency with this approach should be adequately justified.*

The submission by RMS notes that:

3) *The traffic modelling assumes that the intersection of the Princes Highway and West Dapto Road would be signalised by mid 2012, and that at the time of preparing their submission (dated 7 September 2012) works had not yet commenced.*

The submission by WCC states

4) *A Traffic Management Plan is to be implemented during the construction phases of the Project.*

The submission from Asciano notes the potential for:

5) *Adverse impacts upon traffic within the site and surrounding.*

Response

Traffic and Transport impacts are assessed in Chapter 15 of the EA and the Transport Assessment presented in Appendix I of the EA.

With regard to operational traffic assessment methodology utilised for assessment of the Project, Section 5 of the Traffic Assessment identifies that a sensitivity analysis has been conducted using an increase of material accepted at the facility of 20% (Sensitivity Test 1) and of 40% (Sensitivity Test 2). Both tests model the worst case operating conditions where operational and background traffic occur along with cell construction and capping at the same time. Other conservative assumptions of the modelling are detailed in the Traffic Assessment (Appendix I of the EA).

A Traffic Management Plan is proposed to be prepared prior to commencement of construction and operation. As noted in Section 15.2.1 of the EA, while the traffic modeling assumes the Princes Highway/West Dapto Road intersection (including installation of traffic signals) upgrade, the traffic Impact Assessment provided in Appendix I of the EA identifies that even if the intersection upgrade is delayed beyond construction of the Project there is adequate road capacity to cater for the anticipated additional construction traffic generated by the Project.

3.13 Socio-economic

The submission from Asciano noted:

1) *adverse socio-economic considerations to the site and surrounding area.*

Response

The socio-economic impacts are assessed in Chapter 18 of the EA and the assessment demonstrates a net benefit to the community.

3.14 Visual Assessment

The submission from Asciano noted:

1) *adverse impact on visual amenity.*

Response

The visual impacts are assessed in Chapter 17 of the EA. The overall potential visual impact of the Project is assessed as generally low to moderate, with mitigation measures proposed to reduce potential impact of the Project.

3.15 Bushfire Risk

The submission from Asciano noted:

1) *increase in the potential of bushfire hazard upon the site and surrounding area.*

Response

Bushfire risk is assessed in Chapter 19 of the EA. The assessment considered that with identified safeguards and mitigation measures, the project would not result in a significant risk to human health, life or property or the biophysical environment.

4.0 MODIFICATIONS MADE TO THE PROJECT

4.1 Overview

In order to address comments received from DPI principally relating to potential offsite noise impacts (refer Section 3.4 of the Report), the final Stage of the EA (4-2) is proposed to be split into two parts (Stage 4-2A and Stage 4-2B) (Refer Figure 1).

The breakdown of Stage 4-2 into two parts allows for a further level of detail on the duration of operations in this stage, in particular the duration of operations in proximity to Receiver N1. The approximate stage volumes and timelines of the parts of Stage 4 are presented in Table 7.

Table 7: Approximate Stage 4 Volumes and Timelines

Stage	Area (m2)	Airspace (cum)	Life of Cell (Years)	Operation Period	Proposed Capping Construction Period *	Proposed Liner Construction Period *
4-1	27,000	152,000	1.1	2046-2048	2048	2046
4-2A	9,000	300,000	2.1	2048-2050	2051	2047
4-2B	33,000	555,000	4.0	2050-2054	2054-2055	2049
Stage 4 Total	69,000	1,007,000	7.2	2046-2054	2048-2055	2046-2050

*not continuous during this period

The breakdown in Table 7 shows that the duration for landfilling in Stage 4 was previously nine years.

4.2 Noise

Stage 4-2 has been split into two parts (4-2A and 4-2B) divided by the existing ridgeline, such that Stage 4-2A sits behind the ridgeline. The division of Stage 4-2 into two parts would act to attenuate noise from operations in Stage 2A due to increased distance to the N1 receptor and also due to the ridge line acting as a buffer (refer to Section 3.4.2 of the Report). Additional noise modelling has been undertaken to assess the impact on sensitive receiver N1 for stages 4-2A, demonstrating that the noise generated meets applicable criteria for the Project as identified in Section 3.4.2 of the Report).

It is proposed that the Project would be subject to further detailed noise modelling prior to commencement of stage 4-2B construction. This is identified within the revised draft Statement of Commitments presented in Section 5.0 of the Report.

5.0 REVISED DRAFT STATEMENT OF COMMITMENTS

Chapter 21 of the EA presented the draft Statement of Commitments to outline all proposed environmental management and monitoring measures to reduce adverse impacts of the Project.

The draft Statement of Commitments has been revised to reflect the issues and modifications to the Project as identified within the Report. WCC commits to implementing these commitments with approval of the Project.

The final Statement of Commitments would be considered by DPI and identified with determination of the Project. Should approval be granted, the final Statement of Commitments would become part of the Project approval conditions.

Table 8: Revised Draft Statement of Commitments

Issue	Commitments
General	■ Wollongong City Council would implement the Project in accordance with the EA and conditions of approval as provided by the determining authority. ■ Wollongong City Council commit to considering the Concept Site Masterplan for future planning of resource recovery activities on the Whytes Gully RRP site. This includes consideration of an appropriate footprint for future resource recovery activities and access requirements. ■ By 2014 Wollongong City Council's Waste Strategy commits Wollongong City Council to reviewing available alternative waste technologies as identified in Wollongong City Council's Waste Strategy. ■ If the Project is approved, it is proposed that Wollongong City Council would surrender existing development consents of relevance to the Project site. This does not include the existing development consent for the MRF, which is not affected by the Project.
Waste Management Strategy	■ Wollongong City Council would implement the Project in accordance with the "Wollongong City Council Waste and Resource Recovery Strategy 2012 to 2022" as provided in Appendix B and future updates of this document as relevant to the Project. ■ Detailed design of the Project would consider and address constraints and opportunities identified within the EA.
Environmental management plans	■ A Construction Environmental Management Plan would be prepared and implemented to guide environmental management and monitoring activities during construction. The CEMP would include specific environmental issue sub-plans to reduce potential impacts and in accordance with relevant commitments identified within the EA and within this table. A monitoring program shall be conducted throughout the construction period to monitor compliance with the CEMP. ■ The Landfill Environmental Management Plan (LEMP) would be implemented to be consistent with the draft LEMP provided in Appendix P. This includes implementation measures to guide environmental management and monitoring activities during operation as identified within the EA in addition to further specific issues identified within this Table. ■

Issue	Commitments
Noise	Wollongong City Council commit to the following with regard to noise: ■ All mobile equipment would be selected to minimise noise emissions. Equipment would be fitted with silencers and be in good working order. ■ Broadband reversing alarms would be used for all site equipment. ■ Construction activities would be limited to the recommended construction hours where feasible and reasonable. ■ Consultation with residents who are identified as potentially affected by cumulative and operational noise exceedances and communication of details of the construction and operational program on a regular basis. ■ Provide a community liaison phone number and permanent site contact so that noise complaints would be received and addressed in a timely manner. ■ Submission of a noise impact assessment and associated mitigation measures for Stage 4-2b for approval prior to commencement of construction of Stage 4-2b.
Greenhouse Gas	Wollongong City Council commit to the following: ■ An active landfill gas management system would be installed including flaring and/or combustion to reduce potential greenhouse gas emissions from the landfill. ■ Potential energy efficiency measures would be considered in the detailed design phase of the Project and be implemented and monitored through an Energy Savings Action Plan in accordance with the "Guidelines for Energy Savings Action Plans (DEUS 2005).
Erosion and Sedimentation Control	■ An Erosion and Sedimentation Control Plan would be developed as part of the CEMP in general accordance with the following erosion and sedimentation control principles including: ▪ Construction of earth bunds and diversion drains upslope and around the perimeter of construction areas where surface disturbance occurs, to prevent clean surface water entering these areas. ▪ Erection of silt fences or straw bales at strategic locations (i.e. around stockpiles) to manage the migration of fines. ▪ Construction of temporary sediment retention ponds. ▪ Dust suppression as needed. ▪ Reducing the surface area disturbed by construction activities at any one time. ▪ Regular inspection and maintenance of sediment and erosion control structures. ▪ Protecting and retaining vegetation and surface cover where possible.

Issue	Commitments
	▪ Placement of an erosion protection barrier (e.g. grassing) at the completion of works. ▪ Using designated access roads and paths where possible. ▪ Removing soil adhering to the wheels and undercarriage of trucks (e.g. by wheel wash) prior to departure from the Project site. ▪ Limit both the size of any stockpile footprints and the time between excavation and removal off-site of materials. ▪ Do not place stockpiles within 30 m of any watercourse. ▪ Stabilise all disturbed areas as soon as practicable. Temporary vegetative destabilisation techniques must be applied to any disturbed soil to prevent areas remaining bare for more than 28 days. ▪ Stabilise all temporary and permanent drainage immediately. ▪ Maintain all sediments and erosion control measures in effective condition until the works are completed and the site is stabilised. ▪ Release "Dirty" Stormwater, captured and stored by sediment and erosion control measures or site works, after treatment and testing to confirm compliance with relevant criteria. ▪ A monitoring program shall be conducted by throughout the construction period to monitor compliance with the CEMP. ■ Proposed erosion and sediment control measures that would be applied during operation of the Project are outlined in the draft LEMP (Appendix P).
Acid Sulfate Soils	In the event of discovery of Acid Sulfate Soils, procedures would be implemented/adopted to mitigate potential impacts on the environment in accordance with appropriate guidance and legislation and as identified in Chapter 12 of the EA.
Contamination	In the event of discovery of previously unidentified area(s) of potentially contaminated material, procedures would be implemented/adopted to mitigate potential impacts on the environment, employees and the public in accordance with appropriate guidance and legislation and as identified in Chapter 12 of the EA.
Surface water	■ A Surface Water Management Plan would be developed as part of the CEMP in general accordance with the following control principles: ▪ Bund fuels, oils, paints, and other chemicals onsite to comply with the requirements of relevant legislation. ▪ Bunds must be fitted with an impervious floor and must not be fitted with a drain valve. ▪ Remove accidental spills of soil or other materials. ■ Wollongong City Council would commit to the following key principles in developing the surface water management controls for operation of the

<table>
<tr><th>Issue</th><th>Commitments</th></tr>
<tr><td></td><td>Project.
▪ Diversion of clean drainage directly into Dapto Creek. Runoff from areas that are unaffected by the development would be allowed to discharge directly from the site to Dapto Creek.
▪ Runoff from areas that are likely to generate sediment such as the new cell construction areas and stockpile areas would be directed into the Surface Water Ponds.
▪ Reduce the volume of runoff to Surface Water Ponds by reducing the contributing catchment area at any particular time.
▪ Keep sources of different water quality types separate from each other.
▪ Construction of a perimeter bund around the entire active landfill area to prevent surface water from entering the landfill area.
▪ Construction of a diversion drain around the entire landfill area to collect all runoff from disturbed areas (but outside exposed/uncapped active waste cell area(s)) which would drain to the sedimentation basin
▪ The existing surface water ponds would be used for Stage 1 to 3 of the development.
▪ The Surface Water ponds would be downsized for Stage 4 onwards, as Stage 1 to 3 would be rehabilitated and runoff would be directed offsite to Dapto Creek.
▪ Re-use ‘dirty’ water for dust suppression.</td></tr>
<tr><td>Groundwater</td><td>■ A Construction Quality Assurance (CQA) system would be implemented for cell construction. Detailed CQA requirements are embedded in the Technical Specification of the Design Report (Appendix O).
■ During the operational phase of the Project a number of engineering measures and management strategies would be used to mitigate impacts to groundwater. Further documented within the EA these include:
▪ Leachate Barrier System and Leachate Collection System
▪ Leachate Pond
▪ Leachate Treatment Plant
▪ Groundwater separation
▪ Monitoring
– A network of groundwater bores would be used to monitoring groundwater quality and trends at the Project Site. This would include a regular programme of groundwater sampling and assessment as detailed in the LEMP.
– The leachate management system would be monitored in accordance with measures described in the LEMP including direct monitoring for the purposes of system integrity, leachate quantity and quality.</td></tr>
</table>

Issue	Commitments
	– Groundwater Assessment Program to monitor background concentrations. If a significant change in concentration for any of the indicator parameters is detected over two consecutive monitoring periods, then the affected groundwater monitoring bores would be resampled and assessed and OEH notified (if required). Following this a groundwater remediation plan may be developed in accordance with the LEMP. – Combined surface water and groundwater monitoring program to gain an understanding of surface water and groundwater interaction and to assess potential impacts on the downstream environment including Dapto Creek and GDEs
Leachate Management	Wollongong City Council commit to the following with respect to leachate management: ■ Segregation of leachate from surface water and groundwater; ■ Maintain pond levels with adequate freeboard to minimise the potential for overflow; ■ Continue to monitor leachate discharge to sewer in accordance with Trade Waste Agreement.
Flora & fauna	Wollongong City Council commit to the following to ensure the Project maintains or improves the biodiversity values of the region. ■ Clearing for the purposes of bushfire protection would be restricted to non-native vegetation communities (Acacia Scrub/Exotic, Closed Exotic Grassland, Planted). In accordance with the Bushfire Assessment, clearing or trimming of the Illawarra Subtropical Rainforest on the site is proposed to be avoided. ■ Removal of native vegetation communities and fauna habitats during construction and operation of the Project be avoided and minimised where possible. ■ Undertaking two additional targeted surveys for the Green and Golden Bell Frog in the peak breeding season to confirm results of targeted surveys undertaken in November/December 2011 and early January 2012. ■ Waterbody removal and associated vegetation removal being undertaken over the spring or summer months when fauna species are most active. ■ Undertaking protection of all retained trees. Tree protection measures such as temporary fencing will be implemented for any trees potentially indirectly impacted by the Project. ■ Installation of protective fencing around all retained native vegetation. This is particularly important for areas of ISTR EEC where there is a risk of indirect impact. ■ Installation of sediment and erosion controls as required including for potential indirect impacts to the ISTR EEC. ■ Ensure machinery parking, equipment or materials storage compounds,

Issue	Commitments
	temporary stockpiling of excavated material and work areas are outside sensitive natural features including retained native vegetation, wetlands and drainage lines. ■ Logs removed with any vegetation removal would be relocated into areas of retained vegetation, for the purpose of providing fauna habitat. ■ A weed control program would be undertaken in accordance with the LEMP. ■ Undertake revegetation of cleared and disturbed areas using a range of native species of local provenance for the purpose of managing weeds, controlling soil erosion, and maintaining fauna habitat in accordance with the Landscape Strategy (Appendix N). ■ Maintain suitable buffer distances from nearby waterways. These buffer distances are recommended based on the stream orders of waterways and the subsequent categories identified within the “Wollongong City Council Development Control Plan 2009”. ■ Following the disturbance of existing surface water ponds, landscaping would be undertaken to enhance existing riparian zone vegetation associated at the ponds to be in accordance with appropriate riparian buffer widths. The vegetation buffer is proposed to be constructed to an average width of 5 metres where possible to improve the existing aquatic habitats. ■ Extend the current water quality monitoring program to include one monitoring location on Dapto Creek, upstream of the discharge point and two locations downstream. ■ Biodiversity and habitat values would be maintained and increased where possible by planting a range of indigenous species. ■ Offsetting measures, and measures to monitor the success of these offsets, would be outlined in a Vegetation Management Plan.
Air quality	Wollongong City Council commits to the following with regard to air quality: ■ Watering of unsealed haul roads and disturbed surfaces (including construction areas). ■ Restricting the size of disturbed areas as much as practicable. ■ Disturbed areas would be rehabilitation progressively in accordance with the Landscape Strategy. ■ Prevention of truck over-loading and covering dusty loads. ■ Washing down trucks before they leave the site. ■ Maintaining equipment and plant appropriately to ensure efficient operation. ■ The active landfill area would be covered following the completion of waste placement at the end of each day with landfill lids or approximately 150 mm of daily cover material or other cover system.

Issue	Commitments
	■ Adhering to appropriate hours of construction and operation. ■ Temporarily suspending operations under extreme wind speed conditions. ■ Giving consideration to reducing the footprint of the active cell area and daily cover and increasing the thickness of daily cover to control odour as required, particularly during the operation of Stage 1 during waste relocation works and Stage 4. ■ An air quality (including dust and odour) management strategy would be incorporated into the CEMP. ■ Monitoring in accordance with the EPL and ongoing assessment.
Traffic and transport	Wollongong City Council commit to: ■ Appropriate management and maintenance of road pavement of Reddalls Road intersection to Whytes Gully RRP and site access. ■ The CEMP for the Project would include a traffic management plan identifying truck movements to and from the site, internal access, interactions with general public, parking and access requirements for construction personnel and safety signage and training of personnel in traffic management in accordance with relevant requirements and guidelines of the RTA in terms of road safety and network efficiency. ■ Where possible, trucks to the site would be scheduled to avoid peak hour and within standard hours of operation, except in emergencies.
Heritage	Wollongong City Council commit to the following with regard to heritage (indigenous and non-indigenous): ■ Registered Aboriginal parties identified within the EA would be informed about the management of Aboriginal cultural heritage sites within Whytes Gully RRP where they may be impacted upon by the Project. ■ Identified potential archaeological deposits within the Whytes Gully RRP site would be left in their identified location and not salvaged unless the Project cannot avoid impacting upon these sites. If salvage is required Wollongong City Council would consult with the relevant statutory bodies and provide an opportunity for collection of the cultural material from the site. ■ Monitoring of construction would be completed for the Project where in proximity to listed heritage items (i.e. Glengarry Cottage) to ensure there is no disturbance to heritage significance. ■ A heritage induction including indigenous and non-indigenous heritage is proposed to be incorporated within the general induction during construction of the Project. ■ Should indigenous or non-indigenous cultural material be identified during any works, construction and/or operation will cease in the vicinity of the find and the appropriate representative at OEH will be contacted.

Issue	Commitments
Visual	Wollongong City Council commit to: ■ Staging and planning of landfill activities to reduce the extent to which they would be visible during the construction and operation of the Project. ■ Implementation of the Landscape Strategy (Appendix N of the EA) to reduce and manage potential long term visual impacts. ■ Reducing the area of un-vegetated landfill slope, both permanent and temporary, by staging the operations and progressively establishing a vegetation cover on each section of slope as they are completed. ■ Revegetating the proposed landfill slopes with mix of shrubs and small trees and grass to create a landscape character similar to adjoining rural areas. ■ Adopting design options (when suitable) to be in keeping with the surroundings of the site including native grasses and dark toned colours for existing and proposed structures to reduce their visual contrast with their landscape setting. ■ Consulting with residents (as identified within the relevant chapter of the EA) to discuss the potential for planting to be carried out close to their houses to screen views of the landfill operations. ■ Subject to bushfire protection requirements (such as trimming of mature trees), existing native vegetation would be retained where possible to provide visual screening and contribute to the landscape character of Whytes Gully RRP. ■ Screen planting with dense tall tree planting on natural ground would be used to block views to the site, particularly from adjoining residences.
Socio-Economic	Wollongong City Council commit to ensuring: ■ A Stakeholder Strategy would be implemented throughout the delivery of the Project. Provided within environmental management documentation (LEMP) the Stakeholder Strategy would provide procedures for communication with stakeholders, procedures for the dissemination of information to the community, identification of the communication channels available for the community and stakeholders to provide feedback on the Project, a protocol for the Project to respond to any enquires or feedback and for managing site visits and property inspections. ■ Implementation of measures to reduce the potential for construction and operation impacts upon amenity as identified within the relevant chapters of the EA and the draft Statement of Commitments.
Hazards and Risk	Wollongong City Council commit to ensuring: ■ No smoking around plant equipment and within designated areas only. ■ Any dangerous goods would be stored in accordance with normal dangerous goods storage procedures. ■ Spill containment to be managed in accordance with relevant Australian

Issue	Commitments
	Standards. ■ Safety hazards would be managed through occupational health and safety procedures. ■ Environmental hazards would be managed through the CEMP and LEMP. ■ Fire protection (including fire extinguishers, separation distances) would be provided in accordance with relevant Australian Standards and as identified within the EA. ■ Fire suppression and protection systems serviced and inspected periodically. ■ Water carts would continue to be made available at the site. ■ Site emergency response plan including emergency contact numbers provided within management system for the site. ■ The site landscaping would not exceed a fuel load of 2 t/ha. ■ Planted trees that are retained on the site would have the lower branches trimmed (cut off) to a height of 2 m above the ground. The tree trimming works may be staged with priority given to the protection of assets and fuel load reduction adjacent to roads. ■ An asset protection zone (APZ) of 10 m would be maintained around existing site buildings. ■ A perimeter firebreak of 5 metres be established around the entire Whytes Gully RRP site and around buildings (roads and access tracks including offsite roads and tracks, may be utilised to form the fire break). ■ Wind-blown litter would be managed as outlined in the LEMP. ■ Coordination of vegetation planting and removal with bushfire management requirements that include access tracks and fuel management zones. ■ Flammable materials would be removed from site fencing as outlined in the LEMP. ■ The LEMP would be implemented to ensure reduction of hazards and risk associated with delivery and/or processing of waste. ■ A Vegetation Management Strategy (including Weed management) would be developed within the LEMP to ensure that vegetation is managed to not exceed recommended fuel loads in relevant guidelines. ■ The general public would not be allowed direct access to the landfill. ■ Security of the site would be maintained during construction and operation including security fencing, which is locked after hours of operation. ■ Waste entry and flows would be monitored and controlled in accordance with the LEMP.

Issue	Commitments
Rehabilitation and Final Landform	Wollongong City Council commit to: ■ Development of a final landform that integrates with the surrounding landscape and environment. ■ Implementing of the Design Report to ensure that appropriate capping of the landfill is completed progressively throughout the Project. ■ Implementing the LEMP to ensure appropriate post closure monitoring and maintenance. This includes contingency and remediation measures should environmental monitoring indicate that the closed landfill is impacting upon air, surface water, groundwater or amenity of nearby receptors. This also includes procedures for maintaining the landfill surface post closure and repairing damage to the capping system.
Stakeholder Engagement	Wollongong City Council commit to ongoing regular consultation with the community on the Project through: ■ Community Consultative Committee for the Whytes Gully RRP. ■ Phone line to communicate issues to Whytes Gully RRP management. ■ Complaints management process (as provided in the draft LEMP). ■ Clear signage at construction sites during construction. ■ Stakeholder satisfaction surveys and feedback forms (as part of wider Wollongong City Council activity). ■ Ongoing use of interactive web-based activities including updates of the Project website.

6.0 REFERENCES

DEC (2005) “Recovering Bushland on the Cumberland Plain: Best practice guidelines for the management and restoration of bushland.”

DECC (2009) “Interim Construction Noise Guideline”

DIPNR (2004) “Riparian Corridor Management Study.”

EPA (2006) “Technical Framework: Assessment and management of odour from stationary sources in NSW. Published by the Department of Environment and Conservation, November 2006.”

EPA (2010) “Victoria’s Best Practice Environmental Management – Siting, Design, Operation and Rehabilitation of Landfills”

Katestone (2011) “NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining.” (Prepared for the Office of Environment and Heritage, June 2011, by Katestone Environmental Pty Ltd).

NSW Office of Water (July 2012) “Guidelines for riparian corridors on waterfront land.”

NSW EPA (1999) “Industrial Noise Policy”

Report Signature Page

GOLDER ASSOCIATES PTY LTD

Kelly Dohle
Environmental Engineer

Jacinta McMahon
Associate, Principal Environmental Engineer

KAD/JLM/kad

A.B.N. 64 006 107 857

c:\users\dfaria\documents\whytes gully\117625003_207_r_rev0_response_to_submissions_preferred_project_report final.docx

APPENDIX A

Surface Water Routing and Flood Analysis

December 2012

WHYTES GULLY LANDFILL

Surface Water Routing and Flood Analysis

Submitted to:
Wollongong City Council
NSW Department of Planning and Infrastructure

Report Number. 117625003_213_R_Rev0

REPORT

Golder Associates

Table of Contents

FIGURES

APPENDICES

1.0 INTRODUCTION

Golder Associates Pty Ltd (Golder) has produced this surface water routing and flood analysis to evaluate the downstream floodplain conditions and how they may affect the Whytes Gully Resource Recovery Park (RRP) site. This report also ascertains the pre-development runoff characteristics discharging from the site.

1.1 Background

An Environmental Assessment (EA) (Golder 2012) was submitted for community consultation on March 2012 Golder received comments on September 2012 regarding surface water management and onsite flooding from:

- Office of Environment & Heritage (OEH) *(Ref: DOC12/34399);*
- Wollongong City Council (WCC) *(Ref: MP-2011/94, dated 5 Sept 2012);*
- NSW Dept of planning & Infrastructure (DoPI) *(Ref: 11/19432);* and
- Asciano *(Ref: 11_0094, dated 6 Sept 2012).*

Specifically, comments were received regarding the effects of floodplain levels on the proposed site (flooding currently shown from the 100 year floodplain). Additionally, it was requested that the completion of a runoff routing analysis to ascertain what the peak pre-development flow rates are discharging off the site, which would then be used as Permissible Site Discharge (PSD) rate for the proposed development.

1.2 Objectives

To respond to comments provided through the submissions, the following objectives were derived:

- evaluate floodplain modelling that has been made available since the submission of the EA report to provided updated comments on the effects of flood plain on the proposed site;
- model the existing pre-development site to evaluate possible flood behaviour on site and link with current flood modelling; and
- model the existing pre-development site to ascertain PSD discharge rates.

2.0 PREVIOUS FLOOD MODELLING

Since the submission of the EA , an extension to the Mullet Creek, West Dapto flood model has been made available in the form of the Bewsher Consulting Pty Ltd report (Bewsher 2011).

The revised 100 year ARI flood levels on Figure 7 of the Bewsher report, flood water appears to have been generated on the existing Whytes Gully landfill site and is shown building up against the northern edge of the carriageway and overtops Reddalls Road before discharging into Dapto Creek. An extract of Figure 7 showing the Whytes Gully site has been shown in Figure 1 below.

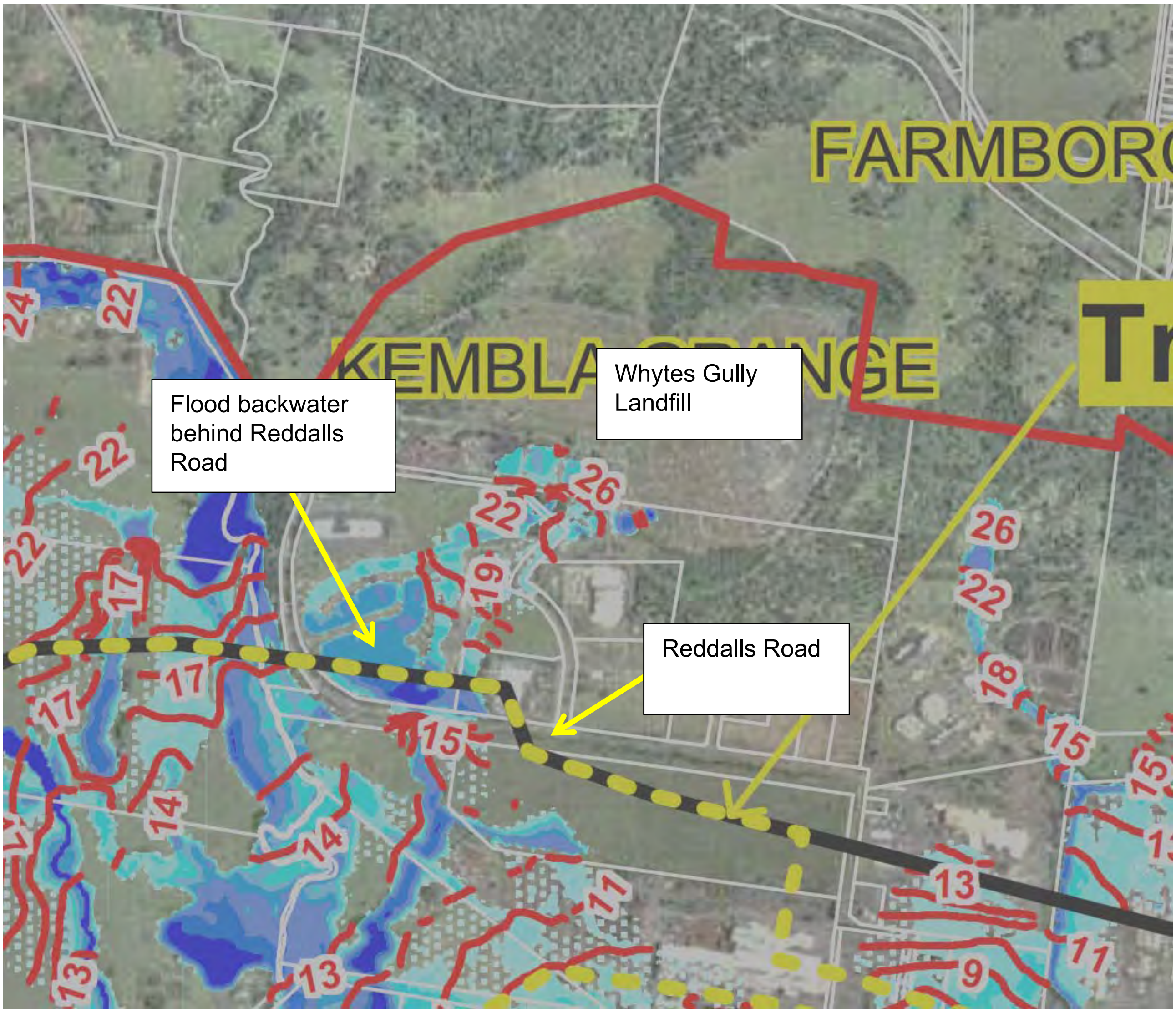


Figure 1: An extract from Bewsher's extended flood model (figure 7) completed December 2011

There is a significant drop in water level through Reddalls Road reported by the Bewsher's flood model as seen on the Figure 1. The water level downstream of Reddalls Road is approximately 13 m AHD. The water level upstream of Reddalls Road is over 16 m AHD, which is about the level of the sag in Reddalls Road (approximately 16.75 m AHD).

It is our opinion that the culverts (twin 2500 mm diameter) under Reddalls Road have not been modelled within Bewsher's extended flood model, as these may have been classified as minor structures for the intent of their overall model. If the culverts have not been taken into account the flood extents shown may be overestimated within the Whytes Gully Landfill, particularly the lower end of the site.

As part of our runoff routing analysis, the 100 year ARI event is modelled to better estimate the flood characteristics of the twin 2500 mm diameter culverts under Reddalls Road and the lower portion of the site. If onsite flood depths are not similar to that of Figure 7 of the Bewsher report it is assumed that their model has not accounted for the these culverts.

3.0 RUNOFF ROUTING ANALYSIS

An XPSWMM hydraulics model was set up to simulate the flows in and out of the existing sediment ponds to estimate runoff characteristics for the pre-development catchment throughout the ponds and at the outfall into Dapto Creek.

The Laurenson's non-linear routing method was used within XPSWMM to simulate the rainfall/runoff process. Rainfall depths were retrieved from the Bureau of Meteorology website. Conservative assumptions were made for losses and other catchment parameters, as it an ungauged catchment.

The below Figure 2 is the XPSWMM schematic model used.

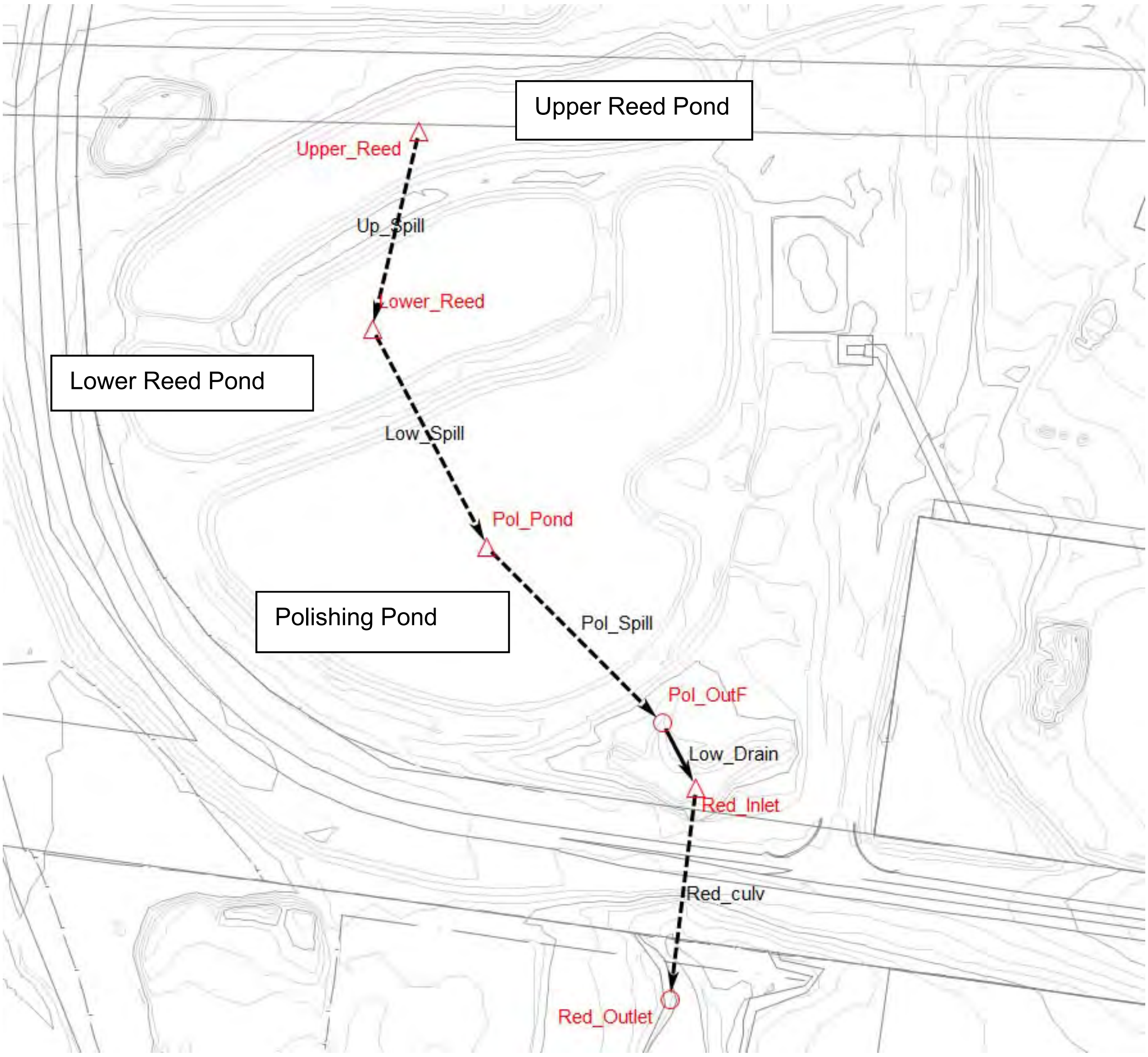


Figure 2: XPSWMM schematic model

The model is made up of:

- three ponds (upper reed pond, lower reed pond and polishing pond) and their corresponding outfalls/spillways;

- a storage node for the existing volume at the Reddalls Road culvert inlet; and
- the twin 2500 mm diameter culverts at Reddalls Road.

The inputs into the model have been based on the long-section design drawing produced by Forbes & Rigby (Forbes & Rigby 2003) and a Photogrammetry Ground Survey produced by KFW & Associates Pty Ltd (KFW 2011).

An initial depth of all three ponds have been set at the dry weather level shown on the design long sections to simulate the available dynamic storage within the ponds.

The outfall is modelled with a fixed back water level of 13 m AHD to simulate the floodplain level in Dapto Creek just downstream of the culvert as discussed in Section 2.0.

A pre-development catchment plan was evaluated and input into the model. The pre-development catchment plan can be found in Appendix A.

3.1 Onsite Flood Level

The resulting maximum water levels upstream of the Reddalls Road culverts for the peak 100 year ARI is 14.77 m AHD, which is below the soffit of the Reddalls Road culverts (approx. 15.28 m AHD) and below the sag level within Reddalls Road where an overspill would occur (approx. 16.75 m AHD). Figure 3 presents the water levels for a 100 year ARI storm event upstream of the Reddalls Road Culverts.

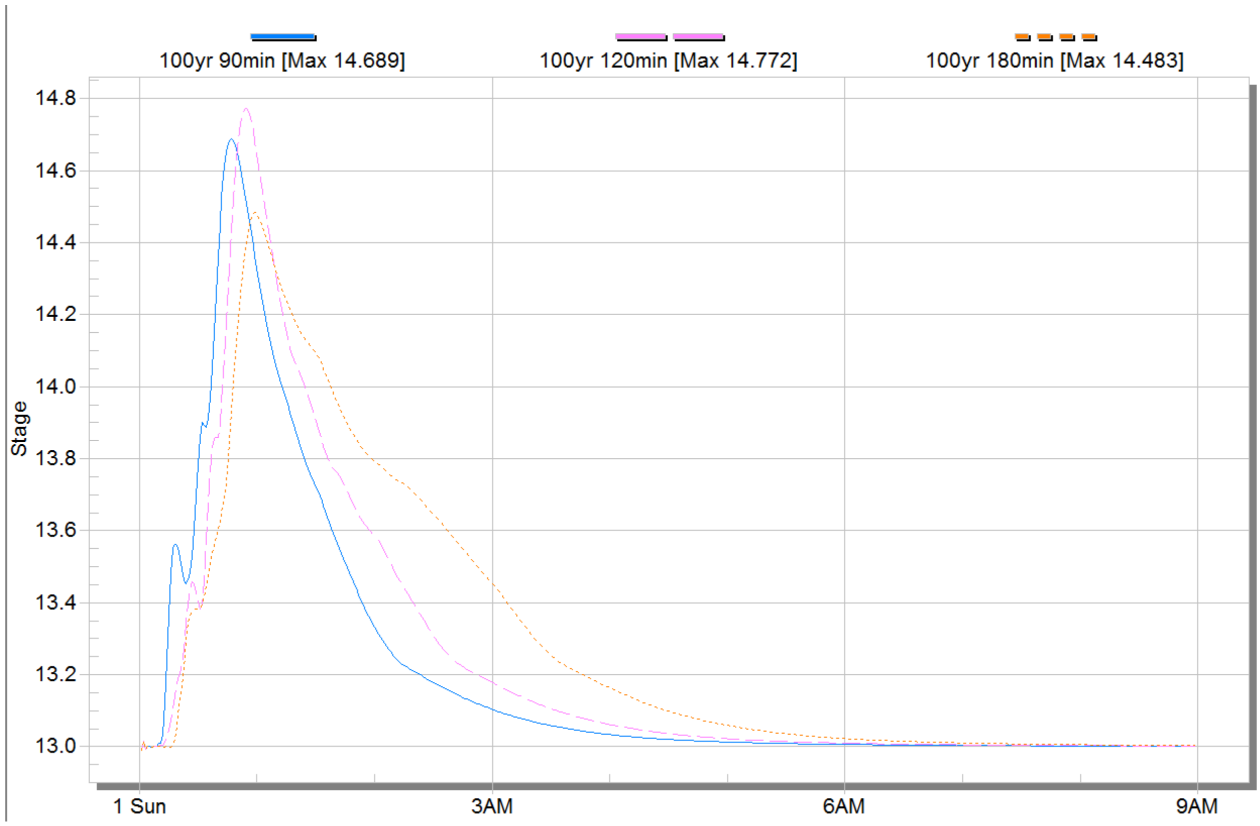


Figure 3: 100 year ARI pre-developed water level upstream of Reddalls Culverts

3.2 Permissible Site Discharge

The resulting 5 year ARI peak discharge through the site's outfall through Reddalls Road Culverts is 7.04 m^3/s. It was found that critical duration for a 5 year ARI storm event is the 2 hour storm event as depicted within Figure 4.

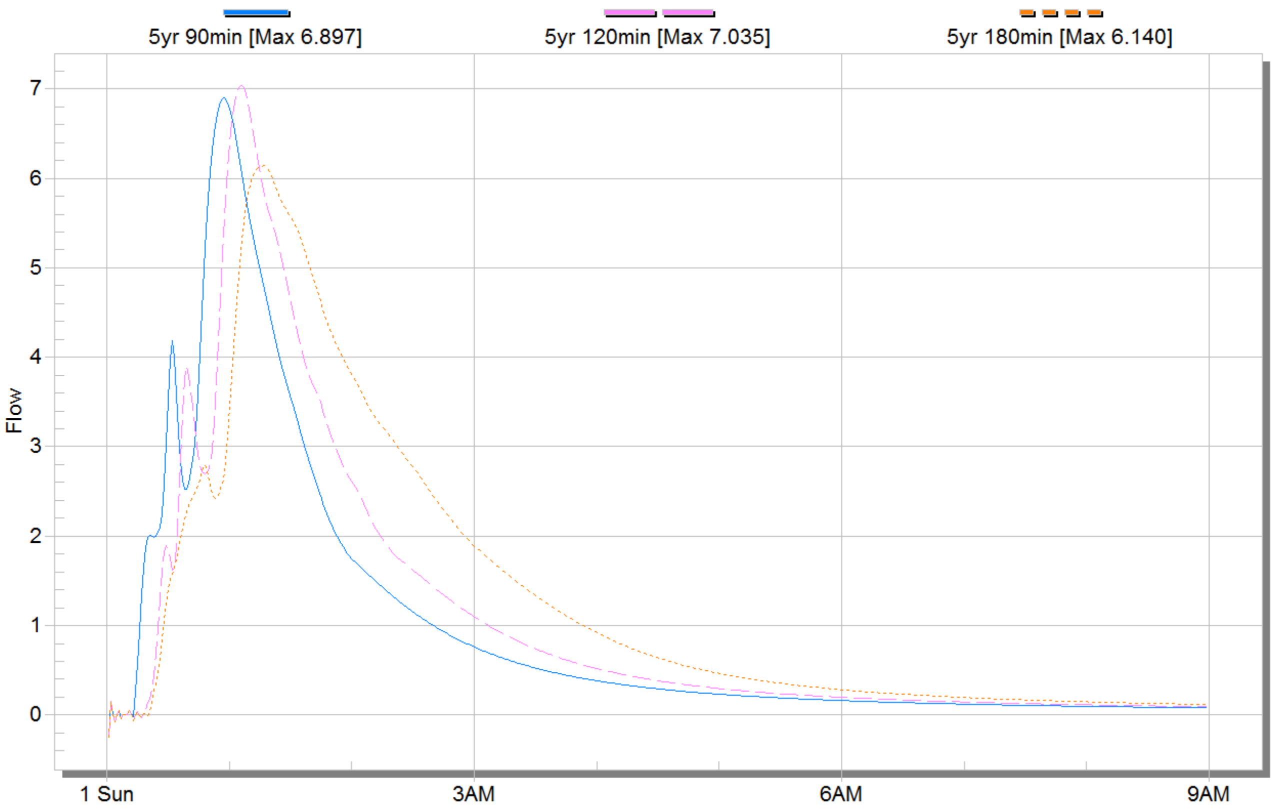


Figure 4: 5 year ARI pre-developed site discharge at Reddall's Road Culverts

The resulting 100 year ARI peak discharge through the site's outfall through Reddalls Road Culverts is 18.1 m^3/s. It was found that the critical duration for a 100 year ARI storm event is the 2 hour storm event as depicted within Figure 5.

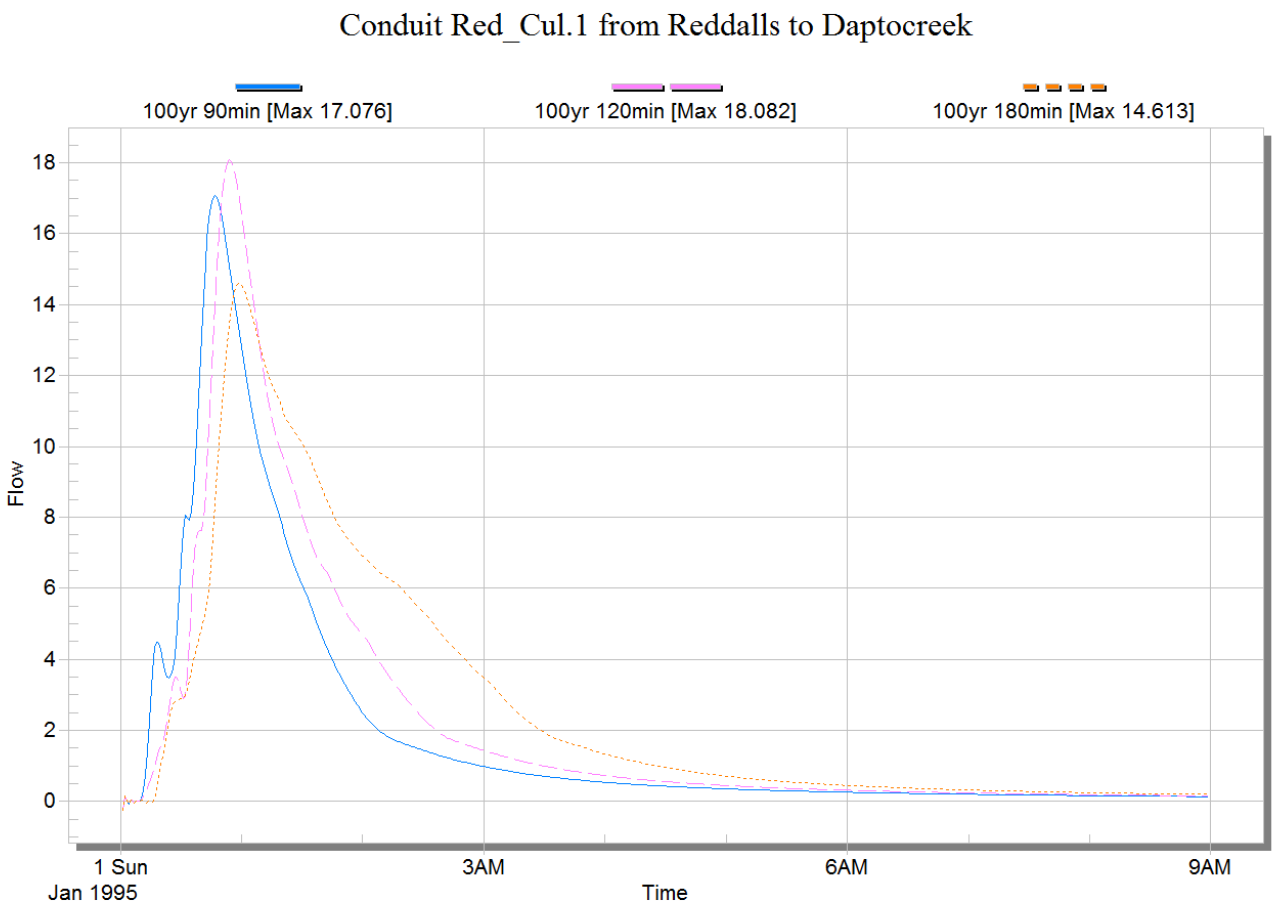


Figure 5: 100 year ARI pre-developed site discharge at Reddall's Road Culverts

4.0 SUMMARY

Our review of recently available flood modelling report (Bewsher's 2011) regarding possible site flooding includes the following:

- It is likely that the culverts (twin 2500 mm diameter) under Reddalls Road have not been modelled within Bewsher's extended flood model as these may have been classified as minor structures for the intent of their overall model.
- If the culverts have not been taken into account, the flood extents shown in the Bewsher's report may be overestimated at the site.
- As part of the runoff routing analysis, the 100 year ARI was modelled to estimate the flood characteristics of the twin 2500 mm diameter culverts at Reddalls Road.
- Our estimated 100 year ARI floodlevel upstream of the Reddalls Road Culverts is 14.77 m AHD, which is below the soffit of the Reddalls Road Culvert (approx. 15.28 m AHD) and below the sag level within Reddalls Road where an overspill would occur (approx. 16.75 m AHD).

The resulting Permissible Site Discharge (PSD) requirements are as follows:

- 5 year ARI, 2 hr peak storm event at Dapto Creek outfall = 7.04 m^3/s
- 100 year ARI, 2 hr peak storm event at Dapto Creek outfall = 18.1 m^3/s.

5.0 LIMITATION

Your attention is drawn to the document – "Limitations", which is included at the end of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimise the risk associated with the service provided for this project. The document is not intended to reduce the level of responsibility accepted by Golder, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

6.0 REFERENCE

- Bewsher Consultanting Pty Ltd, 2011, Mullet Creek, West Dapto Extension of Flood Model, Hydrologic and Hydraulic Modelling Report, Prepared on behalf of Wollongong City Council
- Department of Environment & Climate Change, 2008, "Managing Urban Stormwater: Soil and Construction: Volume 2B Waste Landfills", Published by DECC, Canberra
- Landcom, 2004, "Managing Urban Storm Water: Soil and Construction, Volume 1", Published by DECC, NSW
- Forbes & Rigby Pty Ltd, 2003, Reference "Leachate & Stormwater Pond Design, Whytes Gully Waste Depot, Site master profiles, Drawing no. 5003, Rev P2", Prepared for Wollongong City Council
- KFW & Associates Pty Ltd, 2011, Reference "Overall Site Plan Whytes Gully Waste Disposal Area West Dapto", Drawing no. SV01, Rev B
- Golder Associates Pty Ltd, March 2012 "Environmental Assessment – Whytes Gully New Landfill Cell", Ref: 117625003_159_R_Rev0

Report Signature Page

GOLDER ASSOCIATES PTY LTD

Mike Niisato
Civil Engineer

Scott Stoneman
Principal Water Resource Engineer

MN/SS/mn

A.B.N. 64 006 107 857

https://aupws.golder.com/117625003wollongongcitycouncilnewcellwhytesgully/project doc/413 response to submissions/117625003_xxx_m_reva_route analysis.docx

APPENDIX A

Pre-development Catchment Plan

LEGEND

CATCHMENT AREAS		HECTARES
	AREA 1A	3.00 Ha
	AREA 1B	2.20 Ha
	AREA 1C	2.00 Ha
	AREA 2	2.00 Ha
	AREA 3	8.60 Ha
	AREA 4	2.00 Ha
	AREA 5	4.00 Ha
	AREA 6	10.30 Ha
	AREA 7	10.00 Ha
	AREA 8	1.90 Ha
	AREA 9	0.80 Ha
	AREA 10	9.00 Ha
	AREA 11	4.60 Ha
	CATCHMENT BOUNDARIES	
	SITE BOUNDARY	
	DRAINAGE AND FLOW DIRECTION	
	LEACHATE PONDS	
	SURFACEWATER PONDS	

SOURCE:

- BASE DRAWING TAKEN FROM K F WILLIAMS & ASSOCIATES WHYTES PHOTOGRAMMETRY AND GROUND SURVEY 20-07-11
- GRID COORDINATES ARE MGA 94, ZONE 56

nearmap IMAGE DATED 06.11.2012 SOURCED WITH PERMISSION FROM NEARMAP ON 21.11.2012 IMAGE GEOREFERENCED BY GOLDER AND INTENDED FOR INDICATIVE PURPOSES ONLY www.nearmap.com.au

ISSUED FOR
PRELIMINARY
NOT FOR CONSTRUCTION

1:4,000 — 0 80 160 240m

Golder Associates www.golder.com GOLDER ASSOCIATES PTY. LTD.	CLIENT: WOLLONGONG CITY COUNCIL	PROJECT: STAGE I PROPOSED WORKS WHYTES GULLY LANDFILL GAS COLLECTION SYSTEM
	DRAWN BY: HC — DATE: 21.11.2012	DRAWING TITLE: EXISTING CATCHMENT BOUNDARIES AND SURFACE WATER MANAGEMENT
	CHECKED BY: MN — DATE: 30.11.2012	
	SCALE: 1:4,000 — SHEET SIZE: A3	PROJECT No: 117625003 — DOC No: 213 — DOC TYPE: R — FIGURE No: F001 — REVISION: 0 — FIGURE 1

Plot Date: 20 December 2012 Time:10:22:55 AM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\FIGURES - File Name:117625003-213-R-F001-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-WHYTES PHOTOGRAMMETRY AND GOUND SURVEY 20-07-11.dwg; 117625003-XREFAERIAL 06_11_2012.dwg; Nearmap_Logo.jpg; WGCoords.jpg; 1-1.jpg;

APPENDIX B

Limitations

LIMITATIONS

This Document has been provided by Golder Associates Pty Ltd ("Golder") subject to the following limitations:

This Document has been prepared for the particular purpose outlined in Golder's proposal and no responsibility is accepted for the use of this Document, in whole or in part, in other contexts or for any other purpose.

The scope and the period of Golder's Services are as described in Golder's proposal, and are subject to restrictions and limitations. Golder did not perform a complete assessment of all possible conditions or circumstances that may exist at the site referenced in the Document. If a service is not expressly indicated, do not assume it has been provided. If a matter is not addressed, do not assume that any determination has been made by Golder in regards to it.

Conditions may exist which were undetectable given the limited nature of the enquiry Golder was retained to undertake with respect to the site. Variations in conditions may occur between investigatory locations, and there may be special conditions pertaining to the site which have not been revealed by the investigation and which have not therefore been taken into account in the Document. Accordingly, additional studies and actions may be required.

In addition, it is recognised that the passage of time affects the information and assessment provided in this Document. Golder's opinions are based upon information that existed at the time of the production of the Document. It is understood that the Services provided allowed Golder to form no more than an opinion of the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings, or any laws or regulations.

Any assessments made in this Document are based on the conditions indicated from published sources and the investigation described. No warranty is included, either express or implied, that the actual conditions will conform exactly to the assessments contained in this Document.

Where data supplied by the client or other external sources, including previous site investigation data, have been used, it has been assumed that the information is correct unless otherwise stated. No responsibility is accepted by Golder for incomplete or inaccurate data supplied by others.

Golder may have retained subconsultants affiliated with Golder to provide Services for the benefit of Golder. To the maximum extent allowed by law, the Client acknowledges and agrees it will not have any direct legal recourse to, and waives any claim, demand, or cause of action against, Golder's affiliated companies, and their employees, officers and directors.

This Document is provided for sole use by the Client and is confidential to it and its professional advisers. No responsibility whatsoever for the contents of this Document will be accepted to any person other than the Client. Any use which a third party makes of this Document, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Golder accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this Document.

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Pty Ltd
124 Pacific Highway
St. Leonards, New South Wales 2065
Australia
T: +61 2 9478 3900

Golder Associates

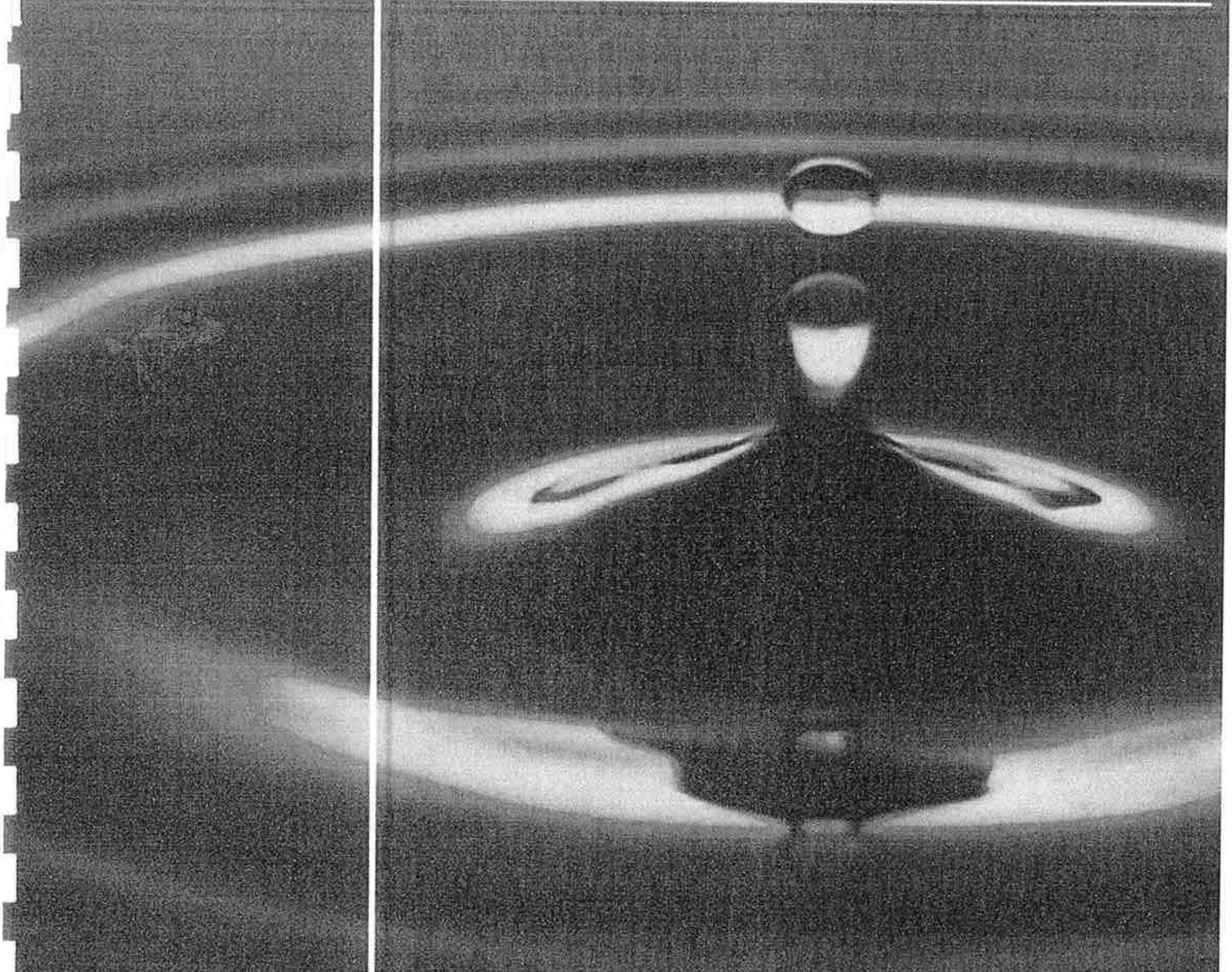
APPENDIX E

Whytes Gully Landfill Surface Water and Leachate Management Plan (RIENCO Consulting, 2008)
Whytes Gully Landfill Leachate Management Study (Forbes Rigby, August 2002)

APPENDIX E

Whytes Gully Landfill Surface Water and Leachate Management Plan (RIENCO Consulting, 2008)
Whytes Gully Landfill Leachate Management Study (Forbes Rigby, August 2002)

RIENCO
Consulting



Whytes Gully Landfill Surface Water and Leachate Management Plan 2008

DRAFT

for

Wollongong City Council

November 2008

Document Control

Report title:

WHYTES GULLY LANDFILL SURFACE WATER AND LEACHATE MANAGEMENT PLAN 2008

Prepared for:

WOLLONGONG CITY COUNCIL

Prepared by:

RIENCO CONSULTING
Water Engineering Specialists
PO Box 5431 Wollongong NSW 2500
4/163 Keira St Wollongong NSW 2500
ACN 000 960 850 ABN 14 000 960 850
Ph 0242 250 500 Fax 0242 250 555
Email secretary@rienco.com.au

Project No: 8015-1

Version History:

Version	Released	Status	Author	Reviewer	Approval
P0	27/11/2008	Draft	SR	EHR	EHR
P1	05/12/2008	Draft	SR	EHR	EHR

Issue History:

Version	Issued	Copies	Format	Issued To	By
P0	27/11/2008	1	PDF	L Dunstan (WCC)	SR
P1	05/12/2008	3	Paper	L Dunstan (WCC)	SR

Executive Summary

Whytes Gully Landfill is the principal waste facility for Wollongong City. It is located at Reddalls Road, West Dapto to the south west of Wollongong CBD. This report investigates improvements to the operation of the existing landfill in order to reduce generation of leachate from the site and better manage stormwater runoff.

At Whytes Gully, leachate is collected via a sub-surface drainage system beneath the landfill. This collection system drains by gravity to temporary leachate storage ponds before discharge to sewer. Recent wet weather over the period 2007 to 2008 has resulted in accumulation of leachate in excess of the pond capacity, resulting in pond overflow on a more frequent basis than anticipated. An analysis of recorded site rainfall and pond level data for the period April 2007 to July 2008 found that on an average basis approximately 36% of the rainfall which fell on the landfill and ponds was converted to leachate. It was also found that leachate production is highly sensitive to extended periods of wet weather and that this sensitivity is in part due to several small but efficient cross-connections between the leachate and stormwater systems.

In order to reduce leachate generation, Council must reduce the average infiltration rate across the landfill capping including removal of cross-connections. In order to assess the effectiveness of reduced infiltration rates, a monthly water balance of the site was developed. Results demonstrate that a reduction in the area used for active filling to a maximum of 2 hectares, along with an average minimum reduction in infiltration of 10% across the Eastern Gully, will reduce the generation of leachate to more acceptable levels.

Rainfall that does not evaporate or infiltrate to become leachate, is collected in open drains and directed as surface water towards a series of constructed stormwater ponds before discharging into Dapto Creek. The catchment surface over which this surface water flows is generally well protected by vegetation, however there are localised opportunities for scour and erosion. Natural soils are potentially dispersive making focussed effort towards source control of erosion at these sites of high importance.

A two-dimensional hydrodynamic model of the surface flowpaths was constructed and confirms potential cross-connections of surface water into the leachate system that should be removed. Also stormwater pond sizing using the NSW Department of Housing 'Blue Book' found that the existing stormwater ponds are of sufficient volume to provide treatment however stabilisation works and revegetation works are required in order to meet the original design intent.

These observations informed the development of management measures for both the leachate and surface water systems. The selected measures were low cost options that yielded high benefit in terms of the performance objectives sought. Key measures include: reducing the active fill zone to 2 hectares, reducing average infiltration across the Eastern Gully by a minimum 10%, and maintenance of ponds at maximum 50% capacity.

In addition, several non-structural measures were identified for implementation involving:

- *Planning to provide certainty for long term leachate and surface water management.*
- *Investigations to allow targeting of any further short term improvements.*
- *Monitoring to ensure ongoing and improved understanding of system behaviour.*

The complex nature of these systems and their interaction with variable site and climatic conditions warrants a cautious approach. Accordingly, management options that demonstrate clear benefits should be implemented immediately, followed by a period of observation and additional data collection. If continued system failure is observed, even after implementation of 'stand out' solutions, then additional measures should be considered. However with improved data availability these future decisions can be made with more certainty.

Table of Contents

Appendices

Figures

Tables

1 Introduction

1.1 Background

Whytes Gully Landfill is the principal waste facility for Wollongong City and is located at Reddalls Road, West Dapto to the south west of Wollongong CBD. For the purpose of environmental licensing the landfill is classified as a 'Class 1' facility able to accept domestic and commercial waste including putrescibles. The landfill commenced operation in 1984 and is managed by Wollongong City Council. A basic site plan is shown below whilst a more detailed version is included in **Appendix A**.

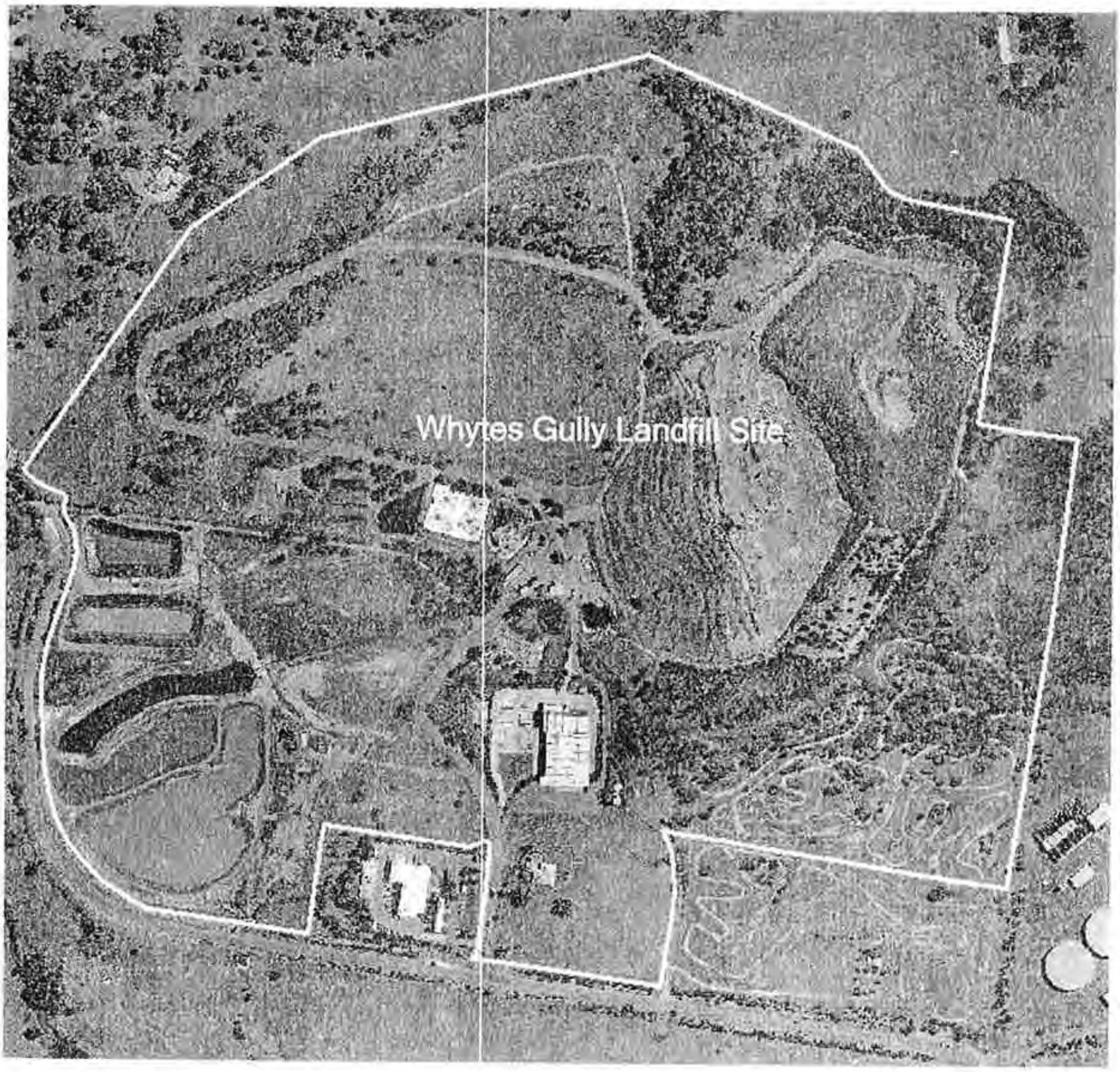


Figure 1.1 Whytes Gully Landfill Site (circa 2006)

As a consequence of past overflows from the leachate ponds, Council is investigating improvements to the operation of the existing landfill in order to reduce generation of leachate from the site and better manage stormwater runoff. As part of this process Council has engaged water engineering specialists, Rienco Consulting, to prepare a 'Surface Water and Leachate Management Plan' for the site in its current state of development (this document) to highlight the causes of these past problems and provide guidance in respect to their elimination.

1.2 Objectives

The objectives of this investigation and Plan are then to;

- Describe the existing surface water and leachate collection system
- Identify possible causes of leachate overflow or polluted stormwater
- Identify and assess available short term management options to address problems
- Develop a list of specific recommended actions to be implemented immediately
- Develop a list of considerations for future surface water and leachate management

1.3 Limitations

This document relates to the existing site and its current operational regime. The site is anticipated to change physically over time due to normal filling activities. Aspects of its operation may also change due to changes in waste material availability, waste management technology and legislative environment. It is also noted that Council may be seeking approval for an expansion of the site.

Any significant changes to the site and its operation may change the behaviour and interaction of surface water and leachate on the site. The advice provided herein may therefore lose relevance or need to be altered as time passes. Accordingly it is recommended that a periodic review of this plan be undertaken on an annual basis or before significant changes occur at the site.

2 General Site Description

2.1 Overview

The landfill site comprises two natural gullies known as the 'Western Gully' and 'Eastern Gully', located at the base of a prominent escarpment ridgeline. Landfilling commenced in the Western Gully in 1984 and was completed in 1993. The Eastern Gully is currently subject to filling operations and has approximately 4 years of remaining capacity.

Both gullies have been constructed as a series of stacked horizontal cells, progressively terraced in an upslope direction. The outer faces (sloping) of each cell combine to form an 'intermediate cover' for the entire emplacement on completion. The material used for the outer face is locally sourced VENM, preferably with high clay content.

The uppermost horizontal face of each cell is buried beneath the next cell above and comprises of coalwash (Western Gully) or slag (Eastern Gully). This material is referred to as 'daily cover'. Each cell is approximately 3m in total thickness and is made up of a series of 'lifts', each of which are also covered by a thin layer of daily cover to form a trafficable surface.

Over the period of operation of the site, Council has observed a significant change in the nature of materials available for use as intermediate cover. Council has observed that the clay content of the Western Gully's intermediate capping is on average higher than the Eastern Gully. The Western Gully also has gentler grade which has resulted in thicker capping with higher rates of compaction. It is also noted that the Western Gully does not have a base liner and is founded on bedrock whilst the Eastern Gully has an impermeable base liner.

To the south of the landfill and at the valley low point there are several large constructed ponds that collect leachate and stormwater from the site. These ponds and their collection systems are described in **Section 2.2** and **Section 2.3**.

Final capping with high clay content compacted material has not yet been undertaken at the site pending the possible development of a third emplacement stage as described in **Section 2.4**. However for modelling purposes the Western Gully capping has been characterised as performing more like a final cap layer.

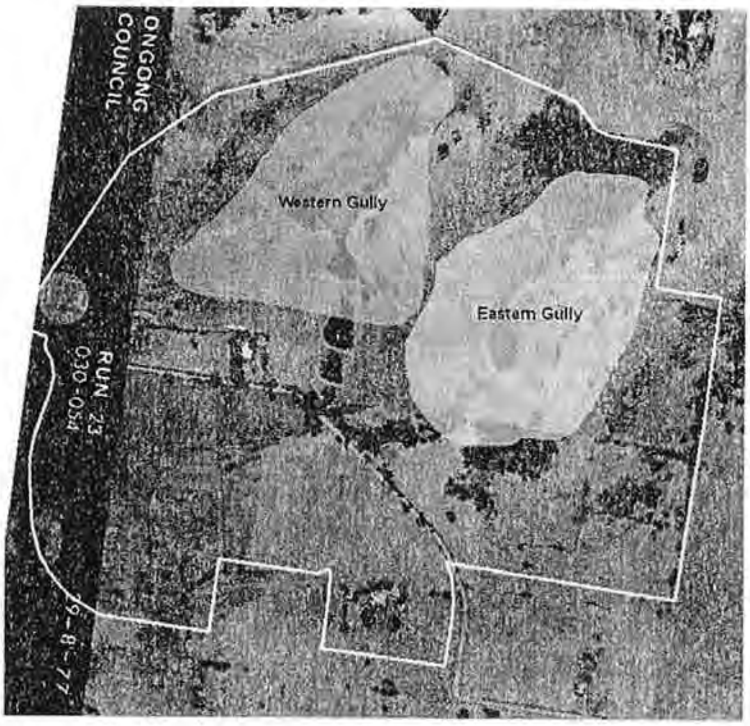


Figure 2.1 Aerial Photo of Landfill Site circa 1977 (before landfill)

Figure 2.2 Aerial Photo of Landfill Site circa 2006

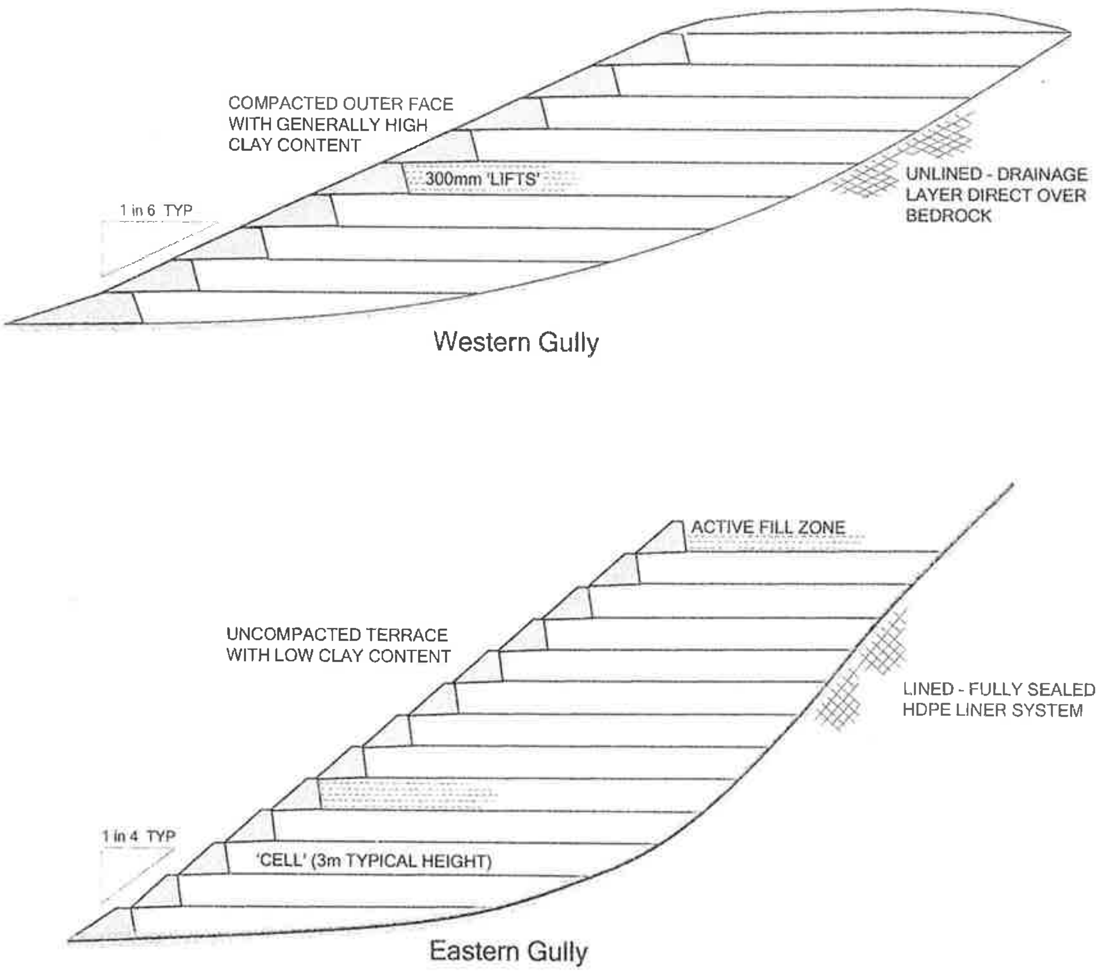


Figure 2.3 Whytes Gully Landfill Typical Sections (not to scale)

2.2 Leachate System

Leachate comprises of water that has come into contact with waste. Leachate is generated by:

1. infiltration of rainfall through the capping into the emplacement proper
2. direct cross-flow of surface water into the leachate collection network
3. importation within waste delivered to the site
4. infiltration of groundwater through the base liner up into the emplaced material

At Whytes Gully, leachate is collected via a sub-surface drainage system located at the base of the landfill. This comprises a sand drainage layer containing a network of slotted collection pipes that drain by gravity to the leachate ponds. There are also several points at which there are cross-connections between surface water and the leachate pipe network. These cross-connections were originally designed to capture surface runoff from parts of the capping and input them into the leachate system. Collected leachate is then directed to temporary leachate storage ponds.

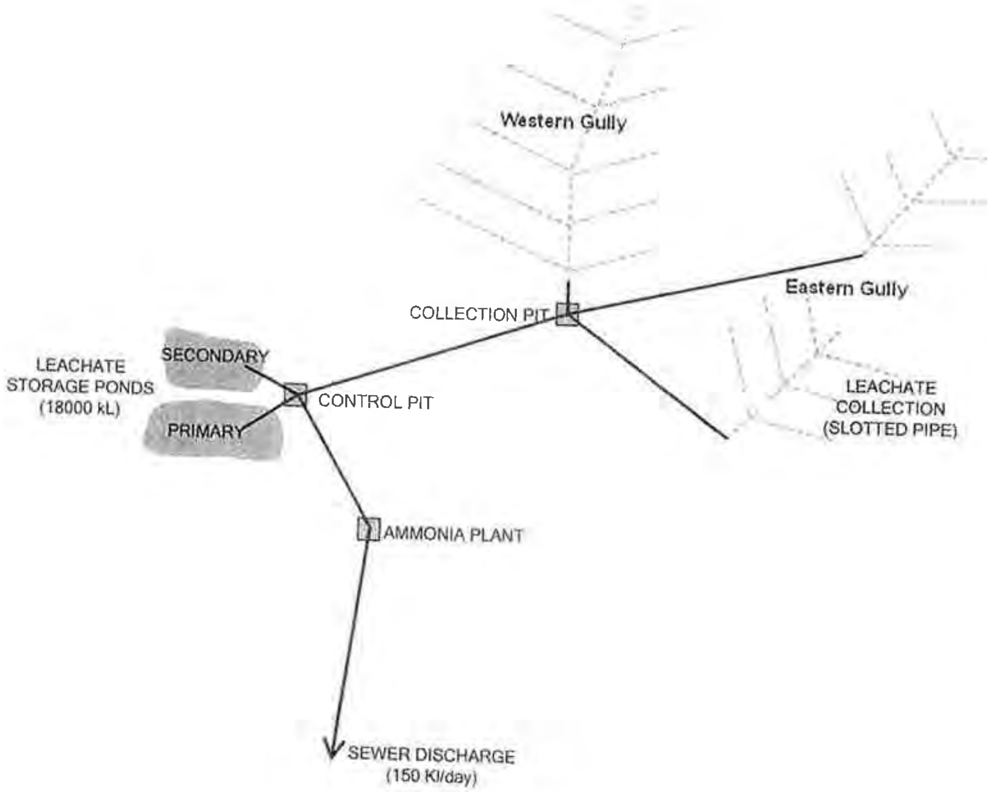


Figure 2.4 Leachate System Components

The leachate ponds at Whytes Gully were constructed in 2004 though not commissioned until 2006. There are two separate ponds referred to as the 'Primary Pond (P1)' and 'Secondary Pond S1' which have a combined storage capacity of approximately 18000 kL. These ponds temporarily store leachate before discharge off site via sewer. Immediately prior to sewer discharge, leachate is treated to reduce its ammonia concentration in compliance with Council's trade waste agreement. It is noted that sewer discharge is currently limited to a maximum of 150 kL per day due to capacity constraints in the downstream sewer trunk main. Discharge via tanker truck is also undertaken on demand to supplement this discharge capacity.

The adopted design criterion used to establish the leachate storage volume was capture of the '1 in 25 year 24 hour' storm event. This was assessed using a calibrated daily time-step water balance model and a design storm event of 360mm total rain depth over a 24 hour period (Forbes Rigby, 2002). Capture of the design event assumed a maximum starting volume (at the beginning of the design event) of 8100 kL. It was recommended in this earlier report that Council maintain the ponds at or below this volume and that the area of daily cover must be minimized in order to achieve this.

2.3 Surface Water System

Surface water runoff occurs during heavy rainfall when the infiltration capacity of the soil is exceeded. This water is collected in open drains and directed towards a series of constructed stormwater ponds. Where possible, surface water from those parts of the catchment that are outside the landfill site or that remain undisturbed have been directed away from the stormwater ponds. Some surface runoff from those areas of landfill comprising daily and intermediate cover is also directed towards the leachate collection system.

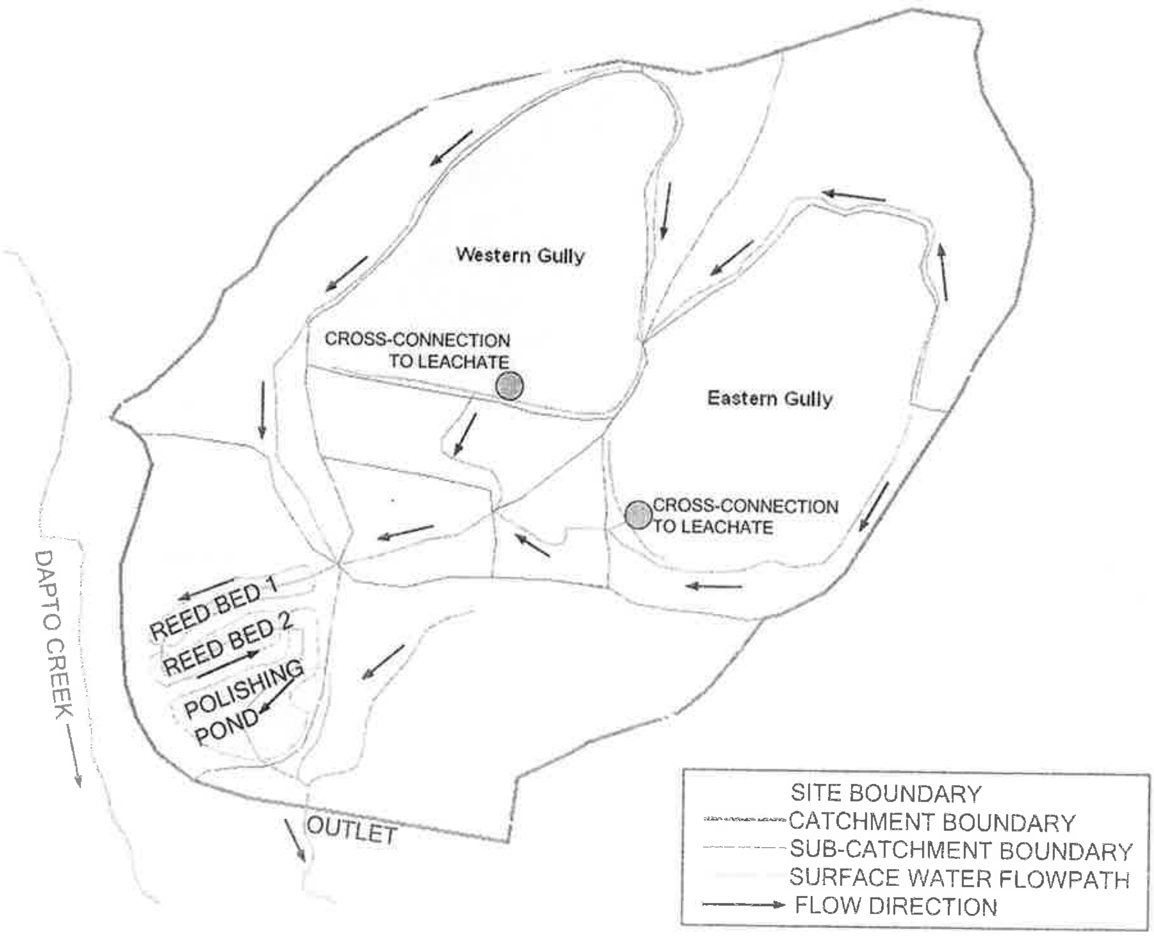


Figure 2.5 Surface Water System Components

The stormwater ponds were constructed in 2004 at the same time as the leachate ponds. They comprise three sequentially connected ponds, configured with a linear flow path to enhance their treatment capacity. Ponds 1 and 2 include 'reed beds' designed to contain thick vegetation and enhance stormwater treatment, whilst the last pond is much deeper and is predominantly open water. The stormwater ponds have a combined static (permanent) volume of approximately 32,000 kL and a dynamic volume (between the level of the low flow outlet and spillway) of 8,000 kL. This dynamic storage is designed to drain out of the stormwater ponds over a period of 36 hours.

2.4 Future Landfill Extension 'Stage 3'

The Western Gully and Eastern Gully were each planned and designed separately as Stage's 1 and 2 of the overall landfill operation. A third and final stage (also referred to as the 'Western Gully Extension') has been identified for future expansion of available landfill capacity. Conceptually the third stage is proposed to extend out from the current landfill, burying both Stage 1 and Stage 2 and bridging between the two.

Figure 2.6 Proposed Stage 3 Whytes Gully Landfill (approximate extent only)

Approvals and detailed planning for Stage 3 have not yet commenced. It is anticipated that the Eastern Gully will reach capacity in approximately 4 years time and that Stage 3 will follow on immediately, assuming approval is obtained.

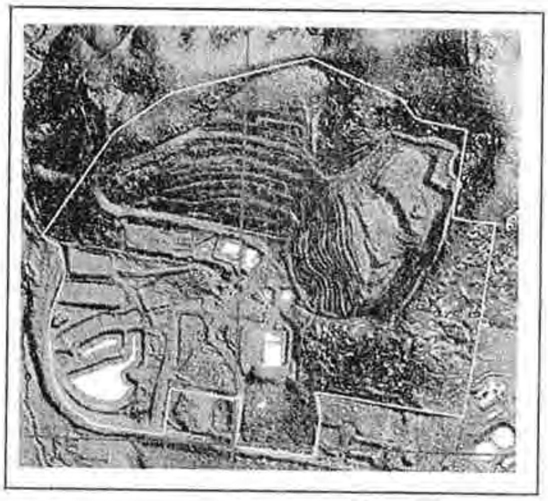
It is noted that the existing leachate and stormwater ponds were designed in anticipation of Stage 3 construction and have been sized and positioned accordingly (Forbes Rigby, 2002).

3 Available Data

3.1 Spatial

Aerial Photography
High resolution aerial photography recently captured for the site (circa 2006) and surrounds and spatially referenced (see **Appendix A** for larger format graphic).

Li DAR
High resolution ground height data recently captured for the site and spatially referenced. This dataset has a nominal height accuracy of +/- 100mm and includes spot heights at typically less than 2m spacing. These spot heights were subsequently processed by Rienco into a Digital Elevation Model (DEM).



Ground Survey
Ground height data captured by Council's surveyors and providing high accuracy (mm) detail of ground features including small topographic features such as table drains and embankment crests. This data is captured on a regular six monthly cycle as part of Council's monitoring program to enable periodic calculation of waste levies. Survey captured in June 2007, December 2007 and June 2008 was obtained for this investigation.

3.2 Non-Spatial

Previous Reports

A number of reports were supplied by Council and include information with respect to water management at the site as follows:

Whytes Gully Landfill Extension Landfill Management Plan (Maunsell, 1992)

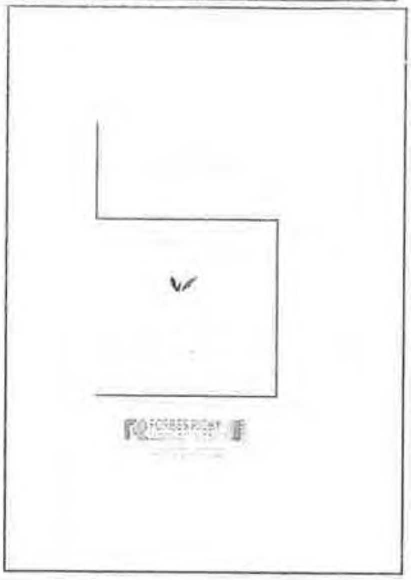
This report was prepared prior to the commencement of the Stage 2 landfill (Eastern Gully) in accordance with the requirements of DECC (formerly NSW EPA). The report provides guidance for the establishment and operation of Stage 2 and includes conceptual details of the proposed landform, filling plan, operations plan, gas control, and surface water and leachate systems.

Whytes Gully Landfill Extension - Environmental Management Plan (Maunsell Pty Ltd 1998)

This LEMP was prepared in 1998 following for the most part the requirements of the EPA Guidelines for Solid Waste Landfills. It was prepared to permit Council to fulfil its regulatory and licencing roles and as a document to promote improvements in landfill operations in the future.

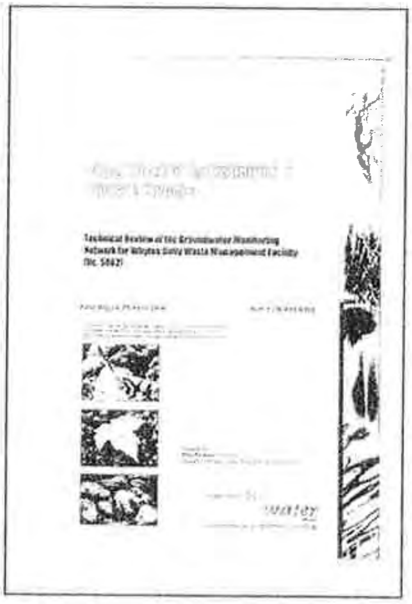
Whytes Gully Landfill Leachate Management Study (Forbes Rigby, 2002)

This study investigated generation of leachate at the site and provided conceptual details for proposed new leachate and stormwater ponds (since constructed). New ponds were required to facilitate site re-configuration, possible future expansion (Stage 3) and to address observed deficiencies in leachate storage. Whilst recommendations were made with respect to appropriate management practices to mimimize leachate generation, the reports focus was conceptual design of new ponds.



Technical Review of the Groundwater Monitoring Network for Whytes Gully Waste Management Facility (Earth2Water, 2008)

This report identified several issues with respect to leachate management at the site. Further groundwater and surface water monitoring was recommended to improve general understanding of the groundwater regime and groundwater/surface water interaction. The report identified high leachate generation potential at the site and the need for additional control measures including improved capping and redirection of stormwater away from leachate collection systems.



Rainfall and Leachate Pond Data

Manly Hydraulic Laboratory (MHL) on behalf of Wollongong City Council maintains a continuous record of both rainfall and leachate pond levels at Whytes Gully. These gauges were installed in late 2006. Available data includes:

- Continuous water level 'Primary Pond' (P1)
- Continuous water level 'Secondary Pond' (S1)
- Continuous rainfall gauge located at Secondary Pond (S1)

Whilst data is collected continuously, data was retrieved for the period of interest (April 2007 to October 2008) in hourly intervals.

Leachate Discharge Records

Council maintains detailed records of the volume of leachate discharged from the ponds to sewer in accordance with its Sydney Water trade waste agreement. Records were supplied for the 2 year period between July 2006 and July 2008 in the form of periodic flow meter readings. For the purpose of analysis these were processed into an average hourly time series.

Due to extended periods of wet weather beginning mid 2007 and resultant elevated leachate pond levels, Council commenced with supplementary discharge of leachate to sewer via tanker truck. Records of tanker volumes were supplied for the period August 2007 to June 2008 in the form of periodic volume records. These were also processed into an average hourly time series.

Other Data

Other information obtained for use in this investigation included:

- Long-term monthly average rainfall statistics for the Wollongong Post Office rainfall gauge located approximately
- Long-term monthly average evaporation statistics for the Sydney Airport weather station

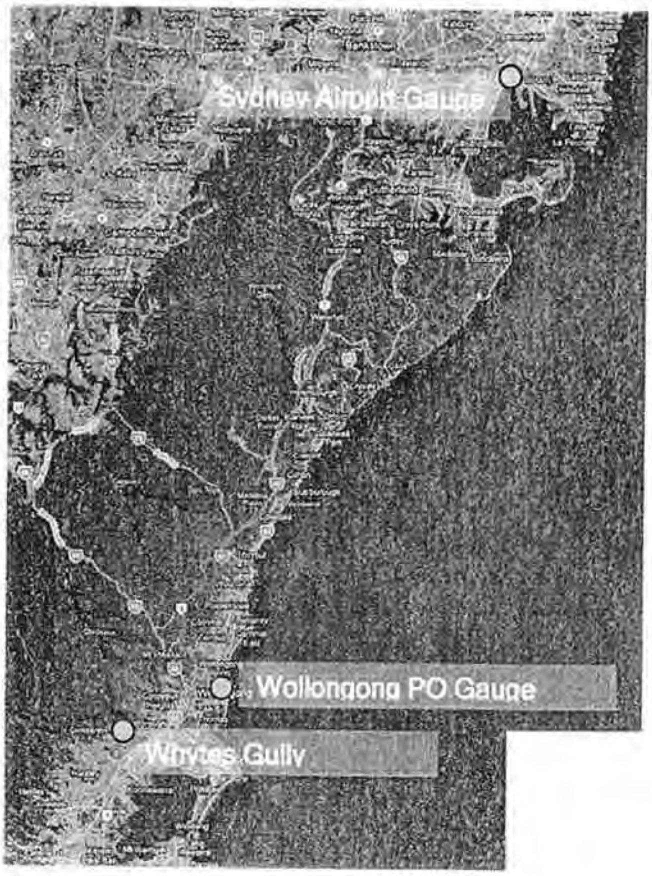


Figure 3.1 Climate Gauge Locations

4 Performance Objectives

4.1.1 Environmental Licencing Requirements

The Whytes Gully landfill is a regulated disposal facility subject to Environmental Protection Licence No. 5862. The conditions of this licence provide minimum performance objectives for leachate and stormwater management systems viz.

"There must be no discharge of leachate to waters under dry weather conditions or storm event(s) of less than 1:25 year 24 hour recurrence interval"

and

"There must be no discharge of contaminated (TSS>50mg/L) *stormwater to waters under dry weather conditions or storm event(s) of less than 1:10 year 24 hour recurrence interval".*

4.1.2 Pond Design Criteria

It is relevant to note the design criteria used for sizing of existing treatment ponds as documented in the *Whytes Gully Landfill Leachate Management Study* (Forbes Rigby, 2002). The ponds were designed with the intent of meeting the performance objectives required under the Environmental Protection Licence described above. Any performance related design criteria will also need to be included or re-assessed as part of this management plan.

Leachate Ponds

Key design criteria used for establishing the storage capacity of the existing leachate ponds included:

- 1 in 25 year 24hr 'design' storm with a total rain depth of 360mm producing 6750 kL of leachate (assessed using a calibrated daily timestep model)
- Approximate 30% average rain to leachate conversion rate incorporating landfill with 5.7 ha 'Daily Cover', 2.7 ha 'Intermediate Cover', and 21 ha 'Final Cover' (based on an assumed worst case daily cover scenario and implementation of Stage 3)
- Maximum wet weather sewer discharge rate of 150kL/day
- Maximum starting pond volume of 8100kL prior to storm commencement (based on assumption of 90% volume of the old leachate ponds).
- New pond volume = 8100kL + 6750kL + 20% factor of safety = 18000kL

Stormwater Ponds

Key design criteria used for establishing the storage capacity of the existing stormwater ponds include:

- Total catchment area draining to stormwater ponds of 50ha
- 1 in 10 year 24 hr 'design' storm with a total rain depth of 288mm producing 70,000kL of stormwater over 24 hours. Average daily discharge rate during the design event of 800 L/s.

- Minimum storage capacity equivalent to the capacity of the old ponds (since decommissioned and removed) on the basis that the old ponds had demonstrated adequate performance (N.B. final design outcome involved ponds with twice the storage capacity of the old ponds).

- Pond layout incorporating good wetland design including linear flowpath, vegetated reed beds, and dynamic storage.

- In the event of leachate pond overflow (due to wet weather or pump failure), the leachate ponds overflow into the stormwater pond system before discharge to Dapto Creek (to provide some pre-treatment).

No specific calculations were undertaken to confirm the ability of the stormwater ponds to ensure licence discharge requirements were met (ostensibly due to the difficulty of demonstrating compliance with a concentration based objective). The ponds were instead designed based on conservative design assumptions and empirical evidence that the previous ponds were providing good performance.

4.1.3 Other Objectives

In addition to the above performance objectives and design criteria, DECC have indicated that the stormwater pond design should now be re-assessed against the requirements of the NSW Department of Housing 'Soils and Construction' Guideline ('The Blue Book'). This re-assessment has been undertaken and is described in **Section 5.2.4**.

5 Existing Behaviour

5.1 Leachate System

5.1.1 Generally

The existing behaviour of the Whytes Gully leachate system can be generally characterised by a continuous but variable flow of leachate that increases during periods of prolonged wet weather. During wet periods, leachate accumulates in the storage ponds resulting in diminished capacity to store leachate produced by any subsequent storms.

As a result of higher than anticipated leachate flows and diminishing available storage, leachate pond overflow events have occurred more regularly than anticipated by design and expected by Council and DECC. Four recent overflow events were observed in June 2007, November 2007, December 2007 and February 2008.

System behaviour over the past two years has been influenced by the following factors:

	Factor	Description
1	Leachate & Surface Water Interaction	*There are significant localised cross-connections between the surface water and leachate systems increasing the volume of leachate produced following heavy rain*
2	Capping Permeability	*High average permeability of landfill capping materials particularly in areas of daily cover results in conversion of a high proportion of rainfall into leachate*
3	Patterns of Rainfall	*The system experiences high average rainfall that varies considerably with climatic cycles (i.e. el nino, la nina). Wet weather events do not often occur in isolation but as a series of wet weather events over several wet months. This significantly increases the volume of leachate base flow during these times.*
4	Leachate Storage Volume	*The available total leachate storage volume is fixed (approx 18000 kL) Ponds have been close to full for extended periods during the time that problems have been experienced.*
5	Discharge Capacity	*The system has a small but fixed outflow discharge rate (maximum 150kL/day via sewer) The only means of increasing outflow is by tankering.*

Whilst a full and detailed understanding of the above factors and their interaction is desirable, this requires large amounts of information, much of which remains unavailable at this stage. It is also relevant to note that Factors 3, 4 and 5 are reasonably fixed conditions. This plan must therefore focus on understanding (within existing data constraints) the mechanism by which rainfall is converted to leachate via surface water interaction (Factor 1) and capping infiltration (Factor 2), and how this conversion rate might be reduced.

5.1.2 Analysis of Rainfall and Pond Data

Continuous site rainfall and leachate pond level monitoring data was obtained for the period April 2007 to October 2008. Data processing was undertaken in order to convert measured pond levels into a corresponding storage volume. The storage volumes for the 'Primary' and 'Secondary' ponds were then summed to provide a total stored volume at the site. Conversion between pond level and volume was undertaken using a height-storage relationship derived from design drawings of each pond. A time series plot is shown in **Figure 5.1** below.

During this period the collected pond level data experienced several datum shifts (changes in gauge zero) and gauge 'bounces' (unexpected rapid rise and fall of recorded level). Where possible these gauge issues were corrected in the derived time series. It is understood Council has since resolved these issues and that future data will be of a higher overall quality.

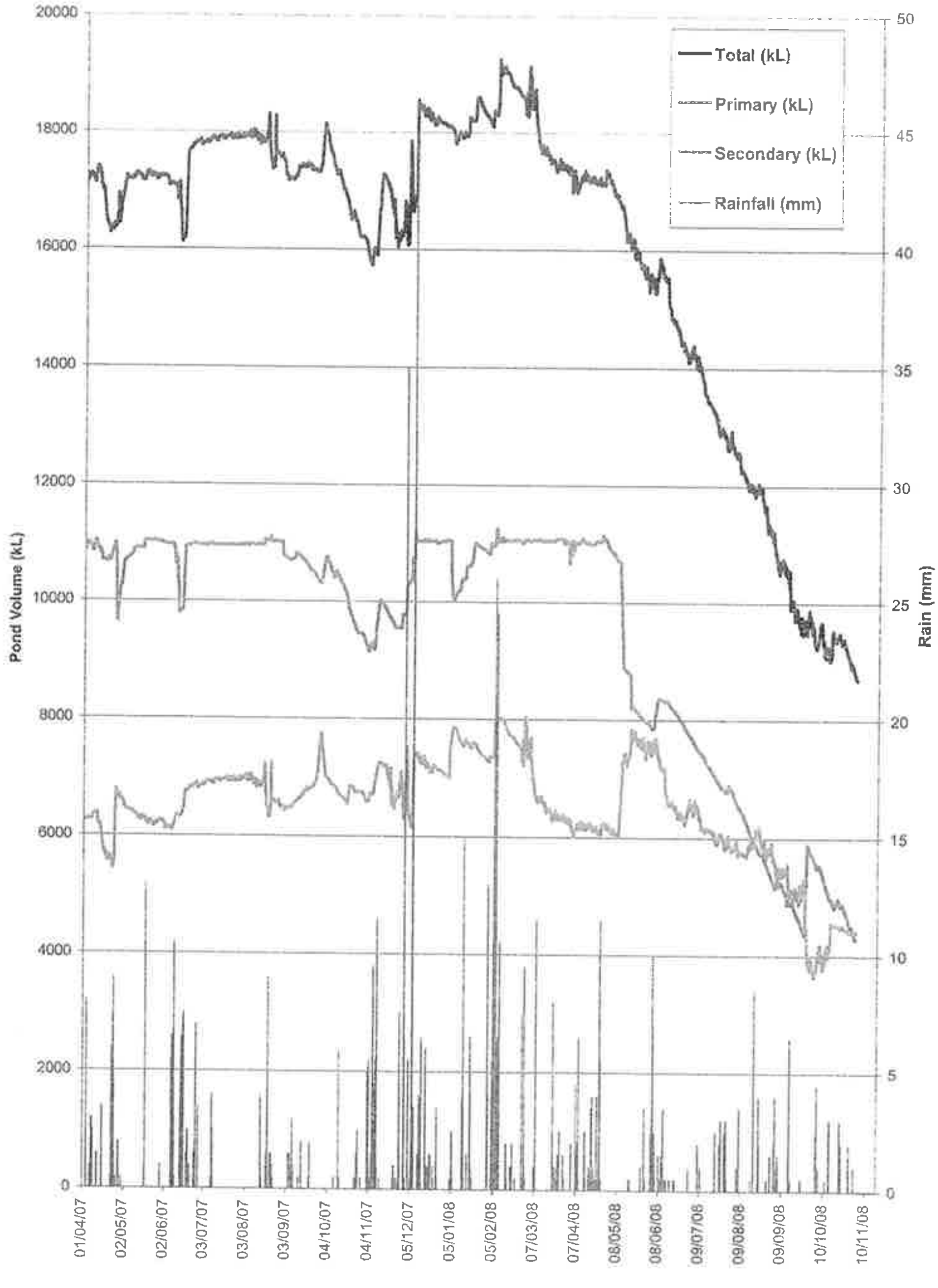


Figure 5.1 Recorded Rainfall and Leachate Pond Volumes April 2007 - October 2008

The time-series plot in **Figure 5.1** shows an extended wet period between April 2007 and April 2008 where the ponds were almost full or overflowing. This corresponds to an equivalent period of high rainfall including four major wet periods in June 2007, November 2007, December 2007 and February 2008. This behaviour confirms the sensitivity of stored leachate volume to extended periods of high rainfall.

Comparison of recent measured monthly rainfall totals against long term averages indicates the rainfall experienced at Whytes Gully between April 2007 and April 2008 was high and that four of these months approached or exceeded long term 90th percentile monthly averages. Observed overflow events occurred during these same extreme wet months.

Table 5.1 Monthly Rainfall at Whytes Gully Compared to Long Term Averages

Month Year	Measured Rainfall (mm)	Long Term Average Monthly Rainfall (mm)*	Long Term 90th Percentile Monthly Rainfall (mm)*
April 2007	132	129	259
May 2007	18	115	226
June 2007	**252**	**107**	**262**
July 2007	19	92	208
August 2007	69	61	141
September 2007	32	65	140
October 2007	19	67	134
November 2007	**230**	**72**	**132**
December 2007	**186**	**86**	**173**
January 2008	92	106	229
February 2008	**291**	**110**	**257**
March 2008	53	118	226
April 2008	111	129	259
May 2008	6	115	226
June 2008	83	107	262
July 2008	47	92	208
August 2008	34	61	141
September 2008	47	65	140
October 2008	67	67	134

** BOM Wollongong Post Office - Gauge no. 068069 (approx 80 years of record)*

Since April 2008 a significant decline in stored leachate volume has been observed to a current level of approximately 9000kL (50% of capacity). The system therefore demonstrates capacity to recover quickly when drier weather resumes, however this currently relies on supplementary tankering of leachate off-site.

In order to gain a more detailed understanding of the proportion of incident rainfall on the landfill converted to leachate during a typical storm, a leachate mass-balance was undertaken. Analysis was undertaken for four separate storm events over the period October to December 2007 (refer **Figure 5.2** and **Table 5.2** below). The calculation accounts for the volume of leachate discharged from the ponds via sewer, supplementary tankering and evaporation.

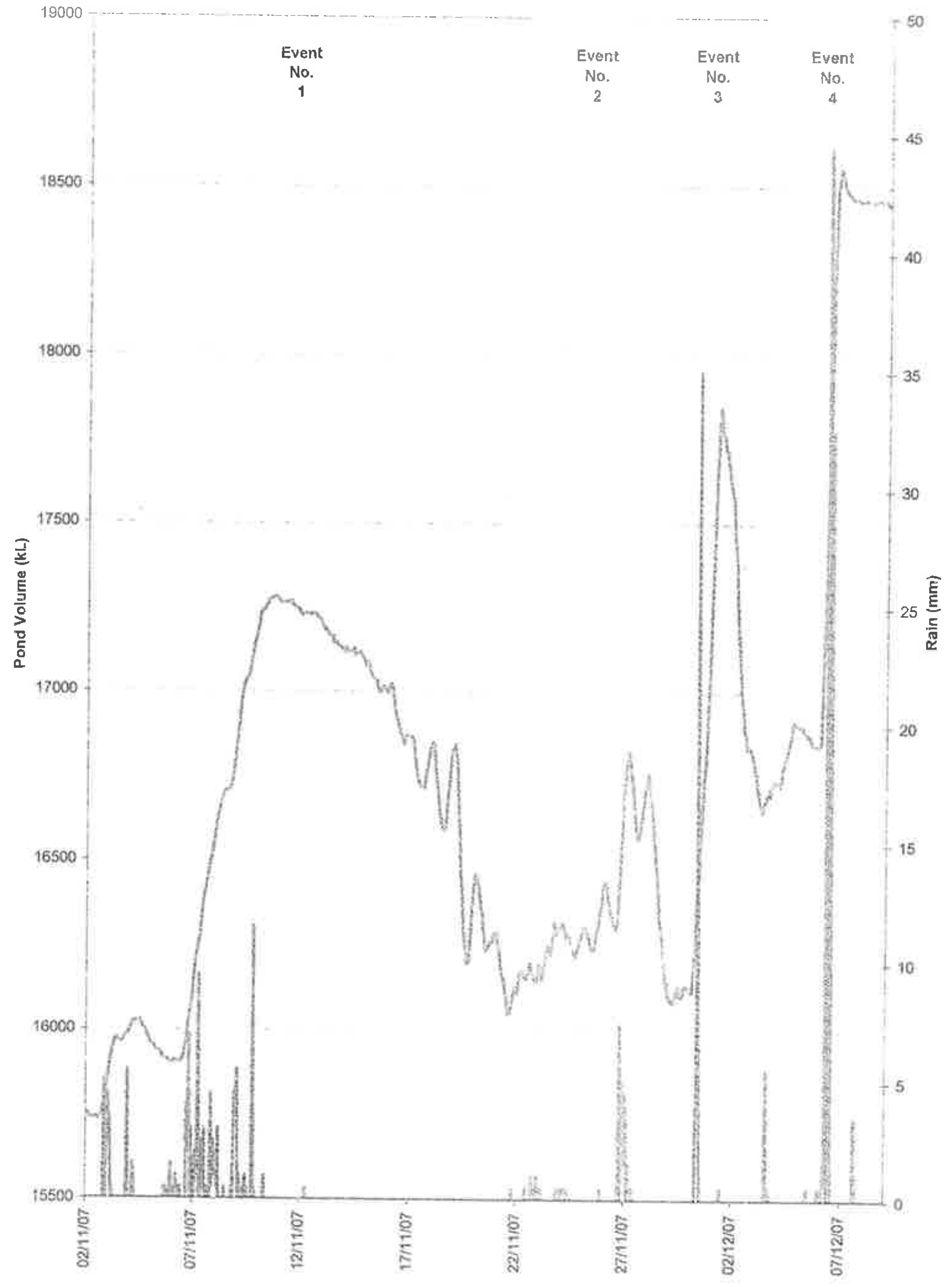


Figure 5.2 Storm Event Analysis Period October 2007 to December 2007

Table 5.2 Whytes Gully Storm Event Analysis

Event No.	1	2	3	4
Type	Storm	Storm	Storm	Storm -overflow
Start Time	2/11/2007	22/11/2007	30/11/2007	3/12/2007
End Time	21/11/2007	29/11/2007	2/12/2007	7/12/2007
No. Days in Event	20	8	3	5
Rain Depth (mm)	138	40	53	129
Total Area of Landfill and Ponds (ha)	20	20	20	20
Area of Ponds Only (ha)	1.2	1.2	1.2	1.2
Total Rain Volume (kL)	27600	7900	10500	25700
Rain Volume Direct Into Ponds (kL)	1656	474	630	1542
Rain Volume Falling on Landfill (kL)	**25944**	**7426**	**9870**	**24158**
Pond Volume Start (kL)	15755	16113	16126	16761
Pond Volume Finish (kL)	16120	16125	16776	18459
Change in Pond Volume (kL)	365	12	650	1698
Discharge Volume (i.e. Sewer-Tanker-Evap) (kL)	3679	1416	530	1039
Total Inflow Into Ponds (kL)	4044	1428	1180	2737
Total Inflow Into Ponds - Less Direct Rainfall (kL)	**2388**	**954**	**550**	**1195**
Leachate as Proportion of Rain On Landfill (%)	**9**	**13**	**6**	**5**
Average Inflow Rate - Excluding Direct Rainfall (kL/d)	120	120	186	241
Average Inflow Rate - Excluding Direct Rainfall (L/s)	1.4	1.4	2.2	2.8

The above analysis indicates that an average 10% of incident rainfall on the landfill surface is converted to leachate and enters the leachate ponds quickly (days). This 'quick' percentage is variable and dependant on the specific characteristics of the storm.

Whilst unable to be measured, a further volume of 'quick' leachate was generated during the four leachate overflow events. The total volume of additional leachate produced during these overflow events is considered to be small on a long term basis (less than 5% of total rainfall), but nevertheless a significant proportion of the leachate that can be produced quickly during a storm.

It is considered that the primary mechanism for this 'quick' leachate production is direct cross-connection between the surface water and leachate systems and preferential flowpaths through the landfill.

The above estimates of 'quick' leachate production do not allow for slow storage and release of rainfall that infiltrates the capping, is absorbed into the emplacement proper and then slowly released over subsequent weeks and months. The equivalent mass-balance calculation to **Table 5.2**, if undertaken over the entire 14 month period April 2007 to July 2008 (i.e. combination of storms and inter-event dry periods) indicates that during this period a total rain volume of 308,000 kL fell on the landfill surface and that this generated approximately 76,000 kL of leachate (N.B. this excludes the volume of leachate overflow unable to be measured). This translates into 25%

conversion of rainfall to leachate (excluding overflow) or a further 15% of incident rainfall in addition to the calculated 10% 'quick' release.

Mass balance calculations from inter-event dry periods indicate a typical slow release rate for this 'slow' leachate component of approximately 140kL per day (1.6 L/s). This is an upperbound and expected to reduce during normal to dry years.

During the 14 month period April 2007 to July 2008, a further volume of 20,000 kL of leachate was generated by rain falling direct on the pond surface. This represents a further 6% rainfall to leachate conversion and confirms that direct rainfall is a significant contributor to leachate pond inflows.

Combining estimated values for 'quick' leachate (10%), pond overflow (5%), 'slow' leachate (15%), and direct rainfall (6%), suggests that on a long term basis (during a reasonably wet period) approximately 36% of incident rainfall on the combined landfill and leachate pond surfaces becomes inflow to the leachate ponds. The remainder of incident rainfall is converted to surface runoff or evaporates/transpires from the landfill surface.

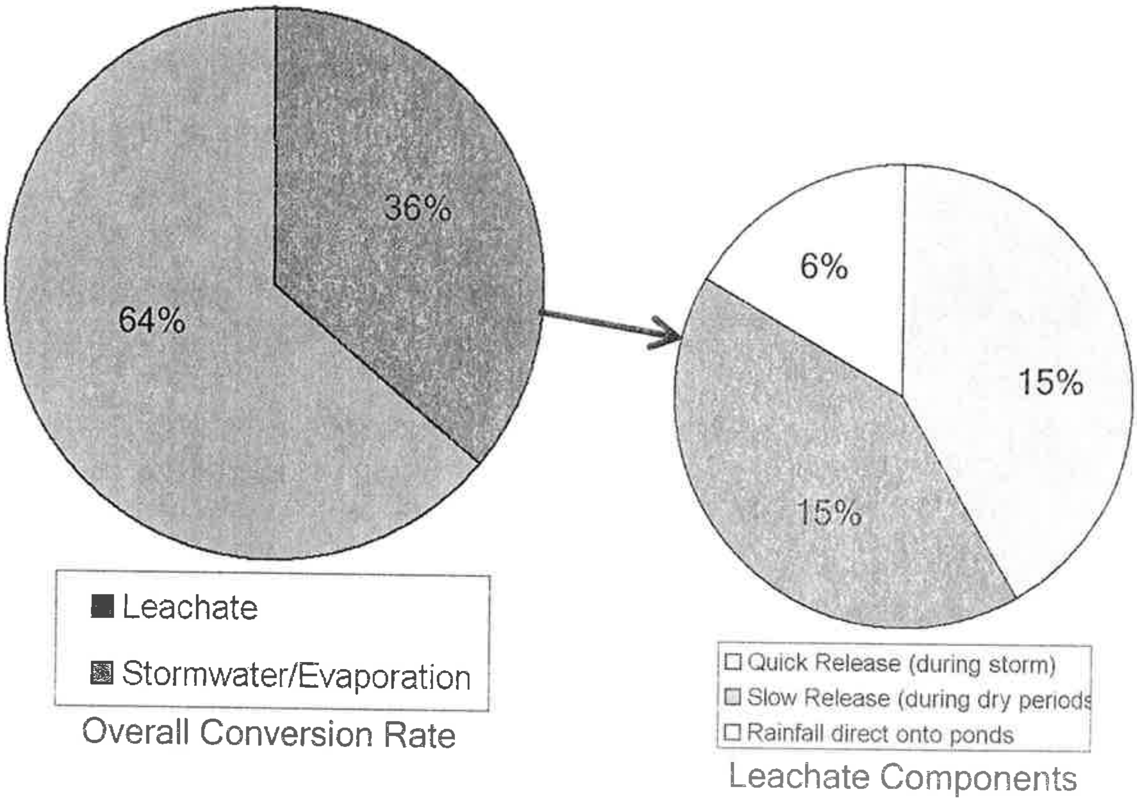


Figure 5.3 Conversion of Rainfall to Leachate at Whytes Gully

As an interesting comparison the previous investigation that formed the basis of the leachate pond design (Forbes Rigby, 2002), found a long term rainfall to leachate conversion rate of 28% (calculated using a calibrated daily balance model over a 5 year period between 1997 and 2001). This is slightly lower but generally consistent with the results of the mass balance described above and gives confidence to the design basis of the existing leachate ponds. However the observed frequency of recent overflow events highlights the sensitivity of leachate production to increases in leachate generation rates during wet weather and the difficulty of applying a simplistic '1 in 25 year' design criteria to areas with re-current storm rainfall patterns. To meet the intent of the original design criteria, Council must reduce leachate generation rates and ensure the leachate ponds are maintained at lower levels even during wet periods.

5.1.3 Conclusion

Key conclusions that can be made with respect to leachate behaviour at Whytes Gully include:

- Stored leachate volume is sensitive to extended periods of high rainfall as experienced over the period April 2007 to April 2008. This is a reflection of rainfall patterns in the Illawarra (i.e. wet weather events do not occur in isolation), high leachate generation rates (i.e. high capping permeability and cross-connections with surface water) and the limited available discharge capacity of the leachate system (i.e. fixed rate sewer disharge).
- On a long term basis approximately 36% of rainfall on the combined landfill and leachate pond surfaces is currently converted to leachate. This is comprised of approximately 15% which is quickly converted (during a storm event), 15% which is slowly converted (over subsequent weeks and months) and 6% direct rainfall into the leachate ponds.
- Mass balance calculations from baseflow periods indicate a typical long term leachate release rate during dry periods of approximately 140kL per day (1.6 L/s). This is an upperbound and expected to reduce during normal to dry years.
- The leachate system demonstrates capacity to recover quickly (i.e. storage levels drop) when drier weather resumes, however this currently relies on supplementary tankering of leachate off-site.
- To meet the intent of the original design criteria, Council must reduce leachate generation rates and ensure the leachate ponds are maintained at lower levels even during wet periods.
- Improved leachate monitoring would enable improved understanding of seasonal variations and the relative contribution of different areas of the landfill to leachate production. This would in turn assist with development of additional targeted management measures.

5.2 Surface Water System

5.2.1 Generally

The Whytes Gully site has an overall catchment of 50 ha stretching between the top of a ridge to the north and Reddalls Road to the south. The entire catchment drains through the Whytes Gully stormwater treatment ponds prior to discharge (refer **Figure 2.5**).

The catchment includes disturbed landfill areas including areas of intermediate and daily cover, hardstand areas, buildings and an internal road system. Due to topographic constraints, undisturbed areas in the upper catchment (north of the landfill) also drain through the site. A series of cut-off drains direct flow from these upstream areas past the active fill zone and into the stormwater ponds.

Whilst the surface water system appears to perform reasonably well during minor storm events, problems have been observed during heavy rainfall including:

- Flow breaking out across the tip face and/or entering the leachate system via direct connections with that system (via open pits and risers)
- Ammonia and sediment laden stormwater passing through the stormwater ponds

A preliminary assessment has been undertaken in order to confirm the behaviour of the existing surface water system and the extent to which observed problems warrant a major review. This assessment focuses on the three key interconnected elements of the surface water system, viz:

1. The catchment surface (**Section 5.2.2**)
2. The surface water collection and conveyance systems (**Section 5.2.3**)
3. The stormwater treatment ponds (**Section 5.2.4**)

5.2.2 Catchment Surface

The catchment surface can be characterised as:

- Steep with highly modified topography
- Well vegetated but with localised areas of disturbance
- Variable soil types including a significant proportion of imported soil and cover materials, natural soils are fine and potentially dispersibie clays

On a long term basis, it is anticipated that the catchment will have a surface water yield equivalent to approximately 30% of incident rainfall. This is a typical value for a rural catchment in the Illawarra (ref: *Table F2, Managing Urban Stormwater: Council Handbook (Draft) NSW EPA, 1998*). However the catchments steep topography and clay dominated soil types will result in much higher rainfall to runoff conversion during heavy storms (approaching 100% for short periods).

Whilst the catchment is generally well protected against erosion due to a good cover of vegetation, heavy rainfall can also result in localised scour and rilling in areas of cover disturbance. These areas include:

- The active tip face
- Areas of intermediate cover with poor vegetation cover
- Temporary stockpiles
- Unlined cut-off drains
- Steep outer terraces of the Eastern Gully
- Hardstand areas used for scrap metal collection and composting

Although not specifically an erosion problem, sediment is also entrained into the surface water system through wash-off of accumulated soil and particulates on internal haul roads.

Council has a number of smaller stormwater treatment ponds located around the site to provide pre-treatment of surface water from the catchment before entering the main stormwater pond system. However given the potentially dispersive soils at the site a more focussed effort towards source control of sediment is suggested with appropriate recommendations to be incorporated into this management plan.

5.2.3 Collection Systems

In the initial design of the surface stormwater collection system, all runoff from the emplacement capping was deliberately collected by a series of sloped benches and swales and directed into the stormwater or leachate collection system at the toe of the emplacement.

In general, surface runoff from the benches is directed:

- For the Western Gully - toward a surface drain formed along the eastern edge of the Western Gully. This runoff is then directed into the stormwater ponds, however during heavy rainfall this can overtop into an open leachate collection pit at the bottom end of the central drain.
- For the Eastern Gully - toward the east where it flows down the eastern side of the Eastern Gully in an open drain formed by the intersection of the emplaced fill and the membrane lining the gully. This runoff is directed into an open collection pond at the toe of eastern Gully and into a leachate line riser inlet. Due to settlement of the landfill the east flowing benches do not have sufficient capacity for large storm events and can result in overflow down the face of the terraces.

Surface runoff from land above and to the east of the Western Gully and Eastern Gully is directed via perimeter surface drains around the emplacements into small stormwater collection ponds. Any surface runoff from the benches that does not enter the leachate collection pit (Western Gully) or pond (Eastern Gully) spills into the stormwater treatment system via these small collection ponds.

As a consequence of this arrangement, a considerable volume of surface runoff that need not be directed into the leachate system enters the leachate system in any event capable of generating surface runoff. In events capable of overtopping the Eastern Gully collection pond, surface runoff from the emplacement benches mixes with leachate already in the collection pond at the start of the storm. The surface and leachate systems are shown diagrammatically in **Figure 2.4** and **Figure 2.5**.

To confirm anecdotal descriptions of surface flow behaviour and to provide a framework against which future works might be evaluated, a 2D hydrodynamic (Tuflow) model of the site was constructed. The hydrodynamic model incorporates the full catchment down to Reddalls Road and was simulated using an intense storm equivalent to the 100 Year Average Recurrence Interval, 1 hour duration storm developed using the methodologies prescribed in Australian Rainfall & Runoff (2001). Surface topography was defined using the topography existing in December 2007. As shown in **Figure 5.4** and **Figure 5.5** below, the modelled flow paths and observations are in good agreement.

Figure 5.4 Flow Depths 15 min into Storm

Figure 5.5 Flow Depths 45 min into Storm

The model reinforces earlier observations that surface water has and will continue to enter the leachate system at the following locations, in all significant storm events, unless steps are taken to modify flow behaviour at these locations:

- The collection pond at the toe of the Eastern Gully which was designed to capture surface water runoff from the outer face benches of the Eastern Gully and direct into the leachate system.
- The open leachate collection pit in the leachate system located at the toe of the Western Gully, which are located in or adjacent to a surface stormwater flowpath.
- As surface flow directly into the leachate storage ponds either as overland flow, from the adjacent emplacement face or direct rainfall.

In addition, the model reinforces the view that any leachate contained in the Eastern Gully collection pond has and will continue to mix with any stormwater in all significant storm events, unless steps are also taken to modify flow behaviour at this location.

5.2.4 Stormwater Treatment Ponds

The stormwater treatment ponds provide treatment to surface water prior to discharge from the site. The pond design is typical of a constructed wetland with a linear flowpath, reed beds, dynamic storage and polishing pond.

The general observation has been made that the ponds perform well with respect to licensed discharge limits, though during recent overflow events mixing with leachate resulted in detection of ammonia in grab sampling undertaken at the overall discharge point. Periodic monitoring has also indicated sediment laden water discharging from the ponds following heavy rainfall. Whilst the ponds observe good design practice, vegetation within the reed beds was not able to be well established due to drought conditions at time of planting. Localised scour can also be observed around the pond shoreline and spillways connecting the reed beds. These factors will contribute to reduced treatment effectiveness compared to that anticipated at design.

Performance of the ponds is unable to be assessed in a detail manner with currently available information, however DECC has requested that a sensibility check be undertaken using the requirements of the NSW Department of Housing's *Managing Urban Stormwater: Soils and Construction* (2004), also known as the 'Blue Book'.

The following table documents the key input assumptions used in calculating pond size in accordance with the Blue Book. Parameters and their values were estimated from relevant tables and figures in the document. It is noted that a higher than normal 90th percentile rainfall depth was adopted in keeping with the high environmental outcomes being sought. A standard calculation spreadsheet providing further detail is included in **Appendix B**.

Parameter	Value
Catchment Area (ha)	50
Disturbed Area (ha)	20
Soil Type	D,F
Design Rainfall (days)	5
Design Rainfall (percentile)	90
Design Rainfall Depth (mm)	60.8
Rainfall Erosivity Factor (R-factor)	5840
Runoff Co-efficient (Cv)	0.63

Using this approach an estimated sediment basin volume of approximately 29,000 m^3 is calculated, comprising of a 19,000 m^3 settling volume and 10,000 m^3 sediment storage. This compares to a total volume within the existing ponds of 40,000 m^3, comprising of 32,000 m^3 of permanent (static) storage and 8000 m^3 of dynamic storage (drawn down over 36 hours).

Although the design basis of the existing stormwater ponds is more closely aligned to that of a constructed wetland, the above sensibility check again confirms the general adequacy of the stormwater pond volume. Nevertheless, observations of ammonia and sediment laden stormwater leaving the site are continued cause for concern.

As part of this management plan, improved leachate management will reduce the potential for overflow into the stormwater ponds thereby reducing potential for contamination of stormwater with ammonia and other typical leachate contaminants. Improved source control to reduce the mobilisation and transport of fine clays from erosion sites in the catchment will also lead to improved water quality in the ponds. With respect to the stormwater ponds themselves, stabilisation works and establishment of vegetation in accordance with the original design intent will enhance the ability of the ponds to treat stormwater to the high standard which is sought.

5.2.5 Conclusions

Key conclusions that can be drawn with respect to existing surface water behaviour at Whytes Gully are:

- The catchment is generally well protected against erosion due to a good cover of vegetation, however heavy rainfall can result in localised scour and rilling in areas of cover disturbance.
- Given the potentially dispersive soils at the site, a more focussed effort towards source control of sediment is required.
- A potentially considerable volume of surface water enters the leachate system at existing collection points at the foot of each landfill gully. Sealing of these entry points will be an important for managing excess leachate generation.
- A sensibility check undertaken in accordance with the NSW Department of Housing 'Blue Book' confirms the general adequacy of the stormwater pond sizing. However, stabilisation works and establishment of vegetation in accordance with the original design intent should be undertaken to improve their performance.

6 Management Options

6.1 General Approach

The general approach towards surface water and leachate management suggested for the site involves selection of low cost options that yield high benefit in terms of the performance objectives sought. In addition, an approach that targets observed problems at their source should be developed in preference to 'end of pipe' treatment solutions, as these may encourage poor site management practices.

Notwithstanding the fact that a reasonable understanding of the leachate and surface water management systems has been achieved, the complex nature of these systems and their interaction with variable site and climatic conditions warrants a cautious approach. Accordingly, management options that demonstrate clear benefits should be implemented immediately, followed by a period of observation and additional data collection. If continued system failure is observed, even after implementation of 'stand out' solutions, then additional measures should be considered. However with improved data availability these future decisions can be made with more certainty.

Any management decisions made should also be mindful that the site is in an interim phase and may undergo considerable change as part of the proposed Stage 3 expansion.

The remainder of this chapter outlines recommendations for specific measures to be undertaken in the short term, in order to improve leachate and surface water management at the site. **Chapter 7** then consolidates these measures into a concise list of actions, a 'Surface Water and Leachate Management Plan'.

6.2 Leachate System

6.2.1 Available Options

Leachate management at Whytes Gully includes the following available options:

1	Reduce generation of leachate	A. Decrease capping permeability
		B. Eliminate cross-connections between surface water and leachate systems
		C. Rain cover over leachate ponds
2	Increase available temporary storage	A. Increase leachate storage pond capacity
		B. Re-injection of leachate into landfill
3	Increase the rate of leachate discharge	A. Increased sewer discharge
		B. Supplementary tankering
		C. Irrigation onto landfill surface

Based on the observed behaviour of the system as described in **Chapter 5**, the most effective short term strategy recommended for the site is a combination of Option 1A, 1B and 3B. Both Options 1A and 1B provide a robust solution by targeting the problem at its source (i.e. decreasing the generation of leachate). Option 3B is considered a good solution for providing the temporary increase in discharge necessary to maintain freeboard in the ponds during prolonged wet weather. Further description of these measures and conceptual assessment of their benefits is provided in **Section 6.2.2**.

Other available leachate management options are either costly for the benefit derived (1C, 2A, 3A), or are of questionable effectiveness during prolonged wet weather (2B, 3C). These options are also less focussed on targeting the problem (i.e. excess leachate production during wet weather), and if implemented could encourage poor capping management practices. These less effective options could be re-explored in the future if further changes in leachate management are sought or if the cost of these options is reduced, for example if additional sewer discharge capacity became available at low cost.

6.2.2 Conceptual Water Balance Modelling

Model Overview

Leachate management improvements were assessed using a conceptual landfill water balance model constructed for the site in consultation with DECC. A conceptual model diagram is shown in **Figure 6.1** below.

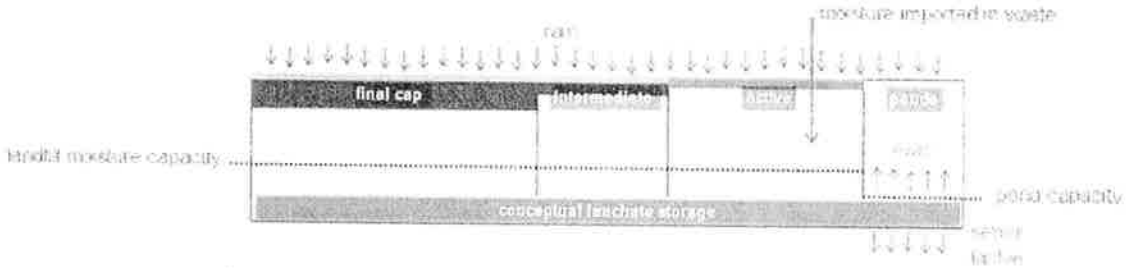


Figure 6.1 Conceptual Landfill Water Balance Model

A detailed description of the model and its components is included in **Appendix C**. In summary, the model incorporates:

- Conceptual water balance using averaged monthly rainfall
- Ability to include high rainfall (90th percentile) wet years
- Consideration of different capping types and leachate generation rates
- Allowance for leachate losses (discharge to sewer, tankering and evaporation from ponds)
- Ability to vary the above factors over a 20 year forward looking simulation period to assess impact of future management changes

- Allowance for importation of leachate within waste
- Overall 'lumped' moisture accounting (i.e. no separate consideration between leachate stored in the landfill and in the ponds)

The conceptual water balance model was used to assess the average reduction in leachate generation that must be achieved in order to achieve long-term improvements. In practical terms, these reductions are achieved by decreasing the average permeability of the landfill through improved capping and elimination of cross-connections between the surface water and leachate systems.

Modelled Leachate Generation Rates

A key input for the conceptual water balance model is the leachate generation rate of the landfill, i.e. the rate at which rainfall is converted to leachate (a function of landfill permeability). Whilst Council has endeavoured to ensure the landfill is constructed in a manner that reduces the infiltration of rainfall, there are practical considerations that result in variable infiltration across the site at any point in time.

The active fill zone (also referred to as 'Daily cover') requires free-draining materials that are quickly trafficable after rainfall. These areas are expected to experience high infiltration.

Areas of 'intermediate cover' do not require the same degree of trafficability, however variable infiltration is expected as the quality and quantity of available VENM materials changes over time. Also the level of compaction that can be achieved varies according to the slope of the outer cell face. In this regard, Council has observed changes in cover material at Whytes Gully, in particular:

- The first few cells of the Western Gully (i.e. bottom of the slope) were constructed using coalwash as both daily and intermediate cover
- Intermediate cover on the Western Gully then quickly transitioned to higher clay content VENM
- During construction of the upper half (approximately) of the Western Gully high quality clay materials were available for use
- The lower (steeper) half of the Western Gully was compacted by track rolling with an excavator during cell construction whereas the upper (flatter) half was able to be compacted using a roller on completion
- Over the period of construction of the Eastern Gully the quality and quantity of VENM available has declined
- The generally steeper slopes of the Eastern Gully have resulted in lower compaction rates on intermediate cover areas (i.e. similar to lower half of the Western Gully)

Based on the above observations, modelling for this and previous investigations have assumed that the Western Gully capping layer behaves in a similar manner to a final capping layer (i.e. low average permeability), whilst the Eastern Gully intermediate cover and daily cover areas are much more permeable.

The most permeable locations within the landfill are those locations where direct cross-connections occur between the surface water and leachate systems. Whilst these cross-connections are small in area and only operate during heavy storms, they are highly effective and can inject large quantities of water into the leachate system during major events (refer **Section 5.2.3**).

Based on the analysis described in **Chapter 5**, an existing average leachate generation rate of approximately 36% was established for the landfill and the ponds. This is an averaged value and in reality incorporates a wide range of cover types and permeability across the site including direct connections with surface water.

For the purpose of modelling, an existing case distribution of leachate generation rates across the site was assumed. Due to uncertainty attached to these values 'low', 'medium' and 'high' leachate generation rates were modelled for the existing case scenario.

Table 6.1 Modelled Leachate Generation Rates

Location	Area (ha)	Leachate Generation Rate Low	Medium	High
Western Gully	9.2	10	10	10
Eastern Gully - Intermediate	3.9	30	40	50
Eastern Gully - Active Zone	5.7	60	70	80
Ponds	1.2	90	90	90
Weighted Average Permeability		*33*	*38*	*43*

The 'medium' leachate generation scenario is most closely comparable to the results of the analysis undertaken in **Chapter 5** with a weighted average permeability of 38% (c.f. a calculated value of 36%) The medium scenario was adopted as a baseline starting condition from which management scenarios were applied and assessed.

For all scenario's, leachate generation rates for the Western Gully and Ponds were held fixed as there is less uncertainty associated with these rates and less scope to easily reduce them.

Management Scenarios

Four management scenarios were modelled for a 20 year forward looking simulation period commencing July 2008 and ending July 2028 as described in **Table 6.2** below.

It is noted that this modelling intends to demonstrate the effectiveness of these management scenarios as applied to the current site. Accordingly the overall area of the site and its various capping types were fixed for the full 20 year simulation period, except where a specific change in capping condition formed part of the management scenario. In reality the site will change from year to year as part of normal site development. As long as these changes are consistent with the adopted management scenario, then any future changes will not compromise the predicted outcomes.

Table 6.2 Modelled Leachate Management Scenarios

Scenario	Description
Scenario 1	**Existing Case** *Assumes no change in capping areas or their management, continued high rate sewer discharge (150 kL/d) and tankering, with wet year approximately every ten years.*
Scenario 2	**Reduced Active Zone and 10% drop in leachate generation** *Assumes active zone (daily cover) reduced to 2ha in extent, infiltration reduced by an average 10% for intermediate and active areas (i.e. from 40% to 30% and 70% to 60% respectively) through improved capping and drainage. Continued high rate sewer discharge (150 kL/d) but no tankering. Wet year approximately every ten years.*
Scenario 3	**Reduced Active Zone and 20% drop in leachate generation** *Assumes active zone (daily cover) reduced to 2ha in extent, infiltration reduced by an average 20% for intermediate and active areas (i.e. from 40% to 20% and 70% to 50% respectively) through improved capping and drainage. Continued high rate sewer discharge (150 kL/d) but no tankering. Wet year approximately every ten years.*
Scenario 4	**Scenario 3 with Reduced Sewer Discharge** *Assumes active zone (daily cover) reduced to 2ha in extent, infiltration reduced by an average 20% for intermediate and active areas through improved capping and drainage. Medium rate sewer discharge (120 kL/d) but no tankering. Wet year approximately every ten years.*

Model Results

The model results from each of the four scenarios are presented below as a series of graphs showing the modelled change in leachate over a 20 year forward looking simulation period commencing July 2008 and ending July 2028. A 90th percentile wet year was applied at Year 1, 10 and 20.

Each graph shows a thin black dashed line representing a total theoretical capacity of the landfill to retain leachate, comprising of leachate storage within both the landfill and in temporary storage ponds. This capacity increases slowly over time as the landfill grows in volume. It can be inferred that any scenario that results in a cumulative leachate volume increasing over time at a rate faster than the total theoretical capacity will result in system failure (i.e. pond overflow).

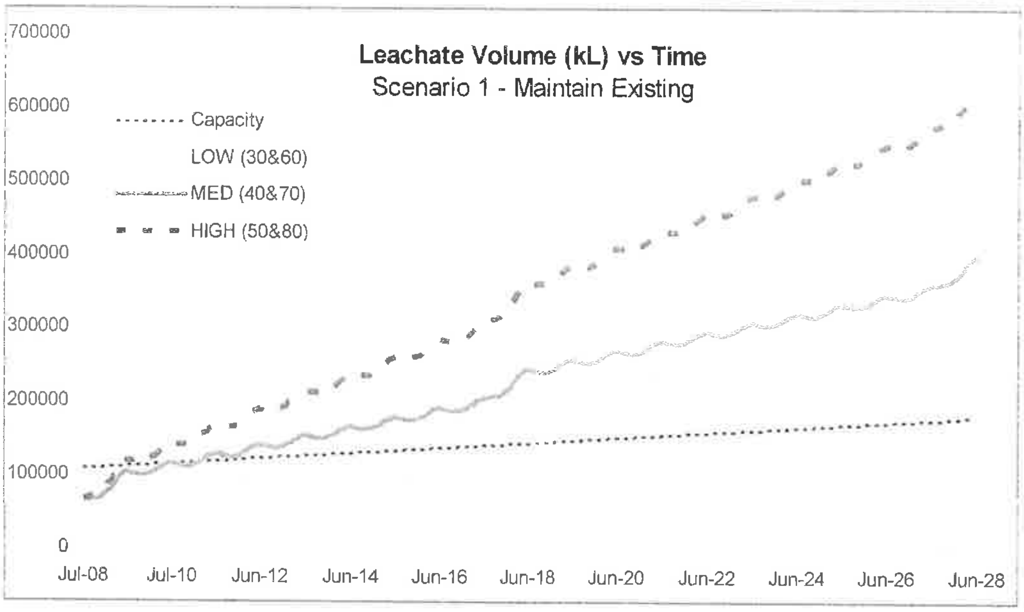


Figure 6.2 Change in Leachate Volume with Time - Scenario 1

The Scenario 1 model results (**Figure 6.2** above) demonstrate that under existing conditions there is a high tendency to accumulate leachate with time for all assumed leachate generation rate conditions (low, medium and high). Separation between the three curves shows high sensitivity to assumed infiltration rates on the intermediate and active zones. Whilst it is difficult to confirm which of the three curves is closest to the current reality, all show leachate accumulation and suggest action is required to change the current situation.

For comparative purposes, each subsequent graph in the remainder of this section also shows the results of the above scenario (Scenario 1), including low, medium, and high leachate generation rate conditions. It is again noted however that each scenario adopts the 'medium' condition as a baseline from which possible improvements are to be made. The altered scenario condition is shown as a thick black line in each graph.

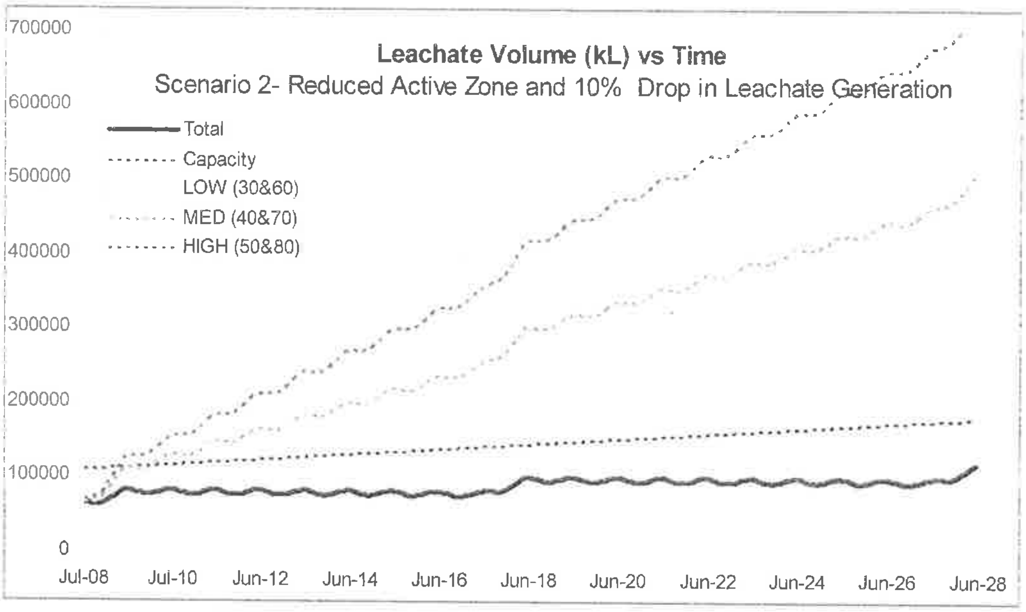


Figure 6.3 Change in Leachate Volume with Time - Scenario 2

Implementation of Scenario 2 (shown above) demonstrates that a significant reduction in leachate accumulation can be achieved through adoption of the suggested measures. At the end of the 20 year simulation period, implementation of Scenario 2 results in a reduction in accumulated leachate from 500,000 kL down to 120,000 kL, representing an overall reduction of 380,000kL.

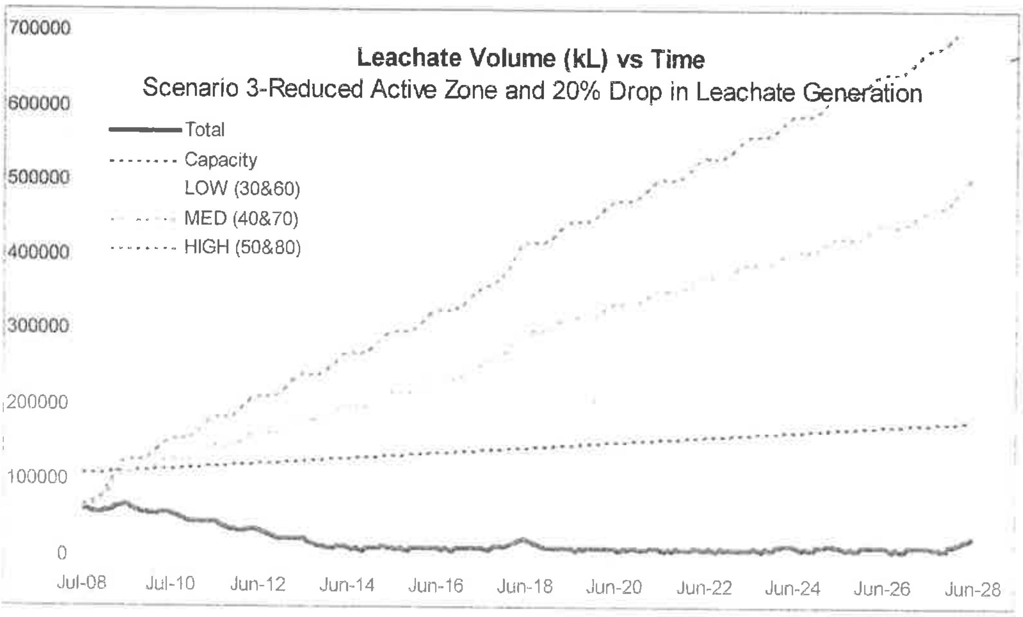


Figure 6.4 Change in Leachate Volume with Time - Scenario 3

Implementation of Scenario 3 demonstrates even further reductions in leachate accumulation can be achieved to the point where the landfill will effectively become dry in approximately 5 years, after which time the system will require only maintenance levels of leachate storage and disposal.

It is again noted that the results presented are based on a conceptual model only, it is anticipated that there will be more actual variation in leachate stored over time and that even after an effective drying out stage is achieved, prolonged wet periods will result in leachate accumulation spikes close to the theoretical capacity of the system. Importantly however the overall balance between leachate generation and discharge rates are more strongly in favour of a dry system.

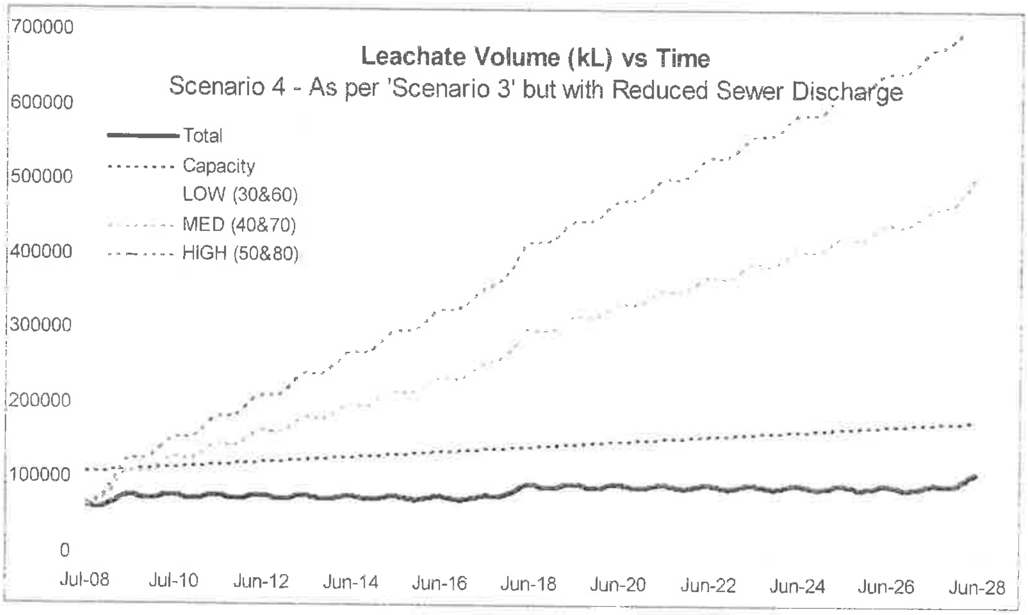


Figure 6.5 Change in Leachate Volume with Time - Scenario 4

Scenario 4 demonstrates the impact of a small reduction in sewer discharge rate from 150 kL/day to 120 kL/d. While leachate accumulation remains below total theoretical capacity, it continues to increase slowly with time. A high sewer discharge rate should therefore be maintained until such time as the area of intermediate capping transitions to a highly impermeable final capping.

Implementation

The above results indicate that effective leachate management will require a significant reduction in the area associated with active filling from a current 5.7 ha to 2 ha, as well as a reduction in leachate generation on the Eastern Gully by a minimum of 10% but preferably by 20%.

Based on discussions with Council the reduction in active fill zone can be achieved via a modified approach to waste emplacement including a temporary transfer station already implemented and used by the public. This enables the area required for active tipping to be reduced to that required by commercial waste trucks only. In the longer term this transfer station will be formalised and located near the main entry of the site.

Reductions in leachate generation by a minimum of 10% on the Eastern Gully are to be achieved by a combination of measures including:

- Sealing of existing surface water and leachate cross-connections
- Progressive modification of the active fill zone to create cells with increased surface cross-fall towards the edge of the emplacement
- Sealing of the interface between the base liner and the active fill zone so that clean surface water from the base liner is not encouraged to find preferential flowpaths through the landfill and instead remains in the surface water system
- Use of temporary flexible geo-membranes to decrease permeability of intermediate and active (daily) cover areas on the Eastern Gully. Options include spray on polymeric coatings, PVC plastic sheeting buried beneath topsoil, or EPDM flexible rubber liner. It is understood that Council is currently trialling spray-on coating options and if successful will consider implementation over a larger area. Geotechnical investigation and leachate monitoring will be used to assess to which areas these membranes and coatings are best applied (refer **Section 6.4**).

Council should also commence stockpiling of clay based VENM on the top of the Eastern Gully to provide a reduction in infiltration during the period of stockpiling and for the longer term to ensure availability of materials for future capping of the overall site.

A further available option subject to geotechnical investigation and review of construction feasibility may be the reshaping of the Eastern Gully intermediate cover terracing to increase drainage cross-fall. This can be achieved by regrading the crest of each existing terrace downslope and away from the outer face of the adjoining cell. Material obtained from trimming could be used to create increased longitudinal fall on selected terraces (say every 5th terrace) to convey accumulated surface water away to the edge of the landfill. This option may be difficult to pursue due to construction safety issues and should be carefully assessed prior to commencement.

Conclusions

- The conceptual model results confirm a high sensitivity between leachate generation rate and long term accumulation of leachate.
- In order to improve the balance between leachate generation and discharge, Council must decrease the area of active filling (daily cover) to a minimum of 2 hectares, and reduce the rate of infiltration through the landfill capping on both the active zone and intermediate cover areas by a minimum of 10% (but preferably by 20%).
- A 20% reduction in infiltration rates will see the landfill become effectively dry after 5 years. This means the amount of leachate being produced will drop significantly and allow reduced average sewer discharge.
- Existing rates of sewer discharge will need to be maintained, however large reductions in infiltration will enable Council to decrease sewer discharge rates over time.

- Whilst not able to be demonstrated by this conceptual model, it is anticipated that even if the landfill becomes effectively dry, prolonged wet periods will result in spikes of leachate accumulation. More intense management of leachate during these periods will continue to be required even after implementation of this plan.

6.3 Surface Water System

Based on the observed performance of the surface water system and the analysis described in Chapter 5, it is recommended that the following surface water management options be pursued:

- Improved management practices to reduce sediment transport from erosion risk areas. This will include a combination of typical sediment and erosion control strategies including cleanwater diversion, mulching, hydroseeding, silt fences, hay bale barriers and temporary sediment basins.

- Sealing of existing cross-connections between the surface water and leachate systems, located at the toe of the Eastern and Western Gully emplacements

- Improvements to the existing stormwater ponds, including stabilisation works around the pond shoreline and establishment of vegetation in accordance with the original design intent.

6.4 Planning Investigations & Monitoring

The following non-structural works are recommended for consideration as part of the overall management strategy:

Planning

- Commence planning for the proposed Stage 3 landfill expansion including preliminary designs and approvals. This activity will permit longer term planning for leachate and surface water management infrastructure to be undertaken with greater certainty. As part of this planning and design process, consideration should be given to ways in which the Stage 3 expansion can reduce leachate generation and better manage surface water in both the short term (during the active life of Stage 3) and in the longer term.

- Finalise proposals for a Waste Transfer Station located near the site entrance. Once implemented this facility will improve the management of commercial and domestic vehicles accessing the tip face and allow the active filling zone footprint to be kept to a minimum.

Investigations

- Undertake a geotechnical investigation in order to gain better appreciation of the permeability of existing capping materials across the site and to assist with identification and targeting of measures required to reduce the infiltration of rainfall through the various capping layers. A technical brief has been prepared for this work and is included in **Appendix D**.

- Undertake a brief annual review of this document and the assumptions contained within it. If significant change in the site occurs or if there is significant change in the way in which

Council must manage the landfill operation then different strategies may be warranted. The annual review should include a summary analysis of the rainfall, pond and discharge data and discussion of observed trends in average leachate production. A reduction in leachate production should be observed if the recommendations of this plan are implemented successfully.

Monitoring

- Monitoring of the flow of leachate in each of the separate leachate lines entering the collection pit should be undertaken in order to assess the relative contribution of leachate from different segments of the landfill. This will allow future additional management measures to better target the source of greatest leachate volume.
- Maximum Height Indicators (MHI) should be installed near the overflow spillways on each of the leachate storage ponds. These could be used in conjunction with the existing continuous monitoring gauges to better assess the volume of leachate discharge in the event of future overflow. It is noted that the continuous gauges do not have sufficient resolution at this depth to permit accurate measurement without the additional ability to correct the data using MHI results.
- Monitoring of leachate pond levels and rainfall at the site should continue in order to permit periodic checks on leachate production rates and assess the adequacy of the measures described in this plan.
- Additional surface water monitoring in accordance with recommendations of the recent report by Earth2Water (2008). This will enable improved assessment of the effectiveness of the surface water treatment ponds.

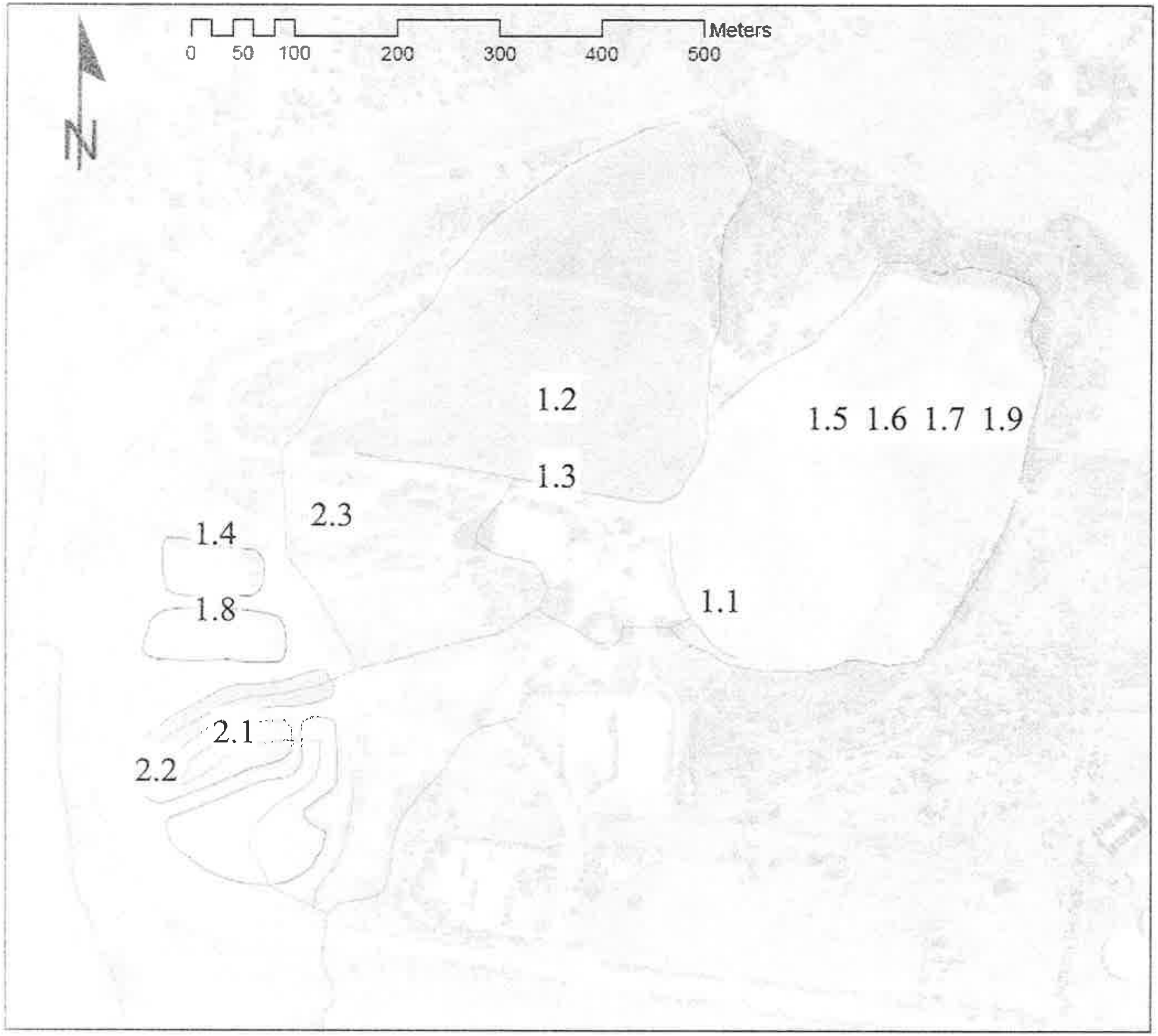
7 Surface Water and Leachate Management Plan 2008

The measures proposed as part of this Surface water and Leachate Management Plan are listed in the table below and are also shown in **Figure 7.1** overleaf.

Table 7.1 Proposed Surface Water and Leachate Management Measures

	Description of Proposed Measures	Indicative Cost ($K)	Indicative Timing (months)
1	**Leachate Management**		
1.1	Cap and remove leachate pit at toe of Eastern Gully	10	3
1.2	Cap risers within Western Gully	2	3
1.3	Seal concrete leachate pits at toe of Western Gully	5	3
1.4	Bunding of leachate ponds to protect from surface sheet flow	1	3
1.5	Reduce footprint of Active Zone to 2 ha (including tip face)	*[a]*	6
1.6	Improve surface drainage of active zone (increase cross-fall)	*[a]*	6
1.7	Reduce permeability of intermediate cover and active fill zone on Eastern Gully by 10% minimum (preferably by 20%)	100	6
1.8	Maintain ponds at 50% storage maximum, resume tankering if required.	50	ongoing
1.9	Stockpiling of clay based VENM for future capping	*[a]*	ongoing
	Surface Water Management		
2.1	Refurbishment of stormwater ponds to ensure plant re-establishment within reed beds in accordance with original design.	50	24
2.2	Improved armouring of spillways between reed beds to prevent erosion	10	3
2.3	Improved sediment control on disturbed sites	*[a]*	ongoing
	Planning, Investigations & Monitoring		
3.1	Install flow monitoring equipment on leachate lines	30	3
3.2	Install Maximum Height Indicators on leachate ponds	2	3
3.3	Undertake geotechnical investigation of existing capping materials	20	6
3.4	Engage consultants to undertake design of waste transfer station	50	12
3.5	Engage consultants to prepare concept design and gain approvals for Stage 3	250	36
3.6	Continued monitoring of leachate pond levels and rainfall	*[a]*	ongoing
3.7	Additional surface water monitoring in accordance with Earth2Water report (2008)	*[a]*	ongoing
3.8	Annual review of the Surface Water and Leachate Management Plan	*[a]*	ongoing

[a] assume no cost if undertaken as part of normal operations



	Description of Proposed Measures
1	Leachate Management
1.1	Cap and remove leachate pit at toe of Eastern Gully
1.2	Cap risers within Western Gully
1.3	Seal concrete leachate pits at toe of Western Gully
1.4	Bunding of leachate ponds to protect from surface sheet flow
1.5	Reduce footprint of Active Zone to 2 ha (including tip face)
1.6	Improve surface drainage of active zone (increase cross-fall)
1.7	Reduce permeability of intermediate cover and active fill zone on Eastern Gully by 10% minimum (preferably by 20%)
1.8	Maintain ponds at 50% storage maximum, resume tankering if required.
1.9	Stockpiling of clay based VENM for future capping
2	Surface Water Management
2.1	Refurbishment of stormwater ponds to ensure plant re-establishment within reed beds in accordance with original design.
2.2	Improved armouring of spillways between reed beds to prevent erosion
2.3	Improved sediment control on disturbed sites
3	Planning, Investigations & Monitoring
3.1	Install flow monitoring equipment on leachate lines
3.2	Install Maximum Height Indicators on leachate ponds
3.3	Undertake geotechnical investigation of existing capping materials
3.4	Engage consultants to undertake design of waste transfer station
3.5	Engage consultants to prepare concept design and gain approvals for Stage 3
3.6	Continued monitoring of leachate pond levels and rainfall
3.7	Additional surface water monitoring in accordance with Earth2Water report (2008)
3.8	Annual review of the Surface Water and Leachate Management Plan

Whytes Gully Landfill Surface Water and Leachate Management Plan 2008

8 General Guidance for Future Plans

The following heads of consideration are provided for future site management plans, new infrastructure or site operations that either directly or indirectly impact on surface water and leachate systems at Whytes Gully:

- The existing leachate storage and stormwater management ponds have been designed on the basis of several key assumptions (refer **Chapter 4**). Consideration should be given to how any future activity might impact on these assumptions and therefore pond performance. If the impact is significant then action should be taken to change the activity or alternatively to make a compensatory increase in pond capacity or effectiveness.

- Leachate generation is highly sensitive to the infiltration rate of the capping material. Future capping construction should look to make use of materials with low permeability, particularly in areas of shallow grade. Stockpiling of clay based VENM materials for future capping is recommended.

- Leachate generation is highly sensitive to the area of active filling as this area is typically permeable and of shallow grade in order to meet trafficability requirements. The area of active filling should be kept to a minimum footprint less than 2 hectares.

- If Stage 3 proceeds, the current capping material on (Stages 1 and 2) will at some stage be stripped and replaced with a base liner for Stage 3. The stripping of old cap materials is a sensitive activity that will impact on leachate generation and stormwater quality. An appropriate construction design and schedule should be devised that minimises the risk of this activity.

- Do not re-introduce cross-connections between the surface water and leachate collections systems. These cross-connections significantly increase leachate generation.

- Future designs should look for opportunity to divert clean water away from the leachate and stormwater treatment ponds to minimise their hydraulic loading.

- Future design should look to maximise the gradient of landfill capping materials (daily, intermediate and final) whilst still meeting compaction and permeability requirements. Designs should at the same time minimise the gradient of surface water collection drains traversing the landfill to minimise erosion. If required, hard lining (gabion mattress or equivalent) should be employed in the invert of surface water drains in steep areas.

- The existing system is constrained by a fixed discharge capacity. This capacity cannot be increased in a cost effective manner at this stage, however future development of West Dapto will likely result in additional trunk main capacity. Additional sewer discharge capacity for wet weather periods should be sought at this possible future stage.

- When developing any temporary surface capping strategies, consider minimisation of the impact on vegetation cover, as vegetation provides erosion protection and reduces average capping saturation during inter-event periods (due to enhanced evapo-transpiration).

SITE PLAN

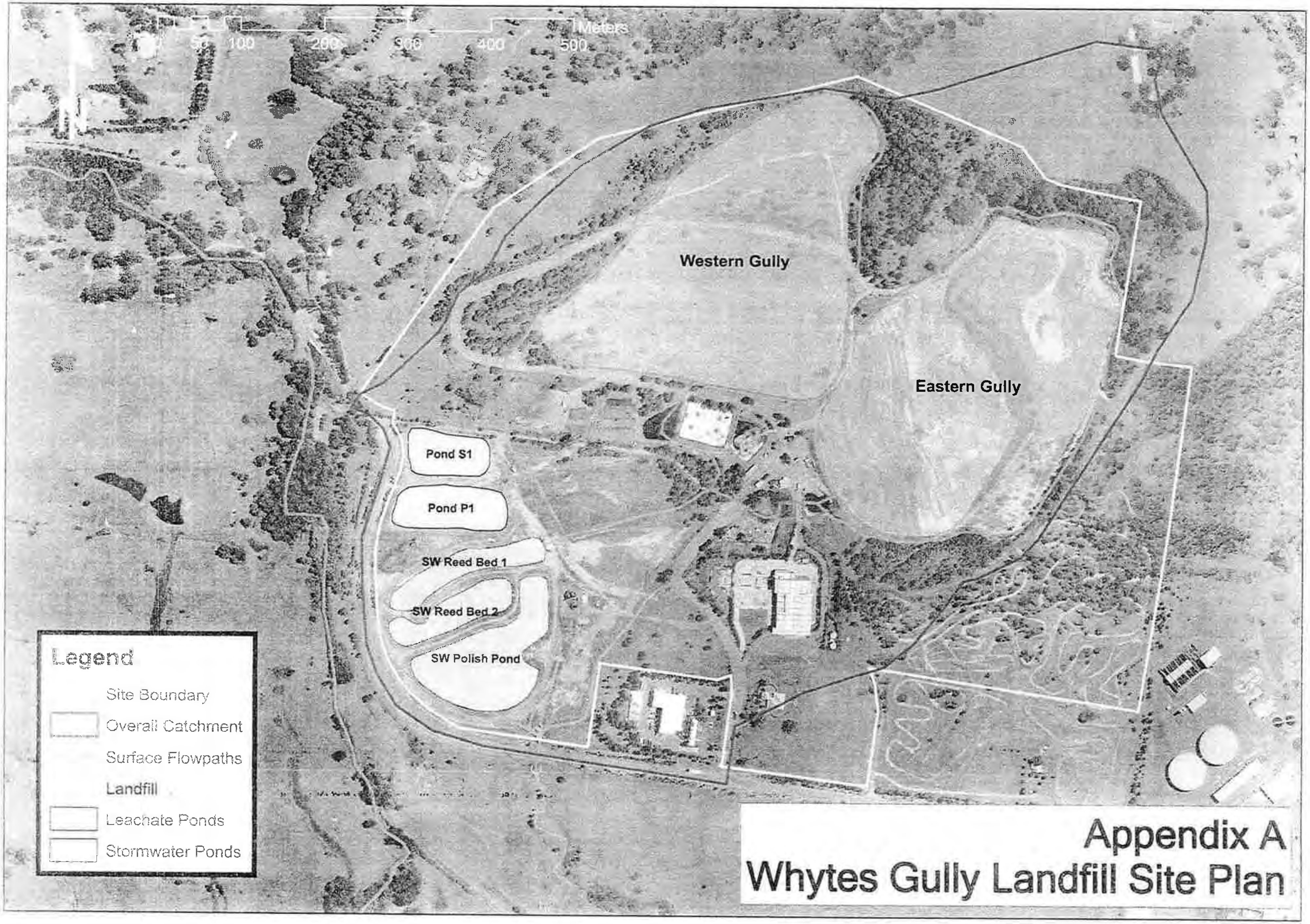
A

A

A

A

APPENDIX A



Appendix A
Whytes Gully Landfill Site Plan

STORMWATER POND CALCULATIONS

B

B

B

B

APPENDIX B

3. Volume of Sediment Basins: *Type C* Soils

Basin volume = settling zone volume + sediment storage volume

Settling Zone Volume

The settling zone volume for *Type C* soils is calculated to provide capacity to allow the design particle (e.g. 0.02 mm in diameter) to settle in the peak flow expected from the design storm (e.g. 0.25-year ARI) The volume of the basin's settling zone (V) can be determined as a function of the basin's surface area and depth to allow for particles to settle. Peak flow/discharge for the 0.25-year, ARI storm is given by the Rational Formula:

$$Q_{tc,0.25} = 0.5 \times [0.00278 \times C_{10} \times F_y \times I_{1yr,tc} \times A]\ (m^3/sec)$$

where:

$Q_{tc,0.25}$ = flow rate (m^3/sec) for the 0.25 ARI storm event

C_{10} = runoff coefficient (dimensionless for ARI of 10 years)

F_y = frequency factor for 1 year ARI storm

$I_{1 yr,tc}$ = average rainfall intensity (mm/hr) for the 1-year ARI storm

A = area of catchment in hectares (ha)

Basin surface area (A) = area factor x $Q_{tc,0.25}$ m^2

Particle settling velocities under ideal conditions (Section 6.3.5(e))

Particle Size	Area Factor
0.100	170
0.050	635
0.020	4100

Volume of settling zone = basin surface area x depth (Section 6.3.5(e)(ii))

Sediment Storage Zone Volume

In the standard calculation, the sediment storage zone is 100 percent of the setting zone. However, designers can work to capture the 2-month soil loss as calculated by the RUSLE (Section 6.3.5(e)(iv)), in which case the "Detailed Calculation" spreadsheets should be used.

Total Basin Volume

Site	$Q_{tc,0.25}$ (m^3/s)	Area factor	Basin surface area (m^2)	Depth of settling zone (m)	Settling zone volume (m^3)	Sediment storage volume (m^3)	Total basin volume (m^3)	Basin shape		
								L:W Ratio	Length (m)	Width (m)
WGL	2.010	4100	8240	0.6	4944	4944	9888			
		4100								
		4100								
		4100								
		4100								
		4100								

2. Storm Flow Calculations

Peak flow is given by the Rational Formula:

$$Qy = 0.00278 \times C_{10} \times F_Y \times I_{y,tc} \times A$$

where:

- Q_y is peak flow rate (m^3/sec) of average recurrence interval (ARI) of "Y" years
- C_{10} is the runoff coefficient (dimensionless) for ARI of 10 years. Rural runoff coefficients are given in Volume 2, figure 5 of Pilgrim (1998), while urban runoff coefficients are given in Volume 1, Book VIII, figure 1.13 of Pilgrim (1998) and construction runoff coefficients are given in Appendix F
- F_y is a frequency factor for "Y" years. Rural values are given in Volume 1, Book IV, Table 1.1 of Pilgrim (1998) while urban coefficients are given in Volume 1, Book VIII, Table 1.6 of Pilgrim (1998)
- A is the catchment area in hectares (ha)
- $I_{y,tc}$ is the average rainfall intensity (mm/hr) for an ARI of "Y" years and a design duration of "tc" (minutes or hours)

Time of concentration (t_c) = $0.76 \times (A/100)^{0.38}$ hrs (Volume 1, Book IV of Pilgrim, 1998)

Note: For urban catchments the time of concentration should be determined by more precise calculations or reduced by a factor of 50 per cent.

Peak flow calculations, 1

Site	A (ha)	tc (mins)	Rainfall intensity, I, mm/hr						C_{10}
			$1_{yr,tc}$	$5_{yr,tc}$	$10_{yr,tc}$	$20_{yr,tc}$	$50_{yr,tc}$	$100_{yr,tc}$	
WGL	50	35	53	90	102	118	140	156	0.88

Peak flow calculations, 2

ARI yrs	Frequency factor (F_y)	Peak flows						Comment
		WGL						
		(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m3/s)	
$1_{yr,tc}$	0.62	4.019						Zone C <500m
$5_{yr,tc}$	0.9	9.908						Zone C <500m
$10_{yr,tc}$	1	12.477						Zone C <500m
$20_{yr,tc}$	1.1	15.877						Zone C <500m
$50_{yr,tc}$	1.1368571	19.468						Zone C <500m
$100_{yr,tc}$	1.1792	22.501						Zone C <500m

Note: These "Standard Calculation" spreadsheets relate only to low erosion hazard lands as identified in figure 4.6 where the designer chooses to not use the RUSLE to size sediment basins. The more "Detailed Calculation" spreadsheets should be used on high erosion hazard lands as identified by figure 4.6 or where the designer chooses to run the RUSLE in calculations.

1. Site Data Sheet

Site name: **Whytes Gully Landfill**

Site location: **Whytes Gully Landfill, Reddals Road, Kembla Grange**

Precinct:

Description of site: **Small catchment containing landfill site incorporating a 50ha total catchment of which no more than 20ha is disturbed (conservative)**

Site area	Site						Remarks
	WGL						
Total catchment area (ha)	50						
Disturbed catchment area (ha)	20						

Soil analysis

Soil landscape							DIPNR mapping (if relevant)
Soil Texture Group	D						Sections 6.3.3(c), (d) and (e)

Rainfall data

Design rainfall depth (days)	5						See Sections 6.3.4 (d) and (e)
Design rainfall depth (percentile)	90						See Sections 6.3.4 (f) and (g)
x-day, y-percentile rainfall event	60.8						See Section 6.3.4 (h)
Rainfall intensity: 2-year, 6-hour storm	16						See IFD chart for the site
Rainfall erosivity (R-factor)	5840						Automatic calculation from above data

Comments: Assume 5 day rainfall depth (standard), 90th percentile rainfall (sensitive site) and type F or D soils

4. Volume of Sediment Basins, *Type D* and *Type F* Soils

Basin volume = settling zone volume + sediment storage zone volume

Settling Zone Volume

The settling zone volume for *Type F* and *Type D* soils is calculated to provide capacity to contain all runoff expected from up to the y-percentile rainfall event. The volume of the basin's settling zone (V) can be determined as a function of the basin's surface area and depth to allow for particles to settle and can be determined by the following equation:

$$V = 10 \times C_v \times A \times R_{y\text{-}\%ile,\ x\text{-}day}\ (m^3)$$

where:

10 = a unit conversion factor

C_v = the volumetric runoff coefficient defined as that portion of rainfall that runs off as stormwater over the x-day period

R = is the x-day total rainfall depth (mm) that is not exceeded in y percent of rainfall events. (See Sections 6.3.4(d), (e), (f), (g) and (h)).

A = total catchment area (ha)

Sediment Storage Zone Volume

In the standard calculation, the sediment storage zone is 50 percent of the setting zone. However, designers can work to capture the 2-month soil loss as calculated by the RUSLE (Section 6.3.4(i)(ii)), in which case the "Detailed Calculation" spreadsheets should be used.

Total Basin Volume

Site	C_v	R x-day y-%ile	Total catchment area (ha)	Settling zone volume (m^3)	Sediment storage volume (m^3)	Total basin volume (m^3)
WGL	0.63	60.8	50	19152	9576	28728

CONCEPTUAL LEACHATE WATER BALANCE MODEL

C

C

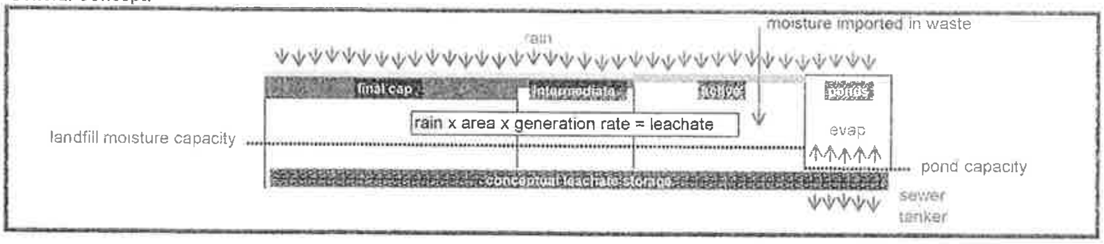
C

C

APPENDIX C

LEACHATE FORECAST MODEL - NOTES

General Concept:



Key Limitations:

- *Planning tool only. Do not use for design purposes.*
- *Monthly timestep does not account for shorter term physical processes such as rainfall intensity and antecedant moisture.*
- *Averaging of rainfall does not account for typical patterns of rainfall in Eastern Australia (i.e. episodic 'la nina' & 'el nino')*
- *Leachate generation rates must implicitly account for any variability within capping material of a particular class*
- *Does not differente between leachate in landfill and leachate in ponds nor any migration between.*

	Notes on General Model Construction:	**Notes Specifically Related to This Site:**
A1	*Model uses average monthly rainfall for the site but has facility to incorporate up to three 'wet years' (see note A2)*	*Monthly data from Bureau of Meteorology (Wollongong Post Office - gauge no. 068069)*
A2	*Model uses 90th percentile monthly rainfall (i.e.'wet year') for year numbers entered in yellow cells (maximum of 3). Leave blank if only average rainfall to be used.*	*Wet year assumed in Year No. 1, 10 and 20 (i.e. approximately once every 10 years)*
A3	*This column contains a list of 'year no.s' that are used to automatically assign data from yellow cells (user input data) to the water balance model below. This allows accounting for yearly variation of management activities such as changes in landfill capping in accordance with a filling plan, or progressive reduction in infiltration through improved drainage.*	*This model was run for a full 20 year period commencing July 2008.*
B1	*Area of landfill that comprises of final capping (i.e. low permeability, well compacted materials of a permanent nature)*	*As at December 2007 the site had a total 'final cap' area of 9.2ha represented by the Western Gully (measured using precise computer based measurement)*

B2	*Area of landfill that comprises of intermediate capping (i.e. moderate permeability uncompacted materials of a semi-permanent nature)*	*As at December 2007 the site had a total 'intermediate' area of 3.9ha represented by the steep terraces on the southern half of the Eastern Gully (measured using precise computer based measurement)*
B3	*Area of landfill that is being actively filled and comprises of daily cover only (i.e. low permeability, poorly compacted material)*	*As at December 2007 the site had a total 'active fill' area of 5.7ha represented by the Eastern Gully tip face and the intermediate cover to the north which is relatively flat and drains across the tip face and therefore included as part of the active zone (measured using precise computer based measurement)*
B4	*Area of leachate ponds (and areas surrounding) that contribute to leachate generation.*	*As at December 2007 the site had a total 'pond' area of 1.2ha represented by the pond surface and adjoining plastic lined areas (measured using precise computer based measurement)*
C1	*Proportion of rainfall that is converted to leachate. Adopted rate must allow for surface runoff and evapotranspiration which are proportional to the composition of the capping material, vegetation cover, slope and rainfall intensity.*	*Assumed rate of 10%. Low infiltration is expected for tight compacted clay (K = 1x10-9) on a steep slope with high intensity rainfall and vigourous vegetation growth (i.e. high evapotranspiration).*
C2	*Proportion of rainfall that is converted to leachate. Adopted rate must allow for surface runoff and evapotranspiration which are proportional to the composition of the capping material, vegetation cover, slope and rainfall intensity.*	*Intermediate cover areas expected to have higher permeability due to poor compaction and moderate permeability materials (variable mix of sand, silt, clay). At Whytes Gully, mitigating factors include steep slope, high rainfall intensity and thick vegetation. Modelled range between 30% and 50%.*
C3	*Proportion of rainfall that is converted to leachate. Adopted rate must allow for surface runoff and evapotranspiration which are proportional to the composition of the capping material, vegetation cover, slope and rainfall intensity.*	*Active (daily cover) areas expected to have higher permeability due to poor compaction, flat slope and high permeability materials (uncemented slag material). Some evaporation from surface moisture store may occur following light rain. Modelled range between 60% and 80%.*
C4	*Proportion of rainfall that is converted to leachate. Adopted rate must allow for surface runoff and evapotranspiration which are proportional to the composition of the capping material, vegetation cover, slope and rainfall intensity.*	*Pond areas expected to have higher permeability, 100% for water surface but slightly reduced for evap off plastic liner around pond, say 90% average for entire pond area.*
D1	*Loss of leachate via discharge to sewer. Monthly rate in kL. For numerical stability losses no longer occur when total volume of leachate in the system drops below a certain threshold (refer Note G3).*	*Three rates adopted depending on scenario: low pumping rate (90kL/day or 2738kL/month), medium pumping rate (120kL/dey or 3650kL/month), high pumping rate (150kL/day or 4563kL/month). A medium pumping rate is equivalent to using the low rate and high rate each 50% of the time.*

D2	*Loss of leachate via tanker truck. Monthly rate in kL. For numerical stability losses no longer occur when total volume of leachate in the system drops below a certain threshold (refer Note G3).*	*Single rate adopted (29kL/day or 882kL/month) based on average tanker rates during period 2007-2008*
D3	*Loss of leachate via evaporation from ponds. Monthly rate in kL. For numerical stability losses no longer occur when total volume of leachate in the system drops below a certain threshold (refer Note G3).*	*Single rate adopted of 760kL/month calculated as an average 152mm of monthly evaporation (Sydney Airport BOM Gauge) multiplied by an average pond area of 0.5ha.*
E1	*Monthly Leachate Generation - Monthly volume of leachate imported in waste. Calculated automatically as typical leachate content multipled by monthly imported waste tonnage.*	*Assume 10,000 tonnes per month with a typical free leachate content of 0.03kL/tonne*
E2	*Monthly Leachate Generation - Monthly volume of leachate generated from areas of final capping. Calculated automatically using rainfall multiplied by area multiplied by generation rate.*	*Calculated using assumed rainfall, area and leachate generation rate*
E3	*Monthly Leachate Generation - Monthly volume of leachate generated from areas of intermediate capping. Calculated automatically using rainfall multiplied by area multiplied by generation rate.*	*Calculated using assumed rainfall, area and leachate generation rate*
E4	*Monthly Leachate Generation - Monthly volume of leachate generated from areas of active fill (daily cover). Calculated automatically using rainfall multiplied by area multiplied by generation rate.*	*Calculated using assumed rainfall, area and leachate generation rate*
E5	*Monthly Leachate Generation - Monthly volume of leachate generated by rainfall direct on ponds and surrounds. Calculated automatically using rainfall multiplied by area multiplied by generation rate.*	*Calculated using assumed rainfall, area and leachate generation rate*
F1	*Total volume of leachate stored within the landfill and ponds. Calculated on a monthly basis as the total volume of leachate from the previous month PLUS leachate generated in the month MINUS leachate lost in the month. Starting values for first month calculated from user inputs (see Notes G1 and G2). Does not account for loss of leachate during pond overflow.*	*Calculated value (also see Note G2)*

F2	*Total 'capacity' of landfill to assimilate leachate. Notional capacity of storage within landfill calculated as: total emplaced tonnage of waste (tonnes) MULTIPLIED by leachate capacity (kL/tonne) PLUS capacity of leachate ponds. Formula accounts for continual monthly import of waste (and therefore continual increase in notional capacity). Not used for leachate water balance but included for graphing purposes. Prolonged periods where stored leachate exceeds the total capacity, signifies the need for improved leachate management.*	*Calculated value (also see Note G2)*
G1	*Reference table of various leachate discharge rates. Not used by any formulae in spreadsheet but should be manually entered into relevant user input cells (see D1 and D2)*	*Sewer rates based on WCC's current arrangements with Sydney Water. Medium rate to be used for years where 50% of time on high rate and 50% on low rate. Tanker rates based on recorded data during period 2007 to 2008.*
G2	*Landfill parameters:Total volume of waste in landfill; volume of waste imported monthly; typical maximum free leachate content of waste (i.e. above background moisture levels able to freely drain out over time); leachate content at start of simulation*	*Estimated values for Whytes Gully*
G3	*Pond parameters:Total volume of leachate ponds; volume of pond at start of simulation; average surface area of leachate pond (for evaporation calculation); monthly evaporation rate; and 'stop loss threshold' which is a leachate storage threshold below which no further losses are assumed (equivalent to an effectively 'dry' landfill).*	*Estimated values for Whytes Gully. Pond volume based on new leachate pond design capacity. Assumed 100% full at start due to wet antecedant conditions. Evaporation based on typical annual evaporation of 1800mm as measured at Sydney Airport BOM gauge.*
G4	*This is a volume check in order to test that the calculations correctly balance leachate inputs and outputs. Some numerical error occurs due to rounding and zeroing of storages and losses. If total volume error is less than 1% then the balance is considered acceptable. If greater, the user should check all input data and calculations.*	*Calculated value*
G5	*These columns contain additional results that have been copy and pasted from calculation columns for inclusion in the graphs 'source data' range. These are static values and do not update automatically. Delete if not required.*	*Calculated values. The 'Scenario 1 - Maintain Existing' Low, Medium and High infiltration curves have been included on all graphs for reference purposes.*

LEACHATE FORECAST

Site: WHYTES GULLY LANDFILL, WEST DAPTO
Scenario: 1 - Maintain Existing
Description: Assume no change in capping areas or their management, continued high rate sewer discharge and tankering, with wet year approximately every ten years.
Results: High sensitivity to infiltration rates on intermediate and active zone, adopt medium range as reference condition for further scenario analysis.

Rainfall (mm)

Assume Avg monthly rainfall except for:
90th %ile Rain in Year No. 1
90th %ile Rain in Year No. 10
90th %ile Rain in Year No. 20

Monthly Rainfall	Average mm	90th%ile mm
January	106	140
February	110	146
March	118	157
April	129	172
May	115	153
June	107	142
July	92	122
August	61	81
September	65	87
October	67	89
November	72	96
December	86	114
Total	1129	1499

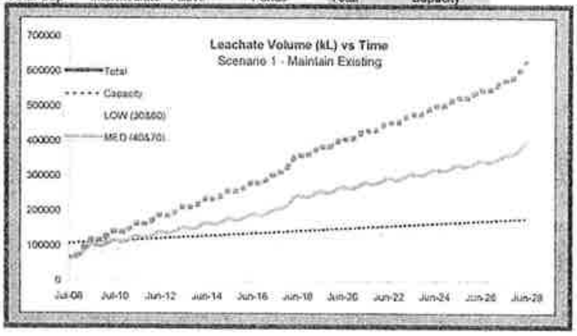
	Leachate Generation Areas (ha)				Leachate Generation Rates (%)				Monthly Leachate Losses (kL)		
Year No	Final Cap	Intermediate	Active	Ponds	Final Cap	Intermediate	Active	Ponds	Sewer	Tanker	PondEvap
1	9.2	3.9	5.7	1.2	10	40	70	90	4563	882	760
2	9.2	3.9	5.7	1.2	10	40	70	90	4563	882	760
3	9.2	3.9	5.7	1.2	10	40	70	90	4563	882	760
4	9.2	3.9	5.7	1.2	10	40	70	90	4563	882	760
5	9.2	3.9	5.7	1.2	10	40	70	90	4563	882	760
6	9.2	3.9	5.7	1.2	10	40	70	90	4563	882	760
7	9.2	3.9	5.7	1.2	10	40	70	90	4563	882	760
8	9.2	3.9	5.7	1.2	10	40	70	90	4563	882	760
9	9.2	3.9	5.7	1.2	10	40	70	90	4563	882	760
10	9.2	3.9	5.7	1.2	10	40	70	90	4563	882	760
11	9.2	3.9	5.7	1.2	10	40	70	90	4563	882	760
12	9.2	3.9	5.7	1.2	10	40	70	90	4563	882	760
13	9.2	3.9	5.7	1.2	10	40	70	90	4563	882	760
14	9.2	3.9	5.7	1.2	10	40	70	90	4563	882	760
15	9.2	3.9	5.7	1.2	10	40	70	90	4563	882	760
16	9.2	3.9	5.7	1.2	10	40	70	90	4563	882	760
17	9.2	3.9	5.7	1.2	10	40	70	90	4563	882	760
18	9.2	3.9	5.7	1.2	10	40	70	90	4563	882	760
19	9.2	3.9	5.7	1.2	10	40	70	90	4563	882	760
20	9.2	3.9	5.7	1.2	10	40	70	90	4563	882	760

4563	882	760

Monthly Leachate Generation (kL)

Total Leachate (kL)

Imported	Final Cap	Intermediate	Active	Ponds	Total	Capacity
150						
150						
150						
150						
150						
150						
150						
150						
150						
150						
150						
150						
150						
150						
150						
150						
150						
150						
150						
150						
					66158	108000



Sewer & Tanker Rates

Sewer High (kL/month)	4563
Sewer Med (kL/month)	3650
Sewer Low (kL/month)	2738
Tanker (kL/month)	882

Landfill Parameters

Total waste volume start (t)	3000000
Monthly imported waste (t)	10000
Leachate capacity (kL/t)	0.03
Leachate at start (kL/t)	0.015

Pond Parameters

Pond capacity (kL)	18000
Pond Start Vol (%)	100
Water Surface Area (ha)	0.5
Monthly evap (mm)	152
Stop Loss Threshold (kL)	10000

Volume Check

Leachate Generated (a)	1824467	
Total Losses (b)	1489200	
Change in Storage (c)	332108	
(a) - (b) - (c) =	3158	
%	0.17	Ok

Additional Results for Graph

GEOTECHNICAL BRIEF

D

D

D

D

APPENDIX D

Technical Brief 001

Characterisation of Existing Capping Materials at Whytes Gully Landfill

Project Background

Whytes Gully Landfill is the principal waste facility for Wollongong City and is located at Reddalls Road, West Dapto to the south west of Wollongong CBD. For purposes of licensing the landfill is classified as a 'Class 1' facility able to accept domestic and commercial waste including putrescibles. The landfill commenced operation in 1984 and is managed by Wollongong City Council.

Council is making improvements to the operation of the existing landfill in order to reduce generation of leachate from the site. Council has engaged water engineering specialists, Rienco Consulting, to prepare a 'Surface Water and Leachate Management Plan'. Preliminary investigations by Rienco have highlighted the sensitive relationship between leachate generation and the permeability of capping materials.

A geotechnical investigation has been recommended by Rienco in order to gain better appreciation of the permeability of existing capping materials and to assist with identification and targeting of improvement measures.

Site Description

The landfill site comprises of two natural gullies known as the 'Western Gully' and 'Eastern Gully', located at the base of a prominent escarpment ridgeline. Landfilling commenced in the Western Gully and was completed in the late 1990's. The Eastern Gully is currently subject to filling operations and has approximately 4 years of remaining capacity.

Both gullies have been constructed as a series of overlying horizontal cells progressively terraced in an upslope direction. The outer faces (sloping) of each cell combine to form an 'intermediate cover' for the entire emplacement on completion. The material used for the outer face is locally sourced VENM, preferably with high clay content. The upper faces (flat) of each cell are each buried beneath the next cell above and generally comprise of coalwash (Western Gully) or slag (Eastern Gully). This material is referred to as 'daily cover'. Each cell is approximately 3m in total thickness and is made up of a series of 'lifts', each of which are also covered by a thin layer of daily cover to form a trafficable surface.

A sketch is attached showing aerial photography of the site taken in 2006 along with digitized polygons showing areas of different cover material based on December 2007 survey.

Whilst Council has endeavoured to ensure the landfill is constructed in a manner that reduces the infiltration of rainfall, there are practical considerations that result in variable infiltration across the site at any point in time. 'Daily cover' requires free-draining materials that are quickly trafficable after rainfall. As expected, these areas experience high infiltration. Areas of 'intermediate cover' do not require the same degree of trafficability, however variable infiltration is expected as the quality and quantity of available VENM materials changes over time. Also the level of compaction that can be achieved varies according to the slope of the outer cell face.

In this regard, Council has observed changes in cover material at Whytes Gully, in particular:

- The first few cells of the Western Gully (i.e. bottom of the slope) were constructed using coalwash as both daily and intermediate cover
- Intermediate cover on the Western Gully then quickly transitioned to higher clay content VENM
- During construction of the upper half (approximately) of the Western Gully high quality clay materials were available for use
- The lower (steeper) half of the Western Gully was compacted by track rolling with an excavator during cell construction whereas the upper (flatter) half was able to be compacted using a roller on completion
- Over the period of construction of the Eastern Gully the quality and quantity of VENM available has declined
- The generally steeper slopes of the Eastern Gully have resulted in lower compaction rates on intermediate cover areas (i.e. similar to lower half of the Western Gully)

Scope of Services

The services required under this brief are for the provision of geotechnical advice relating to the characterisation of surface capping materials across the existing landfill including description of: general capping material type; thickness; density; permeability; and how these characteristics vary spatially and with depth.

It is envisaged that the work required will involve a combination of both field and lab testing. Initially field testing would be undertaken at a large number of locations (e.g. hand DCP) to confirm spatial variation in capping material. This would then be followed by more detailed characterisation for a sub-set of these locations. Separate sampling will be required for areas of intermediate and daily cover, and also locations where there is a known variation in cover material and compaction type (as described above and in the attached sketch and as observed on site).

The key deliverable will be an interpretive report containing test results, summaries, geotechnical interpretation, and interpretive plans and figures (showing spatial variation). The consultant is also to provide co-ordinate details for test locations for Council's future reference (MGA94 Zone 56). GPS positioning will be accepted provided co-ordinate locations are accurate to within approximately 5m.

Proposal Submission & Conditions of Engagement

The client for this project is Wollongong City Council with engagement in accordance with Council's standard supply contract conditions (refer http://www.wollongong.nsw.gov.au/business/5241.asp).

To allow comparison of tenders, proposals should be submitted on a provisional lump sum basis assuming a total of 30 field test locations, 10 of which will be subject to detailed lab testing. A separate schedule of rates should be supplied for each of the tests to be undertaken, along with a suggested minimum number of sample locations and tests. Prior to engagement Council will liaise with the preferred tenderer to confirm the testing regime to be adopted and adjust the lump sum fee accordingly. The recommended testing regime should balance minimisation of costs with the need to quantify any significant spatial variability in the characteristics of capping materials.

If tenderers have alternative investigation methodologies that they would like to propose, then they are encouraged to supply details in their proposal as a separate option for Council's consideration.

Proposals are to be submitted electronically to Rienco Consulting (steve.roso@rienco.com.au) and addressed as follows:

Wollongong City Council
c/o Rienco Consulting
PO BOX 5431
Wollongong NSW 2500

During proposal preparation, tenderers should contact Steve Roso of Rienco Consulting for further assistance and information (steve.roso@rienco.com.au or ph 0400 562 162).

FORBES RIGBY PTY LTD

engineers • planners • scientists

WHYTES GULLY LANDFILL

LEACHATE MANAGEMENT STUDY

FOR

WOLLONGONG CITY COUNCIL

WOLLONGONG
City of Innovation

AUGUST 2002

Forbes Rigby Pty Ltd Reference 99095-03 Report 001 Rev 0

FORBES RIGBY PTY LTD
ENGINEERS · PLANNERS · SCIENTISTS
Quality Endorsed Company ISO 9001 LIC QEC10608 Standards Australia

278 KEIRA STREET WOLLONGONG NSW 2500 PH: [02] 4228 4133 FAX [02] 4228 6811
email: secretary@forbesrigby.com.au

TABLE OF CONTENTS

APPENDICES

EXECUTIVE SUMMARY

This study provides an investigation into leachate management at the Whytes Gully Landfill site. The study was carried out using a water balance model to determine an appropriate volume for proposed new leachate pond facilities in accordance with EPA licence conditions.

The water balance model incorporates a detailed breakdown of the numerous water inputs and outputs within the overall landfill system including leachate and stormwater. The model was calibrated using recorded pond volumes for the period 1997 –2001 by adjustment of runoff co-efficients, moisture store depths and other key variables. The model results show good correlation between calculated and actual volumes.

The water balance model was then used in 'design-mode' to model leachate generation under future conditions. The assumed model changes include implementation of the proposed Western Gully Extension in conjunction with a conservative active fill zone area. A 'design' rainfall for the licence event of 360mm in 24 hours was assumed based on standard Australian Rainfall & Runoff (1987) methodology. This 'design' rainfall was checked by analysis of 89 years of recorded data from a nearby daily-read rain gauge and was found to be conservative.

The model predicts that the leachate generated by a licence event is approximately 6750m^3. This was combined with a (conservative) estimated starting pond volume during 'base flow' conditions of 8100m^3, to give a recommended minimum leachate pond volume of 15,000m^3.

Designs for the leachate ponds were then developed, including adoption of a factor of safety of 1.2 to give a final leachate pond volume of 18,000m^3 configured as two separate ponds with the ability to temporarily decommission each individually.

A separate stormwater pond design was developed incorporating modern wetland design features using an initial target volume equivalent to existing ponds, noting that the existing ponds have performed well over time and therefore provide a sound basis for future design.

Recommendations

It was recommended by the study that Council submit this report to the EPA in fulfilment of PRP U6.1, and furthermore, that designs for leachate and stormwater ponds be further developed and a development application prepared using the estimated volumes as calculated.

With regard to management of leachate it was recommended that Council endeavour to minimise the active fill zone area, as this was found to be a large contributor to leachate generation. Also, once constructed the new ponds should be maintained at a level equivalent to existing ponds to ensure the design storm can be captured.

1. INTRODUCTION

1.1. BACKGROUND

Wollongong City Council currently owns and operates the Whytes Gully Waste Disposal Depot at West Dapto which is Wollongong's primary domestic waste disposal facility. The site is licensed to accept more than 100,000 tonnes of waste per year.

As part of plans for future expansion of the facility, existing leachate collection ponds will be relocated. In response, Council engaged Forbes Rigby Pty Ltd to undertake this leachate management study to establish appropriate leachate storage volumes and concept designs for the new ponds.

In addition, Council is required as part of its Pollution Reduction Program (PRP), to improve leachate management on site as the existing leachate ponds have not been functioning as well as desired.

1.2. OBJECTIVES

The primary objectives of this report are to:
- Describe the water balance model process used to establish leachate storage volumes;
- Provide a summary of water balance model results;
- Establish appropriate leachate and stormwater pond design criteria;
- Give recommendations for the pond design and leachate management system to form the basis of a subsequent Development Application for construction.

This report is also intended to be submitted to the EPA in fulfilment of PRP U6.1.

1.3. REPORT STRUCTURE

The study report has been structured in the following manner:

Chapter 1 gives an overview of the site and the objectives of the study.

Chapter 2 describes the site in more detail including current water management practices for leachate, stormwater and clean water.

Chapter 3 describes the water balance modelling process including: the model structure; the process of model calibration; and development of a 'design-mode' model used to predict an appropriate leachate volume for the proposed new ponds.

Chapter 4 provides design criteria for the proposed leachate and stormwater ponds and describes the development of concept designs for them.

Chapter 5 gives the study conclusions and recommendations.

Supporting graphical material is included in the report, and comprises:
- A plan showing the site and its various sub-catchments **Figure 2.1**.
- An extract from the daily water balance model showing model structure– in **Appendix A**.
- Plans showing conceptual designs for proposed leachate and stormwater ponds - included in **Appendix B** and **C** respectively.

2. SITE DESCRIPTION

2.1. GENERALLY

The site is located at Reddalls Road, West Dapto, approximately 12 km south of Wollongong CBD. The landfill occupies a small valley of approximately 50 ha which forms part of the Dapto Creek catchment. The valley rises from RL 20m on the Dapto Creek floodplain to about RL120 where it meets a ridge at Farmborough Heights. The catchment is predominantly cleared with a small patch of remnant rainforest along the upper edge of the landfill area (refer **Figure 2.1**).

The landfill facility which commenced in 1984 comprises two separate engineered landfills each within its own small gully separated by a small central ridge. These are referred to as western gully and eastern gully. The western gully landfill was completed and capped in 1993 while the eastern gully was commenced immediately thereafter. The eastern gully was split into 4 stages and is presently up to the third stage out of four. It is estimated that the eastern gully will be fully completed within 4 to 5 years depending on rate of waste receival.

The western gully landfill is an unlined landfill, emplaced directly onto bedrock. It has a thick clay capping (up to 2m thickness) to reduce infiltration of surface water. It also has a system of subsurface leachate collection drains feeding into the existing leachate collection pond.

The eastern gully landfill uses more modern engineering techniques and incorporates a fully sealed HDPE liner at its base to exclude all infiltration of groundwater and prevent leachate seepage. The liner has a granular drainage blanket which collects leachate for discharge to the pond system.

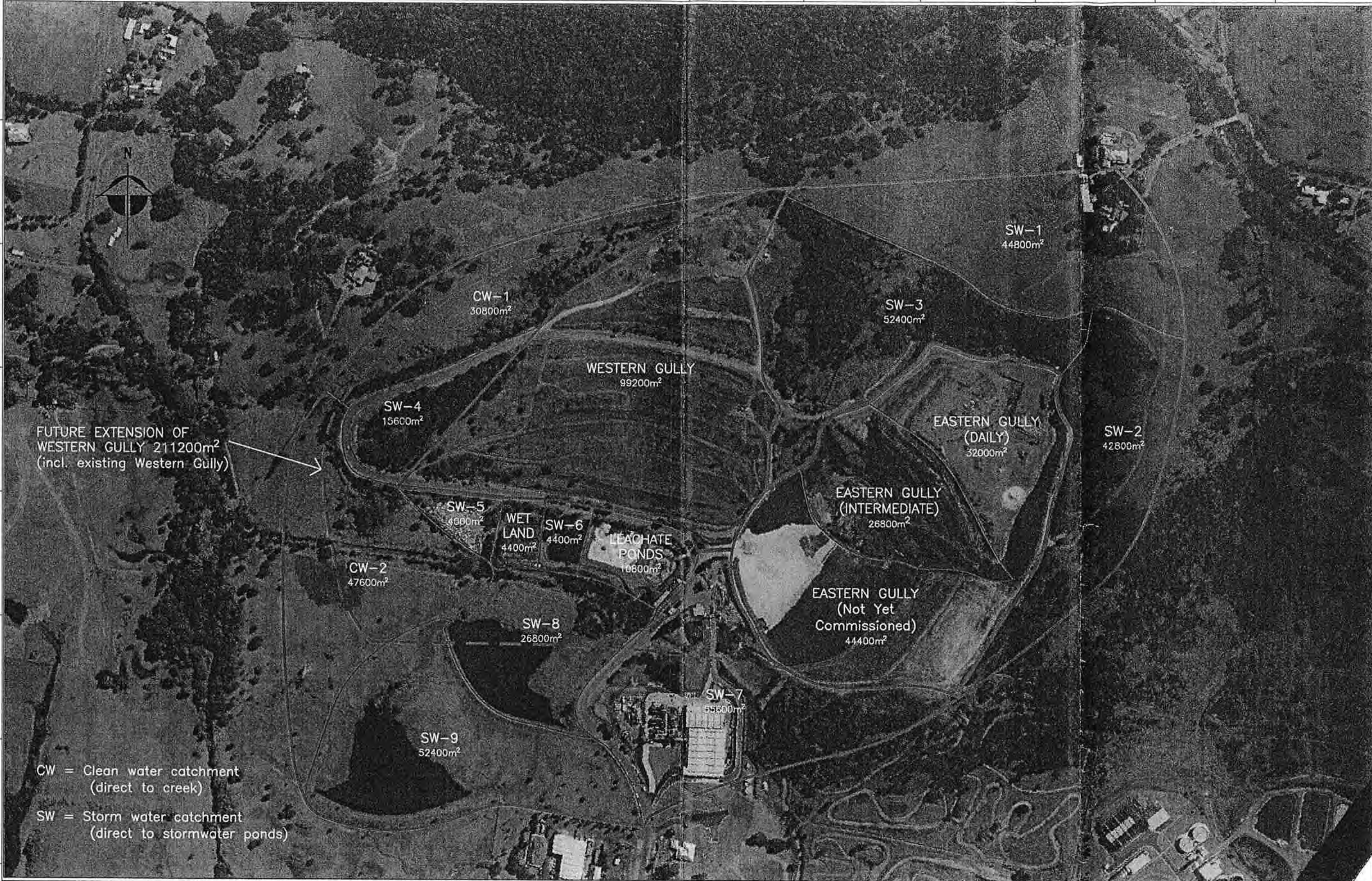
The site is located close to the Illawarra escarpment and as such, receives a considerable amount of rainfall, on average 1200-1300mm per year. The orographic influence of the escarpment, close proximity to the ocean and generally sporadic climatic conditions result in much of this rainfall being unevenly distributed throughout the year.

Natural soils on the site are predominantly clays and silty clays overlaying an interbedded siltstone/ sandstone bedrock. The low permeability soils combined with steep slopes on the valley sides result in large amounts of runoff from the upper natural parts of the catchment. Surface soils in the landfill area are generally imported clay and topsoil materials or natural soils obtained from stockpiles constructed during site stripping. A local groundwater system which flows through the interbedded siltstone/sandstone matrix discharges into the base of the unlined western gully.

2.2. CURRENT WATER MANAGEMENT PRACTICES

Ideally, an effective landfill water management system requires each of the different types of contaminated water to be kept separated. This is generally good practice as it reduces the additional expense associated with the need to provide added leachate storage and treatment facilities. At Whytes Gully, leachate, stormwater and clean runoff are managed separately using a system of diversions and piped drainage. **Figure 2.1** shows the various areas within the study catchment that contribute to each of these.

DO NOT SCALE | IF IN DOUBT ASK



REV	DATE	BY	APP.	DETAILS

DRAWING STATUS		
DESIGN BY	SR	JAN 2002
DRAWN BY	PCF	01/02/02
DRAFTING CHECK		
DESIGN CHECK		
FINAL APPROVAL		

PRELIMINARY

SCALE: (on A1 Original) 1:2000

DATUM: AHD

FORBES RIGBY PTY LTD
Engineers Planners & Scientists
Quality Endorsed Company, ISO 9001 LIC QEC 10508, Standards Australia
278 KEIRA STREET, WOLLONGONG, NSW 2500
Ph: (02) 4228 4133 Facsimile: (02) 4228 6811 ACN 003 936 981

PROJECT TITLE
LEACHATE POND DESIGN
WHYTES GULLY
WASTE DEPOT
for
WOLLONGONG CITY COUNCIL

DRAWING TITLE
WHYTES GULLY
SUB–CATCHMENT PLAN
APRIL 2001

Project No.	Drawing No.	REV
99095	Fig. 2.1	P0

A1

Leachate

Leachate, comprising water which has come into direct contact with waste, is collected from the base of the landfill via a network of subsurface drainage lines. The source of this water includes:

- rainfall that has infiltrated through the capping layer;
- groundwater entering the base of the landfill;
- surface water runoff from the active fill zone/daily cover; and
- seepage resulting from the moisture content of the waste.

This leachate can have high concentrations of BOD, Ammonia and other contaminants.

At Whytes Gully leachate is collected in a series of collection wells from where it is fed into a large storage dam (referred to as the 'main' dam). Within the main dam, leachate undergoes some treatment through a combination of aeration using 4 low speed surface aerators and bacterial digestion/conversion. The process of bacterial digestion and conversion is assisted through dosing with a specially formulated bacterial culture. The leachate is then fed into a smaller 'disposal' dam where it undergoes continued (but less intensive) aeration before ultimately being discharged to the Sydney Water sewer system.

An irrigation system is currently installed and utilised on an infrequent basis to irrigate treated leachate onto the capped western gully. Upon irrigation, leachate undergoes some chemical treatment through assimilation into surface soils and plant material. The actual volume of leachate is also reduced through a natural evapotranspiration process.

The two leachate ponds have an approximate combined volume of 9,000m^3. While the ponds were originally sized to meet EPA requirements at the time, occasionally the available storage volume is exceeded. When this occurs leachate discharges into the stormwater treatment system.

It is understood Council is presently investigating methods by which leachate will undergo further treatment before discharge to sewer, in order to meet strict trade waste requirements recently imposed by Sydney Water.

Stormwater

Stormwater is collected from areas that have been disturbed through landfill activities such as final capping, intermediate cover (areas where waste emplacement is generally not envisaged for more than several months) and internal roadways, but excludes areas of daily cover. Stormwater is generally less contaminated than leachate, principally containing fine sediment particles washed off exposed soil surfaces. It can however sometimes have minor traces of leachate, particularly if rainfall occurs soon after irrigation.

Stormwater is collected by a series of surface contour drains (piped in some sections), which feed into one of two large stormwater ponds located at the downstream end of the site. These ponds are open water based treatment systems with some fringing macrophytes. These ponds afford high levels of treatment based on Council's monitoring records. This is thought to be principally a result of the large volume of these ponds resulting in significant hydraulic residence time. The ponds discharge into Dapto Creek and eventually Lake Illawarra.

Clean Runoff

Clean runoff comes from those parts of the catchment that remain undisturbed due to landfilling operations. At Whytes Gully these are principally those areas along the crest of the bounding ridgelines which comprises a relatively small proportion of the overall catchment. Runoff from such areas is considered clean and uncontaminated and can therefore be discharged directly downstream without undergoing any treatment. Clean runoff is prevented from crossing the landfill surface by a large cut-off drain along the upslope edge of the landfill. This drain conveys water around the western side of the stormwater ponds and into Dapto Creek.

It is noted that due to topographic constraints, some areas within the catchment that could be considered 'clean', are actually directed into the stormwater system.

2.3. EPA LICENCE

The Whytes Gully facility is operated by Wollongong City Council and is licensed (license no. 5862) by the NSW Environmental Protection Authority (EPA) under the Protection Of the Environment Operations Act (POEO), 1997. The site is classified for the purpose of EPA licensing as a solid waste (Class 1) landfill capable of accepting more than 100,000 tonnes per year including inert and putrescible wastes.

With regard to water management, the site has two licensed discharge points corresponding to the overflow points of each of the leachate and stormwater ponds. The licence requires that:

"There must be no discharge of contaminated (TSS>50mg/L) *stormwater to waters under dry weather conditions or storm event(s) of less than 1:10 year 24 hour recurrence interval".*

And that:

"There must be no discharge of leachate to waters under dry weather conditions or storm event(s) of less than 1:25 year 24 hour recurrence interval"

Despite best endeavours, there were several discharges from the leachate storage ponds during the period 1997 – 2001 as a result of prolonged wet weather and intense rainfall. These events (although not measured) were estimated to be less severe than the licence event.

With regard to the stormwater ponds, Council's records have shown they have functioned in accord with their design intent with no discharges in excess of the licence requirements apart from during instances of leachate overflow.

3. WATER BALANCE MODELLING

In order to establish an appropriate volume for the proposed new leachate storage ponds, a detailed water balance model of the Whytes Gully catchment was constructed. This model was calibrated using recorded leachate data and then used to simulate a 'design' event. The following sections describe the modelling process and outcomes.

3.1. MODEL STRUCTURE

The model was constructed using spreadsheet software (Microsoft Excel), and incorporates a detailed breakdown of the numerous water inputs and outputs within the overall system. Widely adopted and well known hydrologic numerical relationships were used to describe the various water cycle processes and quantify each components contribution to final leachate volumes. The model also included the stormwater system, though this was not the primary objective of the model.

The model was constructed using a daily time step. This represents a significant refinement over many commonly employed water balance models but was considered necessary in order to more accurately establish the leachate generated by the licence event.

Due to the complex nature of modelling the movement of water in a highly modified environment, the model was built using a series of separate components. A brief description of each component is given below (with further detail included in **Appendix A**):

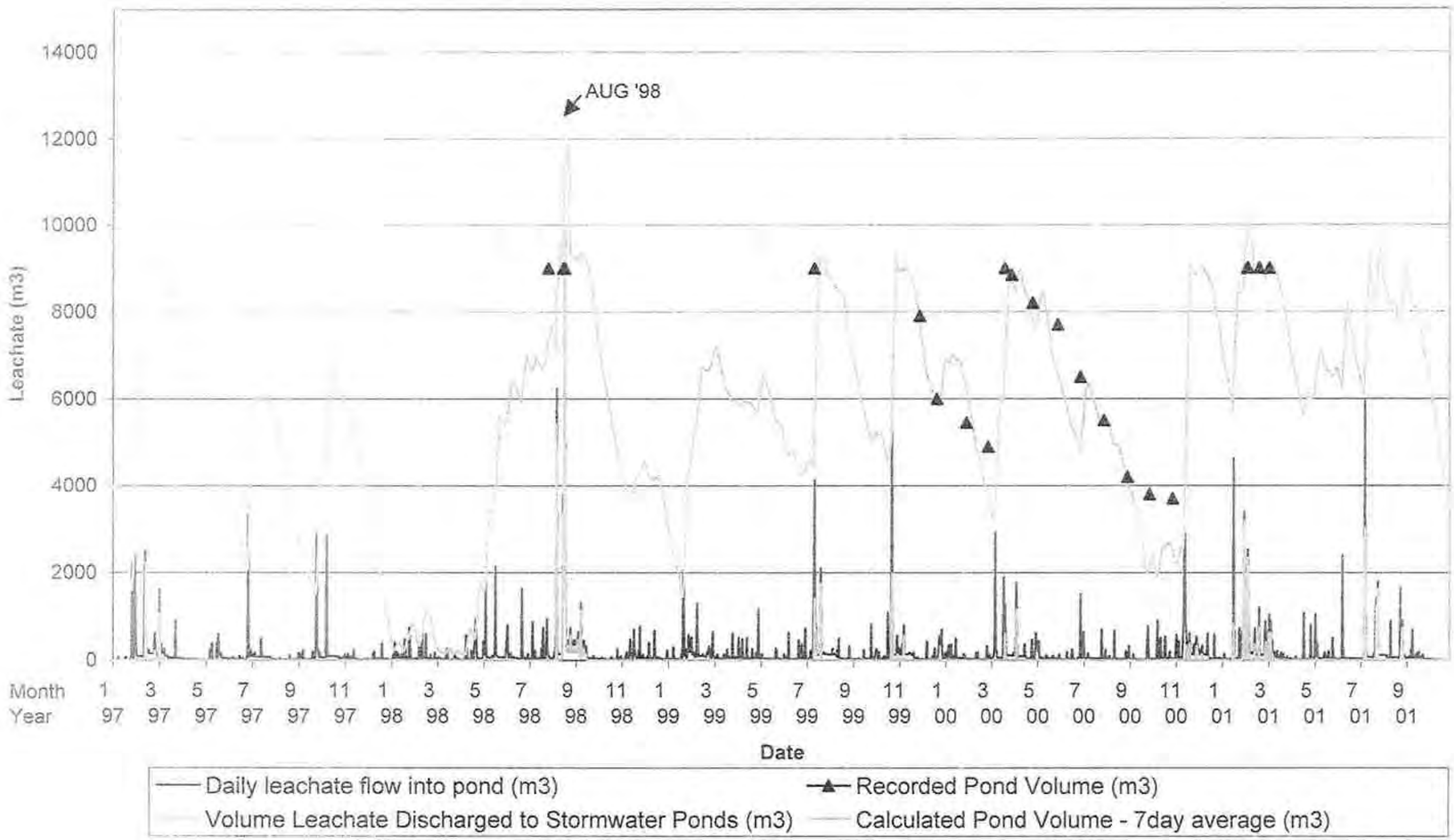
Global Data
This component includes information applying to the entire site. This includes:

- Daily rainfall data, from the closest gauge for which a reliable record could be obtained for the period being modelled. This included a gauge at Wongawilli maintained by the Department of Public Works and Services- Manly Hydraulic Lab (MHL) supplemented by data obtained from gauges at Wollongong CBD and Oak Flats. A correction factor was applied to the latter based on average annual totals.
- Daily pan evaporation data obtained from the Sydney Airport weather station (administered by the Bureau of Meteorology) which is the closest long term weather station recording this type of data.
- Empirical, crop and seasonal factors based on conservative evapo-transpiration values supplied in literature and which are themselves based on measurement.

Western and Eastern Gullies
For each of the two gullies a separate water balance was constructed comprising the following elements:

- An 'Area Schedule' which gives an area breakdown of the different surface types in each gully including: final cover (capping); intermediate cover; daily cover; and any areas that have not been commissioned for landfill use. Areas were estimated from April 2001 photography as shown in **Figure 2.1**. The model allows the areas to be altered progressively to account for changes in landuse cover. Although limited data was available, some significant area changes were included such as occurred during the transition between Stage 2 and Stage 3 of the eastern gully.
- A moisture store and permeability calculation that calculates rainfall infiltration through the final cover (and ultimately into the leachate pond) based on an assumed moisture store depth and measured clay permeability (k).

Modelled Leachate Pond Volume 1997 - 2001



Parameters adjusted to achieve this calibration curve include, surface runoff co-efficients, moisture store depths, groundwater inflow and triggers for sewer pumping rate. These are factors for which there are no site specific data or for which measurement is generally impractical. The other parameters in the model were generally well understood values not requiring adjustment or they were based on field measurement with significant sample size and therefore high confidence limits attached.

Although the model results are still only an approximation of the actual leachate generation processes which are occurring within the landfill, the model shows good correlation between calculated and actual volumes, giving confidence to its predictive capabilities. In particular, it is noted that the model correctly predicted several pond overflows which correspond to known events in July 1998, August 1998, July 1999, March 2000 and February 2001. The August 1998 discharge which is labelled on the chart was predicted to be the worst of these.

3.3. USE OF MODEL IN DESIGN-MODE

The calibration model was then converted into a design simulation model for the purpose of predicting the design leachate pond volume for the proposed new leachate pond facility. This involved the following steps:

- Adjustment to catchment areas to (as closely as possible) reflect future 'worst case' conditions;
- Establishment of an appropriate 'design' 24 hour rainfall depth;
- Storm frequency analysis using locally recorded data to confirm the appropriateness of the 'design' storm;
- Establishment of appropriate antecedent rainfall conditions; and
- Calculation of an appropriate leachate pond volume as a basis for pond design.
- Calculation of a daily stormwater runoff total to assist with stormwater pond design.

Each of these are described further in the following sub-sections.

3.3.1. Area Adjustment

It is anticipated that the proposed new leachate pond facility will ultimately service the landfill until its eventual closure. Accordingly, the ponds should be designed to accommodate proposed future expansion.

To achieve this, the various catchment areas in the model were adjusted. The western gully surface area was increased to reflect the future extent of the western gully extension as indicated on **Figure 2.1**. This increased the area available for capping infiltration (compared to existing conditions) and therefore the volume of leachate produced.

In addition, the areas of the eastern gully were adjusted to reflect the same conditions prevailing at the site during early 2001 where, because of the transition between Stages 2 and 3, a large area of both stages was uncapped and available for rapid rainfall infiltration. This condition subsequently lead to a leachate overflow event in February 2001 and represents a 'worst case' scenario that could potentially occur in the future and therefore should be considered during design. It is noted that these active areas were assumed to be in the eastern gully for modelling convenience, but are in reality more likely to be in the western gully extension (however this does not impact on model results).

It is noted that the sensitivity of the model is such that it is less critical to accurately establish the area of final capping than it is to establish the area of daily cover. This is because the capped areas generally work well at eliminating leachate production. What this means for the leachate pond volume ultimately predicted is that even if the final area of capping was to be larger than that estimated at this time (for example if a design change was to require even further expansion), the requirement for leachate pond volume would most likely remain unchanged.

3.3.2. Design Rainfall

The EPA licence for the site requires that no leachate be discharged from the site for events up to and including the 1:25 year, 24 hour recurrence interval event. While no specific guidance is given in the licence with regard to the actual methodology for determining the corresponding rainfall depth, Forbes Rigby were instructed by Council to adopt the rainfall intensity estimation procedures advocated by the principal national guideline *Australian Rainfall and Runoff (1987)*, which is produced by the Institution of Engineers, Australia.

An in-house program developed by Forbes Rigby (IFD Plot v1.0) was used to produce an Intensity Frequency Duration (IFD) curve for the nearby Wongawilli gauge (see **Figure 3.2** below). This is the same gauge from which daily rainfall data was obtained for calibration purposes. It is also noted that rainfall intensities at Wongawilli are comparable to those at Whytes Gully, the two locations having the same relative proximity to the escarpment.

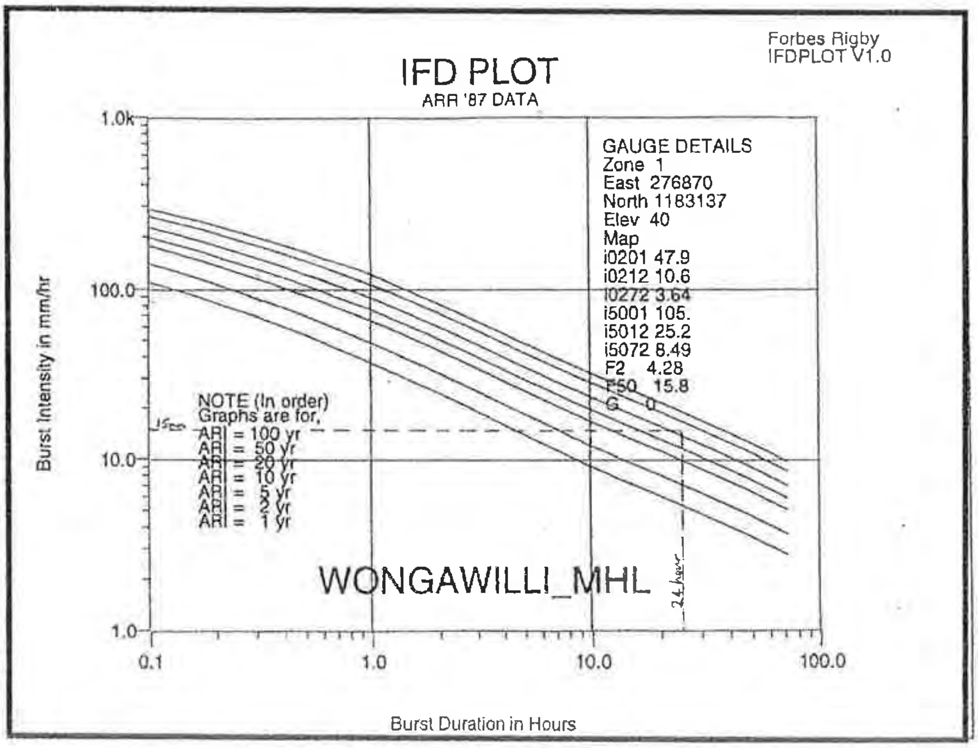


Figure 3.2: IFD Curve for Wongawilli MHL Gauge

Interpolation from the IFD curve in **Figure 3.2** indicates a 1:25 year 24 hour 'design' rainfall intensity of approximately 15mm/hour, equivalent to a 360mm total rainfall depth for the event.

The 'design' rainfall depth estimated above compares with a maximum 24 hour total for the August 1998 storm event of 242mm as recorded at the Wongawilli Gauge, suggesting that 24 hour rainfall during the August 1998 event may have had a recurrence interval of only about 10 years.

Where critical, an independent check of design rainfall estimates should be carried out using a storm frequency analysis. This statistical analysis of recorded data allows the actual frequency of rainfall events to be established for a particular gauge. Unfortunately this process cannot always be followed as it relies on having a large continuous data set from a nearby gauge.

Fortunately, we were able to obtain a long term dataset from a nearby gauge known as 'Stanes Dyke'. This gauge is located less than 2km distant from Whytes Gully in the direction of Wongawilli. Importantly, the gauge location shares the same proximity to the escarpment as Whytes Gully and is therefore considered a reliable indicator of site rainfall. The data was obtained for the 89 year period spanning 1898 to 1987 and therefore also provides a statistically significant dataset.

The data was converted from standard Bureau of Meteorology format into a sequential series of daily totals. This data was then sorted from highest to lowest to establish the highest recorded totals at that gauge. **Table 3.1** below shows the 15 highest recorded 24 hour storm totals at the Stanes Dyke gauge for the period 1898 to 1987.

Table 3.1: Highest Recorded 24 hour Storms – Stanes Dyke Gauge (West Dapto)

Date	24 hr Rainfall (mm)	Rank	ARI
11-Mar-1975	306	1	89
21-Oct-1959	279	2	45
19-Nov-1961	279	3	30
19-Feb-1984	275	4	22
13-Jan-1911	263	5	18
24-Mar-1914	254	6	15
17-May-1943	249	7	13
16-Apr-1969	249	8	11
7-Jan-1934	247	9	10
4-Sep-1931	229	10	9
18-Feb-1984	227	11	8
11-Feb-1956	226	12	7
10-Feb-1956	225	13	7
30-Dec-1914	211	14	6
14-Nov-1969	205	15	6

Interestingly the notorious 19 February 1984 event which was particularly severe in the upper reaches of Mullet Creek is only ranked 4th in terms of maximum 24 hour total, however the preceding day is also ranked highly as a separate event. The two combined to produce an event much more severe than would have occurred if either had occurred in isolation.

Based on the logic that the rank 1 rainfall total had not been exceeded, while the rank 2 had occurred or been exceeded 2 times and the rank 3 occurred or exceeded 3 times within the 89 year period, it follows that an approximate ARI for an event can be determined by dividing the length of record (89 years) by the rank of that event. While this is a simple approximation method which is probably not appropriate for determining the ARI of the highest rank event in the record, it does give an indication of actual rainfalls that could be expected for smaller events (say) on average once every 10 – 25 years.

From **Table 3.1** it is estimated that the rainfall total for the 1 in 25 year, 24 hour event lies somewhere in the range of 275 to 279mm. This is considerably less than the estimated 360mm for the 'design' event calculated using AR&R. It is unclear as to why this discrepancy arises but it is most likely a result of the design estimation methods being for any 24 hour period whereas the daily rainfall measures are for a discrete time period (9am to 9am).

Notwithstanding the above comparison, analysis of the recorded dataset gives confidence to the adoption of the design rainfall estimate of 360mm/day for leachate volume estimation, as it is significantly higher than recorded data and therefore would appear to incorporate an additional factor of safety.

3.3.3. Antecedent conditions

It is obviously inappropriate to assume an empty pond condition occurring prior to the design storm event. Furthermore, rainfall events seldom occur in isolation and often coincide with a seasonal wet period induced by climatic cycles. Based on this, a further consideration made during modelling was the establishment of an appropriate antecedent model condition for design volume estimation. Two aspects were considered:

A) Starting Pond Volume
B) Antecedent Rainfall

For this study, the following conservative antecedent conditions were assumed:

A) Starting Pond Volume

For a significant time, the existing leachate facilities have operated reasonably successfully with the exception of overflows during some major events. However, even during the period in early 2001 where a significant surface area was available for leachate generation, the pond volume was not significantly exceeded. The water balance model predicted a surplus of less than 1000m^3 for each event, which based on discussions with Council staff could even be an overestimate.

Given history suggests that the pond can be maintained at a level below the current pond capacity of 9,000m^3 for the majority of wet weather periods (excluding some major events), it was assumed for the purpose of modelling that this same 'base flow' condition could be maintained in the future noting that even with the western gully extension, leachate 'base flows' are unlikely to be significantly greater than current levels. A starting pond volume of 8,100m^3, was therefore adopted as a starting pond volume for design of the future pond with the calculated leachate 'peak flows' for the design event being accumulated on top of this. 8,100m^3 represents 90% of the existing pond volume and is therefore a conservatively high average pond volume. It is necessary however to use a conservatively high value since some additional leachate contribution could be expected during 'base flow' periods due to future increases in final capping area.

It is important to note that this assumption is independent of the actual volume of the existing pond. It simply provides an above average pond starting volume for the new (proposed) facility based on historical observations of leachate production during above average 'base flow' conditions as evidenced by pond volume recorded in the old (existing) facility. This consistent 'base flow' condition arises because the rate of leachate production is closely linked to the area of the active fill zone, and this area is generally kept fairly constant over time. As evidenced in early 2001, dramatic changes to active fill zone result in dramatic changes to leachate production. It is therefore recommended that Council wherever possible maintain the active fill zone as small as possible.

It is also important that the operation guidelines for the new facility incorporate the objective of maintaining sewer pumping rates such that pond volume is maintained at current levels and that any additional capacity be kept 'in reserve' for capture of leachate from large storm events.

B) Antecedent Rainfall

Antecedent rainfall is a factor which Council has reported as being particularly significant at Whytes Gully. It has been observed that a number of small events, each having a recurrence interval less than the design event, can occur in quick succession resulting in pond overflow. Overflow occurs principally because the rate of discharge to sewer is insufficient to draw down the pond volume during the inter-event period. Also, the sum of the rainfall depths in several small events often exceeds the total depth of the single design event for which the site is licensed. This was confirmed during calibration of the water balance model for this study which predicted several overflows because of this.

In order to establish a leachate generation rate which is representative of actual rainfall patterns, it is necessary to consider the amount of rain that occurs leading up to a storm event. It was noted previously that the landfill hydrology is such that it will generally respond to rainfall slower than a surface water system. Some segments of the landfill may respond rapidly, however others such as the infiltration through capping may respond more slowly, up to several weeks. It is therefore important that a model for design purposes include more than simply a single 24 hour storm burst.

For the design water balance model, the design storm event of 360mm per day was embedded within the week of rain which occurred during a recorded event equivalent to the 1 in 25 year recurrence interval. For Stanes Dyke Gauge, the adopted week of rain was that of the 19 November 1961 which (based on the storm frequency analysis described in **Section 3.3.3**) was estimated to be a slightly less frequent event than the licence storm (30 year ARI c.f. 25 year ARI).

Table 3.2: Adopted Antecedent Rainfall Conditions

Day	Nov' 1961 recorded event (mm/day)		Adopted 1 in 25 year design event (mm/day)
1	10.4		10.4
2	5.3		5.3
3	195.6		195.6
4	279.4	⇨	**360**
5	42.2		42.2
6	161.5		161.5
7	51.6		51.6

The above synthetised storm was input to the model and used to estimate the design leachate volume. It should be noted that the pond starting volume condition described above, also incorporates an allowance for antecedent rainfall since the existing leachate storage is generally only greater than 90% of existing pond capacity after there has been a reasonable wet period. During dry periods, the leachate volume in storage is considerably less.

3.3.4. Leachate Pond Volume

Based on the above assumptions, the model was used to predict leachate generation during a continuous sequence spanning the same 5 years as the calibration model, except that at regular intervals (corresponding to a 90% full 'base flow' pond condition), the adopted design storm (including a full week of rain) was used as input to the model.

The estimated peak leachate pond inflow generated by the 1 in 25 year event as calculated by the model is 6,750m^3 in one day. This is approximately 75% of the current pond capacity and suggests that if a design event was to occur at the present time then an overflow would occur unless the starting pond level was less than 25% of its present capacity.

The total leachate pond volume required in the new facility is assessed as 15,000m^3, as shown in **Table 3.3**.

Table 3.3: Modelled Leachate Storage Volume

Storage Volume Component	Volume (m^3)
Observed threshold level at which pond can readily be maintained during wet weather based on more than 10 years of operating history (including an allowance for future increases in 'base flow' due to additional capping area).	8,100
Modelled peak leachate inflow during the licenced 1 in 25 year event [a]	6,750
TOTAL	**15,000**

[a] Based on a total leachate generating area of 27 ha (that includes proposed western gully extension) and 6 ha of daily cover.

3.3.5. Stormwater Pond Volume

Using a similar methodology to that described in **Sections 3.3.1** to **3.3.4**, a preliminary estimate of stormwater volumes was made, except assuming a 1 in 10 year storm event being the licence condition for stormwater. It is important to note however that the licence limitations on stormwater discharge allow discharge during an event, provided it does not exceed a maximum suspended solids concentration of 50mg/L. The stormwater volumes calculated by the model are therefore not necessarily indicative of the pond storage requirements as a much smaller pond (suitably designed) would still be able to treat stormwater to a level sufficient for discharge without having to capture the entire storm.

The model predicts a total daily discharge of approximately 70,000 m^3 for the design 1 in 10 year 24 hour event. This is equivalent to an average flowrate at the catchment outlet of approximately 0.8m^3/s for the entire day. It is noted that this volume and flowrate should be used as a guide only, as the hydrologic relationships that produce surface runoff are different to those producing leachate. The rate of inflow is also only one of several factors that have been used to establish appropriate design criteria for the proposed new stormwater ponds. It is for this reason that the water balance model was constructed with the primary objective of establishing leachate volume, and with stormwater volume only an ancillary objective.

It is noted that the existing ponds which have an approximate volume of 20,000m^3, have performed well over time. This further suggests that adoption of the modelled total discharge of stormwater is unnecessary. Instead it is proposed to adopt the existing pond volume as an initial target for the proposed new facility as described further in **Section 4.2**.

4. POND CONCEPT DESIGN

This section provides guidelines for the design of the proposed leachate and stormwater ponds. Design criteria and concept designs have been prepared for each, and will form the basis of a development application for the works. Following consent a further stage of detailed design would be required. Also some elements of the design may be reviewed and altered by Council to optimise total life cycle costs and environmental outcomes.

4.1. LEACHATE PONDS

A concept design has been prepared for the proposed new leachate pond facility. Drawings showing details of the design are included in **Appendix B** while further description of key design elements is given below.

Pond Location

Council has identified a preferred pond location on land in its ownership near the western junction of old Reddalls Road and the new road deviation. This site is bordered by the old Reddalls Road formation to the north, the Integral Energy Power line easement to the south the new Reddalls Road to the west and the proposed future extension of the Western Gully to the east.

Although it was originally intended to locate the ponds such that they did not encroach onto the proposed future extension of the Western Gully, it became apparent that some encroachment would be necessary in order to achieve the required volume.

Nevertheless, the proposed location is suitable for pond construction as it is reasonably flat and at the bottom of the catchment thus facilitating gravity fed drainage. Other areas to the south and south east would also be suitable but these have already been reserved for other future uses including proposed stormwater ponds (refer **Section 4.2**).

Integral Energy have been consulted and advise that they are willing to permit the encroachment of pond batters inside their easement to the south.

Geotechnical Constraints

A geotechnical investigation was recently undertaken by Coffey Geosciences to establish sub-surface conditions at the site. In summary, the investigation report concluded that:

- The site is underlain by silty clays and extremely weathered sandstone (suitable for excavation)
- The depth to bedrock progressively deepens from about 1.5m at the northern end to more than 4m at the southern end of the site (near Dapto Creek.).
- Some groundwater was encountered in test pits suggesting that some dewatering will be required during construction.
- Soils are potentially dispersive.
- Further investigations should be undertaken at the detailed design stage when pond location/design has been developed further.

This investigation also confirms that the pond can be constructed in the preferred pond location with minimal rock excavation. Excavated materials can generally be used for embankment construction, provided that adequate compaction and maximum 1 in 3 batters are achieved.

Pond Volume
The minimum leachate pond volume, based on the water balance investigations carried out for this study is 15,000m^3. However, given the inherent uncertainty of any model prediction it is considered appropriate to apply a factor of safety of 1.2 to this value, giving a total maximum leachate pond volume of 18,000m^3.

In addition, a small amount of freeboard is required to allow for controlled spillway discharge. Given the relatively low inflows expected (which are limited to the inlet pipe capacity) a 300mm freeboard is considered adequate.

Configuration
A two pond configuration has been developed to allow one of the ponds to be temporarily decommissioned for maintenance as required. This also provides an efficient design from a construction perspective as embankment height and rock excavation is minimised.

The shape of the ponds is as rectilinear as possible to avoid stagnant areas and encourage mixing. This also makes the ponds simpler to construct. It is noted that unlike Stormwater ponds, a long flow path through the ponds is unnecessary provided adequate contact with aeration equipment is available.

As noted in **Chapter 3**, it is important that the pond operator maintain the ponds well below capacity to allow capture of design events. A two pond configuration may allow one pond to be permanently on-line with the second only used for emergency storage. This arrangement is shown on the concept design but may be altered at detail design if considered undesireable.

Pond Depth
To minimise stratification, and discourage the development of excessively anaerobic conditions at the bottom of the pond. Overall pond depth should be limited to a maximum of 4m.

Internal batters are proposed at a gradient of 1 in 3 therefore the average depth of the pond will be less than 4m once these grades are taken into account.

Pond Lining
Given the nature of the material being stored, combined with the close proximity of Dapto Creek, a fully sealed HDPE liner has been recommended by Coffey Geosciences for installation in the base and sides of the pond. The liner will also assist with prevention of bank instability due to dispersive clays and rapid draw down of the pond. However, it is noted that at detailed design stage alternative options could be explored including provision of cut-off walls and possibly lining with clay.

Inlet Structure
Each of the ponds should have a facility to be together, or separately, filled by the gravity fed landfill leachate system. At present, leachate is collected in collection wells where it is fed by gravity to a sump then pumped into the 'main' dam. The new facility will also as far as practical, utilise gravity fed drainage, but this may need to be augmented with a transfer pump if insufficient fall is available.

The inlet lines can simply discharge into the pond via a small headwall, preferably at the top of the pond to prevent submergence of the line.

Provision should also be made for transfer between ponds. The lower pond should be able to be pumped to the upper pond while the upper pond should feed by gravity (through a valved pipeline) into the lower pond as required.

Outlet Structure

Leachate will leave the ponds via 2 principle mechanisms:

1. pumping to sewer
2. spillway discharge

Both ponds should have facility to pump to the sewer line which is located close to the eastern limit of the ponds. This could occur at a central pump house.

An armoured spillway will be required, allowing surcharge to transfer from the upper to the lower pond and the lower pond to the Stormwater pond. This spillway should be lined using a reno mattress or other appropriate material resistant to leachate.

Aeration and Dosing Equipment

To prevent development of odours and to assist with ammonia removal, aeration equipment similar to the current system should be incorporated into the pond design. If the lower pond was used as the primary facility then aeration effort should be concentrated in this pond. However a small aerator would also be necessary in the emergency storage pond.

The aerators should be floated in the pond at evenly distributed locations and tethered to the shore with steel cable. A fully sealed 3 phase power supply would be attached to one of these cables extending to each aerator.

An axial flow mixer may also need to be incorporated into each pond to ensure good contact between aerators and the leachate. The mixer would most likely be attached to a submerged freestanding pole. This inclusion of the mixer should be reviewed at the detailed design stage to confirm that its inclusion is conducive to ammonia removal noting that the development of some anaerobic zones may assist in this regard.

A hardstand area for dosing and delivery of chemicals (if required) should be provided close to power supply and the central pump house.

Maintenance Access

The perimeter of the ponds should be accessible by small machinery to facilitate access. A minimum embankment width of 3m is recommended with hardstand gravel or concrete being provided where longitudinal grades exceed 1 in 10.

The access track around the pond should be, where possible, graded at 5% away from the pond. A clean water cut-off drain should also be incorporated into the access track around the upstream edge of both ponds.

Fencing/Landscape

A minimum 2m high chainmesh fence with lockable access gates (4.8m wide at two points) should be provided to prevent unauthorised access.

The area surrounding the pond, particularly adjacent Reddalls Road, should be heavily landscaped to provide a visual buffer. No trees should be planted on the pond embankments or within 3m of the pond edge.

Monitoring and Operations

While outside the intent of this study, it is worth noting that the proposed leachate ponds will require a comprehensive monitoring system including a series of piezometers installed down gradient to assess potential for leachate migration via groundwater (due to possible liner failure). This monitoring should commence prior to pond commissioning to allow statistically significant ambient groundwater quality data to be collected.

In addition, critical pond infrastructure such as transfer pumps, sewer discharge pumps and dosing equipment should incorporate redundancy and have visible signalling (preferably relayed back to the weighbridge) advising of any pump failure.

An operations guideline should also be developed including:

- method of operation of all equipment;
- details of pond maintenance/operation regime; and
- plans showing location, depth and capacities of all pond infrastructure.

4.2. STORMWATER PONDS

Due to future expansion of the Whytes Gully facility, Council intends to re-construct the existing stormwater ponds in a new location to the south - west of the existing ponds. Council has requested that design of these ponds be integrated with the leachate pond design as Council intends on submitting a combined Development Application (DA) for all ponds.

A concept design has been prepared for the new stormwater pond facility. Drawings showing details of the design are included in **Appendix C**. It is noted that further design development is anticipated prior to DA submission, incorporating Council comments on the concept design. The final design submitted for approval may therefore vary.

The following provides further description of the key design elements.

Pond Location

Council has identified a preferred stormwater pond location immediately to the south of the proposed leachate ponds and the Integral Energy easement. This site is bordered by the new Reddalls Road along the western and southern sides and the THEISS recycling depot the east. An existing stormwater pond encroaches into this area and will need to be partly removed. The proposed location is considered ideal for pond construction being level and at the bottom of the catchment. The proposed location is also downstream of the leachate ponds allowing any overflow events to be captured and treated by the stormwater pond system.

Geotechnical Constraints

The Coffey Geosciences investigation described in **Section 4.1** was extended to the proposed stormwater pond site. The investigation confirms that the stormwater ponds should require limited rock excavation (as depth to bedrock is generally greater than 4m). Natural soil materials have reasonable low permeability, suggesting that the ponds may be sufficiently self sealing without the need for a separate liner. This would need review with additional test pitting at detail design stage.

Pond Volume

Unlike the leachate containment ponds for which no discharge is permitted in the licence event, stormwater is able to be discharged provided it achieves a minimum treatment level. The current licence requires a minimum treatment level for Total Suspended Solids (TSS) of 50mg/L. There are several ways by which this can be achieved using a pond treatment system.

Traditionally the approach adopted has been for a large water body to be excavated, with stormwater being directed into the upstream end. As the stormwater passes through the water body, the low velocities created allow solid particles to settle out of suspension.

Generally the longer the average detention time, the greater the level of treatment. Some macrophyte plantings are provided along the fringe of the pond to assist with development of a natural wetland system. The large water quality ponds at Horsely are a well known example of this system.

The more modern approach to water quality control ponds is a greater focus on Macrophyte plantings to assist with settlement and filtration. Macrophytes, provide for enhanced settling as they encourage more quiescent conditions, and physical trapping of particles. As a result of these conditions, a greater level of treatment can be provided within a smaller area than the older style open water body pond configuration. Sub-surface flow wetlands are also commonly used and provide even greater treatment levels though at greatly reduced flowrates.

Notwithstanding the above, some open water bodies are required to provide a more resilient wetland habitat, which in turn encourages the uptake of nutrients.

The existing ponds at Whytes Gully are open water type and were sized on the basis of a minimum capture volume of 250m^3/hectare of catchment which equates to a minimum volume of 12,500m^3 for the study catchment (50ha). This is a rule of thumb value which is widely adopted for sizing of stormwater ponds. The rule of thumb is based on this volume being equivalent to a 'first flush' runoff capture of 25mm which is generally the most polluted component of the runoff hydrograph.

Due to the availability of land at the time, the actual volume of the existing ponds was made larger than necessary and is estimated to be 50% larger than the 'rule of thumb' (i.e. 20,000m^3 approx). To date this volume has proven to provide excellent treatment levels meeting licence conditions which is as expected given the larger than required capture volume.

Based on the above, and the fact that the current system performs well, the initial target volume for the new system has been set at 20,000m^3. However, it is envisaged that through optimisation of design, a reduced pond volume would be found to provide equivalent treatment levels.

Following submission of this report but prior to DA submission, further investigations will be required to confirm the final pond volume required, based on an optimised layout. The attached concept design only aims to broadly convey a desireable configuration, with final excavation depths and volumes to be subsequently calculated once Council has had an opportunity to review.

Configuration and Depth

To optimise the treatment efficiency of the pond the following configuration is proposed.

Component	*Description*
Gross Pollutant Trap (GPT)	*This is a mechanical screen located at the upstream end of the pond to filter out coarse debris (typically litter that has escaped from the landfill site). The trap will require regular clean out.*
Inlet Zone	*This is a locally deepened zone (1-2m deep) immediately downstream of the GPT which is intended to provide a primary sedimentation function. Coarse sediments will be trapped in this area, preventing accretion and build up in the shallow areas downstream.*
Reed Beds 1 and 2	*These are linear ponds that are broad and shallow to encourage thick macrophyte growth. This area will*

	provide a high level of water treatment. The average depth of this zone is about 0.5m, however this is made up of various different depth zones, each of which encourage variable vegetation and oxygen conditions (and therefore improved treatment). The change in depth is achieved by a series of low subsurface mounds oriented perpendicular to the flow direction to ensure flow is evenly distributed across the available flow path. The ponds are linear to maximise the contact between stormwater and macrophytes.
Polishing Pond	*This is a large open water body intended for final polishing of water that is discharged from the reed bed. Biological uptake, further sedimentation and solar disinfection are primary mechanisms occurring in this pond. The polishing pond will be similar in configuration to the existing pond with areas of deep water and fringing macrophytes.*

Pond Lining

Lining of stormwater ponds is generally only required in order to ensure water levels are maintained at sufficient levels to sustain macrophyte growth. Geotechnical investigations suggest that soils in the area generally have low permeability. Full clay lining to contain water may not therefore be required but will require confirmation at detailed design stage.

Within macrophyte and intermittently wet zones, a minimum 300mm thick topsoil layer is required on the base of the ponds as a growth medium.

Inlet Structure

The primary inlet to the pond will comprise a Gross Pollutant Trap and deepened inlet zone as described above. A secondary inlet will comprise surcharge flows from the primary leachate dam which will enter the Stormwater Pond just upstream of Reed Bed 1.

To avoid having flood flows pass through the reed beds, a high flow by-pass that directs flow into the polishing pond is incorporated into the Inlet Zone.

Outlet Structure

Stormwater will leave the ponds via 2 principle mechanisms:

1. Discharge via a low flow outlet; and
2. Discharge via an armoured spillway set at the maximum storage level

These structures will be located at the downstream end of the polishing pond, adjacent to the existing Reddalls Road culvert. Typically, the low flow outlet will comprise a concrete pit structure to limit the rate of outflow. The form envisaged in this application is a pit with 'upstand' grate located on the edge of the pond and small diameter outlet pipe. The invert of the pipe being set 0.5m below maximum storage level.

The spillway, comprising turf or possibly reno mattress (depending on final design), will be designed to safely pass extreme flows from the catchment with an amount of freeboard.

The difference in elevation between the low flow outlet and the spillway will allow for dynamic storage in the pond. This increases the effectiveness of the pond by providing increased detention time for short intense storms.

Maintenance Access

The perimeter of the ponds should be accessible by small machinery to facilitate maintenance. A minimum embankment width of 3m is recommended with hardstand gravel or concrete being provided where longitudinal grades exceed 1 in 10.

Fencing/Landscape

Although fencing is less critical than the leachate pond, a minimum 2m high chainmesh fence with lockable access gates (4.8m wide at two points) should be provided along the Reddalls Road Frontage to prevent unauthorised access.

With regard to landscaping, Macrophyte areas should be planted with wetland species, to encourage rapid establishment. A range of different types should be considered as each has a different depth tolerance and will therefore colonise different areas within the ponds. A range of species will also make the pond ecosystem more robust.

The upland areas surrounding the pond, particularly adjacent Reddalls Road, should be heavily landscaped to provide a visual buffer and enhance the pond ecology.

5. CONCLUSIONS & RECOMMENDATIONS

5.1. CONCLUSIONS

Water Balance Modelling

- A site specific water balance model was used to predict leachate generation rates for the Whytes Gully Landfill and was calibrated over the simulation period 1997 to 2001, showing good correlation with recorded pond levels.

- The model was used in 'design mode' using an assumed catchment condition that takes into account future landfill expansion and a 'worst case' active fill zone component.

- A 'design' 1 in 25 year 24 hour rainfall depth was adopted based on standard Australian Rainfall & Runoff (1987) procedures. This was also checked against recorded data from a nearby gauge using a storm frequency analysis and found to be conservative.

- The model estimates that the surplus leachate generated by a licence event is approximately 6750m^3 which is equivalent to 75% of the existing storage.

- As a basis for design, an assumed pond starting volume under 'base flow' conditions of 8,100 m^3 was adopted. This volume represents an upper limit level at which leachate storage has been reliably maintained over its operating lifetime.

- The minimum volume requirement for the new leachate ponds has therefore been set at <u>15,000m^3</u> being the addition (to the nearest thousand) of the surplus leachate generated by a licence event (6750m^3) and the elevated 'base flow' pond starting level (8100m^3).

Leachate Pond Design

- The conceptual design for the leachate ponds includes a two pond configuration located at the western end of the new Reddalls Road deviation.

- A factor of safety was applied to the final pond volume giving a total leachate pond volume of 18,000m^3. This is approximately twice the capacity of the existing pond system.
- The proposed design incorporates provision for each pond to be operated separately with separate intakes and sewer discharge lines allowing temporary decommissioning as required.
- Standard provisions for maintenance access, fencing and landscaping have also been made.

Stormwater Pond Design

- A conceptual design for proposed new stormwater ponds has been prepared and incorporates modern wetland design features including increased macrophyte areas and provision for dynamic storage.

- The pond size has been initially set on the basis of the volume of existing facilities. These existing facilities have proven to be effective over the long term and therefore provide a sound basis for future design. Nevertheless, it is envisaged that overall pond size could be justifiably reduced, given the anticipated improvements to treatment efficiency resulting from the proposed new configuration.

5.2. RECOMMENDATIONS

It is recommended that:

- Council submit this report to the EPA as part of its obligations under its pollution Reduction Program PRP U6.1;

- That the conceptual leachate and stormwater pond designs prepared as part of this study be considered for further design development and a development application prepared;

- That further geotechnical investigations be undertake prior to detailed design to investigate alternative less expensive options for leachate pond lining and also confirm clay lining is not required for the proposed stormwater facilities;

- With regard to operation of the site, to reduce potential for leachate production it is recommended that Council endeavour to maintain the area of active fill zones to a minimum. Active fill zones are identified as being the greatest potential contributor to leachate generation;

- Also, once constructed, the proposed leachate facilities should be maintained at a level equivalent to existing pond volumes, with additional storage being reserved for capture of the design event.

Prepared by
for and on behalf of
FORBES RIGBY PTY LTD

Steven Roso
(Civil/Environmental Engineer)

Reviewed by

Paul Nichols
(Director)

APPENDIX A

DAILY WATER BALANCE

WHYTES GULLY WATER BALANCE - CALIBRATION MODEL

Global Data

Crop Factor	0.6
Seasonal Factor (Spring)	1
Seasonal Factor (Summer)	1.2
Seasonal Factor (Autumn)	1
Seasonal Factor (Winter)	0.8

Simulation Period = 1997 to 2001

Evaporation pan data used = Sydney Airport

Rain gauges used = Wongawilli (mm/day)
Oak Flats (adjusted) (mm/day)
Wollongong CBD (mm/day)

Year	Month	Day		Adjusted Wongawilli data	Daily Rainfall Data (Oak Flats)	Adjusted Oak Flats data	Daily rainfall data (Wollongong CBD)	Adjusted Wollongong CBD data	Modelled Rainfall	30 Day average Modelled Rainfall	Seasonal Factor (from table above)	Daily Evaporation Data (Sydney Airport)	Adjusted Daily Evaporation Data
				1		1.2		1					1
1997	1	1	1/1/97	1			0	0	0.5	0.5	1.2	7.6	7.6
1997	1	2	1/2/97	0			0	0	0	0.3	1.2	6.8	6.8
1997	1	3	1/3/97	0			0	0	0	0.2	1.2	6.2	6.2
1997	1	4	1/4/97	0			0	0	0	0.1	1.2	8	8
1997	1	5	1/5/97	0			0	0	0	0.1	1.2	8	8
1997	1	6	1/6/97	0			0	0	0	0.1	1.2	11.8	11.8
1997	1	7	1/7/97	1			0	0	0.5	0.1	1.2	10.8	10.8
1997	1	8	1/8/97	2			0	0	1.5	0.3	1.2	8.2	8.2
1997	1	9	1/9/97	0			0	0	0	0.3	1.2	6.2	6.2
1997	1	10	1/10/97	0			0	0	0	0.3	1.2	6.2	6.2
1997	1	11	1/11/97	0			0	0	0	0.2	1.2	6.8	6.8
1997	1	12	1/12/97	0			0	0	0	0.2	1.2	9.8	9.8

ACTUAL MODEL EXTENDS DOWNWARDS (1 ROW PER DAY FOR 5 YEARS)

WHYTES GULLY WATER BALANCE - CALIBRATION MODEL

Western Gully

Western Gully Area Schedule					Moisture Store Calcs (area of final cover)							
					Maximum Moisture Store Depth (mm)							300
					Initial Moisture Store Depth (mm)							150
					Final Cover Runoff Co-efficient - C							0.3
					Initial Rainfall Loss (mm)							2.5
Total Area (m2)	Area Not Yet Commissioned (m2)	Area of Daily Cover (m2)	Area if Intermediate Cover (m2)	Area of Final Cover (m2)	Initial Surface Runoff (mm)	Moisture Store Recharge (mm)	Moisture Store (after recharge) (mm)	Moisture Store Excess (mm)	Moisture Store (after removal of excess) (mm)	EvapoTranspiration (mm)	Moisture Store (at end of day) (mm)	Total Surface Runoff (mm)
99200	0	0	0	99200	0	1	151	0	151	3	148	0
99200	0	0	0	99200	0	0	148	0	148	2	145	0
99200	0	0	0	99200	0	0	145	0	145	2	143	0
99200	0	0	0	99200	0	0	143	0	143	3	140	0
99200	0	0	0	99200	0	0	140	0	140	3	137	0
99200	0	0	0	99200	0	0	137	0	137	4	134	0
99200	0	0	0	99200	0	1	134	0	134	3	131	0
99200	0	0	0	99200	0	2	132	0	132	3	129	0
99200	0	0	0	99200	0	0	129	0	129	2	127	0
99200	0	0	0	99200	0	0	127	0	127	2	125	0
99200	0	0	0	99200	0	0	125	0	125	2	123	0
99200	0	0	0	99200	0	0	123	0	123	3	120	0

ACTUAL MODEL EXTENDS DOWNWARDS (1 ROW PER DAY FOR 5 YEARS)

WHYTES GULLY WATER BALANCE - CALIBRATION MODEL

Capping Permeabilty Calcs			Leachate Generation Calcs - All Areas					
Thickness of Clay Capping (mm)		2000	Rainfall Loss Factor Daily Cover - L_d				0.4	
Permeability of Clay Capping - k (m/s)		1.0E-08	Rainfall Loss Factor Intermediate Cover- L_i				0.5	
Permeability of Clay Capping - k (mm/d)		0.9						
			Daily Cover			Intermediate Cover		
Vertical Hydraulic Gradient in Capping Layer	Rainfall Infiltration (mm/unit area)	24 hr Lagged Rainfall Infiltration (mm per unit area)	Volume of Rainfall onto area of Daily cover (m3)	Volume of rainfall lost from areas of daily cover (m3)	Leachate for Area of Daily Cover (m3)	Volume of Rainfall onto area of intermediate cover (m3)	Volume of rainfall lost from areas of intermediate cover (m3)	Leachate from Area of Intermediate Cover (m3)
0.074	0.064	0.000	0	0	0	0	0	0
0.073	0.063	0.064	0	0	0	0	0	0
0.072	0.062	0.063	0	0	0	0	0	0
0.070	0.061	0.062	0	0	0	0	0	0
0.069	0.059	0.061	0	0	0	0	0	0
0.067	0.058	0.059	0	0	0	0	0	0
0.065	0.056	0.058	0	0	0	0	0	0
0.065	0.056	0.056	0	0	0	0	0	0
0.064	0.055	0.056	0	0	0	0	0	0
0.063	0.054	0.055	0	0	0	0	0	0
0.062	0.053	0.054	0	0	0	0	0	0
0.060	0.052	0.053	0	0	0	0	0	0

ACTUAL MODEL EXTENDS DOWNWARDS (1 ROW PER DAY FOR 5 YEARS)

WHYTES GULLY WATER BALANCE - CALIBRATION MODEL

Leachate Generation Calcs - All Areas						Stormwater Generation Calcs - (areas not yet commissioned and final cover)				Ground Water
						Runoff Co-efficient Grassed - C_G 0.3 Runoff Co-efficient Forest - C_F 0.2 Runoff Co-efficient Paved - C_P 0.9 Runoff Co-efficient exposed earth - C_E 0.4				% of 30 day av Rain 5
Final Cover			Totals							
Rainfall onto final cover (m3)	Evaporation from areas of final cover (m3)	Leachate from Infiltration into Final Cover (m3)	Total Rainfall	Total Evapoation	Total Leachate (m3)	Stormwater from Area Not Yet Commissioned (m3)	Evap from areas not yet commissioned (m3)	Stormwater from Area of Final Cover (m3)	Total stormwater runoff	
50	272	0	50	272	0	0	0	0	0	7.2
0	239	6	0	239	6	0	0	0	0	3.6
0	214	6	0	214	6	0	0	0	0	2.4
0	272	6	0	272	6	0	0	0	0	1.8
0	267	6	0	267	6	0	0	0	0	1.4
0	386	6	0	386	6	0	0	0	0	1.2
50	345	6	50	345	6	0	0	0	0	2.0
149	258	6	149	258	6	0	0	0	0	4.5
0	191	6	0	191	6	0	0	0	0	4.0
0	188	5	0	188	5	0	0	0	0	3.6
0	203	5	0	203	5	0	0	0	0	3.3
0	288	5	0	288	5	0	0	0	0	3.0

ACTUAL MODEL EXTENDS DOWNWARDS (1 ROW PER DAY FOR 5 YEARS)

WHYTES GULLY WATER BALANCE - CALIBRATION MODEL

Eastern Gully

Eastern Gully Area Schedule					Moisture Store Calcs (area of final cover)								
					Maximum Moisture Store Depth (mm)								300
					Initial Moisture Store Depth (mm)								100
					Final Cover Runoff Co-efficient - C								0.3
					Initial Rainfall Loss (mm)								2.5
Total Area (m2)	Area Not Yet Commissioned (m2)	Area of Daily Cover (m2)	Area if Intermediate Cover (m2)	Area of Final Cover (m2)	Initial Surface Runoff (mm)	Moisture Store Recharge (mm)	Moisture Store (after recharge) (mm)	Moisture Store Excess (mm)	Moisture Store (after removal of excess) (mm)	EvapoTranspiration (mm)	Moisture Store (at end of day) (mm)	Total Surface Runoff (mm)	
103200	44400	32000	26800	0	0	1	101	0	101	2	99	0	
103200	44400	32000	26800	0	0	0	99	0	99	2	97	0	
103200	44400	32000	26800	0	0	0	97	0	97	1	96	0	
103200	44400	32000	26800	0	0	0	96	0	96	2	94	0	
103200	44400	32000	26800	0	0	0	94	0	94	2	92	0	
103200	44400	32000	26800	0	0	0	92	0	92	3	89	0	
103200	44400	32000	26800	0	0	1	90	0	90	2	87	0	
103200	44400	32000	26800	0	0	2	89	0	89	2	87	0	
103200	44400	32000	26800	0	0	0	87	0	87	1	86	0	
103200	44400	32000	26800	0	0	0	86	0	86	1	85	0	
103200	44400	32000	26800	0	0	0	85	0	85	1	83	0	
103200	44400	32000	26800	0	0	0	83	0	83	2	81	0	

ACTUAL MODEL EXTENDS DOWNWARDS (1 ROW PER DAY FOR 5 YEARS)

WHYTES GULLY WATER BALANCE - CALIBRATION MODEL

Capping Permeabilty Calcs			Leachate Generation Calcs - All Areas					
Thickness of Clay Capping (m)		1000	Rainfall Loss Factor Daily Cover - L_d				0.4	
Permeability of Clay Capping - k (m/s)		1.0E-09	Rainfall Loss Factor Intermediate Cover- L_i				0.5	
Permeability of Clay Capping - k (mm/d)		0.1						
			Daily Cover			Intermediate Cover		
Vertical Hydraulic Gradient in Capping Layer	Rainfall Infiltration (mm/unit area)	24 hr Lagged Rainfall Infiltration (mm per unit area)	Volume of Rainfall onto area of Daily cover (m3)	Volume of rainfall lost from areas of daily cover (m3)	Leachate for Area of Daily Cover (m3)	Volume of Rainfall onto area of intermediate cover (m3)	Volume of rainfall lost from areas of intermediate cover (m3)	Leachate from Area of Intermediate Cover (m3)
0.099	0.009	0.000	16	6	10	13	7	7
0.097	0.008	0.009	0	0	0	0	0	0
0.096	0.008	0.008	0	0	0	0	0	0
0.094	0.008	0.008	0	0	0	0	0	0
0.092	0.008	0.008	0	0	0	0	0	0
0.089	0.008	0.008	0	0	0	0	0	0
0.087	0.008	0.008	16	6	10	13	7	7
0.087	0.008	0.008	48	19	29	40	20	20
0.086	0.007	0.008	0	0	0	0	0	0
0.085	0.007	0.007	0	0	0	0	0	0
0.083	0.007	0.007	0	0	0	0	0	0
0.081	0.007	0.007	0	0	0	0	0	0

ACTUAL MODEL EXTENDS DOWNWARDS (1 ROW PER DAY FOR 5 YEARS)

WHYTES GULLY WATER BALANCE - CALIBRATION MODEL

Leachate Generation Calcs - All Areas						Stormwater Generation Calcs - (areas not commissioned and final cover)			
						Runoff Co-efficient Grassed - C_G			0.3
						Runoff Co-efficient Forest - C_F			0.2
						Runoff Co-efficient Paved - C_P			0.9
						Runoff Co-efficient exposed earth - C_E			0.4
Final Cover			Totals						
Rainfall onto final cover (m3)	Evaporation from areas of final cover (m3)	Leachate from Infiltration into Final Cover (m3)	Total Rainfall	Total Evaporation	Total Leachate (m3)	Stormwater from Area Not Yet Commissioned (m3)	Evap from areas not yet commissioned (m3)	Stormwater from Area of Final Cover (m3)	Total stormwater runoff
0	0	0	29	13	16	9	13	0	9
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	29	13	16	9	13	0	9
0	0	0	88	39	49	27	40	0	27
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

ACTUAL MODEL EXTENDS DOWNWARDS (1 ROW PER DAY FOR 5 YEARS)

WHYTES GULLY WATER BALANCE - CALIBRATION MODEL

Residual Areas Directed to Stormwater

Residual Area Schedule

*Note: excludes pond surface

Stormwater Generation Calcs

Runoff Co-efficient Grass - C_G	0.3
Runoff Co-efficient Forest - C_F	0.2
Runoff Co-efficient Paved - C_P	0.9

				Grass		Forest		Paved		Totals	
Total Area *	Areas of Grass	Areas of Forest	Areas Paved	stormwater from grass areas	Absorbtion/Evaporation from grassed areas	Stormwater from forest area	Absorbtion/Evaporation from forest	Stormwater from paved areas	Absorbtion/ Evaporation from paved areas	Total stormwater runoff (m3)	Total Absorbed/Evaporated (m3)
286200	115800	110800	59600	0	0	11	44	27	3	38	47
286200	115800	110800	59600	0	0	0	0	0	0	0	0
286200	115800	110800	59600	0	0	0	0	0	0	0	0
286200	115800	110800	59600	0	0	0	0	0	0	0	0
286200	115800	110800	59600	0	0	0	0	0	0	0	0
286200	115800	110800	59600	0	0	0	0	0	0	0	0
286200	115800	110800	59600	17	41	11	44	27	3	55	88
286200	115800	110800	59600	52	122	33	133	80	9	166	263
286200	115800	110800	59600	0	0	0	0	0	0	0	0
286200	115800	110800	59600	0	0	0	0	0	0	0	0
286200	115800	110800	59600	0	0	0	0	0	0	0	0
286200	115800	110800	59600	0	0	0	0	0	0	0	0

ACTUAL MODEL EXTENDS DOWNWARDS (1 ROW PER DAY FOR 5 YEARS)

WHYTES GULLY WATER BALANCE - CALIBRATION MODEL

Direct to Ponds					
Leachate Pond Areas			Stormwater pond areas		
Evap reduction factor		0.8	Evap reduction factor		0.9
Leachate Pond Surface Area (m2)	Rainfall direct into ponds (m3)	Evaporation from pond surface (m3)	Stormwater Pond Surafce Areas (combined) (m2)	Rainfall direct into ponds (m3)	Evaporation from pond surface (m3)
6600	3	40	21200	11	145
6600	0	36	21200	0	130
6600	0	33	21200	0	118
6600	0	42	21200	0	153
6600	0	42	21200	0	153
6600	0	62	21200	0	225
6600	3	57	21200	11	206
6600	10	43	21200	32	156
6600	0	33	21200	0	118
6600	0	33	21200	0	118
6600	0	36	21200	0	130
6600	0	52	21200	0	187

ACTUAL MODEL EXTENDS DOWNWARDS (1 ROW PER DAY FOR 5 YEARS)

WHYTES GULLY WATER BALANCE - CALIBRATION MODEL

Leachate Totals

Starting Pond Volume (m3)	4000	High Pump Rate (m3/d)	150
Maximum Pond Volume (m3)	9000	Low Pump Rate (m3/d)	90
Minimum pond volume (m3)	200		
Min vol to start High Pump Rate (m	7000		
Daily rainfall to start HPR (mm/d)	10		

**Note: all pond volumes and areas are combined values*

Daily leachate flow into pond (m3)	Pumped to Sewer (m3)	Evaporation from Pond (m3)	Cumulative Pond Volume (m3)	Calculated Pond Volume 7day average (m3)	Recorded Pond Volume (m3)	Volume Leachate Discharged to Stormwater Ponds (m3)	Recorded discharges
27	90	40	4000	4000		0	
10	90	36	3884	3942		0	
9	90	33	3770	3885		0	
8	90	42	3646	3825		0	
7	90	42	3521	3764		0	
7	90	62	3376	3699		0	
27	90	57	3256	3636		0	
69	90	43	3191	3520		0	
10	90	33	3078	3405		0	
9	90	33	2965	3290		0	
9	90	36	2847	3176		0	
8	90	52	2714	3061		0	

ACTUAL MODEL EXTENDS DOWNWARDS (1 ROW PER DAY FOR 5 YEARS)

WHYTES GULLY WATER BALANCE - CALIBRATION MODEL

Stormwater Totals

Starting Pond Volume (m3) 23000
Maximum Pond Volume 25000

Note: all pond volumes and areas are combined values.

Daily stormwater flow into pond (m3)	Evaporation from Pond (m3)	Cumulative Pond Volume (before discharge to creek) (m3)	Calculated Pond Volume 7 Day Average (m3)	Volume Stormwater Discharged to Dapto Creek (m3)
57	145	23000	23000	0
0	130	22912	22956	0
0	118	22783	22898	0
0	153	22664	22840	0
0	153	22512	22774	0
0	225	22359	22705	0
75	206	22134	22623	0
224	156	22003	22481	0
0	118	22070	22361	0
0	118	21952	22242	0
0	130	21834	22123	0
0	187	21704	22008	0

ACTUAL MODEL EXTENDS DOWNWARDS (1 ROW PER DAY FOR 5 YEARS)

WHYTES GULLY WATER BALANCE - CALIBRATION MODEL

Check

Total rain in	Total Groundwater in	evap from daily, intermediate, not commissioned	evap from residual areas	Lost from leachate pond (evap, sewer)	lost from stormwater (evap or dapto ck)	total water lost	total rain on final cover	total stormwater from final cover	Total evapotrans from final cover	total infiltration through capping
258	7	26	47	130	145	621	50	0	272	0
0	4	0	0	126	130	495	0	0	239	6
0	2	0	0	123	118	455	0	0	214	6
0	2	0	0	132	153	557	0	0	272	6
0	1	0	0	132	153	552	0	0	267	6
0	1	0	0	152	225	764	0	0	386	6
258	2	26	88	147	206	812	50	0	345	6
775	4	79	263	133	156	890	149	0	258	6
0	4	0	0	123	118	432	0	0	191	6
0	4	0	0	123	118	429	0	0	188	5
0	3	0	0	126	130	459	0	0	203	5
0	3	0	0	142	187	616	0	0	288	5

ACTUAL MODEL EXTENDS DOWNWARDS (1 ROW PER DAY FOR 5 YEARS)

WHYTES GULLY WATER BALANCE - CALIBRATION MODEL

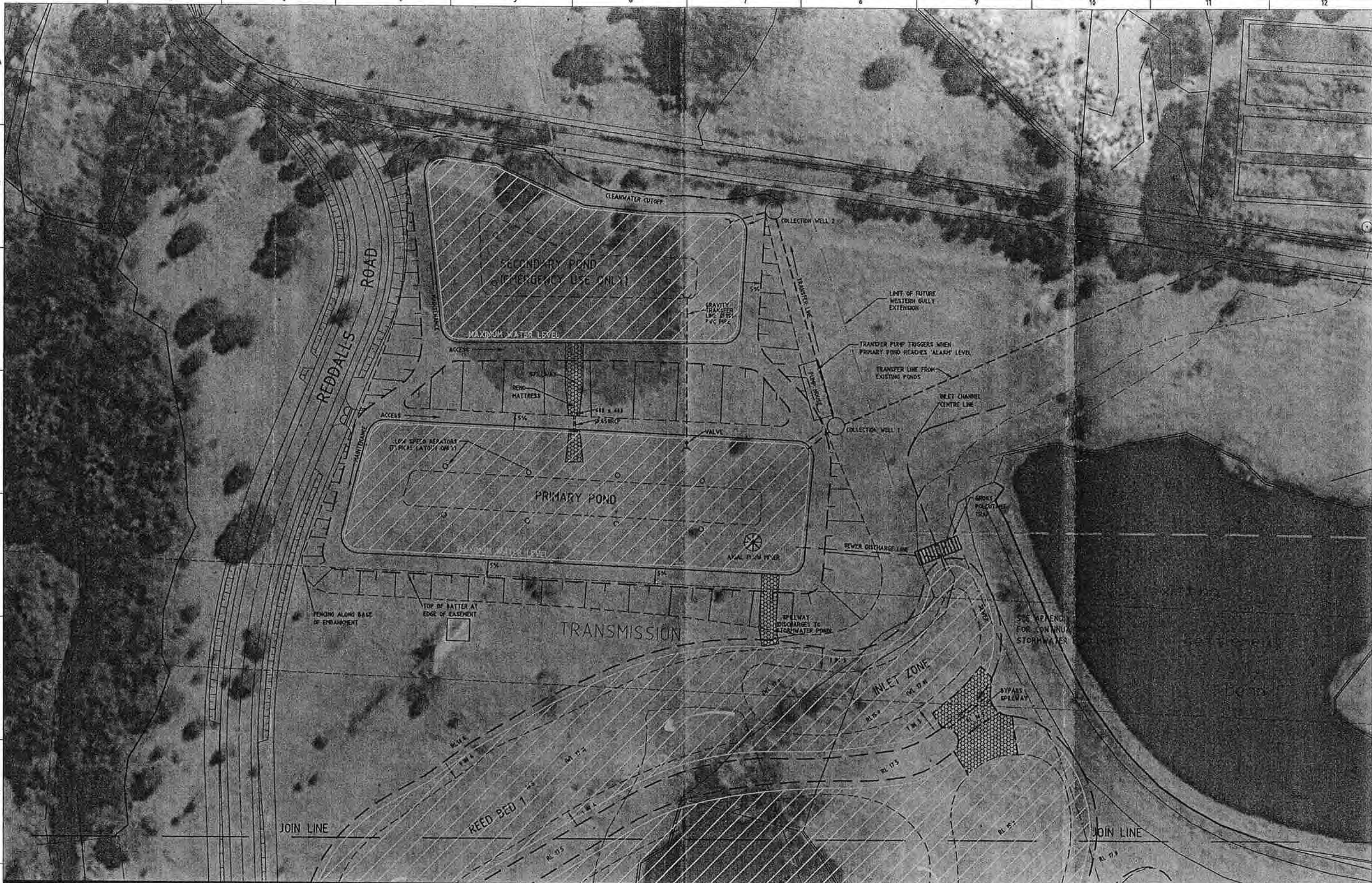
residual area water balance			[illegible]		[illegible]	
rain on residual areas	stormwater from residual areas	evap from residual areas	rain	leachate, stormwater and evap	rain	stormwater and evap
143	38	47	29	29	22	22
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
143	55	88	29	29	22	22
429	166	263	88	88	67	67
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0

ACTUAL MODEL EXTENDS DOWNWARDS (1 ROW PER DAY FOR 5 YEARS)

APPENDIX B

LEACHATE POND CONCEPT DESIGN

DO NOT SCALE | IF IN DOUBT ASK



REV	DATE	BY	APP.	DETAILS

DRAWING STATUS		
DESIGN BY	SR/PCF	12/04/02
DRAWN BY	PK/PCF	27/08/02
DRAFTING CHECK	SR	6/12/02
DESIGN CHECK	SR	6/12/02
FINAL APPROVAL	SR	8/12/02

FOR APPROVAL

0 10 20 30
SCALE 1:500

SCALE: (on A1 Original) 1:500

DATUM: AHD

FORBES RIGBY PTY LTD
Engineers Planners & Scientists
Quality Endorsed Company, ISO 9001 LIC QEC 10508, Standards Australia
278 KEIRA STREET, WOLLONGONG, NSW 2500
Ph: (02) 4228 4133 Facsimile: (02) 4228 6811 ACN 003 936 981

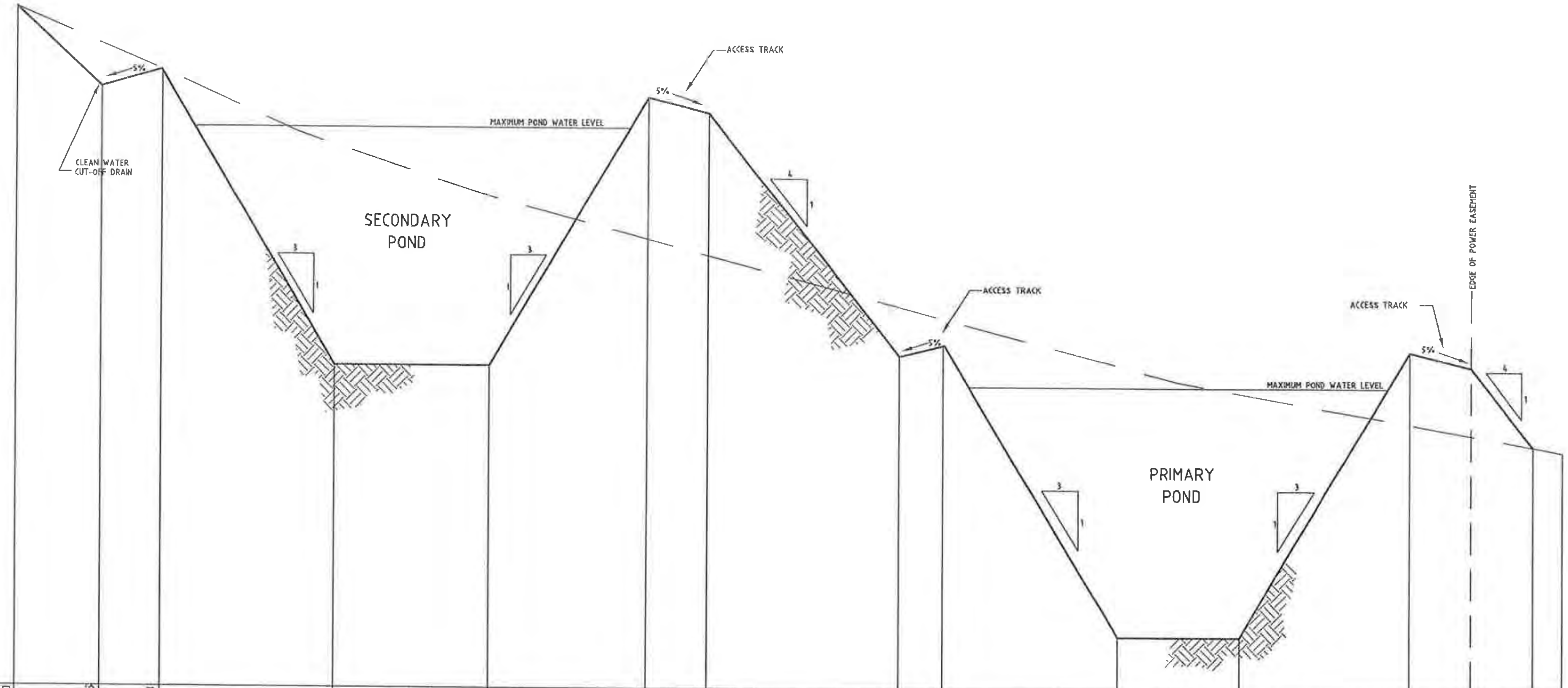
PROJECT TITLE
LEACHATE POND DESIGN
WHYTES GULLY
WASTE DEPOT
for
WOLLONGONG CITY COUNCIL

DRAWING TITLE
LEACHATE
PONDS CONCEPTUAL
LAYOUT

Project No.	Drawing No.	REV
99095	3001	0

A1

DO NOT SCALE IF IN DOUBT ASK



DESIGN SURFACE LEVEL	26.00	24.75	25.00	20.21	20.21	24.58	24.33	20.40	20.57	15.87	15.87	20.50	20.25	18.97	18.88
CHAINAGE	0.00	7.00	12.00	26.27	38.91	52.81	56.98	72.73	76.37	90.62	100.63	114.52	119.52	124.64	127.87

LEACHATE PONDS LONGSECTION
SCALE 1:1000 H, 1:200 V

LEGEND
EXISTING SURFACE LEVEL
DESIGN SURFACE LEVEL

REV	DATE	BY	APP.	DETAILS

DRAWING STATUS

DESIGN BY	SR	26/08/02
DRAWN BY	PK	27/08/02
DRAFTING CHECK	SR	6/12/02
DESIGN CHECK	SR	6/12/02
FINAL APPROVAL	SR	6/12/02

FOR APPROVAL

SCALE: (on A1 Original) AS SHOWN

DATUM: AHD

FORBES RIGBY PTY LTD
Engineers Planners & Scientists
Quality Endorsed Company, ISO 9001 LIC QEC 10508, Standards Australia
278 KEIRA STREET, WOLLONGONG, NSW 2500
Ph: (02) 4228 4133 Facsimile: (02) 4228 6811 ACN 003 936 981

PROJECT TITLE
LEACHATE POND DESIGN
WHYTES GULLY
WASTE DEPOT
for
WOLLONGONG CITY COUNCIL

DRAWING TITLE
LEACHATE
PONDS CONCEPTUAL
LONGSECTION

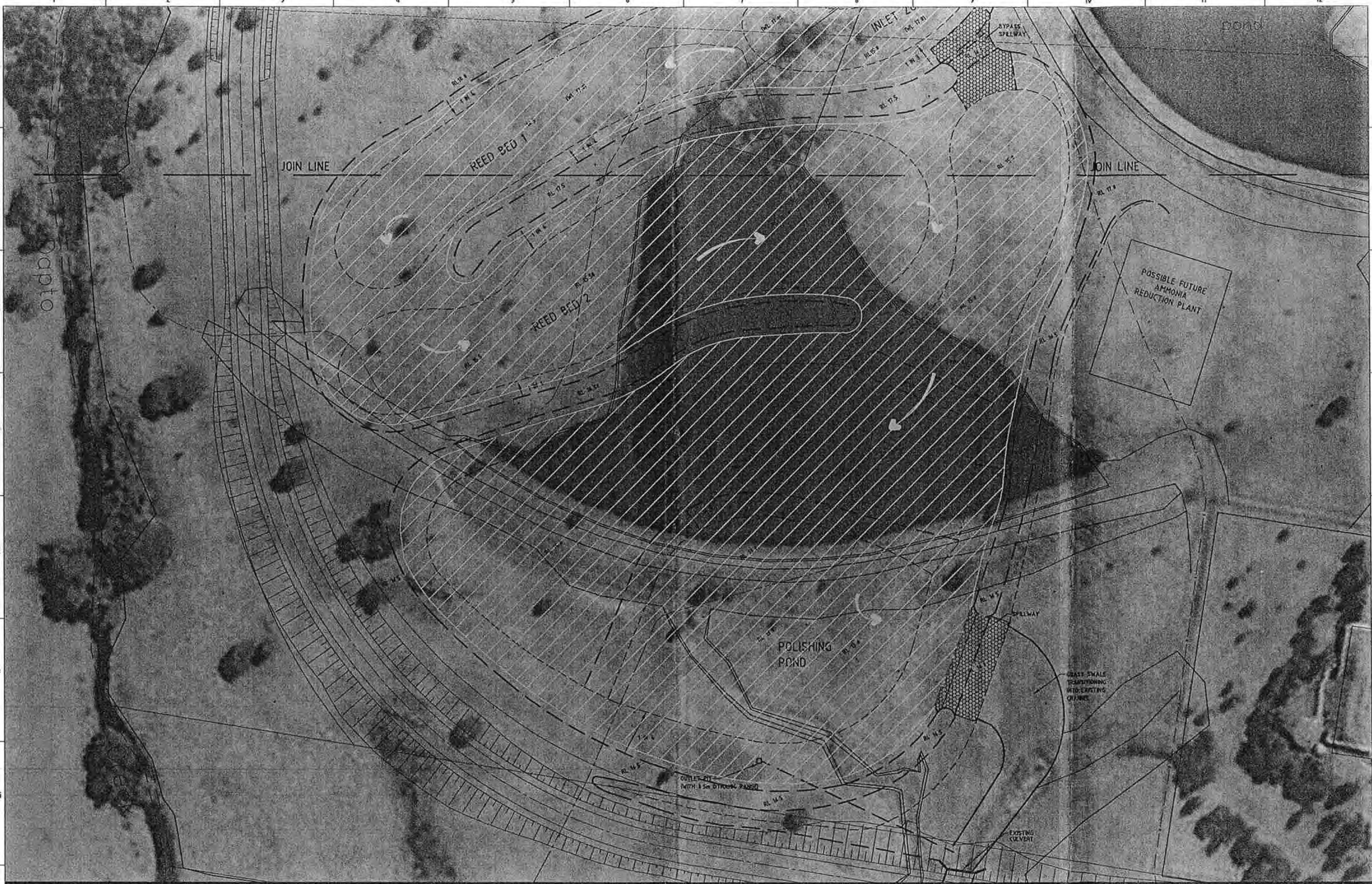
Project No.	Drawing No.	REV
99095	3002	0

A1

APPENDIX C

STORMWATER POND CONCEPT DESIGN

DO NOT SCALE IF IN DOUBT ASK



REV	DATE	BY	APP.	DETAILS
P1	24/10/01	PK		AMENDED SPILLWAY LOCATION

DRAWING STATUS		
DESIGN BY	SR/PCF	12/04/02
DRAWN BY	PCF/PK	12/04/02
DRAFTING CHECK	SR	6/12/02
DESIGN CHECK	SR	6/12/02
FINAL APPROVAL	SR	6/12/02

FOR APPROVAL

0 10 20 30
SCALE 1:500

SCALE: (on A1 Original) 1:500

DATUM: AHD

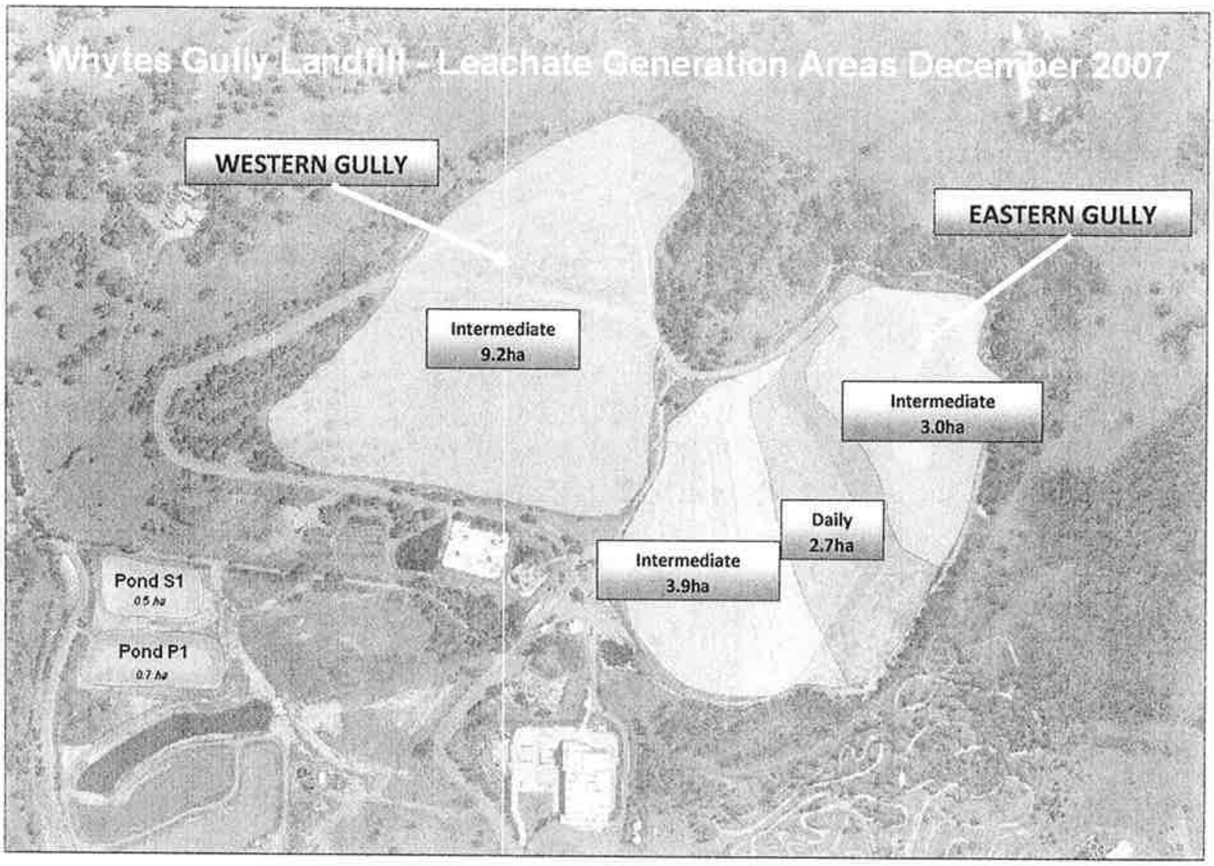
FORBES RIGBY PTY LTD
Engineers Planners & Scientists
Quality Endorsed Company, ISO 9001 LIC QEC 10508, Standards Australia
278 KEIRA STREET, WOLLONGONG, NSW 2500
Ph: (02) 4228 4133 Facsimile: (02) 4228 6811 ACN 003 936 981

PROJECT TITLE
LEACHATE POND DESIGN
WHYTES GULLY
WASTE DEPOT
for
WOLLONGONG CITY COUNCIL

DRAWING TITLE
STORMWATER
PONDS CONCEPTUAL
LAYOUT

Project No.	Drawing No.	REV
99095	3003	0

A1


Whytes Gully Landfill - Leachate Generation Areas December 2007
WESTERN GULLY
EASTERN GULLY
Intermediate
9.2ha
Intermediate
3.0ha
Daily
2.7ha
Intermediate
3.9ha
Pond S1
0.5 ha
Pond P1
0.7 ha

APPENDIX F

Landfill Master Plan

March 2012

REPORT

Whytes Gully New Landfill Cell Landfill Master Plan

Submitted to:
Wollongong City Council

Report Number. 117625003-143-R-Rev0

REPORT

Table of Contents

1.0 INTRODUCTION

Golder Associates Pty Ltd (Golder) has been engaged by Wollongong City Council to prepare documentation to support the Whytes Gully New Landfill Cell Project (the Project).

Located at the existing Whytes Gully Resource Recovery Park (Whytes Gully RRP), the Project would create approximately 6 million m^3 of additional landfill capacity in addition to associated infrastructure. The new landfill cell would be constructed on top of, and integrated with, existing landfill cells on the site, in a 'piggyback' formation.

This Landfill Master Plan presents an overview of the development of the Whytes Gully New Landfill Cell, and provides information on the planned stage-by-stage development.

Detail on the design is provided in the Preliminary Design Report (Golder 2012d) Reference 117625003_058_R_Rev0

2.0 PROJECT OVERVIEW

2.1 Project Elements

The Project would consist of the following key components:

- New Landfill Cell Construction (Stage 1, 2A, 2B, 3 and 4)
- New Landfill Cell Operation (Stage 1, 2A, 2B, 3 and 4)
- Progressive Landfill Rehabilitation and Revegetation of the finished Landform
- Surface Water Drains and Surface Water Ponds
- Leachate Ponds
- Leachate Treatment Plant Upgrade
- Landfill Gas Extraction
- Ancillary – demolition of existing buildings, construction of temporary and permanent roads.

A Project Footprint Plan is provided in Figure 1 and Final Landform Plan is presented on Figure 2.

2.2 New Landfill Cell Capacity and Life

The term "airspace" refers to the available volume for landfill material placement between an upper and lower surface, with the upper surface typically corresponding to the design levels for the top of a planned landfill. The New Landfill Cell project is designed to provide for 40 years or more of landfill operations at an airspace consumption rate of 140,000 m^3/yr. The project is planned to be developed in a number of workable stages with each stage providing at least two years of landfill airspace.

3.0 OVERALL PROJECT STAGING

3.1 New Landfill Cell Staging

The proposed landfill would be constructed in five stages (Stage 1, Stage 2A, Stage 2B, Stage 3, Stage 4), including eleven cells (Cells 1, 2, 2A, 2B, 3, 4, 4A and Piggy Back Cells 1, 2A, 2B, 3), to enable the gradual development of the landfill site. A gradual development approach is beneficial in reducing the active footprint of the landfill and consequently reducing potential impacts upon the environment and allowing progressive rehabilitation throughout the life of the proposed landfill. The main stages of the development are presented in Figure 3. The cell locations are presented in Figure 4. Table 1 outlines the approximate airspace, life and timeline for the development of each stage of the Project's new landfill cell.

Table 1: Approximate Stage Volumes and Timelines of the Project New Landfill Cell

Stage	Cells	Piggy Back Cells	Area (m^2)	Airspace (cum)	Life of Cell (Years)	Operation Period	Proposed Capping Construction Period *	Proposed Liner Construction Period *
1	1	1	82,000	912,000	4.4	2013 - 2018	2016 - 2019	2013 - 2016
2A	2A	2A	22,500	343,000	2.4	2018 - 2020	2020 - 2021	2017 – 2018
2B	2, 2B	2B	81,200	2,134,000	15.2	2020 - 2035	2023 - 2036	2019 – 2031
3	3	3	67,200	1,589,000	11.3	2035 - 2046	2038 - 2047	2035 – 2041
4	4, 4A	none	69,000	1,007,000	7.2	2046 - 2054	2048 - 2055	2046 – 2050
TOTAL			**321,900**	**5,985,000**	**40.5**			

* Not continuous during period

Staging plans including temporary access roads are presented in Appendix A, Figures 1 to 11.

The overall staging sequence is summarised as follows:

- Stage 1 covers the Eastern Gully landfill, a section of the Western Gully landfill and a non-landfilled area at the foot of the Eastern Gully landfill that is occupied by roads and stormwater infrastructure.

  In order to divert stormwater from the northern side of the Eastern Gully landfill to the southern side, waste will have to be removed from the eastern most portion of the Eastern Gully landfill. This waste (approximately 300,000 cu.m.) would be placed in Stage 1 of the newly constructed landfill.

- Stage 2 covers part of the Western Gully landfill, a non-landfilled area at the toe of the Western Gully landfill that is occupied by roads and stormwater infrastructure and a non-landfilled ridge line between the eastern and western gully landfills.

- Stage 3 covers part of the Western Gully landfill and a non-landfilled area at the toe of the Western Gully that is occupied by roads, the green waste process area and stockpiling areas.

- Stage 4 covers a non-landfilled area to the west of the Western Gully landfill as well a non-landfilled area at the toe of the Western Gully landfill that is currently occupied by roads and the Primary and Secondary Leachate Ponds.

While one stage is providing for waste filling, the liner for the succeeding stage is proposed to be constructed. In addition, at the completion of waste filling in each stage, that stage would be capped and rehabilitated whilst waste is being landfilled in subsequent cells.

3.2 Staging of Stormwater Infrastructure

The surface water management controls would be progressively developed as the landfilling areas are developed. A drainage philosophy has been designed based on the construction staging of the proposed new landfill cell and offsite discharge constraints. The following summarises the staged approach. Figure 5 presents the staged approach to surface water management. Figure 1 presents the surface water pond down sizing.

Stage 1 and Stage 2A:

The drainage philosophy up to the completion of Stage 2A is to discharge the whole 50 ha catchment to the existing sediment pond. A minor existing discharge offsite from the Western Ridge would be maintained.

Stage 2B:

After completion of Stage 2B the Eastern Gully would become fully capped and therefore surface runoff would become 'clean' runoff. During Stage 2B a new 'clean' drain can be constructed to bypass the sediment pond and discharge directly to the Dapto creek outfall. This drain would be constructed between the existing leachate treatment plant and the surface water ponds. On completion of stage 2B, approximately 24 ha will discharge directly to Dapto Creek and 26 ha to the existing sediment pond.

Stage 3:

On completion of Stage 3, approximately 30 ha will be discharged directly to Dapto Creek and 20 ha to the existing sediment pond. Due to the extent of the Stage 4 works the existing leachate ponds will require relocating towards the end of Stage 3. At this stage it is proposed that the leachate pond is relocated to the footprint of the two reed bed ponds and downsize the existing surface water pond. The downsizing of the surface water pond at this stage is possible due to approximately 60 percent of the original 50 ha catchment now discharging directly to the Dapto Creek outfall.

Stage 4:

The downsized surface water pond is designed for a 20 ha catchment. The clean 30 ha catchment would discharge unrestricted to the Dapto Creek outfall. The surface water pond would be made up of sediment pond and onsite surface water detention pond. The outflow from the pond to the Dapto Creek outfall would be restricted to meet discharge constraints and the resultant attenuated runoff detained within the surface water pond.

3.3 Staging of Other Associated Infrastructure

The staging for associated infrastructure is presented in Table 3 below.

Table 2: Construction and Operation Staging for Other Concept Master Plan Elements

Infrastructure	Commence Construction	Commence Operation
Amenities relocate to Old SWERF building (to make way for Stage 1 landfill construction)	late 2012	2013
Landfill Gas to Flare and/or Energy Facility	mid 2012	2012
Leachate Pond Construction	End of Stage 3 Landfilling (2045)	2045
Surface Water Pond Downsize	End of Stage 3 Landfilling (2045)	2045

3.4 Staging of Easements and Services Relocation

The location of easements and other development constraints on the site are shown on Figure 6. These are summarised as follows:

- An easement for the 132 kV overhead power transmission line which runs east to west across the site, situated south of the Eastern Gully landfill and north of Reddalls Road.
- Power lines as well as a Telstra line run along Old Reddalls Road.
- Power supply easement for the leachate treatment plant runs along the northern edge of the MRF boundary.
- A private power line easement exists in the northern part of the site and crosses the Western Gully landfill. It is understood this line is de-energised and due for decommissioning.
- A sewer line exists between the leachate treatment plant and Reddalls Road.

Service and easements along Old Reddalls Road should be relocated and removed before 2020 prior to construction of Cell 2 (assuming no decommission work is required for any powerlines/substation located within Cell 1 footprint).

Private easement power lines should be removed prior to 2041 for the construction of the upper portion of Piggy Back Cell 3.

All other easements would not be impacted by the Project.

4.0 CELL CONSTRUCTION

Three distinct types of ground conditions can be identified for proposed new landfill areas of the Project :

1) Non-landfilled areas primarily occupied by infrastructure such as roads, soil fill placement, and ponds,. (south of existing landfill Footprint) and would include Cells 1 to 4.

2) Non-landfilled areas that have remained largely undisturbed (Western Ridge and Central Ridge) including Cells 2A, 2B and 4A.

3) The Eastern Gully and Western Gully landfill (Existing Waste) including Piggy Back 1, 2A, 2B, 3.

The cell design varies depending on the ground conditions. Main activities of the construction and landfilling of each cell types are summarised as below. Cell locations are presented in Figure 4.

Cells 1 to 4

1) Construction of temporary stormwater diversion system and erosion and control measures prior the construction of each cell;

2) Excavation of excess material to form the subgrade in accordance to the design and stockpiling materials for cover material;

3) Excavation of unsuitable materials and backfilling with imported materials to prepare subgrade;

4) Construction of perimeter bund and internal bunds;

5) Construction of base liner system;

6) Construction of leachate collection system, leachate sump and connecting to the leachate drainage system; this includes a leachate collection blanket comprising a layer of drainage aggregate;

7) Filling waste in the cell;

8) Placement of intermediate cover to temporary and permanent batters of the cell and progressive vegetation of batters;

9) Construction of passive and active gas collection systems and capping system in each area.

Cells 2A, 2B and 4A

The main activities in these cells are generally similar to those described in the construction of Cell 1 to 4 above with the exception of:

1) The natural materials in these areas are to be excavated to approximately 5.0 m below ground level. These materials may be used in the cell construction or may be used as daily cover. These materials could be excavated and stockpiled or progressively excavated as required to reduce double handling. The excavation is to be finished prior to the construction of the cell base liner;

2) Excavation on subgrade surface to create cross-slope benches, providing platform for cross-slope leachate collection pipes;

3) A geocomposite drainage net will be used in leachate collection system rather than drainage aggregate along with a 300 mm thick protection layer above the liner system.

Piggy Back Cells 1, 2A, 2B, 3

1) Cut to fill to form subgrade surface on the existing landfill areas and stockpiling excess materials for use as daily cover;

2) Excavation of subgrade surface to create cross-slope benches, providing platform for cross-slope leachate collection pipes;

3) Construction of perimeter bund and internal bunds;

4) Construction of piggy back liner system including passive gas collection system underneath liner

5) Construction of leachate collection system connecting with the existing leachate collection system;

6) Placement of 300 mm protection layer;

7) Filling waste in the cell;

8) Placement of intermediate cover to temporary and permanent batters of the cell and progressive vegetation of batters;

9) Construction of passive and active gas collection systems and capping system in each area.

5.0 LANDFILL STAGING PLAN

Staging plans for the Whytes Gully New landfill Cell are presented in Appendix A, Figures 1 – 11. These staging plans include temporary and permanent access roads, areas of cell construction and lining, landfilling and capping. Surface Water Staging is presented in Figure 5. The following table summarises the works to be undertaken in each Stage.

Table 3: New Landfill Cell Works Staging

Stage 1-1: Approximately 2012 – 2013 (Appendix A Figure 1)	
Cell Construction	Stage 1-1 (Cell 1 and lower portion PB 1)
Landfilling	Complete filling on Eastern Gully Landfill Platform.
Capping and Rehabilitation	Not required.
Access Road	Construction of new access road A - B, going across the existing Green Waste Processing Centre prior to the construction of liner in Cell 1. Construction of temporary access road C - D on Western Gully Landfill along western side of Stage 1.
Permanent Surface Water	Construction of diversion channel for surface water drainage from Central Ridge (C-D) connected with existing drainage system to discharge to surface water pond.
Excavation	Excavation of existing material on Eastern Gully Landfill to average 1.5 m depth to form subgrade surface; for use as daily cover material.
Other	Relocation of existing amenities to Old SWERT building. Demolishing of existing infrastructure and removal of services with Cell 1 footprint. Construction of new leachate drainage system for the existing leachate collection systems in the existing Western and Eastern Gully Landfill (beneath the Cell 1 liner system). Construction of active landfill gas extraction on existing Western and Eastern Gully landfill areas in 2012.
Stage 1-1 and 1-2: Approx 2013 – 2015 (Appendix A Figure 2)	
Cell Construction	Stage 1-2 (upper portion PB 1)
Landfilling	Stage 1-1 (Cell 1 and lower portion PB 1)
Capping and Rehabilitation	Not required
Access Road	Construction of permanent access road E – E1. Forming access road E1 - F on waste during the filling of Stage 1-1.
Permanent Surface Water	Not required
Excavation	Complete excavation of material in Cell 2A prior to the construction of Stage 2A.

Staging 1-2 and 2A: Approximately 2015 – 2018 (Appendix A Figure 3)	
Cell Construction	Stage 2A (Cell 2A and PB 2A)
Landfilling	Stage 1-2 (Cell 1 and PB 1) Waste Cutback on Eastern Gully Landfill (Waste relocation to Stage 1-1)
Capping and Rehabilitation	not required
Access Roads	Construction of temporary access road D - D1 during filling of Stage 1-2. Removal of access road within Stage 2A footprint (refer Appendix A Figure 2 for location). Construction access road E1 - F during capping Stage 1-1.
Permanent Surface Water	Construction of swale drain along eastern boundary of the waste cutback and perimeter drain along southern edge of Cell 1, to discharge into the existing surface stormwater pond.
Excavation	Not required
Other	Progressive construction of active landfill gas extraction in new waste.

Stage 2A and 2B-1: Approximately 2018 – 2021 (Appendix A Figure 4)	
Cell Construction	Stage 2B-1 (Cell 2 and PB2B)
Landfilling	Stage 2A (PB 2A and Cell 2A)
Capping and Rehabilitation	Progressive Stage 1
Access Road	Construction access road G - H - I for filling of Stage 2A. Construction of access road I – J on waste during the filling of Stage 2A. Removal of access roads B - C and C - C1 located within Stage 2B-1 footprint.
Permanent Surface Water Drain	Construction drainage channel to discharge clean stormwater from northern site catchment and Stage 1 cap area off site.
Excavation of On-Site Materials	Not required
Other	Relocation of services (Telstra and Power) to along old Reddalls Road. Progressive construction of active landfill gas extraction in new waste.

Stage 2B-1 and 2B-2: 2021 – 2026 (Appendix A Figure 5)	
Cell Construction	Stage 2B-2 (PB2B)
Landfilling	Stage 2B-1 (Cell2 and PB2B)
Capping and Rehabilitation	Progressive Stage 1, Stage 2A
Access Road	Construction of permanent landfill access road I - J, during capping Stage 2A. Construction of temporary access road B - K adjacent to Stage 2B. Forming access road F – B on waste during the filling of Stage 2B-1. Road surface to be constructed during/after capping.
Permanent Surface Water	Construction of perimeter drain along the edge of Stage 2A, discharged to the clean water drain along eastern cell boundary. Construction of clean drainage channel along north western and western boundary of the site.
Excavation of On-Site Materials	Complete excavation of Cell 2B prior to the construction of Stage 2B-3.
Other	Progressive construction of active landfill gas extraction in new waste.
Stage 2B-2 and 2B-3: Approximately 2026 – 2031 (Appendix A Figure 6)	
Cell Construction	Stage 2B-3 (Cell 2B and PB2B)
Landfilling	Stage 2B-2 (PB2B)
Capping and Rehabilitation	Progressive Stage 1, Stage 2A, Stage 2B-1
Access Road	Removal of access road K - D located within Stage 2B-3 footprint. Construction of access road F – B for Stage 2B-3 during capping Stage 2B-1.
Permanent Surface Water	Not required
Other	Progressive construction of active landfill gas extraction in new waste.

Stage 2B-3 and 3-1: Approximately 2031 – 2035 (Appendix A Figure 7)	
Cell Construction	Stage 3-1 (Cell3 and PB3)
Landfilling	Stage 2B3
Capping and Rehabilitation	Progressive Stage 1, Stage 2A, Stage 2B-1, Stage 2B-2
Access Road	Removal of access road A - B - B1 located within Stage 3-1 footprint (refer Figure 6 for location of access road). Construction of temporary access road H – H1 during the filling of Stage 2B-3. Removal of access road B – N at end of Stage 2B-3.
Permanent Surface Water Drain	Not required
Excavation	Excavation of borrow materials within PB3-1 footprint completed prior to the construction of Stage 3–1.
Other	Progressive construction of active landfill gas extraction in new waste. Removal of private powerlines prior to construction of Stage 3-2.
Stage 3-1 and 3-2: Approximately 2035 – 2041 (Appendix A Figure 8)	
Cell Construction	Stage 3-2 (PB3)
Landfilling	Stage 3-2 (Cell3 and PB3)
Capping and Rehabilitation	Progressive Stage 1, Stage 2A, Stage 2B-1, Stage 2B-2, Stage 2B-3
Access Road	Construction of access roads A - M - N on waste during the filling of Stage 3-1 and access road G - L - H for the filling of Stage 3-2. Removal of access roads G - H and G - K located within Stage 3-2 footprint.(refer Figure 7 for location)
Permanent Surface Water	Connecting perimeter drain along Cell 2 boundary to the clean water channel discharged off site.
Excavation of On-Site Materials	Excavation of borrow materials within Stage 4-1 footprint completed prior to Stage 4-1 cell construction.
Others	Progressive construction of active landfill gas extraction in new waste. Relocation of leachate pond(s) prior to Cell 4 construction 2045. Downsizing of surface water pond(s) prior to leachate pond relocation.

Stage 3-2 and 4-1: Approximately 2041 – 2047 (Appendix A Figure 9)	
Cell Construction	Stage 4-1 (Cell 4)
Landfilling	Stage 3-2 (PB3)
Capping and Rehabilitation	Progressive Stage 1, Stage 2A, Stage 2B-1, Stage 2B-2, Stage 2B-3, Stage 3-1, Stage 3- 2
Access Road	Construction of temporary access road Z – Z1 during the filling of Stage 3-2.
Permanent Surface Water	Construction of perimeter drain along Cell 3 and Cell 2B boundary, discharged to the existing stormwater ponds.
Excavation of On-Site Materials	Excavation of Cell 4A completed prior to Stage 4-2.
Other	Progressive construction of active landfill gas extraction in new waste.
Stage 4-1 and 4-2: Approximately 2047 – 2050 (Appendix A Figure 10)	
Cell Construction	Stage 4-2 (Cell 4A)
Landfilling	Stage 4-1 (Cell 4)
Capping and Rehabilitation	Progressive Stage 1, Stage 2A, Stage 2B-1, Stage 2B-2, Stage 2B-3, Stage 3-1, Stage 3- 2
Access Road	Removal of access road (M-N-G-L) located within Stage 4-2 footprint during Cell 4A construction.
Permanent Surface Water Drain	Connecting perimeter drain along Cell 3 boundary to the clean water channel discharged off site.
Excavation of On-Site Materials	Not required
Others	Progressive construction of active landfill gas extraction in new waste.

Stage 4-2 : Approximately 2050 – 2054 (Appendix A Figure 11)	
Cell Construction	None
Landfilling	Stage 4-2
Capping and Rehabilitation	Stage 4
Access Road	Forming access road M – O and P – Q on waste during the filling of Stage 4-2. Construction of access road O – P for the filling of Stage 4-2. Completing the permanent access road for final landform during capping of Stage 4-2.
Permanent Surface Water Drain	Completing the perimeter drain around the final landform.
Excavation of On-Site Materials	Not required
Others	Not required Progressive construction of active landfill gas extraction in new waste.

Report Signature Page

Ryan Huynh
Civil Engineer

Jacinta McMahon
Principal Environmental Engineer

JM/GRS/rh

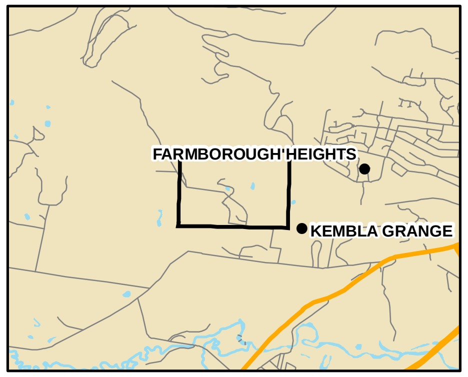
A.B.N. 64 006 107 857

c:\users\dfaria\documents\whytes gully\new folder\reports for appendices\117625003-143-r-rev0-landfill_master_plan.docx

WHYTES GULLY NEW LANDFILL CELL
LANDFILL MASTER PLAN

WOLLONGONG CITY COUNCIL

PROJECT FOOTPRINT



LEGEND

- Contours of Final Landform (5 m interval)
- Site Boundary
- Approximate Extent of Waste
- Extent of Landfill Works
- Indicative New Leachate Pond Footprint New Leachate Pond to be established prior to commencement of Stage 4 construction
- Indicative New Surface Water Pond Footprint Surface Water Pond to be reduced in size prior to commencement of Stage 4 construction
- Indicative, augmented LTP footprint. LTP footprint will be assessed at the end of 2014.
- Existing Leachate Treatment Plant (LTP) Footprint

NOTES

Extent of waste based on site observations and information provided by Council.

Aerial Ortho-Photograph provided by AAM Pty. Ltd. taken on 16 May 2011, Reference 18763A. Image Georeferenced.

Extent of landfill works as per Golder Design Report.

0 25 50 100 150 metres

SCALE (at A3) **1:3,800**

Coordinate System: GDA 1994 MGA Zone 56

PROJECT: **117625003**
DATE: **22/02/2012**
DRAWN: **FA**
CHECKED: **JMc**

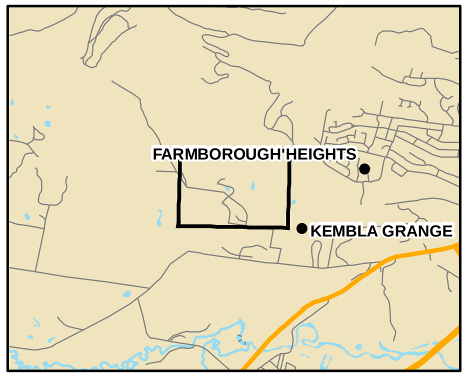
FIGURE 1

Golder Associates

File Location: J:\GIS\Jobs\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Workspaces\117625003_116_R_F0002_ProjectFootprint_Rev1.mxd

WHYTES GULLY NEW LANDFILL CELL
LANDFILL MASTER PLAN
WOLLONGONG CITY COUNCIL

FINAL LANDFORM



LEGEND

- Contours of Final Landform (5 m interval)
- Site Boundary
- Extent of Landfill Works

NOTES

Aerial Ortho-Photograph provided by AAM Pty. Ltd. taken on 16 May 2011, Reference 18763A. Image Georeferenced.

Extent of landfill works and final contours as per Golder Design Report.

0 25 50 100 150 metres

SCALE (at A3) 1:3,800

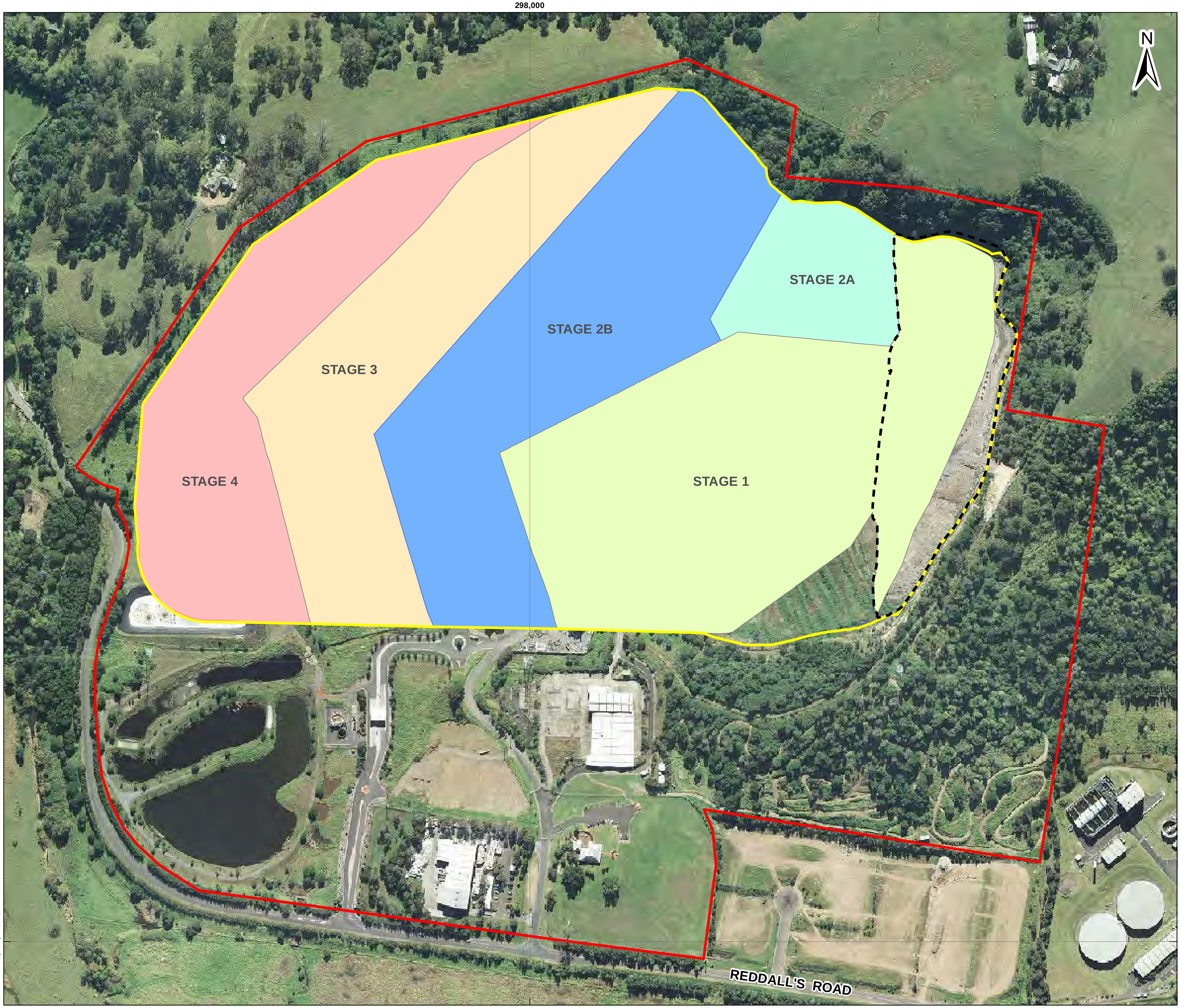
Coordinate System: GDA 1994 MGA Zone 56

PROJECT:	117625003
DATE:	5/03/2012
DRAWN:	FA
CHECKED:	JMc

FIGURE 2

Golder Associates

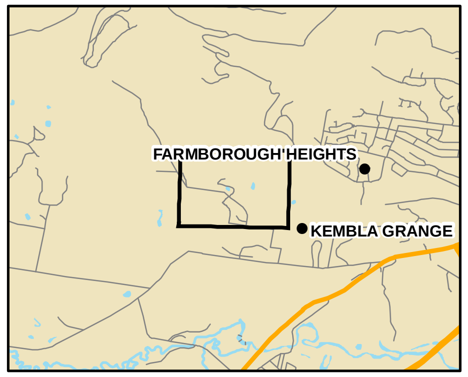
File Location: J:\GIS\Jobs\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Workspaces\117625003_128_R_F0001_Landform_Rev0.mxd



WHYTES GULLY NEW LANDFILL CELL
LANDFILL MASTER PLAN

WOLLONGONG CITY COUNCIL

PROJECT STAGING



LEGEND

- Site Boundary
- Extent of Landfill Works
- Proposed Area of Waste Cut
- Stage1
- Stage2a
- Stage2b
- Stage3
- Stage4

NOTES

Extent of waste based on site observations and information provided by Council.

Aerial Ortho-Photograph provided by AAM Pty. Ltd. taken on 16 May 2011, Reference 18763A. Image Georeferenced.

Extent of landfill works as per Golder Design Report.

0 25 50 100 150 metres

SCALE (at A3) 1:3,800

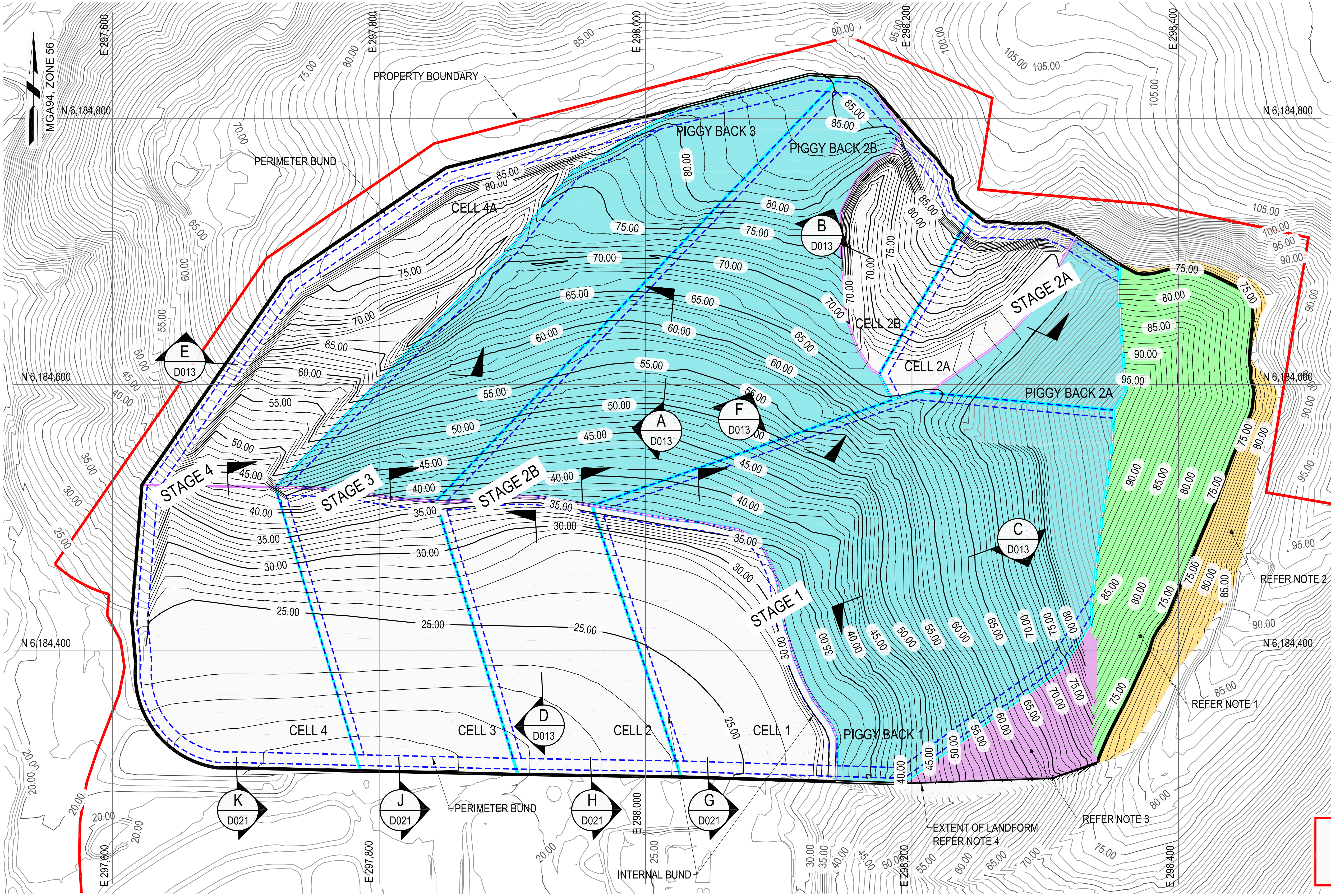
Coordinate System: GDA 1994 MGA Zone 56

PROJECT: 117625003
DATE: 26/03/2012
DRAWN: FA
CHECKED: JMc

FIGURE 3

Golder Associates

File Location: J:\GIS\Jobs\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Workspaces\117625003_116_R_F0001_ProjectStaging_Rev1.mxd



LEGEND

- PROPERTY BOUNDARY
- EXTENT OF LANDFORM
- PROPOSED BUNDS
- STAGING BOUNDARY
- CELL BOUNDARY
- PIGGY BACK AREA

NOTES:

1. SHADED AREA INDICATES PORTION OF WASTE CUTBACK WHERE A WASTE BATTER WILL REMAIN AFTER THE CUTBACK IS COMPLETE. CONTOUR LEVELS INDICATE THE WASTE BATTER SURFACE.
2. SHADED AREA INDICATES PORTION OF WASTE CUTBACK WHERE ALL WASTE WILL BE REMOVED. CONTOUR LEVELS INDICATE NATURAL GROUND AFTER WASTE REMOVAL.
3. SHADED AREA INDICATES AREA WHERE FINAL CAP WILL BE INSTALLED WITH NO ADDITIONAL WASTE PLACEMENT.
4. ADDITIONAL WASTE PLACEMENT TO OCCUR WITHIN THE EXTENT OF LANDFORM, EXCEPT WITHIN SHADED AREAS IDENTIFIED IN NOTE 1 AND NOTE 3.

ISSUED FOR
PRELIMINARY
NOT FOR CONSTRUCTION

BASE DRAWING TAKEN FROM K F WILLIAMS AND ASSOCIATES DRG.WHYTES PHOTOGRAMMETRY AND GROUND SURVEY 20-07-11.dxf DATED 20 JULY 2011.

1:3,000

0 60 120 180m

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
B	ISSUED FOR PRELIMINARY	EJ JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	
A	DRAFT - ISSUED FOR CLIENT REVIEW	H CAMPBELL	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	23.01.2012

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL

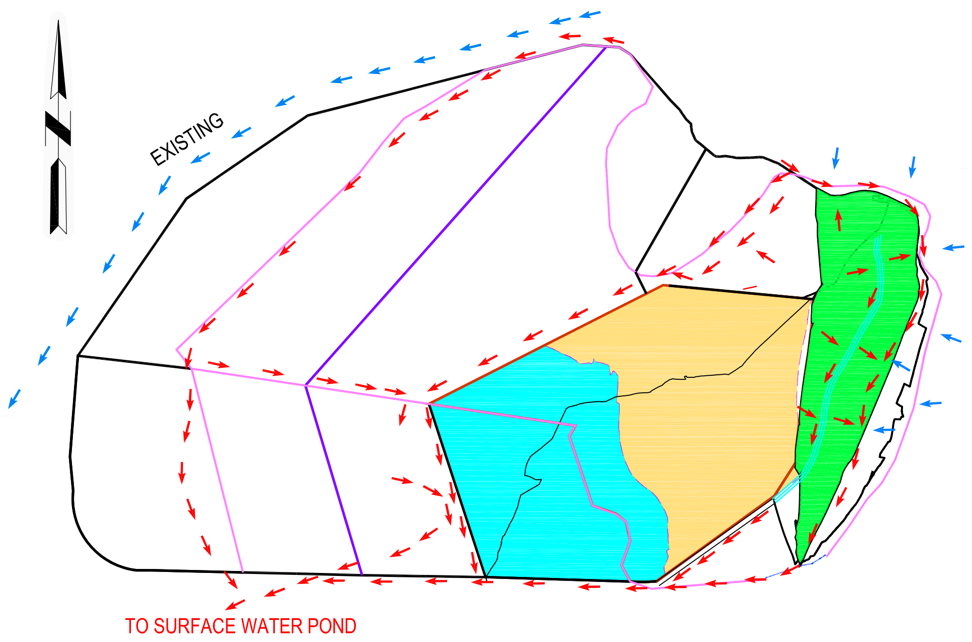
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: STAGING AND SUBGRADE PREPARATION PLAN

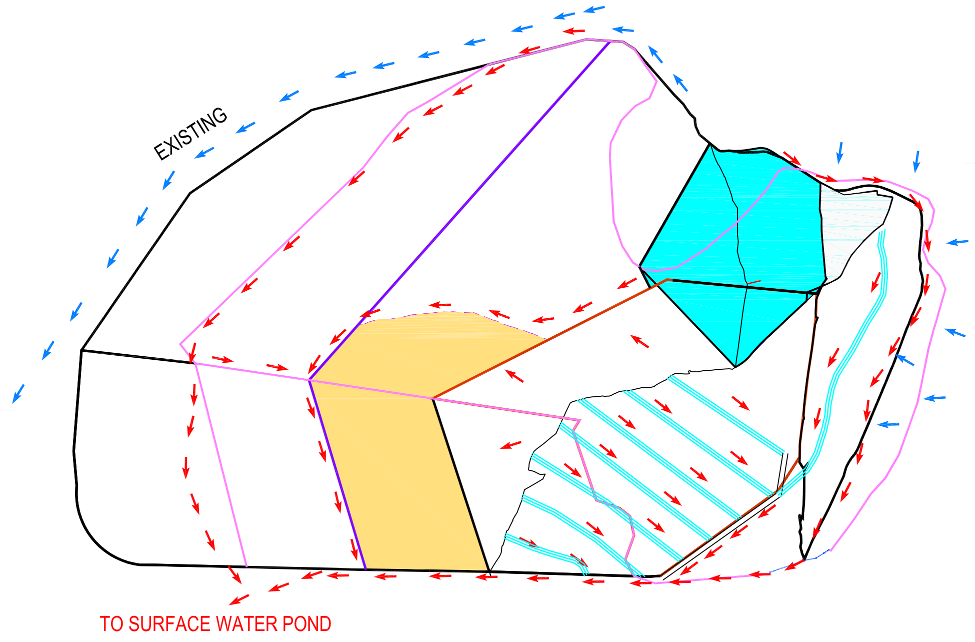
LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJ JEET	J McMAHON	1:3,000	A3	117625003	143	S	FIGURE 4	B

Plot Date: 5 March 2012 Time:10:28:22 AM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\DRAWINGS - File Name:117625003-145-S-D012-REVB.dwg
Xref: 117625003-XREF-WASTE CUT BACK TO EXISTING.dwg; 117625003-XREF-SITE EXTENT BOUNDARIES.dwg; 117625003-XREF-SUBGRADE COMBINED.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-INTERNAL AND EXTERNAL BUND.dwg; GAP_LOGO-A3.dwg;

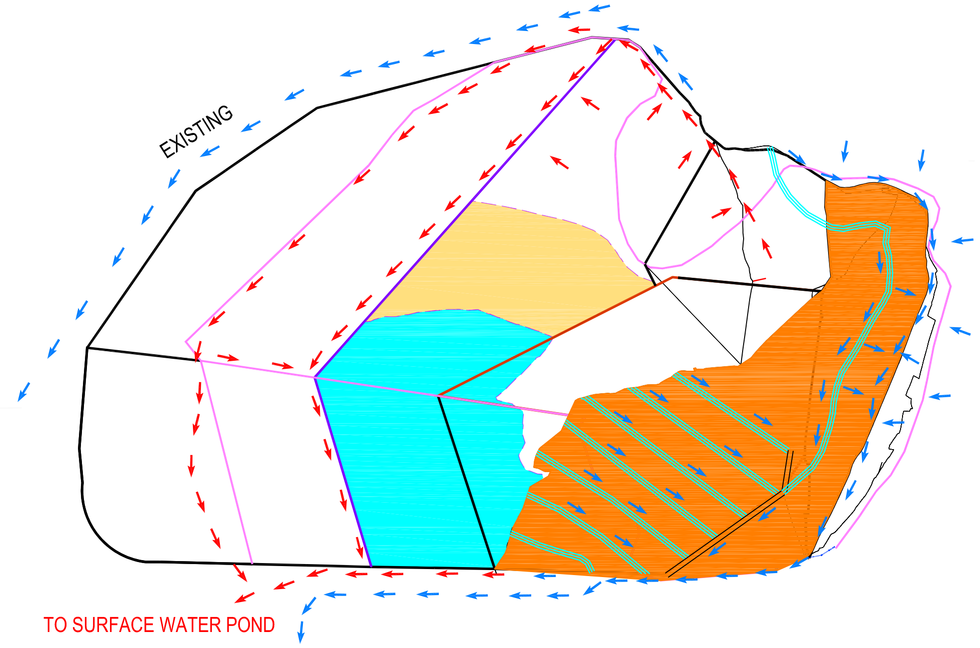
NOTE: DRAWINGS SHOW REPRESENTATIVE CONDITIONS AT AN INTERMEDIATE TIME DURING LINING AND FILLING OF EACH STAGE



STAGE 1
SCALE 1:7,500

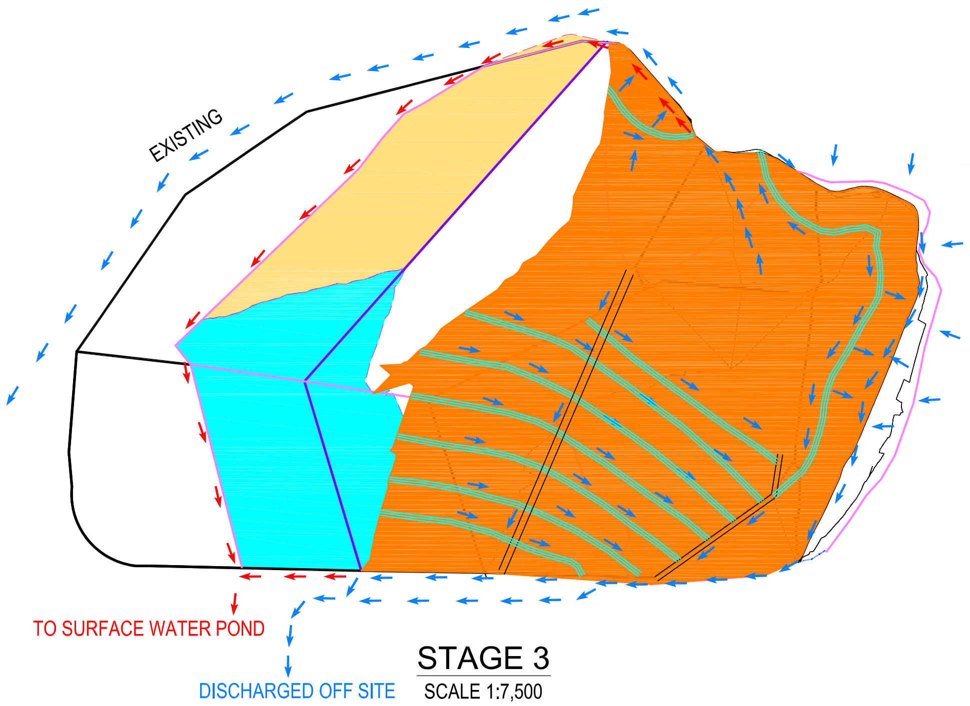


STAGE 2A
SCALE 1:7,500

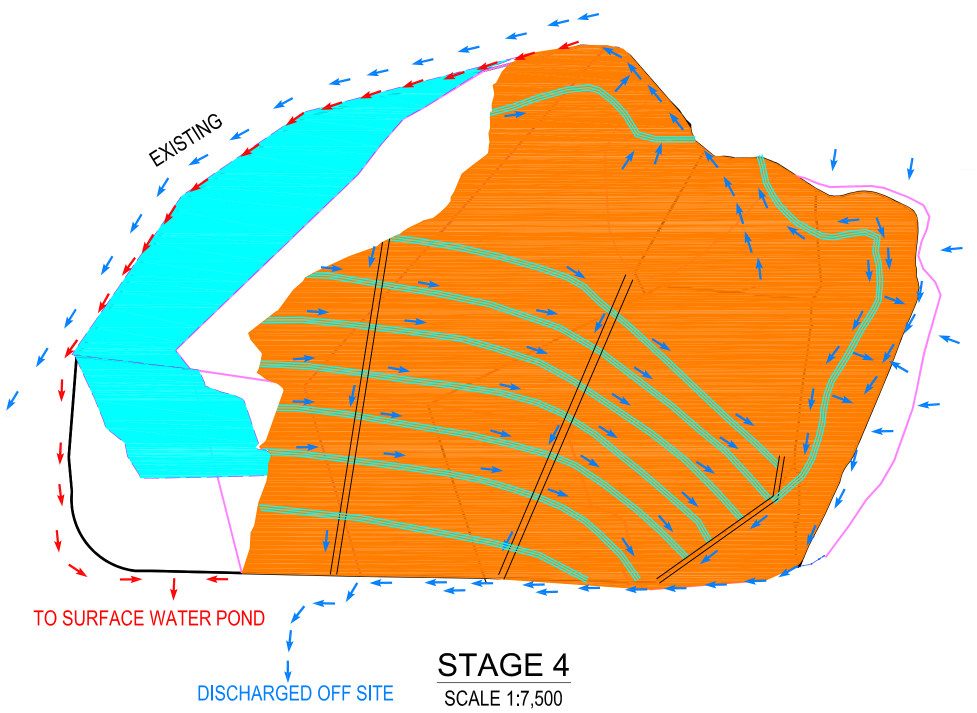


DISCHARGED OFF SITE

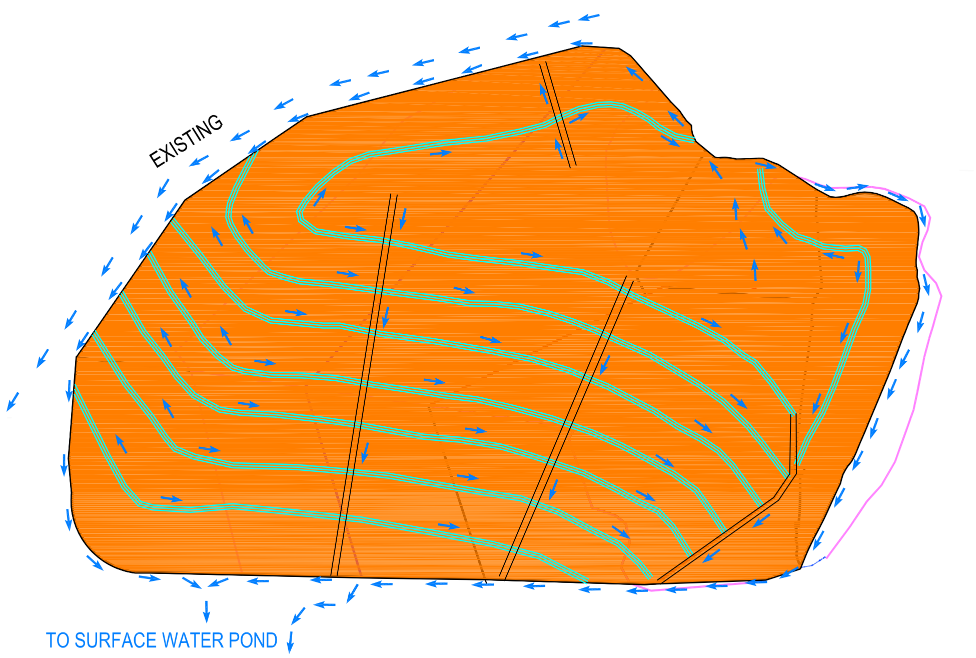
STAGE 2B
SCALE 1:7,500



STAGE 3
SCALE 1:7,500



STAGE 4
SCALE 1:7,500



STAGE FINAL
SCALE 1:7,500

LEGEND

- CLEAN WATER
- DIRTY WATER
- WASTE CUTBACK AREA
- ACTIVE FILLING AREA
- LINING AREA
- CAPPED AREA
- PROPOSED BENCHES
- PROPOSED DROP STRUCTURE

ISSUED FOR
PRELIMINARY
NOT FOR CONSTRUCTION

1:7,500 — 0 150 300 450m

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
	ISSUED FOR PRELIMINARY	E J JEET	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	
A	DRAFT - ISSUED FOR CLIENT REVIEW	C GIBCUS	R HUYNH	R HUYNH	G SCHMERTMANN	G SCHMERTMANN	23.01.2012

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: SURFACE WATER MANAGEMENT SYSTEM CONCEPT PLAN

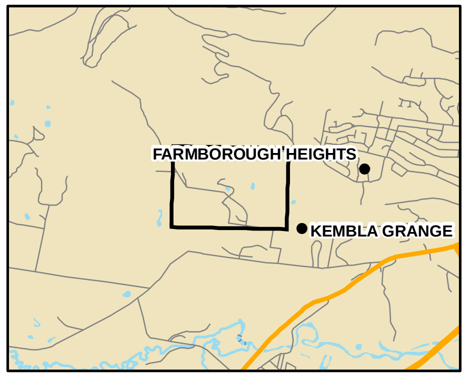
LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJ JEET	J McMAHON	1:7,500	A3	117625003	143	S	FIGURE 5	B

Plot Date: 1 March 2012 Time:10:49:14 AM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\DRAWINGS - File Name:117625003-145-S-D051-REVB.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-STAGING - STAGE 1.dwg; 117625003-XREF-STAGING - STAGE 2A.dwg; 117625003-XREF-STAGING - STAGE 2B.dwg; 117625003-XREF-STAGING - STAGE 4.dwg; 117625003-XREF-STAGING - STAGE 3.dwg;

WHYTES GULLY NEW LANDFILL CELL
LANDFILL MASTER PLAN

WOLLONGONG CITY COUNCIL

DEVELOPMENT CONSTRAINTS



LEGEND

- Site Boundary
- Cadastre
- Easement
- Flood Planning Area (West Dapto LEP)
- Interpreted Flood Planning Area (50 cm Freeboard)
- Heritage
- Aboriginal Archaeological Sites (12/01/2012)
- AHIMS Results in Study Area (12/01/2012)
- Extent of Landfill Works

NOTES

Historic locations digitised by Golder from reports supplied by Wollongong City Council

Aerial Ortho-Photograph provided by AAM Pty. Ltd. taken on 16 May 2011, Reference 18763A. Image Georeferenced.

Site contours based on survey by KFW Williams, dated 20/07/2011

0 12.5 25 50 75 100 125 150 metres

SCALE (at A3) 1:4,000

Coordinate System: GDA 1994 MGA Zone 56

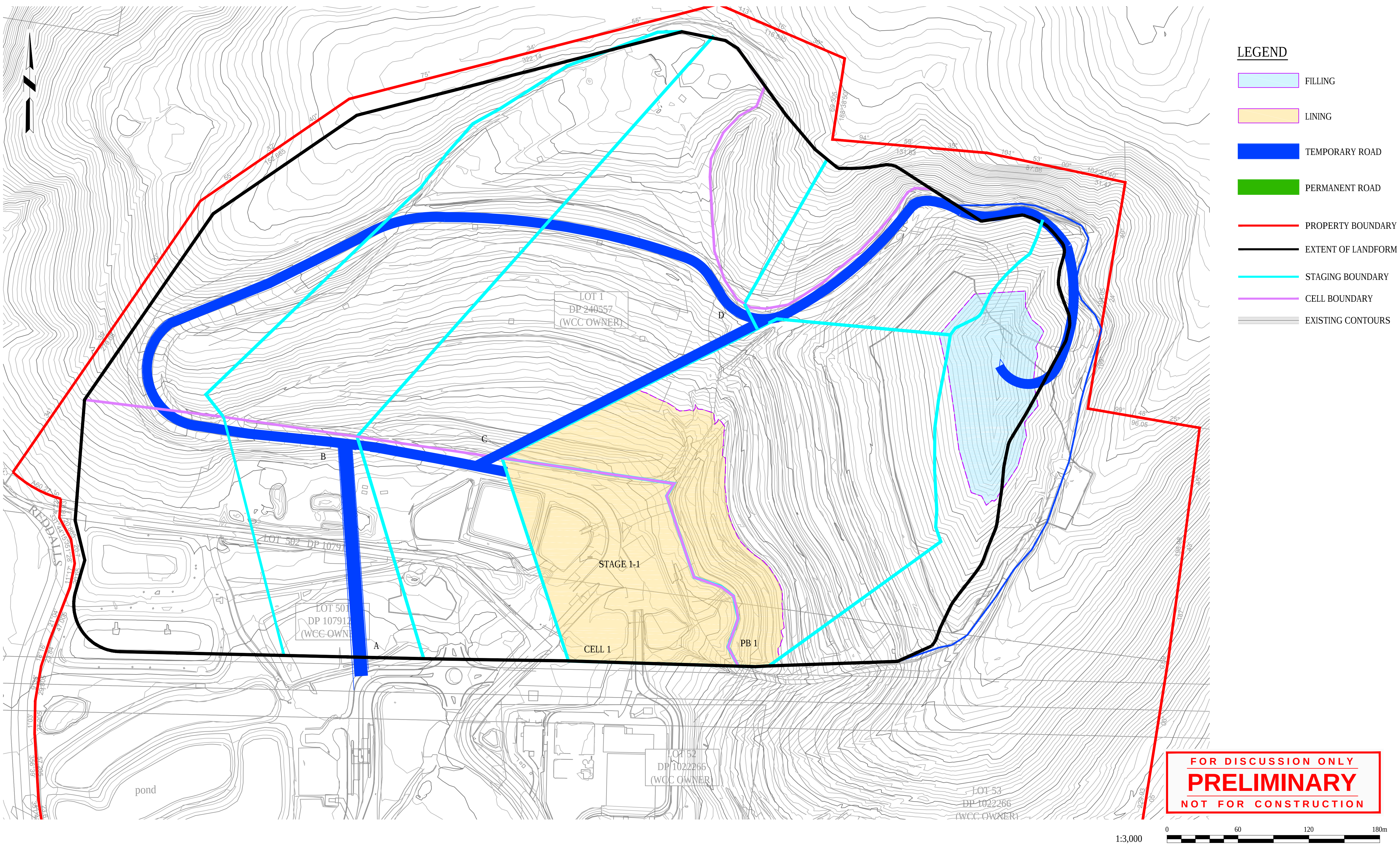
PROJECT:	117625003
DATE:	26/03/2012
DRAWN:	FA
CHECKED:	JMc

FIGURE 6

Golder Associates

APPENDIX A

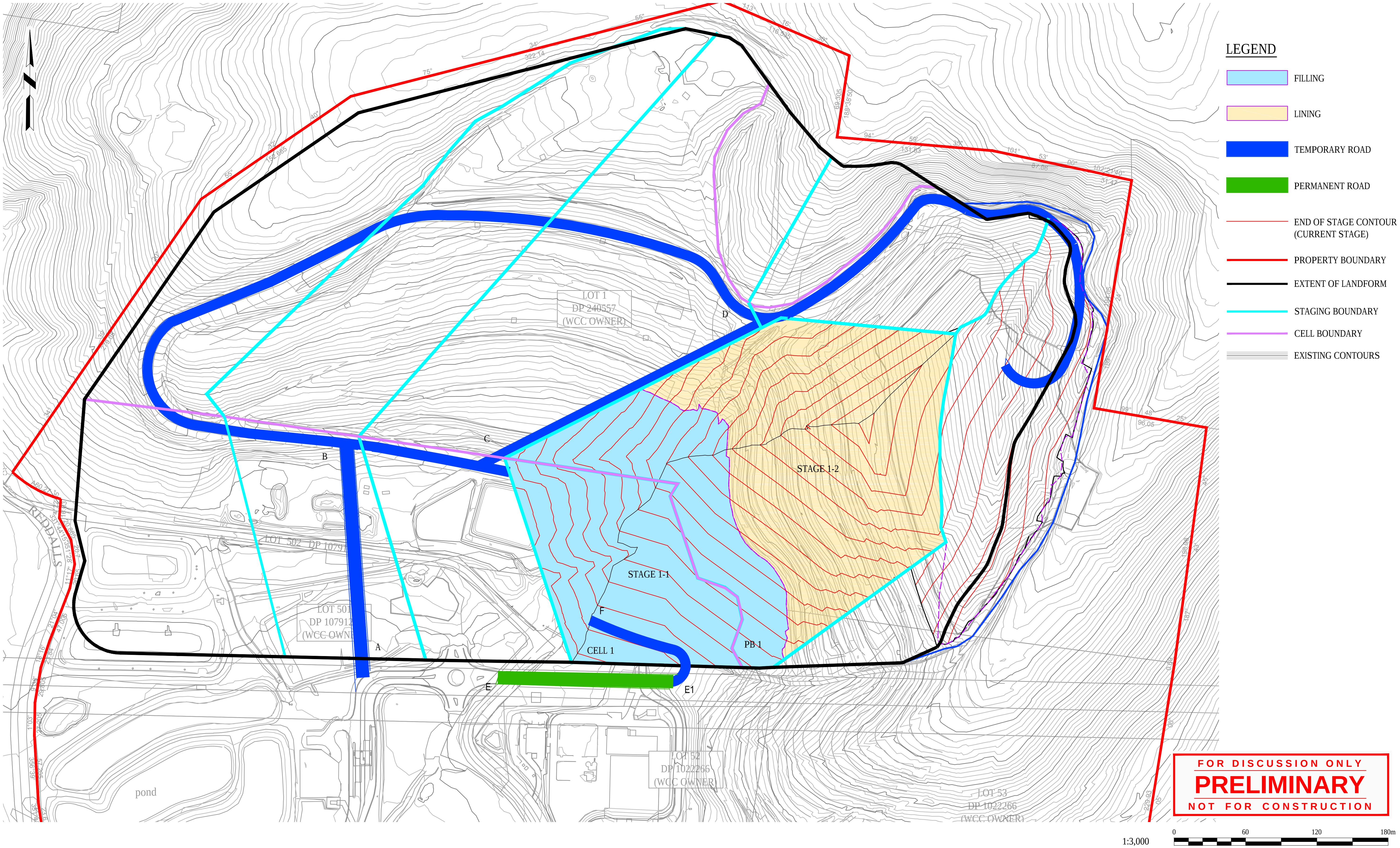
Whytes Gully New Landfill Cell Staging Plans



CLIENT		PROJECT
WOLLONGONG CITY COUNCIL		PRELIMINARY CONCEPT - WHYTES GULLY LANDFILL
DRAWN BY: EJ JEET	DATE: 21 MARCH 2012	DRAWING TITLE: FIRST STAGE
CHECKED BY: R HUYNH	DATE: 21 MARCH 2012	
SCALE: 1:3,000	SHEET SIZE: A3	PROJECT No: 117625003; DOC No: 143; DOC TYPE: R; FIGURE No: F007; REVISION: 0; FIGURE 1

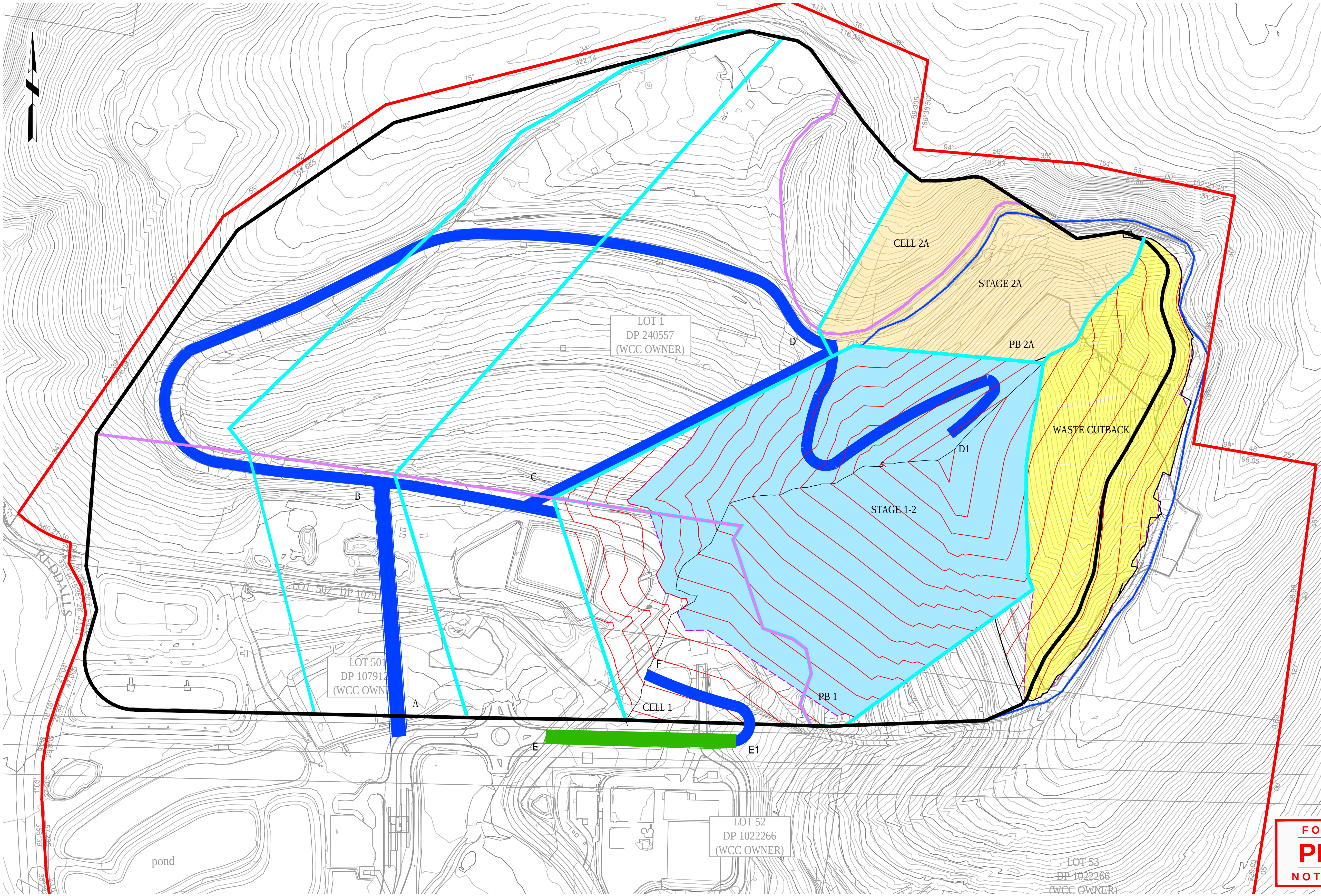
Golder Associates
www.golder.com
GOLDER ASSOCIATES PTY. LTD.

Plot Date: 26 March 2012 Time:12:01:09 PM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\FIGURES - File Name:117625003-143-R-F007-REV0.dwg
Xref: 117625003-XREF-EXISTING BREAKLINES.dwg; 117625003-XREF-PROPOSED ROADS.dwg; GAP_LOGO-A3.dwg;



Golder Associates — www.golder.com — GOLDER ASSOCIATES PTY. LTD.	CLIENT: WOLLONGONG CITY COUNCIL		PROJECT: PRELIMINARY CONCEPT - WHYTES GULLY LANDFILL				
	DRAWN BY: EJ JEET	DATE: 21 MARCH 2012	DRAWING TITLE: STAGE 1-1 AND STAGE 1-2				
	CHECKED BY: R HUYNH	DATE: 21 MARCH 2012					
	SCALE: 1:3,000	SHEET SIZE: A3	PROJECT No: 117625003	DOC No: 143	DOC TYPE: R	FIGURE No: F008	REVISION: 0 — FIGURE 2

Plot Date: 26 March 2012 Time:12:00:32 PM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\FIGURES - File Name:117625003-143-R-F008-REV0.dwg
Xref: 117625003-XREF-EXISTING BREAKLINES.dwg; 117625003-XREF-PROPOSED ROADS.dwg; GAP_LOGO-A3.dwg;



LEGEND

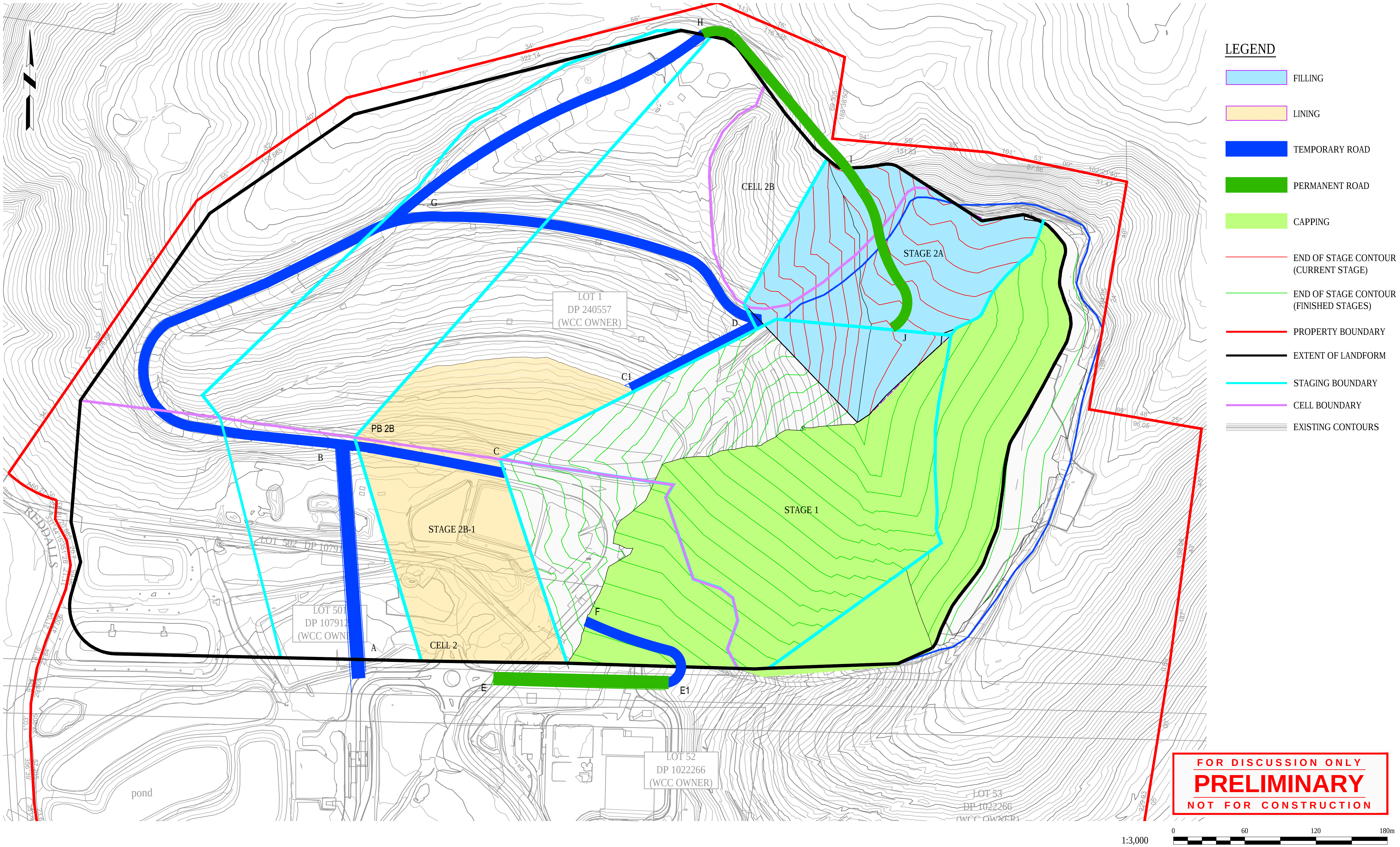
- FILLING
- LINING
- TEMPORARY ROAD
- PERMANENT ROAD
- WASTE CUTBACK
- END OF STAGE CONTOUR (CURRENT STAGE)
- PROPERTY BOUNDARY
- EXTENT OF LANDFORM
- STAGING BOUNDARY
- CELL BOUNDARY
- EXISTING CONTOURS

FOR DISCUSSION ONLY
PRELIMINARY
NOT FOR CONSTRUCTION

1:3,000 — 0 60 120 180m

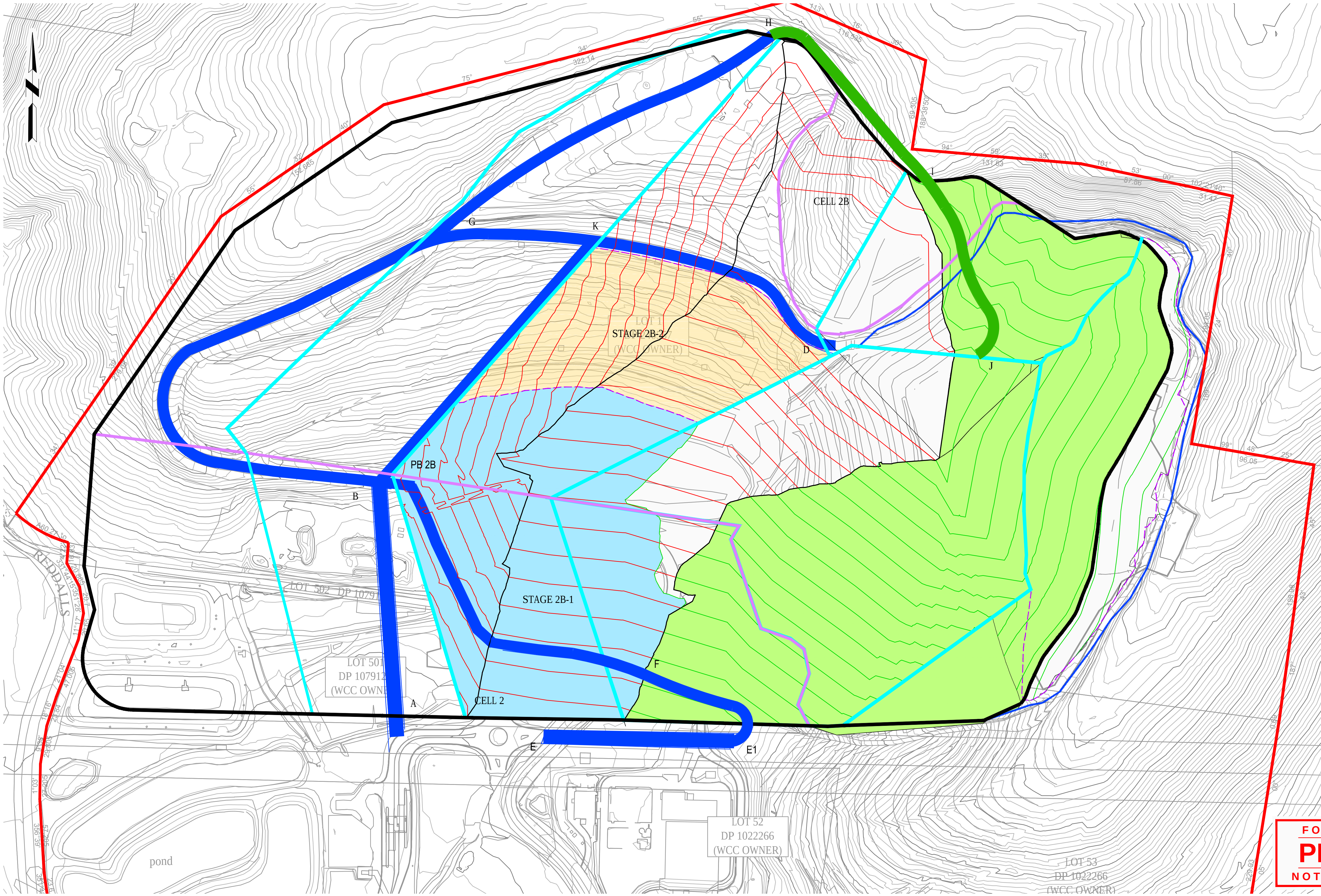
Golder Associates www.golder.com GOLDER ASSOCIATES PTY. LTD.	CLIENT: WOLLONGONG CITY COUNCIL		PROJECT: PRELIMINARY CONCEPT - WHYTES GULLY LANDFILL	
	DRAWN BY: EJ JEET	DATE: 21 MARCH 2012	DRAWING TITLE: STAGE 1-2 AND STAGE 2A	
	CHECKED BY: R HUYNH	DATE: 21 MARCH 2012		
	SCALE: 1:3,000	SHEET SIZE: A3	PROJECT No: 117625003; DOC No: 143; DOC TYPE: R; FIGURE No: F009; REVISION: 0	FIGURE 3

Plot Date: 26 March 2012 Time:11:59:27 AM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\FIGURES - File Name:117625003-143-R-F009-REV0.dwg
Xref: 117625003-XREF-EXISTING BREAKLINES.dwg; 117625003-XREF-PROPOSED ROADS.dwg; GAP_LOGO-A3.dwg;



Golder Associates www.golder.com GOLDER ASSOCIATES PTY. LTD.	CLIENT: WOLLONGONG CITY COUNCIL			PROJECT: PRELIMINARY CONCEPT - WHYTES GULLY LANDFILL			
	DRAWN BY: EJ JEET	DATE: 21 MARCH 2012		DRAWING TITLE: STAGE 2A AND STAGE 2B-1			
	CHECKED BY: R HUYNH	DATE: 21 MARCH 2012					
	SCALE: 1:3,000		SHEET SIZE: A3	PROJECT No: 117625003	DOC No: 143	DOC TYPE: R	FIGURE No: F010 / REVISION: 0 / FIGURE 4

Plot Date: 27 March 2012 Time:10:34:01 AM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\FIGURES - File Name:117625003-143-R-F010-REV0.dwg
Xref: 117625003-XREF-EXISTING BREAKLINES.dwg; 117625003-XREF-PROPOSED ROADS.dwg; GAP_LOGO-A3.dwg;



LEGEND

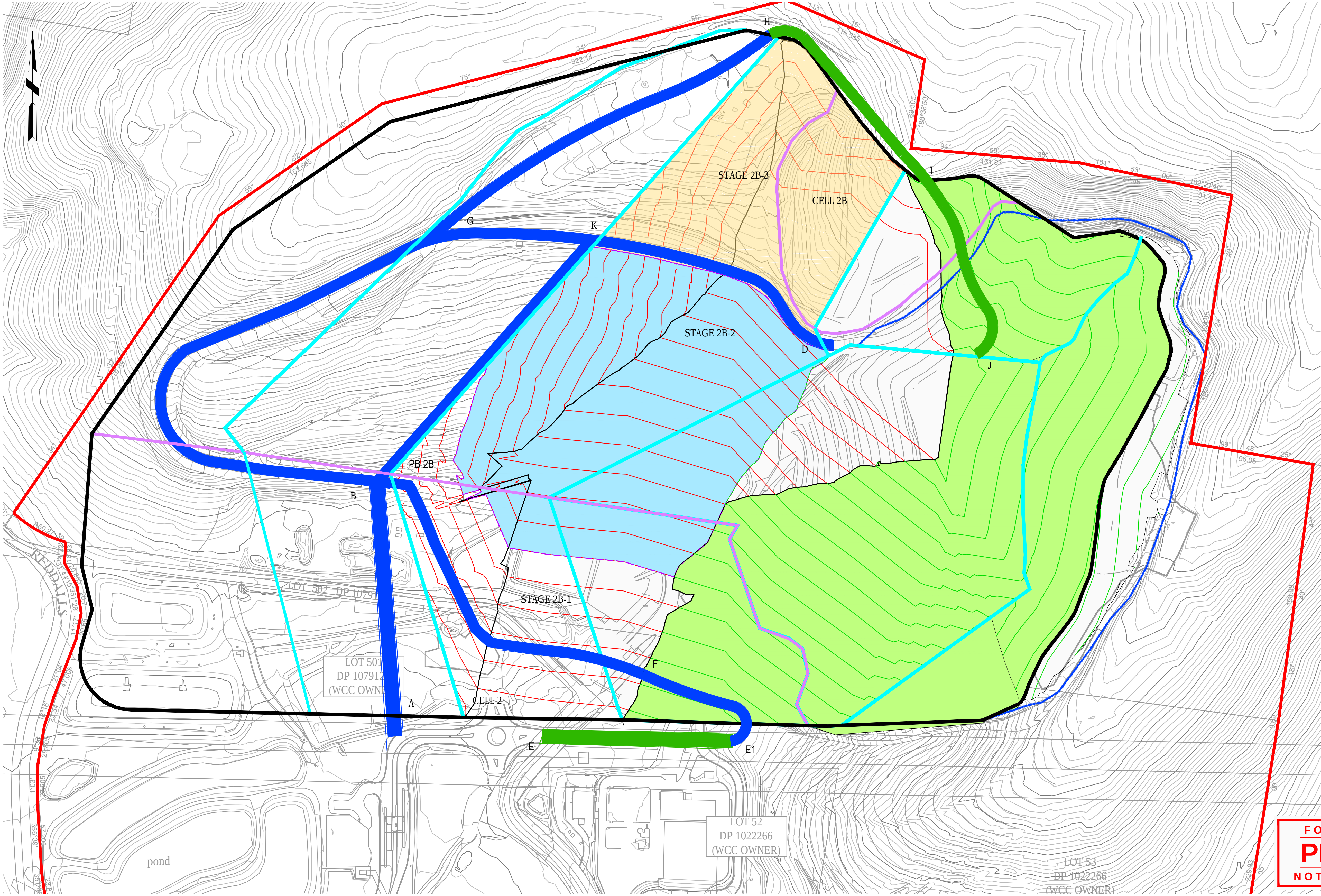
- FILLING
- LINING
- TEMPORARY ROAD
- PERMANENT ROAD
- CAPPING
- END OF STAGE CONTOUR (CURRENT STAGE)
- END OF STAGE CONTOUR (FINISHED STAGES)
- PROPERTY BOUNDARY
- EXTENT OF LANDFORM
- STAGING BOUNDARY
- CELL BOUNDARY
- EXISTING CONTOURS

FOR DISCUSSION ONLY
PRELIMINARY
NOT FOR CONSTRUCTION

1:3,000 — 0 60 120 180m

Golder Associates www.golder.com GOLDER ASSOCIATES PTY. LTD.	CLIENT: WOLLONGONG CITY COUNCIL		PROJECT: PRELIMINARY CONCEPT - WHYTES GULLY LANDFILL	
	DRAWN BY: EJ JEET	DATE: 21 MARCH 2012	DRAWING TITLE: STAGE 2B-1 AND STAGE 2B-2	
	CHECKED BY: R HUYNH	DATE: 21 MARCH 2012		
	SCALE: 1:3,000	SHEET SIZE: A3	PROJECT No: 117625003 · DOC No: 143 · DOC TYPE: R · FIGURE No: F011 · REVISION: 0	FIGURE 5

Plot Date: 27 March 2012 Time:10:33:19 AM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\FIGURES - File Name:117625003-143-R-F011-REV0.dwg
Xref: 117625003-XREF-EXISTING BREAKLINES.dwg; 117625003-XREF-PROPOSED ROADS.dwg; GAP_LOGO-A3.dwg;



LEGEND

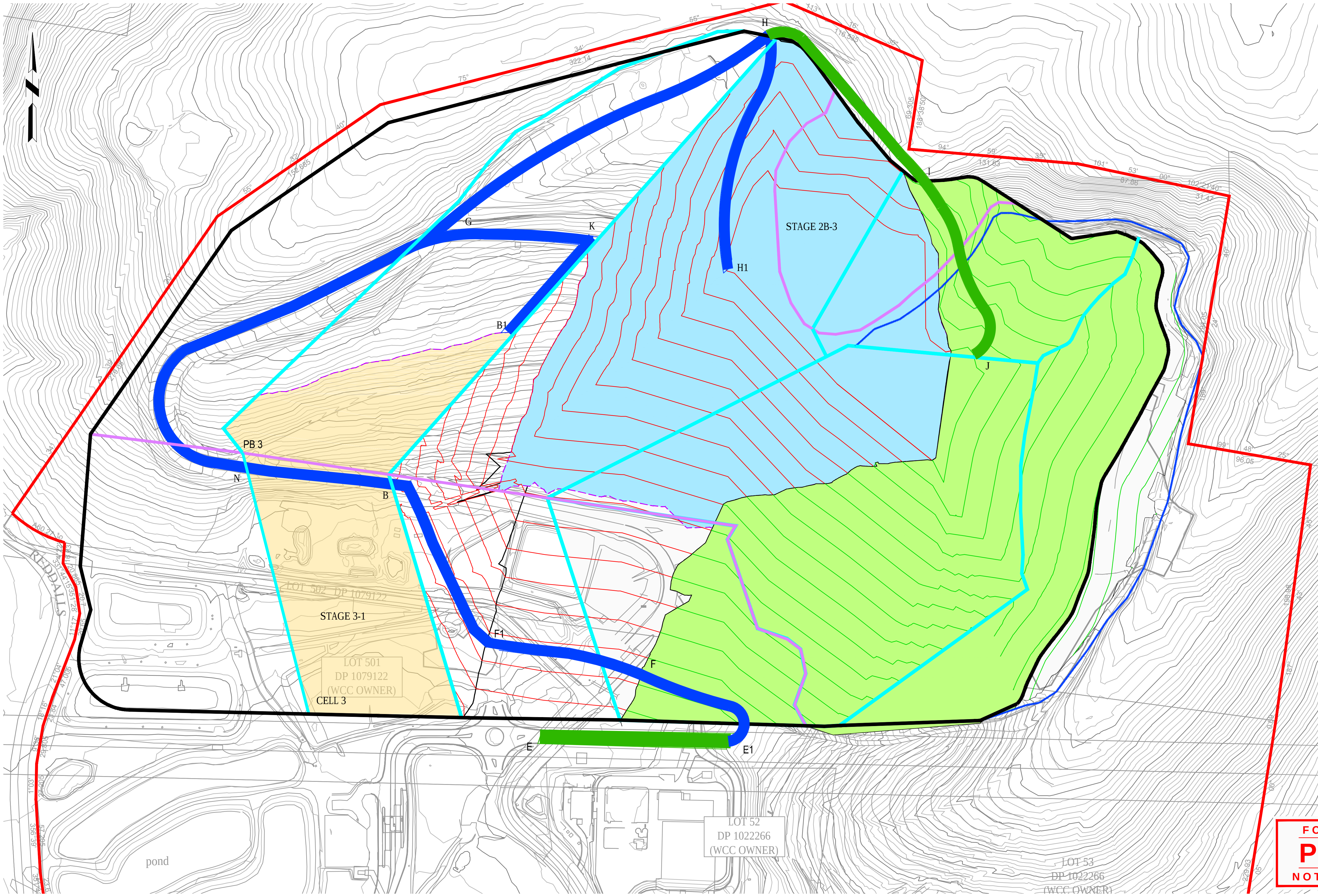
- FILLING
- LINING
- TEMPORARY ROAD
- PERMANENT ROAD
- CAPPING
- END OF STAGE CONTOUR (CURRENT STAGE)
- END OF STAGE CONTOUR (FINISHED STAGES)
- PROPERTY BOUNDARY
- EXTENT OF LANDFORM
- STAGING BOUNDARY
- CELL BOUNDARY
- EXISTING CONTOURS

FOR DISCUSSION ONLY
PRELIMINARY
NOT FOR CONSTRUCTION

1:3,000 — 0 60 120 180m

Golder Associates www.golder.com GOLDER ASSOCIATES PTY. LTD.	CLIENT: WOLLONGONG CITY COUNCIL		PROJECT: PRELIMINARY CONCEPT - WHYTES GULLY LANDFILL			
	DRAWN BY: EJ JEET	DATE: 21 MARCH 2012	DRAWING TITLE: STAGE 2B-2 AND STAGE 2B-3			
	CHECKED BY: R HUYNH	DATE: 21 MARCH 2012				
	SCALE: 1:3,000	SHEET SIZE: A3	PROJECT No: 117625003	DOC No: 143	DOC TYPE: R	FIGURE No: F012 / REVISION: 0 / FIGURE 6

Plot Date: 27 March 2012 Time:10:29:06 AM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\FIGURES - File Name:117625003-143-R-F012-REV0.dwg
Xref: 117625003-XREF-EXISTING BREAKLINES.dwg; 117625003-XREF-PROPOSED ROADS.dwg; GAP_LOGO-A3.dwg;



LEGEND

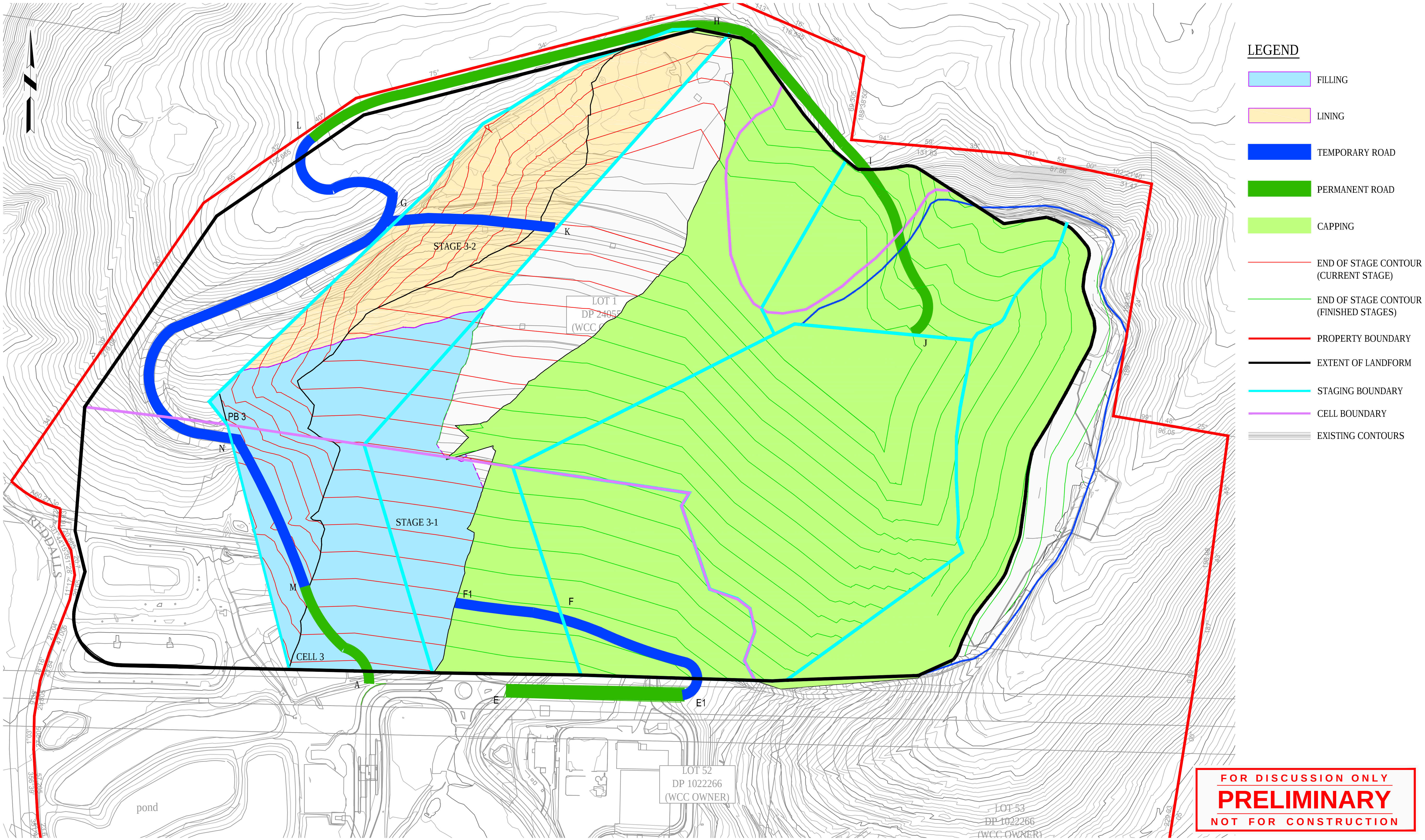
- FILLING
- LINING
- TEMPORARY ROAD
- PERMANENT ROAD
- CAPPING
- END OF STAGE CONTOUR (CURRENT STAGE)
- END OF STAGE CONTOUR (FINISHED STAGES)
- PROPERTY BOUNDARY
- EXTENT OF LANDFORM
- STAGING BOUNDARY
- CELL BOUNDARY
- EXISTING CONTOURS

FOR DISCUSSION ONLY
PRELIMINARY
NOT FOR CONSTRUCTION

1:3,000 — 0, 60, 120, 180m

Golder Associates	CLIENT: WOLLONGONG CITY COUNCIL			PROJECT: PRELIMINARY CONCEPT - WHYTES GULLY LANDFILL				
	DRAWN BY: EJ JEET	DATE: 21 MARCH 2012		DRAWING TITLE: STAGE 2B-3 AND STAGE 3-1				
	CHECKED BY: R HUYNH	DATE: 21 MARCH 2012						
www.golder.com GOLDER ASSOCIATES PTY. LTD.	SCALE: 1:3,000		SHEET SIZE: A3	PROJECT No: 117625003	DOC No: 143	DOC TYPE: R	FIGURE No: F013	REVISION: 0 — FIGURE 7

Plot Date: 27 March 2012 Time:10:29:42 AM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\FIGURES - File Name:117625003-143-R-F013-REV0.dwg
Xref: 117625003-XREF-EXISTING BREAKLINES.dwg; 117625003-XREF-PROPOSED ROADS.dwg; GAP_LOGO-A3.dwg;

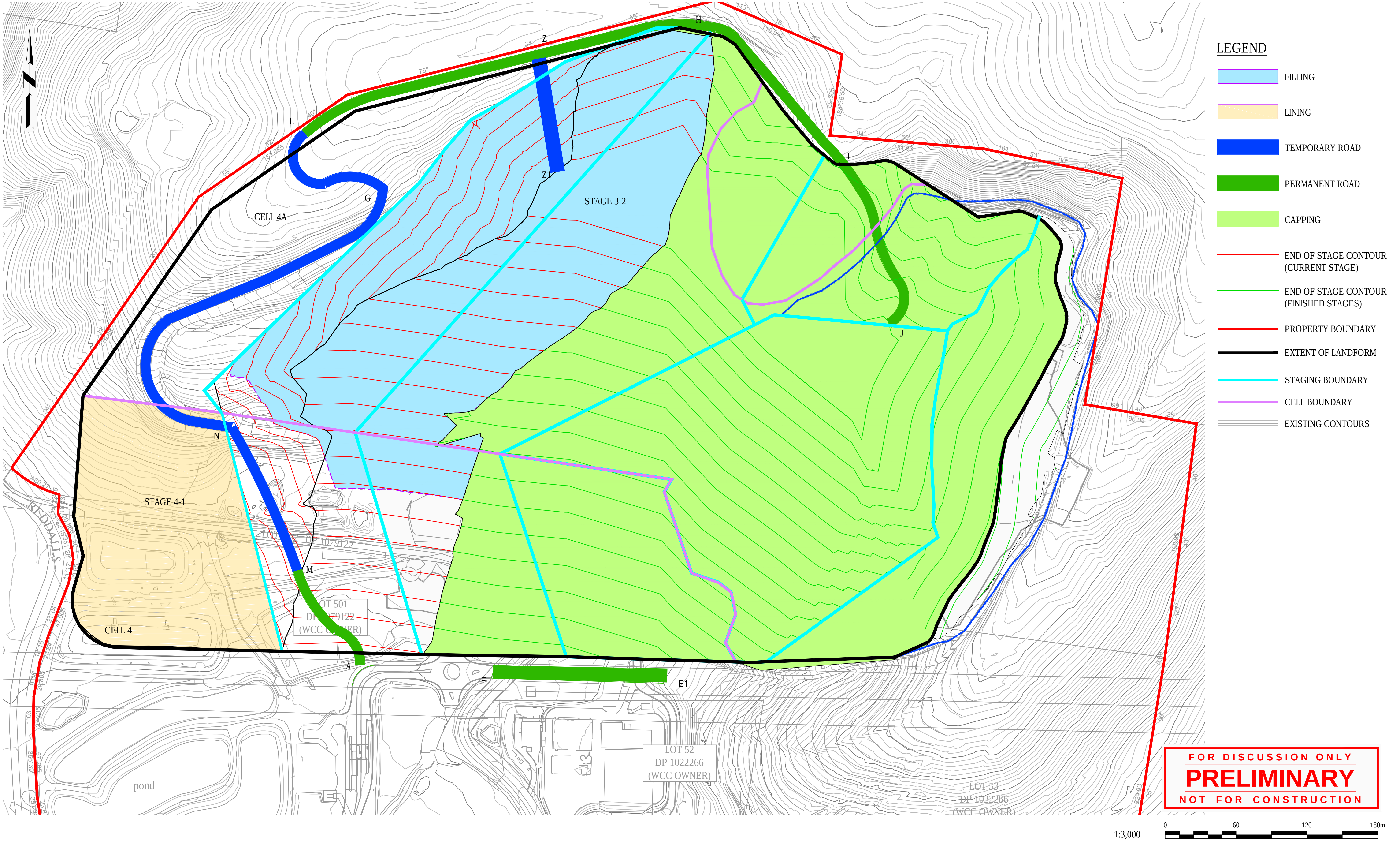


FOR DISCUSSION ONLY
PRELIMINARY
NOT FOR CONSTRUCTION

1:3,000 — 0, 60, 120, 180m

Golder Associates, www.golder.com, GOLDER ASSOCIATES PTY. LTD.	CLIENT: WOLLONGONG CITY COUNCIL		PROJECT: PRELIMINARY CONCEPT - WHYTES GULLY LANDFILL				
	DRAWN BY: EJ JEET	DATE: 21 MARCH 2012	DRAWING TITLE: STAGE 3-1 AND STAGE 3-2				
	CHECKED BY: R HUYNH	DATE: 21 MARCH 2012					
	SCALE: 1:3,000	SHEET SIZE: A3	PROJECT No: 117625003	DOC No: 143	DOC TYPE: R	FIGURE No: F014	REVISION: 0 — FIGURE 8

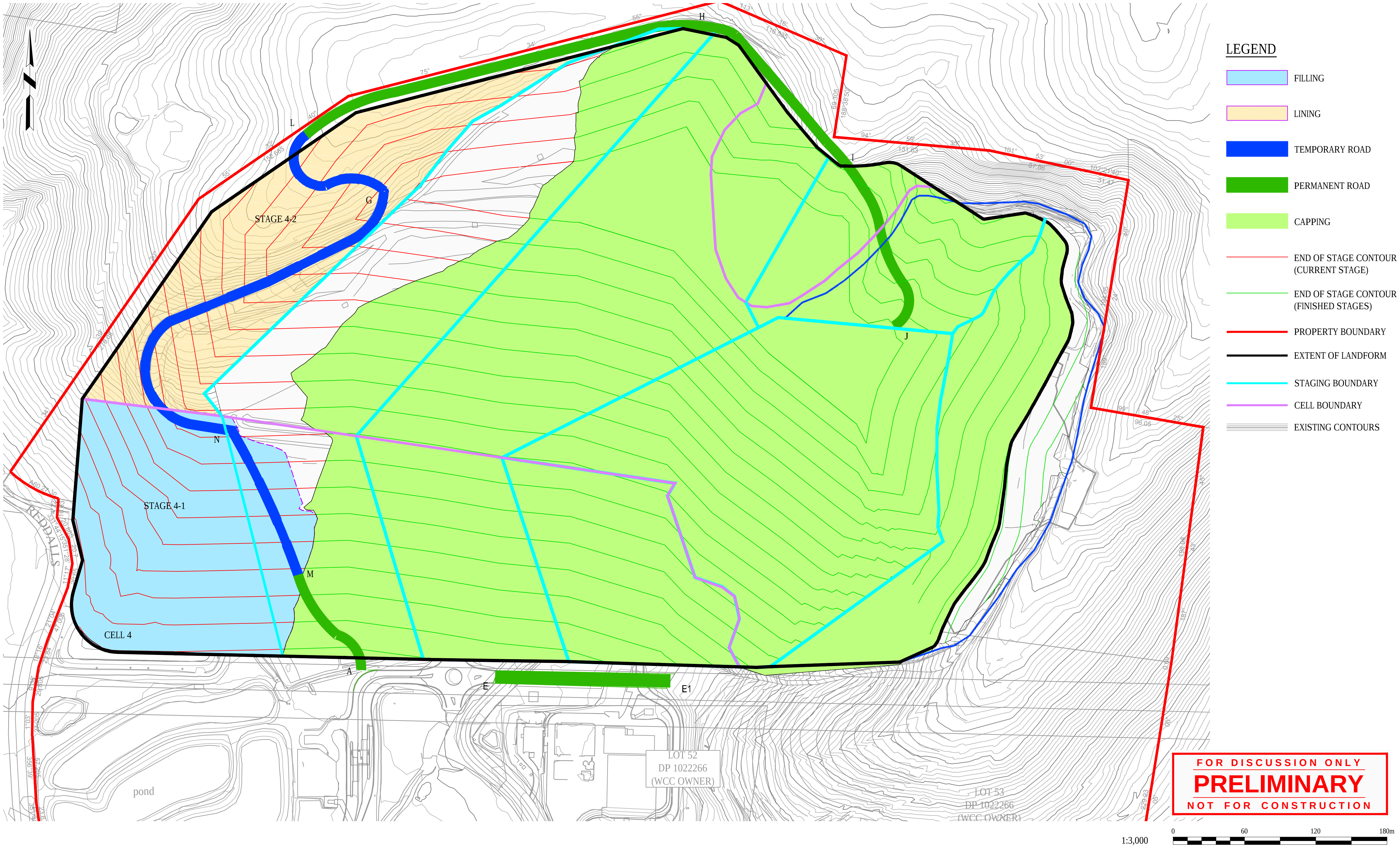
Plot Date: 27 March 2012 Time:10:30:05 AM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\FIGURES - File Name:117625003-143-R-F014-REV0.dwg
Xref: 117625003-XREF-EXISTING BREAKLINES.dwg; GAP_LOGO-A3.dwg;



CLIENT	WOLLONGONG CITY COUNCIL	
PROJECT	PRELIMINARY CONCEPT - WHYTES GULLY LANDFILL	
DRAWN BY	EJ JEET	DATE 21 MARCH 2012
CHECKED BY	R HUYNH	DATE 21 MARCH 2012
DRAWING TITLE	STAGE 3-2 AND STAGE 4-1	
SCALE	1:3,000	SHEET SIZE A3
PROJECT No 117625003	DOC No 143	DOC TYPE R
FIGURE No F015	REVISION 0	FIGURE 9

Golder Associates
www.golder.com
GOLDER ASSOCIATES PTY. LTD.

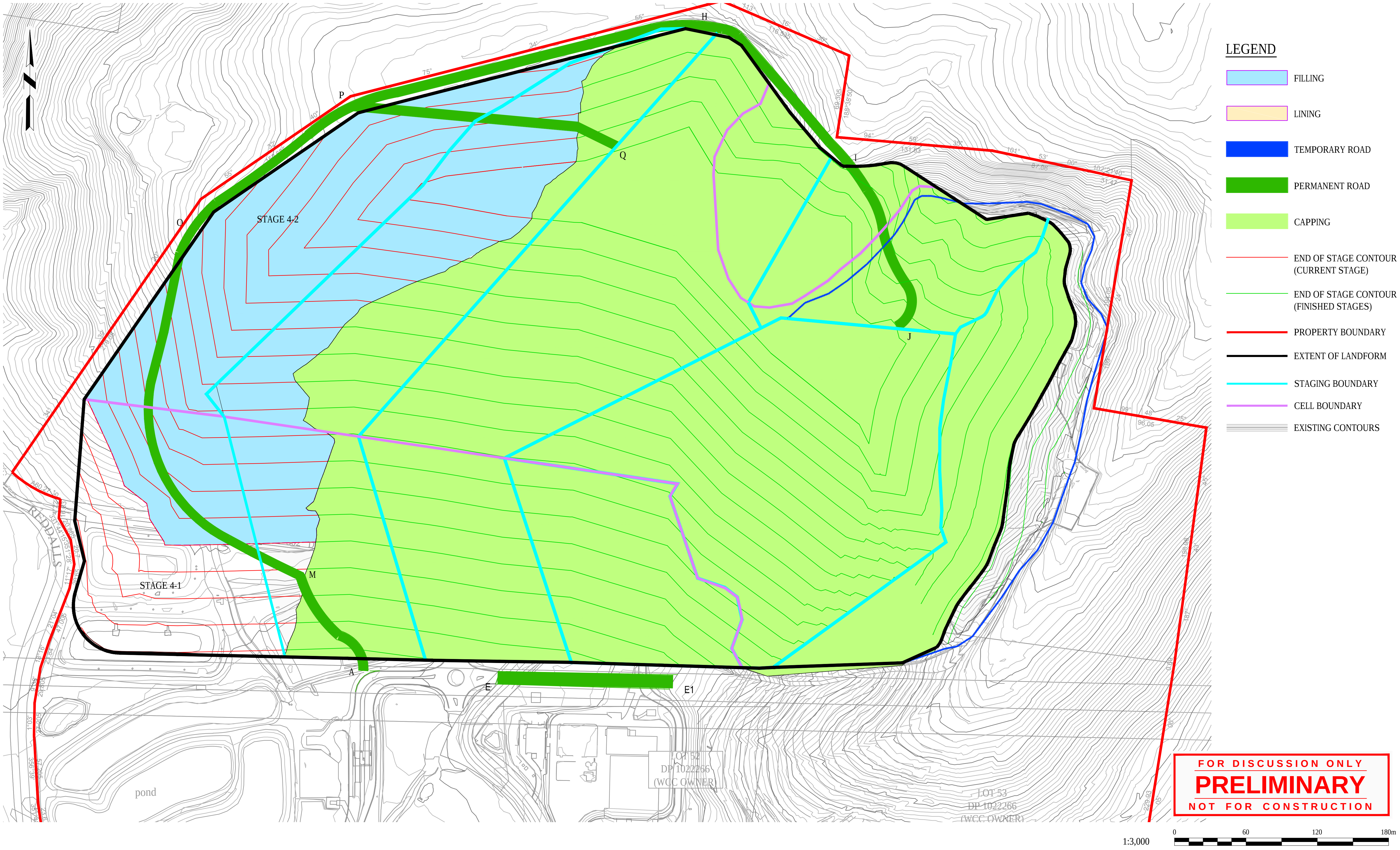
Plot Date: 27 March 2012 Time:10:32:35 AM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\FIGURES - File Name:117625003-143-R-F015-REV0.dwg
Xref: 117625003-XREF-EXISTING BREAKLINES.dwg; 117625003-XREF-PROPOSED ROADS.dwg; GAP_LOGO-A3.dwg;



Golder Associates
www.golder.com
GOLDER ASSOCIATES PTY. LTD.

CLIENT	WOLLONGONG CITY COUNCIL	PROJECT	PRELIMINARY CONCEPT - WHYTES GULLY LANDFILL
DRAWN BY: EJ JEET	DATE: 21 MARCH 2012	DRAWING TITLE	STAGE 4-1 AND STAGE 4-2
CHECKED BY: R HUYNH	DATE: 21 MARCH 2012		
SCALE: 1:3,000	SHEET SIZE: A3	PROJECT No: 117625003 / DOC No: 143 / DOC TYPE: R / FIGURE No: F016 / REVISION: 0	FIGURE 10

Plot Date: 27 March 2012 Time:10:31:46 AM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\FIGURES - File Name:117625003-143-R-F016-REV0.dwg
Xref: 117625003-XREF-EXISTING BREAKLINES.dwg; GAP_LOGO-A3.dwg;



CLIENT		PROJECT				
WOLLONGONG CITY COUNCIL		PRELIMINARY CONCEPT - WHYTES GULLY LANDFILL				
DRAWN BY: EJ JEET	DATE: 21 MARCH 2012	DRAWING TITLE: STAGE 4-2				
CHECKED BY: R HUYNH	DATE: 21 MARCH 2012					
SCALE: 1:3,000	SHEET SIZE: A3	PROJECT No: 117625003	DOC No: 143	DOC TYPE: R	FIGURE No: F017	REVISION: 0

FIGURE 11

Golder Associates
www.golder.com
GOLDER ASSOCIATES PTY. LTD.

Plot Date: 22 March 2012 Time:10:36:02 AM By: Jeet, Elvin Path: K:\Des\2011\117625003 WHYTES GULLY\FIGURES - File Name:117625003-143-R-F017-REV0.dwg
Xref: 117625003-XREF-EXISTING BREAKLINES.dwg; 117625003-XREF-PROPOSED ROADS.dwg; GAP_LOGO-A3.dwg;

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Pty Ltd
124 Pacific Highway
St. Leonards, New South Wales 2065
Australia
T: +61 2 9478 3900

Golder Associates

APPENDIX G

Complaints Register Form

WHYTES GULLY RESOURCE RECOVERY PARK

COMPLAINTS REGISTER

MONTH ………………………………………………………………

SUPERVISOR …………………………………………………..

DATE ……………………………………………………………

DATE	TIME	COMPLAINT	DESCRIPTION	ACTION	RESPONSIBILITY FOR ACTION	DATE FOR ACTION	SIGNATURE	COMMENTS

form number:
date:

Golder Associates

WHYTES GULLY RESOURCE RECOVERY PARK

INCIDENTS REGISTER

MONTH ………………………………………………………………

SUPERVISOR ……………………………………………………..

DATE ……………………………………………………………….

DATE	TIME	INCIDENT	DESCRIPTION	ACTION	RESPONSIBILITY FOR ACTION	DATE FOR ACTION	SIGNATURE	COMMENTS

form number:
date:

Golder Associates

APPENDIX H

Standard Operating Procedures

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF THE WATER TRUCK

Candidate:		Assessor:		Date:
Business Unit:	Assessment: 1 ( ) 2 ( ) 3 ( )		Competent: ( )	Date of Competency:

EVIDENCE OF COMPLIANCE	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
Qualifications Required: (Certifications sighted where appropriate, e.g. Driver's Licence)			
1. Class C Drivers Licence required for street access.			
2. On the Job Training by Bankstown City Council.			

Personal Protective Equipment PPE: Is the follow PPE being used correctly -	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Eye protection (for sun and impact)			
2. Safety boots (steel capped)			
3. Sunscreen (as appropriate)			
4. Hat			
5. Gloves			
6. Long sleeved shirt, trousers, or approved design shorts			

Other Tools & Equipment: Are the following tools and equipment available for use -	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Standard Operating Procedure			
2. First Aid Kit - Type "C"			
3. Stand pipe			

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF THE WATER TRUCK

Pre-use - Have the checks identified by the procedure been performed by the operator prior to use of the unit? Did these include:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Lights and indicators			
2. Hydraulic oil level			
3. Tyre pressure and condition			
4. Radiator coolant level			
5. The mirrors			
6. The horn operates			
7. Fuel and oil level			
8. Brakes and brake lights are working - forward and reverse.			
9. Steering - forward and reverse.			

Start-up - Has the operator performed start-up as per the procedure? Did this include:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Getting into the vehicle safely			
2. Starting the engine properly			
3. Adjusting the seat correctly			
4. Using the seat belt			
5. Being able to explain why the seat must be adjusted and the site speed limit must be observed			
6. Switching on the amber rotating beacon.			

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF THE WATER TRUCK

Operation - Is the operator operating the unit as per the procedure? Did this include:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Does the operator understand his responsibilities when operating?			
2. Does the operator understand the responsibilities of the team leader?			
3. Does the operator watch out for pedestrians?			
4. Does the operator abide by the speed limits?			
5. Does the operator start the water pump motor properly?			
6. Does the operator wet down the required areas?			
7. Does the operator wind up the windows of the vehicle if the water tank is empty?			
8. Does the operator use correct manual handling techniques?			
9. Does the operator park close to the hydrant when filling?			
10. Does the operator fit the stand pipe to the hydrant?			
11. Does the operator fill the tank?			
12. Does the operator stop filling when it is indicated?			
13. Can the operator explain the reasons for the above steps?			

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF THE WATER TRUCK

Close down	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Does the operator watch for pedestrians and comply with site speed limits?			
2. Does the operator drive to the compound?			
3. Does the operator leave the engine to idle for approximately 2 minutes?			
4. Does the operator turn off the engine and remove the key?			
5. Does the operator exit the cabin safely?			
6. Does the operator lock the cabin?			
7. Does the operator drain the air tank, keeping clear of the valve?			
8. Does the operator place the keys in a secure location?			
9. Can the operator explain the above steps?			

End of Job:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Did the operator explain cleaning in a competent manner?			
2. Did the operator lubricate all grease nipples?			
3. Did the operator refuel safely?			
4. Can the operator explain who to report faults and problems to?			

Emergency:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Is the operator aware of what actions to take during an emergency?			
2. Is the operator aware of how to stop the unit during an emergency?			
3. Is the operator aware of the types of emergency likely to occur?			

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF THE WATER TRUCK

Environmental Management	**COMPETENT**	**NOT YET COMPETENT**	**NOT ASSESSED**
1. Is the operator aware of how to obtain the Spill Kits?			
2. Has the operator been trained to manage spills?			
3. Did the operator know how to dispose of all wastes properly?			
4. Has all plant and equipment been operated with environmental control mechanisms in place? Eg. Noise/dust suppression devices.			
5. Was cleaning and maintenance carried out without causing pollution of the environment? Eg. Cleaned in the designated area away from stormwater system.			
6. Were chemicals, oils, and fuels handled, stored, and transported correctly to avoid pollution of the environment?			
7. Was the plant and equipment operated so as to avoid excessive dust and noise?			

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF THE WATER TRUCK

Additional Comments/Actions:

....

....

....

....

....

....

....

....

....

Date Actions met:..

Signed: Assessor: .... Date: .... Assessment 1

Candidate:..

Assessor: .... Date: .... Assessment 2

Candidate:..

Assessor: .... Date: .... Assessment 3

Candidate:..

*Note: The candidate is signing that the feedback took place and not that they are in agreement with the decision.

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF A BULLDOZER

Candidate:		Assessor:	Date:
Business Unit:	Assessment: 1 ( ) 2 ( ) 3 ( )	Competent: ( )	Date of Competency:

EVIDENCE OF COMPLIANCE	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
Qualifications Required: (Certifications sighted where appropriate, e.g. Driver's Licence)			
1. On the Job Training by Bankstown City Council.			

Personal Protective Equipment PPE: Is the follow PPE being used correctly -	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Hearing protection (ear muffs)			
2. Eye protection (for sun and impact)			
3. Safety boots (steel capped)			
4. Sunscreen			
5. Hat - wide brim			
6. Gloves			
7. Long sleeved shirt and trousers or shorts of approved design			

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF A BULLDOZER

Other Tools & Equipment: Are the following tools and equipment available for use -	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Standard Operating Procedure			
2. First Aid Kit - Type "C"			
3. "Spud" bar			
4. Small spade			
5. Grease gun			

Pre-use - Have the checks identified by the procedure been performed by the operator prior to use of the unit? Did these include:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Lights and indicators			
2. Hydraulic oil level			
3. Radiator coolant level			
4. Fuel level			
5. Brakes and brake lights are working - forward and reverse.			
6. Steering - forward and reverse.			

Start-up - Has the operator performed start-up as per the procedure? Did this include:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Getting into the bulldozer			
2. Starting the engine properly			
3. Adjusting the seat correctly			
4. Using the seat belt			
5. Understanding why the seat must be adjusted and the 40kph speed limit must be observed			

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF A BULLDOZER

Operation - Is the operator operating the unit as per the procedure? Did this include:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Understanding his responsibilities when operating			
2. Understanding the responsibilities of the team leader			
3. When covering garbage, looking out for any pedestrians			
4. When covering garbage, explaining the dangers posed by large obstacles or contamination and what to do about them			
5. When building cell walls, keeping the mound to the set maximum dimensions			
6. When building cell walls, create a cell at maximum 3m x 4m			
7. When building cell walls, keeping clear of reversing soil trucks			
8. When building cell walls, properly compact cells and remove large objects			

Close down - Did the operator:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Park the bulldozer correctly			
2. Watch out for pedestrians			
3. Allow the engine to idle for 2 minutes before switching off			
4. Remove the key and operate isolation switch			
5. Get off bulldozer safely			
6. Lock up the shed			
7. Explain the reason for the above actions			

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF A BULLDOZER

End of Job - Did the operator:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Clean the bulldozer in a competent manner			
2. Lubricate all the grease nipples			
3. Use caution when removing the radiator cap			
4. Wash down the radiator			
5. Clean the tracks with the "Spud" bar and spade at the tip			
6. Use the correct manual handling techniques			
7. Refuel correctly			
8. Explain who to report faults and problems to			

Emergency:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Is the operator aware of what actions to take during an emergency?			
2. Is the operator aware of how to stop the unit during an emergency?			
3. Is the operator aware of the types of emergency likely to occur?			

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF A BULLDOZER

Environmental Management	**COMPETENT**	**NOT YET COMPETENT**	**NOT ASSESSED**
1. Is the operator aware of where to find the Spill Kits?			
2. Has the operator been trained to manage spills?			
3. Did the operator know how to dispose of all wastes properly?			
4. Has all plant and equipment been operated with environmental control mechanisms in place? Eg. Noise/dust suppression devices.			
5. Was cleaning and maintenance carried out without causing pollution of the environment? Eg. Cleaned in the designated area away from stormwater system.			
6. Were chemicals, oils, and fuels handled, stored, and transported correctly to avoid pollution of the environment?			
7. Was the plant and equipment operated so as to avoid excessive dust and noise?			

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF A BULLDOZER

Additional Comments/Actions:

....

....

....

....

....

....

....

....

....

Date Actions met:...

Signed: Assessor: .... Date: .... Assessment 1

Candidate:..

Assessor: .... Date: .... Assessment 2

Candidate:..

Assessor: .... Date: .... Assessment 3

Candidate:..

*Note: The candidate is signing that the feedback took place and not that they are in agreement with the decision.

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF A WASTE TIP TRUCK

Candidate:		Assessor:		Date:
Business Unit:	Assessment: 1 ( ) 2 ( ) 3 ( )		Competent: ( )	Date of Competency:

EVIDENCE OF COMPLIANCE	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
Qualifications Required: (Certifications sighted where appropriate, e.g. Driver's Licence)			
1. Class C Drivers Licence required for street access.			
2. On the Job Training by Bankstown City Council.			

Personal Protective Equipment PPE: Is the follow PPE being used correctly -	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Safety boots (steel capped)			
2. Sunscreen (when working outside the cabin)			
3. Hat - wide brim (when working outside the cabin)			
4. Gloves (when required)			
5. Long sleeved shirt and trousers or shorts of approved design			

Other Tools & Equipment: Are the following tools and equipment available for use -	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Standard Operating Procedure			
2. First Aid Kit - Type "C"			
3. Standard tool kit			

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF A WASTE TIP TRUCK

Pre-use - Have the checks identified by the procedure been performed by the operator prior to use of the unit? Did these include:	**COMPETENT**	**NOT YET COMPETENT**	**NOT ASSESSED**
1. Lights and indicators			
2. Hydraulic oil level			
3. Tyre pressure and condition			
4. Radiator coolant level			
5. The mirrors			
6. The horn operates			
7. Fuel level			
8. Brakes and brake lights are working - forward and reverse.			
9. Steering - forward and reverse.			
10. Reversing beeper			

Start-up - Has the operator performed start-up as per the procedure? Did this include:	**COMPETENT**	**NOT YET COMPETENT**	**NOT ASSESSED**
1. Getting into the vehicle safely			
2. Starting the engine properly			
3. Understanding the reason for waiting for the buzzer to stop and what to do if it doesn't			
4. Adjusting the seat correctly			
5. Using the seat belt			
6. Understanding why the seat must be adjusted			
7. Observing the speed limit			

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF A WASTE TIP TRUCK

Operation - Is the operator operating the unit as per the procedure? Did this include:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Does the operator understand his responsibilities when operating?			
2. Does the operator understand the responsibilities of the team leader?			
3. Does the operator understand the need to limit to 4 the number of scoops of the front end loader so as not to overload the tray?			
4. Does the operator check that all persons are clear before reversing or driving off?			
5. Does the operator understand and demonstrate the correct sequence of PTO disengagement and use of the cabin lever to raise the tray?			
6. Does the operator disengage the PTO before attempting to move forward and empty the tray?			
7. Does the operator lower the tray properly?			

Close down	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Does the operator park in the correct location and use the handbrake?			
2. Does the operator allow the engine to idle for 2 minutes before switching off?			
3. Does the operator remove the key after locking the vehicle?			
4. Does the operator use the handles to exit the vehicle?			
5. Does the operator place the key in secure stowage?			

End of Job:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Does the operator refuel the vehicle properly?			
2. Does the operator know who to report faults and problems to?			

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF A WASTE TIP TRUCK

Emergency:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Is the operator aware of what actions to take with regard to the vehicle during an emergency?			
2. Is the operator aware of how to stop the unit during an emergency?			
3. Is the operator aware of the types of emergency likely to occur?			

Environmental Management	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Is the operator aware of where to find the Spill Kits?			
2. Has the operator been trained to manage spills?			
3. Did the operator know how to dispose of all wastes properly?			
4. Has all plant and equipment been operated with environmental control mechanisms in place? Eg. Noise/dust suppression devices.			
5. Was cleaning and maintenance carried out without causing pollution of the environment? Eg. Cleaned in the designated area away from stormwater system.			
6. Were chemicals, oils, and fuels handled, stored, and transported correctly to avoid pollution of the environment?			
7. Was the plant and equipment operated so as to avoid excessive dust and noise?			

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF A WASTE TIP TRUCK

Additional Comments/Actions:

....

....

....

....

....

....

....

....

....

Date Actions met:..

Signed: Assessor: .... Date: .... Assessment 1

Candidate:...

Assessor: .... Date: .... Assessment 2

Candidate:...

Assessor: .... Date: .... Assessment 3

Candidate:...

*Note: The candidate is signing that the feedback took place and not that they are in agreement with the decision.

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF A FRONT END LOADER

Candidate:	Assessor:		Date:
Business Unit:	Assessment: 1 ( ) 2 ( ) 3 ( )	Competent: ( )	Date of Competency:

EVIDENCE OF COMPLIANCE	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
Qualifications Required: (Certifications sighted where appropriate, e.g. Driver's Licence)			
1. National Certificate of Competency Class LB - Front End Loader/Back Hoe			
2. Class C Drivers Licence required for street access.			
3. On the Job Training by Bankstown City Council.			

Personal Protective Equipment PPE: Is the follow PPE being used correctly -	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Eye protection (for sun and impact)			
2. Safety boots (steel capped)			
3. Sunscreen (when working outside the cabin)			
4. Hat - wide brim (when working outside the cabin)			
5. Gloves where required			
6. Long sleeved shirt and trousers or approved design shorts			

Other Tools & Equipment: Are the following tools and equipment available for use -	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Standard Operating Procedure			
2. First Aid Kit - Type "C"			
3. Standard tool kit			
4. Grease			

5. Stilson spanner (adjustable)			

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF A FRONT END LOADER

Pre-use - Have the checks identified by the procedure been performed by the operator prior to use of the unit? Did these include:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Lights and indicators			
2. Hydraulic oil level			
3. Tyre pressure and condition			
4. Radiator coolant level			
5. The mirrors			
6. The horn operates			
7. Fuel level			
8. Brakes and brake lights are working - forward and reverse.			
9. Application of grease to the self greaser of the vehicle			
10. Reversing beeper working			
11. Steering - forward and reverse			

Start-up - Has the operator performed start-up as per the procedure? Did this include:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Getting into the vehicle safely			
2. Starting the engine properly			
3. Adjusting the seat correctly			
4. Using the seat belt			
5. Understanding why the seat must be adjusted and the 40 kph speed limit must be observed			

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF A FRONT END LOADER

Operation - Is the operator operating the unit as per the procedure? Did this include:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Understanding his responsibilities when operating			
2. Understanding the responsibilities of the team leader			
3. Lifting the load with the bucket			
4. "Crowding" the bucket correctly			
5. Looking for pedestrians or other vehicles before reversing or driving off			
6. Emptying the bucket			
7. Using the bucket at the correct angle (45 degrees) and profile (teeth down) to spread out the waste			
8. Explaining why the bucket is always to be left lowered onto the ground when the machine is unattended or stationary			

Close down	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Did the operator park in the correct place?			
2. Did the operator allow the engine to idle for 2 minutes before switching off?			
3. Did the operator lower the bucket with teeth down before switching the engine off?			
3. Did the operator exit the vehicle in a safe manner?			
4. Did the operator remove the key and leave it in the secure location?			
5. Did the operator explain the reasons for the above actions?			

End of Job:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Did the operator clean the vehicle in a competent manner?			
2. Did the operator refuel the vehicle safely?			
3. Did the operator know who to report faults and problems to?			

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF A FRONT END LOADER

Emergency:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Is the operator aware of what actions to take during an emergency?			
2. Is the operator aware of how to stop the unit during an emergency?			
3. Is the operator aware of the types of emergency likely to occur?			

Environmental Management	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Is the operator aware of where to find the Spill Kits?			
2. Has the operator been trained to manage spills?			
3. Did the operator know how to dispose of all wastes properly?			
4. Has all plant and equipment been operated with environmental control mechanisms in place? Eg. Noise/dust suppression devices.			
5. Was cleaning and maintenance carried out without causing pollution of the environment? Eg. Cleaned in the designated area away from stormwater system.			
6. Were chemicals, oils, and fuels handled, stored, and transported correctly to avoid pollution of the environment?			
7. Was the plant and equipment operated so as to avoid excessive dust and noise?			

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF A FRONT END LOADER

Additional Comments/Actions:

....

....

....

....

....

....

....

....

....

Date Actions met:..

Signed: Assessor: .... Date: .... Assessment 1

Candidate:...

Assessor: .... Date: .... Assessment 2

Candidate:...

Assessor: .... Date: .... Assessment 3

Candidate:...

*Note: The candidate is signing that the feedback took place and not that they are in agreement with the decision.

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF A COMPACTOR

Candidate:	Assessor:		Date:
Business Unit:	Assessment: 1 ( ) 2 ( ) 3 ( )	Competent: ( )	Date of Competency:

EVIDENCE OF COMPLIANCE	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
Qualifications Required: (Certifications sighted where appropriate, e.g. Driver's Licence)			
1. On the Job Training by Bankstown City Council.			

Personal Protective Equipment PPE: Is the follow PPE being used correctly -	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Eye protection (for sun and impact)			
2. Safety boots (steel capped)			
3. Sunscreen (when working outside the cabin)			
4. Hat - wide brim (when working outside the cabin)			
5. Gloves (when required)			
6. Long sleeved shirt and trousers or shorts of approved design			

Other Tools & Equipment: Are the following tools and equipment available for use -	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Standard Operating Procedure			
2. First Aid Kit - Type "C"			
3. Standard tool kit			
4. Grease gun			

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF A COMPACTOR

Pre-use - Have the checks identified by the procedure been performed by the operator prior to use of the unit? Did these include:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Lights and indicators			
2. Hydraulic oil level			
3. Radiator coolant level			
4. The mirrors			
5. The horn operates			
6. Fuel level			
7. Brakes and brake lights are working - forward and reverse.			
8. Steering - forward and reverse.			

Start-up - Has the operator performed start-up as per the procedure? Did this include:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Getting into the vehicle safely			
2. Explaining the self diagnostic action of the vehicle on start up and what to do if the buzzer and light do not switch off after 20 seconds			
3. Starting the engine properly			
4. Adjusting the seat correctly			
5. Using the seat belt			
6. Understanding why the seat must be adjusted			
7. Switching on the amber rotating beacon			
8. Lifting the blade			
9. Looking out for any persons when driving off			

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF A COMPACTOR

Operation - Is the operator operating the unit as per the procedure? Did this include:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Understanding his responsibilities when operating			
2. Understanding the responsibilities of the team leader			
3. Using the blade to correctly spread the rubbish			
4. Compacting rubbish correctly			
5. Explaining the dangers posed by pipes/timber and how to deal with them			

Close down - Did the operator:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Park the vehicle nose into the shed			
2. Lower the blade to the floor			
3. Allow the engine to idle for 2 minutes			
4. Switch off the engine and remove the key			
5. Lock the cabin and exit safely			
6. Turn off the "Kill Switch"			
7. Put the key in a secure location			
8. Lock the shed gates			
9. Explain the reason for the above activities			

End of Job - Did the operator:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Explain the cleaning of the backhoe in a competent manner			
2. Lubricate all the grease nipples			
3. Demonstrate correct refuelling techniques			
4. Explain who to report faults and problems to			

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF A COMPACTOR

Emergency:	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Is the operator aware of what actions to take during an emergency?			
2. Is the operator aware of how to stop the unit during an emergency?			
3. Is the operator aware of the types of emergency likely to occur?			

Environmental Management	COMPETENT	NOT YET COMPETENT	NOT ASSESSED
1. Is the operator aware of where to find the Spill Kits?			
2. Has the operator been trained to manage spills?			
3. Did the operator know how to dispose of all wastes properly?			
4. Has all plant and equipment been operated with environmental control mechanisms in place? Eg. Noise/dust suppression devices.			
5. Was cleaning and maintenance carried out without causing pollution of the environment? Eg. Cleaned in the designated area away from stormwater system.			
6. Were chemicals, oils, and fuels handled, stored, and transported correctly to avoid pollution of the environment?			
7. Was the plant and equipment operated so as to avoid excessive dust and noise?			

STANDARD ASSESSMENT CHECKLIST FOR THE OPERATION & USE OF A COMPACTOR

Additional Comments/Actions:

....

....

....

....

....

....

....

....

....

Date Actions met:..

Signed: Assessor: .... Date: .... Assessment 1

Candidate:...

Assessor: .... Date: .... Assessment 2

Candidate:...

Assessor: .... Date: .... Assessment 3

Candidate:...

*Note: The candidate is signing that the feedback took place and not that they are in agreement with the decision.

WOLLONGONG
City of Innovation

WOLLONGONG CITY COUNCIL
EMPLOYEE CONTRACTOR LEACHATE POND INDUCTION

EMPLOYEE/CONTRACTOR

NAME________________________

ρ ☐ Site Layout

ρ ☐ Overview of Operations

ρ ☐ Site Access / Parking

ρ ☐ Site Specific Hazards

ρ ☐ Advise of location of underground services (power & leachate)

ρ ☐ Advise leachate valve pit as confined space.

ρ ☐ Advise of leachate pond liner hazard. (no operations without harness and safety line)

ρ ☐ Equipment operations

ρ ☐ Personal Protective Equipment

ρ ☐ Vehicle Movement

ρ ☐ Environmental Requirements

ρ ☐ Advise electrical and securing cable disconnection only, to be undertaken from pontoon.

ρ

Employee Signature____________________________________ Date__________________

Inductor Signature_____________________________________ Date__________________

INDUCTION FOR CONTRACTORS WORKING AT

WHYTES GULLY WASTE DISPOSAL DEPOT

TABLE OF CONTENTS

WHYTES GULLY WASTE DISPOSAL DEPOT
CONTRACTOR INDUCTION MANUAL

1. INTRODUCTION

Welcome to Whytes Gully Waste Disposal Depot. Any contract you enter into with us requires you and your employees and subcontractors to act according to this document.

Companies, and the contractors they employ, are legally responsible for ensuring the health and safety of all employees on-site. In many cases a company may also be held responsible for the safety of a contractor's employee working on a company site.

The impact of operations on others, eg., members of the public and even trespassers, must also be taken into account.

2. OCCUPATIONAL HEALTH AND SAFETY

Every employer shall ensure the health, safety and welfare at work of all employees. Health and safety legislation sets down strict health and safety duties on all people within the workplace including contractors. We expect you to know what these requirements are and to carry them out. We include here, as a reminder, a brief summary of the main provisions relating to contractors. (The term "safety" as used in this document incorporates "health and safety".) Your duties as a contractor under the Occupational Health and Safety Act are summarised as follows:

- To provide your employees and subcontractors with a safe place of work.
- To provide your employees and subcontractors with safe work systems.
- To provide your employees and subcontractors with safety training.
- To ensure that your employees and subcontractors use the safety equipment required.
- To provide your employees and subcontractors safety information, instruction, training, and supervision.

Your employees and subcontractors responsibilities under the Occupational Health and Safety Act are summarised as follows:

- To co-operate with your managers on health and safety matters.
- To use the safety equipment you provide.
- To correct or report unsafe situations to you.
- To report incidents and injuries to you.
- To follow safety rules and safe operating procedures agreed upon as follows.

WorkCover penalties apply to breaches of the OH&S Act.
For further information please refer to the OH&S Act, Section 19.

3. BEHAVIOUR FOR CONTRACTORS

- Report any hazard that is beyond your control (eg., a change to the original job that has introduced new unexpected danger).

- Use the correct safety equipment and protective clothing for the job (eg., welding screens, breathing protection, eye protection, hearing protection, foot protection, tags, flashing lights, guards, electrical earth leakage devices, fire equipment, fall restraints, etc.).

- Obey rules, signs, and instructions and only use equipment that you are authorised to use (obey signposts and warning notices; obtain work permits for jobs with special risks; comply with special rules developed for specific work areas).

- Use safe lifting tactics with easy loads, and get help or mechanical assistance for heavy loads (use fork lift trucks, cranes and hoists rather than manual handling).

- Know our emergency procedures (find out what to do in the event of a substance leak, fire, or other possible emergency; learn where the emergency shower and eyewash stations are; learn where the evacuation control point is; know how to raise the emergency alarm and how to telephone for help).

- Ask if you are in doubt about any health or safety procedure .

4. ADMINISTRATIVE PROCEDURES

- Contractors are to sign on and off at the Weighbridge Office or agreed location and shall provide the company name, time of start and finish. They must inform the Whytes Gully Waste Disposal Depot (WGWDD) Leading Hand (or nominee) of their location of work so they can be contacted in the event of an emergency or evacuation.

- Contractors will be issued a contractor / visitors identification card which is to be worn at all times whilst on site.

- A service report shall be submitted to the WGWDD Leading Hand or nominated officer on completion of work. Failure to comply with this requirement may result in payment being withheld and contractors contract being reviewed.

- Contractors are to be aware that noise restrictions may apply due to waste depot's activities.

5. EVACUATION OF PREMISES

WGWDD aims to maintain its premises in a safe condition and without risk to health and to provide a safe means of access or egress. In the event that an emergency situation occurs, emergency procedures are to be maintained to ensure that all staff, customers and visitors (including contractors) act efficiently and safely. Contractors shall take directions off the WGWDD Leading Hand (or nominee) in the event of an evacuation. Contractors should turn off all machinery and ensure hazards are isolated before evacuating the site.

Contractors working on site shall pick up a copy of the evacuation plan for the WGWDD and make themselves familiar with the site.

Contractors shall ensure all access ways are kept clear at all times.

6. SECURITY OF PREMISES

All contractors are responsible for securing their place of work to areas that have been unlocked or opened for their benefit.

7. ELECTRICAL SAFETY

Contractors are to comply with industry standards regarding the tagging of plant and equipment, and electrical installations by using the **"Danger Tag"** to eliminate the risk to employees while working on plant and equipment and the **"Out Of Service Tag"** to identify the defective or damaged equipment.

- Contractors are to comply with the WorkCover Regulations for the testing and tagging of electrical appliances and leads, ie., all electrical tools and leads must be regularly inspected by a licensed electrician.

- All electrical installations shall comply with the SAA Wiring Rules.

- Always make sure your site is protected by an earth leakage device.

- All electrical work shall be carried out by a licensed electrician.

- All fittings to an extension cord to be either non re-wirable (moulded) or transparent. Extension cords must be supported above any work area and passageway to provide clear access for personnel and vehicles, and to prevent damage to them.

- Extension cord to be heavy duty according to AS 3199.

- Double adapters and "piggy back" connections shall not be used.

8. SMOKING

Wollongong City Council has a policy that does not allow smoking inside any buildings under Council's care and control.

9. NOTIFICATION OF ACCIDENTS AND FIRST AID

- If you are injured on site you must report any incident, near miss or hazard to the WGWDD Leading Hand (or nominee) as soon as possible. The Accident/Incident report form shall be used to record all injuries and work related illnesses experienced by all staff, customers and visitors (this includes contractors). In some situations, an internal investigation into an accident will be carried out by the contractor and/or Council, for the purpose of taking preventative action. A copy of the report is to be provided to Council at the conclusion of the investigation

10. PERSONAL PROTECTION

- Approved hearing / eye protection to be worn at all designated areas where appropriate safety signs are displayed and when operating any machinery, eg., angle grinders, power saws, lawn mowers, edge trimmers, etc.

- Approved safety footwear must be worn by contractors at all times.

- Hard hats must be worn at all times in areas designated as a “construction site”.

- In dusty conditions, wear an approved dust mask or respirator.

11. BARRICADES / SCAFFOLDING

- Contractors are to ensure workers and the general public are protected on, or adjacent to, construction sites by the effective use of barricades, temporary fencing, and overhead protection.

- When working on or at 1.8 metres of height, contractors are to ensure all work is performed in accordance with the WorkCover Code of Practice for safe work on roofs.

- Ladders must be in good condition, free from splits, or broken or loose rungs.

- When constructing scaffolding, ensure foundations are adequate to take the load.

- Scaffolding must be tied to the building every 3.6 metres (maximum) of height and length and adequately braced in all directions.

- Ensure handrails and kickplates are provided on all working platforms and provide safe access to all working platforms more than two metres high.

- Mobile scaffolds should have lockable castor wheels, which must be locked when the scaffold is in use.

- Ensure metal scaffolding is at least 4.6 metres from bare electrical conductors.

12. TRENCHES AND EXCAVATIONS

When working with trenches and excavations the following precautions should be taken:

- Check with appropriate authority the location of underground services.

- Provide and secure a suitable barrier or guardrails around any excavation.

- If a worker is required to be in a trench greater than 1.5 metres (less in unstable ground) the sides of the trench must be shored according to WorkCover requirements.

13. HARASSMENT

The WGWDD has policies on the prevention of harassment. The policy aims to encourage a harassment free environment for staff, customers and visitors. The policy covers all forms of harassment, including sex-based, racial, disabilities, and marital status. All staff and contractors have a general responsibility to maintain acceptable standards of conduct and promote a harassment free environment. Harassment is a breach of proper standards of conduct and professional behaviour and in extreme cases may constitute a criminal offence under Federal and NSW legislation.

14. HAZARDOUS SUBSTANCES

Contractors shall comply with the Occupational, Health and Safety (Hazardous Substances) Regulation 1996. The object of this regulation is to minimise the risks to health due to exposure to hazardous substances in places of work. This regulation includes the following:

- ensuring that hazardous substances are correctly labelled, material safety data sheets are maintained, and substances are correctly stored.

This regulation applies to and in respect of self-employed persons in the same way as it applies to and in respect of employers.

When using poisons or corrosives, ensure you read and understand the label before you start. Work in a well-ventilated area or wear an approved respirator. Use personal safety protection recommended by the manufacturer.

15. CONFINED SPACES

The WGWDD has adopted the Occupational, Health and Safety (Confined Spaces) Regulation 1990 and AS 2865 - Safe Working in Confined Spaces as the minimum standard for confined spaces.

A confined space is a compartment or area with a limited opening for access and usually no alternative escape route, which a person may enter at any time or be allowed to enter and where the atmosphere or environment may be hazardous to those who are required to enter the confined space. This regulation is to ensure workers are not placed at risk of injury or illness.

Contractors operating at the WGWDD site must comply with the confined space regulations.

16. OUTDOOR WORKERS

Skin cancers are very common in Australia among people exposed to the sun. One type of skin cancer that can be caused by exposure to the sun is melanoma. It is a particularly aggressive cancer, and causes many deaths. People working in the sun should wear wide brimmed hats or neck covers under hard bats, blackout sunscreen, and long sleeve shirts. Sunglasses complying with AS 1067 should be worn to provide protection against the sun.

17. CLEANING UP OF SITE

All visible external and internal surfaces, including fittings, fixtures, and equipment, shall be free of marks, dirt, dust, vermin, and unwanted materials, as a condition of completion.

I / we have read the above conditions agree to comply with the requirements as detailed in the Induction for Contractors Manual.

Print Name: ____

Signature: ____ Date: _______________

Company Name: ____

Copy to file
Copy to Contractor

WOLLONGONG
City of Innovation

WOLLONGONG CITY COUNCIL
EMPLOYEE INDUCTION

EMPLOYEE NAME_______________________________

ρ ☐Overview of Operations

ρ ☐Work Team Structure

ρ ☐Site Layout & Amenities

ρ ☐Site Access / Parking

ρ ☐Incident / Accident Emergency Management including Site Evacuation

ρ ☐Incident / Accident Reporting

ρ ☐Responsibilities

ρ ☐Site Specific Hazards (Use risk identification sheet)

ρ ☐Safe Work Method Statements

ρ ☐Personal Protective Equipment

ρ ☐Traffic Control Plans & Vehicle Movement Plans

ρ ☐Plant Requirements

ρ ☐First Aid

ρ ☐Environmental Requirements

ρ ☐Leachate ponds induction

Employee Signature____________________________________ Date__________________

Inductor Signature_____________________________________ Date__________________

PROCEDURE

How to conduct Daily Inspections at Whytes Gully Waste Depot

There are two (2) Operational Checklists that must be completed Daily + 1 Leading Hand Inspection

- Daily Operational Checklist - TRIM Z11/121137
  - Tip Face Control - Inspection
  - Transfer Station

- Daily Operational Checklist - TRIM Z11/121176
  - Leachate Ponds Inspection
  - Ammonia Plant Inspection
  - Settling Ponds Inspection
  - Weighbridge

1. Tip Face Control Inspection

<u>Tip Face Control inspection must be conducted prior to opening of the Waste Depot</u>

- Loader operative conducts his daily plant inspection – see plant inspection daily checklist
- Refer to Flowchart Plant Preparation & Reporting TRIM Z11/106557
- Loader Operator drives to Tip Face and conducts Tip Face inspection as per the Daily Operational Checklist – Tip Face Control

COPY OF CURRENT TRAFFIC CONTROL PLAN & DAILY OPERATIONAL TIP FACE CONTROL CHECKLIST MUST BE LOCATED IN THE LOADER

2. Leachate, Ammonia Plant, Settling Ponds, Inspections

<u>This inspection must be completed daily</u>

- The Inspection is conducted by Additional Waste Operative
- Conduct inspection and complete the checklist daily

INSPECTION CHECKLISTS MUST BE COMPLETED AT TIME OF INSPECTION

LEADING HAND TO ENSURE BOTH DOCUMENTS ARE COMPLETED

- Rectify any actions required if safe to do so.
- Document the problem and action taken on the inspection sheet.
- Record and report outstanding actions to Leading Hand for further consideration.

Questions
What are they checking for when:

- Inspecting dust and noise control in place
- Leachate pond levels (what should they be)
- General faults and safety issues (examples)
- Daily flow meter reading litre/second (do we need a procedure for this and where is this info documented and filed?
- Monthly meter reading Leachate to sewer (should this be put on the I&T register and matrix? Where is this info documented and filed?

What needs t be inspected at green waste, recycled and developed Areas ? Any monitoring/reporting to be conducted and who need this information? Where are the documents stored

1. If an inspection identifies a non conformance/not acceptable (cross on the inspection sheet) What do we do about it? Is info recorded on the sheet or in the Operative's diary? If control cant be implemented at local/site level when is the issue escalated to next level and how is this done? Should these issues be raised at team brief and minuted and escalated to Operational manager/Waste manager/Divisional manager for action depending on delegated authority?

WASTE SERVICES OH&S RECORDS KEEPING PROCEDURE

The OH&S records management system is used to effectively store, maintain and destroy important documents that are used and referred to regularly in the work area. This procedure outlines the function of the OH&S "Table of Contents" document and provides a step-by-step process to the safekeeping and retracing of such documents.

Refer to OHS Records Management and Divisional Document Control + OHS Records Management Procedures on the intranet.

TABLE OF CONTENTS/(SITE RECORDS CONTENT LIST)

The Table of Contents page is the primary list of all OHS documents kept on a site. It should be referred to whenever a document is to be filed, recalled, forwarded to Information Management Section; or destroyed. This sheet should be kept as a hardcopy in a file directory or other reference folder that is available to be accessed by all employees. Whytes Gully hard copy is located on the board near the Verification Matrix. The electronic copy is filed in TRIM Z11/103359 ; Glengarry TRIM Z11/35094

The Table of Contents table has seven (7) columns for each document registered on the list; this includes: Record type, location, responsibility, confidentiality, storing time, destroying method and comments. Each document that is to be kept on site (hence, must be on the Table of Contents sheet) must have all columns filled before it is stored in its location. At Glengarry the Waste Business Support & Systems Operator is responsible for ensuring the Table of Contents is kept up to date and is reviewed monthly to ensure documents are destroyed when required.

Record Type

The record type column is the documents name that is to be filed. This name should contain as much detail as possible for ease of reference when locating records later. E.g. Building Evacuation Test Drills 1/1/2010 to (date)

Location

This lists the exact location of the document(s) within the workplace. If it belongs to another division, that division/building (that holds the document) may be listed. Each division should have their own respective file directories and listing the building on the table of contents page will link that document to that building's own OHS records register.

For those records kept in the immediate workplace a direct path is required for listing the location of the record. All shelves, drawers and cabinets are labelled with a reference code for filing purposes. The location column of the Table of Contents contains a systematic directory to finding the OHS record

Note: Some documents may have more than one location. For example Safety Committee meeting minutes are stored on site as a hardcopy and an electronic copy filed on the intranet. In such cases; both locations are noted and separated by a comma.

Responsibility

Each document that is added to the Table of Contents is allocated with a person that is responsible for storing it in the correct location as well as maintaining/sorting and destroying the document where necessary. The employee position allocated with responsibility is dependent on the document and its purpose. Responsibility may also be established by file location and should be assigned to an employee *position* and not an individual, hence persons acting in job positions are also given responsibility of the documents. For e.g. responsibility might be assigned to "Works Coordinator", and not an individual's name, on the sheet.

Although one person is allocated as having responsibility for the document, others may also retrieve or view documents. The ability to view any such documents is subject to the respective confidentiality category, defined hereafter.

Confidentiality

Confidentiality is an important factor in the storing of documents. This column on the Table of Contents sheet is labelled on a "yes/no" basis, where applicable. It should be noted that if a document *is* confidential then it should be filed appropriately in a locked cabinet or secure folder etc.

Documents that are labelled with a yes in the "Confidentiality Required" column are only to be retrieved by, or with permission from, the person outlined in the Responsibility column. Confidential records are kept in the locked storage room at South Depot.

Records to be Kept

This column indicates the period of time that the document(s) are to be kept in the relating work area and what is to be done with them after expiry. Depending on the document, after it has been stored on site for a period it may then be forwarded into Information Management Section for permanent filing or destroyed.

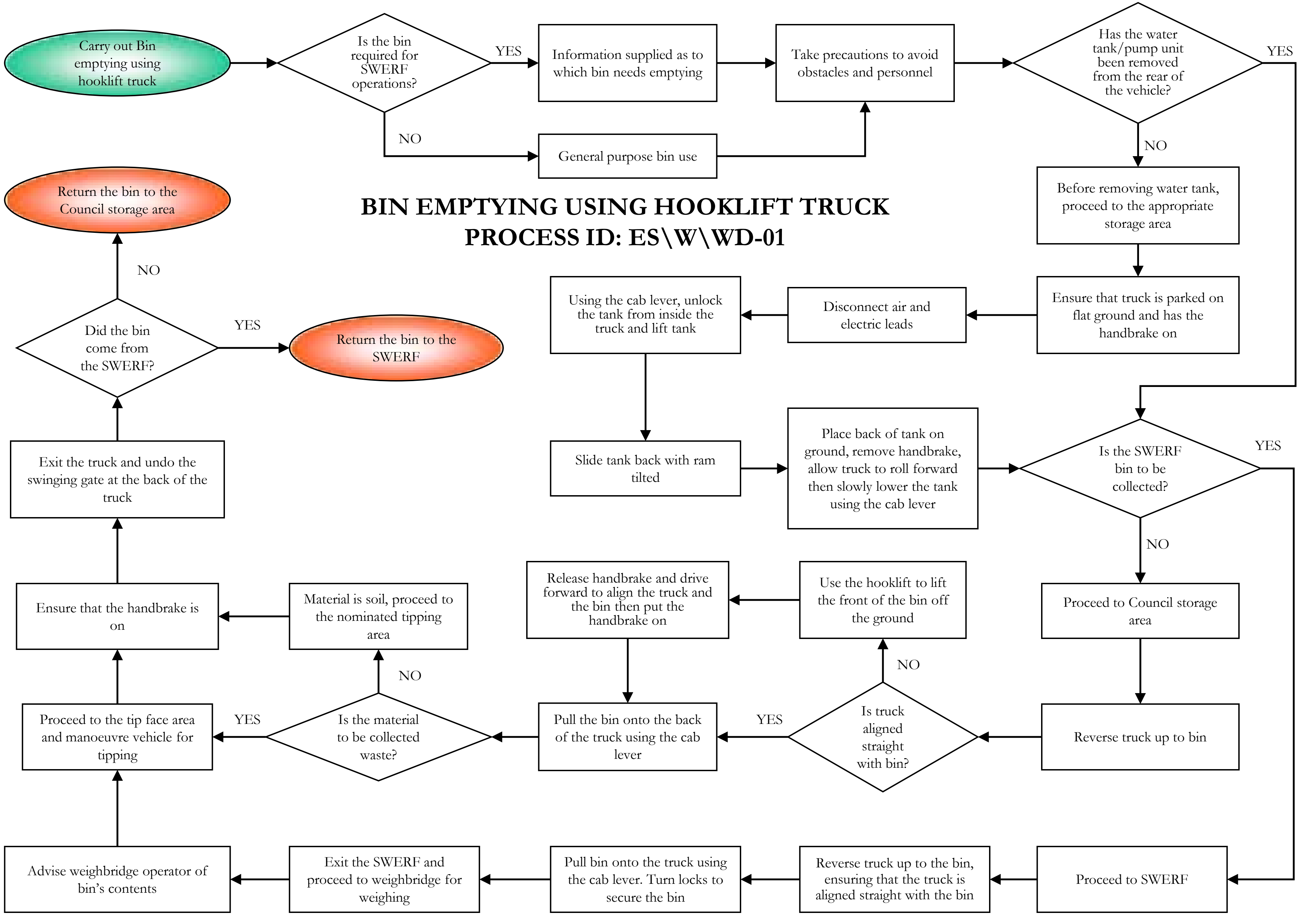
How Records are Destroyed

The generic method for destroying documents is shredding. This column will be labelled with either "Secure Shredding" or "Non Secure Shredding" depending on the documents confidentiality (or otherwise).

Comments

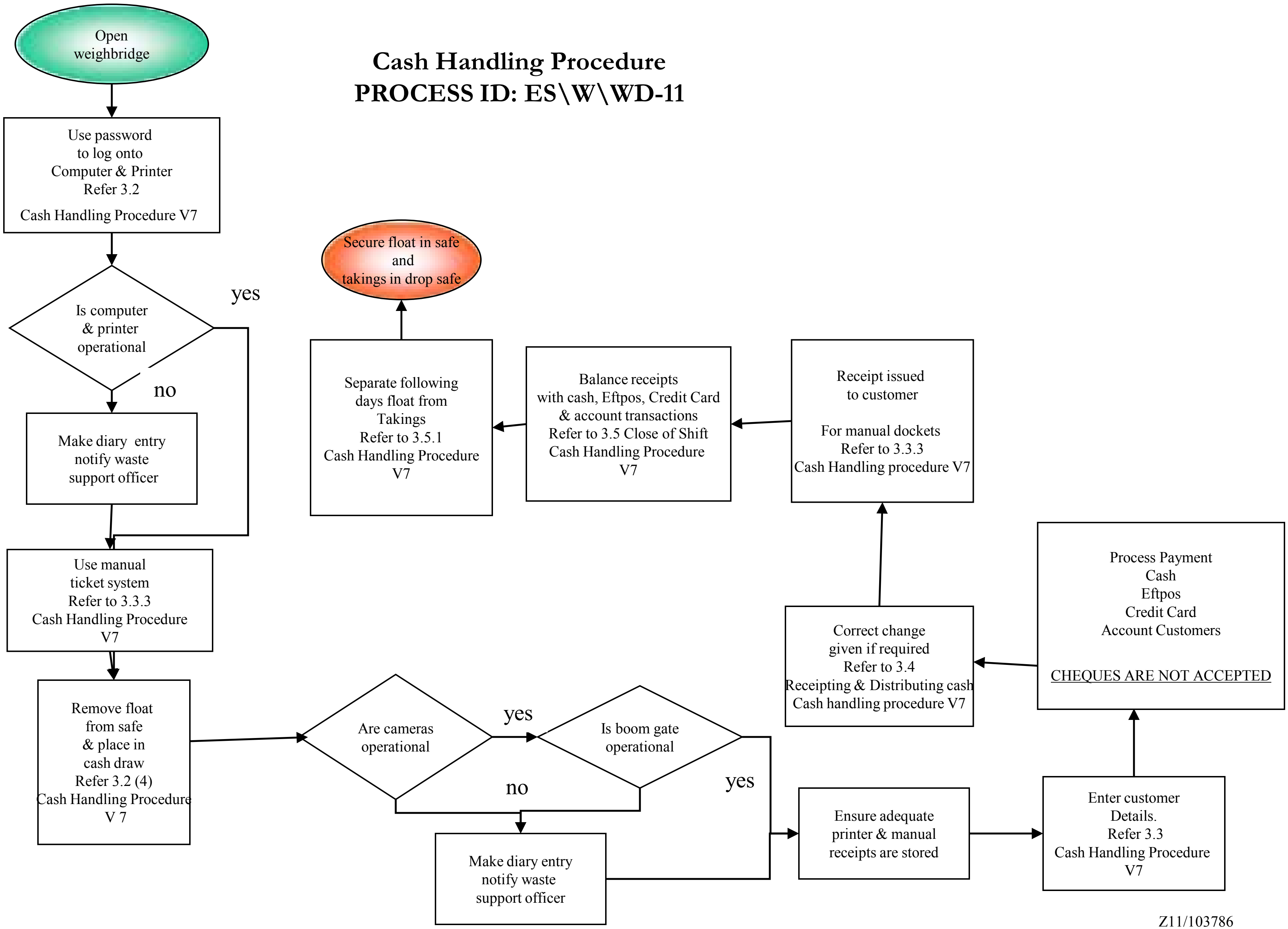
The comments column provides a space to put any notes regarding the filing, maintaining or destroying of the documentation. This section may also be used to briefly define the document or place any other comments as appropriate.

BIN EMPTYING USING HOOKLIFT TRUCK
PROCESS ID: ES\W\WD-01

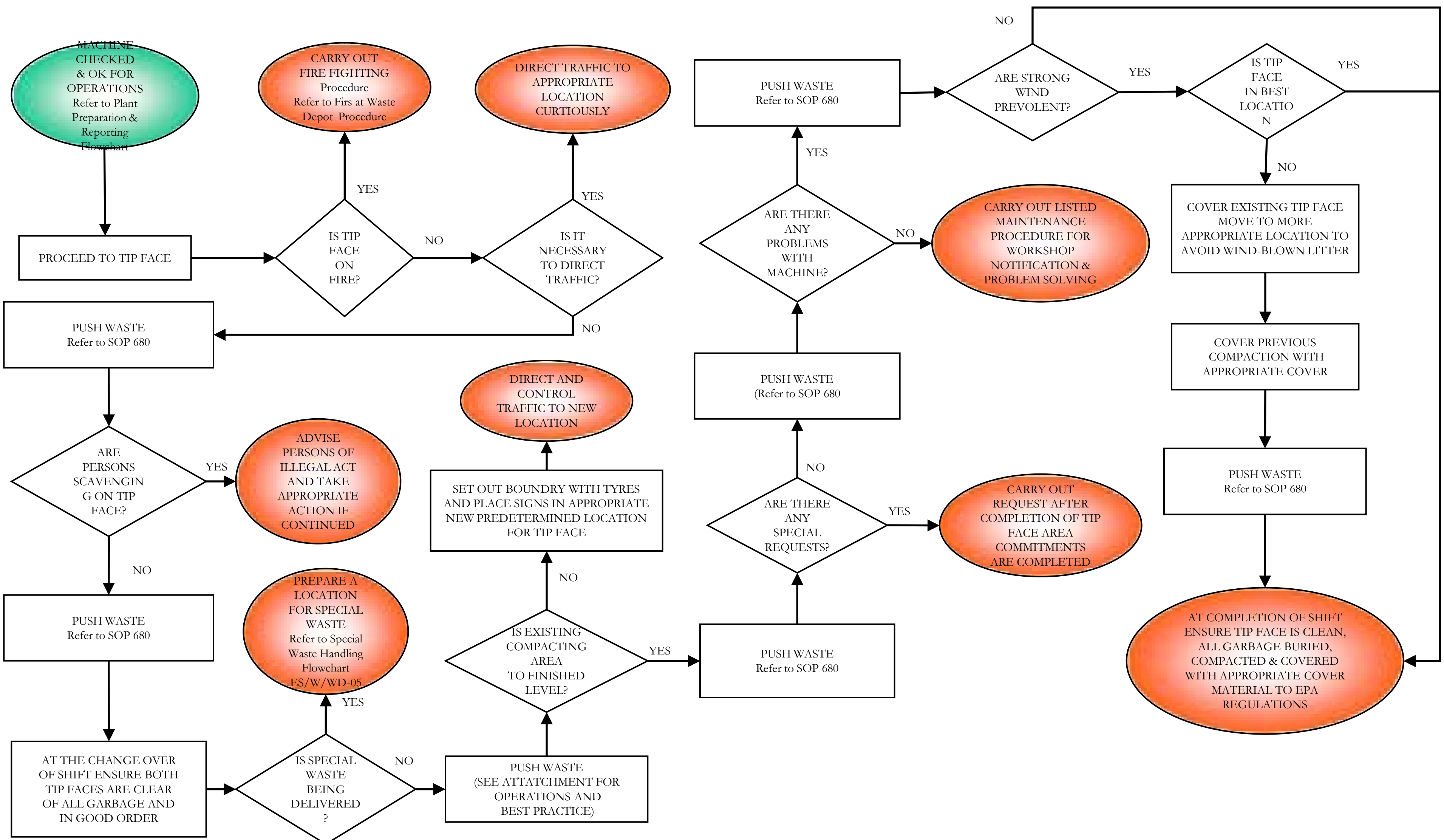


Z11/103783

Cash Handling Procedure
PROCESS ID: ES\W\WD-11



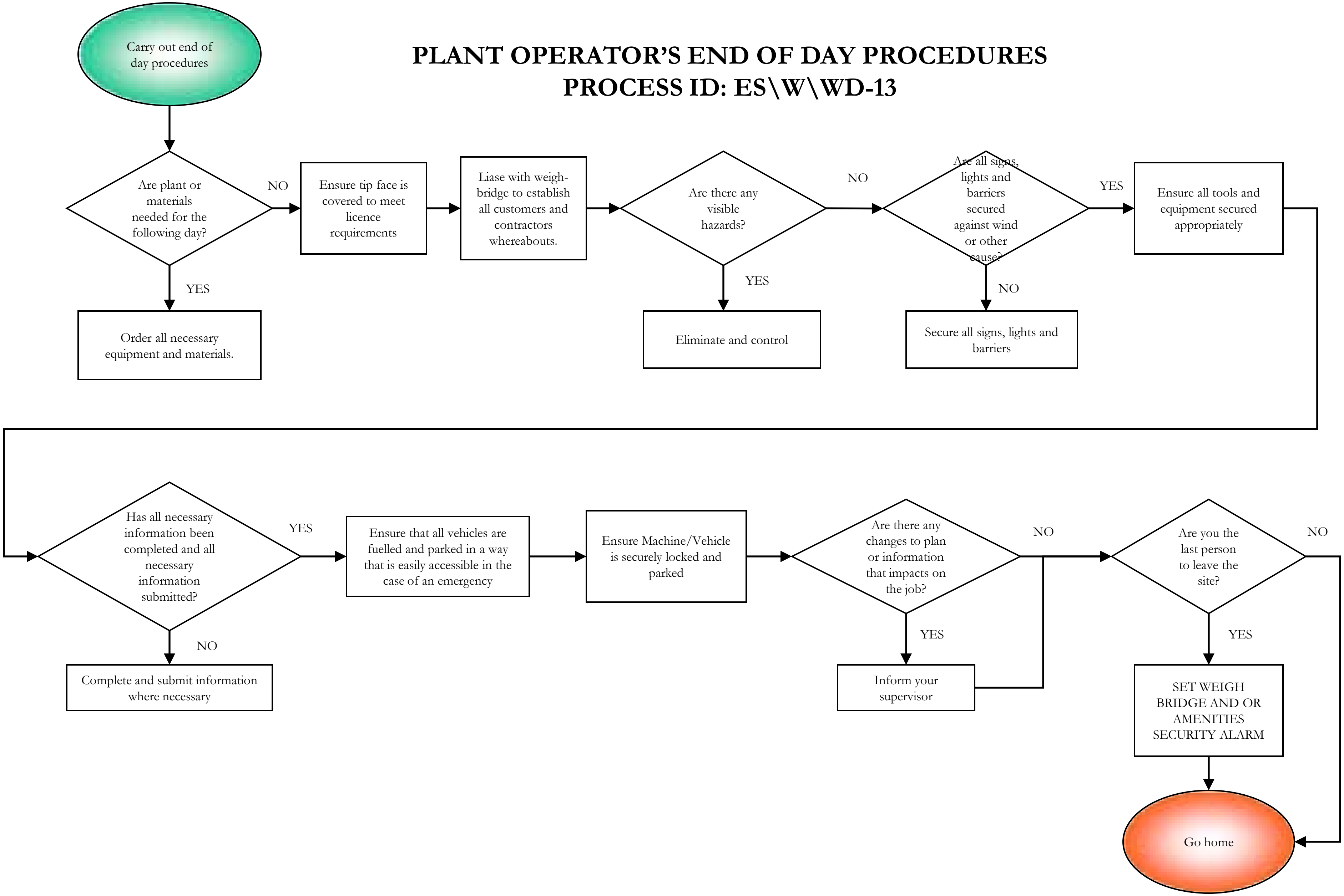
Z11/103786



COMPACTOR TIP FACE OPERATIONS
PROCESS ID: ES\W\WD-04

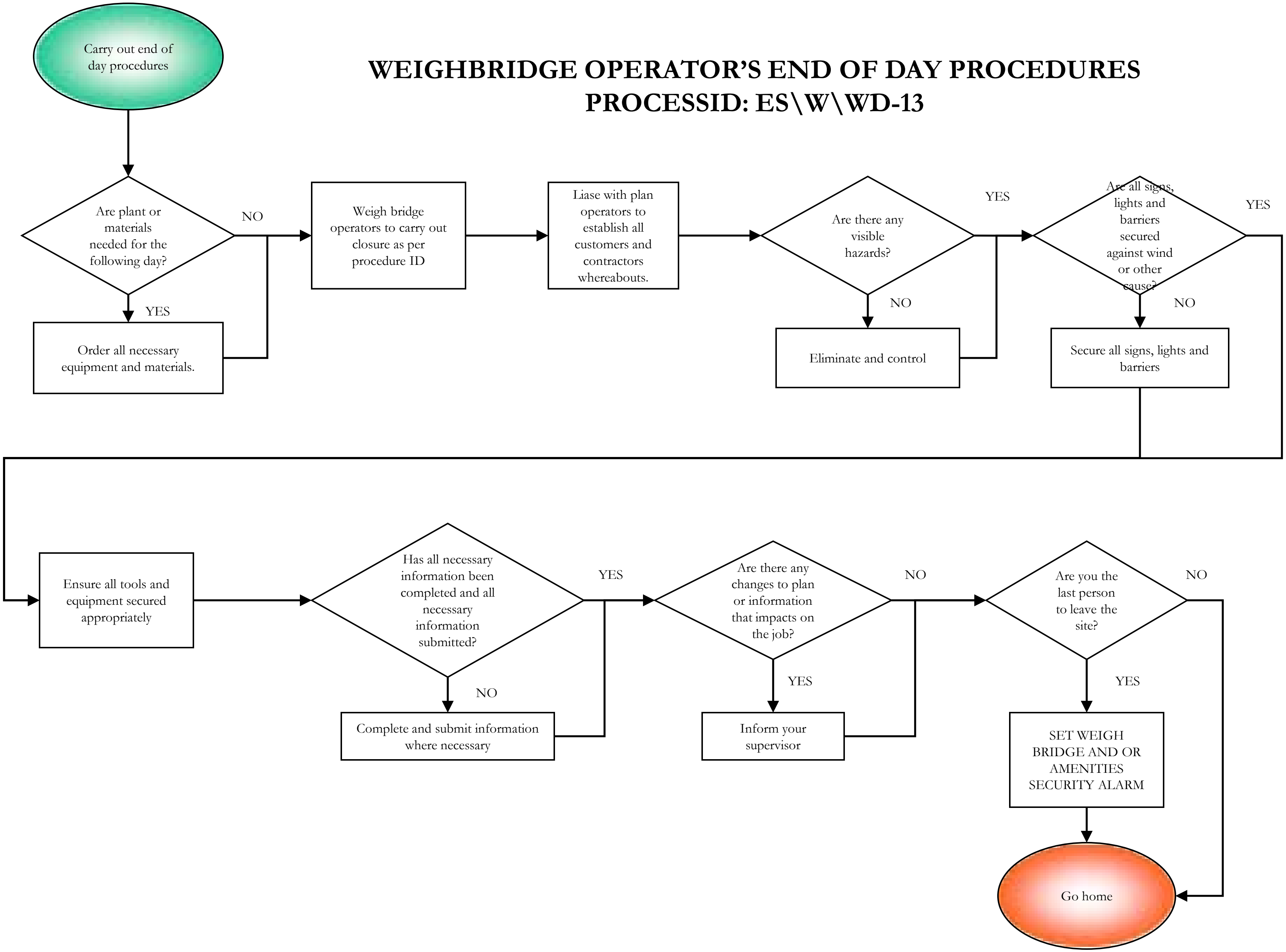
TRIM Z11/103787

PLANT OPERATOR'S END OF DAY PROCEDURES
PROCESS ID: ES\W\WD-13



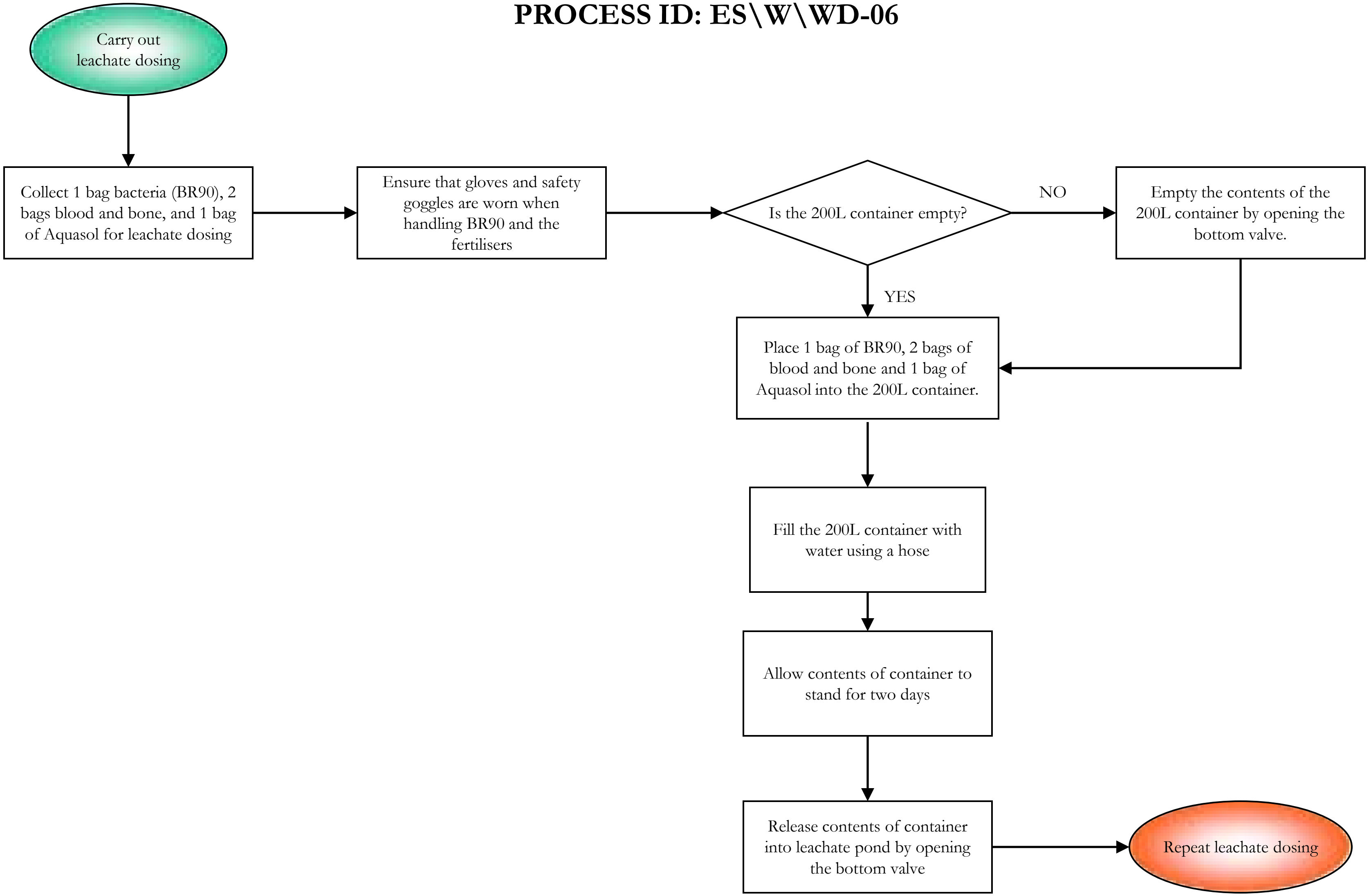
TRIM Z11/103790

WEIGHBRIDGE OPERATOR'S END OF DAY PROCEDURES
PROCESSID: ES\W\WD-13



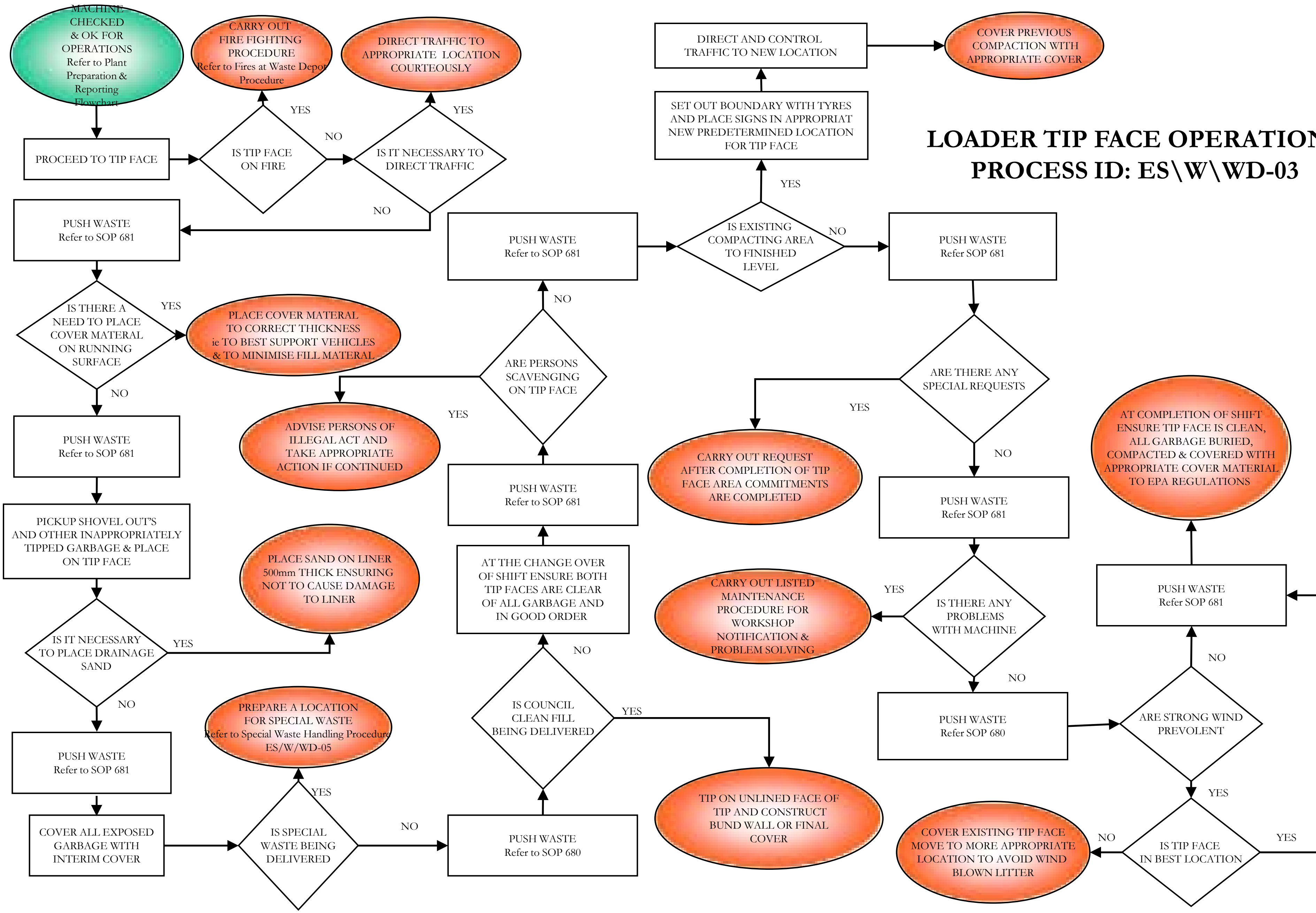
TRIM Z11/103791

LEACHATE DOSING
PROCESS ID: ES\W\WD-06



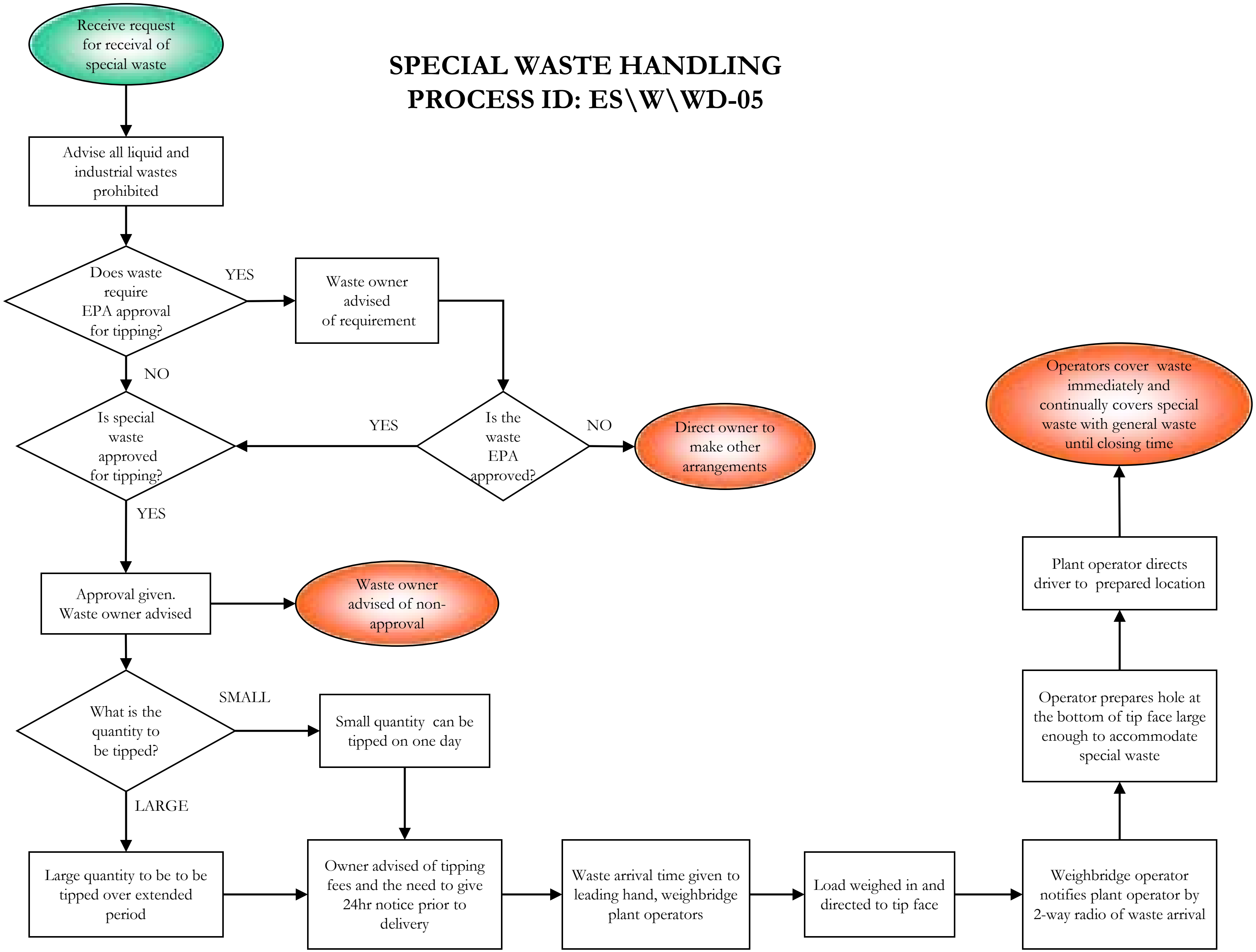
TRIM Z11/103793

LOADER TIP FACE OPERATIONS
PROCESS ID: ES\W\WD-03



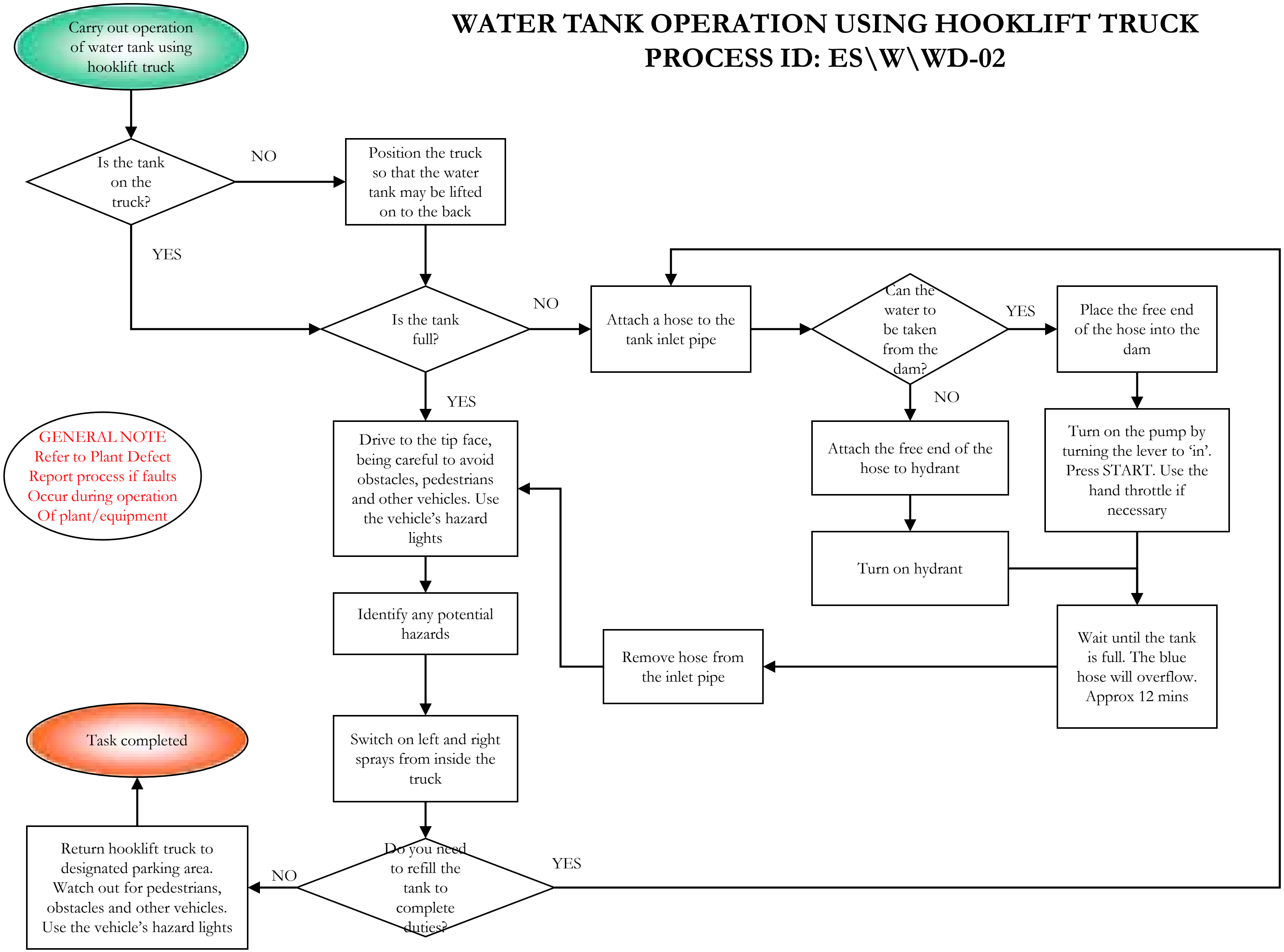
Z11/103795

SPECIAL WASTE HANDLING
PROCESS ID: ES\W\WD-05



Z11/103797

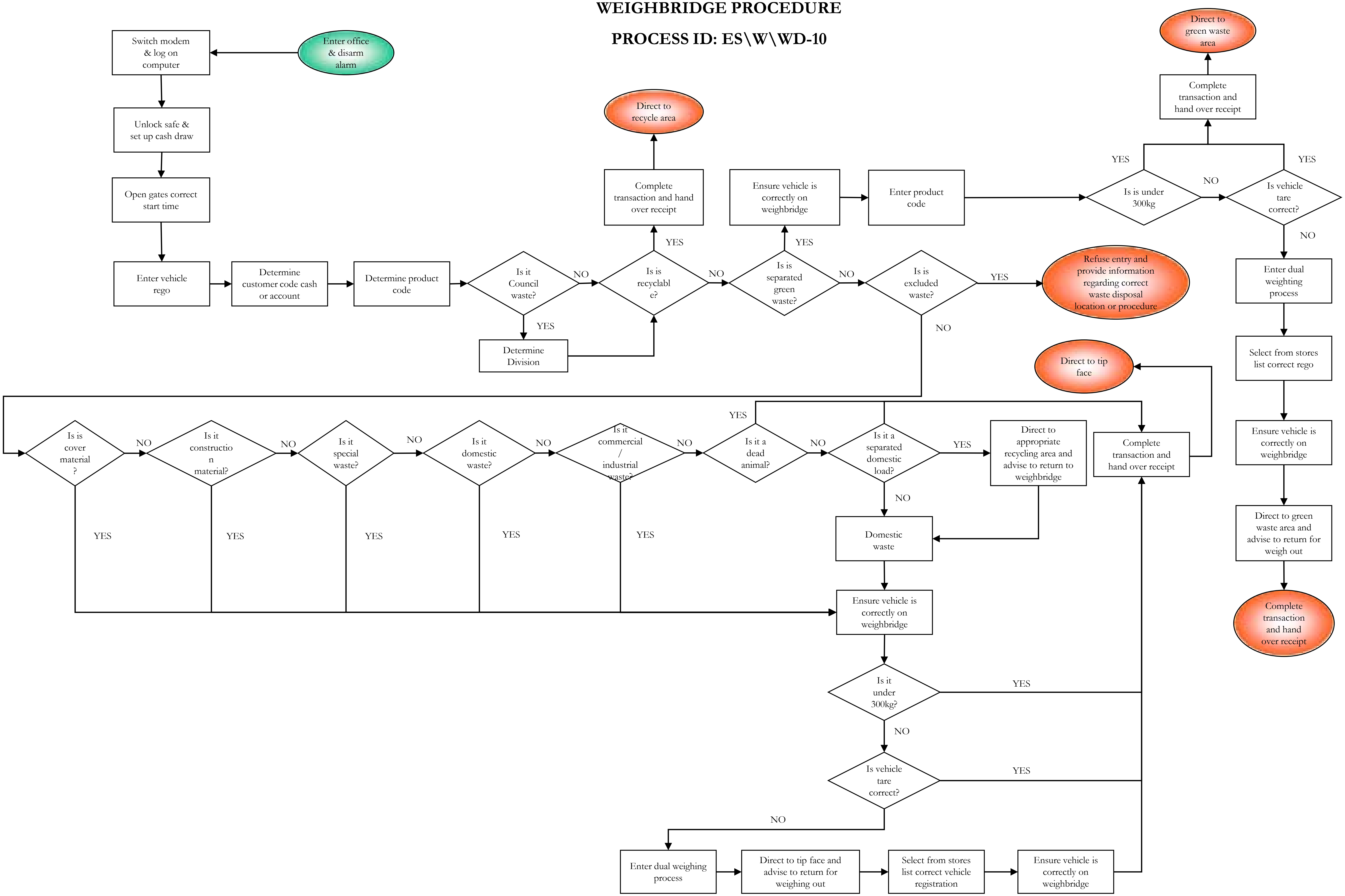
WATER TANK OPERATION USING HOOKLIFT TRUCK
PROCESS ID: ES\W\WD-02



Z11/103804

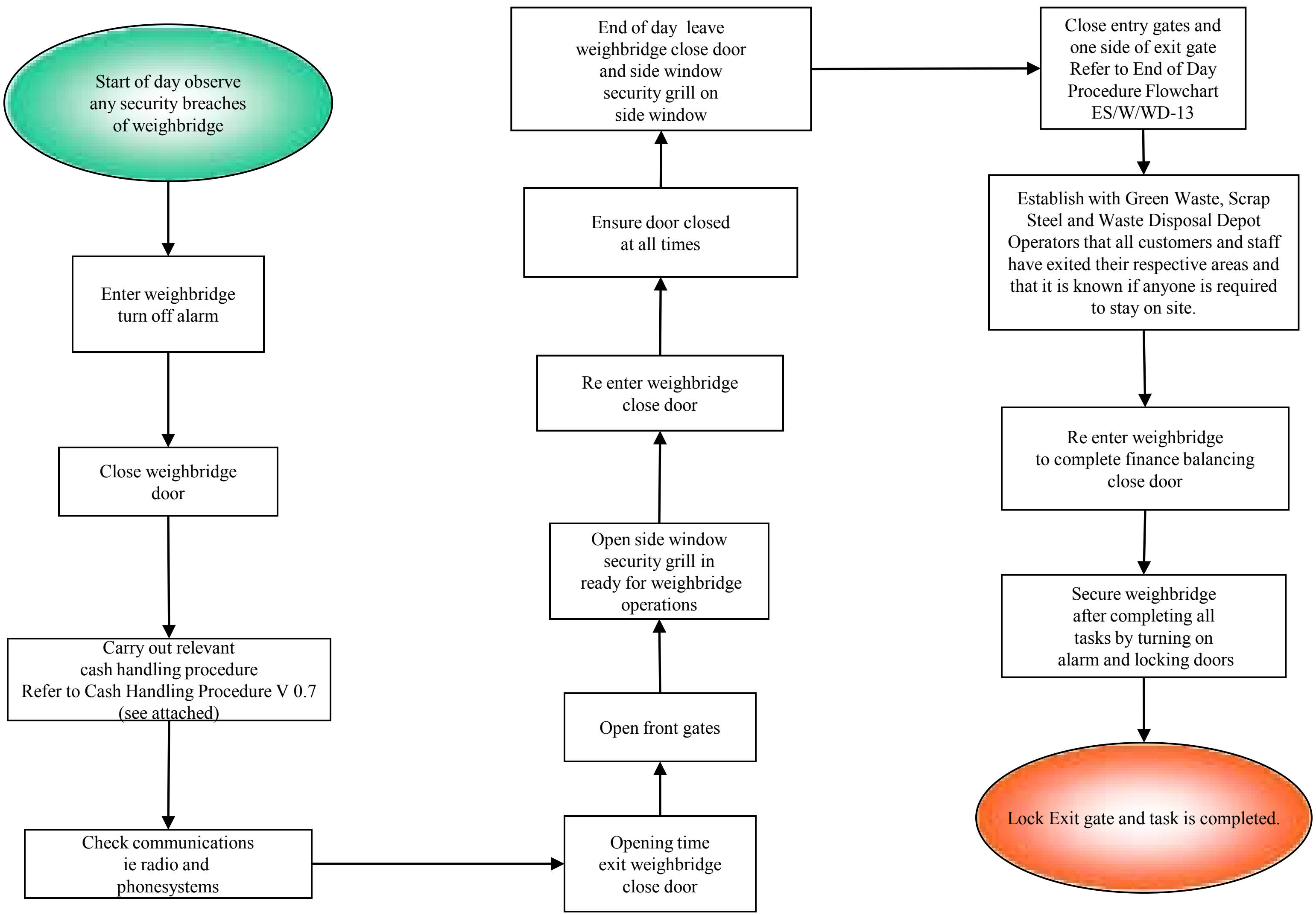
WEIGHBRIDGE PROCEDURE

PROCESS ID: ES\W\WD-10



Z11/103806

WEIGHBRIDGE SECURITY PROCEDURE
PROCESS ID: ES\W\WD-12



OPERATING PROCEDURE - BIN EMPTYING USING HOOKLIFT TRUCK

NAME OF PROCEDURE: **BIN EMPTYING USING HOOKLIFT TRUCK**	
DIVISION: **ENGINEERING SERVICES/WASTE**	PROCESS ID: **ES\W\WD-01**
RESPONSIBLE POSITION:	
REVISION:	ISSUE: **DECEMBER 2002**
RELATED PROCESSES:	

Purpose

To provide a regular bin service to the SWERF facility and the Whytes Gully disposal depot while ensuring maximum safety to Council and SWERF employees as well as the general public.

Boundaries

The boundaries for this operation are limited to those activities necessary for the proper management of waste, through the servicing of bins.

Equipment Options

Equipment options are inclusive of all Council plant and equipment as well as any other equipment deemed necessary, which can be dry-hired or supplied by contract. This area is constrained only by availability, suitability, training and safety.

Materials Options

Materials options are constrained only by availability, training, safety and suitability. They must comply with Council or Australian standards and not breach any EPA guidelines. If hazardous they must be accompanied by an appropriate Materials Safety Data Sheet (MSDS) and any use is dependent on full safety compliance inclusive of protective clothing, environmental impact assessment and accredited training.

Team Skills Required

- Manual handling
- Traffic control
- OH&S.
- Working with hand tools
- Working with mechanical plant
- Environmental awareness
- Handling hazardous materials
- Risk analysis
- Appropriate licenses, training and certification
- Plant operators

Team Skills Desirable

- Engineering materials
- Understanding of common law
- First aid certificate

Working References

- Occupational health and safety
- AS 1742.3 Traffic Control Devices For Road And Pedestrian Works
- Plant operator's manuals
- Plant safety policy
- WCC works procedures
- WCC plant safe operating procedures
- EPA requirements

Documentation

- Consultation
- Daily time sheets
- Asset management record
- Work as executed data
- Estimated costs
- Cost dissection numbers
- Traffic management plan
- Pre-construction risk assessment
- EPA management plan

Intervention Level

- As directed

Cost Recording Procedure

It is essential that an accurate assessment of time, materials, plant and labour be recorded to benchmark and establish unit costs. The individual breakdowns are listed on the particular works procedure.

Work Procedure

- Complete all vehicle safety checks (see plant operator's manual)

- Receive information as to which bin requires emptying.

- Ensure that the handbrake is on and that the air and electrical leads are disconnected, before attempting to remove the water tank from the back of the truck.

- To remove tank from truck, use the lever in the cab to unlock and lift the tank. Slide the tank back with the ram tilted, and place the back of the tank on the ground.

- Let truck roll forward by removing the handbrake, then slowly lower the tank using the cab lever.

- Drive to the bin to be emptied, being careful to avoid obstacles, pedestrians and other vehicles

- If waste is collected from the SWERF, load must be weighed at the weighbridge before proceeding to the tipping site.

- If material is soil, proceed to the nominated area for tipping.
- To tip the material, exit the truck and undo the swinging gate at the back of the truck.
- Return bin to the place that it was picked up.
- Tasks completed.

Appendices

OPERATING PROCEDURE - WATER TANK OPERATION USING HOOKLIFT TRUCK

NAME OF PROCEDURE: **WATER TANK OPERATION USING HOOKLIFT TRUCK**	
DIVISION: **ENGINEERING SERVICES/WASTE**	PROCESS ID: **ES\W\WD-02**
RESPONSIBLE POSITION:	
REVISION:	ISSUE: **DECEMBER 2002**
RELATED PROCESSES:	

Purpose

To provide a dust-free tip site that complies with EPA requirements, while ensuring the safety of crew and the public.

Boundaries

The boundaries for this operation are limited to those activities necessary to ensure safety and productivity prior to commencing on site works

Equipment Options

Equipment options are inclusive of all Council plant and equipment as well as any other equipment deemed necessary, which can be dry-hired or supplied by contract. This area is constrained only by availability, suitability, training and safety.

Materials Options

Materials options are constrained only by availability, training, safety and suitability. They must comply with Council or Australian standards and not breach any EPA guidelines. If hazardous they must be accompanied by an appropriate Materials Safety Data Sheet (MSDS) and any use is dependent on full safety compliance inclusive of protective clothing, environmental impact assessment and accredited training.

Team Skills Required

- Manual handling
- Traffic control
- OH&S.
- Working with hand tools
- Working with mechanical plant
- Environmental awareness
- Handling hazardous materials
- Risk analysis
- Appropriate licenses, training and certification
- Plant operators

Team Skills Desirable

- Engineering materials
- Understanding of common law
- First aid certificate

Working References

- Occupational health and safety
- AS 1742.3 Traffic Control Devices For Road And Pedestrian Works
- Plant operator's manuals
- Plant safety policy
- WCC works procedures
- WCC plant safe operating procedures
- EPA requirements

Documentation

- Consultation
- Daily time sheets
- Asset management record
- Work as executed data
- Estimated costs
- Cost dissection numbers
- Traffic management plan
- Pre-construction risk assessment
- EPA management plan

Intervention Level

- HP (supervisor approval necessary to extend works)
- As directed

Cost Recording Procedure

It is essential that an accurate assessment of time, materials, plant and labour be recorded to benchmark and establish unit costs. The individual breakdowns are listed on the particular works procedure.

Work Procedure

- Complete all vehicle safety checks (see plant operator's manual)

- Attach and secure one end of the hose to inlet pipe on the water tank, and place the other end in the dam or hydrant from where water is to be collected. Ensure that hose is straight (ie that there are no kinks in the hose).

- On the water pump, turn the lever to 'in', and press start, using the hand throttle on the pump if necessary.

- The tank usually takes about 12 minutes to fill to 10000L. Once it is full the blue hose will overflow, and then the pump is switched off.

- The hose is then removed from the inlet pipe.

- Truck is then driven up to the tip face, ensuring that hazard lights are switched on and working, taking care to avoid public vehicles, loaders and compactors.

- Switch on left and right sprays, from control panel inside the truck to avoid getting wet, and water down the tip face – this procedure is usually repeated daily, depending on weather conditions.

- If required, return to dam or hydrant and fill tank with more water in order to complete duties.

- Tasks completed.

Appendices

OPERATING PROCEDURE - SPECIAL WASTE HANDLING

NAME OF PROCEDURE: **SPECIAL WASTE HANDLING**	
DIVISION: **ENGINEERING SERVICES/WASTE**	PROCESS ID: **ES\W\WD-05**
RESPONSIBLE POSITION:	
REVISION:	ISSUE: **DECEMBER 2002**
RELATED PROCESSES:	

Purpose

To ensure that special wastes are disposed of quickly and efficiently, while guaranteeing maximum safety for employees and public

Boundaries

The boundaries for this operation are limited to those activities necessary to ensure safety of Council employees and members of the public during the burial of special wastes.

Equipment Options

Equipment options are inclusive of all Council plant and equipment as well as any other equipment deemed necessary, which can be dry-hired or supplied by contract. This area is constrained only by availability, suitability, training and safety.

Materials Options

Materials options are constrained only by availability, training, safety and suitability. They must comply with Council or Australian standards and not breach any EPA guidelines. If hazardous they must be accompanied by an appropriate Materials Safety Data Sheet (MSDS) and any use is dependent on full safety compliance inclusive of protective clothing, environmental impact assessment and accredited training.

Team Skills Required

- Manual handling
- Traffic control
- OH&S
- Working with hand tools
- Working with mechanical plant
- Environmental awareness
- Handling hazardous materials
- Risk analysis
- Appropriate licenses, training and certification
- Plant operators

Team Skills Desirable

- Engineering materials
- Understanding of common law
- First aid certificate

Working References

- Occupational health and safety
- AS 1742.3 Traffic Control Devices For Road And Pedestrian Works
- Plant operator's manuals
- Plant safety procedure
- WCC works procedures
- WCC plant safe operating procedures
- EPA requirements

Documentation

- Consultation
- Daily time sheets
- Asset management record
- Work as executed data
- Estimated costs
- Cost dissection numbers
- Traffic management plan
- Pre-construction risk assessment
- EPA management plan

Intervention Level

- HP (supervisor's approval necessary to extend works)
- As directed

Cost Recording Procedure

It is essential that an accurate assessment of time, materials, plant and labour be recorded to benchmark and establish unit costs. The individual breakdowns are listed on the particular works procedure.

Work Procedure

- Receive request for the receival of special waste and advise that all industrial and liquid wastes are prohibited in the tip.

- If the waste requires EPA approval and advise the owner of this requirement. If the EPA does not approve of the special waste tipping, direct the owner to make other arrangements.

- If the waste does not require approval from the EPA or the EPA has approved the tipping of this material, find out what quantity is required for tipping. Small loads can be tipped on the same day. Large quantities must be tipped over an extended period of time.

- Owner should be advised of the tipping fees and that they need to give the tip 24 hours notice prior to the wast arriving.

- Waste arrival time given to leading hand, weighbridge and plant operators

- The waste is weighed on arrival and directed to the tip face. The weighbridge operator notifies plant operator by 2-way radio of waste arrival.

- Operator prepares hole at the bottom of the tip face that is large enough to accommodate special waste

- Plant operator directs owner to prepared position and when then covers the waste immediately and continually until closing time.

Safety Procedures

- Ensure all regulations are adhered to and then special waste is handled in the safest possible way.

- When using plant equipment, operate at slow speed when working at tip face.

- When using plant equipment, (compactor etc) travel no closer than 2m to other vehicles.

- When using plant equipment, ensure that at all times no vehicles are at rear of machine, check rear-vision mirrors when reversing.

Appendices

OPERATING PROCEDURE - LEACHATE DOSING

NAME OF PROCEDURE: **LEACHATE DOSING**	
DIVISION: **ENGINEERING SERVICES/WASTE**	PROCESS ID: **ES\W\WD-06**
RESPONSIBLE POSITION:	
REVISION:	ISSUE: **DECEMBER 2002**
RELATED PROCESSES:	

Purpose

To ensure proper treatment of bacteria used for the dosing of leachate.

Boundaries

The boundaries for this operation are limited to those activities necessary to ensure the proper treatment of the bacteria, while ensuring the safety of employees and public.

Equipment Required

- Correct PPE (including gloves, goggles, facemask, high visibility clothing and steel capped boots)
- 200 litre drum with tap at the bottom

Equipment Options

Equipment options are inclusive of all Council plant and equipment as well as any other equipment deemed necessary, which can be dry-hired or supplied by contract. This area is constrained only by availability, suitability, training and safety.

Materials Required

- Bacteria
- Fertiliser
- Water

Materials Options

Materials options are constrained only by availability, training, safety and suitability. They must comply with Council or Australian standards and not breach any EPA guidelines. If hazardous they must be accompanied by an appropriate Materials Safety Data Sheet (MSDS) and any use are dependent on full safety compliance inclusive of protective clothing, environmental impact assessment and accredited training.

Team Skills Required

- Manual handling
- Traffic control
- OH&S.
- Working with hand tools
- Handling hazardous materials
- Risk analysis
- Appropriate licenses, training and certification
- Environmental awareness

Team Skills Desirable

- Engineering materials
- Understanding of common law
- First aid certificate

Working References

- Occupational health and safety
- AS 1742.3 Traffic Control Devices For Road And Pedestrian Works
- Plant operator's manuals
- Plant safety policy
- WCC works procedures
- WCC plant safe operating procedures
- EPA requirements

Documentation

- Consultation
- Daily time sheets
- Asset management record
- Work as executed data
- Estimated costs
- Traffic Management Plan
- Pre-construction risk assessment
- EPA management plan

Intervention Level

- As directed

Cost Recording Procedure

It is essential that an accurate assessment of time, materials, plant and labour be recorded to benchmark and establish unit costs. The individual breakdowns are listed on the particular works procedure.

Work Procedure

- Ensure that there is sufficient crew to perform the task satisfactorily.

- Correct PPE must be worn and used, including safety glasses and gloves, when mixing and applying the bacteria.

- 2 bags of fertiliser (blood and bone), 1 bag of bacteria, and 1 bag of stabilising agent are placed into the 44-gallon drums.

- The drums are then topped up with water and left to react for 2 days.

- After reaction time is complete, the tap is opened and the liquid runs into the leachate ponds.

- The use of leachate dosing is limited to three days a week (Monday. Wednesday and Friday) and on the weekend the worker is to only check and take measurement.

Appendices

OPERATING PROCEDURE - 18 LITRE HAND SPRAY PUMP

NAME OF PROCEDURE: **18 LITRE HAND SPRAY PUMP**	
DIVISION: **ENGINEERING SERVICES/WASTE**	PROCESS ID: **ES\W\WD-07**
RESPONSIBLE POSITION:	
REVISION:	ISSUE: **DECEMBER 2002**
RELATED PROCESSES:	

Purpose

To ensure the safe and proper operation of an 18 litres hand spray pump for the spraying of herbicide and the safety of crew and the public.

Boundaries

The boundaries for this operation are limited to those activities necessary to ensure that weeds are controlled at the waste depots, while guaranteeing the safety of the crew, the public and the environment. The extent of the process is from determining the boundary of task and storage of equipment after cleaning.

Equipment Required

- 18L hand spray pump
- Correct PPE (Gloves, sun hat, sunscreen, safety goggles, high-visibility clothing and face mask)

Equipment Options

Equipment options are inclusive of all Council plant and equipment as well as any other equipment deemed necessary, which can be dry-hired or supplied by contract. This area is constrained only by availability, suitability, training and safety.

Materials Required

- Herbicide (Roundup)
- Water

Materials Options

Materials options are constrained only by availability, training, safety and suitability. They must comply with Council or Australian standards and not breach any EPA guidelines. If hazardous they must be accompanied by an appropriate Materials Safety Data Sheet (MSDS) and any use are dependent on full safety compliance inclusive of protective clothing, environmental impact assessment and accredited training.

Team Skills Required

- Manual handling
- Traffic control
- OH&S.
- Working with hand tools
- Working with mechanical plant
- Environmental awareness
- Handling hazardous materials
- Risk analysis
- Appropriate licenses, training and certification
- Plant operators

Team Skills Desirable

- Engineering materials
- Understanding of common law
- First aid certificate

Working References

- Occupational health and safety
- AS 1742.3 Traffic control devices for road and pedestrian works
- Plant operator's manuals
- Plant safety policy
- WCC works procedures
- WCC plant safe operating procedures
- EPA requirements

Documentation

- Poisons handling ID sheet
- Daily time sheets
- Work as executed data
- Traffic management plan
- Pre-construction risk assessment
- EPA management plan

Intervention Level

- As directed

Cost Recording Procedure

It is essential that an accurate assessment of time, materials, plant and labour be recorded to benchmark and establish unit costs. The individual breakdowns are listed on the particular works procedure.

Work Procedure

- Fill out the poisons handling identification sheet

- During windy or rainy weather, herbicide is not to be used.

- Precaution should be taken to ensure that persons do not contact with herbicide directly.

- Carry out work site assessment plan

- Crew exit the vehicle, picks up necessary equipment and materials from the back of the truck, ensuring that the correct PPE is worn (refer to EQUIPMENT REQUIRED of this SOP).

- Put up "herbicide spraying in progress" signs to warn the public.

- Make sure that the pump is lubricated before mixing chemicals

- Mix the herbicide in the 18L tank as per the manufacturer's directions displayed on the herbicide container. Add indicator dye as necessary.

- Close the lid and ensure that it is on securely

- Wash hands after touching chemicals or equipment used in mixing.

- To carry, grip the top handle and place the tank one side from your body and hold the gun with the other hand.

- To operate, first pressurise the tank using the handle.

- When operating sprayer, stand up-wind and keep well away from the nozzle of the sprayer.

- To complete the job, retract lever of the handgun until no more poison comes out. Ensure poison in the container is washed out with water thoroughly.

- If required, fill tank with more herbicide solution, mixed as per manufacturer's directions, to complete duties. The operating procedure is repeated if necessary.

- Ensure that the area is left clean and that all personnel and equipment are removed from the area.

- Job to be finished by checking all tools is appropriately secured in the truck before leaving the area.

- Task completed

Appendices

OPERATING PROCEDURE - VICTA LAWN MOWERS

NAME OF PROCEDURE: **VICTA LAWN MOWERS**	
DIVISION: **ENGINEERING SERVICES/WASTE**	PROCESS ID: **ES\W\WD-08**
RESPONSIBLE POSITION:	
REVISION:	ISSUE: **DECEMBER 2002**
RELATED PROCESSES:	

Purpose

To ensure the safe and proper operation of Victa lawnmowers.

Boundaries

This procedure covers the safe operation and minor field maintenance necessary for the safe and effective utilisation of this machine by Council staff.

Cost Recording Procedure

It is essential that an accurate assessment of time, materials, plant and labour be recorded to benchmark and establish unit costs. The individual breakdowns are listed on the particular works procedure.

Work Procedure

IMPORTANT

White finger disease

Prolonged use of this machine can cause white finger disease due to the vibration. This condition reduces the hand's ability to feel and regulate temperature, produces numbness and burning sensations and can cause nerve and circulatory damage. Monitor closely the condition of your hands and fingers and if any of the above symptoms appear stop work and seek immediate medical advice.

- Never use mower unless grass catcher and/or guards are correctly assembled and fitted.

CAUTION!

- Before cleaning blockages, removing grass catcher, inspection mower or carrying out adjustment, maintenance and repair = STOP engine, disconnect plug lead from spark plug and wedge it between cylinder fins.

- Do not use mower unless guards or grass catcher supplied by Victa are in place.

- Stop the engine whenever you leave the mower.

- Do not run the machine in a poorly ventilated area.
- Never work on, or carry mower when running.
- Do not add fuel while the engine is funning or hot – spilling gasoline on a hot engine may cause fire or explosion.

Before Starting

1. Ensure all risk assessment, traffic management, EPS and other relevant planning has been completed in accordance with council policy.
2. Establish extent of works.
3. Secure site inclusive of clean, clear work area.
4. Visually inspect mower to ensure blades, blade bolts, and cutter assembly are not worn or damaged. Always replace damaged or worn blades and bolts in sets to preserve correct balance.
5. Ensure fuel tank is full and that engine oil is at required levels.
6. Ensure surface dust is cleaned away especially around the carburettor and fuel lied area.
7. Check for grass build up around the engine and muffler, which could cause over heating or a fire hazard.
8. Ensure the area is well ventilated.
9. Ensure protective clothing is worn, inclusive of:

Steel capped boots	Long sleeved shirt/long trousers
Gloves	Helmet (optional)
Face shield (optional)	Safety glasses
Hearing protection	Dust mask

1. Ensure handles are dry, clean and free from oil and fuel.
2. Adjust mower height to suit conditions and add catcher if required.
3. Assess area to be mown and remove all sticks, stones, wire and other debris prior to commencing mowing.
4. Be aware of local conditions, particularly the noise component of mowing. If work is to be undertaken in an area that amplifies the sound or members of the public may be subjected to extensive exposure to noise consider adjusting mowing program to lessen impact.
5. Only a fully trained operator is authorised to use this machine.

Starting

1. Place mower on level ground free of any objects that could contact the blade.
2. Turn the fuel lever to 'on'.
3. Move the throttle lever to run then back to start in one smooth movement.
4. (cold engine) Press the primer three times pausing between each press.
5. (warm engine) Priming may not be necessary.
6. Pull start grip slowly until you feel the starter engage, then give the grip a brisk, strong pull.
7. Do not pull the start cord out more than 70cm (28 inches) and do not allow it to snap back, instead guide it slowly back into the housing.
8. Run engine in 'Start' position for 10 seconds then move throttle lever to 'Run'.

Operation

- Keep throttle position in 'Run' position for all mowing conditions.
- Ensure you have good footing.
- Do not over reach.
- Do not carry machine, or work on it while it is running.
- Good light is essential for safe, effective mowing.
- Do not tilt mower when starting or operating.
- Mow across the face of a slope, never up and down.
- Never mow by pulling the mower towards yourself. You may slip and pull the mower on top of yourself.
- Always hold firmly with both hands.
- Always walk, never run.

Stopping

- Moving the throttle to the 'Stop' position stops the engine.
- Turn fuel tap to 'Off'.

Cleaning Up

- Ensure all rubbish is collected for proper disposal.
- Ensure area is left clean and safe.
- Ensure usage time is recorded for charging.

Maintenance

- All maintenance (other than cleaning and fuelling) to be undertaken by workshop staff.

Appendices

OPERATING PROCEDURE - JOHN DEERE RIDE-ON MOWERS

NAME OF PROCEDURE: **OPERATING JOHN DEERE RIDE-ON MOWERS**	
DIVISION: **ENGINEERING SERVICES/WASTE**	PROCESS ID: **ES\W\WD-09**
RESPONSIBLE POSITION:	
REVISION:	ISSUE: **DECEMBER 2002**
RELATED PROCESSES: **GENERIC PROCEDURES** **OH&S PROCEDURES**	

Purpose

To ensure the safe and proper operation of John Deere Ride-On Lawn Mowers.

Boundaries

This procedure covers the safe operation and minor field maintenance necessary for the safe and effective utilisation of this machine by Council staff.

Cost Recording Procedure

It is essential that an accurate assessment of time, materials, plant and labour be recorded to benchmark and establish unit costs. The individual breakdowns are listed on the particular works procedure.

Work Procedure

CAUTION!

- Refer to operator's manual for highlighted cautions with symbol for operations.
- Move the vehicle to an outside area before running the engine. **DO NOT** run the engine in an enclosed area without adequate ventilation.
- Only a fully trained operator is authorised to use this machine.
- Before backing up, disengage the mower and carefully check the area around the machine.
- Machine to be attended by operator at all times, once removed from storage container, except for instances of machine breakdown. Operator to obtain assistance to transport machine to storage container this time to be kept to the utmost minimum.
- Operator to follow breakdown notification procedure if machine needs repairs.
- Machine to be secured in storage container after operations and clean-up.

Fuel vapours are explosive and flammable

- Do not smoke while handling fuel.
- Keep fuel away from flames and sparks.
- Shut off engine before servicing.
- Cool engine before servicing.
- Work in a well-ventilated area.
- Clean up spilled fuel immediately.
- Run the machine only long enough to move to or from storage
- **DO NOT** store machine in a building where fumes may reach an open flame or spark.
- Allow the engine to cool before storing the machine in an enclosure.

DO NOT add fuel while the engine is running or hot – spilling gasoline on a hot engine may cause fire or explosion.

BEFORE STARTING

- Refer to operator's manual for operating instructions
- Ensure all risk assessment, traffic management, EPA and other relevant planning has been completed in accordance with Council policy.
- Establish extent of works.
- Secure site inclusive of clean, clear work area.
- Ensure completion of hand mowing around dams, trees and other obstacles with hand mower and weed-eater, also entire areas under all groups of trees.
- Assess area to be mown and remove all sticks, stones, wire and other debris prior to commencing mowing to reduce hazard to persons and machine
- Visually inspect mower to ensure blades, blade bolts, and cutter assembly are not worn or damaged. Always replace damaged or worn blades and bolts in sets to preserve correct balance.
- Check for grass build up around the engine and muffler, which could cause over heating or a fire hazard.
- Ensure sun protective clothing and sunscreen is worn.

- Ensure protective clothing is worn, inclusive of:

Steel capped boots	Long sleeved shirt/long trousers
Gloves	Helmet (optional)
Hearing protection	Safety glasses
	Dust mask (optional)

- Be aware of local conditions, particularly the noise component of mowing. If work is to be undertaken in an area that amplifies the sound or members of the public may be subjected to extensive exposure to noise consider adjusting mowing program to lessen impact.

STARTING

- Refer to the operator's manual for start up operation.
- Move the machine from storage container to an outside area.
- Carry out all inspections.
- Adjust mower height to suit conditions.

OPERATION

- Refer to operator's manual for operating instructions
- Good light is essential for safe, effective mowing.
- Mow up and down slope never across the face of a slope.
- Operator to be aware of traffic movement on access roads, whilst moving between job sites.

CLEANING UP

- Refer to operator's manual for operating instructions.
- Ensure machine is comprehensively cleaned and serviced at the end of usage. (approx. 30min to be set aside)
- Ensure all rubbish is collected for proper disposal.
- Ensure area is left clean and safe.
- Ensure usage time is recorded for charging.

MAINTENANCE

- Refer to operator's manual for operating instructions.
- All maintenance (other than cleaning and fuelling) to be undertaken by workshop staff.

Appendices

OPERATING PROCEDURE - WEIGHBRIDGE OPERATIONS

NAME OF PROCEDURE: **WEIGHBRIDGE OPERATIONS**	
DIVISION: **ENGINEERING SERVICES/WASTE**	PROCESS ID: **ES\W\WD-10**
RESPONSIBLE POSITION:	
REVISION:	ISSUE: **DECEMBER 2002**
RELATED PROCESSES: **ES\W\WD-11, ES\W\WD-12**	

Purpose

To ensure the safe operation of the weighbridge and boom gate

Boundaries

The boundaries for this operation are limited to those activities necessary to ensure safety and security of Council staff and the public.

Team Skills Required

- Manual handling
- Traffic control
- OH&S.
- Working with hand tools
- Working with mechanical plant
- Environmental awareness
- Handling hazardous materials
- Risk analysis
- Appropriate licenses, training and certification
- Plant operators

Team Skills Desirable

- Engineering materials
- Understanding of common law
- First aid certificate

Working References

- Occupational health and safety
- AS 1742.3 Traffic Control Devices For Road And Pedestrian Works
- Plant operator's manuals
- Plant safety policy
- WCC works procedures
- WCC plant safe operating procedures
- EPA requirements

Documentation

- Consultation
- Daily time sheets
- Asset management record
- Work as executed data
- Estimated costs
- Cost dissection numbers
- Traffic management plan
- Pre-construction risk assessment
- EPA management plan

Intervention Level

- As directed

Cost Recording Procedure

It is essential that an accurate assessment of time, materials, plant and labour be recorded to benchmark and establish unit costs. The individual breakdowns are listed on the particular works procedure.

Work Procedure

- Conduct a visual audit to assess any potential hazards and take measures to eliminate or control these.

- Ensure area is signed in accordance with traffic management plan and that all lights, barriers, signs etc are secured and can be easily viewed by the customers.

- Enter the office and disarm the alarm.

- Switch on the modem and log onto the computer.

- Unlock the safe and set up the cash draw.

- Open the gates at the correct start time.

- As vehicle proceeds onto the weighbridge, note the registration number using the television screen and enter it into the computer database.

- Ensure that only one vehicle is on the weighbridge at any one time.

- Determine customer code, and whether it will be a cash or account transaction.

- Ask customer as to the contents of the load and enter information into the computer.

- If required, collect any money charged based on the load type and weight of the material. Provide a receipt if requested.

- If suspicious about load and a vehicle inspection is required, advise the customer in a pleasant and polite manner, and exit the office to proceed to the vehicle. Conduct visual examination, carefully checking under any covering material for any material not allowed in the tip site.

- If any prohibited material is found, inform the customer that they must not enter the tip site, and instruct them how to safely exit the site.

- For vehicles with at tare weight of more than 300kg, determine whether the tare weight is correct. If it is not correct, enter the transaction as a dual weighing process. Advise the customer to return for weighing out.

- When asked, provide clear directions to customers as to areas to proceed for dumping of rubbish.

APPENDICES

OPERATING PROCEDURE – CASH HANDLING PROCEDURE

NAME OF PROCEDURE: **CASH HANDLING PROCEDURE**	
DIVISION: **ENGINEERING SERVICES/WASTE**	PROCESS ID: **ES\W\WD-11**
RESPONSIBLE POSITION:	
REVISION:	ISSUE: **DECEMBER 2002**
RELATED PROCESSES: **ES\W\WE-10**	

Purpose

To ensure that the financial transactions occurring at the waste disposal depots are handled in the best, most efficient method and that the correct income is received.

Boundaries

The boundaries of this operation are restricted to those activities that require the exchange of money between the customer and the weighbridge operator.

Material Options

Materials options are constrained only by availability, training, safety and suitability. They must comply with Council or Australian Standards and not breach any EPA guidelines. If hazardous they must be accompanied by an appropriate Materials Safety Data Sheet (MSDS) and any use is dependent on full safety compliance inclusive of protective clothing, environmental impact assessment and accredited training.

Team Skills Required

- Manual handling
- Traffic control
- OH&S.
- Working with hand tools
- Working with mechanical plant
- Environmental awareness
- Handling hazardous materials
- Risk analysis
- Appropriate licenses, training and certification
- Computer and numeracy skills

Team Skills Desirable

- Engineering materials
- Understanding of common law
- First aid certificate

Working References

- Occupational health and safety
- AS 1742.3 Traffic Control Devices For Road And Pedestrian Works
- Plant operator's manuals
- Plant safety policy
- WCC works procedures
- WCC plant safe operating procedures
- EPA requirements

Documentation

- Consultation
- Daily time sheets
- Asset management record
- Work as executed data
- Estimated costs
- Cost dissection numbers
- Traffic management plan
- Pre-construction risk assessment
- EPA management plan

Intervention Level

- HP (supervisor approval necessary to extend works as directed)
- As directed

Cost Recording Procedure

It is essential that an accurate assessment of time, materials, plant and labour be recorded to benchmark and establish unit costs. The individual breakdowns are listed on the particular works procedure.

Work Procedures

- Open weighbridge and use password to log onto computer and printer
- If the computer is not operational make a diary entry and notify waste support officer and use the manual ticket system until computer problem has been rectified.
- Remove float from safe and place in cash draw
- Ensure that the camera's and boom gate are operational and if not make diary entry and notify waste support officer.
- Ensure an adequate supply of manual or printed receipts.
- When a customer arrives enter customer details as per weighbridge procedure.
- If the customer elects to pay by cash, ensure correct change is given and give customer receipt for transaction.

- If the customer elects to pay with cheque, determine if it will be for single or multiple loads. If the cheque is for a single load, supply customer with a receipt. If the customer supplies a signed blank cheque for multiple loads, ensure all receipts are pinned to the blank cheque and at the end of the multiple loads the total is tallied and that the customer is suppled with a final receipt.

- Balance receipts with cash, cheques and account customers. Separate following days float from takings.

- Secure float and takings in safe.

APPENDICES

OPERATING PROCEDURE - END OF DAY PROCEDURES

NAME OF PROCEDURE: **END OF DAY PROCEDURES**	
DIVISION: **ENGINEERING SERVICES/WASTE**	PROCESS ID: **ES\W\WD-13**
RESPONSIBLE POSITION:	
REVISION:	ISSUE: **DECEMBER 2002**
RELATED PROCESSES: **ES\W\WD-10, ES\W\WD-11, ES\W\WD-12**	

Purpose

To ensure safety and security through the attention to detail of work sites at day's end.

Boundaries

The boundaries for this operation are limited to those activities necessary to ensure safety and security of Council work sites

Material Options

Materials options are constrained only by availability, training, safety and suitability. They must comply with Council or Australian Standards and not breach any EPA guidelines. If hazardous they must be accompanied by an appropriate Materials Safety Data Sheet (MSDS) and any use is dependent on full safety compliance inclusive of protective clothing, environmental impact assessment and accredited training.

Team Skills Required

- Manual handling
- Traffic control
- OH&S.
- Working with hand tools
- Working with mechanical plant
- Environmental awareness
- Handling hazardous materials
- Risk analysis
- Appropriate licenses, training and certification
- Plant operators

Team Skills Desirable

- Engineering materials
- Understanding of common law
- First aid level certificate

Working References

- Occupational health and safety
- AS 1742.3 Traffic Control Devices For Road And Pedestrian Works
- Plant operator's manuals
- Plant safety policy
- WCC works procedures
- WCC plant safe operating procedures
- EPA requirements

Documentation

- Consultation

- Daily time sheets
- Asset management record
- Work as executed data
- Estimated costs
- Cost dissection numbers
- Traffic management plan
- Pre-construction risk assessment
- EPA management plan

Intervention Level

- HP (supervisor approval necessary to extend works as directed)
- As directed

Cost Recording Procedure

It is essential that an accurate assessment of time, materials, plant and labour be recorded to benchmark and establish unit costs. The individual breakdowns are listed on the particular works procedure.

Work Procedures

Weighbridge

- Conduct a visual audit to assess any potential hazards and take measures to eliminate, or control them.

- Inform supervisor of any changes to plan or other information that impacts on the job.

- Adherence to the works procedure "depot security" should be followed if working back or the last one to leave the depot. If finishing on site then an adaptation of this should be followed.

- Consider weather conditions and take appropriate action to negate potential problems.

- Ensure area is signed in accordance with traffic management plan and that all lights, barriers, signs etc are secured to prevent being tipped over by the wind or other cause. This inspection must be recorded in your diary and on the traffic management documentation

Plant Operators

- Conduct a visual audit to assess any potential hazards and take measures to eliminate, or control them.

- Ensure area is signed in accordance with traffic management plan and that all lights, barriers, signs etc are secured to prevent being tipped over by the wind or other cause. This inspection must be recorded in your diary and on the traffic management documentation.

- If applicable, check that all tools and equipment are cleaned and appropriately secured.

- Ensure all machinery is as secure from vandalism as is possible and correctly stopped and parked in accordance with the stopping and parking requirements as listed in the plant SOPs (ES\W\WD-01 through ES\W\WD-04).

- All loads must be properly secured for transport

- All measuring up and recording of information must be completed and if necessary submitted

- Waste material should be tipped at the appropriate site (remember recycling) unless it is more appropriate to do in the morning. Do not leave heavy loads on the vehicle over night if it can be avoided, as this can be detrimental to vehicle's suspension.

- For the next day, order all necessary plant equipment and materials as required and arrange collection time or delivery.

- If applicable, fuel all vehicles and park in a manner that will allow their quick and easy removal in case of use in an out of hours-emergency situation.

- Inform supervisor of any changes to plan or other information that impacts on the job.

- Adherence to the works procedure “depot security” should be followed if working back or the last one to leave the depot. If finishing on site then an adaptation of this should be followed.

- Consider weather conditions and take appropriate action to negate potential problems.

Appendices

OPERATING PROCEDURE – USE OF HEBICIDES

NAME OF PROCEDURE: **USE OF HERBICIDES**	
DIVISION: **ENGINEERING SERVICES/WASTE**	PROCESS ID: **ES\W\WD-14**
RESPONSIBLE POSITION:	
REVISION:	ISSUE: **DECEMBER 2002**
RELATED PROCESSES:	

Purpose

To provide an aesthetically pleasing waste depot by controlling weeds, via the use of a herbicide.

Boundaries

The boundaries for this operation are limited to those activities necessary to ensure adequate cleanliness of the waste depot, while ensuring the safety of the crew, public and environment. The extent of the process is from determining the boundary of task and storage of equipment after cleaning.

Equipment Required

- Correct PPE (Gloves, sun hat, sunscreen, safety goggles, high-visibility clothing and face mask)
- Herbicide (**Roundup**)
- Water
- Container

Material Options

Materials options are constrained only by availability, training, safety and suitability. They must comply with Council or Australian Standards and not breach any EPA guidelines. If hazardous they must be accompanied by an appropriate Materials Safety Data Sheet (MSDS) and any use is dependent on full safety compliance inclusive of protective clothing, environmental impact assessment and accredited training.

Team Skills Required

- Manual handling
- Traffic control
- OH&S.
- Working with hand tools
- Working with mechanical plant
- Environmental awareness
- Handling hazardous materials
- Risk analysis
- Appropriate licenses, training and certification
- Plant operators

Team Skills Desirable

- Engineering materials
- Understanding of common law
- First aid certificate

Working References

- Occupational health and safety
- AS 1742.3 Traffic Control Devices For Road And Pedestrian Works
- Plant operator's manuals
- Plant safety policy
- WCC works procedures
- WCC plant safe operating procedures
- EPA requirements

Documentation

- Consultation

- Daily time sheets
- Asset management record
- Work as executed data
- Estimated costs
- Cost dissection numbers
- Traffic management plan
- Pre-construction risk assessment
- EPA management plan

Intervention Level

- HP (supervisor approval necessary to extend works as directed)
- As directed

Cost Recording Procedure

It is essential that an accurate assessment of time, materials, plant and labour be recorded to benchmark and establish unit costs. The individual breakdowns are listed on the particular works procedure.

Work Procedures

- When using Herbicide adhere to manufacturer directions for usage, safety directions, first aid, storage and disposal.

- Ensure that there is sufficient crew to perform the tasks satisfactorily.
-
- Herbicide (**Roundup**) is only mixed up as required in the correct ratios as instructed on the container by the manufacturer.

- Herbicide is placed into container.

- Herbicide is spot sprayed on any weeds forming in cracks in the pavement and around edges.
-
- During windy or rainy weather, herbicide is not to be used.
-
- Correct PPE must be worn and used, including facemasks, when mixing and applying the poison.
-
- If in any doubt stop and ask for clarification from your supervisor before proceeding.
-

Appendices

OPERATING PROCEDURE – VISITOR INDUCTION

NAME OF PROCEDURE: **VISITOR INDUCTION**	
DIVISION: **ENGINEERING SERVICES/WASTE**	PROCESS ID: **ES\W\WD-15**
RESPONSIBLE POSITION:	
REVISION:	ISSUE: **DECEMBER 2002**
RELATED PROCESSES:	

Purpose

To minimise risk and dangers associated with visitors operating within Wollongong City Council's waste disposal depots by inducting them to the site and potential hazards.

Boundaries

The boundaries for this operation are limited to those activities necessary to ensure adequate induction and instruction of visitors to the waste disposal depots.

Equipment Required

- Correct PPE (Gloves, sun hat, sunscreen, safety goggles, high-visibility clothing and face mask)

Material Options

Materials options are constrained only by availability, training, safety and suitability. They must comply with Council or Australian Standards and not breach any EPA guidelines. If hazardous they must be accompanied by an appropriate Materials Safety Data Sheet (MSDS) and any use is dependent on full safety compliance inclusive of protective clothing, environmental impact assessment and accredited training.

Team Skills Required

- Manual handling
- Traffic control
- OH&S.
- Working with hand tools
- Working with mechanical plant
- Environmental awareness
- Handling hazardous materials
- Risk analysis
- Appropriate licenses, training and certification
- Plant operators

Team Skills Desirable

- Engineering materials
- Understanding of common law
- First aid certificate

Working References

- Occupational health and safety
- AS 1742.3 Traffic Control Devices For Road And Pedestrian Works
- Plant operator's manuals
- Plant safety policy
- WCC works procedures
- WCC plant safe operating procedures
- EPA requirements

Documentation

- Consultation

- Daily time sheets
- Asset management record
- Work as executed data
- Estimated costs
- Cost dissection numbers
- Traffic management plan
- Pre-construction risk assessment
- EPA management plan

Intervention Level

- HP (supervisor approval necessary to extend works as directed)
- As directed

Cost Recording Procedure

It is essential that an accurate assessment of time, materials, plant and labour be recorded to benchmark and establish unit costs. The individual breakdowns are listed on the particular works procedure.

Work Procedures

- Vehicle enters the Waste Depot and visitor asks for advice or instructions from the gate keeper.

- A determination is made as to whether the visitor wishes to go to either the scrap steel area or to the green waste area.

- If the visitor wishes to go to the scrap steel area, the SWERF Facility or the Green Waste Area the gatekeeper will advice on the direction to take and contact the appropriate person and alert them to the visitors impending arrival.

SWERF – Direct to gates and intercom
Green Waste Soil Co – Site Person Steve
Metal Recyclers Metal Corp – Site Person Mark

- If the request is to travel elsewhere within the Waste Disposal Depot it is necessary to determine if the person is required to carry out work inspections, visiting staff or site for council, before directing them to the designated parking area to await for induction and instruction.

- The weighbridge attendant is to personally induct or request another member of staff to induct visitor.

Appendices

OPERATING PROCEDURE - COMPACTOR TIP FACE OPERATIONS

NAME OF PROCEDURE: **COMPACTOR TIP FACE OPERATIONS**	
DIVISION: **ENGINEERING SERVICES/WASTE**	PROCESS ID: **ES\W\WD-04**
RESPONSIBLE POSITION:	
REVISION:	ISSUE: **DECEMBER 2002**
RELATED PROCESSES:	

Purpose

To ensure the efficient compaction of tipped rubbish while guaranteeing maximum safety for employees and public

Boundaries

The boundaries for this operation are limited to those activities necessary to ensure safety of Council employees and members of the public during the compaction of rubbish at the tip face.

Equipment Options

Equipment options are inclusive of all Council plant and equipment as well as any other equipment deemed necessary, which can be dry-hired or supplied by contract. This area is constrained only by availability, suitability, training and safety.

Materials Options

Materials options are constrained only by availability, training, safety and suitability. They must comply with Council or Australian standards and not breach any EPA guidelines. If hazardous they must be accompanied by an appropriate Materials Safety Data Sheet (MSDS) and any use is dependent on full safety compliance inclusive of protective clothing, environmental impact assessment and accredited training.

Team Skills Required

- Manual handling
- Traffic control
- OH&S.
- Working with hand tools
- Working with mechanical plant
- Environmental awareness
- Handling hazardous materials
- Risk analysis
- Appropriate licenses, training and certification
- Plant operators

Team Skills Desirable

- Engineering materials
- Understanding of common law
- First aid certificate

Working References

- Occupational health and safety
- AS 1742.3 Traffic Control Devices For Road And Pedestrian Works
- Plant operator's manuals
- Plant safety policy
- WCC works procedures
- WCC plant safe operating procedures
- EPA requirements

Documentation

- Consultation
- Daily time sheets
- Asset management record
- Work as executed data
- Estimated costs
- Cost dissection numbers
- Traffic management plan
- Pre-construction risk assessment
- EPA management plan

Intervention Level

- HP (supervisor's approval necessary to extend works)
- As directed

Cost Recording Procedure

It is essential that an accurate assessment of time, materials, plant and labour be recorded to benchmark and establish unit costs. The individual breakdowns are listed on the particular works procedure.

Work Procedure

- Complete all plant safety checks and ensure that machine is in proper working order.

- Proceed to tip face

- Identify potential hazards, such as fire or lack of traffic control.

- Compactor to continuously spread & compact received garbage to ensure even amounts of waste are placed to best optimise odour control, wind blown litter and compaction of waste in layers, approx 0.3m thick.

- Construct compaction area of no wider than 50m x 2½ times compactor width in 3 x 1m layers to finish at a level, approx 3m high.

- Exposed face to be constructed to a slope by building garbage up in layers of 1m, stepping in 1m for next 1m lift and so on to finished level. First layer to have longitudinal edge compacted at 45° (to provide access for loader for the placement of cover material) and ramping one end for compactor and loader access.

Safety Procedures

- Operate at slow speed when working at tip face.
- Travel no closer than 2m to other vehicles.
- Ensure at all times no vehicles are at rear of machine, check rear-vision mirrors when reversing.

Appendices

OPERATING PROCEDURE - LOADER TIP FACE OPERATIONS

NAME OF PROCEDURE: **LOADER TIP FACE OPERATIONS**	
DIVISION: **ENGINEERING SERVICES/WASTE**	PROCESS ID: **ES\W\WD-03**
RESPONSIBLE POSITION:	
REVISION:	ISSUE: **DECEMBER 2002**
RELATED PROCESSES:	

Purpose

To ensure the efficient compaction of tipped rubbish while guaranteeing maximum safety for employees and public

Boundaries

The boundaries for this operation are limited to those activities necessary to ensure safety of Council employees and members of the public during the compaction of rubbish at the tip face.

Equipment Options

Equipment options are inclusive of all Council plant and equipment as well as any other equipment deemed necessary, which can be dry-hired or supplied by contract. This area is constrained only by availability, suitability, training and safety.

Materials Options

Materials options are constrained only by availability, training, safety and suitability. They must comply with Council or Australian standards and not breach any EPA guidelines. If hazardous they must be accompanied by an appropriate Materials Safety Data Sheet (MSDS) and any use is dependent on full safety compliance inclusive of protective clothing, environmental impact assessment and accredited training.

Team Skills Required

- Manual handling
- Traffic control
- OH&S.
- Working with hand tools
- Working with mechanical plant
- Environmental awareness
- Handling hazardous materials
- Risk analysis
- Appropriate licenses, training and certification
- Plant operators

Team Skills Desirable

- Engineering materials
- Understanding of common law
- First aid certificate

Working References

- Occupational health and safety
- AS 1742.3 Traffic Control Devices For Road And Pedestrian Works
- Plant operator's manuals
- Plant safety policy
- WCC works procedures
- WCC plant safe operating procedures
- EPA requirements

Documentation

- Consultation
- Daily time sheets
- Asset management record
- Work as executed data
- Estimated costs
- Cost dissection numbers
- Traffic management plan
- Pre-construction risk assessment
- EPA management plan

Intervention Level

- HP (supervisor's approval necessary to extend works)
- As directed

Cost Recording Procedure

It is essential that an accurate assessment of time, materials, plant and labour be recorded to benchmark and establish unit costs. The individual breakdowns are listed on the particular works procedure.

Work Procedure

- Complete all plant safety checks and ensure that machine is in proper working order before proceeding to the tip face.

- Identify potential hazards, such as fire or lack of traffic control.

- Push waste at tip face to compactor continually to ensure even amounts of waste are placed to best optimise odour control, wind blown litter and compaction of waste in layers, approx 300mm thick. Ensure that inappropriately placed garbage is moved to the tip face.

- Construct tipping area no wider than 50 metres.

- Place drainage sand where necessary, to a thickness of 500mm, making sure not to damage the liner.

- If cover material is required, place 150mm thickness.

- Special waste (such as animal carcasses) should be placed at a prepared location.

- Clean fill may be tipped on an unlined section of the tip and shall have a bund wall or final cover constructed.

- Any persons found scavenging at the tip shall be informed that it is an illegal act and shall be dealt with appropriately if they persist.

- When existing compacted area reaches finished level, all traffic should be diverted to the next predetermined tipping area. Set out the new boundary using tyres and place signs appropriately.

- When shift is complete, make sure that the tip face is clean and that all garbage has been buried, compacted and covered with appropriate covering material to EPA regulations.

- Task complete.

Safety Procedures

- Operate at slow speed when working at tip face.

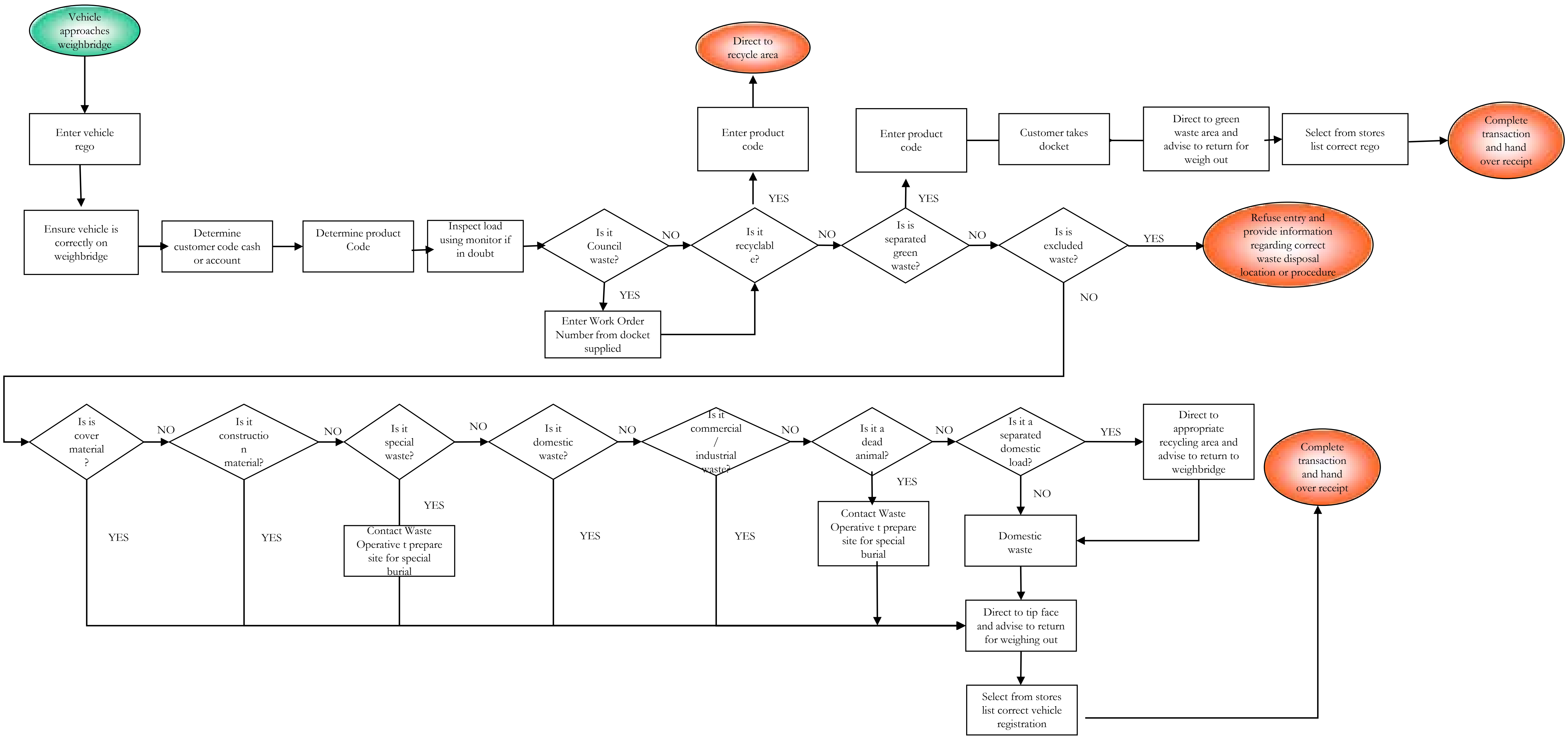
- Travel no closer than 2 metres to other vehicles.

- Ensure that at all times no vehicles are at rear of machine, check rear-vision mirrors when reversing.

Appendices

WEIGHBRIDGE – Identifying incoming waste & determining product code PROCEDURE

PROCESS ID: ES\W\WD-10A



PROCEDURE SHEET FOR FIRES AT COUNCIL'S RESOURCE RECOVERY CENTRE

The following are steps to be taken in case of fire:

Please Remember

All RESOUCE RECOVERY CENTER'S (RRC) fires are to be treated as toxic and potentially dangerous.

IN THE INSTANCES OF FIRES, ALL DESIGNATED STAFF WORKING IN THE VICINITY OF THE TIP FIRE SHALL ACTIVATE THEIR PORTABLE BREATHING APPARATUS AND WEAR THEIR PROTECTIVE CLOTHING

THE FOLLOWING STEPS ARE TO BE CARRIED OUT

1 The Leading Hand (RRC) will assume control of all actions and decisions until the arrival of a Supervisor.

2 The Leading Hand will ensure the nearest Fire Brigade is contacted (through 000) and appropriate Supervisor notified.
Whytes Gully (000 details nearest cross road West Dapto Rd & Reddalls Rd and right turn at Resource Recovery Centre sign)
Hellensburgh (000 details , Bottom end of Parkes St, right Into Halls Rd, then Right Into Nixon Place)

3 The entry gate will be closed immediately, and the public will be asked to vacate the RRC. All staff will be moved to a safe location.

4 All RRC staff available and not engaged in actual fire fighting will be used to control the movement of the public.

5 The Leading Hand/Supervisor will liaise with the attending Fire Brigade who on arrival will take control of fire fighting duties. **Whytes Gully RRC** (Closest Hydrant West Dapto Rd south of Reddalls Rd at Rail Crossing West side) **Helensburgh RRC** (Closest Hydrant, Gardners Place, turn right at Halls Rd then left into Gardners Place)

6 In the event of a request from the attending Fire Brigade for the provision of Plant/Equipment for fire fighting purposes, the Leading Hand/Supervisor is to arrange for the supply of such items.

7 At the conclusion of the fire fighting activities, and after consultation with the attending Fire Brigade Officers, the Leading Hand/Supervisor will decide as to when the RRC is ready to be reopened to the public.

8 The Supervisor will contact the Manager Waste Services to arrange for any necessary media releases and the notification to DCC.

COMPACTOR TRUCK FIRES/TRAILER FIRES

These fires are to be treated as toxic and potentially dangerous and the following procedures should be adopted.

1 The Gatekeeper/Leading hand shall direct the vehicle to an appropriate location away from the tip face. (Consideration being given to wind, public & ability for best fire control)

2 The Leading Hand will ensure the nearest Fire Brigade (through 000) is notified and activate his portable breathing apparatus and supervise the discharge of the load.

3 After assessment by the RRC Leading Hand, the load on fire will be attempted to be smothered with cover material using RRC machinery. The operator of any machinery in this situation will be required to wear breathing apparatus and suitable protective clothing.

NOTE:

At all times the attending Fire Brigade will take control of Fire Fighting activities.

******

10 July 1995
ES.IKF/GS

WOLLONGONG CITY COUNCIL
DAILY SITE INSPECTION SHEET
Tip Face

WOLLONGONG
City of Innovation

DATE ________________________ Name(conducting inspection) ____________________________

Indicate in the following manner:

✓ **Acceptable** ✗ **Not Acceptable** ***N/A*** **Not Applicable** ***N/C*** **Not Checked**

- Rectify any actions required if safe to do so.
- Document the problem and action taken on this inspection sheet.
- Record and report outstanding actions to Leading Hand for further consideration.

TIP FACE CONTROL		ACTION REQ'D
• Work area free from rubbish & obstructions (ie reinforcement/puncture)	☐	☐
• Clear and safe entry and exit from the tip face and transfer stations	☐	☐
• Signage and devices erected according to the traffic control plan	☐	☐
• Traffic signs uncovered and in correct place	☐	☐
• Dust Controls in place	☐	☐
• Appropriate barricades, in place	☐	☐
• Transfer station block clearly painted and in place	☐	☐
• Transfer station barricades in place	☐	☐
• Check for general faults or safety issues	☐	☐

ACTIONS

____

____

____

____

____

Signed ________________________________ **Dated** __________________

Z11/121137

WOLLONGONG CITY COUNCIL
DAILY SITE INSPECTION SHEET
Leachate Ponds; Ammonia Plant; Settling Ponds and Weighbridge

WOLLONGONG
City of Innovation

DATE ______________________ Name(conducting inspection) __________________________

Indicate in the following manner:

✓ **Acceptable** ✗ **Not Acceptable** ***N/A*** **Not Applicable** ***N/C*** **Not Checked**

- Rectify any actions required if safe to do so.
- Document the problem and action taken on this inspection sheet.
- Record and report outstanding actions to Leading Hand for further consideration.

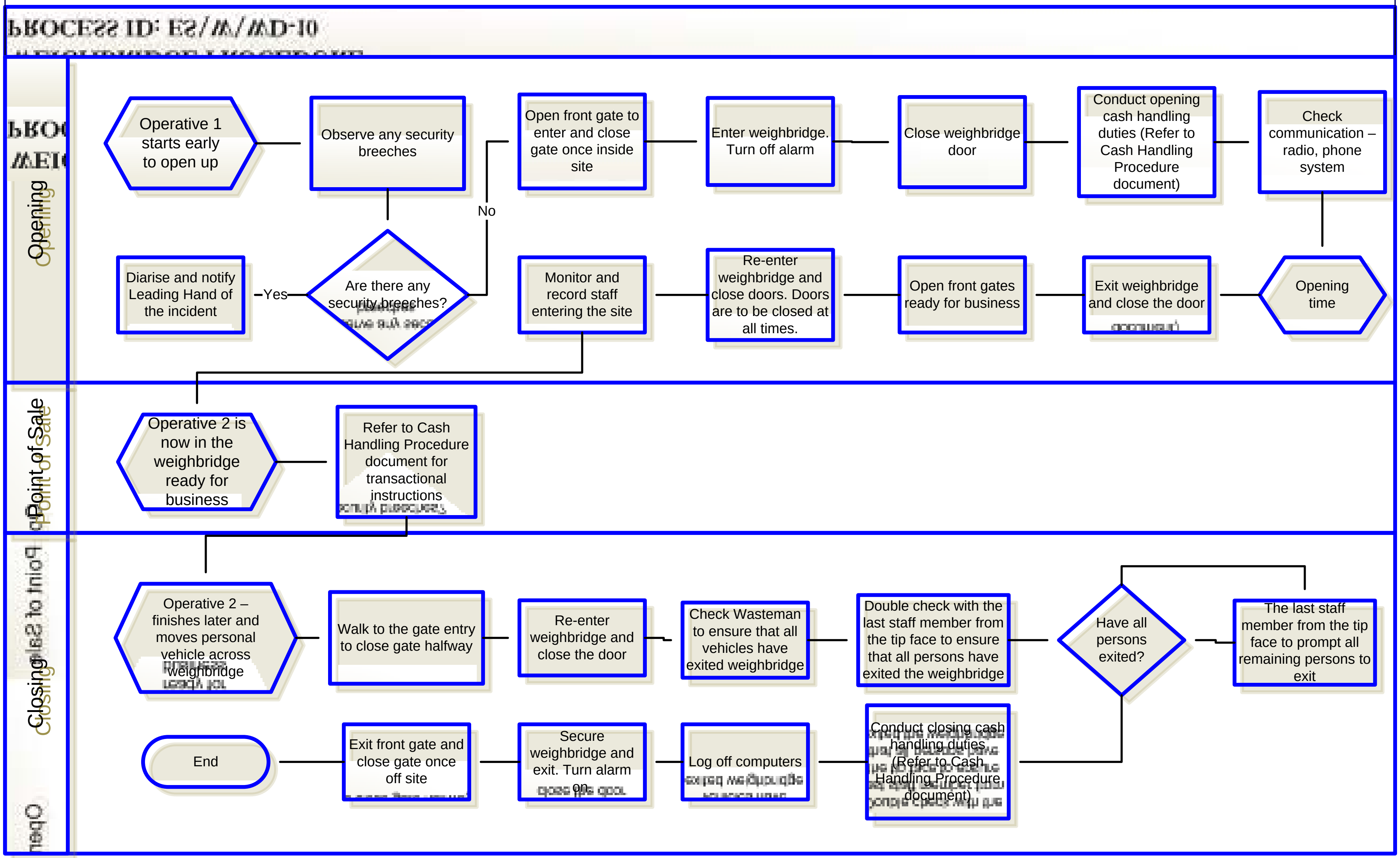
LEACHATE PONDS INSPECTION			ACTION REQ'D
• Inspect fencing and gates for damage or illegal entry	☐		☐
• Inspect aerators for funtionalilty	☐		☐
• Inspect suction pump is operational	☐		☐
• Check leachate ponds level, report if at high levels	☐		☐
• Record daily Flow metre reading litre/second accumulative and in to ponds. • compile weekly report each Sunday	☐	Litre/Sec ________ Volume ________	☐
• Visual inspection for extensive foaming	☐		☐
• Leachate pit not overflowing	☐		☐
AMMONIA PLANT INSPECTION			
• Visual inspection for foam and solids overflow	☐		☐
• Meter reading Leachate to Sewer	☐	Volume ________ Time ________	☐
• Filter bin not overflowing, geotube in place	☐		☐
• SBR Ammonia Plant free of excessive foam	☐		☐
SETTLING PONDS			
• Inspection for overflow after rain at pit outlet to creek	☐		☐
• Meter reading Leachate to Sewer	☐		☐
• Ponds not overflowing	☐		☐
• Ponds free of excessive foam	☐		☐
WEIGHBRIDGE INSPECTION			
• Check 2 way radios, all plant and equipment	☐		☐
• Check function of traffic control devices eg lights & boomgates.	☐		☐
• Check for general faults or safety issues	☐		☐

(Continued Next Page)

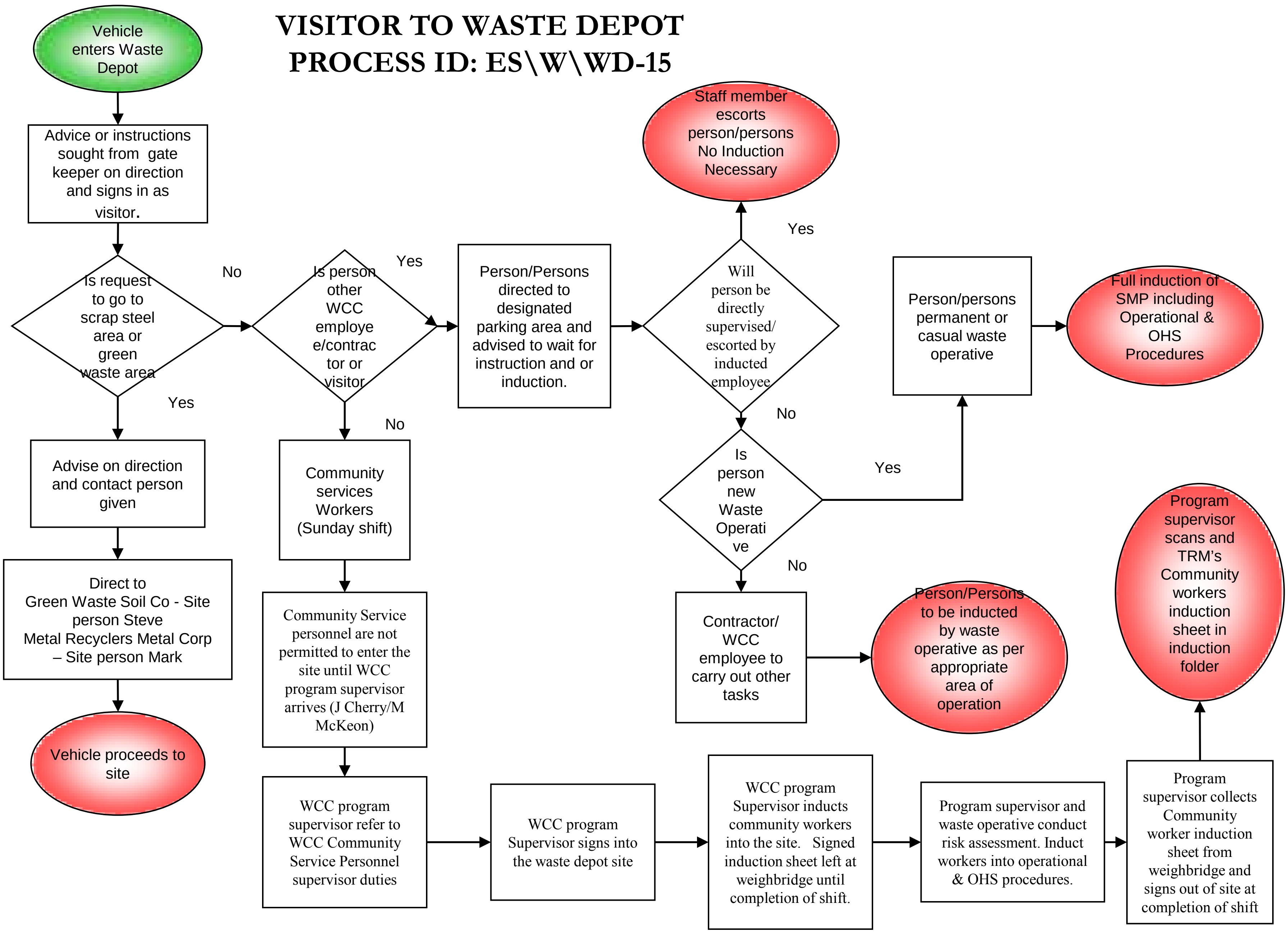
ACTIONS

Signed________________________________Date__________________

WEIGHBRIDGE PROCEDURE
PROCESS ID: ES\W\WD-10



VISITOR TO WASTE DEPOT
PROCESS ID: ES\W\WD-15



APPENDIX I

Whytes Gully New Landfill Cell Preliminary Design Report and Whytes Gully Resource Recovery Park Detailed Design Report – Tender Packages 1, 2 and 3

REPORT

29 June 2013

WHYTES GULLY RESOURCE RECOVERY PARK

Detailed Design Report - Tender Packages 1, 2 and 3

Submitted to:
Wollongong City Council

Report Number. 117625003_224_R_Rev0

Distribution:

Wollongong City Council

Golder Associates

Table of Contents

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

1.1 Report Objective

This detailed design report has been prepared on behalf of Wollongong City Council and presents the detailed design for a portion of the proposed New Landfill Cell expansion project at the Whytes Gully Resource Recovery Park (RRP) near Kembla Grange, NSW.

This report presents the detailed design that has been undertaken subsequent to the preliminary (50%) design. The preliminary design was presented in the Preliminary Design Report: "Report for Preliminary Design," Golder Associates, April 2012. The Preliminary Design Report sets out the design approach, relevant guidelines and design parameters for the project.

This report indicates how the preliminary design has been progressed to detailed design. Details of modelling and analysis undertaken for detailed design are provided in appendices to this report.

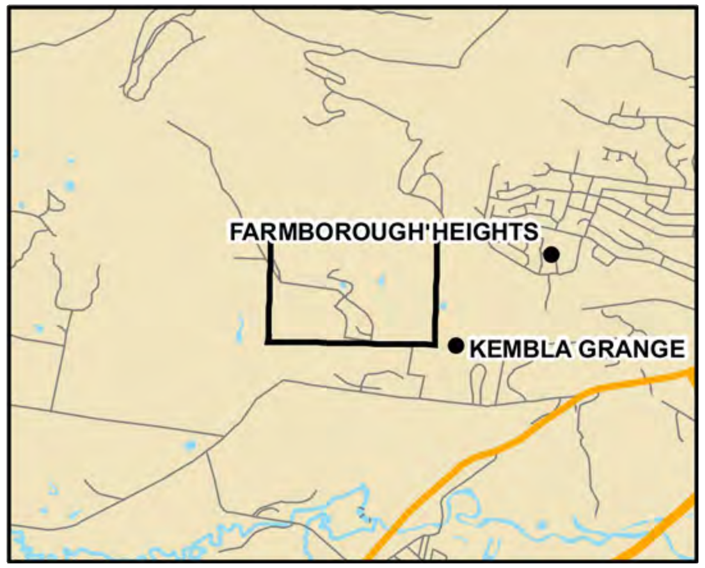
1.2 Layout and Extent of Detailed Design

The detailed design has been prepared for the first portion of the New Landfill Cell project that is planned for construction. This portion comprises approximately 10ha of new landfill liner, with associated earthworks and surface water management components, and will provide more than one million cubic metres of landfill storage volume (airspace). This represents roughly 20% to 30%of the entire New Landfill Cell Project, presented in the Preliminary Design Report as having a total new landfill liner area of 35ha and approximately six million cubic metres of landfill airspace volume.

The detailed design has been developed to provide for three sequential episodes of construction, referred to as Tender Packages 1, 2 and 3, with Tender Package 1 organised into sub-packages 1A and 1B. The general location of works for each of the tender packages is indicated in Figure 1. Tender Packages 1, 2 and 3 occupy areas within with project Stage 1 and Stage 2B as identified in the Preliminary Design Report. The basis for the layout and extent of each tender package is outlined in the table below.

Table 1: Construction Areas for Tender Packages 1, 2 and 3

Tender Package No.	Landfill Liner Area (ha)	Approx. Filling Time (years)	Location / Layout (refer Figure 1)
1A	2.6	1	Cell base liner area below the toe of the existing Eastern Gully landfill and piggy back liner area on the lower portion of the existing southwest-facing Eastern Gully landfill slope. This configuration provides a favourable ratio of landfill airspace to cell base liner area. The cell base liner area is relatively narrow to allow use of the existing landfill access road during Tender Package 1A and 1B construction. Note: Tender Package 1A, as the initial portion of the New Landfill Cell project, also includes significant works for of surface water diversion/management, replacement of existing leachate collection pipes, and road construction.
1B	3.4	1 to 2	Extension of the piggy back liner area of Package 1A into the upper portion of the existing southwest-facing Eastern Gully landfill slope.
2	1.9	2 to 3	Extension of Tender Package 1A into the area below the toe of the existing Western Gully landfill (cell base liner) and onto a small area of the existing south-facing Western Gully landfill slope (piggy back liner). The existing landfill access road will be removed by Tender Package 2 construction; therefore, construction will be preceded by development of an alternate landfill access road, separate to this report. Installation of additional leachate collection measures for the existing Western Gully landfill is also expected prior to construction, separate to this report.
3	2.4	2 to 3	Westward extension of Tender Package 2 cell base liner area. The surface water diversion on the Western Gully landfill will be blocked by this construction; therefore, construction will be preceded by development of an alternate drainage path, separate to this report.



SITE LOCALITY
SCALE N.T.S.

LEGEND

- PROPERTY BOUNDARY
- WORKS AREA BOUNDARY
- EXTENT OF EXISTING LINER (REFER NOTE 1)
- APPROXIMATE EXTENT OF EXISTING WASTE (REFER NOTE 2)
- EXTENT OF PACKAGE 1A LINER WORKS
- EXTENT OF PACKAGE 1B LINER WORKS
- EXTENT OF PACKAGE 2 LINER WORKS
- EXTENT OF PACKAGE 3 LINER WORKS

NOTES:

1. EXTENT OF LINER IN EASTERN GULLY BASED ON "PACIFIC LINING CO. AUSTRALIA PTY. LTD PDF DRAWINGS 267 / 1 DATED NOV. 1996 AND 287 / 1 DATED MAY 1998"; "WOLLONGONG CITY COUNCIL AS BUILT SURVEY FOR HDPE LINER ON EASTERN GULLY LANDFILL, CADD DRAWING 'WHYTES GULLY 3D', RECEIVED 09-11-2011"; AND "K.F. WILLIAMS & ASSOCIATES PTY. LTD CADD DRAWING SV01 REV B DATED 26-07-2011".
2. APPROX. EXTENT OF WASTE BASED PRIMARILY ON SITE OBSERVATION AND INFORMATION FROM COUNCIL.
3. SITE FEATURES CURRENT AT 2011

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

0 80 160 240m

1:4,000

SOURCES:

- HISTORIC LOCATIONS DIGITISED BY GOLDER FROM REPORTS SUPPLIED BY WOLLONGONG CITY COUNCIL
- BASE DRAWING TAKEN FROM K F WILLIAMS AND ASSOCIATES DRG.WHYTES PHOTOGRAMMETRY AND GROUND SURVEY 20-07-11.dxf DATED 20 JULY 2011
- COORDINATE SYSTEM GDA 1994 MGA ZONE 56

Golder Associates
www.golder.com
GOLDER ASSOCIATES PTY. LTD.

CLIENT: WOLLONGONG CITY COUNCIL		PROJECT: WHYTES GULLY LANDFILL CELL - DETAILED DESIGN	
DRAWN BY: EJJ	DATE: 13.06.2013	DRAWING TITLE: EXTENT OF LINING WORKS TENDER PACKAGES 1A,1B, 2 & 3	
CHECKED BY: KAD	DATE: 13.06.2013		
SCALE: 1:4,000	SHEET SIZE: A3	PROJECT No: 117625003 / DOC No: 224 / DOC TYPE: R / FIGURE No: F001 / REVISION: 0	FIGURE 1

Plot Date: 13 June 2013 Time:4:49:14 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\FIGURES - File Name:117625003-224-R-F001-REV0.dwg
Xref: 117625003-XREF-Imagery - AAM May 2011.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOIUNDARY.dwg; GAP_LOGO-A3.dwg; 117625003-XREF-WORKS AREA - PACKAGE3.dwg; Whytes-Gully_16052011_10cm.jpg;

The detailed design presents information for construction of landfill liner areas and associated works for Tender Packages 1, 2 and 3 but does not cover detailed landfill filling/operation requirements or detailed capping system design. These items are to be addressed in the future.

The detailed design does not include the “Eastern Waste Cutback,” which comprises a significant relocation of waste from the existing Eastern Gully Landfill (see Section 5.2 of the Preliminary Design Report). The purpose of the Eastern Waste Cutback is to provide a surface water drainage channel along the eastern edge of the project when existing drainage paths become unavailable due to New Landfill Cell construction. The areas selected for construction of Tender Packages 1, 2 and 3 allow ongoing surface water drainage during construction of Tender Package 1 and 2 (and potentially Tender Package 3) and allow the Eastern Waste Cutback to be deferred to a later design stage.

1.3 Detailed Design Documents

The detailed design for Tender Packages 1, 2 and 3 comprises the items presented in the table below.

Table 2: Detailed Design Documents for Tender Packages 1, 2 and 3

Document	Description	Location
Detailed Design Documents		
Detailed Design Report	Presents and describes detailed design information. To be read in conjunction with the Preliminary Design Report	this report
Detailed Design Drawings	Detailed engineering drawings (“for construction” status):	
	Tender Package 1 – 36 sheets; Drawing numbers D1001 to D1072	Appendix A-1
	Tender Package 2 – 21 sheets; Drawing numbers D2001 to D2071	Appendix A-2
	Tender Package 3 – 18 sheets; Drawing numbers D3001 to D3053	Appendix A-3
Technical Specification for Detailed Design	Specifications for landfill construction materials and construction works, including reporting and Construction Quality Assurance (CQA) requirements :	
	Tender Package 1	Appendix B-1
	Tender Package 2	Appendix B-2
	Tender Package 3	Appendix B-3
Supporting Documents - appended to this report		
Addendum to April 2012 Interpretative Geotechnical Investigation Report for 50% Design	Detailed slope stability and settlement calculations: Tender Packages 1, 2 and 3	
	Technical Memorandum (No. 214): Slope Stability Assessment, May 2013. Slope stability analysis for detailed design including interim waste slopes.	Appendix C-1
	Technical Memorandum (No. 248): Settlement Load Test- Analysis Report, May 2013. Back analysis of waste settlement parameters.	Appendix C-2
	Technical Memorandum (No. 255): Settlement Analysis for Piggy Back Liner at Eastern Gully, May 2013. Settlement analysis for detailed design.	Appendix C-3
	Technical Memorandum (No. 256): Settlement Analysis for Piggy Back Liner- Soft Spots, May 2013. Settlement analysis for detailed design.	Appendix C-4
Addendum to March 2012 Hydrogeological	Technical memorandum (No. 211): Groundwater Contours- Reasonable Maximum Unconfined Water	Appendix D

Document	Description	Location
Investigation Report.	Table Surface, Dec 2012. Presents updated water table levels within landfill cell base liner areas.	
Leachate Collection System Design	Technical memorandum (No. 227): Leachate Collection, May 2013. Leachate pipe and drainage material sizing and spacing calculations for detailed design.	Appendix E
Leachate Generation and Water Balance Modelling	Technical memorandum (No. 250): Leachate Generation and Water Balance Modelling, May 2013. Leachate generation calculations related to landfill development with Tender Packages 1, 2 and 3.	Appendix F
Surface Water Design	Technical memorandum (No. 233): Drainage Design, March 2013. Surface water drainage approach and calculations for detailed design.	Appendix G
International Peer Review	Review letters from international peer reviewer	Appendix H

1.4 Report Overview

This report provides detailed design information for Tender Packages 1, 2 and 3 (refer Sections 1.2 and 1.3). This report should be read in conjunction with the April 2012 Preliminary Design Report which sets out the overall design approach, relevant guidelines and design parameters for the New Landfill Cell project.

The remainder of this report is organised into the following chapters, each corresponding to an area where significant work has been undertaken in advancing the design from preliminary to detailed status:

- Slope Stability;
- Piggy Back Liner Design;
- Cell Base Liner Design;
- Leachate Collection;
- Landfill Gas Extraction;
- Surface Water; and
- Construction Quality Management.

Supporting information is provided in the appendices of this report, including results of an international peer review of this report (Appendix H).

2.0 SLOPE STABILITY

2.1 Preliminary Design

Slope stability was identified as a key design issue for the New Landfill Cell project and was addressed in Sections 3.3.6 and 4.8 of the Preliminary Design Report (Golder, April 2012). Factors affecting slope stability include landform geometry, soil stratigraphy, groundwater and leachate levels, existing and new waste characteristics, and design details for the piggy back liner system and cell base liner system.

The Preliminary Design Report presented slope stability analyses for the proposed final landform slopes which demonstrated acceptable slope stability factors of safety. The Preliminary Design Report indicated that additional slope stability analyses were to be performed during detailed design to consider interim landfill slopes that will be present at various stages of landfill development (refer below).

2.2 Stability of Interim Landfill Slopes

Analysis Information

Slope stability analyses of interim landfill slopes which will be present during landfill development have been performed for detailed design. The analyses are presented in Appendix C-1. The analyses considered six potentially critical cross sections within the areas of Tender Packages 1, 2 and 3. The analysis methodology and range of loading conditions are the same as considered for the final landfill slopes for the preliminary design.

It was necessary for the slope stability analyses for detailed design to consider certain factors in more detail than had been needed for the analyses for preliminary design. These factors related to subsurface conditions for existing alluvium and colluvium materials underlying interim landfill slopes, assumed shear strength parameters for landfill waste materials, and required minimum shear strength parameters for the piggy back and cell base liners. Refer to Appendix C-1 for details.

The slope stability analyses for detailed design also considered changes in the design levels for the cell base liner subgrade surface from those in the preliminary design. Specifically, subgrade was deepened and flattened in some cell base liner areas within Tender Package 1 in order to achieve acceptable slope stability factors of safety for interim landfill slopes for Tender Package 1. The analyses for detailed design also resulted in changes in the required minimum shear strength parameters for piggy back and cell base liners.

Factors of Safety

Calculated slope stability factors of safety for interim waste slopes along the six selected cross sections within Tender Packages 1, 2 and 3 are presented in the table below, extracted from Appendix C-1.

Table 3: Summary - Interim Slope Stability Analysis Results for Tender Packages 1, 2 and 3

Failure Mechanism	Condition	Target FoS	Calculated FoS Range
Circular through alluvium	Long-term	1.5	1.83 – 2.38
	Short-term	1.3	1.40 – 2.09
	Earthquake	1.0	1.18 – 1.77
Non-circular (sliding) along proposed piggy back and cell base liners at <u>peak</u> strength	Long-term	1.5	1.52 – 1.85
	Earthquake	1.1	1.29 – 1.55
Non-circular (sliding) along proposed piggy back and cell base liners at <u>residual</u> strength	Long-term	1.2	1.22 – 1.47
	Earthquake	1.0	1.03 - 1.21

Based on these analysis results, the target slope stability factors of safety are achieved for interim waste slopes for Tender Packages 1, 2 and 3.

Liner Shear Strength Requirements

The analyses for detailed design resulted in revisions to the required minimum shear strength parameters for materials and interfaces within the piggy back and cell base liners that were presented in Section 4.8 of the Preliminary Design Report. The revised requirements are presented in the table below, extracted from Appendix C-1.

Table 4: Liner Internal and Interface Shear Strength Requirements for Tender Packages 1, 2 and 3

Liner Area	**Minimum Equivalent Shear Strength within Liner System**			
	Peak		**Residual**	
	Drained Friction Angle (Φ')(°)	**Drained Cohesion (c')(kPa)**	**Drained Friction Angle (Φ')(°)**	**Drained Cohesion (c')(kPa)**
Tender Package 1 – Piggy Back Liner Tender Package 1 – Cell Base Liner Tender Package 2 – Cell Base Liner	19	0 14		0
Tender Package 2 – Piggy Back Liner	17	0	7	0
Tender Package 3 – Cell Base Liner	17	0	11	0

These liner shear strength requirements have been adopted within the Technical Specifications for Tender Packages 1, 2 and 3 (Section 2.2.19 in Appendices B-1, B-2, B-3). The Technical Specifications require laboratory testing, comprising interface shear and internal shear strength testing of all liner components, at both material approval and as-delivered stages to demonstrate that liner strength requirements are met.

Interim Slope Angle Requirements

As reported in Appendix C-1, the analyses for detailed design demonstrate that stability of interim waste slopes within Tender Packages 1, 2 and 3 is dependent on the slope of the leading waste face. Specifically, an interim waste slope inclination of 3.5H:1V or flatter is required for the leading (i.e., west and southwest facing) slope that will be formed during waste placement within the Tender Packages 1, 2 and 3 areas. Interim waste slopes that face west-northwest and do not toe out in the cell base liner area may be constructed at an inclination of 3H:1V or flatter.

Golder recommends that these interim waste slope angle requirements are incorporated into the Safety in Design Risk Register for the project and the applicable Landfill Environmental Management Plan and/or other landfill operations plan.

2.3 Piggy Back Liner Construction Stability

Analysis Information

Slope stability analyses for the multi-layer piggy back liner system during landfill construction have been performed for detailed design of Tender Packages 1 and 2 (note: piggy back liner is not present in Tender Package 3). The analyses are presented in Appendix C-1. The potential failure mechanism considered is downslope sliding along a surface within the piggy back liner during an exposure period when there is only a thin layer of soil material placed on the liner. This potential failure mechanism can be referred to as "veneer" stability and was not addressed in the Preliminary Design Report. Refer to Section 3.0 for more information on piggy back liner design components.

Relevant details of the piggy back liner construction stability analyses for detailed design are as below.

- The exposure period for the analyses corresponds to the time interval between placement of the protection material over the liner and overlying landfill waste placement. Golder recommends a maximum value of 1 year for this interval for piggy back liner areas for Tender Packages 1 and 2.

- The analyses considered the range of slope angles included in the piggy back liner subgrade design for Tender Packages 1 and 2. These slopes angles are 3H:1V to 4H:1V or flatter, with locally steeper slopes of 2H:1V in limited areas.
- The analyses considered the potential for pore pressures to develop above the geomembrane component of the liner due to rainwater infiltration and saturation of protection material. This potential is related to site rainfall and the design of the drainage components within the piggy back liner. A maximum saturated thickness of half of the protection material thickness was adopted for the analyses.
- The analyses did not directly consider potential pore pressure from gas and/or perched leachate below the geomembrane. This is based on the gas venting system for the piggy back liner design which is expected to be effective in venting gas and possibly draining leachate from below the piggy back liner (refer Section 6.0).
- Shear strength parameters for the analyses are based on the small confining stress levels expected for a “veneer” stability failure mechanism, in the order of 5 to 10 kPa.

Factors of Safety

Calculated slope stability factors of safety for piggy back liner construction stability within Tender Packages 1and 2 are presented in the table below, extracted from Appendix C-1.

Table 5: Summary of Piggy Back Liner Construction Stability Analysis Results

Case	Water Condition	Liner Shear Strength	Target FoS	Calculated FoS
A: Steepest subgrade design slope, 2H:1V, in limited areas. Protection material above the liner at a flatter slope - 2.5H:1V.	No pore pressure build up considered due to limited areas of 2H:1V slopes	Peak	1.3	1.47
		Residual	1.1	1.18
B: Prevailing subgrade design slopes ranging from 3H:1V to 4H:1. Protection material above the liner is placed at the same slope angle as the liner and with min. 0.3 m thickness.	Saturated condition in lower half of protection material layer, i.e., saturated thickness of 0.15 m.	Peak	1.1	1.33 – 1.75
		Residual	1.0	1.09 – 1.42

Based on these analysis results, the target slope stability factors of safety are achieved for the piggy back liner construction stability analyses for Tender Packages 1 and 2.

Liner Shear Strength Requirements

The analyses for detailed design resulted in required minimum shear strength parameters for materials and interfaces within the piggy back liner as given in the table below, extracted from Appendix C-1.

Table 6: Liner Internal and Interface Shear Strength Requirements - Piggy Back Liner Construction Stability

Liner Area	Minimum Equivalent Shear Strength within Liner System			
	Peak		Residual	
	Drained Friction Angle (Φ’)(°)	Drained Cohesion (c’)(kPa)	Drained Friction Angle (Φ’)(°)	Drained Cohesion (c’)(kPa)
Tender Package 1 & 2 – Piggy Back Liner: (a) liner components above the geomembrane; (b) low confining stress	30	0 25		0

These liner shear strength requirements have been adopted within the Technical Specifications for Tender Packages 1 and 2 (Section 2.2.19 in Appendices B-1 and B-2). The Technical Specifications require laboratory testing, comprising interface shear and internal shear strength testing of relevant liner components, at both material approval and as-delivered stages to demonstrate that liner strength requirements are met.

Other Requirements

As a result of the analyses, the design elements described below have been implemented in the detailed design for the piggy back liner.

- The protection material layer is designed at a slope of 2.5H:1V or flatter in the steep (2H:1V) subgrade areas in order to maintain acceptable FOS levels. This is incorporated in the Design Drawings (e.g. Appendix A-1, Sheet D1025)
- The detailed design for the geocomposite drain within the piggy back liner has been developed to limit the saturated zone thickness within the protection material layer to less than 150 mm during potential severe rainfall events that might occur during a 1-year exposure period for piggy back liner construction stability. Refer to Section 5.3 and Appendix E for additional information.

Golder recommends that a 1-year maximum exposure period for piggy back liner construction stability, as described under the ‘Analysis Information” heading above, is incorporated into the Safety in Design Risk Register for the project and the applicable Landfill Environmental Management Plan and/or other landfill operations plan.   This is also discussed in Sections 3.2 and 3.3 with respect to piggy back liner design details.

3.0 PIGGY BACK LINER DESIGN

3.1 Preliminary Design

Piggy Back Liner design was addressed in Sections 4.3.2, 4.3.3 and 4.3.5 of the Preliminary Design Report. The preliminary design considered subgrade geometry, foundation requirements, liner system components, and materials and installation requirements.

The preliminary design also considered potential effects of liner deformations arising from settlement of existing landfill waste underlying the piggy back liner, using indicative values for waste compressibility from published literature. The Preliminary Design Report indicated that site-specific compressibility values would be assessed for detailed design based on settlement loading trials at the site (refer section 3.4).

The components of the piggy back liner system are unchanged from the preliminary design. The system is shown in Figure 2 below, which is excerpted from the final Design Drawings for Tender Package 1 (Appendix A-1, sheet D1022) and Tender Package 2(Appendix A-2, sheet D2022).

The piggy back liner is not present in Tender Package 3.

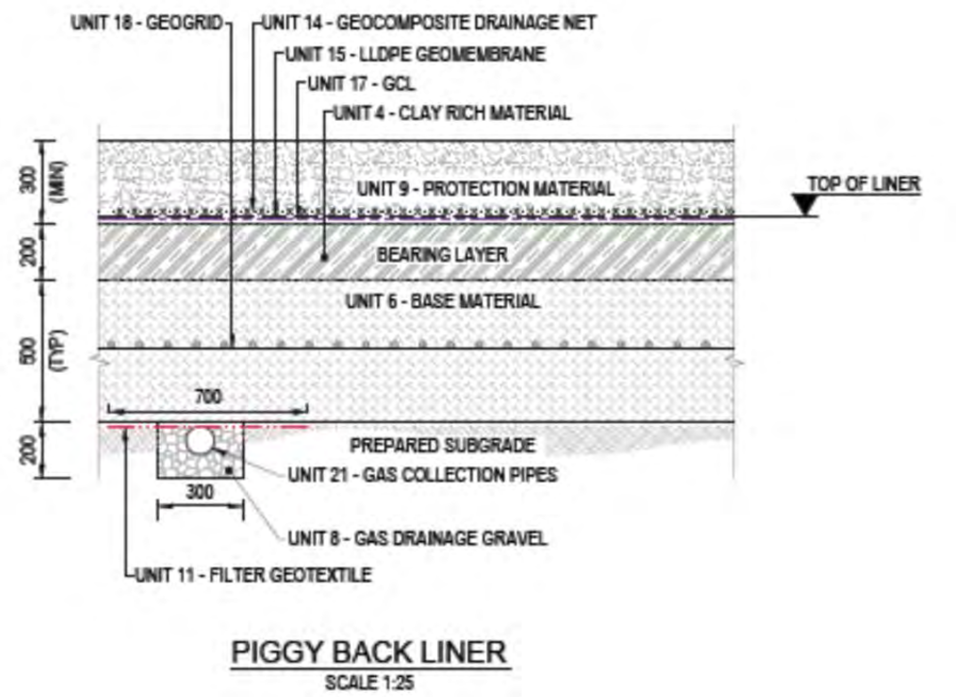


Figure 2: Piggy Back Liner Detail for Detailed Design

The liner cross section in areas immediately adjacent to cross-slope leachate collection pipes differs from the typical section in that drainage aggregate is present, rather than geocomposite drainage net, with a cushion geotextile placed between the drainage aggregate and the LLDPE geomembrane (e.g. Design Drawing sheet D1044, detail 2, Appendix A-1). The specification for the cushion geotextile will be finalised prior to construction based on the results of ongoing geomembrane puncture protection testing. Interim test results indicate that the final specification will require a non-woven needle punched cushion geotextile with a mass of at least 700 gm/m^2, which has been revised upward from the value of 550 gm/m^2 presented in the preliminary design.

3.2 Staging of Piggy Back Liner Construction

The detailed design reflects the design intent for waste placement over each portion of the piggy back liner to take place within approximately one year of liner installation. This intent is based on the rationale below.

At the time of installation, all areas of the piggy back liner are to be covered with a layer of protection material within a 48 hour period (refer Appendix B-1 section 4.10.4). The purpose of the protection material is to provide confinement for the GCL layer and also to reduce the potential for liner disturbance from wind and water forces. The potential for liner disturbance from such forces will be largely eliminated when waste placement occurs above the liner in each area. Therefore, to manage liner disturbance risk and also reduce the potential for protection material loss (e.g. erosion), the time interval between piggy back liner installation and waste placement should be restricted. The detailed design has adopted a maximum time interval of approximately one year based on general project experience.

Golder therefore recommends that a 1-year maximum time interval between piggy back liner installation in any area and waste placement in that area is applied to the project, and that this is incorporated into the Safety in Design Risk Register for the project and the applicable landfill Operations Plan.

3.3 Subgrade for Piggy Back Liner

The detailed Design Drawings present piggy back liner subgrade levels for Tender Package 1 in Appendix A-1 (sheets D1011, D1012, D1015, and D1016) and for Tender Package 2 in Appendix A-2 (sheets 2011 and 2013). These drawings include demarcation lines for the boundary between piggy back liner and cell base liner areas. Subgrade design levels are generally similar to those for the preliminary design, with notable revisions as indicated below, and discussed subsequently.

- The detailed design for Tender Package 1 includes two intermediate benches, at approximate elevations RL 50 m and RL 70 m, representing temporary termination points for stages of piggy back liner construction.
- The detailed design for Tender Package 1A includes steepened grades near the existing toe berm for the Eastern Gully landfill batter.
- The detailed design for Tender Packages 1 and 2 includes a revised detail for cross-slope leachate collection pipe formation.

Subgrade Construction for Piggy Back Liner for Tender Packages 1 and 2

The detailed design for Tender Packages 1 and 2 includes specific construction requirements for subgrade formation in the Technical Specification (Appendix B-1, sections 4.1.3.1 and 4.1.3.3). The design intent is to excavate cover materials, for re-use onsite as landfill daily cover, while maintaining a minimum 300 mm cover thickness above landfill waste materials. The specification requirements include shallow test pitting in advance of excavation to reduce the potential for inadvertent excavation into landfill waste materials.

The detailed design has used the survey of the existing landfill surface survey from July 2011 (most recent available) to establish subgrade design levels that maintain the minimum 300 mm cover thickness above landfill waste materials. Settlement of the landfill surface in the order of 100 mm, but variable, is likely to occur between the survey date and the anticipated date of subgrade construction in approximately late 2013 to 2014. Such surface settlement will reduce the amount of excavation required to reach design subgrade levels and will therefore facilitate maintenance of the minimum 300 mm cover.

Intermediate Benches for Tender Package 1

Piggy back liner construction will progress from lower elevations toward higher elevations and it will likely be necessary to periodically halt liner construction so that the maximum time interval between liner installation and waste placement is limited to approximately one year, as discussed in Section 3.2 above. The detailed design includes intermediate benches developed in the subgrade surface to provide suitable locations for temporary liner termination. These benches are positioned at approximate elevations RL 50 m and RL 70 m, to provide approximately one year of landfilling volume for each bench-to-bench interval.

Intermediate bench details are shown in Design Drawings (Appendix A-1 sheets D1025, D1056). These details include geometry, drainage and piggy back liner component arrangements for both the temporary liner termination condition and the final bench condition after the upslope lining connection is made.

The design intent for the temporary liner termination condition includes the items described below.

- Bench width: The bench width of 4 m is as wide as practically achievable given the constraint on excavation depth due to the existing cover soil thickness and a maximum local slope of 2H:1V adopted for the piggy back liner.
- Safety: The 1 m high edge bund is a safety feature for personnel and plant working on the bench.
- Stormwater drainage: Stormwater will flow down to the bench from the upper landfill slope and drain laterally along the bench. The channel defined by the edge bund and the upper landfill slope will accommodate a 10-year average recurrence interval (ARI) storm event with more than 500 mm freeboard (refer Section 7.0 and Appendix F). The channel will be lined.
- Erosion of Protection Soil: The risk of erosion of the Protection Soil below the bench as a result of channel overtopping is reduced because of the substantial freeboard provided by the combination of the edge bund height and the channel width (previous bullet item).
- Liner undermining: The risk of undermining of the piggy back liner by water flow is reduced by the following measures: (a) the channel will be lined with a flexible channel liner to minimise channel seepage and erosion(refer Appendix B-1 section 2.2.38 “Unit 38 – Drain Liner”); (b) a relatively deep liner anchor trench is used on the bench such that a substantial depth of erosion/seepage would have to occur in order for water to access the geomembrane liner; and (c) additional protection is provided by the edge bund and marking geotextile.
- Water entering Geocomposite Drainage Layer: The risk of surface water entering the geocomposite drainage net along its leading edge, and thereby inducing pore pressures that destabilise the Protection Soil below the bench, is reduced by the following measures: (a) the channel will be lined with a flexible channel liner to minimise channel seepage and erosion (see previous bullet item); and (b) the geocomposite drainage net is terminated approximately 2 m from the channel base and is covered by the edge bund such that a significant seepage path length or erosion depth would be required for water in the channel to reach the geocomposite.

The design intent for the liner in the final bench condition includes the items described below.

- Liner Anchoring: The detailed design includes cutting the downslope geomembrane in the anchor trench prior to welding the upslope geomembrane to the downslope geomembrane (Design Drawing D1025). Cutting the geomembrane detaches it from the anchor trench, thus reducing restraint on the completed final liner in order to reduce any future stress concentrations that could develop due to future piggy back settlement deformations. Cutting the geomembrane also allows a fusion welding process to be used, rather than an extrusion welding process. It is noted that particular attention must be paid to geomembrane protection from wind uplift while installing the upslope geomembrane and making the connection at the bench (refer Appendix B-1 section 4.11.3 heading ‘Method of Placement’) and that slope ballast tubes or other robust methods may need to be considered in addition to sand bag ballasting.
- Geocomposite Drainage Layer: The termination point of the geocomposite drainage net from the lower slope provides for a separation distance of approximately 3 m from the leachate collection pipe on the bench and the upslope geocomposite drainage net. This physical interruption in the leachate drainage layer will promote leachate flow into the pipe and reduce the potential for additive downslope leachate flow. This effect is also discussed further in Section 5.3.

Steepened grades at Existing Toe Berm for Tender Package 1A

For detailed design, the piggy back liner subgrade in the area upslope of the existing toe berm has been steepened from that used for the preliminary design to a grade of approximately 10%, as shown in Design Drawing D1013, section F (Appendix A-1). The steepened grade has been selected to facilitate long-term leachate drainage based on the piggy back liner settlement analyses for this local area performed for detailed design (Appendix C-3). Specific construction requirements for fill placement to construct the subgrade in this area are given in Appendix B-1, section 4.1.3.2.

Cross-Slope Leachate Collection Pipes for Tender Packages 1 and 2

The formation for cross-slope leachate collection pipes for Tender Packages 1 and 2 has been revised from the preliminary design to that shown in Design Drawings sheets D1044, D2044 (Appendices A-1 and A-2). The revised formation requires local reshaping of only the base material layer to form the transverse bench for leachate pipe positioning, with no reshaping of the underlying subgrade surface. This revision improves constructability in that it reduces the risk of disturbing existing waste that would be associated with subgrade reshaping and makes any necessary field adjustments to pipe alignment easier to implement.

The cross-slope leachate collection pipe detail shows that the termination point of the geocomposite drainage net below the pipe provides for a separation distance of approximately 1 m from the leachate collection pipe and the upslope geocomposite drainage net. This physical interruption in the leachate drainage layer will promote leachate flow into the pipe and reduce the potential for additive downslope leachate flow. This effect is also discussed further in Section 5.3.

3.4 Piggy Back Liner Deformation

The detailed design has further considered potential effects of liner deformations arising from settlement of existing landfill waste underlying the piggy back liner, using site-specific values for waste compressibility derived from settlement loading trials completed at the site. At the time of the preliminary design, results from the settlement loading trials were not available. Relevant discussion is provided below.

Settlement Loading Trials

Test fills for settlement loading were constructed in March and April 2012 at two locations on the Western Gully Landfill surface in order to assess the effect of surface loading on the existing landfill waste. The principal characteristics of the test fills are as given below. Settlement plates were installed for settlement monitoring during and after filling.

- Upper Test Fill - The overall fill footprint is approximately 30x30 m, with a platform area approximately 20x20 m, positioned at approximate elevation RL +75 m AHD. The total fill volume was 1,430 m^3, with average fill thickness of 1.96 m in the platform area, and batter angles of approximately 2H:1V. The total weight of fill was 3,880 tonnes. The average vertical loading achieved in the platform area was 5.3 t/m^2, or 52 kPa. This test fill targeted younger layers of existing Western Gully waste.

- Lower Test Fill - The overall fill footprint is approximately 22x22 m, with a platform area approximately 12x12 m, positioned at approximate elevation RL +45 m AHD. The total fill volume was 1,030 m^3, with average fill thickness of 3.15 m in the platform area, and batter angles of approximately 2H:1V. The total weight of fill was 2,490 tonnes. The average vertical loading achieved in the platform area was 7.6 t/m^2, or 75 kPa. This test fill targeted older layers of existing Western Gully waste.

It is noted that test fills were not constructed on the Eastern Gully Landfill due to access and topographical constraints and landfilling operations.

Settlement monuments were installed at 19 locations on the existing landfill surface in February 2012 - eight monuments on the Eastern Gully Landfill and eleven monuments on the Western Gully Landfill. Each monument comprised a steel star picket and a survey target, with the star pickets driven into the existing landfill surface until high resistance was encountered. Monthly settlement measurements have been made. The settlement monuments allow assessment of ongoing settlements of the existing landfill waste with no additional surface loading applied.

Measured settlements over a six month period for the test fills were between 100 and 200 mm; and measured settlements over a nine month period for the settlement monuments were up to 500 mm.

Back Analyses for Site-Specific Waste Compressibility

Measured settlements from the settlement loading trials have been analysed for the detailed design to assess waste behaviour and establish compressibility parameters for estimating future settlements of the piggy back liner. This is referred to as 'back analysis'. Back analysis methods and results are presented in Appendix C-2. The back analyses provided the waste compressibility parameters given below which have been applied for estimated future piggy back liner settlements (refer following sections).

- Western Gully: The back-analysed compressibility parameters for the Western Gully reflect 'very low to low' compressibility relative to landfill waste compressibility values in the technical literature. The results suggest that the waste materials at the upper test fill may be somewhat more compressible than those at the lower fill. Settlement calculations for the piggy back liner on the existing waste at the Western Gully should generally adopt the following design parameters:
  - Modified Primary Compression Index, C_R=0.12; Modified Secondary Compression Index, $C_{\alpha\varepsilon}$=0.04
- Eastern Gully: The back-analysis results indicate that the modified secondary compression index, $C_{\alpha\varepsilon}$, of existing waste at the Eastern Gully may vary between 0.045 and 0.085. This is consistent with 'low to intermediate' compressibility relative to landfill waste compressibility values reported in the technical literature. Settlement calculations for the piggy back liner on the existing waste at the Eastern Gully should generally adopt the following design parameters:
  - Modified Primary Compression Index, C_R=0.20; Modified Secondary Compression Index, $C_{\alpha\varepsilon}$=0.07

Settlement Analyses for Tender Package 1 (Cross Sectional)

Cross sectional settlement analyses for the piggy back liner in the Eastern Gully have been updated from those presented in the preliminary design to reflect site-specific waste compressibility parameters as presented above. The analyses for detailed design also reflect the Tender Package 1 design subgrade contours. The approach and method for the analyses is presented in Appendix C-3 and is essentially the same as in Section 4.3.3 of the Preliminary Design Report.

Relevant discussion for the analyses for detailed design is provided below (refer Appendix C-3).

- The settlement analyses for detailed design consider long-term conditions for the piggy back liner on the Eastern Gully. The analyses address settlements that could develop in the piggy back liner after landfilling over the liner to form the final landform proposed in the Preliminary Design Report. The purpose is to assess potential settlements along the envisaged drainage paths across the liner and also to assess potential tensile strains that may develop in the geomembrane component of the liner.
- The analyses considered four cross sections along contour lines of the existing Eastern Gully landfill surface and two long sections along the axis of the gully. The sections along the contour lines were chosen to represent general cross-slope leachate drainage paths. The sections along the gully axis were chosen because they have significant variation in thickness of existing waste and proposed new waste and therefore have potential to experience differential settlements that could induce liner tensile strains.
- Creep settlements of the existing waste layers underlying the piggy back liner, corresponding to waste decomposition and other mechanisms, are assumed to commence upon their initial filling date. Settlements are calculated for 40 years after piggy back liner construction and new waste placement.

Key analyses results are presented in the table below.

Table 7: Cross-Sectional Settlement Analysis Results- Piggy Back Liner for Tender Package 1

Settlement Cross Section Location [1]	Max. Long-Term Settlement	Max. Long-Term Tensile Strain in Lining System[2]	Max. Long-Term Grade Change in Lining System[2]
Cross-Slope (Section C-C)	2.1 m	0.1 %	4.3 %

Settlement Cross Section Location [1]	Max. Long-Term Settlement	Max. Long-Term Tensile Strain in Lining System[2]	Max. Long-Term Grade Change in Lining System[2]
Cross-Slope (Section D-D)	4.6 m	0.1 %	5.3 %
Cross-Slope (Section E-E)	4.1 m	0.2 %	6.6 %
Cross-Slope (Section F-F)	5.3 m	0.2 %	6.0 %
Gully Axis (Section G-G)	4.9 m	1.7 %	NA
Gully Axis (Section G-G')	3.2 m	1.1 %	NA

Notes: 1. Cross section locations indicated in Appendix C-3
2. Tensile Strain and Grade Change is average value in 10 m intervals between settlement calculation points.
3. Grade change not relevant for sections along gully axis because pre-settlement grades are steep

Calculated settlement of the piggy b ack liner ranges up to 5.3 m, with the area of highest predicted settlements generally corresponding to the original Eastern Gully centre line. The results have influenced the detailed leachate collection system design as indicated below (refer Section5.3).

- The detailed design for cross-slope leachate pipes directs drainage towards the area of highest predicted settlements in order that settlements will facilitate rather than disrupt leachate collection (refer Section 5.3). It is not feasible for the detailed design of cross-slope leachate collection pipes to address the calculated potential grade changes of up to 6.6% by any other approach.

- The detailed leachate collection design also includes multiple downslope primary collection pipes with frequent cross-slope pipes to provide multiple potential flow pathways and maintain leachate collection on the piggy back liner in case of irregular settlements.

The maximum calculated value for average settlement-induced tensile strain is 1.7% and in most areas the value is well below 1%. It is noted that the corresponding value obtained for the Western Gully during the preliminary design was 2% (refer Preliminary Design Report, Appendix D). These values are representative of the tensile strains that would be experienced by the LLDPE geomembrane within the piggy back liner. Allowing for some local strain concentration, we consider that the maximum local geomembrane tensile strain is therefore not likely to exceed 5%. This is less than the allowable tensile strain of 8% for textured LLDPE geomembrane, as discussed in Section 4.3.3 of the Preliminary Design Report under heading 'Design of Foundation Layer,' indicating acceptable design.

Additional discussion and calculations regarding geo membrane tensile strain is described i n the followi ng section.

Settlement Analyses for Tender Packages 1 and 2 (Local Soft Spot)

Settlement analyses for local waste soft spots beneath the piggy back liner in the Western Gully and Eastern Gully have been updated from those presented in the preliminary design to reflect site-specific waste compressibility parameters. The approach and method for the analyses is presented in Appendix C-4 and is essentially the same as in Section 4.3.3 of the Preliminary Design Report.

Relevant discussion for the analyses for detailed design is provided below (refer Appendix C-4).

- The sequence of landfill development in the Western Gully and Eastern Gully has been represented in more detail in the analyses for detailed design.

- As in the cross-sectional analyses described above, creep settlements of the existing waste layers underlying the piggy back liner, corresponding to waste decomposition and other mechanisms, are assumed to commence upon their initial filling date. Settlements are calculated for 40 years after piggy back liner construction and new waste placement.

- Western Gully Model Cases

- Base Case: The compressibility parameters of the host material for the Western Gully were taken as C_R=0.12and $C_{\alpha\varepsilon}$=0.02, representative of 'very low to low' waste compressibility. This is generally consistent with the site-specific values discussed above. The compressibility parameters for the soft spot were taken as C_R =0.24 and $C_{\alpha\varepsilon}$ =0.14, representative of 'high' waste compressibility.
- Sensitivity Case 1:The compressibility for the soft spot was increased by using C_R =0.33 and $C_{\alpha\varepsilon}$=0.14 (i.e., higher primary compressibility) representative of 'very high' waste compressibility.
- Sensitivity Case 2: The compressibility for the soft spot was decreased by using C_R =0.18 and $C_{\alpha\varepsilon}$=0.06, representative of 'intermediate' waste compressibility.

■ Eastern Gully Model Cases

- Base Case: The compressibility parameters of the host material for the Eastern Gully were taken as C_R=0.20 and $C_{\alpha\varepsilon}$=0.07, representative of 'intermediate' waste compressibility. This is generally consistent with the site-specific values discussed above. The compressibility parameters for the soft spot were taken as C_R =0.24 and $C_{\alpha\varepsilon}$ =0.14, representative of 'high' waste compressibility.
- Sensitivity Case 1: The compressibility for the soft spot was increased by using C_R =0.50 and $C_{\alpha\varepsilon}$=0.17, representative of 'very high' waste compressibility.
- Sensitivity Case 2: The compressibility for the soft spot was modified by using C_R =0.33 and $C_{\alpha\varepsilon}$=0.17, also representative of 'very high' waste compressibility.

Key analyses results are presented in the table below. The calculated long-term settlement profile for all cases reflects the influence of the soft spot material, with a depression of about 8 m radius centred over the soft spot.

Table 8: Local 'Soft Spot' Deformation Analysis Results - Piggy Back Liner for Tender Packages 1 and 2

Location	Case	Max. Long-Term Tensile Strain [1]		Depth of Settlement Depression	Settlement Gradient
		LLDPE Geomembrane	Geogrid Reinforcement		
Western Gully	Base case	5.2 %	2.8 %	1.8 m	4.4H:1V
	Sensitivity Case 1	6.5 %	4.1 %	1.9 m	4.2H:1V
Eastern Gully	Base case	3.4 %	1.5 %	1.0 m	8.0H:1V
	Sensitivity Case 1	7.5 %	4.3 %	1.6 m	5.0H:1V

Notes: 1. Computed max. tensile strain occurs at the 'shoulder' of the circular settlement depression.

The differences between the Base Case and Sensitivity Case 1, which is more severe than Sensitivity Case 2, are evident in the results in the table.

Discussion of Tensile Strains

■ *Strain Superposition*: As presented above under the heading 'Settlement Analyses for Tender Package 1 (Cross Sectional)', the estimated maximum average tensile strain in the piggy back liner from the cross-sectional analysis of long-term differential settlements is approximately 2 % for both the Western Gully and Eastern Gully. This tensile strain may be superimposed on the calculated geomembrane and geogrid strains from the 'Base Case' local soft spot analysis to provide an additive tensile strain value, which is conservative in that in practice it is highly unlikely that the most severe tensile strain conditions for both types of settlement analyses would occur at the same location on the landfill. It is noted that such a superposition has not been made with the calculated strains from the 'Sensitivity Case 1' local soft spot analysis because of the severity of the assumed soft spot properties for Sensitivity Case 1.

- *LLDPE Geomembrane*: For the LLDPE geomembrane, when the calculated maximum tensile strain due to the soft spot, 5.2% and 3.4% for the Western Gully and Eastern Gully 'Base Case' models, respectively is superimposed with the maximum value of 2% from the cross sectional analyses, the resulting additive tensile strain is approximately 7% and 5.5%, respectively. This is less than the allowable tensile strain of 8% for textured LLDPE geomembrane, as discussed in Section 4.3.3 of the Preliminary Design Report under heading 'Design of Foundation Layer,' indicating acceptable design.

  Considering Sensitivity Case 1, the computed localised maximum tensile strains in the geomembrane are 6.5% and 7.5%, respectively for the Western Gully and Eastern Gully. These values are also less than the allowable tensile strain for textured LLDPE geomembrane.

- *Geogrid*: For the geogrid, when the calculated maximum tensile strain due to the soft spot, 2.8% and 1.5% for the Western Gully and Eastern Gully 'Base Case' models, respectively is superimposed with the maximum value of 2% from the cross sectional analyses, the resulting additive tensile strain is approximately 5% and 3.5%, respectively. This is within a typical limiting tensile strain for many geogrid products. Based on this result, a long-term strain value of 5% for assessment of geogrid stiffness has been retained in the Technical Specification from the preliminary design.

  Considering Sensitivity Case 1, the computed localised maximum tensile strains in the geogrid are 4.1% and 4.3%, respectively for the Western Gully and Eastern Gully. These values are also less than 5%.

Discussion of Settlement Gradient

As indicated in the table above, the steepest calculated settlement gradient across the piggy back liner after long-term settlement is approximately 4H:1V for all models. This gradient is approximately equal to the slope gradients used for the piggy back liner design (generally 3H:1V to 5H:1V), and therefore the deformed piggy back liner surface resulting from the modelled soft spot settlement is not likely to result in significant leachate ponding or disruption of the leachate collection layer.

Summary for Detailed Design

The results of the additional analyses for detailed design have confirmed that the piggy back liner and foundation layer design, and the accompanying material specifications, as prepared for the Preliminary Design Report remain appropriate for Tender Packages1 and 2. As previously noted, piggy back liner is not present in Tender Package 3.

4.0 CELL BASE LINER DESIGN

4.1 Preliminary Design

Cell base liner design was addressed in Sections 4.3.2, 4.3.4 and 4.3.5of the Preliminary Design Report and also in the Preliminary Technical Specification. The preliminary design considered subgrade geometry, groundwater separation, foundation requirements, liner system components, and materials and installation requirements.

The components of the cell base liner system are unchanged from the preliminary design. The system is shown in Figure 3 below, which is excerpted from the final Design Drawings for Tender Package 1 (Appendix A-1, sheet D1021), Tender Package 2 (Appendix A-2, sheet D2021), and Tender Package 3 (Appendix A-3, sheet D3021).

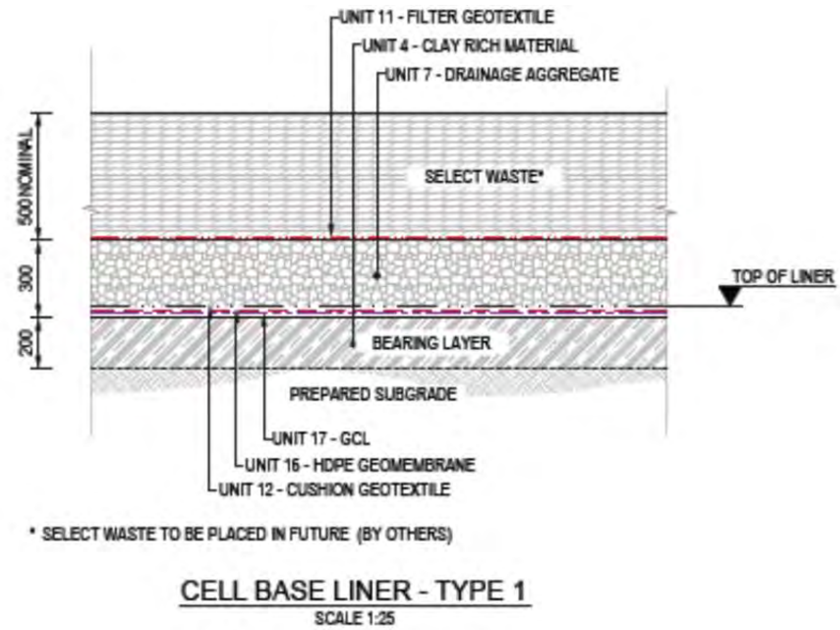


Figure 3: Cell Base Liner Detail for Detailed Design

4.2 Cushion Geotextile

The cell base liner cross section includes a cushion geotextile (Unit 12) placed between the drainage aggregate and the HDPE geomembrane. The specification for the cushion geotextile will be finalised prior to construction based on the results of ongoing geomembrane puncture protection testing. Interim test results indicate that the final specification will require a non-woven needle punched cushion geotextile with a mass of at least 700 gm/m^2, which has been revised upward from the value of 550 gm/m^2 presented in the preliminary design.

4.3 Subgrade for Cell Base Liner

The detailed Design Drawings presents cell base liner subgrade levels for Tender Package 1 in Appendix A-1 (sheets D1011 and D1015), for Tender Package 2 in Appendix A-2 (sheets 2011 and 2013), and for Tender Package 3 in Appendix A-3 (sheets 3011 and 3013). Subgrade design levels for the cell base liner are generally similar to those for the preliminary design, with all three Tender Packages retaining the minimum 2% overall grades and minimum 1% leachate drainage pipe grades as used in the preliminary design. Notable revisions to the preliminary design are as indicated below.

- Subgrade design levels along the northern edge and northeast corner of the cell base liner area for Tender Package 1A are deeper and flatter than for the preliminary design. Natural materials along the toe of the existing Eastern and Western Gully landfills in this area will be excavated up to 5.0 m below existing ground level to establish the revised subgrade levels (e.g. Appendix A-1, sheet D1013, section B). This revision has been made in order to achieve acceptable slope stability factors of safety for interim landfill slopes for Tender Package 1 (refer Section 2.2).

- Subgrade design levels along the south-western edge of the cell base liner area for Tender Package 1A have been locally revised to provide a minimum 1% grade for the leachate collection pipe that drains toward the sump at this location. This shown in the Design Drawings, sheet D1013- sections A and C and sheet D1047- sections A to C (Appendix A-1).
- Overall adjustments in subgrade levels for the three Tender Packages have also been made for detailed design to maintain a 2 m separation between the base of the leachate sumps and the groundwater table, consistent with the discussion in Section 3.3.5 of the Preliminary Design Report. These adjustments have considered the further groundwater data and interpretation of anticipated future groundwater table levels that has become available subsequent to the preliminary design, as presented in Appendix D.

The detailed design includes specific construction requirements for subgrade formation related to filling of existing ponds within the cell base liner area. These requirements are given in the Technical Specifications for the three Tender Packages (e.g., Appendix B-1, section 4.1.3.4). The detailed design also includes specific construction requirements for removal of existing services and service trench materials within the cell base liner area prior to subgrade construction (e.g., Appendix B-1, sections 4.1.1 and 4.1.2).

5.0 LEACHATE COLLECTION

5.1 Preliminary Design

Leachate collection system components, and their operational arrangement/layout, were addressed in Sections 4.3.3 and 4.3.4 of the Preliminary Design Report and in the accompanying Preliminary Design Drawings. The approach for leachate collection is unchanged from the preliminary design.

The preliminary design did not include details for pipe spacing, pipe sizing, geocomposite drain specifications, leachate drainage pits and other items. These have been addressed in the detailed design, as described in the remainder of this section.

5.2 Connection of Existing Leachate Collection Pipes

The presence and disposition for existing leachate collection pipes at the site was discussed in Sections 3.3.4 and 4.3.4 of the Preliminary Design Report. The approach for the existing pipes is unchanged from the preliminary design.

The detailed design includes alignment, invert levels, and trench details for the leachate drainage pipe (Unit 25) which will be overlain by the cell base lining system and up to 30 m of future waste (Appendix A-1 sheets D1045 and D1046, Appendix A-2 sheets D2045 and D2046). This pipe has been designed with the features outlined below given its location below the liner system and relative inaccessibility in the future.

- Solid wall HDPE pipe with wall thickness, minimum embedment depth and bedding support materials selected based on anticipated construction loads and future waste loads. Pipe Material type and wall thickness (SDR 11) are indicated in the Technical Specification (Appendix B-1 section 2.2.25). Required embedment depths and support materials are indicated in Appendix A-1 (sheet D1045) and Appendix A-2 (sheet D2045).
- Pipe diameter (315 mm) and invert grades (minimum 1%) designed to provide high flow capacity.
- The pipe trench also includes a perforated leak detection pipe (Unit 28), which is positioned within the granular bedding materials at the base of trench, to provide a collection and drainage contingency for potential leakage from the primary drainage pipe. The design intent is for the leak detection pipe to normally remain inactive, with the pipe valve periodically opened to assess flow quantity and quality.
- Pipe access for inspection and cleanout is provided at the leachate drainage pit for both the drainage pipe and leak detection pipe.

The detailed design includes specific construction requirements for location, removal and reconnection of the existing leachate collection pipes from the Eastern Gully landfill. The detailed design also includes requirements for temporary leachate management during this process. These requirements are given in the Technical Specifications for Tender Package 1 (e.g., Appendix B-1, section 4.3) and on Design Drawing D1046 (Appendix A-1).

It is noted that as in the preliminary design, the detailed design does not include the anticipated leachate collection works for the Western Gully that were described in Section 3.3.4 of the Preliminary Design Report. These works are to be designed and undertaken separately, prior to the construction of Tender Package 2.

5.3 Leachate Collection for Piggy Back Liner

Geocomposite Drainage Net - Required Properties

The required hydraulic properties for the geocomposite drainage net (Unit 14) have been evaluated for detailed design considering a range of design cases as indicated in Appendix E. The controlling design case is for the condition after liner installation and before covering with landfill waste where the geocomposite is required to drain infiltrating rainwater to maintain stability of the protection material layer (Unit 9). This design case also resulted in a hydraulic conductivity requirement for the protection material and maximum spacing requirements for cross-slope leachate collection pipes.

The required geocomposite drainage net and protection material properties are given in the Technical Specification (e.g., Appendix B-1, sections 2.2.9 and 2.2.14). The maximum spacing requirements for cross-slope leachate collection pipes are discussed below.

It is noted that the geocomposite drainage net design assumes that the physical interruption of the drainage net layer at the bench that is included in the design details for cross-slope leachate collection pipes will promote leachate flow into the pipe and minimise the potential for additive downslope leachate flow. The relevant design details for cross-slope leachate collection pipes and intermediate subgrade benches have been previously discussed (refer Section3.3).

Leachate Collection Pipe Layout and Pipe Sizes

The layout of leachate collection pipes in the piggy back liner area for the detailed design is presented for Tender Package 1 in Design Drawings D1041 and D1042 (Appendix A-1) and for Tender Package 2 in Design Drawing D2041 (Appendix A-2). The pipe layout reflects the design requirements and approach given below. Some of these requirements are based on predicted future waste settlements as presented in Section 3.4 under the heading 'Settlement Analyses for Tender Package 1 (Cross Sectional)'.

- The spacing between cross-slope pipes is based on the calculated maximum values from Appendix E that are related to geocomposite drainage net properties. The maximum allowable pipe spacing ranges from 10 m in relatively flat piggy back areas to 20 m in steeper areas.
- The pipe layout for Tender Package 1 includes numerous down-slope header pipes to provide redundant leachate drainage paths. The design intent is to provide a robust pipe drainage system that will continue to function effectively when subject to large total and differential settlements in the existing Eastern Gully waste beneath the piggy back liner.
- The pipe layout for Tender Package 1 is based on cross-slope drainage being directed, to the degree practicable, toward the original centreline of the Eastern Gully, which the area is of highest predicted piggy back liner settlement. This approach will potentially allow future settlements to facilitate rather than disrupt leachate collection.

Leachate collection pipe sizes have been selected for detailed design based on consideration of a number of leachate generation and rainwater infiltration scenarios as indicated in Appendix E. Pipe sizes are as summarised in the table below and given in the Technical Specification (e.g., Appendix B-1 section 2.2.23).

Table 9: Leachate Collection Pipes for Tender Packages 1, 2 and 3

Leachate Collection Pipe Designation (all Unit 23)	Function	Pipe Material	Outside Diameter (mm)	Inside Diameter (mm)	SDR
Type 1	cross-slope collection pipe	all HDPE (PE 100 material class)	160	136	all 13.6
Type 2	down-slope header pipe		315	267	
Type 3	cell base liner area - collection pipe		355	300	

5.4 Leachate Collection for Cell Base Liner

Drainage Aggregate - Required Properties

Required properties for the drainage aggregate (Unit 7) have been revised and extended for detailed design as summarised below and given in the Technical Specification (e.g., Appendix B-1, section 2.2.7).

- The required gradation has been modified to allow a larger maximum particle size to accommodate more commonly locally available materials. It is recognised that this change may result in additional geomembrane puncture protection requirements. Consequently, puncture protection testing is being conducted for the project, as mentioned in Sections 3.1 and 4.2, using a representative gravel material with a relatively large maximum particle size.

- Particle aspect ratio requirements have been added to reduce the presence of elongated particles that may cause increased geomembrane puncture risk. In addition, the angularity requirement in the preliminary design specification has been removed based on the practical difficulty of evaluation and enforcement of angularity.

- Requirements for maximum calcium carbonate content and acid solubility have been added to improve material durability.

The detailed design includes specific placement and testing requirements for the drainage aggregate that are additional to those in the preliminary design. A major intent of the additional requirements is to reduce the potential for fines generation during material handling and placement. These requirements are given in the Technical Specifications (e.g., Appendix B-1, section 4.15).

Leachate Collection Pipe Layout and Pipe Sizes

The layout of leachate collection pipes in the cell base liner area for the detailed design is presented for Tender Package 1 in Design Drawing D1041 (Appendix A-1), for Tender Package 2 in Design Drawing D2041 (Appendix A-2), and for Tender Package 3 in Design Drawing D3041 (Appendix A-3). The pipe layout reflects the design requirements and approach given below.

- A robust and durable pipe system for the cell base is warranted because all collected leachate from future piggyback expansion areas must flow through the cell base area to reach the sumps.

- All pipes are Unit 23-Type 3 pipes with the same diameter. Use of a uniform pipe size will facilitate leachate flow through pipe connections and simplify pipe installation. The relatively large pipe diameter indicated in Table 9 is based on pipe sizing calculations (Appendix E) and will provide significant clogging resistance.

- Pipe alignments have been selected to maintain minimum pipe invert slopes of 1% and maximum flow path lengths between pipes of 50 m.

- The pipe layouts include multiple pipe flow pathways to the sump in order to provide redundant leachate drainage paths. The design intent is to provide a robust pipe drainage system that can continue to function effectively when subject to potential differential settlements from foundation soils.

The leachate sump outlet pipes (Unit 24) that extend between the landfill sumps and the leachate drainage pits, and that also extend between the leachate drainage pits, have been sized to match the flow capacity of the Unit 23-Type 3 pipes. The majority of the leachate sump outlet pipes are Unit 24-Type 2 with an outside diameter of 355 mm. Short sections of Unit 24-Type 1, with an outside diameter of 400 mm, extend from the sumps and telescope with Unit 24-Type 2. The Unit 24 pipes are designed at SDR 26 and are thinner walled than the Unit 23 pipes due to the smaller future loading expected along the edge of the landfill. Full Unit 24 pipe requirements are given in the Technical Specification (e.g., Appendix B-1, section 2.2.24).

5.5 Leachate Drainage Pits

The detailed design includes specific requirements for the leachate drainage pits located outside the southern edge of the cell base area. Pit details are shown in the Design Drawings (e.g. Appendix A-1 sheet D1045). The leachate drainage pits include the key features given below.

- The pits are large diameter (2.5 m) in order to allow for access and working space. Numerous large diameter pipes enter each pit.

- All pipes entering the pits are valved to provide flexibility for leachate management and system maintenance.
- Stainless steel stub pipes are used for all pit penetrations because stainless steel is chemically resistant and has a relatively small thermal expansion coefficient compared to HDPE. Previous experience is that penetration points with large HDPE pipes may lose their seal due to cyclic HDPE expansion and contraction.
- All pipes bend down at a right angle after entering the pit and outlet beneath a standing water level. The design intent is to create a water seal for each pit to help isolate the pit atmosphere from any gases (e.g., methane) that may enter leachate collection pipes.
- The leachate drainage pit for Tender Package 1 receives drainage from the adjacent landfill sump, but also from pipes that connect to the existing leachate collection systems beneath the base liner. As a result the pit will be approximately 4 m deep, which is significantly deeper than those for the other Tender Packages. Also, two adjacent 2.5 m diameter risers (Unit 27) are required for Tender Package 1 to provide sufficient space for all the pipe works.

5.6 Leachate Generation Modelling

The preliminary design included leachate generation estimates, using a monthly water balance model, for the proposed sequence of landfill development. These estimates were reported in Section 4.7 of the Preliminary Design Report, along with discussion of existing and proposed leachate management measures at the site, including leachate storage, treatment and disposal. While the proposed leachate management measures from the preliminary design are unchanged for the detailed design of Tender Packages 1, 2 and 3, the leachate generation estimates have been updated to account for the revised landfill development sequence associated with Tender Packages 1, 2 and 3 (refer Table 1).

The updated leachate generation modelling for detailed design is presented in Appendix F. The updated modelling, which has retained the same water balance approach and key assumptions used for the preliminary design modelling, indicates that the landfill development sequence associated with Tender Packages 1, 2 and 3 results in generally lower leachate generation rates than for the preliminary design modelling. The updated modelling (Appendix F) concludes that:

- Monthly leachate water balance modelling using average rainfall indicates that the existing leachate storage ponds have adequate capacity for calculated leachate generation rates for the period of landfill construction and operation associated with Tender Packages 1, 2 and 3; and
- Sensitivity analyses indicate the existing leachate storage ponds have adequate capacity for two consecutive years of 90th percentile rainfall occurring during the period of landfill construction and operation associated with Tender Packages 1, 2 and 3.

Recommendations from the updated leachate generation modelling include: (i) ongoing monitoring and review of actual leachate generation volumes and rainfall at the site; and (ii) removal of accumulated leachate in the Western Gully prior to commencement of construction of Tender Package 2 (refer Section 5.2).

6.0 LANDFILL GAS EXTRACTION

Preliminary Design

The preliminary design included discussion of relevant issues for the landfill expansion project related to management of landfill gas being generated from the existing waste (refer Sections 3.3.3.3 and 4.6 of the Preliminary Design Report). The detailed design for Tender Packages 1, 2 and 3 presents additional design details as presented below.

It is noted that management of gas generated from waste landfilled within the Tender Package 1, 2 and 3 expansion areas is addressed separate to this report.

Future Gas Wells in Eastern Gully Existing Waste

Current plans are for vertical gas extraction wells to be installed in the upper portion of the existing Eastern Gully landfill, with some proposed wells being within the footprint of the piggyback liner for Tender Package 1B, as indicated in Design Drawing D1072 (Appendix A-1). These proposed wells would be installed prior to piggy back liner installation.

The approach outlined below has been adopted for detailed design of the piggy back liner in the vicinity of the proposed wells. This approach is similar to the “Well Cut Off” option discussed in Section 3.3.3.3 of the Preliminary Design Report.

- Prior to piggy back liner construction each gas well location will be prepared by: (a) installing a telescopic or collapsing well head with 2 m or more displacement capacity and surveying it’s as-installed location; (b) installing a subsurface lateral flow line extending outside the edge of the piggy back liner; and (c) removing all gas infrastructure to a depth of at least 1 m below the design liner subgrade surface.
- Install a 150 mm thick reinforced concrete protection slab on the prepared subgrade surface, centred on the gas well head coordinates, as shown in Detail 2 on Design Drawing D1072 (Appendix A-1), or a continuous circular slab with equivalent dimensions. The protection slab will provide a contingency against the chance of gas well components penetrating the piggy back liner as a result of ongoing waste settlement if the telescopic or collapsing well head is not fully effective.
- Install the base material layer over the protection slab and then complete piggy back liner installation.

Existing Gas Wells in Western Gully

The piggy back liner in Tender Packages 1 and 2 extends over a portion of the existing Western Gully landfill where gas wells have been previously installed. For these areas, the approach adopted for detailed design is that any existing gas wells are to be removed prior to construction of the piggy back liner subgrade, as indicated by notes on Design Drawings D1072 and D2072.

Gas Venting System Layout and Pipe Sizes

The elements of the gas venting system beneath the subgrade of the piggy back liner that were presented in Section 4.3.3 (heading ‘Landfill Gas Collection’) of the Preliminary Design Report have been retained for detailed design. The purpose of the system is provide for drainage of landfill gas present immediately beneath the piggy back lining system in order to prevent pressure build up and discourage lateral migration. As noted previously in Section 2.3 with respect to liner stability, the gas venting system may also be effective in draining any locally perched leachate from below the piggy back liner.

The layout of the gas venting system in the piggy back liner area for the detailed design is presented for Tender Package 1 in Design Drawings D1071 and D1072 (Appendix A-1) and for Tender Package 2 in Design Drawing D2072 (Appendix A-2). The pipe layout reflects the design requirements and approach given below.

- Gas collection pipes (Unit 21-perforated) within shallow gravel trenches are spaced at 20 to 25 m spacing and connected to upslope-downslope pipes (Unit 21-solid wall). The collection pipes are primarily gas flow pathways and therefore are not required to be installed with minimum invert slopes.
- The upslope-downslope gas pipes can transfer collected gas upslope to vent points and also transfer any collected liquid downslope to a lateral gas pipe (Unit 21-solid wall) which is connected into the leachate collection system. The lateral gas pipe is required to be installed with continuous falls toward the leachate connection points.
- The gas venting system also provides a connection point for two known existing water drainage pipes from beneath the original Eastern Gully liner system. This is indicated on Design Drawing D1071.
- The system includes temporary vent points that may facilitate future upslope extension of the system outside of the Tender Package 1, 2 and 3 area.

7.0 SURFACE WATER

7.1 Preliminary Design

Surface water design concepts were discussed in Sections 3.3.7 and 4.5 of the Preliminary Design Report and in the accompanying Preliminary Design Drawings. The preliminary design did not include details for drainage alignments, sizing, materials and other items. These have been addressed in the detailed design, as described in the remainder of this section.

7.2 Surface Water Design Components

Overview

The detailed design for Tender Packages 1, 2 and 3 comprises a number of surface water drains that were not developed in the Preliminary Design Report. Layout of these drains is shown on Design Drawings D1051, D2051 and D3051. These drains are summarised below with additional description in Table 10.

- Diversion channel from central ridge: This channel collects and diverts runoff from the catchment upslope of the central ridge and from a portion of the Western Gully landfill batter to existing site stormwater infrastructure on the western side of the Tender Package 2 area. The total length of the channel components is approximately 350 m with a total elevation drop of 36 m. The longest portion of the channel is a 220 m open channel drain traversing the existing Western Gully landfill batter. This channel will be removed during future stages of landfill construction.

- Permanent southern perimeter drain: This drain diverts existing runoff from the eastern ridge and future runoff from the temporary eastern perimeter drain (see below) to existing stormwater infrastructure in the western side of the site. The drain is sized to accommodate future runoff from the fully developed site, including from the proposed Eastern Waste Cutback area described in the Preliminary Design Report. This drain is progressively constructed in three sections corresponding to the three tender packages, with each section temporarily delivering water into the existing site stormwater system. The total length of the drain is approximately 280 m with a total elevation drop of 17 m.

- Temporary eastern perimeter drain: This drain collects and diverts runoff outside the eastern edge of Tender Package 1A and 1B. This drain is on the Eastern Gully landfill surface and it accepts water from the temporary Stage 1A bench drain (see below) and delivers water to the permanent southern perimeter drain (see above). This drain is progressively constructed in sections corresponding to the interim subgrade bench levels for Tender Packages 1A and 1B (refer Section3.3). The total length of the drain is approximately 350 m with a total elevation drop of 63 m. This drain will be replaced and/or upgraded during future landfill capping works.

- Temporary Stage 1A bench drain. This drain collects and diverts runoff from upslope of the leading edge of piggy back liner construction for Tender Packages 1A and 1B. The eastern portion of this drain delivers water into the temporary eastern perimeter drain (see above) and has a total length of approximately 200 m with a total elevation drop of 2 m. The western portion of this drain delivers water to the vicinity of the diversion channel from central ridge (see above) and has a total length of approximately 80 m with a total elevation drop of 3 m.

  The initial location of this drain is at the upper edge of Tender Package 1A at approximate elevation RL 50 m (refer Section 3.3), which is where the catchment will be largest. However the drain will subsequently be relocated to the interim subgrade bench within Tender Package 1B at approximate elevation RL 70 m, and then removed when construction for Tender Package 1B advances above this elevation.

Table 10: Major Surface Water Design Components for Tender Packages 1, 2 and 3

Name	Description	Design Drawings (App. A)	Discussion
Diversion channel from central ridge	Comprises five components, listed upstream-to-downstream: (i) open channel drain on central ridge; (ii) culvert under existing road; (iii) open channel drain on Western Gully landfill surface (riprap lining); (iv) culvert under proposed landfill road; (v) gabion cascade structure.	D1052 to D1056	Constructed for Tender Package 1. This channel will be functional for Tender Packages 1 and 2. For Tender Package 3, components (i) to (iii) will be functional and the disposition of components (iv) and (v) is uncertain.
Permanent southern perimeter drain	Comprises an open channel drain outside the southern edge of the landfill with a permanent gabion mattress-lined portion and a permanent inverted box culvert portion. Temporary riprap lining is used during progressive drain construction.	D1057& D1058; D2051 to D2053; D3051 to D3053	Eastern portion constructed for Tender Package 1 and extended progressively westward in Tender Packages 2 and 3. Western portion in Tender Packages 2 and 3 comprises an inverted box culvert due to space constraints. Sized for long-term potential catchment area, including Eastern Waste Cutback and drainage from final landfill landform.
Temporary eastern perimeter drain	Comprises an open channel drain with riprap lining located on the Eastern Gully landfill surface and outside the eastern edge of the Tender Package 1 area.	D1059	Southern portion constructed for Tender Package 1A and extended progressively northward in Tender Packages 1B. This drain will be functional for Tender Packages 1, 2 and 3 but will be replaced and/or upgraded during future landfill capping works.
Temporary Stage 1A bench drain	Comprises an open channel drain with flexible membrane lining located on interim subgrade benches within Tender Package 1. Design is integral with piggy back subgrade construction.	D1051 & D1056	This drain will be functional for Tender Package 1A only, after which it will be removed and replaced by a similar drain at a higher elevation. The initial position of the drain provides the most critical case for sizing and design.

Connections to Existing System

The surface water design elements for Tender Packages 1, 2 and 3 drainage design connect to the existing site stormwater system at the locations described above. These connections are generally temporary and will be removed or replaced during future stages of landfill construction. Connection into the existing system is based on the approach that the catchment areas contributing flow to the existing system are not increased by Package 1, 2 and 3 construction and therefore there is low risk that the new design components will alter flows to the degree that significant stormwater-induced damage would occur. Further, risk of stormwater-induced environmental release from the site is not significantly changed by the design due to the presence of the existing large-capacity pond system at the downstream end of the site.

It is noted that the detailed surface water drainage design for Tender Packages 1, 2 and 3 does not provide a functional outlet for water flowing in the Diversion Channel from the Central Ridge for Tender Package 3. Specifically, construction of Tender package 3 includes removal of the gabion cascade structure at the downstream end of the channel and does not provide an alternate outlet. As indicated in Table 1, an alternate outlet or other drainage flow path is to be designed and constructed prior to construction of Tender Package 3.

7.3 Detailed Design

Methodology

The Technical Memorandum attached as Appendix G presents the methodology, assumptions and results for the detailed surface water drainage design for the Tender Packages 1, 2 and 3. The design approach is summarised below.

- Catchments: The catchments contributing flow to each of the drains were assessed considering existing surface topography of the site and surrounds, landfill design landforms for Tender Packages 1, 2 and 3, and the final proposed landfill landform from the Preliminary Design Report. The assessment took into account long-term drainage requirements and proposed landfill development, for example, the catchment for the permanent southern perimeter drain includes the area upslope of the central ridge that could contribute flows if the Eastern Waste Cutback is undertaken in the future; as well as the main batter of the final landfill landform after the entire proposed cell expansion project is complete.
- Storm Events: An appropriate storm recurrence interval was selected for each drain, ranging from 10 years for the temporary Stage 1A bench drain to 100 years for the permanent southern perimeter drain. Rainfall intensity-frequency-duration (IFD) data for the site from the Australian Bureau of Meteorology was used to identify appropriate rainfall intensities for use in Rational Method Calculations (see below).
- Flow Rates: The Rational Method was used to estimate the peak storm runoff flow rate for the design of the drains and channels.

The results of these design steps are summarised in the table below, extracted from Appendix G.

Table 11: Hydrology Design Runoff Results for Tender Packages 1, 2 and 3

	Catchment Area (ha)	Runoff Peak Flow (m^3/s)
100 Year ARI Results		
Package 1 Permanent Southern Perimeter Drain	20.3	5.4
Package 2 Permanent Southern Perimeter Drain	24.4	6.6
Package 3 Permanent Southern Perimeter Drain	28.2	7.6
20 Year ARI Results		
Diversion channel from Central Ridge- Upper Culvert	12.9	5.4
Diversion channel from Central Ridge – Gabion Cascade and Lower Culvert	17.6	6.6
Temporary Eastern Perimeter Drain	5.1	1.0
10 Year ARI Results		
Temporary Stage 1A Bench Drain	3.6	0.9

Channel and drain sizing and lining design was undertaken using Manning's equation, riprap design guidelines, gabion and gabion mattress design methods and culvert design procedures as detailed in Appendix G. Drain design constraints included:

- Variable drain slopes from very steep (>10%) to moderate (5-10%) to mild (<5%);
- prohibition on excavation on existing landfill surfaces to construct/establish drains;
- Limit of 3.5 m for top width of the permanent southern perimeter drain in downstream reaches due to narrow alignment available between landfill edge and the existing paved road.

The basis for the detailed design of the drains also included the following for the super-critical flow regime in high velocity drain reaches:

- Utilise pervious rock lined drain, gabion mattress or gabion basket where not constrained by drain top width site limitations;
- Utilise concrete lined drain where top width is constrained; applicable to the lower reaches of the permanent southern perimeter drain; and

- Utilise gabion cascade structure for the lower reach of the diversion drain from central ridge due to geometry constraints.

Results

The resulting detailed drain designs are presented in Appendix G and have been implemented in the drain layouts, long sections, and details in the Design Drawings identified in Table 10.

The detailed design includes specific materials for drain construction, identified as in the table below. Material property requirements are given in the Technical Specifications (e.g., Appendix B-1, sections 2.2.32 to 2.2.38).

Table 12: Materials for Surface Water Drain Construction for Tender Packages 1, 2 and 3

Material Number	Name
Unit 32	Riprap armourstone and aggregate for gabion baskets and wire mattress
Unit 33	Granular material for concrete pipe installation
Unit 34	Rock filled gabions and mattresses
Unit 35	Enkmat® turf reinforcement mat (TRM)
Unit 36	Precast reinforced concrete box culvert (RCBC)
Unit 37	Precast reinforced concrete pipes (RCP)
Unit 38	Channel liner

The detailed design also includes specific requirements for drain construction. These requirements are given in the Technical Specifications (e.g., Appendix B-1, section 4.18) and additionally on some of the Design Drawings identified in Table 10.

8.0 CONSTRUCTION QUALITY MANAGEMENT

The construction quality management approach outlined in section 5.1 of the Preliminary Design Report has been retained within the detailed design of Tender Packages 1, 2 and 3. Construction quality management requirements are integral within the Technical Specification for Tender Packages 1, 2 and 3 (Appendices B-1, B-2 and B-3). Included are requirements related to the additional design features developed for detailed design and presented in the preceding sections of this report.

A summary of the construction quality management requirements within the Technical Specification is presented in the remainder of this section.

The construction quality management system for construction comprises construction Contractor requirements and Superintendent actions. Contractor requirements include preparing management plans, preparing work method statements, material testing, compaction testing, surveying, notifying for Inspection Points, and preparing Hold Point documentation and works-as-executed (WAE) documentation. Superintendent actions include review and approval of Contractor submittals and documentation, inspecting construction works, conducting audit testing, attending Inspection Points, and releasing Hold Points. Superintendent actions are typically referred to as Construction Quality Assurance (CQA).

Quality management requirements include the items given below.

- *Hold Point*: An identified point in the landfill construction sequence where the Contractor must halt work and provide required information to the Superintendent. The Contractor must not resume work until the Hold Point is released, in writing, by the Superintendent.
- *Full Time Inspection*: The Superintendent or in some cases the GITA (Geotechnical Inspection and Testing Authority), will be present on a full-time (continuous) basis for certain construction activities to provide additional confidence that construction is proceeding in accordance with Technical Specification requirements and design intent. Activities where full-time inspection is planned to be undertaken include geomembrane installation and seaming.
- *Field Testing*: Certain construction activities will require real-time field testing during construction. Examples include testing for confirmation of as-delivered material properties, testing of geomembrane welds, and compaction testing (refer following bullet point).
- *Compaction Testing*: Testing for as-constructed density and moisture content will be routinely performed on all soil construction materials. The Contractor will be required to engage an independent GITA to inspect earthworks construction and perform compaction testing.
- *Survey*: Numerous requirements for surveying of constructed alignments, inverts, and constructed soil and geosynthetic material surfaces are include in the Technical Specification. The survey provides data for Works-as-Executed (WAE) documentation and for confirming that design layer thicknesses have been achieved in liner and capping systems.
- *Audit Testing*: The Superintendent will arrange, at his discretion, for sampling and testing of delivered and emplaced construction materials, including soils and geosynthetics, to provide material property measurements that are independent of measurements by the Contractor. Activities where audit testing is likely to be undertaken include geosynthetic and clay (Unit 5) installation/compaction.

Prior to construction, the Superintendent will prepare a comprehensive list of required construction quality management items and required actions based on the Technical Specification and other construction Contract documents.

9.0 LIMITATIONS

This Document has been provided by Golder Associates Pty Ltd ("Golder") subject to the following limitations:

This Document has been prepared for the particular purpose outlined in Golder's proposal and no responsibility is accepted for the use of this Document, in whole or in part, in other contexts or for any other purpose.

The scope and the period of Golder's Services are as described in Golder's proposal, and are subject to restrictions and limitations. Golder did not perform a complete assessment of all possible conditions or circumstances that may exist at the site referenced in the Document. If a service is not expressly indicated, do not assume it has been provided. If a matter is not addressed, do not assume that any determination has been made by Golder in regards to it.

Conditions may exist which were undetectable given the limited nature of the enquiry Golder was retained to undertake with respect to the site. Variations in conditions may occur between investigatory locations, and there may be special conditions pertaining to the site which have not been revealed by the investigation and which have not therefore been taken into account in the Document. Accordingly, additional studies and actions may be required.

In addition, it is recognised that the passage of time affects the information and assessment provided in this Document. Golder's opinions are based upon information that existed at the time of the production of the Document. It is understood that the Services provided allowed Golder to form no more than an opinion of the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings, or any laws or regulations.

Any assessments made in this Document are based on the conditions indicated from published sources and the investigation described. No warranty is included, either express or implied, that the actual conditions will conform exactly to the assessments contained in this Document.

Where data supplied by the client or other external sources, including previous site investigation data, have been used, it has been assumed that the information is correct unless otherwise stated. No responsibility is accepted by Golder for incomplete or inaccurate data supplied by others.

Golder may have retained subconsultants affiliated with Golder to provide Services for the benefit of Golder. To the maximum extent allowed by law, the Client acknowledges and agrees it will not have any direct legal recourse to, and waives any claim, demand, or cause of action against, Golder's affiliated companies, and their employees, officers and directors.

This Document is provided for sole use by the Client and is confidential to it and its professional advisers. No responsibility whatsoever for the contents of this Document will be accepted to any person other than the Client. Any use which a third party makes of this Document, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Golder accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this Document.

Report Signature Page

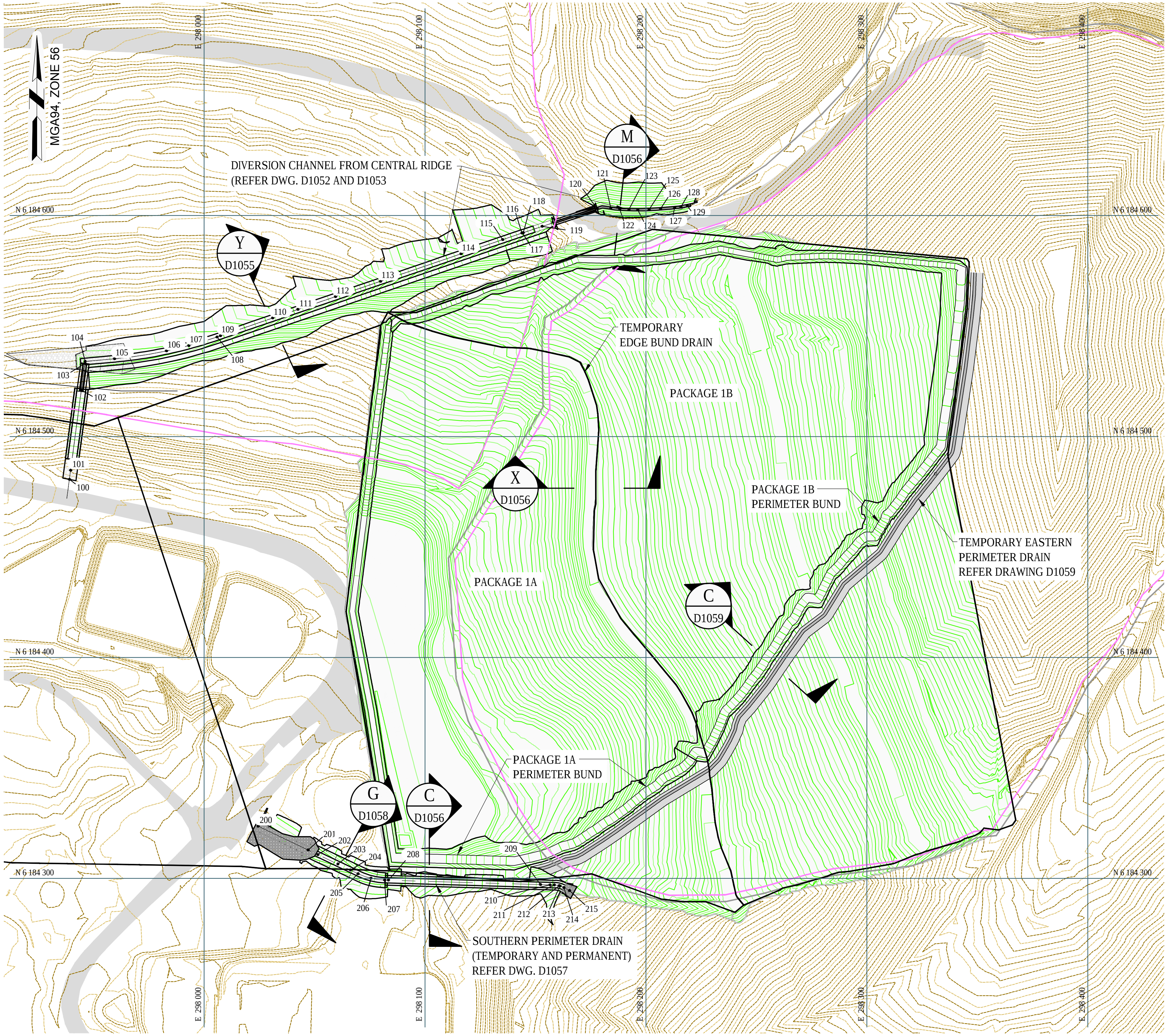
Kelly Dohle
Senior Environmental Engineer

Gary Schmertmann
Associate

GRS/JM/gs

A.B.N. 64 006 107 857

u:\kad\whytes gully\docs to pdf\117625003_224_r_rev0_detailed design report.docx



SETOUT TABLE

POINT No.	EASTING (m)	NORTHING (m)	ELEVATION
100	297939.08	6184480.61	RL 28.14
101	297939.64	6184484.76	RL 28.70
102	297944.49	6184521.03	RL 40.53
103	297946.09	6184533.00	RL 41.13
104	297946.22	6184533.96	RL 41.17
105	297959.51	6184535.17	RL 41.53
106	297982.98	6184538.72	RL 41.86
107	297993.07	6184541.15	RL 42.00
108	298005.87	6184545.04	RL 42.76
109	298007.42	6184545.57	RL 42.85
110	298031.06	6184553.62	RL 45.33
111	298042.48	6184557.52	RL 47.33
112	298059.46	6184563.30	RL 48.77
113	298079.85	6184570.25	RL 52.66
114	298116.25	6184582.66	RL 57.92
115	298135.17	6184589.11	RL 60.25
116	298143.90	6184592.09	RL 61.98
117	298144.19	6184592.18	RL 62.04
118	298144.48	6184592.28	RL 62.10
119	298153.04	6184595.08	RL 63.79
120	298177.89	6184603.19	RL 0.00
121	298184.09	6184603.37	RL 64.21
122	298188.18	6184602.89	RL 64.24
123	298192.30	6184602.71	RL 64.27
124	298196.28	6184602.67	RL 64.30
125	298201.44	6184602.75	RL 64.34
126	298206.59	6184603.06	RL 64.38
127	298213.00	6184603.59	RL 64.43
128	298215.86	6184603.92	RL 64.45
129	298218.69	6184604.45	RL 64.48

SETOUT TABLE

POINT No.	EASTING (m)	NORTHING (m)	ELEVATION
200	298024.49	6184323.62	RL 21.64
201	298047.11	6184312.88	RL 22.28
202	298051.54	6184310.78	RL 22.40
203	298060.58	6184306.49	RL 23.13
204	298066.27	6184303.79	RL 23.89
205	298069.71	6184302.15	RL 24.35
206	298075.54	6184300.09	RL 24.47
207	298081.71	6184299.26	RL 24.59
208	298083.46	6184299.21	RL 24.62
209	298152.27	6184297.20	RL 33.77
210	298156.56	6184297.07	RL 33.86
211	298158.51	6184297.01	RL 34.08
212	298160.73	6184296.69	RL 34.32
213	298161.13	6184296.58	RL 34.37
214	298162.88	6184295.86	RL 34.93
215	298165.42	6184294.52	RL 35.80

LEGEND

- PROPERTY BOUNDARY
- EXTENT OF EXISTING LINER (REFER NOTE D1003)
- PACKAGE BOUNDARY
- APPROX. EXTENT OF EXISTING WASTE (REFER D1003)
- EASEMENT
- PROPOSED CONTOURS (REFER NOTE 1)
- EXISTING CONTOURS

ISSUED FOR
CONSTRUCTION

NOTES:

1. PROPOSED CONTOURS REPRESENT SUBGRADE LEVELS, BUNDS AND DRAINAGE STRUCTURES

0 40 80 120m
1:2,000

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

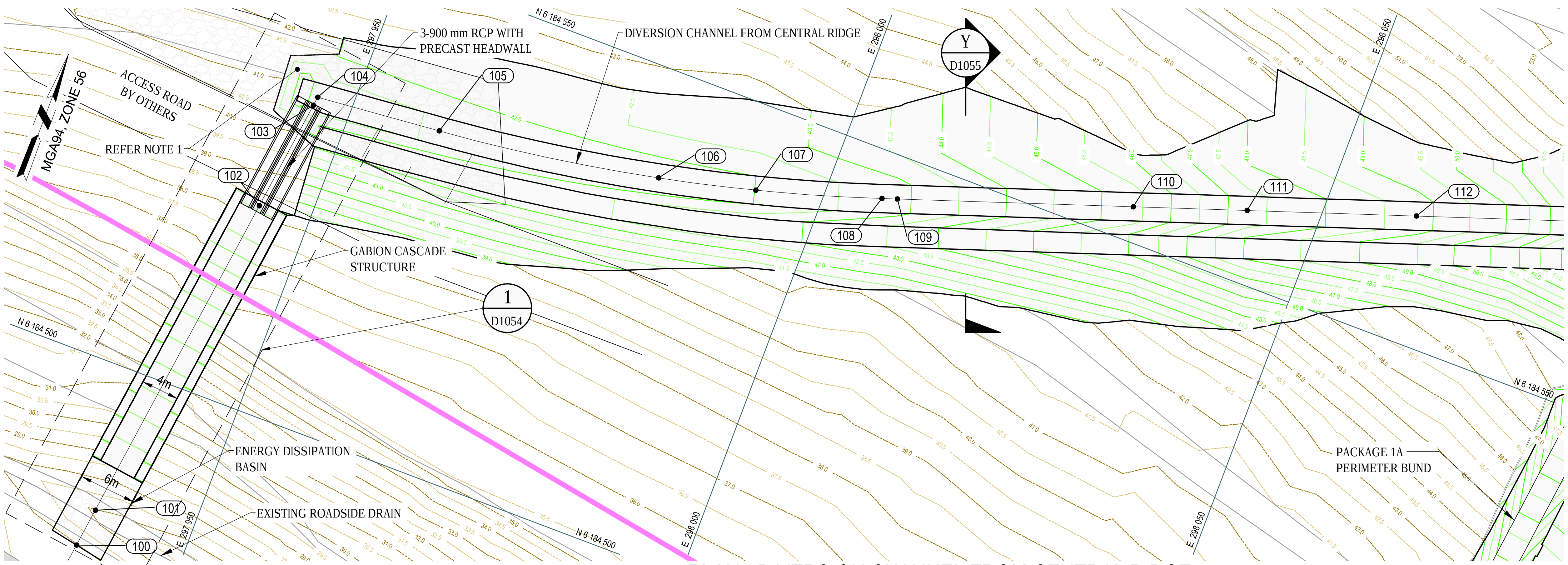
CLIENT: WOOLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: DRAINAGE LAYOUT PACKAGE 1

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1051	0

Plot Date: 28 March 2013 Time:9:19:43 AM By: Henry, Steven Path: K:\Hyd\2011\117625003 Whytes Gully\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1051-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOUNDARY.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-BUND STAGE 1B.dwg; 117625003-XREF-BASE LINER STAGE 1A.dwg; 117625003-XREF-BASE LINER STAGE 1B.dwg; 117625003-XREF-WHYTES PHOTOGRAMMETRY AND GOUND SURVEY 20-07-11-2-A.dwg; 117625003-XREF-DRAINS PACKAGE 1.dwg; 1076350



PLAN - DIVERSION CHANNEL FROM CENTRAL RIDGE

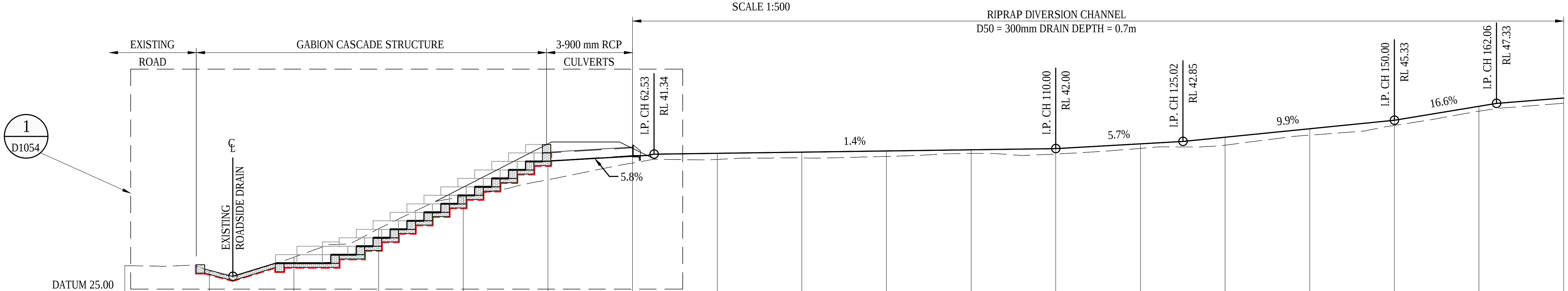
SCALE 1:500

LEGEND

- APPROX. EXTENT OF EXISTING WASTE (REFER D1003)
- PROPOSED CONTOURS
- EXISTING CONTOURS
- (73) SET OUT POINTS (SEE D1051 FOR SET OUT TABLE)

NOTES

1. RIPRAP TO EXTEND UP TO RL 42 AT WESTERN LIMIT OF CHANNEL. RIPRAP TO BE PLACED AGAINST ACCESS ROAD BATTER.



NATURAL SURFACE	28.20	27.62	29.20	32.55	36.35	38.33	40.31	40.72	40.90	41.08	41.42	41.37	42.03	42.40	43.59	44.73	46.41	47.35
DESIGN SURFACE			28.49	31.49	36.49	40.53	41.10	41.45	41.59	41.72	41.86	42.00	42.57	43.35	44.34	45.33	46.99	47.97
DEPTH			-0.71	-1.07	0.13	2.19	0.80	0.72	0.68	0.64	0.44	0.63	0.54	0.95	0.75	0.60	0.58	0.62
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00

LONG SECTION - DIVERSION CHANNEL FROM CENTRAL RIDGE

SCALE 1:500

ISSUED FOR

CONSTRUCTION

0 10 20 30m

1:500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates

124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

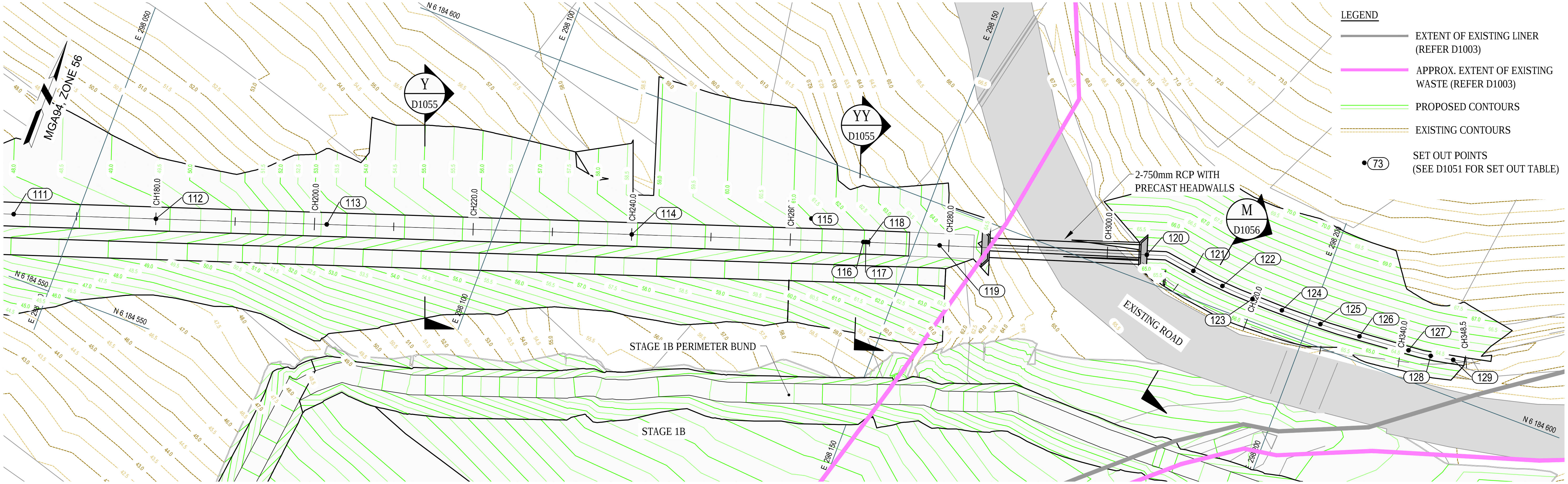
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: DIVERSION CHANNEL FROM CENTRAL RIDGE PLAN AND LONG SECTION SHEET 1 OF 2

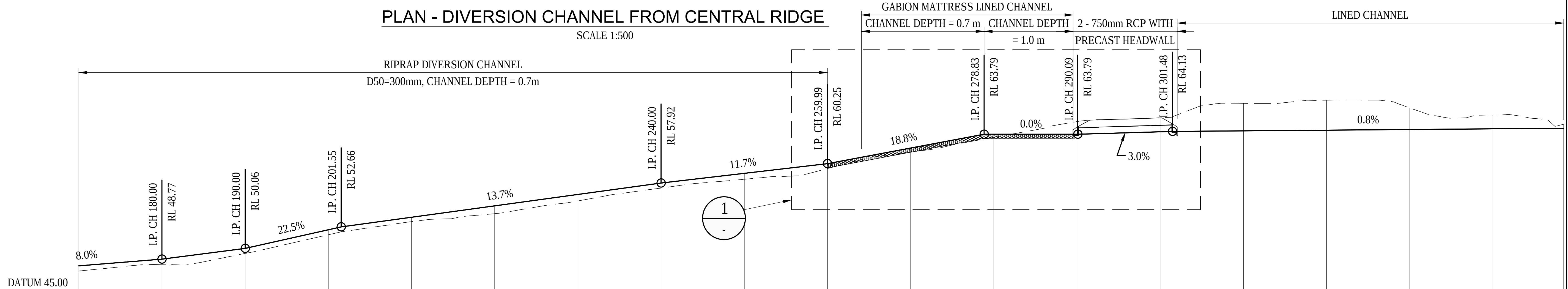
LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1052	0

Plot Date: 28 March 2013 Time:9:21:00 AM By: Henry, Steven Path: K:\Hyd\2011\117625003 Whytes Gully\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1052-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING BREAKLINES.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOUNDARY.dwg; 117625003-XREF-BASE LINER STAGE 1A.dwg; 117625003-XREF-BASE LINER STAGE 1B.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-BUND STAGE 1B.dwg; 117625003-XREF-SUBGRADE STAGE 1B.dwg; 117625003-XREF-SUBGRADE STAGE 1A.dwg; 117



PLAN - DIVERSION CHANNEL FROM CENTRAL RIDGE

SCALE 1:500



NATURAL SURFACE	47.35	48.17	49.46	51.71	53.28	54.24	55.76	57.32	58.37	59.65	61.63	63.40	65.30	65.76	67.49	67.87	66.94	66.07	64.99
DESIGN SURFACE	47.97	48.77	50.06	52.31	53.81	55.18	56.55	57.92	59.08	60.25	62.13	63.79	63.79	64.08	64.19	64.27	64.35	64.43	64.50
DEPTH	0.62	0.60	0.60	0.60	0.53	0.94	0.79	0.60	0.71	0.60	0.50	0.39	-1.51	-1.68	-3.30	-3.59	-2.58	-1.65	-0.49
CHAINAGE	170.00	180.00	190.00	200.00	210.00	220.00	230.00	240.00	250.00	260.00	270.00	280.00	290.00	300.00	310.00	320.00	330.00	340.00	348.50

LONG SECTION - DIVERSION CHANNEL FROM CENTRAL RIDGE

SCALE 1:500

ISSUED FOR

CONSTRUCTION

0 10 20 30m
1:500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: DIVERSION CHANNEL FROM CENTRAL RIDGE
PLAN AND LONG SECTION
SHEET 2 OF 2

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	1:500	A3	117625003	220	L	D1053	0

Plot Date: 28 March 2013 Time:9:35:53 AM By: Henry, Steven Path: K:\Hyd\2011\117625003 Whytes Gully\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1052-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING BREAKLINES.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOUNDARY.dwg; 117625003-XREF-BASE LINER STAGE 1A.dwg; 117625003-XREF-BASE LINER STAGE 1B.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-BUND STAGE 1B.dwg; 117625003-XREF-SUBGRADE STAGE 1B.dwg; 117625003-XREF-SUBGRADE STAGE 1A.dwg; 117

GABION NOTES:

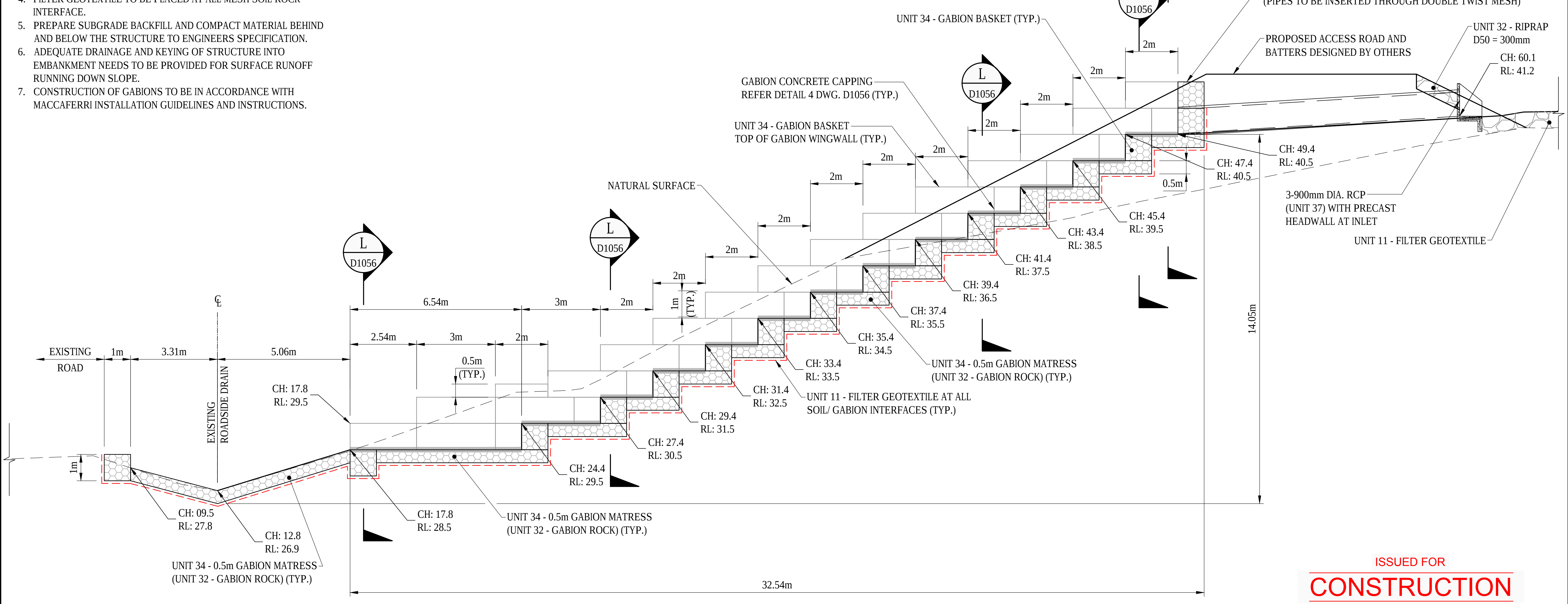
1. GABIONS AND GABION MATRESS: DOUBLE TWISTED, HEXAGONAL WIRE MESH GABIONS OF NOMINAL 80x100 MESH, WITH 3.4mm O/D FRAME WIRE AND 2.7mm MESH WIRE, COMPLETE WITH DIAPHRAGMS AT 1m CENTRES. ALL COMPONENTS TO BE MECHANICALLY CONNECTED AT THE PRODUCTION FACILITY WITH MINIMUM CONNECTION STRENGTH REQUIREMENTS AS PER TABLE 2 OF ASTM A975.
2. ALL WIRE IS MILD STEEL, GALMEC COATED (95% ZINC + 5% ALUMINIUM ALLOY) TO THE REQUIREMENTS OF ASTM B750-99 AND HEAT BONDED THROUGH EXTRUSION WITH AN ADDITIONAL 0.5mm HEAVY DUTY GREY PVC COATING. GABIONS MUST HAVE A VALID BRITISH BOARD OF AGRÉMENT (BBA) CERTIFICATE FOR GALFRAN + PVC WIRE.
3. THE GABION FILL MATERIAL TO BE IN ACCORDANCE WITH AS 2758.4 - 2000.
4. FILTER GEOTEXTILE TO BE PLACED AT ALL MESH SOIL ROCK INTERFACE.
5. PREPARE SUBGRADE BACKFILL AND COMPACT MATERIAL BEHIND AND BELOW THE STRUCTURE TO ENGINEERS SPECIFICATION.
6. ADEQUATE DRAINAGE AND KEYING OF STRUCTURE INTO EMBANKMENT NEEDS TO BE PROVIDED FOR SURFACE RUNOFF RUNNING DOWN SLOPE.
7. CONSTRUCTION OF GABIONS TO BE IN ACCORDANCE WITH MACCAFERRI INSTALLATION GUIDELINES AND INSTRUCTIONS.

CONCRETE CAPPING:

1. THE PURPOSE OF CONCRETE CAPPING IS TO HAVE 100mm OF CONCRETE EMBEDDED WITHIN THE GABION BASKET OR MATRESS. THE CONSTRUCTION SEQUENCE BEING:
   a) FILL THE GABION BASKET OR MATTRESS WITH SPECIFIED ROCK TO 100mm BELOW THE TOP OF THE GABION MESH.
   b) POUR THE CONCRETE TO THE SPECIFIED CAPPING THICKNESS.
   c) ALL OTHER ASPECTS OF CONSTRUCTION AND PLACEMENT OF GABION STRUCTURES TO FOLLOW BEST CONSTRUCTION PRACTICES.

CULVERT NOTES:

1. CULVERTS SHALL BE INSTALLED ACCORDING TO RMS DRAWING MD.R11.A01.B WITH A MINIMUM SURFACE TO CROWN COVER OF 0.6 m. PIPE LOADING CLASS SHALL MEET IN-SERVICE LOAD HLP400 AND CONSTRUCTION LOAD T44, WHICHEVER IS GREATER.



ISSUED FOR
CONSTRUCTION

DETAIL 1 (D1052) GABION CASCADE STRUCTURE
SCALE 1:150

0 3 6 9m
1:150

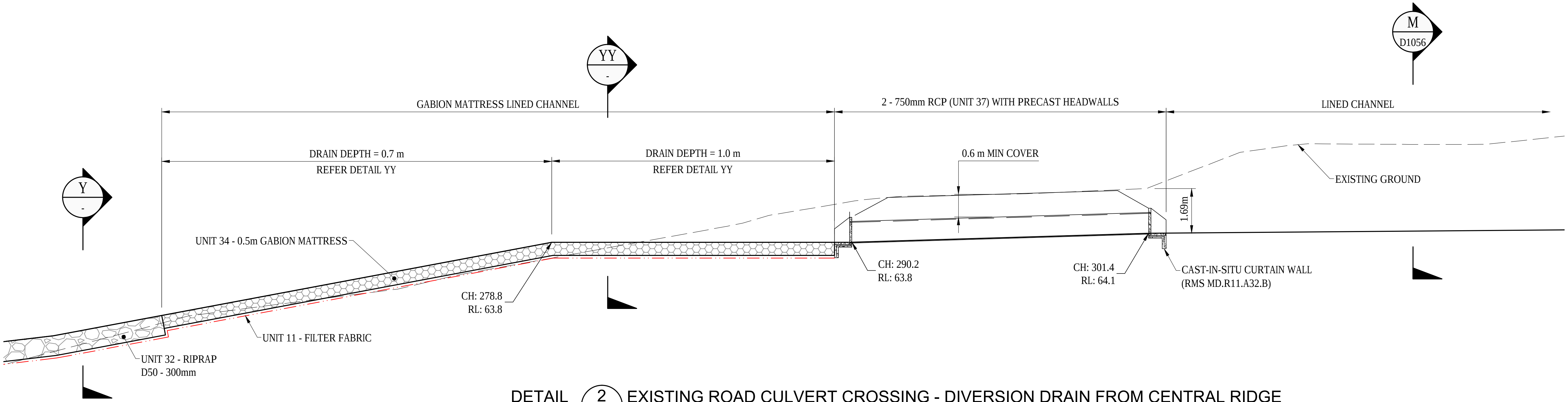
REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNIL
PROJECT: WHYTES GULLY LANFILL - NEW CELL DESIGN
DRAWING TITLE: DIVERSION CHANNEL FROM CENTRAL RIDGE GABION CASCADE STRUCTURE SECTION

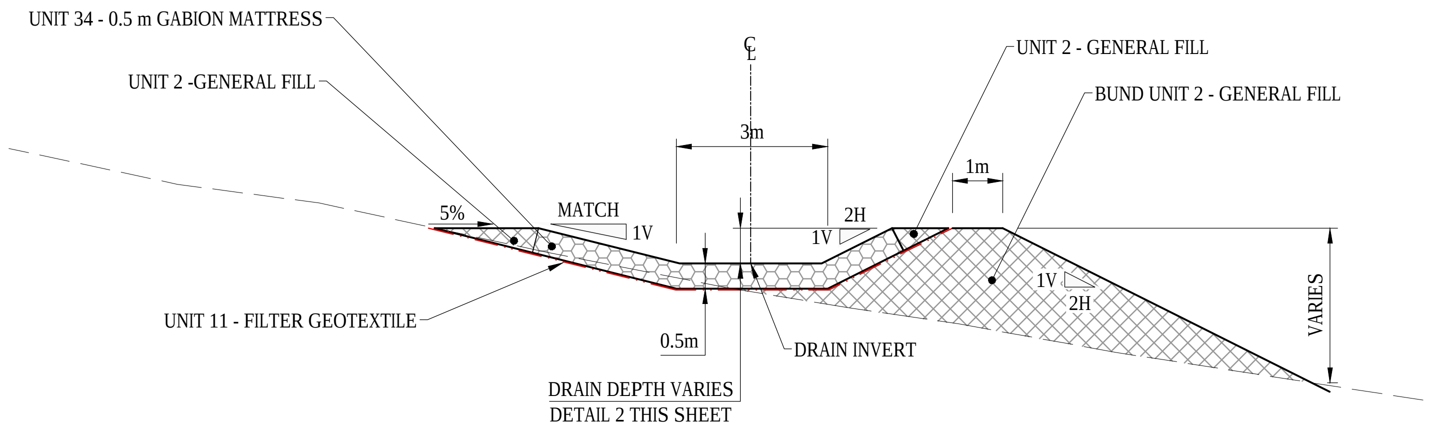
LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1054	0

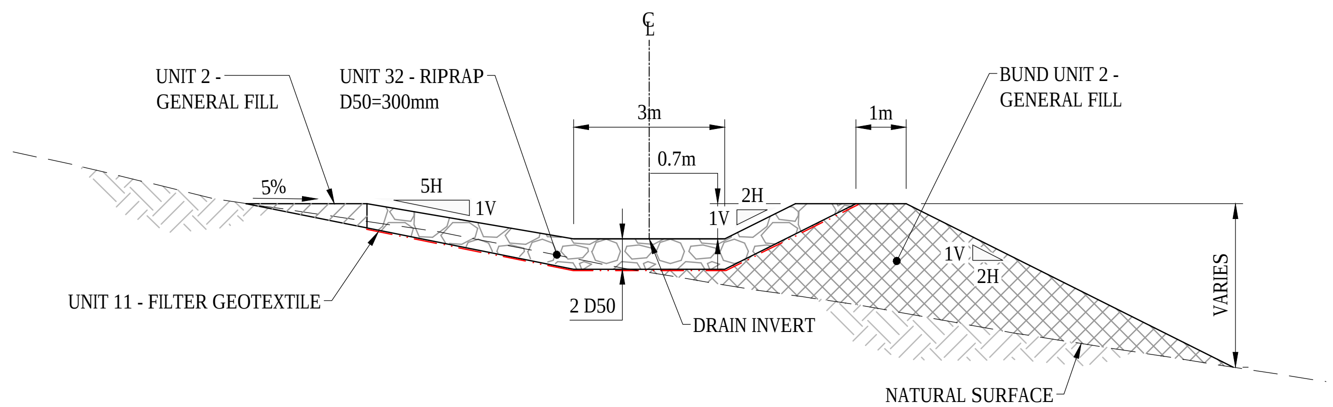
Plot Date: 28 March 2013 Time:9:21:39 AM By: Henry, Steven Path: K:\Hyd\2011\117625003 Whytes Gully\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1054-REV0.dwg
Xref: GAP_LOGO-A3.dwg;



DETAIL 2 (D1053) EXISTING ROAD CULVERT CROSSING - DIVERSION DRAIN FROM CENTRAL RIDGE

SCALE 1:150





SECTION YY (1053) (-) TYPICAL GABION DIVERSON CHANNEL FROM CENTRAL RIDGE

SCALE 1:150

SECTION Y (D1051) (D1052) (D1053) (-) TYPICAL RIPRAP DIVERSION CHANNEL FROM CENTRAL RIDGE

SCALE 1:150

ISSUED FOR
CONSTRUCTION

0 3 6 9m
1:150

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

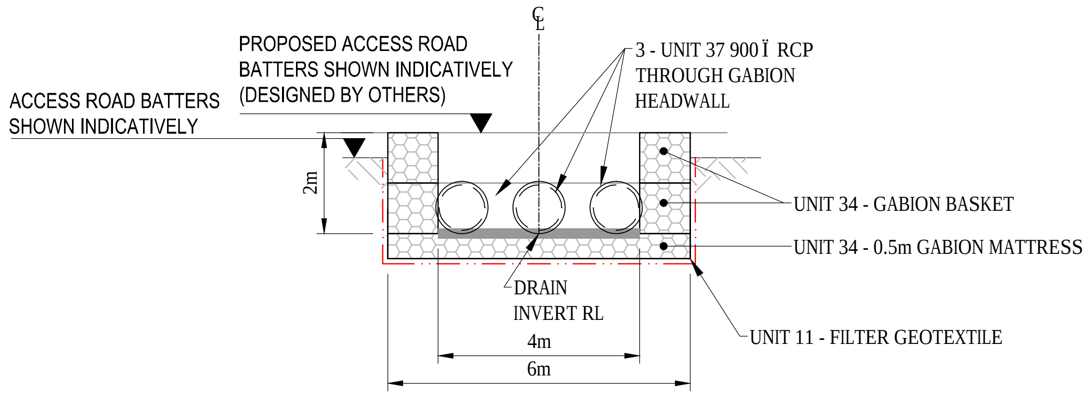
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

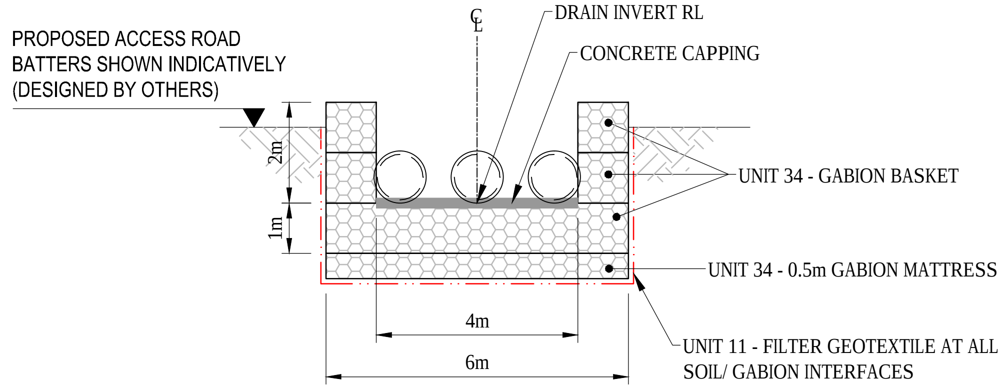
DRAWING TITLE: DIVERSION CHANNEL FROM CENTRAL RIDGE
SECTIONS AND DETAILS
SHEET 1 OF 2

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1055	0

Plot Date: 28 March 2013 Time:9:22:45 AM By: Henry, Steven Path: K:\Hyd\2011\117625003 Whytes Gully\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1055-REV0.dwg
Xref: GAP_LOGO-A3.dwg;



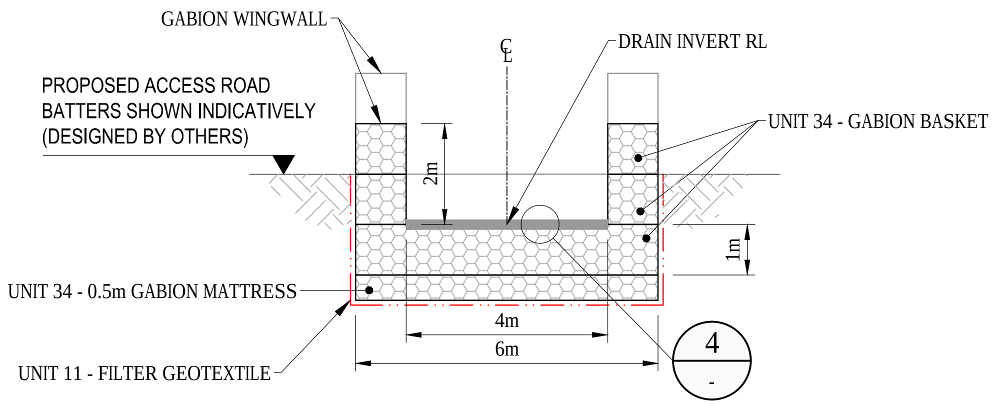
SECTION J GABION CASCADE STEP
SCALE 1:150 D1054



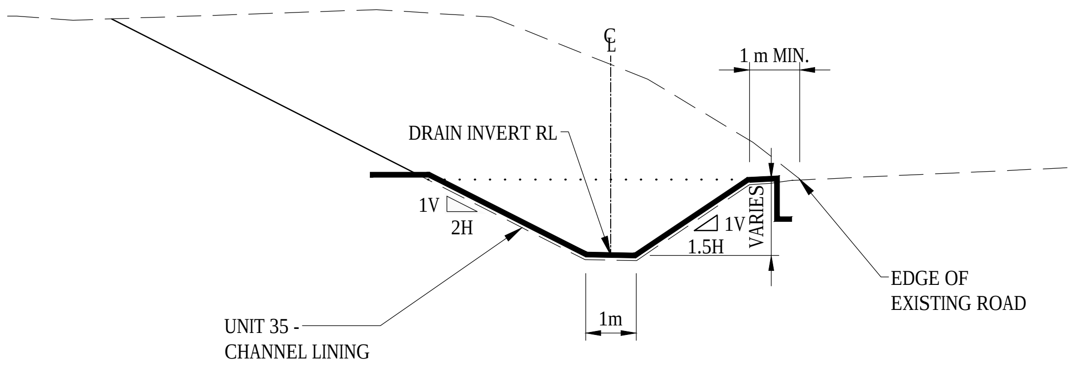
SECTION K GABION CASCADE STEP
SCALE 1:150 D1054

GABION NOTES:

1. GABIONS AND GABION MATRESS: DOUBLE TWISTED, HEXAGONAL WIRE MESH GABIONS OF NOMINAL 80x100 MESH, WITH 3.4mm O/D FRAME WIRE AND 2.7mm MESH WIRE, COMPLETE WITH DIAPHRAGMS AT 1m CENTRES. ALL COMPONENTS TO BE MECHANICALLY CONNECTED AT THE PRODUCTION FACILITY WITH MINIMUM CONNECTION STRENGTH REQUIREMENTS AS PER TABLE 2 OF ASTM A975.
2. ALL WIRE IS MILD STEEL, GALMEC COATED (95% ZINC + 5% ALUMINIUM ALLOY) TO THE REQUIREMENTS OF ASTM B750-99 AND HEAT BONDED THROUGH EXTRUSION WITH AN ADDITIONAL 0.5mm HEAVY DUTY GREY PVC COATING. GABIONS MUST HAVE A VALID BRITISH BOARD OF AGRÉMENT (BBA) CERTIFICATE FOR GALFRAN + PVC WIRE.
3. THE GABION FILL MATERIAL TO BE IN ACCORDANCE WITH AS 2758.4 - 2000.
4. FILTER GEOTEXTILE TO BE PLACED AT ALL MESH SOIL ROCK INTERFACE.
5. PREPARE SUBGRADE BACKFILL AND COMPACT MATERIAL BEHIND AND BELOW THE STRUCTURE TO ENGINEERS SPECIFICATION.
6. ADEQUATE DRAINAGE AND KEYING OF STRUCTURE INTO EMBANKMENT NEEDS TO BE PROVIDED FOR SURFACE RUNOFF RUNNING DOWN SLOPE.
7. CONSTRUCTION OF GABIONS TO BE IN ACCORDANCE WITH MACCAFERRI INSTALLATION GUIDELINES AND INSTRUCTIONS.



SECTION L GABION CASCADE STEP
SCALE 1:150 D1054



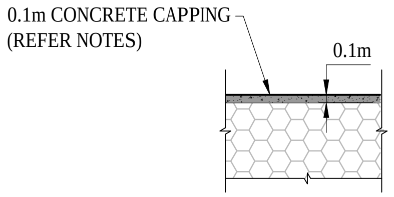
SECTION M LINED CHANEL
SCALE 1:150 D1051 D1055

CONCRETE CAPPING:

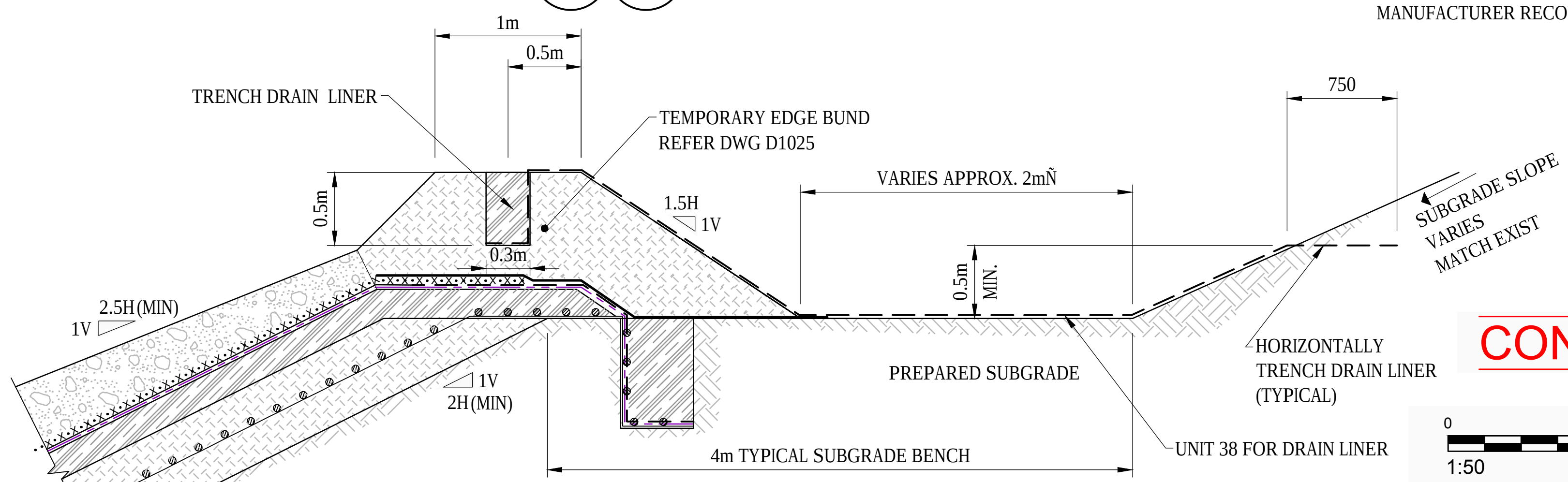
1. THE PURPOSE OF CONCRETE CAPPING IS TO HAVE 100mm OF CONCRETE EMBEDDED WITHIN THE GABION BASKET OR MATRESS. THE CONSTRUCTION SEQUENCE BEING:
   a) FILL THE GABION BASKET OR MATTRESS WITH SPECIFIED ROCK TO 100mm BELOW THE TOP OF THE GABION MESH.
   b) POUR THE CONCRETE TO THE SPECIFIED CAPPING THICKNESS.
   c) ALL OTHER ASPECTS OF CONSTRUCTION AND PLACEMENT OF GABION STRUCTURES TO FOLLOW BEST CONSTRUCTION PRACTICES.

LINED CHANNEL

1. INSTALL AND ANCHOR UNIT 35 CHANNEL LINING PER MANUFACTURER RECOMMENDATIONS.

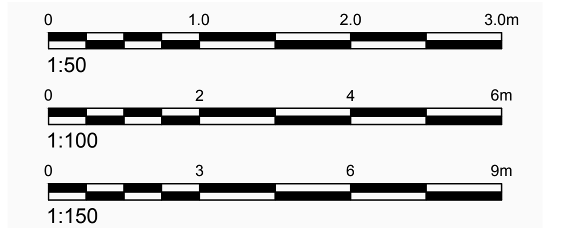


DETAIL 4 GABION CONCRETE CAPPING
SCALE 1:100 D1054



SECTION X TEMPORARY EDGE BUND DRAIN
SCALE 1:50 D1051

ISSUED FOR
CONSTRUCTION



REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates

124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

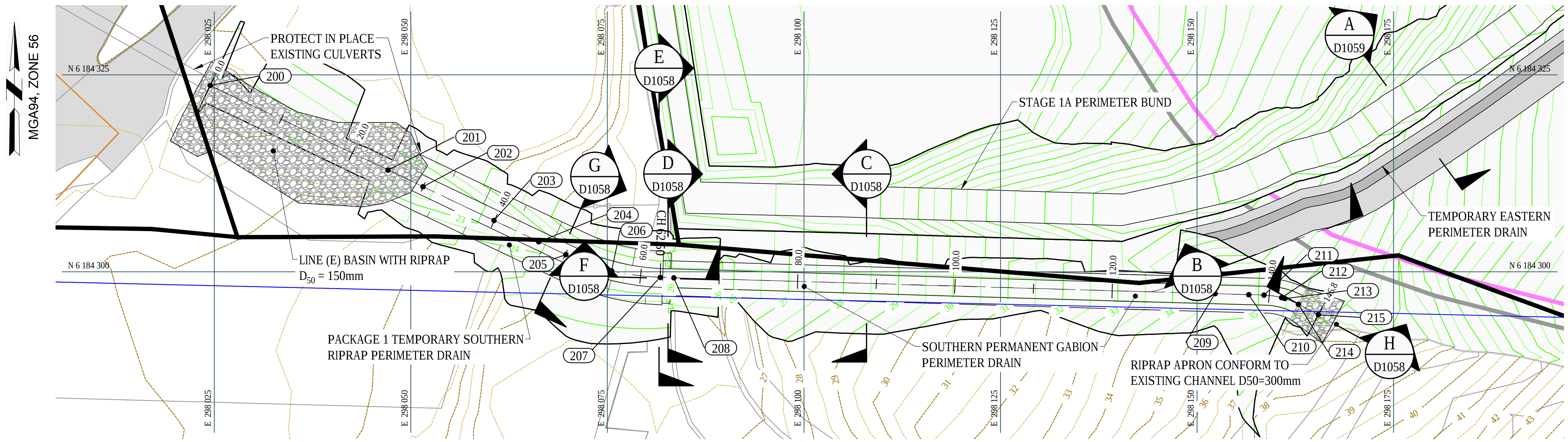
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY - NEW CELL DESIGN

DRAWING TITLE: DIVERSION CHANNEL FROM CENTRAL RIDGE DETAILS AND SECTIONS SHEET 2 OF 2

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1056	0

Plot Date: 28 March 2013 Time:9:24:00 AM By: Henry, Steven Path: K:\Hyd\2011\117625003 Whytes Gully\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1056-REV0.dwg
Xref: GAP_LOGO-A3.dwg;

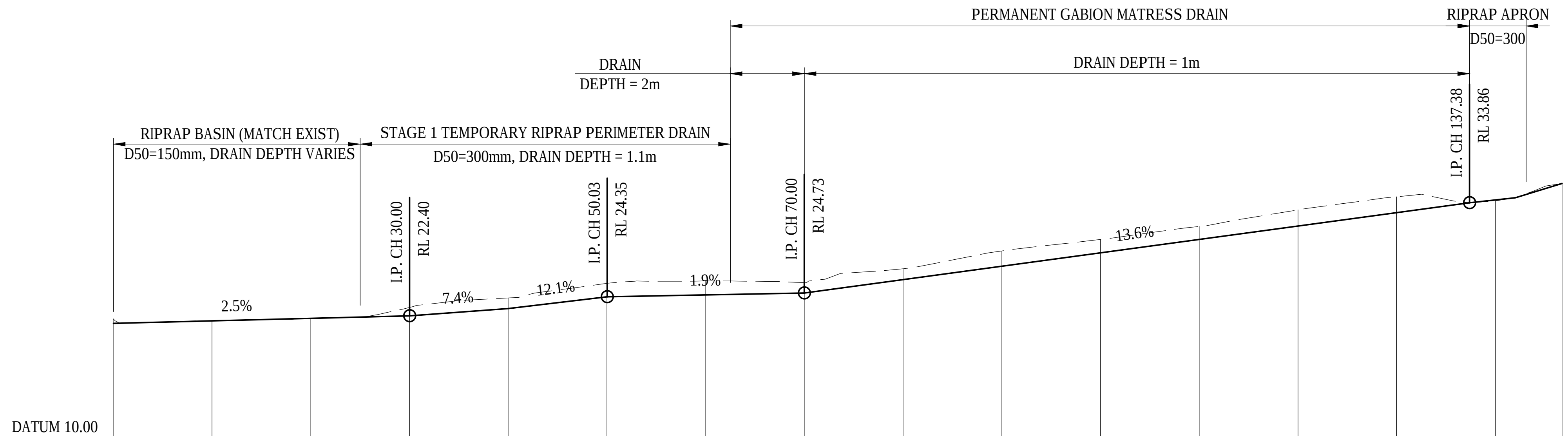


LEGEND

- EXTENT OF EXISTING LINER (REFER D1003)
- PACKAGE BOUNDARY
- APPROX. EXTENT OF EXISTING WASTE (REFER D1003)
- EASEMENT
- PROPOSED CONTOURS
- EXISTING CONTOURS
- •73 SET OUT POINTS (SEE D1051 FOR SET OUT TABLE)

PLAN - SOUTHERN PERMANENT DRAIN

SCALE 1:600



NATURAL SURFACE	22.11	21.93	22.14	23.25	24.21	25.69	25.93	25.77	27.17	28.99	30.15	31.47	33.15	34.47	34.06	35.80
DESIGN SURFACE		21.90	22.15	22.40	23.13	24.34	24.54	24.73	26.09	27.44	28.80	30.15	31.51	32.86	34.15	35.80
DEPTH		0.03	-0.02	0.85	1.08	1.35	1.39	1.04	1.08	1.55	1.35	1.32	1.64	1.61	-0.09	0.00
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	146.76

LONG SECTION - SOUTHERN PERMANENT DRAIN

SCALE 1:600

ISSUED FOR
CONSTRUCTION

0 12 24 36m
1:600

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

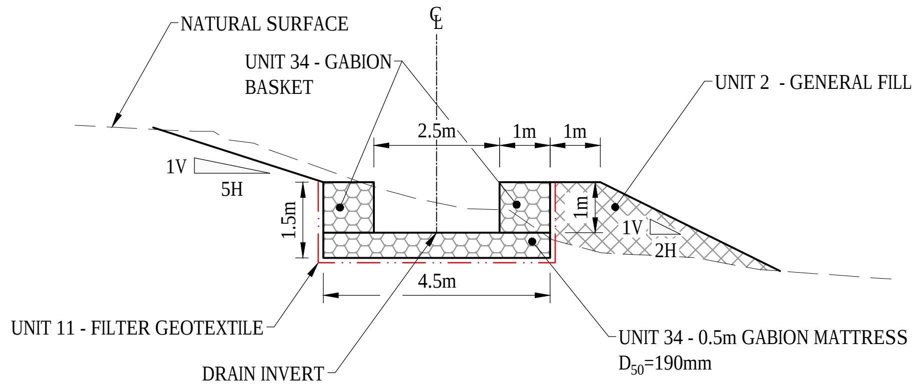
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

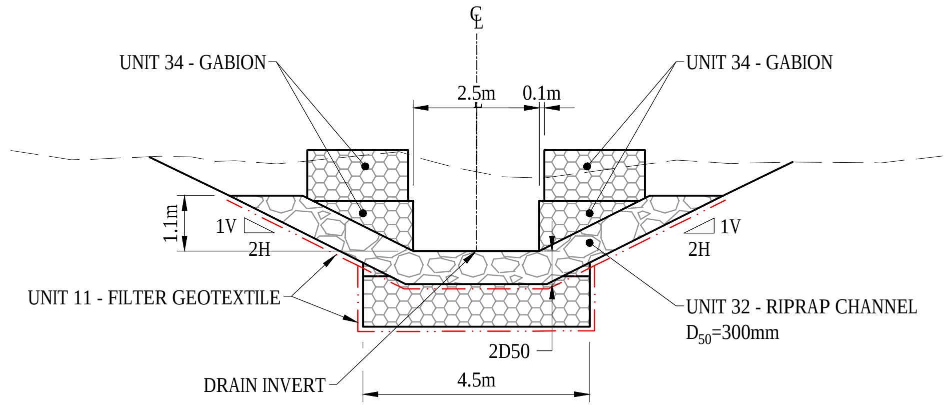
DRAWING TITLE: SOUTHERN PERIMETER DRAIN PLAN AND LONG SECTION

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1057	0

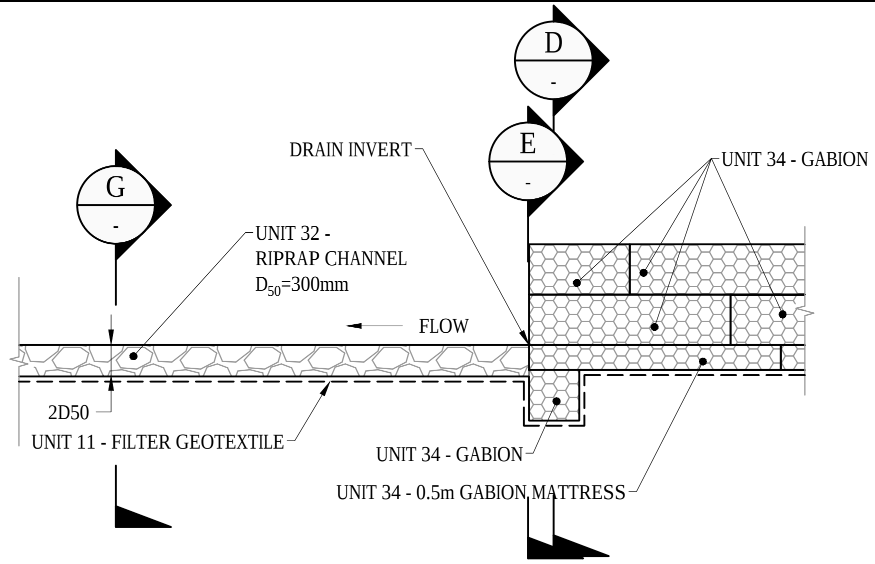
Plot Date: 28 March 2013 Time:9:30:34 AM By: Henry, Steven Path: K:\Hyd\2011\117625003 Whytes Gully\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1057-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING BREAKLINES.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOUNDARY.dwg; 117625003-XREF-BASE LINER STAGE 1B.dwg; 117625003-XREF-BUND STAGE 1B.dwg; 117625003-XREF-SUBGRADE STAGE 1B.dwg; 117625003-XREF-DRAINS PACKAGE 1.dwg; 117625003-XREF-CELL STAGE BOUNDARY.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117



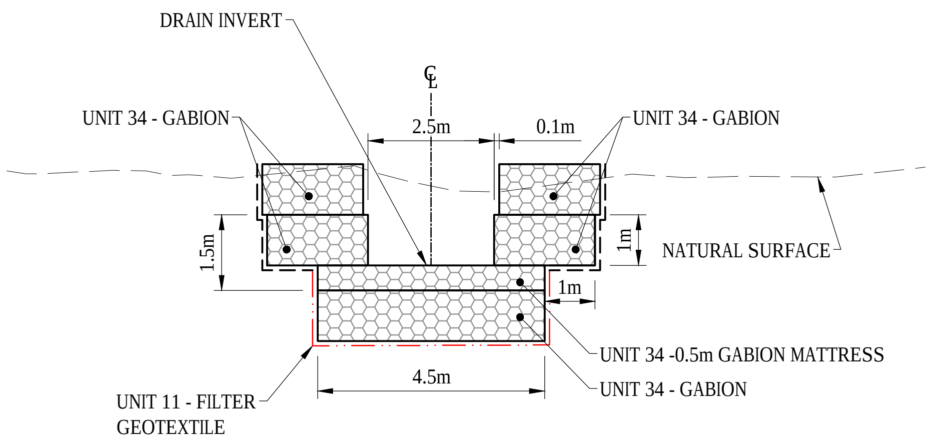
SECTION C PERMANENT DRAIN
SCALE 1:150 D1051 D1051



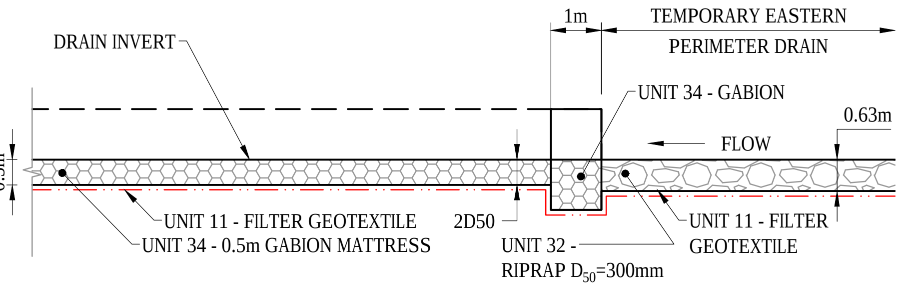
SECTION E STAGE 1 TEMPORARY DRAIN TRANSITION
SCALE 1:150 D1057 -



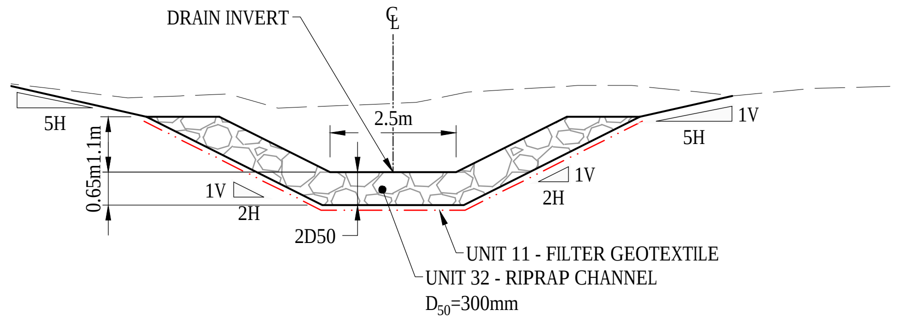
SECTION F PERMANENT DRAIN TO STAGE 1 TEMPORARY DRAIN TRANSITION
SCALE 1:150 D1057



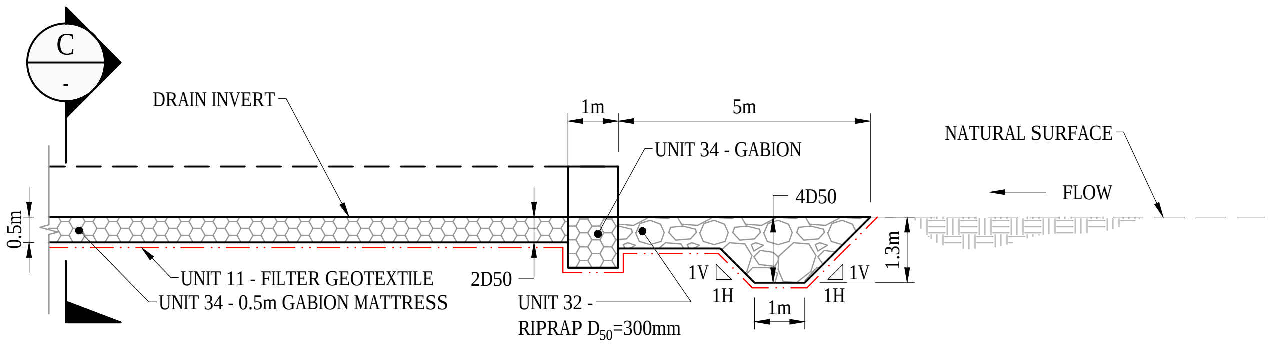
SECTION D END OF GABION DRAIN
SCALE 1:150 D1057 -



SECTION B TEMPORARY EASTERN DRAIN TO GABION CHANNEL TRANSITION
SCALE 1:150 D1057



SECTION G STAGE 1 TEMPORARY DRAIN
SCALE 1:150 D1057 -



SECTION H EXISTING DRAIN TO GABION CHANNEL TRANSITION
SCALE 1:150 D1057

ISSUED FOR
CONSTRUCTION

0 3 6 9m
1:150

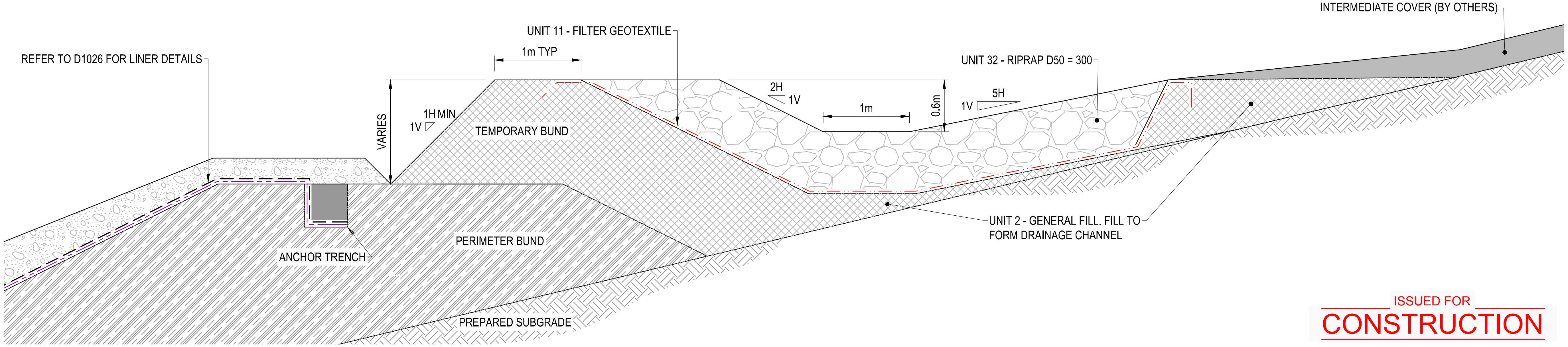
REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN
DRAWING TITLE: SOUTHERN PERIMETER DRAIN SECTIONS AND DETAILS

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1058	0

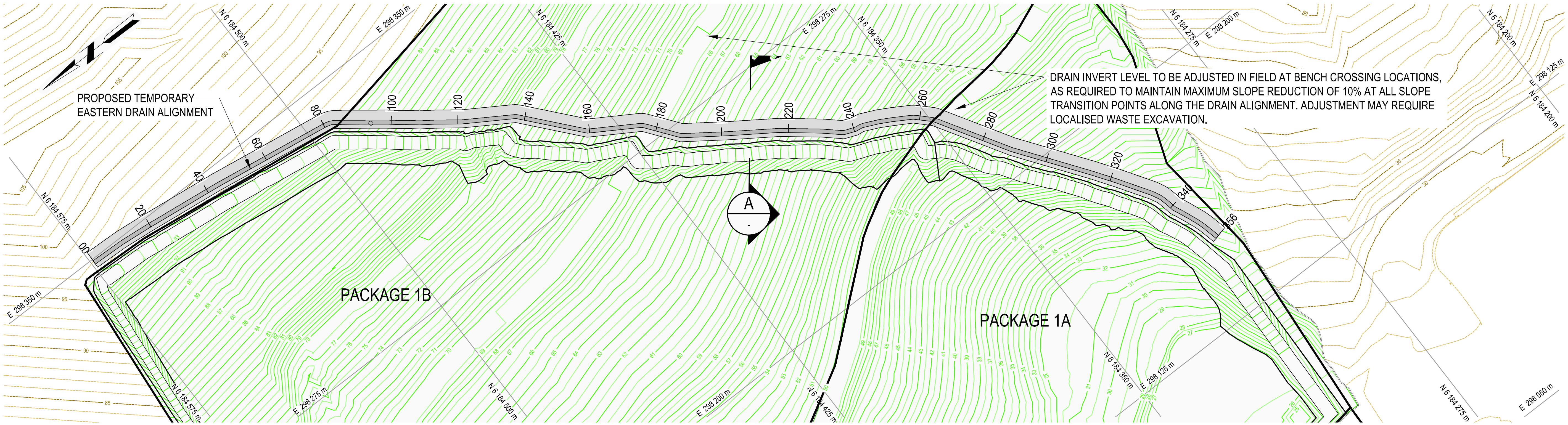
Plot Date: 28 March 2013 Time:9:32:09 AM By: Henry, Steven Path: K:\Hyd\2011\117625003 Whytes Gully\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1058-REV0.dwg
Xref: GAP_LOGO-A3.dwg;



ISSUED FOR
CONSTRUCTION

0 25 50 75m
1:1,250

SECTION A - TYPICAL SECTION - TEMPORARY EASTERN DRAIN
NOT TO SCALE



TEMPORARY EASTERN DRAIN ALIGNMENT - PLAN VIEW
SCALE 1:1,250

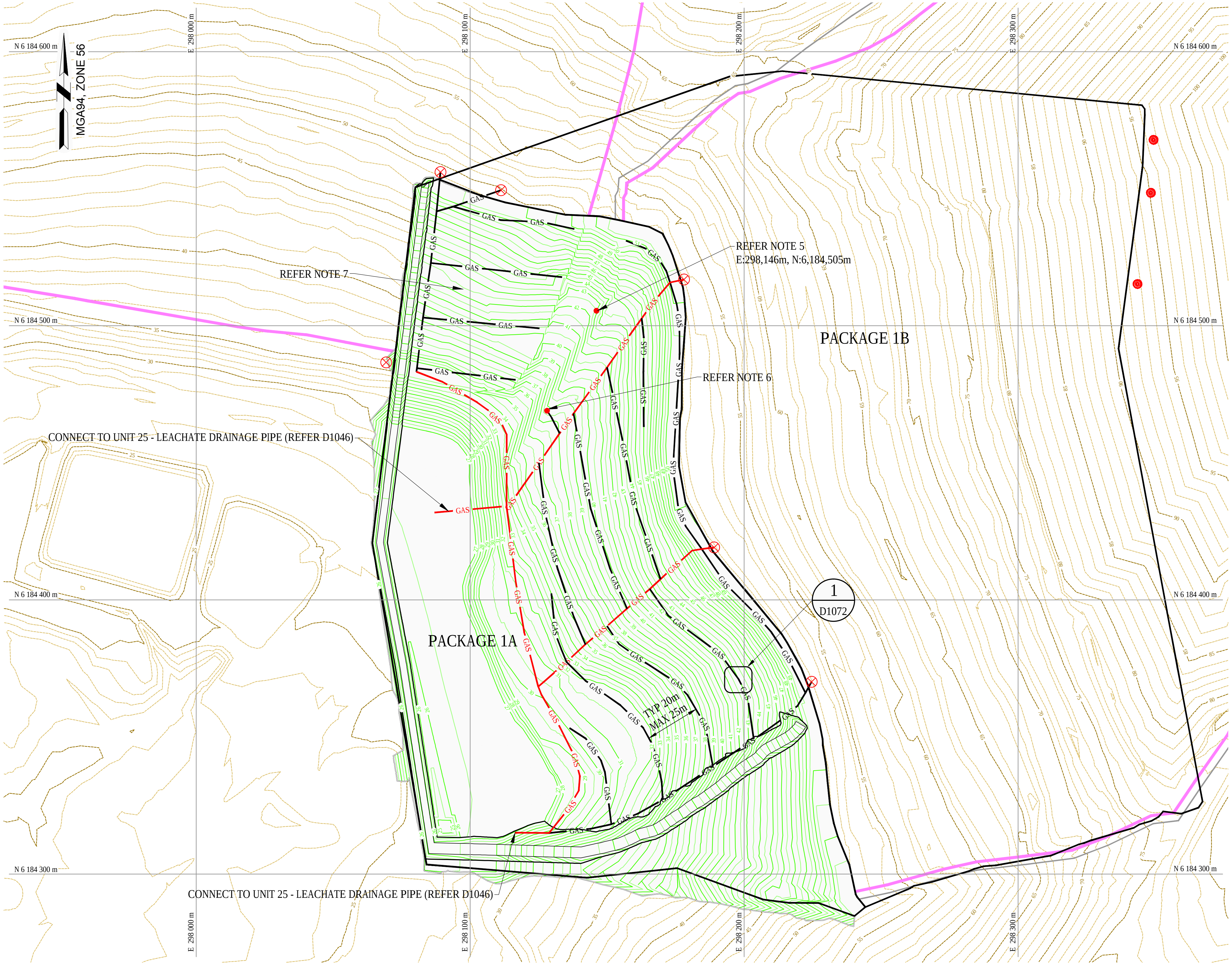
REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN
DRAWING TITLE: TEMPORARY EASTERN PERIMETER DRAIN ALIGNMENT AND DETAILS

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1059	0

Plot Date: 28 March 2013 Time:10:49:26 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1059-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-SUBGRADE STAGE 1A.dwg; 117625003-XREF-SUBGRADE STAGE 1B.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-BUND STAGE 1B.dwg; 117625003-XREF-CELL STAGE BOUNDARY.dwg;



LEGEND

- EXTENT OF EXISTING LINER (REFER DRAWING D1003)
- PACKAGE BOUNDARY
- APPROX. EXTENT OF EXISTING WASTE (REFER DRAWING D1003)
- SUBGRADE CONTOURS
- EXISTING CONTOURS
- GAS — UNIT 21 - GAS COLLECTION PIPE(PERFORATED WALL)
- GAS — UNIT 21 - GAS COLLECTION PIPE (SOLID WALL)
- TEMPORARY GAS VENT (REFER NOTE 4)

NOTE:

1. REFER TO D1001 FOR GENERAL NOTES, MATERIAL LIST AND DRAWING REFERENCES.
2. GAS COLLECTION PIPES TO BE CONNECTED AT ALL INTERSECTIONS.
3. GAS COLLECTION PIPES TO BE ALIGNED APPROXIMATELY AS INDICATED.
4. PROVIDE TEMPORARY COVERED VENT TO ACCOMMODATE FUTURE EXTENSION OF GAS COLLECTION PIPE.
5. LOCATE EXISTING DRAINAGE PIPE (100mm D, SLOTTED WALL) AND CONNECT TO UNIT 21 PIPE. CONNECTION IS TO BE MADE TO SAME STANDARD AS FOR UNIT 21 PIPE. CONNECTION LOCATION IS BASED ON SURVEY INFORMATION. NOTE: EXISTING PIPE IS POTENTIALLY ACTIVE AND DRAINING WATER FROM BELOW THE EXISTING EASTERN GULLY LANDFILL LINER SYSTEM.
6. LOCATE AND CONNECT EXISTING DRAINAGE PIPE. SAME AS DESCRIBED IN NOTE 5 EXCEPT CONNECTION LOCATION IS INDICATIVE ONLY.
7. EXISTING GAS WELLS IN WESTERN GULLY LANDFILL TO BE REMOVED BY OTHERS PRIOR TO SUBGRADE FORMATION

ISSUED FOR
CONSTRUCTION

0 30 60 90m
1:1,500

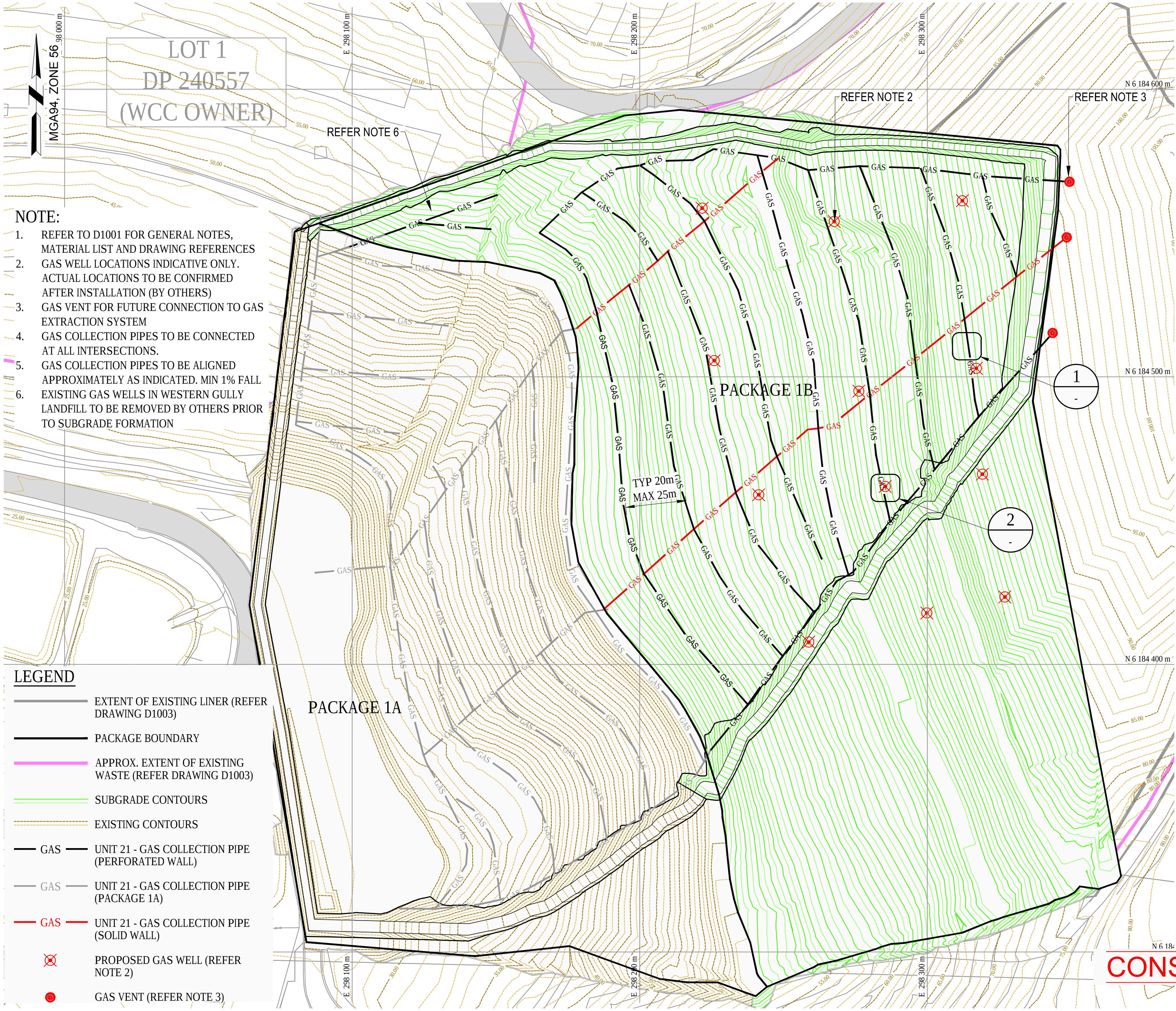
REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN
DRAWING TITLE: PIGGY BACK GAS VENTING PLAN PACKAGE 1A

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	1:1,500	A3	117625003	220	L	D1071	0

Plot Date: 28 March 2013 Time:10:48:25 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1071-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOUNDARY.dwg; 117625003-XREF-SUBGRADE STAGE 1A.dwg; 117625003-XREF-CELL STAGE BOUNDARY.dwg; 117625003-XREF-PIGGY BACK GAS VENTING.dwg;

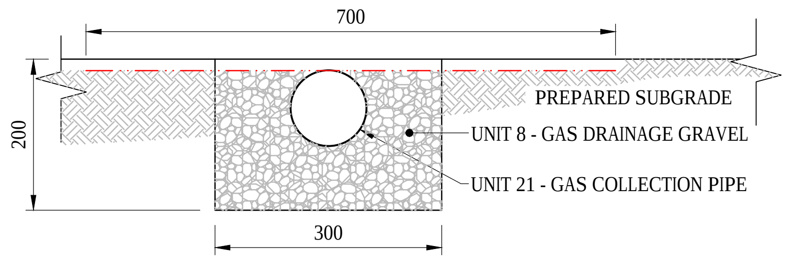


NOTE:

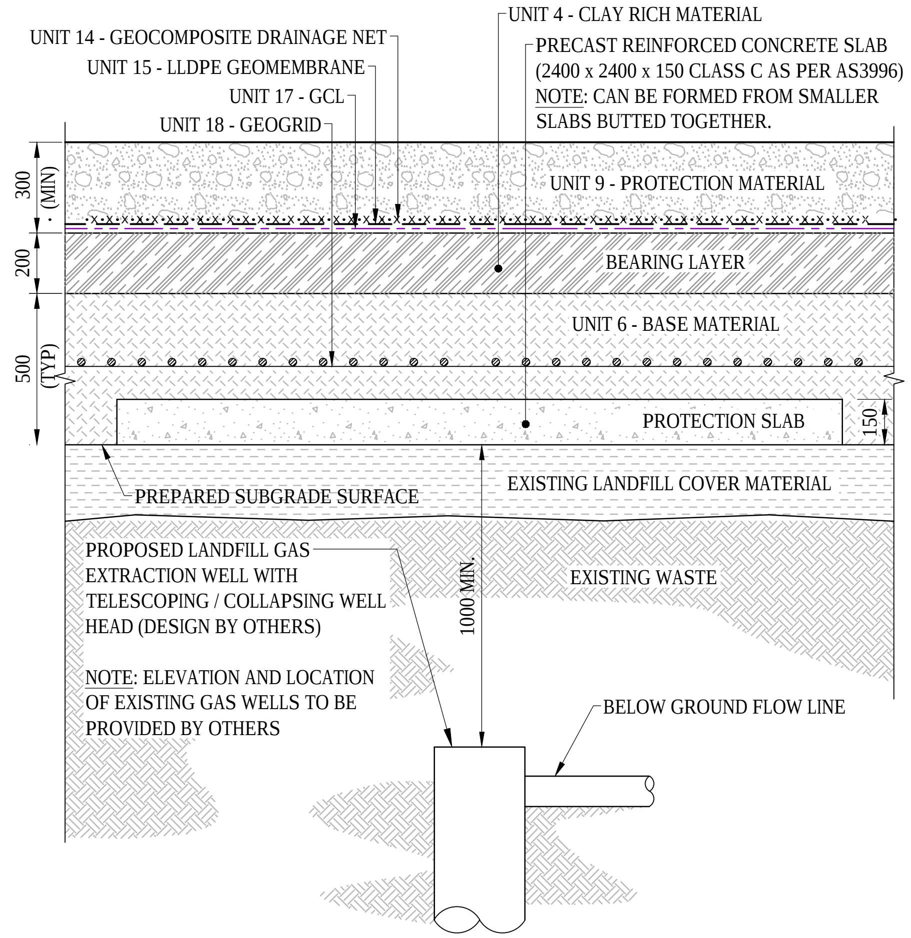
1. REFER TO D1001 FOR GENERAL NOTES, MATERIAL LIST AND DRAWING REFERENCES
2. GAS WELL LOCATIONS INDICATIVE ONLY. ACTUAL LOCATIONS TO BE CONFIRMED AFTER INSTALLATION (BY OTHERS)
3. GAS VENT FOR FUTURE CONNECTION TO GAS EXTRACTION SYSTEM
4. GAS COLLECTION PIPES TO BE CONNECTED AT ALL INTERSECTIONS.
5. GAS COLLECTION PIPES TO BE ALIGNED APPROXIMATELY AS INDICATED. MIN 1% FALL
6. EXISTING GAS WELLS IN WESTERN GULLY LANDFILL TO BE REMOVED BY OTHERS PRIOR TO SUBGRADE FORMATION

LEGEND

- EXTENT OF EXISTING LINER (REFER DRAWING D1003)
- PACKAGE BOUNDARY
- APPROX. EXTENT OF EXISTING WASTE (REFER DRAWING D1003)
- SUBGRADE CONTOURS
- EXISTING CONTOURS
- GAS — UNIT 21 - GAS COLLECTION PIPE (PERFORATED WALL)
- GAS — UNIT 21 - GAS COLLECTION PIPE (PACKAGE 1A)
- GAS — UNIT 21 - GAS COLLECTION PIPE (SOLID WALL)
- PROPOSED GAS WELL (REFER NOTE 2)
- GAS VENT (REFER NOTE 3)



DETAIL 1 TYPICAL GAS TRENCH DETAIL
SCALE 1:10



DETAIL 2 PROTECTION SLAB AT VERTICAL GAS WELL FOR PIGGY BACK LINER SYSTEM
SCALE 1:25

Scale bars: 0 – 200 – 400 – 600mm 1:10; 0 – 500 – 1,000 – 1,500mm 1:25; 0 – 30 – 60 – 90m 1:1,500

ISSUED FOR CONSTRUCTION

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

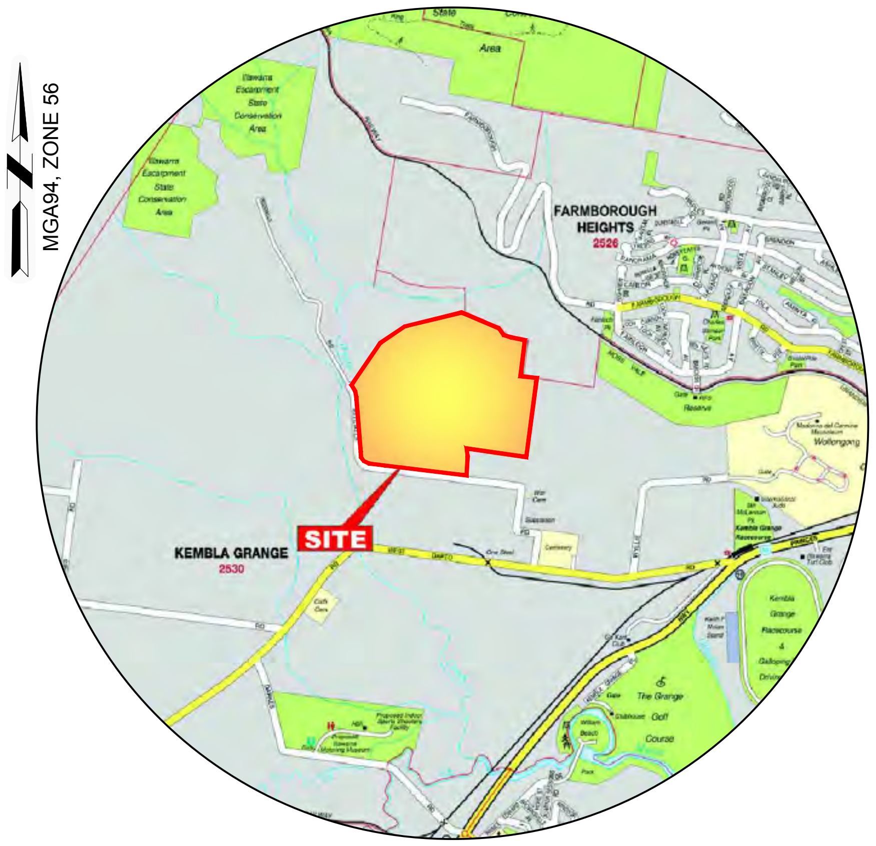
Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN
DRAWING TITLE: PIGGY BACK GAS VENTING PACKAGE 1B

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1072	0

Plot Date: 28 March 2013 Time:10:47:46 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1072-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING BREAKLINES.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOUNDARY.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-BUND STAGE 1B.dwg; 117625003-XREF-SUBGRADE STAGE 1A.dwg; 117625003-XREF-SUBGRADE STAGE 1B.dwg; 117625003-XREF-PIGGY BACK GAS VENTING.dwg; 117625003-XREF-CELL STAGE BOUNDARY.dwg

WOLLONGONG CITY COUNCIL
WHYTES GULLY LANDFILL - NEW CELL DESIGN



LOCALITY PLAN

NOT TO SCALE

NOTES:

1. THESE NOTES APPLY TO ALL PROJECT DRAWINGS IN THE SET UNLESS NOTED OTHERWISE AND SHALL BE READ IN CONJUNCTION WITH THE SPECIFICATION.
2. ALL LEVELS ARE IN METRES TO AUSTRALIAN HEIGHT DATUM (AHD).
3. ALL CO-ORDINATES ARE IN METRES TO MAP GRID AUSTRALIA (MGA).
4. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
5. DIMENSIONS AND LOCATION OF EXISTING STRUCTURES SHALL BE CONFIRMED ON SITE BY THE CONTRACTOR PRIOR TO COMMENCEMENT OF WORKS.
6. LOCATION AND DEPTH OF ALL SERVICES TO BE VERIFIED BY THE CONTRACTOR PRIOR TO COMMENCEMENT OF WORKS.
7. DIMENSIONS SHALL NOT BE SCALED OFF DRAWINGS.

NOT FOR CONSTRUCTION - ISSUED FOR
CLIENT REVIEW

DRAWING LIST

TENDER PACKAGE 2

D2001	SITE LOCALITY AND DRAWING LIST - PACKAGE 2
D2002	SITE PLAN AND WORKS AREA - PACKAGE 2
D2003	2011 CONTOURS AND EASEMENTS - PACKAGE 2
D2011	SUBGRADE PREPARATION PLAN - PACKAGE 2
D2012	SUBGRADE PREPARATION SECTIONS - PACKAGE 2
D2013	PERIMETER BUND AND INTERNAL BUND PLAN AND SETOUT - PACKAGE 2
D2014	PERIMETER BUND AND INTERNAL BUND LONG SECTIONS - PACKAGE 2
D2015	PERIMETER BUND AND INTERNAL BUND CROSS SECTIONS - PACKAGE 2
D2021	LINER DETAILS - SHEET 1 - PACKAGE 2
D2022	LINER DETAILS - SHEET 2 - PACKAGE 2
D2023	LINER DETAILS - SHEET 3 - PACKAGE 2
D2030s	NOT USED
D2041	TOP OF LINER AND LEACHATE COLLECTION SYSTEM PLAN AND SETOUT - PACKAGE 2
D2042	LEACHATE SUMP PLAN AND DETAILS - PACKAGE 2
D2043	LEACHATE COLLECTION SYSTEM DETAIL SHEET 1 - PACKAGE 2
D2044	LEACHATE COLLECTION SYSTEM DETAIL SHEET 2 - PACKAGE 2
D2045	LEACHATE COLLECTION SYSTEM DETAIL SHEET 3 - PACKAGE 2
D2046	CONNECTION TO EXISTING LEACHATE SYSTEM AND LEACHATE DRAINAGE PIPE, PLAN AND SETOUT
D2051	SOUTHERN PERIMETER DRAIN - PLAN AND SETOUT - PACKAGE 2
D2052	SOUTHERN PERIMETER DRAIN - PLAN AND LONG SECTION - PACKAGE 2
D2053	SOUTHERN PERIMETER DRAIN DETAILS - PACKAGE 2
D2060s	NOT USED
D2071	PIGGY BACK GAS VENTING PLAN - PACKAGE 2

MATERIAL LIST

UNIT 1	NOT USED
UNIT 2	GENERAL FILL
UNIT 3	COVER MATERIAL
UNIT 4	CLAY RICH MATERIAL
UNIT 5	CLAY MATERIAL
UNIT 6	BASE MATERIAL
UNIT 7	DRAINAGE AGGREGATE
UNIT 8	GAS DRAINAGE AGGREGATE
UNIT 9	PROTECTION MATERIAL
UNIT 11	FILTER GEOTEXTILE
UNIT 12	CUSHION GEOTEXTILE
UNIT 13	NOT USED
UNIT 14	GEOCOMPOSITE DRAINAGE NET
UNIT 15	LLDPE GEOMEMBRANE
UNIT 16	HDPE GEOMEMBRANE
UNIT 17	GCL
UNIT 18	GEOGRID
UNIT 21 (GAS — GAS)	GAS COLLECTION PIPE
UNIT 22	NOT USED
UNIT 23	LEACHATE COLLECTION PIPE
UNIT 24	LEACHATE SUMP OUTLET PIPE
UNIT 25	LEACHATE DRAINAGE PIPE
UNIT 26	NOT USED
UNIT 27	LEACHATE SUMP RISER
UNIT 28	NOT SHOWN
UNIT 31	BENTONITE
UNIT 32	RIPRAP ARMOURSTONE AND AGGREGATE FOR GABION BASKETS AND WIRE MATTRESS
UNIT 33	NOT USED
UNIT 34	ROCK FILLED GABIONS AND MATTRESSES
UNIT 35	NOT USED
UNIT 36	PRECAST REINFORCED CONCRETE BOX CULVERT (RCBC)
UNIT 37	NOT USED
UNIT 38	NOT USED

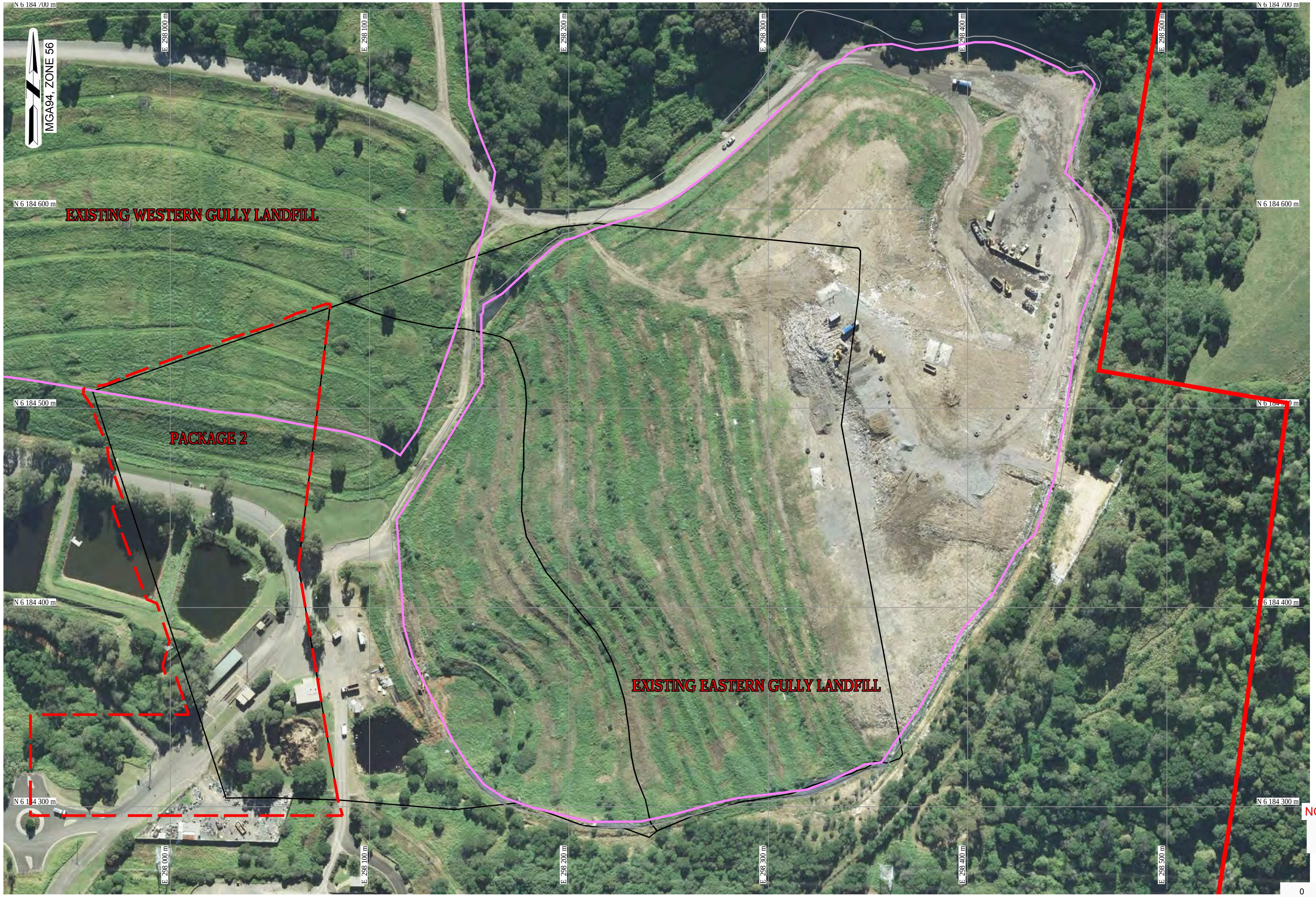
REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.05.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN
DRAWING TITLE: SITE LOCALITY AND DRAWING LIST - PACKAGE 2

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D2001	A

Plot Date: 5 April 2013 Time:5:58:44 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 2 - File Name:117625003-220-L-D2001-REVA.dwg
Xref: GAP_LOGO-A3.dwg; WHYTES GULLY UBD.jpg;



LEGEND

- PROPERTY BOUNDARY
- PACKAGE BOUNDARY
- WORKS AREA BOUNDARY APPROX.
- EXTENT OF EXISTING WASTE (REFER NOTE 1)

NOTES:

1. APPROX. EXTENT OF WASTE BASED PRIMARILY ON SITE OBSERVATION AND INFORMATION FROM COUNCIL.
2. AERIAL ORTHO-PHOTOGRAPH PROVIDED BY AAM PTY LTD TAKEN ON 16TH MAY 2011, REFRENCE 18763A. IMAGE GEOREFERENCED
PACKAGE 1 CONSTRUCTION NOT SHOWN

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

0 40 80 120m

1:2,000

BASE DRAWING TAKEN FROM K F WILLIAMS AND ASSOCIATES DWG. WHYTES PHOTOGRAMMETRY AND GROUND SURVEY 20.07.2011,DATED 20TH JULY 2011

SITE PLAN AND WORK AREAS - PACKAGE 2

SCALE 1:2,000

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.05.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

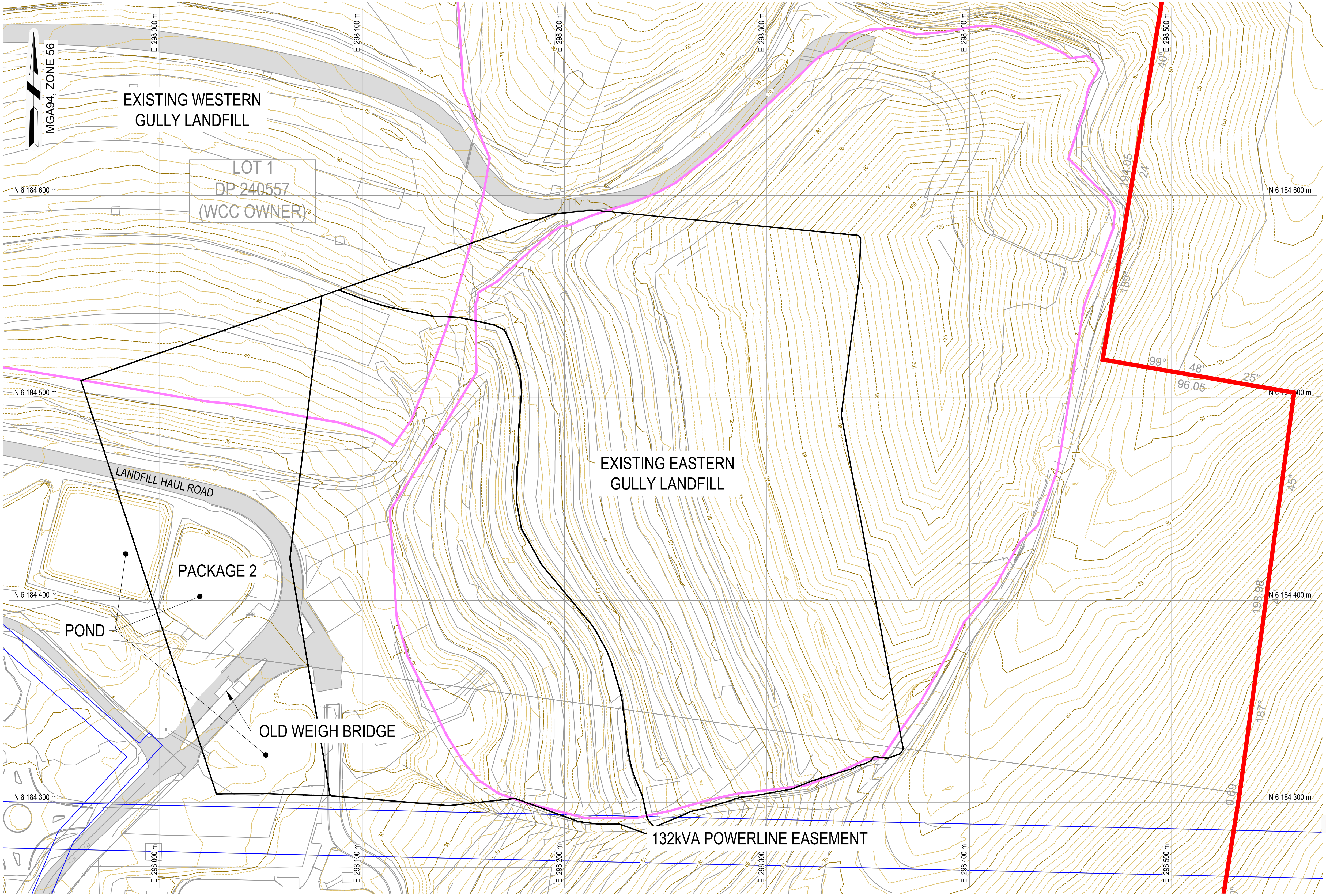
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: SITE PLAN AND WORKS AREA PACKAGE 2

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	1:2000	A3	117625003	220	L	D2002	A

Plot Date: 5 April 2013 Time:6:00:40 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 2 - File Name:117625003-220-L-D2002-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-Imagery - AAM May 2011.dwg; 117625003-XREF-CELL STAGE BOUNDARY.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOIUNDARY.dwg; 117625003-XREF-WORKS AREA - PACKAGE2.dwg; Whytes-Gully_16052011_10cm.jpg;



LEGEND

- PROPERTY BOUNDARY
- PACKAGE BOUNDARY
- APPROX. EXTENT OF EXISTING WASTE (REFER NOTE 1)

NOTES:

1. APPROX. EXTENT OF WASTE BASED PRIMARILY ON SITE OBSERVATION AND INFORMATION FROM COUNCIL.
2. CONTOURS ABOVE RL 75m ON EASTERN GULLY LANDFILL REFLECT FINAL PROFILE DESIGN FOR EASTERN GULLY (GOLDER DRAWING 097625103-006-R-F019-REVA)

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

0 40 80 120m

1:2,000

BASE DRAWING TAKEN FROM K F WILLIAMS AND ASSOCIATES DRG.WHYTES PHOTOGRAMMETRY AND GROUND SURVEY 20-07-11.dxf DATED 20 JULY 2011.

2011 CONTOURS AND EASEMENT - PACKAGE 2

SCALE 1:2,000

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.05.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

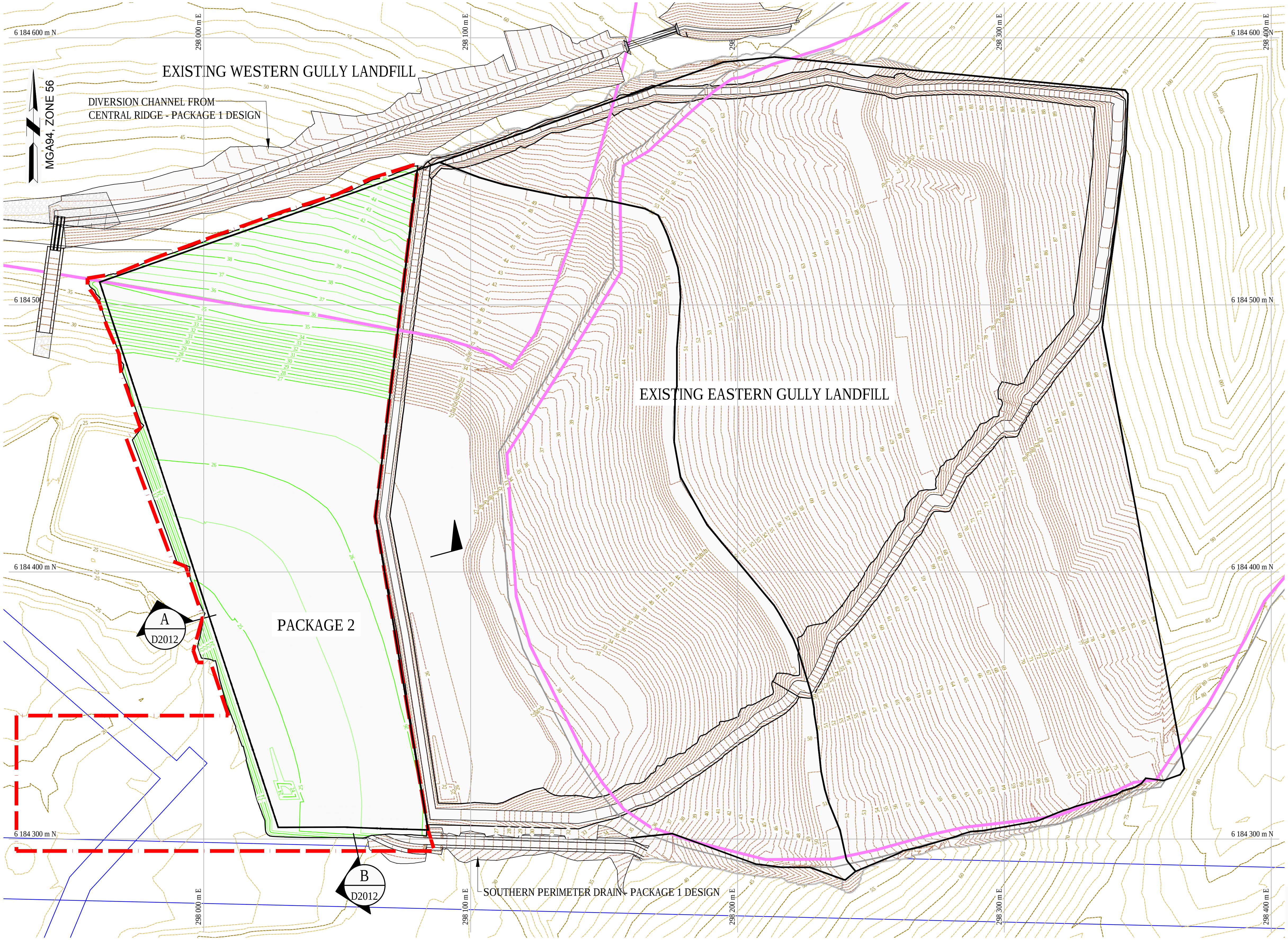
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: 2011 CONTOURS AND EASEMENTS PACKAGE 2

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D2003	A

Plot Date: 5 April 2013 Time:7:16:11 PM By: Campbell, Helen Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 2 - File Name:117625003-220-L-D2003-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-Cadastre and easement.dwg; 117625003-XREF-EXISTING BREAKLINES.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOIUNDARY.dwg; 117625003-XREF-CELL STAGE BOUNDARY.dwg;



LEGEND

- PACKAGE BOUNDARY
- WORKS AREA BOUNDARY
- APPROX. EXTENT OF EXISTING WASTE (REFER DRAWING D2003)
- PACKAGE 1 DESIGN CONTOURS
- SUBGRADE CONTOURS
- 2011 CONTOURS
- EASEMENT

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

0 30 60 90m

1:1,500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.05.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

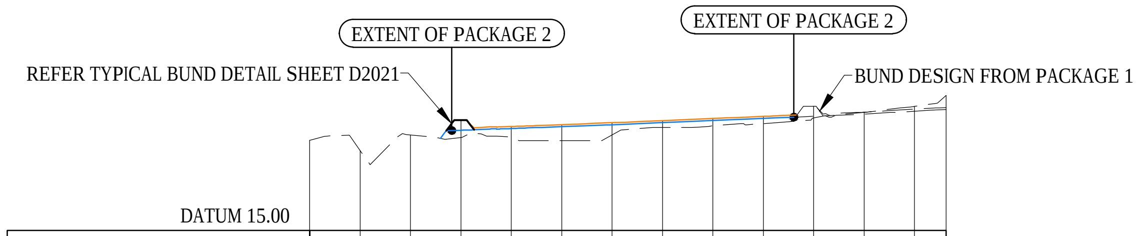
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: SUBGRADE PREPARATION PLAN PACKAGE 2

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	1:1,500	A3	117625003	220	L	D2011	A

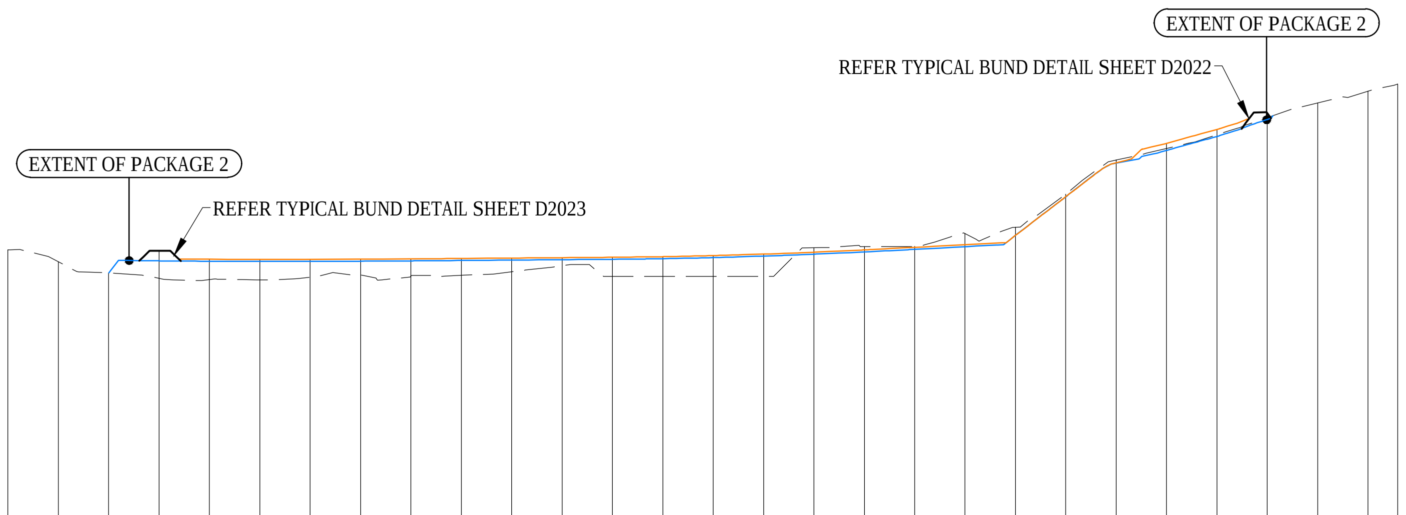
Plot Date: 5 April 2013 Time:6:11:20 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 2 - File Name:117625003-220-L-D2011-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOUNDARY.dwg; 117625003-XREF-SUBGRADE STAGE 1A.dwg; 117625003-XREF-SUBGRADE STAGE 1B.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-BUND STAGE 1B.dwg; 117625003-XREF-WORKS AREA - PACKAGE2.dwg; 117625003-XREF-SUBGRADE STAGE 2.dwg; 117625003-XREF-Cadastre and easement.dwg;



	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	126.31
EXISTING SURFACE	23.91	22.89	24.42	24.19	24.23	23.87	24.45	25.18	25.33	25.57	26.14	26.67	27.26	28.34
SUBGRADE				24.90	25.07	25.26	25.45	25.65	25.86	26.07				
TOP OF LINER					25.27	25.46	25.65	25.85	26.06	26.27				
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	126.31

SECTION A D2011 TYPICAL SECTION

HOR SCALE 1:1,500
VER SCALE 1:750



	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00	220.00	230.00	240.00	250.00	260.00	270.00	275.90
EXISTING SURFACE	26.49	25.31	24.20	23.67	23.54	23.51	23.76	23.97	23.88	23.98	24.32	24.91	23.87	23.87	23.87	23.87	26.69	26.81	26.83	28.10	28.73	32.01	35.39	36.54	37.90	39.60	41.06	42.22	42.93
SUBGRADE				25.40	25.36	25.33	25.34	25.36	25.39	25.43	25.47	25.51	25.55	25.61	25.72	25.87	26.05	26.28	26.54	26.80	27.91	31.76	35.09	36.35	37.73	39.41			
TOP OF LINER					25.56	25.54	25.54	25.56	25.60	25.63	25.67	25.71	25.75	25.81	25.92	26.07	26.25	26.48	26.74	27.00	27.91	31.76	35.12	37.05	38.43				
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00	220.00	230.00	240.00	250.00	260.00	270.00	275.90

SECTION B D2011 TYPICAL SECTION

HOR SCALE 1:1,500
VER SCALE 1:750

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

0 15 30 45m
1:750

0 30 60 90m
1:1,500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.05.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

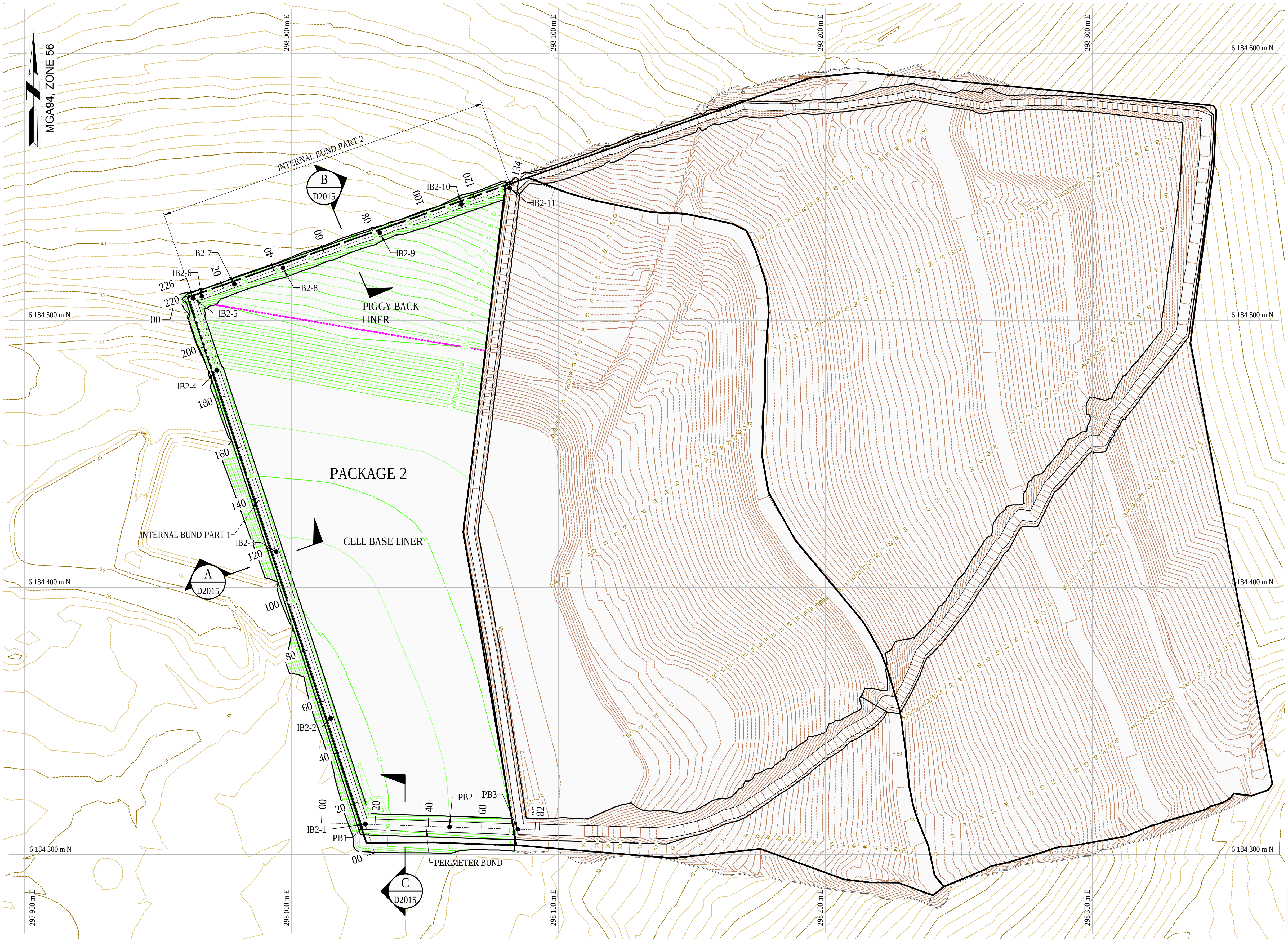
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: SUBGRADE PREPARATION SECTIONS PACKAGE 2

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D2012	A

Plot Date: 5 April 2013 Time:6:08:34 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 2 - File Name:117625003-220-L-D2012-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-SUBGRADE SECTIONS - STAGE 2.dwg;



LEGEND

- PACKAGE BOUNDARY
- BUND SUBGRADE CONTOURS
- 2011 CONTOURS
- CONNECTION LINE - CELL BASE LINER AND PIGGY BACK LINER
- PACKAGE 1 DESIGN CONTOURS (SUBGRADE AND BUNDS)

PACKAGE 2 BUND - SETOUT			
NUMBER	EASTING	NORTHING	LEVEL
IB2-1	298027.53	6184311.28	25.71
IB2-2	298014.56	6184350.92	25.71
IB2-3	297994.14	6184413.28	26.34
IB2-4	297971.89	6184481.26	27.98
IB2-5	297963.08	6184508.17	36.00
IB2-6	297966.31	6184509.00	36.83
IB2-7	297978.46	6184513.46	37.71
IB2-8	297996.68	6184519.55	39.19
IB2-9	298032.94	6184532.72	42.08
IB2-10	298063.54	6184543.33	45.68
IB2-11	298081.57	6184549.56	48.58
PB1	298027.53	6184311.28	25.71
PB2	298059.11	6184310.25	26.50
PB3	298084.63	6184309.42	27.09

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

0 30 60 90m

1:1,500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.05.2013

Golder Associates

124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

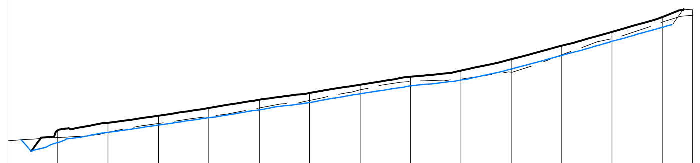
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: PERIMETER BUND AND INTERNAL BUND PLAN AND SETOUT PACKAGE 2

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	1:1,500	A3	117625003	220	L	D2013	A

Plot Date: 5 April 2013 Time:6:10:14 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 2 - File Name:117625003-220-L-D2013-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-SUBGRADE STAGE 2.dwg; 117625003-XREF-SUBGRADE STAGE 1B.dwg; 117625003-XREF-SUBGRADE STAGE 1A.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-BUND STAGE 1B.dwg; 117625003-XREF-BUND STAGE 2.dwg; 117625003-XREF-CELL STAGE BOUNDARY.dwg;

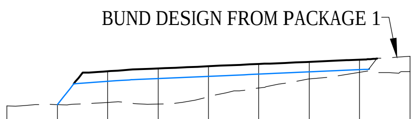


DATUM 30.00

EXISTING SURFACE	35.64	35.95	36.46	37.36	38.05	38.90	39.64	40.68	41.51	41.77	42.45	44.16	45.77	47.39	48.09
SUBGRADE		35.46	36.48	37.20	37.92	38.71	39.44	40.29	41.08	41.65	42.76	44.09	45.49	46.90	
DESIGN SURFACE		36.65	37.43	38.13	38.88	39.71	40.38	41.20	41.99	42.60	43.72	45.05	46.44	47.92	
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	136.00

LONGITUDINAL SECTION OF INTERNAL BUND PART 2

SCALE 1:1,500(H) 1:750(V)

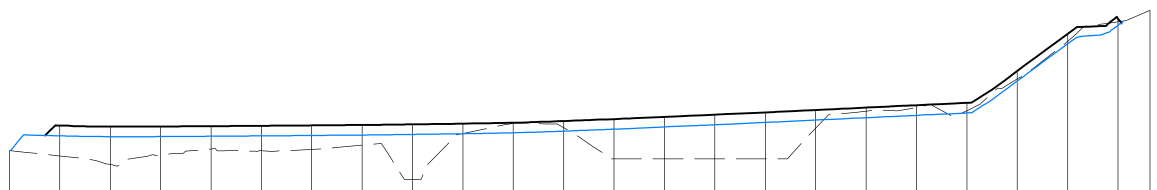


DATUM 20.00

EXISTING SURFACE	22.40	22.52	22.73	22.57	23.27	24.18	25.07	25.72	25.78
SUBGRADE			24.82	25.11	25.33	25.54	25.76	25.98	
DESIGN SURFACE			25.82	26.11	26.33	26.54	26.76	26.98	
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00

LONGITUDINAL SECTION OF PERIMETER BUND

SCALE 1:1,500(H) 1:750(V)



DATUM 15.00

EXISTING SURFACE	23.26	22.71	21.89	22.82	23.41	23.25	23.36	23.78	20.40	24.92	25.93	25.51	22.43	22.43	22.43	22.43	25.47	27.15	27.48	27.18	30.36	34.07	36.03	37.15
SUBGRADE		24.71	24.63	24.63	24.67	24.70	24.74	24.79	24.85	24.92	25.01	25.17	25.37	25.59	25.81	26.03	26.27	26.51	26.74	26.98	30.15	33.83	35.69	
DESIGN SURFACE		25.73	25.63	25.63	25.66	25.70	25.74	25.79	25.85	25.92	26.01	26.17	26.37	26.59	26.81	27.03	27.27	27.51	27.74	27.98	31.14	34.81	36.33	
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00	220.00	226.32

LONGITUDINAL SECTION OF INTERNAL BUND PART 1

SCALE 1:1,500(H) 1:750(V)

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

0 15 30 45m

1:750

0 30 60 90m

1:1,500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.05.2013

Golder Associates

124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL

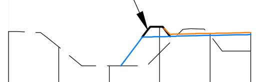
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: PERIMETER BUND AND INTERNAL BUND LONG SECTIONS PACKAGE 2

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D2014	A

Plot Date: 5 April 2013 Time:6:18:02 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 2 - File Name:117625003-220-L-D2014-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-SECTIONS.dwg;

REFER TYPICAL BUND DETAIL SHEET D2021



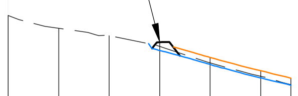
DATUM 20.00

EXISTING SURFACE	25.80	24.29	22.43	23.70	25.46	23.87
SUBGRADE				25.31	25.43	25.53
TOP OF LINER					25.63	25.73
DESIGN SURFACE				26.30		
CHAINAGE	0.00	10.00	20.00	30.00	40.00	48.05

SECTION A (D2013) TYPICAL SECTION

HOR SCALE 1:1,500
VER SCALE 1:750

REFER TYPICAL BUND DETAIL SHEET D2022



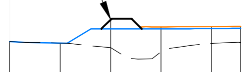
DATUM 35.00

EXISTING SURFACE	43.79	42.52	41.79	40.73	39.11	37.77	36.94
SUBGRADE				40.33	38.93	37.62	36.89
TOP OF LINER					39.63	38.32	37.59
DESIGN SURFACE				41.15			
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	56.00

SECTION B (D2013) TYPICAL SECTION

HOR SCALE 1:1,500
VER SCALE 1:750

REFER TYPICAL BUND DETAIL SHEET D2023



DATUM 20.00

EXISTING SURFACE	23.84	23.71	23.25	22.88	23.67	23.78
SUBGRADE	23.84	23.71	25.14	25.13	25.16	25.19
TOP OF LINER				25.33	25.36	25.39
DESIGN SURFACE			26.05			
CHAINAGE	0.00	10.00	20.00	30.00	40.00	45.81

SECTION C (D2013) TYPICAL SECTION

HOR SCALE 1:1,500
VER SCALE 1:750

NOT FOR CONSTRUCTION - ISSUED FOR
CLIENT REVIEW

0 15 30 45m
1:750
0 30 60 90m
1:1,500

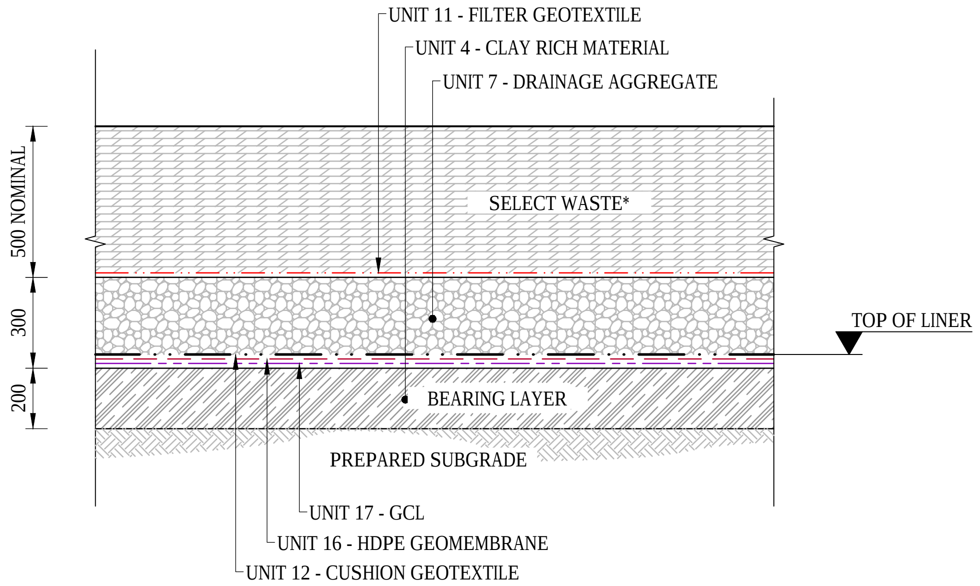
REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.05.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN
DRAWING TITLE: PERIMETER BUND AND INTERNAL BUND CROSS SECTIONS PACKAGE 2

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D2015	A

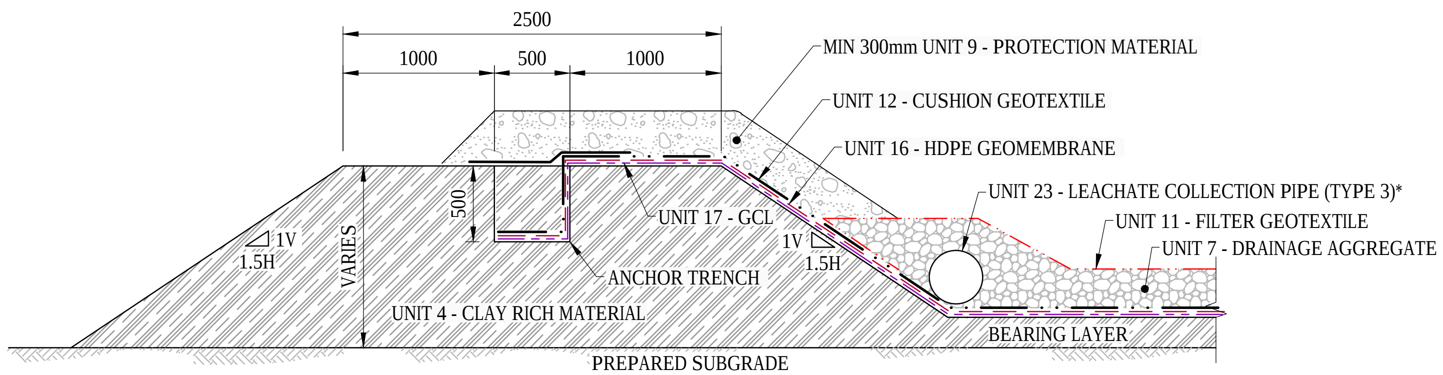
Plot Date: 5 April 2013 Time:6:29:04 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 2 - File Name:117625003-220-L-D2015-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-SECTIONS.dwg;



* SELECT WASTE TO BE PLACED IN FUTURE (BY OTHERS)

CELL BASE LINER

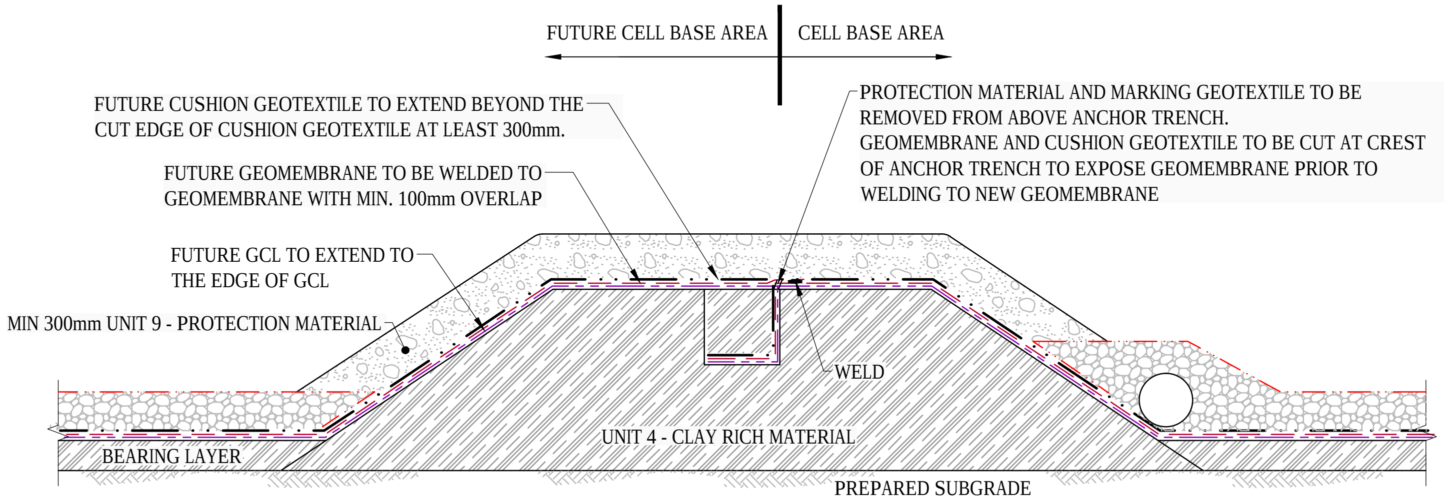
SCALE 1:25



* LEACHATE COLLECTION PIPE NOT PRESENT IN ALL AREAS

BASE LINER - TYPICAL DETAIL FOR INTERIM TERMINATION AT INTERNAL BUND

SCALE 1:50



BASE LINER - TYPICAL INTERNAL BUND DETAIL FOR CONNECTION OF FUTURE BASE LINER

SCALE 1:50

NOT FOR CONSTRUCTION - ISSUED FOR
CLIENT REVIEW

0 500 1,000 1,500mm
1:25
0 1,000 2,000 3,000mm
1:50

NOTES:

1. REFER TO DRAWING D2001 FOR GENERAL NOTES AND LEGEND

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.05.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

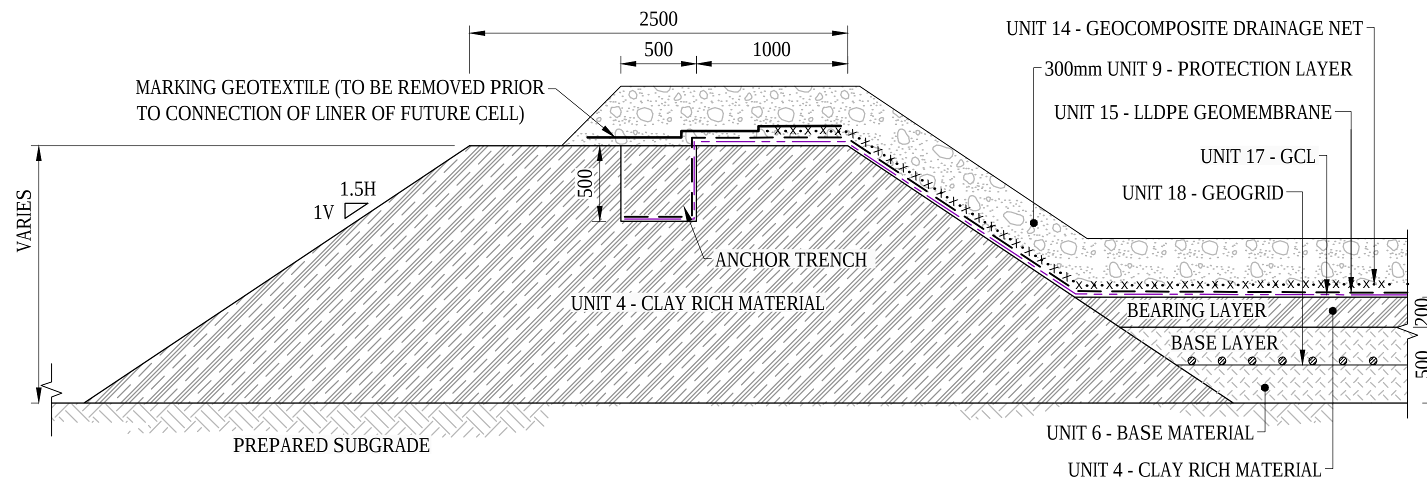
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: LINER DETAILS - SHEET 1 PACKAGE 2

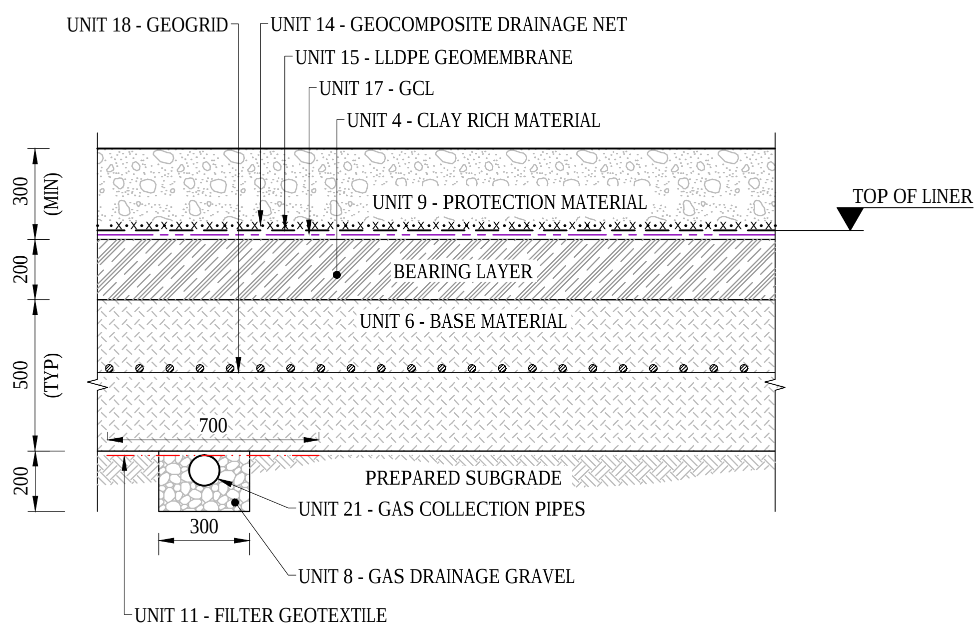
LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D2021	A

Plot Date: 5 April 2013 Time:6:32:36 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 2 - File Name:117625003-220-L-D2021-REVA.dwg
Xref: GAP_LOGO-A3.dwg;



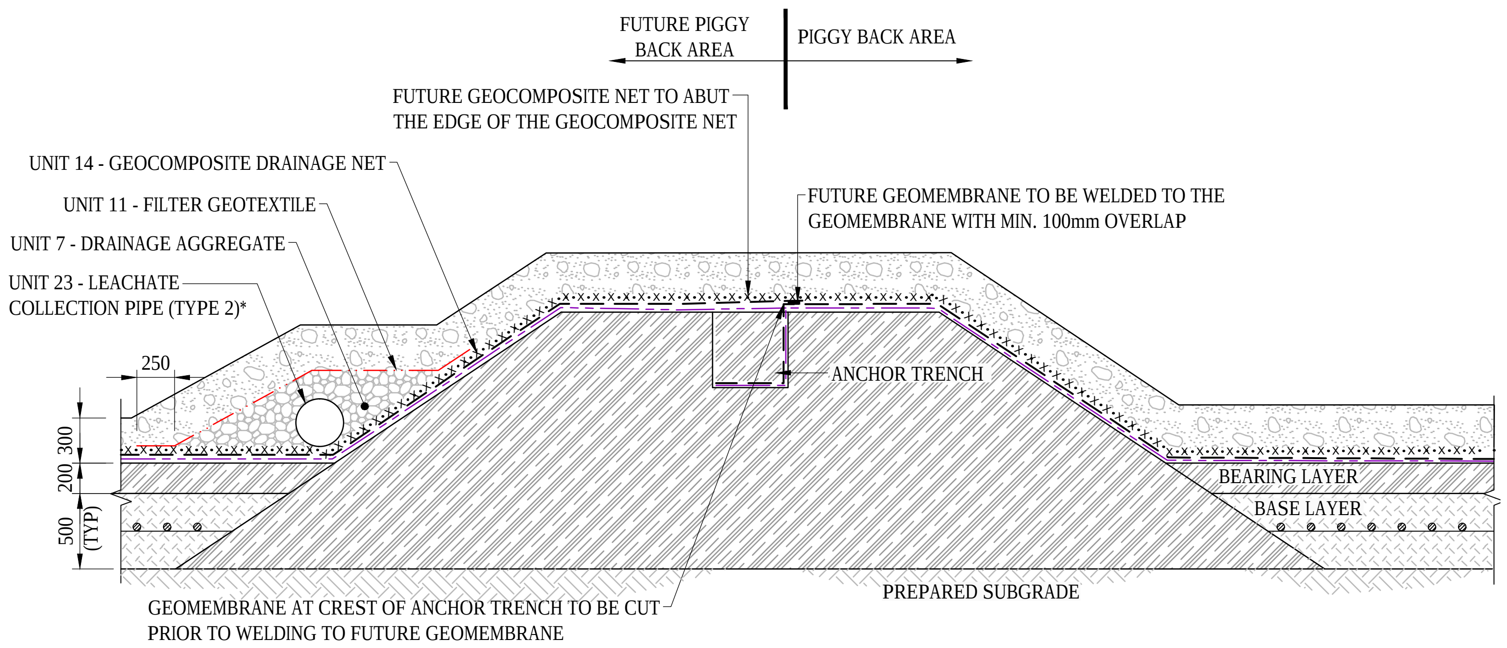
PIGGY BACK LINER - TYPICAL DETAIL FOR INTERIM TERMINATION AT INTERNAL BUND

SCALE 1:50



PIGGY BACK LINER

SCALE 1:25



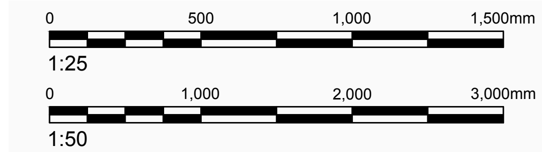
* LEACHATE COLLECTION PIPE NOT PRESENT IN ALL AREAS

PIGGY BACK LINER - TYPICAL INTERNAL BUND DETAIL FOR CONNECTION OF FUTURE PIGGY BACK LINER

SCALE 1:50

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW



NOTES:

1. REFER TO DRAWING D2001 FOR GENERAL NOTES AND LEGEND

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.05.2013

124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

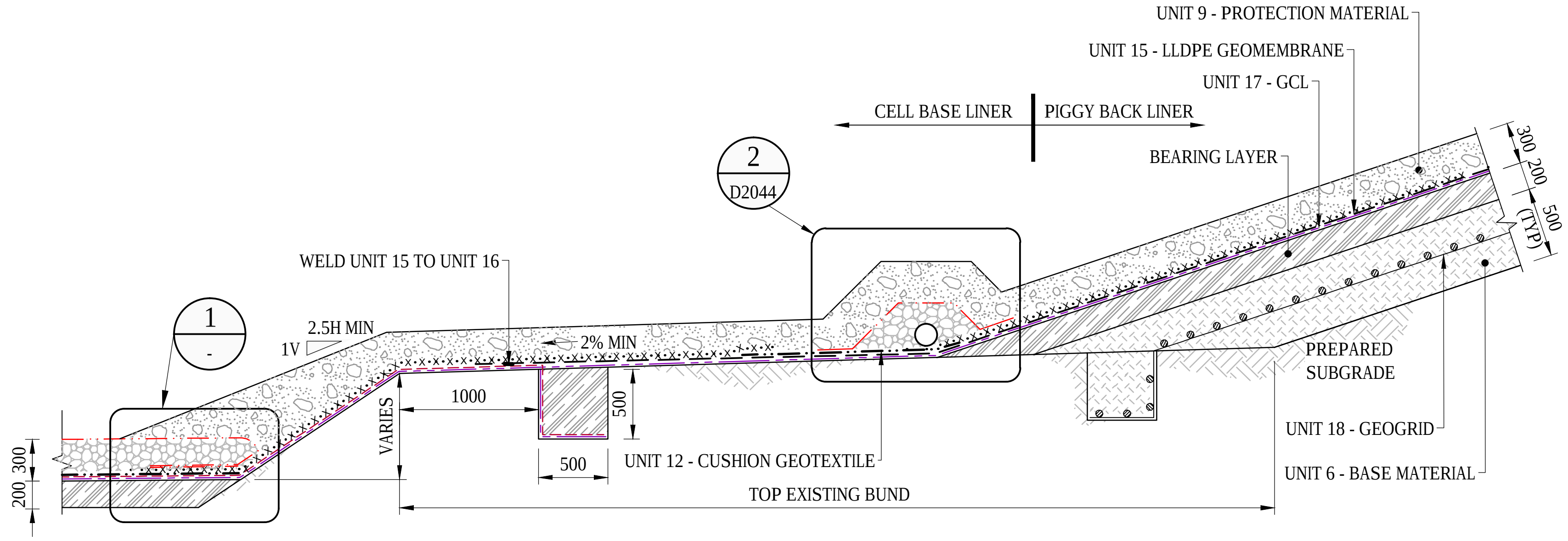
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: LINER DETAILS - SHEET 2 PACKAGE 2

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D2022	A

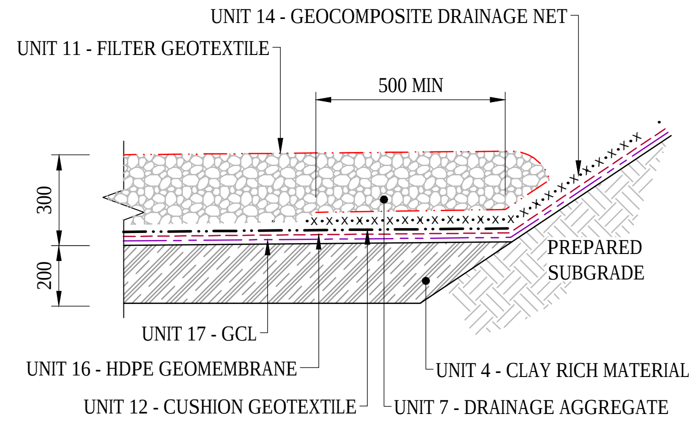
Plot Date: 5 April 2013 Time:6:33:52 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 2 - File Name:117625003-220-L-D2022-REVA.dwg
Xref: GAP_LOGO-A3.dwg;



NOTE: LEACHATE COLLECTION PIPE NOT PRESENT IN ALL AREAS

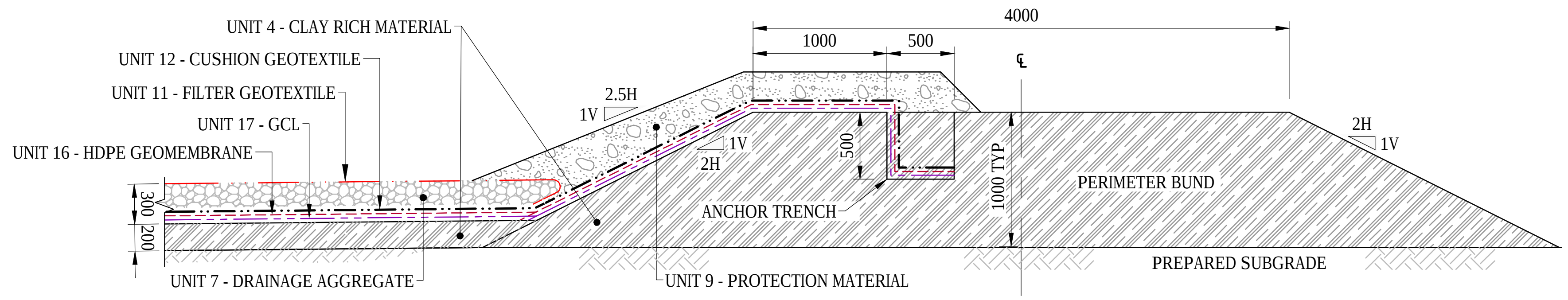
LINER CONNECTION - CELL BASE LINER TO PIGGY BACK LINER

SCALE 1:50



1 - TYPICAL DETAIL

SCALE 1:25



TYPICAL DETAIL OF BASE LINER ALONG PERIMETER BUND

SCALE 1:50

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

0 500 1,000 1,500mm

1:25

0 1,000 2,000 3,000mm

1:50

NOTES:

1. REFER TO DRAWING D2001 FOR GENERAL NOTES AND LEGEND

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.05.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: LINER DETAILS - SHEET 3 PACKAGE 2

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D2023	A

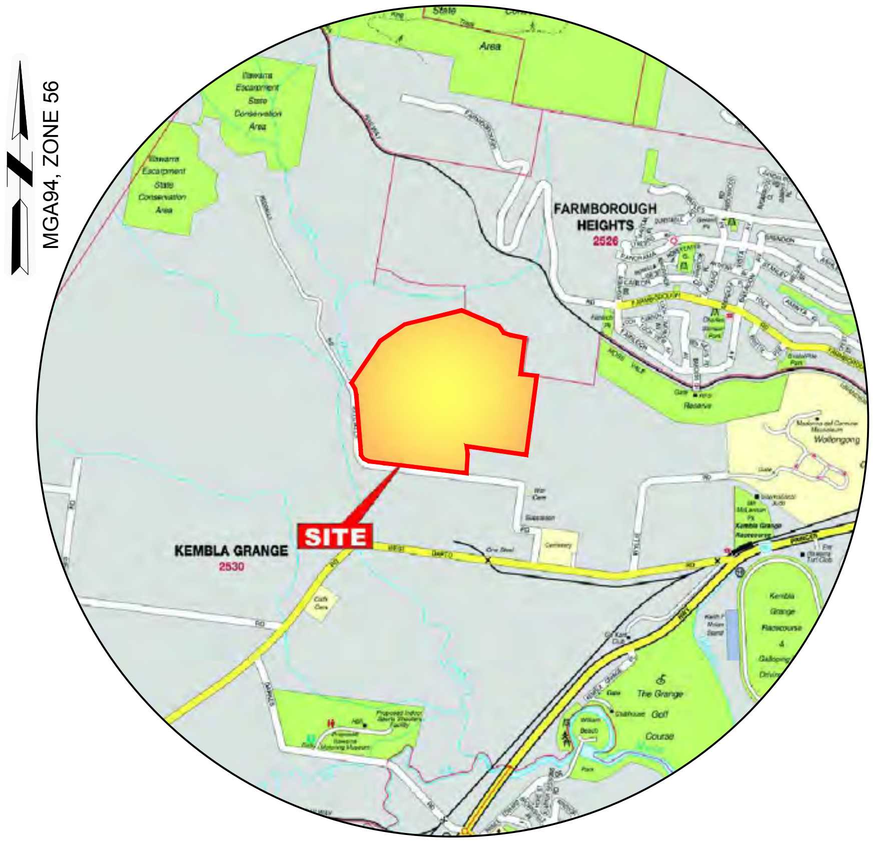
Plot Date: 5 April 2013 Time:6:35:15 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 2 - File Name:117625003-220-L-D2023-REVA.dwg
Xref: GAP_LOGO-A3.dwg;

APPENDIX A

Design Drawings - Tender Packages 1, 2 and 3

WOLLONGONG CITY COUNCIL
WHYTES GULLY LANDFILL - NEW CELL DESIGN

MGA94, ZONE 56



LOCALITY PLAN

NOT TO SCALE

NOTES:

1. THESE NOTES APPLY TO ALL PROJECT DRAWINGS IN THE SET UNLESS NOTED OTHERWISE AND SHALL BE READ IN CONJUNCTION WITH THE SPECIFICATION.
2. ALL LEVELS ARE IN METRES TO AUSTRALIAN HEIGHT DATUM (AHD).
3. ALL CO-ORDINATES ARE IN METRES TO MAP GRID AUSTRALIA (MGA).
4. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
5. DIMENSIONS AND LOCATION OF EXISTING STRUCTURES SHALL BE CONFIRMED ON SITE BY THE CONTRACTOR PRIOR TO COMMENCEMENT OF WORKS.
6. LOCATION AND DEPTH OF ALL SERVICES TO BE VERIFIED BY THE CONTRACTOR PRIOR TO COMMENCEMENT OF WORKS.
7. DIMENSIONS SHALL NOT BE SCALED OFF DRAWINGS.

ISSUED FOR

CONSTRUCTION

DRAWING LIST

TENDER PACKAGE 1

D1001	SITE LOCALITY AND DRAWING LIST
D1002	SITE PLAN AND WORK AREAS
D1003	EXISTING CONTOURS AND EASEMENTS
D1011	SUBGRADE PREPARATION PLAN - PACKAGE 1A
D1012	SUBGRADE PREPARATION PLAN - PACKAGE 1B
D1013	SUBGRADE PREPARATION SECTIONS - PACKAGE 1A
D1014	SUBGRADE PREPARATION SECTIONS - PACKAGE 1B
D1015	PERIMETER BUND AND INTERNAL BUND PLAN AND SETOUT - PACKAGE 1A
D1016	PERIMETER BUND AND INTERNAL BUND PLAN AND SETOUT - PACKAGE 1B
D1017	PERIMETER BUND LONG SECTIONS - PACKAGE 1A
D1018	PERIMETER BUND LONG SECTIONS - PACKAGE 1B
D1019	PERIMETER BUND AND INTERNAL BUND CROSS SECTIONS
D1021	LINER DETAILS - SHEET 1
D1022	LINER DETAILS - SHEET 2
D1023	LINER DETAILS - SHEET 3
D1024	LINER DETAILS - SHEET 4
D1025	LINER DETAILS - SHEET 5
D1026	LINER DETAILS - SHEET 6
D1030s	NOT USED
D1041	TOP OF LINER AND LEACHATE COLLECTION SYSTEM PLAN AND SETOUT - PACKAGE 1A
D1042	TOP OF LINER AND LEACHATE COLLECTION SYSTEM PLAN AND SETOUT - PACKAGE 1B
D1043	LEACHATE COLLECTION SYSTEM DETAILS - SHEET 1
D1044	LEACHATE COLLECTION SYSTEM DETAILS - SHEET 2
D1045	LEACHATE COLLECTION SYSTEM DETAILS - SHEET 3
D1046	CONNECTION TO EXISTING LEACHATE SYSTEM AND LEACHATE DRAINAGE PIPE PLAN AND SETOUT
D1047	LEACHATE SUMP PLAN AND DETAILS
D1051	DRAINS AND SETOUTS - PACKAGE 1
D1052	DIVERSION CHANNEL FROM CENTRAL RIDGE - PLAN AND LONG SECTION - SHEET 1 OF 2
D1053	DIVERSION CHANNEL FROM CENTRAL RIDGE - PLAN AND LONG SECTION - SHEET 2 OF 2
D1054	DIVERSION CHANNEL FROM CENTRAL RIDGE - DROP STRUCTURE PLAN AND DRAIN SECTIONS AND DETAILS - SHEET 1 OF 3
D1055	DIVERSION CHANNEL FROM CENTRAL RIDGE - SECTIONS AND DETAILS SHEET 2 OF 3
D1056	DIVERSION CHANNEL FROM CENTRAL RIDGE - CULVERT CROSS SECTIONS AND DETAILS SHEET 3 OF 3
D1057	SOUTHERN PERIMETER DRAIN - PLAN AND LONG SECTION - PACKAGE 1
D1058	SOUTHERN PERIMETER DRAIN - SECTIONS AND DETAILS - PACKAGE 1
D1059	TEMPORARY EASTERN PERIMETER DRAIN - ALIGNMENT AND DETAILS
D1060s	NOT USED
D1071	PIGGY BACK GAS VENTING PLAN - PACKAGE 1A
D1072	PIGGY BACK GAS VENTING PLAN - PACKAGE 1B

MATERIAL LIST

Symbol	Unit	Material
	UNIT 1	NOT USED
	UNIT 2	GENERAL FILL
	UNIT 3	COVER MATERIAL
	UNIT 4	CLAY RICH MATERIAL
	UNIT 5	CLAY MATERIAL
	UNIT 6	BASE MATERIAL
	UNIT 7	DRAINAGE AGGREGATE
	UNIT 8	GAS DRAINAGE AGGREGATE
	UNIT 9	PROTECTION MATERIAL
	UNIT 11	FILTER GEOTEXTILE
	UNIT 12	CUSHION GEOTEXTILE
	UNIT 13	NOT USED
	UNIT 14	GEOCOMPOSITE DRAINAGE NET (LEACHATE)
	UNIT 15	LLDPE GEOMEMBRANE
	UNIT 16	HDPE GEOMEMBRANE
	UNIT 17	GCL
	UNIT 18	GEOGRID
GAS GAS	UNIT 21	GAS COLLECTION PIPE
D	UNIT 22	GROUNDWATER DRAINAGE PIPE
	UNIT 23	LEACHATE COLLECTION PIPE
	UNIT 24	LEACHATE SUMP OUTLET PIPE
	UNIT 25	LEACHATE DRAINAGE PIPE
	UNIT 26	NOT USED
	UNIT 27	LEACHATE SUMP RISER
	UNIT 28	LEAK DETECTION PIPE
	UNIT 31	BENTONITE
	UNIT 32	RIPRAP ARMOURSTONE AND AGGREGATE FOR GABION BASKETS AND WIRE MATTRESS
	UNIT 33	GRANULAR MATERIAL FOR CONCRETE PIPE INSTALLATION
	UNIT 34	ROCK FILLED GABIONS AND MATTRESSES
	UNIT 35	ENKAMAT® TURF REINFORCEMENT MAT (TRM)
	UNIT 36	PRECAST REINFORCED CONCRETE BOX CULVERT (RCBC)
	UNIT 37	PRECAST REINFORCED CONCRETE PIPES (RCP)
	UNIT 38	CHANNEL LINER

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates

124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

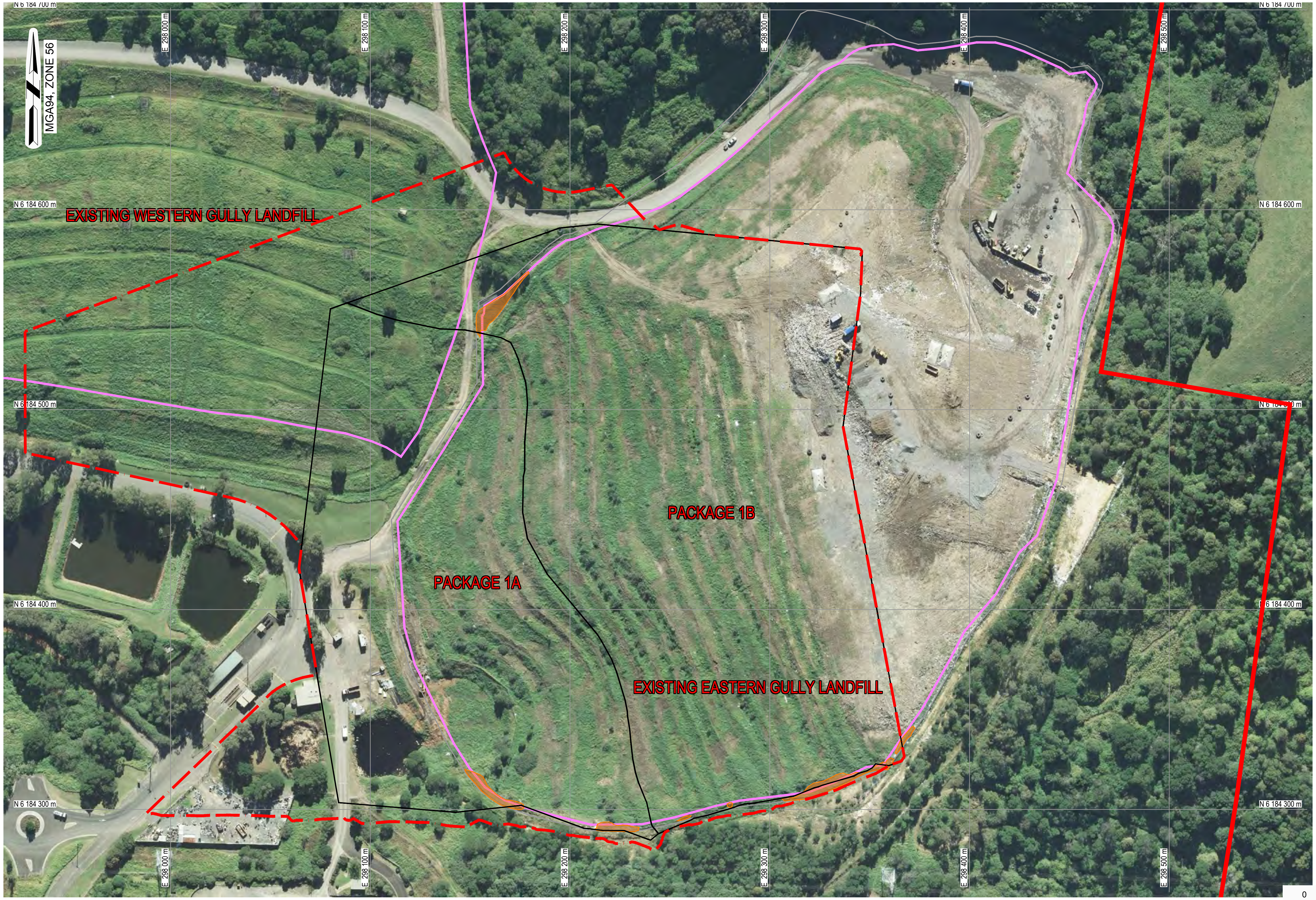
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: SITE LOCALITY AND DRAWING LIST

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	NOT TO SCALE	A3	117625003	220	L	D1001	0

Plot Date: 28 March 2013 Time:10:16:53 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1001-REV0.dwg
Xref: GAP_LOGO-A3.dwg; WHYTES GULLY UBD.jpg;



LEGEND

- PROPERTY BOUNDARY
- PACKAGE BOUNDARY
- WORKS AREA BOUNDARY
- EXTENT OF EXISTING LINER (REFER NOTE 1)
- APPROX. EXTENT OF EXISTING WASTE (REFER NOTE 2)
- APPROXIMATE EXPOSED EXISTING LINER AREAS (REFER NOTE 3)

NOTES:

1. EXTENT OF LINER IN EASTERN GULLY BASED ON "PACIFIC LINING CO. AUSTRALIA PTY. LTD PDF DRAWINGS 267 / 1 DATED NOV. 1996 AND 287 / 1 DATED MAY 1998"; "WOLLONGONG CITY COUNCIL AS BUILT SURVEY FOR HDPE LINER ON EASTERN GULLY LANDFILL, CADD DRAWING 'WHYTES GULLY 3D', RECEIVED 09-11-2011"; AND "K.F. WILLIAMS & ASSOCIATES PTY. LTD CADD DRAWING SV01 REV B DATED 26-07-2011".
2. APPROX. EXTENT OF WASTE BASED PRIMARILY ON SITE OBSERVATION AND INFORMATION FROM COUNCIL.
3. EXPOSED EXISTING LINER AREAS BASED ON AERIAL PHOTO TAKEN BY AAM GROUP/KF WILLIAMS SURVEYOR ON 20TH JULY 2011

SOURCE:

- BASE DRAWING TAKEN FROM K F WILLIAMS AND ASSOCIATES DWG. WHYTES PHOTOGRAMMETRY AND GROUND SURVEY 20.07.2011, DATED 20TH JULY 2011
- AERIAL ORTHO-PHOTOGRAPH PROVIDED BY AAM PTY LTD TAKEN ON 16TH MAY 2011, REFRENCE 18763A. IMAGE GEOREFERENCED

ISSUED FOR

CONSTRUCTION

0 40 80 120m

1:2,000

SITE PLAN AND WORK AREAS - PACKAGE 1

SCALE 1:2,000

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

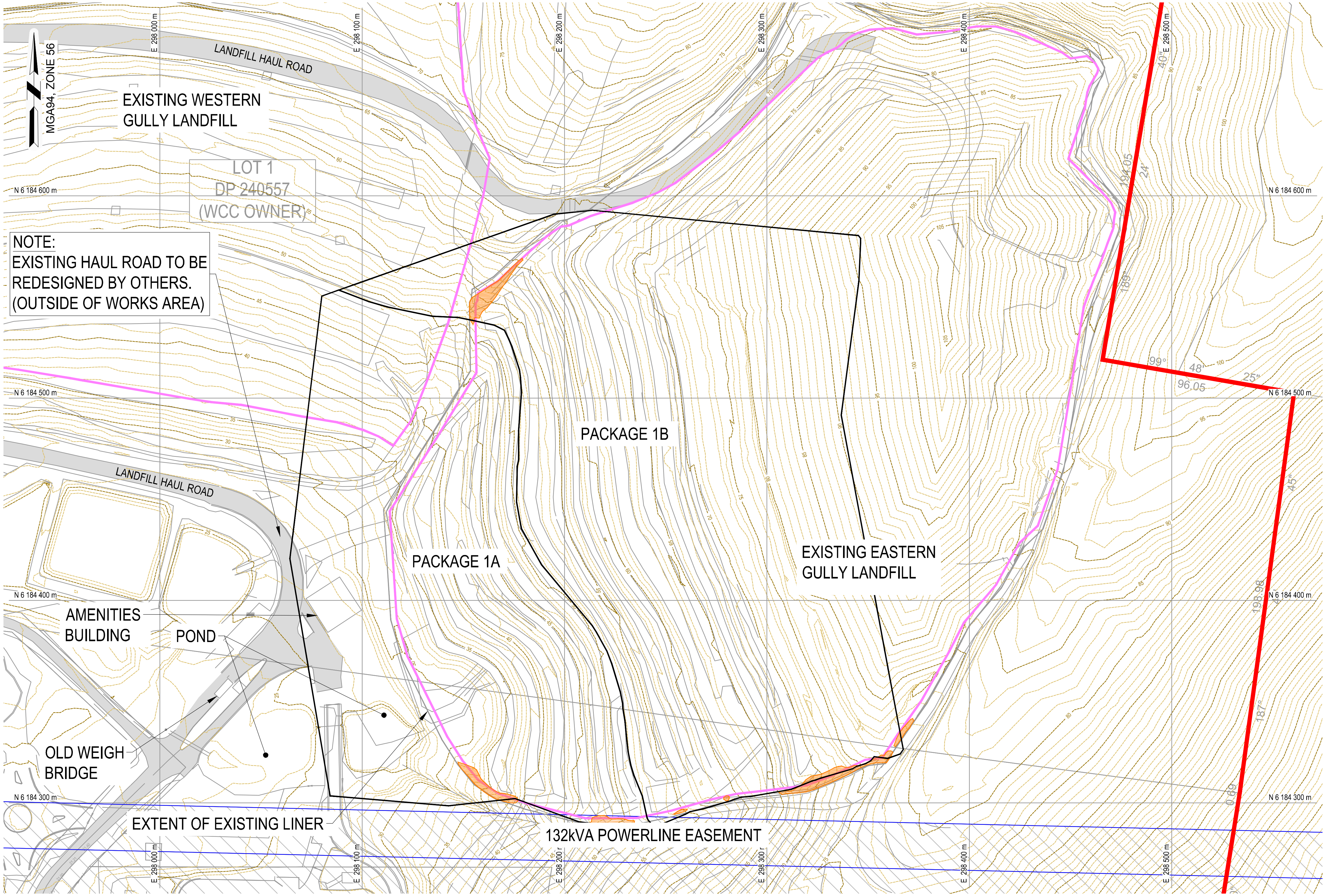
Golder Associates

124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT	WOLLONGONG CITY COUNCIL
PROJECT	WHYTES GULLY LANDFILL - NEW CELL DESIGN
DRAWING TITLE	SITE PLAN AND WORKS AREA - PACKAGE 1

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	1:2,000	A3	117625003	220	L	D1002	0

Plot Date: 28 March 2013 Time:10:21:52 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1002-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-Imagery - AAM May 2011.dwg; 117625003-XREF-WORKS AREA.dwg; 117625003-XREF-EXPOSED EXISTING LINER.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOIUNDARY.dwg; Whytes-Gully_16052011_10cm.jpg;



LEGEND

- PROPERTY BOUNDARY
- EXTENT OF EXISTING LINER (REFER NOTE 1)
- PACKAGE BOUNDARY
- APPROX. EXTENT OF EXISTING WASTE (REFER NOTE 2)
- APPROXIMATE EXPOSED EXISTING LINER AREAS (NOTE 4)

NOTES:

1. EXTENT OF LINER IN EASTERN GULLY BASED ON "PACIFIC LINING CO. AUSTRALIA PTY. LTD PDF DRAWINGS 267 / 1 DATED NOV. 1996 AND 287 / 1 DATED MAY 1998"; "WOLLONGONG CITY COUNCIL AS BUILT SURVEY FOR HDPE LINER ON EASTERN GULLY LANDFILL, CADD DRAWING 'WHYTES GULLY 3D', RECEIVED 09-11-2011"; AND "K.F. WILLIAMS & ASSOCIATES PTY. LTD CADD DRAWING SV01 REV B DATED 26-07-2011".
2. APPROX. EXTENT OF WASTE BASED PRIMARILY ON SITE OBSERVATION AND INFORMATION FROM COUNCIL.
3. CONTOURS ABOVE RL 75m ON EASTERN GULLY LANDFILL REFLECT CURRENT FINAL PROFILE DESIGN FOR EASTERN GULLY (GOLDER DRAWING 097625103-006-R-F019-REVA)
4. EXPOSED EXISTING LINER AREAS BASED ON AERIAL PHOTO TAKEN BY AAM GROUP/KF WILLIAMS SURVEYOR ON 20TH JULY 2011

ISSUED FOR
CONSTRUCTION

0 40 80 120m
1:2,000

EXISTING CONTOURS AND EASEMENTS

SCALE 1:2,000

BASE DRAWING TAKEN FROM K F WILLIAMS AND ASSOCIATES DRG.WHYTES PHOTOGRAMMETRY AND GROUND SURVEY 20-07-11.dxf DATED 20 JULY 2011.

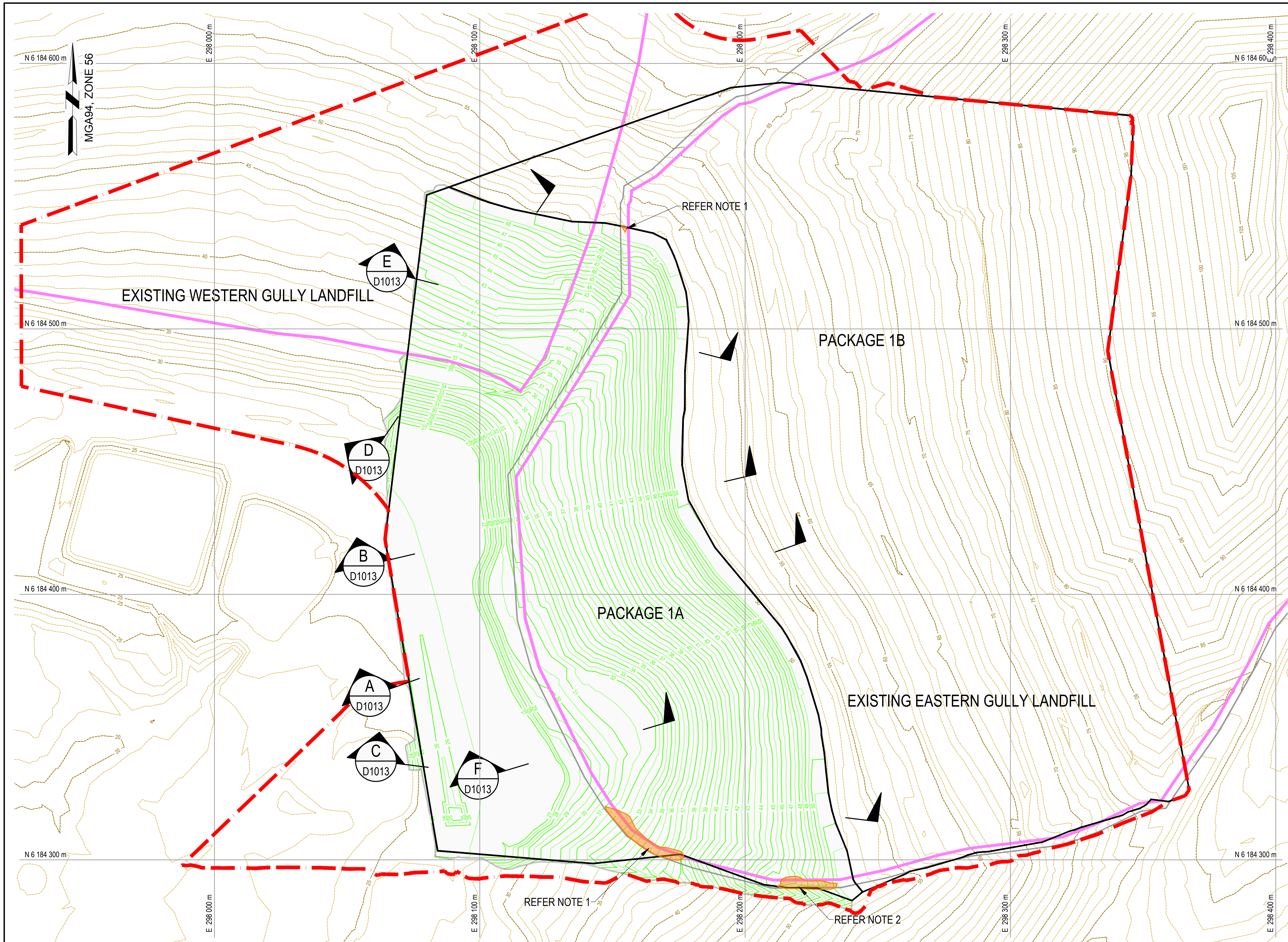
REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN
DRAWING TITLE: EXISTING CONTOURS AND EASEMENTS

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	1:2,000	A3	117625003	220	L	D1003	0

Plot Date: 28 March 2013 Time:10:21:25 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1003-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-Cadastre and easement.dwg; 117625003-XREF-EXISTING BREAKLINES.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOIUNDARY.dwg; 117625003-XREF-EXPOSED EXISTING LINER.dwg;



LEGEND

- EXTENT OF EXISTING LINER (REFER DRAWING D1003)
- PACKAGE BOUNDARY
- APPROX. EXTENT OF EXISTING WASTE (REFER DRAWING D1003)
- SUBGRADE CONTOURS
- EXISTING CONTOURS
- WORKS AREA BOUNDARY
- APPROXIMATE EXPOSED EXISTING LINER AREAS (REFER DRAWING D1003)

NOTES:

1. EXPOSED GEOMEMBRANE LINER WITHIN PIGGY BACK LINER AREA TO BE CUT AT SUBGRADE LEVEL AND REMOVED.
2. SUBGRADE LEVELS TO BE MODIFIED IN FIELD TO AVOID DAMAGING EXPOSED GEOMEMBRANE LINER OUTSIDE PIGGY BACK LINER AREA.

ISSUED FOR
CONSTRUCTION

0 30 60 90m
1:1,500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

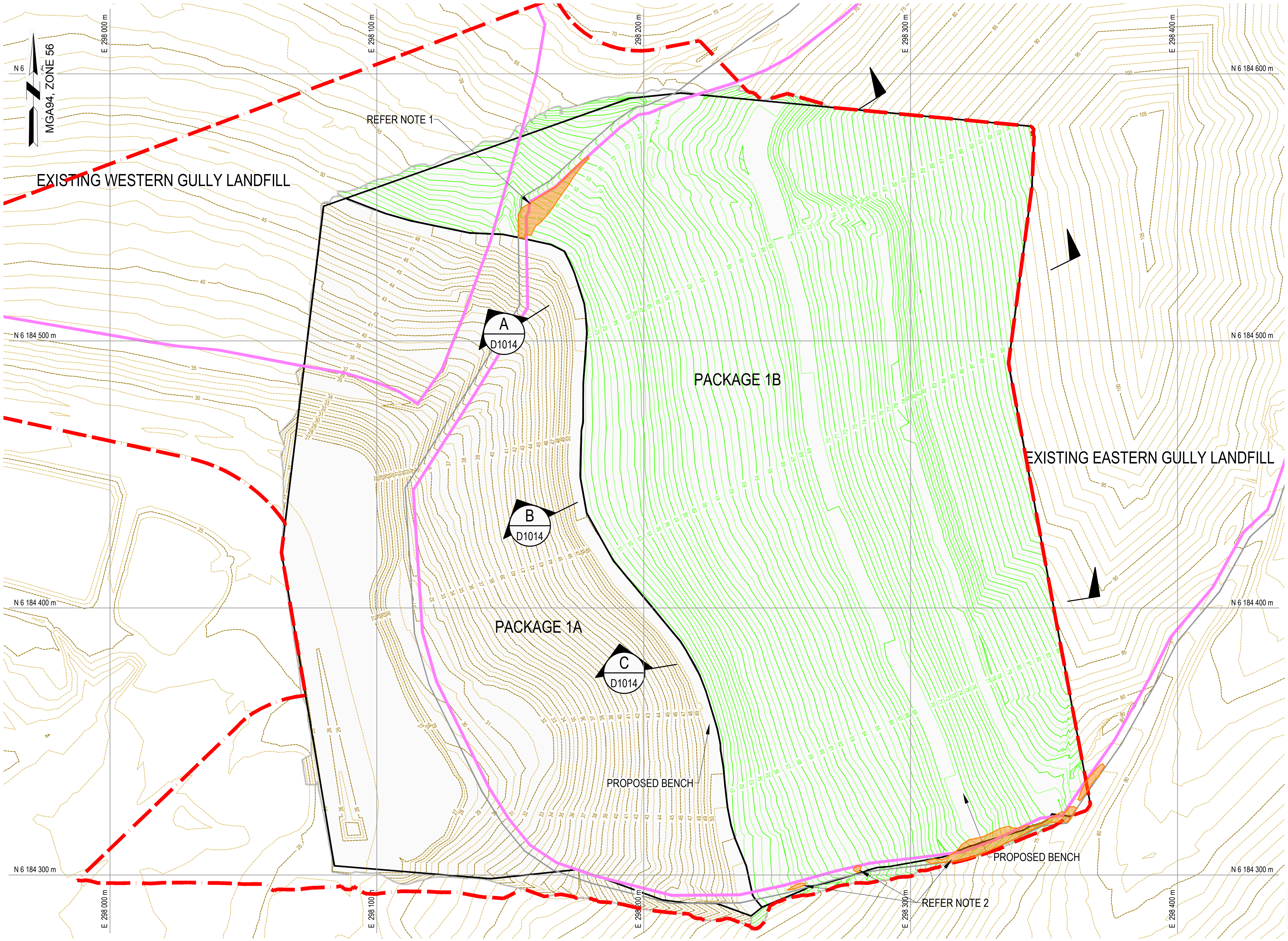
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: SUBGRADE PREPARATION PLAN PACKAGE 1A

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	1:1,500	A3	117625003	220	L	D1011	0

Plot Date: 28 March 2013 Time:10:20:55 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1011-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-SUBGRADE STAGE 1A.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOIUNDARY.dwg; 117625003-XREF-WORKS AREA.dwg; 117625003-XREF-CELL STAGE BOUNDARY.dwg; 117625003-XREF-EXPOSED EXISTING LINER.dwg;



LEGEND

- EXTENT OF EXISTING LINER (REFER DRAWING D1003)
- PACKAGE BOUNDARY
- APPROX. EXTENT OF EXISTING WASTE (REFER DRAWING D1003)
- SUBGRADE CONTOURS
- EXISTING CONTOURS
- WORKS AREA BOUNDARY
- APPROXIMATE EXPOSED EXISTING LINER AREAS (REFER DRAWING D1003)

NOTES:

1. EXPOSED GEOMEMBRANE LINER WITHIN PIGGY BACK LINER AREA TO BE CUT AT SUBGRADE LEVEL AND REMOVED.
2. SUBGRADE LEVELS TO BE MODIFIED IN FIELD TO AVOID DAMAGING EXPOSED GEOMEMBRANE LINER OUTSIDE PIGGY BACK LINER AREA.

ISSUED FOR
CONSTRUCTION

0 30 60 90m
1:1,500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

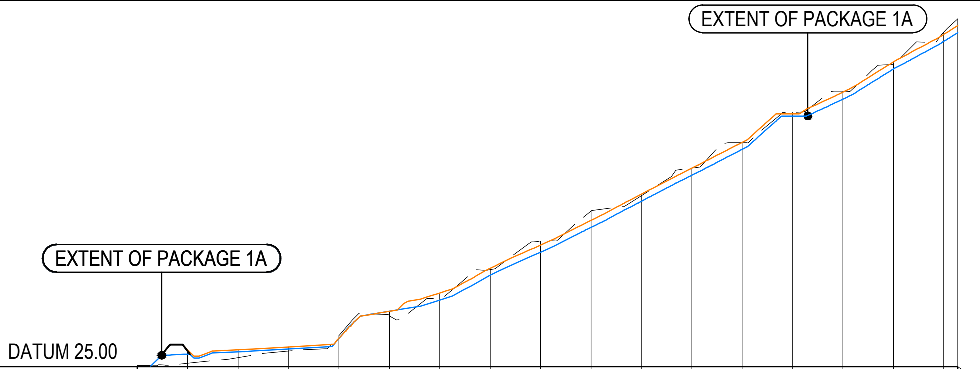
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: SUBGRADE PREPARATION PLAN PACKAGE 1B

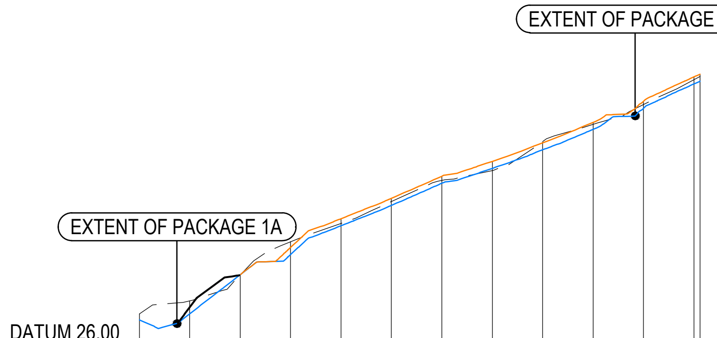
LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	1:1,500	A3	117625003	220	L	D1012	0

Plot Date: 28 March 2013 Time:10:20:23 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1012-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOIUNDARY.dwg; 117625003-XREF-SUBGRADE STAGE 1B.dwg; 117625003-XREF-CELL STAGE BOUNDARY.dwg; 117625003-XREF-SUBGRADE STAGE 1A.dwg; 117625003-XREF-WORKS AREA.dwg; 117625003-XREF-EXPOSED EXISTING LINER.dwg;



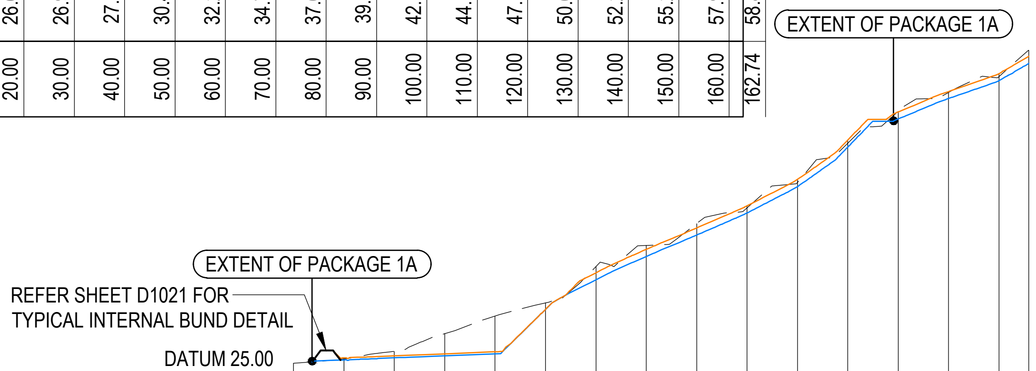
EXISTING SURFACE	25.11	25.34	25.90	26.53	28.08	30.09	31.88	34.63	37.43	40.43	41.96	44.70	47.20	50.22	52.31	54.96	58.17	59.50
SUBGRADE		26.23	26.47	26.75	27.79	30.48	31.59	34.05	36.36	38.81	41.40	43.97	46.54	49.85	51.52	54.52	57.26	58.11
TOP OF LINER		26.65	26.67	26.95	27.81	30.48	32.29	34.75	37.06	39.51	42.10	44.67	47.24	50.05	52.22	55.22	57.96	58.82
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	162.74

SECTION A D1011
SCALE 1:1,500(H)
SCALE 1:750(V)



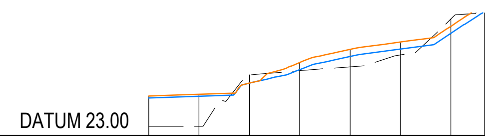
EXISTING SURFACE	29.34	30.64	33.21	36.51	38.34	40.52	42.60	43.59	46.45	48.17	50.15	52.60	52.92
SUBGRADE	28.75	29.36	33.25	35.25	38.10	40.13	42.32	43.80	45.65	47.68	49.77	52.18	52.45
TOP OF LINER				35.96	38.80	40.83	43.02	44.50	46.35	48.38	50.46	52.88	53.15
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	111.20

SECTION D D1011
SCALE 1:1,500(H)
SCALE 1:750(V)



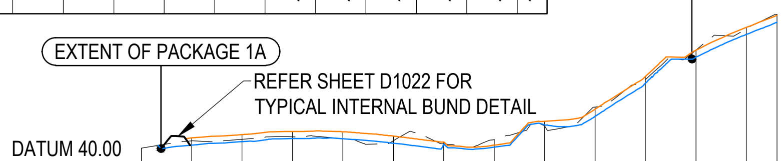
EXISTING SURFACE	26.04	26.47	27.22	28.98	30.71	32.03	35.62	37.72	39.87	41.45	43.97	47.86	51.02	52.90	54.45	57.09
SUBGRADE		26.37	26.58	26.78	26.98	31.39	34.30	36.63	38.75	40.94	43.56	47.48	50.27	52.29	54.06	55.76
TOP OF LINER		26.57	26.78	26.98	27.18	31.39	35.00	37.33	39.45	41.64	44.27	48.18	50.97	52.99	54.76	56.46
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	145.90

SECTION B D1011
SCALE 1:1,500(H)
SCALE 1:750(V)



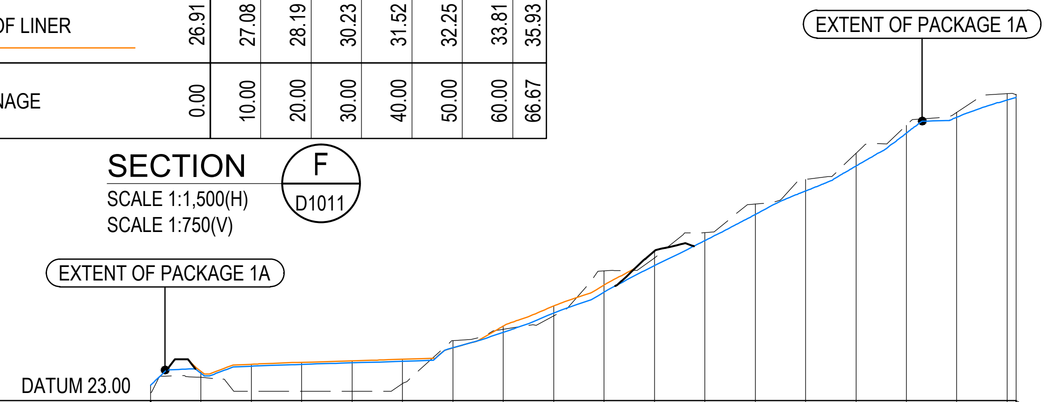
EXISTING SURFACE	23.93	23.93	29.00	29.42	29.79	30.97	34.52	35.90
SUBGRADE	26.71	26.88	28.19	29.52	30.82	31.55	33.11	35.23
TOP OF LINER	26.91	27.08	28.19	30.23	31.52	32.25	33.81	35.93
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	66.67

SECTION F D1011
SCALE 1:1,500(H)
SCALE 1:750(V)



EXISTING SURFACE	41.52	42.26	42.41	42.67	42.47	42.27	41.94	42.39	43.74	45.60	48.35	51.26	53.38	54.80
SUBGRADE		41.84	42.17	42.50	42.46	42.02	41.94	41.64	43.84	44.67	47.98	50.54	52.81	54.01
TOP OF LINER		42.54	42.87	43.20	43.16	42.73	42.14	41.84	44.19	45.38	48.66	51.24	53.51	54.71
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	126.10

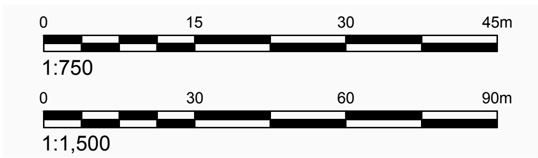
SECTION E D1011
SCALE 1:1,500(H)
SCALE 1:750(V)



EXISTING SURFACE	23.76	25.31	23.93	23.93	23.93	24.69	28.95	30.07	31.42	35.87	37.16	39.65	42.50	44.93	47.53	50.31	51.60	53.45	53.37
SUBGRADE	24.52	25.71	26.41	26.60	26.74	26.90	28.24	29.77	31.68	33.77	36.38	38.87	41.45	43.79	46.27	49.53	51.11	52.81	53.07
TOP OF LINER		25.91	26.61	26.80	26.94	27.10	28.23	30.40	32.38	34.47									
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00	171.77

SECTION C D1011
SCALE 1:1,500(H)
SCALE 1:750(V)

ISSUED FOR
CONSTRUCTION



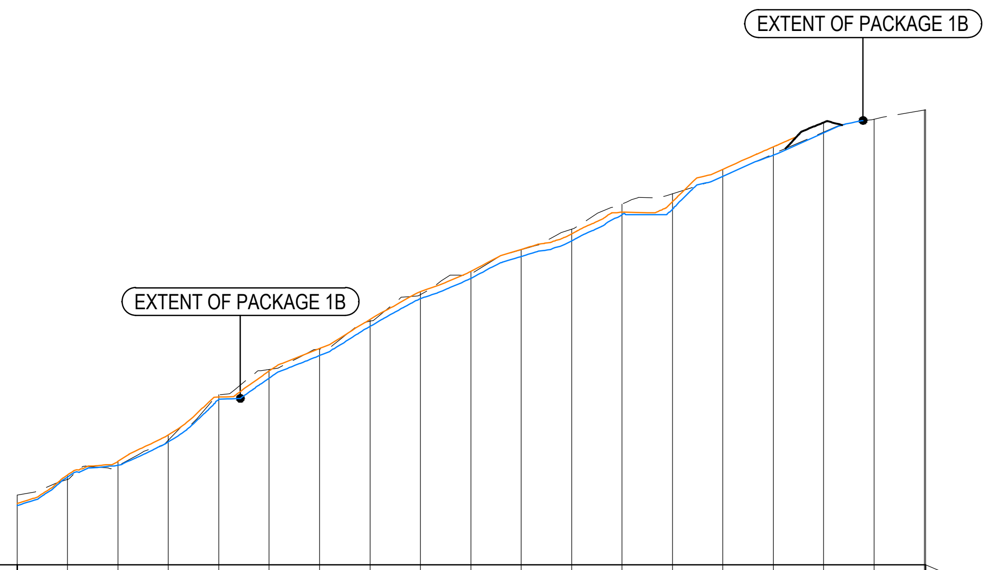
REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN
DRAWING TITLE: SUBGRADE PREPARATION SECTIONS PACKAGE 1A

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1013	0

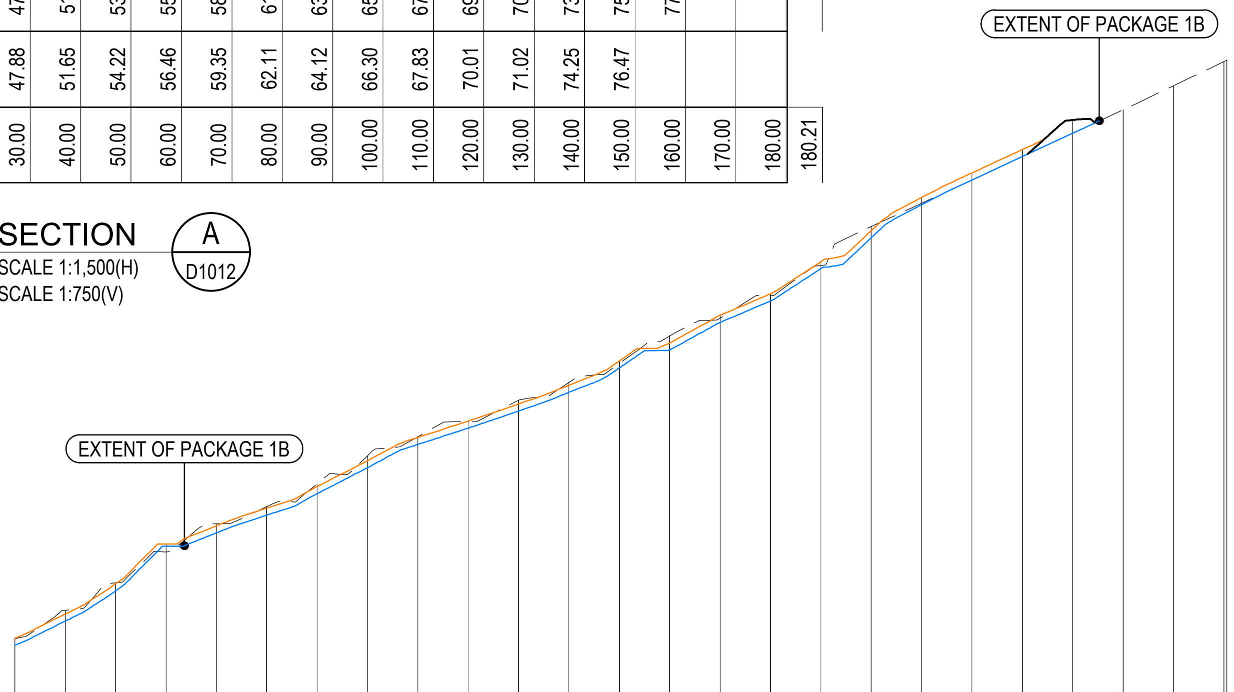
Plot Date: 28 March 2013 Time:10:19:50 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1013-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-SUBGRADE SECTIONS - STAGE 1A.dwg;



DATUM 35.00

EXISTING SURFACE	41.90	43.47	44.82	47.36	51.86	54.39	56.39	59.17	61.82	63.85	66.26	68.30	70.80	71.83	73.55	75.77	77.95	79.22	80.15	80.17
SUBGRADE	40.87	43.71	44.87	47.20	51.41	53.52	55.76	58.65	61.41	63.42	65.60	67.13	69.75	70.28	73.54	75.64	77.86			
BASE OF LINER	41.08	43.91	45.29	47.88	51.65	54.22	56.46	59.35	62.11	64.12	66.30	67.83	70.01	71.02	74.25	76.47				
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00	180.00	180.21

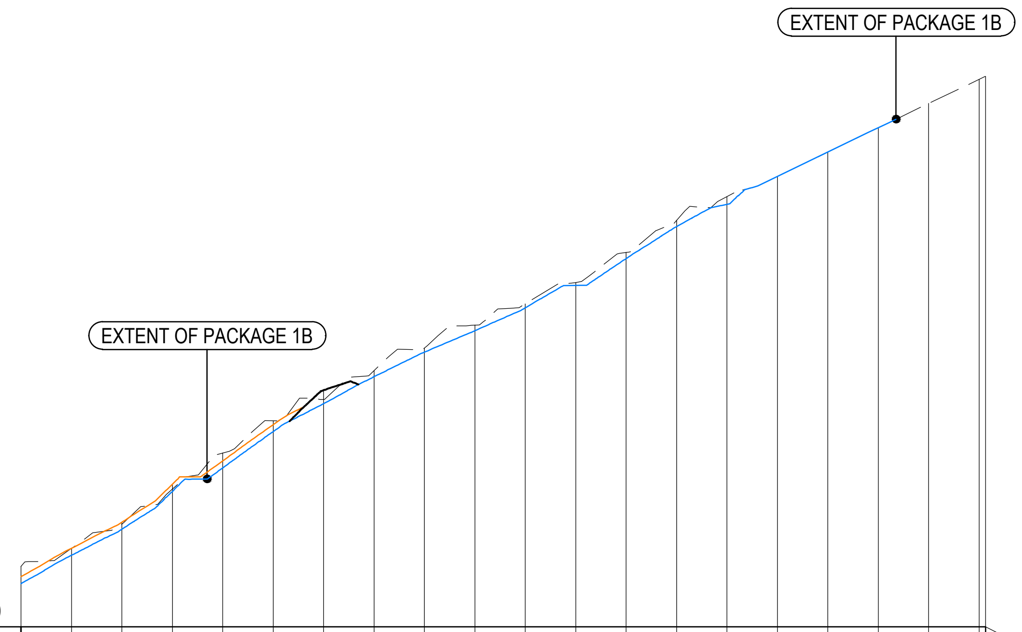
SECTION A D1012
SCALE 1:1,500(H)
SCALE 1:750(V)



DATUM 35.00

EXISTING SURFACE	40.85	43.67	46.40	49.47	52.26	53.95	56.19	58.98	60.89	62.38	64.51	66.29	68.16	70.90	72.66	74.90	77.88	81.73	84.05	86.36	88.69	91.01	93.32	95.70	98.10	98.24
SUBGRADE	40.19	42.59	45.59	50.04	51.35	53.11	55.24	57.81	60.13	61.74	63.44	65.30	67.71	69.50	72.23	74.35	77.56	80.62	83.90	86.36	88.69	91.01				
BASE OF LINER	40.89	43.30	46.29	50.24	52.05	53.81	55.94	58.51	60.83	62.45	64.14	66.00	68.41	70.20	72.95	75.06	78.26	81.32	84.63	87.06	89.38					
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00	220.00	230.00	240.00	240.57

SECTION B D1012
SCALE 1:1,500(H)
SCALE 1:750(V)

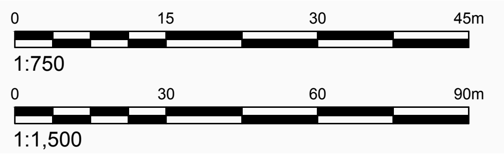


DATUM 35.00

EXISTING SURFACE	41.00	42.77	45.17	48.65	52.25	55.45	57.56	60.41	62.67	64.95	67.06	69.16	72.15	75.34	77.69	79.70	82.12	84.53	86.95	89.33	89.64
SUBGRADE	39.29	42.08	44.68	48.43	50.76	54.37	57.14	59.82	62.25	64.39	66.65	68.88	71.55	74.72	76.94	79.70	82.12	84.53			
BASE OF LINER	39.99	42.78	45.38	49.13	51.46	55.07															
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	191.30

SECTION C D1012
SCALE 1:1,500(H)
SCALE 1:750(V)

ISSUED FOR
CONSTRUCTION



REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

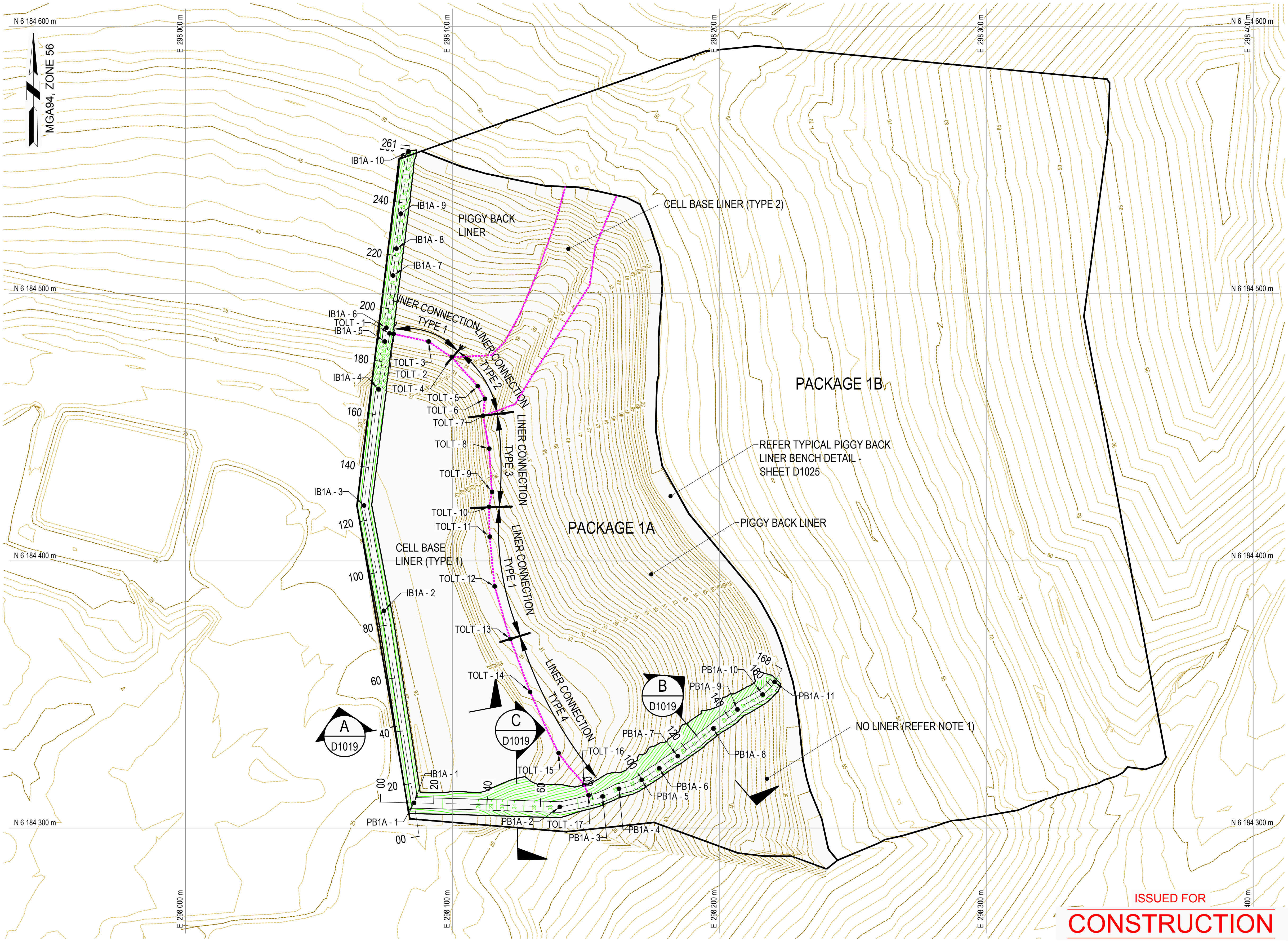
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: SUBGRADE PREPARATION SECTIONS PACKAGE 1B

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1014	0

Plot Date: 28 March 2013 Time:10:19:07 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1014-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-SUBGRADE SECTIONS - STAGE 1B.dwg;



LEGEND

- PACKAGE BOUNDARY
- BUND CONTOURS
- EXISTING CONTOURS
- TRANSITION LINE BETWEEN LINER TYPES

NOTES:

1. AREA WITH NO LINER TO HAVE INTERIM CAPPING LAYER INSTALLED BY OTHERS. NO FUTURE WASTE PLACEMENT IN THIS AREA.

PACKAGE 1A INTERNAL BUND - SETOUT			
NUMBER	EASTING	NORTHING	LEVEL
IB1A - 1	298085.64	6184309.39	27.12
IB1A - 2	298074.35	6184381.22	27.21
IB1A - 3	298066.86	6184420.71	27.32
IB1A - 4	298072.34	6184464.19	28.01
IB1A - 5	298074.61	6184482.14	35.50
IB1A - 6	298075.26	6184487.29	35.70
IB1A - 7	298077.74	6184506.85	40.52
IB1A - 8	298079.01	6184516.93	42.50
IB1A - 9	298080.67	6184530.00	44.50
IB1A - 10	298083.61	6184553.27	48.32

PACKAGE 1A PERIMETER BUND - SETOUT			
NUMBER	EASTING	NORTHING	LEVEL
PB1A - 1	298085.64	6184309.39	27.12
PB1A - 2	298140.26	6184307.83	33.47
PB1A - 3	298156.29	6184311.77	34.40
PB1A - 4	298162.43	6184314.62	35.14
PB1A - 5	298170.93	6184318.03	36.69
PB1A - 6	298177.51	6184322.33	38.12
PB1A - 7	298184.40	6184326.90	39.48
PB1A - 8	298197.80	6184337.22	42.97
PB1A - 9	298206.80	6184344.32	45.45
PB1A - 10	298216.22	6184349.94	48.07
PB1A - 11	298220.71	6184354.61	49.78

TOP OF LINER TRANSITION - SETOUT		
NUMBER	EASTING	NORTHING
TOLT - 1	298076.49	6184485.17
TOLT - 2	298077.98	6184485.00
TOLT - 3	298091.09	6184482.14
TOLT - 4	298099.75	6184476.26
TOLT - 5	298109.49	6184465.41
TOLT - 6	298112.19	6184460.66
TOLT - 7	298111.49	6184454.28
TOLT - 8	298113.79	6184441.97
TOLT - 9	298114.82	6184425.80
TOLT - 10	298113.75	6184420.21
TOLT - 11	298113.98	6184409.07
TOLT - 12	298115.88	6184390.42
TOLT - 13	298121.75	6184370.78
TOLT - 14	298129.15	6184350.92
TOLT - 15	298139.78	6184328.06
TOLT - 16	298149.31	6184316.05
TOLT - 17	298151.06	6184312.24

ISSUED FOR
CONSTRUCTION

0 30 60 90m
1:1,500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

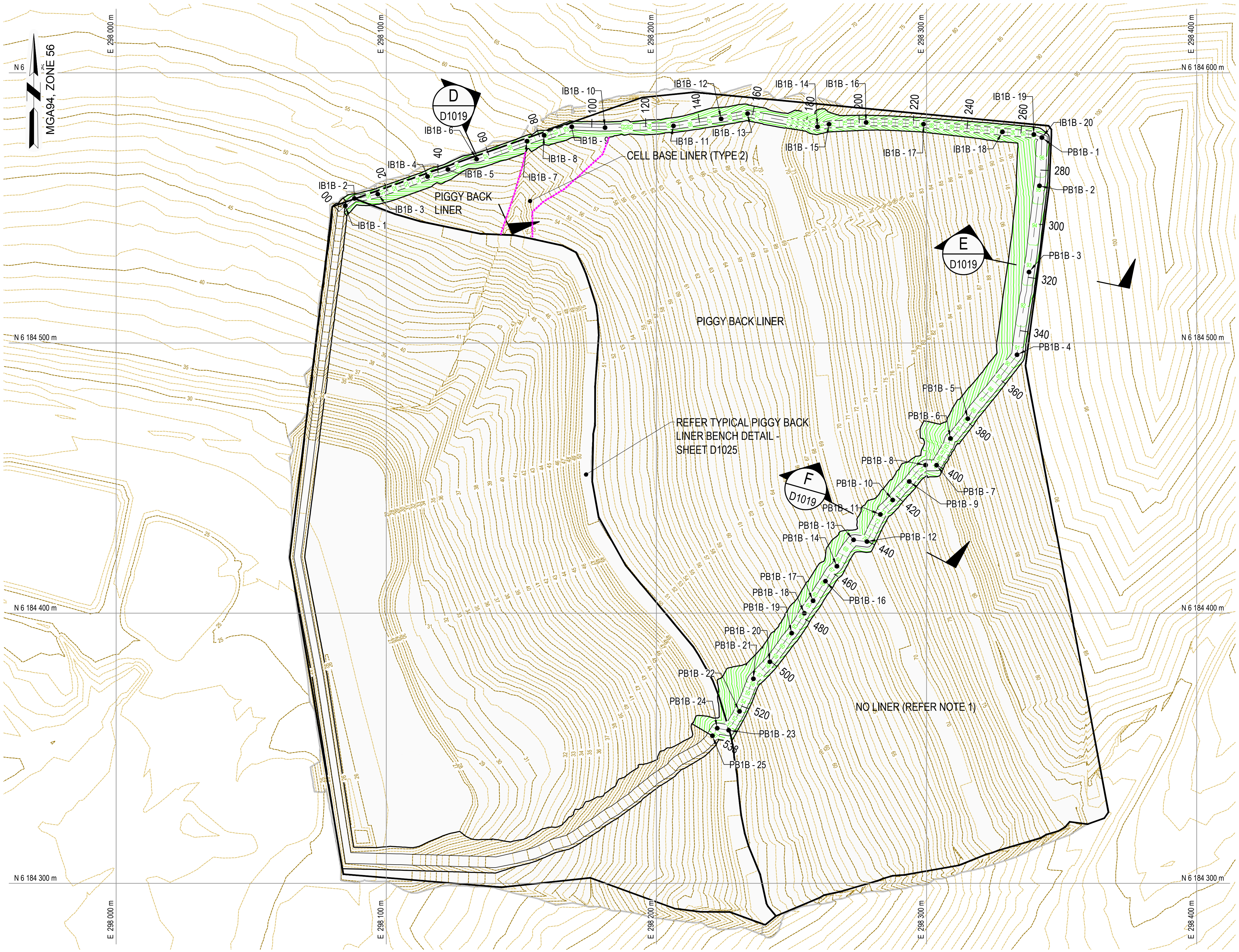
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: PERIMETER BUND AND INTERNAL BUND PLAN AND SETOUT PACKAGE 1A

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	1:1,500	A3	117625003	220	L	D1015	0

Plot Date: 28 March 2013 Time:10:27:05 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1015-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-SUBGRADE STAGE 1A.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-CELL STAGE BOUNDARY.dwg;



LEGEND

- PACKAGE BOUNDARY
- BUND CONTOURS
- EXISTING CONTOURS
- TRANSITION LINE BETWEEN LINER TYPES

NOTES:

1. AREA WITH NO LINER TO HAVE INTERIM CAPPING LAYER INSTALLED BY OTHERS. NO FUTURE WASTE PLACEMENT IN THIS AREA

PACKAGE 1B INTERNAL BUND - SETOUT				PACKAGE 1B PERIMETER BUND - SETOUT			
NUMBER	EASTING	NORTHING	LEVEL	NUMBER	EASTING	NORTHING	LEVEL
IB1B - 1	298084.81	6184550.79	49.20	PB1B - 1	298342.72	6184575.99	96.40
IB1B - 2	298088.22	6184553.46	49.18	PB1B - 2	298341.78	6184558.14	95.21
IB1B - 3	298096.86	6184555.08	50.55	PB1B - 3	298337.91	6184526.25	92.83
IB1B - 4	298115.27	6184561.56	54.80	PB1B - 4	298333.49	6184495.61	90.81
IB1B - 5	298122.79	6184564.19	55.82	PB1B - 5	298315.25	6184471.97	85.19
IB1B - 6	298133.40	6184568.03	56.63	PB1B - 6	298308.83	6184464.65	83.02
IB1B - 7	298152.06	6184574.68	58.95	PB1B - 7	298303.72	6184454.75	79.10
IB1B - 8	298158.41	6184576.80	59.87	PB1B - 8	298299.63	6184454.80	78.61
IB1B - 9	298168.64	6184580.02	62.42	PB1B - 9	298293.59	6184448.72	76.50
IB1B - 10	298180.97	6184579.70	62.89	PB1B - 10	298287.48	6184441.84	74.34
IB1B - 11	298206.30	6184580.34	65.22	PB1B - 11	298282.91	6184436.51	72.67
IB1B - 12	298223.95	6184582.93	67.59	PB1B - 12	298277.92	6184426.47	69.92
IB1B - 13	298233.75	6184584.88	69.19	PB1B - 13	298272.98	6184427.14	69.83
IB1B - 14	298259.62	6184580.01	75.51	PB1B - 14	298266.80	6184417.33	67.48
IB1B - 15	298263.89	6184580.94	76.59	PB1B - 16	298262.55	6184411.82	66.19
IB1B - 16	298277.60	6184581.59	79.83	PB1B - 17	298257.99	6184404.56	64.50
IB1B - 17	298298.88	6184580.98	85.18	PB1B - 18	298254.76	6184399.96	63.34
IB1B - 18	298328.06	6184578.10	93.03	PB1B - 19	298250.08	6184392.59	61.35
IB1B - 19	298339.73	6184577.11	96.00	PB1B - 20	298242.01	6184381.99	58.31
IB1B - 20	298342.72	6184575.99	96.40	PB1B - 21	298235.88	6184375.67	56.46
				PB1B - 22	298230.76	6184363.63	52.92
				PB1B - 23	298226.76	6184356.64	50.60
				PB1B - 24	298222.50	6184357.43	50.53
				PB1B - 25	298220.72	6184354.62	49.78

ISSUED FOR
CONSTRUCTION

0 30 60 90m
1:1,500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

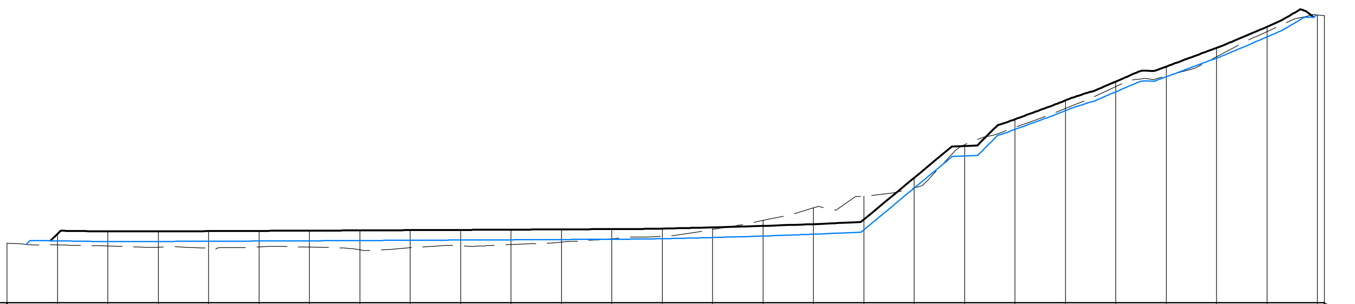
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: PERIMETER BUND AND INTERNAL BUND PLAN AND SETOUT PACKAGE 1B

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	1:1,500	A3	117625003	220	L	D1016	0

Plot Date: 28 March 2013 Time:10:26:26 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1016-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-SUBGRADE STAGE 1A.dwg; 117625003-XREF-SUBGRADE STAGE 1B.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-BUND STAGE 1B.dwg; 117625003-XREF-CELL STAGE BOUNDARY.dwg;

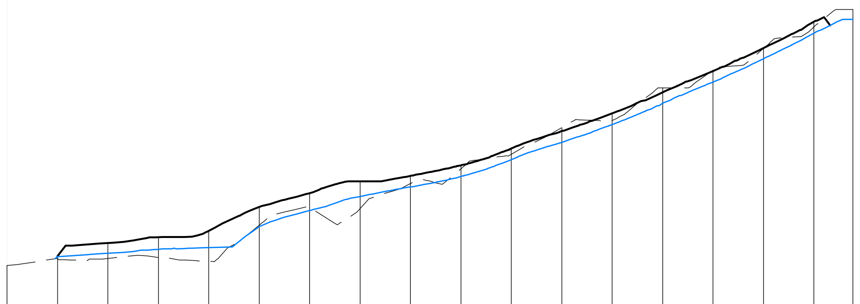


DATUM 20.00

CHAINAGE	EXISTING SURFACE	SUBGRADE	DESIGN SURFACE
0.00	25.92		
10.00	25.74	26.14	26.82
20.00	25.62	26.08	27.09
30.00	25.50	26.08	27.09
40.00	25.45	26.10	27.10
50.00	25.53	26.12	27.13
60.00	25.52	26.14	27.15
70.00	25.24	26.17	27.17
80.00	25.46	26.19	27.20
90.00	25.64	26.22	27.22
100.00	25.76	26.24	27.25
110.00	26.00	26.27	27.27
120.00	26.35	26.30	27.30
130.00	26.60	26.35	27.36
140.00	27.26	26.47	27.47
150.00	28.17	26.61	27.61
160.00	29.41	26.80	27.80
170.00	30.57	27.24	28.25
180.00	31.39	31.38	32.39
190.00	35.67	34.55	35.55
200.00	37.39	37.19	38.20
210.00	39.27	39.05	40.07
220.00	41.45	40.93	41.94
230.00	42.49	42.41	43.43
240.00	44.40	44.25	45.27
250.00	46.90	46.36	47.38
260.00	48.54		
261.39	48.47		

LONGITUDINAL SECTION OF PACKAGE 1A INTERNAL BUND

SCALE 1:1,500(H) 1:750(V)



DATUM 20.00

CHAINAGE	EXISTING SURFACE	SUBGRADE	DESIGN SURFACE
0.00	25.15		
10.00	25.85	26.03	26.07
20.00	25.84	26.36	27.38
30.00	25.95	26.75	27.95
40.00	25.55	26.92	28.58
50.00	29.15	29.02	30.95
60.00	30.96	30.60	32.34
70.00	30.79	31.97	33.50
80.00	33.28	32.94	34.04
90.00	34.74	33.98	35.07
100.00	36.18	35.65	36.76
110.00	38.81	37.36	38.48
120.00	39.54	39.13	40.24
130.00	42.75	41.22	42.31
140.00	44.53	43.35	44.42
150.00	46.67	45.66	46.72
160.00	48.81	48.19	49.32
167.70	50.53	49.56	

LONGITUDINAL SECTION OF PACKAGE 1A PERIMETER BUND

SCALE 1:1,500(H) 1:750(V)

ISSUED FOR
CONSTRUCTION

0 15 30 45m
1:750
0 30 60 90m
1:1,500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

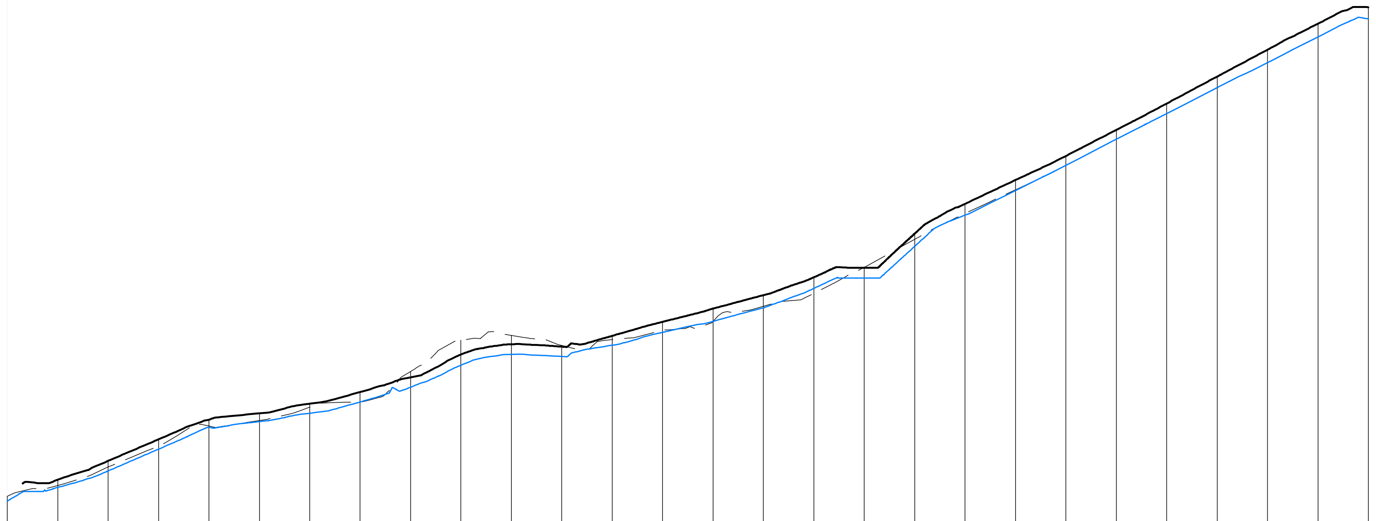
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: PERIMETER BUND LONG SECTIONS PACKAGE 1A

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1017	0

Plot Date: 28 March 2013 Time:10:25:44 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1017-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-SECTIONS.dwg;

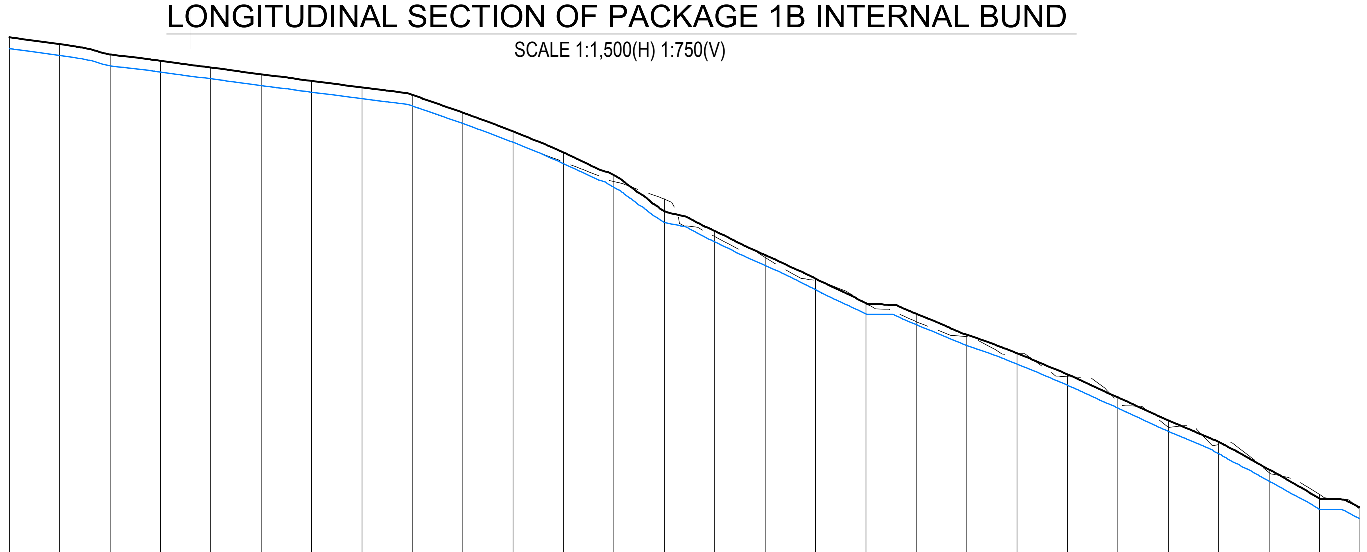


DATUM 45.00

EXISTING SURFACE	47.89	48.96	50.79	52.88	54.86	55.41	56.73	57.26	60.27	63.38	63.84	62.85	63.42	64.37	65.24	66.74	68.02	70.60	73.37	75.93	78.29	80.71	83.29	85.85	88.41	90.90	93.45	95.25
SUBGRADE	47.41	48.76	50.40	52.56	54.75	55.29	56.12	57.25	58.70	60.89	61.96	61.75	62.86	64.15	65.25	66.57	68.51	69.53	72.68	75.77	78.22	80.71	83.29	85.85	88.41	90.90	93.45	95.25
DESIGN SURFACE		49.53	51.40	53.54	55.49	56.11	57.08	58.23	59.69	61.95	62.96	62.73	63.80	65.19	66.50	67.83	69.61	70.55	73.94	76.89	79.25	81.64	84.22	86.84	89.51	92.18	94.76	96.38
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00	220.00	230.00	240.00	250.00	260.00	270.00

LONGITUDINAL SECTION OF PACKAGE 1B INTERNAL BUND

SCALE 1:1,500(H) 1:750(V)



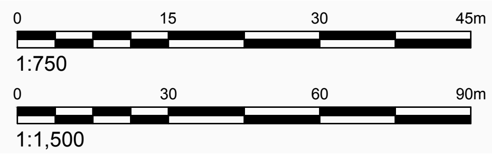
DATUM 45.00

EXISTING SURFACE	95.25	94.55	93.54	92.92	92.26	91.58	90.92	90.28	89.56	87.81	85.95	83.98	82.06	80.34	76.60	74.53	72.25	69.96	68.17	66.69	64.99	62.71	60.14	57.70	55.99	53.21	51.04	49.64
SUBGRADE	95.25	94.55	93.54	92.92	92.26	91.58	90.92	90.28	89.56	87.81	85.95	83.83	81.49	78.00	76.08	73.74	71.34	68.94	67.87	65.81	63.96	61.87	59.60	57.29	55.08	52.35	49.55	48.65
DESIGN SURFACE	96.38	95.68	94.67	94.04	93.38	92.70	92.04	91.40	90.66	88.90	87.03	84.95	82.69	79.11	77.16	74.78	72.45	70.00	68.95	66.88	65.03	62.94	60.65	58.37	56.25	53.49	50.64	
CHAINAGE	270.00	280.00	290.00	300.00	310.00	320.00	330.00	340.00	350.00	360.00	370.00	380.00	390.00	400.00	410.00	420.00	430.00	440.00	450.00	460.00	470.00	480.00	490.00	500.00	510.00	520.00	530.00	537.89

LONGITUDINAL SECTION OF PACKAGE 1B PERIMETER BUND CONTINUED

SCALE 1:1,500(H) 1:750(V)

ISSUED FOR
CONSTRUCTION



REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

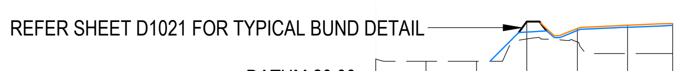
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: PERIMETER BUND LONG SECTIONS PACKAGE 1B

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1018	0

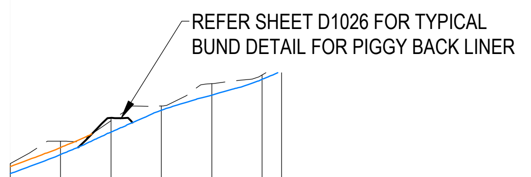
Plot Date: 28 March 2013 Time:10:25:14 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1018-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-SECTIONS.dwg;



DATUM 20.00

EXISTING SURFACE	23.40	23.16	23.16	25.38	25.07	23.93	23.93
SUBGRADE				26.08	26.21	26.54	26.72
TOP OF LINER					26.41	26.74	26.92
DESIGN SURFACE				27.10			
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	58.92

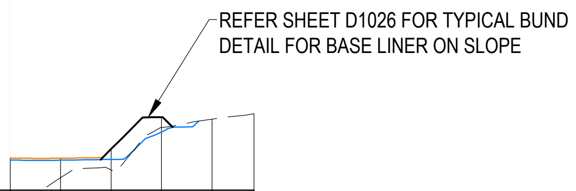
SECTION A D1015
HOR SCALE 1:1,500
VER SCALE 1:750



DATUM 30.00

EXISTING SURFACE	36.99	39.23	41.26	42.71	44.93	45.80	46.87
SUBGRADE	36.00	37.89	40.11	42.28	43.79	45.36	46.15
TOP OF LINER	36.70	38.59					
DESIGN SURFACE			41.53				
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	53.84

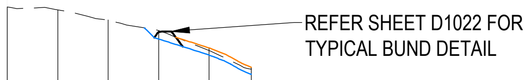
SECTION B D1015
HOR SCALE 1:1,500
VER SCALE 1:750



DATUM 23.93

EXISTING SURFACE	23.93	25.15	25.92	30.12	30.96	31.50
SUBGRADE	26.92	26.89	26.97	29.69		
TOP OF LINER	27.12	27.09				
DESIGN SURFACE			28.00	31.16		
CHAINAGE	0.00	10.00	20.00	30.00	40.00	48.32

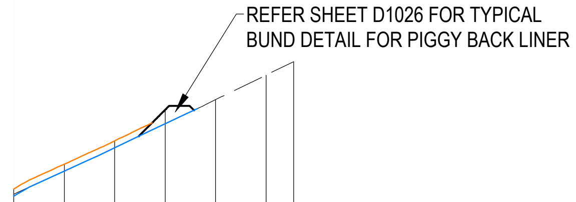
SECTION C D1015
HOR SCALE 1:1,500
VER SCALE 1:750



DATUM 50.00

EXISTING SURFACE	59.67	59.38	58.39	57.34	55.38	53.54
SUBGRADE				56.52	54.94	53.09
TOP OF LINER					55.64	53.74
DESIGN SURFACE				57.21		
CHAINAGE	0.00	10.00	20.00	30.00	40.00	48.37

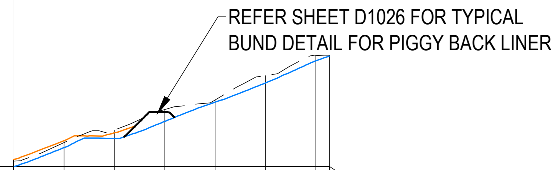
SECTION D D1016
HOR SCALE 1:1,500
VER SCALE 1:750



DATUM 80.00

EXISTING SURFACE	84.84	87.13	89.44	91.83	94.21	96.65	97.97
SUBGRADE	84.65	87.13	89.44	91.83			
TOP OF LINER	85.35	87.83	90.14				
DESIGN SURFACE				93.21			
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	55.46

SECTION E D1016
HOR SCALE 1:1,500
VER SCALE 1:750



DATUM 66.19

EXISTING SURFACE	66.73	68.59	69.82	71.84	72.82	75.22	77.23	77.26
SUBGRADE	66.19	68.07	68.99	70.68	72.58	74.49	76.68	77.19
TOP OF LINER	66.89	68.77	69.54					
DESIGN SURFACE				71.58				
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	62.72

SECTION F D1016
HOR SCALE 1:1,500
VER SCALE 1:750

ISSUED FOR
CONSTRUCTION

0 15 30 45m
1:750

0 30 60 90m
1:1,500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

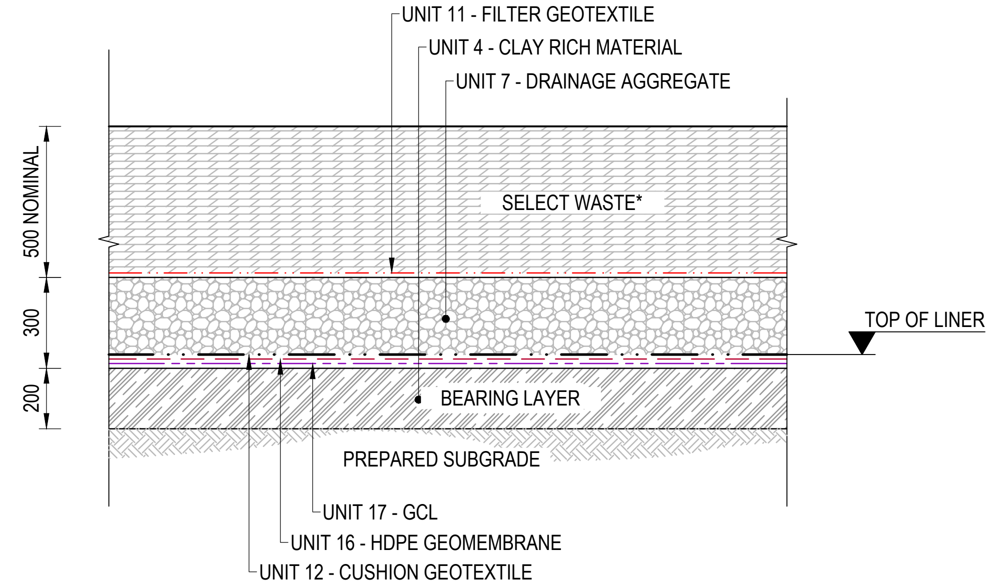
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: PERIMETER BUND AND INTERNAL BUND CROSS SECTIONS

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1019	0

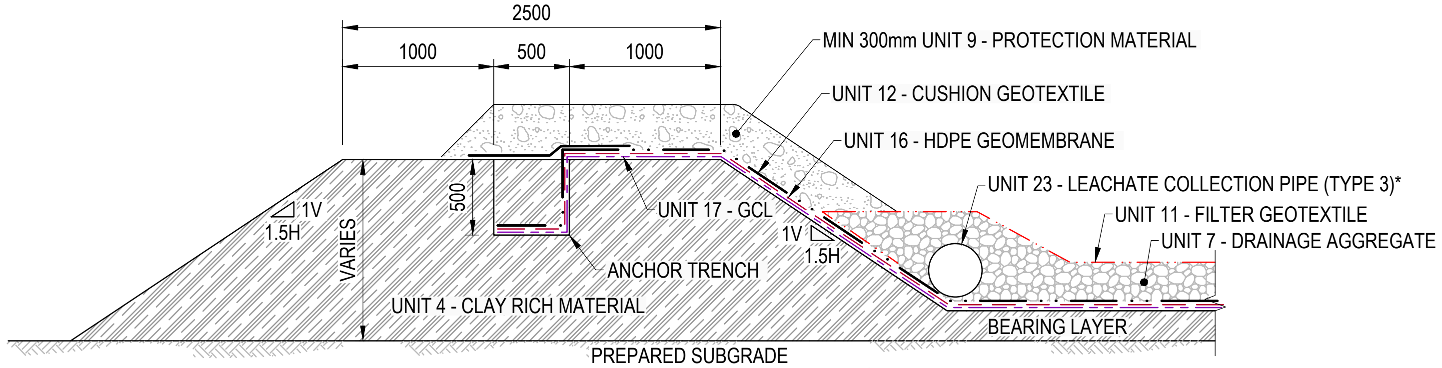
Plot Date: 28 March 2013 Time:10:24:40 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1019-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-SECTIONS.dwg;



* SELECT WASTE TO BE PLACED IN FUTURE (BY OTHERS)

CELL BASE LINER - TYPE 1

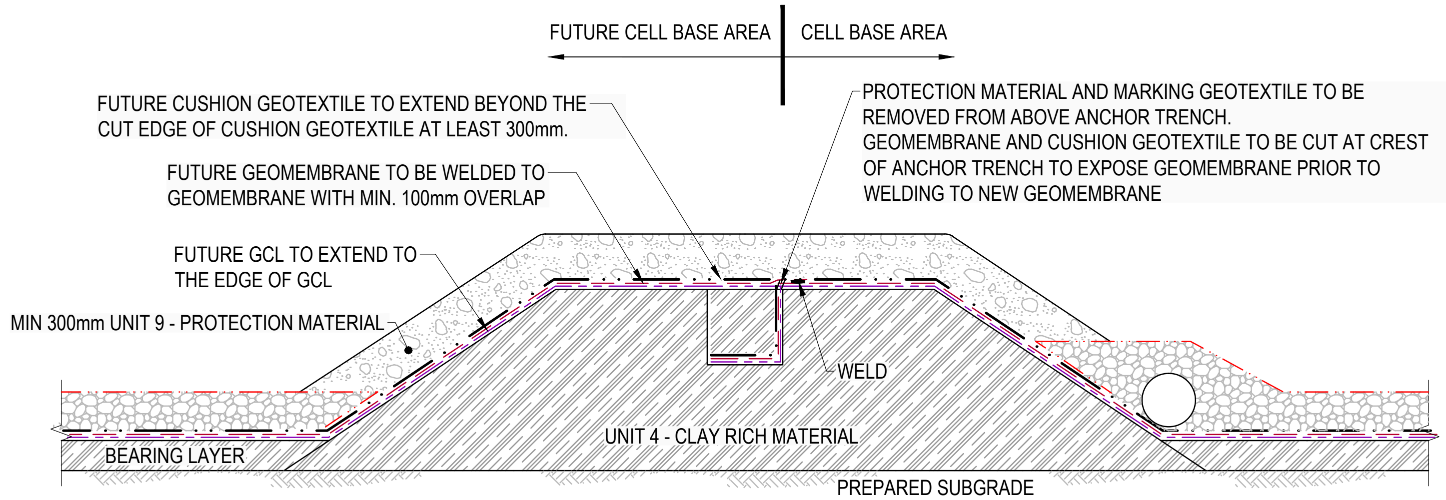
SCALE 1:25



* LEACHATE COLLECTION PIPE NOT PRESENT IN ALL AREAS

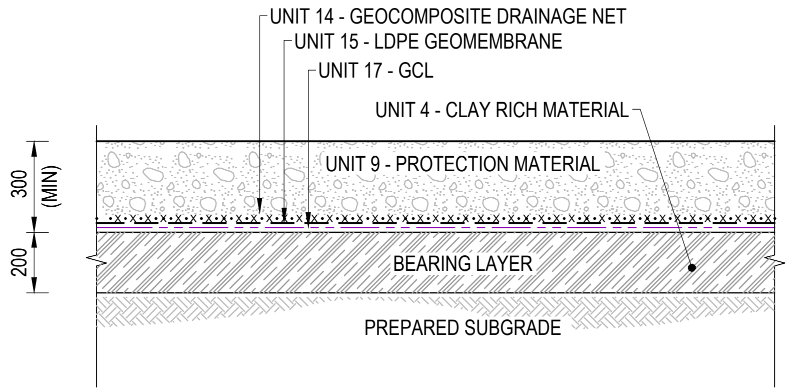
BASE LINER - TYPICAL DETAIL FOR INTERIM TERMINATION AT INTERNAL BUND

SCALE 1:50



BASE LINER - TYPICAL INTERNAL BUND DETAIL FOR CONNECTION OF FUTURE BASE LINER

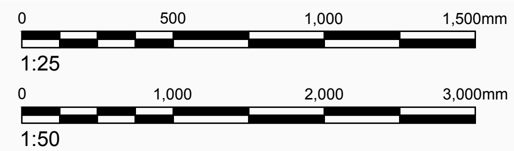
SCALE 1:50



CELL BASE LINER TYPE 2 - FOR NATURAL GROUND SURFACE BETWEEN EXISTING EASTERN & WESTERN GULLY LANDFILLS

SCALE 1:25

ISSUED FOR
CONSTRUCTION



NOTES:

1. REFER TO DRAWING D1001 FOR GENERAL NOTES AND LEGEND

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

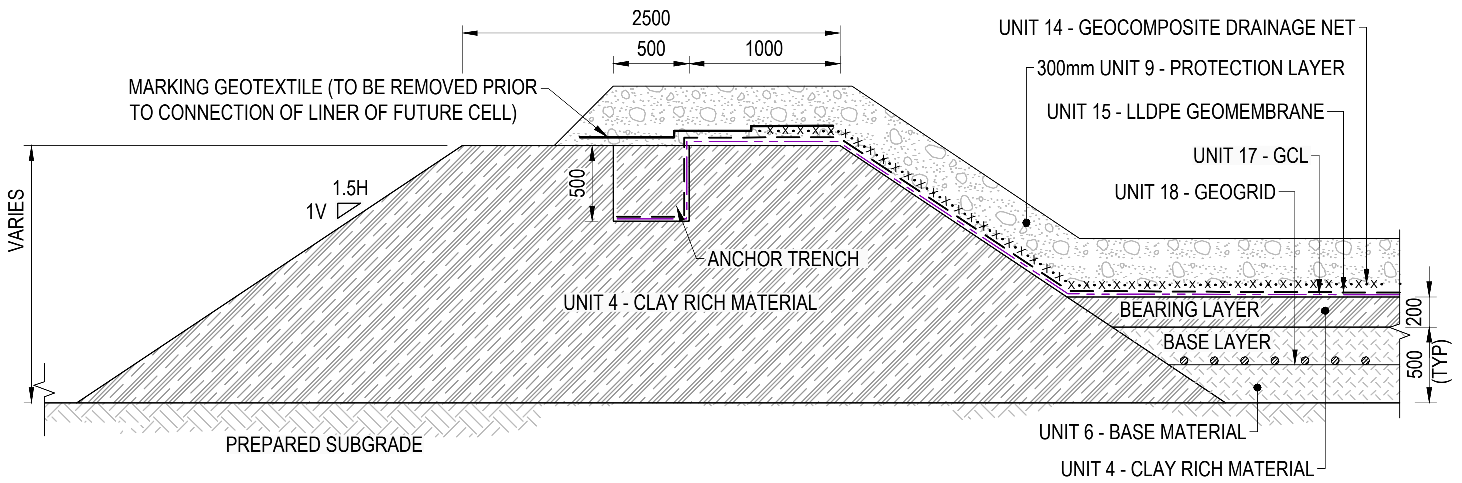
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: LINER DETAILS SHEET 1

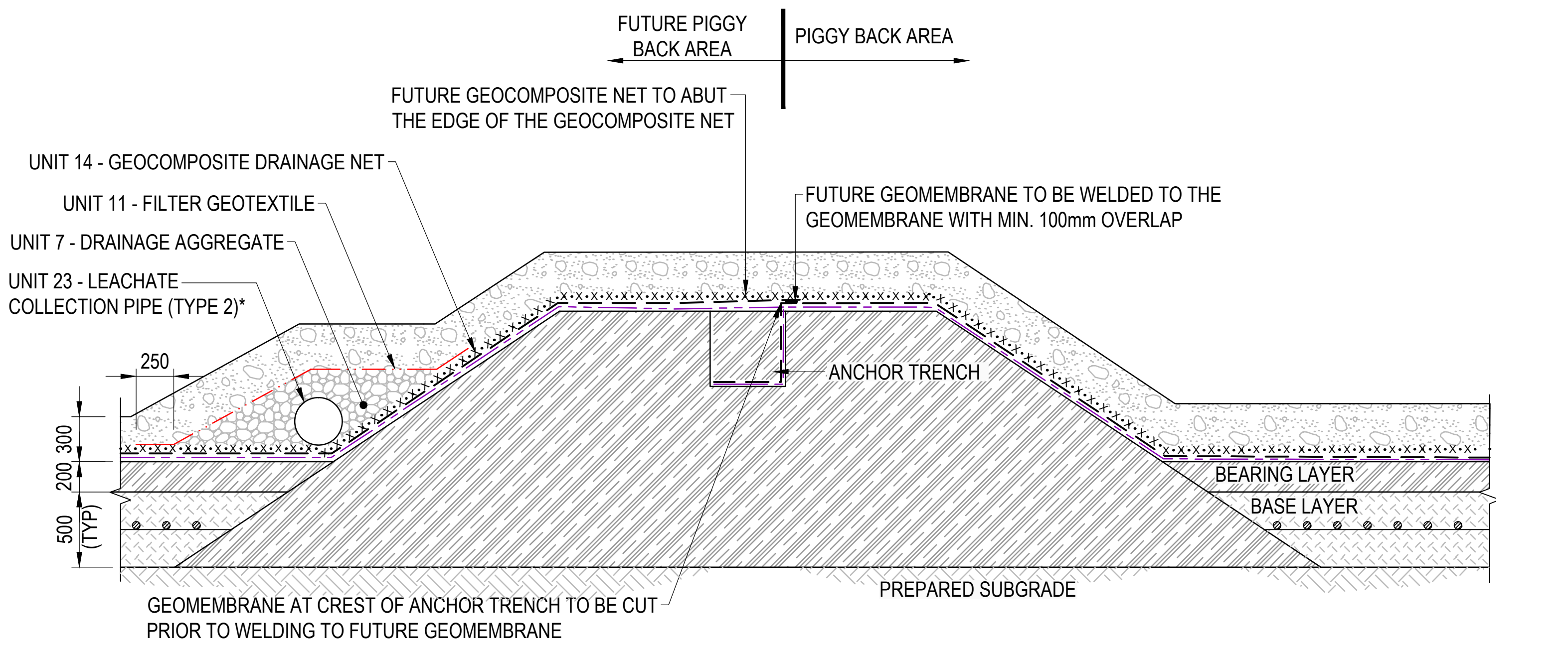
LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1021	0

Plot Date: 28 March 2013 Time:10:36:28 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1021-REV0.dwg
Xref: GAP_LOGO-A3.dwg;



PIGGY BACK LINER - TYPICAL DETAIL FOR INTERIM TERMINATION AT INTERNAL BUND

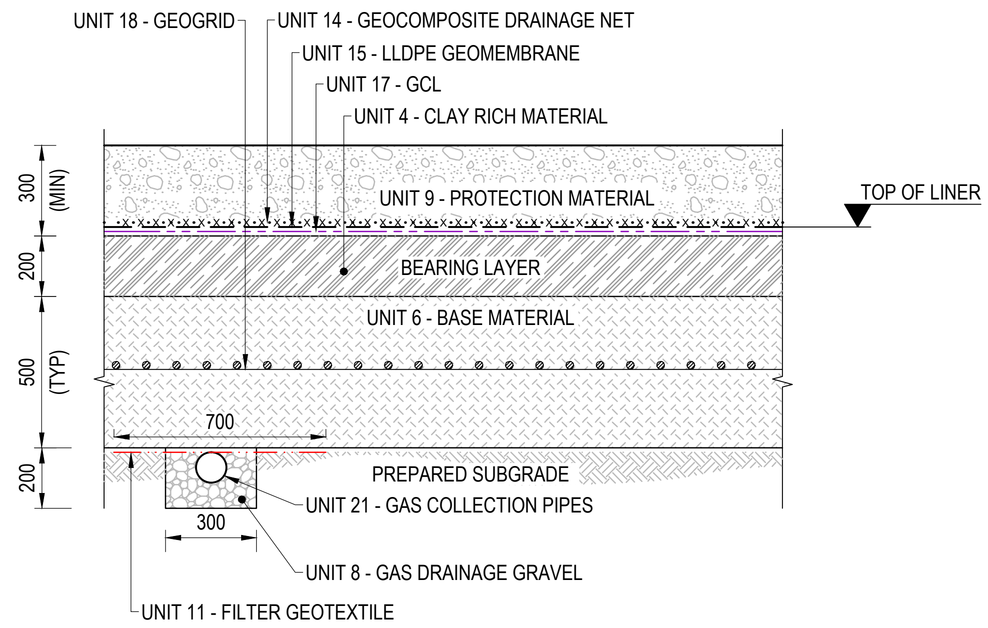
SCALE 1:50



* LEACHATE COLLECTION PIPE NOT PRESENT IN ALL AREAS

PIGGY BACK LINER - TYPICAL INTERNAL BUND DETAIL FOR CONNECTION OF FUTURE PIGGY BACK LINER

SCALE 1:50



PIGGY BACK LINER

SCALE 1:25

ISSUED FOR
CONSTRUCTION

NOTES:

1. REFER TO DRAWING D1001 FOR GENERAL NOTES AND LEGEND

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

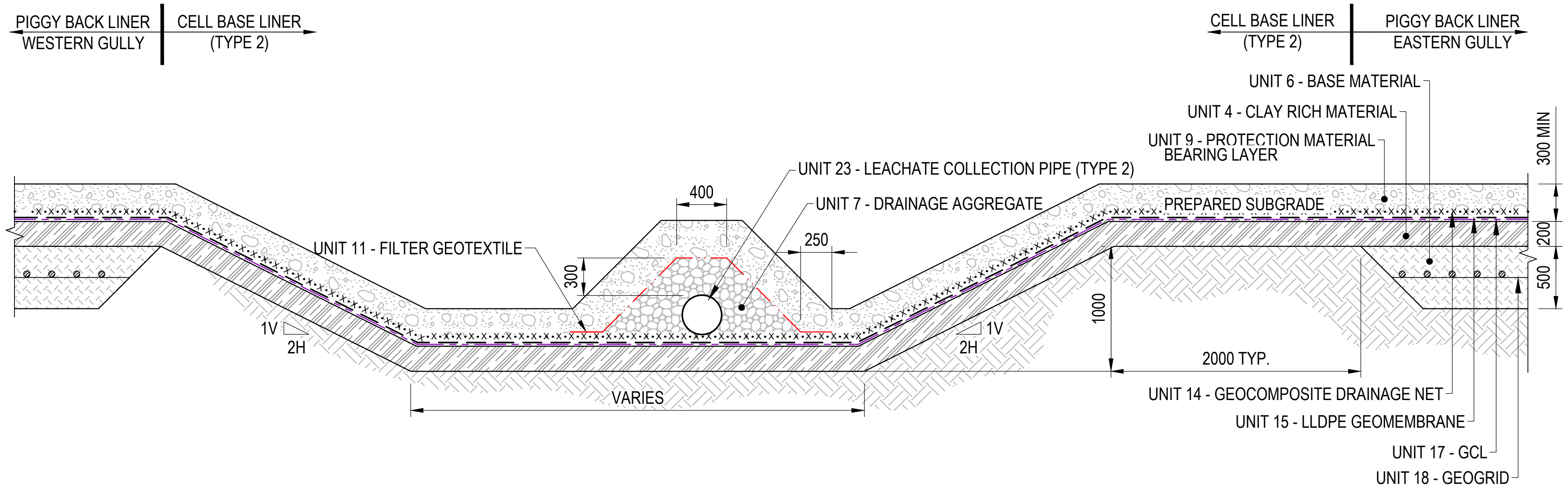
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: LINER DETAILS SHEET 2

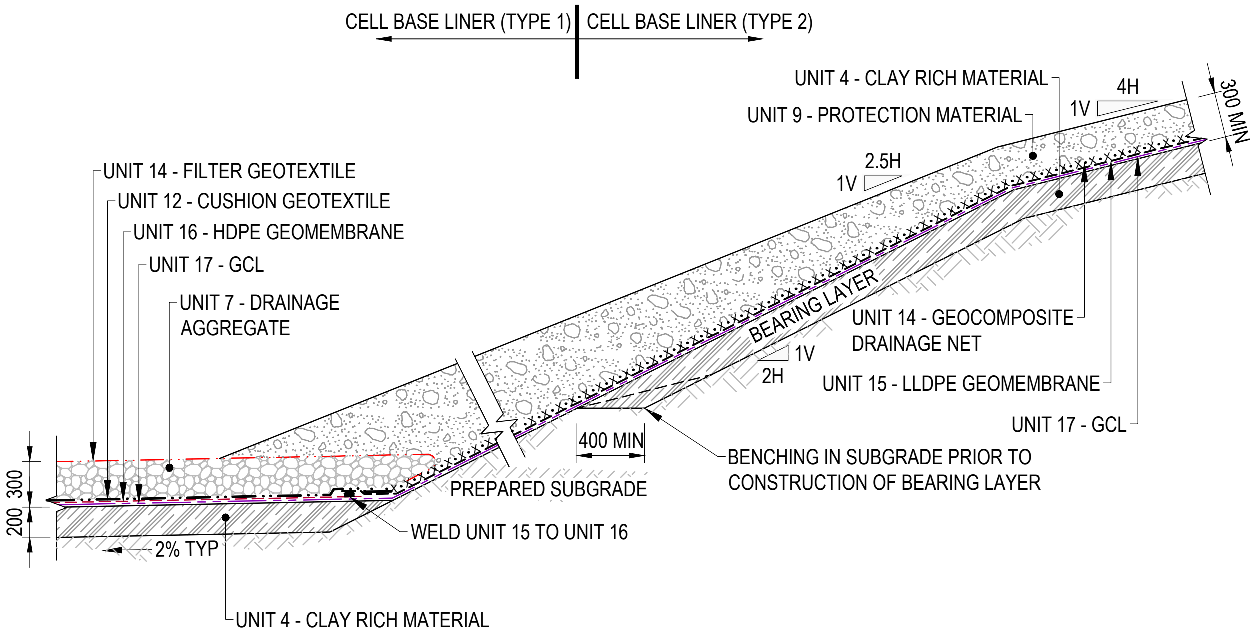
LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1022	0

Plot Date: 28 March 2013 Time:10:35:29 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1022-REV0.dwg
Xref: GAP_LOGO-A3.dwg;



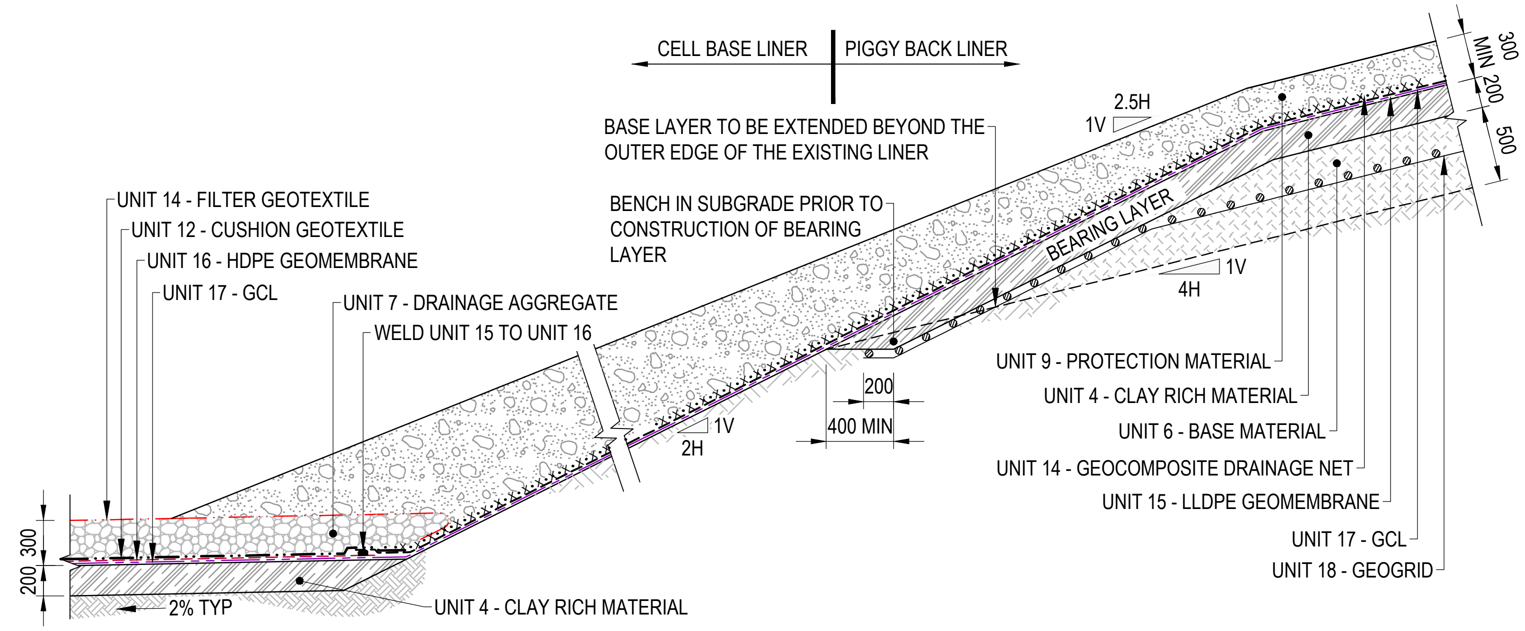
LINER DETAIL - TYPICAL ACROSS EASTERN AND WESTERN GULLY LANDFILLS

SCALE 1:50



LINER CONNECTION - TYPE 2

SCALE 1:50



LINER CONNECTION - TYPE 3

SCALE 1:50

ISSUED FOR
CONSTRUCTION

0 500 1,000 1,500mm
1:25
0 1,000 2,000 3,000mm
1:50

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

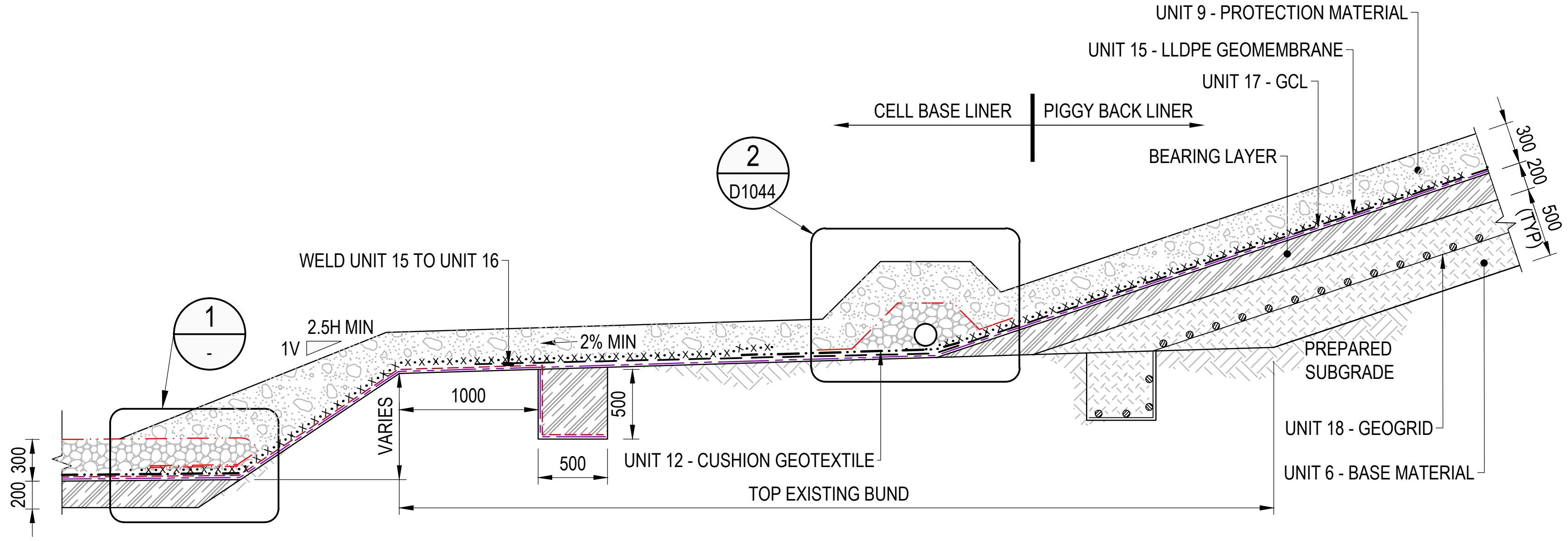
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: LINER DETAILS SHEET 3

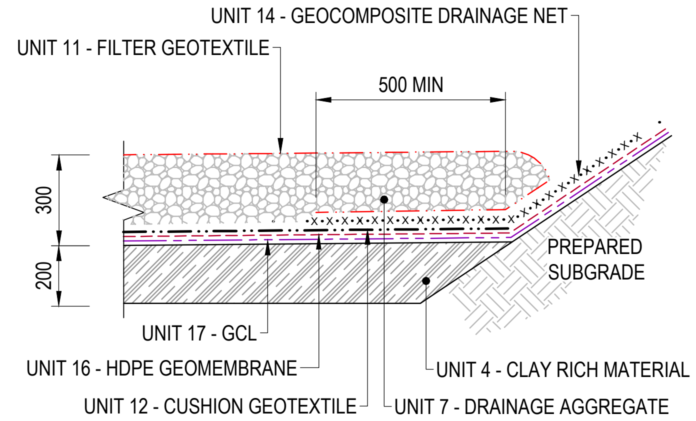
LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1023	0

Plot Date: 28 March 2013 Time:10:34:34 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1023-REV0.dwg
Xref: GAP_LOGO-A3.dwg;

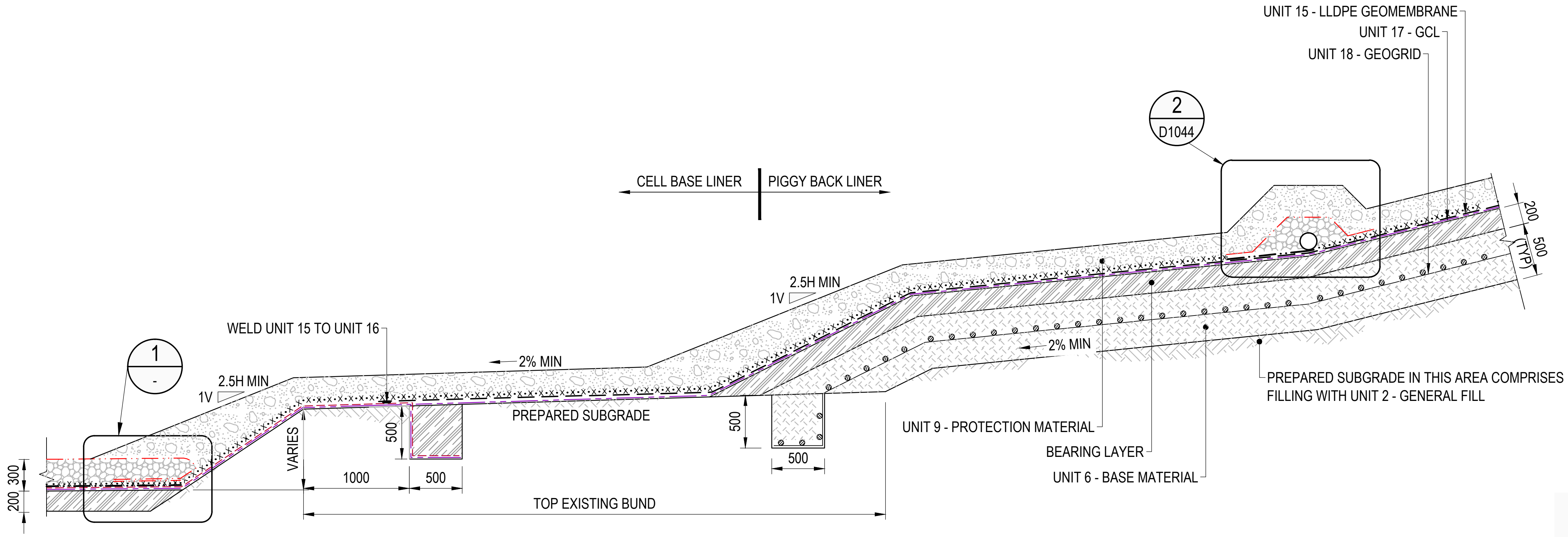


NOTE: LEACHATE COLLECTION PIPE NOT PRESENT IN ALL AREAS

LINER CONNECTION - TYPE 1
SCALE 1:50



1 - TYPICAL DETAIL
SCALE 1:25



NOTES:
1. REFER TO DRAWING D1001 FOR GENERAL NOTES AND LEGEND

LINER CONNECTION - TYPE 4
SCALE 1:50

ISSUED FOR
CONSTRUCTION

0 500 1,000 1,500mm
1:25
0 1,000 2,000 3,000mm
1:50

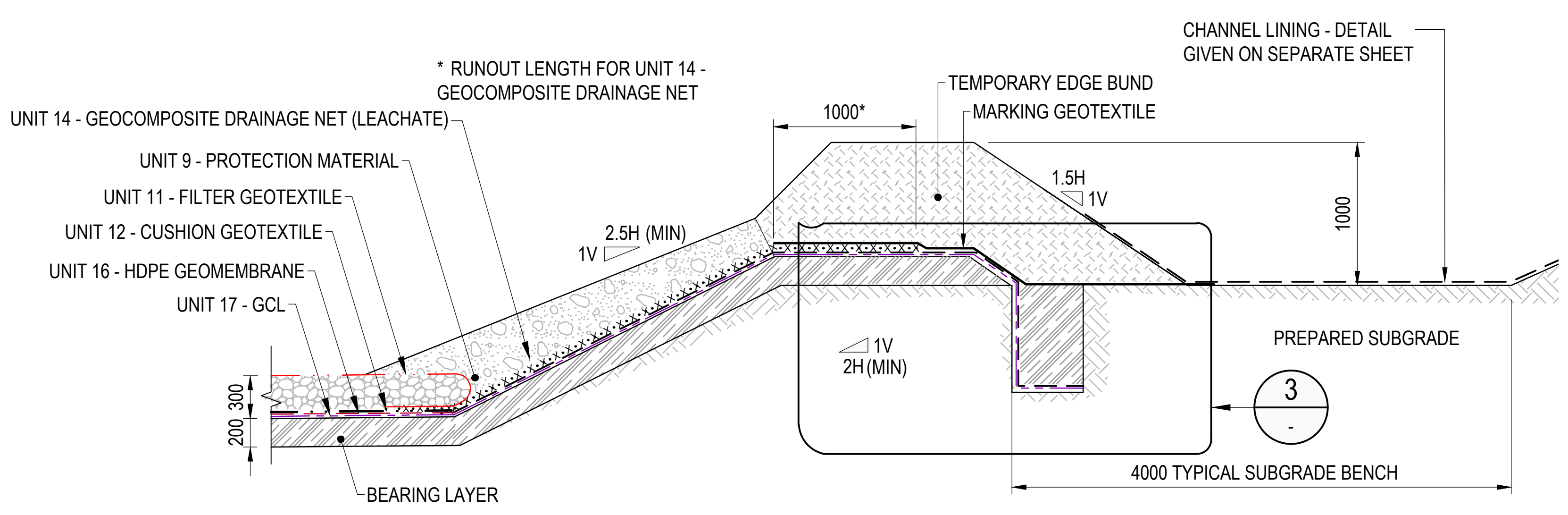
REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN
DRAWING TITLE: LINER DETAILS SHEET 4

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1024	0

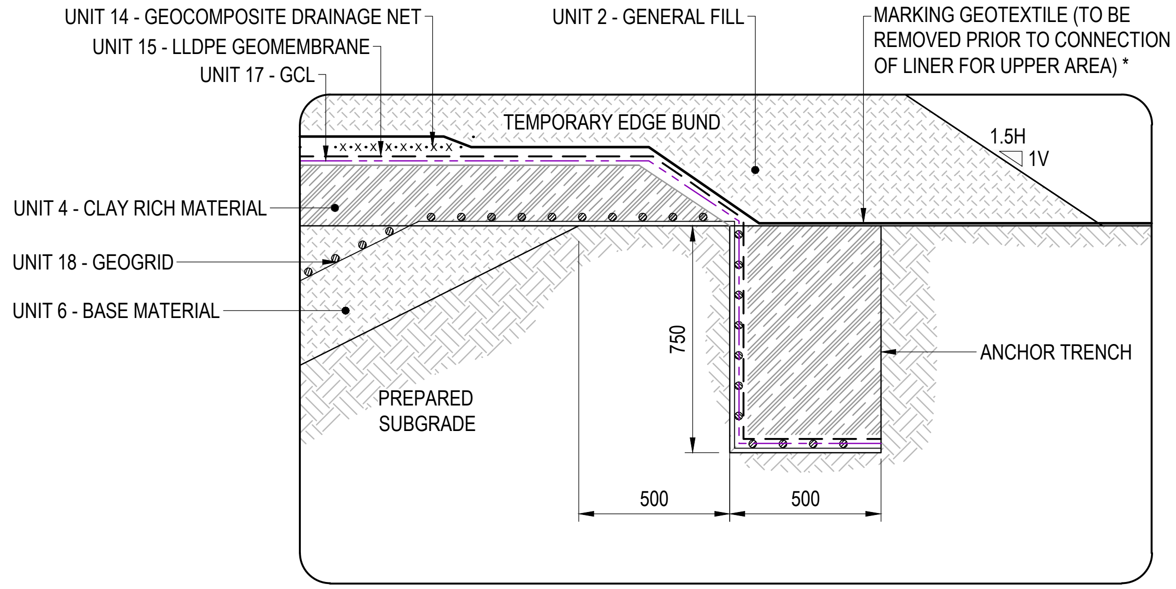
Plot Date: 28 March 2013 Time:10:32:57 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1024-REV0.dwg
Xref: GAP_LOGO-A3.dwg;



NOTE: GAS COLLECTION PIPE (UNIT 21) ON BENCH NOT SHOWN FOR CLARITY. REFER SHEETS D1071 AND D1072

BASE CELL LINER - INTERIM TERMINATION AT INTERNAL BUND FOR CONNECTING WITH PIGGY BACK LINER

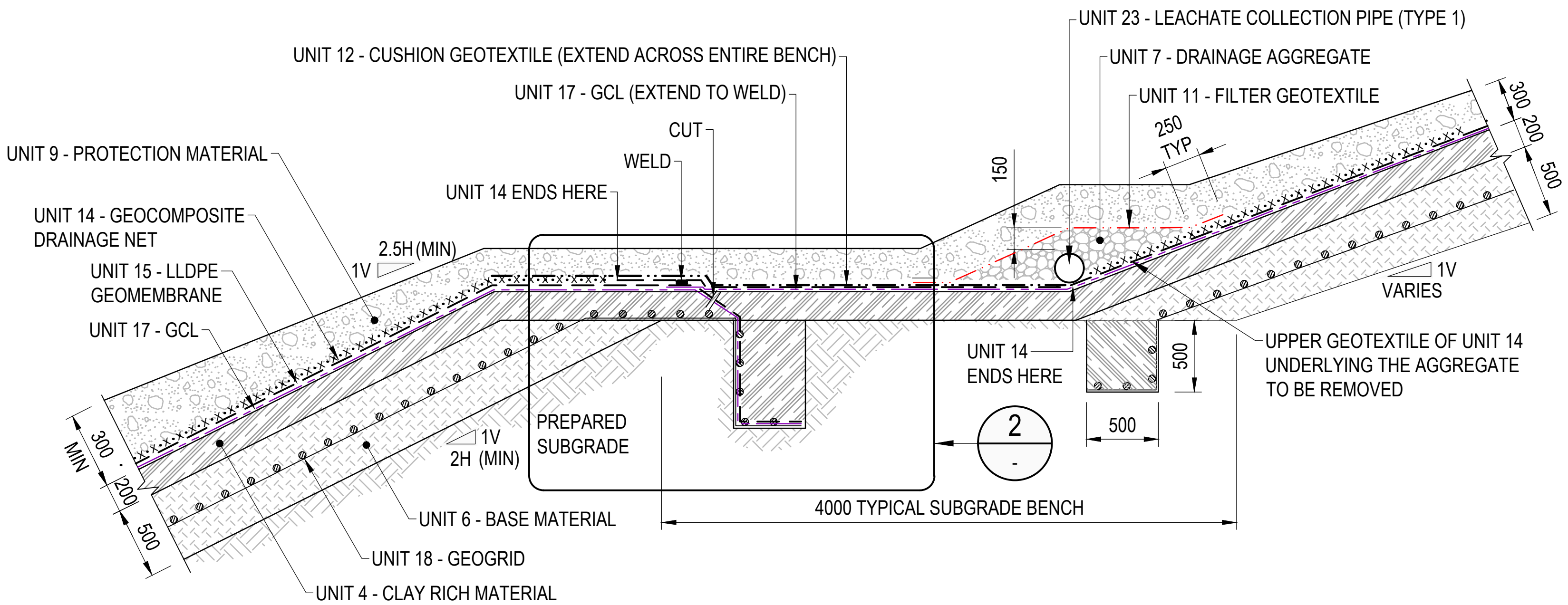
SCALE 1:50



* MARKING GEOTEXTILE TO EXTEND PAST TOE OF EDGE BUND IN ORDER THAT IT CAN BE LOCATED AT THE TIME OF LINER EXTENSION

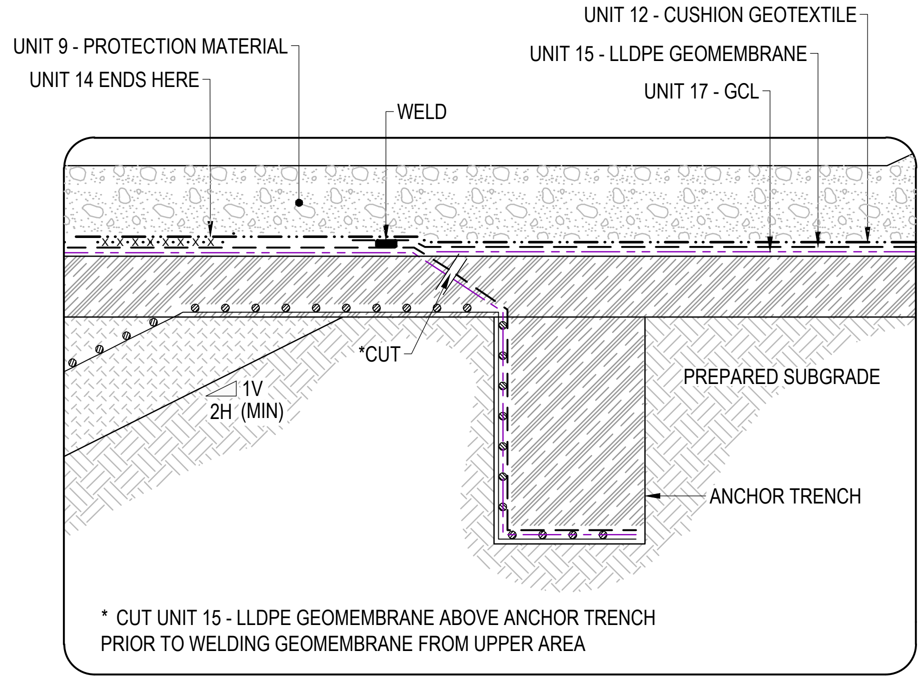
3 DETAIL FOR LINER TERMINATION AND ANCHOR TRENCH AT BENCH

SCALE 1:25



PIGGY BACK LINER - TYPICAL FUTURE CONNECTION OF UPPER AREA TO LOWER AREA

SCALE 1:50



2 DETAIL FOR CONNECTION OF UPPER GEOMEMBRANE

SCALE 1:25

0 500 1,000 1,500mm
1:25
0 1,000 2,000 3,000mm
1:50

ISSUED FOR
CONSTRUCTION

NOTES:

1. REFER TO DRAWING D1001 FOR GENERAL NOTES AND LEGEND

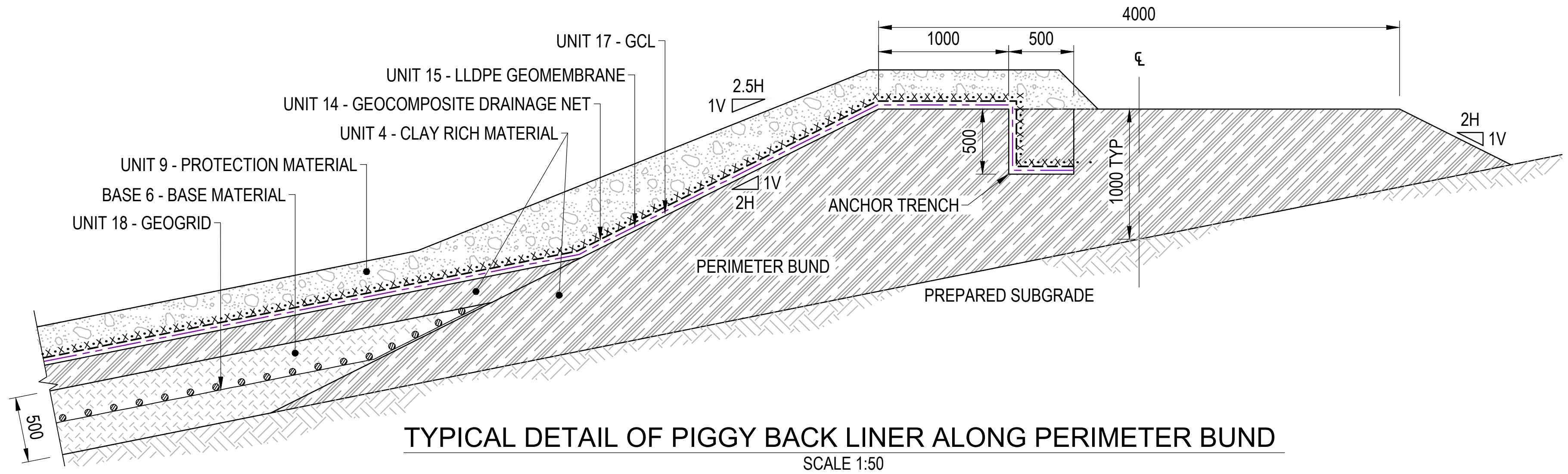
REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN
DRAWING TITLE: LINER DETAILS SHEET 5

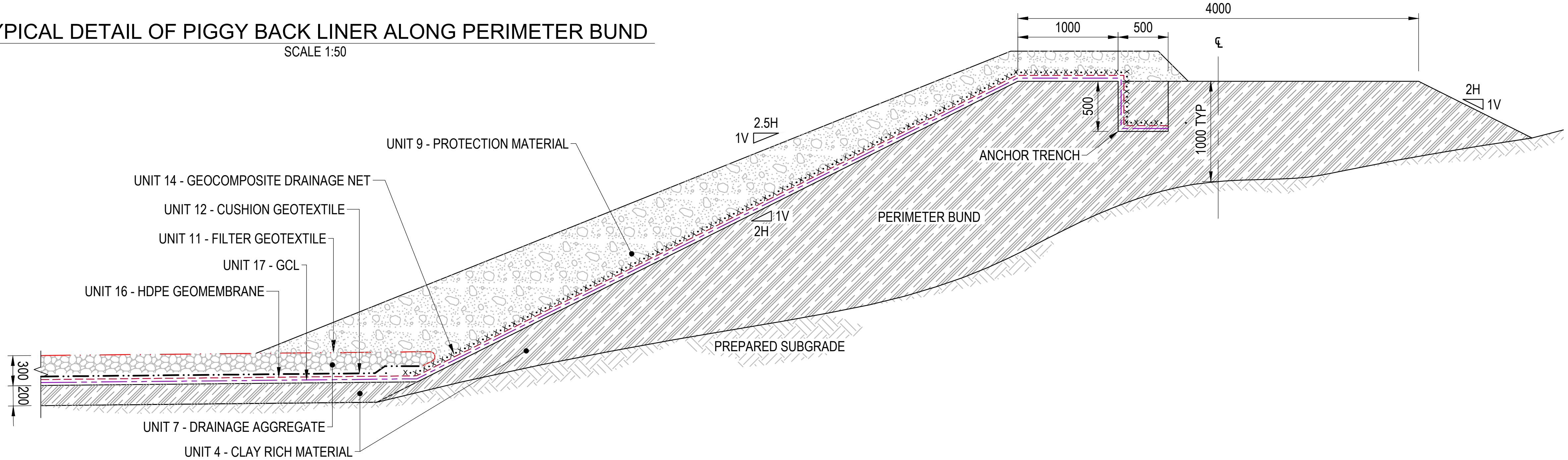
LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1025	0

Plot Date: 28 March 2013 Time:10:31:51 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1025-REV0.dwg
Xref: GAP_LOGO-A3.dwg;



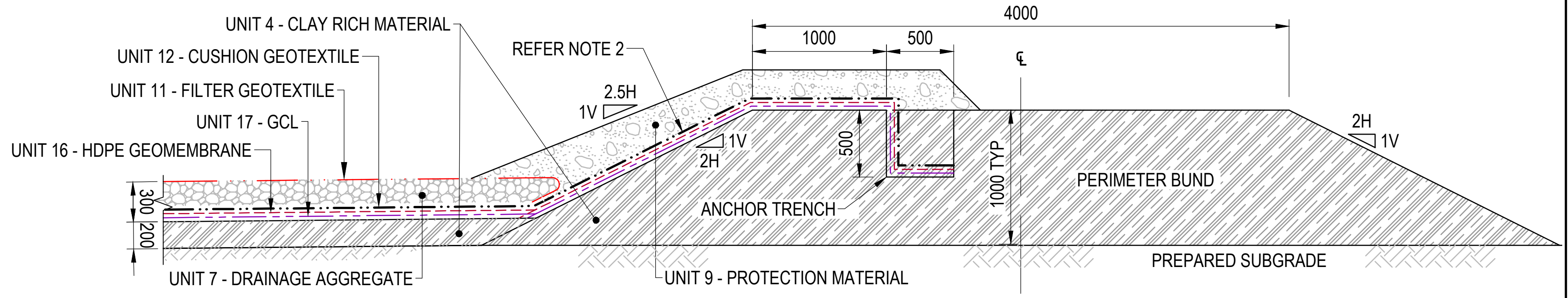
TYPICAL DETAIL OF PIGGY BACK LINER ALONG PERIMETER BUND

SCALE 1:50



TYPICAL DETAIL OF BASE LINER ALONG PERIMETER BUND ON SLOPE

SCALE 1:50



TYPICAL DETAIL OF BASE LINER ALONG PERIMETER BUND ON FLAT AREA

SCALE 1:50

NOTES:

1. REFER TO DRAWING D1001 FOR GENERAL NOTES AND LEGEND.
2. WHEN PERIMETER BUND SLOPE HEIGHT EXCEEDS 1.5m; REPLACE UNIT 12 CUSHION GEOTEXTILE ON SLOPE WITH UNIT 14 GEOCOMPOSITE DRAINAGE NET AS SHOWN ON DETAIL ABOVE 'TYPICAL DETAIL OF BASE LINER ALONG PERIMTER BUND ON SLOPE"

ISSUED FOR
CONSTRUCTION

0 500 1,000 1,500mm
1:25
0 1,000 2,000 3,000mm
1:50

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

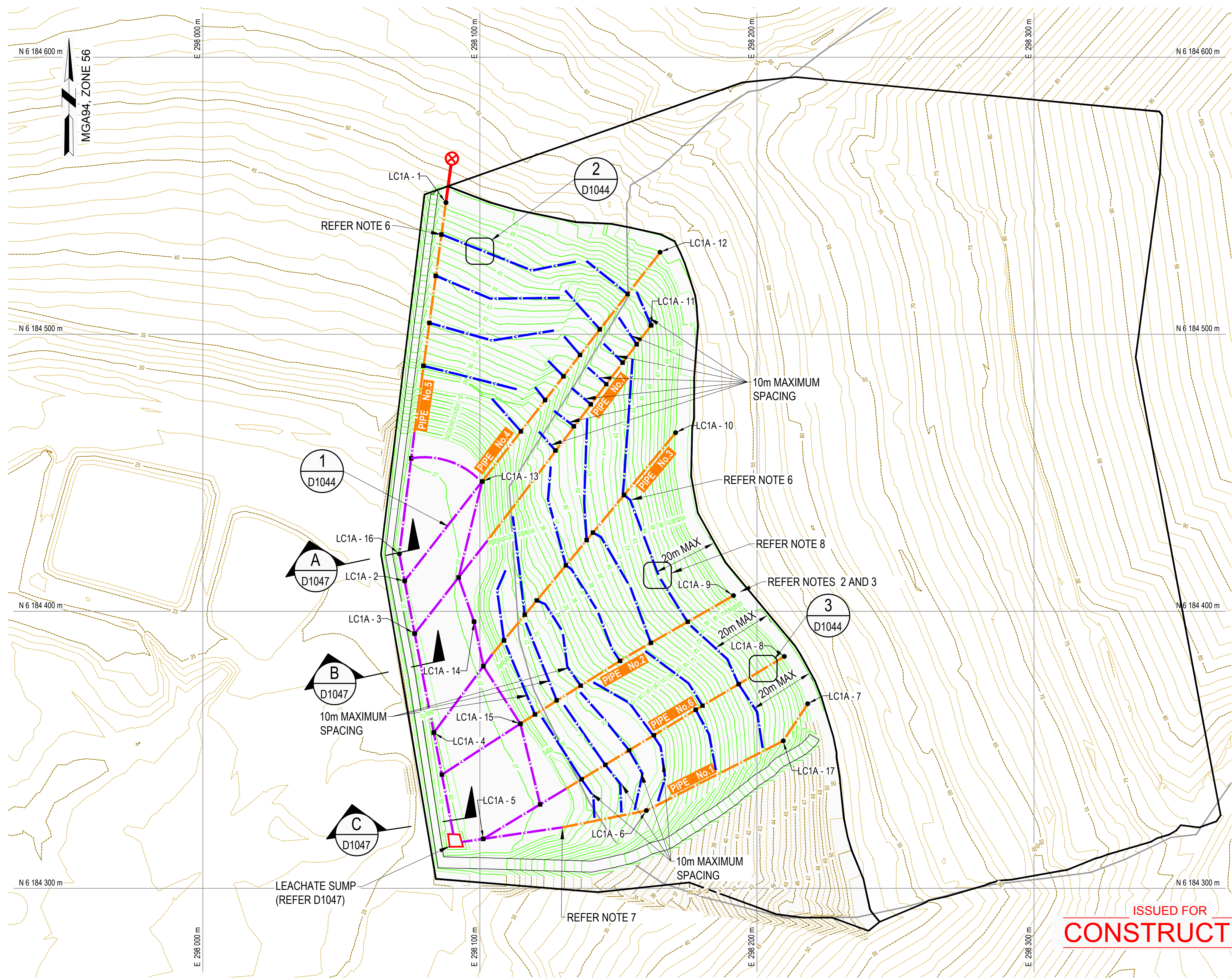
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: LINER DETAILS SHEET 6

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1026	0

Plot Date: 28 March 2013 Time:10:31:16 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1026-REV0.dwg
Xref: GAP_LOGO-A3.dwg;



LEGEND

- UNIT 23 - LEACHATE COLLECTION PIPE TYPE 1
- UNIT 23 - LEACHATE COLLECTION PIPE TYPE 2
- UNIT 23 - LEACHATE COLLECTION PIPE TYPE 3
- TEMPORARY LEACHATE PIPE CLEANOUT POINT
- PIPE CONNECTION (REFER NOTE 8)
- PACKAGE BOUNDARY
- TOP OF LINER CONTOURS
- EXISTING CONTOURS

NOTE:

1. REFER TO D001 FOR GENERAL NOTES, MATERIAL LIST AND DRAWING REFERENCES.
2. TYPE 2 PIPES TERMINATING ON BENCH TO BE CAPPED. THESE PIPES TO BE EXTENDED IN FUTURE.
3. ALL PIPES TERMINATING AT BENCHES OR AT TEMPORARY/FINAL LEACHATE PIPE CLEANOUT POINTS ARE TO CAPPED WITH AN AIRTIGHT CAP AND CLEARLY LABELED "WARNING: EXPLOSIVE GASES MAY BE PRESENT (METHANE)".
4. TYPE 3 PIPES MINIMUM 1% FALL. TYPE 1 AND TYPE 2 PIPES MINIMUM 2% FALL.
5. MAXIMUM 15 METRES DISTANCE BETWEEN TYPE 3 PIPES (MEASURED PERPENDICULAR TO SLOPE) UNLESS OTHERWISE INDICATED.
6. CHANGES IN PIPE DIRECTION NEEDED TO MAINTAIN FALL AND TO FACILITATE CONNECTION GEOMETRY ARE LIMITED TO MAXIMUM 30 DEGREE SWEEPING BENDS.
7. USE ECCENTRIC REDUCERS FOR CONNECTION OF TYPE 2 TO TYPE 3.
8. PIPE CONNECTION LOCATIONS INDICATE WHERE PIPES ARE TO BE CONNECTED WITH SUITABLE FITTINGS. IF PIPE ALIGNMENTS ARE ADJACENT (WITHIN 2m) AND NO PIPE CONNECTION IS INDICATED, THEN THE ADJACENT PIPES ARE TO TERMINATE SEPARATELY WITH SOLID END CAPS, HOWEVER THE UNIT 7 - DRAINAGE AGGREGATE SURROUNDS OF THE PIPES ARE TO BE CONNECTED..

PACKAGE 1A LEACHATE COLLECTION - SETOUT		
NUMBER	EASTING	NORTHING
LC1A - 1	298087.72	6184547.45
LC1A - 2	298072.81	6184410.90
LC1A - 3	298076.46	6184391.94
LC1A - 4	298083.36	6184356.18
LC1A - 5	298101.19	6184317.85
LC1A - 6	298160.07	6184328.03
LC1A - 7	298218.28	6184366.61
LC1A - 8	298209.84	6184383.64
LC1A - 9	298191.50	6184405.62
LC1A - 10	298170.63	6184464.41
LC1A - 11	298161.80	6184503.20
LC1A - 12	298164.99	6184529.58
LC1A - 13	298100.75	6184446.77
LC1A - 14	298097.88	6184396.22
LC1A - 15	298114.62	6184359.36
LC1A - 16	298070.92	6184420.70
LC1A - 17	298209.43	6184353.17

0 30 60 90m
1:1,500

ISSUED FOR
CONSTRUCTION

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

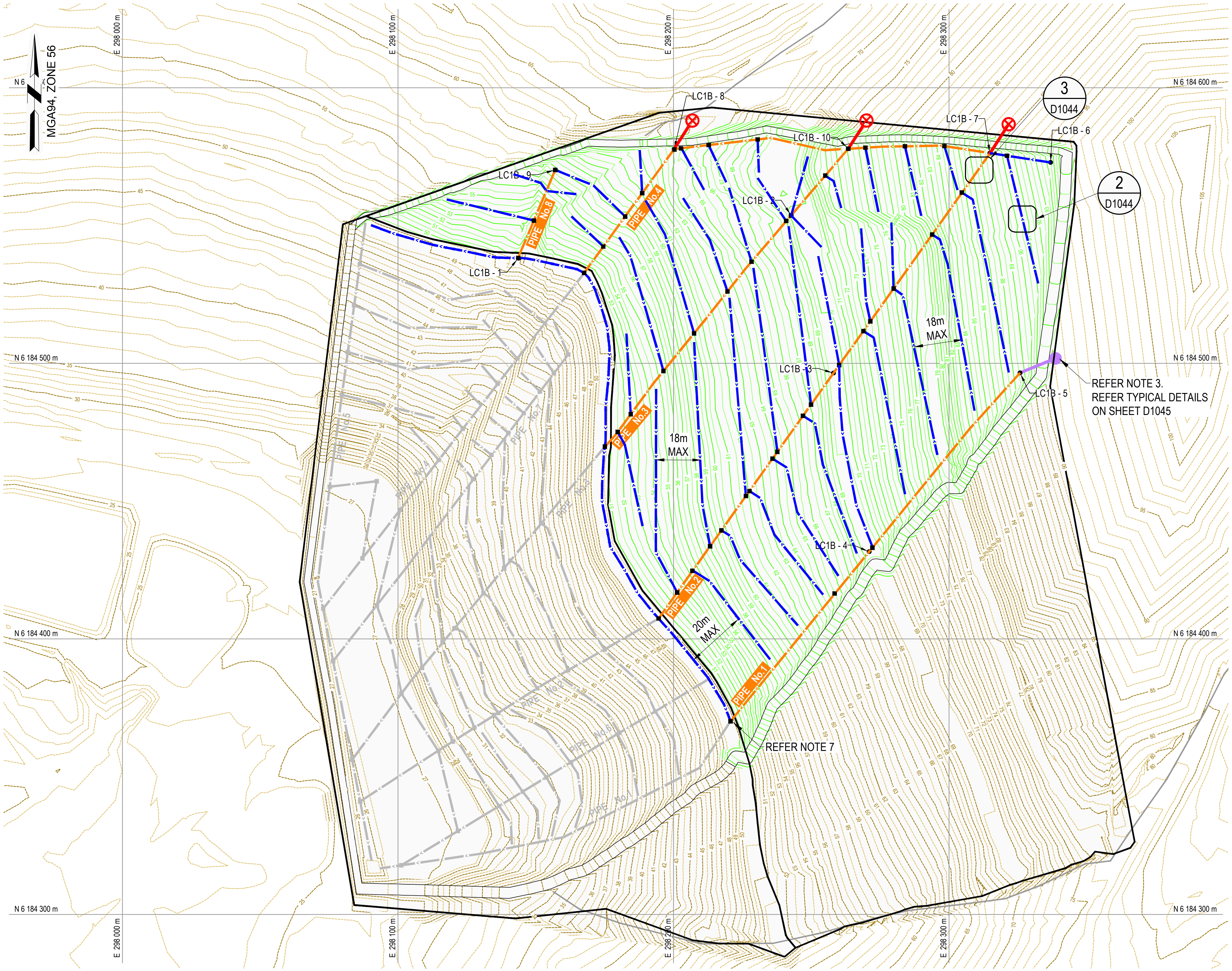
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: TOP OF LINER AND LEACHATE COLLECTION SYSTEM PLAN AND SETOUT - PACKAGE 1A

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	1:1,500	A3	117625003	220	L	D1041	0

Plot Date: 28 March 2013 Time:10:45:06 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1041-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-BASE LINER STAGE 1A.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOIUNDARY.dwg; 117625003-XREF-LEACHATE PIPING STAGE 1A.dwg; 117625003-XREF-CELL STAGE BOUNDARY.dwg; 117625003-XREF-SUBGRADE STAGE 1A.dwg;



LEGEND

- UNIT 23 - LEACHATE COLLECTION PIPE TYPE 1
- UNIT 23 - LEACHATE COLLECTION PIPE TYPE 2
- UNIT 23 - LEACHATE COLLECTION PIPE TYPE 3
- PACKAGE 1A COLLECTION PIPE LAYOUT
- TEMPORARY LEACHATE PIPE CLEANOUT POINT
- LEACHATE PIPE CLEANOUT POINT
- PIPE CONNECTION (REFER NOTE 6)
- PACKAGE BOUNDARY
- TOP OF LINER CONTOURS
- EXISTING CONTOURS

NOTE:

1. REFER TO D001 FOR GENERAL NOTES, MATERIAL LIST AND DRAWING REFERENCES.
2. PIPES ON BENCHES FALL AS PER TOP OF LINER GRADES. ALL OTHER PIPES MINIMUM 2% FALL
3. ALL PIPES TERMINATING AT TEMPORARY BENCHES OR AT TEMPORARY/FINAL LEACHATE PIPE CLEANOUT POINTS ARE TO CAPPED WITH AN AIRTIGHT CAP AND CLEARLY LABELED "WARNING: EXPLOSIVE GASES MAY BE PRESENT (METHANE)"
4. MAXIMUM 15 METRES DISTANCE BETWEEN TYPE 1 PIPES (MEASURED PERPENDICULAR TO SLOPE) UNLESS OTHERWISE INDICATED
5. CHANGES IN PIPE DIRECTION NEEDED TO MAINTAIN FALL AND TO FACILITATE CONNECTION GEOMETRY ARE LIMITED TO MAXIMUM 30 DEGREE SWEEPING BENDS.
6. PIPE CONNECTION LOCATIONS INDICATE WHERE PIPES ARE TO BE CONNECTED WITH SUITABLE FITTINGS. IF PIPE ALIGNMENTS ARE ADJACENT (WITHIN 2m) AND NO PIPE CONNECTION IS INDICATED, THEN THE ADJACENT PIPES ARE TO TERMINATE SEPARATELY WITH SOLID END CAPS, HOWEVER THE UNIT 7 - DRAINAGE AGGREGATE SURROUNDS OF THE PIPES ARE TO BE CONNECTED.
7. CONNECT AND EXTEND PIPE NOS. 1 TO 4 FORM PACKAGE 1A INTO PACKAGE 1B

PACKAGE 1B LEACHATE COLLECTION - SETOUT		
NUMBER	EASTING	NORTHING
LC1B - 1	298143.69	6184538.12
LC1B - 2	298242.69	6184553.64
LC1B - 3	298258.04	6184496.43
LC1B - 4	298270.99	6184431.61
LC1B - 5	298325.75	6184496.53
LC1B - 6	298336.84	6184572.89
LC1B - 7	298314.78	6184576.23
LC1B - 8	298200.22	6184577.61
LC1B - 9	298157.07	6184570.15
LC1B - 10	298263.42	6184577.85

ISSUED FOR
CONSTRUCTION

0 30 60 90m
1:1,500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

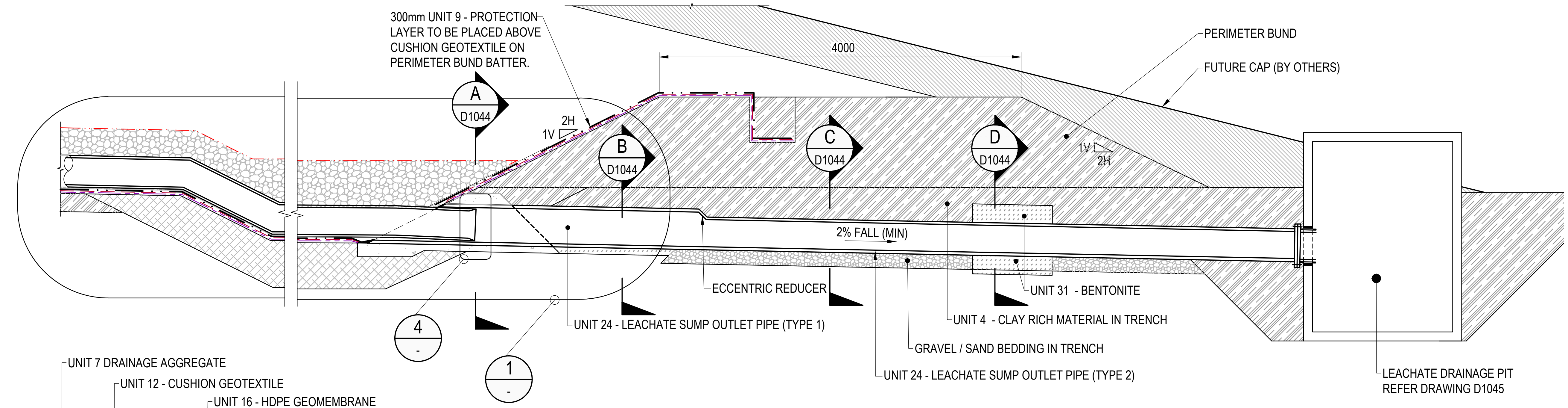
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: TOP OF LINER AND LEACHATE COLLECTION SYSTEM PLAN AND SETOUT - PACKAGE 1B

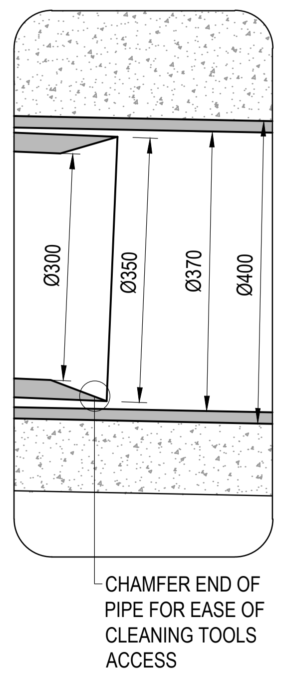
LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	1:1,500	A3	117625003	220	L	D1042	0

Plot Date: 28 March 2013 Time:10:44:24 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1042-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOIUNDARY.dwg; 117625003-XREF-BASE LINER STAGE 1A.dwg; 117625003-XREF-BASE LINER STAGE 1B.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-BUND STAGE 1B.dwg; 117625003-XREF-LEACHATE PIPING STAGE 1A GREY.dwg; 117625003-XREF-SUBGRADE STAGE 1A.dwg; 117625003-XREF-SUBGRADE STAGE



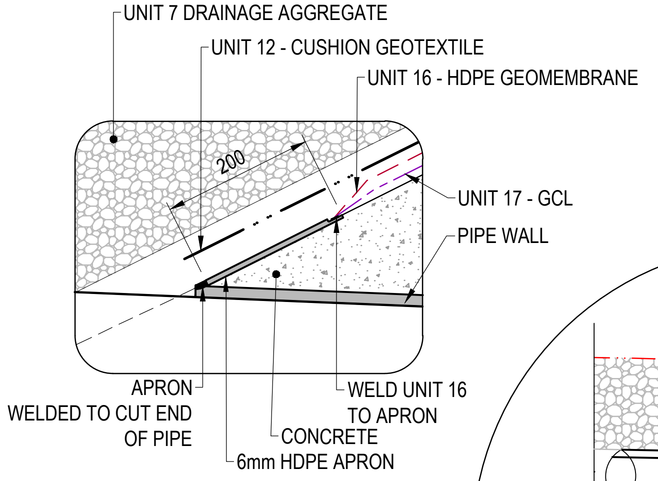
LEACHATE SUMP

SCALE 1:50



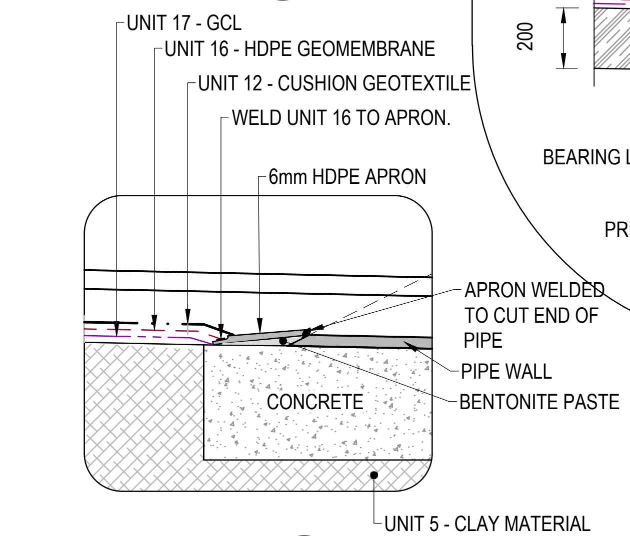
DETAIL 4

SCALE 1:10



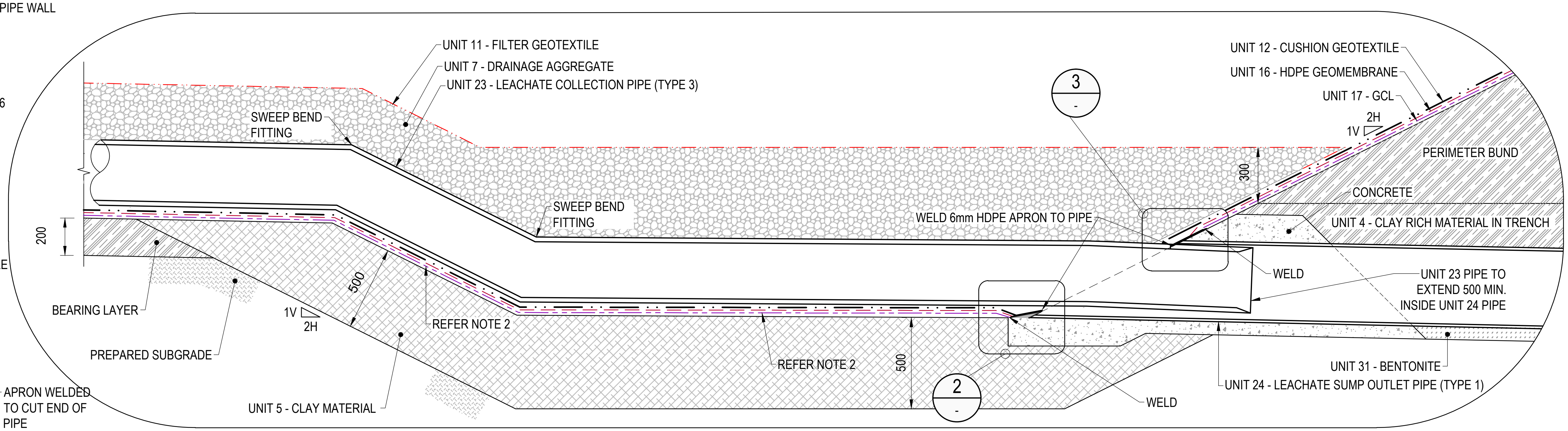
DETAIL 3

SCALE 1:10



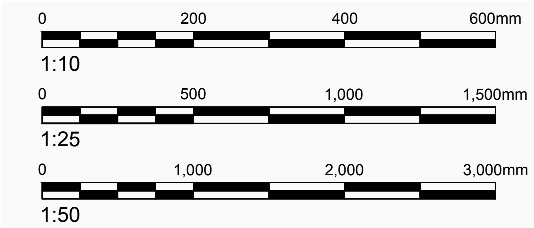
DETAIL 2

SCALE 1:10



DETAIL 1

SCALE 1:25



NOTES:

1. REFER TO DRAWING D1001 FOR GENERAL NOTES AND LEGEND.
2. DOUBLE THICKNESS OF UNIT 17 - GCL TO BE USED IN SUMP LINER.

ISSUED FOR

CONSTRUCTION

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates

124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

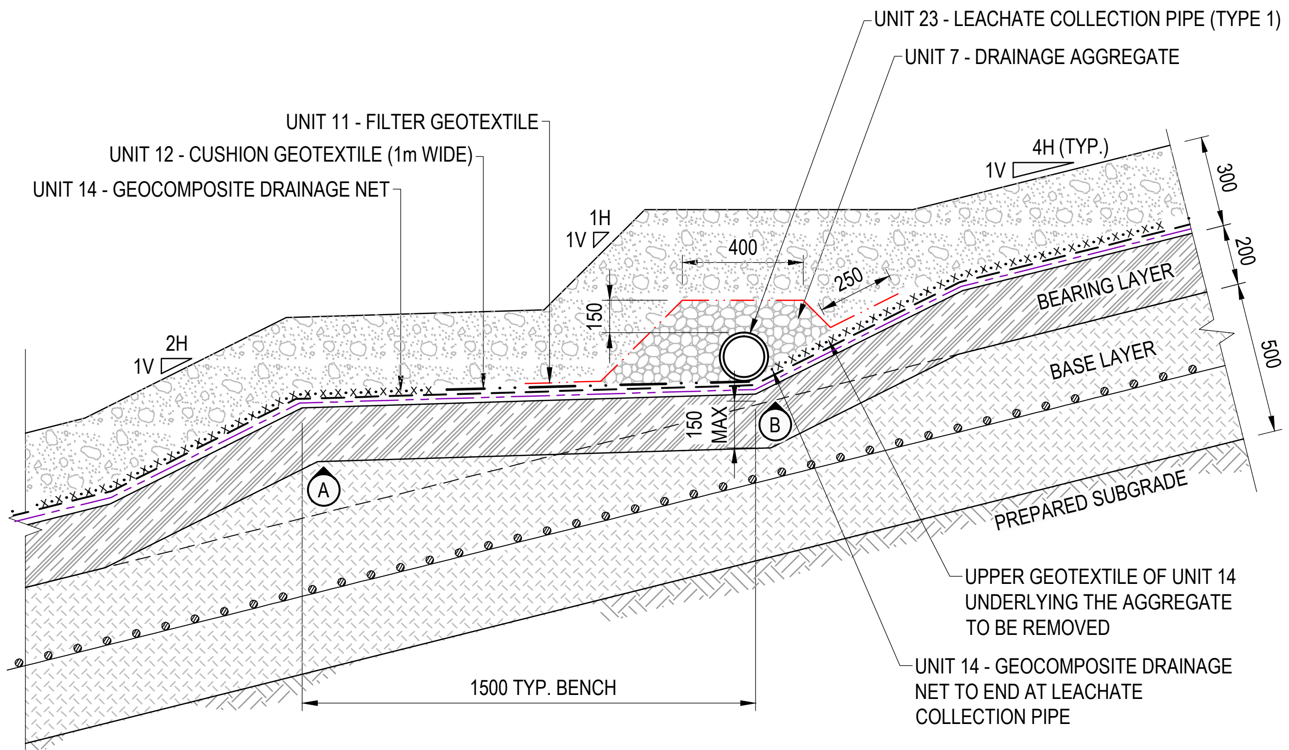
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: LEACHATE COLLECTION SYSTEM DETAILS SHEET 1

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1043	0

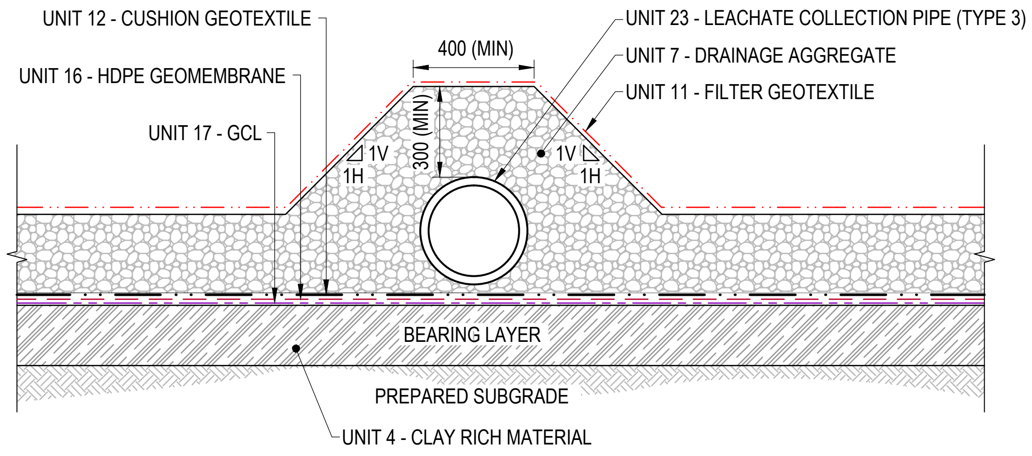
Plot Date: 28 March 2013 Time:10:43:36 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1043-REV0.dwg
Xref: GAP_LOGO-A3.dwg;



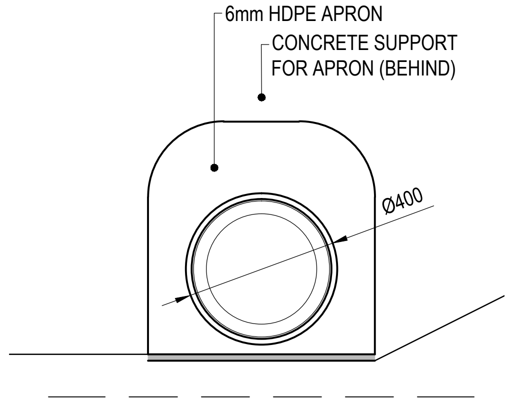
DETAIL 2 TYPICAL DETAIL LEACHATE COLLECTION PIPE FOR PIGGY BACK LINER CROSS-SLOPE PIPES
SCALE 1:25 D1024 D1041 D1042

(A) INCREASE THICKNESS OF BASE LAYER TO FORM BENCH

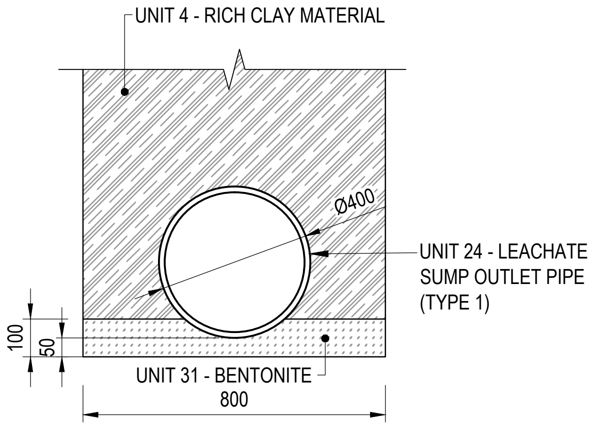
(B) REDUCE THICKNESS OF BASE LAYER TO FORM BENCH



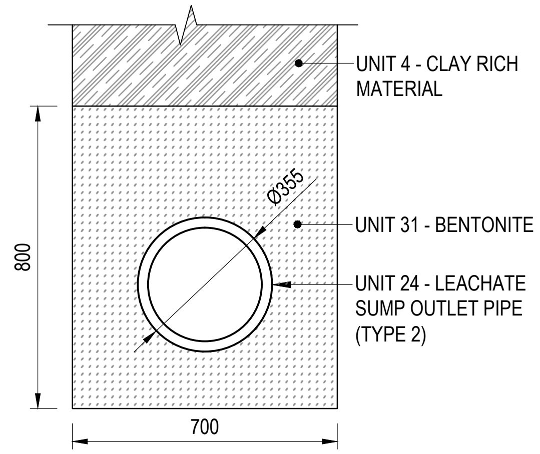
DETAIL 1 TYPICAL DETAIL LEACHATE COLLECTION PIPE FOR BASE CELLS
SCALE 1:25 D1041



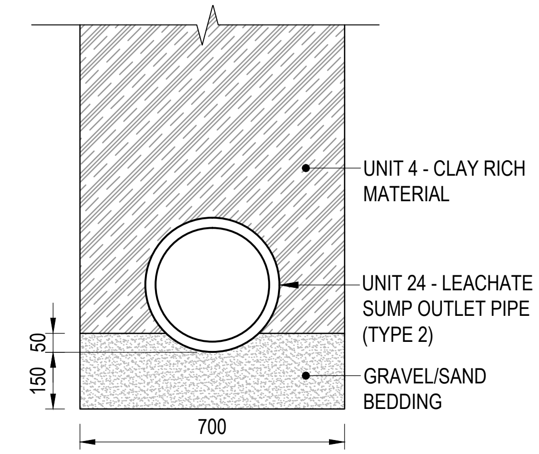
SECTION A
SCALE 1:20 D1043



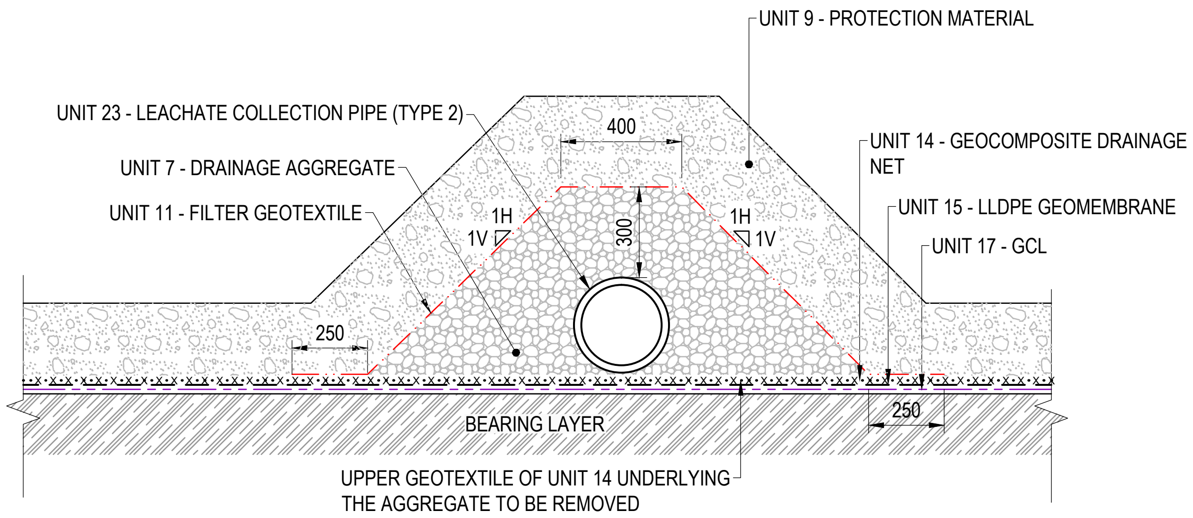
SECTION B
SCALE 1:20 D1043



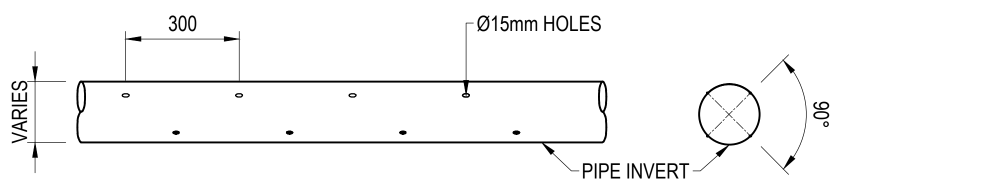
SECTION D BENTONITE PLUG
SCALE 1:20 D1043
NOTE: BENTONITE PLUG EXTENDS FOR 900 MIN. ALONG PIPE LENGTH



SECTION C
SCALE 1:20 D1043



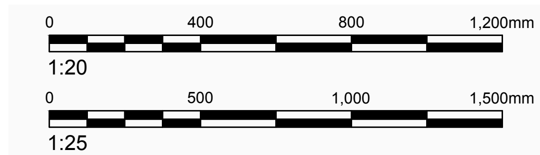
DETAIL 3 TYPICAL DETAIL LEACHATE COLLECTION PIPE FOR PIGGY BACK LINER DOWN-SLOPE PIPES
SCALE 1:25 D1041 D1042



LEACHATE PIPE PERFORATION DETAIL
SCALE 1:20

NOTE: PIPE TO BE INSTALLED WITH HOLES IN ORIENTATION SHOWN

ISSUED FOR
CONSTRUCTION



NOTES:

1. REFER TO DRAWING D1001 FOR GENERAL NOTES AND LEGEND

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

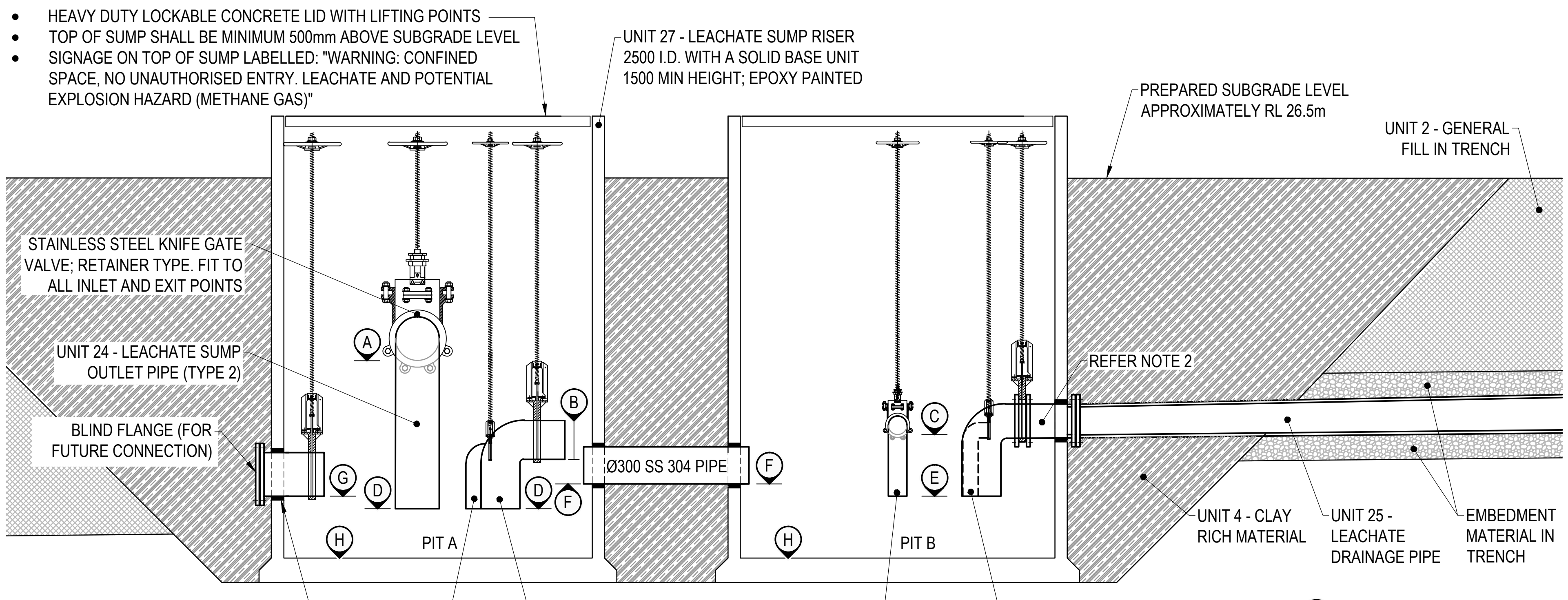
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: LEACHATE COLLECTION SYSTEM DETAILS SHEET 2

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1044	0

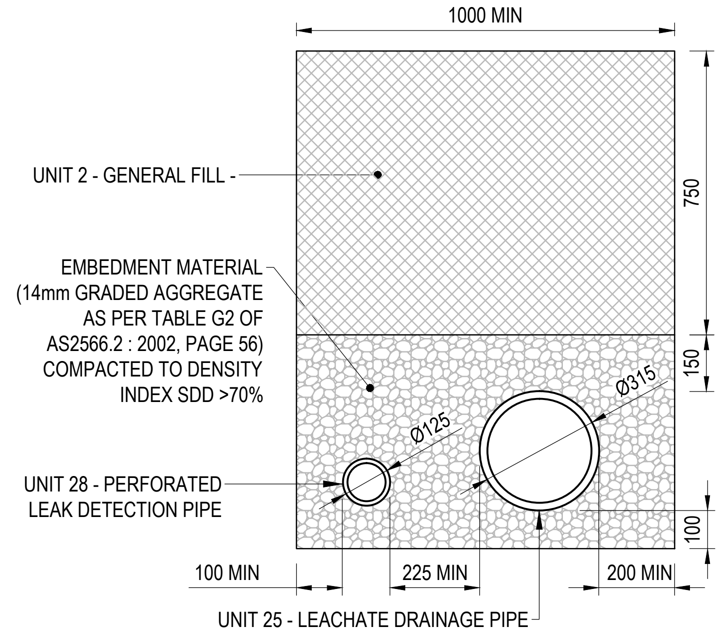
Plot Date: 28 March 2013 Time:10:42:39 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1044-REV0.dwg
Xref: GAP_LOGO-A3.dwg;



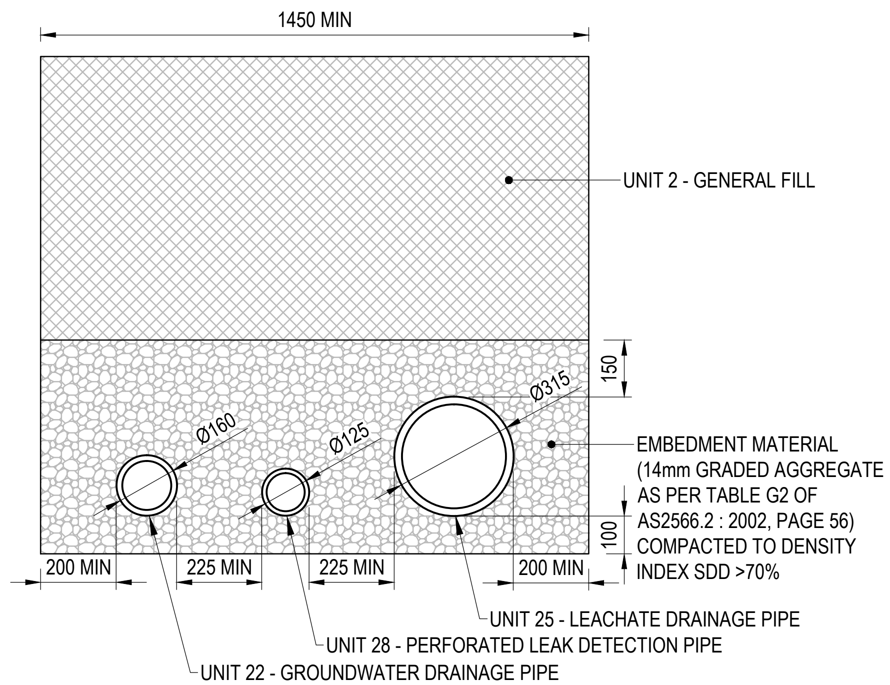
LEACHATE DRAINAGE PIT
N.T.S. (APPROXIMATE SCALE 1:50)

LEACHATE DRAINAGE PIT INVERT LEVEL SCHEDULE

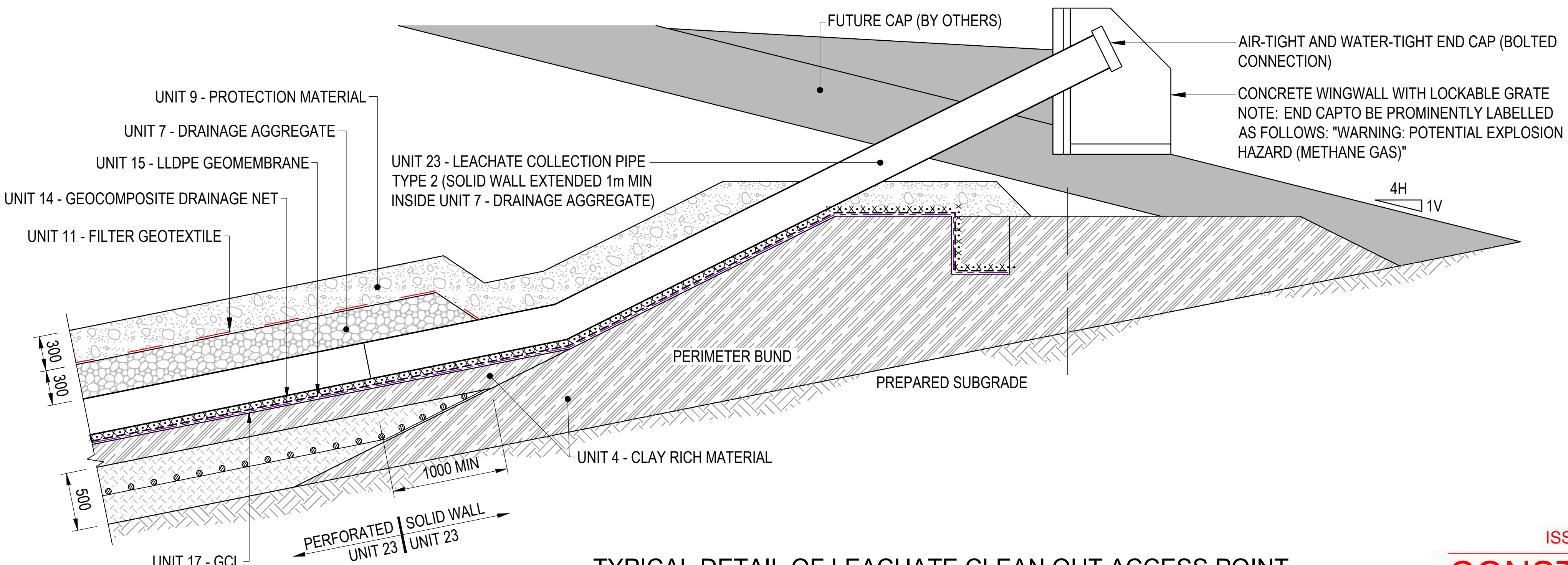
ITEM	INVERT LEVEL
A	24.30
B	23.50
C	23.70
D	23.10
E	23.20
F	23.30
G	23.20
H	22.70



SECTION A (D1046)
SCALE 1:20



SECTION B (D1046)
SCALE 1:20



TYPICAL DETAIL OF LEACHATE CLEAN OUT ACCESS POINT
SCALE 1:50

ISSUED FOR
CONSTRUCTION

0	400	800	1,200mm

1:20

0	1,000	2,000	3,000mm

1:50

NOTES:

1. REFER TO DRAWING D1001 FOR GENERAL NOTES AND LEGEND
2. FIT ALL PIPE PENETRATIONS INTO PIT WITH A SS304 PIPE STUB - DOUBLE FLANGED, MIN LENGTH 500

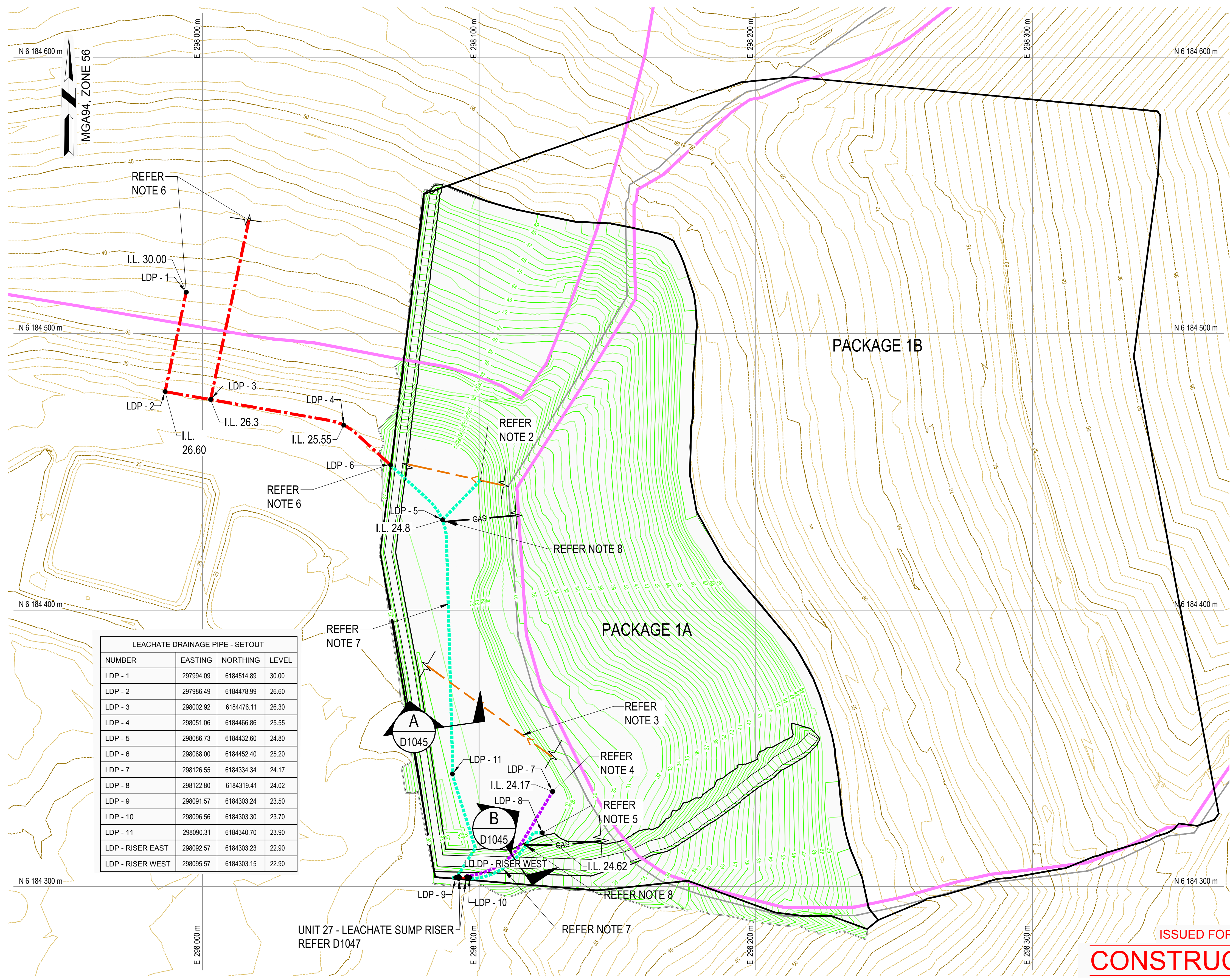
REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN
DRAWING TITLE: LEACHATE COLLECTION SYSTEM DETAILS SHEET 3

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1045	0

Plot Date: 28 March 2013 Time:10:41:51 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1045-REV0.dwg
Xref: GAP_LOGO-A3.dwg;



LEACHATE DRAINAGE PIPE - SETOUT			
NUMBER	EASTING	NORTHING	LEVEL
LDP - 1	297994.09	6184514.89	30.00
LDP - 2	297986.49	6184478.99	26.60
LDP - 3	298002.92	6184476.11	26.30
LDP - 4	298051.06	6184466.86	25.55
LDP - 5	298086.73	6184432.60	24.80
LDP - 6	298068.00	6184452.40	25.20
LDP - 7	298126.55	6184334.34	24.17
LDP - 8	298122.80	6184319.41	24.02
LDP - 9	298091.57	6184303.24	23.50
LDP - 10	298096.56	6184303.30	23.70
LDP - 11	298090.31	6184340.70	23.90
LDP - RISER EAST	298092.57	6184303.23	22.90
LDP - RISER WEST	298095.57	6184303.15	22.90

LEGEND

- EXISTING LEACHATE PIPE (APPROXIMATE ALIGNMENT)
- UNIT 22 - GROUNDWATER DRAINAGE PIPE
- FUTURE LEACHATE PIPE (FOR INFORMATION ONLY)
- UNIT 25 - LEACHATE DRAINAGE PIPE
- GAS — UNIT 21 - GAS COLLECTION PIPE
- EXISTING CONTOURS
- SUBGRADE CONTOURS

NOTES:

1. THE NEW LEACHATE DRAINAGE PIPES SHOWN ON THIS DRAWING CONVEY LIQUIDS FROM EXISTING DRAINAGE PIPES IN THE EASTERN GULLY AND WESTERN GULLY LANDFILLS INTO THE NEW LEACHATE COLLECTION SYSTEM. ALL NEW PIPES SHOWN IN THIS DRAWING ARE TO BE INSTALLED BENEATH NEW LINING SYSTEMS. ALL EXISTING DRAINAGE PIPES SHOWN IN THIS DRAWING ARE TO BE ASSUMED ACTIVE WITH LEACHATE FLOW.
2. LOCATE EXISTING BURIED HDPE PIPE (300mm D, SOLID WALL) AND CONNECT TO UNIT 25 PIPE. CONNECTION IS TO BE MADE TO SAME STANDARD AS FOR UNIT 25 PIPE. REMOVE DOWNSLOPE PORTION OF EXISTING BURIED HDPE PIPE WITHIN CELL BASE LINER AREA AND BACKFILL TRENCH IF BELOW SUBGRADE DESIGN LEVELS. NOTE: EXISTING PIPE IS ACTIVE (REFER NOTE 1). BASED ON A PREVIOUS WCC DESIGN DRAWING (2761-C2-1, DEC 1999) THE PIPE IS ALIGNED APPROXIMATELY AS SHOWN AND IS PRESENT NEAR COORDINATES E: 298,100m AND N: 6,184,445m AT AN INVERT LEVEL OF BETWEEN RL 26m AND RL 28m.
3. LOCATE AND PLUG EXISTING BURIED HDPE PIPE (300mm D, SOLID WALL) USING A PURPOSE MADE PLUGGING SYSTEM. REMOVE DOWNSLOPE PORTION OF EXISTING BURIED HDPE PIPE WITHIN CELL BASE LINER AREA AND BACKFILL TRENCH. NOTE: EXISTING PIPE IS ACTIVE (REFER NOTE 1). BASED ON A PREVIOUS WCC DESIGN DRAWING (2761-C2-1, DEC 1999) THE PIPE IS ALIGNED APPROXIMATELY AS SHOWN AND IS PRESENT NEAR COORDINATES E: 298,115m AND N: 6,184,355m AT AN INVERT LEVEL OF APPROXIMATELY RL 25m.
4. CONNECT EXISTING PIPE (100 mm D, SOLID WALL) TO UNIT 22 PIPE AT THE INDICATED COORDINATES AND INVERT LEVEL. CONNECTION IS TO BE MADE TO SAME STANDARD AS FOR UNIT 22 PIPE. NOTE: EXISTING PIPE IS ACTIVE (REFER NOTE 1).
5. CONNECT EXISTING CAPPED PIPE (300mm D, SOLID WALL) TO UNIT 25 PIPE AT THE INDICATED COORDINATES AND INVERT LEVEL. CONNECTION IS TO BE MADE TO SAME STANDARD AS FOR UNIT 25 PIPE. NOTE: EXISTING PIPE IS CURRENTLY CAPPED BUT IS DIRECTLY CONNECTED INTO ACTIVE DRAINAGE SYSTEMS (REFER NOTE 1).
6. PROVIDE TEMPORARY CAP AND ACCESSIBLE CONNECTION POINT FOR FUTURE EXTENSION OF UNIT 25 PIPE. TEMPORARY CAP TO BE AIRTIGHT AND CLEARLY LABELED "WARNING: EXPLOSIVE GASES MAY BE PRESENT (METHANE)". THE FUTURE LEACHATE SYSTEM PIPES FOR THE WESTERN GULLY ARE SHOWN FOR INFORMATION ONLY.
7. LEAK DETECTION PIPES (UNIT 28) ASSOCIATED WITH THE UNIT 25 PIPES ARE NOT SHOWN FOR CLARITY. REFER SHEET D1045.
8. CONNECT PIGGY BACK GAS COLLECTION PIPE TO LEACHATE DRAINAGE PIPE (REFER SHEET D1071)

ISSUED FOR
CONSTRUCTION

0 30 60 90m
1:1,500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

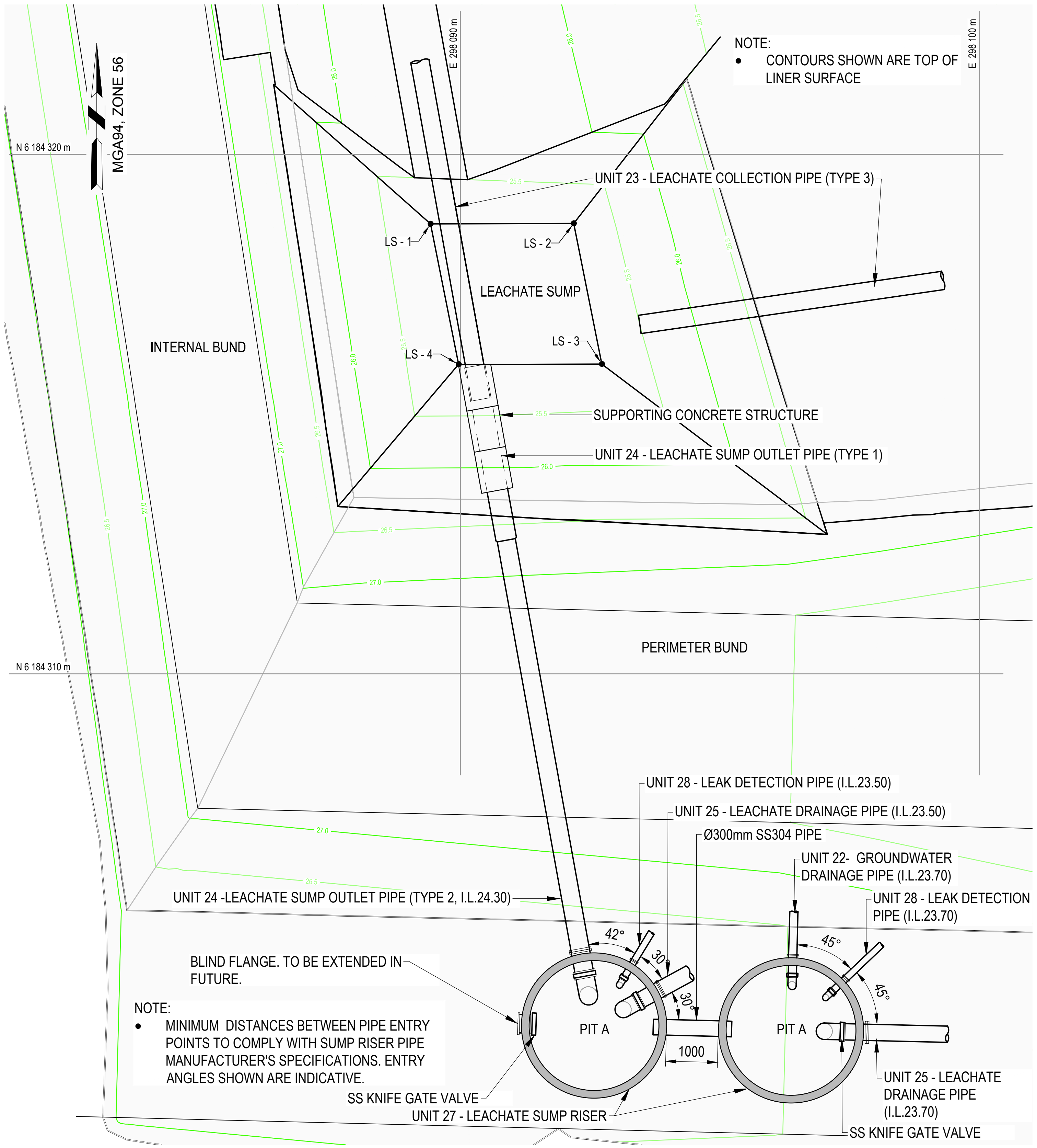
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: CONNECTION TO EXISTING LEACHATE SYSTEM AND LEACHATE DRAINAGE PIPE PLAN AND SETOUT

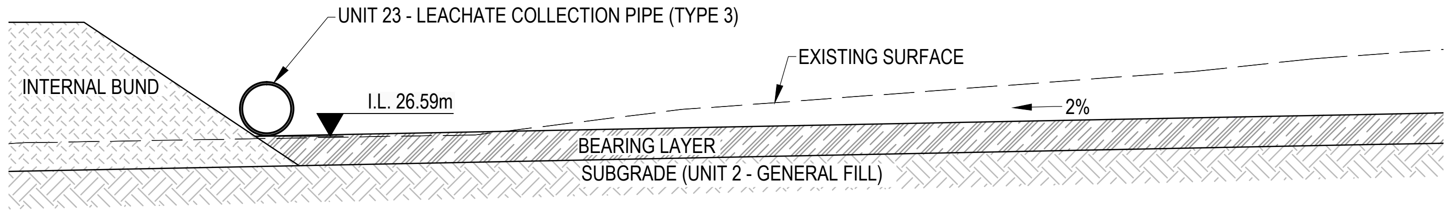
LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	1:1,500	A3	117625003	220	L	D1046	0

Plot Date: 28 March 2013 Time:10:41:05 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1046-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOIUNDARY.dwg; 117625003-XREF-SUBGRADE STAGE 1A.dwg; 117625003-XREF-CELL STAGE BOUNDARY.dwg;

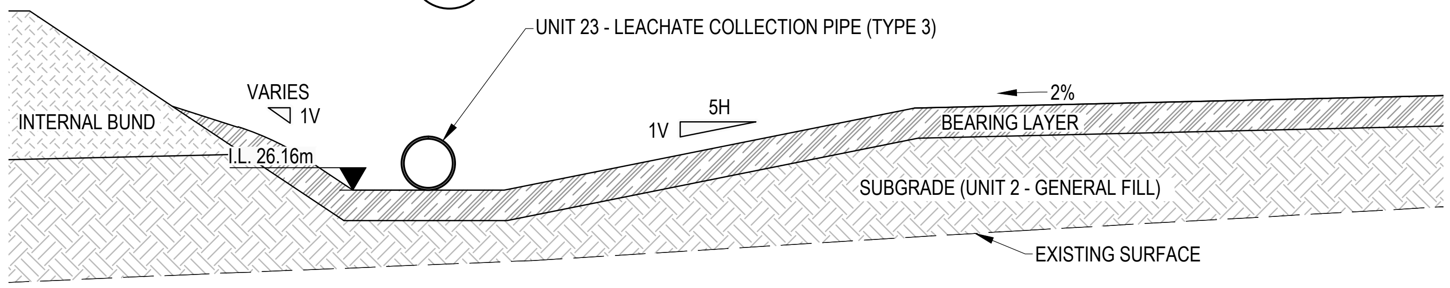


PLAN - LEACHATE SUMP
SCALE 1:100

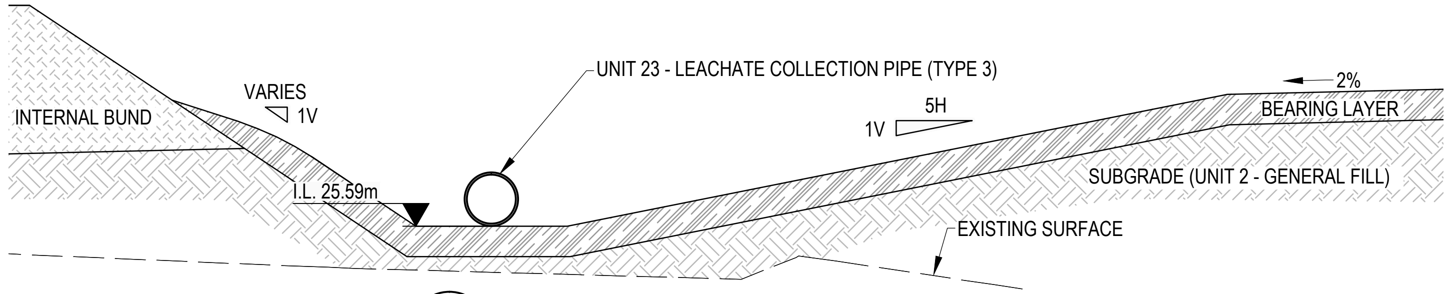
NOTE: REFER TO SHEET D1045 FOR DRAINAGE PIT DETAILS



SECTION A
SCALE 1:50
D1041



SECTION B
SCALE 1:50
D1041



SECTION C
SCALE 1:50
D1041

PACKAGE 1 SUMP - SETOUT

NUMBER	EASTING	NORTHING	TOP OF LINER LEVEL
LS - 1	298089.42	6184318.66	25.06
LS - 2	298092.18	6184318.67	25.12
LS - 3	298092.72	6184315.97	25.06
LS - 4	298089.96	6184315.96	25.00

ISSUED FOR CONSTRUCTION

0 1.0 2.0 3.0m
1:50

0 2 4 6m
1:100

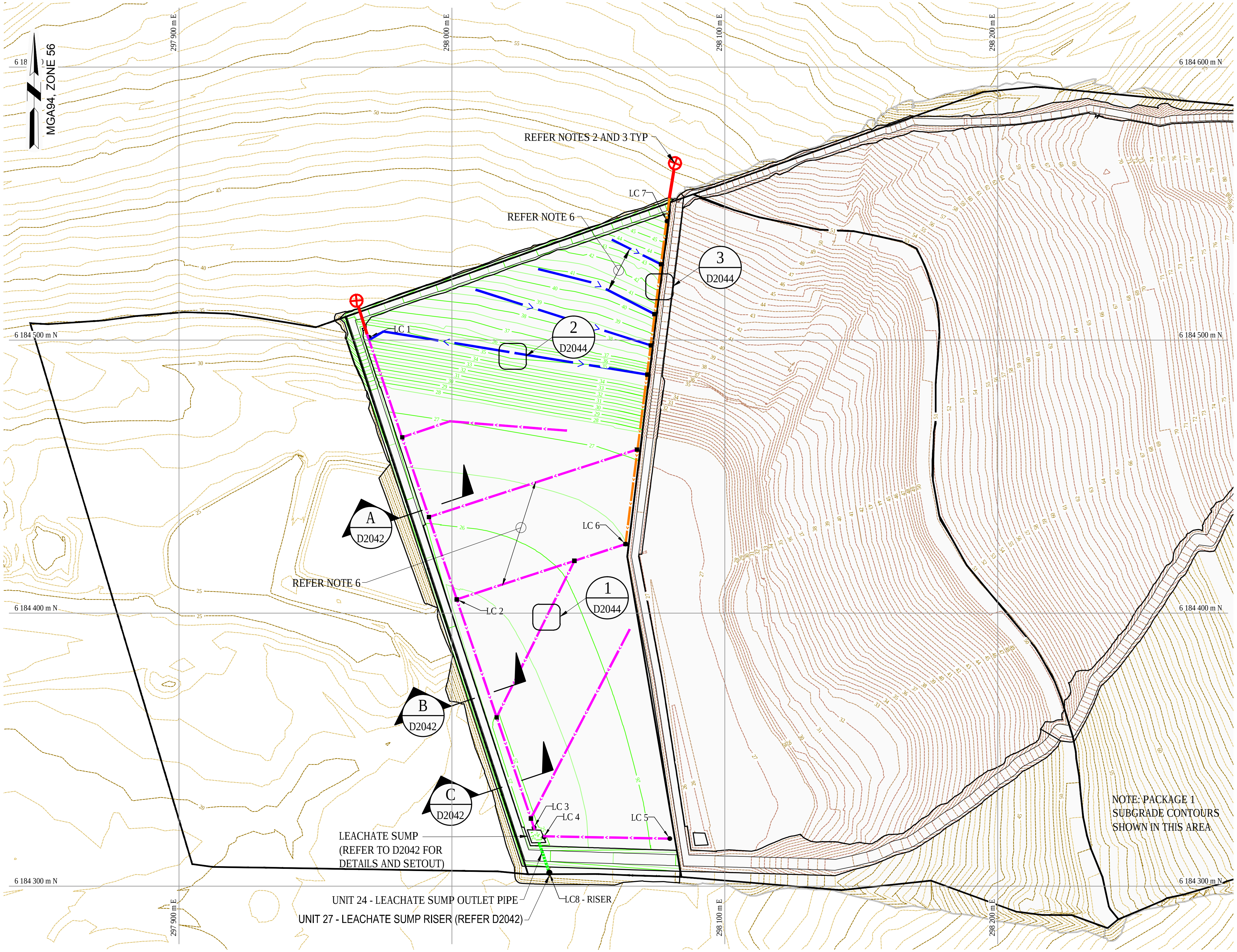
REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
0	ISSUED FOR CONSTRUCTION	EJJ	DD	RH	GRS	GRS	28.03.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN
DRAWING TITLE: LEACHATE SUMP PLAN AND DETAILS

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	GRS	AS SHOWN	A3	117625003	220	L	D1047	0

Plot Date: 28 March 2013 Time:10:40:26 AM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 1 - File Name:117625003-220-L-D1047-REV0.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-BASE LINER STAGE 1A.dwg; 117625003-XREF-SUBGRADE STAGE 1A.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg;



LEGEND

- UNIT 23 - LEACHATE COLLECTION PIPE TYPE 1
- UNIT 23 - LEACHATE COLLECTION PIPE TYPE 2
- UNIT 23 - LEACHATE COLLECTION PIPE TYPE 3
- UNIT 24 - LEACHATE SUMP OUTLET PIPE
- TEMPORARY LEACHATE PIPE CLEANOUT POINT
- PIPE CONNECTION (REFER NOTE 8)
- PACKAGE BOUNDARY
- TOP OF LINER AND BUND CONTOURS
- 2011 CONTOURS
- PACKAGE 1 DESIGN CONTOURS (TOP OF LINER AND BUND)

NOTE:

1. REFER TO D2001 FOR GENERAL NOTES, MATERIAL LIST AND DRAWING REFERENCES.
2. PIPE TO BE EXTENDED IN FUTURE
3. ALL PIPES TERMINATING AT TEMPORARY LEACHATE PIPE CLEANOUT POINTS TO BE CAPPED WITH AN AIRTIGHT CAP AND CLEARLY LABELLED ïWARNING: EXPLOSIVE GASES MAY BE PRESENT (METHANE)ì.
4. ALL TYPE 3 PIPES MINIMUM 1% FALL
5. TYPE 1 AND 2 PIPES MINIMUM 2% FALL. TYPE 1 PIPE ON BENCH TO MATCH BENCH SLOPE
6. MAXIMUM 15m DISTANCE BETWEEN TYPE 1 PIPES MEASURED PERPENDICULAR TO SLOPE. MAXIMUM 50m DISTANCE BETWEEN TYPE 3 PIPES MEASURED PERPENDICULAR TO SLOPE
7. MAXIMUM PIPE FITTING BEND 30Á WITH SWEEPING BENDS ONLY
8. USE ECCENTRIC REDUCERS FOR CONNECTION OF TYPE 2 TO TYPE 3 PIPES
9. ALL PIPE TERMINATIONS TO HAVE SOLID END CAPS

PACKAGE 2 LEACHATE COLLECTION - SETOUT		
NUMBER	EASTING	NORTHING
LC 1	297969.75	6184501.04
LC 2	298001.82	6184405.04
LC 3	298030.10	6184321.47
LC 4	298033.73	6184318.01
LC 5	298079.86	6184317.44
LC 6	298063.63	6184425.31
LC 7	298078.82	6184543.56
LC8 - RISER	298035.71	6184304.93

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

0 30 60 90m

1:1,500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.05.2013

Golder Associates

124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

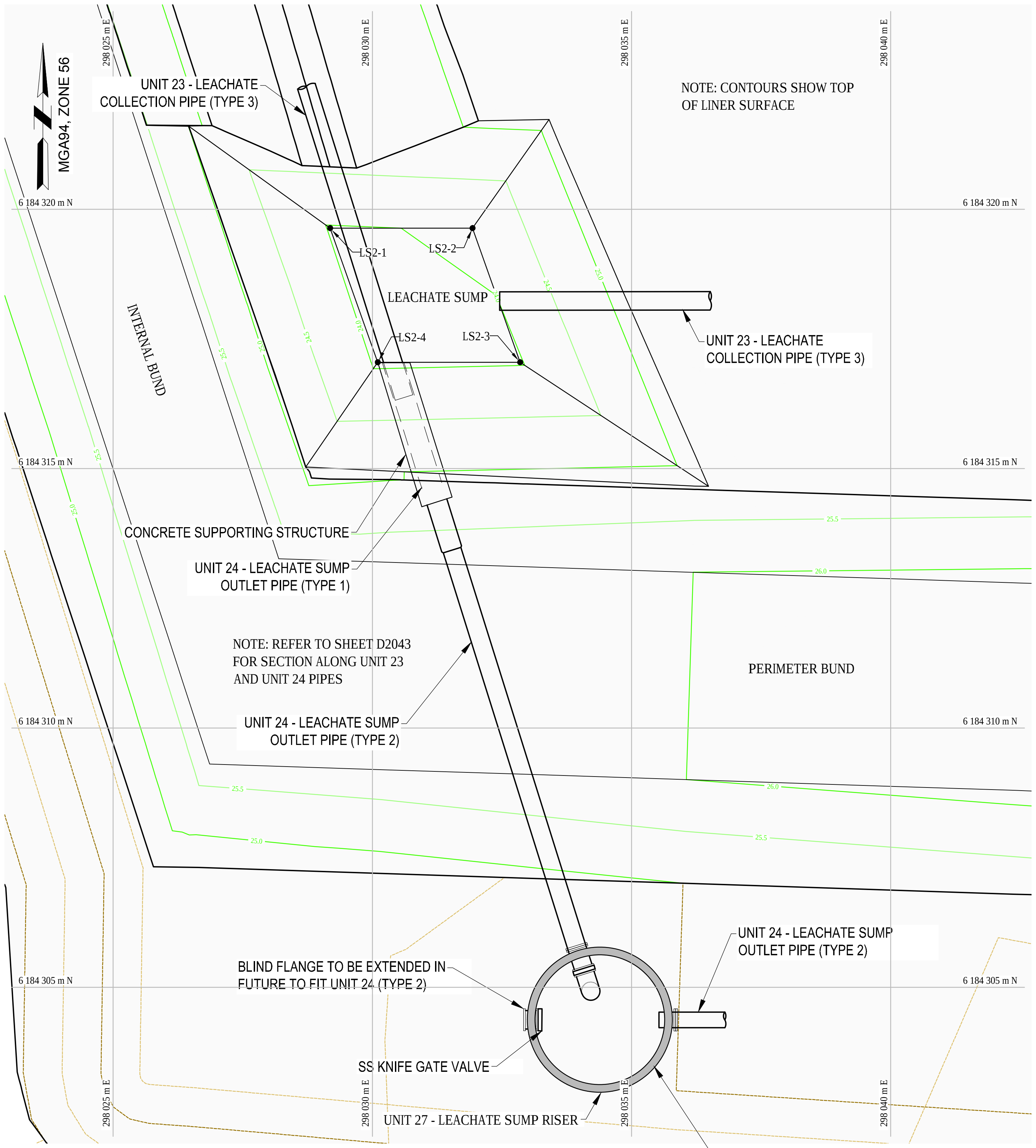
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: TOP OF LINER AND LEACHATE COLLECTION SYSTEM PLAN AND SETOUT - PACKAGE 2

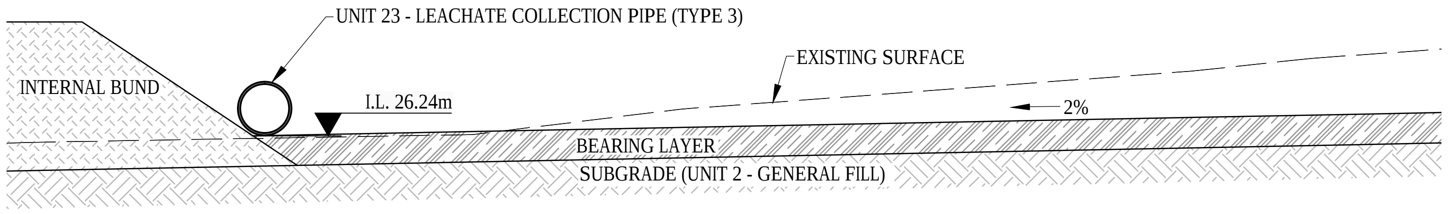
LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D2041	A

Plot Date: 5 April 2013 Time:6:40:23 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 2 - File Name:117625003-220-L-D2041-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-BASE LINER STAGE 2.dwg; 117625003-XREF-BUND STAGE 2.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-BUND STAGE 1B.dwg; 117625003-XREF-BASE LINER STAGE 1A.dwg; 117625003-XREF-BASE LINER STAGE 1B.dwg; 117625003-XREF-CELL STAGE BOUNDARY.dwg; 117625003-XREF-LEACHATE PIPING STAGE 2.dwg; 117625003-XREF-SUBGRADI



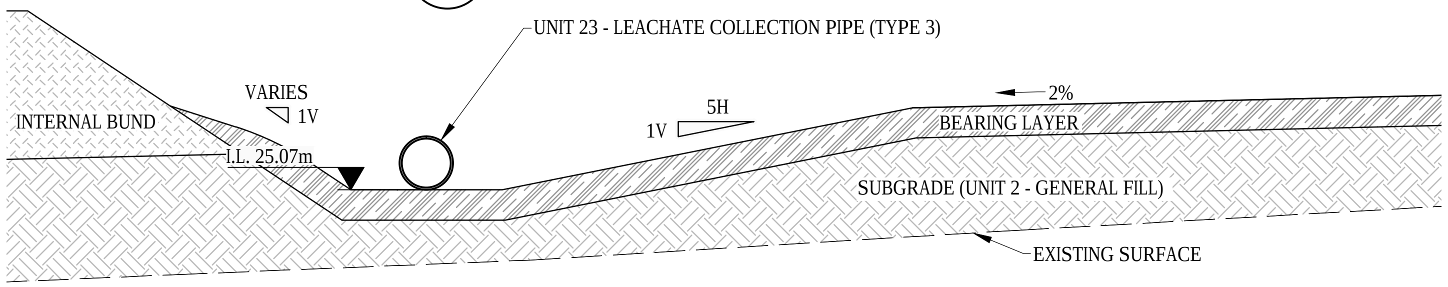
PLAN - LEACHATE SUMP

SCALE 1:100



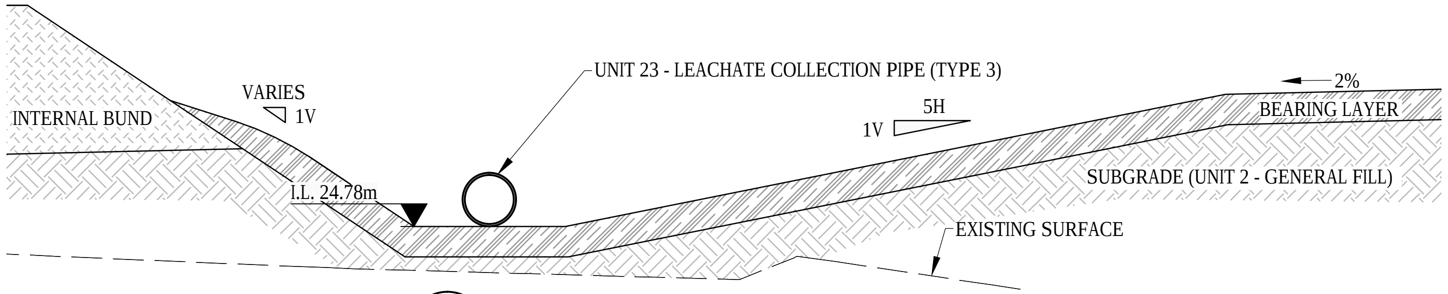
SECTION A D2041

SCALE 1:50



SECTION B D2041

SCALE 1:50



SECTION C D2041

SCALE 1:50

PACKAGE 2 SUMP - SETOUT			
NUMBER	EASTING	NORTHING	TOP OF LINER LEVEL
LS2-1	298029.19	6184319.63	23.97
LS2-2	298031.93	6184319.64	24.03
LS2-3	298032.85	6184317.05	23.97
LS2-4	298030.11	6184317.05	23.94

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

0 1.0 2.0 3.0m
1:50

0 2 4 6m
1:100

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.05.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

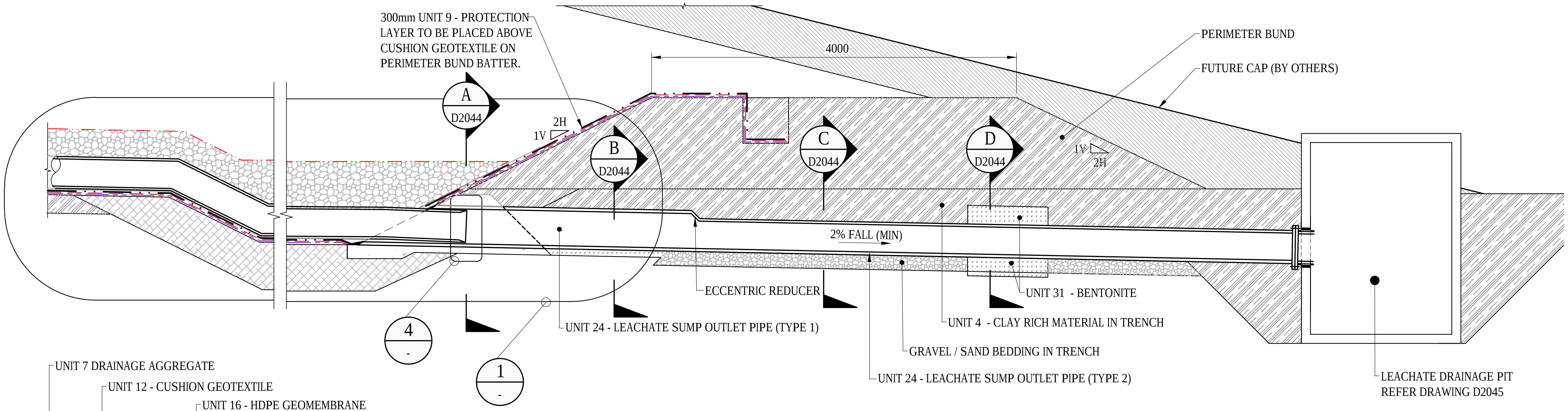
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

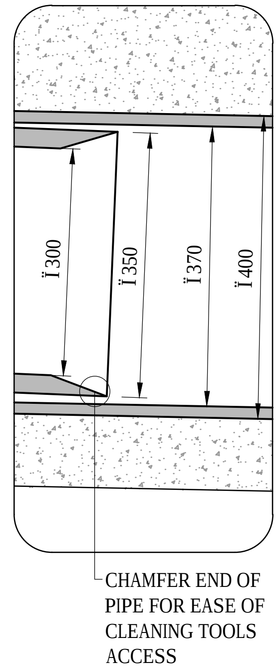
DRAWING TITLE: LEACHATE SUMP PLAN AND DETAILS - PACKAGE 2

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D2042	A

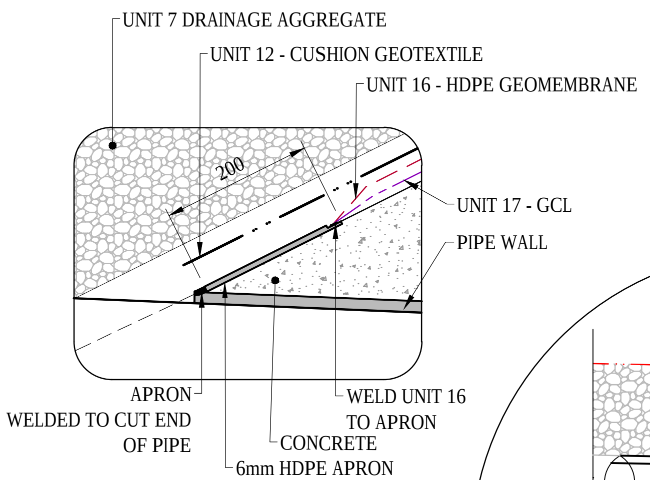
Plot Date: 5 April 2013 Time:6:42:27 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 2 - File Name:117625003-220-L-D2042-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOUNDARY.dwg; 117625003-XREF-SUBGRADE STAGE 2.dwg; 117625003-XREF-BUND STAGE 2.dwg; 117625003-XREF-BASE LINER STAGE 2.dwg



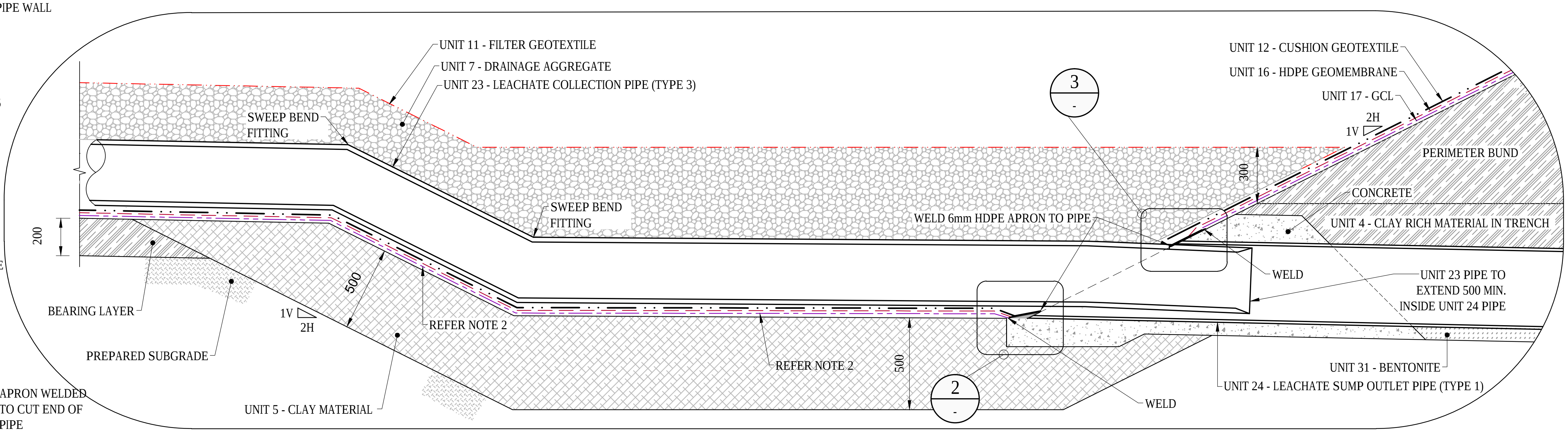
LEACHATE SUMP
SCALE 1:50



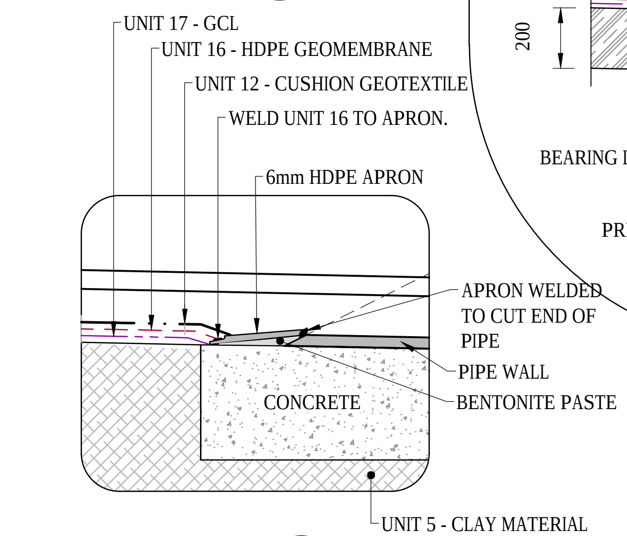
DETAIL 4 -
SCALE 1:10



DETAIL 3 -
SCALE 1:10



DETAIL 1 -
SCALE 1:25



DETAIL 2 -
SCALE 1:10

NOTES:

1. REFER TO DRAWING D2001 FOR GENERAL NOTES AND LEGEND.
2. DOUBLE THICKNESS OF UNIT 17 - GCL TO BE USED IN SUMP LINER.

NOT FOR CONSTRUCTION - ISSUED FOR
CLIENT REVIEW

0 200 400 600mm
1:10
0 500 1,000 1,500mm
1:25
0 1,000 2,000 3,000mm
1:50

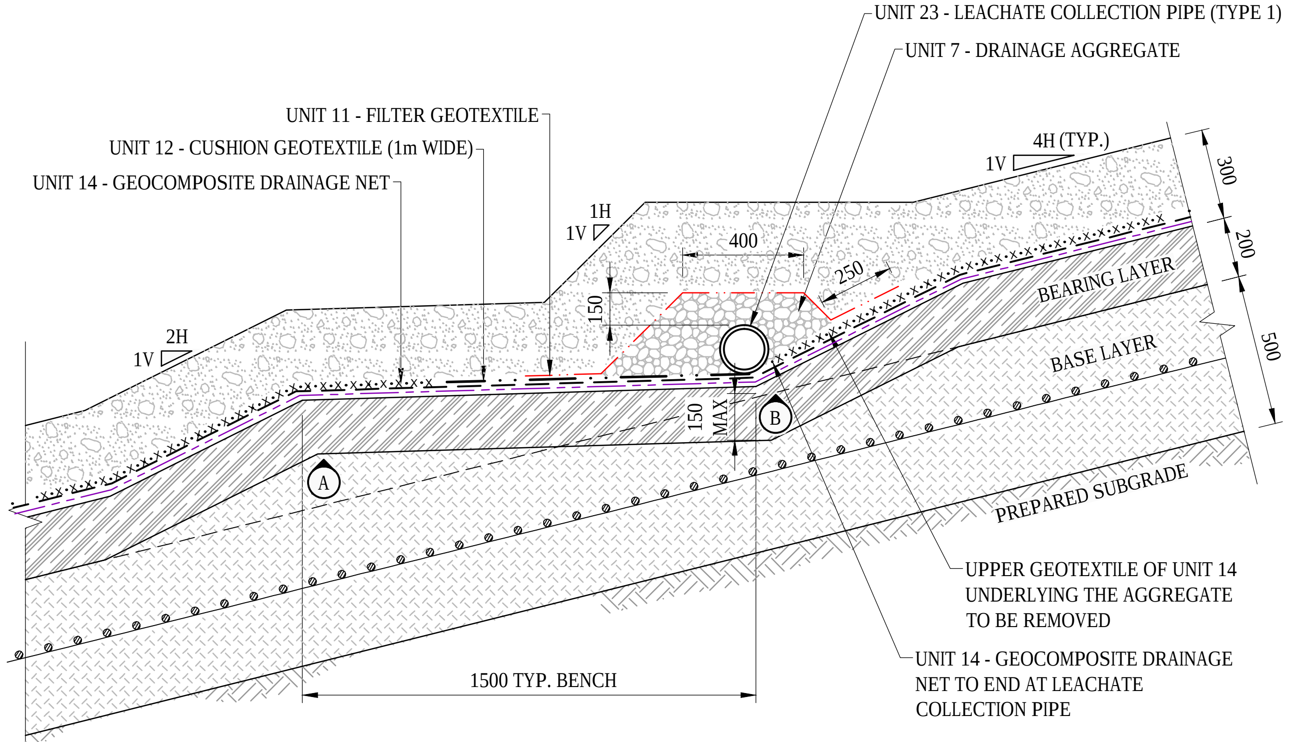
REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.05.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN
DRAWING TITLE: LEACHATE COLLECTION SYSTEM DETAILS - SHEET 1
PACKAGE 2

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D2043	A

Plot Date: 5 April 2013 Time:6:45:24 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 2 - File Name:117625003-220-L-D2043-REVA.dwg
Xref: GAP_LOGO-A3.dwg;

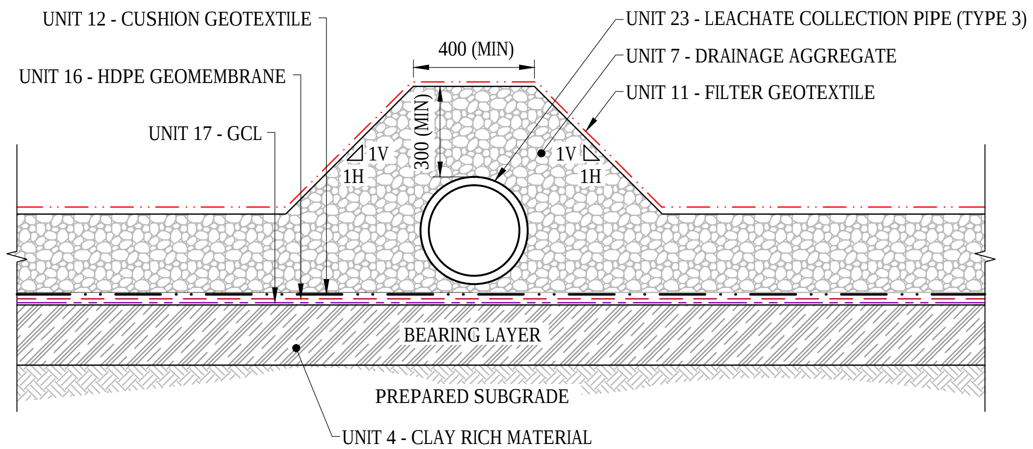


DETAIL 2 (D2023 / D2041) TYPICAL DETAIL LEACHATE COLLECTION PIPE FOR PIGGY BACK LINER CROSS-SLOPE PIPES

SCALE 1:25

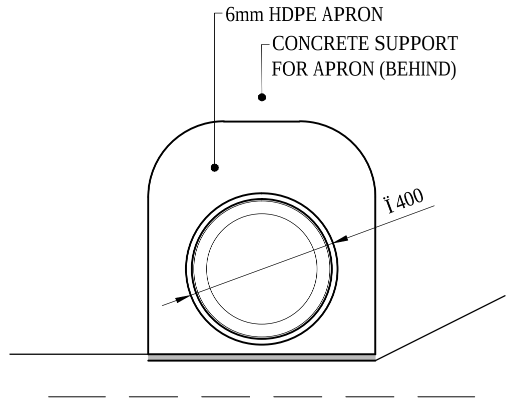
(A) INCREASE THICKNESS OF BASE LAYER TO FORM BENCH

(B) REDUCE THICKNESS OF BASE LAYER TO FORM BENCH



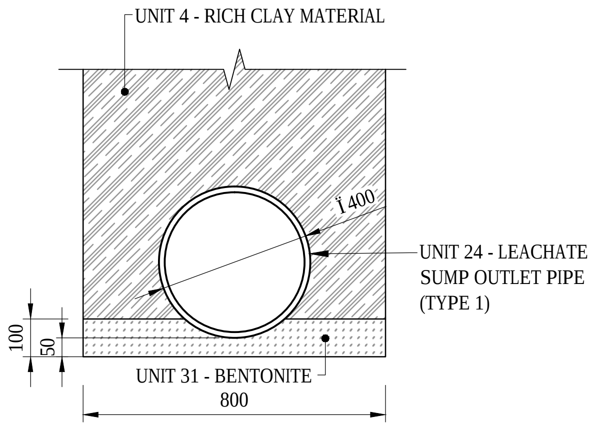
DETAIL 1 (D2041) TYPICAL DETAIL LEACHATE COLLECTION PIPE FOR CELL BASE LINER

SCALE 1:25



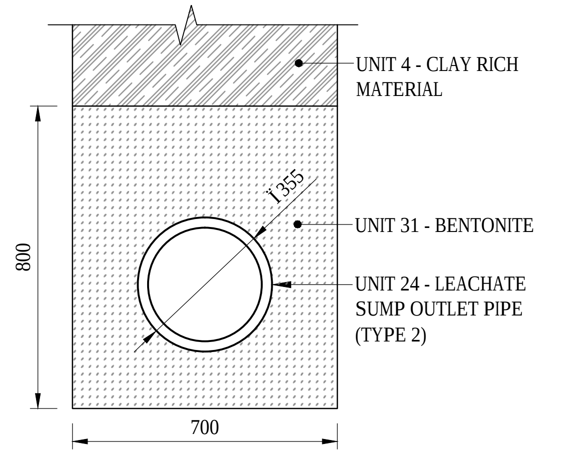
SECTION A (D2043)

SCALE 1:20



SECTION B (D2043)

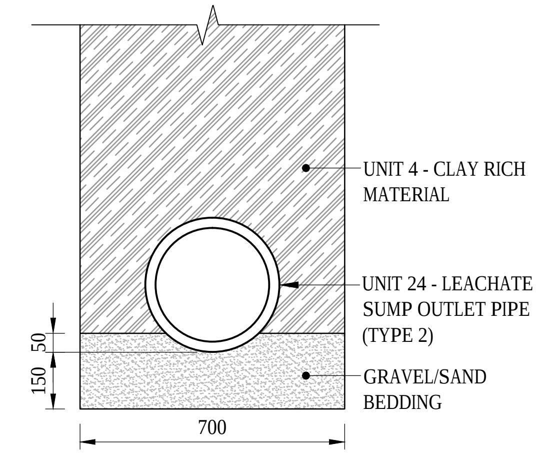
SCALE 1:20



SECTION D (D2043) BENTONITE PLUG

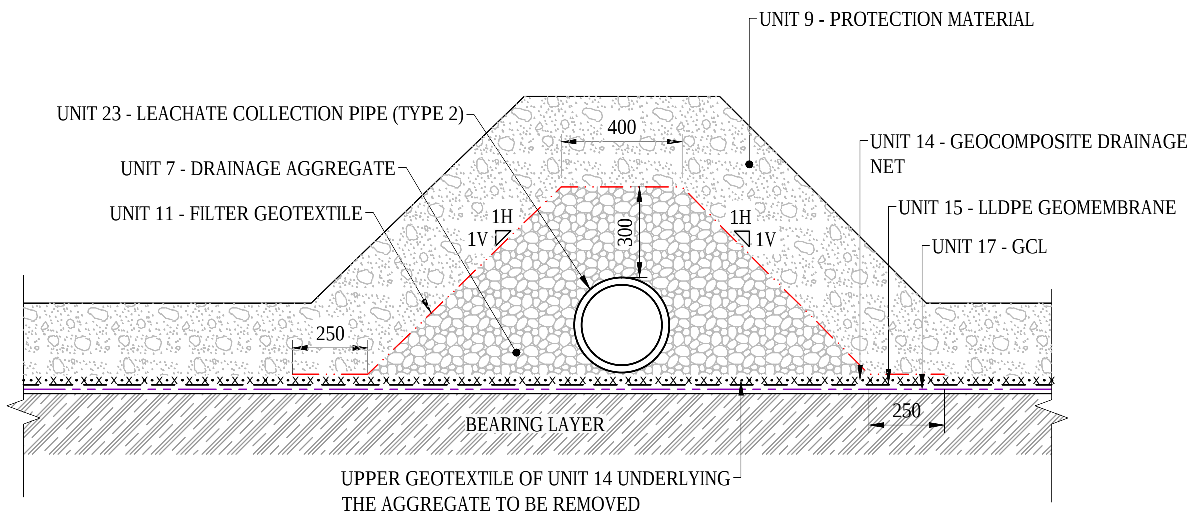
SCALE 1:20

NOTE: BENTONITE PLUG EXTENDS FOR 900 MIN. ALONG PIPE LENGTH



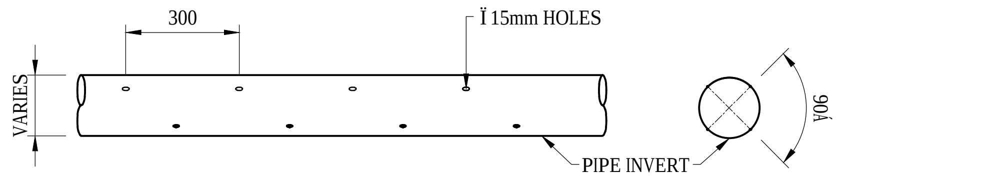
SECTION C (D2043)

SCALE 1:20



DETAIL 3 (D2041) TYPICAL DETAIL LEACHATE COLLECTION PIPE FOR PIGGY BACK LINER DOWN-SLOPE PIPES

SCALE 1:25



LEACHATE PIPE PERFORATION DETAIL

SCALE 1:20

NOTE: PIPE TO BE INSTALLED WITH HOLES IN ORIENTATION SHOWN

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

0 400 800 1,200mm
1:20

0 500 1,000 1,500mm
1:25

NOTES:

1. REFER TO DRAWING D2001 FOR GENERAL NOTES AND LEGEND

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.05.2013

Golder Associates

124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

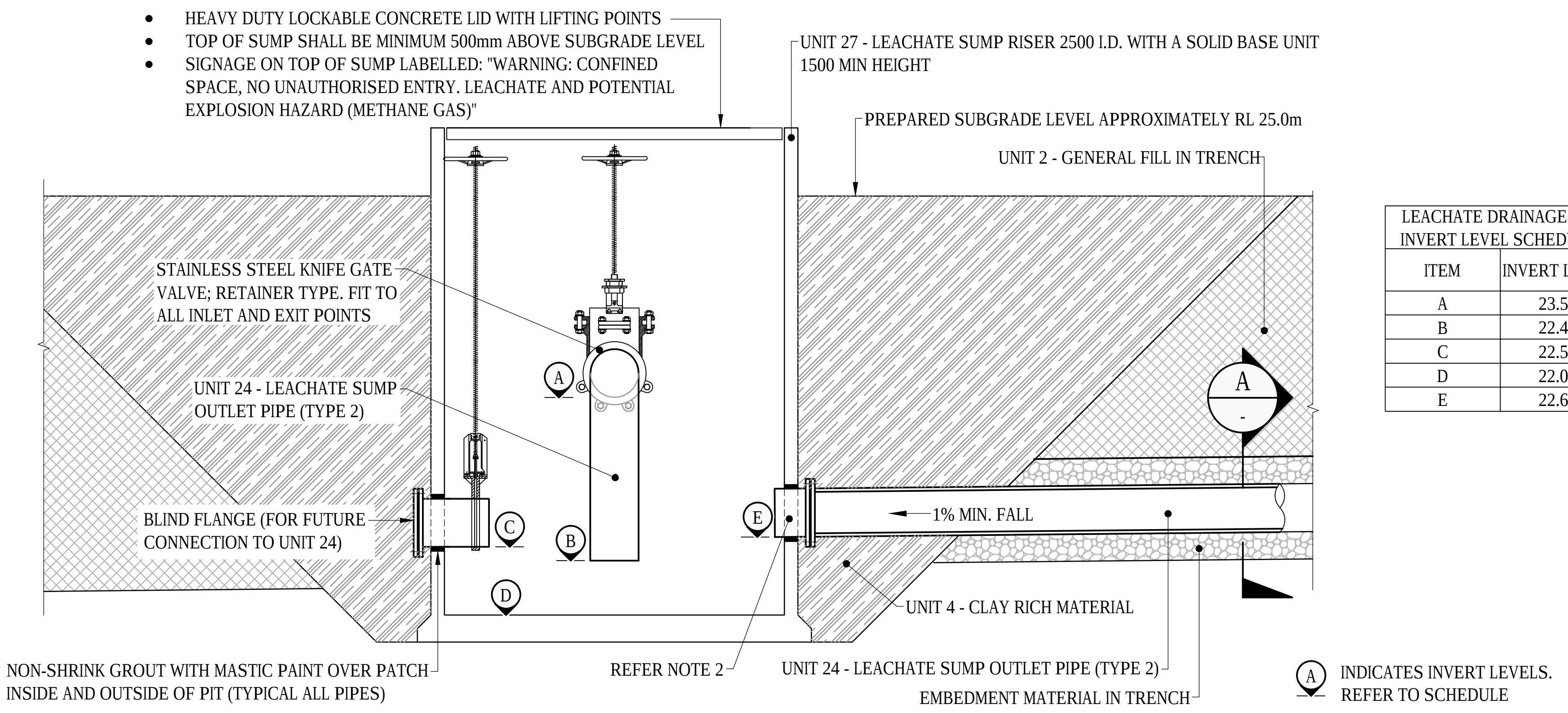
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: LEACHATE COLLECTION SYSTEM DETAILS - SHEET 2 PACKAGE 2

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D2044	A

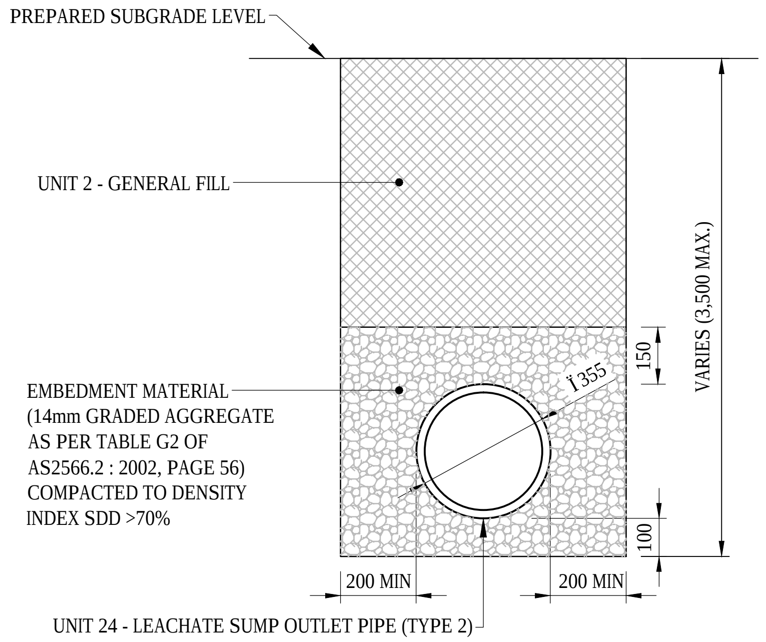
Plot Date: 5 April 2013 Time:6:47:14 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 2 - File Name:117625003-220-L-D2044-REVA.dwg
Xref: GAP_LOGO-A3.dwg;



LEACHATE DRAINAGE PIT INVERT LEVEL SCHEDULE	
ITEM	INVERT LEVEL
A	23.50
B	22.40
C	22.50
D	22.00
E	22.60

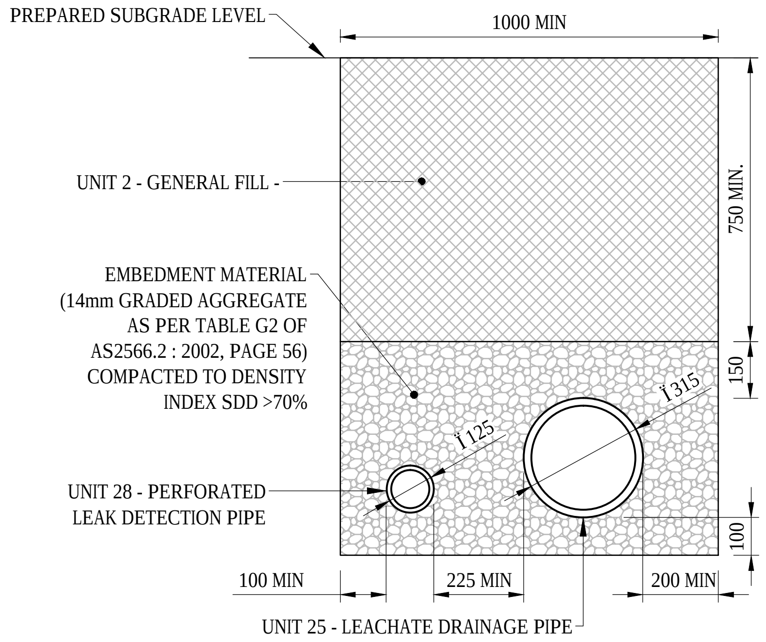
LEACHATE DRAINAGE PIT

N.T.S. (APPROXIMATE SCALE 1:50)



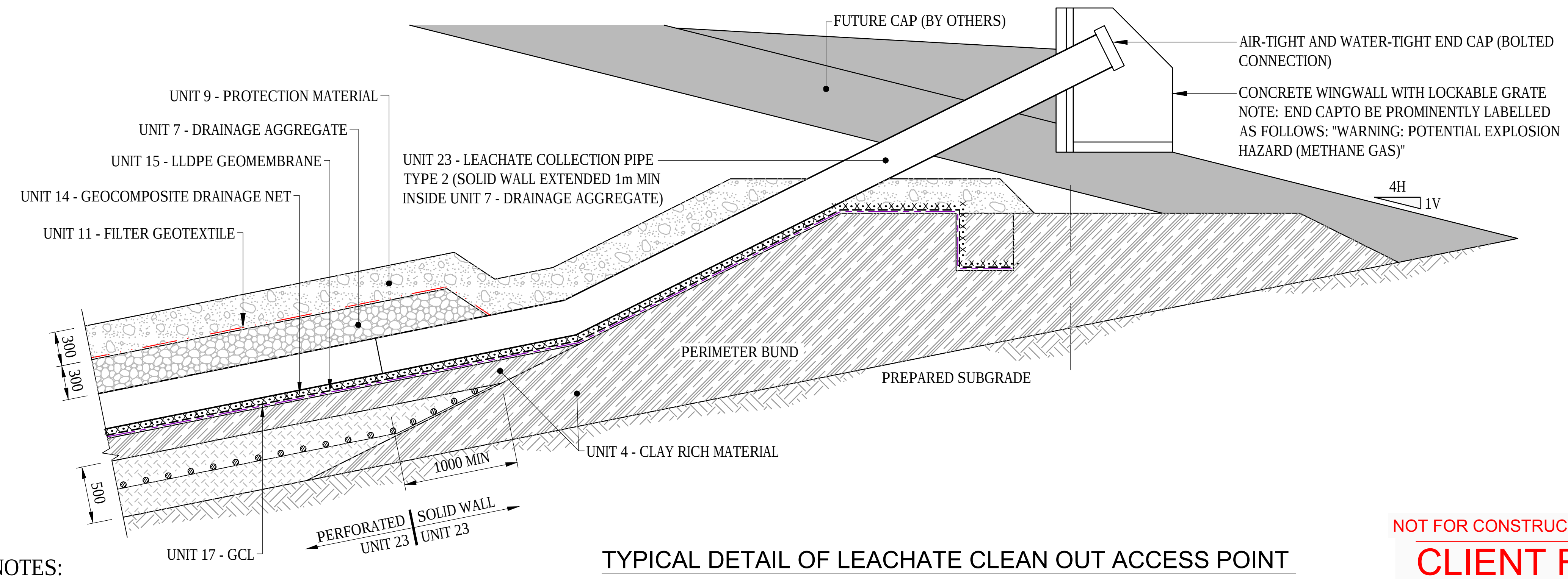
SECTION A

SCALE 1:20



SECTION B (D2046)

SCALE 1:20

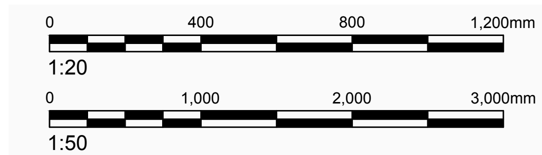


TYPICAL DETAIL OF LEACHATE CLEAN OUT ACCESS POINT

SCALE 1:50

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW



NOTES:

1. REFER TO DRAWING D2001 FOR GENERAL NOTES AND LEGEND
2. FIT ALL PIPE PENETRATIONS INTO PIT WITH A SS304 PIPE STUB - DOUBLE FLANGED, MIN LENGTH 500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.05.2013

Golder Associates

124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

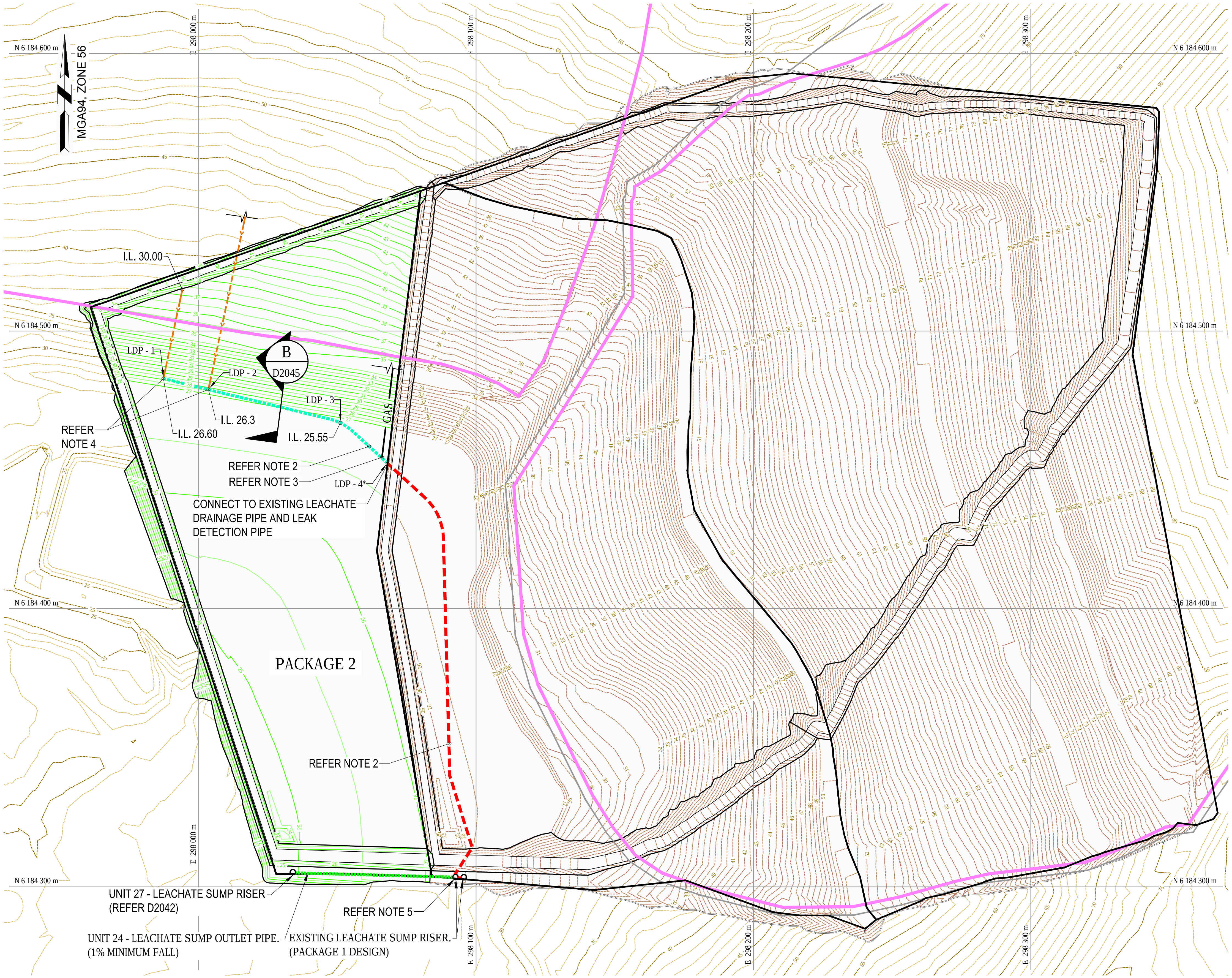
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: LEACHATE COLLECTION SYSTEM DETAILS - SHEET 3 PACKAGE 2

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D2045	A

Plot Date: 5 April 2013 Time:6:49:10 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 2 - File Name:117625003-220-L-D2045-REVA.dwg
Xref: GAP_LOGO-A3.dwg;



LEGEND

- PROPOSED LEACHATE PIPE (APPROXIMATE ALIGNMENT)
- EXISTING LEACHATE DRAINAGE PIPE (PACKAGE 1 DESIGN)
- GAS — UNIT 21 - GAS COLLECTION PIPE
- UNIT 24 - LEACHATE SUMP OUTLET PIPE
- UNIT 25 - LEACHATE DRAINAGE PIPE
- PACKAGE 1 DESIGN CONTOURS (SUBGRADE AND BUNDS)
- SUBGRADE CONTOURS
- PACKAGE BOUNDARY
- 2011 CONTOURS

NOTES:

1. THE NEW LEACHATE DRAINAGE PIPE SHOWN ON THIS DRAWING CONVEYS LIQUIDS FROM PROPOSED DRAINAGE PIPES IN THE WESTERN GULLY LANDFILL INTO THE NEW LEACHATE COLLECTION SYSTEM. ALL NEW PIPES SHOWN IN THIS DRAWING ARE TO BE INSTALLED BENEATH NEW LINING SYSTEMS. ALL PROPOSED DRAINAGE PIPES SHOWN IN THIS DRAWING ARE TO BE ASSUMED ACTIVE WITH LEACHATE FLOW.
2. LEAK DETECTION PIPES (UNIT 28) ASSOCIATED WITH THE UNIT 25 PIPES ARE NOT SHOWN FOR CLARITY.
3. CONNECT PIGGY BACK GAS COLLECTION PIPE TO LEACHATE DRAINAGE PIPE (REFER SHEET D2071).
4. CONNECT PROPOSED LEACHATE PIPES FROM WESTERN GULLY LANDFILL TO UNIT 25 PIPE. CONNECTION IS TO BE MADE TO THE SAME STANDARD AS FOR UNIT 25 PIPE.
5. CONNECT UNIT 24 TO THE OUTLET FLANGE STUB OF THE EXISTING LEACHATE SUMP RISER PIPE.

LEACHATE DRAIANGE PIPE - SETOUT

NUMBER	EASTING	NORTHING
LDP - 1	297987.30	6184482.84
LDP - 2	298003.51	6184478.89
LDP - 3	298051.06	6184466.86
LDP - 4*	298068.00	6184452.40

* MATCH TO EXISTING PIPES FROM PACKAGE 1

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

0 30 60 90m

1:1,500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.05.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

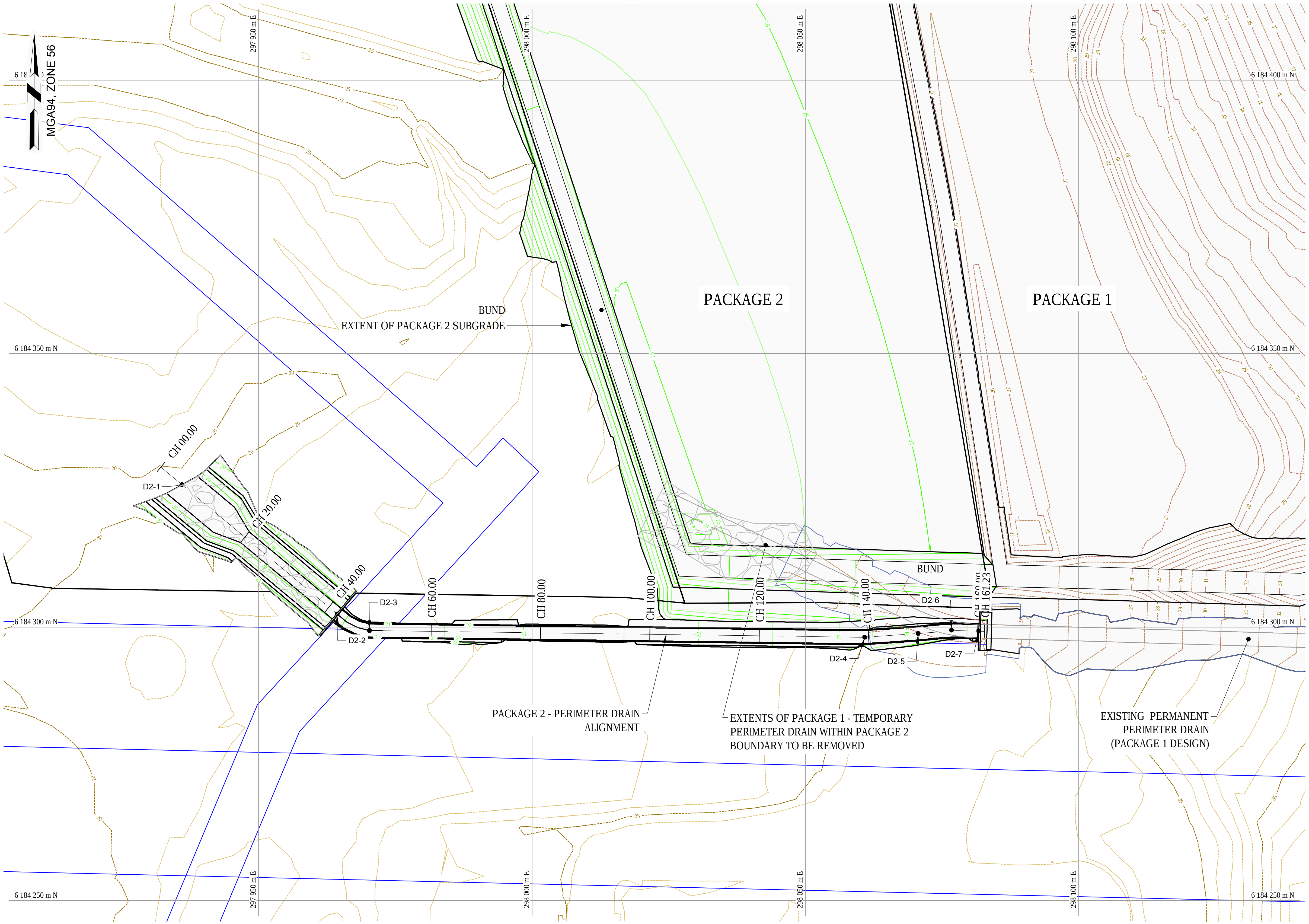
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: CONNECTION TO EXISTING LEACHATE SYSTEM AND LEACHATE DRAINAGE PIPE PLAN AND SETOUT

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	1:1,500	A3	117625003	220	L	D2046	A

Plot Date: 5 April 2013 Time:6:51:17 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 2 - File Name:117625003-220-L-D2046-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOUNDARY.dwg; 117625003-XREF-SUBGRADE STAGE 2.dwg; 117625003-XREF-SUBGRADE STAGE 1B.dwg; 117625003-XREF-SUBGRADE STAGE 1A.dwg; 117625003-XREF-BUND STAGE 2.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-BUND STAGE 1B.dwg; 117625003-XREF-CELL STAGE BOUNDARY.dwg;



LEGEND

- PACKAGE 1 DESIGN CONTOUR
- PROPOSED CONTOURS (REFER NOTE 1)
- PACKAGE BOUNDARY
- EASEMENT
- 2011 CONTOURS

NOTES:

1. PROPOSED CONTOURS REPRESENT SUBGRADE LEVELS, BUNDS AND DRAINAGE STRUCTURES

PACKAGE 2 - PERMANENT PERIMETER DRAIN SETOUT			
POINT No.	EASTING (m)	NORTHING (m)	INVERT LEVEL
D2-1	297935.98	6184326.03	19.50
D2-2	297964.37	6184302.39	19.94
D2-3	297970.27	6184299.38	20.16
D2-4	298060.86	6184298.14	23.38
D2-5	298070.64	6184298.84	24.14
D2-6	298076.72	6184299.43	24.38
D2-7	298081.72	6184299.27	24.59

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

0 15 30 45m

1:750

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	CRA	GRS	GRS	05.05.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

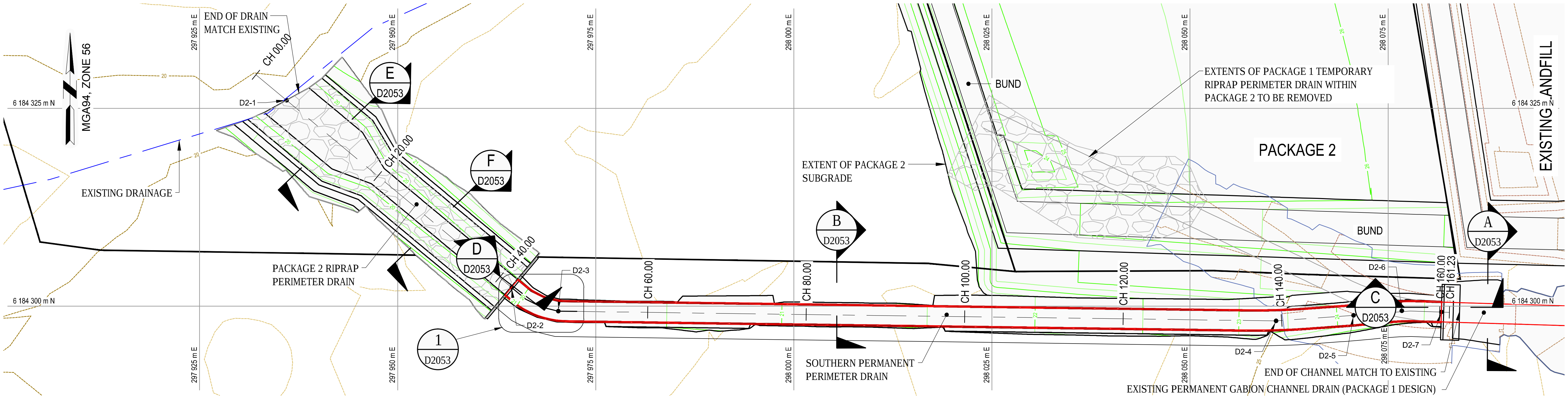
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: SOUTHERN PERIMETER DRAIN - PLAN AND SETOUT PACKAGE 2

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D2051	A

Plot Date: 5 April 2013 Time:7:25:54 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 2 - File Name:117625003-220-L-D2051-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-BASE LINER STAGE 2.dwg; 117625003-XREF-SUBGRADE STAGE 2.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-BUND STAGE 2.dwg; 117625003-XREF-Cadastre and easement.dwg; 117625003-XREF-SUBGRADE STAGE 1A.dwg; 117625003-XREF-BASE LINER STAGE 1A.dwg; 117625003-XREF-DRAINS PACKAGE 2.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg;



PLAN - SOUTHERN PERMANENT DRAIN

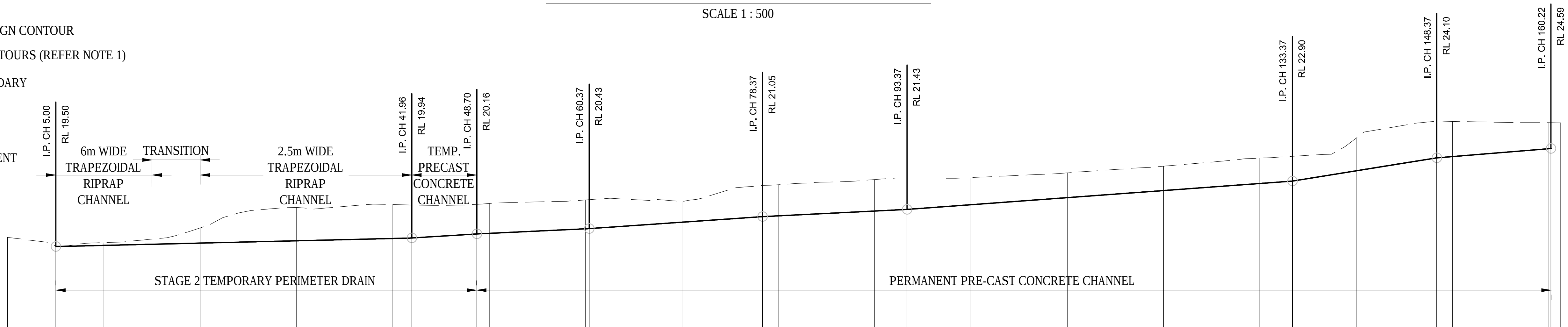
SCALE 1 : 500

LEGEND

- PACKAGE 1 DESIGN CONTOUR
- PROPOSED CONTOURS (REFER NOTE 1)
- PACKAGE BOUNDARY
- 2011 CONTOURS

NOTES:

1. PROPOSED CONTOURS REPRESENT SUBGRADE LEVELS, BUNDS AND DRAINAGE STRUCTURES



GRADE: 1.2% | 3.2% | 2.4% | 3.4% | 2.5% | 3.7% | 8.0% | 4.1%

NATURAL SURFACE	19.98	19.70	20.47	21.53	21.68	21.74	21.92	21.83	22.71	22.97	23.08	23.33	23.68	24.09	25.13	26.00	25.93 25.93
DESIGN SURFACE		19.56	19.68	19.80	19.92	20.19	20.42	20.76	21.09	21.34	21.67	22.04	22.41	22.78	23.43	24.17	24.58
DEPTH		0.14	0.79	1.73	1.76	1.55	1.50	1.07	1.62	1.63	1.41	1.28	1.27	1.32	1.70	1.83	1.35
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00 161.23

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

LONG SECTION - SOUTHERN PERMANENT DRAIN

HOR. SCALE 1 : 500 VER SCALE 1:250

0 5 10 15m 1:250

0 10 20 30m 1:500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	CRA	GRS	GRS	05.05.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

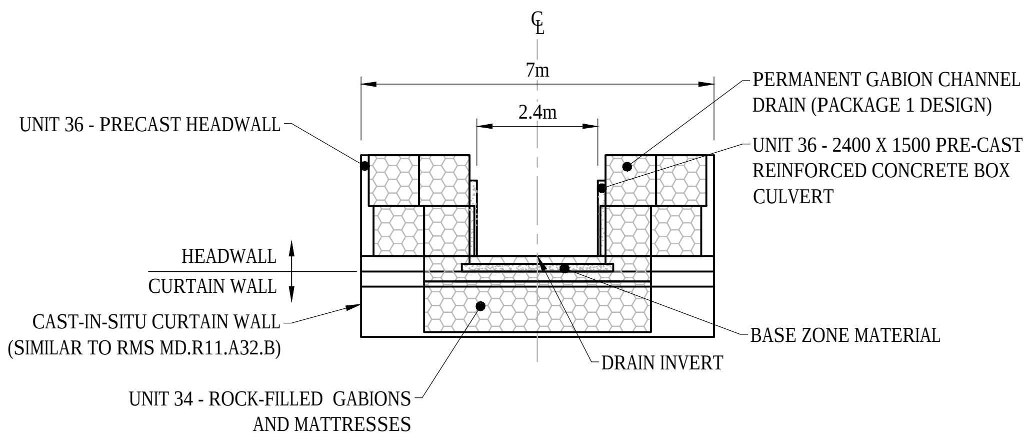
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

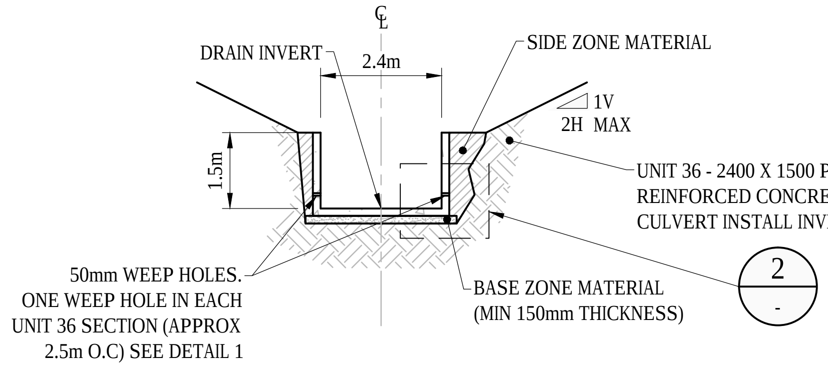
DRAWING TITLE: SOUTHERN PERIMETER DRAIN PLAN AND LONG SECTION - PACKAGE 2

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D2052	A

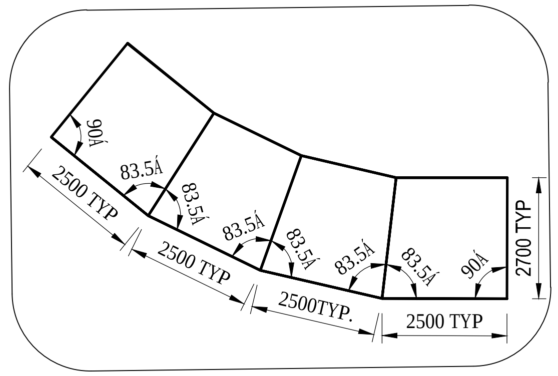
Plot Date: 5 April 2013 Time:7:56:27 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 2 - File Name:117625003-220-L-D2052-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-SUBGRADE STAGE 2.dwg; 117625003-XREF-BASE LINER STAGE 1A.dwg; 117625003-XREF-BASE LINER STAGE 1B.dwg; 117625003-XREF-BASE LINER STAGE 2.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-BUND STAGE 1B.dwg; 117625003-XREF-BUND STAGE 2.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-DRAINS PACKAGE 2.dwg; 117625003-XREF-SUBGRADE STAGE 1A.



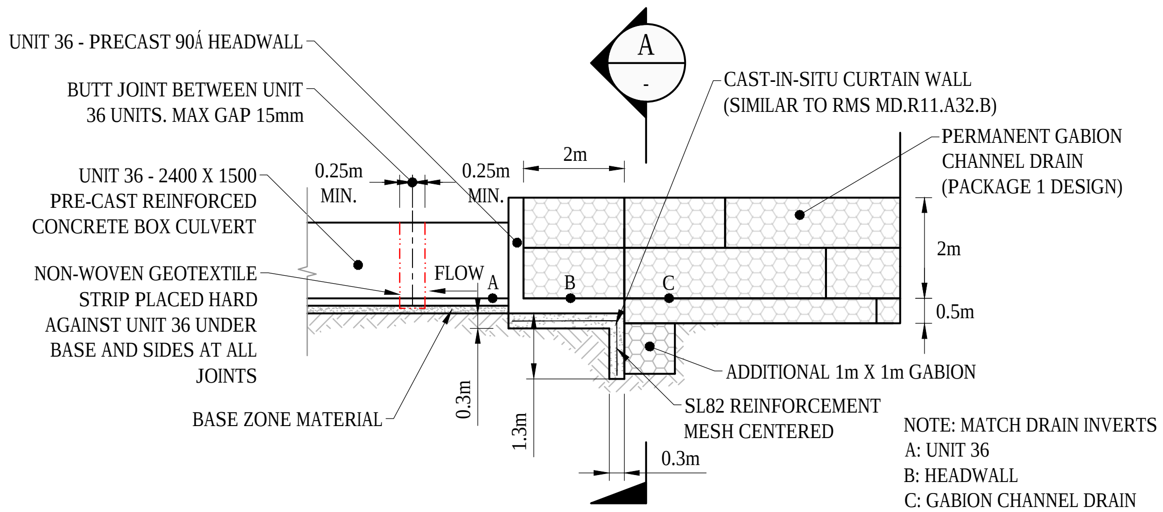
SECTION A - PERMANENT DRAIN TO EXISTING PACKAGE 1 DRAIN CONNECTION
SCALE 1:150
D2502



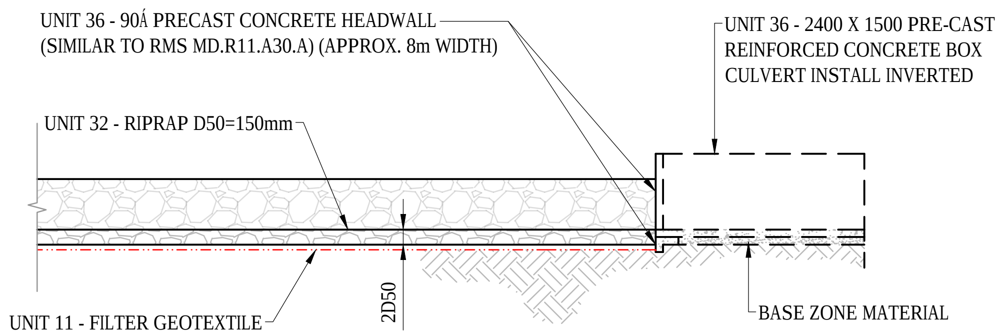
SECTION B PERMANENT DRAIN
SCALE 1:150
D2502



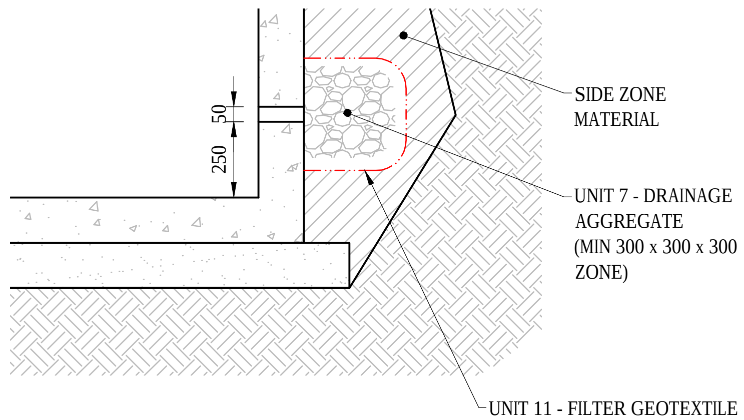
DETAIL 1
SCALE 1:150
D2052



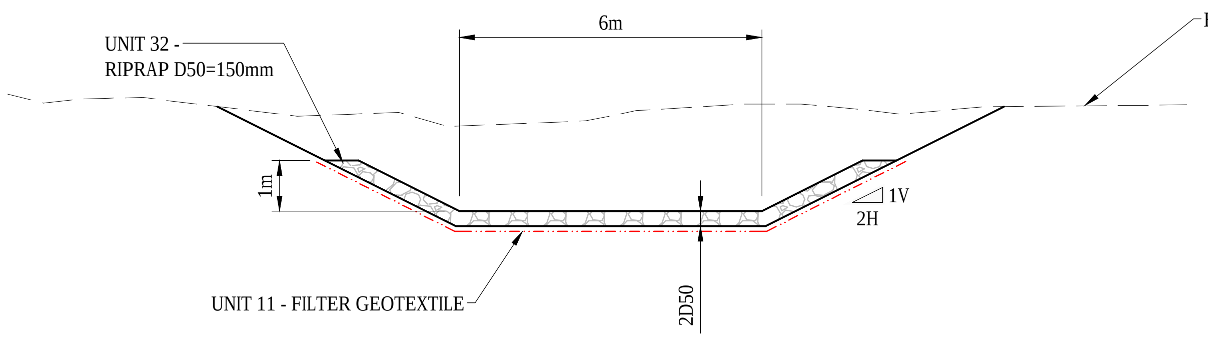
SECTION C PERMANENT DRAIN TO EXISTING PACKAGE 1 DRAIN CONNECTION
SCALE 1:150
D2502



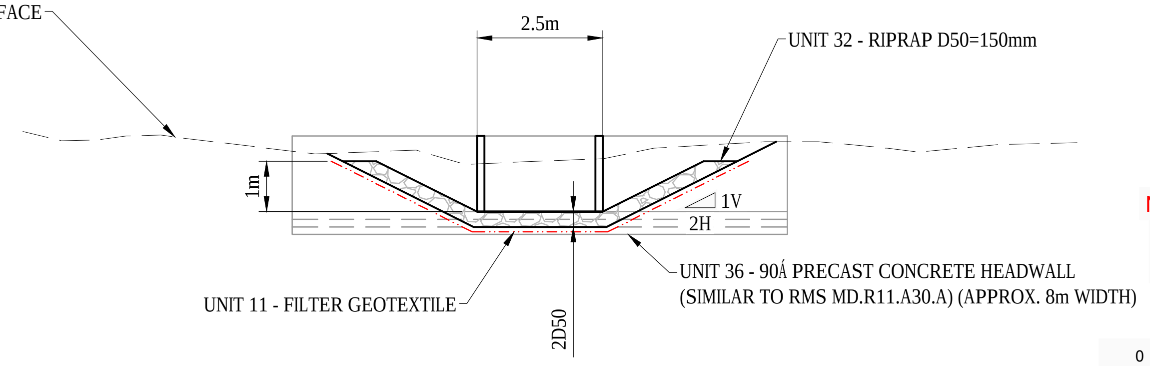
SECTION D BOX CULVERT DRAIN TO RIPRAP DRAIN TRANSITION
SCALE 1:150
D2502



DETAIL 2 WEEP HOLE
SCALE 1:25
-

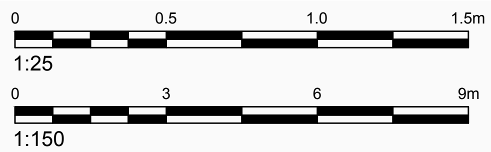


SECTION E PACKAGE 2 TEMPORARY DRAIN
SCALE 1:150
D2502



SECTION F PACKAGE 2 TEMPORARY DRAIN
SCALE 1:150
D2502

NOT FOR CONSTRUCTION - ISSUED FOR
CLIENT REVIEW



REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	CRA	GRS	GRS	05.05.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

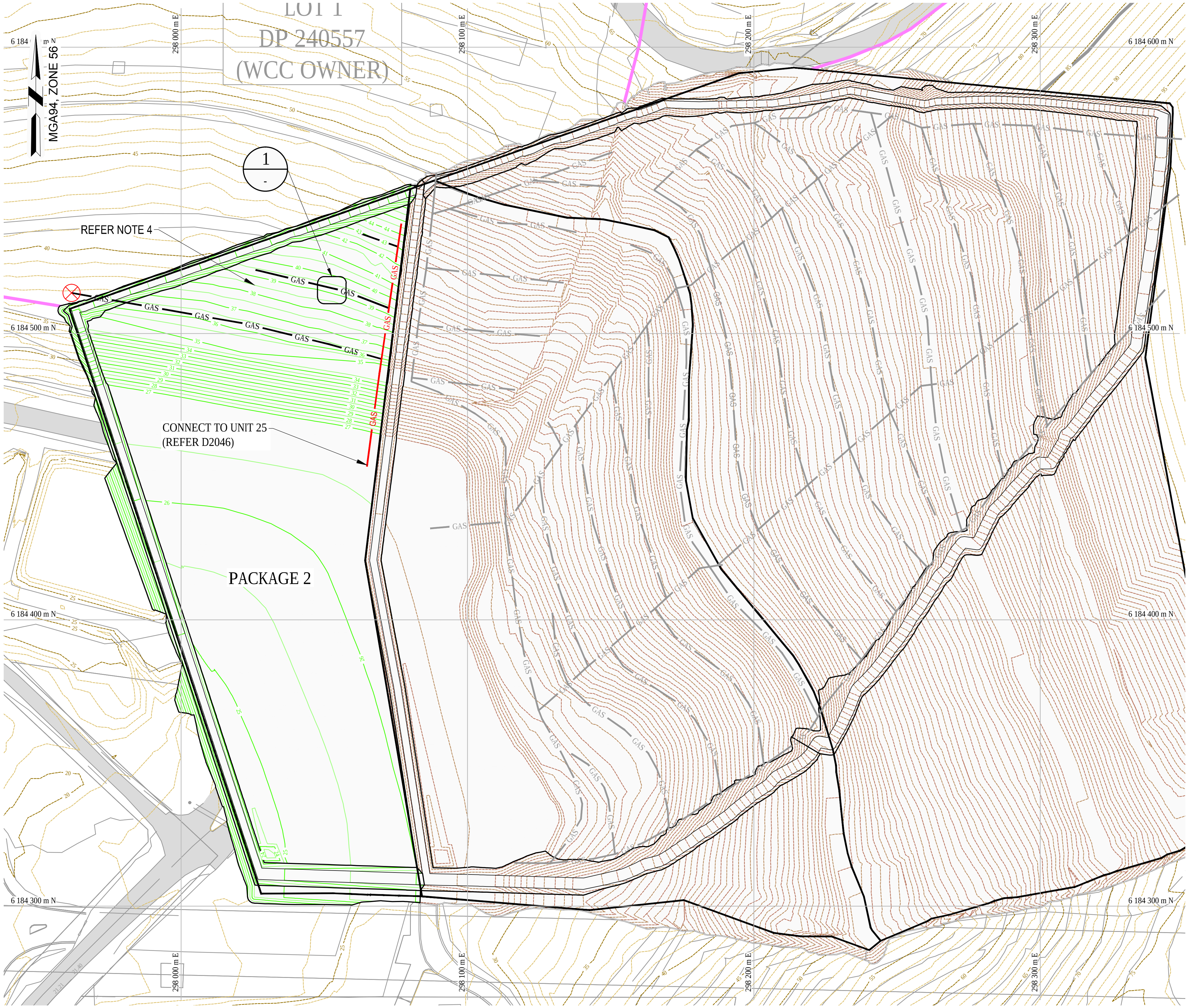
CLIENT: WOLLONGONG CITY COUNCIL

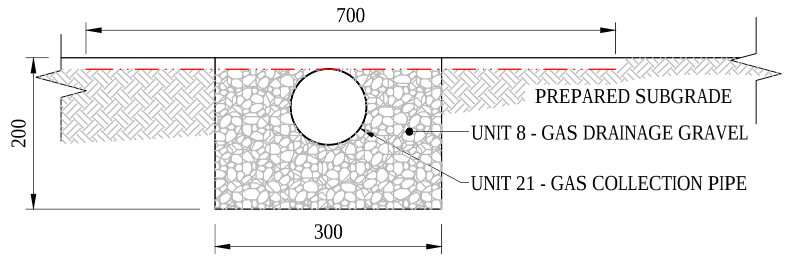
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: SOUTHERN PERIMETER DRAIN DETAILS PACKAGE 2

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D2053	A

Plot Date: 9 April 2013 Time:4:27:00 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 2 - File Name:117625003-220-L-D2053-REVA.dwg
Xref: GAP_LOGO-A3.dwg;





DETAIL 1 TYPICAL GAS TRENCH DETAIL

SCALE 1:10

LEGEND

- PACKAGE 1 DESIGN CONTOURS (SUBGRADE AND BUNDS)
- PACKAGE BOUNDARY
- APPROX. EXTENT OF EXISTING WASTE (REFER DRAWING D1003)
- SUBGRADE CONTOURS
- 2011 CONTOURS
- GAS — UNIT 21 - GAS COLLECTION PIPE (PERFORATED WALL)
- GAS — UNIT 21 - GAS COLLECTION PIPE (PACKAGE 1)
- GAS — UNIT 21 - GAS COLLECTION PIPE (SOLID WALL)
- ⊗ TEMPORARY GAS VENT (REFER NOTE 5)

NOTE:

1. REFER TO D2001 FOR GENERAL NOTES, MATERIAL LIST AND DRAWING REFERENCES
2. GAS COLLECTION PIPES TO BE CONNECTED AT ALL INTERSECTIONS
3. GAS COLLECTION PIPES TO BE ALIGNED APPROXIMATELY AS INDICATED
4. EXISTING GAS WELLS IN WESTERN GULLY LANDFILL TO BE REMOVED BY OTHERS PRIOR TO SUBGRADE FORMATION
5. PROVIDE TEMPORARY COVERED VENT TO ACCOMMODATE FUTURE EXTENSION OF GAS COLLECTION PIPE.

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

0 200 400 600mm
1:10
0 30 60 90m
1:1,500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.05.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: PIGGY BACK GAS VENTING PLAN PACKAGE 2

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D2071	A

Plot Date: 5 April 2013 Time:6:59:14 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 2 - File Name:117625003-220-L-D2071-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOUNDARY.dwg; 117625003-XREF-EXISTING BREAKLINES.dwg; 117625003-XREF-SUBGRADE STAGE 2.dwg; 117625003-XREF-SUBGRADE STAGE 1A.dwg; 117625003-XREF-SUBGRADE STAGE 1B.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-BUND STAGE 1B.dwg; 117625003-XREF-BUND STAGE 2.dwg; 117625003-XF

TECHNICAL MEMORANDUM

DATE 28 May 2013 **PROJECT No.** 117625003_255_M_Rev0

TO Michael Herraman
Wollongong City Council

CC Jacinta McMahon

FROM Saman Zargarbashi, Gary Schmertmann **EMAIL** szargarbashi@golder.com.au

WHYTES GULLY RESOURCE RECOVERY PARK (WGRRP) NEW LANDFILL CELL – SETTLEMENT ANALYSES FOR PIGGY BACK LINER AT EASTERN GULLY

Introduction

This technical memorandum presents the outcome of settlement analyses we have undertaken for detailed design to reflect long-term conditions for the piggy back liner on the Eastern Gully of WGRRP. The analyses considered settlements that could develop in the piggy back liner after landfilling over the liner to form the final landform proposed in the preliminary design report (April 2012). The purpose of these analyses was to assess potential settlements along the envisaged drainage paths across the liner and also to assess potential tensile strains that may develop in the geomembrane component of the liner

Assessment Methodology and Assumptions

The following methodology has been adopted:

- Review existing information and create the landfill geotechnical model,
- Select representative sections across/along the Eastern Gully where drainage paths are envisaged for the proposed new landfill cell.
- Establish settlement models for the above sections adopting compressibility parameters for the existing Municipal Solid Waste (MSW) in accordance with our previous assessments (i.e. Golder memos No. 117625003_253_M_Rev0 and 117625003_254_M_Rev0) and reported values in the literature.
- Undertake sensitivity analysis to assess potential effects of variation in the new fill thickness on the assessment outcome.

Available historical survey data[1] suggest four filling periods for the Eastern Gully, as follows:

- Stage 1A: February 1993 to December 2001,
- Stage 1B: December 2001 to June 2004,
- Stage 2: June 2004 to December 2009,
- Stage 3: December 2009 to 2013.

At any location, the uppermost of these stages define the surface for the piggy back liner. Underlying stage boundaries, if any, define boundaries between wastes of differing ages.

In this assessment, we have considered four cross sections along contour lines of the existing Eastern Gully landfill surface and two long sections along the axis of the gully, as shown in the attached plan, Figure 1. The sections along the contour lines were chosen to represent general cross-slope leachate drainage paths we

[1] For further details refer to the Golder Report 'Interpretative Geotechnical Investigation Report for 50% Design', No 117625003_059_R-Rev 1, dated April 2012

envisage for the piggy back liner. Settlement potential along these sections will influence detailed leachate collection system design. The sections along the gully axis were chosen because they have significant variation in thickness of existing waste and proposed new waste and therefore have potential to experience differential settlements that could induce liner tensile strains.

Cross sections are presented in Figures 2a to 7a showing the final landform surface and top of the above stages 1 to 3 of existing waste placement along each section. These figures also indicate the piggy back liner surface.

The settlement analyses assume the followings:

- Both: (i) grade change of the piggy back liner and; (ii) tensile strain of the geomembrane in the piggy back liner may result from differential settlements between points along the cross sections considered. Total settlement at each calculation point is estimated by a one-dimensional (1D) settlement prediction.
- Tensile strains are based on the calculated change in length, due to differential settlement, of a straight line between settlement calculation points. This provides an estimate of average settlement-induced tensile strain within each calculation interval.
- A modified primary compression index, $c_R = \dfrac{c_c}{1+e_o}$, of $c_R = 0.2$ is adopted in the analyses for the existing MSW in the Eastern Gully (c_c and e_o are primary compression index and initial void ratio, respectively). This is based on c_R values reported by Gourc & Olivier[2] [2005] for MSW with *Intermediate Compressibility*. Anecdotal evidences indicate that existing waste lifts within the landfill were approximately 3 m thick and have been covered by a soil layer, approximately 300 mm thick. Therefore we consider that at least 20% (by mass) of the existing MSW comprises soil. This not only reduces secondary (creep) settlement potential, but also we expect that it would result in low to intermediate waste compressibility. The compressibility assessment carried out for the Western Gully (refer Golder Memo No. 117625003_253_M_Rev0) resulted in C_R values from 0.04 to 0.13 which, although relevant to the older waste in the Western Gully, suggests that waste placement at the site does not result in a high compressibility waste mass. Consequently, we deem there is low risk of exceeding the primary settlement calculated using $c_R = 0.2$ for the existing Eastern Gully waste.
- The existing MSW in the Eastern Gully is assumed to be slightly overconsolidated, reflecting an equivalent preload surcharge of 25 kPa (refer Golder memo 117625003_253_M_Rev0), with a modified re-compression index equal to one-sixth of the magnitude of the modified primary compression index (i.e., equal to 0.2 / 6 = 0.033).
- A creep coefficient, or modified secondary compression index, $c_{\alpha\varepsilon} = \dfrac{c_\alpha}{1+e_o}$, $c_{\alpha\varepsilon} = 0.07$ is assumed for the existing Eastern Gully waste in accordance with our settlement back analysis calculations undertaken for the Eastern Gully (Golder Memo No. 117625003_254_M_Rev0).
- Creep settlements of the existing waste layers underlying the piggy back liner, corresponding to waste decomposition and other mechanisms, are assumed to commence at start of their respective filling period. Settlements are calculated to the year 2055, representing a time approximately 40 years after piggy back liner construction and overfill waste placement, referred to as ‘long-term’ in this memo.

Settlement Potential behind Existing Toe Berm

Based on verbal evidence, we note that young (possibly uncompacted or poorly compacted) MSW is present in an approximate 4 m thick layer behind the Eastern Gully landfill toe berm, in the location indicated on Figure 1. This condition is understood to have resulted from excavation of original waste in this area within the past few years, to facilitate leachate collection system repairs, and subsequent waste backfilling.

[2] Gourc, J. P., Olivier, F. ‘ Calibration of the Incremental Settlement Prediction Model (ISPM) from field monitoring campaigns’, International Workshop “Hydro-Physico-Mechanics of Landfills, Grenoble University, 21-22 March 2005.

At this location we consider that the potential for long-term differential settlement of the piggy back liner is relatively large. This is due to the relatively high potential compressibility of the backfilled waste and the relatively steep slope of the inboard batter of the toe berm. At this location there is potential for the drainage grade of the piggy back liner to reverse and interrupt drainage of the new landfill leachate, and also for high geomembrane tensile strains to develop.

We have consequently undertaken a preliminary assessment of differential settlements at this location. We assumed the backfilled waste materials in this location had been placed in 2009 and were covered by approximately 1 m of uncompacted soil. The assumed geometry and material parameters adopted in this assessment are shown in Figure 8. Filling to locally increase the piggy back liner grades between Points A and B, as suggested in the figure, would be with compacted soil fill rather than additional landfill waste.

Assessment Outcome

Tables A1 to A6 summarise details of settlement calculations at each section. The as-installed ("existing") and predicted post-settlement profile at year 2055 of the piggy back liner for each of the cross-sections is presented in Figures 2b to 7b. Predicted settlement of the piggy back liner ranges up to 5.3 m, with the area of highest predicted settlements indicated by the hatched zone in Figure 1. The hatched zone generally corresponds to the area with the largest thickness of future waste placement along the original gully centre line.

Although the maximum predicted long-term piggy back liner settlement is more than 5 m, calculated settlement-induced average grade changes are limited to 7% and average geomembrane tensile strains are limited to 1.7%. In most areas, the calculated average geomembrane tensile strain is well below 1%.

As shown in Figures 2b to 7b, the post-settlement liner profiles suggest that the detailed design should direct cross-slope leachate drainage on the piggy back liner primarily towards the hatched zone shown in Figure 1 in order that the higher settlements expected within this zone will facilitate rather than disrupt leachate collection. It is not considered feasible for detailed leachate collection design to address large potential grade changes of up to 7% by any other approach. The detailed design should also consider use of multiple upslope-downslope oriented primary collection pipes with frequent cross-slope pipes to provide multiple potential flow pathways and maintain effective leachate collection on the piggy back liner in case of irregular settlements.

Table 1, below, present calculated average tensile strains developed in geomembrane at each cross section through year 2055. The maximum calculated value for average tensile strain is 1.7% and we consider that the maximum local geomembrane tensile strain is therefore not likely to exceed 5%, which is less than the typical maximum allowable strain for textured LLDPE geomembrane (approximately 8%). See also Golder Memo No. 117625003_256_M_Rev0 for additional discussion and calculations regarding geomembrane tensile strain.

Table 1: Calculated long-term geomembrane tensile strain within piggy-back liner

Section	maximum average tensile strain (%)	Location (interval)	Remark
C-C	0.10	Ch. 10 to 20 m	
D-D	0.14	Ch. 10 to 20 m & 30 to 40 m	Differential settlements due to staged waste placement of new landfill were also considered by differentiating between packages 1a to 3 filling periods.
E-E	0.22	Ch. 530 to 540 m	
F-F	0.18	Ch. 160 to 180 m	Increasing final landform elevation to RL 105 m AHD locally around Chainage 250 to 350 m, could increase tensile strain to 1 %.
G-G	1.67	Ch. 360 to 380 m	
G-G'	1.09	Ch. 240 to 270 m	

Our assessment for the uncompacted waste area (Figure 8) has considered differential settlement between Point A, over the crest of the toe berm, and Point B, over the inboard toe of the toe berm. For the assumed geometry and material parameters indicated in Figure 8, calculated long-term settlement of the piggy back liner at Point B is 1.0 to 1.5 m depending on the assumed age of the existing waste. Assuming negligible settlement at Point A, and considering likely 2D effects, we recommend that the detailed design provide a 10% piggy back liner grade in this local area. Use of such a local design grade is expected to reduce the potential for leachate drainage grade reversal and geomembrane tensile strain development to acceptably small values.

If you have any questions regarding this memorandum, please contact the undersigned.

Saman Zargarbashi
Senior Geotechnical Engineer

Gary Schmertmann
Principal Geotechnical Engineer

SZ/GRS/sz

Attachments:
Tables A1 to A6: Settlement Calculations (6 No pages)
Figure 1: WGRRP – Eastern Gully Plan and Settlement Sections (1 No Page).
Figures 2 to 7: Stratigraphy and post-landfill closure settlements at different sections (6 No page)
Figure 8: Assumed Model for Uncompacted Waste Area (1 No Page)

2. EXISTING WASTE SETTLEMENT CALCULATION

Eastern Gully Landfill - Section C-C

TABLE A1

Waste Materials	Old waste				New Waste	Basis of adopted value
Material	stage 1a	stage 1b	stage 2	Stage 3		
waste type	MSW	MSW	MSW	MSW	New	from available site information
Unit Weight (kN/m3)	11	11	11	11	11	assumed based on waste type
C-ce (mod primary)	0.2	0.2	0.2	0.2	NA	range from Gourc & Olivier (2005) is 0.12 to >0.24
C-c alph (mod secondary)	0.07	0.07	0.07	0.07	NA	range from Gourc & Olivier (2005) is 0.02 to >0.14
average age in mid 2013(yr)	20.3	11.5	9	3.5	-	from available site information

Filling Stages :
Stage 1a: Feb 1993 to Dec 2001
Stage 1b: Dec 2001 to June 2004
Stage 2: June 2004 to Dec 2009
Stage 3: Dec 2009 to Feb 2012

2.1 SHORT-TERM "PRIMARY CONSOLIDATION"

Section 12.4.2 Settlement of existing solid waste: Eq 12.9, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{c\varepsilon} \times \log \frac{\sigma_0 + \Delta\sigma}{\sigma_0}$$

$C_{c\varepsilon}$ - Modified primary compression index

Assumptions

use Sigma-0 = current vertical stress at layer midpoint
use delta-sigma = vertical stress increase from new waste placement

Preload surcharge (kPa)	25

2.2 LONG-TERM "SECONDARY CONSOLIDATION"

Section 12.4.2 Settlement of existing solid waste: Eq 12.11, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{\alpha\varepsilon} \times \log \frac{t_{final}}{t_{initial}}$$

$C_{\alpha\varepsilon}$ - Modified secondary compression index

Assumptions

use t-initial= average age in Oct 2013
use t-final= t-initial plus 42 years

t initial = starting time of the secondary settlement. Assumed to be equal to the age of the existing landfill for vertical expansion.
t final = ending time of the secondary settlement
MSW assumed to be normally consolidated.

2.1 Short-Term "Primary" Settlement of Liner

Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	0	0
Chainage (m)	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	0	0
Thickness of New Landfill Waste Filling Stages (m)																										
Capping Layer	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Total thickness of new waste	32.31	33.07	30.66	29.89	27.7	25.37	23.35	21.5	19.65	18	16.66	16.11	15.97	15.78	15.1	13.73	13.84	11.8	9.86	7.58	5.2	2.72	0.44	0	0	0
Thickness Eastern Gully Filling Stage3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sigma-0 (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Delta-sigma (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Eastern Gully Filling Stage2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sigma-0 (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Delta-sigma (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Eastern Gully Filling Stage1b	1.64	2.51	4.68	6.26	8.18	9.79	11.12	12.14	13.23	13.94	14.55	15.07	15.49	15.65	14.34	12.31	13.19	12.18	10.26	8.64	6.95	5.24	2.61	0.00	0.00	0.00
Sigma-0 (kN/m2)	9.02	13.81	25.74	34.43	44.99	53.85	61.16	66.77	72.77	76.67	80.03	82.89	85.20	86.08	78.87	67.71	72.55	66.99	56.43	47.52	38.23	28.82	14.36	NA	NA	NA
Delta-sigma (kN/m2)	377.41	385.77	359.26	350.79	326.70	301.07	278.85	258.50	238.15	220.00	205.26	199.21	197.67	195.58	188.10	173.03	174.24	151.80	130.46	105.38	79.20	51.92	26.84	NA	NA	NA
Calc settlement of layer (m)	0.38	0.55	0.87	1.07	1.24	1.33	1.38	1.39	1.39	1.35	1.32	1.32	1.33	1.32	1.23	1.08	1.12	0.97	0.79	0.61	0.42	0.23	0.05	0.00	0.00	0.00
Thickness Eastern Gully Filling Stage1a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sigma-0 (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Delta-sigma (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total "Primary" settlement (m)	0.38	0.55	0.87	1.07	1.24	1.33	1.38	1.39	1.39	1.35	1.32	1.32	1.33	1.32	1.23	1.08	1.12	0.97	0.79	0.61	0.42	0.23	0.05	0.00	0.00	0.00

2.2 Long-Term "Secondary" Settlement of Liner

Note: for the purpose of this secondary settlement calculation, all piggy back liner and overlying new waste is assumed to be placed at the same time.

Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	0	0
New Waste																										
Total Thickness	32.31	33.07	30.66	29.89	27.70	25.37	23.35	21.50	19.65	18.00	16.66	16.11	15.97	15.78	15.10	13.73	13.84	11.80	9.86	7.58	5.20	2.72	0.44	0.00	0.00	0.00
Old Waste																										
Thickness Eastern Gully Filling Stage3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
T-final (yr)	45.50	45.50	45.50	45.50	45.50	45.50	45.50	45.50	45.50	45.50	45.50	45.50	45.50	45.50	45.50	45.50	45.50	45.50	45.50	45.50	45.50	45.50	45.50	45.50	45.50	45.50
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Eastern Gully Filling Stage2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
T-final (yr)	51.00	51.00	51.00	51.00	51.00	51.00	51.00	51.00	51.00	51.00	51.00	51.00	51.00	51.00	51.00	51.00	51.00	51.00	51.00	51.00	51.00	51.00	51.00	51.00	51.00	51.00
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Eastern Gully Filling Stage1b	1.64	2.51	4.68	6.26	8.18	9.79	11.12	12.14	13.23	13.94	14.55	15.07	15.49	15.65	14.34	12.31	13.19	12.18	10.26	8.64	6.95	5.24	2.61	0.00	0.00	0.00
T-initial (yr)	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50
T-final (yr)	53.50	53.50	53.50	53.50	53.50	53.50	53.50	53.50	53.50	53.50	53.50	53.50	53.50	53.50	53.50	53.50	53.50	53.50	53.50	53.50	53.50	53.50	53.50	53.50	53.50	53.50
Calc settlement of layer (m)	0.08	0.12	0.22	0.29	0.38	0.46	0.52	0.57	0.62	0.65	0.68	0.70	0.72	0.73	0.67	0.58	0.62	0.57	0.48	0.40	0.32	0.24	0.12	0.00	0.00	0.00
Thickness Eastern Gully Filling Stage1a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30
T-final (yr)	62.30	62.30	62.30	62.30	62.30	62.30	62.30	62.30	62.30	62.30	62.30	62.30	62.30	62.30	62.30	62.30	62.30	62.30	62.30	62.30	62.30	62.30	62.30	62.30	62.30	62.30
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total "Secondary" settlement(m)	**0.08**	**0.12**	**0.22**	**0.29**	**0.38**	**0.46**	**0.52**	**0.57**	**0.62**	**0.65**	**0.68**	**0.70**	**0.72**	**0.73**	**0.67**	**0.58**	**0.62**	**0.57**	**0.48**	**0.40**	**0.32**	**0.24**	**0.12**	**0.00**	**0.00**	**0.00**

Settlement of natural ground are negligible.

Sum of calculated "Primary" and "Secondary" settlement (m)	0.45	0.66	1.09	1.36	1.62	1.79	1.90	1.96	2.00	2.01	2.00	2.02	2.05	2.05	1.90	1.65	1.74	1.54	1.27	1.02	0.75	0.48	0.17	0.00	0.00	0.00

117625003 Whytes Gully New Landfill Cell

2. EXISTING WASTE SETTLEMENT CALCULATION

Eastern Gully Landfill - Section D-D

TABLE A2

Waste Materials	Old waste				New Waste	Basis of adopted value
Material	stage 1a	stage 1b	stage 2	Stage 3		
waste type	MSW	MSW	MSW	MSW	New	from available site information
Unit Weight (kN/m3)	11	11	11	11	11	assumed based on waste type
C-ce (mod primary)	0.2	0.2	0.2	0.2	NA	range from Gourc & Olivier (2005) is 0.12 to >0.24
C-c alph (mod secondary)	0.07	0.07	0.07	0.07	NA	range from Gourc & Olivier (2005) is 0.02 to >0.14
average age in mid 2013(yr)	20.3	11.5	9	3.5	-	from available site information

Filling Stages :
Stage 1a: Feb 1993 to Dec 2001
Stage 1b: Dec 2001 to June 2004
Stage 2: June 2004 to Dec 2009
Stage 3: Dec 2009 to Feb 2012

2.1 SHORT-TERM "PRIMARY CONSOLIDATION"

Section 12.4.2 Settlement of existing solid waste: Eq 12.9, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{c\varepsilon} \times \log \frac{\sigma_0 + \Delta\sigma}{\sigma_0}$$

$C_{c\varepsilon}$ - Modified primary compression index

Assumptions

use Sigma-0 = current vertical stress at layer midpoint
use delta-sigma = vertical stress increase from new waste placement

Preload surcharge (kPa)	25

2.2 LONG-TERM "SECONDARY CONSOLIDATION"

Section 12.4.2 Settlement of existing solid waste: Eq 12.11, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{\alpha\varepsilon} \times \log \frac{t_{final}}{t_{initial}}$$

$C_{\alpha\varepsilon}$ - Modified secondary compression index

Assumptions

use t-initial= average age in Oct 2013
use t-final= t-initial plus 40 years

t initial = starting time of the secondary settlement. Assumed to be equal to the age of the existing landfill for vertical expansion.
t final = ending time of the secondary settlement
MSW assumed to be normally consolidated.

2.1 Short-Term "Primary" Settlement of Liner

Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Chainage (m)	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250
Thickness of New Landfill Waste Filling Stages (m)																										
Capping Layer	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Total thickness of new waste	39.99	40	39.36	38.33	37.01	35.31	33.56	31.85	29.91	30.31	32.77	31.46	29.47	27.34	25.72	23.72	21.46	19.31	17.54	16.64	15.27	13.87	12.56	9.58	6.91	4.46
Thickness Eastern Gully Filling Stage3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sigma-0 (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Delta-sigma (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Eastern Gully Filling Stage2	3.78	6.16	9.16	12.62	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
Sigma-0 (kN/m2)	20.79	33.88	50.38	69.41	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50
Delta-sigma (kN/m2)	461.89	462.00	454.96	443.63	429.11	410.41	391.16	372.35	351.01	355.41	382.47	368.06	346.17	322.74	304.92	282.92	258.06	234.41	214.94	205.04	189.97	174.57	160.16	127.38	98.01	71.06
Calc settlement of layer (m)	0.82	1.19	1.57	1.91	1.92	1.87	1.83	1.78	1.72	1.74	1.80	1.77	1.71	1.65	1.59	1.53	1.44	1.36	1.28	1.25	1.18	1.11	1.05	0.87	0.69	0.50
Thickness Eastern Gully Filling Stage1b	0.00	0.00	0.00	0.00	3.39	7.39	11.00	12.76	15.99	16.56	14.38	16.66	19.12	20.28	20.98	21.48	21.96	22.00	21.57	20.23	17.81	15.97	14.06	12.03	9.69	7.19
Sigma-0 (kN/m2)	NA	NA	NA	NA	161.65	183.65	203.50	213.18	230.95	234.08	222.09	234.63	248.16	254.54	258.39	261.14	263.78	264.00	261.64	254.27	240.96	230.84	220.33	209.17	196.30	182.55
Delta-sigma (kN/m2)	NA	NA	NA	NA	429.11	410.41	391.16	372.35	351.01	355.41	382.47	368.06	346.17	322.74	304.92	282.92	258.06	234.41	214.94	205.04	189.97	174.57	160.16	127.38	98.01	71.06
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.35	0.69	0.93	1.02	1.16	1.21	1.14	1.24	1.32	1.30	1.28	1.23	1.16	1.07	0.98	0.90	0.77	0.66	0.56	0.40	0.26	0.14
Thickness Eastern Gully Filling Stage1a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sigma-0 (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Delta-sigma (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total "Primary" settlement (m)	0.82	1.19	1.57	1.91	2.26	2.56	2.76	2.80	2.89	2.94	2.94	3.01	3.03	2.95	2.87	2.75	2.60	2.43	2.27	2.15	1.95	1.78	1.60	1.27	0.95	0.64

2.2 Long-Term "Secondary" Settlement of Liner

Note: for the purpose of this secondary settlement calculation, all piggy back liner and overlying new waste is assumed to be placed at the same time.

Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
New Waste																										
Total Thickness	39.99	40.00	39.36	38.33	37.01	35.31	33.56	31.85	29.91	30.31	32.77	31.46	29.47	27.34	25.72	23.72	21.46	19.31	17.54	16.64	15.27	13.87	12.56	9.58	6.91	4.46
Old Waste																										
Thickness Eastern Gully Filling Stage3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
T-final (yr)	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Eastern Gully Filling Stage2	3.78	6.16	9.16	12.62	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
T-initial (yr)	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
T-final (yr)	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00
Calc settlement of layer (m)	0.19	0.32	0.47	0.65	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
Thickness Eastern Gully Filling Stage1b	0.00	0.00	0.00	0.00	3.39	7.39	11.00	12.76	15.99	16.56	14.38	16.66	19.12	20.28	20.98	21.48	21.96	22.00	21.57	20.23	17.81	15.97	14.06	12.03	9.69	7.19
T-initial (yr)	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50
T-final (yr)	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.15	0.34	0.50	0.58	0.73	0.75	0.66	0.76	0.87	0.92	0.96	0.98	1.00	1.00	0.98	0.92	0.81	0.73	0.64	0.55	0.44	0.33
Thickness Eastern Gully Filling Stage1a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30
T-final (yr)	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total "Secondary" settlement(m)	**0.19**	**0.32**	**0.47**	**0.65**	**0.82**	**1.01**	**1.17**	**1.25**	**1.40**	**1.42**	**1.33**	**1.43**	**1.54**	**1.59**	**1.63**	**1.65**	**1.67**	**1.67**	**1.65**	**1.59**	**1.48**	**1.40**	**1.31**	**1.22**	**1.11**	**1.00**

Settlement of natural ground are negligible.

Sum of calculated "Primary" and "Secondary" settlement (m)	1.01	1.51	2.04	2.56	3.09	3.56	3.93	4.05	4.29	4.37	4.27	4.44	4.57	4.54	4.50	4.40	4.27	4.10	3.92	3.74	3.44	3.17	2.91	2.49	2.06	1.63

117625003 Whytes Gully New Landfill Cell

2. EXISTING WASTE SETTLEMENT CALCULATION

Eastern Gully Landfill - Section E-E

TABLE A3

Waste Materials	Old waste				New Waste	Basis of adopted value
Material	stage 1a	stage 1b	stage 2	Stage 3		
waste type	MSW	MSW	MSW	MSW	New	from available site information
Unit Weight (kN/m3)	11	11	11	11	11	assumed based on waste type
C-ce (mod primary)	0.2	0.2	0.2	0.2	NA	range from Gourc & Olivier (2005) is 0.12 to >0.24
C-c alph (mod secondary)	0.07	0.07	0.07	0.07	NA	range from Gourc & Olivier (2005) is 0.02 to >0.14
average age in mid 2013(yr)	20.3	11.5	9	3.5	-	from available site information

Filling Stages :
Stage 1a: Feb 1993 to Dec 2001
Stage 1b: Dec 2001 to June 2004
Stage 2: June 2004 to Dec 2009
Stage 3: Dec 2009 to Feb 2012

2.1 SHORT-TERM "PRIMARY CONSOLIDATION"

Section 12.4.2 Settlement of existing solid waste: Eq 12.9, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{c\varepsilon} \times \log \frac{\sigma_0 + \Delta\sigma}{\sigma_0}$$

$C_{c\varepsilon}$ - Modified primary compression index

Assumptions

use Sigma-0 = current vertical stress at layer midpoint
use delta-sigma = vertical stress increase from new waste placement

Preload surcharge (kPa)	25

2.2 LONG-TERM "SECONDARY CONSOLIDATION"

Section 12.4.2 Settlement of existing solid waste: Eq 12.11, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{\alpha\varepsilon} \times \log \frac{t_{final}}{t_{initial}}$$

$C_{\alpha\varepsilon}$ - Modified secondary compression index

Assumptions

use t-initial= average age in Oct 2013
use t-final= t-initial plus 40 years

t initial = starting time of the secondary settlement. Assumed to be equal to the age of the existing landfill for vertical expansion.
t final = ending time of the secondary settlement
MSW assumed to be normally consolidated.

2.1 Short-Term "Primary" Settlement of Liner

Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Chainage (m)	190	200	210	220	230	280	320	380	430	440	450	460	470	480	490	500	510	520	530	540	550	560	570	580	0	0
Thickness of New Landfill Waste Filling Stages (m)																										
Capping Layer	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Total thickness of new waste	0.26	2.15	2.83	5.04	7.52	18.53	28	27.99	26.39	25.85	25.71	23.38	20.15	17.11	14.11	11.14	8.03	5.46	3	-0.25	-0.11	3.95	3.43	1.36	0	0
Thickness Eastern Gully Filling Stage3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sigma-0 (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Delta-sigma (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Eastern Gully Filling Stage2	3.78	6.16	9.16	12.62	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
Sigma-0 (kN/m2)	20.79	33.88	50.38	69.41	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50	71.50
Delta-sigma (kN/m2)	24.86	45.65	53.13	77.44	104.72	225.83	330.00	329.89	312.29	306.35	304.81	279.18	243.65	210.21	177.21	144.54	110.33	82.06	55.00	19.25	20.79	65.45	59.73	36.96	22.00	22.00
Calc settlement of layer (m)	0.04	0.21	0.31	0.54	0.74	1.33	1.67	1.67	1.62	1.60	1.59	1.51	1.39	1.27	1.13	0.97	0.77	0.58	0.36	-0.01	0.01	0.45	0.40	0.19	0.02	0.02
Thickness Eastern Gully Filling Stage1b	0.00	0.00	0.00	0.00	3.39	7.39	11.00	12.76	15.99	16.56	14.38	16.66	19.12	20.28	20.98	21.48	21.96	22.00	21.57	20.23	17.81	15.97	14.06	12.03	9.69	7.19
Sigma-0 (kN/m2)	NA	NA	NA	NA	161.65	183.65	203.50	213.18	230.95	234.08	222.09	234.63	248.16	254.54	258.39	261.14	263.78	264.00	261.64	254.27	240.96	230.84	220.33	209.17	196.30	182.55
Delta-sigma (kN/m2)	NA	NA	NA	NA	104.72	225.83	330.00	329.89	312.29	306.35	304.81	279.18	243.65	210.21	177.21	144.54	110.33	82.06	55.00	19.25	20.79	65.45	59.73	36.96	22.00	22.00
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.11	0.45	0.83	0.93	1.07	1.08	0.97	1.01	1.00	0.92	0.81	0.68	0.52	0.37	0.21	-0.01	0.00	0.23	0.18	0.07	0.01	0.00
Thickness Eastern Gully Filling Stage1a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sigma-0 (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Delta-sigma (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total "Primary" settlement (m)	0.04	0.21	0.31	0.54	0.85	1.77	2.49	2.60	2.68	2.68	2.56	2.53	2.40	2.19	1.94	1.65	1.29	0.95	0.58	-0.02	0.01	0.68	0.59	0.26	0.03	0.03

2.2 Long-Term "Secondary" Settlement of Liner

Note: for the purpose of this secondary settlement calculation, all piggy back liner and overlying new waste is assumed to be placed at the same time.

Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
New Waste																										
Total Thickness	0.26	2.15	2.83	5.04	7.52	18.53	28.00	27.99	26.39	25.85	25.71	23.38	20.15	17.11	14.11	11.14	8.03	5.46	3.00	-0.25	-0.11	3.95	3.43	1.36	0.00	0.00
Old Waste																										
Thickness Eastern Gully Filling Stage3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
T-final (yr)	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Eastern Gully Filling Stage2	3.78	6.16	9.16	12.62	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
T-initial (yr)	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
T-final (yr)	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00
Calc settlement of layer (m)	0.19	0.32	0.47	0.65	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
Thickness Eastern Gully Filling Stage1b	0.00	0.00	0.00	0.00	3.39	7.39	11.00	12.76	15.99	16.56	14.38	16.66	19.12	20.28	20.98	21.48	21.96	22.00	21.57	20.23	17.81	15.97	14.06	12.03	9.69	7.19
T-initial (yr)	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50
T-final (yr)	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.15	0.34	0.50	0.58	0.73	0.75	0.66	0.76	0.87	0.92	0.96	0.98	1.00	1.00	0.98	0.92	0.81	0.73	0.64	0.55	0.44	0.33
Thickness Eastern Gully Filling Stage1a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30
T-final (yr)	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total "Secondary" settlement(m)	**0.19**	**0.32**	**0.47**	**0.65**	**0.82**	**1.01**	**1.17**	**1.25**	**1.40**	**1.42**	**1.33**	**1.43**	**1.54**	**1.59**	**1.63**	**1.65**	**1.67**	**1.67**	**1.65**	**1.59**	**1.48**	**1.40**	**1.31**	**1.22**	**1.11**	**1.00**

Settlement of natural ground are negligible.

Sum of calculated "Primary" and "Secondary" settlement (m)	0.24	0.53	0.78	1.19	1.67	2.78	3.67	3.85	4.08	4.10	3.89	3.95	3.94	3.78	3.56	3.29	2.96	2.63	2.23	1.57	1.49	2.08	1.90	1.48	1.14	1.02

117625003 Whytes Gully New Landfill Cell

2. EXISTING WASTE SETTLEMENT CALCULATION

Eastern Gully Landfill - Section F-F

TABLE A4

Waste Materials	Old waste				New Waste	Basis of adopted value
Material	stage 1a	stage 1b	stage 2	Stage 3		
waste type	MSW	MSW	MSW	MSW	New	from available site information
Unit Weight (kN/m3)	11	11	11	11	11	assumed based on waste type
C-ce (mod primary)	0.2	0.2	0.2	0.2	NA	range from Gourc & Olivier (2005) is 0.12 to >0.24
C-c alph (mod secondary)	0.07	0.07	0.07	0.07	NA	range from Gourc & Olivier (2005) is 0.02 to >0.14
average age in mid 2013(yr)	20.3	11.5	9	3.5	-	from available site information

Filling Stages :
Stage 1a: Feb 1993 to Dec 2001
Stage 1b: Dec 2001 to June 2004
Stage 2: June 2004 to Dec 2009
Stage 3: Dec 2009 to Feb 2012

2.1 SHORT-TERM "PRIMARY CONSOLIDATION"

Section 12.4.2 Settlement of existing solid waste: Eq 12.9, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{c\varepsilon} \times \log \frac{\sigma_0 + \Delta\sigma}{\sigma_0}$$

$C_{c\varepsilon}$ - Modified primary compression index

Assumptions

use Sigma-0 = current vertical stress at layer midpoint
use delta-sigma = vertical stress increase from new waste placement

Preload surcharge (kPa)	25

2.2 LONG-TERM "SECONDARY CONSOLIDATION"

Section 12.4.2 Settlement of existing solid waste: Eq 12.11, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{\alpha\varepsilon} \times \log \frac{t_{final}}{t_{initial}}$$

$C_{\alpha\varepsilon}$ - Modified secondary compression index

Assumptions

use t-initial= average age in Oct 2013
use t-final= t-initial plus 40 years

t initial = starting time of the secondary settlement. Assumed to be equal to the age of the existing landfill for vertical expansion.
t final = ending time of the secondary settlement
MSW assumed to be normally consolidated.

2.1 Short-Term "Primary" Settlement of Liner

Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Chainage (m)	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350	360	370	380	390	400
Thickness of New Landfill Waste Filling Stages (m)																										
Capping Layer	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Total thickness of new waste	0	1.09	3.59	6.1	8.8	11.63	14.46	17.3	18.98	18.97	18.99	17.98	16.45	14.8	13.37	12.34	11.47	10.71	9.91	9.02	7.86	6.75	5.46	3.97	2.34	0.57
Thickness Eastern Gully Filling Stage3	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Sigma-0 (kN/m2)	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00
Delta-sigma (kN/m2)	22.00	33.99	61.49	89.10	118.80	149.93	181.06	212.30	230.78	230.67	230.89	219.78	202.95	184.80	169.07	157.74	148.17	139.81	131.01	121.22	108.46	96.25	82.06	65.67	47.74	28.27
Calc settlement of layer (m)	0.02	0.10	0.24	0.34	0.43	0.49	0.55	0.60	0.63	0.63	0.63	0.61	0.59	0.56	0.53	0.51	0.49	0.47	0.45	0.43	0.40	0.36	0.32	0.26	0.18	0.07
Thickness Eastern Gully Filling Stage2	27.35	29.18	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	28.68	25.24
Sigma-0 (kN/m2)	194.43	204.49	209.00	209.00	209.00	209.00	209.00	209.00	209.00	209.00	209.00	209.00	209.00	209.00	209.00	209.00	209.00	209.00	209.00	209.00	209.00	209.00	209.00	209.00	201.74	182.82
Delta-sigma (kN/m2)	22.00	33.99	61.49	89.10	118.80	149.93	181.06	212.30	230.78	230.67	230.89	219.78	202.95	184.80	169.07	157.74	148.17	139.81	131.01	121.22	108.46	96.25	82.06	65.67	47.74	28.27
Calc settlement of layer (m)	0.02	0.15	0.43	0.68	0.93	1.16	1.38	1.58	1.69	1.69	1.69	1.63	1.52	1.41	1.30	1.22	1.15	1.09	1.02	0.95	0.84	0.74	0.62	0.47	0.29	0.08
Thickness Eastern Gully Filling Stage1b	0.00	0.00	2.58	6.21	7.47	7.89	7.97	8.65	9.18	13.02	14.92	15.89	16.21	15.37	14.01	12.30	10.52	10.17	9.40	8.29	7.36	6.46	4.39	1.73	0.00	0.00
Sigma-0 (kN/m2)	NA	NA	388.19	408.16	415.09	417.40	417.84	421.58	424.49	445.61	456.06	461.40	463.16	458.54	451.06	441.65	431.86	429.94	425.70	419.60	414.48	409.53	398.15	383.52	NA	NA
Delta-sigma (kN/m2)	NA	NA	61.49	89.10	118.80	149.93	181.06	212.30	230.78	230.67	230.89	219.78	202.95	184.80	169.07	157.74	148.17	139.81	131.01	121.22	108.46	96.25	82.06	65.67	NA	NA
Calc settlement of layer (m)	0.00	0.00	0.02	0.08	0.13	0.18	0.22	0.27	0.31	0.42	0.47	0.48	0.45	0.39	0.33	0.28	0.23	0.21	0.18	0.15	0.12	0.09	0.05	0.02	0.00	0.00
Thickness Eastern Gully Filling Stage1a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sigma-0 (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Delta-sigma (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total "Primary" settlement (m)	0.04	0.25	0.69	1.10	1.48	1.84	2.15	2.45	2.63	2.74	2.80	2.72	2.56	2.36	2.16	2.01	1.87	1.77	1.66	1.53	1.36	1.20	0.99	0.74	0.47	0.15

2.2 Long-Term "Secondary" Settlement of Liner

Note: for the purpose of this secondary settlement calculation, all piggy back liner and overlying new waste is assumed to be placed at the same time.

Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
New Waste																										
Total Thickness	0.00	1.09	3.59	6.10	8.80	11.63	14.46	17.30	18.98	18.97	18.99	17.98	16.45	14.80	13.37	12.34	11.47	10.71	9.91	9.02	7.86	6.75	5.46	3.97	2.34	0.57
Old Waste																										
Thickness Eastern Gully Filling Stage3	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
T-initial (yr)	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
T-final (yr)	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50
Calc settlement of layer (m)	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
Thickness Eastern Gully Filling Stage2	27.35	29.18	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	28.68	25.24
T-initial (yr)	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
T-final (yr)	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00
Calc settlement of layer (m)	1.41	1.50	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.48	1.30
Thickness Eastern Gully Filling Stage1b	0.00	0.00	2.58	6.21	7.47	7.89	7.97	8.65	9.18	13.02	14.92	15.89	16.21	15.37	14.01	12.30	10.52	10.17	9.40	8.29	7.36	6.46	4.39	1.73	0.00	0.00
T-initial (yr)	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50
T-final (yr)	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50
Calc settlement of layer (m)	0.00	0.00	0.12	0.28	0.34	0.36	0.36	0.39	0.42	0.59	0.68	0.72	0.74	0.70	0.64	0.56	0.48	0.46	0.43	0.38	0.34	0.29	0.20	0.08	0.00	0.00
Thickness Eastern Gully Filling Stage1a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30
T-final (yr)	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total "Secondary" settlement(m)	**1.72**	**1.81**	**1.97**	**2.13**	**2.19**	**2.21**	**2.22**	**2.25**	**2.27**	**2.45**	**2.53**	**2.58**	**2.59**	**2.55**	**2.49**	**2.41**	**2.33**	**2.32**	**2.28**	**2.23**	**2.19**	**2.15**	**2.05**	**1.93**	**1.78**	**1.61**

Settlement of natural ground are negligible.

Sum of calculated "Primary" and "Secondary" settlement (m)	1.75	2.06	2.66	3.24	3.68	4.05	4.36	4.70	4.90	5.19	5.33	5.29	5.15	4.91	4.65	4.42	4.20	4.09	3.94	3.76	3.55	3.34	3.04	2.67	2.25	1.76

2. EXISTING WASTE SETTLEMENT CALCULATION

Eastern Gully Landfill - Section G-G'

TABLE A5

Waste Materials	Old waste				New Waste	Basis of adopted value
Material	stage 1a	stage 1b	stage 2	Stage 3		
waste type	MSW	MSW	MSW	MSW	New	from available site information
Unit Weight (kN/m3)	11	11	11	11	11	assumed based on waste type
C-ce (mod primary)	0.2	0.2	0.2	0.2	NA	range from Gourc & Olivier (2005) is 0.12 to >0.24
C-c alph (mod secondary)	0.07	0.07	0.07	0.07	NA	range from Gourc & Olivier (2005) is 0.02 to >0.14
average age in mid 2013(yr)	20.3	11.5	9	3.5	-	from available site information

Filling Stages :
Stage 1a: Feb 1993 to Dec 2001
Stage 1b: Dec 2001 to June 2004
Stage 2: June 2004 to Dec 2009
Stage 3: Dec 2009 to Feb 2012

2.1 SHORT-TERM "PRIMARY CONSOLIDATION"

Section 12.4.2 Settlement of existing solid waste: Eq 12.9, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{c\varepsilon} \times \log \frac{\sigma_0 + \Delta\sigma}{\sigma_0}$$

$C_{c\varepsilon}$ - Modified primary compression index

Assumptions

use Sigma-0 = current vertical stress at layer midpoint
use delta-sigma = vertical stress increase from new waste placement

Preload surcharge (kPa)	25

2.2 LONG-TERM "SECONDARY CONSOLIDATION"

Section 12.4.2 Settlement of existing solid waste: Eq 12.11, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{\alpha\varepsilon} \times \log \frac{t_{final}}{t_{initial}}$$

$C_{\alpha\varepsilon}$ - Modified secondary compression index

Assumptions

use t-initial= average age in Oct 2013
use t-final= t-initial plus 40 years

t initial = starting time of the secondary settlement. Assumed to be equal to the age of the existing landfill for vertical expansion.
t final = ending time of the secondary settlement
MSW assumed to be normally consolidated.

2.1 Short-Term "Primary" Settlement of Liner

Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	0
Chainage (m)	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	0
Thickness of New Landfill Waste Filling Stages (m)																										
Capping Layer	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Total thickness of new waste	9.49	11.54	11.58	12.24	11.82	11.18	11.87	12.58	11.76	11.55	11.1	11.22	10.71	11.68	11.45	12.15	12.9	13.1	12.32	12.01	9.53	5.58	3.52	1.61	-0.18	0
Thickness Eastern Gully Filling Stage3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.26	3.48	3.72	3.63	3.38	0.00
Sigma-0 (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6.93	19.14	20.46	19.97	18.59	NA
Delta-sigma (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	126.83	83.38	60.72	39.71	20.02	NA
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.30	0.23	0.13	0.01	0.00
Thickness Eastern Gully Filling Stage2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.05	6.38	9.10	12.43	14.22	16.38	14.63	13.52	12.69	12.01	11.43	10.00	6.67	3.33	0.00	0.00	0.00
Sigma-0 (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	16.78	35.09	50.05	68.37	78.21	90.09	80.45	74.38	69.79	66.04	62.88	68.86	74.95	59.25	39.93	NA	NA
Delta-sigma (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	149.05	144.10	145.42	139.81	150.48	147.95	155.65	163.90	166.10	157.52	154.11	126.83	83.38	60.72	39.71	NA	NA
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.66	0.81	0.92	1.04	1.09	1.08	1.08	1.06	0.99	0.95	0.68	0.29	0.12	0.00	0.00	0.00
Thickness Eastern Gully Filling Stage1b	1.40	1.82	4.30	5.88	8.70	11.78	12.99	14.31	17.14	16.20	12.87	9.53	6.20	2.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sigma-0 (kN/m2)	7.70	10.01	23.65	32.34	47.85	64.79	71.45	78.71	94.27	122.65	140.95	152.53	170.83	172.19	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Delta-sigma (kN/m2)	126.39	148.94	149.38	156.64	152.02	144.98	152.57	160.38	151.36	149.05	144.10	145.42	139.81	150.48	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calc settlement of layer (m)	0.20	0.27	0.52	0.66	0.82	0.92	1.01	1.10	1.13	0.90	0.64	0.45	0.26	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Eastern Gully Filling Stage1a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.38	4.86	7.54	10.46	12.69	15.35	18.68	20.30	22.31	24.09	26.00	27.28	28.28	27.99	24.32	0.00
Sigma-0 (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	224.82	231.68	246.40	245.50	249.98	245.34	251.48	251.24	254.80	258.24	266.86	261.67	233.11	193.88	170.94	NA
Delta-sigma (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	144.10	145.42	139.81	150.48	147.95	155.65	163.90	166.10	157.52	154.11	126.83	83.38	60.72	39.71	20.02	NA
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.17	0.24	0.36	0.42	0.55	0.69	0.76	0.78	0.82	0.71	0.48	0.36	0.21	0.05	0.00
Total "Primary" settlement (m)	0.20	0.27	0.52	0.66	0.82	0.92	1.01	1.10	1.13	1.31	1.37	1.43	1.42	1.53	1.52	1.63	1.77	1.82	1.77	1.77	1.58	1.07	0.71	0.34	0.05	0.00

2.2 Long-Term "Secondary" Settlement of Liner

Note: for the purpose of this secondary settlement calculation, all piggy back liner and overlying new waste is assumed to be placed at the same time.

Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	0
New Waste																										
Total Thickness	9.49	11.54	11.58	12.24	11.82	11.18	11.87	12.58	11.76	11.55	11.10	11.22	10.71	11.68	11.45	12.15	12.90	13.10	12.32	12.01	9.53	5.58	3.52	1.61	-0.18	0.00
Old Waste																										
Thickness Eastern Gully Filling Stage3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.26	3.48	3.72	3.63	3.38	0.00
T-initial (yr)	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
T-final (yr)	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.27	0.28	0.28	0.26	0.00
Thickness Eastern Gully Filling Stage2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.05	6.38	9.10	12.43	14.22	16.38	14.63	13.52	12.69	12.01	11.43	10.00	6.67	3.33	0.00	0.00	0.00
T-initial (yr)	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
T-final (yr)	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.33	0.47	0.64	0.73	0.84	0.75	0.70	0.65	0.62	0.59	0.52	0.34	0.17	0.00	0.00	0.00
Thickness Eastern Gully Filling Stage1b	1.40	1.82	4.30	5.88	8.70	11.78	12.99	14.31	17.14	16.20	12.87	9.53	6.20	2.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50
T-final (yr)	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50
Calc settlement of layer (m)	0.06	0.08	0.20	0.27	0.40	0.54	0.59	0.65	0.78	0.74	0.59	0.43	0.28	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Eastern Gully Filling Stage1a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.38	4.86	7.54	10.46	12.69	15.35	18.68	20.30	22.31	24.09	26.00	27.28	28.28	27.99	24.32	0.00
T-initial (yr)	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30
T-final (yr)	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.16	0.25	0.35	0.42	0.51	0.62	0.67	0.74	0.80	0.86	0.90	0.94	0.93	0.80	0.00
Total "Secondary" settlement(m)	**0.06**	**0.08**	**0.20**	**0.27**	**0.40**	**0.54**	**0.59**	**0.65**	**0.78**	**0.90**	**0.99**	**1.06**	**1.17**	**1.21**	**1.26**	**1.26**	**1.31**	**1.33**	**1.36**	**1.39**	**1.47**	**1.51**	**1.39**	**1.20**	**1.06**	**0.00**

Settlement of natural ground are negligible.

Sum of calculated "Primary" and "Secondary" settlement (m)	0.26	0.36	0.71	0.93	1.21	1.46	1.60	1.75	1.92	2.20	2.37	2.49	2.60	2.74	2.78	2.89	3.08	3.14	3.13	3.16	3.05	2.58	2.10	1.54	1.12	0.00

117625003 Whytes Gully New Landfill Cell

2. EXISTING WASTE SETTLEMENT CALCULATION

Eastern Gully Landfill - Section G-G

TABLE A6

Waste Materials	Old waste				New Waste	Basis of adopted value
Material	stage 1a	stage 1b	stage 2	Stage 3		
waste type	MSW	MSW	MSW	MSW	New	from available site information
Unit Weight (kN/m3)	11	11	11	11	11	assumed based on waste type
C-ce (mod primary)	0.2	0.2	0.2	0.2	NA	range from Gourc & Olivier (2005) is 0.12 to >0.24
C-c alph (mod secondary)	0.07	0.07	0.07	0.07	NA	range from Gourc & Olivier (2005) is 0.02 to >0.14
average age in mid 2013(yr)	20.3	11.5	9	3.5	-	from available site information

Filling Stages :
Stage 1a: Feb 1993 to Dec 2001
Stage 1b: Dec 2001 to June 2004
Stage 2: June 2004 to Dec 2009
Stage 3: Dec 2009 to Feb 2012

2.1 SHORT-TERM "PRIMARY CONSOLIDATION"

Section 12.4.2 Settlement of existing solid waste: Eq 12.9, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{c\varepsilon} \times \log \frac{\sigma_0 + \Delta\sigma}{\sigma_0}$$

$C_{c\varepsilon}$ - Modified primary compression index

Assumptions

use Sigma-0 = current vertical stress at layer midpoint
use delta-sigma = vertical stress increase from new waste placement

Preload surcharge (kPa)	25

2.2 LONG-TERM "SECONDARY CONSOLIDATION"

Section 12.4.2 Settlement of existing solid waste: Eq 12.11, Ref Xuede, Koerner and Gray P.451

$$s = H \times C_{\alpha\varepsilon} \times \log \frac{t_{final}}{t_{initial}}$$

$C_{\alpha\varepsilon}$ - Modified secondary compression index

Assumptions

use t-initial= average age in Oct 2013
use t-final= t-initial plus 40 years

t initial = starting time of the secondary settlement. Assumed to be equal to the age of the existing landfill for vertical expansion.
t final = ending time of the secondary settlement
MSW assumed to be normally consolidated.

2.1 Short-Term "Primary" Settlement of Liner

Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	0
Chainage (m)	50	90	140	180	220	260	270	280	290	300	310	320	330	340	350	360	370	380	390	400	410	420	430	440	450	0
Thickness of New Landfill Waste Filling Stages (m)																										
Capping Layer	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Total thickness of new waste	11.19	15.97	16.31	21.07	27.38	34.36	32.97	31.41	29.68	28.33	26.53	24.82	22.33	19.83	15.46	10.62	5.79	0.96	0	0	0	0	0	0	0	0
Thickness Eastern Gully Filling Stage3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.16	6.17	9.33	12.22	15.07	17.85	16.83	14.67	12.62	10.60	8.80	7.30	4.18	0.00
Sigma-0 (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	17.38	33.94	51.32	67.21	82.89	98.18	92.57	80.68	69.41	58.30	48.40	40.15	22.99	NA
Delta-sigma (kN/m2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	267.63	240.13	192.06	138.82	85.69	32.56	22.00	22.00	22.00	22.00	22.00	22.00	22.00	NA
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.87	0.99	0.91	0.64	0.15	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00
Thickness Eastern Gully Filling Stage2	0.00	0.00	0.23	7.14	12.81	9.14	7.99	6.21	4.61	2.62	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sigma-0 (kN/m2)	NA	NA	1.26	39.27	70.46	50.27	43.93	34.17	25.36	14.39	5.96	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Delta-sigma (kN/m2)	NA	NA	201.41	253.77	323.18	399.96	384.67	367.51	348.48	333.63	313.83	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calc settlement of layer (m)	0.00	0.00	0.05	0.99	1.63	1.47	1.32	1.08	0.85	0.53	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Eastern Gully Filling Stage1b	0.00	9.73	21.81	20.23	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sigma-0 (kN/m2)	NA	53.52	122.49	189.81	168.41	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Delta-sigma (kN/m2)	NA	197.67	201.41	253.77	323.18	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calc settlement of layer (m)	0.00	1.04	1.55	1.31	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Eastern Gully Filling Stage1a	0.00	0.00	0.00	0.00	15.23	26.41	28.74	30.85	32.30	33.26	35.05	37.16	34.96	32.60	30.39	28.64	27.35	26.92	26.32	24.38	23.39	20.57	14.32	7.94	4.13	0.00
Sigma-0 (kN/m2)	NA	NA	NA	NA	279.68	245.80	245.94	238.00	228.36	211.73	204.67	204.38	227.04	247.17	269.78	291.94	316.20	344.41	329.89	295.46	267.47	229.74	175.56	123.97	68.70	NA
Delta-sigma (kN/m2)	NA	NA	NA	NA	323.18	399.96	384.67	367.51	348.48	333.63	313.83	295.02	267.63	240.13	192.06	138.82	85.69	32.56	22.00	22.00	22.00	22.00	22.00	22.00	22.00	NA
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.92	2.03	2.15	2.28	2.36	2.46	2.54	2.57	2.10	1.69	1.22	0.80	0.42	0.07	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Total "Primary" settlement (m)	0.00	1.04	1.60	2.30	2.97	3.50	3.47	3.36	3.21	3.00	2.78	2.57	2.66	2.57	2.22	1.71	1.06	0.23	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.00

2.2 Long-Term "Secondary" Settlement of Liner

Note: for the purpose of this secondary settlement calculation, all piggy back liner and overlying new waste is assumed to be placed at the same time.

Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	0
New Waste																										
Total Thickness	11.19	15.97	16.31	21.07	27.38	34.36	32.97	31.41	29.68	28.33	26.53	24.82	22.33	19.83	15.46	10.62	5.79	0.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Old Waste																										
Thickness Eastern Gully Filling Stage3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.16	6.17	9.33	12.22	15.07	17.85	16.83	14.67	12.62	10.60	8.80	7.30	4.18	0.00
T-initial (yr)	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
T-final (yr)	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.47	0.71	0.94	1.15	1.37	1.29	1.12	0.97	0.81	0.67	0.56	0.32	0.00
Thickness Eastern Gully Filling Stage2	0.00	0.00	0.23	7.14	12.81	9.14	7.99	6.21	4.61	2.62	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
T-final (yr)	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00
Calc settlement of layer (m)	0.00	0.00	0.01	0.37	0.66	0.47	0.41	0.32	0.24	0.13	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Eastern Gully Filling Stage1b	0.00	9.73	21.81	20.23	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-initial (yr)	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50
T-final (yr)	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50
Calc settlement of layer (m)	0.00	0.44	0.99	0.92	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thickness Eastern Gully Filling Stage1a	0.00	0.00	0.00	0.00	15.23	26.41	28.74	30.85	32.30	33.26	35.05	37.16	34.96	32.60	30.39	28.64	27.35	26.92	26.32	24.38	23.39	20.57	14.32	7.94	4.13	0.00
T-initial (yr)	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30	20.30
T-final (yr)	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30	60.30
Calc settlement of layer (m)	0.00	0.00	0.00	0.00	0.50	0.87	0.95	1.02	1.07	1.10	1.16	1.23	1.16	1.08	1.01	0.95	0.91	0.89	0.87	0.81	0.77	0.68	0.47	0.26	0.14	0.00
Total "Secondary" settlement(m)	**0.00**	**0.44**	**1.01**	**1.29**	**1.39**	**1.34**	**1.36**	**1.34**	**1.31**	**1.24**	**1.22**	**1.23**	**1.40**	**1.55**	**1.72**	**1.88**	**2.06**	**2.26**	**2.16**	**1.93**	**1.74**	**1.49**	**1.15**	**0.82**	**0.46**	**0.00**

Settlement of natural ground are negligible.

Sum of calculated "Primary" and "Secondary" settlement (m)	0.00	1.48	2.61	3.59	4.36	4.85	4.83	4.70	4.51	4.23	4.00	3.80	4.06	4.12	3.94	3.59	3.12	2.48	2.19	1.96	1.77	1.52	1.18	0.85	0.48	0.00

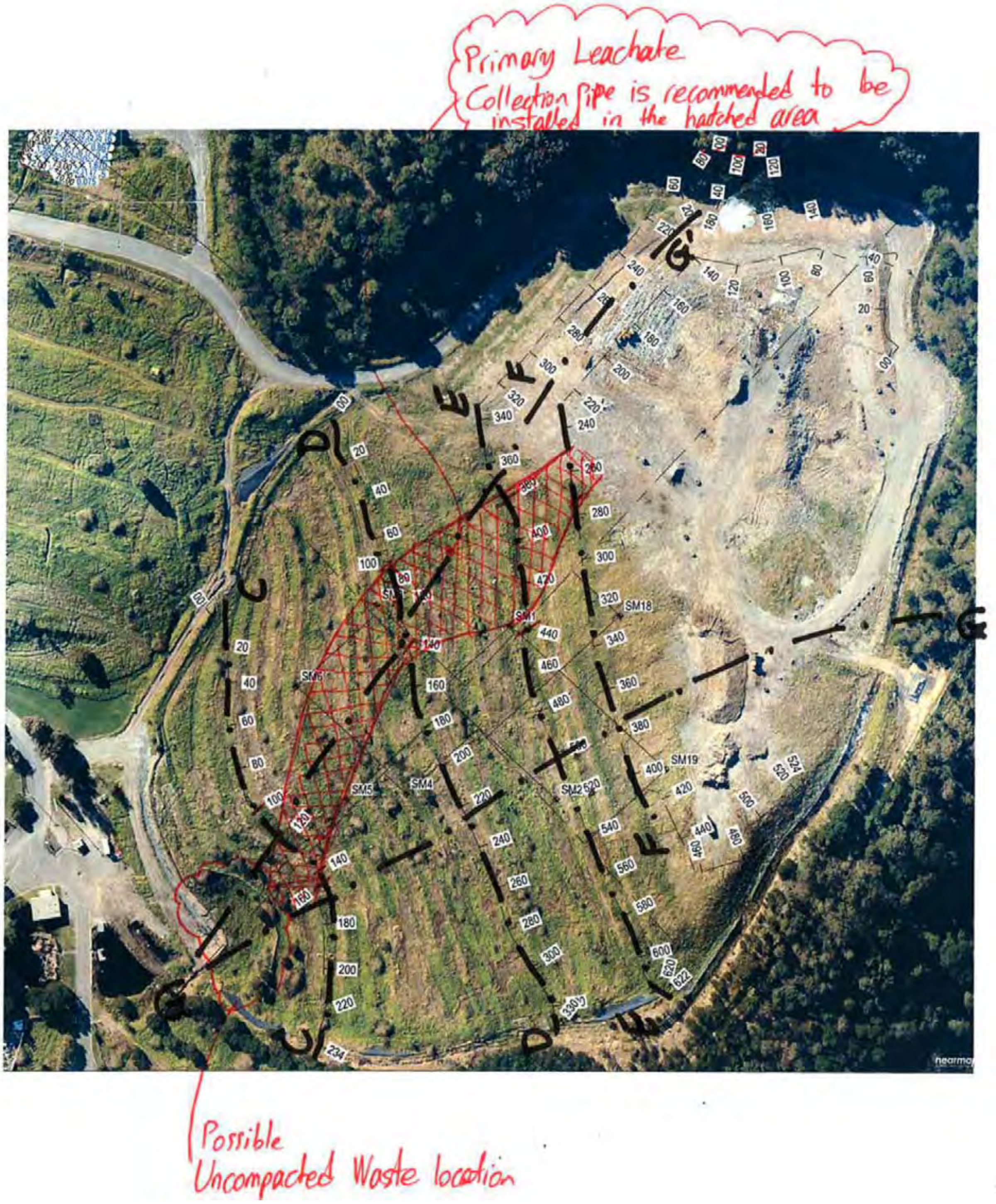
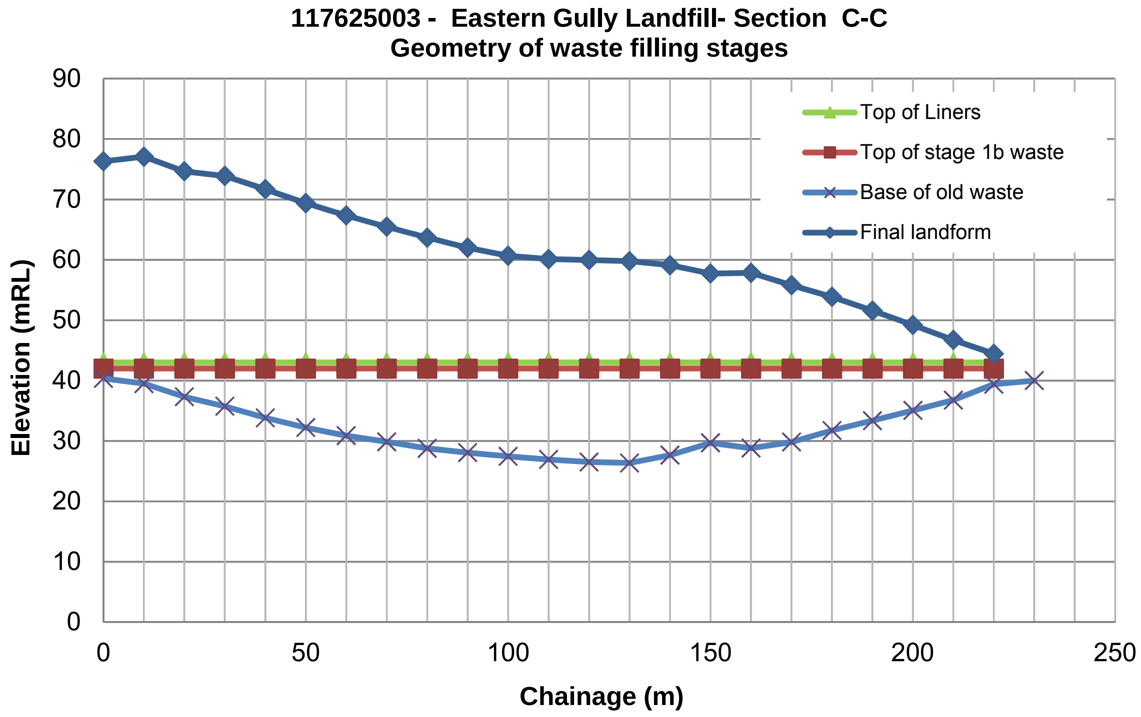
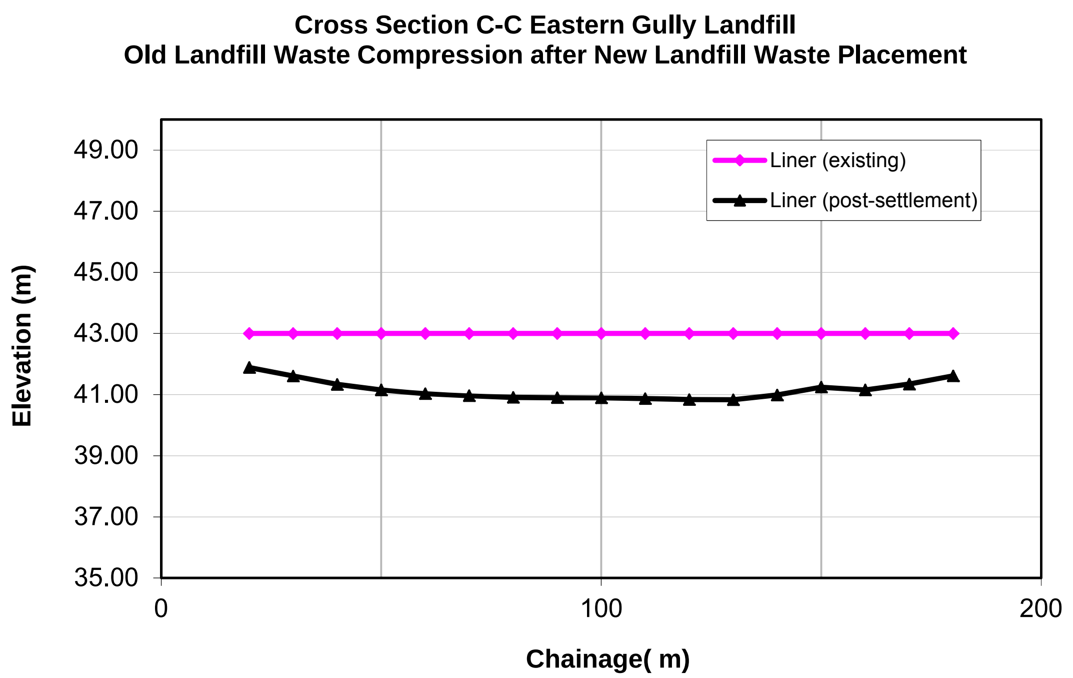


Figure 1– WGRRP - Eastern Gully Plan and analysed sections.

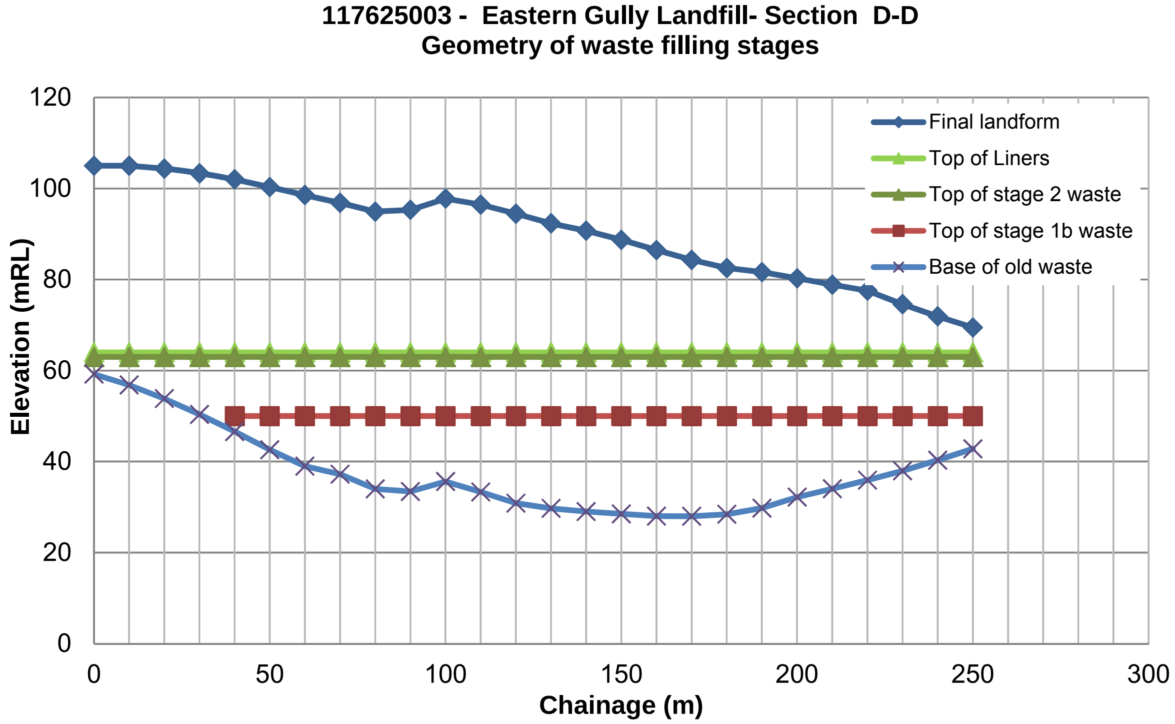


(a)

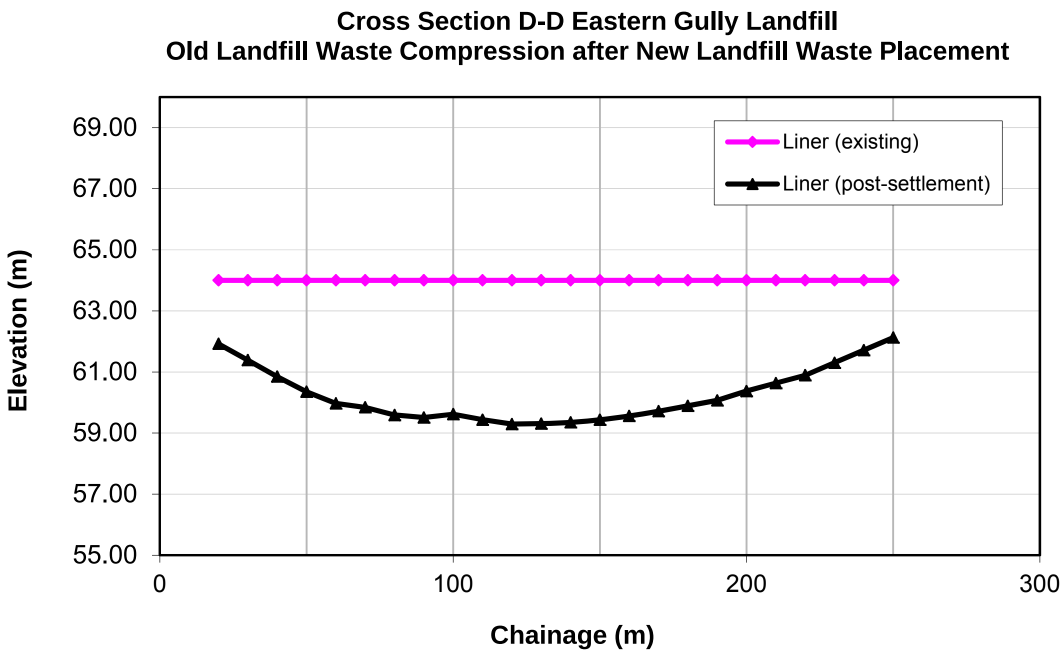


(b)

Figure 2- Section C-C (a) settlement model stratigraphy, and (b) anticipated elevations in year 2055.

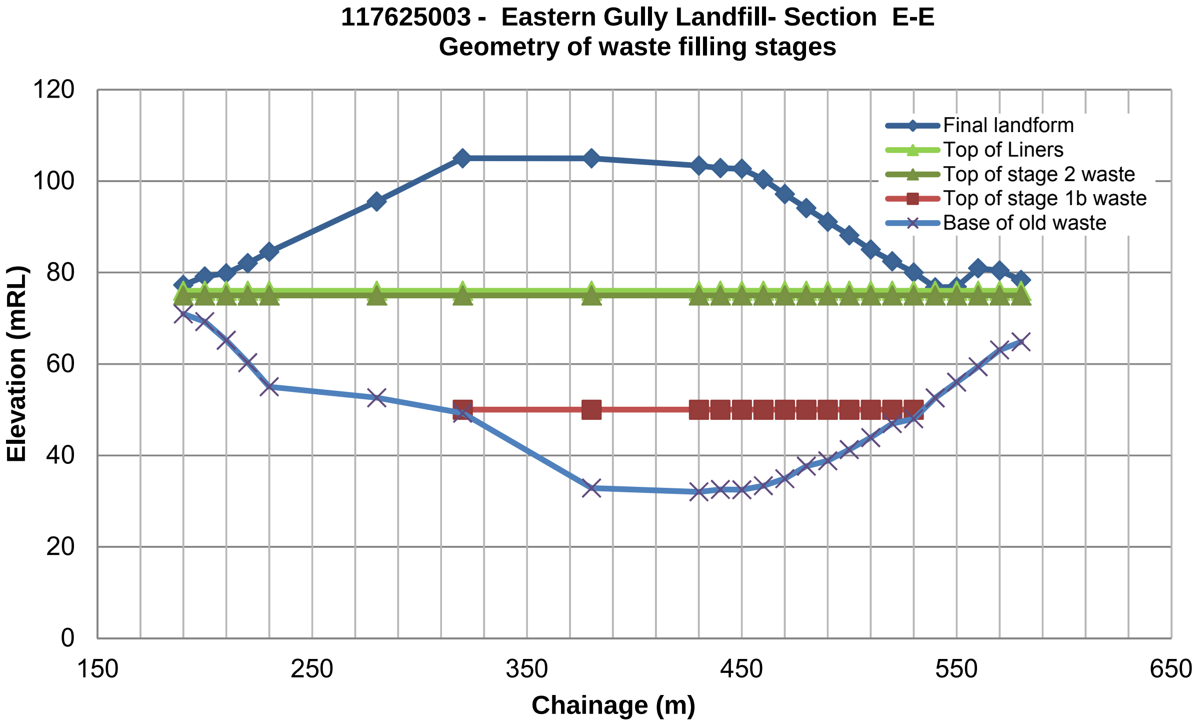


(a)

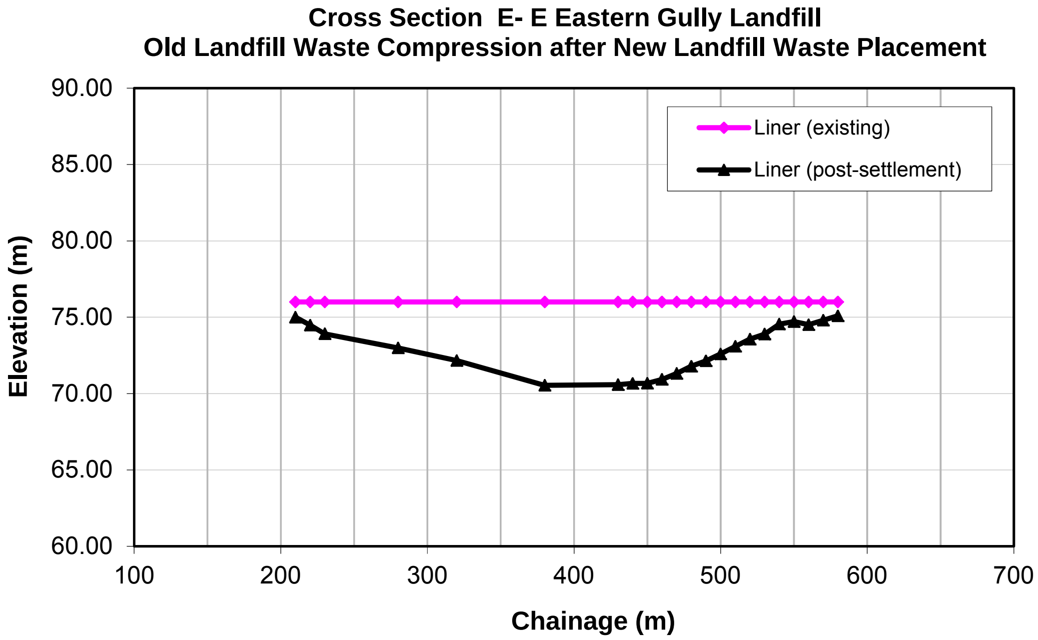


(b)

Figure 3- Section D-D: (a) settlement model stratigraphy, and (b) anticipated elevations in year 2055.

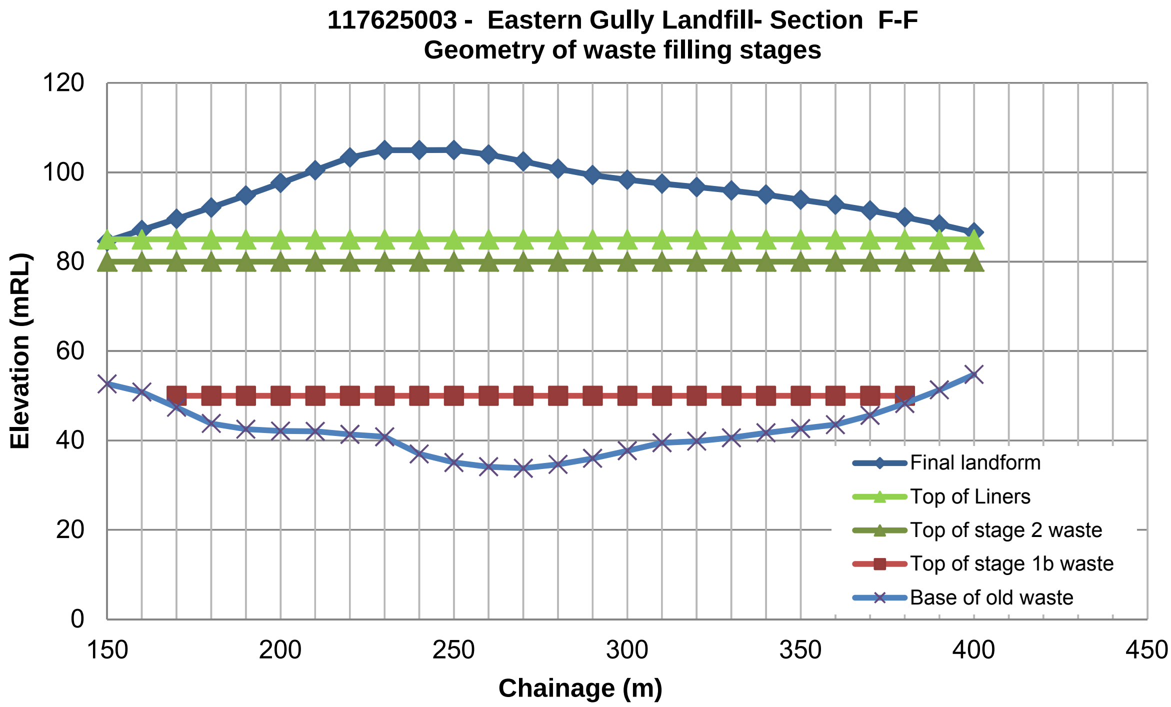


(a)

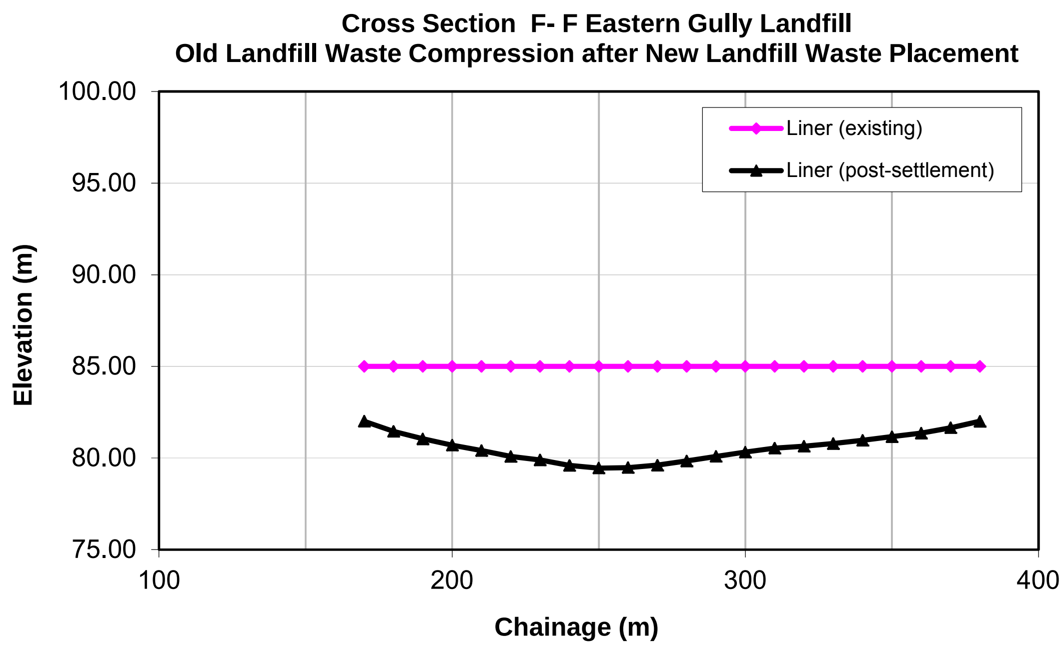


(b)

Figure 4- Section E-E: (a) settlement model stratigraphy, and (b) anticipated elevations in year 2055.

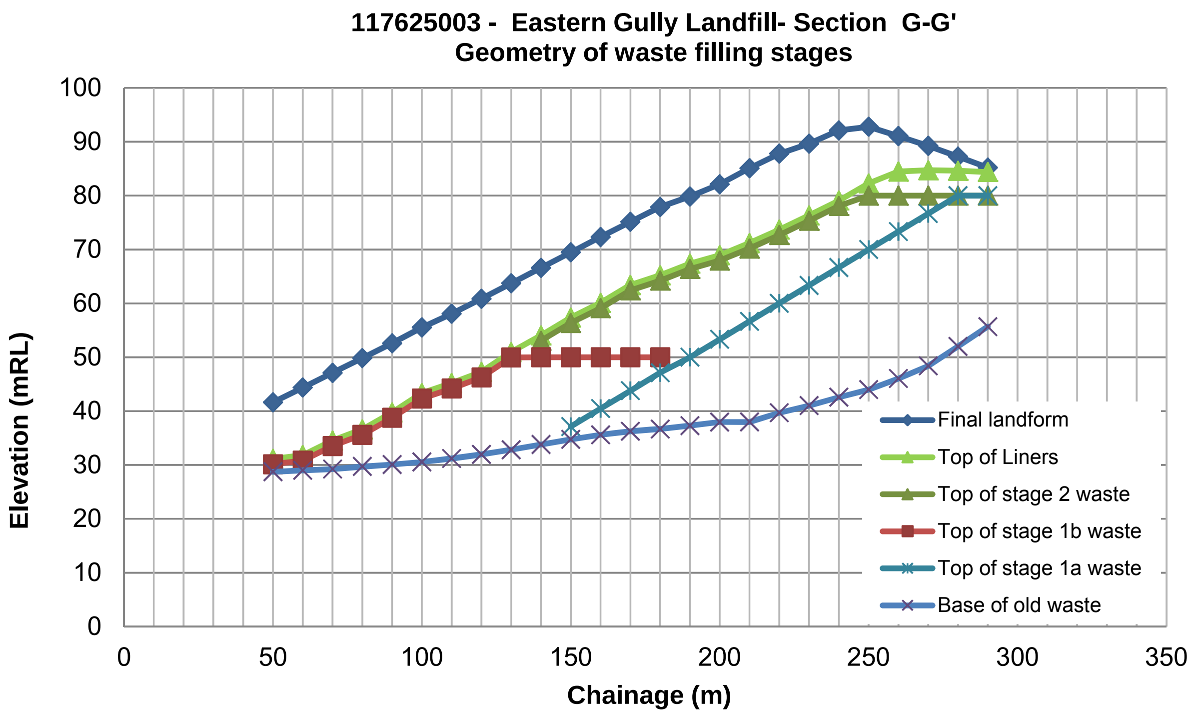


(a)

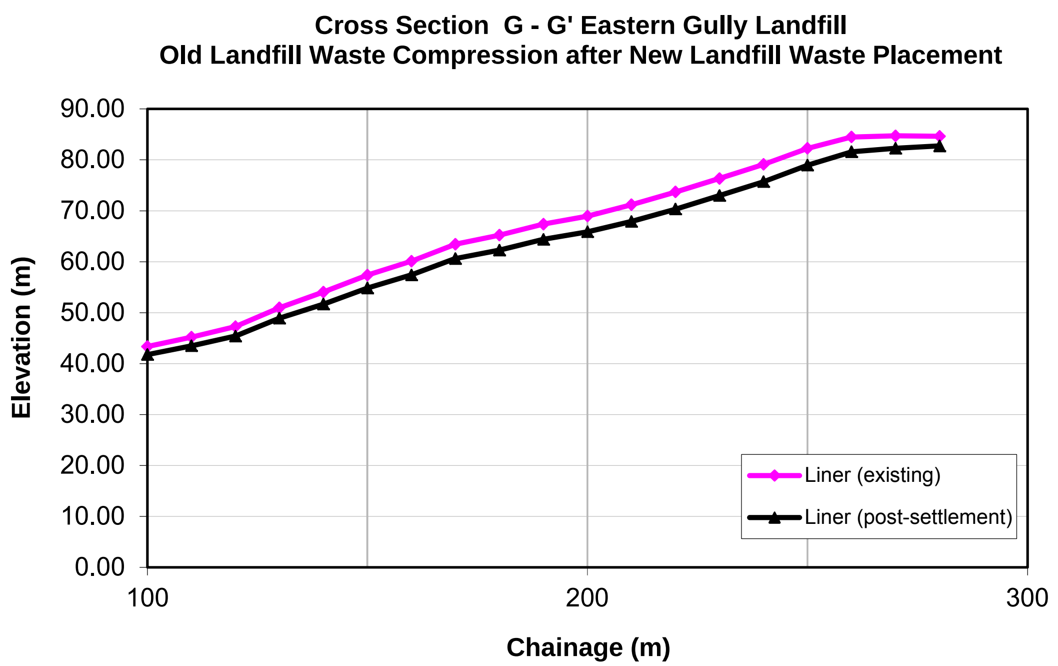


(b)

Figure 5- Section F-F: (a) settlement model stratigraphy, and (b) anticipated elevations in year 2055.

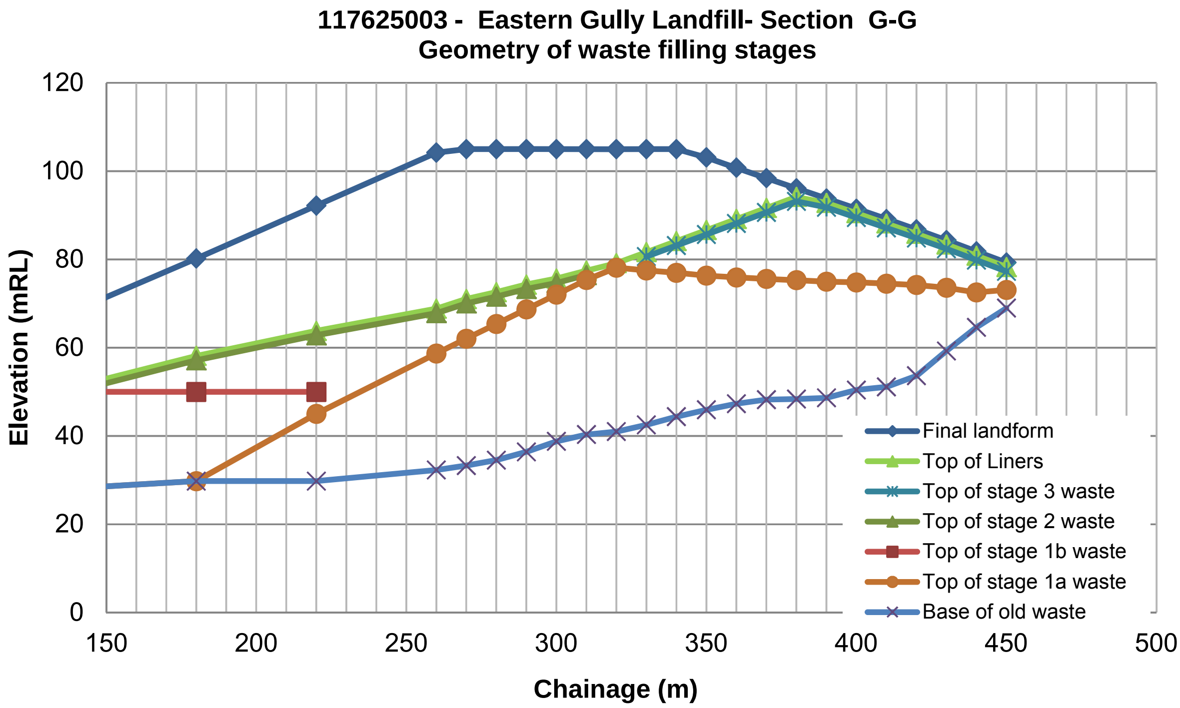


(a)

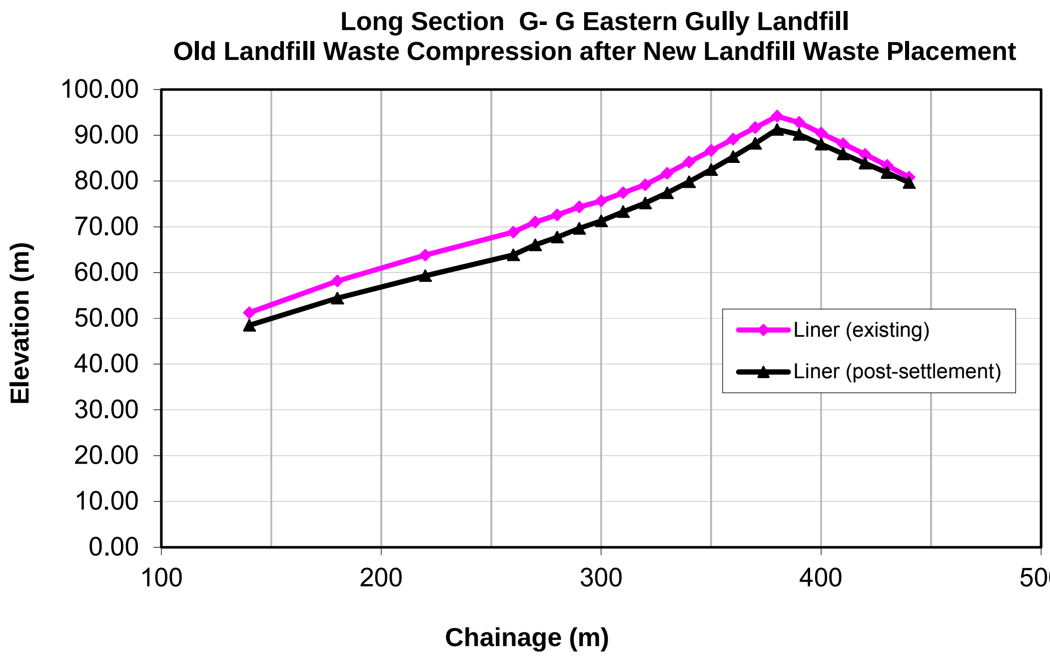


(b)

Figure 6- Section G-G': (a) settlement model stratigraphy, and (b) anticipated elevations in year 2055.



(a)



(b)

Figure 7- Section G-G: (a) settlement model stratigraphy, and (b) anticipated elevations in year 2055.

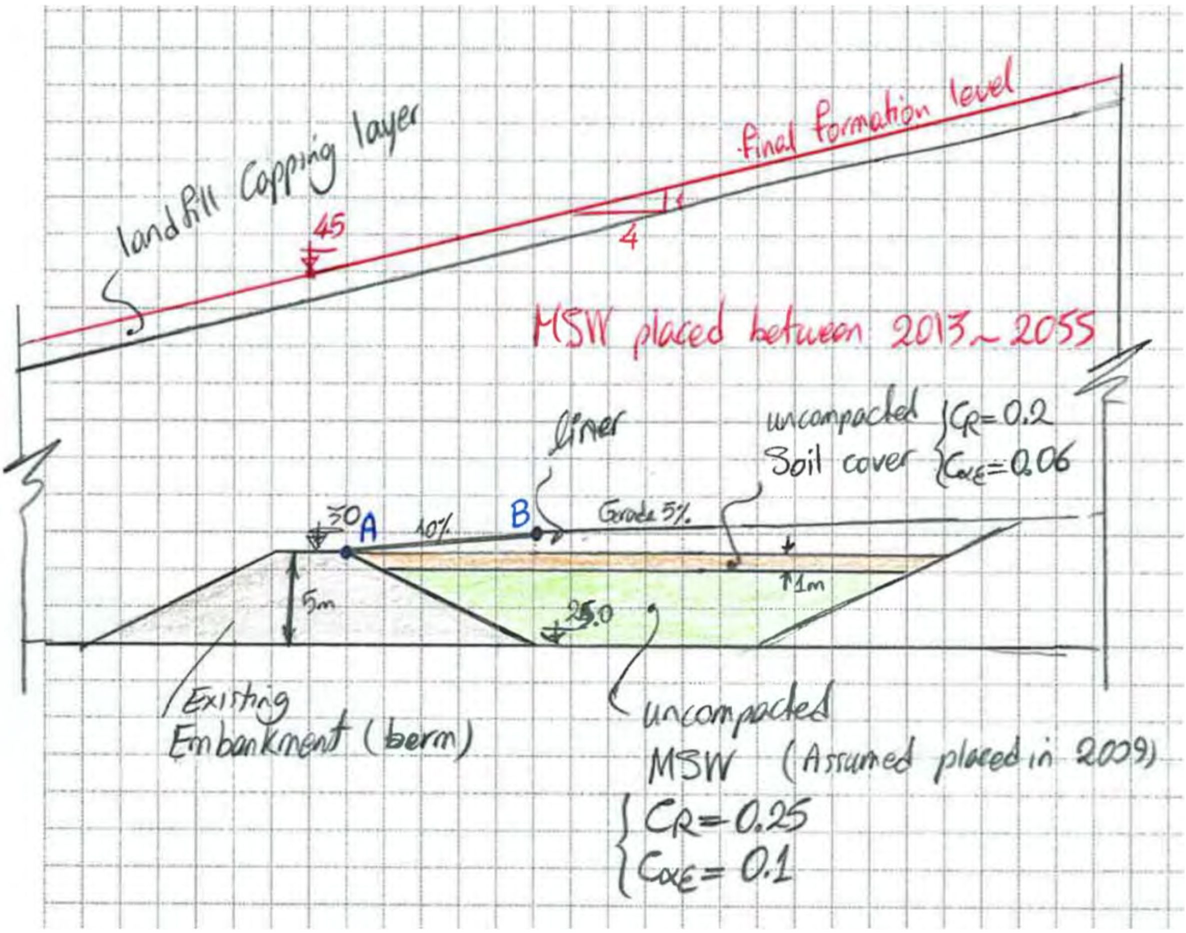


Figure 8- Stratigraphy and model parameters assumed at the uncompacted waste location (see also Figure 1).

TECHNICAL MEMORANDUM

DATE 30 May 2013 **REFERENCE No.** 117625003_256_M_Rev0

TO Michael Herraman
Wollongong City Council

CC Gary Schmertmann

FROM Saman Zargarbashi **EMAIL** szargarbashi@golder.com.au

WHYTES GULLY RESOURCE RECOVERY PARK (WGRRP) NEW LANDFILL CELL – SETTLEMENT ANALYSES FOR PIGGY BACK LINER AROUND HYPOTHETICAL SOFT SPOTS

1.0 INTRODUCTION

Golder Associates (Golder) has previously undertaken finite element PLAXIS analyses to model the performance of the piggy back liner and the new landfill cell base liner during the various stages of construction and operation. The assessment was presented in the Appendix D of the Golder Report 'Interpretative Geotechnical Investigation Report for 50% Design', No. 117625003_059_R_Rev 1, dated April 2012 ('Golder (2012)').

Since then, we have studied the settlements observed due to the trial pads in the WGRRP Western Gully (WG) and at the settlement monuments installed in the Eastern Gully (EG), as detailed in the Golder Memos No. 117625003-253-M-Rev0 and 117625003-254-M-Rev0, and we obtained more information about compressibility of the existing waste materials. This assessment presents revised PLAXIS finite element analyses, which were carried out to assess forces and strains within the liner systems resulting from differential settlement around hypothetical soft spots below piggy back liner, and uses updated compressibility parameters for existing waste materials in the EG and WG.

2.0 MODELLING APPROACH

"Local" axisymmetric PLAXIS models were developed to represent hypothetical circular soft spots in the western and eastern gullies in order to assess the interaction between the existing landfill materials and the proposed new landfill materials and potential local deformations of the piggy back liner. The models incorporate two geosynthetic layers (geogrid and geomembrane) within the piggy back liner and a nominally sized buried soft spot within the existing landfill. Further details of the modelling approach have been presented in the Golder (2012) report.

The components of the piggy back liner design are unchanged from those proposed at the time of preliminary design and are as modelled in the Golder (2012) report. The piggy back liner is shown schematically in Figure 1 below.

3.0 MATERIAL PROPERTIES

Material properties used in the analyses are summarised in Table 1, attached. Compressibility parameters were selected based on the back calculation analyses carried out using trial pads settlements and readings at the settlement monuments, as presented in the Golder memos No. 117625003_253_M_Rev0 and 117625003_254_M_Rev0.

As the landfill behaviour is expected to be dominated by global creep settlements resulting from ongoing decomposition of the landfill, the "soft soil creep" constitutive model in PLAXIS was adopted for the landfill materials (Unit 41) including the prepared cohesive subgrade overlying the existing landfill.

An elasto-plastic Mohr-Coulomb constitutive model was adopted for base material (Unit 6) within the liner system and compacted clay-rich bearing material (Unit 4).

The geogrid and geomembrane components were modelled using structural ‘Geogrid’ elements provided in PLAXIS . The stress-strain characteristics for these components were estimated from typical laboratory test data from manufacturers and published literature. In the PLAXIS model, tensile stiffness is input as modulus times cross sectional area (EA) properties, compressive stiffness is assumed negligible. Factored base case EA values of 500 kN/m and 80 KN/m have been adopted for the geogrid and LLDPE layers, respectively, based on values used in previous projects. These factored design values correspond to equivalent stiffness material reduction factors (in the direction of the geogrid bars) of 1.6 on a medium-weight geogrid product such as Secugrid 40/40 Q1 , and a factor of approximately 8 for the 1.5mm thick LLDPE geomembrane liner such as Permathene L200. We note that these factors are intended to reflect a stiffness reduction due to installation damage, creep and other factors, and are considered reasonable for the purpose of this modelling. We also note that the axisymmetric nature of the model implies that the geosynthetic layers can act in all horizontal directions, and we have considered this is preparing the project technical specifications for the geogrid, which is typically a distinctly directional product.

The soil/geotextile interfaces in PLAXIS are modelled as having zero thickness, along which sliding can occur, according to user-defined strength and stiffness properties. Interfaces were modelled using the appropriate interface element shear strength properties summarised in Figure 1, below. The soil/geotextile interface stiffness properties which apply before yielding are equal to the adjacent host soil properties. The sensitivity of the design to interface stiffness was checked by doubling the interface stiffness, but this had an insignificant effect on mobilised liner forces.

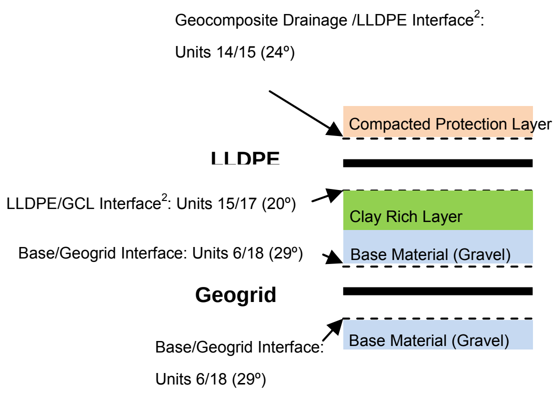


Figure 1: Piggy back liner details (placed on top of existing landfill)

4.0 PLAXIS AXISYMMETRIC ANALYSIS

4.1 Analyses Sections

Axisymmetric models for WG and EG were created near the location of maximum new landfill thickness to explore geogrid and liner behaviour at a more localised level of detail. The main purpose of the axisymmetric model is to assess the impact of a potential softer area within the existing landfill on tensile strains in the LLDPE geomembrane. The results will then be further considered via superposition with predicted tensile strains from calculations considering other differential settlement mechanisms (Golder Memo No. 117625003-255-M-Rev0).

To perform an upper bound assessment of variation in landfill compressibility over a short distance, a hypothetical zone of “soft landfill” was introduced into the model as a zone measuring 6m in diameter and 5m thick, buried 2m below the piggy back liner in an area of higher stiffness existing landfill. A study carried out for a similar landfill in Victoria[1] identified this soft spot geometry as reasonable in terms of differential settlements on the basis that some excavation and surface compaction of existing landfill materials will be carried out to shallow depths below the liner in the course of subgrade preparation for piggy back liner installation (Manassero, 2006). This is also considered the case for the current analyses based on the subgrade preparation specifications prepared by Golder for the Whytes Gully project. Overall, we consider that this soft spot geometry provides a reasonable basis for analysing the effects of potential landfill variability on piggy back liner performance. We note that existence of a soft spot as described above is less likely for upper waste layers placed in recent years in the Eastern Gully landfill due to better waste placement management implemented in recent years. Nevertheless, in this assessment we have used similar soft spot geometry for both the Eastern Gully and Western Gully models.

4.2 Construction Sequence

Assumed filling history of the Western Gully landfill and Eastern Gully landfill are shown in Figures 2 and 3, respectively, which are based on available historical survey plans and the filling plans developed for the preliminary design. These are considered relevant for the PLAXIS modelling for detailed design.

Western Gully:

The construction sequence and timing used for the PLAXIS axisymmetric analysis for the Western Gully are the same as adopted for the Golder (2012) report and are as follows:

1) Old fill placement:
   - to RL 70 m and consolidation for 7 years (end 1991);
   - to RL 73 m and consolidation for 5 years (end 1996);
   - to RL 85 m and consolidation for 15 years (end 2011);

   Note: the modelled sequence underestimates the age of the existing Western Gully waste above RL 70, which was actually placed between 1991 and 1993, but this is considered to be conservative as the younger landfill in the as-modelled condition will experience larger post-construction creep settlements
2) Liner Placement (2013);
3) New fill placement :
   - to RL 73 m and consolidation for 20 years (end 2032);
   - to RL 82 m and consolidation for 10 years (end 2042);
   - to RL 93 m and consolidation for 10 years (end 2052);
   - to RL 112 m and consolidation for 9 years (end 2061); and
4) Consolidation for 40 years (end 2101).

Eastern Gully:

The construction sequence and timing used for the PLAXIS axisymmetric analysis for the Eastern Gully are as follows:

1) Old fill placement to RL 72.5 m and consolidation for 6 years (end 2013);
2) Liner placement (2013);
3) New fill placement to RL 105 m and consolidation for 5 years (2018); and
4) Consolidation for 40 years (end 2063).

Manassero, M. 2006. 'Geosynthetic Reinforced Composite Clay Liner Performance Evaluation Under Differential Settlements 07217-PPPXVVE06-MAR', Studio Geotecnico Italiano, Milan

Given the shallow depths represented in the axisymmetric model, leachate levels did not apply. The axisymmetric model geometry is shown below in Figures 4 and 5.

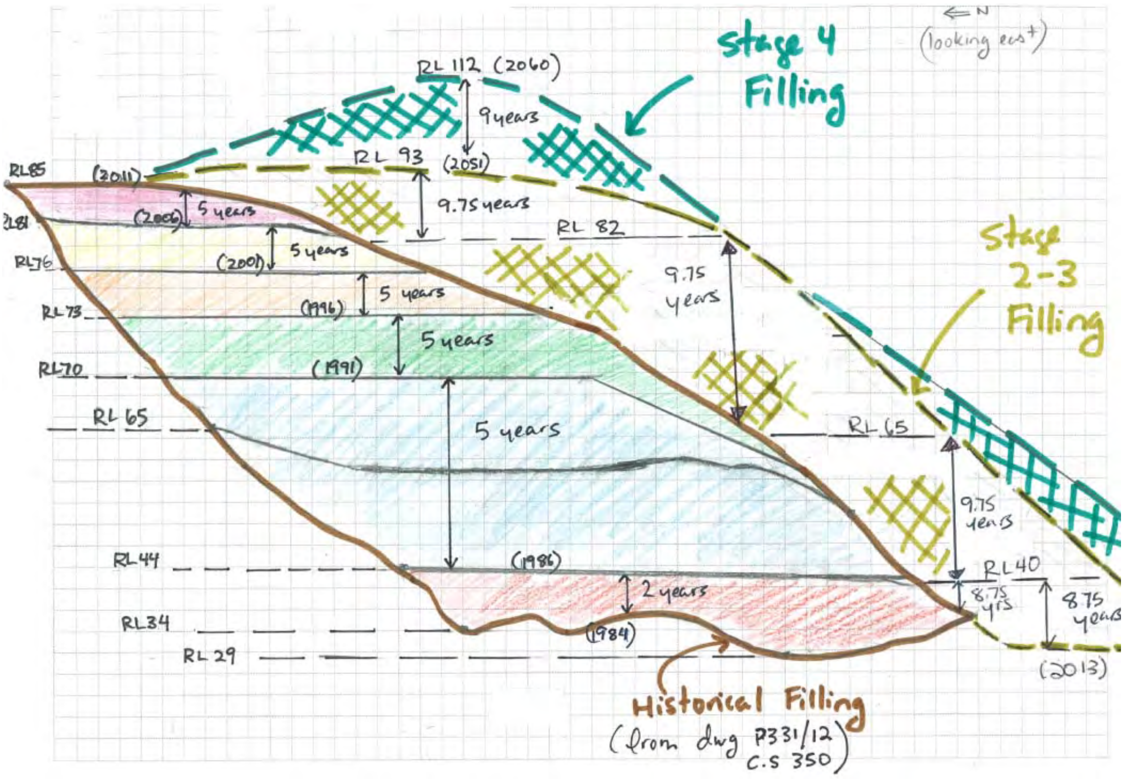


Figure 2: Assumed filling history for the western gully.

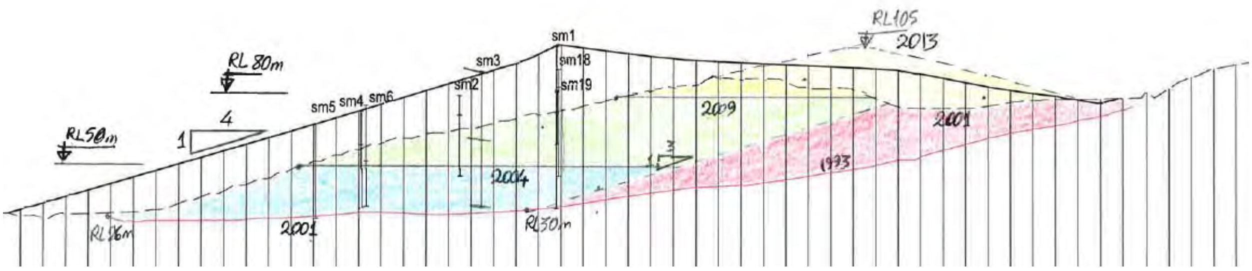


Figure 3: Assumed filling history for the eastern gully.

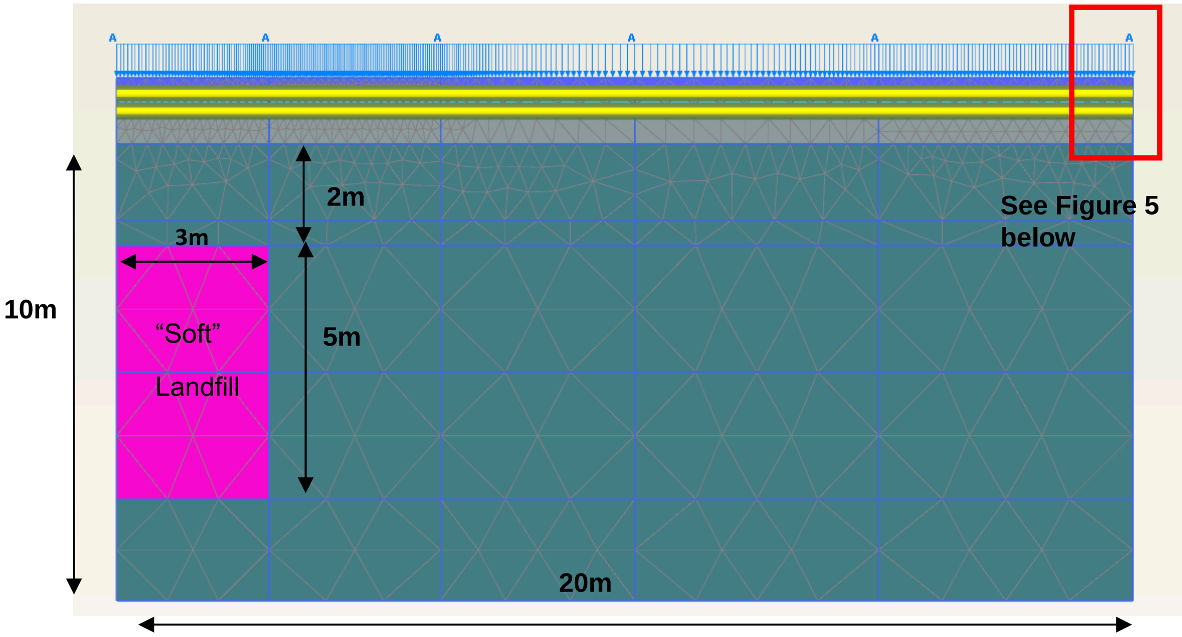


Figure 4: General layout of PLAXIS axisymmetric analysis

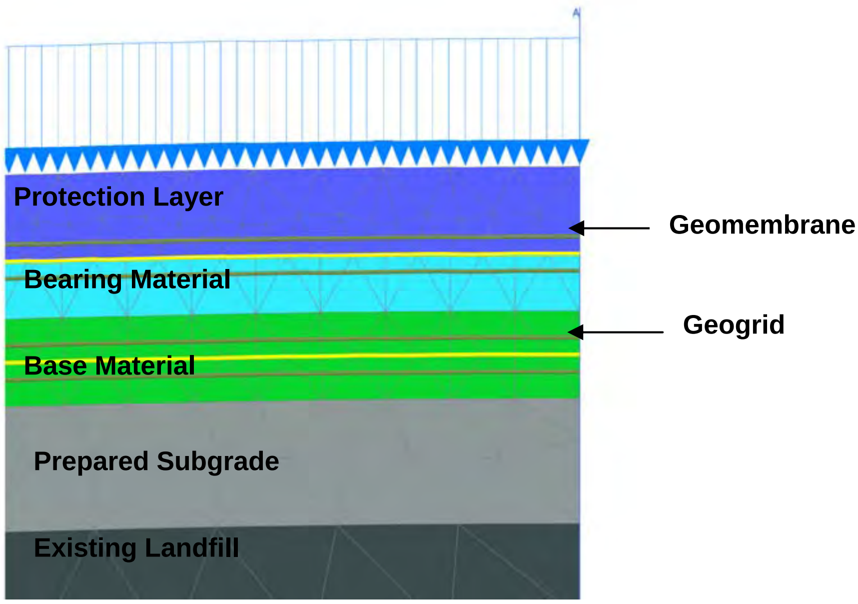


Figure 5: Detail View of Liner Components in PLAXIS axisymmetric analysis

4.3 Sensitivity analyses

Golder (2012) considered basic sensitivity analyses to quantify the effect of varying landfill and liner stiffness, and removal of the geogrid in the Western Gully. In this assessment for detailed design, we have done further sensitivity analyses to assess the effect of existing landfill compressibility, as outlined below.

It is noted that we have adopted compressibility parameters for the "host" waste material surrounding the soft spot in the axisymmetric model that correspond to those obtained from back analysis of waste settlements for detailed design (Golder Memos No. 117625003-253-M-Rev0 and 117625003-254-M-Rev0). Relatively higher compressibility parameters have been adopted for the soft spot based on literature values and judgement. We note that adopting higher compressibility parameters for the soft spot, relative to the host material, effectively increases computed differential settlements and strain levels in the geosynthetic layers.

Definition of terms used below is as follows: Cc= modified primary compression index, Ca= modified secondary compression (also referred to as creep coefficient). References to a general level of compressibility, such as “very low to low” compressibility, are with respect to values for municipal solid waste identified by Gourc & Olivier (2005)[2].

Western Gully Model:

- **Base Case:**
  The compressibility parameters of the host material for the Western Gully were taken as Cc=0.12 and Ca=0.02 (representing “very low” compressibility). This is consistent with the findings in Golder Memo No. 117625003-253-M-Rev0 for the Western Gully. Although the Golder Memo recommended a Ca value of 0.04, we have adopted a value of 0.02 herein because this makes both the Cc and Ca values at the lower bound of the range for “very low to low” compressibility. The compressibility parameters for the soft spot were taken as Cc=0.24, Ca=0.14 (representing “high” compressibility).
- **Sensitivity Case 1:** The compressibility parameters for the soft spot were increased to Cc=0.33, Ca=0.14 (i.e., higher primary compressibility);
- **Sensitivity Case 2:** The compressibility parameters for the soft spot were decreased to Cc=0.18, Ca=0.06 (representing “intermediate” compressibility);

Eastern Gully Model:

- **Base Case:**
  The compressibility parameters of the host material for the Eastern Gully were taken as Cc=0.20 and Ca=0.07 (representing “intermediate” compressibility). This is consistent with the findings in Golder Memo No. 117625003-254-M-Rev0 and the values adopted in Golder Memo No. 117625003-255-M-Rev0 for the Eastern Gully. The compressibility parameters for the soft spot were taken as Cc=0.24, Ca=0.14 (representing “high” compressibility).
- **Sensitivity Case 1:** The compressibility parameters for the soft spot were increased to Cc=0.5, Ca=0.17[3](representing “very high” compressibility);
- **Sensitivity Case 2:** The compressibility parameters for the soft spot were modified to Cc=0.33, Ca=0.17 (also representing “very high” compressibility);

4.4 Analysis Results

Figures 6 and 7 present computed long-term displacement contours and vertical displacement (settlement) profiles for the Western Gully and Eastern Gully ‘Base Case’ and ‘Sensitivity Case 1’ models. The long-term settlement profile reflects the presence of the soft landfill material, as expected, with a depression of about 8 m radius centred over the soft spot. As shown in these figures, the maximum differential settlement gradient across the piggy back liner after long-term settlement is approximately 1:4 for both models. These gradients are approximately equal to the slope gradients used for the piggy back liner design (generally 3H:1V to 5H:1V), and therefore the deformed piggy back liner surface resulting from the modelled soft spot settlement is not likely to result in significant leachate ponding.

As indicated in Figures 6b and 7b, the difference between the Base Case and Sensitivity Case 1 (more severe than Sensitivity Case 2) is evident in the deeper predicted long-term settlement depression for Sensitivity Case 1. The more pronounced effect is for the Eastern Gully (Figure 7b) where the depression depth increases from approximately 1.0 m to 1.6 m for Sensitivity Case 1.

Figures 8 and 9 illustrate the variation of computed long-term axial force and tensile strain of geosynthetic layers for different cases. Strains in geosynthetic layers are simply obtained by dividing the Liner/Geogrid Forces by the user-defined (factored) stiffness (EA) value to obtain the strain at a given location. This approach accounts for both vertical displacements (settlements) and horizontal displacements of the geosynthetic layers.

---

[2] Gourc, J. P., Olivier, F. ‘ Calibration of the Incremental Settlement Prediction Model (ISPM) from field monitoring campaigns’, International Workshop “Hydro-Physico-Mechanics of Landfills, Grenoble University, 21-22 March 2005.

[3] The compressibility parameters were limited to these values, as we noted that higher compressibility values for a soft spot cause their collapse even before applying the new landfill loading. This indicates that higher compressibility parameters are unlikely for a soft spot with assumed geometry.

Geogrid: As seen in these figures, the computed localised maximum axial force in the geogrid due to the soft spot is approximately 14 and 7.5 kN/m for the Western Gully and Eastern Gully 'Base Case' models, respectively, with associated localised maximum tensile strains of 2.8% and 1.5%. Conservatively superimposing the estimated maximum tensile strain in the piggy back liner from global-scale analysis of long-term differential settlements[4] of approximately 2 % with a maximum hypothetical local soft spot geogrid tensile strain of 3 % , as indicated in the preceding sentence, results in a predicted maximum geogrid tensile strain of less than 5 %. This is within a typical limiting tensile strain for geogrid products and, in practice it is highly unlikely that these two conditions would occur at the same location on the landfill.

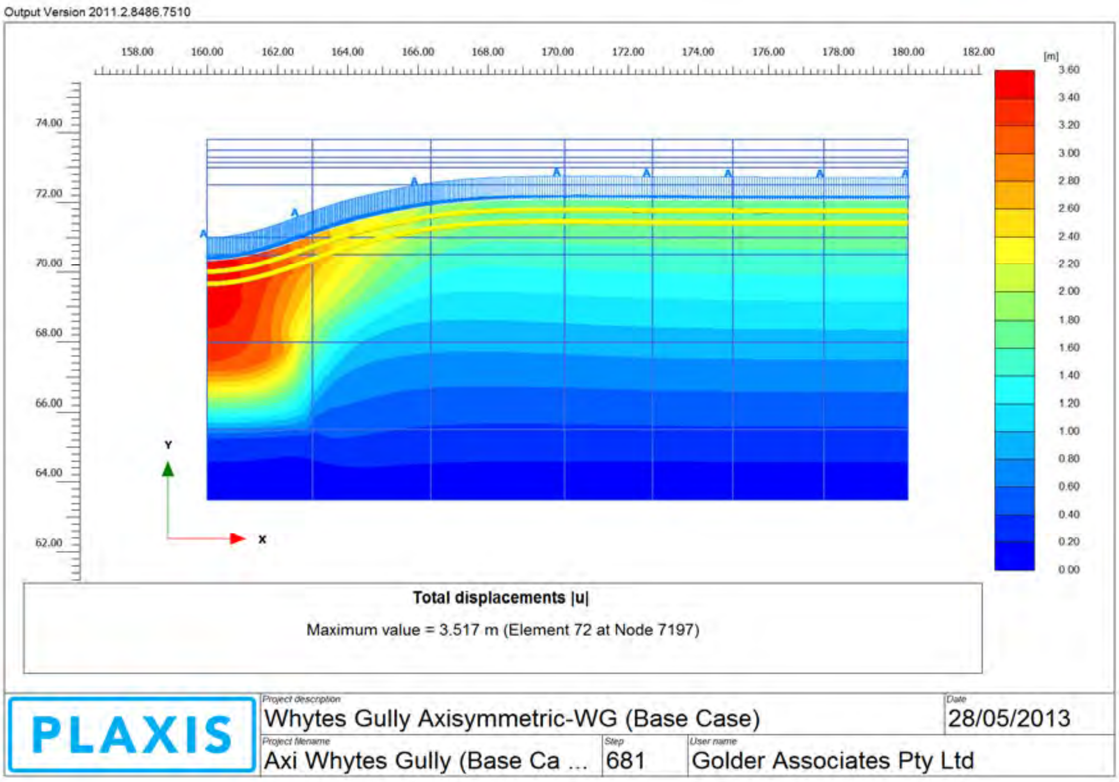
Considering Sensitivity Case 1, as seen in Figures 8b and 9b, the computed localised maximum geogrid tensile strains are 4.1% and 4.3%, respectively for the Western Gully and Eastern Gully. These values are also less than the typical limiting tensile strain for geogrid products. Note that we have not superimposed the computed strains from Sensitivity Case 1 with other computed values because of the relative severity of the assumed soft spot properties for Sensitivity Case 1.

Geomembrane: As seen in Figures 8b and 9b, the computed localised maximum tensile strain in the geomembrane due to the soft spot is approximately 5.2% and 3.4% for the Western Gully and Eastern Gully 'Base Case' models, respectively. Conservatively superimposing the estimated maximum tensile strain in the piggy back liner from global-scale analysis of long-term differential settlements of approximately 2 % (as in preceding discussion for geogrid) with a maximum hypothetical local soft spot geogrid tensile strain of 5%, as indicated in the preceding sentence, results in a predicted maximum geogrid tensile strain of approximately 7%. This is within a typical limiting tensile strain of approximately 8% for textured LLDPE geomembrane and, in practice it is highly unlikely that these two conditions would occur at the same location on the landfill.

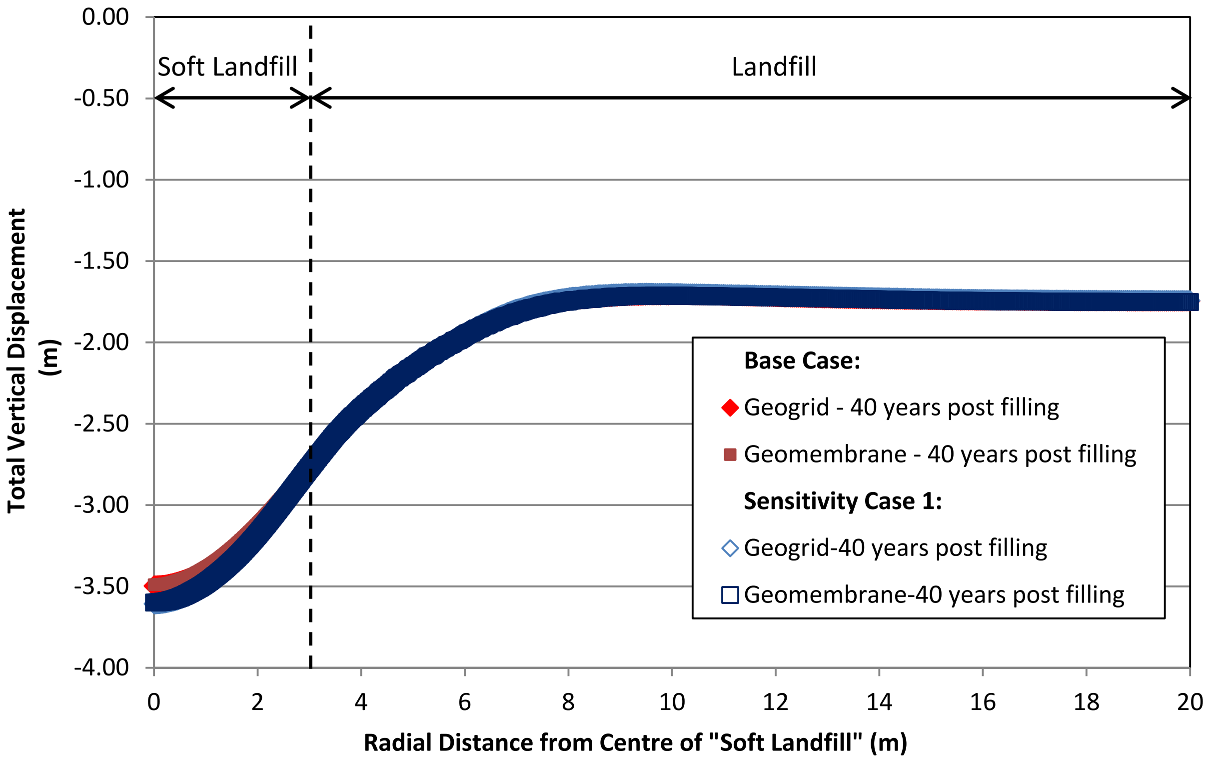
Considering Sensitivity Case 1, as also seen in Figures 8b and 9b, the computed localised maximum tensile strain in the geomembrane are 6.5% and 7.5%, respectively for the Western Gully and Eastern Gully. These values are also less than the typical limiting tensile strain for textured LLDPE geomembrane. Note that we have not superimposed the computed strains from Sensitivity Case 1 with other computed values because of the relative severity of the assumed soft spot properties for Sensitivity Case 1.

Soil-Geogrid Interface: The computed shear stress levels along the soil/geogrid interface are highest near the edge of the soft spot, where tensile forces and strains are highest, and are within about 70% of the interface yield shear stress value (after 40 years). Corresponding relative movements at the soil/geogrid interface are anticipated to be less than 5 millimetre. These results indicate that the model is predicting stable behaviour of the soil-geogrid system.

[4] Maximum tensile strain in the piggy back liner calculated from global-scale settlement analysis of the existing waste was estimated to be about 2% and 1.7% for the Western and Eastern gullies, respectively. Refer to Appendix D of the Golder (2012) report for the Western Gully and the more recent Golder memo No. 117625003-255-TM-Rev0, for the Eastern Gully settlement calculations.

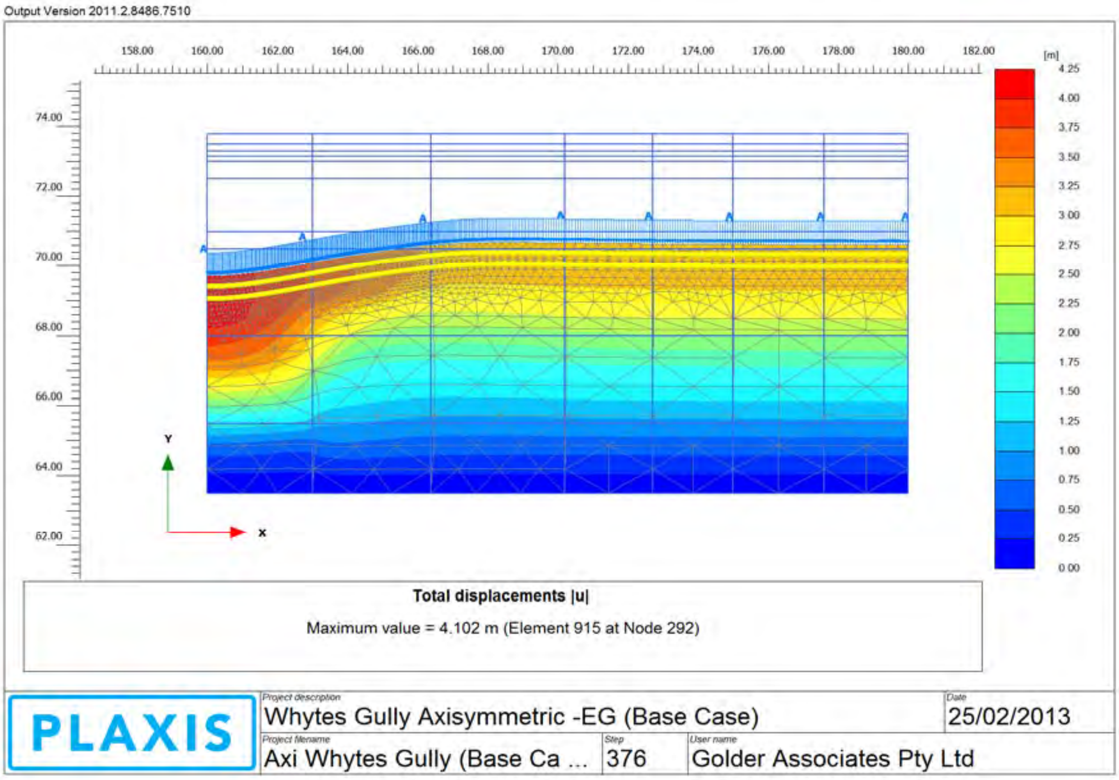


(a) Total displacement contours

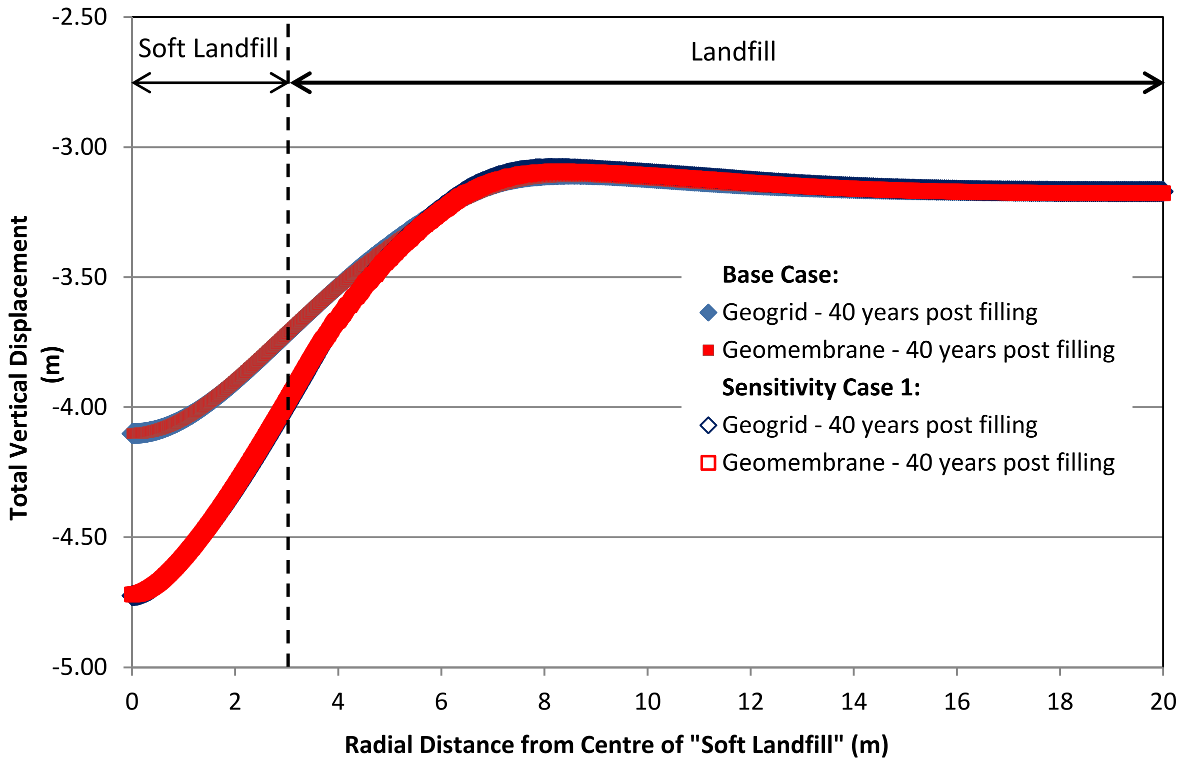


(b)Geogrid and Geomembrane vertical displacements

Figure 6: Displacement at 40 years from end of filling – Western Gully (Base Case).

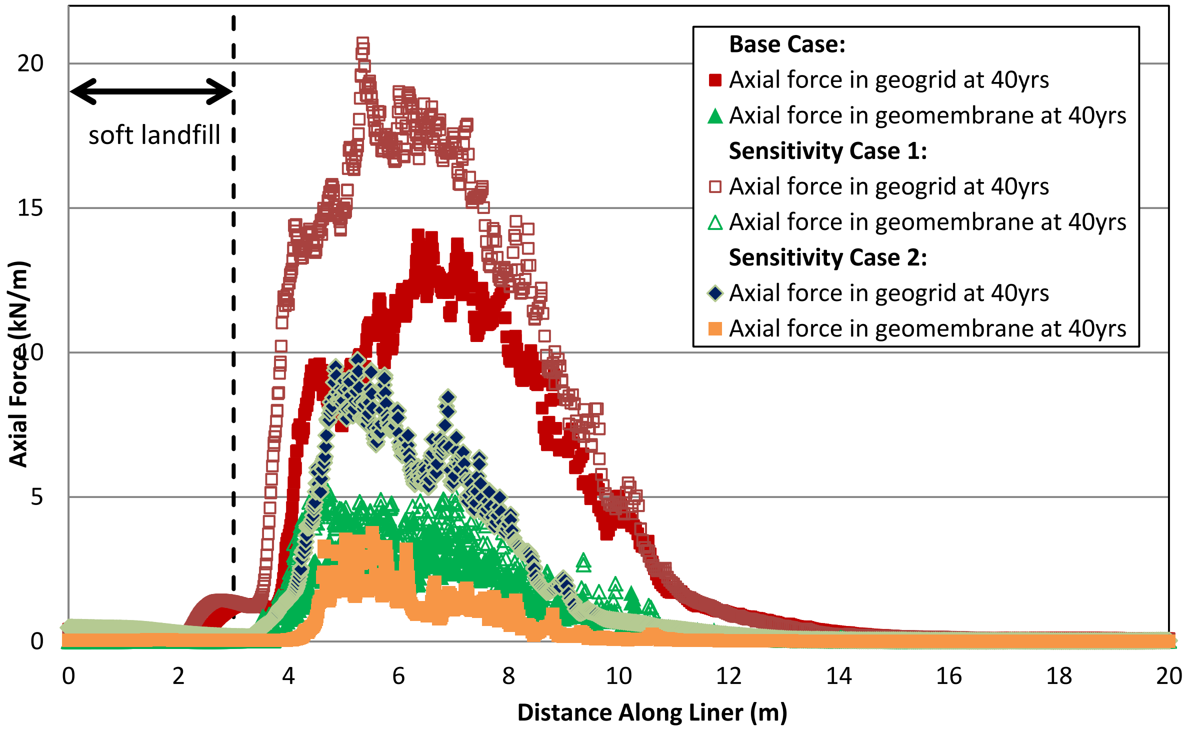


(a) Total displacement contours

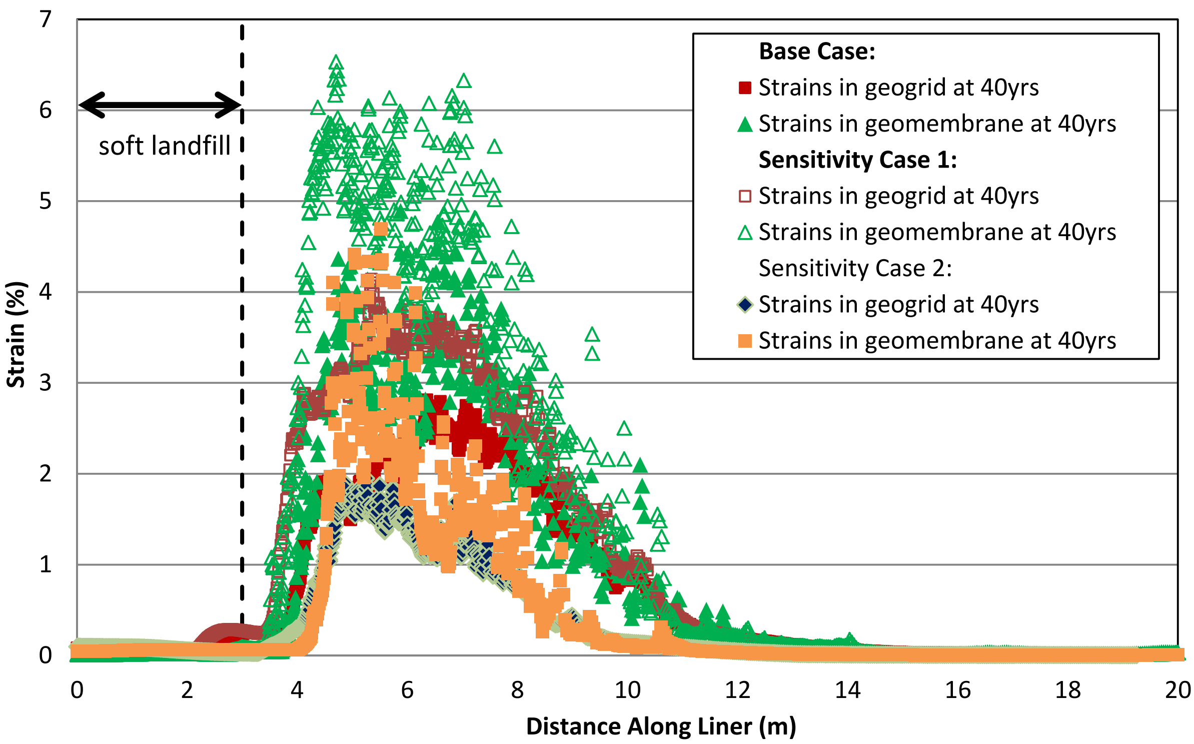


(b) Geogrid and Geomembrane vertical displacements

Figure 7: Displacement contours at 40 years from end of filling – Eastern Gully (Base Case).

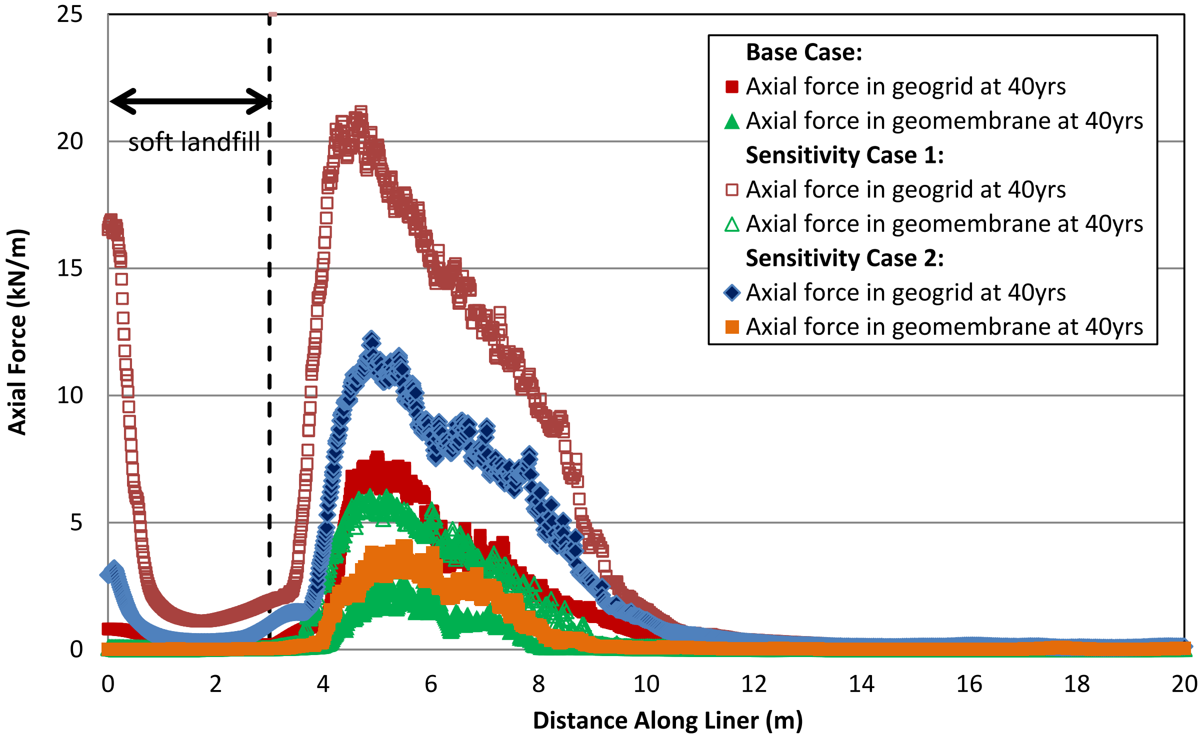


(a)

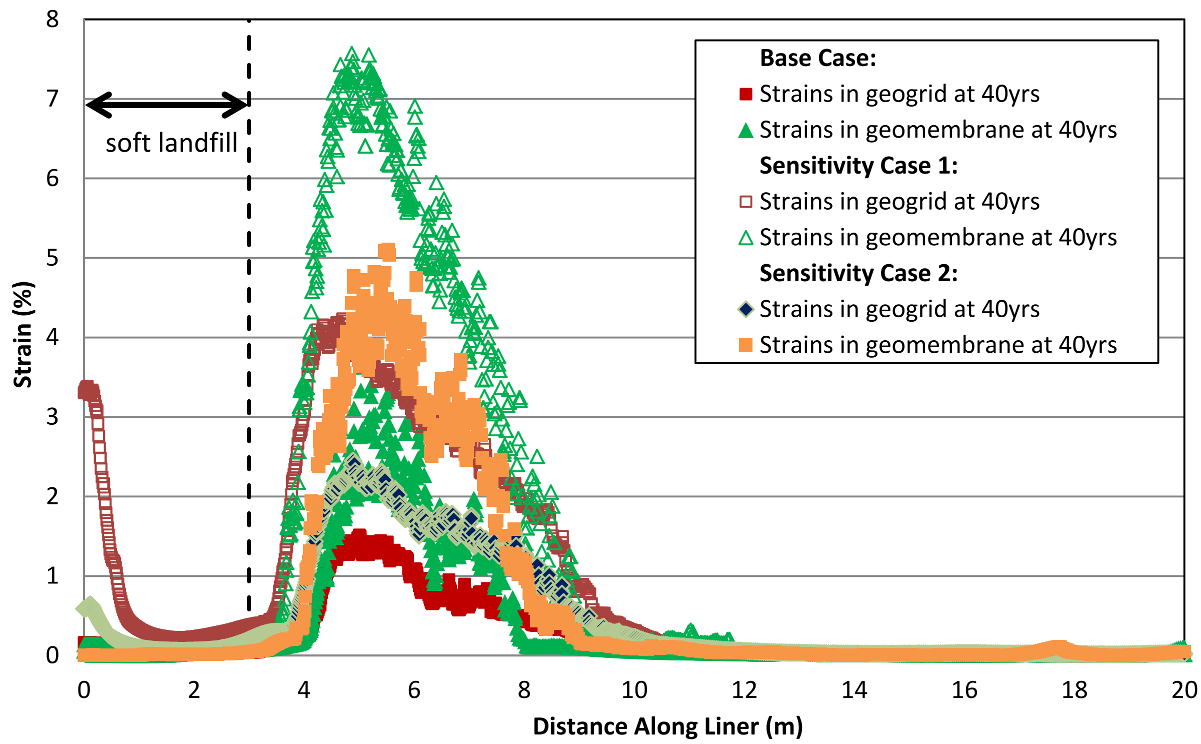


(b)

Figure 8: Western gully analysis results: (a) axial forces, and (b) strains of geosynthetic layers at 40 years from end of filling.



(a)



(b)

Figure 9: Eastern gully analysis results: (a) axial forces, and (b) strains of geosynthetic layers at 40 years from end of filling.

5.0 SUMMARY

Further to the Golder (2012) preliminary design for the New Landfill Cell project, additional analyses have been conducted for detailed design to assess the potential effect of hypothetical soft spots within existing waste on the long-term integrity and performance of the piggy back liner system. The additional analyses considered both the Western Gully and Eastern Gully landfills and used results from back analyses of settlement load trial measurements and surface settlement monitoring conducted at the site subsequent to the preliminary design.

The results of the additional analyses are consistent with overall expectations of piggy back liner behaviour and demonstrate that the use of a geogrid with a long-term tensile stiffness of 500 kN/m provides necessary reinforcement to limit maximum tensile strains in the geogrid and geomembrane layers to below 5% and 8%, respectively – even for a sensitivity case which considers a highly softened soft spot. This geogrid requirement is considered applicable to piggy back lining construction in both the Western Gully and Eastern Gully landfills.

Please Note: The current detailed design being prepared for project Tender Packages 1, 2 and 3 includes a relatively small area of piggy back liner construction in the Western Gully landfill. Future detailed design for additional Western Gully landfill areas could use additional settlement measurements and analyses to further consider the geogrid stiffness requirement for the piggy back liner.

If you have any questions regarding this memorandum, please contact the undersigned.

Saman Zargarbashi
Senior Geotechnical Engineer

Gary Schmertmann
Principal Geotechnical Engineer

SZ/JDM:GRS/sz

Attachment: Table 1: Material Input Parameters (1 page)

https://aupws.golder.com/117625003wollongongcitycouncilnewcellwhytesgully/project doc/320 90percent design/3205 settlement and deformation/117625003_256_m_rev0_plaxis analysis soft spot analysis.docx

Table 1- Material Input Parameters

Geogrid				
Material set				
Identification number		1	2	3
Identification		Interface 1 - Geogrid	Interface 2 - Geomembrane	Interface 1 - Geomembrane
Material type		Elastic	Elastic	Elastic
EA	kN/m	500	80	80

Soil - Mohr Coulomb										
Identification number		8	9	10	11	12	13	14	16	17
Identification		Interface Unit 12-16	Unit 6 - Base Material	Interface Unit 6-18	Interface Unit 15-17	Unit 4 - Clay Rich bearing (co	Interface Unit 16-17	Unit 9 - Protection Material	Interface 14-15	Interface 15-17 (peak)
Material model		Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Drainage type		Drained	Drained	Drained	Drained	Drained	Drained	Drained	Drained	Drained
General properties										
γ_unsat	kN/m^3	11	18	10	10	19	10	19	11	10
γ_sat	kN/m^3	11	18	10	10	19	10	19	11	10
Advanced										
Void ratio										
Dilatancy cut-off		No	No	No	No	No	No	No	No	No
e_init		2	0.5	0.5	0.5	0.5	0.5	0.5	2	0.5
e_min		0	0	0	0	0	0	0	0	0
e_max		999	999	999	999	999	999	999	999	999
Damping										
Rayleigh α		0	0	0	0	0	0	0	0	0
Rayleigh β		0	0	0	0	0	0	0	0	0
Parameters										
Material set										
E	kN/m^2	1.50E+04	3.00E+04	3.00E+04	1.50E+04	1.00E+04	3.00E+04	3.00E+04	1.50E+04	1.50E+04
ν (nu)		0.3	0.3	0.3	0.3	0.3	0	0.25	0.3	0.3
Alternatives										
G	kN/m^2	5769	1.15E+04	1.15E+04	5769	3846	1.50E+04	1.20E+04	5769	5769
E_oed	kN/m^2	2.02E+04	4.04E+04	4.04E+04	2.02E+04	1.35E+04	3.00E+04	3.60E+04	2.02E+04	2.02E+04
Strength										
c_ref	kN/m^2	0.01	0.01	1.00E-03	0.01	1.00E-03	1.00E-03	2	0.01	0.01
φ (phi)	°	24	32	29	12	28	24	30	24	20
ψ (psi)	°	0	0	0	0	0	0	0	0	0
Velocities										
V_s	m/s	71.69	79.26	106.3	75.19	44.54	121.2	78.67	71.69	75.19
V_p	m/s	134.1	148.3	198.9	140.7	83.33	171.5	136.3	134.1	140.7
Stiffness										
E_inc	kN/m^2/m	0	0	0	0	0	0	0	0	0
y_ref	m	0	0	0	0	0	0	0	0	0
Strength										
c_inc	kN/m^2/m	0	0	0	0	0	0	0	0	0
y_ref	m	0	0	0	0	0	0	0	0	0
Tension cut-off		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Tensile strength	kN/m^2	0	0	0	0	0	0	0	0	0
Interfaces										
Strength		Manual	Manual	Rigid	Rigid	Rigid	Rigid	Rigid	Manual	Rigid
R_inter		0.67	0.89	1	1	1	1	1	0.67	1
Real interface thickness										
δ_inter		0	0	0	0	0	0	0	0	0
Initial										
K0 settings										
K_0 determination		Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic
K_0,x		0.5933	0.4701	0.5152	0.7921	0.5305	0.5933	0.5	0.5933	0.658
Flow parameters										
Material set										
k_x	m/day	0	0.86	0	0	8.60E-03	0	0.86	0	0
k_y	m/day	0	0.86	0	0	8.60E-03	0	0.86	0	0
-ψ_unsat	m	0	0	0	0	0	0	1.00E+04	0	0
e_init		2	0.5	0.5	0.5	0.5	0.5	0.5	2	0.5
Change of permeability										
c_k		1.00E+15	1.00E+15	1.00E+15	1.00E+15	1.00E+15	1.00E+15	1.00E+15	1.00E+15	1.00E+15

Soil - Soft Soil Creep						
			Eastern Gully Model (Base Case)		Western Gully Model (Base Case)	
Identification number		15	3	18	3	18
Identification		Subgrade (Compacted Old Landfill)	Unit 41b - Old Landfill	Soft Landfill	Unit 41b - Old Landfill	Soft Landfill
Material model		Soft soil creep	Soft soil creep	Soft soil creep	Soft soil creep	Soft soil creep
Drainage type		Drained	Drained	Drained	Drained	Drained
General properties						
γ_unsat	kN/m^3	11	11	15	11	15
γ_sat	kN/m^3	11	11	15	11	15
Advanced						
Void ratio						
Dilatancy cut-off		No	No	No	No	No
e_init		2	2	2	2	2
e_min		0	0	0	0	0
e_max		999	999	999	999	999
Damping						
Rayleigh α		0	0	0	0	0
Rayleigh β		0	0	0	0	0
C_c		0.36	0.6	0.72	0.36	0.72
C_s		0.036	0.06	0.072	0.036	0.072
C_α		0.02	0.21	0.42	0.06	0.42
e_init		2	2	2	2	2
Strength						
c_ref	kN/m^2	2	2	2	2	2
φ (phi)	°	35	30	30	30	30
ψ (psi)	°	0	0	0	0	0
Advanced						
Set to default values		No	Yes	Yes	Yes	Yes
Stiffness						
ν_ur		0.15	0.15	0.15	0.15	0.15
K_0^nc		0.5575	0.5	0.5	0.5	0.5
M		1.418	1.589	1.589	1.589	1.589
Interfaces						
Strength		Rigid	Rigid	Rigid	Rigid	Rigid
R_inter		1	1	1	1	1
Real interface thickness						
δ_inter		0	0	0	0	0
K_0,x		1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10
Overconsolidation						
OCR		1.1	1.1	1.5	1.1	1.5
POP	kN/m^2	20	20	20	20	20
k_x	m/day	8.64	8.64	8.64	8.64	8.64
k_y	m/day	8.64	8.64	8.64	8.64	8.64
-ψ_unsat	m	0	0	0	0	0
e_init		2	2	2	2	2
Change of permeability						
c_k		1.00E+15	1.00E+15	1.00E+15	1.00E+15	1.00E+15

APPENDIX D

Addendum to March 2012 Hydrogeological Investigation Report

TECHNICAL MEMORANDUM

DATE 20 December 2012 **PROJECT No.** 117625003_211_M_Rev0

TO Gary Schmertmann

CC Ryan Huynh, Jacinta McMahon, Parnel Richards

FROM Remalia Sharplin, Lange Jorstad **EMAIL** rsharplin@golder.com.au, ljorstad@golder.com.au

GROUNDWATER CONTOURS – REASONABLE MAXIMUM UNCONFINED WATER TABLE SURFACE

This technical memorandum has been prepared to provide an interpretation of groundwater levels in the shallow alluvium (i.e. the water table) within the New Cell Floor investigation area, Whytes Gully.

Water levels were measured in all six shallow wells in the vicinity of the cell floor investigation area on 19 January 2012 (Table 1). The standing water levels (SWL) are presented in both metres below top of casing (mBTOC) and metres below ground level (mBGL), and converted to m Australian Height Datum (mAHD).

Table 1: Groundwater Levels Recorded 19 January 2012

Shallow Monitoring Well	Casing Stick Up (m)	TOC (mAHD)	Manually Recorded SWL		
			mBGL	mBTOC	mAHD
GMW108S	0.58	19.47	1.75	2.33	17.14
GMW109S	0.54	17.84	2.57	3.10	14.74
GABH06S	0.59	22.67	1.24	1.83	20.84
GABH205	0.63	20.35	0.98	1.61	18.74
GABH206	0.56	21.73	1.30	1.86	19.87
GABH207	0.56	23.36	2.26	2.82	20.54

A potentiometric surface generated from the available data is presented in Figure 1. The contours indicate a south-west flow direction consistent with previous interpretations of shallow groundwater flow (Hydrogeological Investigation Report, Golder ref no. 117625003_070_R_Rev0, dated March 2012).

The water levels measured on 19 January 2012 represent a period of reasonable high standing water levels, as indicated by hydrographs for two shallow wells in the cell floor investigation area (GABH205 and GABH06S) recorded between November 2011 and October 2012. According to the hydrographs, the peak (shallowest) water levels during the monitoring period were:

- GABH205: 0.65 mBGL on 21 March 2012; and
- GABH06S: 0.84 mBGL on 23 March 2012.

The peak levels occurred after a period of increased rainfall (54% of the 2012 annual rainfall occurred from January to March Station No. 068241, www.bom.gov.au) and represent the highest water levels in the current data set.

Table 2: Peak SWL Recorded by Installed Transducers in March 2012

Shallow monitoring Well	Peak SWL (mBGL)	SWL 19 January (mBGL)	Relative Water Level Rise
GABH06S	0.84	1.24	32%
GABH205	0.65	0.98	34%

The magnitude of water level rise was generally consistent (32 to 34%, respectively) for the two wells between 19 January 2012 and peak levels recorded in March 2012 (Table 2). During the week leading up to the 19 January 2012 monitoring event, the groundwater levels appeared to level out briefly before rising again (refer to the attached figures of Golder 2012 technical memorandum, reference no. 117625003_206_M_Rev0).

Water levels were not continuously monitored in the remaining shallow wells in the cell floor investigation area; however peak water levels for each well were approximated by adjusting the water level measurements from 19 January 2012 by the relative rise recorded in the two wells with continuous monitoring (conservatively estimated as a 35% relative rise). A summary of the measured and approximated peak water levels for the cell floor investigation area is presented in Table 3, and a corresponding potentiometric surface is presented in Figure 2.

Table 3: Peak SWL for all Shallow Monitoring Wells

Shallow Monitoring Well	Peak March SWL (mBGL)	Peak March SWL (mAHD)
GMW108S	*1.14*	*17.76*
GMW109S	*1.67*	*15.64*
GABH06S	0.84	21.24
GABH205	0.65	19.07
GABH206	*0.85*	*20.32*
GABH207	*1.47*	*21.34*

Note:
SWLs in italics were estimated by applying a 35% rise from the 19 January 2012 SWLs based on the similar relative rise recorded in continuously monitored wells GABH06S and GABH205 (refer to Table 1) .

The approach adopted to estimate the peak water level surface in March 2012 is considered to be reasonable on the basis of the following:

- The hydrographs for wells GABH06S and GABH205 exhibit nearly identical water level patterns, a consistent relative rise in water levels between January and March 2012, and a consistent hydraulic gradient of 0.015 m/m between the two wells for January and March 2012, suggesting a consistent dynamic water level response in the shallow aquifer in the cell floor investigation area;
- The shallow wells in the vicinity of the cell floor investigation area are located in relatively close proximity to each other, have similar well construction, and are screened within similar lithological material in the shallow aquifer;
- The highest groundwater level manually measured in January 2012 (GABH06S) also had peak March water levels available from transducer records for comparison;

- Manually measured water levels for GABH205 were available for the January and March 2012 monitoring events for comparison with the transducer records;
- Using the peak March 2012 water levels measured at GABH06S (21.24 m AHD) and estimated for GABH207 (21.34 mAHD), the highest water levels at the site fall at the same location; and
- The estimated potentiometric surface for peak water levels in March 2012 exhibits a consistent flow direction and hydraulic gradient with the January 2012 contours.

Using the available data, the water levels presented in Table 3 and the contours shown on Figure 2 are therefore considered to represent the reasonable maximum unconfined water table surface.

The contours from Figures 1 and 2 are also available electronically as .dwg and .dxf files suitable for use in CAD.

Please do not hesitate to contact the undersigned with any questions regarding this assessment.

Remalia Sharplin
Project Hydrogeologist

Lange Jorstad
Principal Hydrogeologist

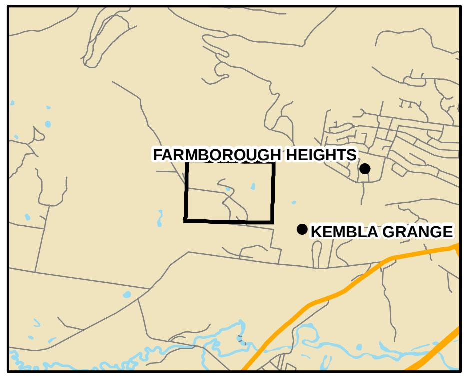
Please log details for signature use every time you access this file thanks

Name	Date	Document Identification No
Gemma Garry	01/08/2008	087623082 Invoice SYD04370
Gemma Garry	01/08/2008	077623082_invoice 6 cover letter.doc
Gemma Garry	01/08/2008	marketing\dwe cover letter.doc
Gemma Garry	12/08/2008	077623128 001 l rev0.doc
Gemma Garry	13/08/2008	reporting\077623114 002 r rev1 final.doc
Rosanne Bell	29/8/08	http://golderportal/cws/corporateservices/gaims/gaimsaustralia/scanned signatures/lange_jorstad_signature.doc
Genelly Formento	01/09/2008	http://golderportal/cws/corporateservices/gaims/gaimsaustralia/scanned signatures/lange_jorstad_signature.doc
Genelly Formento	02/09/2008	Invoice SYD04423
Rosanne Bell	3/9/08	http://golderportal/Cws/CorporateServices/GAIMS/GAIMSAustralia/Scanned signatures/Lange_Jorstad_signature.doc
Gemma Garry	25/09/2008	087622085_sds_badgerys creek\087622085 008 r rev0 2000 groundwater study final.doc
Gemma Garry	17/10/2008	http://golderportal/cws/corporateservices/gaims/gaimsaustralia/scanned signatures/lange_jorstad_signature.doc
Gemma Garry	20/10/2008	http://golderportal/cws/corporateservices/gaims/gaimsaustralia/scanned signatures/lange_jorstad_signature.doc
Gemma Garry	20/10/2008	Invoice SYD04503
Gemma Garry	16/12/2008	http://golderportal/cws/corporateservices/gaims/gaimsaustralia/scanned signatures/lange_jorstad_signature.doc
Genelly Formento	19/01/2009	http://golderportal/cws/corporateservices/gaims/gaimsaustralia/scanned signatures/lange_jorstad_signature.doc
Genelly Formento	19/01/2009	http://golderportal/cws/corporateservices/gaims/gaimsaustralia/scanned signatures/lange_jorstad_signature.doc
Gemma Garry	05/02/09	http://golderportal/cws/corporateservices/gaims/gaimsaustralia/scanned signatures/lange_jorstad_signature.doc
Gemma Garry	27/02/09	http://golderportal/cws/corporateservices/gaims/gaimsaustralia/scanned signatures/lange_jorstad_signature.doc
Gemma Garry	03/04/09	http://golderportal/cws/corporateservices/gaims/gaimsaustralia/scanned signatures/lange_jorstad_signature.doc
Kathryn Raine	21.04.09	http://golderportal/cws/corporateservices/gaims/gaimsaustralia/scanned signatures/lange_jorstad_signature.doc
Genelly Formento	29/04/2009	http://golderportal/cws/corporateservices/gaims/gaimsaustralia/scanned signatures/lange_jorstad_signature.doc
Genelly Formento	13/05/2009	http://golderportal/cws/corporateservices/gaims/gaimsaustralia/scanned signatures/lange_jorstad_signature.doc
Kathryn Raine	21.05.09	http://golderportal/cws/corporateservices/gaims/gaimsaustralia/scanned signatures/lange_jorstad_signature.doc

RS/LJ/rs,lj

\\syd1-s-file02\users\remalia\whytes\contours\tech memo 211\117625003-211-m-rev0.docx

SHALLOW GROUNDWATER CONTOURS (JANUARY 2012)



LEGEND

19 January 2012 Contours

GMWH06S (20.84)

NOTES

0 10 20 40 60 80 100 metres

SCALE (at A3) 1:3,000

117625003

11/12/2012

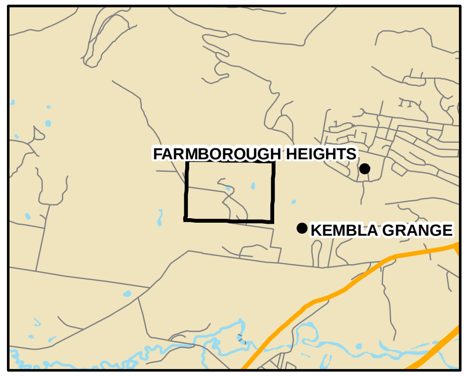
RS

LBJ

FIGURE 1

Golder Associates

REASONABLE MAXIMUM GROUNDWATER CONTOURS (MARCH 2012)



LEGEND

Peak March 2012 Contours

GMWH06S (21.24)

NOTES

0 10 20 40 60 80 100 metres

SCALE (at A3) 1:3,000

117625003
11/12/2012
RS
LBJ

FIGURE 2

Golder Associates

APPENDIX E

Leachate Collection Design

TECHNICAL MEMORANDUM

DATE 29 June 2013 **REFERENCE No.** 117625003_227_M_Rev0

TO Michael Herramann
Wollongong City Council

CC

FROM Kelly Dohle, Gary Schmertmann **EMAIL** kdohle@golder.com.au, gschmertmann@golder.com.au

LEACHATE COLLECTION DESIGN

1.0 INTRODUCTION

This memorandum describes the leachate collection design for Packages 1A, 1B, 2 and 3 of the Whytes Gully New Landfill Cell Project. Design of the leachate collection system has been undertaken for the Cell Base Liner, and Piggy Back Liner.

The detailed design presented in this memorandum builds on the concept design presented in the "Whytes Gully New Landfill Cell Report for Preliminary Design" (Golder, April 2012) reference 117625003_058_R_Rev0. Design features of the proposed leachate collection system are detailed in Section 4.0 of the Report for Preliminary Design.

2.0 LEACHATE COLLECTION DESIGN

2.1 Cell Base Liner Leachate Collection System

The leachate collection blanket for the cell base liner has been designed to maintain a head on the liner of less than 300 mm. The leachate collection blanket comprises a 300 mm thick layer of high porosity drainage aggregate with an overlying geotextile filter. The leachate collection blanket is supplemented with a network of slotted leachate collection pipes to intercept and remove leachate flowing within the blanket. The leachate collection blanket has been designed to be generally consistent with the requirements of the "Best Practice Environmental Management Siting, Design, Operation and Rehabilitation of Landfills" (BPEM) (EPA Victoria 2010) and the "Environmental Guidelines: Solid Waste Landfills" (NSW Landfill Guidelines) (NSW EPA 1996). The leachate collection layer has the following properties:

- Leachate collection pipe falls are a minimum 1% and down-slope spacing between pipes is a maximum of 50 m.
- Gradation of the drainage aggregate: maximum particle size 40 mm, Passing 19 mm sieve < 20%, Passing 13.2 mm sieve < 10% and <2% fines.
- Hydraulic conductivity of the drainage aggregate of specified minimum 1×10^{-3} m/s. Note: This specified minimum value reflects the highest permeability that can be measured with typical testing equipment. The actual value anticipated for drainage aggregate of the required gradation is in the order of 100 times greater.
- Specification for a maximum allowance of misshapen particles to reduce aggressivity to the underlying geomembrane.
- Specifications for maximum calcium carbonate content, non-solubility in acid and wet/dry strength for durability of material in a leachate environment.

- Recycled materials or materials of ash/slag origin are not permitted.

Calculations by the method in Giroud et al. (2000) for a relevant leachate generation rate[1], the design geometry conditions (base slope of 2.2% and maximum length between collection pipes of 50 m), and a reasonable lower bound hydraulic conductivity of the drainage aggregate ($5x10^{-3}$ m/s), result in a maximum leachate head of approximately 200 mm. Actual maximum leachate heads in the cell base liner area would be expected to be significantly smaller due to the hydraulic conductivity of the drainage aggregate typically being significantly larger than the specification value (refer note above). The leachate collection pipe sizing design is presented in Section 3.0.

2.2 Piggy Back Liner Leachate Collection System

The preliminary design of the leachate collection system overlying the piggy back liner is described in Section 4.3.3 of the Report for Preliminary Design (Golder 2012). The design of this system has been revised during detail design such that the 300 mm protection material layer (providing liner protection and confinement for the GCL) overlying the geocomposite drainage layer has been specified to provide a dual layer drainage system, with the protection material providing drainage capacity in addition to the geocomposite drain. It is noted that the drainage capacity of the protection material is relevant only for the short-term case of rainwater collection prior to waste placement (referred to as Case A below).

Hydraulic design of the dual layer leachate collection system has been undertaken following the approach set out by Giroud presented in the paper “Liquid flow equations for drainage systems composed of two layers including a geocomposite” (Giroud et al, 2004).

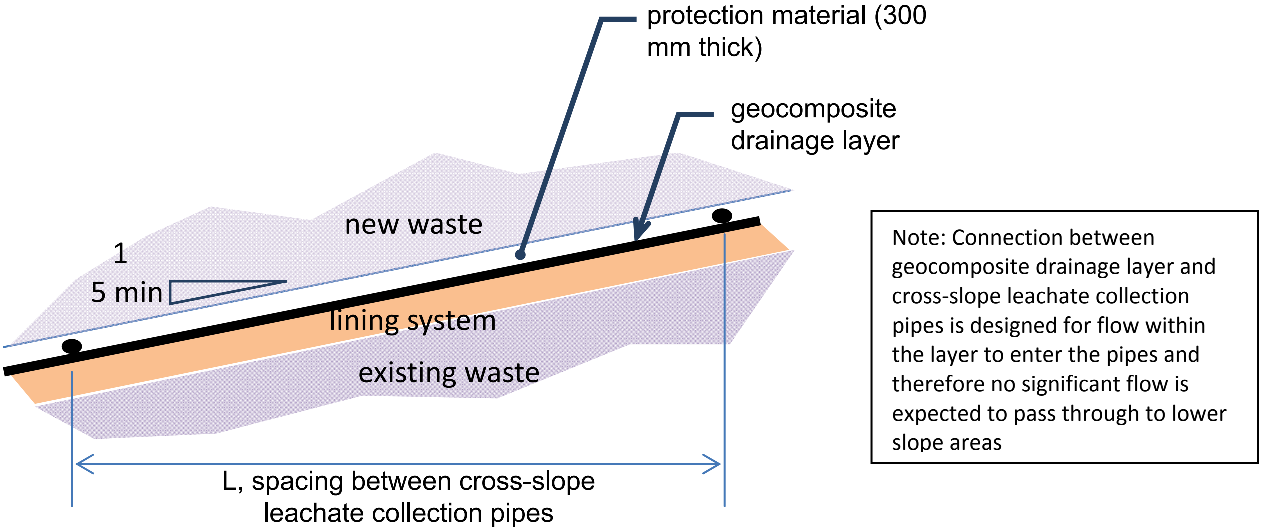


Figure 1: Piggy back liner leachate drainage design

The drainage function of the geocomposite drainage layer is to collect water or leachate infiltrating from above and convey it to the nearest cross-slope leachate collection pipe. This will serve to minimise the potential for liquid pressure build up above the lining system, thus reducing leakage through the lining system (environmental benefit) and maintaining relatively high shear strength along the upper surface of the lining system (slope stability benefit). As noted on Figure 1 above, the geocomposite will be connected to the cross-slope leachate collection pipe in such a way that liquid that is flowing downslope within the

[1]Leachate generation rate= $4.39x10^{-7}$ m/s (i.e. 38 mm/day). This reflects plausible worst-case conditions during initial placement of waste and has been established in a similar manner to that in Section 3.2, based on the indicated 90th percentile monthly rainfall (0.379 m), an infiltration factor of 0.6 to represent an active landfill operations area, and a peak flow factor of 5. This is the same rate used for Case B in Section 2.2.2.

geocomposite is expected to enter the pipe and therefore not pass through to lower slope areas in significant amounts. This means that downslope flows are not additive and each length of geocomposite between collection pipes will be designed to function independently.

For the case of rainwater collection prior to waste placement (referred to as Case A below), the design will assess: (i) the required flow capacity of the geocomposite and overlying protection material; and (ii) the required spacing between leachate collection pipes; in order to convey the anticipated flows and prevent the drainage layer from developing a pressure head greater than 50% of the thickness of the protection material layer at any point (i.e. less than 150 mm). The maximum pressure head was selected for stability of the protection material (refer to 117625003_214_M_Rev0_Slope stability assessment for detailed design). For leachate collection cases (referred to as Cases B and C below) the design criterion is that pressure head build up remains less than the thickness of the geocomposite material.

2.2.1 Hydraulic properties of leachate collection blanket layer

Hydraulic properties of the piggy back liner leachate collection system used for detailed design are presented in Table 1.

Table 1: Hydraulic properties of leachate collection layer in piggy back liner

Property	Layer 1 – Geocomposite (Unit 14)	Layer 2 – Protection Material (Unit 9)
Thickness of transmissive layer	6.8 mm at 200 kPa normal pressure(thickness of tri-planar geocomposite core)	300 mm
Hydraulic conductivity / flow rate	■ Hydraulic flow rate ≥ $0.63 \times 10^{-3} m^3/s$ per metre width at 20 kPa normal stress with hydraulic gradient i = 0.1 (measured between rigid plates) (Typical value) ■ Hydraulic flow rate ≥ $0.3 \times 10^{-3} m^3/s$ per metre width at 200 kPa normal stress with hydraulic gradient i = 0.1 (measured between rigid plates) (Typical value)	k >1×10^{-3} m/s (see discussion below)

The saturated hydraulic conductivity of the geocomposite was adjusted by reduction factors to account for intrusion of the geotextile (RF_{IN}), creep deformation of the geonet (RF_{CR}) and clogging of the geonet overtime due to chemical (RF_{CC}) and biological clogging (RF_{BC}).The reduction factors used are presented in Table 2. The reduction factors were selected based on Table 1 of *Hydraulic Design of Liquid Collection Layers* (Giroud et. al., 2000).

It is noted that the saturated hydraulic conductivity of the protection material reflects a relatively short-term requirement for (Case A) because all areas of the piggy back liner are to be covered with landfill waste within approximately 1-year of liner installation. After waste placement, the saturated hydraulic conductivity of the protection material is not expected to have a meaningful influence on leachate collection performance.

2.2.2 Selection of liquid supply rate q_h for Geocomposite Design Cases

In order to determine the critical liquid supply rate (q_h), or infiltration rate, for design of the leachate collection layer, three infiltration cases were assessed. The different parameters and reduction factors for each case are presented in Table 2.

Case A considers leachate collection prior to waste placement. The infiltration flow rate is set as the flow rate generated by the highest intensity rainfall event with a 20 year Average Recurrence Interval (ARI) that delivers volume of rainfall sufficient to saturate the bottom half of the protection soil layer, assuming a porosity of 0.3. The storm event duration identified with this criterion was 20 min, with an intensity of 138 mm/hr, based on the rainfall IFD table for the site[2] (Intensity-Rainfall-Duration).

Case B considers leachate collection during the initial placement of waste. The infiltration flow rate has been established in a similar manner to that in Section 3.2, based on the indicated 90th percentile monthly rainfall (0.379 m), an infiltration factor of 0.6 to represent an active landfill operations area, and a peak flow factor of 5.

Case C addresses long-term conditions after completion of landfilling and final cap installation. In this case, anticipated flows would be leachate infiltrating through final capping materials at relatively low rates.

[2] IFD table presented in Section 1.2 of Appendix B of the March 2012 "Surface Water Assessment" (Golder memo117625003_160_M_Rev0)

Table 2: Design cases for geocomposite in piggy back liner

Design Case	Description of Conditions	Timeframe	Infiltrating Liquid	Peak infiltration rate q_h (m/s)	Normal Stress Level	Indicative Normal Stress	RF_{IMIN}	RF_{IN}	RF_{CR}	RF_{CC}	RF_{BC}	Π_{RF}	Target Factor of Safety
A	Leachate collection, prior to waste placement	short term	rain water	3.83×10^{-5} (138 mm/hr)	Low: 300 mm protection layer	20	1.5	1	1.2	1	1	1.8	2.5
B	Leachate collection, during placement of initial waste lifts	medium term	leachate	4.39×10^{-7} (38 mm/day)	Moderate: 10 to 20 m waste	200	1.5	1	1.4	1.5	1.5	4.7	2.5
C	Leachate collection, after final waste placement	long term	leachate	1.00×10^{-7} (9 mm/day)	High: >20 m waste	400	1.5	1.2	2	2	2	14.4	2.5

2.2.3 Leachate collection pipe spacing

Calculations indicate that the critical case for design of the cross-slope leachate collection pipe spacing was geocomposite Design Case A. Drainage capacity under Case B and C (with higher reduction factors but significantly lower liquid supply rates than Case A) is still within the permissible maximum head range when the pipe spacing is set to match Case A.

Table 3 presents pipe spacing L for a range of piggy back liner slopes encountered for the design for Case A, and shows the maximum head is within the permissible maximum range for the pipe spacing considered.

The results in Table 3 show that the maximum head is sensitive to small changes in the pipe spacing for the given liquid supply rate and layer design. This was taken into consideration when selecting the pipe layout for the detailed design.

Table 3: Pipe spacing and maximum head for piggy back liner (Geocomposite Design Case A)

Parameter	Units	a	b	c	e	f
Slope of Liner (tanβ)	-	0.1	0.22	0.22	0.33	0.33
Pipe spacing (L)	m	10	14.0	14.5	20.0	21.5
Maximum head (h_{max})	m	0.113	0.063	0.114	0.024	0.144

3.0 LEACHATE PIPE SIZING

3.1 Overview

Leachate collection pipes within the new lining systems are sized to:

- Leachate Pipe Design Case A: Convey predicted peak leachate flow rates arising from *average* monthly rainfall conditions such that:
  - the calculated maximum height of flow within the pipe is less than 20% of the pipe diameter, in order to contain average flows within the lower portion of the pipe, largely below the drilled drainage perforation holes; and
  - the calculated maximum flow velocity is greater than 0.75 m/s, to provide a nominal self-cleaning velocity
- Leachate Pipe Design Case B: Convey predicted peak leachate flow rates arising from *90th percentile* monthly rainfall conditions, with superimposed flow arising from significant rainfall on leachate collection system areas soon after their construction, such that:
  - The calculated maximum height of flow within the pipe is less than 80% of the pipe diameter, thus providing excess pipe flow capacity to allow for unanticipated flow rates or pipe conditions.
- Leachate Pipe Design Case C: Convey predicted rainwater flow rates arising from direct rainfall on areas of leachate collection system that are temporarily exposed (no cover) during construction, such that:
  - The calculated maximum height of flow within the pipe is less than 80% of the pipe diameter, thus providing excess pipe flow capacity to allow for unanticipated flow rates or pipe conditions.

3.2 Methodology

3.2.1 Leachate Pipe Design Case A - Average Monthly Rainfall

Approach

Case A will be considered for the detailed design of leachate header pipes at the landfill base.

Leachate generation and collection has been assumed to occur in response to rainfall, with leachate collected in any single month arising from rainfall within the same month (i.e., no time lag). When considering relatively high rainfall months, as in the approach adopted herein, the no-time-lag approach for monthly rainfall versus leachate generation/collection is likely to be conservative.

The following formula is used, with terms as defined below:

$$Peak\ Leachate\ Flow\ Rate\ \ (m^3/s) =$$

$$\frac{Monthly\ Rainfall\ (m)\ \cdot Average\ Infiltration\ Factor \cdot Tributary\ Area\ (m^2) \cdot Peak\ Flow\ Factor}{No. of\ seconds\ in\ one\ month\ \ (i.e.\ 2{,}628{,}000)}$$

Monthly Rainfall

Consider monthly rainfall based on the data presented in the Golder memo “Leachate Generation and Water Balance Modelling” dated March 2012 (Ref. 117625003_151_M_Rev0) for the Whytes Gully site. This data is from the rainfall record (1950-1977) at the Port Kembla Signal Station.

- Average: Select the month with the highest average rainfall. The month is March and the rainfall value is 0.184 m. Note that this value corresponds to approximately the 80^{th} percentile of all the recorded monthly values.

Average Infiltration Factor

The average infiltration factor is the ratio of the amount of collected leachate to the amount of rainfall. This factor therefore accounts for a number of mechanisms such as surface runoff, surface evaporation, plant uptake/transpiration and water storage in the waste (assumed negligible) as considered on a monthly time scale. Different average infiltration factors will apply to landfill surface areas with differing cover characteristics, as indicated below. The values are the same as used in the Golder memo “Leachate Generation and Water Balance Modelling” dated March 2012 (Ref. 117625003_151_M_Rev0).

- Daily Cover (active landfill operation area): value= 0.6
- Intermediate Capping: value= 0.2
- Final Capping: value= 0.01
- No cover (during construction) = 1.0

Tributary Area

The tributary area for the calculation is the total landfill surface area contributing flow into the leachate collection pipe being considered, or pipe catchment area (measured in plan view).

The tributary areas for differing surface conditions that are applicable for Case A are the maximum values occurring in Tender Packages 1, 2 and 3 for the design pipe arrangements. The tributary areas used for the detailed design are presented in Table 4. For the calculation, the area of daily cover will be assumed to be a maximum of 1 hectare, which is considered reasonable and is the same value used in the Golder memo “Leachate Generation and Water Balance Modelling” dated March 2012 (Ref. 117625003_151_M_Rev0).

Peak Flow Factor

The calculation for peak leachate flow rate is based on monthly rainfall and will reflect average flow rates over the time scale of a month. The calculation is therefore expected to underestimate higher flow rates that would likely occur over shorter time scales, such as a daily time scale. This unfavourable effect is mitigated in the calculation by use of the maximum monthly rainfall values (refer “Monthly Rainfall” above) with the no-time-lag approach (refer “Approach” above), and also mitigated with the peak flow factor discussed below.

The peak flow factor is used to increase the calculated flows to better reflect likely peak leachate collection rates. For this calculation, a peak flow factor value of five has been adopted. This value is based on the measured ratio of peak to average leachate collection rates for seven municipal solid waste landfills, at varying stages of operation, over a 7-10 year period as summarised by Rowe et al. (2004) from data by Bonaparte et al. (2002). The measured ratios ranged from 2.5 to 5.5.

3.2.2 Leachate Pipe Design Case B - 90th Percentile Monthly Rainfall

Case B will be considered for the detailed design of the leachate header pipes in the cell base liner area.

Monthly Rainfall

The peak leachate flow rate is calculated using the same approach given for average monthly rainfall above, however using the following monthly rainfall:

- 90th Percentile: Select the month with the highest synthesized 90th percentile rainfall value. The month is March and the rainfall value is 0.379 m, or approximately 0.5 mm/hr. Refer Golder memo “Leachate Generation and Water Balance Modelling” dated March 2012 (Ref.117625003_151_M_Rev0). Note that this value corresponds to approximately the 97th percentile of all the recorded monthly values.

Additional leachate flow arising from significant rainfall on leachate collection system areas soon after their construction is then superimposed on the above calculated value. This additional flow is discussed below.

Additional Leachate Flow arising from Rainfall Events on Newly Constructed Areas

Individual storm events can potentially generate significant short-term flows in leachate collection pipes due to relatively rapid infiltration and collection in areas where the leachate collection system has recently been installed and there is minimal thickness of soil or waste cover above the system. This is in contrast to leachate collection in landfill operation areas with a relatively greater cover thickness – in such areas the effect of individual storm events will be attenuated in time and it is generally appropriate to consider monthly rainfall.

The approach used to calculate these short-term flows is to consider a rainfall event with a 20 year ARI (average recurrence interval) and a 72-hour duration occurring in areas that have one lift or less of waste in place above the leachate collection system. This is consistent with the 2010 BPEM guidelines (p. 23) from the Victoria EPA which indicate that a 20-year ARI storm event occurring on areas with one lift of waste in place should be used to assess leachate pipe sizing.

The following formula is used, with terms as defined below:

$$Short\ Term\ Leachate\ Flow\ Rate\ \ (m^3/s) =$$

$$\frac{Rainfall\ Intensity\ (m/hr) \cdot Infiltration\ Factor \cdot Tributary\ Area\ (m^2)}{No.of\ seconds\ in\ one\ hour\ (i.e.\ 3600)}$$

- *Rainfall Intensity*: The rainfall intensity for a 20 year ARI event with 72-hour duration at the site is 6.8 mm/hr (0.0068 m/hr). This value is taken from the IFD table for the site.[3] For reference, the corresponding 24-hour and 48-hour values are 12.9 and 8.8 mm/hr respectively.

- *Infiltration Factor*: The infiltration factor is the maximum ratio of the rate of collected leachate collection to the average rainfall intensity that occurs during the duration of the rainfall event. This factor is primarily related to the degree of surface runoff that occurs on the relatively thin cover and the degree to which such runoff can be directed away from the leachate collection system. Different infiltration factors have been assumed for different areas, as indicated below:

[3]IFD table presented in Section 1.2 of Appendix B of the March 2012 “Surface Water Assessment” (Golder memo117625003_160_M_Rev0).

- Areas with protective soil cover layer and/or one lift or less of waste in place: The infiltration factor for these areas is assumed to be 0.8, indicating that a minor amount of surface runoff and diversion will be achieved during the rainfall event.
- Areas where leachate collection system construction is partially complete and/or where construction is completed and the leachate collection system remains temporarily exposed: The infiltration factor for these areas is assumed to be 1.0, indicating that the maximum rate of leachate collection is taken as equal to the average rainfall intensity during the 72-hour event duration.

Tributary Area

For detailed design of the leachate header pipes in the cell base liner area, the tributary areas for differing surface conditions that are applicable for Case B are similar to those used for Case A and are presented in Table 4.

3.2.3 Leachate Pipe Design Case C – Rainfall Event During Liner Construction

Case C will be considered for the detailed design of the cross-slope collection pipes and the down-slope header pipes in the piggy back liner area.

The following formula is used to calculate flows collected from rain falling on exposed (no cover) leachate collection system areas. Terms in the formula are defined below.

$$Short\ Term\ Leachate\ Flow\ Rate\ \ (m^3/s) = \frac{Rainfall\ Intensity\ (m/hr)\cdot Infiltration\ Factor\cdot Tributary\ Area\ (m^2)}{No.of\ seconds\ in\ one\ hour\ (i.e.\ 3600)}$$

- *Rainfall Intensity*: The rainfall intensity used for the detailed design is for a 20 year ARI, 90 min rainfall event (65 mm/hr). This value is taken from the IFD table for the site.[4] It is noted that this is a lower intensity value than used for Geocomposite Design Case A in section 2.2.2 (i.e., 138 mm/hr) but is considered generally consistent given the longer time of concentration for the large tributary areas under consideration for Leachate Pipe Case C.
- *Infiltration Factor*: The infiltration factor is 1.0 for the exposed (no cover) leachate collection system areas under consideration, indicating that the maximum rate of leachate collection is taken as equal to the rainfall intensity.
- *Tributary Areas*: Tributary areas are based on the maximum catchment areas for single pipes occurring in the piggy back liner areas for Tender Packages 1, 2 and 3 (refer Design Drawings). The maximum tributary area for a cross-slope leachate collection pipe is 1200 m^2 (60 m x 20 m); and the maximum tributary area for a down-slope leachate header pipe is 10,800 m^2 (120 m x 90 m).

It is noted that the rainfall intensity identified for this design case (65 mm/hr) is approximately ten times larger than those identified for Design Cases A and B and therefore it is considered unnecessary to check the design for the cross-slope collection pipes and the down-slope header pipes in the piggy back liner area against Design Cases A and B.

3.3 Header pipe sizing for cell base area

Peak leachate flow rates for Design Cases A and B have been calculated as indicated in Section 3.2, using the tributary areas presented in the table below. These areas generally represent a stage at which Tender Package 1A and the lower portion of Tender Package 1B are constructed and partially landfilled and the uppermost portion of Tender Package 1B is newly constructed with no cover material.

[4] IFD table presented in Section 1.2 of Appendix B of the March 2012 “Surface Water Assessment” (Golder memo117625003_160_M_Rev0).

Table 4: Infiltration Rates and Tributary Areas for Header Pipe in Cell Base

Area type	% Infiltration	Tributary Area (m^2)	
		Leachate Pipe Design Case A	**Leachate Pipe Design Case B**
Daily Cover with 2 lifts or more of waste	60	10,000	10,000
Intermediate Capping	20	48,000	38,000
Final Capping	1	0	0
Construction (no cover)	100	5,000	10,000
Daily cover with 1 lift of waste or less (used for Case B rainfall event)	80	NA	5,000

Case A

The calculated peak leachate flow rate for Design Case A is 7.2 L/s.

Pipe flow capacity calculations using Manning's equation for partially full pipes under gravity flow have been performed for detailed design. It is noted that the standard Manning coefficient requires modification when applied to partially full pipes. All leachate pipes within the cell base liner leachate collection layer have been designed as HDPE pipes with nominal outside diameter of 355 mm and inside diameter of 300 mm (SDR 13.6).

This sized pipe, at the minimum design pipe invert slope of 1% for the cell base liner and with a Manning coefficient of 0.009 for HDPE pipe, has a calculated flow capacity of 9.5 L/s and an average flow velocity of 0.94 m/s for a flow height of 20% of the pipe inside diameter. These results indicate that the selected pipe size provides a factor of safety of 1.3 for the flow rate requirement and meets the minimum velocity requirement for Design Case A as given in Section 3.1.

Case B

The calculated peak leachate flow rate for Design Case B is 36.3 L/s, with approximately 25% of the flow arising from the average monthly component and 75% arising from the rainfall event component. The calculated flow capacity for the cell base pipe size (i.e., HDPE pipe, O.D. 355 mm, I.D. 300 mm) for a height of flow of80% of the pipe inside diameter is 124L/s. This result indicates that the selected pipe size provides a factor of safety of more than three for the flow rate requirement for Design Case B as given in Section 3.1.

3.4 Collection and header pipe sizing for piggy back area

The calculated peak water flow rates for Design Case C are presented in the table below. The flow rates are 22 L/s and 195 L/s for the cross-slope collection pipe and the down-slope header pipe, respectively.

Pipe flow capacity calculations using Manning's equation have been performed, as in Section 3.3, and the results are given in the table below. The pipe invert slope in Manning's equation calculation varies for each leachate collection pipe under consideration based on the piggy back landfill liner system design grades. Typical minimum slopes were used as a conservative approach: cross-slope collections pipe calculations used a slope of 2% and down-slope header pipe calculations used a slope of 10%. The calculations used a Manning coefficient of 0.009 for HDPE pipe.

Table 5: Pipe sizing for Piggy Back Area – Design Case C

Parameter	Cross-Slope Collection pipe	Down-Slope Header pipe
Peak Flow Rate Calculation		
Rainfall event	20 yr ARI, 90 minute duration	
Rainfall Intensity (mm/hr)	65	
Tributary Area (m^2)	1,200	10,800
Peak/ave factor	1	1
Q = Calculated Peak Flow (L/s)	21.7	195
HDPE Pipe Flow Capacity Calculation		
Pipe Slope %	2	10
Pipe outside diameter (mm)	160	315
Pipe inside diameter D (mm)	136	267
C_{80} = Calculated flow capacity for flow depth 0.8D, (L/s)	21.3	288
Factor of Safety (C_{80}/Q)	1.0	1.5

Cross-slope Collection Pipe

The calculated flow capacity for the nominated cross-slope collection pipe size (i.e., HDPE pipe, O.D. 160 mm, I.D. 136 mm, SDR 13.6) for a height of flow of 80% of the pipe inside diameter is 21.3L/s. This result indicates that the selected pipe size is just adequate to meet the flow rate requirement for Design Case C as given in Section 3.1.

Down-Slope Header Pipe

The calculated flow capacity for the nominated down-slope header pipe size (i.e., HDPE pipe, O.D. 315 mm, I.D. 267 mm, SDR 13.6) for a height of flow of 80% of the pipe inside diameter is 288 L/s. This result indicates the selected pipe size provides a factor of safety of 1.5 for the flow rate requirement for Design Case C as given in Section 3.1.

4.0 REFERENCES

Bonaparte, R., Daniel, D., and Koerner, R., 2002, Assessment and Recommendations for Improving the Performance of Waste Containment Systems, CR-821448-01-0, Environmental Protection Agency, Washington, DC.

EPA Victoria (September 2010) *Best Practice Environmental Management – Siting, Design, Operation and Rehabilitation of Landfills (Publication 788.1)*

Giroud, J.P., J.G. Zornberg and A. Zhao (2000), "*Hydraulic Design of Geosynthetic and Granular LiquidCollection Layers*", Geosynthetics International, Vol 7, No.s 4-6, pp. 285-380.

Giroud, J.P., A. Zhao, H.M. Tomlinson and J.G.Zornberg. (2004), "*Liquid flow equations for drainage systems composed of two layers including a geocomposite*", Geosynthetics International, Vol 11, No. 1, pp. 43-58.

Golder Associates (April 2012) *Whytes Gully New Landfill Cell Report for Preliminary Design*
NSW EPA (1996) *Environmental Guidelines: Solid Waste Landfills*

Rowe, R.K., Quigley, R.M., Brachman, R.W.I., and Booker, J.R., 2004, Barrier Systems for Waste Disposal Facilities, 2nd Edition, Spon Press, p. 439.

Kelly Dohle
Senior Environmental Engineer

Gary Schmertmann
Associate

KAD/GRS/kad

u:\kad\whytes gully\docs to pdf\app e 117625003_227_m_rev0_leachate collection design.docx

APPENDIX F

Leachate Generation and Water Balance Modelling

TECHNICAL MEMORANDUM

DATE 29 June 2013 **REFERENCENo.** 117625003_250_M_Rev0

TO Michael Herraman
Wollongong City Council

CC

FROM Kelly Dohle, Gary Schmertmann **EMAIL** kdohle@golder.com.au; gschmertmann@golder.com.au

LEACHATE GENERATION AND WATER BALANCE MODELLING – PACKAGE 1A TO PACKAGE 3

1.0 INTRODUCTION

This memorandum describes the leachate generation and water balance modelling that has been undertaken to assess the leachate storage requirements associated with Packages 1A, 1B, 2 and 3 of the Whytes Gully New Landfill Cell Project. The modelling undertaken follows the approach presented for the 50% design in the Golder technical memorandum dated March 2012 "Leachate Generation and Water Balance Modelling" (ref. 117625003_151_M_Rev0). The 50% design memorandum presented:

- Review of existing leachate management and flows;
- Leachate generation modelling of existing and new landfill cells;
- Assessment of leachate pond capacity;
- Discussion of leachate management options.

The 50% design memorandum also presented a discussion of existing leachate management at the site, including leachate generation, storage, treatment and disposal, and a discussion of proposed leachate management. The proposed leachate management has not been modified for the detailed design of construction packages 1A, 1B, 2 and 3.

This memorandum provides an update to the leachate generation and water balance modelling, and in particular:

- Leachate generation modelling of existing and new landfill cells for construction packages 1A, 1B, 2 and 3; and
- Assessment of leachate pond capacity with respect to the leachate generated for construction packages 1A, 1B, 2 and 3.

2.0 LEACHATE GENERATION MODELLING

The leachate generation has been modelled using a Microsoft excel based site water balance model using monthly timesteps (as required in *Director General Requirements for Whytes Gully Waste Disposal Facility – New Landfill Cells, Reddalls Road, Kembla Grange,Office of Environment and Water Director General Requirements*, dated 5 August 2011). The water balance has been conducted throughout the proposed construction and operation of packages 1A, 1B, 2 and 3 at the site considering existing and proposed design conditions. The modelling data input and assumptions are outlined below.

2.1 Staging Plan

The development strategy for the site involves the construction of the new landfill cell in 5 Stages (Stages 1, 2A, 2B, 3 and 4), with each stage comprising staggered liner construction, waste filling, and final capping. The order of construction has been modified since preparation of the 50% design, with the first four construction'Packages' as follows: Package 1A and 1B generally in the area of Stage 1 and involving significant area of piggy back lining, and Packages 2 and 3 progressing westward along the toe of the existing landfill and involving minimal or no piggy back lining.Package 1A is anticipated to be ready to accept waste by the end of 2013. The proposed timeline for construction of the first four Packages is presented in Table 1 with months numbered sequentially from the start of liner construction in Package 1A.

Table 1: Proposed Construction Staging Plan (to nearest 100 m^2 or m^3)

Package	Area (m^2)	Area of final capping installed in stage by end of package (m^2)	Area of final capping installed in stage by end of stage as a proportion of cumulative package areas	Area of existing waste covered by PB liner (m^2)	Volume (m^3)	Liner Construction			Waste Filling			Final Capping		
						Start (month)	End (month)	Duration (months)	Start (month)	End (month)	Duration at current filling rates (months)	Start (month)	End (month)	Duration (months)
1A	25930	10000	39%	18470	161000	1	6	5	6	20	14	44	46	2
1B	34200	17800	46%	34200	305400	14	20	6	20	46	26	46	52	6
2	18500	3200	39%	3450	433000	40	46	6	46	83	37	83	88	5
3	24100	10100	40%	0	378600	77	83	6	83	115	32	115	121	6
Total	102730	-	-	56120	1278000									

2.2 Rainfall and Evaporation

The mean monthly rainfall records at Port Kembla Signal Station (Station No. 068053), sourced from the Bureau of Meteorology (BOM) were adopted in the base case leachate generation model. Port Kembla Signal Station, located approximately 8.5 km from the site, is the closest BOM station with rainfall data available. The rainfall records for Port Kembla Signal Station span from 1950 to 1977. The calculated monthly mean rainfall rates have been adopted. Calibration of the average records against the 5 years of available site data (provided by Council) has shown the Port Kembla Signal Station average values to be higher.

Based on the 27 years of rainfall records available for Port Kembla Signal Station, the statistical 90th percentile annual total rainfall is 1767 mm. The monthly 90th percentile rainfall has been synthesised as follows:

- Calculating the average distribution of rainfall throughout the wettest 5 years recorded for Port Kembla Signal Station (ie. calculating theaverage percentage of annual rainfall that falls in each month); and
- Apportioning the statistical 90th percentile annual total rainfall (1767 mm) across the months accordingly.

The mean monthly evaporation rate records at Nowra RAN Air Station (Station No. 068076), sourced from the BOM and corrected using a Pan Evaporation Factor of 0.8 were also adopted in the leachate generation model. Nowra RAN Air Station, located approximately 58 km from the site, is the closest BOM station with evaporation data available.

The adopted rainfall and evaporation data are presented in Table 2 below.

Table 2: Rainfall and Evaporation Rates (to nearest mm)

Month	Mean Rainfall (mm)	Synthethised 90th Percentile Rainfall (mm)	Factored Mean Evaporation (mm)
January	116	88	94
February	158	263	74
March	184	379	67
April	93	131	77
May	89	93	102
June	140	150	115
July	63	90	139
August	88	119	144
September	55	43	169
October	108	169	154
November	94	171	137
December	90	72	114
Annual	1279	1767	1385

2.3 ModellingAssumptions

The following assumptions have been adopted in the leachate balance modelling:

Geometry and Landfilling Rate

- Landfill airspace is consumed at a rate of 140,000 m^3 per year for the operation life of the landfill.
- All existing waste will be covered by piggy back liner, with the exception of approximately 3.1 ha in Stage 1 (Package 1A and 1B). The area of existing waste that is not covered by a piggy back liner is conservatively assumed to be covered by intermediate cover until the fifth year of the project (month 52) when the construction of the final Package 1A and 1B cap has been completed.
- Area of active filling (daily cover) will be maintained at 10,000 m^2 throughout the operational life of the landfill.
- Intermediate cover is conservatively assumed to progressively cover the area of each proposed stage throughout the period of liner construction in each stage (assumes that the liner will progressively be covered with waste).
- Infiltrating rainwater is assumed to be collected as leachate in the same month as the rainfall occurs. This is equivalent to assuming that all waste is uniform and is at field capacity at the start of the simulation.
- Leachate generation does not include quantities associated with drainage of existing accumulated leachate in the Western Gully (refer Section 2.1 in Memorandum reference 117625003_151_M_Rev0).
- Leachate generation does not include quantities associated with leachate recirculation.

Leachate Ponds

- Existing leachate ponds (retained until the end of Stage 3) have a surface area of approximately 9,000 m^2 and a capacity of 18,000 m^3plus freeboard.
- The leachate ponds were initially assumed to be empty.
- The discharge rate from the leachate ponds is assumed to be 250 kL/day.
- Under average rainfall conditions, direct rainfall into the leachate ponds is assumed to apply to the surface area of the ponds and evaporation is assumed to apply to the base area of the ponds as the ponds have been modelled to be largely empty under average rainfall conditions.
- Under 90th percentile rainfall conditions, direct rainfall and evaporation from the leachate ponds is assumed to apply to the surface area of the ponds as the ponds have been modelled to be near capacity under 90th percentile rainfall conditions.

Existing Leachate Collection System

- Prior to covering with piggy back liner, leachate collection in the existing system is conservatively assumed to correspond to the following rainfall infiltration rate:
  - Existing cover: 20% (Based on Western Gully having up to 2 m cover representing approximately half of the area and Eastern Gully terraced batters being re-profiled with intermediate cover and the active area on the platform of the landfill being filled, covered and profiled to shed surface water representing approximately half of the area).
  - During the construction of the piggy back liner in each stage, the leachate collection in the existing system is assumed to reduce as indicated in Table 3. The reduction is conservatively assumed to begin for each Stage (or construction package) of the project after 50% of the piggyback liner area has been installed in that Stage.

Table 3: Assumed Leachate Collection in Existing System after the Construction of 50% of the Piggy Back Liner

Years after installation of piggy back liner	Leachate collection as a percentage rate occurring prior to the construction of the piggy back liner
1	50%
2	25%
3	15%
4	10%
5 (and thereafter)	5%

The reduction reflects the anticipated effect of the piggyback liner to cut off rainfall infiltration and thereby gradually reduce leachate generation and collection from underlying existing waste. The assumed rate of leachate generation does not reach zero, but rather is assumed to persist at a small rate due to possible ongoing collection of groundwater and to squeezing out of leachate resident in existing waste due to consolidation in response to increased loading from new waste placement.

New Leachate Collection

- Leachate collection in the new system (i.e. piggy back liner and new cell liner) is assumed to correspond to the following rainfall infiltration rates:
  - Daily cover: 60%
  - Intermediate cover: 20%

Final Capping

- The rate of leachate collection resulting from rainfall infiltration after final capping is assumed to correspond to an infiltration rate of 1%. This rate is considered to be conservative for the proposed capping sytem which includes an LLDPE geomembrane layer.
- The final cap of each stage is assumed to be constructed progressively throughout the period of construction of the cap.

2.4 Modelling Results

The predicted monthly leachate collection volumes (based on average monthly rainfall) are summarised in Table 4 below.

Table 4: Modelled Volumes of Leachate Collection (Average Monthly Rainfall)

Package	Leachate Collection (kL/month)		Leachate Requiring Storage (kL/month)*		Cumulative Leachate Storage Required (kL)	
	Minimum	Maximum	Minimum	Maximum	Maximum	At end of Package
1A	2404	8437	0	2244	2922	0
1B	2617	9229	0	3036	4422	0
2	1998	7632	0	1438	2494	0
3	1511	5792	0	0	0	0

Notes:

* After the consideration of rainfall, evaporation and discharge to sewer

The modelled leachate volumes (based on average monthly rainfall) indicate that throughout Packages 1A to 3, the maximum leachate requiring storage (3 3036 kL/month) occurs during the fourth year of the project (month 39) and the maximum cumulative volume of leachate requiring storage (4 422 kL) occurs at the same time. With a capacity of approximately 18 000 kL, the existing leachate ponds are therefore expected to have sufficient capacity to store leachate generated during Packages 1A to 3 under average rainfall conditions.

A graph showing the monthly volume of generated leachate and cumulative leachate volume requiring storage under average rainfall conditions is included below as Figure 1.

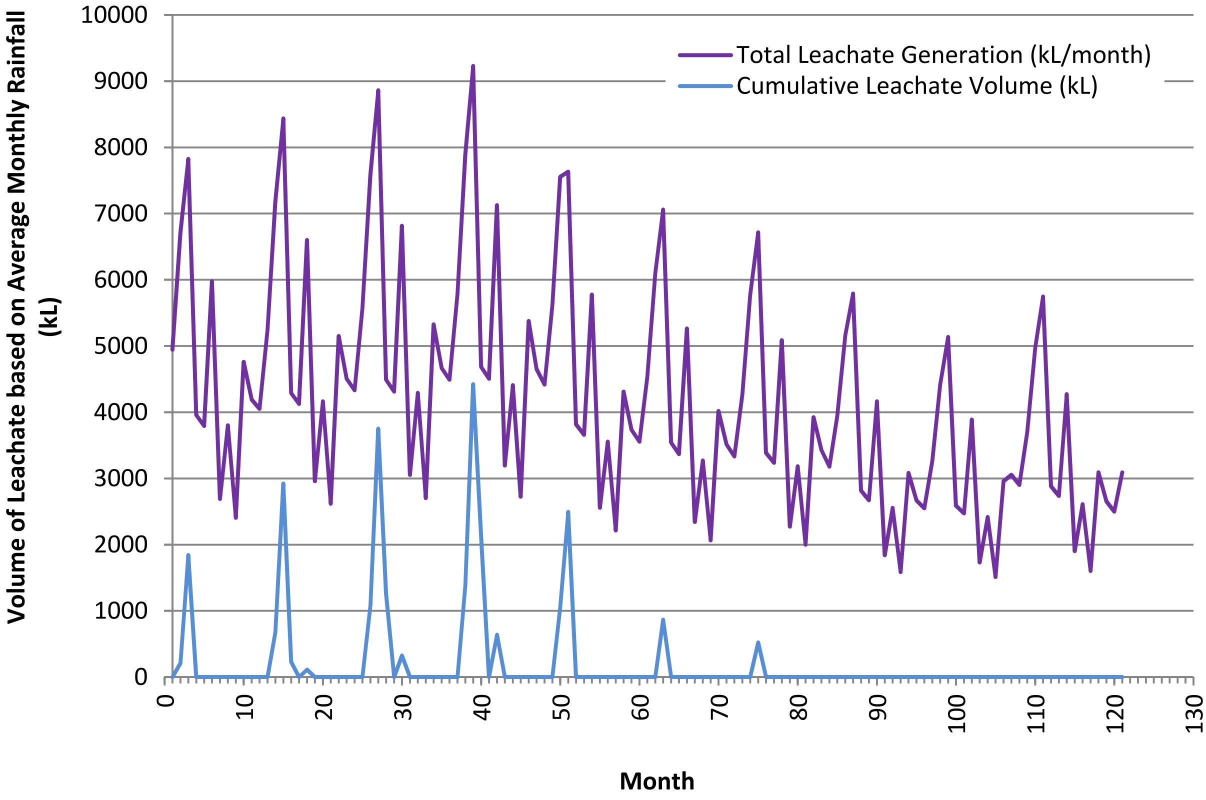


Figure 1: Average monthly rainfall - Leachate Generation and Storage Volumes

2.5 Sensitivity Analyses

As recommended in EPA Victoria's *Best Practice Environmental Management – Siting, Design, Operation and Rehabilitation of Landfills* (Publication 788.1, dated September 2010) (BPEM), the 90th Percentile rainfall data is adopted for two consecutive years as a sensitivity analysis to ensure the system has sufficient capacity over the operational period for Package 1A to Package 3.

The predicted monthly leachate generation volumes (based on 90th percentile monthly rainfall) are summarised in Table 5 below. Years three and four were selected for this analysis as this is the period which results in the highest volume of cumulative leachate storage required.

Table 5:Modelled Volumes of Leachate Collection (90th Percentile Rainfall)

Years	Leachate Collection (kL/month)		Volume of Leachate Requiring Storage (kL/month)*		Cumulative Leachate Storage Required (kL)	
	Minimum	Maximum	Minimum	Maximum	Maximum	At end of year
3	2595	10234	0	5047	6830	0
4	2604	11218	0	6031	8451	0

Notes:

* After the consideration of rainfall, evaporation and discharge to sewer

The modelled volumes (based on 90th Percentile rainfall) indicate that throughout Packages 1A to 3, the maximum leachate requiring storage (6 031 kL/month) and the maximum cumulative volume of leachate requiring storage (8451 kL) occur during the fourth year of the project (month 39). With a capacity of approximately 18 000 kL, the existing leachate ponds are therefore expected to have sufficient capacity to store leachate generated during two consecutive wet years.

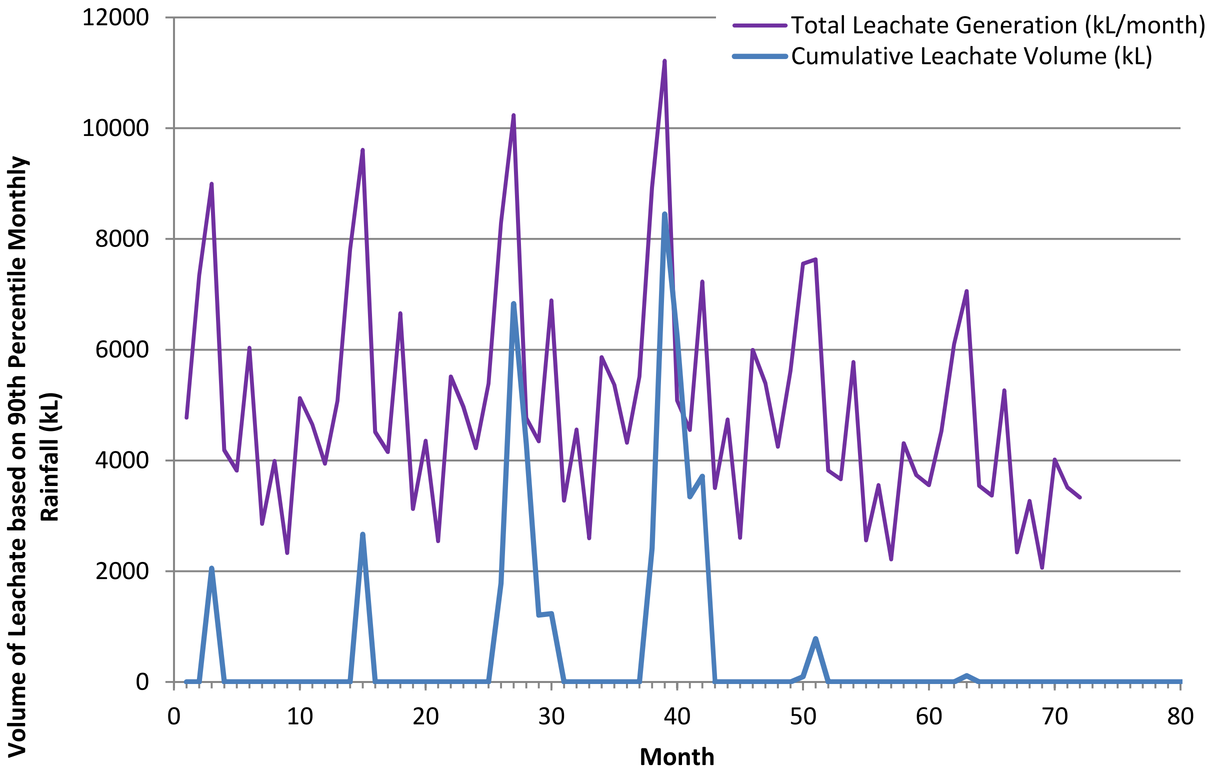


Figure 2: 90th Percentile Rainfall - Leachate Generation and Storage Volumes

2.6 Conclusion

The monthly leachate water balance using average rainfall shows the existing ponds are of adequate capacity for Packages1A to 3.

Sensitivity analyses indicate the ponds are of an adequate capacity for two consecutive years of 90th percentile rainfall.

3.0 RECOMMENDATIONS

Based on the results of this analysis it is proposed to:

- Continue to use the existing leachate treatment and disposal system with the current holistic leachate treatment philosophy.
- Review the resultant leachate generation volumes and rainfall amounts during 2014 and reassess the water balance model assumptions for infiltration rates.
- Continue to review the integrity of the leachate ponds through groundwater analysis and inspection.
- Continue to liaise with Sydney Water on timing for sewer capacity upgrade.Sydney Water may in this time develop firm upgrade plans for the sewer along Reddalls Road and consider an increased discharge limit to sewer for the Project site.
- ‘Drain’, treat and dispose of accumulated leachate in the Western Gully prior to commencement of construction of Packages 2 and 3.

4.0 REFERENCES

EPA Victoria (September 2010) *Best Practice Environmental Management – Siting, Design, Operation and Rehabilitation of Landfills (Publication 788.1)*

Golder Associates (2012), Leachate Generation and Water Balance Modelling Technical Memorandum (ref: 117625003_151_M_Rev0, dated March 2012)

Report Signature Page

Kelly Dohle
Senior Environmental Engineer

Gary Schmertmann
Associate

KAD/GRS/kd

u:\kad\whytes gully\docs to pdf\117625003-250-m-rev0-leachate_generation_and_water_balance_modelling_-detailed_design_(grs_review).docx

List of Attachments

Attachment 1: Extract from Leachate Water Balance Calculations

Attachment 2: Limitations

Golder Associates

BASE CASE - AVERAGE MONTHLY RAINFALL

Key:

Input cells
Output cells

INPUT

Staging Plan

Package	Area (m²)	Area of final capping installed in package by end of package (m²)	Area of final capping installed by end of package as a proportion of total New Landfill area	Area of existing waste covered by PB liner (m²)	Package volume (m³)	Liner Construction			Waste Filling			Final Capping		
						Start (month)	End (month)	Duration (months)	Start (month)	End (month)	Duration at current filling rates (months)	Start (month)	End (month)	Duration (months)
1A	25930	10000	39%	18470	161000	1	6	5	6	20	14	44	46	2
1B	34200	17800	46%	34200	305400	14	20	6	20	46	26	46	52	6
2	18500	3200	39%	3450	433000	40	46	6	46	83	37	83	88	5
3	24100	10100	40%	0	378600	77	83	6	83	115	32	115	121	6
Total	102730	41100		56120	1278000									

Current filling rate	140000	m³/yr
Area of Stage 1 Existing Waste not covered by PB liner	31341	m²
Area of active filling area (daily cover only)	10000	m²

% package final capping (column) installed by end of package (row)

	package 1A	package 1B	package 2	package 3
package 1A	39%	-	-	-
package 1B	39%	46%	-	-
package 2	91%	54%	39%	-
package 3	91%	54%	62%	40%

Leachate Ponds

Existing pond area available for direct rainfall (Stages 1-3)	9000	m²	surface area
Proposed pond area available for direct rainfall (Stage 4)	-	m²	
Existing pond area available for evaporation (Stages 1-3)	2200	m²	base area (as ponds are generally near empty)
Proposed pond area available for evaporation (Stage 4)	-	m²	
Starting volume	0	kL	
Discharge rate to leachate treatment plant (Year 1)	250	kL/day	
	7604	kL/month	
Discharge rate to leachate treatment plant (Year 2 onwards)	250	kL/day	
	7604	kL/month	

area package final capping (column) installed by end of package (row)

	package 1A	package 1B	package 2	package 3
package 1A	10,000	-	-	-
package 1B	10,000	17,800	-	-
package 2	23,500	18,530	3,200	
package 3	23,500	18,530	11,400	10,100

BASE CASE - AVERAGE MONTHLY RAINFALL

Weather Data

	Rainfall (Port Kembla Signal Station 068053)		Pan Evaporation (Nowra RAN Air Station 068076)			Factored Mean Total Evaporation
	Mean Total		Mean Daily		Mean Total	
	mm	m	mm	m	m	m
January	116.1	0.1161	6.2	0.0062	0.186	0.1488
February	157.5	0.1575	5.7	0.0057	0.1767	0.14136
March	183.7	0.1837	4.6	0.0046	0.138	0.1104
April	92.9	0.0929	3.9	0.0039	0.1209	0.09672
May	89	0.089	3	0.003	0.093	0.0744
June	140.3	0.1403	2.8	0.0028	0.084	0.0672
July	62.6	0.0626	3.1	0.0031	0.0961	0.07688
August	87.7	0.0877	4.1	0.0041	0.123	0.0984
September	55	0.055	4.8	0.0048	0.1488	0.11904
October	108	0.108	5.6	0.0056	0.1736	0.13888
November	94.3	0.0943	6	0.006	0.18	0.144
December	90.4	0.0904	6.8	0.0068	0.2108	0.16864
Annual	1278.6	1.2786	4.7	0.0047	1.73	1.38

Pan Evaporation Factor	0.8

Capping Infiltration Rates

Capping	Future Waste			Existing Waste		
	Infiltration (% of rainfall)	ET (% of rainfall)	Runoff (% of rainfall)	Infiltration (% of rainfall)	ET (% of rainfall)	Runoff (% of rainfall)
Daily cover	60%	40%	0%	60%	40%	0%
Intermediate cover	20%	80%	0%	20%	80%	0%
Final capping	1%	80%	19%	1%	80%	19%

Existing Leachate Generation

	2.44	L/s	based on 2010 leachate meter volumes from WCC
Existing landfill leachate generation	6412	kL/month	
	76948	kL/yr	
Equivalent area	185314	m^2	assumes 100% intermediate cover, with 75% of leachate collected
Area of existing waste	185314	m^2	
Area covered by leachate collection	185314	m^2	
Equivalent Existing Infiltration	43%		calculated such that equivalent area = area of existing waste

BASE CASE - AVERAGE MONTHLY RAINFALL

Future Leachate Generation in Existing Waste

Years after piggy back liner is 50% installed	Leachate generation as a percentage of original generation prior to the construction of the piggy back liner
0	100%
1	50%
2	25%
3	15%
4	10%
5 (and thereafter)	5%

% Cover Over Future Waste at Key Events

Event				Month	Package 1A		Package 1B		Package 2		Package 3	
Package 1A	Package1B	Package 2	Package 3		Final	Int.	Final	Int.	Final	Int.	Final	Int.
Commence Liner				1	0%	0%	0%	0%	0%	0%	0%	0%
Complete Liner				6	0%	0%	0%	0%	0%	0%	0%	0%
	Commence Liner			14	0%	57%	0%	0%	0%	0%	0%	0%
ste Start	Complete Liner			20	0%	100%	0%	0%	0%	0%	0%	0%
		Commence Liner		40	0%	100%	0%	77%	0%	0%	0%	0%
Commence Cap				44	0%	81%	0%	92%	0%	0%	0%	0%
Complete Cap	Commence Cap	Complete Liner		46	39%	61%	0%	100%	0%	0%	0%	0%
	Complete Cap			52	39%	61%	46%	54%	0%	16%	0%	0%
			Commence Liner	77	39%	61%	46%	54%	0%	84%	0%	0%
3 Liner End		Commence Cap	Complete Liner	83	39%	61%	46%	54%	0%	100%	0%	0%
		Complete Cap		88	91%	9%	54%	46%	39%	61%	0%	16%
			Commence Cap	115	91%	9%	54%	46%	39%	61%	0%	100%
			Complete Cap	121	91%	9%	54%	46%	62%	38%	40%	60%

BASE CASE - AVERAGE MONTHLY RAINFALL

OUTPUT

Calculated Leachate Collection and Storage Requirements

Stage	Leachate Collection (kL/month)		Leachate Requiring Storage (kL/month)^		Cumulative Leachate Storage Required (kL)	
	Minimum	Maximum	Minimum	Maximum	Maximum	At end of Package
Package 1A	2404	8437	-4967	2244	2922	0
Package 1B	2617	9229	-4754	3036	4422	0
Package 2	1998	7632	-5373	1438	2494	0
Package 3	1511	5792	-5860	3036	0	0

^After the consideration of rainfall, evaporation and discharge to sewer

SENSITIVITY ANALYSIS - 90TH PERCENTILE RAINFALL (YEARS 3 & 4)

Key:

Input cells
Output cells

INPUT

Staging Plan

Package	Area (m^2)	Area of final capping installed in package by end of package (m^2)	Area of final capping installed by end of package as a proportion of total New Landfill area	Area of existing waste covered by PB liner (m^2)	Package volume (m^3)	Liner Construction			Waste Filling			Final Capping		
						Start (month)	End (month)	Duration (months)	Start (month)	End (month)	Duration at current filling rates (months)	Start (month)	End (month)	Duration (months)
1A	25930	10000	39%	18470	161000	1	6	5	6	20	14	44	46	2
1B	34200	17800	46%	34200	305400	14	20	6	20	46	26	46	52	6
2	18500	3200	39%	3450	433000	40	46	6	46	83	37	83	88	5
3	24100	10100	40%	0	378600	77	83	6	83	115	32	115	121	6
Total	102730	41100		56120	1278000									

Current filling rate	140000	m^3/yr
Area of Stage 1 Existing Waste not covered by PB liner	31341	m^2
Area of active filling area (daily cover only)	10000	m^2

% package final capping (column) installed by end of package (row)

	package 1A	package 1B	package 2	package 3
package 1A	39%	-	-	-
package 1B	39%	46%	-	-
package 2	91%	54%	39%	-
package 3	91%	54%	62%	40%

Leachate Ponds

Existing pond area available for direct rainfall (Stages 1-3)	9000	m^2	surface area
Proposed pond area available for direct rainfall (Stage 4)	-	m^2	
Existing pond area available for evaporation (Stages 1-3)	9000	m^2	surface area (as ponds are generally full)
Proposed pond area available for evaporation (Stage 4)	-	m^2	
Starting volume	0	kL	
Discharge rate to leachate treatment plant (Year 1)	250	kL/day	
	7604	kL/month	
Discharge rate to leachate treatment plant (Year 2 onwards)	250	kL/day	
	7604	kL/month	

area package final capping (column) installed by end of package (row)

	package 1A	package 1B	package 2	package 3
package 1A	10,000	-	-	-
package 1B	10,000	17,800	-	-
package 2	23,500	18,530	3,200	
package 3	23,500	18,530	11,400	10,100

Golder Associates

SENSITIVITY ANALYSIS - 90TH PERCENTILE RAINFALL (YEARS 3 & 4)

Weather Data

	Rainfall (Port Kembla Signal Station 068053)				Pan Evaporation (Nowra RAN Air Station 068076)			Factored Mean Total Evaporation
	Mean		Synthetised 90th Percentile Year		Mean Daily		Mean Total	
	mm	m	mm	m	mm	m	m	m
January	116.1	0.1161	87.7	0.0877	6.2	0.0062	0.186	0.1488
February	157.5	0.1575	262.9	0.2629	5.7	0.0057	0.1767	0.14136
March	183.7	0.1837	379.0	0.3790	4.6	0.0046	0.138	0.1104
April	92.9	0.0929	130.5	0.1305	3.9	0.0039	0.1209	0.09672
May	89	0.089	93.3	0.0933	3	0.003	0.093	0.0744
June	140.3	0.1403	149.7	0.1497	2.8	0.0028	0.084	0.0672
July	62.6	0.0626	90.0	0.0900	3.1	0.0031	0.0961	0.07688
August	87.7	0.0877	119.4	0.1194	4.1	0.0041	0.123	0.0984
September	55	0.055	42.6	0.0426	4.8	0.0048	0.1488	0.11904
October	108	0.108	168.9	0.1689	5.6	0.0056	0.1736	0.13888
November	94.3	0.0943	170.8	0.1708	6	0.006	0.18	0.144
December	90.4	0.0904	72.2	0.0722	6.8	0.0068	0.2108	0.16864
Annual	1278.6	1.2786	1767.0	1.7670	4.7	0.0047	1.73	1.38

Pan Evaporation Factor	0.8

Capping Infiltration Rates

Capping	Future Waste			Existing Waste		
	Infiltration (% of rainfall)	ET (% of rainfall)	Runoff (% of rainfall)	Infiltration (% of rainfall)	ET (% of rainfall)	Runoff (% of rainfall)
Daily cover	60%	40%	0%	60%	40%	0%
Intermediate cover	20%	80%	0%	20%	80%	0%
Final capping	1%	80%	19%	1%	80%	19%

Existing Leachate Generation

	Value	Unit	Notes
	2.44	L/s	based on 2010 leachate meter volumes from WCC
Existing landfill leachate generation	6412	kL/month	
	76948	kL/yr	
Equivalent area	185314	m^2	assumes 100% intermediate cover, with 75% of leachate collected
Area of existing waste	185314	m^2	
Area covered by leachate collection	185314	m^2	
Equivalent Existing Infiltration	43%		calculated such that equivalent area = area of existing waste

SENSITIVITY ANALYSIS - 90TH PERCENTILE RAINFALL (YEARS 3 & 4)

Future Leachate Generation in Existing Waste	
Years after piggy back liner is 50% installed	Leachate generation as a percentage of original generation prior to the construction of the piggy back liner
0	100%
1	50%
2	25%
3	15%
4	10%
5 (and thereafter)	5%

% Cover Over Future Waste at Key Events

Event					Month	Package 1A		Package 1B		Package 2		Package 3	
Package 1A	Package1B	Package 2	Package 3			Final	Int.	Final	Int.	Final	Int.	Final	Int.
Commence Liner					0	0%	0%	0%	0%	0%	0%	0%	0%
Complete Liner					6	0%	0%	0%	0%	0%	0%	0%	0%
	Commence Liner				14	57%	0%	0%	0%	0%	0%	0%	0%
l/Waste Start	Complete Liner				20	100%	0%	0%	0%	0%	0%	0%	0%
		Commence Liner			40	100%	0%	77%	0%	0%	0%	0%	0%
Commence Cap					44	81%	0%	92%	0%	0%	0%	0%	0%
Complete Cap	Commence Cap	Complete Liner			46	61%	0%	100%	0%	0%	0%	0%	0%
	Complete Cap				52	61%	46%	54%	0%	16%	0%	0%	0%
			Commence Liner		77	61%	46%	54%	0%	84%	0%	0%	0%
		Commence Cap	Complete Liner		83	61%	46%	54%	0%	100%	0%	0%	0%
kage 3 Liner End		Complete Cap			88	9%	54%	46%	39%	61%	0%	16%	0%
			Commence Cap		115	9%	54%	46%	39%	61%	0%	100%	0%
			Complete Cap		121	9%	54%	46%	62%	38%	40%	60%	0%

Golder Associates

SENSITIVITY ANALYSIS - 90TH PERCENTILE RAINFALL (YEARS 3 & 4)

OUTPUT

Calculated Leachate Collection and Storage Requirements

Year	Leachate Collection (kL/month)		Leachate Requiring Storage (kL/month)^		Cumulative Leachate Storage Required (kL)	
	Minimum	Maximum	Minimum	Maximum	Maximum	At end of Year
3	2595	10234	-5696	5047	6830	0
4	2604	11218	-5688	6031	8451	0

^After the consideration of rainfall, evaporation and discharge to sewer

LIMITATIONS

This Document has been provided by Golder Associates Pty Ltd ("Golder") subject to the following limitations:

This Document has been prepared for the particular purpose outlined in Golder's proposal and no responsibility is accepted for the use of this Document, in whole or in part, in other contexts or for any other purpose.

The scope and the period of Golder's Services are as described in Golder's proposal, and are subject to restrictions and limitations. Golder did not perform a complete assessment of all possible conditions or circumstances that may exist at the site referenced in the Document. If a service is not expressly indicated, do not assume it has been provided. If a matter is not addressed, do not assume that any determination has been made by Golder in regards to it.

Conditions may exist which were undetectable given the limited nature of the enquiry Golder was retained to undertake with respect to the site. Variations in conditions may occur between investigatory locations, and there may be special conditions pertaining to the site which have not been revealed by the investigation and which have not therefore been taken into account in the Document. Accordingly, additional studies and actions may be required.

In addition, it is recognised that the passage of time affects the information and assessment provided in this Document. Golder's opinions are based upon information that existed at the time of the production of the Document. It is understood that the Services provided allowed Golder to form no more than an opinion of the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings, or any laws or regulations.

Any assessments made in this Document are based on the conditions indicated from published sources and the investigation described. No warranty is included, either express or implied, that the actual conditions will conform exactly to the assessments contained in this Document.

Where data supplied by the client or other external sources, including previous site investigation data, have been used, it has been assumed that the information is correct unless otherwise stated. No responsibility is accepted by Golder for incomplete or inaccurate data supplied by others.

Golder may have retained subconsultants affiliated with Golder to provide Services for the benefit of Golder. To the maximum extent allowed by law, the Client acknowledges and agrees it will not have any direct legal recourse to, and waives any claim, demand, or cause of action against, Golder's affiliated companies, and their employees, officers and directors.

This Document is provided for sole use by the Client and is confidential to it and its professional advisers. No responsibility whatsoever for the contents of this Document will be accepted to any person other than the Client. Any use which a third party makes of this Document, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Golder accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this Document.

APPENDIX G

Surface Water Design

Golder Associates

TECHNICAL MEMORANDUM

DATE 18 March 2013 **PROJECT No.** 117625003-233-TM-Rev0

TO Wollongong City Council

CC

FROM Chris Anderson/Gary Schmertmann **EMAIL** cranderson@golder.com.au/gschmertmann@golder.com.au

WYHTES GULLY NEW LANDFILL CELL-DRAINAGE DESIGN

Golder Associates (Golder) has prepared this Technical Memorandum on behalf of Wollongong City Council (Council) for the Whytes Gully New Landfill Cell Project and design (Project). This Technical Memorandum presents the Issued for Construction (IFC) detailed surface water design for the proposed New Landfill Cell expansion project at the Whytes Gully Resource Recovery Park (RRP) near Kembla Grange, NSW. This Technical Memorandum is an appendix to the new design report per the Variation to Agreed Scope of Work Variation Number 22 dated 20 September 2012.[1]

This Technical Memorandum presents the design basis methodology, assumptions and results for the IFC surface water drainage design for the Tender Package 1, Tender Package 2 and Tender Package 3 stages of the Whytes Gully New Landfill Cell project.

The Project surface water drainage design includes the following drains:

- Diversion channel from the central ridge. This channel includes five components, listed upstream-to-downstream: (i) open channel drain on central ridge, also referred to as “Enkamat” drain; (ii) culvert under existing road; (iii) open channel on Western Gully Landfill surface; (iv) culvert under proposed future access road; and (v) gabion cascade structure. Water exiting the base of the gabion cascade structure will enter the existing site stormwater system.

  This channel will be functional for Tender Packages 1 and 2. For Tender Package 3, components (i) to (iii) will be functional and the disposition of components (iv) and (v) is uncertain (refer “Connection to Existing System” section below). This drain will be removed during a future stage of landfill construction.

- Southern permanent drain. This drain will be functional for Tender Packages 1, 2 and 3. This drain accepts water from the temporary eastern perimeter drain. This drain is progressively constructed in three sections corresponding to the three tender packages, with each section temporarily delivering water into the existing site stormwater system.

- Temporary eastern perimeter drain. This drain will be functional for Tender Packages 1, 2 and 3. This drain is on the Eastern Gully Landfill surface. This drain accepts water from the temporary Stage 1A bench drain and delivers water into the southern permanent drain. This drain will be replaced during a future stage of landfill construction.

---

[1] Golder (2012). *Variation Number 22 Proposed Revised Scope of Work for Detailed Design and Tender Documentation*. Golder Associates Pty Ltd document 117625003_189_M_Rev0 submitted to Wollongong City Council. 20 September 2012.

- Temporary Stage 1A bench drain. This drain will be functional for Tender Package 1A only, after which it will be removed. This drain delivers water into temporary eastern perimeter drain.

CONNECTION TO EXISTING SYSTEM

The Project surface water drainage design connects to the existing site stormwater system at the locations indicated in the bullet points above. These connections are temporary and will be removed or replaced during future stages of landfill construction. The design is based on the approach that the catchment areas contributing flow to the existing system will not change and therefore the risk is minor that the new design elements will alter flows to the degree that significant stormwater-induced damage would occur. Further, risk of stormwater-induced environmental release from the site is not significantly changed by the design due to the presence of the existing large-capacity pond system at the downstream end of the site.

It is noted that the Project surface water drainage design does not provide a functional outlet for water flowing in the Diversion Channel from the Central Ridge for Tender Package 3. Specifically, construction of Tender package 3 includes removal of the gabion cascade structure at the downstream end of the channel and does not provide an alternate outlet. Council has advised that an alternate outlet or other drainage flow path is to be designed by others prior to Tender Package 3.

METHODOLOGY

This section describes the data sources, preliminary design methodology and assumptions used for the detailed design.

Topography

Site topography utilises the following references:

- Whytes Photogrammetry and Ground Survey 20-07-11-2-A
- New landfill design landforms for Tender Package 1, Tender Package 2 and Tender Package 3 stages of the Whytes Gully New Landfill Cell project.

Figure 1, Figure 2 and Figure 3 show the catchments for the Project drains.

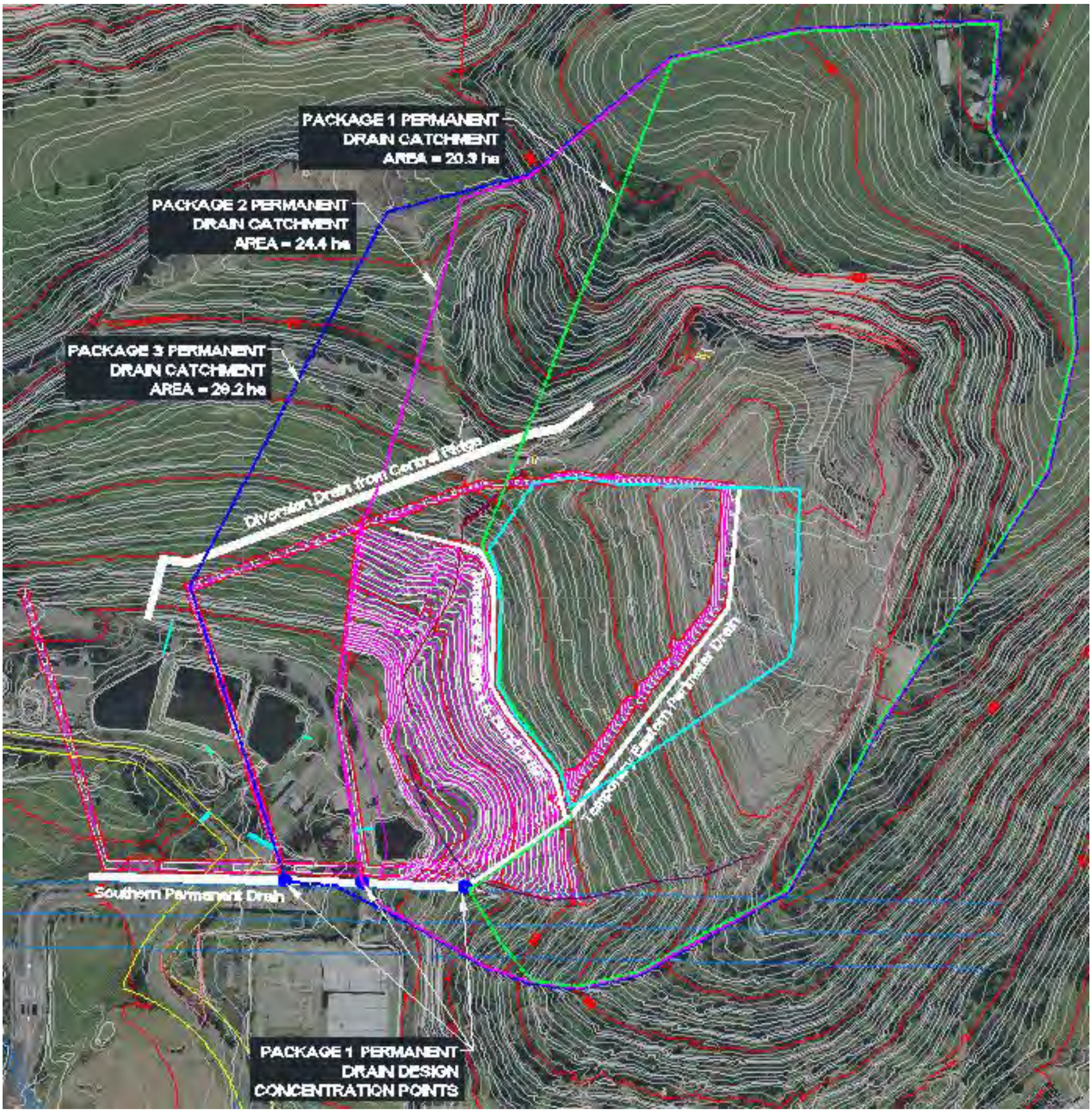


Figure 1: Catchment Map - Southern Permanent Drain

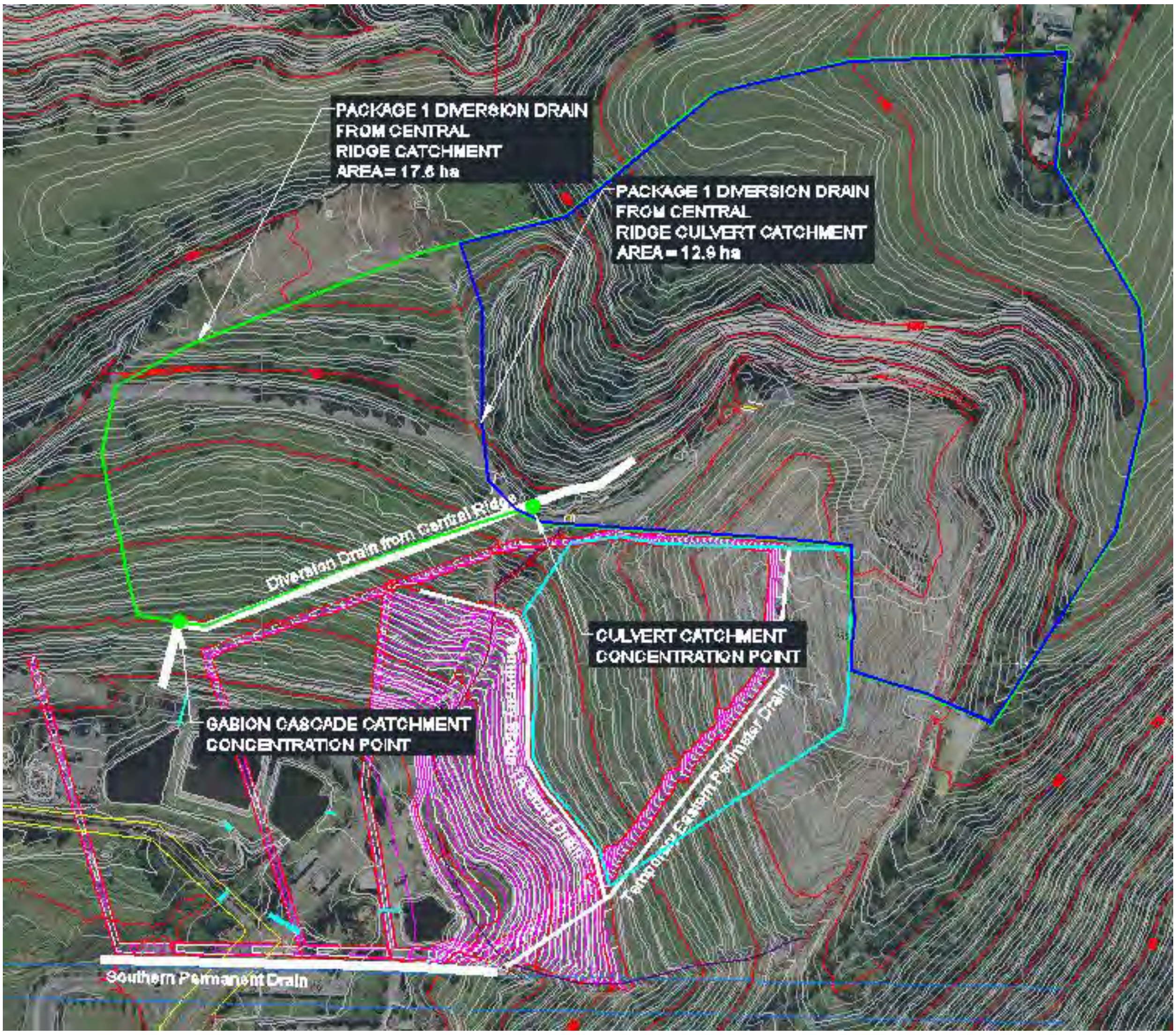


Figure 2: Catchment Map - Diversion Drain from Central Ridge

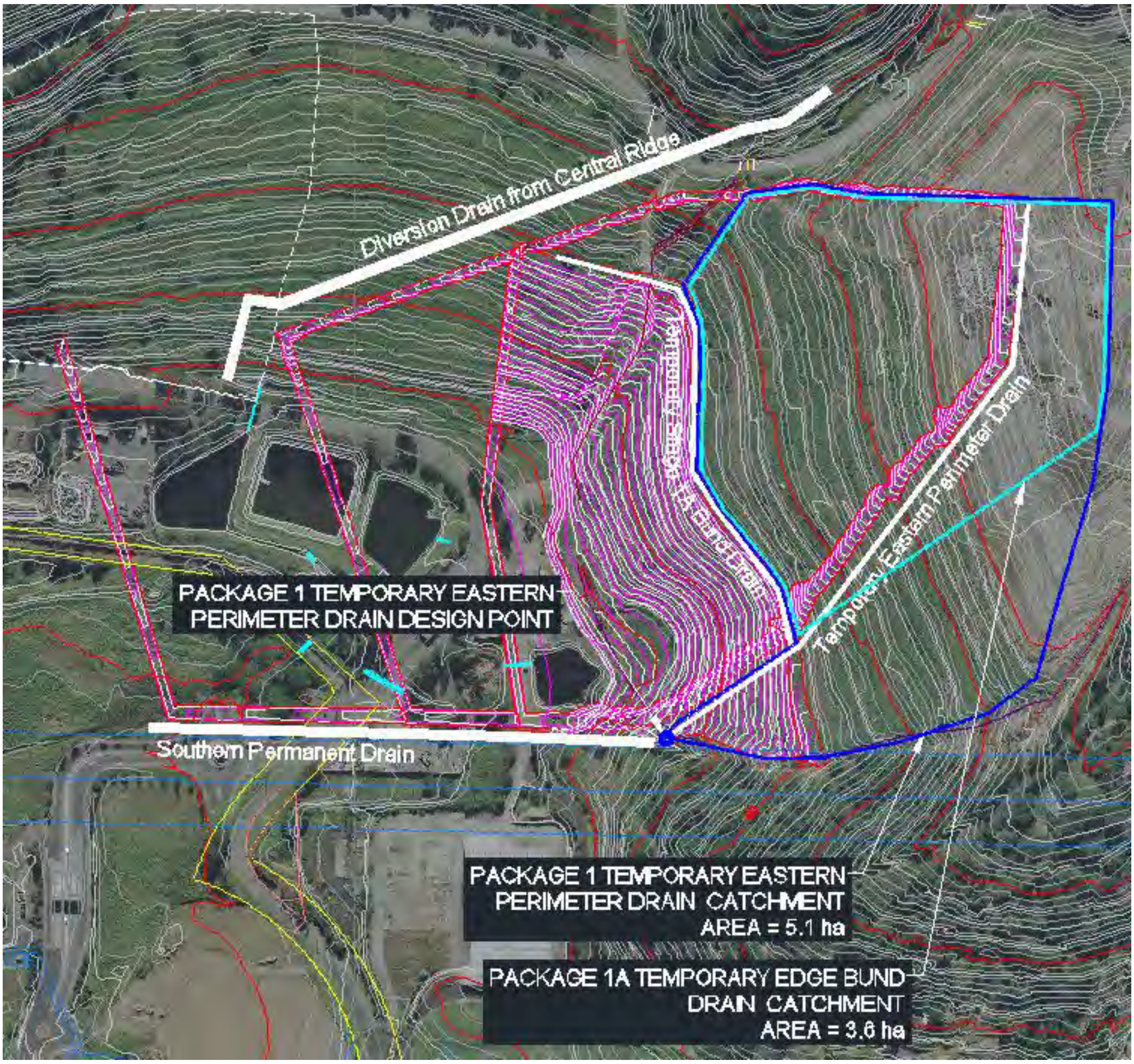


Figure 3: Catchment Map - Stage 1A Temporary Edge Bund

Hydrology

The following describes the hydrologic methods, data source and assumptions used for the stormwater runoff analysis for the Project site. Hydrology is based on the following conditions for the Project surface water drains:

- 100 year ARI storm event
  - Southern Permanent Drain
- 20 year ARI storm event
  - Temporary Eastern Perimeter Drain
  - Diversion Drain from Central Ridge
- 10 year ARI storm event
  - Stage 1A Temporary Edge Bund Drain

Precipitation

Rainfall intensity-frequency-duration (IFD) data for the Wollongong, NSW area is sourced from the Australian Bureau of Meteorology website. The IFD table is included in Attachment 1. Table 1 shows the IFD values for 1 to 100 year ARI storm events.

Table 1: Intensity-Frequency-Duration Values for Wollongong, NSW

DURATION (mins)	Precipitation (mm)						
	1 Year	2 years	5 years	10 years	20 years	50 years	100 years
5	117	148	183	201	227	261	285
10	90	115	143	159	181	209	230
15	76	97	122	136	155	180	198
20	66	85	107	120	138	160	177
25	59	76	97	109	125	146	161
30	54	69	89	100	115	134	149
40	46	60	77	87	101	118	131
50	41	53	69	78	90	106	119
60	37	48	63	71	83	97	109
90	29	37	49	56	65	77	86

Storm Runoff Hydrology

The Rational Method is used to estimate the peak storm runoff for the design of the Project drains and channels.

The Rational method utilises the following methodology for the time of concentration for overland flow and concentrated channel flow.

The Friend's Equation is used to calculate the time of concentration for overland sheet flow.

Friend's Equation: $t_i = 107nL^{0.33}/S^{0.2}$

t_i = initial overland sheet flow travel time, min

L = overland sheet flow path length, m

n = Horton's surface roughness factor

S = slope of flow path, %

Manning's equation is used to estimate the travel time for concentrated channel flow.

Manning's Equation: $t_t \;= nL/60R^{0.66}S^{0.5}$

t_t = travel time of concentrated channel flow, min

n = Manning's roughness coefficient

R = hydraulic radius, m

S = friction slop, m/m

L = length of reach, m

The time of concentration is the sum of the initial overland flow and the travel time of concentrated channel flow.

Time of concentration: $t_c \;= t_i + t_t$

t_c = total time of concentration for use in the Rational Method, min

t_t = travel time of concentrated channel flow, min

t_i = initial overland sheet flow travel time, min

The Rational Method was used to estimate the peak flow rate from the Project catchment.

Rational Method: $Q = \frac{1}{360} C \times i \times A$

Q = peak flow rate, m^3/s

C = runoff coefficient, dimensionless

i = rainfall intensity from IFD table, mm/h

A = catchment area, ha

Runoff coefficient values were estimated using the methodology from the Queensland Urban Drainage Manual (QUDM)[2].

Coefficient of Discharge: $C_y \;=\; F_Y \times C_{10}$

F_Y = Frequency factor, dimensionless

C_y = Coefficient of discharge for a design storm of ARI of 'y' years, dimensionless

C_{10} = 0.7 for all catchments, Coefficient of discharge for a design storm of ARI of 10 years, dimensionless

Drain Design

The drain design for the surface water management associated with the project is based on the capture and diversion of water around the new cell design. The drain design and related construction materials are based on the following constraints:

- Varying degrees of slopes from very steep (S>10%), moderate (10%>Slope>5%) to mild (Slope<5%)
- Differing ARI design storm events result in moderate to low flow design flow
- Excavation is generally not permitted on existing landfill surfaces to construct/establish drains
- Constraining drain top width limitations for the Southern Permanent Drain limit the geometry of the drain to 3.5 metres in downstream reaches.

[2] Queensland Government (2008). *Queensland Urban Drainage Manual-Second Edition*. Department of Natural Resources and Water. GPO Box 2454, Brisbane Qld 4001

The basis for the detailed design for the diversion drains and related facilities includes the following:

- Super-critical flow regime, high velocity reaches
  - Utilise pervious rock lined drain, gabion mattress or gabion basket where not constrained by drain top width site limitations
  - Utilise concrete lined drain where site constraints for top width for the lower reaches of the Southern Permanent Drain
  - Utilise gabion cascade structure for the lower reach of the Diversion Drain from Central Ridge channel.
- Culvert design utilising Reinforced Concrete Pipe (RCP)

The following describes the hydraulic methods, data sources and assumptions used to calculate the final design parameters of the stormwater diversion channels, drains and the culverts. The Manning's equation provides a channel sizing based on the results of the peak runoff hydrology.

Manning's equation: $v = \frac{1}{n} R^{\frac{2}{3}} \times S^{\frac{1}{2}}$

v = flow velocity, m^3/s

R= hydraulic radius, m

S = channel slope, m/m

n = Manning's roughness value, dimensionless

Riprap Armourstone Sizing

Riprap sizing utilises a rock chute design for slopes from 2 to 40% based on empirical testing per Robinson, Rice and Kadavy.[3] The riprap sizing is based on the following equations.

Slope <10%: $D_{50} = [q/(9.76x10^{-7}/S^{-1.5})]^{\frac{1}{1.89}}$

40%>Slope >10%: $D_{50} = [q/(8.07x10^{-6}/S^{-0.58})]^{\frac{1}{1.89}}$

D_{50} = rock particle size for which 50% of the sample is finer, mm

q = highest stable unit discharge, $m^3/s/m$

S = decimal slope, dimensionless

Gabion Cascade and Drain Design

Gabion and gabion mattress design used the following programs from MacCaferri:

- Macra1 Open Channel Hydraulics Program
  - Gabion and gabion mattress design for Southern Permanent Drain where slopes >14%
- Macra2 Weirs Hydraulics Program
  - Gabion cascade structure for Diversion Drain from Central Ridge where slopes >30%

Culvert Hydraulic Design

Culvert hydraulics are calculated using the program HY-8 from the US Department of Transportation and is based on the *Hydraulic Charts for the Selection of Highway Culverts* (Bureau of Public Roads 1965; QLD

[3] K. M. Robinson, C. E. Rice, K. C. Kadavy (1998). *Design of Rock Chutes.* Transactions of the ASAE Vol. 41 (3):621-626

Department of Main Roads 2002). HY-8 is a hydraulic software program for culvert design and includes features to calculate culvert capacity for inlet control, outlet control, tail water depth and roadway overtopping. The following parameters were used to size the RCP culverts:

- Minimum cover over the crown of the RCP of 0.6 metre
- Peak flows in the storm water diversion channel segments
- Downstream storm water diversion channel dimensions
- Roadway data from site topology

RESULTS

Hydrology Results

The following present the results of the detailed design hydrologic analysis. Runoff from surrounding catchments flow to and are diverted around the Project site. The storm runoff peak flow in Table 2 and Attachment 1 are the peak flow design values used for the drain designs.

Table 2: Hydrology Design Runoff Results

Catchment	Area (ha)	Runoff Peak Flow (m^3/s)
100 Year ARI Results		
Package 1 Southern Permanent Drain	20.3	5.4
Package 2 Southern Permanent Drain	24.4	6.6
Package 3 Southern Permanent Drain	28.2	7.6
20 Year ARI Results		
Diversion channel from Central Ridge - Upper Culvert	12.9	5.4
Diversion channel from Central Ridge – Gabion Cascade and Lower Culvert	17.6	6.6
Temporary Eastern Drain	5.1	1.0
10 Year ARI Results		
Stage 1A Bench Drain	3.6	0.9

Drain Design Results

This section presents the results of the detailed design of the storm water diversion drains, the culverts and the gabion cascade for the Project conditions.

Stormwater Diversion Drains

Attachment 1 contains the results of the diversion drain hydraulics and riprap sizing. Gabion channel sizing and gabion cascade structure using Macra1 and Macra2, respectively, are included in Attachment 2.

Table 3 summarises the design results for the Permanent Southern Drain.

Table 3: Design Summary - Permanent Southern Drain 100 Year ARI

Design	Tender Package 1		Tender Package 2		Tender Package 3
Channel Lining	Gabion	Riprap	Concrete	Riprap	Concrete
Channel Width (m)	2.5	2.5	2.5	2.5	2.5
Channel Side Slope (H:V)	Vertical	2:1	Vertical	2:1	Vertical
Channel Length (m)	75	37	106	48	106
Drain Slope (%)	13	8.3 (max)	3.7 to 6.6	2.7	1.8 to 3.7

Design	Tender Package 1		Tender Package 2		Tender Package 3
Peak Flow (m^3/s)	5.4	5.4	6.6	6.6	7.8
Flow Depth (m)	0.36	1.60	0.44	0.65	0.48
Flow Velocity (m/s)	6.0	1.9	6.1	2.7	6.3
Drain Depth (m)	1	21.4	1.5	1.0	1.5
D50 Riprap Size (mm)	190	300	NA	150	NA

Table 4 summarises the design results for the Central Ridge Drain.

Table 4: Design Summary - Central Ridge Drain 20 Year ARI

Design	Tender Package 1		
Channel Lining	Enkamat	Gabion	Riprap
Channel Width (m)	1.0	3.0	3.0
Channel Side Slope (H:V)	2:1 and 1.5:1	2:1 and 5:1	2:1 and 5:1
Channel Length (m)	47	20	210
Drain Slope (%)	0.82	17	1.4 to 22
Peak Flow (m^3/s)	2.5	3.2	3.2
Flow Depth (m)	0.59	0.2	0.26 to 0.53
Flow Velocity (m/s)	2.3	4.7	2.9 to 1.1
Drain Depth (m)	1.0	0.7	0.7
D50 Riprap Size (mm)	NA	190	300

Table 5 summarises the design results for the Stage Bench drain.

Table 5: Design Summary – Stage 1A Bench Drain 10 Year ARI

Design	Tender Package 1
Channel Lining	HDPE
Channel Width (m)	2.3
Channel Side Slope (H:V)	1.5:1 and 3:1
Channel Length (m)	190
Drain Slope (%)	0.1
Peak Flow (m^3/s)	0.9
Flow Depth (m)	0.1
Flow Velocity (m/s)	2.1
Drain Depth (m)	0.5

Culvert Design

The detailed design includes culverts on the Central Ridge Drain to convey runoff under two different roadway crossings. These crossings are located at the following locations on the Central Ridge Drain:

- Two 750 mm diameter RCP culverts under the existing Central Ridge access toad
- Three 900 mm diameter RCP culverts under the new access road at the bottom of the Central Ridge Drain above the gabion cascade structure.

Table 6 summarises the designs for the culverts. HY8 results are included in Attachment 3.

Table 6: Culvert Design Summary

Culvert	Central Ridge Access	Gabion Cascade Structure
Design Storm ARI (year)	20	20
Design Flow (m^3/s)	2.5	3.2
Type	Circular	Circular
Material	Reinforced Concrete	Reinforced Concrete
Inlet Type	Conventional	Conventional
Diameter (mm)	750	900
No. of Barrels	2	3
Minimum Crown Cover	0.6	0.6
Overtopping (20 Year ARI)	No	No

LIMITATIONS

Your attention is drawn to the document – "Limitations", which is attached to this report in Appendix E. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

CRA/GS/wp

c:\users\mniisato\desktop\new folder (2)\117625003-233-m-rev0-drainage design.docx

ATTACHMENT 1: Diversion drain hydraulic design and rip-rap sizing

Golder Associates	Job number/name:	117625003 Whytes Gully
	Date Created:	1/11/2012 14:46
	Created by:	M Niisato/G Hansel
	Last saved:	18/03/2013 22:31
	Checked by:	C Anderson
	Summary:	Hydrology

Rational Method Calculations for Whytes Gully

source: Queensland Urban Drainage Manual

	Southern Permanent Drain Tender Package				Central Ridge Drain		
				Temp East	**Riprap and**	**Enkamat**	
Catchment ID	**1**	**2**	**3**	**Drain**	**Cascade**	**20**	**1A Bund Drain**
ARI (years)	**100**	**100**	**100**	**20**	**20**	**20**	**10**
Catchment Area							
A, catchment area (ha)	20.3	24.4	28.2	5.1	17.6	12.9	3.6
Runoff Coefficent							
*C = Fy * C10*							
Fy, Frequency factor, see Table 4.05.2	1.20	1.20	1.20	1.05	1.05	1.05	1.00
C10, runoff coefficient, see Table 4.05.3, based on light cover and low soil impermeability	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Cy, calc'd runoff coefficient dependent upon ARI	**0.84**	**0.84**	**0.84**	**0.74**	**0.74**	**0.74**	**0.70**
Time of Concentration							
Overland flow - Friend's Equation							
$t = (107\, n\, L^{0.333}) / S^{0.2}$							
L, overland sheet flow path length - up to 200 (m)	100	100	100	100	50	50	100
n, surface roughness/retardance coefficient, see attached table	0.15	0.15	0.15	0.15	0.15	0.15	0.05
S, slope of surface (%)	9.5	9.5	9.5	12	5	5	25
t, calc'd overland travel time (min)	**47.42**	**47.42**	**47.42**	**45.25**	**42.80**	**42.80**	**13.02**
Channel flow - Manning's Equation							
*t = n * L / (60 * R^(2/3) * S^0.5)*							
n, Manning's surface roughness factor	0.047	0.015	0.015	0.055	0.055	0.012	0.012
L, length of reach (m)	975	1050	1075	400	767	500	375
R, hydraulic radius, 0.1 for shallow, 0.2 for intermittent, 0.4 for perennial stream (m)	0.2	0.2	0.2	0.2	0.2	0.2	0.1
S, friction slope (m/m)	0.08	0.08	0.072	0.135	0.052	0.042	0.01
t, calc'd travel time (min)	**7.9**	**2.7**	**2.9**	**2.9**	**9.0**	**1.4**	**3.5**
tc, time of concentration, t1 + t2 + t3 + ... (min)	**55.3**	**50.1**	**50.3**	**48.2**	**51.8**	**44.2**	**16.5**
Rainfall Intensity							
I, rainfall intensity for duration equal to tc, see attached IFD table, (mm/hr)	113.69	118.87	118.65	92.01	88.73	96.35	131.18
Rational Method: Q = 1/360 * C I A							
Q, calc'd peak discharge (m3/s)	**5.4**	**6.8**	**7.8**	**1.0**	**3.2**	**2.5**	**0.9**

Job number/name:	117625003 Whytes Gully		
Date Created:	1/11/2012 14:46		
Created by:	M Niisato/G Hansel		
Last saved:	18/03/2013 22:31		
Checked by:	C Anderson	Checked Date:	
Summary:	Hydraulic Design for riprap lined drains		

Rock Lining Calculations based on *Design of Rock Chutes*

Golder Associates

Reference: Robinson, Rice, Kadavy. 1998. *Design of Rock Chutes* . ASAE.

	Southern Permanent Drain Tender Package					Central Ridge Drain			
Drain ID	**1**	**2**	**2**	**3**	**Temp East Drain**	**Riprap**	**Gabion**	**Enkamat**	**1A Bund Drain**
Catchment, ha	20.3	24.4	24.4	28.2	5.1	17.6	17.6	12.9	3.6
ARI	100	100	100	20	20	20	20	20	10
Material	Riprap	Riprap	Concrete	Concrete	Riprap	Riprap	Riprap	Enkamat 20	
Input Data									
discharge, m³/s	5.40	6.80	6.80	7.80	1.00	3.20	3.20	2.50	0.90
base width, m	2.5	2.5	2.5	2.5	1	3	3	1	2.7
slope, m/m	0.083	0.027	0.037	0.036	0.24	0.22	0.014	0.0082	0.01
L side slope, xH:1V	2	2	0	0	2	5	5	1.5	1.5
R side slope, xH:1V	2	2	0	0	5	2	2	2	3
Freeboard, m	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
n (initial estimate, iterate to match calc'd below)	0.047	0.036	0.015	0.015	0.055	0.055	0.055	0.02	0.012
np, porosity	0.4	0.4			0.4	0.4	0.4		0.4
g, gravity, m/s²	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81
K'	4	4			4	4	4		
SF, rock size safety factor (use >1.0 for long duration peak flows)	1.2	1.2			1.2	1.2	1.2		

Calculate Surface Flow Regime (conservatively assume no subsurface flow)

	1	2	2	3	Temp East Drain	Riprap	Gabion	Enkamat	1A Bund Drain
normal depth (based on Manning's Eq.), m	0.49	0.66	0.44	0.48	0.24	0.26	0.53	0.59	0.14
area (based on normal depth), m²	1.7	2.5	1.1	1.2	0.4	1.1	3.0	1.1	0.4
top width (based on normal depth), m	4.48	5.12	2.59	2.60	1.97	5.58	8.27	2.76	3.13
average width, m	3.49	3.81	2.54	2.55	1.49	4.29	5.63	1.88	2.92
velocity (Q=V/A), m/s	3.1	2.7	6.1	6.3	2.8	2.9	1.1	2.3	2.1
critical depth (watertools.xla), m	0.65	0.74	0.90	0.98	0.36	0.39	0.39	0.63	0.22
froude no. (watertools.xla)	1.6	1.2	3.0	2.9	2.1	2.1	0.6	1.1	1.9
flow regime	supercritical	supercritical	supercritical	supercritical	supercritical	supercritical	subcritical	supercritical	supercritical
unit discharge (discharge/average width), m³/s/m	1.55	1.78	2.67	3.06	0.67	0.75	0.57	1.33	0.31
Wetted perimeter (based on normal depth), m	4.71	5.43	3.38	3.47	2.78	4.90	6.86	3.37	3.41
Hydraulic Radius (based on normal depth),	0.37	0.46	0.33	0.35	0.16	0.21	0.37	0.35	0.13

Estimate rock size

$q = 9.76E-7\ D_{50}^{1.89}\ S_o^{-1.50}$ $\quad S_o < 0.10$

$q = 8.07E-6\ D_{50}^{1.89}\ S_o^{-0.58}$ $\quad 0.10 \le S_o \le 0.40$

	1	2	2	3	Temp East Drain	Riprap	Gabion	Enkamat	1A Bund Drain
D_{50} (s<0.1), m	264.7	117.0			395.6	389.8	37.9		
D_{50} (s>0.1), m	290.7	222.0			259.1	266.4	99.1		
D_{50} x SF, mm	318	140			311	320	46		
Nominal Riprap Size	300	150			300	300	300		

Caculate Manning's roughness coefficient

$n = 0.0292\ (D_{50}\ S_o)^{0.147}$

	1	2	2	3	Temp East Drain	Riprap	Gabion	Enkamat	1A Bund Drain
n, based on equation	0.047	0.036	0.000	0.000	0.055	0.055	0.027	0.000	

Calculate percent subsurface flow

Check initial condition. For long-term condition assume sediment will fill void space of rock.

$V_m = n_p \left(\frac{S_o g D}{K'}\right)^{1/2}$

	1	2	2	3	Temp East Drain	Riprap	Gabion	Enkamat	1A Bund Drain
Vm, velocity within rock, m/s	0.10	0.04			0.17	0.17	0.02		
Riprap thickness, 2*D50, m	0.6	0.3			0.6	0.6	0.1		
qm, unit flow in mantle, m3/s/m	0.06	0.01			0.11	0.11	0.00		
Percent subsurface flow	4%	1%			16%	14%	0%		

Rock Gradation

	1	2	2	3	Temp East Drain	Riprap	Gabion	Enkamat	1A Bund Drain
D_{100}, (D_{100} = 1.5* D_{50}), m	476	211			466	480	68		
D_{85}, (D_{85} = 1.2* D_{50}), m	381	169			373	384	55		
D_{50}, see above, mm	318	140			311	320	46		
D_{15}, (D_{15} = 0.6 * D_{50}), m	191	84			187	192	27		
Liner thickness (2*D_{50}), m	635	281			622	639	91		

Minimum Channel Depth

	1	2	2	3	Temp East Drain	Riprap	Gabion	Enkamat	1A Bund Drain
d, max. depth of flow (max of critical and normal depth), m	0.65	0.74	0.90	0.98	0.36	0.39	0.53	0.63	0.22
Lined channel depth, m	0.95	1.04	1.20	1.28	0.66	0.69	0.83	0.93	0.52
top width (based on max depth), m	6.30	6.67	2.50	2.50	5.65	7.83	8.79	4.26	5.02

Rational Method Reference Tables

Table 4.05.2 Table of frequency factors

A.R.I. (years)	Frequency Factor (F_y)
1	0.80
2	0.85
5	0.95
10	1.00
20	1.05
50	1.15
100	1.20

Table 4.05.3 (b) C_{10} values for Zero Fraction Impervious [1]

Land description	Dense bushland			Medium density bush, or Good grass cover, or High density pasture, or Zero tillage cropping			Light cover bushland, or Poor grass cover, or Low density pasture, or Low cover bare fallows		
Intensity (mm/hr) $^1I_{10}$	**Soil permeability**			**Soil permeability**			**Soil permeability**		
	High	**Med**	**Low**	**High**	**Med**	**Low**	**High**	**Med**	**Low**
39–44	0.08	0.24	0.32	0.16	0.32	0.40	0.24	0.40	0.48
45–49	0.10	0.29	0.39	0.20	0.39	0.49	0.29	0.49	0.59
50–54	0.12	0.35	0.46	0.23	0.46	0.58	0.35	0.58	0.69
55–59	0.13	0.40	0.53	0.27	0.53	0.66	0.40	0.66	0.70
60–64	0.15	0.44	0.59	0.30	0.59	0.70	0.44	0.70	0.70
65–69	0.17	0.50	0.66	0.33	0.66	0.70	0.50	0.70	0.70
70–90	0.18	0.53	0.70	0.35	0.70	0.70	0.53	0.70	0.70

Note: [1] Developed from Qld. Department of Natural Resources & Mines (2005). Coefficients are not suitable for soils compacted by construction activities.

$^1I_{10}$ = One hour rainfall intensity for a 1 in 10 year ARI

C_{10} = Coefficient of discharge for a 1 in 10 year ARI

Rational Method Reference Tables

Surface roughness values for Kinematic Wave Eq. overland flow

Typical values for n^* are:

(i) As quoted by Argue (1986) p.28.

- Paved surfaces = 0.015
- Lawns = 0.25
- Thickly grassed surfaces = 0.50

(ii) As derived from ARR (1998), Book 8, Table 1.4.

Table 4.06.4 Surface roughness or retardance factors

Surface Type	Horton's Roughness Coefficient n^*
Concrete or Asphalt	0.010 – 0.013
Bare Sand	0.010 – 0.016
Gravelled Surface	0.012 – 0.030
Bare Clay-Loam Soil (eroded)	0.012 – 0.033
Sparse Vegetation	0.053 – 0.130
Short Grass Paddock	0.100 – 0.200
Lawns	0.170 – 0.480

Notes (Table 4.06.4):

1. The surface roughness/retardance coefficient n^* is similar but not identical to Manning's "n" value for surface roughness.
2. For further details of this procedure reference should be made to Technical Note 3, Book 8, ARR (1998).

Table 4.06.3 Recommended maximum length of overland sheet flow

Surface Condition	Assumed Maximum Flow Length (m)
Steep (say >10%) grassland (Horton's n = 0.045)	20
Steep (say >10%) bushland (Horton's n = 0.035)	50
Medium gradient (approx. 5%) bushland or grassland	100
Flat (0–1%) bushland or grassland	200

Rational Method Reference Tables

Table 9.05.3 Maximum permissible velocities for consolidated bare earth channels and grassed channels

Channel Gradient (%)	Percentage of stable vegetal cover [1]			
	0 [2]	50	70	100
Erosion resistant soils				
1	0.7	1.6	2.1	2.8
2	0.6	1.4	1.8	2.5
3	0.5	1.3	1.7	2.4
4		1.3	1.6	2.3
5		1.2	1.6	2.2
6			1.5	2.1
8			1.5	2.0
10			1.4	1.9
15			1.3	1.8
20			1.3	1.7
Easily eroded soils				
1	0.5	1.2	1.5	2.1
2	0.5	1.1	1.4	1.9
3	0.4	1.0	1.3	1.8
4		1.0	1.2	1.7
5		0.9	1.2	1.6
6			1.1	1.6
8			1.1	1.5
10			1.1	1.5
15			1.0	1.4
20			0.9	1.3

Notes: [1] Designers should assess the percentage of stable vegetal cover likely to persist under design flow conditions. However it should be assumed that under average conditions the following species are not likely to provide more than the percentage of stable vegetal cover indicated:

- Kikuyu, Pangola and well maintained Couch species – 100%
- Rhodes Grass, poorly maintained Couch species – 70%
- Native species, tussock grasses – 50%

[2] Applies to surface consolidated, but not cultivated

Source: Adapted from NR&M (2004)

Rational Method Reference Tables

For slopes riprap S<10%

Results and Discussion

Rock Slope Stability

Rock chute stability tests were performed in three separate flumes with widths of 0.76, 1.07, and 1.83 m (2.5, 3.5, and 6.0 ft). Two full size prototype structures were also constructed and tested to failure. These large-scale chutes were constructed with a 2.74-m (9-ft) bottom width and 2: 1 side slopes. A total of 38 rock chute stability tests were performed on slopes ranging from 2 to 40% for median rock sizes of 15 to 278 mm. Rock chutes testing was initially limited to slopes between 10 and 40%. However, interest was expressed in slopes below 10%. Eleven tests were conducted on slopes ranging from 2 to 8%. Four of these tests were conducted with bed slopes ranging from 2 to 6% with 2:1 side slopes. Table 1 lists the test results for this study. The tests were performed by introducing a base flow in the rock chute, then increasing the flow incrementally. Orifice plates and air-water differential manometers were used to measure flow in the two smaller models, while Parshall flumes were used to measure flow in the larger models. Rock slope stability was observed at each flow rate, with particular attention directed to stone movement on the slope. The flow rate was increased until the rock chute was judged to be unstable.

Table 1. Test results

Run No.	Flume Width (m)	D_{50} (mm)	Specific Gravity	Geo-metric Std. Dev.	Coef. of Unifor-mity	Slope (%)	Max. Stable q ($m^3/s/m$)
1	1.07	15	2.76	1.42	1.65	10	0.00578
2	1.07	15	2.76	1.42	1.65	12.5	0.00529
3	1.07	15	2.76	1.42	1.65	16.7	0.00378
4	1.07	15	2.76	1.42	1.65	22.2	0.00314
5	1.07	33	2.70	1.42	1.65	10	0.0248
6	1.07	33	2.70	1.42	1.65	12.5	0.0235
7	1.07	33	2.70	1.42	1.65	16.7	0.0186
8	1.07	33	2.70	1.42	1.65	22.2	0.0147
9	0.76	46	—	1.15	1.25	40	0.0381
10	1.07	52	2.82	1.46	1.72	10	0.0762
11	1.07	52	2.82	1.46	1.72	12.5	0.0624
12	1.07	52	2.82	1.46	1.72	16.7	0.0578
13	1.07	52	2.82	1.46	1.72	22.2	0.0483
14	0.76	52	2.82	1.46	1.72	40	0.0349
15	1.07	89	2.54	1.41	1.58	10	0.1738
16	1.07	89	2.54	1.41	1.58	12.5	0.1514
17	1.07	89	2.54	1.41	1.58	16.7	0.1596
18	1.07	89	2.54	1.41	1.58	22.2	0.1105
19	1.83	89	2.54	1.41	1.58	12.5	0.1663
20	1.83	89	2.54	1.41	1.58	22.2	0.1003
21	1.83	89	2.54	1.41	1.58	40	0.0865
22	1.83	145	2.55	1.35	1.54	12.5	0.3307
23	1.83	145	2.55	1.35	1.54	22.2	0.2239
24	1.83	145	2.55	1.35	1.54	40	0.1951
25*	2.74	188	2.58	1.47	1.73	16.7	0.4385
26*	2.74	278	2.59	1.31	1.47	33.3	0.6726
27	1.83	188	2.58	1.47	1.73	8	0.7525
28	1.83	188	2.58	1.47	1.73	22.2	0.5416
29	1.83	188	2.58	1.47	1.73	40	0.3279
30	1.07	52	2.82	1.46	1.72	6	0.1858
31	1.07	33	2.70	1.42	1.65	6	0.0892
32	1.07	33	2.70	1.42	1.65	4	0.1830
33	1.07	15	2.76	1.42	1.65	2	0.0427
34	1.83	192	2.61	1.35	1.58	6	1.6258
35*	1.07	52	2.82	1.46	1.72	6	0.2025
36*	1.07	52	2.82	1.46	1.72	4	0.2546
37*	1.07	33	2.70	1.42	1.65	4	0.1096
38*	1.07	33	2.70	1.42	1.65	2	0.2518

Rainfall Intensity Frequency Duration data for; Wollongong NSW
Geographi 34.4333 Deg. South 150.8833 Deg. East

AUSIFD Version 2.0 20-Feb 2012

Duration (mins)	ARI 1 Year ARI (mm/hr)	2 Year ARI (mm/hr)	5 Year ARI (mm/hr)	10 Year ARI	20 Year ARI	50 Year ARI	100 Year ARI (mm/hr)
5	117	148	183	201	227	261	285
10	90	115	143	159	181	209	230
15	76	97	122	136	155	180	198
20	66	85	107	120	138	160	177
25	59	76	97	109	125	146	161
30	54	69	89	100	115	134	149
40	46.3	60	77	87	101	118	131
50	41	53	69	78	90	106	119
60	37	47.9	63	71	83	97	109
90	28.8	37.4	49.2	56	65	77	86
120	24	31.2	41.2	47.2	55	65	73
150	20.8	27.1	35.9	41.2	48.1	57	64
180	18.5	24.1	32.1	36.9	43.1	51	58
210	16.8	21.9	29.2	33.6	39.2	46.8	53
240	15.4	20.1	26.9	30.9	36.2	43.2	48.6
270	14.3	18.6	25	28.8	33.7	40.3	45.3
300	13.3	17.4	23.4	27	31.6	37.8	42.6
360	11.8	15.5	20.9	24.2	28.3	33.9	38.3
420	10.7	14.1	19	22	25.8	31	34.9
480	9.85	12.9	17.5	20.3	23.8	28.6	32.3
540	9.14	12	16.3	18.9	22.2	26.7	30.1
600	8.54	11.2	15.2	17.7	20.8	25.1	28.3
660	8.04	10.6	14.4	16.7	19.7	23.7	26.8
720	7.6	10	13.6	15.8	18.7	22.5	25.5
840	6.92	9.12	12.5	14.6	17.2	20.8	23.6
960	6.38	8.43	11.6	13.6	16.1	19.4	22.1
1080	5.94	7.85	10.8	12.7	15.1	18.3	20.8
1200	5.57	7.37	10.2	12	14.3	17.3	19.7
1320	5.25	6.96	9.68	11.4	13.5	16.5	18.8
1440	4.98	6.6	9.21	10.8	12.9	15.8	18
1800	4.33	5.76	8.09	9.57	11.4	14	16
2160	3.85	5.13	7.27	8.62	10.3	12.7	14.5
2520	3.48	4.65	6.62	7.88	9.47	11.7	13.4
2880	3.18	4.26	6.09	7.27	8.76	10.8	12.4
3240	2.93	3.93	5.65	6.76	8.17	10.1	11.6
3600	2.72	3.66	5.28	6.33	7.66	9.48	10.9
3960	2.54	3.42	4.95	5.95	7.21	8.95	10.3
4320	2.38	3.21	4.67	5.62	6.82	8.48	9.8

ATTACHMENT 2: Gabion channel and structure sizing

Title: 117625003 Wollongong Council Whytes Gully
Description: By: G Hansel; Checked CRA
Tender Package 1
Rev0 Final-Southern Permanent Drain
Folder:
Date: 18/032013

Notice
Maccaferri is not responsible for the drawings and the calculations trasmitted, since they should be intended as general design outlines and advice,aiming only to the best use of the products.

Run n.1

Gradient [%]	13.00	Froude number	3.21
Discharge [m3/s]	5.40	Cross section [m2]	0.90
Water level [m]	0.36	Wetted perimeter [m]	3.22
Average velocity [m/s]	5.97	Hydraulic radius [m]	0.28

Stretch	Length [m]	V [m/s]	K	Vadm [m/s]	Vb [m/s]	Material	V	tau max [N/m2]	tau adm [N/m2]	GeoFil
2	1.00	0.00	1.00							
2.1	1.00			-	-	Stiff Clay (cohesive)	N	-	-	N
3	1.00	0.75	1.00							
3.1	1.00			6.00	1.25	Gabions 1.00m	N	347.26	288.68	Y
4	2.50	6.03	1.00							
4.1	2.50			6.00	1.25	Gabions 0.50m	N	455.73	470.40	Y
5	1.00	0.75	1.00							
5.1	1.00			6.00	1.25	Gabions 1.00m	N	347.26	288.68	Y
6	1.00	0.00	1.00							
6.1	1.00			-	-	Stiff Clay (cohesive)	N	-	-	N

Title: 117625003 Wollongong Council Whytes Gully
Description: By: G Hansel; Checked CRA
Tender Package 1
Rev0 Final-Southern Permanent Drain
Folder:
Date: 18/032013

Notice
Maccaferri is not responsible for the drawings and the calculations trasmitted, since they should be intended as general design outlines and advice,aiming only to the best use of the products.

Materials used

Description	Roughness	Allow. shear stress [N/m2]	V	Rock d50 [m]	Thickness [m]	Rockfill unit we [kN/m3]	Time [h]	C Shields
Stiff Clay (cohesive)	0.0250	22.00	Y					
Gabions 0.50m	0.0301	470.40	N	0.19	0.50	26.00		0.140
Gabions 1.00m	0.0301	500.00	N	0.19	1.00	26.00		0.140

Macra1 2006

Maccaferri River Analysis

Bank Protections

Title: 117625003 Wollongong Council Whytes Gully

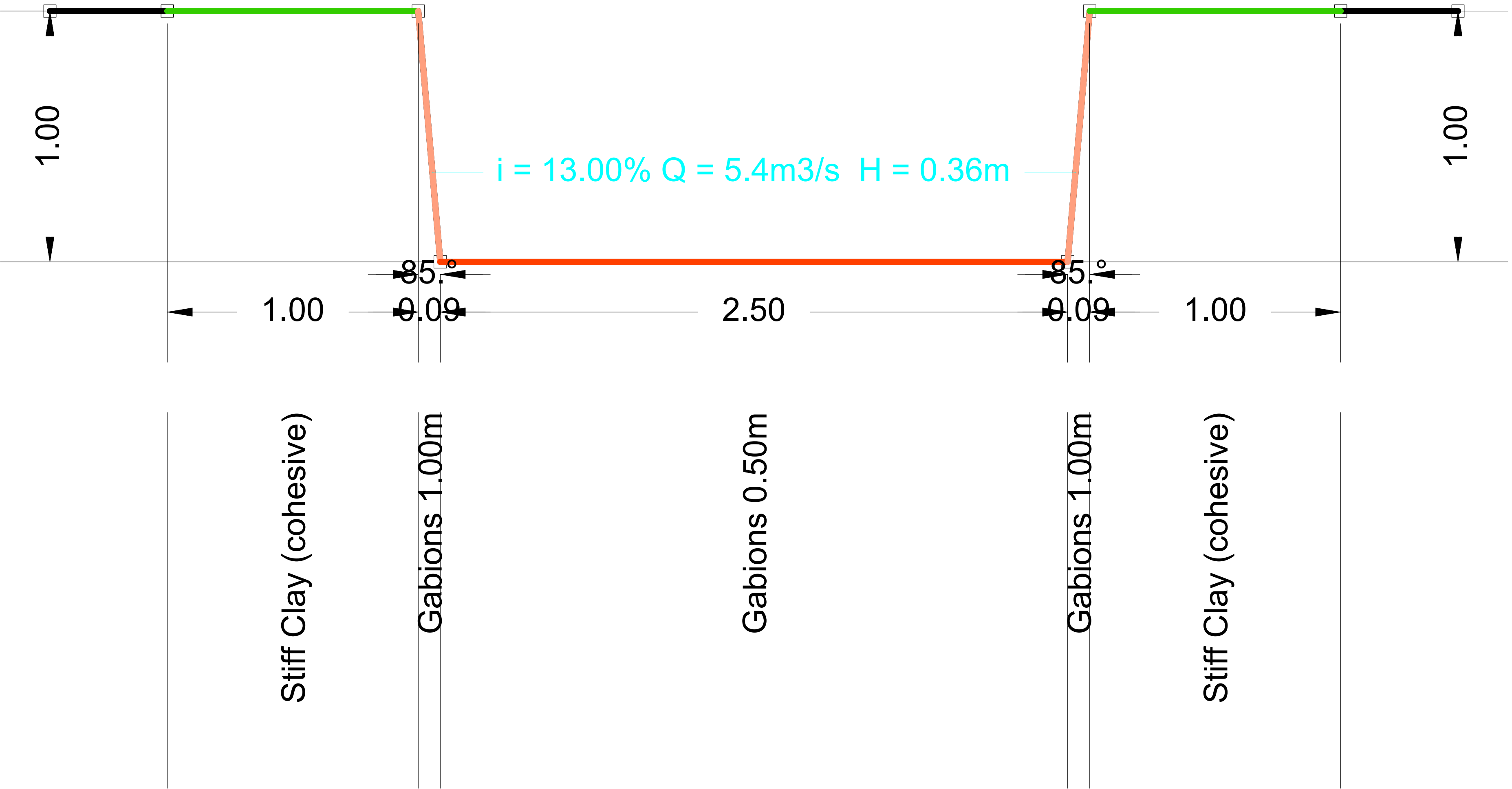
Description: By: G Hansel; Checked CRA

Tender Package 1

Rev0 Final-Southern Permanent Drain

Folder:

Date: 18/032013



Title: 117625003-Macra1 Gabion Trap Design 20130318
Description: By: G Hansel; Checked CRA
Tender Package 1
Rev0 Final-Central Ridge Drain
Folder:
Date: 18/03/2013

Notice
Maccaferri is not responsible for the drawings and the calculations trasmitted, since they should be intended as general design outlines and advice,aiming only to the best use of the products.

Run n.1

Gradient [%]	17.00	Froude number	3.38
Discharge [m3/s]	3.20	Cross section [m2]	0.72
Water level [m]	0.20	Wetted perimeter [m]	4.23
Average velocity [m/s]	4.42	Hydraulic radius [m]	0.17

Stretch	**Length [m]**	**V [m/s]**	**K**	**Vadm [m/s]**	**Vb [m/s]**	**Material**	**V**	**tau max [N/m2]**	**tau adm [N/m2]**	**GeoFil**
2	1.00	0.00	1.00							
2.1	1.00			-	-	Stiff Clay (cohesive)	N	-	-	N
3	1.57	2.76	1.00							
3.1	1.57			6.00	1.53	Gabions 0.50m	N	256.98	402.85	Y
4	3.00	4.72	1.00							
4.1	3.00			6.00	1.53	Gabions 0.50m	N	337.24	470.40	Y
5	2.70	2.91	1.00							
5.1	2.70			6.00	1.53	Gabions 0.50m	N	256.98	448.90	Y
6	1.00	0.00	1.00							
6.1	1.00			-	-	Stiff Clay (cohesive)	N	-	-	N

Title: 117625003-Macra1 Gabion Trap Design 20130318
Description: By: G Hansel; Checked CRA
Tender Package 1
Rev0 Final-Central Ridge Drain
Folder:
Date: 18/03/2013

Notice
Maccaferri is not responsible for the drawings and the calculations trasmitted, since they should be intended as general design outlines and advice,aiming only to the best use of the products.

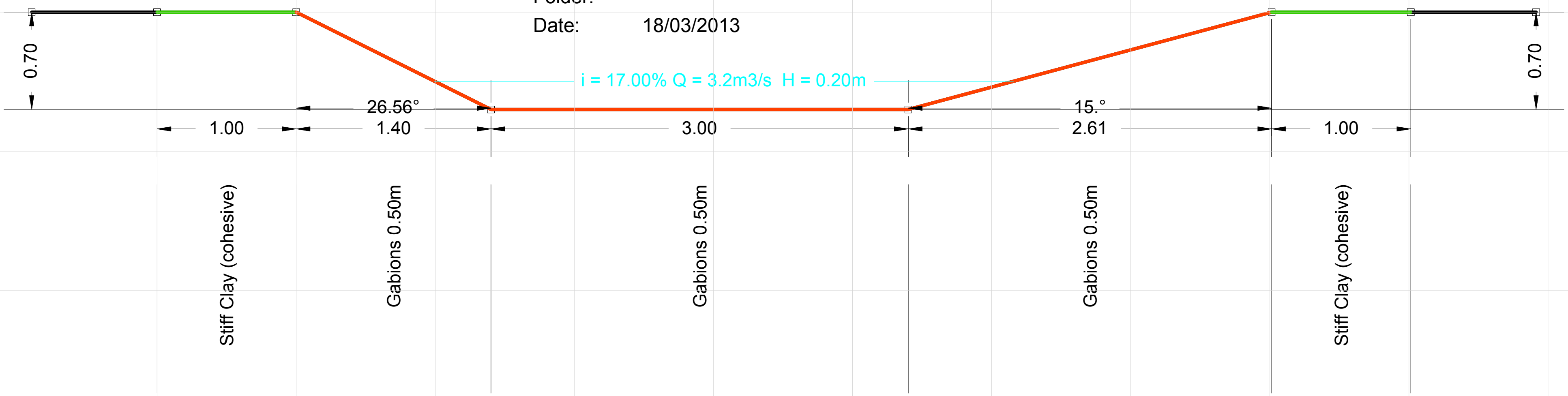
Materials used

Description	Roughness	Allow. shear stress [N/m2]	V	Rock d50 [m]	Thickness [m]	Rockfill unit we	Time [h]	C Shields
Stiff Clay (cohesive)	0.0250	22.00	Y					
Gabions 0.50m	0.0301	470.40	N	0.21	0.50	26.00		0.140

Macra1 2006

Maccaferri River Analysis
Bank Protections

Title: 117625003-Macra1 Gabion Trap Design 20130318
Description: By: G Hansel; Checked CRA
Tender Package 1
Rev0 Final-Central Ridge Drain
Folder:
Date: 18/03/2013



Macra2

Program released to: | Tel:
Company: | EMail:
Title: 117625003 Wollongong City Council Whytes Gully
Description: By: D Graham; Checked: C Anderson
Tender Package 1
Rev0 Final Central Ridge Drain Gabion Cascade
Folder:
Date: 18/03/2013

Notice
Maccaferri is not responsible for the drawings and the calculations trasmitted, since they should be intended as general design outlines and advice,aiming only to the best use of the products.

Run n.1

Design discharge	Q [m3/s]	3.20	Soil unit weight	[kN/m3]	17.70
River bed gradient	i [%]	2.00	Soil friction angle	[deg]	10.00
Roughness coefficient	n	0.030	Soil type		Silt
Soil Granulometry in the pool	dt [mm]	200.00	Gabion porosity	n	0.30
Channel Width	L3 [m]	4.00	Soil-weir friction angle	[deg]	10.00
Bank top elevation	fp [m]	13.50	Soil-foundation friction coefficient	f	0.70
Slope of left bank	Pl [deg]	90.00	Underpressure influence	Sot (%)	50.00
Slope of right bank	Pr [deg]	90.00	Bligh coefficient	Cb	4.00

Weir Data - Stepped Weir

Crest elevation	fg [m]	12.00	Counterweir elevation designed	fc [m]	0.50
Crest width	Lg [m]	4.00	Basin Length designed	Len [m]	9.00
Slope of crest wings	Pg [deg]	90.00	Basin width	[m]	4.00
Total weir height	H [m]	13.00			
H/b		1/3			

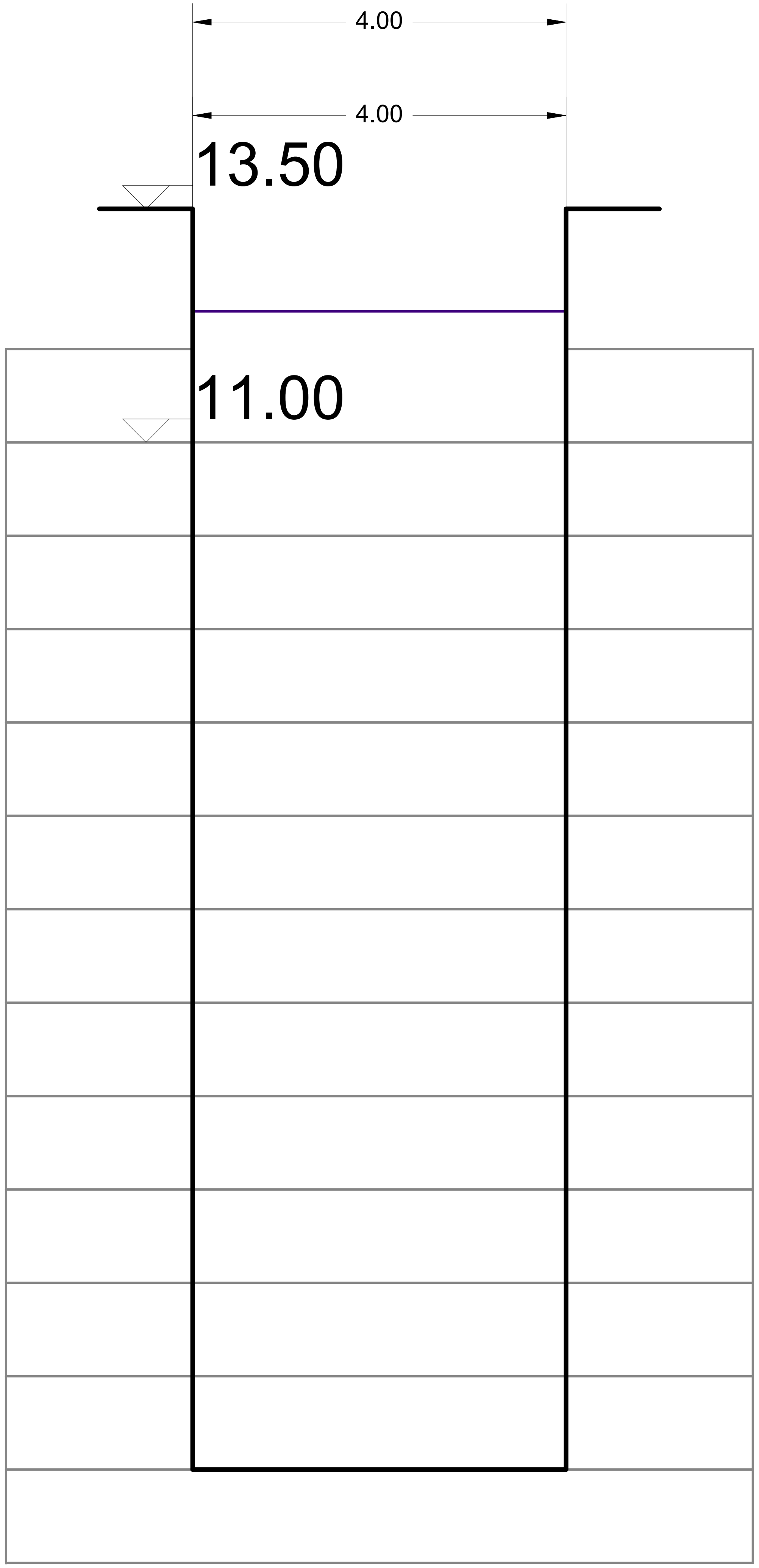
Summary of Hydraulic Results

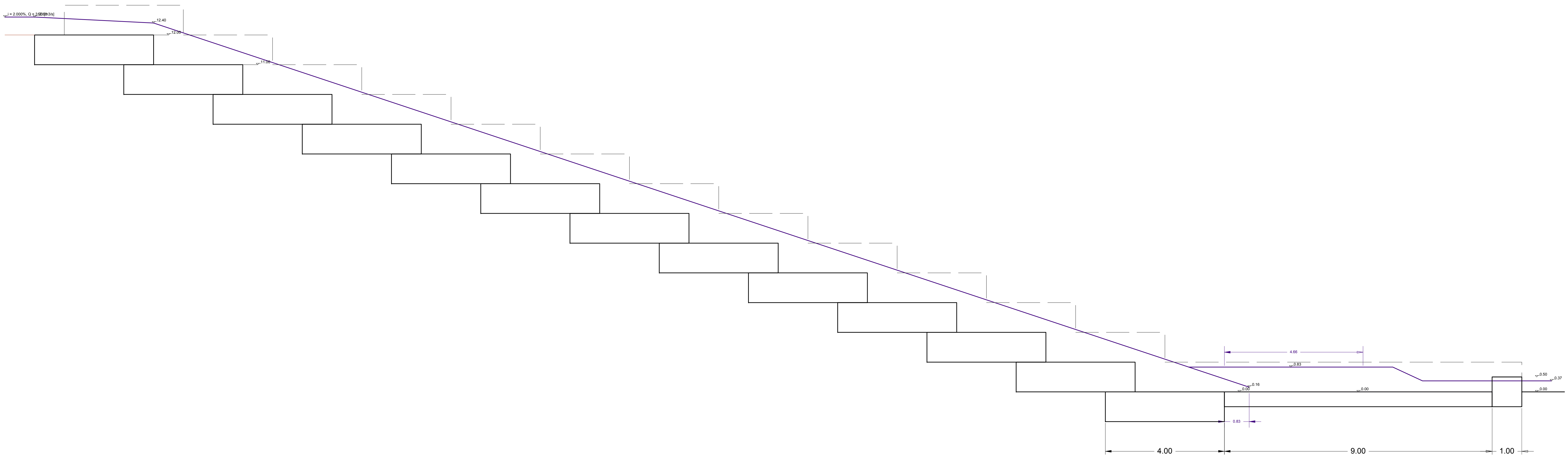
Water elevation on crest	zg [m]	12.40
Water elevation downstream	z3 [m]	0.37
Backwater elevation	z0 [m]	12.60
Scour depth downstream	fb [m]	0.00
Water elevation at the nappe toe	z1 [m]	0.16
Tailwater depth sequent to z1	z2 [m]	0.83
Min. required basin length	LBas [m]	4.66
Min. required counterweir elevation	fc [m]	0.50

MACRA2 2002
Maccaferri River Analysis
Weirs

Title: 117625003 Wollongong City Council Whytes Gully
Description: By: D Graham; Checked: C Anderson
Tender Package 1
Rev0 Final Central Ridge Drain Gabion Cascade
Folder:
Date: 18/03/2013

Program released to:




i = 2.000%
12.40
12.00
11.00
4.66
0.83
0.16
0.00
0.00
0.50
0.37
0.00
0.83
4.00
9.00
1.00

ATTACHMENT 3: Culvert Sizing

HY-8 Culvert Analysis Report

Table 1 - Summary of Culvert Flows at Crossing: Central Ridge Road

Headwater Elevation (m)	Total Discharge (cms)	2-750mm Discharge (cms)	Roadway Discharge (cms)	Iterations
64.13	0.00	0.00	0.00	1
64.41	0.25	0.25	0.00	1
64.55	0.50	0.50	0.00	1
64.67	0.75	0.75	0.00	1
64.78	1.00	1.00	0.00	1
64.89	1.25	1.25	0.00	1
65.00	1.50	1.50	0.00	1
65.13	1.75	1.75	0.00	1
65.29	2.00	2.00	0.00	1
65.46	2.25	2.25	0.00	1
65.66	2.50	2.50	0.00	1
65.77	2.63	2.63	0.00	Overtopping

Table 2 - Culvert Summary Table: 2-750mm

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
0.00	0.00	64.13	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
0.25	0.25	64.41	0.284	0.0*	1-S2n	0.119	0.210	0.121	0.213	2.623	0.342
0.50	0.50	64.55	0.420	0.0*	1-S2n	0.173	0.303	0.191	0.319	2.801	0.432
0.75	0.75	64.67	0.542	0.0*	1-S2n	0.214	0.375	0.242	0.401	3.038	0.491
1.00	1.00	64.78	0.649	0.0*	1-S2n	0.249	0.435	0.287	0.472	3.209	0.537
1.25	1.25	64.89	0.756	0.0*	5-S2n	0.281	0.488	0.328	0.534	3.360	0.575
1.50	1.50	65.00	0.871	0.0*	5-S2n	0.311	0.536	0.367	0.590	3.486	0.608
1.75	1.75	65.13	1.003	0.0*	5-S2n	0.339	0.577	0.404	0.642	3.613	0.636
2.00	2.00	65.29	1.155	0.0*	5-S2n	0.366	0.613	0.439	0.690	3.728	0.661
2.25	2.25	65.46	1.330	0.0*	5-S2n	0.393	0.642	0.471	0.736	3.853	0.684
2.50	2.50	65.66	1.528	1.173	4-FFf	0.419	0.671	0.419	0.778	4.923	0.705

* theoretical depth is impractical. Depth reported is corrected.

****

Inlet Elevation (invert): 64.13 m,   Outlet Elevation (invert): 63.79 m

Culvert Length: 11.51 m,   Culvert Slope: 0.0296

****

Site Data - 2-750mm

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 m

Inlet Elevation: 64.13 m

Outlet Station: 11.50 m

Outlet Elevation: 63.79 m

Number of Barrels: 2

Culvert Data Summary - 2-750mm

Barrel Shape: Circular

Barrel Diameter: 750.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge with Headwall

Inlet Depression: NONE

Table 3 - Downstream Channel Rating Curve (Crossing: Central Ridge Road)

Flow (cms)	Water Surface Elev (m)	Depth (m)	Velocity (m/s)	Shear (Pa)	Froude Number
0.00	63.79	0.00	0.00	0.00	0.00
0.25	64.00	0.21	0.34	2.09	0.25
0.50	64.11	0.32	0.43	3.12	0.26
0.75	64.19	0.40	0.49	3.93	0.27
1.00	64.26	0.47	0.54	4.62	0.28
1.25	64.32	0.53	0.58	5.24	0.28
1.50	64.38	0.59	0.61	5.79	0.29
1.75	64.43	0.64	0.64	6.30	0.29
2.00	64.48	0.69	0.66	6.77	0.29
2.25	64.53	0.74	0.68	7.21	0.29
2.50	64.57	0.78	0.71	7.63	0.30

Tailwater Channel Data - Central Ridge Road

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 3.00 m

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0010

Channel Manning's n: 0.0300

Channel Invert Elevation: 63.79 m

Roadway Data for Crossing: Central Ridge Road

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 m

Crest Elevation: 65.77 m

Roadway Surface: Gravel

Roadway Top Width: 8.00 m

Table 4 - Summary of Culvert Flows at Crossing: Gabion Cascade

Headwater Elevation (m)	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cms)	Iterations
40.96	0.00	0.00	0.00	1
41.21	0.32	0.32	0.00	1
41.32	0.64	0.64	0.00	1
41.41	0.96	0.96	0.00	1
41.50	1.28	1.28	0.00	1
41.58	1.60	1.60	0.00	1
41.65	1.92	1.92	0.00	1
41.72	2.24	2.24	0.00	1
41.79	2.56	2.56	0.00	1
41.86	2.88	2.88	0.00	1
41.93	3.20	3.20	0.00	1
42.58	5.36	5.36	0.00	Overtopping

Table 5 - Culvert Summary Table: Culvert 1

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
0.00	0.00	40.96	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
0.32	0.32	41.21	0.253	0.054	1-S2n	0.146	0.184	0.151	0.144	1.481	0.554
0.64	0.64	41.32	0.362	0.0*	1-S2n	0.211	0.264	0.212	0.222	1.850	0.721
0.96	0.96	41.41	0.449	0.0*	1-S2n	0.264	0.324	0.265	0.286	2.038	0.838
1.28	1.28	41.50	0.540	0.0*	1-S2n	0.305	0.378	0.307	0.344	2.218	0.931
1.60	1.60	41.58	0.620	0.0*	1-S2n	0.345	0.424	0.348	0.397	2.349	1.009
1.92	1.92	41.65	0.693	0.0*	1-S2n	0.382	0.467	0.384	0.446	2.469	1.076
2.24	2.24	41.72	0.762	0.0*	1-S2n	0.416	0.506	0.419	0.493	2.569	1.136
2.56	2.56	41.79	0.831	0.0*	1-S2n	0.451	0.544	0.474	0.538	2.514	1.190
2.88	2.88	41.86	0.900	0.0*	1-S2n	0.484	0.577	0.508	0.581	2.597	1.239
3.20	3.20	41.93	0.972	0.0*	5-S2n	0.516	0.610	0.540	0.623	2.675	1.284

* theoretical depth is impractical. Depth reported is corrected.

****

Inlet Elevation (invert): 40.96 m,   Outlet Elevation (invert): 40.87 m

Culvert Length: 12.00 m,   Culvert Slope: 0.0075

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 m

Inlet Elevation: 40.96 m

Outlet Station: 12.00 m

Outlet Elevation: 40.87 m

Number of Barrels: 3

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 900.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge with Headwall

Inlet Depression: NONE

Table 6 - Downstream Channel Rating Curve (Crossing: Gabion Cascade)

Flow (cms)	Water Surface Elev (m)	Depth (m)	Velocity (m/s)	Shear (Pa)	Froude Number
0.00	40.87	0.00	0.00	0.00	0.00
0.32	41.01	0.14	0.55	1.42	0.47
0.64	41.09	0.22	0.72	2.18	0.49
0.96	41.16	0.29	0.84	2.81	0.50
1.28	41.21	0.34	0.93	3.37	0.51
1.60	41.27	0.40	1.01	3.89	0.51
1.92	41.32	0.45	1.08	4.37	0.51
2.24	41.36	0.49	1.14	4.83	0.52
2.56	41.41	0.54	1.19	5.27	0.52
2.88	41.45	0.58	1.24	5.70	0.52
3.20	41.49	0.62	1.28	6.11	0.52

Tailwater Channel Data - Gabion Cascade

Tailwater Channel Option: Rectangular Channel

Bottom Width: 4.00 m

Channel Slope: 0.0010

Channel Manning's n: 0.0150

Channel Invert Elevation: 40.87 m

Roadway Data for Crossing: Gabion Cascade

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 m

Crest Elevation: 42.58 m

Roadway Surface: Gravel

Roadway Top Width: 8.00 m

APPENDIX H

International Peer Review

Dr. Gary Schmertmann 2013 June 29
Golder Associates
124 Pacific Highway,
St. Leonards,
New South Wales 2065,
Australia

PROJECT: Whytes Gully New Cell Design, Detailed Design Review

Dear Dr. Schmertmann,

Here is the summary of my detailed design review.

In the past few weeks, I performed a review of the detailed design of the Whytes Gully Landfill New Cell. This detailed review was greatly facilitated by the thorough review I had the opportunity to do at the 50% design stage in March-April 2012. In fact, the 50% design review was thorough in great part because it was interactive, as described below.

My involvement in the review process began in September 2011 when I visited the Whytes Gully site and participated in a project design workshop with the Golder design team. Then, I was provided with draft sections of the design as soon as January 2012. Furthermore, considering the importance of the project and knowing that the design team was working diligently, I took advantage of being in New Zealand in January of 2012 for another project to spend four days in Sydney with the design team for the Whytes Gully Landfill New Cell.

Since I was deeply involved in a review capacity during the first half of the design effort, many of the aspects that would normally be addressed in a detailed report review were addressed in my 50% design review. Therefore, the readers of this letter are invited to also read my letter dated 2012 April 25. To minimize repetitions between that letter and the present letter, only items not addressed in my 2012 April 25 letter are discussed below.

Documents used for the detailed design review

To perform my detailed design review, I was provided with the Detailed Design Report Tender Packages 1, 2 and 3, dated 13 June 2013. I was also provided with the Appendix A (Drawings), Appendix B (Technical Specifications), Appendix C (Slope Stabilization and Settlement), Appendix D (Groundwater), Appendix E (Leachate Collection Design), Appendix F (Leachate Generation), and Appendix G (Drainage Design).

Scope of the detailed design review

As agreed with Dr. Schmertmann, my detailed design review focused on the Detailed Design Report, Appendix A, Drawings, Appendix B, Technical Specifications, and Appendix E, Leachate Collection Design. Other Appendices and other aspects of the design had been reviewed extensively at the 50% design stage.

Review of the Detailed Design Report

The Detailed Design Report is well written and well organized. All required aspects of detailed design are included. My main comments can be summarized as follows:

- Evaluation of stability is naturally a key issue. I do not have many comments at this stage, because this was an important aspect of my review at the 50% design stage. I noted that the stability of interim slopes has been included, which is essential. Also, I noted that an appropriate method was used for the "piggyback" slope stability, and that a tapered shape was used for the protection layer to enhance stability at some locations, which is an effective solution. The influence of water on stability was rightfully taken into account.
- An important aspect of detailed design is coordination between several aspects of the design. For example, some slopes were flattened to enhance stability; this may have an adverse impact on leachate flow in the leachate collection system. I encouraged the design team to check this important point and I understand that the flattened slopes were taken into account in the design of the leachate collection system.
- The selection of allowable strain for geomembranes is a delicate issue because several authors (including me) have different views on the fundamental approach. However, there is a general agreement (if not always for the same reasons) on safe values. The merit of the work done by the Golder team is that, based on an extensive knowledge of the current state of the art, the safest possible values were selected.
- As I already said in my letter on the 50% design, great attention has been paid to design details. This is important, because, in the disciplines of waterproofing and drainage, one detail that is incorrect from a conceptual or constructability standpoint may have detrimental consequences. An example of adequate detailed design is the cutting of the geomembrane prior to connecting the upslope geomembrane to the downslope geomembrane, the advantages being less stress in the geomembrane and the replacement of a (weak) extrusion seam by a (strong) fusion seam. However, the interruption of the geocomposite at the upslope/downslope connection may not be consistent with applicable regulations, and I indicated another configuration that could be used if needed.
- A good example of adequate design is the fact that the pipe network is such that pipe slope will increase with the expected settlement.

In conclusion, the Detailed Design Report is satisfactory. After some minor adjustments as suggested in my review, the Detailed Design Report will be complete in my opinion.

Review of Appendix A, Drawings

The drawings are very good and extremely clear. This is remarkable, because clarity is always a challenge with landfill cross sections due to the presence of multiple layers. I am pleased to see that the comments and recommendations I made in 2012 to improve the clarity of the drawings were implemented.

In 2012, I made important technical recommendations on connections between different drainage materials, in particular geocomposite and aggregate. These recommendations were implemented in most locations where they are relevant. However, there are still several locations where details of such connections need to be included.

I noted that a square slab is shown in drawings as a protective structure on top of gas wells. I recommended that a circular slab be used, because it would be less likely to damage the geomembrane in the unlikely event of very large settlement.

I noted that the geogrid was anchored in the same anchor trench as other geosynthetics. I pointed out to the design team that, with such configuration, interface shear strength along the geogrid is generally reduced compared to the case where the geogrid is alone in its own anchor trench. Therefore, I invited the design team to check that the pullout resistance provided to the geogrid by an anchor trench common with other geosynthetics was sufficient. Dr. Schmertmann rightfully pointed out that there are several advantages in using a single anchor trench for all geosynthetics rather than two anchor trenches, and he checked that the calculated pullout resistance provided to the geogrid by a single anchor trench is sufficient.

My general evaluation of the drawings is that, provided the corrections I suggested are implemented, the drawings will be complete.

Review of Appendix B, Technical Specification

At the 50% design stage, I reviewed the material property requirements, and the requirements for construction activities and construction quality management. For the detailed design stage, I focused on some specific aspects of the material property requirements. The main examples are described below:

- I brought to the design team’s knowledge a relatively new development in filter design, which is a method that makes it possible to rationally select the minimum thickness of a geotextile filter. I recommended that this method be used.
- I noted that the same geotextile filter specification is used for geotextiles associated with the liner system and for geotextiles in contact with gabions or riprap. I recommended that

a different specification (with more emphasis on mechanical strength) be used for geotextiles in contact with gabions or riprap. I understand that this change will be adopted.

- I reviewed the results of laboratory full-scale tests that were performed to evaluate the protection provided by a geotextile cushion against geomembrane puncture by aggregate. The tests showed that the required geotextile cushion is more consistent with the European practice than with the US practice. This is satisfactory because the European practice is more conservative (but not overconservative). The design team should be commended for ordering these tests rather than being tempted by less expensive but less adequate geotextile selection.
- I attracted the attention of the design team to the fact that many international specifications are based on polypropylene geotextiles whereas polyester geotextiles are often used in Australia. (Incidentally, it should be noted that polyester geotextiles are at least as good as polypropylene geotextiles. The international practice is in large part influenced by the cost of polymers.) I pointed out that conversions of some international specifications may be necessary to account for the difference in density between the two polymers.

In conclusion, with some adjustments suggested by my comments, the specifications prepared for this project are satisfactory. Furthermore, they are presented in a very clear manner and are well organized.

Review of Appendix E, Leachate Collection Design

Leachate collection design was not done at the 50% design stage for the good reasons indicated in my letter dated 2012 April 25. Therefore, it was appropriate to review this appendix in particular.

Based on my review, I can say that the leachate collection design has been done in accordance with the state of practice and has used the appropriate design method for a two-layer drainage system. However, I pointed out that the hydraulic transmissivity values used in the method imply that this property is measured in a test that simulates the actual boundary conditions that exist in the field. Therefore, proper coordination is required between design calculations and specifications for materials and tests. As a result, minor changes in the specification may be required.

Conclusion

Based on this detailed design review and the review I performed at the 50% design stage, I can conclude without hesitation that the design of the Whytes Gully New Cell is consistent with the state of practice and in many respects is at the level of the state of the art. All the important issues have been identified. All the design methods used are correct and are implemented with the latest published information available and advanced analytical and numerical tools, particularly for the piggyback lining system. My experience indicates that the design is consistent with international practice and is likely to be adequate from a regulatory standpoint when all the relatively minor changes I have suggested are implemented.

The interactive approach to design review, as had been practiced in the first half of the design effort, has been fruitful. I must congratulate Dr. Schmertmann and the Golder design team for their dedication to excellence. In many aspects of the design, they have used the most recent and advanced publications to support their analyses. To put things in perspective, I am very critical of landfill designs that, too often, only follow the minimum requirements mandated by regulations. This is not the case here, by far.

I am, therefore, grateful for the opportunity that was given to me to review this excellent work.

Sincerely,

J.P. Giroud

Dr. Gary Schmertmann
Golder Associates
124 Pacific Highway,
St. Leonards,
New South Wales 2065,
Australia

2012 April 25

PROJECT: Whytes Gully New Cell Design, Preliminary (50%) Design Review

Dear Dr. Schmertmann,

During the past three months, I performed a review of the design as it was progressing, and I gave my comments. I believe this interactive approach is far more effective than reviewing a voluminous report at the last minute. Indeed, an interactive approach can prevent expenditure of effort on inappropriate design options and streamlines the final review process.

My involvement in the review began in September 2011 when I visited the Whytes Gully site and participated in a project design workshop with the design team. I was provided with draft sections of the design as soon as January 2012. Furthermore, considering the importance of the project and knowing that your team was working diligently, I took advantage of being in New Zealand in January to spend four days in Sydney with your team. I must say that this interactive review was productive, because I have noted in reviewing the documents I have received from you since March 2012 that all of the comments I had made during these intensive four days in Sydney had been implemented or had been used to improve drawings, refine analyses and clarify descriptions.

As a result, in the final stage of my review of the 50% design, I have only minor suggestions, which do not affect my review conclusions.

This letter summarizes my review of the 50% design.

Documents used for the preliminary (50%) design review

To perform my review, I was provided with the Report for Preliminary Design, dated April 2012. In fact, I received various sections of this report as soon as March 2012, as they became available, which was helpful.

I was also provided with the Appendices A, B and C to the Report for Preliminary Design: Appendix A, Drawings; Appendix B, Technical Specifications; and Appendix C, Geotechnical Interpretation and Analyses.

Review of the Report for Preliminary Design

In reviewing the Report for Preliminary Design, I noted the following:

- The Report is well written and well organized.
- Key issues are properly identified. For example, the decision regarding including the piggyback lining system in the eastern gully is appropriate and I completely agree with this decision.
- The technical issues related to the piggyback lining system have been properly identified, namely: impact on leachate, impact on landfill gas, impact of settlement on the piggyback lining system, etc.
- The piggyback design issues have been addressed using state-of-the-art methods, as discussed later in this letter.
- The regulatory aspects are adequately addressed. I fully agree with the decision of following the Victoria BPEM guidelines for landfill lining, which are consistent with international regulations and practice. In particular, the composite liner concept is clearly presented and adequately used.
- Great attention has been paid to design details. This is important, because, in the disciplines of waterproofing and drainage, one detail that is incorrect from a conceptual or constructability standpoint may have detrimental consequences.

In conclusion, the Report for Preliminary Design is satisfactory. In fact, in my opinion, it contains more details than normally needed at the 50% design stage. This is beneficial as it will certainly facilitate the preparation of the 90% design.

Review of Appendix A, Drawings

I reviewed three successive sets of Drawings, starting in mid-January. During my visit in January, I made numerous comments and recommendations to improve the clarity of the drawings and the consistency between the different drawings. I also made important technical comments on design details such as connections between different drainage materials. My general evaluation of the drawings is that the final set of drawings I reviewed has appropriate technical content and contains all the drawings needed for a 50% design.

Review of Appendix B, Technical Specification

I did not review in detail Appendix B, Technical Specification. However, I reviewed Chapter 2, the material property requirements, and Chapter 3, the requirements for construction activities and construction quality management.

In reviewing the material property requirements (i.e. Chapter 2), I made sure that the specifications were consistent with international practice. It is important to note that that the scope of the technical specification at the 50% design stage is necessarily limited because some properties cannot be specified before the 90% design is completed. This is the case in particular of the drainage geocomposite material.

Regarding the requirements for construction activities and construction quality management (i.e. Chapter 3), my evaluation is that key items such as geomembrane installation, testing and documentation (items which were examined during the course of the review) have been adequately considered for this stage of the design.

In conclusion, Appendix B addresses all the materials that need to be specified and the important aspects of construction and construction quality that need to be addressed at the 50% design stage. However, more work is needed to finalize this appendix at the 90% design stage.

Review of Appendix C, Geotechnical Interpretation and Analyses

I did not review in detail all parts of Appendix C, Geotechnical Interpretation and Analyses. However, during the course of the interactive review process, I reviewed key items such as settlement analysis, piggyback liner deformation analysis/geogrid design and landfill slope stability. I discussed my comments with the design team. The comments were used to improve the analyses and my evaluation is that these comments have been adequately considered.

I was particularly interested in the “Deformation Analysis Results” section because it is essential to the piggy-back design, and because state-of-the-art methodology used. This is due in great part to the fact that you are very knowledgeable about all important publications on the subject of deformation analysis, as I could see during our discussions in January.

I noted that Appendix C does not contain a section on liquid control/drainage design. I indicated to the design team that I agree that such a section is not required at this stage, because it is more appropriate to do the drainage design last (i.e. after settlement and deformation analyses). A section on drainage design will need to be added at the 90% design stage. In the meantime, I noted that the leachate collection drainage length shown in the 50% design drawings is reasonable and no drastic change should be needed as a result of the calculations to be performed for the 90% design.

In conclusion, my evaluation is that Appendix C addresses all the issues that need to be considered at the 50% design stage. In particular, important issues such as slope stability, settlement and liner deformation are addressed thoroughly. Furthermore, Appendix C contains all of the numerical results needed at the 50% design stage.

General evaluation of the design

In the process of my review, I made numerous comments on non-technical points (e.g. terminology, consistency, clarity of explanations) to make sure the work product would be presented in a manner that is well accepted by landfill experts and would be informative for non-expert readers.

It is important to note that, while making non-technical comments, I was not distracted from my essential mission which is to ensure that the landfill cell design is technically sound. From this viewpoint, my impression is very positive and can be summarized as follows:

- The set of drawings contains all the drawings needed for a 50% design and the drawings are presented in a clear and consistent manner. Technical details in the drawings are adequate.
- The geotechnical design report will address all design aspects when a section on liquid control/drainage design is added at the 90% design stage.
- The methodology used for all aspects of design relevant to the 50% design (i.e. stability, settlement, and deformation) is correct, and the analyses are performed with advanced analytical and numerical tools and an excellent knowledge of the state of the art.

This last comment is perhaps my most important comment on the review I performed of the 50% design.

Conclusion

Based on this review, I can state that the 50% design is satisfactory. All the important issues have been identified. All the design methods used are correct and are implemented with the latest published information available and advanced analytical and numerical tools, particularly for the piggyback lining system. My experience indicates that the design is consistent with international practice and is likely to be adequate from a regulatory standpoint.

In my opinion and based on my experience, the degree of detail in the design report and in the numerical analyses exceeds what is typically expected for a 50% design.

I am very pleased that the interactive approach to design review, as we have practiced since January, has been fruitful. As a result, I have no suggestion for changes.

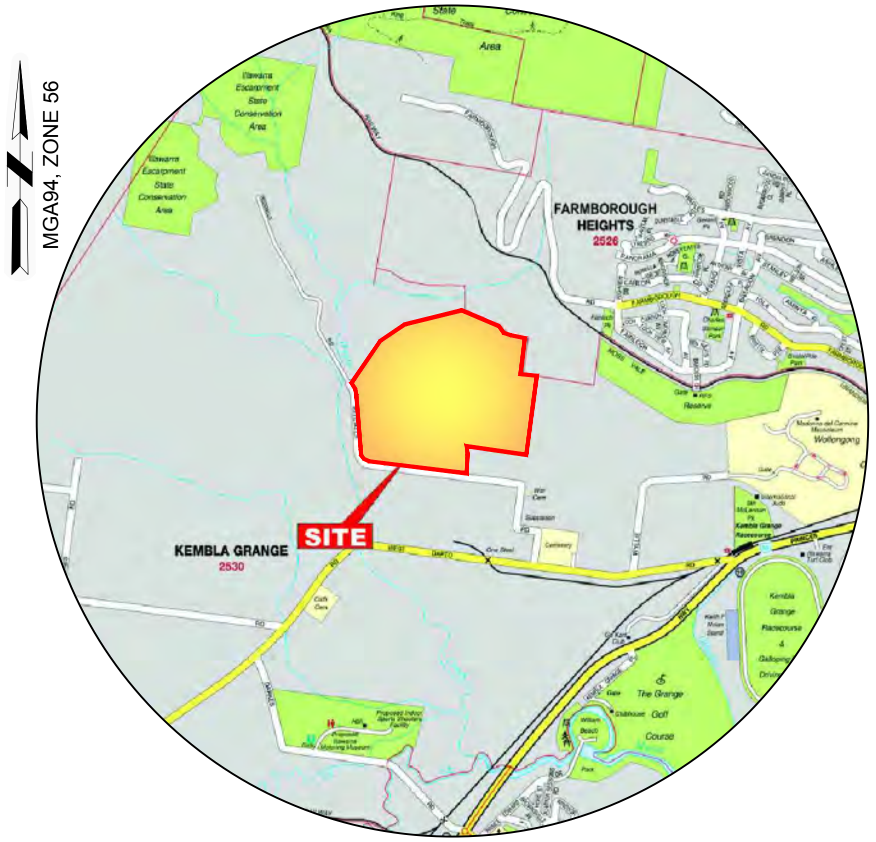
I thank you for the opportunity that was given to me to review this excellent work.

Sincerely,

J.P. Giroud

WOLLONGONG CITY COUNCIL
WHYTES GULLY LANDFILL - NEW CELL DESIGN

MGA94, ZONE 56



LOCALITY PLAN
NOT TO SCALE

NOTES:

1. THESE NOTES APPLY TO ALL PROJECT DRAWINGS IN THE SET UNLESS NOTED OTHERWISE AND SHALL BE READ IN CONJUNCTION WITH THE SPECIFICATION.
2. ALL LEVELS ARE IN METRES TO AUSTRALIAN HEIGHT DATUM (AHD).
3. ALL CO-ORDINATES ARE IN METRES TO MAP GRID AUSTRALIA (MGA).
4. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
5. DIMENSIONS AND LOCATION OF EXISTING STRUCTURES SHALL BE CONFIRMED ON SITE BY THE CONTRACTOR PRIOR TO COMMENCEMENT OF WORKS.
6. LOCATION AND DEPTH OF ALL SERVICES TO BE VERIFIED BY THE CONTRACTOR PRIOR TO COMMENCEMENT OF WORKS.
7. DIMENSIONS SHALL NOT BE SCALED OFF DRAWINGS.

NOT FOR CONSTRUCTION - ISSUED FOR
CLIENT REVIEW

DRAWING LIST

DRAWING LIST	TENDER PACKAGE 3
D3001	SITE LOCALITY AND DRAWING LIST - PACKAGE 3
D3002	SITE PLAN AND WORK AREAS - PACKAGE 3
D3003	2011 CONTOURS AND EASEMENT - PACKAGE 3
D3011	SUBGRADE PREPARATION PLAN - PACKAGE 3
D3012	SUBGRADE PREPARATION SECTIONS - PACKAGE 3
D3013	PERIMETER BUND AND INTERNAL BUND PLAN AND SETOUT - PACKAGE 3
D3014	PERIMETER BUND AND INTERNAL BUND LONG SECTIONS - PACKAGE 3
D3015	PERIMETER BUND AND INTERNAL BUND CROSS SECTIONS
D3021	LINER DETAILS - SHEET 1 - PACKAGE 3
D3022	LINER DETAILS - SHEET 2 - PACKAGE 3
D3030s	NOT USED
D3041	TOP OF LINER AND LEACHATE COLLECTION SYSTEM PLAN AND SETOUT - PACKAGE 3
D3042	LEACHATE SUMP PLAN AND DETAILS - PACKAGE 3
D3043	LEACHATE COLLECTION SYSTEM DETAILS - SHEET 1 - PACKAGE 3
D3044	LEACHATE COLLECTION SYSTEM DETAILS - SHEET 2 - PACKAGE 3
D3045	LEACHATE COLLECTION SYSTEM DETAILS - SHEET 3 - PACKAGE 3
D3051	SOUTHERN PERIMETER DRAIN - GENERAL ARRANGEMENT AND SETOUT - PACKAGE 3
D3052	SOUTHERN PERIMETER DRAIN- PLAN AND LONG SECTION - PACKAGE 3
D3053	SOUTHERN PERIMETER DRAIN- DETAILS AND SECTIONS - PACKAGE 3
D3060s	NOT USED
D3070s	NOT USED

MATERIAL LIST

UNIT 1	NOT USED
UNIT 2	GENERAL FILL
UNIT 3	COVER MATERIAL
UNIT 4	CLAY RICH MATERIAL
UNIT 5	CLAY MATERIAL
UNIT 6	BASE MATERIAL
UNIT 7	DRAINAGE AGGREGATE
UNIT 8	NOT USED
UNIT 9	PROTECTION MATERIAL
UNIT 11	FILTER GEOTEXTILE
UNIT 12	CUSHION GEOTEXTILE
UNIT 13	NOT USED
UNIT 14	GEOCOMPOSITE DRAINAGE NET
UNIT 15	NOT USED
UNIT 16	HDPE GEOMEMBRANE
UNIT 17	GCL
UNIT 18	NOT USED
UNIT 21	NOT USED
UNIT 22	NOT USED
UNIT 23	LEACHATE COLLECTION PIPE
UNIT 24	LEACHATE SUMP OUTLET PIPE
UNIT 25	NOT USED
UNIT 26	NOT USED
UNIT 27	LEACHATE SUMP RISER
UNIT 28	NOT USED
UNIT 31	BENTONITE
UNIT 32	RIPRAP ARMOURSTONE AND AGGREGATE FOR GABION BASKETS AND WIRE MATTRESS
UNIT 33	NOT USED
UNIT 34	ROCK FILLED GABIONS AND MATTRESSES
UNIT 35	NOT USED
UNIT 36	PRECAST REINFORCED CONCRETE BOX CULVERT (RCBC)
UNIT 37	NOT USED
UNIT 38	CHANNEL LINER

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.04.2013

Golder Associates

124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

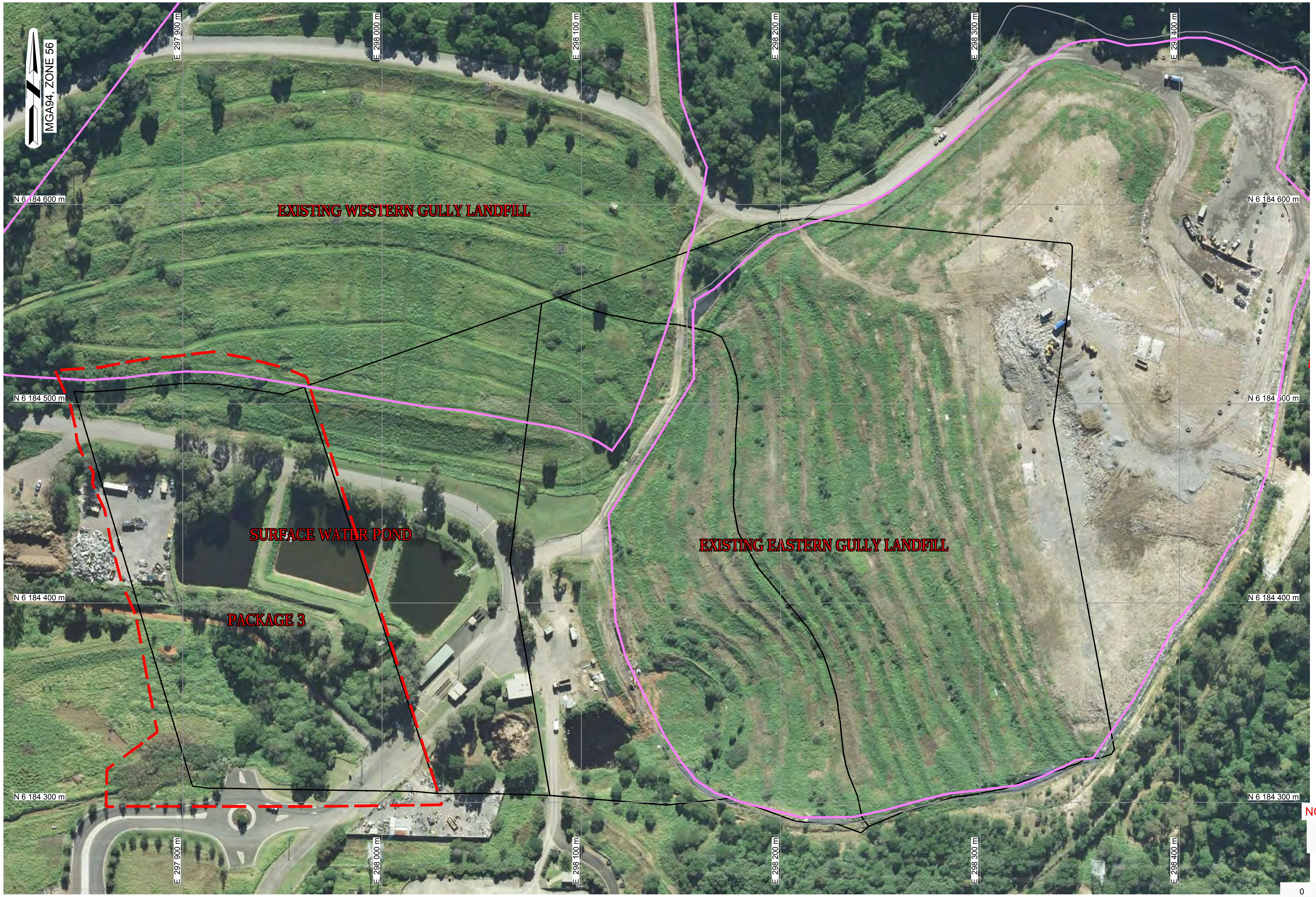
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: SITE LOCALITY AND DRAWING LIST - PACKAGE 3

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D3001	A

Plot Date: 5 April 2013 Time:5:53:09 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 3 - File Name:117625003-220-L-D3001-REVA.dwg
Xref: GAP_LOGO-A3.dwg; WHYTES GULLY UBD.jpg;



LEGEND

- PROPERTY BOUNDARY
- PACKAGE BOUNDARY
- WORKS AREA BOUNDARY APPROX.
- EXTENT OF EXISTING WASTE (REFER NOTE 1)

NOTES:

1. APPROX. EXTENT OF WASTE BASED PRIMARILY ON SITE OBSERVATION AND INFORMATION FROM COUNCIL.
2. AERIAL ORTHO-PHOTOGRAPH PROVIDED BY AAM PTY LTD TAKEN ON 16TH MAY 2011, REFERENCE 18763A. IMAGE GEOREFERENCED
   PACKAGE 1 AND 2 CONSTRUCTION NOT SHOWN

NOT FOR CONSTRUCTION - ISSUED FOR
CLIENT REVIEW

0 40 80 120m
1:2,000

BASE DRAWING TAKEN FROM K F WILLIAMS AND ASSOCIATES DRG.WHYTES PHOTOGRAMMETRY AND GROUND SURVEY 20-07-11.dxf DATED 20 JULY 2011.

SITE PLAN AND WORK AREAS - PACKAGE 3

SCALE 1:2,000

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.04.2013

Golder Associates

124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

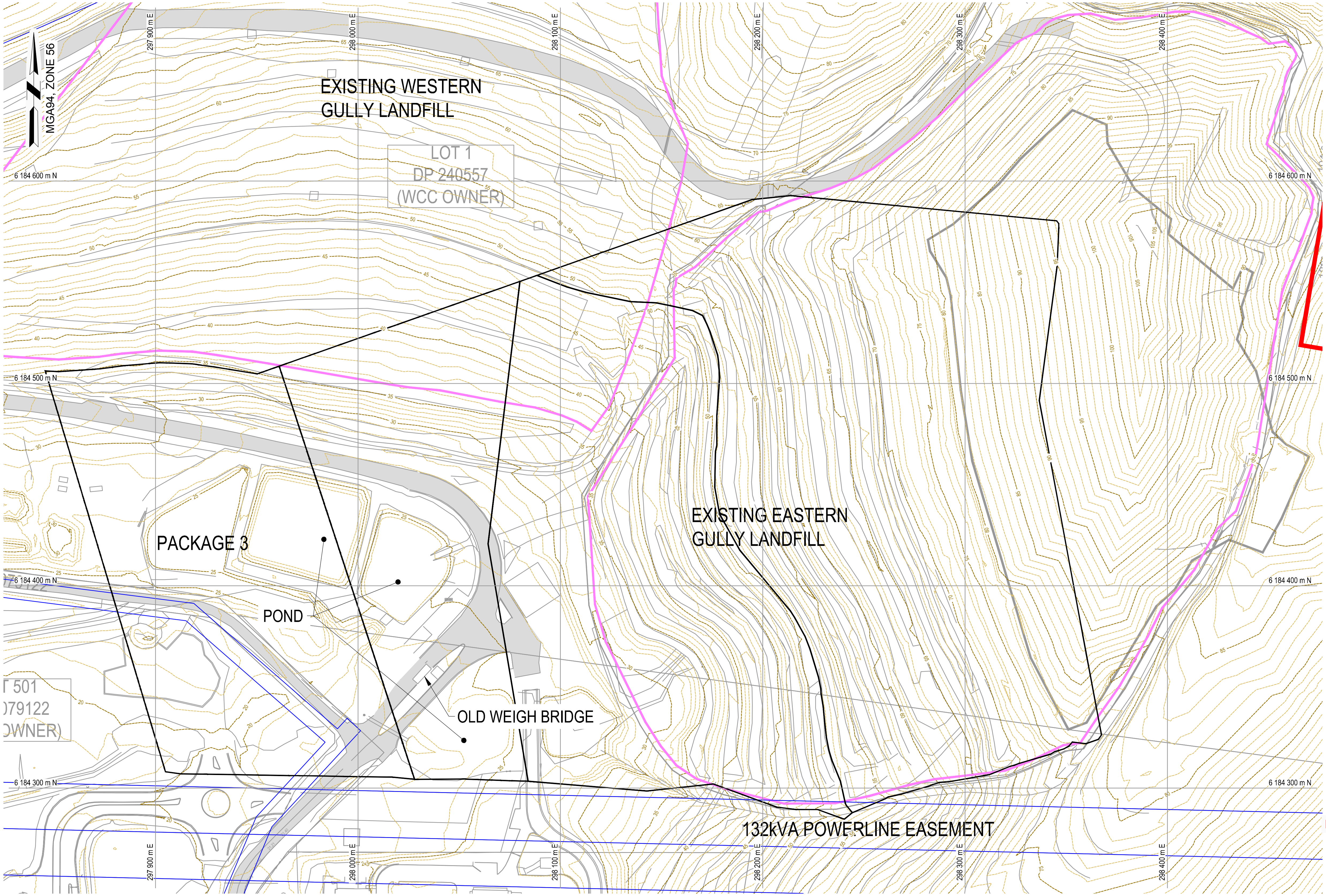
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: SITE PLAN AND WORKS AREA PACKAGE 3

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	1:2,000	A3	117625003	220	L	D3002	A

Plot Date: 5 April 2013 Time:4:58:03 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 3 - File Name:117625003-220-L-D3002-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-Imagery - AAM May 2011.dwg; 117625003-XREF-CELL STAGE BOUNDARY.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOIUNDARY.dwg; 117625003-XREF-WORKS AREA - PACKAGE3.dwg; Whytes-Gully_16052011_10cm.jpg;



LEGEND

- PROPERTY BOUNDARY
- PACKAGE BOUNDARY
- APPROX. EXTENT OF EXISTING WASTE (REFER NOTE 1)

NOTES:

1. APPROX. EXTENT OF WASTE BASED PRIMARILY ON SITE OBSERVATION AND INFORMATION FROM COUNCIL.
2. CONTOURS ABOVE RL 75m ON EASTERN GULLY LANDFILL REFLECT FINAL PROFILE DESIGN FOR EASTERN GULLY (GOLDER DRAWING 097625103-006-R-F019-REVA)

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

0 40 80 120m

1:2,000

BASE DRAWING TAKEN FROM K F WILLIAMS AND ASSOCIATES DRG.WHYTES PHOTOGRAMMETRY AND GROUND SURVEY 20-07-11.dxf DATED 20 JULY 2011.

2011 CONTOURS AND EASEMENT - PACKAGE 3

SCALE 1:2,000

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.04.2013

Golder Associates

124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

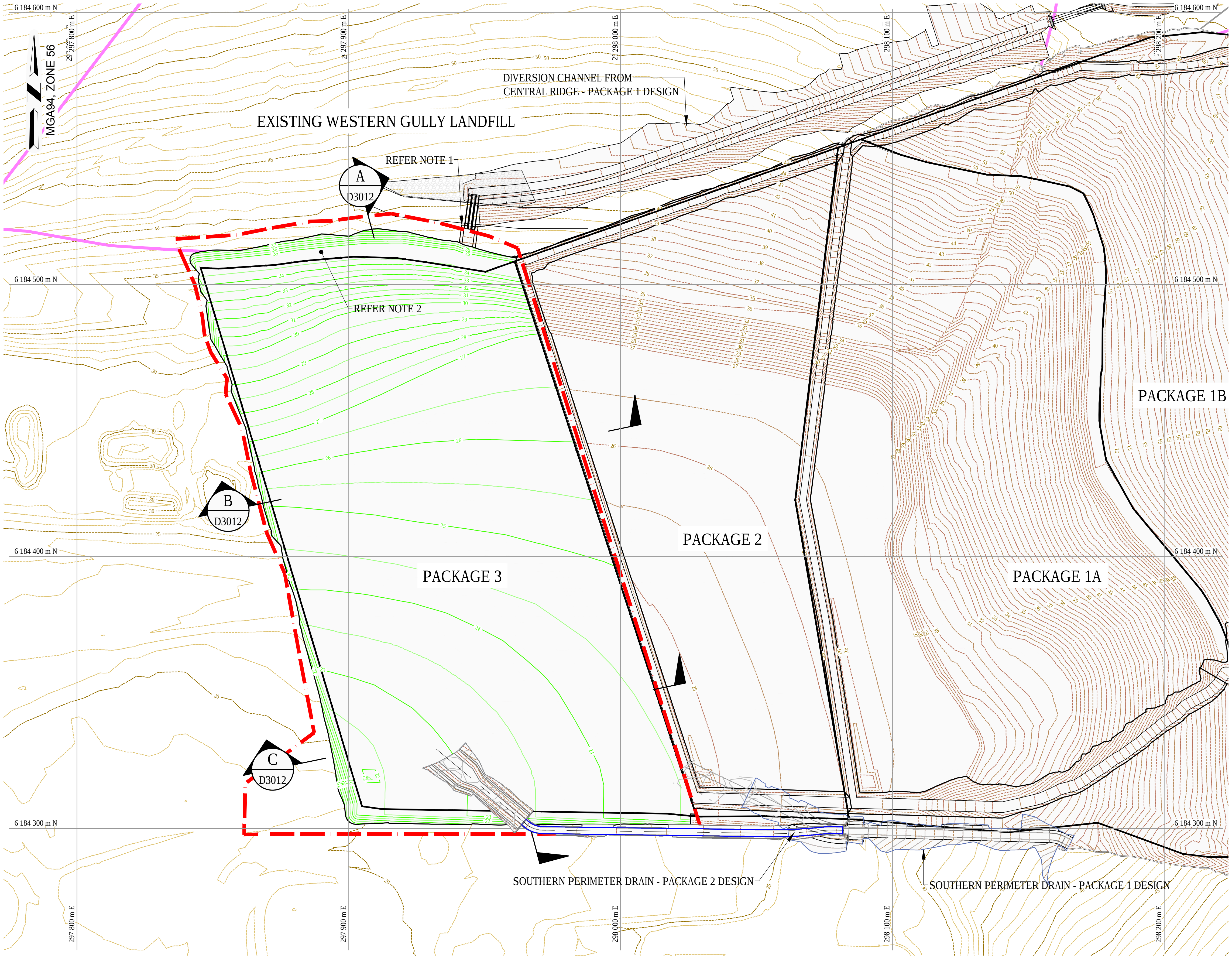
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: 2011 CONTOURS AND EASEMENT PACKAGE 3

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	1:2,000	A3	117625003	220	L	D3003	A

Plot Date: 5 April 2013 Time:4:59:28 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 3 - File Name:117625003-220-L-D3003-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING BREAKLINES.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOUNDARY.dwg; 117625003-XREF-Cadastre and easement.dwg; 117625003-XREF-CELL STAGE BOUNDARY.dwg;



LEGEND

- PACKAGE BOUNDARY
- WORKS AREA BOUNDARY
- APPROX. EXTENT OF EXISTING WASTE (REFER DRAWING D3003)
- PACKAGE 1 AND 2 DESIGN CONTOURS
- SUBGRADE CONTOURS
- 2011 CONTOURS

NOTES:

1. CULVERT AND GABION CASCADE STRUCTURE OF DIVERSION CHANNEL FROM CENTRAL RIDGE SHALL BE REMOVED PRIOR TO CONSTRUCTION OF PACKAGE 3. THE CHANNEL IS THEREFORE REQUIRED TO BE DIVERTED FROM THE PACKAGE 3 AREA (FUTURE DESIGN BY OTHERS). REFER NOTE 2.
2. THE INTERIM DRAINAGE CHANNEL ON THE BENCH (REFER SHEET D3022) SHALL NOT BE USED TO DIVERT THE "DIVERSION CHANNEL FROM CENTRAL RIDGE" FROM THE PACKAGE 3 AREA.

NOT FOR CONSTRUCTION - ISSUED FOR
CLIENT REVIEW

0 30 60 90m
1:1,500

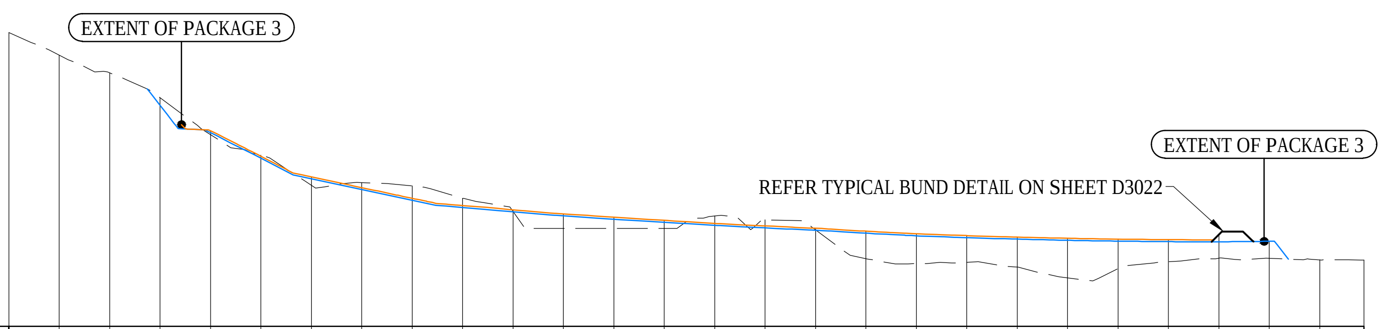
REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.04.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN
DRAWING TITLE: SUBGRADE PREPARATION PLAN PACKAGE 3

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	1:1,500	A3	117625003	220	L	D3011	A

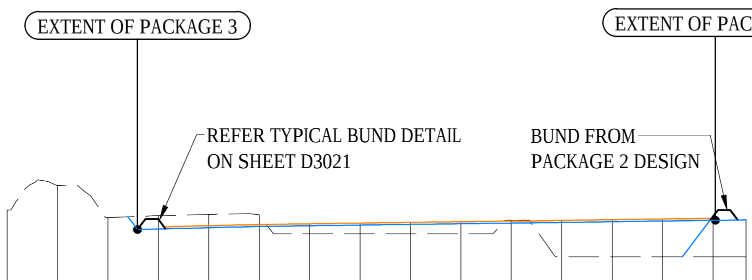
Plot Date: 5 April 2013 Time:5:02:32 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 3 - File Name:117625003-220-L-D3011-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOUNDARY.dwg; 117625003-XREF-SUBGRADE STAGE 1A.dwg; 117625003-XREF-SUBGRADE STAGE 1B.dwg; 117625003-XREF-SUBGRADE STAGE 2.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-BUND STAGE 1B.dwg; 117625003-XREF-BUND STAGE 2.dwg; 117625003-XREF-CELL STAGE BOUNDARY.dwg; 117625003-



DATUM 15.00

EXISTING SURFACE	44.13	41.89	40.13	37.67	34.02	31.98	28.98	29.24	28.92	27.71	26.40	24.71	24.71	24.71	25.95	25.57	24.58	21.71	21.22	21.35	20.89	19.82	20.73	21.41	21.75	21.76	21.60	21.58
SUBGRADE				36.91	34.20	31.67	29.62	28.56	27.50	26.78	26.36	25.95	25.63	25.32	25.02	24.76	24.53	24.24	23.98	23.80	23.65	23.53	23.45	23.40	23.39	23.44		
TOP OF LINER					34.40	31.87	29.82	28.76	27.70	26.98	26.56	26.15	25.83	25.52	25.22	24.96	24.73	24.44	24.18	24.00	23.85	23.73	23.65	23.60				
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00	220.00	230.00	240.00	250.00	260.00	268.75

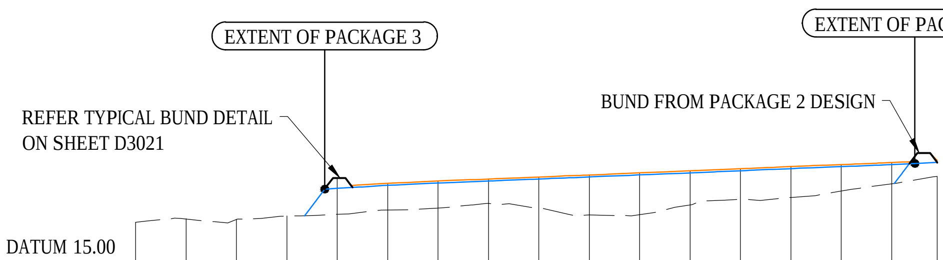
SECTION A D3011
HORIZ 1:1,500
VERT 1:750



DATUM 20.00

EXISTING SURFACE	27.04	29.51	26.32	26.50	26.63	26.56	24.71	24.71	24.71	24.71	26.04	22.43	22.43	22.43	22.43	22.43
SUBGRADE				25.18	25.31	25.41	25.50	25.57	25.64	25.70	25.76	25.83	25.90	25.97	26.03	
TOP OF LINER					25.50	25.61	25.70	25.77	25.84	25.90	25.96	26.03	26.10	26.17		
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	146.54

SECTION B D3011
HORIZ 1:1,500
VERT 1:750



DATUM 15.00

EXISTING SURFACE	18.86	19.19	19.15	19.48	19.65	20.08	20.26	20.74	20.29	19.58	19.62	20.56	21.12	21.32	21.96	22.67	23.41
SUBGRADE					22.21	22.52	22.74	22.94	23.14	23.34	23.55	23.75	23.96	24.17	24.37	24.57	
TOP OF LINER						22.72	22.94	23.14	23.34	23.54	23.75	23.95	24.16	24.37	24.57	24.77	
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	159.04

SECTION C D3011
HORIZ 1:1,500
VERT 1:750

0 15 30 45m
1:750
0 30 60 90m
1:1,500

NOT FOR CONSTRUCTION - ISSUED FOR
CLIENT REVIEW

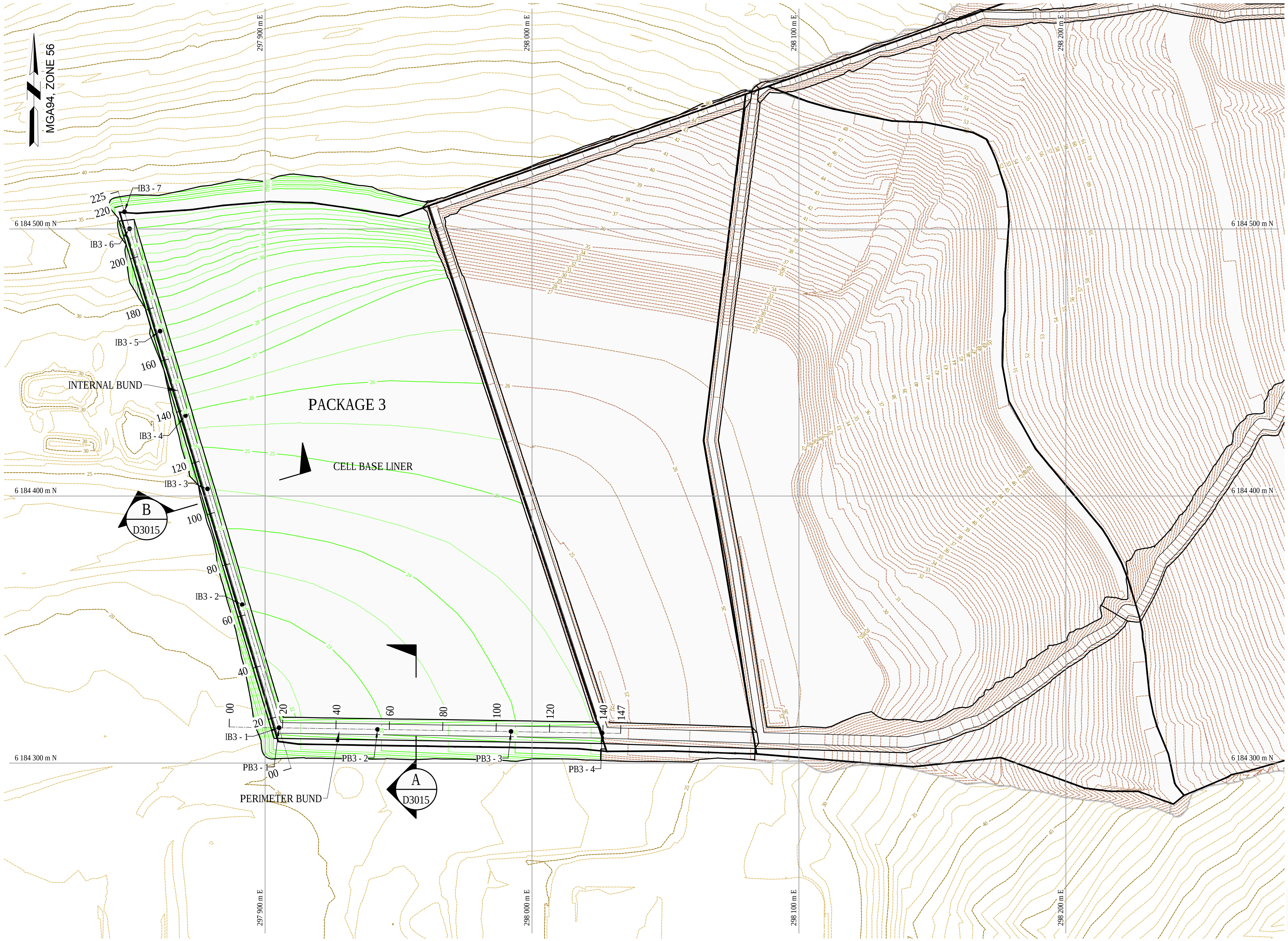
REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.04.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN
DRAWING TITLE: SUBGRADE PREPARATION SECTIONS PACKAGE 3

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	1:2,000	A3	117625003	220	L	D3012	A

Plot Date: 5 April 2013 Time:5:05:38 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 3 - File Name:117625003-220-L-D3012-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-SUBGRADE SECTIONS - STAGE 3.dwg;



LEGEND

- PACKAGE BOUNDARY
- BUND SUBGRADE CONTOURS
- 2011 CONTOURS
- PACKAGE 1 AND 2 DESIGN CONTOURS (SUBGRADE AND BUNDS)

PACKAGE 3 INTERNAL BUND - SETOUT

NUMBER	EASTING	NORTHING	LEVEL
IB3 - 1	297905.19	6184313.19	23.26
IB3 - 2	297891.79	6184357.88	24.00
IB3 - 3	297878.38	6184402.63	25.50
IB3 - 4	297869.74	6184431.44	27.00
IB3 - 5	297860.19	6184463.44	30.00
IB3 - 6	297849.17	6184500.05	35.00
IB3 - 7	297847.28	6184506.37	35.00

PACKAGE 3 PERIMETER BUND - SETOUT

NUMBER	EASTING	NORTHING	LEVEL
PB3 - 1	297905.19	6184313.19	23.26
PB3 - 2	297943.63	6184312.60	24.00
PB3 - 3	297993.77	6184311.74	25.00
PB3 - 4	298026.23	6184311.23	25.69

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

0 30 60 90m
1:1,500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.04.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

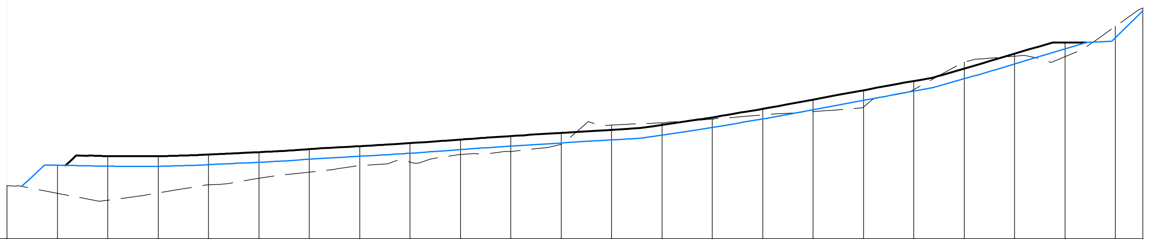
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: PERIMETER BUND AND INTERNAL BUND PLAN AND SETOUT PACKAGE 3

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	1:1,500	A3	117625003	220	L	D3013	A

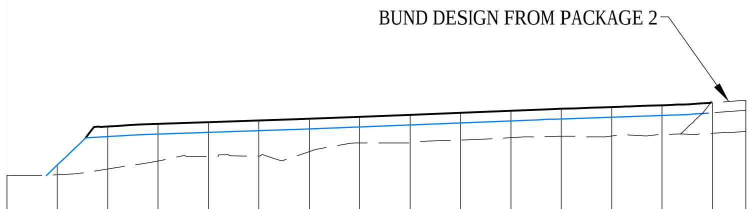
Plot Date: 5 April 2013 Time:5:27:57 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 3 - File Name:117625003-220-L-D3013-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-SUBGRADE STAGE 3.dwg; 117625003-XREF-SUBGRADE STAGE 1A.dwg; 117625003-XREF-SUBGRADE STAGE 1B.dwg; 117625003-XREF-SUBGRADE STAGE 2.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-BUND STAGE 1B.dwg; 117625003-XREF-BUND STAGE 2.dwg; 117625003-XREF-BUND STAGE 3.dwg; 117625003-XREF-CELL STAGE BOUNDARY.dwg



EXISTING SURFACE	20.28	19.53	18.86	19.57	20.36	21.02	21.64	22.27	22.64	23.40	23.68	24.41	26.30	26.52	26.88	27.31	27.63	28.09	29.83	32.55	33.13	33.07	36.09	37.93
SUBGRADE		22.31	22.22	22.21	22.37	22.61	22.91	23.21	23.51	23.86	24.21	24.52	24.83	25.31	26.06	26.91	27.83	28.75	29.67	30.89	32.36	33.87	34.94	37.63
DESIGN SURFACE			23.22	23.21	23.37	23.61	23.91	24.21	24.51	24.86	25.21	25.52	25.83	26.31	27.06	27.91	28.83	29.75	30.67	31.91	33.37	34.50		
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00	220.00	225.48

LONGITUDINAL SECTION OF PACKAGE 2 INTERNAL BUND

SCALE 1:1,500(H) 1:750(V)



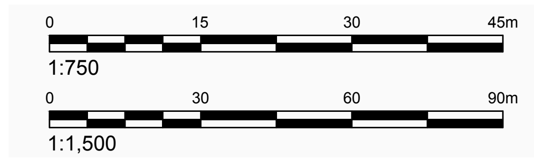
EXISTING SURFACE	18.47	18.50	19.09	19.87	20.33	20.37	20.80	21.65	21.67	21.95	22.18	22.32	22.35	22.51	22.62	22.81
SUBGRADE		19.47	22.30	22.55	22.72	22.88	23.06	23.26	23.46	23.66	23.86	24.05	24.22	24.40		
DESIGN SURFACE			23.30	23.55	23.72	23.88	24.06	24.26	24.46	24.66	24.86	25.05	25.22	25.40		
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	146.66

LONGITUDINAL SECTION OF PACKAGE 2 PERIMETER BUND

SCALE 1:1,500(H) 1:750(V)

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW



REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.04.2013

Golder Associates

124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

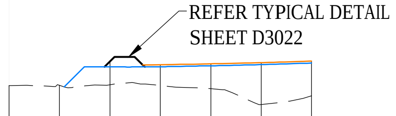
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: PERIMETER BUND AND INTERNAL BUND LONG SECTIONS PACKAGE 3

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D3014	A

Plot Date: 5 April 2013 Time:5:26:38 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 3 - File Name:117625003-220-L-D3014-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-SECTIONS.dwg;

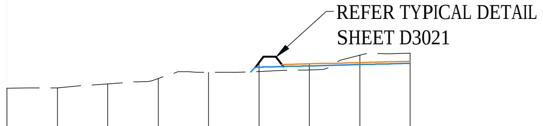


DATUM 15.00

EXISTING SURFACE	21.40	21.42	21.50	21.41	21.09	19.52	20.37
SUBGRADE			23.26	23.28	23.37	23.49	23.65
TOP OF LINER				23.49	23.57	23.69	23.85
DESIGN SURFACE			23.80				
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	59.97

SECTION A D3013 TYPICAL SECTION

HOR SCALE 1:1,500
VER SCALE 1:750



DATUM 15.00

EXISTING SURFACE	22.24	22.28	22.68	23.19	23.82	23.91	24.06	25.53	25.73
SUBGRADE						24.34	24.46	24.59	24.72
TOP OF LINER							24.66	24.79	24.92
DESIGN SURFACE						24.79			
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00

SECTION B D3013 TYPICAL SECTION

HOR SCALE 1:1,500
VER SCALE 1:750

NOT FOR CONSTRUCTION - ISSUED FOR
CLIENT REVIEW

0 15 30 45m
1:750
0 30 60 90m
1:1,500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.04.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

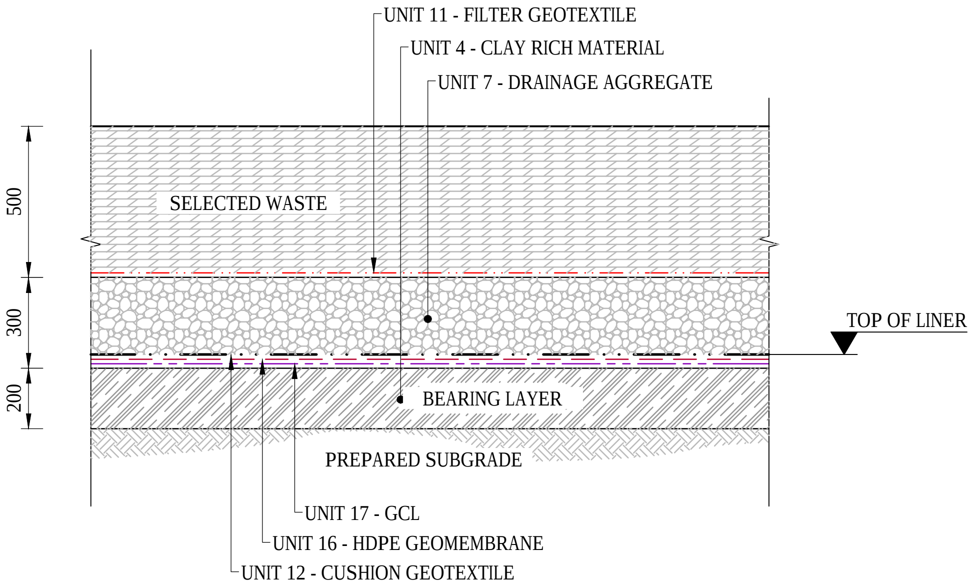
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: PERIMETER BUND AND INTERNAL BUND CROSS SECTIONS PACKAGE 3

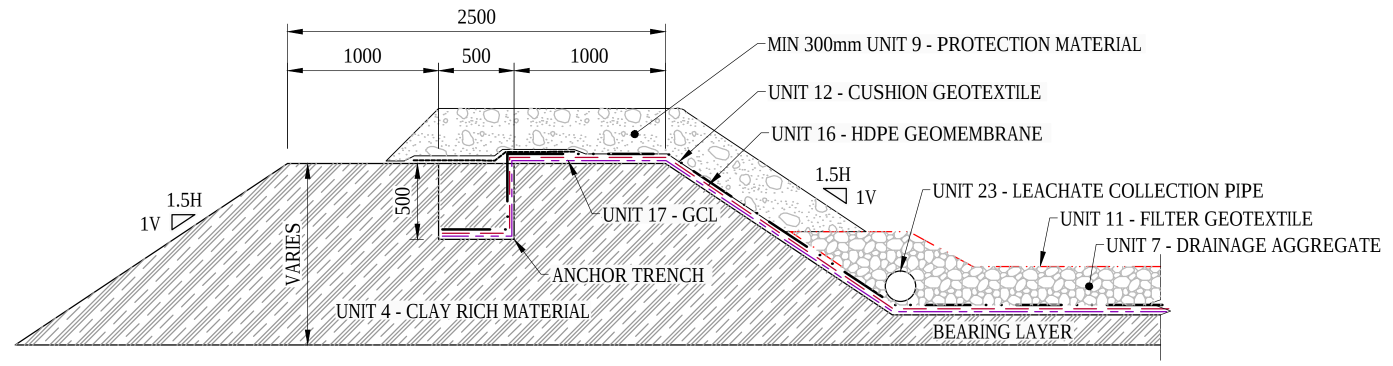
LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D3015	A

Plot Date: 5 April 2013 Time:5:12:45 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 3 - File Name:117625003-220-L-D3015-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-SECTIONS.dwg;



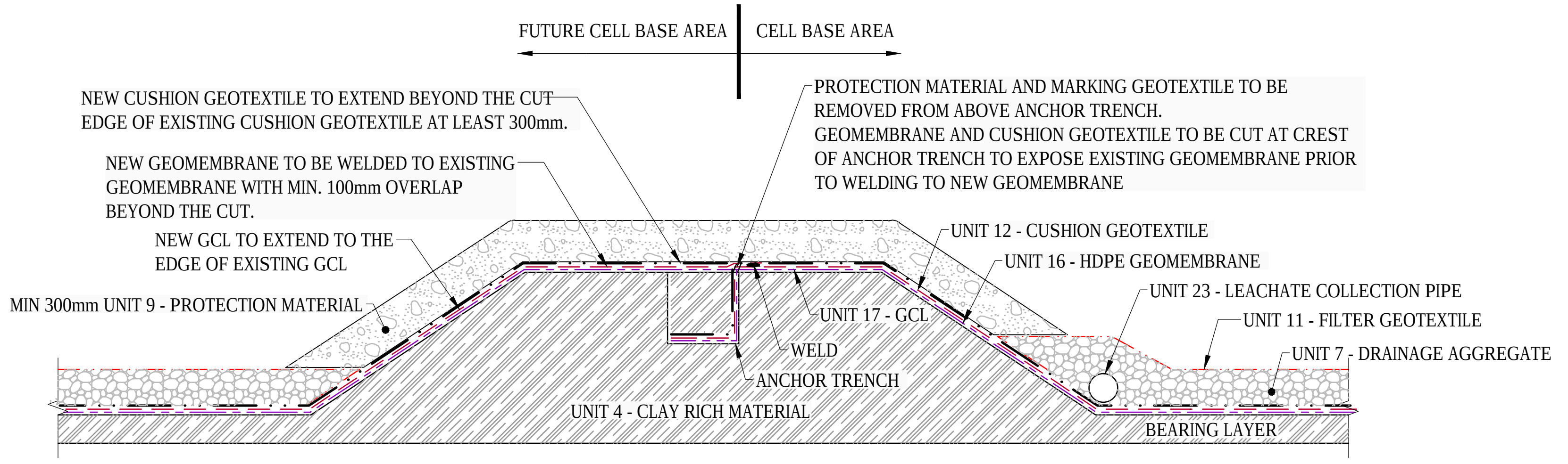
CELL BASE LINER

SCALE 1:25



BASE LINER - DETAIL FOR INTERIM TERMINATION AT INTERNAL BUND

SCALE 1:50

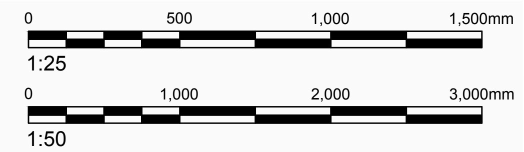


BASE LINER - INTERNAL BUND DETAIL

SCALE 1:50

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW



NOTES:

1. REFER TO DRAWING D3001 FOR GENERAL NOTES AND LEGEND

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.04.2013

124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

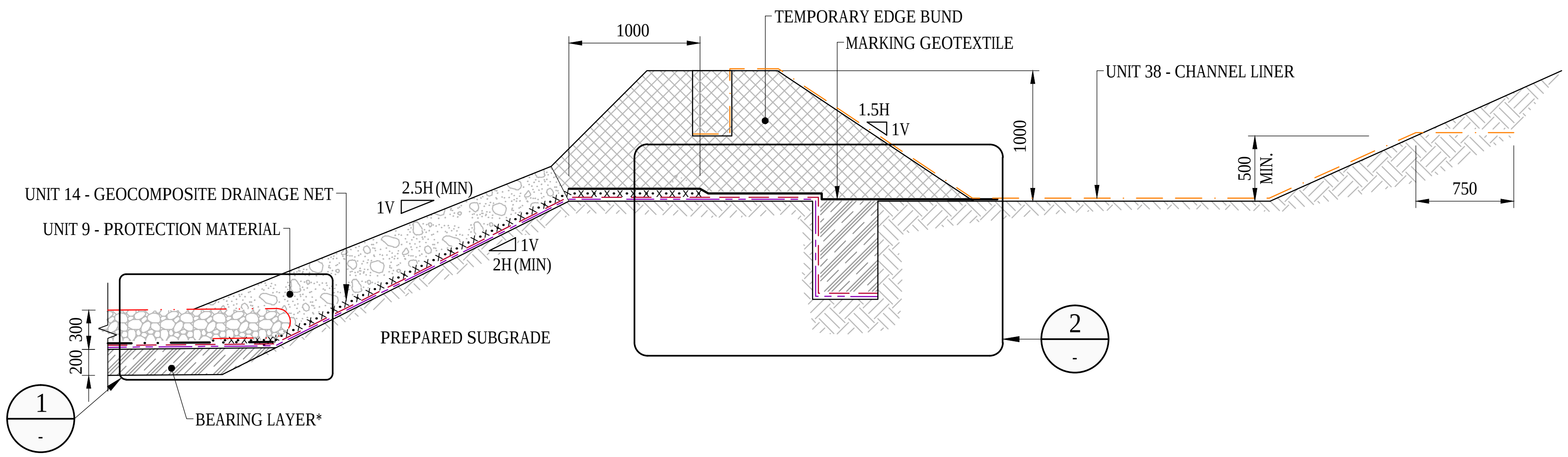
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: LINER DETAILS - SHEET 1
PACKAGE 3

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D3021	A

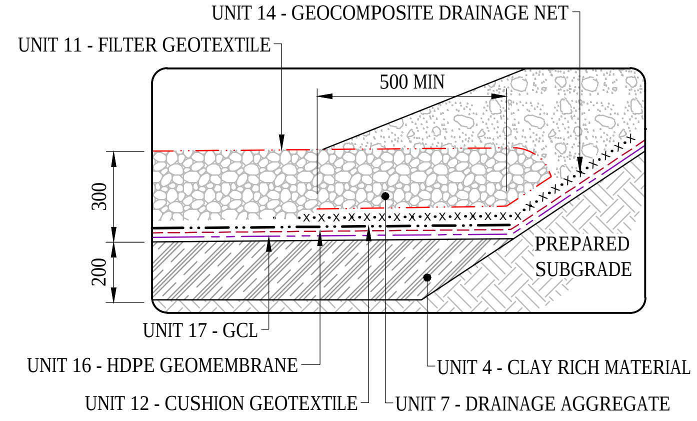
Plot Date: 5 April 2013 Time:6:25:36 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 3 - File Name:117625003-220-L-D3021-REVA.dwg
Xref: GAP_LOGO-A3.dwg;



* BEARING LAYER MAY EXTEND TO TOP OF BUND IN SOME AREAS

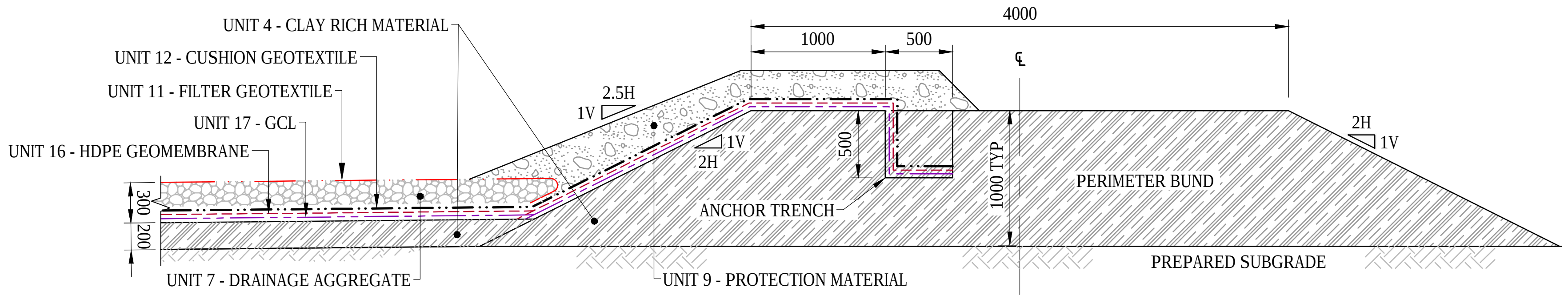
CELL BASE LINER - NTERIM TERMINATION AT BENCH FOR FUTURE CONNECTION OF PIGGY BACK LINER

SCALE 1:50



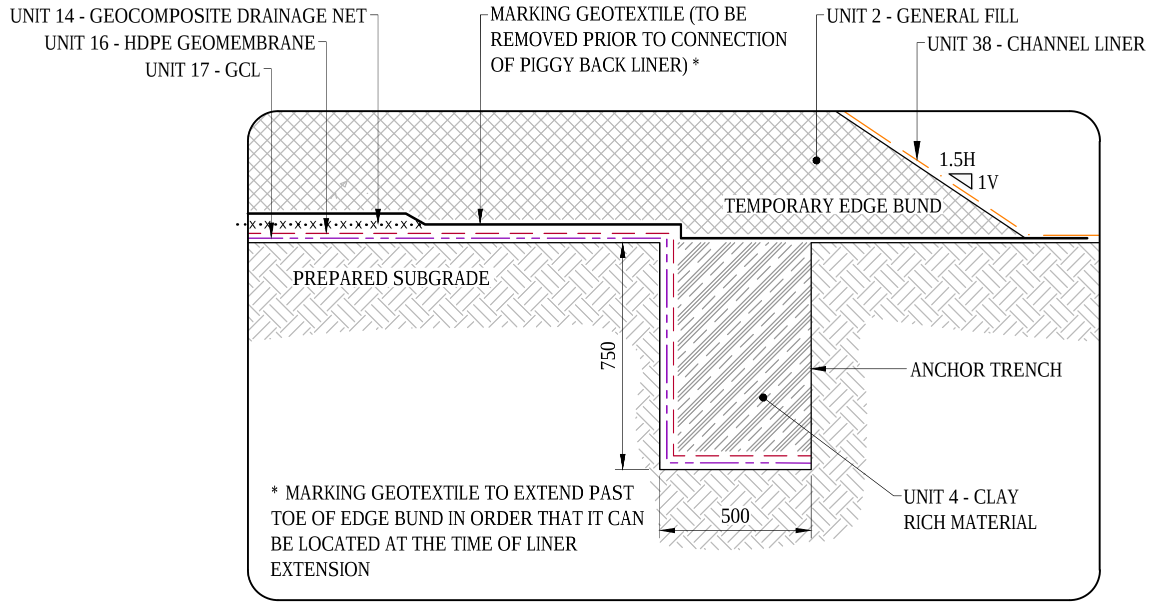
1 TYPICAL DETAIL

SCALE 1:25



TYPICAL DETAIL OF CELL BASE LINER ALONG PERIMETER BUND

SCALE 1:50



2 DETAIL FOR LINER TERMINATION AND ANCHOR TRENCH AT BENCH

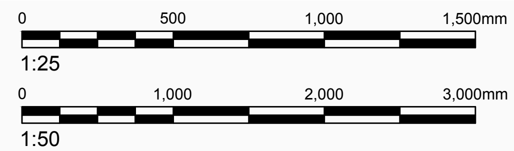
SCALE 1:25

NOTES:

1. REFER TO DRAWING D3001 FOR GENERAL NOTES AND LEGEND.

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW



REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.04.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

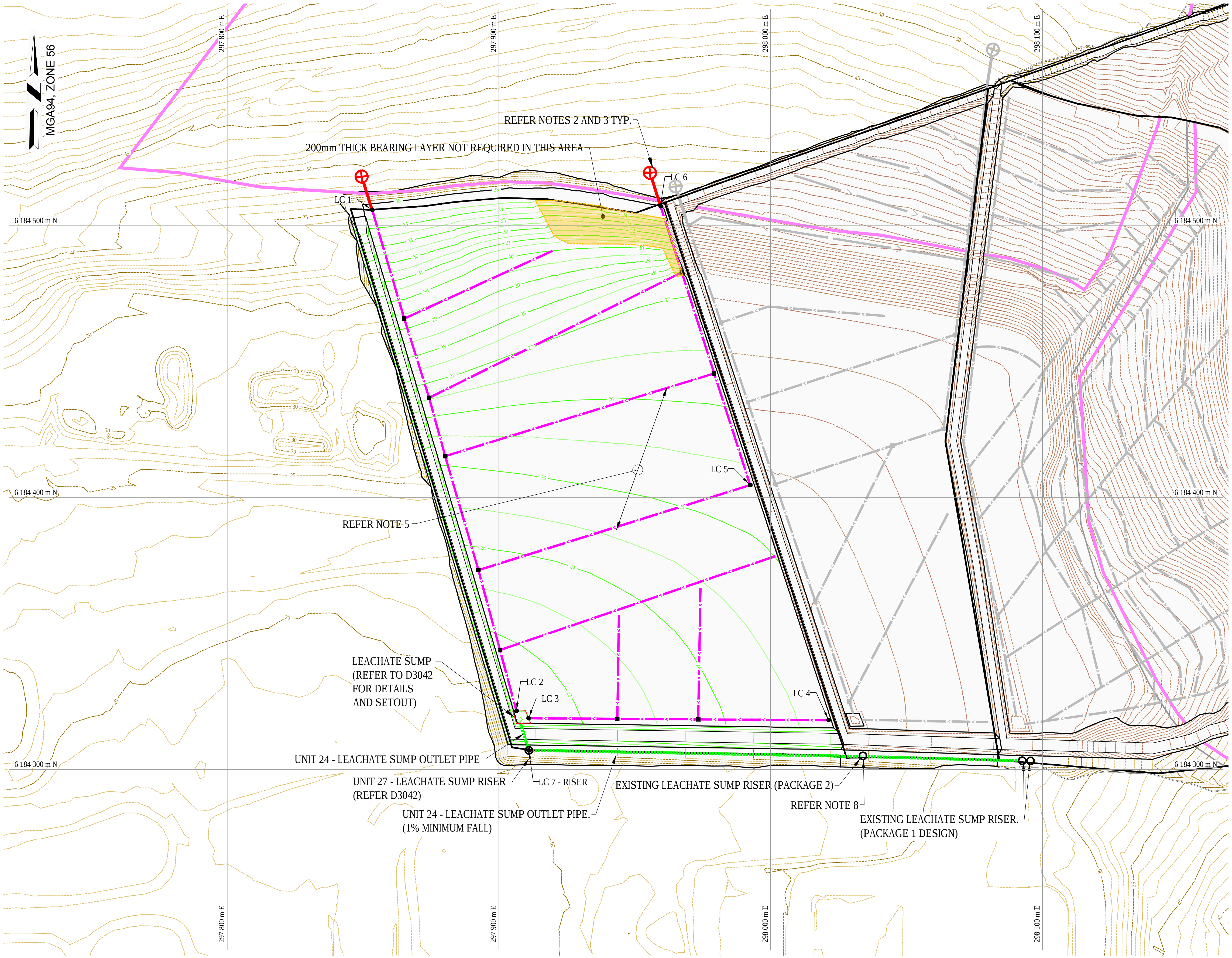
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: LINER DETAILS - SHEET 2
PACKAGE 3

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D3022	A

Plot Date: 5 April 2013 Time:7:25:07 PM By: Campbell, Helen Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 3 - File Name:117625003-220-L-D3022-REVA.dwg
Xref: GAP_LOGO-A3.dwg;



LEGEND

- UNIT 23 - LEACHATE COLLECTION PIPE
- TEMPORARY LEACHATE PIPE CLEANOUT POINT
- PIPE CONNECTION
- PACKAGE BOUNDARY
- TOP OF LINER CONTOURS
- 2011 CONTOURS
- PACKAGE 1 AND 2 DESIGN CONTOURS (TOP OF LINER AND BUNDS)
- UNIT 24 - LEACHATE SUMP OUTLET PIPE

NOTES:

1. REFER TO D3001 FOR GENERAL NOTES, MATERIAL LIST AND DRAWING REFERENCES.
2. PIPE TO BE EXTENDED IN FUTURE
3. ALL PIPES TERMINATING AT BENCHES OR AT TEMPORARY/FINAL LEACHATE PIPE CLEANOUT POINTS ARE TO CAPPED WITH AN AIRTIGHT CAP AND CLEARLY LABELED ìWARNING: EXPLOSIVE GASES MAY BE PRESENT (METHANE)î.
4. ALL PIPES MINIMUM 1% FALL
5. MAXIMUM 50m DISTANCE BETWEEN PIPES MEASURED PERPENDICULAR TO SLOPE
6. MAXIMUM PIPE FITTING BEND 30Á WITH SWEEPING BENDS ONLY
7. ALL PIPE TERMINATIONS TO HAVE SOLID END CAPS
8. CONNECT UNIT 24 TO THE OUTLET FLANGE STUB OF THE EXISTING LEACHATE SUMP RISER PIPE.

PACKAGE 3 LEACHATE COLLECTION - SETOUT		
NUMBER	EASTING	NORTHING
LC 1	297853.42	6184505.79
LC 2	297906.48	6184321.55
LC 3	297910.95	6184318.92
LC 4	298021.30	6184318.19
LC 5	297992.46	6184404.63
LC 6	297959.50	6184507.23
LC 7 - RISER	297911.02	6184307.05

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

0 30 60 90m

1:1,500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.04.2013

Golder Associates

124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

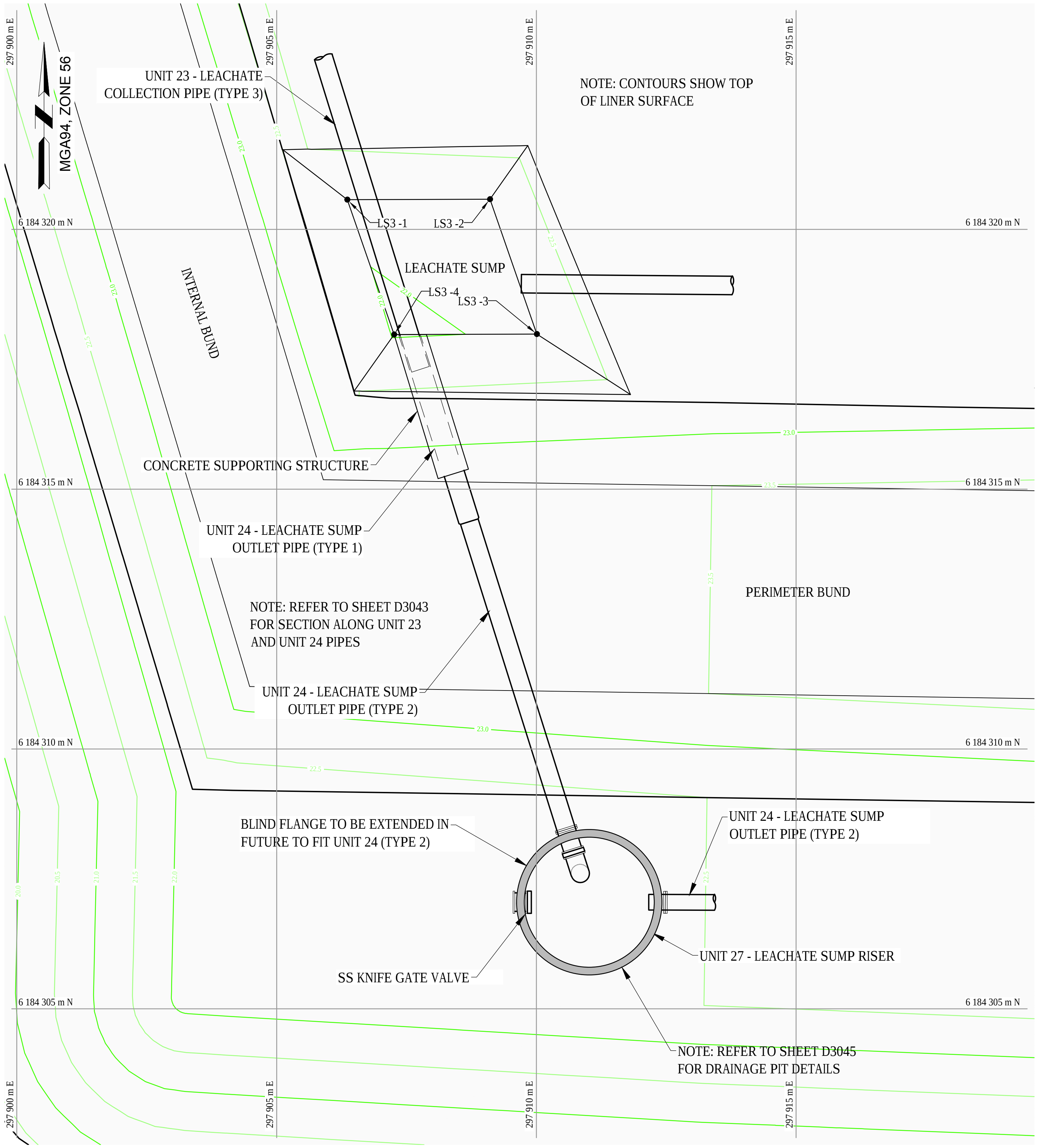
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: TOP OF LINER AND LEACHATE COLLECTION SYSTEM PLAN AND SETOUT - PACKAGE 3

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	1:1,500	A3	117625003	220	L	D3041	A

Plot Date: 5 April 2013 Time:5:39:27 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 3 - File Name:117625003-220-L-D3041-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOUNDARY.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-BUND STAGE 1B.dwg; 117625003-XREF-BUND STAGE 2.dwg; 117625003-XREF-BUND STAGE 3.dwg; 117625003-XREF-BASE LINER STAGE 1A.dwg; 117625003-XREF-BASE LINER STAGE 1B.dwg; 117625003-XREF-BASE LINER STAGE 2.dwg; 117625003-XREF-BA



PLAN - LEACHATE SUMP

SCALE 1:100

PACKAGE 3 SUMP - SETOUT			
NUMBER	EASTING	NORTHING	TOP OF LINER LEVEL
LS3 -1	297906.36	6184320.57	22.03
LS3 -2	297909.11	6184320.58	22.09
LS3 -3	297910.01	6184317.98	22.03
LS3 -4	297907.26	6184317.98	21.97

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

0 2 4 6m

1:100

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.04.2013

Golder Associates

124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

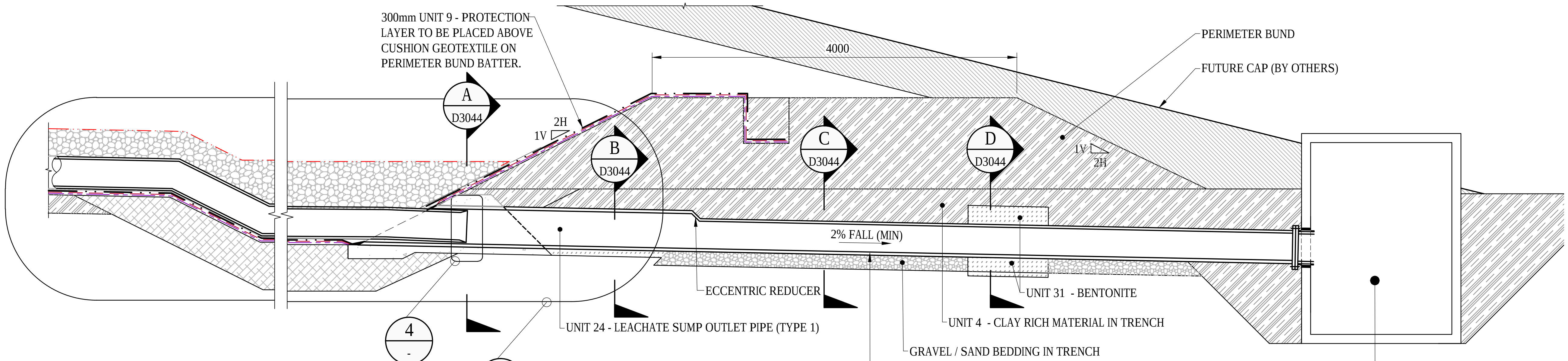
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: LEACHATE SUMP PLAN AND DETAILS - PACKAGE 3

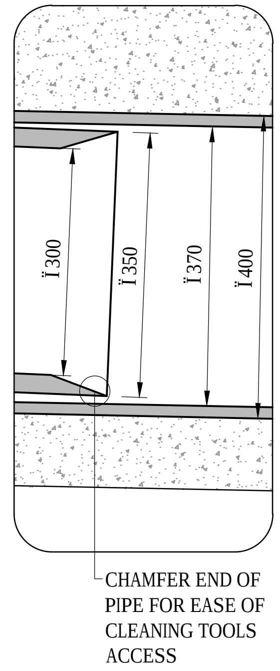
LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	1:100	A3	117625003	220	L	D3042	A

Plot Date: 5 April 2013 Time:7:26:39 PM By: Campbell, Helen Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 3 - File Name:117625003-220-L-D3042-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg; 117625003-XREF-EXISTING LINER AND PROPERTY BOUNDARY.dwg; 117625003-XREF-SUBGRADE STAGE 3.dwg; 117625003-XREF-BUND STAGE 3.dwg; 117625003-XREF-BASE LINER STAGE 3.dwg;



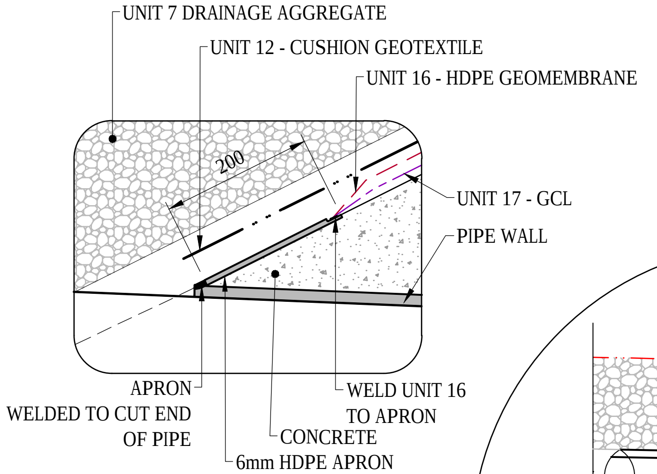
LEACHATE SUMP

SCALE 1:50



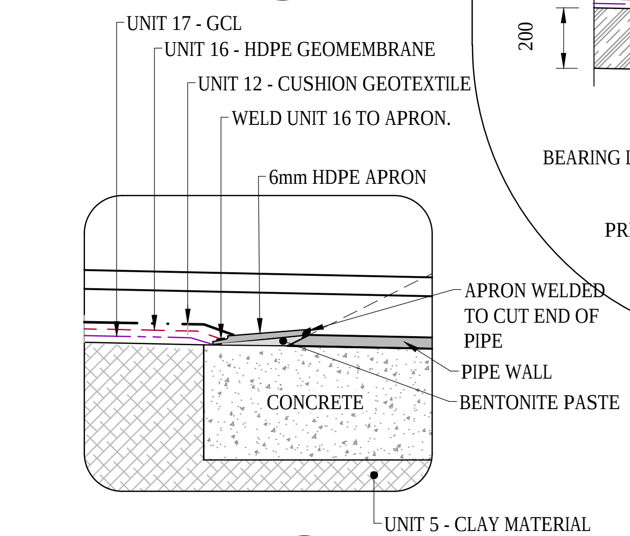
DETAIL 4

SCALE 1:10



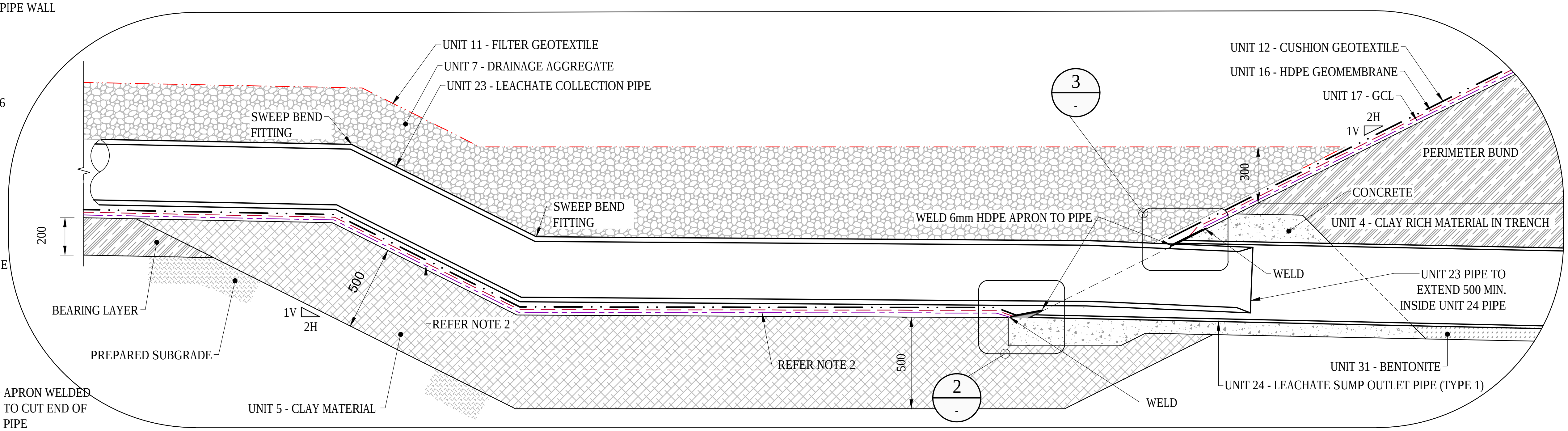
DETAIL 3

SCALE 1:10



DETAIL 2

SCALE 1:10



DETAIL 1

SCALE 1:25

0 200 400 600mm
1:10

0 500 1,000 1,500mm
1:25

0 1,000 2,000 3,000mm
1:50

NOTES:

1. REFER TO DRAWING D3001 FOR GENERAL NOTES AND LEGEND.
2. DOUBLE THICKNESS OF UNIT 17 - GCL TO BE USED IN SUMP LINER.

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.04.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

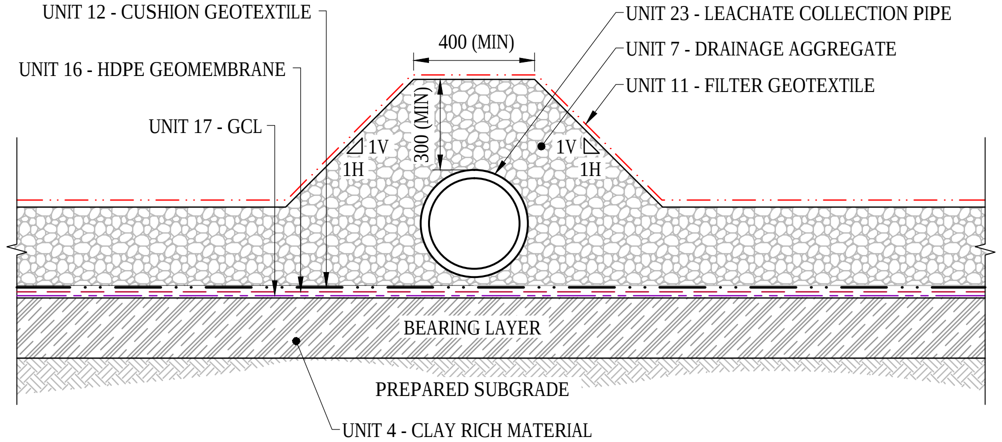
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: LEACHATE COLLECTION SYSTEM DETAILS - SHEET 1 PACKAGE 3

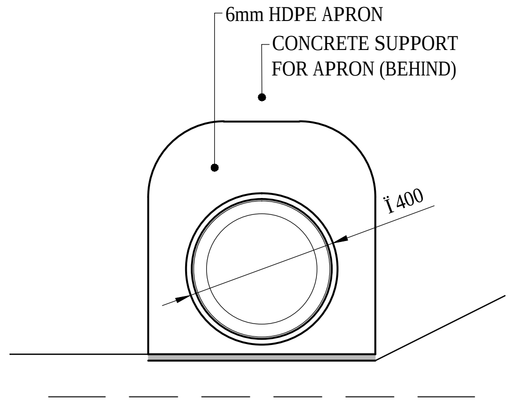
LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D3043	A

Plot Date: 5 April 2013 Time:5:45:19 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 3 - File Name:117625003-220-L-D3043-REVA.dwg
Xref: GAP_LOGO-A3.dwg;



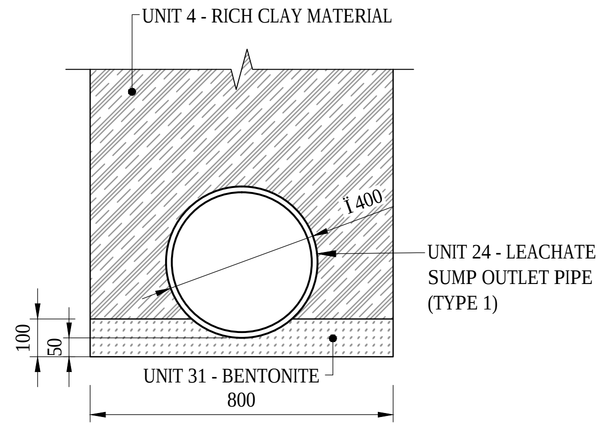
DETAIL 1 (D3041) TYPICAL DETAIL LEACHATE COLLECTION PIPE FOR CELL BASE LINER

SCALE 1:25



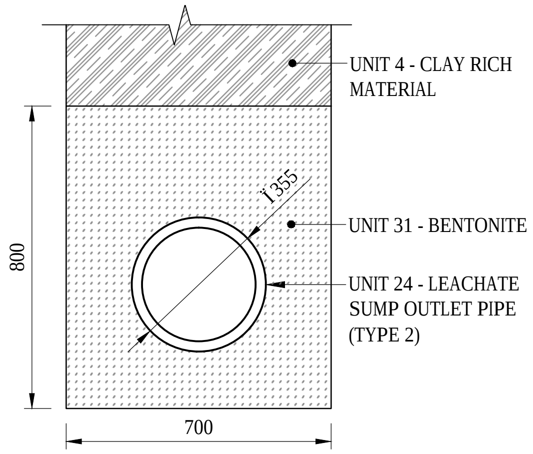
SECTION A (D3043)

SCALE 1:20



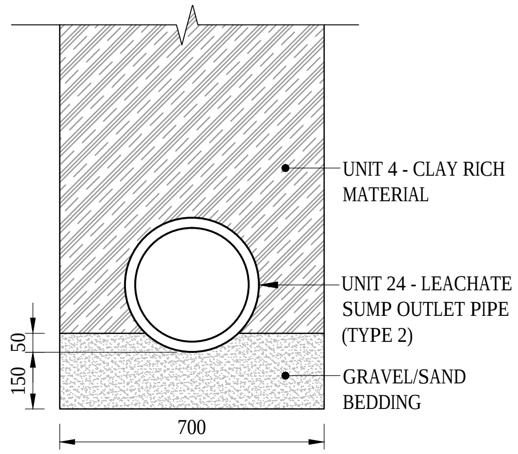
SECTION B (D3043)

SCALE 1:20



SECTION D (D3043) BENTONITE PLUG

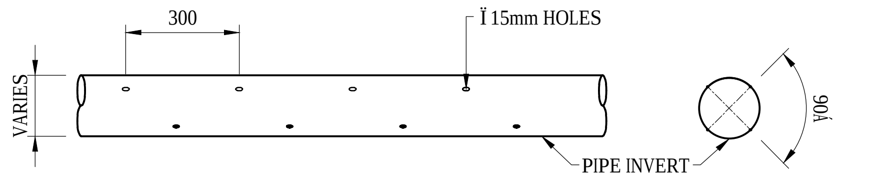
SCALE 1:20



SECTION C (D3043)

SCALE 1:20

NOTE: BENTONITE PLUG
EXTENDS FOR 900 MIN.
ALONG PIPE LENGTH



LEACHATE PIPE PERFORATION DETAIL

SCALE 1:20

NOTE: PIPE TO BE
INSTALLED WITH HOLES IN
ORIENTATION SHOWN

NOT FOR CONSTRUCTION - ISSUED FOR
CLIENT REVIEW

0 400 800 1,200mm
1:20

0 500 1,000 1,500mm
1:25

NOTES:

1. REFER TO DRAWING D3001 FOR GENERAL NOTES AND LEGEND

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.04.2013

Golder Associates

124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

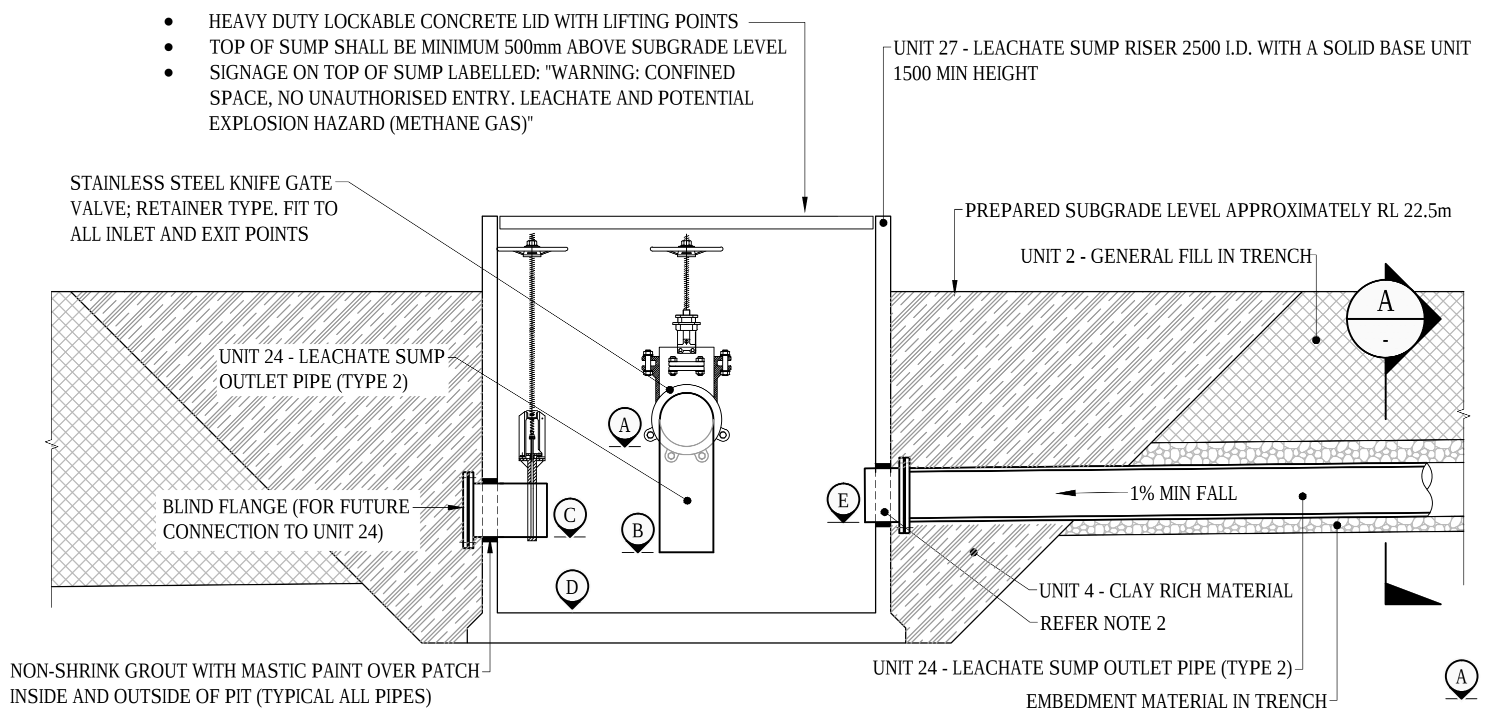
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: LEACHATE COLLECTION SYSTEM DETAILS - SHEET 2 PACKAGE 3

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D3044	A

Plot Date: 5 April 2013 Time:5:46:46 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 3 - File Name:117625003-220-L-D3044-REVA.dwg
Xref: GAP_LOGO-A3.dwg;

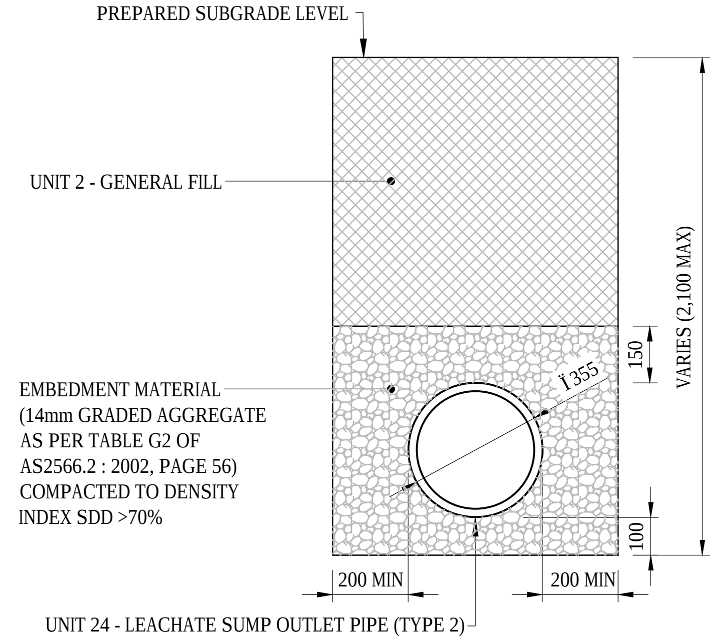


LEACHATE DRAINAGE PIT INVERT LEVEL SCHEDULE	
ITEM	INVERT LEVEL
A	21.7
B	21.0
C	21.1
D	20.6
E	21.2

Ⓐ INDICATES INVERT LEVELS. REFER TO SCHEDULE

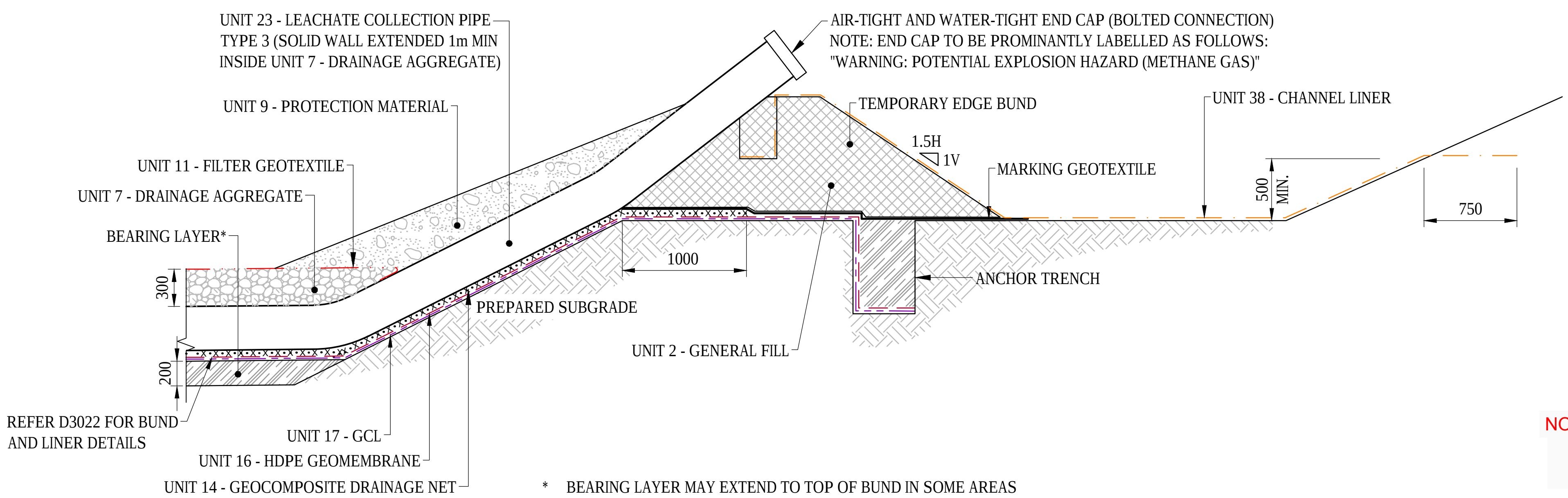
LEACHATE DRAINAGE PIT

N.T.S. (APPROXIMATE SCALE 1:50)



SECTION A -

SCALE 1:20



* BEARING LAYER MAY EXTEND TO TOP OF BUND IN SOME AREAS

TYPICAL DETAIL OF TEMPORARY LEACHATE CLEAN OUT ACCESS POINT

SCALE 1:50

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

0 400 800 1,200mm
1:20

0 1,000 2,000 3,000mm
1:50

NOTES:

1. REFER TO DRAWING D3001 FOR GENERAL NOTES AND LEGEND
2. FIT ALL PIPE PENETRATIONS INTO PIT WITH A SS304 PIPE STUB - DOUBLE FLANGED, MIN LENGTH 500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	RH	GRS	GRS	05.04.2013

Golder Associates

124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

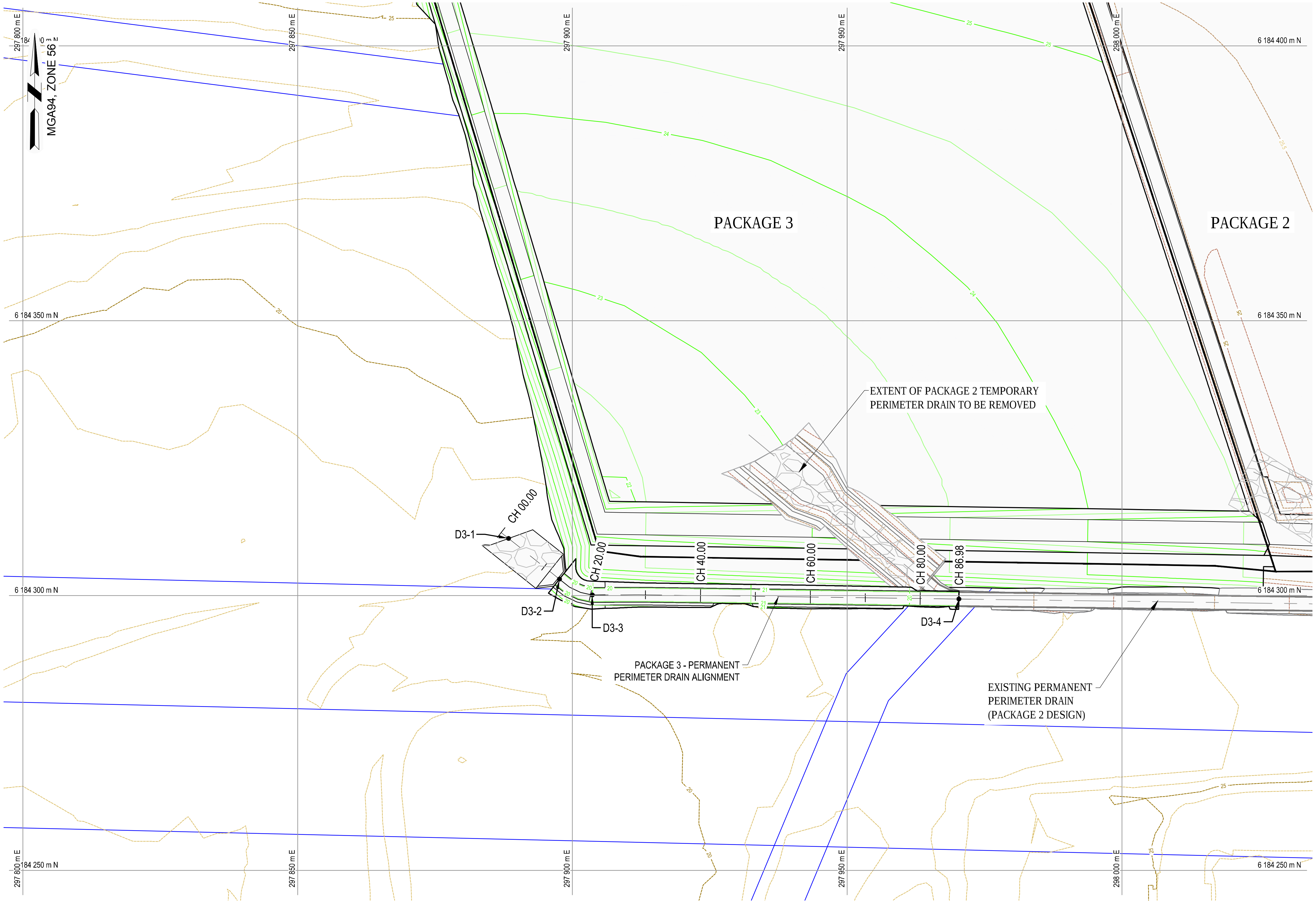
CLIENT: WOLLONGONG CITY COUNCIL

PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: LEACHATE COLLECTION SYSTEM DETAILS - SHEET 3 PACKAGE 3

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D3045	A

Plot Date: 5 April 2013 Time:6:26:38 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 3 - File Name:117625003-220-L-D3045-REVA.dwg
Xref: GAP_LOGO-A3.dwg;



LEGEND

- PACKAGE 1 AND 2 DESIGN CONTOUR
- PROPOSED CONTOURS (REFER NOTE 1)
- PACKAGE BOUNDARY
- EASEMENT
- 2011 CONTOURS

NOTES:

1. PROPOSED CONTOURS REPRESENT SUBGRADE LEVELS, BUNDS AND DRAINAGE STRUCTURES

PACKAGE 3 - PERMANENT PERIMETER DRAIN SETOUT

POINT No.	EASTING (m)	NORTHING (m)	INVERT LEVEL
D3-1	297888.37	6184310.40	18.50
D3-2	297897.65	6184303.00	18.90
D3-3	297903.61	6184300.12	19.00
D3-4	297970.31	6184299.38	20.16

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

0 15 30 45m

1:750

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	CRA	GRS	GRS	05.04.2013

Golder Associates

124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL

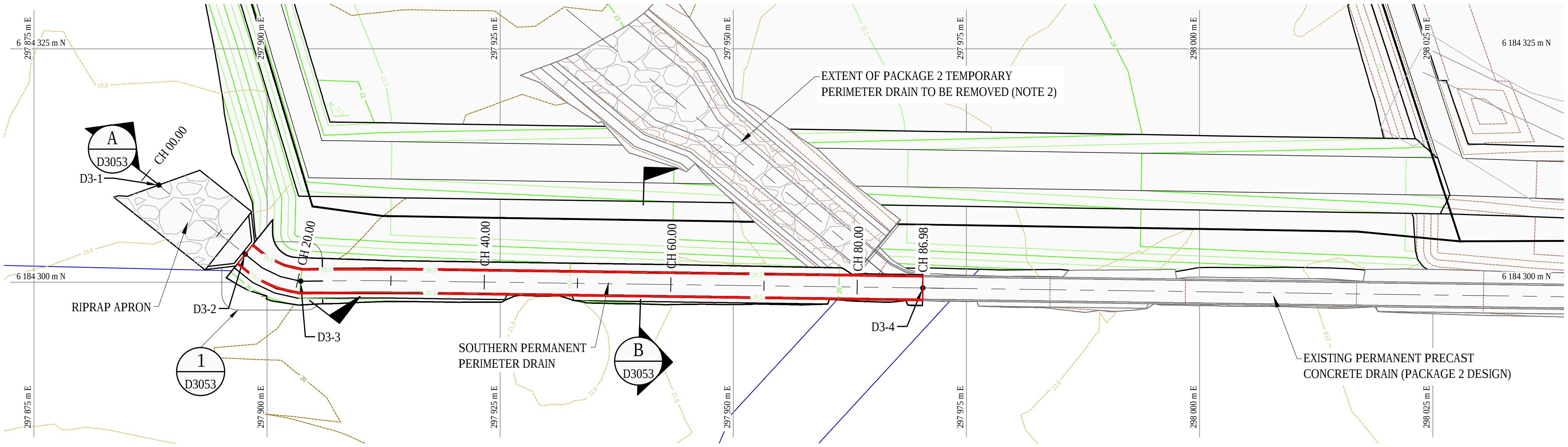
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: SOUTHERN PERIMETER DRAIN - PLAN AND SETOUT PACKAGE 3

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	1:750	A3	117625003	220	L	D3051	A

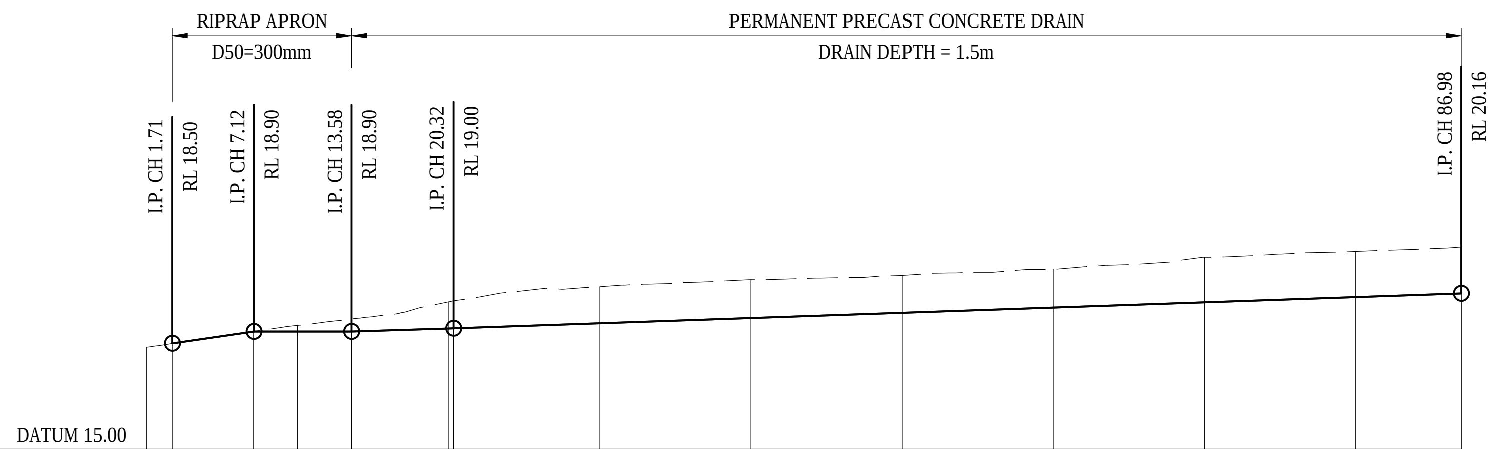
Plot Date: 5 April 2013 Time:7:47:27 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 3 - File Name:117625003-220-L-D3051-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-SUBGRADE STAGE 1A.dwg; 117625003-XREF-SUBGRADE STAGE 2.dwg; 117625003-XREF-SUBGRADE STAGE 3.dwg; 117625003-XREF-BUND STAGE 1A.dwg; 117625003-XREF-BUND STAGE 2.dwg; 117625003-XREF-BUND STAGE 3.dwg; 117625003-XREF-BASE LINER STAGE 2.dwg; 117625003-XREF-DRAINS PACKAGE 3.dwg; 117625003-XREF-DRAINS PACKAGE 2.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg

MGA94, ZONE 56



PLAN - SOUTHERN PERIMETER DRAIN

SCALE 1:500



GRADE: 7.39% | 0.00% | 1.48% | 1.73%

NATURAL SURFACE	18.37	19.10	19.88	20.38	20.62	20.76	20.96	21.36	21.54	21.69
DESIGN SURFACE		18.90	19.00	19.17	19.34	19.51	19.69	19.86	20.03	
DEPTH		0.20	0.89	1.21	1.27	1.24	1.27	1.49	1.51	
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	86.98

LONG SECTION - SOUTHERN PERIMETER DRAIN

HOR. SCALE 1:500 VER SCALE 1:250

LEGEND

- PACKAGE 1 AND 2 DESIGN CONTOUR
- PROPOSED CONTOURS (REFER NOTE 1)
- PACKAGE BOUNDARY
- EASEMENT
- 2011 CONTOURS
- D3-1 SET OUT POINTS (SEE D3051 FOR SET OUT TABLE)

NOTES:

1. PROPOSED CONTOURS REPRESENT SUBGRADE LEVELS, BUNDS AND DRAINAGE STRUCTURES

NOT FOR CONSTRUCTION - ISSUED FOR

CLIENT REVIEW

0 5 10 15m
1:250
0 10 20 30m
1:500

REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	CRA	GRS	GRS	05.04.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL

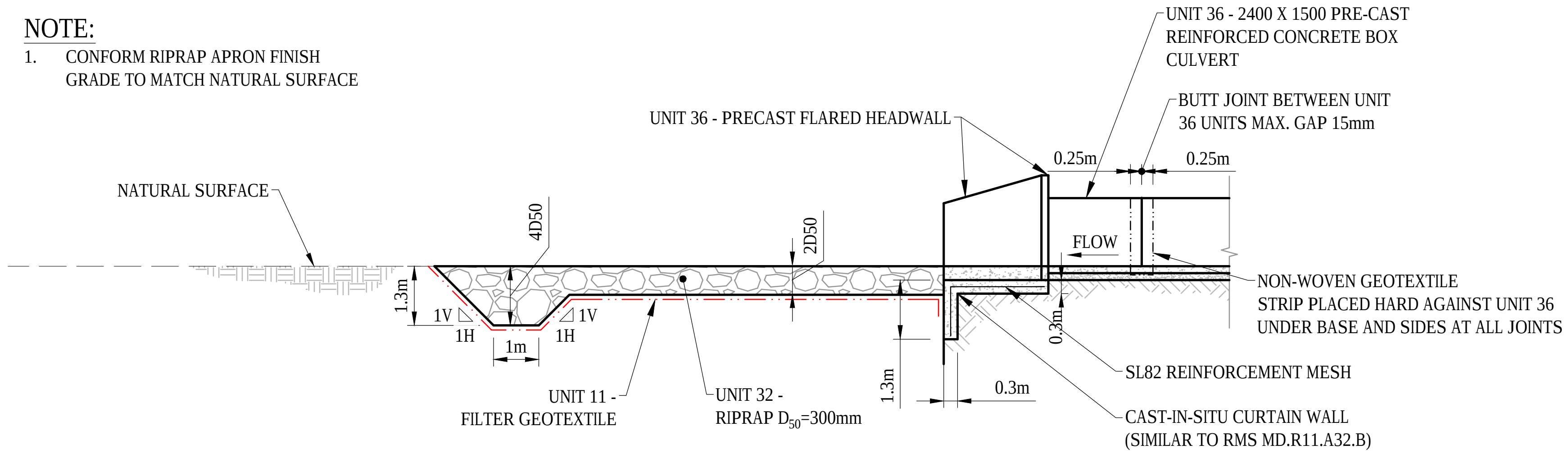
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN

DRAWING TITLE: SOUTHERN PERIMETER DRAIN PLAN AND LONG SECTION - PACKAGE 3

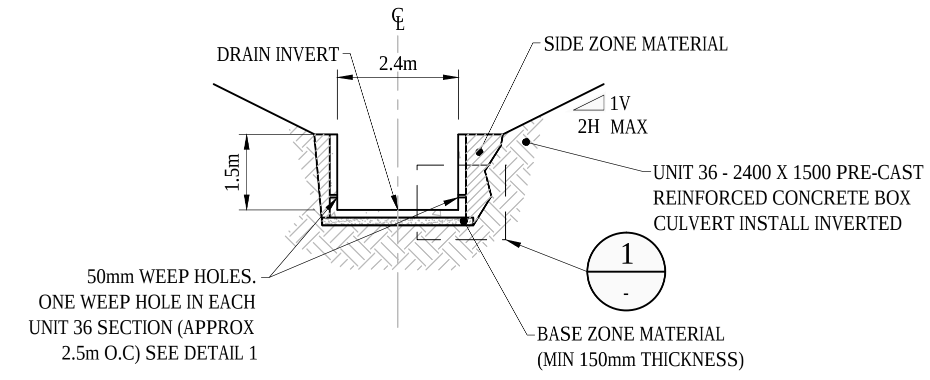
LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D3052	A

Plot Date: 5 April 2013 Time:7:42:44 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 3 - File Name:117625003-220-L-D3052-REVA.dwg
Xref: GAP_LOGO-A3.dwg; 117625003-XREF-SUBGRADE STAGE 2.dwg; 117625003-XREF-SUBGRADE STAGE 3.dwg; 117625003-XREF-BUND STAGE 2.dwg; 117625003-XREF-BUND STAGE 3.dwg; 117625003-XREF-BASE LINER STAGE 2.dwg; 117625003-XREF-Cadastre and easement.dwg; 117625003-XREF-DRAINS PACKAGE 2.dwg; 117625003-XREF-DRAINS PACKAGE 3.dwg; 117625003-XREF-EXISTING GROUND JULY MERGED WITH 2009 GOLDER DESIGN.dwg;

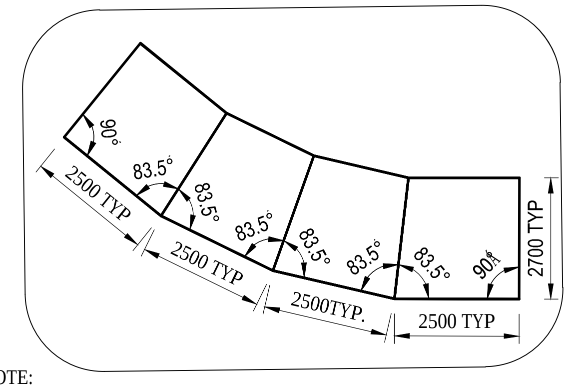
NOTE:
1. CONFORM RIPRAP APRON FINISH GRADE TO MATCH NATURAL SURFACE



SECTION A RIPRAP APRON AND PERMANENT DRAIN
SCALE 1:150
D3052

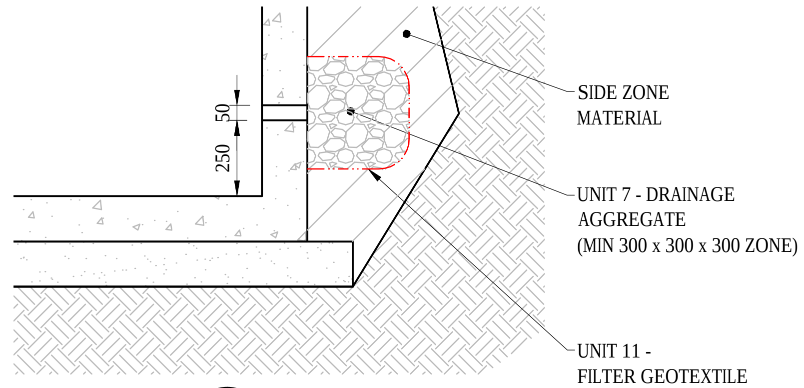


SECTION B PERMANENT DRAIN
SCALE 1:150
D3052



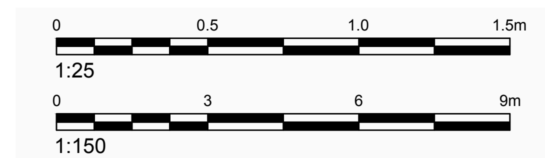
NOTE:
THESE PRECAST UNITS SHALL BE REUSED FROM PACKAGE 2 TEMPORARY DRAIN

DETAIL 1
SCALE 1:150
D3052



DETAIL 1 WEEP HOLE
SCALE 1:150
-

NOT FOR CONSTRUCTION - ISSUED FOR
CLIENT REVIEW



REVISION	DESCRIPTION	DRAWN	DRAWN CHECK	DESIGN	DESIGN CHECK	AUTHORISED	DATE
A	ISSUED FOR CLIENT REVIEW	EJJ	RH	CRA	GRS	GRS	05.04.2013

Golder Associates
124 PACIFIC HIGHWAY
ST LEONARDS, NSW 2065
AUSTRALIA
PH (02) 9478 3900
FAX (02) 9478 3901
WEB: www.golder.com

CLIENT: WOLLONGONG CITY COUNCIL
PROJECT: WHYTES GULLY LANDFILL - NEW CELL DESIGN
DRAWING TITLE: SOUTHERN PERIMETER DRAIN DETAILS PACKAGE 3

LEAD PROJECT DRAFTER	PROJECT MANAGER	SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	DRAWING No	REVISION
EJJ	KAD	AS SHOWN	A3	117625003	220	L	D3053	A

Plot Date: 5 April 2013 Time:7:44:46 PM By: Jeet, Elvin Path: J:\civ\2011\117625003_Wollongong Council_New Landfill Cell_Whytes Gully\Technical Doc\CADD\DRAWINGS\TENDER PACKAGE 3 - File Name:117625003-220-L-D3053-REVA.dwg
Xref: GAP_LOGO-A3.dwg;