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18 November 2014

AWJ Civil Pty Ltd
155 Newton Road
WETHERILL PARK NSW 2164

ATTENTION: MATHEW MIKHAIL
By Email: Mathew@awj.com.au

Dear Mathew

RE: QUARRYWEST, GREYSTANES
GROUNDWATER DRAINAGE SYSTEM ANALYSIS AND REDESIGN

We are pleased to submit our report relating to the groundwater (GW) drainage system at Quarrywest which forms the western portion of the Greystanes Southern Employment Lands (SEL). The report presents the PSM recommendations regarding the GW drainage system and the basis of these recommendations.

Please do not hesitate to contact the undersigned should you have any queries.

For and on behalf of
PELLS SULLIVAN MEYNINK

DAVID PICCOLO

Distribution: 1 electronic copy to AWJ Civil Pty Ltd
Original held by PSM

AWJ Civil Pty Ltd

QUARRYWEST, GREYSTANES
GROUNDWATER DRAINAGE SYSTEM ANALYSIS AND REDESIGN

PSM963-222R NOVEMBER 2014

CONTENTS

FIGURES

APPENDICES

1 INTRODUCTION

This report relates to the groundwater **(GW)** drainage system at Quarrywest which forms the western portion of the Greystanes Southern Employment Lands **(SEL)**. The report presents the PSM recommendations regarding the GW drainage system and the basis of these recommendations.

We note that a GW drainage system has been constructed and been in operation on site since 2010. This report incorporates the knowledge of the performance of the as built GW drainage system in these last 4 years.

The report has been prepared at the request of AWJ Civil Pty Ltd **(AWJ)** in accordance with our proposal letter PSM963-216L dated 11 September 2014.

2 AIM OF GROUNDWATER SYSTEM

We understand the aim of the GW drainage system on site is to control the maximum GW level within the developable area of Quarrywest and the SEL to be below the finished surface level **(FSL)** at the site.

3 SCOPE OF WORK

The scope of work described below has been undertaken to satisfy ourselves and the interested parties that the currently constructed GW drainage system is sufficient in achieving the aim as stated in Section 2 of this report.

The following scope of work has been undertaken:

1. We have documented the existing GW conditions on site on the basis of:
    a. The GW drainage system as it is currently constructed.
    b. The existing surface conditions.
    c. Monitoring of the GW level at the accessible piezometers on site.
    d. Observations regarding GW inflows within Quarrywest.
    e. Measurements of groundwater flow within the current GW drainage system.
2. We note that the site including the drainage system has essentially been unchanged since 2011. The conditions today can thus be considered as representing stable conditions for the environmental factors (rainfall, evaporation, infiltration etc) experienced in this time. We have assessed the GW conditions between 2011 and 2014 and related these to rainfall where possible.
3. We have qualitatively assessed:
    a. The effect of the proposed development on the existing GW levels.
    b. The effect of changes in environmental factors in the future relative to the conditions experienced between 2011 and 2014.

4. We have reviewed the existing GW drainage system design and GW analyses completed by GHD and others in the past.

5. We have undertaken additional 3D GW analysis to investigate the ability of the as built GW drainage system to achieve the aim as stated in Section 2.

   We note that the current design is based on a GHD 3D groundwater flow analysis. Further, we note that GHD have not provided the basis to easily reproduce their analysis.

6. We have prepared this detailed report presenting the outcomes of the above assessments and analysis.

4 EXISTING CONDITIONS

4.1 Surface conditions

We have included two drawings in Appendix A of this report present the Quarrywest site levels in February 2011 (PSM Figure) and August 2014 (Costin Roe Drawing).

Comparison of the two drawings indicates that between February 2011 and August 2014 there has been little or no change to the site surface levels. We understand that in this time no major earthworks were completed on site.

The currently proposed finished surface level of the landform is shown in the Costin Roe drawing in Appendix A and has been reproduced in Figure 1.

4.2 As built drainage system

GHD Drawings 21-15443-GW-0700 TO 0724 provide details of the GHD Design of the GW drainage system for the SEL. These are included in Appendix B of this report. In March 2010 the design was modified to include a connection from the southern end of the eastern drain to the western drain at the southern cut. Details of this modification are presented in two marked up GHD drawings dated March 2010 and included in Appendix B.

Figure 1 presents the:

1. Original GHD GW drainage system design.
2. The revised GHD GW drainage system design which includes the March 2010 modification.
3. The as built GW drainage system.

In summary, the following components of the revised GHD GW drainage system have been completed:

1. GW drainage trench at the toe of the eastern batters north of the southern cut.
2. GW drainage trench at the toe of the western batters:
   a. At the southern cut.
   b. North of the slip zone

3. GW drainage trench connecting components 1 and 2a above (March 2010 modification).
4. Pipe system connecting the southern end of the 2a to Widemere East basin.
5. The rock for the GW drainage trench at the toe of the western batters and south of the slip zone has been blasted only.

4.3 Groundwater observations

4.3.1 Piezometers

GHD Drawing 21-15443-GW-0700 in Appendix B presents the proposed locations of piezometers to be installed within the SEL. Piezometer 7 (Type 1) was lost as a result of Dexus development; piezometers 3, 4, 5 and 6 have not been installed, piezometer 2 (Type 2) could not be located.

Type 1 piezometers refer to piezometers installed in the GW trench; Type 2 refers to piezometers installed in the landform some distance from the GW trench.

Table 4.1 below provides details of the piezometers and water levels measured in piezometers in 1, 2, 8 and 9 in February 2014 and September 2014.

TABLE 4.1
SUMMARY OF GROUND WATER LEVELS

PIEZOMETER	TYPE	DATE	MEASURED DEPTH FROM PIEZOMETER TOP (m)	COLLAR RL (m)	GROUND-WATER RL (m)	COMMENT
1	1	21/02/2014	No ground water recorded	61.03	Below 56	GW located below base of GW trench.
		25/09/2014				
	2	21/02/2014		60.99	Below 55.9	
		25/09/2014				
2	1	21/02/2014		55.67	Below 50.6	
		25/09/2014				
8	1	21/02/2014		61.23	Below 57.3	
		25/09/2014				
9	1	21/02/2014	2.55	56.97	N.A.	Requires further assessment as not consistent with other site observations. Possibly associated with surface inflow.
		25/09/2014	3.25			

The above readings indicate that:

- At least the northern portion of the eastern GW trench are above the GW levels on site.
- GW levels are well below the existing surface level where this corresponds to the FSL.
- Water level measured at 9 is considered to be associated with surface inflow and does not represent GW level.

4.3.2 Aquifer level and pumping

The aquifer level was measured in August 2014 at approximately RL49 m. We understand from Boral that no pumping from the aquifer has occurred since 2011 and the levels have remained essentially unchanged in that time.

4.3.3 Lake levels

We have reviewed the aerial photographs of the SEL between 2009 and 2014. A selection of the photographs reviewed are presented in Appendix C.

We have assessed on the basis of the photographs and the 2011 survey, the water level in the lakes located on the western side of the SEL. Table 4.2 summarises the assessed lake RL and the rainfall in the three month, two month and one month period prior to the photograph as taken from the BOM weather station at Prospect Reservoir.

TABLE 4.2
LAKE LEVELS AND ANTECEDENT RAINFALL

PHOTOGRAPH	APPROXIMATE LAKE RL	ANTECEDENT RAINFALL (mm)		
		3 MONTHS	2 MONTHS	1 MONTH
Sep-11	51.5	176.5	91.3	57.7
Feb-12	52.5	410.1	258.3	140.6
Nov-12	51	62.1	56.5	35.5
Feb-14	51.5	232.3	53.2	20.9

The water level in the lake varied between RL51 m and RL52.5 m. The variation in lake level is related to the antecedent rainfall; this indicates to us that a significant portion of the water in the lake is associated with surface runoff and not groundwater inflows.

Furthermore, the surface geometry of the western portion of the SEL is such that any surface flow from rainfall precipitating in this area, including the batters would report to this lake.

4.3.4 GW observations during recent AWJ earthworks

The northern extent of the lake in Quarrywest has been dewatered as part of the earthworks completed by AWJ in September-October 2014.

A temporary embankment was constructed dividing the north area of the lake from the south area and dewatering undertaken by pumping water from the northern portion to the southern portion.
Lowering of the water was achieved to RL47.3 m, however upon turning off of pumps, the water was observed to recover quickly to between RL48 m and RL49 m.

We interpret this as being an indication of the likely groundwater level at the site, possibly still partially affected by the water levels in the southern half of the lake.

4.3.5 GW trench flows

Boral has indicate that since 2011 the GW flows from the as built drainage system have been fairly uniform. No monitoring of the flows has been undertaken in that time.

On 30 September 2014, PSM measured the flows at the manhole location at the southern end of the western batters of the southern cut, just prior to where the groundwater enters the piped section of the GW system leading to WE basin. The elevation at the base of the manhole is approximately RL41 m. Three pipes delivering water from the GW trench into the manhole are located some 200 mm above the base of the channel.

The flows were estimated by measuring:

1. The depth of water in the channel at the base of the manhole.
2. The cross sectional geometry of the channel.
3. The flow velocity at various locations in the channel using a flow velocity meter.

The estimate flow rates are in the order of 5 l/s. If assumed to be steady over a full day, this flow results in a daily inflow into the GW drainage system of approximately 400 m^3/day.

4.4 Rainfall between 2011 and 2014

We have retrieved the information regarding rainfall at the Prospect Reservoir between 2010 and 2014. The monthly rainfall for this period and the mean and median monthly rainfall (record of 128 yrs) are plotted in Figure 2.

5 PROPOSED FINAL CONDITION

5.1 Finished surface level

The proposed finished surface level at the site is shown on Costin Roe Consulting drawing no. CO10529.21-C40 “Quarrywest – Reconciliation Drive – Civil Works Masterplan”, dated 11/08/2014 Rev 1. This drawing is included in Appendix A.

5.2 Land use

The proposed land use is industrial/commercial similar to the eastern precinct of the SEL.

5.3 Proposed GW drainage system

We propose to maintain the existing as built GW drainage system as shown on Figure 1 and discussed in Section 4.2 of this report and have assessed its expected future performance.

6 QUALITATIVE ASSESSMENT OF FUTURE CONDITION

6.1 General

We have completed a qualitative assessment of the likely future GW levels at the SEL relative to the proposed FSL on the basis of:

1. The GW conditions assessed to have been present between 2011 and 2014 as summarised in Section 6.2.
2. The effect of the proposed development as discussed in Section 6.3.
3. The effect of variations in the rainfall as discussed in Section 6.4.
4. The existing as built GW drainage system as presented in Section 5.3.

6.2 Conceptual model of current GW conditions

Based on the conditions and observations discussed in Section 4 of this report we consider that a reasonable conceptual model of the current GW conditions on site over the last four (4) years is as follows:

1. Regional GW controls are provided by:
    a. Prospect Reservoir to the west providing a constant source of water.
    b. Prospect Creek to the south providing a natural sink for the GW.
    c. GW recharge from rainfall.

2. Locally within the SEL:

   a. The lakes in the western portion of the SEL are a source of GW and together with the undeveloped areas of the SEL provide an increased source of recharge to the GW compared to the developed portions of the site.

   b. The GW level at the location of the aquifer and lakes in the western portion of the SEL is located at between RL48 m and RL50 m.

   c. Where the invert of the eastern drainage trench is above this level the trench is running dry. The flow measured in the drainage trench is likely to be associated with inflow occurring at the southern extent of the GW drainage system where this is located below RL50 m and is currently influenced by the presence of the lakes in the western portion of the SEL.

6.3 Effect of the proposed development

The proposed final land use for Quarrywest is industrial. This combined with the proposed FSL and surface drainage system will result in a significant reduction to the rainfall reaching permeable surfaces and thus recharge from rainfall to the GW.

Industrial developments typically result in a reduction in permeable area in the order of T 80% to 90%.

Furthermore, the proposed FSL will remove the existing lakes. As stated previously, currently and in the last four years, all the surface runoff from the western portion of the SEL has been reporting to these lakes. From these lakes the surface water has a uninterrupted path to the GW. Removal of the lakes will thus significantly reduce the ability of the surface water to recharge the GW.

The proposed FSL will result in the GW being located deeper within the ground profile thus reducing the losses to evapo-transpiration. This is considered a second order effect.

6.4 Variation in rainfall

Figure 2 presents the rainfall between 2011 and 2014 and compares it to the mean, median and 90% rainfall data from the 128 year record from Prospect Reservoir weather station.

From this data we consider that the rainfall experienced on site between 2011 to 2014 represent typical (mean and median) rainfall conditions for the site. The variability in rainfall conditions is such that in 95% of years the rainfall will be less than 50% greater than these typical conditions.

With respect to the effect of the variability on the GW levels on site, we consider that multiple consecutive wet years would result in increased recharge to the GW and potential rising effect on the GW levels.

We have completed sensitivity analyses as part of the modelling presented in Section 8 of this report to quantify this effect.

6.5 Conclusion

On the above basis, with regards to the likely future GW levels at the SEL relative to the proposed FSL we consider that:

1. Over the last four years the GW levels on site have been located between RL48 m and RL50m AHD. These levels are more than 6 m below the FSL within the developable portion of the SEL and more than 3 m below the FSL within the swale.
2. The effect of the proposed development would be to significantly reduce the recharge of the GW on site (by up to 80%). This would in turn result in a lowering of the GW levels.
3. The effect of a 95% percentile wet year would be to increase the available water by up to 50%, the effect on recharge may not be as significant.
4. The combined effect of 2 and 3 above is unlikely to result in GW levels rising significantly higher than current GW levels, and very unlikely to rise to an extent which could result in the GW at or above the FSL within the developable portion of the SEL.
5. The existing as built GW drainage system is sufficient to achieve the aim as stated in Section 2 of this report.

7 REVIEW OF GHD GROUNDWATER ASSESSMENT

7.1 Objective of GHD work

In order to check the effectiveness of its proposed GW drainage system design, in 2007 GHD completed a hydrogeological review of the site and developed a numerical groundwater model for the site.

The hydrogeological review and groundwater modelling is presented in the GHD report titled *"Boral Recycling Pty Ltd - Report for Greystanes Estate - SEL Subdivision - Groundwater Modelling"* dated July 2007. This report is referred to herein as the **GHD GW Modelling Report.**

We note that, much of the information relied upon by GHD to develop their model is not available. Further, the GHD Modflow model was not provided to Boral or AWJ; and the GHD GW Modelling Report does not provide all the inputs to the GHD model.

The stated objectives of the GHD work were to:

1. Predict the impact of the proposed final landform on the groundwater system.
2. Design appropriate groundwater drainage system for the site, so that the water table was maintained at least 2.5 m below the ground level within the site.

7.2 Hydrogeological review

The hydrogeological review compiled a list of published maps and hydrogeological information for the site. This data, in conjunction with borehole data from site, was the basis for the development of conceptual and numerical models.

7.3 Numerical modelling – Calibration

The numerical model was developed by GHD based on the data analysis and findings from conceptual modelling. The conceptual model described the main hydrogeological units, as well as main inflows and outflow zones in the system.

In terms of hydrogeological units, five main zones were defined to represent lithologies from the Hawkesbury Sandstone, Wianamatta Shale, Dolerite, Alluvium and landfill (denominated Artificial Aquifer Fill).

The local source of water was rainfall infiltration, which was associated with outcropping lithologies and land use. The Prospect Reservoir was also considered as an inflow zone through seepage into the aquifers. Outflow zones were mostly associated with Prospect Creek and ephemeral creeks surrounding the site.

The model was calibrated by:

1. Adopting:
    a. Site geometry and land uses at the time of the modelling.
    b. Average yearly rainfall of 1000 mm as a steady state condition
    c. Pervious fraction for various land uses as presented in Table 7.2.
2. Varying:
    a. The hydraulic conductivity for the different hydrogeological units
    b. The rainfall fractions reporting to the groundwater.
3. Matching:
    a. The water level measurements from the site at the time of the modelling.

Tables 7.1 and 7.2 summarise the calibrated hydraulic conductivity parameters which correspond to a recharge value of 3 mm/year for the industrial areas and 20 mm/year for the undeveloped areas (i.e. rainfall fraction of 2%).

TABLE 7.1
CALIBRATED HYDRAULIC CONDUCTIVITIES FROM GHD'S MODEL

UNIT	HYDRAULIC CONDUCTIVITY (m/day)	VERTICAL HYDRAULIC CONDUCTIVITY (m/day)
Landfill	10	1
Dolerite	0.02	0.02
Shale	0.005	0.0005
Sandstone	0.1	0.01

TABLE 7.2
CALIBRATED RECHARGE VALUES FROM GHD MODEL

LAND USE	PERVIOUS FRACTION (%)	RAINFALL FRACTION (%)	FLUX RATE (mm/year)
Industrial	15	2	3
Residential	50	2	10
Undeveloped	100	2	20

It is important to note that the calibration process is unlikely to have resulted in a unique estimate of the set of input variables.

7.4 Numerical modelling – Predictions

Following the model calibration, predictive modelling has been carried out by GHD to assess the suitability of the proposed drainage systems for a range of scenarios.

7.4.1 Calibrated scenario with proposed final landform

The analysis for the final landform modelling involved changes in the calibrated steady-state model to represent the proposed final land form. Changes included:

1. Land use in the site from undeveloped to industrial,
2. Updates in the landfill,
3. Addition of the proposed groundwater drainage system, and
4. Cessation of leakage from the Prospect Hill Surface Storage.

For the calibrated scenario with a flux rate of 3 mm/year over industrial land, the model indicated that no drain inflow would occur i.e. the groundwater level would be positioned below the bottom of the drainage system. The output of this model is included in Appendix D.

The actual GW levels shown in the output are between RL45 m at the southern cut to RL 50 m at the northern end of the SEL. At the location of the current lakes in Quarrywest the model indicates a GW level of between RL46 m and RL48 m.

7.4.2 Sensitivity analyses

Sensitivity analyses were also undertaken in which the flux rate was varied to allow for rainfall fractions of 1%, 5%, 10% and an extreme case of 25%. The output of these models is included in Appendix D.

We note that we have modelled other developments and our calibrations do not support rainfall fractions of 10% or 25% as in any way resulting in realistic estimates of recharge rate. We assume that GHD have modelled these rainfall fractions as sensitivity analyses.

The results indicated that no drain inflow would occur for the runs with rainfall fraction of 1% and 5%. With regards to the model with rainfall fraction of 5%, the results are similar to the model with rainfall fraction of 2%. The GW levels are well below the proposed FSL.

The sensitivity runs for rainfall fraction of 10%, indicates GW levels between RL49 m at SC and RL60 at the north end and significant mounding of water outside the SEL floor. The GW trenches are shown as intercepting water on both the east and west side and total drain inflows of 59.7 m^3/day are reported. The GW levels are still well below the proposed FSL.

The extreme event equivalent to a rainfall fraction of 25% at steady state indicates significant mounding of water internally and externally of the SEL and does not in our opinion represents a realistic condition.

7.5 Discussion

The GHD model has a number of limitations which both GHD and Coffey (acting as a reviewer, letter titled "*Greystanes Estate SEL Subdivision - Groundwater Modelling Review"* dated 19 July 2007) have identified. These limitations are mostly associated with modelling a complex geological environment with limited ability for calibration of the predictive models.

We are now in the more fortunate position of having observed between 2011 and 2014 the behaviour of the GW and the GHD drainage system within the SEL. As discussed in Section 6.3, we consider that this time is a period of rainfall representative of both average and some extreme months and is useful in re-assessing the results of the GHD model.

On this basis, we have compared the results of the models with rainfall fraction of 2% and 5% with the conditions that have existed in the SEL over the last 4 years. We note:

1. GW levels in the SEL are well below the FSL on the eastern side, but are assessed as being between RL48 m and RL50 m where observed at the location of the lakes in Quarrywest and at the aquifer. These observations are consistent with the GHD models.
2. The eastern drain is essentially dry. This observation is consistent with the GHD models.
3. There are however inflows into the drain, as has been measured and reported in Section 4.3.5 of this report.
4. We consider that these inflows are likely to be associated with the southern portion of the drainage system, where the drain is located below RL49 m and drops down to RL42 m at the southern end of the SC.
5. Whilst the GHD models do not indicate inflow into the drains, the drains that have been modelled do not include the portion through the SC which given the GW levels reported by GHD would intercept GW where the levels are shown to be between RL42 m and RL46 m.

On this basis, we consider that the GHD models which adopt a rainfall fraction of 2% to 5% are useful models of the GW conditions at the SEL, both at present and in the future. That is, these two models can be used as a basis for predicting the ability of the as built GW drainage system to achieve the aim as stated in Section 2 of this report.

7.6 Conclusion

The GHD models which adopt a rainfall fraction of 2% and 5% indicate that the GW levels are well below the FSL and below the invert of the western GW trench, i.e. the portions of the GW trench which has not been constructed is not necessary to maintain the GW levels below the FSL.

On this basis, we consider that these models indicate that the as built GW drainage system is sufficient to achieve the aim as stated in Section 2 of this report.

8 PSM GW ANALYSIS

8.1 Aim

In Section 6 we presented a qualitative assessment of the effect of the proposed development on the GW conditions at the SEL. It concluded that the proposed development is unlikely to result in significantly higher water levels than current.

In Section 7 we presented the GHD modelling, which within the discussed limitations, in our opinion provides a reasonable model of the long term GW conditions at the SEL.

In this section, we present additional GW modelling undertaken by PSM to complement the GHD modelling and assess whether the current as built GW drainage system achieves the aim stated in Section 2, i.e. controls the maximum groundwater level within the developable area of Quarrywest and the SEL to be below the finished surface level at the site.

8.2 Approach

The approach we have adopted for the analysis is as follows:

1. Our starting point has been the GHD GW modelling.
2. Within its limitations, the modelling has been accepted as the basis for the current GW system design. Given the complexity of the model, and rather than developing a new model, we have initially attempted to replicate the GHD modelling.
3. We have thus replicated the GHD modelling results by, adopting as much of the GHD data as possible and modifying some of the parameters.
4. We have then modified the model to account for:
    a. The revised landform levels.
    b. The as built geometry of the GW drainage system.
    c. The observed GW conditions on site.

5. We have run the model for rainfall fractions of 2% and 5% and mean annual rainfall (taken as 1000 mm) as well as the wettest year on record (2000 mm) and assessed the ability of the as built geometry GW drainage system to maintain the GW level below the surface level of the developable area of the SEL:

8.3 Modelling tool

The analyses and modelling of the groundwater drainage system were undertaken using FEFLOW (DHI-WASY, 2014). FEFLOW was selected to perform the analysis due to its wide use in the groundwater industry, ability to handle three-dimensional groundwater flow and relative fast implementation and computation times.

The analyses were run in steady-state (equilibrium) mode.

8.4 Model details

8.4.1 General

Model details and results are presented in a series of figures in Appendix E of this report.

8.4.2 Geometry, units and zones

The model extent was defined to replicate GHD's model domain. The finite element formulation of FEFLOW makes use of prismatic triangular elements to discretise the model domain. A total of 214708 model elements was used. These elements were evenly distributed in 4 layers to accommodate the geometries of the different hydrogeologic units of the area.

Figure E1 in Appendix E displays the model domain and discretisation.

Four parameter zones were defined to represent the hydrogeologic properties of the different units, namely Landfill, Dolerite, Shale and Sandstone. The parameter zones are shown in plan in Figure E2, and in a series of sections in Appendix E.

Distribution of recharge zones as per the GHD model were adopted as shown in Figure E3. The pervious fraction adopted for each zone is as per the GHD model and is presented in Table 7.2.

8.4.3 Parameters

Hydraulic conductivities were initially adopted from GHD's model as presented in Table 8.1 and then varied to match the GHD model results for rainfall fractions of 2% and 5%. Table 8.1 below presents both the GHD reported values and the PSM adopted values of conductivity.

The conductivity for the dolerite unit has been changed to better match the both the GHD modelling and the actual conditions. This is discussed further in the results section of this report. We note that the conductivity adopted is well within the range of conductivities reported in testing by GHD.

TABLE 8.1
HYDRAULIC CONDUCTIVITIES IN GHD AND PSM MODEL

UNIT	HYDRAULIC CONDUCTIVITY (m/day)		VERTICAL HYDRAULIC CONDUCTIVITY (m/day)	
	GHD	PSM	GHD	PSM
Landfill	10		1	
Dolerite	0.02	0.2	0.02	0.2
Shale	0.005		0.0005	
Sandstone	0.1		0.01	

8.4.4 Boundary conditions and flux zones

Boundary conditions were assigned to represent the surface water features (surface drainage and reservoir), rainfall infiltration and the GW drainage system. In summary, the following conditions were adopted:

1. Prospect Reservoir was defined with constant head boundaries with a value of RL60 m, which equates to the typical reservoir levels.
2. Surface drainage was also defined using constant head boundaries. The elevation values for the surface drainage were based on elevation data from the site (Digital Terrain Model). These were located at Prospect Creek to the south and other low points in the topography to the north and east of the SEL.
3. Infiltration from rain water was defined with flux boundaries. The flux was varied to reflect the different recharge zones and rates.
4. Two GW drainage systems were adopted:
    a. The GHD design GW drainage system.
    b. The as built GW drainage system as shown on Figure 1.
5. The drainage system was modelled using constant head nodes with elevations equivalent to the base of the GW trench (typically located 4.5 metres below the final landform elevation at the swale location, but deeper through the southern cut).

8.5 Runs

Table 8.2 summarises the runs that were modelled and key inputs to these runs.

The flux rate adopted in the above runs are derived by multiplying a nominal annual mean rainfall of 1000 mm (or in case of run 5 a maximum annual rainfall of 2000 mm) by the ratio of pervious area (dependant on land use) and then by the rainfall fraction.

8.6 Modelling results and discussion

8.6.1 GHD replicate runs

The output of PSM Runs 1 and 2 in terms of groundwater levels and drainage inflow rates are presented in Figures E4 to E5 and Table 8.3 below.

We consider that these runs to provide a reasonable replicate of the GHD runs with equivalent rainfall fraction and thus form an appropriate starting point with regards to the PSM modelling.

We note that to replicate the results of the GHD models we have had to increase the permeability of the dolerite unit from that reported in the GHD reports. Even with this change, some difference in the resulting water levels is observed. These differences can be attributed to one or more of the following causes:

1. Geometrical differences in the model.
   a. GHD do not provide enough details to reproduce the exact model geometry. The only available data for the model reconstruction were the two model cross sections presented in the report.
   b. The elevation of the Prospect Creek and ephemeral creeks within the model domain were based on Digital Terrain Model, and could not be compared to those used in the GHD's model.
   c. The PSM model adopted the GHD design drainage system details. These are different from the details modelled in the GHD analysis particularly through the southern cut.
2. The formulation of FEFLOW regarding unconfined conditions is different from MODFLOW (used in GHD's model). This can accommodated if the numerical layer types from MODFLOW are known, however, layer details were not presented In the GHD GW Modelling report
3. GHD's model report mentioned the occurrence of convergence and mass balance issues throughout the modelling exercise.

8.6.2 PSM runs

The output of PSM Runs 3, 4 and 5 in terms of groundwater levels and drainage inflow rates are presented in Figures E6 to E8 and Table 8.2 below.

The modelling results indicate that, for rainfall fractions of 2% and 5% of the mean annual rainfall and 5% of the maximum annual rainfall, the groundwater levels will remain well below the ground surface.

With regards to each of the model we note that:

1. Run 3 (rainfall fraction of 2%, mean annual rainfall of 1000 mm) is considered to best represent the long term conditions at the site.

2. Run 4 (rainfall fraction of 5%, mean annual rainfall of 1000 mm) is assessed to best match the assessed current conditions both in terms of the current groundwater levels on site and the inflows into the drainage system. We note that as discussed in Section 6 the current recharge into the groundwater from the western portion of the SEL is greater than would be expected in the long term. Thus PSM Run 4 with the higher rainfall fraction can be seen as representing current conditions.

3. Run 5 (rainfall fraction of 5%, maximum annual rainfall of 2000 mm) has been analysed to assess the sensitivity of the model to increased recharge into the groundwater from rainfall. It represents unrealistic conditions that are barely credible to eventuate on site. However the existing as built GW drainage system is observed to be sufficient to maintain the GW levels well below the proposed FSL even under these conditions. This confirms the GHD analysis which indicates that the GHD GW system design was engineered to account for all credible and incredible GW conditions that may eventuate on site.

TABLE 8.2
RUNS FROM PSM ANALYSIS

RUN	NAME	RAINFALL FRACTION	DRAINAGE SYSTEM	DRAINAGE INFLOW (m^3/DAY)	MINIMUM DEPTH TO GW BELOW FSL (m)	
					SURFACE DRAINAGE SWALE	DEVELOPABLE AREA
1	GHD replicate	2%	GHD GW Drainage System	87	4.1	6.1
2	GHD replicate	5%		301	4.5	6.5
3	PSM Run	2%	As built GW drainage system	87	4.9	6.9
4	PSM Run	5%		288	2.5	4.5
5	PSM Sensitivity Run (double annual rainfall)	5%		598	0.3	2.5

8.7 Conclusion

The PSM GW modelling completed and presented in this report indicates that the current as built GW drainage system is sufficient to achieve the aim stated in Section 2 of this report.

9 SUMMARY AND DISCUSSION

Section 2 defined the aim of the GW drainage system on site to be *"to control the maximum GW level within the developable area of Quarrywest and the SEL to be below the finished surface level **(FSL)** at the site."*

The as built GW drainage system on site comprises a drainage trench located 4.5 m below the surface and running at the toe of the eastern batters and through the western side of the southern cut. At the southern cut the drainage trench has an elevation between RL47 m (North) and RL 42 m (South).

Currently the system is sufficient to maintain GW levels at the SEL well below the proposed FSL and has been sufficient to do so over a period of four years between 2011 and 2014. In this period the rainfall conditions have been typical of the conditions expected at the SEL in the future.

Monitoring of the GW system indicates that large portions of the as built GW drainage system are not intercepting the GW for the current GW conditions.

The proposed developments in the SEL east and particularly Quarrywest will significantly reduce the ability of the rainfall to recharge the GW. The development will also remove the current concentrated source of water i.e. the lakes in Quarrywest.

On the above basis, we have completed a qualitative assessment of future GW levels at the SEL. This is presented in Section 6. We conclude that the combined effects of future rainfall variations and the proposed development are unlikely to result in GW levels higher than those assessed to have been experienced in the last four years. That is the as built GW drainage system is sufficient to result in the aim as stated in Section 2 of this report.

Section 7 presents our review of the GW modelling completed by GHD as presented in the GHD GW Modelling Report. GHD modelled a number of scenarios by varying the recharge rate into the GW from rainfall.

GHD calibration against available GW data at the time indicated that a rainfall fraction of 2% best captured the observed behaviour. In our review we compared the results of the GHD models with rainfall fractions of 2% and 5% to the GW conditions as assessed for the last four years. Again, these two runs were assessed as best matching the observed conditions.

Both of these runs indicate that the GW levels are maintained well below the FSL without assistance from the western trench of the GHD GW drainage system (i.e. the portion currently not built). On this basis, we consider that the GHD GW modelling also indicates that as built GW drainage system is sufficient to result in the aim as stated in Section 2 of this report.

Finally, we have completed additional 3D numerical modelling of the GW at the SEL to model the as built GW drainage system and examine the effect of variations in annual rainfall on the GW levels within the SEL.

Section 8 presents the results of this PSM analysis. The GHD modelling was used as the starting point of our modelling. The GHD results were replicated within the limits of the available inputs to the GHD data and the differences in modelling techniques. The models were then modified to account for the proposed FSL and the as built GW drainage system. Models were run for rainfall fractions of 2% and 5% and double the annual rainfall as a sensitivity scenario.

The models indicated:

1. Good correlation to the conditions as assessed for the last four years.
2. The GW levels under typical conditions well below the proposed FSL.
3. The GW levels under over 2 m below the proposed FSL within the developable portion of Quarrywest even under unrealistic adverse conditions that are barely credible to eventuate on site.

On this basis, we consider that the PSM GW modelling also indicates that as built GW drainage system is sufficient to result in the aim as stated in Section 2 of this report.

10 CONCLUSION AND RECOMMENDATIONS

The three approaches adopted and discussed above confirmed that the as built GW drainage system is sufficient to control the maximum GW level within the developable area of Quarrywest and the SEL to be below the finished surface level **(FSL)** at the site.

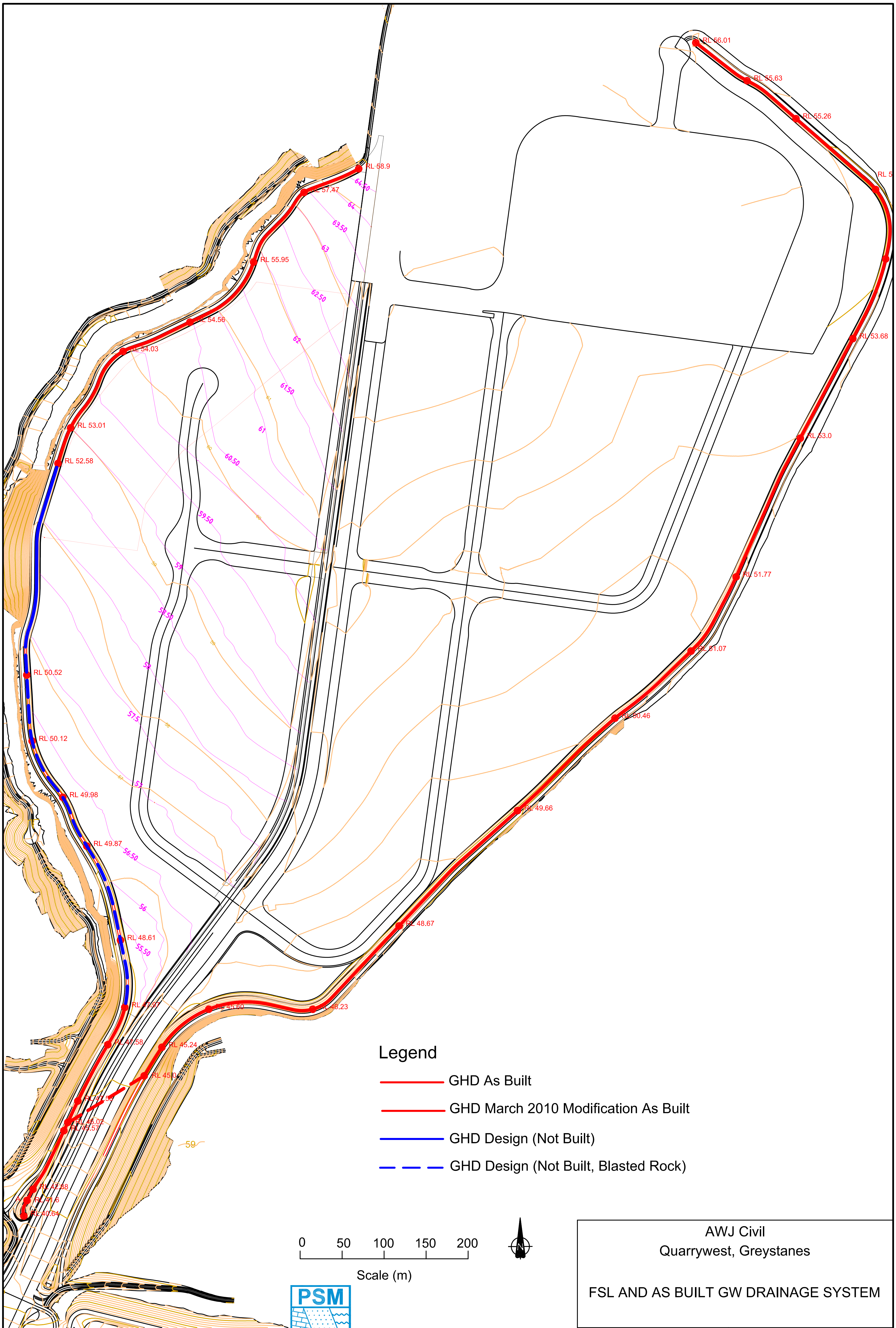
We thus recommend that as built drawing should be prepared to document the as built GW drainage system and no further work be undertaken on the system.

The concrete riser at the aquifer should be terminated with a concrete cap with a durability of 100 years at no higher than 7 m below the FSL. PSM shall provide details regarding filling over the concrete riser.

Please do not hesitate to contact the undersigned should you have any queries.

For and on behalf of
PELLS SULLIVAN MEYNINK

DAVID PICCOLO Principal	GARRY MOSTYN Principal



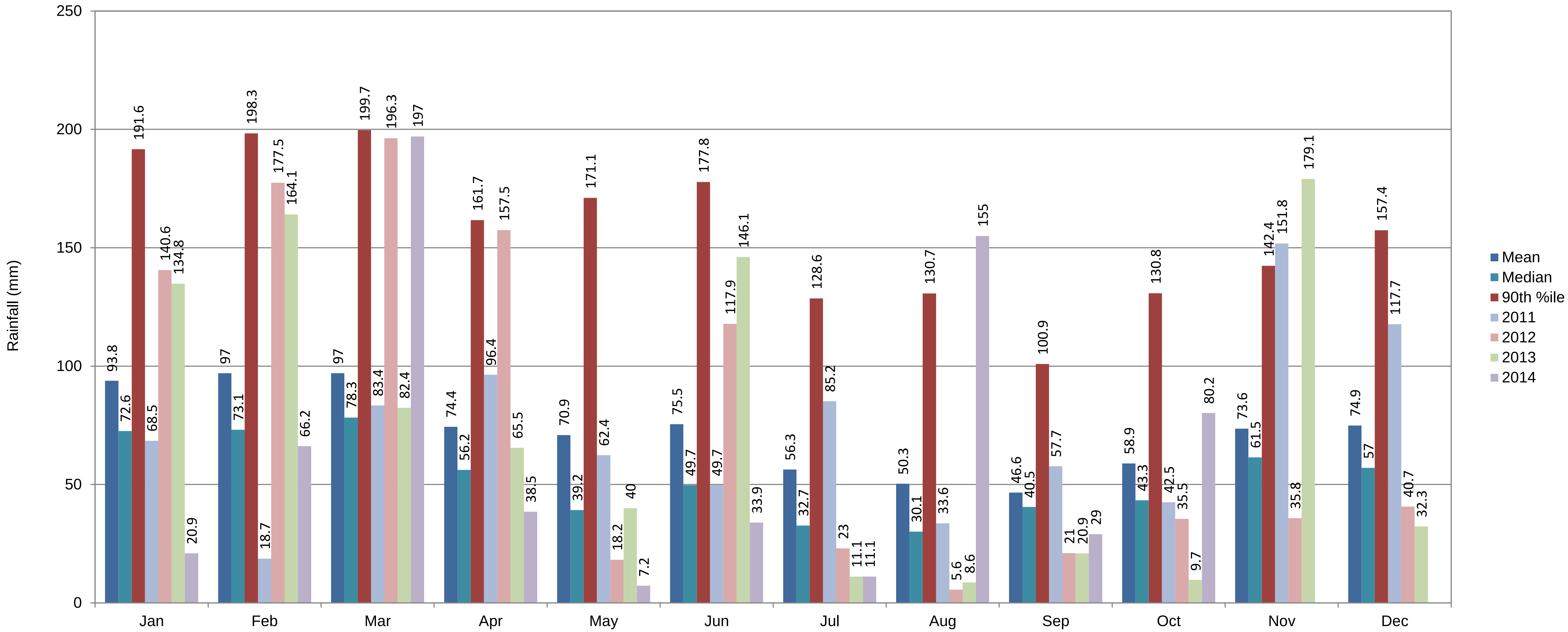
PSM

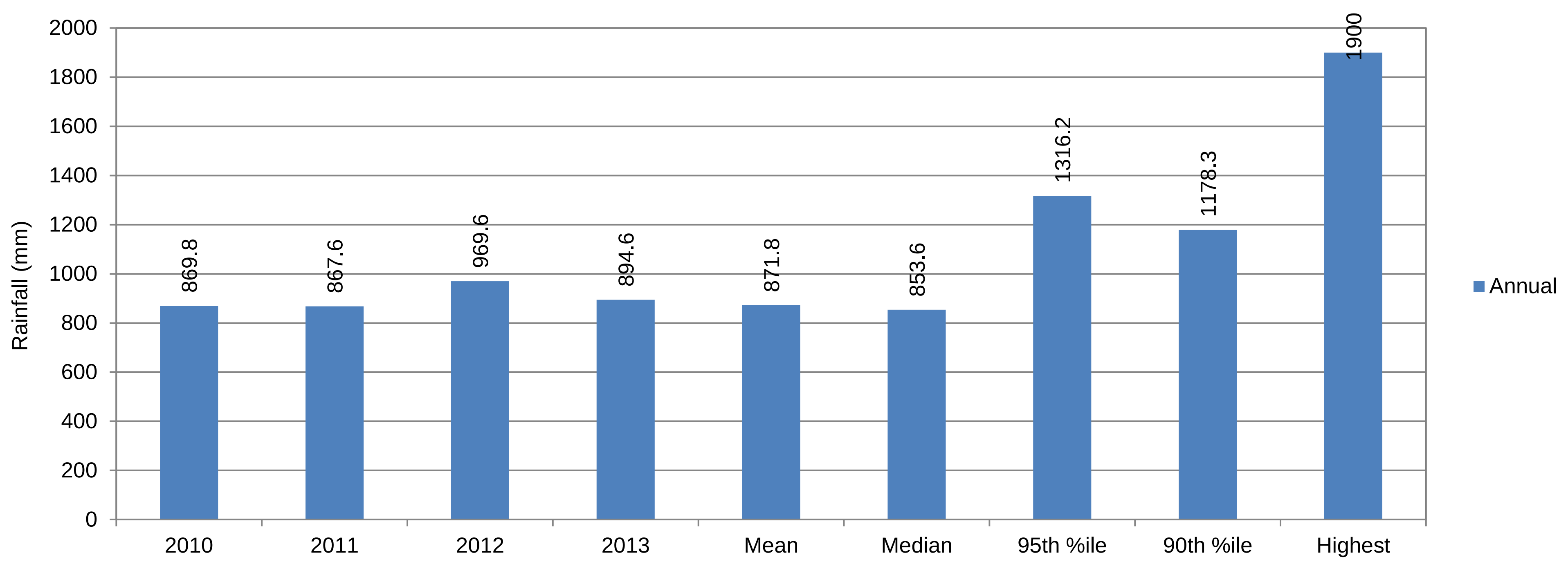
Pells Sullivan Meynink Pty Ltd

AWJ Civil
Quarrywest, Greystanes

FSL AND AS BUILT GW DRAINAGE SYSTEM

PSM963-222R | Figure 1



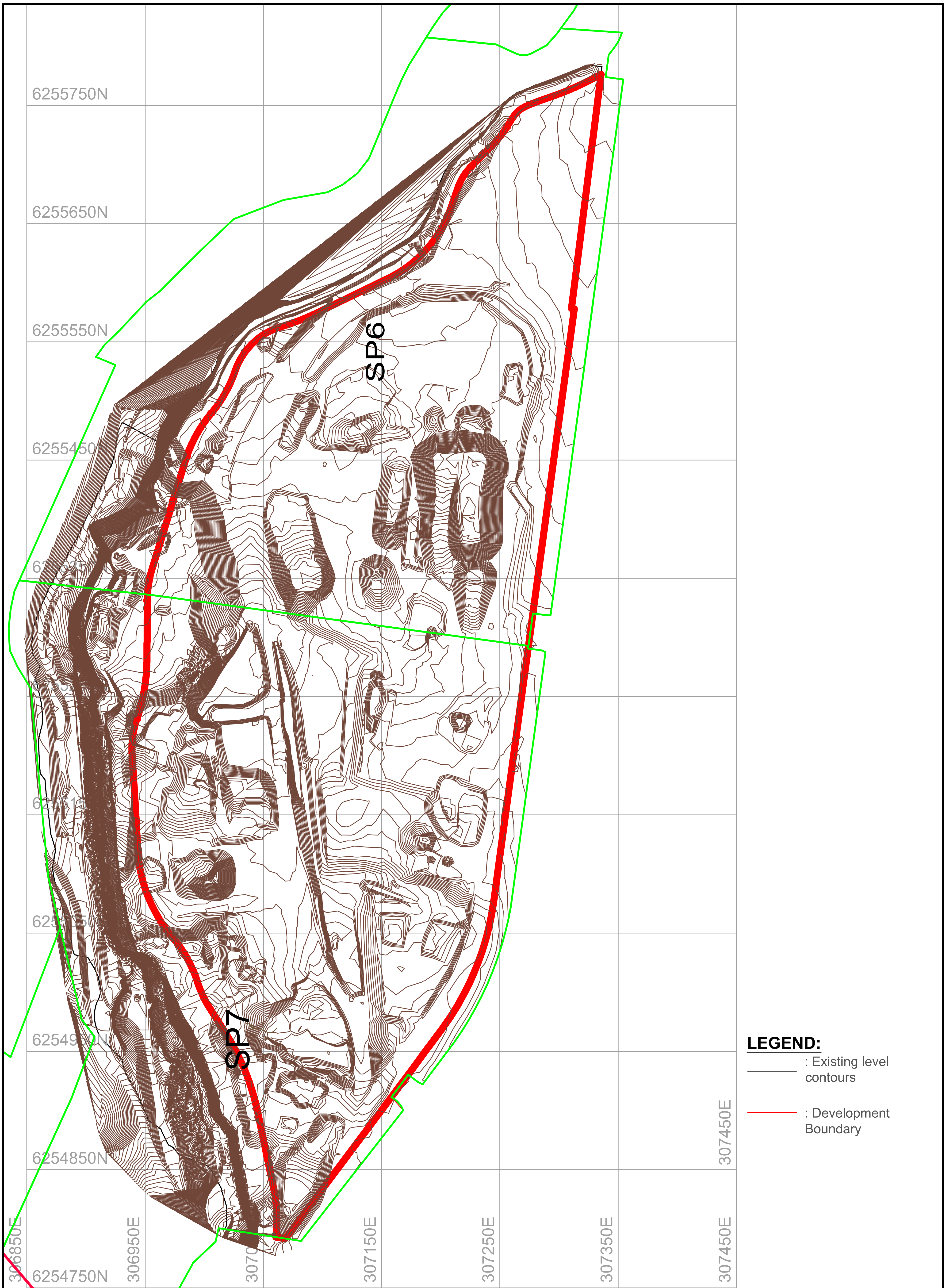


AWJ Civil	
Quarrywest, Greystanes	
PROSPECT RESERVOIR - RAINFALL DATA	
PSM963-222R	Figure 2

Pells Sullivan Meynink

APPENDIX A

REFERENCE DRAWINGS



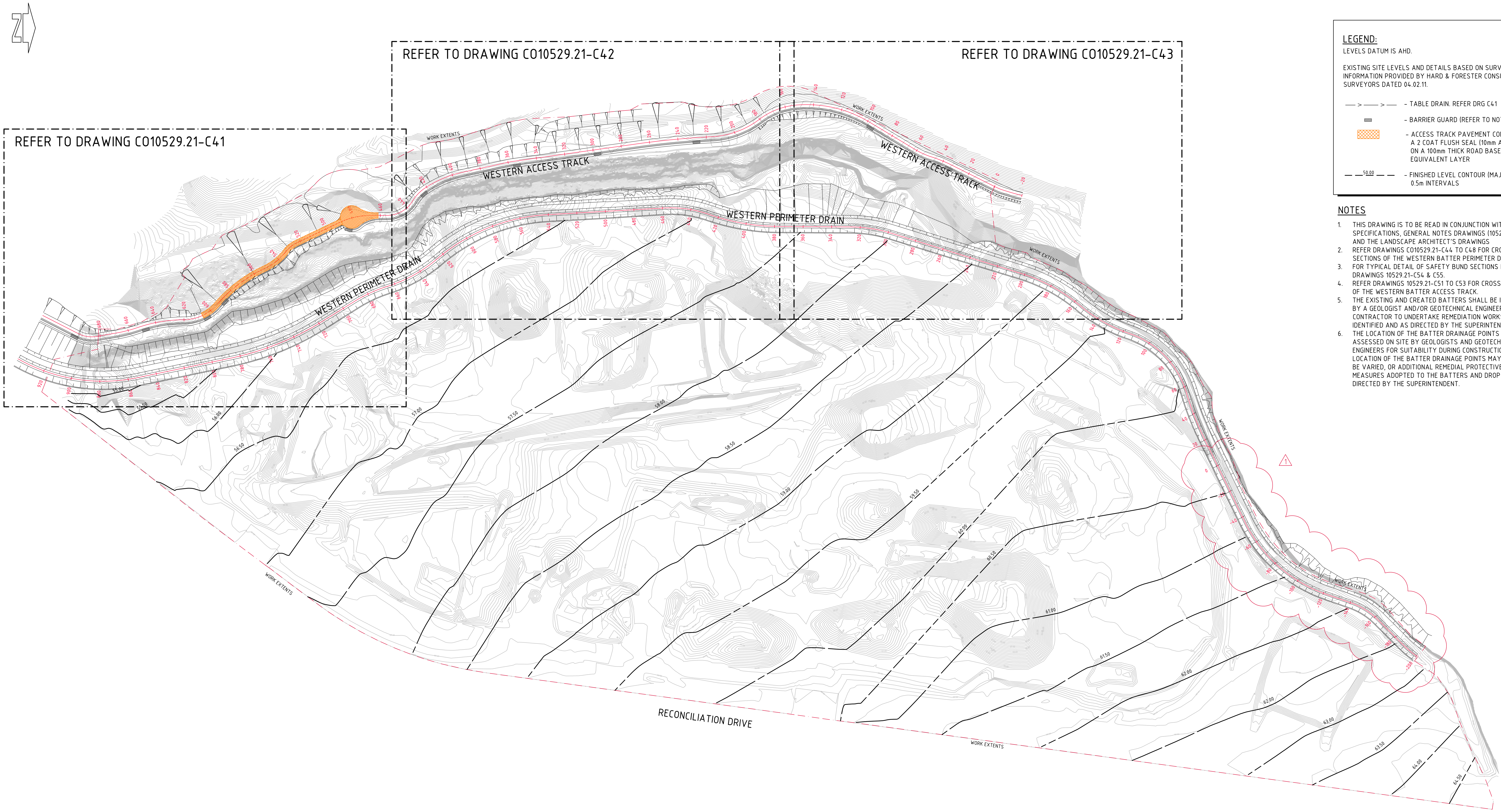
NOTE:
1. Plan is in MGA coordinate system

Pells Sullivan Meynink

AWJ CIVIL

SEL, Greystanes NSW
WESTERN PRECINCT
EXISTING GROUND LEVEL CONTOURS
FEB 2011 SURVEY

PSM963-222R	Figure A1



CIVIL WORKS MASTERPLAN
SCALE 1:1000

LEGEND:

LEVELS DATUM IS AHD.

EXISTING SITE LEVELS AND DETAILS BASED ON SURVEY INFORMATION PROVIDED BY HARD & FORESTER CONSULTING SURVEYORS DATED 04.02.11.

- TABLE DRAIN. REFER DRG C41
- BARRIER GUARD (REFER TO NOTE 6)
- ACCESS TRACK PAVEMENT COMPRISING OF A 2 COAT FLUSH SEAL (10mm AGGREGATE) ON A 100mm THICK ROAD BASE DGB20 OR EQUIVALENT LAYER
- 50.00 FINISHED LEVEL CONTOUR (MAJOR) 0.5m INTERVALS

NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE SPECIFICATIONS, GENERAL NOTES DRAWINGS (10529.21-C10) AND THE LANDSCAPE ARCHITECT'S DRAWINGS
2. REFER DRAWINGS C010529.21-C44 TO C48 FOR CROSS SECTIONS OF THE WESTERN BATTER PERIMETER DRAIN .
3. FOR TYPICAL DETAIL OF SAFETY BUND SECTIONS REFER DRAWINGS 10529.21-C54 & C55.
4. REFER DRAWINGS 10529.21-C51 TO C53 FOR CROSS SECTIONS OF THE WESTERN BATTER ACCESS TRACK.
5. THE EXISTING AND CREATED BATTERS SHALL BE INSPECTED BY A GEOLOGIST AND/OR GEOTECHNICAL ENGINEER. CONTRACTOR TO UNDERTAKE REMEDIATION WORKS AS IDENTIFIED AND AS DIRECTED BY THE SUPERINTENDENT.
6. THE LOCATION OF THE BATTER DRAINAGE POINTS SHALL BE ASSESSED ON SITE BY GEOLOGISTS AND GEOTECHNICAL ENGINEERS FOR SUITABILITY DURING CONSTRUCTION. THE LOCATION OF THE BATTER DRAINAGE POINTS MAY NEED TO BE VARIED, OR ADDITIONAL REMEDIAL PROTECTIVE MEASURES ADOPTED TO THE BATTERS AND DROP POINTS AS DIRECTED BY THE SUPERINTENDENT.

10m 0 10 20 30 40 50 60 70 80 90 100m
SCALE 1:1000 AT A0 SIZE SHEET

FOR CONSTRUCTION

AMENDMENTS	DATE	ISSUE
REVISION AS CLOUDED	11.08.14	1
FOR CONSTRUCTION	29.07.14	0
PRELIMINARY ISSUE	13.06.14	A

CLIENT: AWJ CIVIL

PROJECT: QUARRY WEST
RECONCILIATION DRIVE
PEMULWUY, NSW

DESIGNED	DRAWN	DATE	CHECKED	SIZE	SCALE	CAD REF:
M.W	M.C	10.04.14		A0	AS SHOWN	C010529.21- C40

CONSULT AUSTRALIA

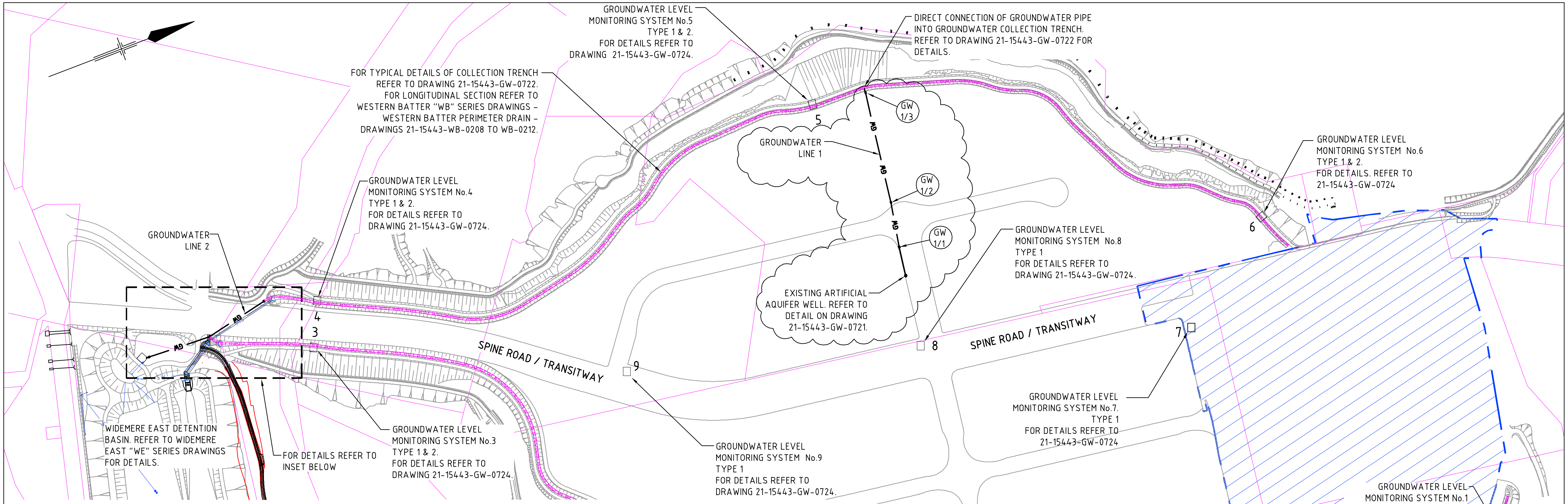
Costin Roe Consulting Pty Ltd.
Consulting Engineers ACN 003 696 446
Level 1, 8 Windmill Street
Walsh Bay, Sydney NSW 2000
Tel: (02) 9251-7699 Fax: (02) 9241-3731
email: mail@costinroe.com.au ©

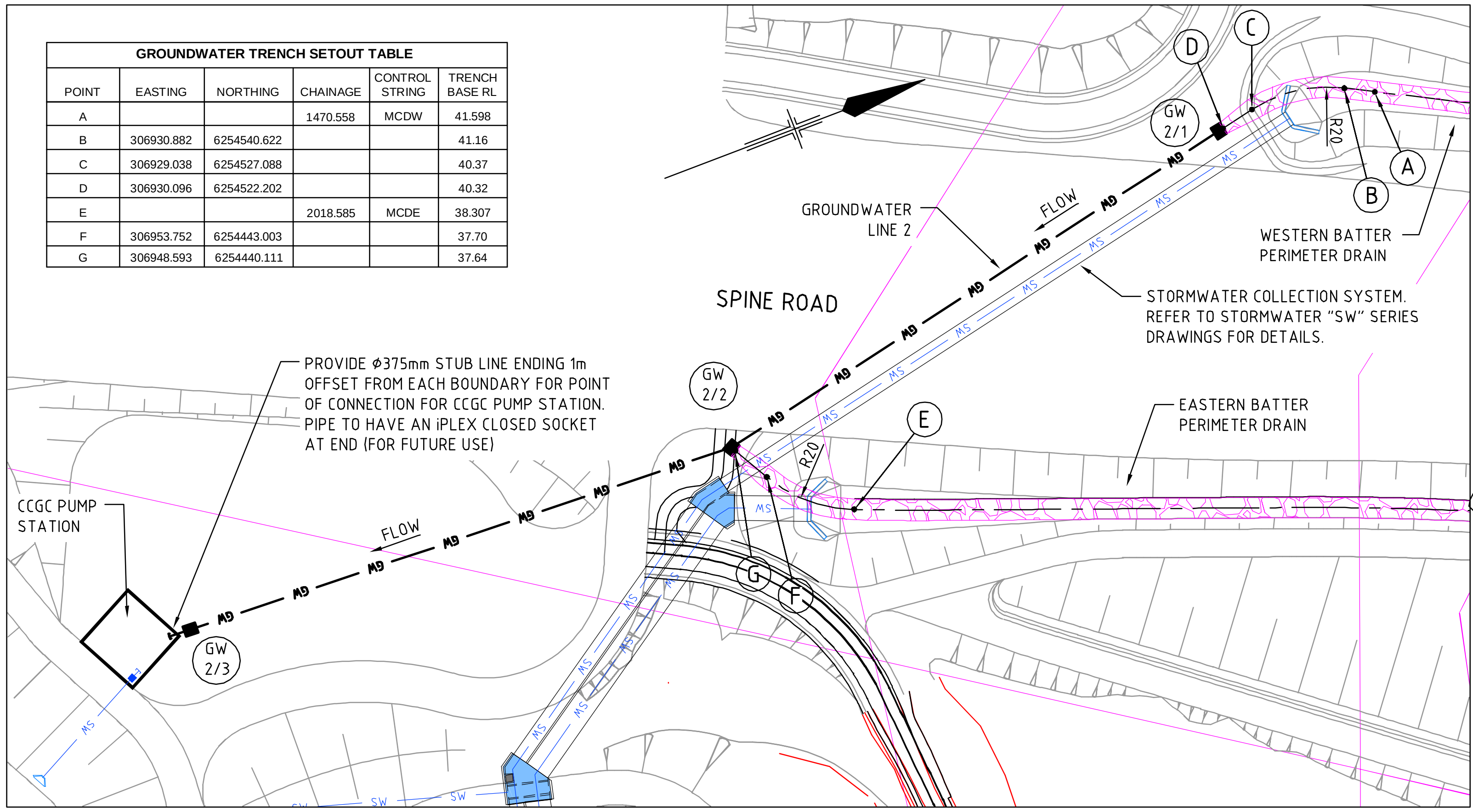
CostinRoe Consulting
Value in Engineering and Management

DRAWING TITLE: CIVIL WORKS MASTERPLAN
DRAWING No: C010529.21-C40
ISSUE: 1

APPENDIX B

GHD GW DRAINAGE SYSTEM





GROUNDWATER TRENCH SETOUT TABLE

POINT	EASTING	NORTHING	CHAINAGE	CONTROL STRING	TRENCH BASE RL
A			1470.558	MCDW	41.598
B	306930.882	6254540.622			41.16
C	306929.038	6254527.088			40.37
D	306930.096	6254522.202			40.32
E			2018.585	MCDE	38.307
F	306953.752	6254443.003			37.70
G	306948.593	6254440.111			37.64

INSET PLAN
SCALE 1:500

GROUNDWATER SETOUT TABLE

MANHOLE/ WELL	EASTING	NORTHING	CHAINAGE	CONTROL STRING
GW1/1	307155.022	6255310.014		
GW1/2	307097.612	6255320.314		
GW1/3	306954.296	6255339.812		
GW2/1	306930.254	6254521.469		
GW2/2	306947.939	6254439.744		
GW2/3	306944.770	6254357.255		
1			43.5	MCDE
2			1059	MCDE
3			1903	MCDE
4			1425	MCDW
5			688	MCDW
6			50	MCDW
7	307385.088	6255624.452		
8	307283.005	6255291.212		
9	307179.934	6254925.445		

LEGEND

- COMPLETED SEPARABLE PORTION 1 WORKS
- GROUNDWATER MANHOLE
- EXISTING ARTIFICIAL AQUIFER
- GROUNDWATER COLLECTION PIPE
- GROUNDWATER COLLECTION TRENCH
- CADASTRAL BOUNDARY
- GROUNDWATER MONITORING WELL.
- STORMWATER PIPE / CULVERT

NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE SPECIFICATIONS.
2. FOR GENERAL NOTES REFER TO DRAWINGS 21-15443-GE-0003 TO GE-0005.
3. FOR GROUNDWATER LONGITUDINAL SECTIONS REFER TO DRAWING 21-15443-GW-0710.
4. FOR DETAILS REFER TO DRAWINGS 21-15443-GW-0720 TO GW-0724.
5. MANHOLE SETOUT POINT TO BE CENTRE OF CHAMBER.
6. MONITORING WELL SETOUT POINT TO BE CENTRE OF CASING.

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
3	GROUNDWATER REDESIGN	JS	FC*	DW*	17.08.11
2	MW CO-ORDINATES AMENDED	MP	FC*	TDI*	06.11.09
1	GROUNDWATER REDESIGN	SA	TDI*	AH*	25.09.08
0	ISSUED FOR CONSTRUCTION	MP	TDI*	AH*	25.01.08

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 5 10 15 20 25m
SCALE 1:500 AT ORIGINAL SIZE

0 25 50 75 100 125m
SCALE 1:2500 AT ORIGINAL SIZE

BORAL

GHD

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Drawn	V.THIAGARAJAH	Designer	J.PERTEL
Drafting Check	T.IRGA*	Design Check	T.IRGA*
Approved (Project Director)	A.HORTON*		
Date	29.01.08		
Scale	1:2500	This Drawing must not be used for Construction unless signed as Approved	

Client **BORAL RECYCLING PTY. LTD.**
Project **GREYSTANES ESTATE SEL**
Title **GROUNDWATER COLLECTION LAYOUT PLAN**

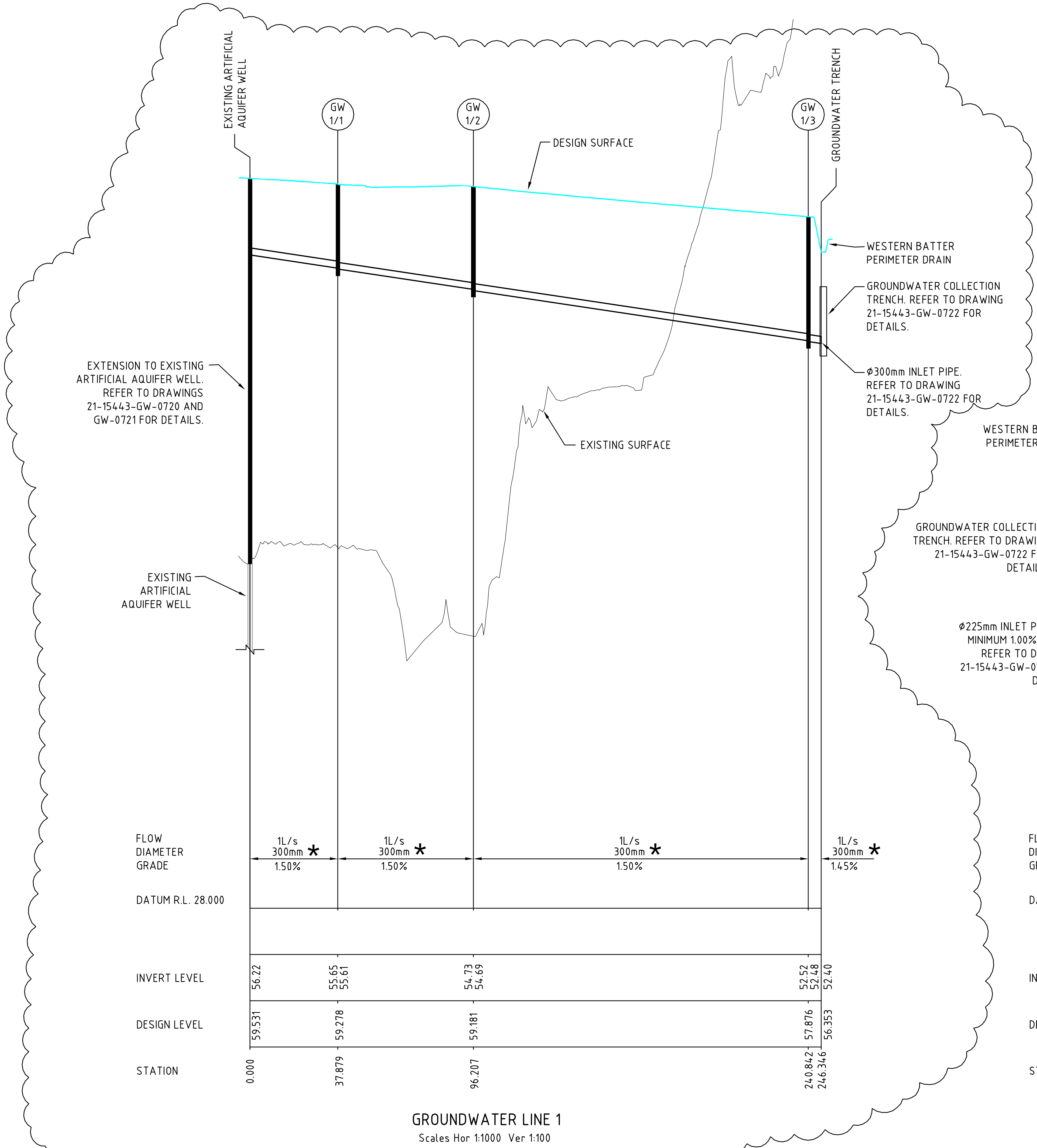
Original Size **A1** **Drawing No: 21-15443-GW-0700** **Rev: 3**

Plot Date: 6 December 2012 - 10:02 AM Plotted by: Steve Atkins Cad File No: G:\21\15443\CADD\Drawings\21-15443-GW-0700.dwg

NOTE

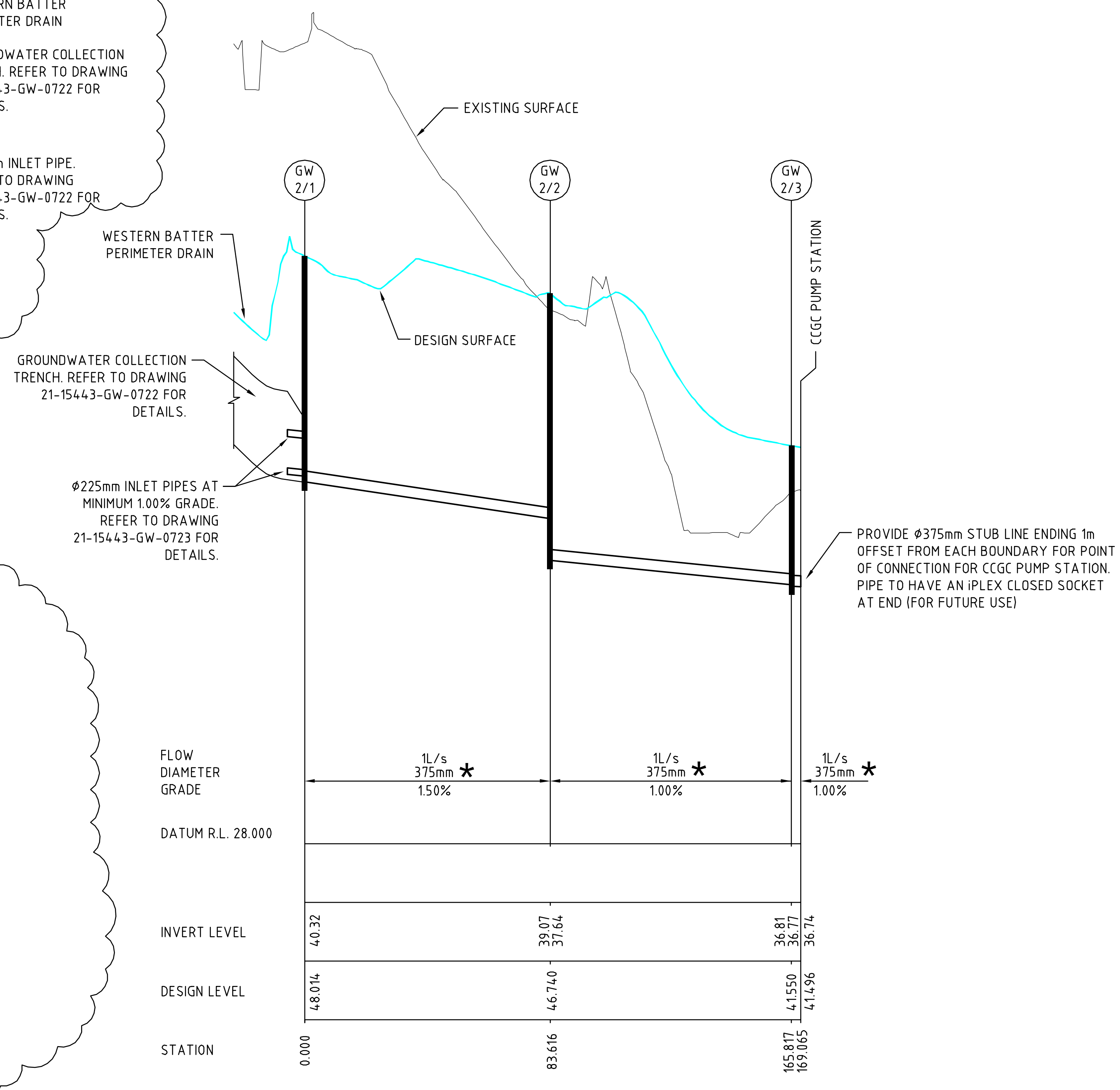
FOR PIT DETAILS REFER TO DRAWING 21-15443-GW-0723

* SPECIFIED PIPE TYPES TO BE iPLEX UPVC "BLACK MAX" OR APPROVED EQUIVALENT.



GROUNDWATER LINE 1

Scales Hor 1:1000 Ver 1:100



GROUNDWATER LINE 2

Scales Hor 1:1000 Ver 1:100

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
2	GROUNDWATER REDESIGN	LS	FC*	DW*	17.08.11
1	GROUNDWATER REDESIGN	SA	TDI*	AH*	25.09.08
0	ISSUED FOR CONSTRUCTION	MP	TDI*	AH*	25.01.08

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 0.5 1.0 1.5 2.0 2.5m VERTICAL
SCALE 1:50 AT ORIGINAL SIZE

0 10 20 30 40 50m HORIZONTAL
SCALE 1:1000 AT ORIGINAL SIZE

BORAL

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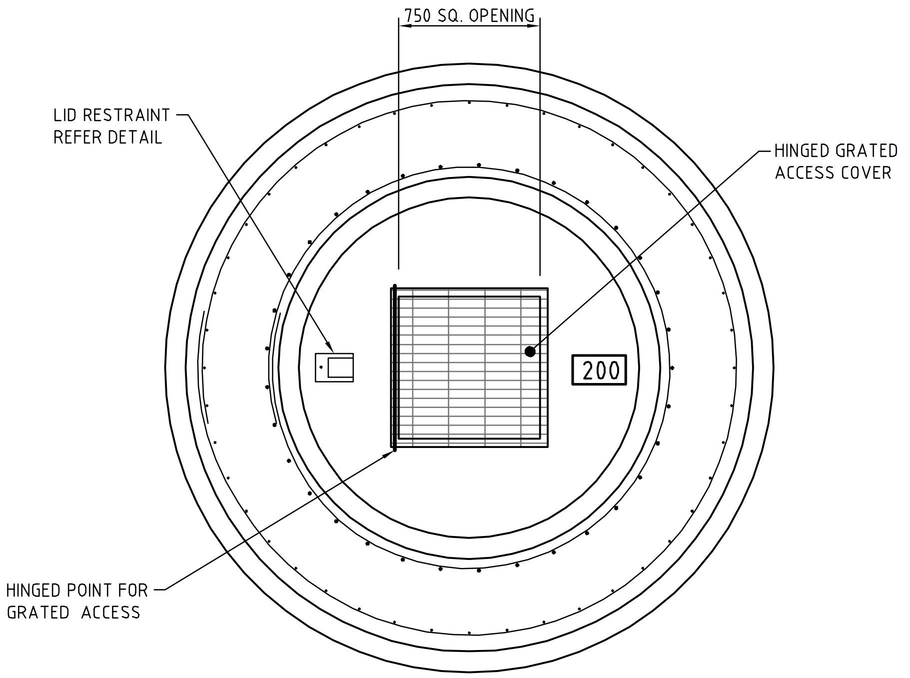
Approved (Project Director)	A.HORTON*		
Date	29.01.08		
Scale	AS SHOWN	This Drawing must not be used for Construction unless signed as Approved	

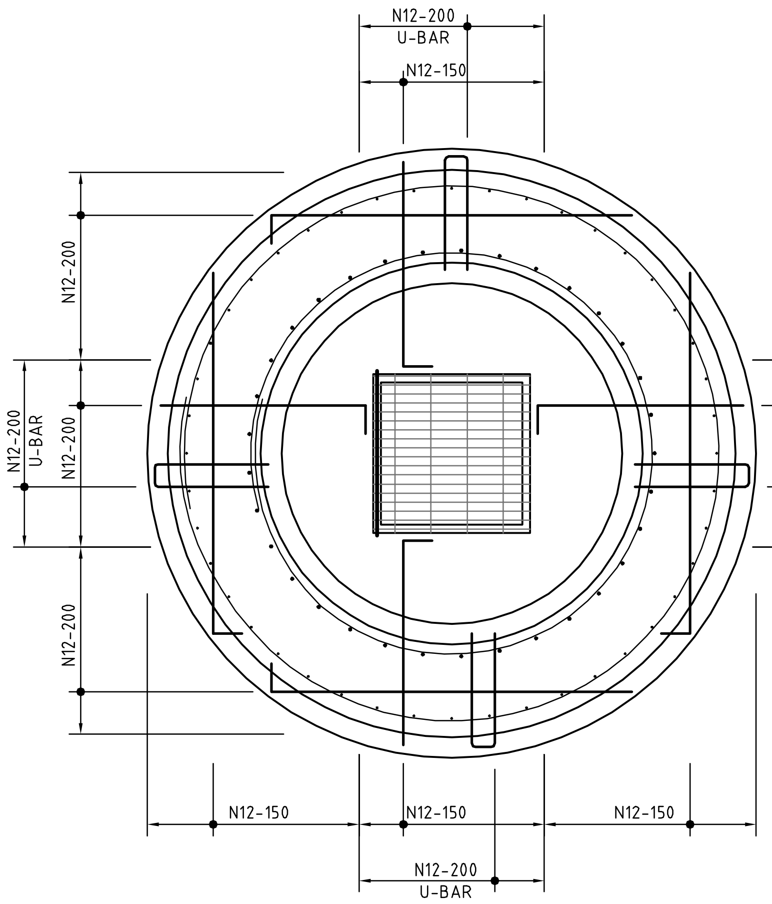
Client **BORAL RECYCLING PTY. LTD.**
Project **GEYSTANES ESTATE SEL**
Title **GROUNDWATER COLLECTION LONGITUDINAL SECTIONS**

Original Size A1 Drawing No: **21-15443-GW-0710** Rev: 2

Plot Date: 6 December 2012 - 10:02 AM Plotted by: Steve Atkins Cad File No: G:\21\15443\CADD\Drawings\21-15443-GW-0710.dwg



LANDING SLAB PLAN
REINFORCEMENT - BOTTOM
SCALE 1 : 20



LANDING SLAB TOP
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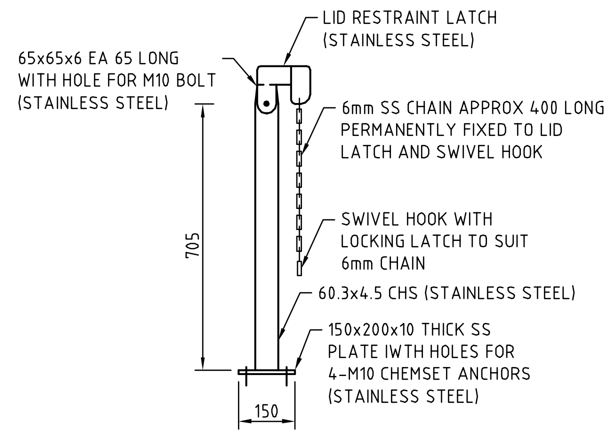
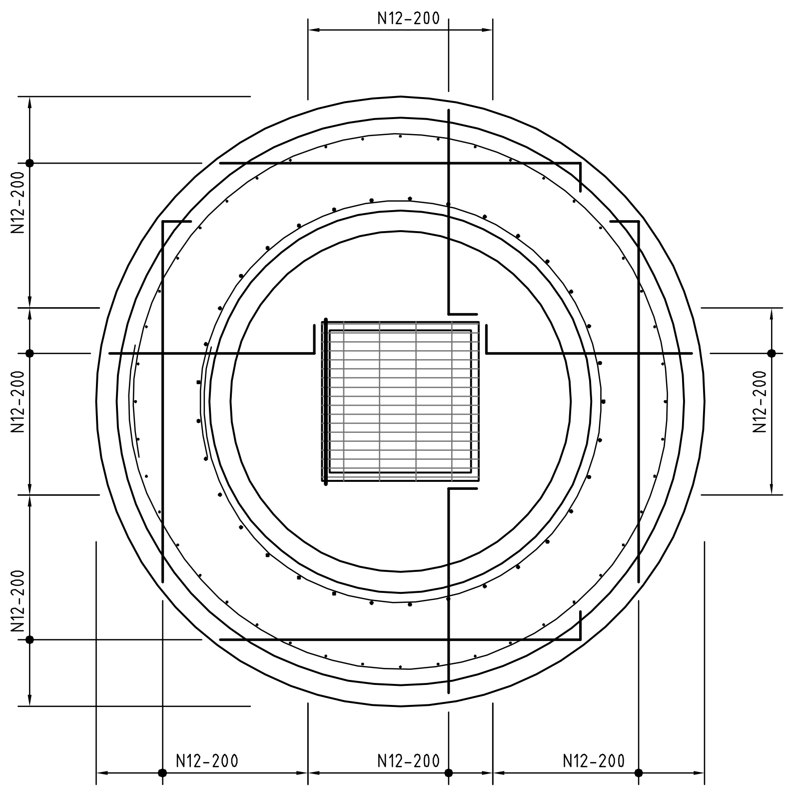
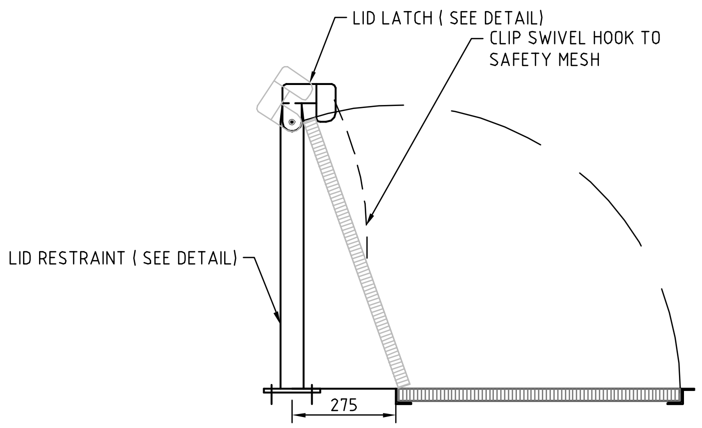


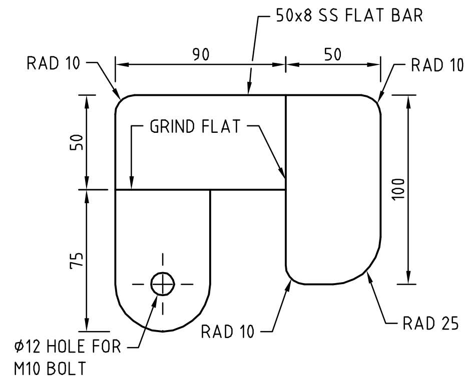
LID RESTRAINT
SCALE 1:10



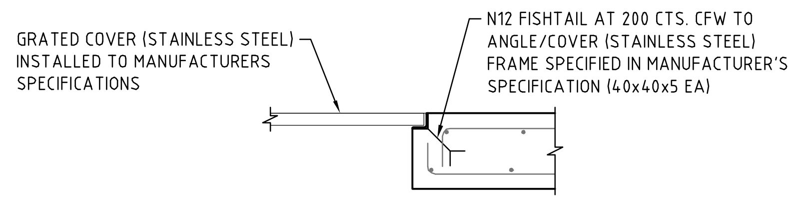
LANDING SLAB PLAN
REINFORCEMENT - BOTTOM
SCALE 1 : 20



GEOMETRY FOR LID RESTRAINT
SCALE 1:10



LID RESTAINT LATCH
SCALE 1:2



1 / - DETAIL
SCALE 1:10

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
1	REVISION CLOUD REMOVED	SA	TDI*	AH*	25.09.08
0	ISSUED FOR CONSTRUCTION	MP	TDI*	AH*	25.01.08

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 100 200 300 400 500mm
SCALE 1:10 AT ORIGINAL SIZE

0 200 400 600 800 1000mm
SCALE 1:20 AT ORIGINAL SIZE

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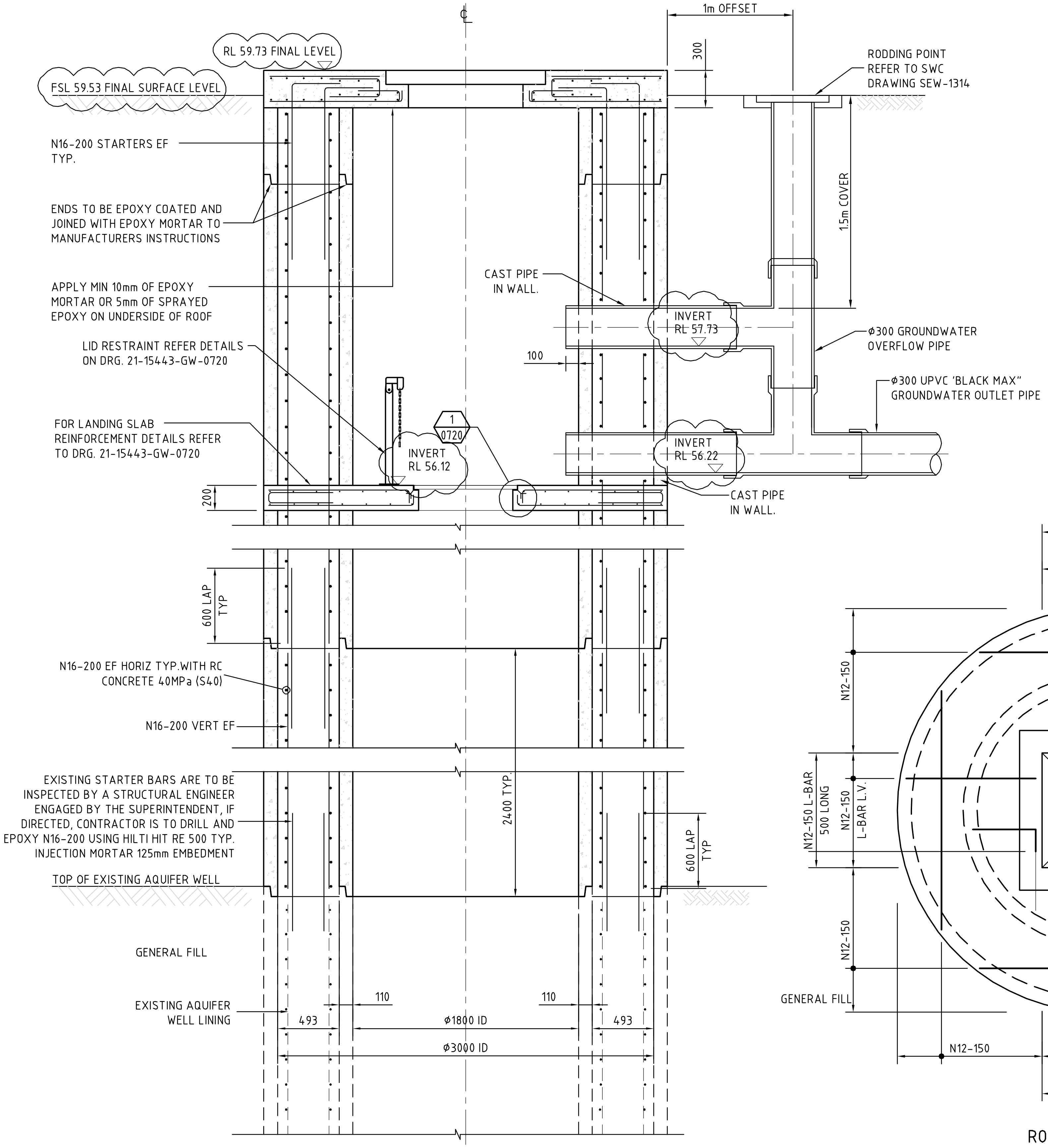
Drafting Check	T.IRGA*	Design Check	T.IRGA*
Approved (Project Director)	A.HORTON*		
Date	29.01.08		
Scale	AS SHOWN	This Drawing must not be used for Construction unless signed as Approved	

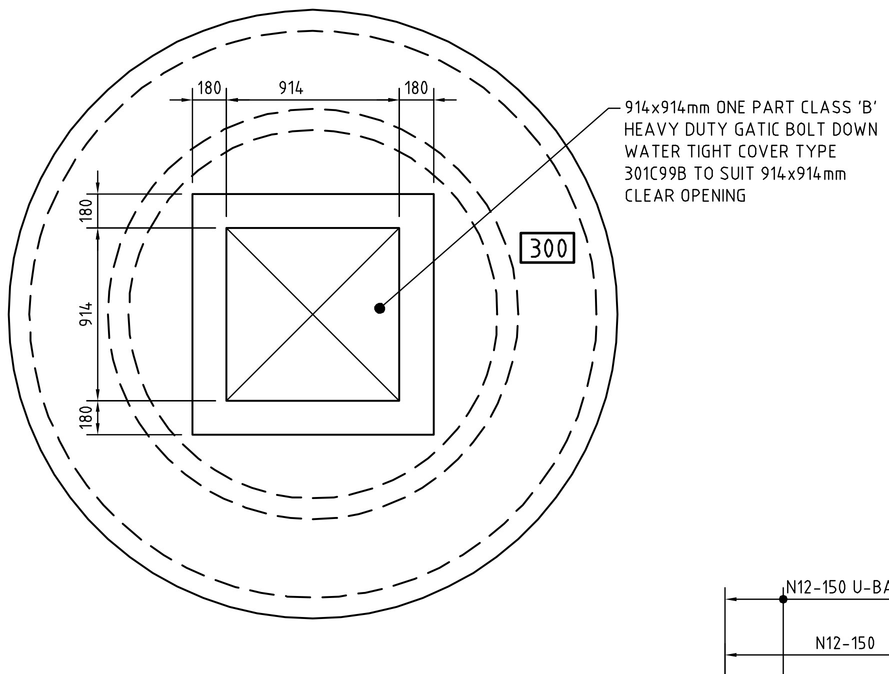
Client **BORAL RECYCLING PTY. LTD.**
Project **GREYSTANES ESTATE SEL**
Title **GROUNDWATER COLLECTION**
AQUIFER WELL DETAILS - SHEET 1 OF 2

Original Size **A1** Drawing No: **21-15443-GW-0720** Rev: **1**

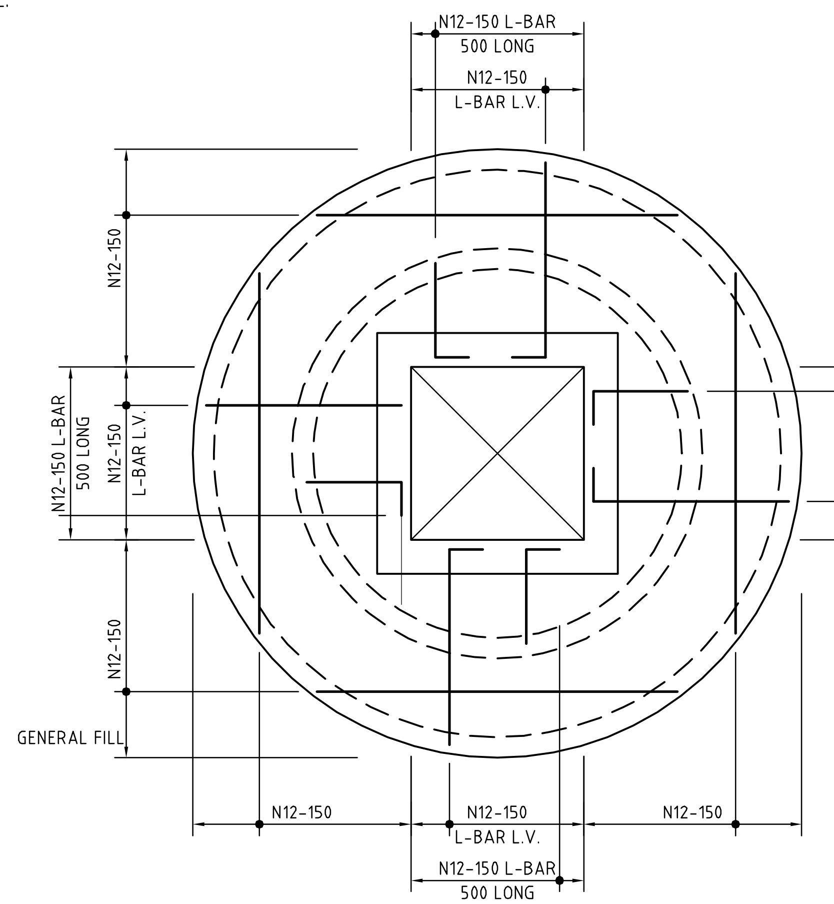
Plot Date: 6 December 2012 - 10:02 AM Plotted by: Steve Atkins Cad File No: G:\21\15443\CADD\Drawings\21-15443-GW-0720.dwg



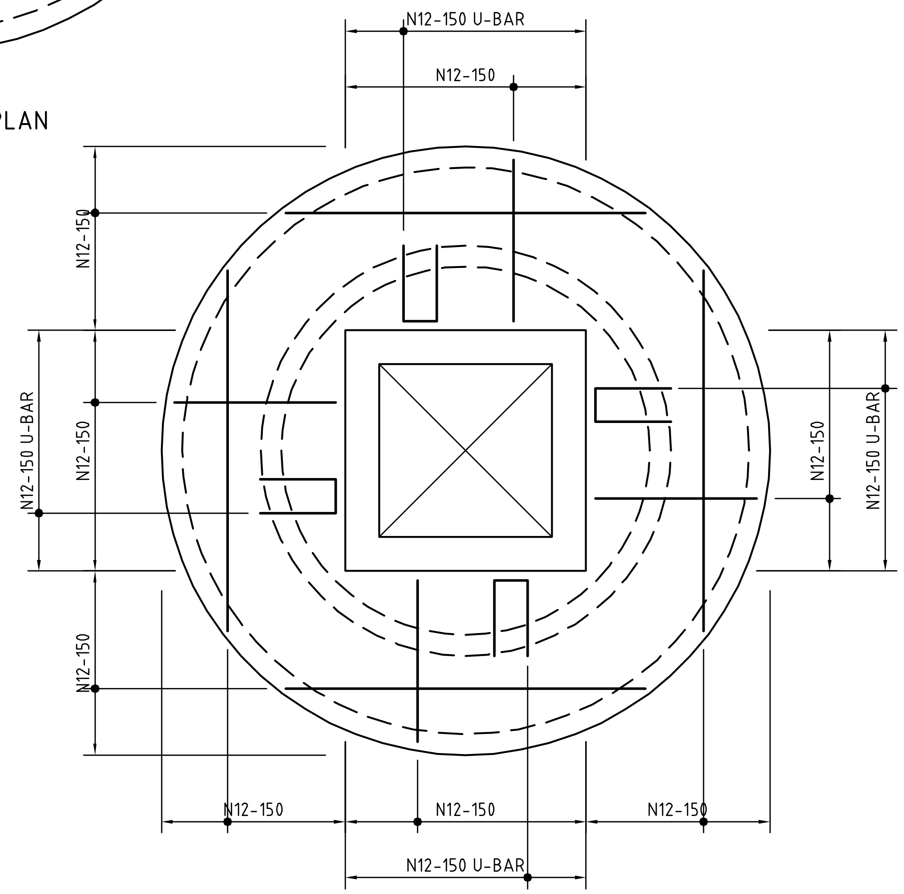
SECTIONAL ELEVATION
AQUIFER WELL
SCALE 1 : 20



ROOF SLAB PLAN
SCALE 1 : 20



ROOF SLAB PLAN
REINFORCEMENT - BOTTOM
SCALE 1 : 20



ROOF SLAB PLAN
REINFORCEMENT - TOP
SCALE 1 : 20

NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE SPECIFICATIONS.
2. FOR GENERAL NOTES REFER DRAWINGS 21-15443-GE-0003 TO 0005.
3. FOR LOCATION OF AQUIFER WELL REFER DRAWING 21-15443-GE-0700
4. CONCRETE COVER = 40mm FOR ROOF
5. CONCRETE COVER = 50mm FOR WALLS
6. CONCRETE f'c 40 MPa
7. IT IS ASSUMED THAT EXISTING PUMP AND ELECTRICAL APPARATUS IS MAINTAINED FOR CONSTRUCTOR USE FOR SITE EARTHWORKS OPERATION. ONCE WORKS ON SITE ARE COMPLETE THE PUMP AND ELECTRICAL APPARATUS ARE TO BE DISASSEMBLED AND REMOVED FROM SITE.

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
2	AQUIFER WELL LEVELS AMENDED	JS	FC*	DW*	10.08.11
1	AQUIFER WELL LEVELS AMENDED	SA	TDI*	AH*	25.09.08
0	ISSUED FOR CONSTRUCTION	MP	TDI*	AH*	25.01.08

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 0.2 0.4 0.6 0.8 1.0m
SCALE 1:20 AT ORIGINAL SIZE

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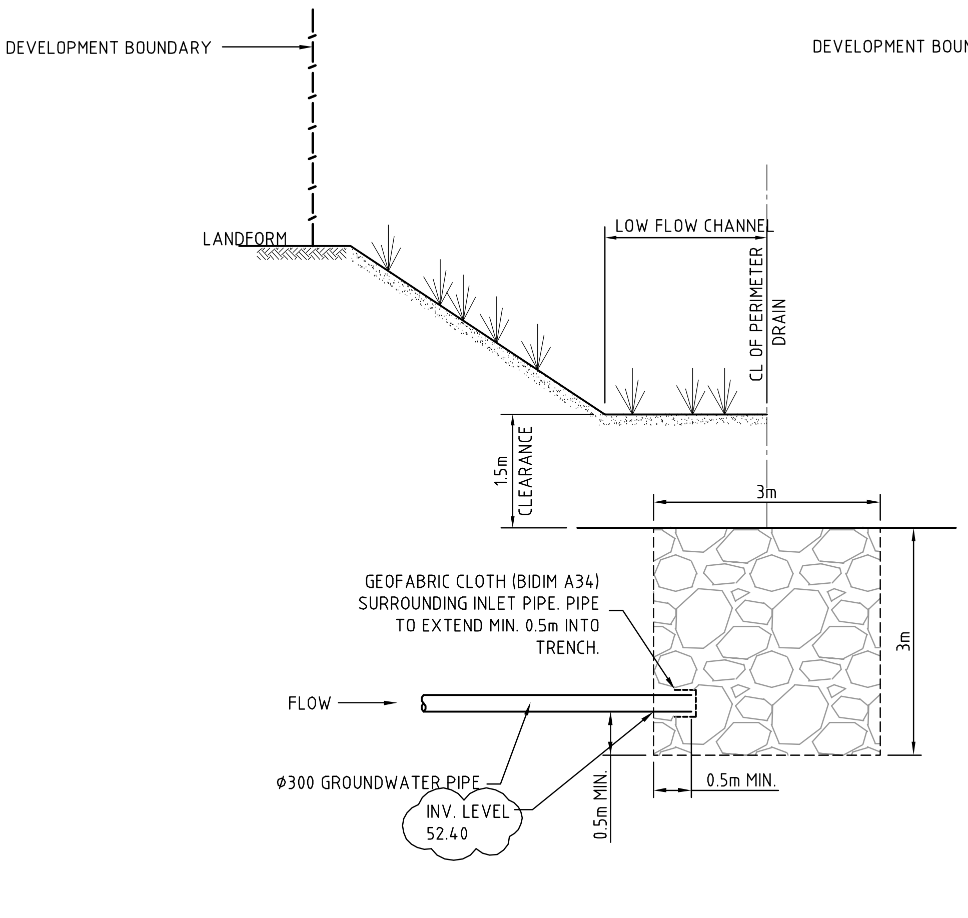
Drafting Check	T.IRGA*	Design Check	T.IRGA*
Approved (Project Director)	A.HORTON*		
Date	29.01.08		
Scale	AS SHOWN	This Drawing must not be used for Construction unless signed as Approved	

Client **BORAL RECYCLING PTY. LTD.**
Project **GREYSTANES ESTATE SEL**
Title **GROUNDWATER COLLECTION**
AQUIFER WELL DETAILS - SHEET 2 OF 2

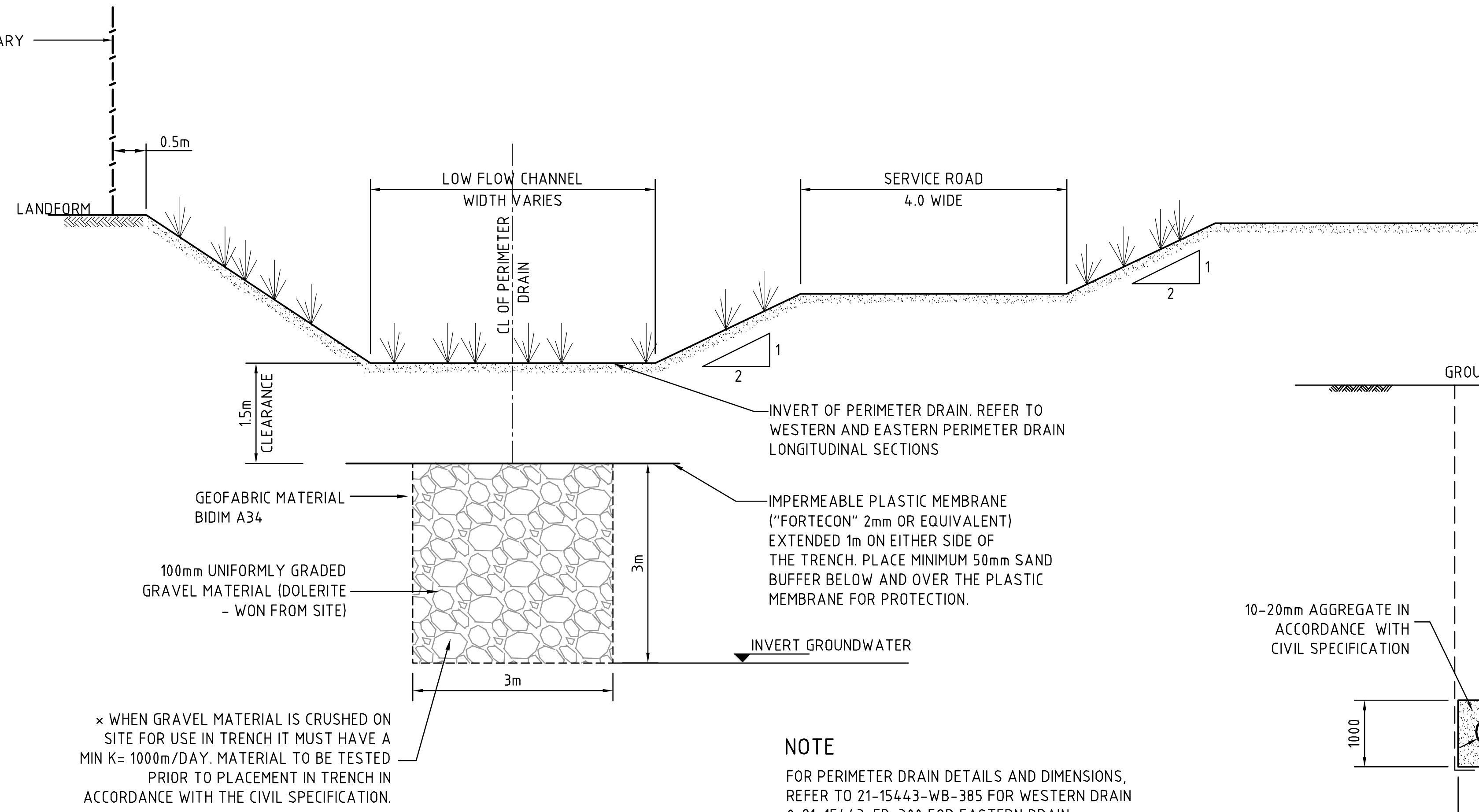
Original Size A1 Drawing No: **21-15443-GW-0721** Rev: 2

Plot Date: 6 December 2012 - 10:02 AM Plotted by: Steve Atkins Cad File No: G:\21\15443\CADD\Drawings\21-15443-GW-0721.dwg



DIRECT CONNECTION DETAIL

SCALE 1:50

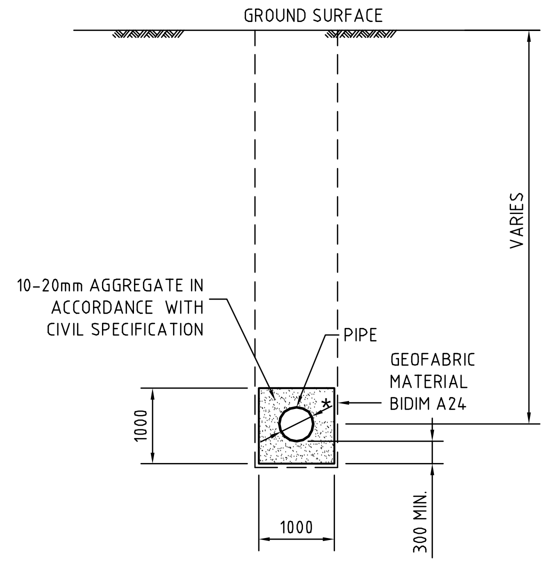


NOTE

FOR PERIMETER DRAIN DETAILS AND DIMENSIONS, REFER TO 21-15443-WB-385 FOR WESTERN DRAIN & 21-15443-EB-300 FOR EASTERN DRAIN.

TYPICAL CROSS SECTION AT PERIMETER CHANNEL

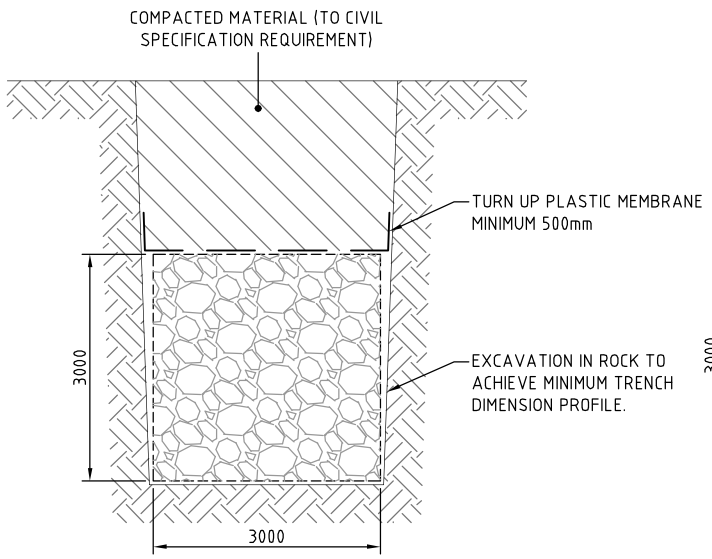
SCALE 1:50



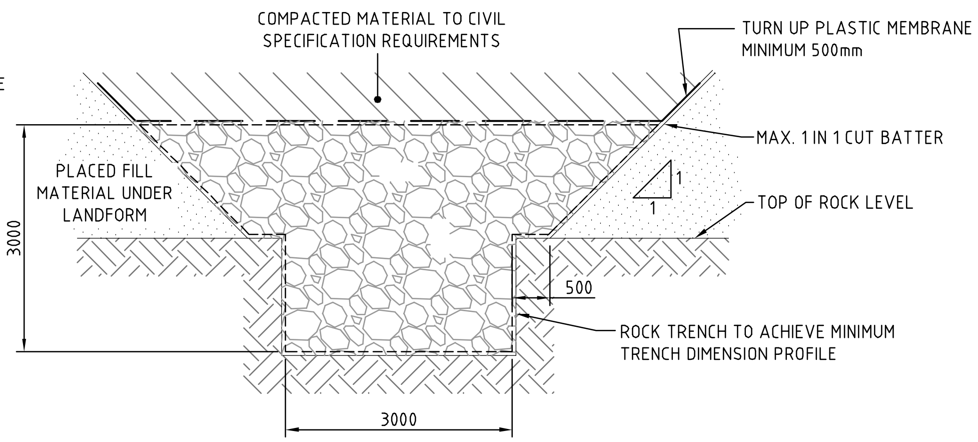
TYPICAL PIPE CROSS SECTION

SCALE 1:50

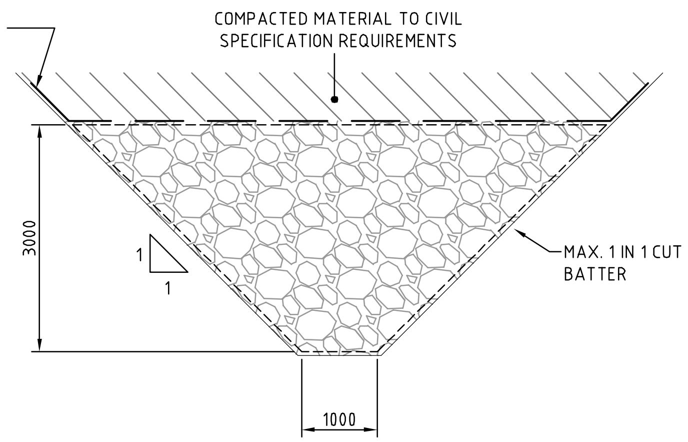
* PIPE DIAMETER VARIES



ROCK TRENCH DETAIL - OPTION 1



PARTIAL ROCK/FILL TRENCH DETAIL - OPTION 2



FULL FILL TRENCH DETAIL - OPTION 3

GROUNDWATER TRENCH CONNECTION METHODS

SCALE 1:50

GROUND WATER TRENCHING OPTIONS PROVIDED ARE ONLY A GUIDE FOR THE CONTRACTOR. ANY OTHER OPTION PROPOSED BY THE CONTRACTOR SHALL ENSURE A MINIMUM BASE WIDTH OF 3m

GROUNDWATER TRENCH CONSTRUCTION TOLERANCES

HORIZONTAL:	LATERALLY UP TO 1m EITHER SIDE OF CENTRELINE OF PERIMETER DRAIN.
INVERT LEVEL:	+0mm ABOVE DESIGN.
HEIGHT:	3m -0mm/+200mm
WIDTH:	ROCK 3m -0mm FILL 1m (AT BASE) -0mm
AREA:	$9m^2$ $-0m^2/+3m^2$

NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE SPECIFICATIONS.
2. FOR GENERAL NOTES REFER DRAWINGS 21-15443-GE-0003 TO 0005.
3. GROUNDWATER PIPE TO BE UPVC iPLEX "BLACK MAX" PIPE OR EQUIVALENT.

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
2	GROUNDWATER INLET PIPE LEVEL AMENDED	SA	TDI*	AH*	25.09.08
1	DIMENSIONS AND TOLERANCES ADDED	SA	TDI*	GJS*	30.06.08
0	ISSUED FOR CONSTRUCTION	MP	TDI*	AH*	25.01.08

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:50 AT ORIGINAL SIZE

BORAL

GHD

DO NOT SCALE

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Drawn	V.THIAGARAJAH	Designer	F.CARROZZA
Drafting Check	T.IRGA*	Design Check	T.IRGA*
Approved (Project Director)	A.HORTON*		
Date	29.01.08		
Scale	AS SHOWN	This Drawing must not be used for Construction unless signed as Approved	

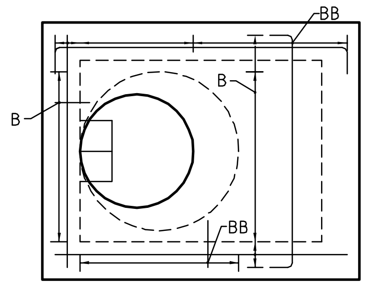
Client **BORAL RECYCLING PTY. LTD.**

Project **GREYSTANES ESTATE SEL**

Title **GROUNDWATER COLLECTION TYPICAL DETAILS - SHEET 1 OF 3**

Original Size **A1** **Drawing No: 21-15443-GW-0722** **Rev: 2**

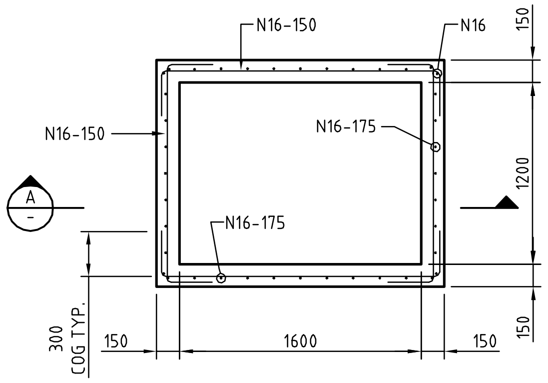
Plot Date: 6 December 2012 - 10:02 AM Plotted by: Steve Atkins Cad File No: G:\21\15443\CADD\Drawings\21-15443-GW-0722.dwg



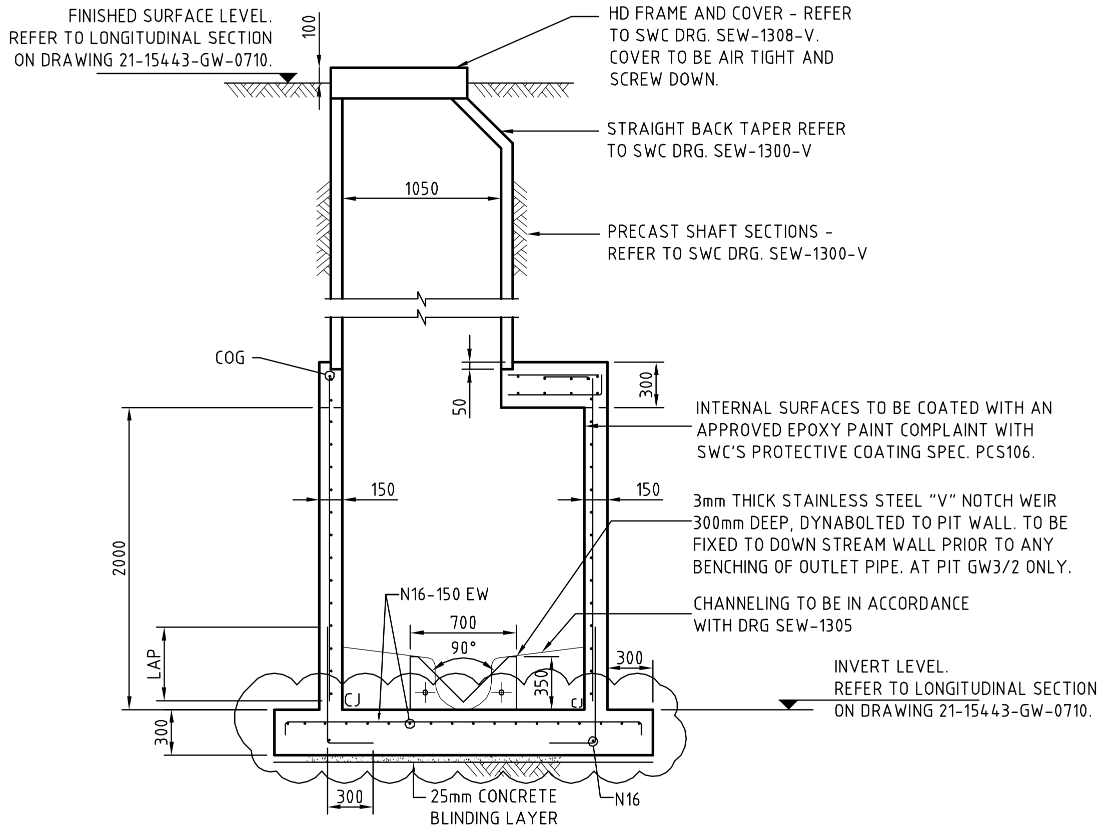
BOTTOM REINFORCEMENT N16-175 U.N.O.
TOP REINFORCEMENT TO BE N16-175

BB	BARS LAID FIRST
B	BARS LAID SECOND
T	BARS LAID THIRD
TT	BARS LAID LAST (FOURTH)

ROOF PLAN
SCALE 1:25

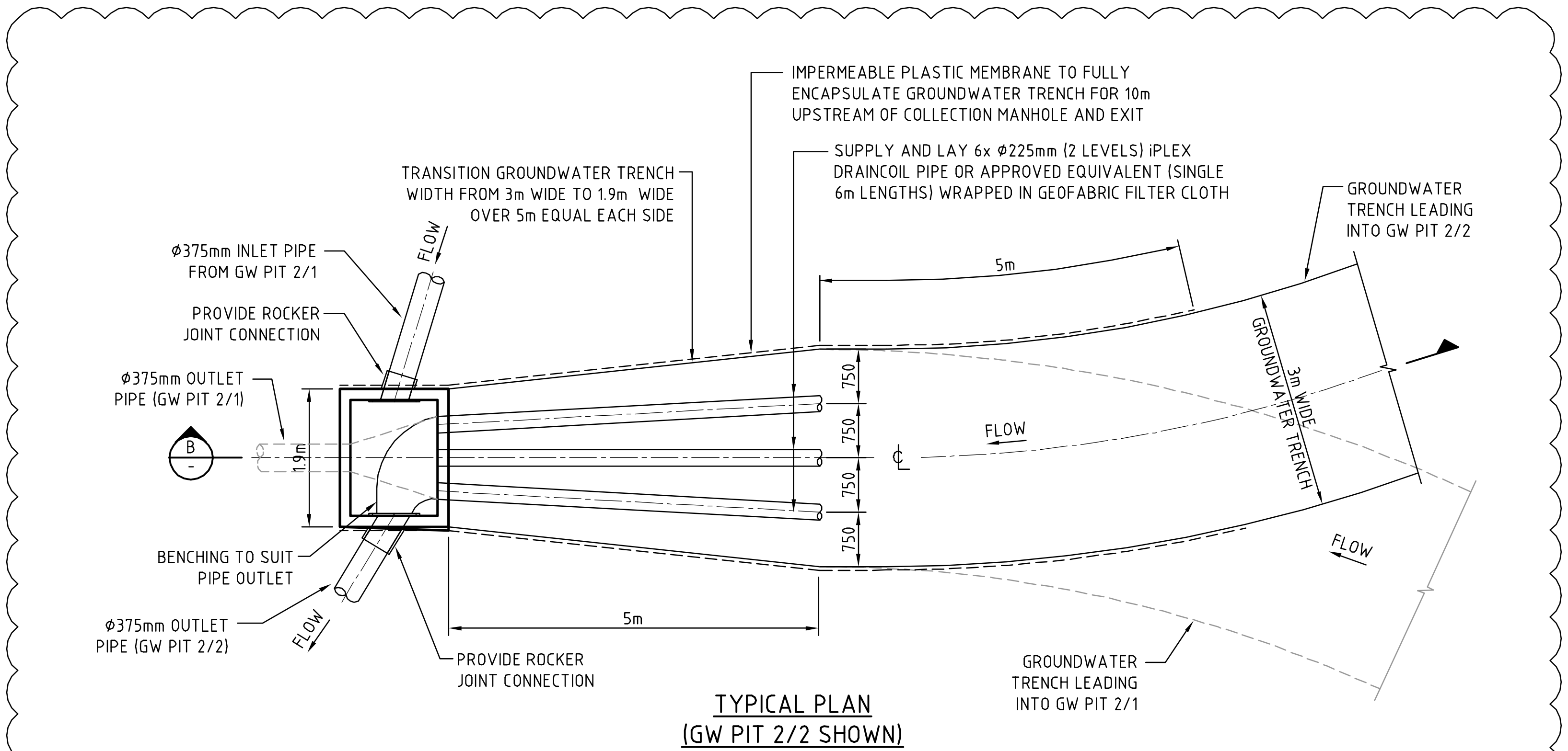


WALL REINFORCEMENT
SCALE 1:25

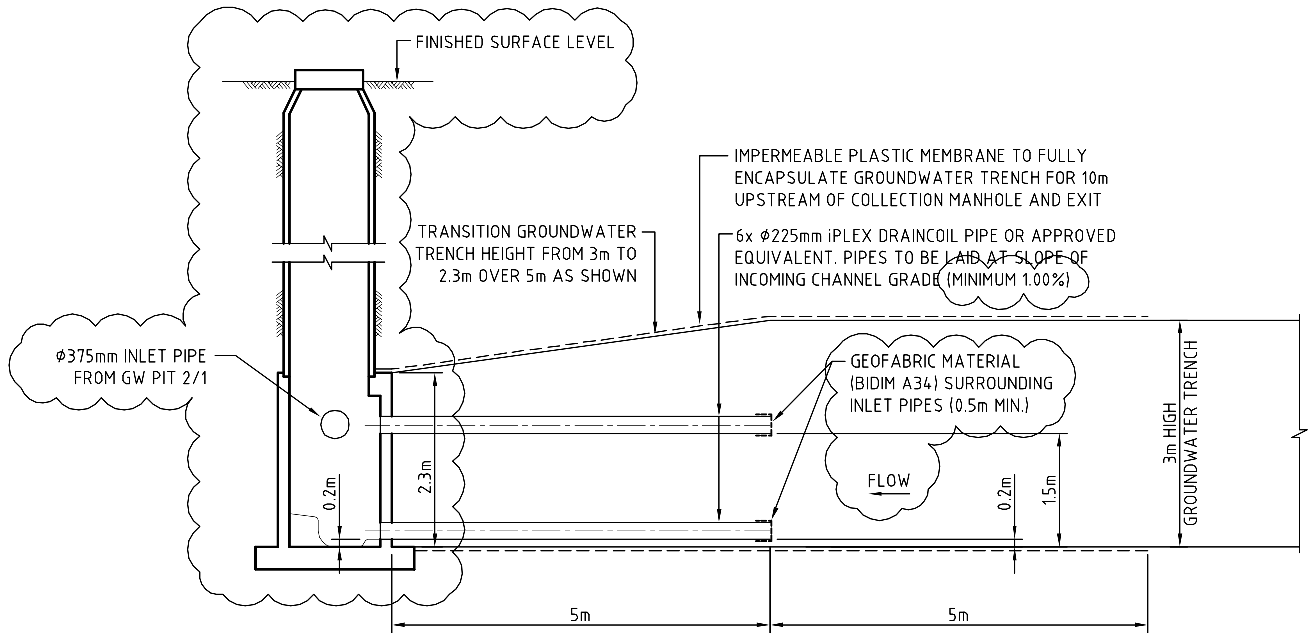


A ELEVATION
SCALE 1: 25

TYPICAL GROUNDWATER MANHOLE DETAILS



TYPICAL PLAN
(GW PIT 2/2 SHOWN)
SCALE 1:50



B ELEVATION
SCALE 1: 50

NOTE:
MANHOLES TO BE CONSTRUCTED TO SEWERAGE CODE OF AUSTRALIA STANDARD WSA02-2002-2.2, SYDNEY WATER EDITION, V2.

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
1	MODIFICATIONS TO GROUNDWATER MANHOLES	SA	TDI*	AH*	25.09.08
0	ISSUED FOR CONSTRUCTION	MP	TDI*	AH*	25.01.08

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 0.25 0.5 0.75 1.0 1.25m
SCALE 1:25 AT ORIGINAL SIZE

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:50 AT ORIGINAL SIZE

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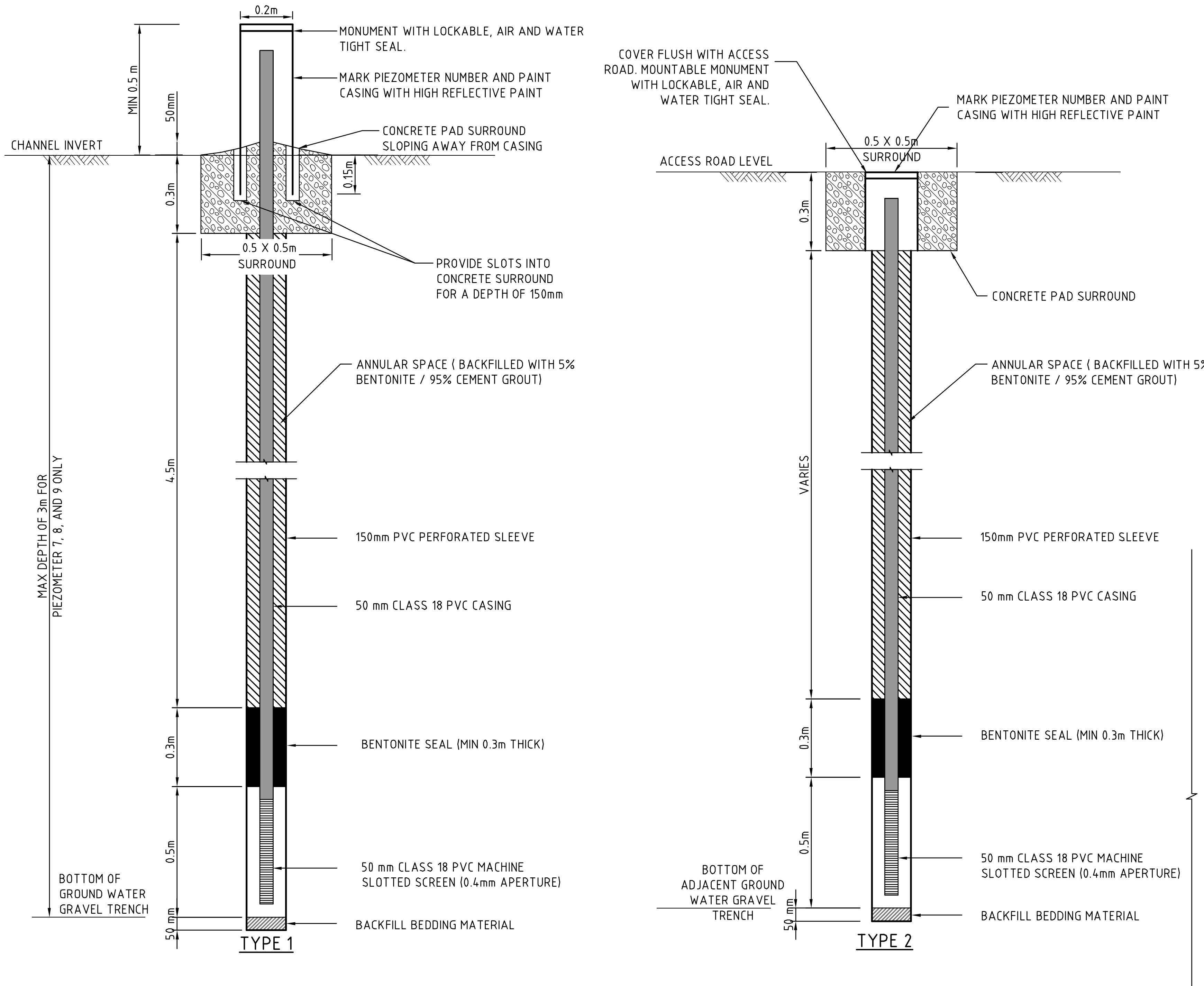
Drawn	V.THIAGARAJAH	Designer	F.CARROZZA
Drafting Check	T.IRGA*	Design Check	T.IRGA*
Approved (Project Director)	A.HORTON*		
Date	29.01.08		
Scale	AS SHOWN	This Drawing must not be used for Construction unless signed as Approved	

Client **BORAL RECYCLING PTY. LTD.**
Project **GREYSTANCES ESTATE SEL**
Title **GROUNDWATER COLLECTION TYPICAL DETAILS - SHEET 2 OF 3**

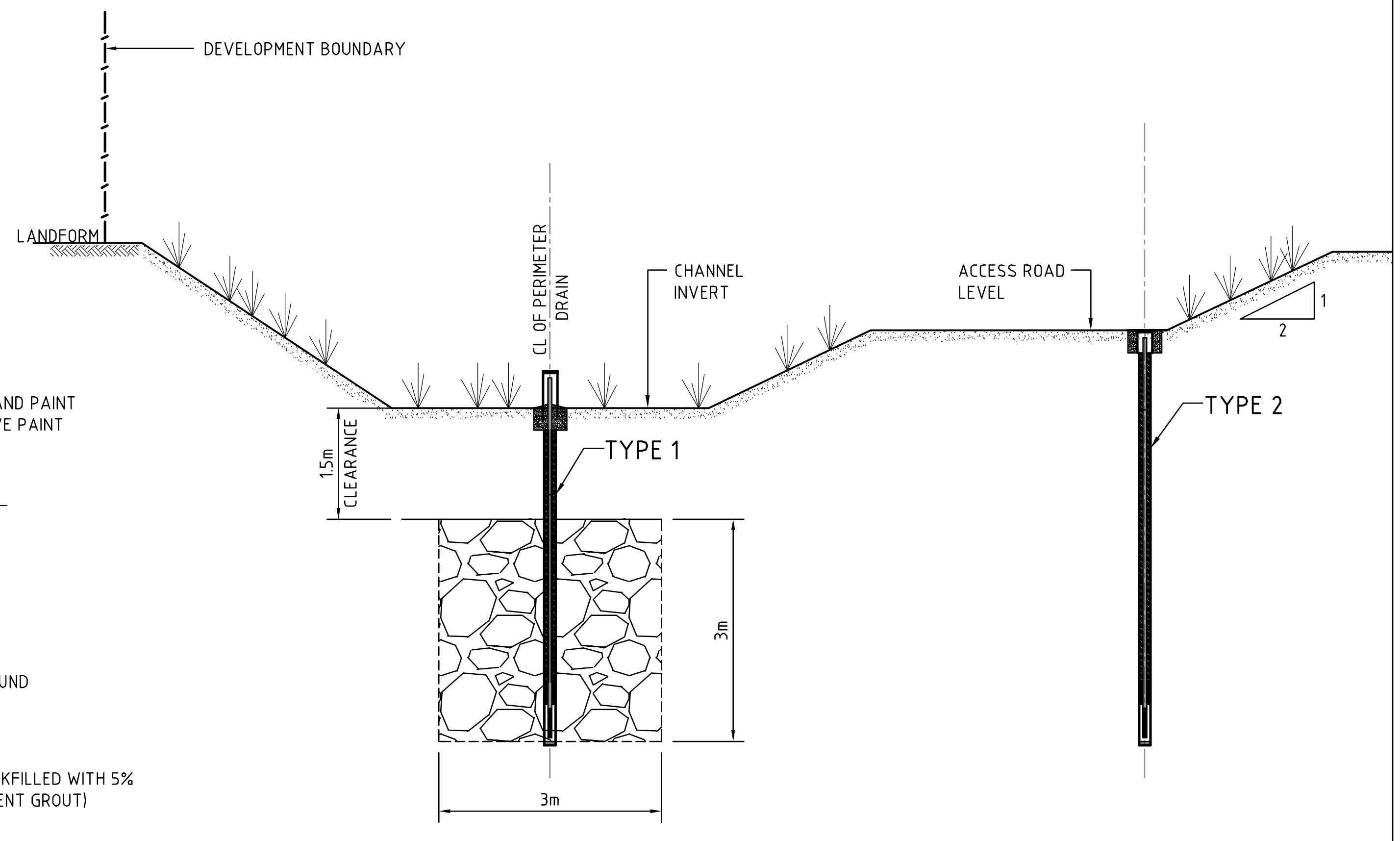
Original Size **A1** **Drawing No: 21-15443-GW-0723** **Rev: 1**

Plot Date: 6 December 2012 - 10:02 AM Plotted by: Steve Atkins Cad File No: G:\21\15443\CADD\Drawings\21-15443-GW-0723.dwg



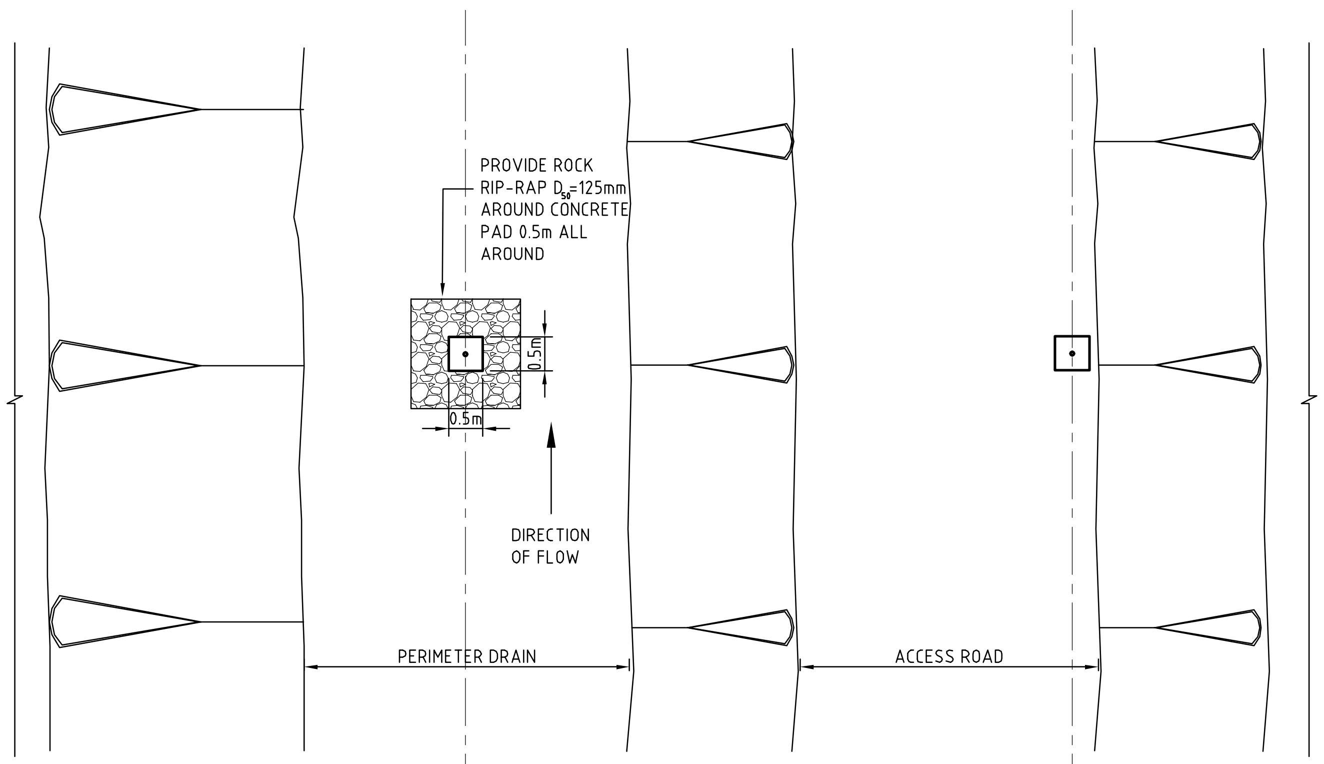
GROUNDWATER LEVEL MONITORING SYSTEM DETAILS

SCALE 1:10



TYPICAL CROSS SECTION AT PERIMETER CHANNEL

SCALE 1:50



TYPICAL PLAN AT PERIMETER CHANNEL

SCALE 1:50

FOR CONSTRUCTION

No	Revision	Drawn	Job Manager	Project Director	Date
0	ISSUED FOR CONSTRUCTION	MP	TDI*	AH*	25.01.08

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 0.1 0.2 0.3 0.4 0.5m
SCALE 1:10 AT ORIGINAL SIZE

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:50 AT ORIGINAL SIZE

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Drawn V.THIAGARAJAH | Designer F.CARROZZA
Drafting Check T.IRGA* | Design Check T.IRGA*
Approved (Project Director) A.HORTON*
Date 29.01.08
Scale AS SHOWN
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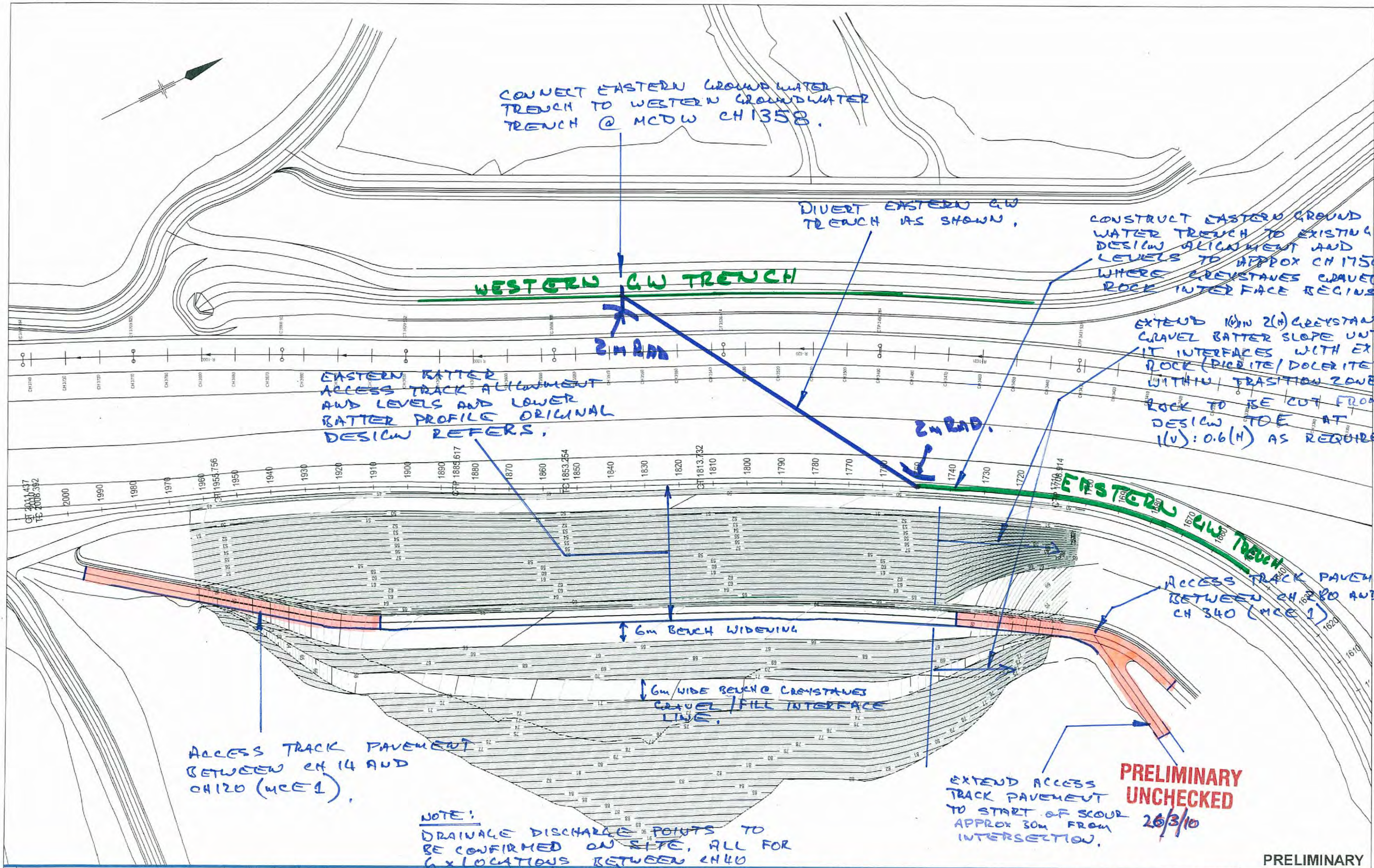
Client **BORAL RECYCLING PTY. LTD.**
Project **GREYSTANES ESTATE SEL**
Title **GROUNDWATER COLLECTION TYPICAL DETAILS - SHEET 3 OF 3**
Original Size **A1**
Drawing No: **21-15443-GW-0724**
Rev: **0**

Plot Date: 6 December 2012 - 10:02 AM Plotted by: Steve Atkins Cad File No: G:\21\15443\CADD\Drawings\21-15443-GW-0724.dwg



PRELIMINARY

UR	UNDER REVISION - FOR INTERNAL GHD USE ONLY					
No	Revision	Note: * indicates signatures on original issue of drawing or last revision of drawing	Drawn	Checked	Approved	Date

0 5 10 15 20 25m
SCALE 1:500 AT ORIGINAL SIZE

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Drawn B.WILLIAMSON	Designed J.MEESOO
Drafting Check	Design Check
Approved	
Date	
Scale AS SHOWN	This Drawing must not be used for Construction unless signed as Approved

Client: **BORAL RECYCLING PTY LTD**
Project: **EAST BATTER PRELIM TREATMENT**
Title: **PLAN OF REVISED DESIGN AREA**

Original Size A1 | Drawing No: **21-15443-SK4034** | Rev: UR

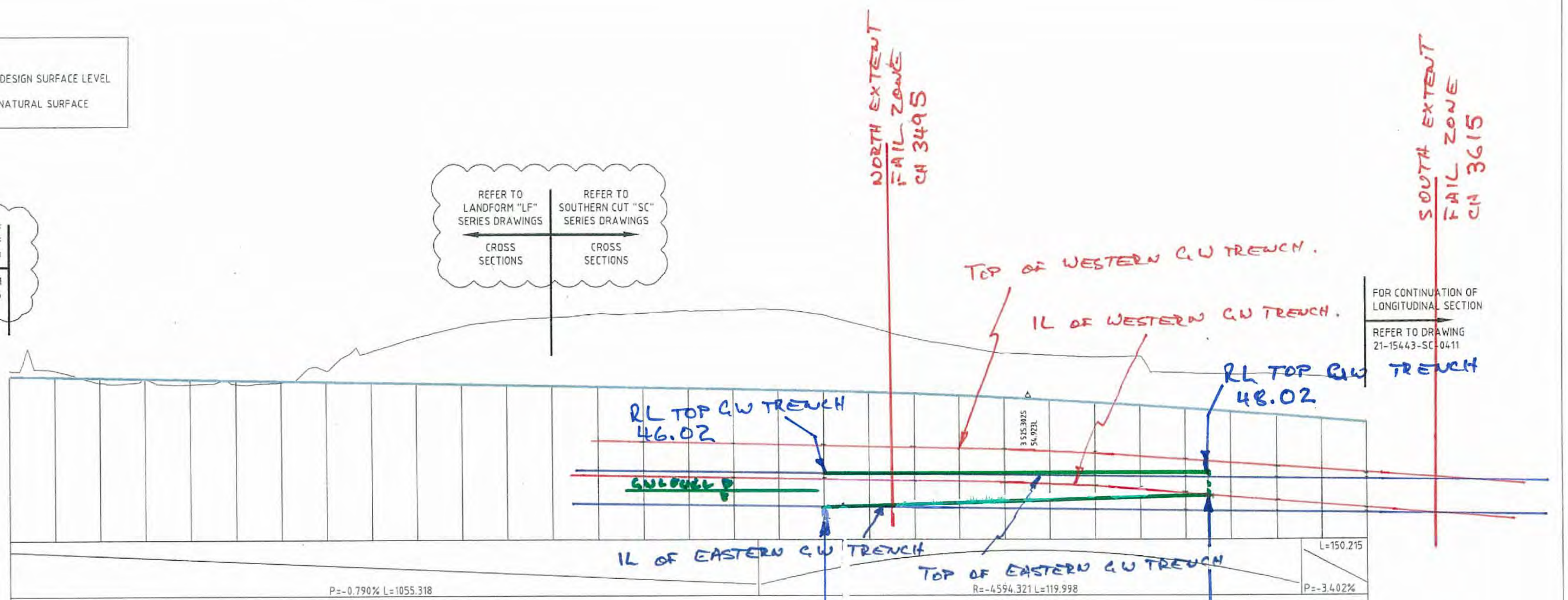
Plot Date 25 March 2010 - 3:52 PM   Plotted by Bronwyn A. Williamson   Cad File No G:\21\15443\CADD\Drawings\21-15443-SK4034.dwg

LEGEND

- DESIGN SURFACE LEVEL
- NATURAL SURFACE

FOR CONTINUATION OF LONGITUDINAL SECTION OF SPINE ROAD
REFER TO LANDFORM DRAWING 21-15443-LF-0115

REFER TO LANDFORM "LF" SERIES DRAWINGS — CROSS SECTIONS
REFER TO SOUTHERN CUT "SC" SERIES DRAWINGS — CROSS SECTIONS



STATION	DESIGN LEVELS	EXISTING LEVELS
3300.000	56.703	57.196
3310.000	56.624	57.195
3320.000	56.545	56.130
3330.000	56.466	56.473
3340.000	56.387	55.939
3350.000	56.308	55.956
3360.000	56.229	56.101
3370.000	56.150	57.131
3380.000	56.071	58.823
3390.000	55.992	60.053
3400.000	55.913	61.036
3410.000	55.834	61.604
3420.000	55.755	61.829
3430.000	55.676	62.142
3440.000	55.597	62.198
3450.000	55.518	62.377
3460.000	55.439	62.454
3470.000	55.357	62.506
3480.000	55.257	62.027
3490.000	55.135	60.953
3500.000	54.992	59.924
3510.000	54.826	59.223
3520.000	54.639	58.574
3530.000	54.430	58.409
3540.000	54.199	58.241
3550.000	53.947	58.329
3560.000	53.673	56.838
3570.000	53.377	56.710
3580.000	53.059	56.721
3590.000	52.722	56.486
3600.000	52.382	56.460

START POINT OF DIVERSION @ MCDE CH 1750 (MC01 CH 3480) (IL 45.02)

END POINT OF DIVERTED GW TRENCH AT MCDW CH 1348 (MC01 CH 3565) (IL 46.01)

MC01 - LONGITUDINAL SECTION SPINE ROAD
SCALE 1:500 (HOR)
1:200 (VER)

GW TRENCH OPT.
T. IRGA 26/3/10

IL .35m

FOR CONSTRUCTION

No	Revision	Drawn	Checked	Approved	Date
1	MINOR DRAFTING AMENDMENTS	SA	TI	AH	24.09.08
0	ISSUED FOR CONSTRUCTION	MP	TDI*	AH*	18.01.08

Note * indicates signatures on original issue of drawing or last revision of drawing

0 2 4 6 8 10m
SCALE 1:200 AT ORIGINAL SIZE
0 5 10 15 20 25m
SCALE 1:500 AT ORIGINAL SIZE

BORAL

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Drawn V.THIAGARAJAH | Designed J.PERTEL
Drafting Check T.IRGA* | Design Check T.IRGA*
Approved A.HORTON*
Date 18.01.08
Scale AS SHOWN
This Drawing must not be used for Construction unless signed as Approved

Client BORAL RECYCLING PTY. LTD.
Project GREYSTANES ESTATE SEL
Title SOUTHERN CUT LONGITUDINAL SECTION (MC01) SHEET 1 OF 3
Original Size A1
Drawing No: 21-15443-SC-0410
Rev: 1

Plot Date 24 September 2008 10:34 AM Cad File No G:\21\15443\CADD\Drawings\21-15443-SC-0410.dwg