

Hanson Construction Materials Pty Ltd



Hydrogeological Assessment:

Hanson's Somersby Quarry Project

ENVIRONMENTAL



WATER



WASTEWATER



GEOTECHNICAL



CIVIL



PROJECT
MANAGEMENT



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1 Overview

1.1 Background

A preliminary Surface and Groundwater Assessment was completed in July, 2008 (Martens and Associates) to detail the surface water and groundwater environment at the proposed quarry expansion site.

The preliminary Surface and Groundwater Assessment formed part of a Preliminary Environmental Assessment (PEA) for the NSW Department of Planning (DoP) as part of an application for a boundary adjustment and expansion of the resource extraction operations of the existing Somersby Quarry (Central Coast Sands) into the subject site.

Subsequent Director-General's Requirements (DGEARs) were released on 22 October, 2008. DGEARs relating to water management included the following:

- A detailed description of the potential incremental and cumulative impacts of the project on groundwater resources in the area during all stages of the project, paying particular attention to potential impacts of the project on Mooney Mooney Creek and the Money Dam catchment; and
- A site water balance detailing the availability of a sustainable water supply and measures to minimise water use and manage any water discharges.

1.2 Scope

This report assesses the potential groundwater related impacts of the proposed development. Primary objectives of the report include the following:

1. Assess the existing groundwater regime.
2. Determine site aquifer hydraulic properties.
3. Identify existing groundwater users which may be impacted by the proposed expansion of operations.
4. Develop a finite-difference groundwater flow model to assess likely groundwater ingress volumes and aquifer drawdown following quarry expansion.

A site water balance is developed within the Surface Water Assessment (Martens and Associates, 2009) for the site with groundwater extraction rates determined in this report used in the water balance.

2 Site and Proposal Description

2.1 Proposed Development

Proposed development involves the following:

1. A boundary adjustment between the existing quarry and the adjoining subject site (part of Lot 10, DP1090880) for the purposes of adding additional area to the existing quarry; and
2. Expansion of the resource extraction operations of the existing quarry into the subject site to extend the life of operations (note annual output will remain unchanged).
3. Extraction within the subject site (existing quarry and proposed lateral expansion area) to 190 mAHD being a level capable of forming an ultimately free-draining surface.

2.2 Existing Quarry Site

The existing quarry site (Central Coast Sands) and proposed expansion site are depicted in Figure 1.

2.3 Proposed Expansion Site

The proposed expansion site (Figure 1) is identified as part of Lot 10 DP 1090880, Keighley Road, Somersby within the Gosford City Council local government area (LGA) and is zoned as 1 (a) Non-Urban. The site has a total area of approximately 8 ha and is currently used for intensive agriculture including:

- Cultivation of avocados,
- Cultivation of oranges, and
- Poultry farming.



Figure 1: Existing quarry site and proposed expansion site (Source: Google Maps, 2009).

3 Regional Groundwater

3.1 Water Sharing Plan

The site lies within Zone 8 of the Kulnura Mangrove Mountain Groundwater Management Area and is therefore subject to management under the Water Sharing Plan for the Kulnura Mangrove Mountain Groundwater Sources (DWE, 2003).

Zone 8 is comprised by the aquifer(s) within the Mooney Mooney and Mullet Creeks sub-catchments (Figure 2).

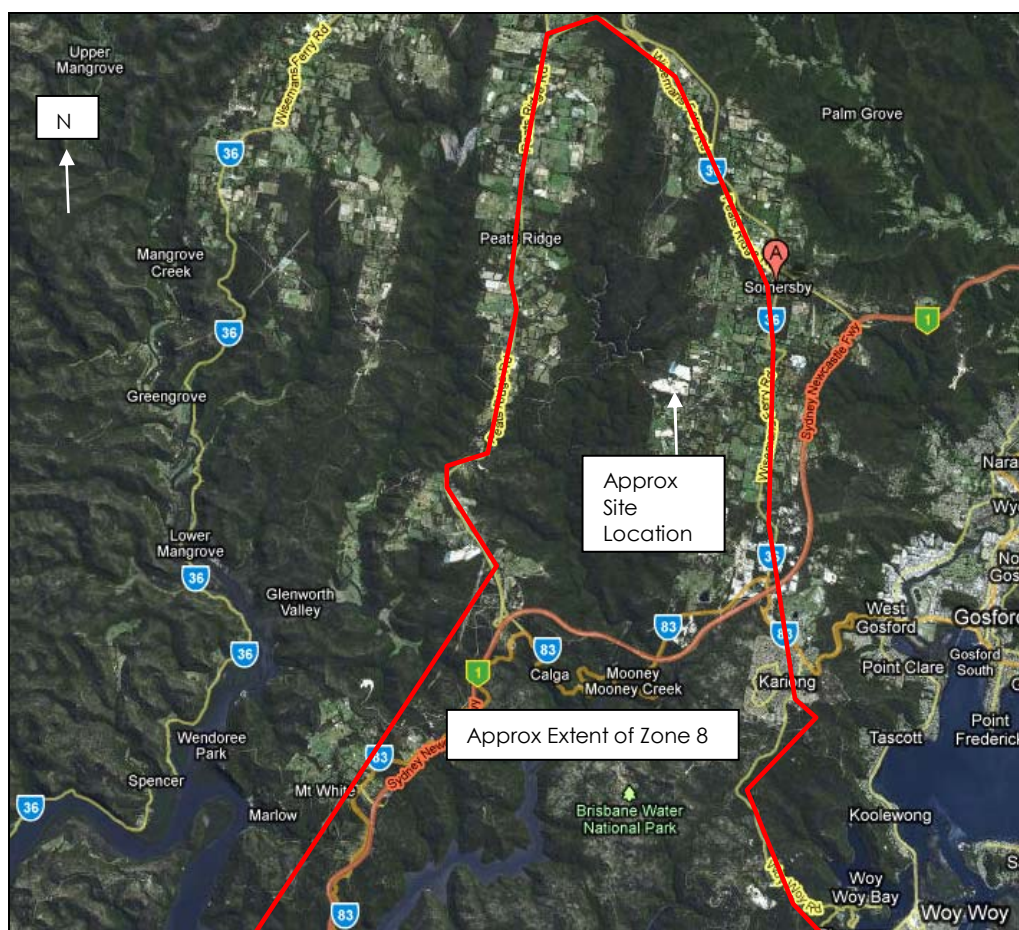


Figure 2: Approximate extent of Zone 8 groundwater management area (Source: Google Maps, 2009). Zone 8 defined based on DWE (2003).

3.2 Water Bearing Strata

The primary water bearing strata for the region is Hawkesbury Sandstone. Aquifers within this stratum exist within zones of permeable sandstone and/or within fractures. Perched groundwater tables above the soil/rock interface along with groundwater discharge at springs are also documented as an important part of the regional hydrogeological regime (Merrick and Alkhatib, 2006).

3.3 Levels

Groundwater levels are likely to vary significantly over the region with changing topography and geology. Groundwater levels are expected to range from near ground level (i.e at the soil/rock interface) to depths of the order of 30 to 50 m below ground level (mBGL).

3.4 Hydraulic Conductivity (K)

Testing within 11 bores located in the vicinity of Calga indicated K ranged from 0.003 m/d to 1.6 m/d (Aquaterra, 2008). The accepted range of K adopted for the calibration of a Somersby groundwater model developed by Robert Carr and Associates (2006) ranged from 0.003 to 0.086 m/d. The commonly referenced K value for Hawkesbury Sandstone is ~0.01 m/d (Hitchcock, 1995). Hydraulic conductivity is likely to vary significantly over the region with changing rock porosity, weathering patterns and fracturing characteristics.

Based on the above K can be expected to frequently be in the order of 0.003 m/d to 0.09 m/d for the Zone 8 region. Site specific K data and discussion is in Section 4.5.

3.5 Quality

Groundwater quality within the upper portion (upper ~ 80 m) of Hawkesbury Sandstone is considered to be good based on typical documented electrical conductivity (EC) values and pH levels. Water is suitable for domestic and agricultural uses.

3.6 Groundwater Users

Bores for domestic and commercial use are common within Zone 8 as parts of the zone are not serviced by a town water system. There are 40 bores within approximately 1.4 km from the existing and proposed expansion site boundaries. Of these bores 33 are licensed. Refer to Attachment B for summary of licensed bore details.

4 Local Groundwater

4.1 Lithology and Geology

4.1.1 Soil

5 shallow boreholes were excavated on the proposed expansion site on the 21st August, 2009. These extended to extremely/moderately weathered rock (rock sufficiently strong to slow downward auger progression) (depths ranging from 0.7 to 1.5 mBGL). Boreholes indicated that the soil profile is comprised of sands, silty sands, clayey sands and sandy clays overlying weathered sandstone.

One borehole (BH2) drilled in the vicinity of a man made drainage channel had water at the soil/rock interface. Based on the proximity of the borehole to the drainage channel the observed water is not expected to be representative of a perched water table but rather is a direct result of the drainage channel. Refer to Attachment B for borehole logs.

4.1.2 Rock

5 deep boreholes were drilled in order to confirm geological conditions and permit piezometer construction. 3 boreholes were excavated in the existing quarry pit to primarily allow closely spaced piezometers to be used in a pump test. The additional 2 boreholes were drilled on the proposed expansion site to confirm groundwater levels and assess the drawdown resulting from the existing quarry operations.

Based on cutting returns, all 5 boreholes confirmed the presence of Hawkesbury Sandstone with interbedded lenses of shale/siltstone and in some cases minor clay lenses. Shale/siltstone lenses were more frequently observed in the boreholes which were drilled in the existing quarry pit.

Boreholes in the quarry pit were drilled to 40 m; 40 m; and 12 mBGL. Boreholes on the proposed expansion site were both drilled to 60 mBGL. Refer to Attachment B for borehole logs.

4.2 Recharge

Based on the modelled recharge for Zone 8 (9,007 ML/yr) and the area of Zone 8 (approximately 15,105 ha) (DWE, 2003), average recharge is of the order of 60 mm/yr. This equates to approximately 4.3% of the

annual average rainfall (1389.2 mm/yr) (closest BOM station of Ourimbah, approx 4.3 km away). This percentage of annual rainfall going to recharge is in the expected typical range of ~1 to 10% for rock aquifers. Recharge is likely to be higher than the average of 4.3% of annual rainfall on the ridge top and in areas of relatively lower slopes with sandy soils. The site is surrounded by relatively lower slopes and can therefore be expected to receive higher recharge.

4.3 Site Piezometers

Site piezometer details are summarised in Table 1.

Table 1: Site piezometer details.

Piezometer Details				
I.D	Depth (mBGL)	Location	Construction	Indicative Water Level Status
P1	40	Quarry pit	6m screen at base, remainder cased, all pipe 50mm, monument.	Generally at level of pit invert.
P2	40	Quarry pit	6m screen at base, remainder cased, all pipe 50mm, monument.	Generally at level of pit invert.
P3	60	Proposed site of expansion	6m screen at base, remainder cased, all pipe 50mm, monument.	Approx 27.5 mBGL.
P4	60	Proposed site of expansion	6m screen at base, remainder cased, all pipe 50mm, monument.	Approx 12 mBGL.
P5	12	Quarry pit	Initial 125mm casing for top 3m (approx) of hole, remainder is open hole.	Generally at level of pit invert.

4.4 Groundwater Levels

Review of public domain bore data (NSW Government Natural Resource Atlas – www.nratlas.nsw.gov.au) indicates that groundwater levels are at a median depth of 14 mBGL for bores that are within approximately 1.4 km of the site (Attachment B). We note that this data has not been verified on-site and has been derived from observations taken across a wide range of dates.

Generalised groundwater levels within piezometers that are located within the existing quarry pit and on the proposed expansion site are in Table 1 whilst detailed measurements are outlined in Table 2.

No long-term monitoring of groundwater levels has been undertaken.

Table 2: Groundwater level measurements.

	Piezometer ID.				
	P1	P2	P3	P4	P5
Date	Groundwater Level (mBGL/mAHD)				
21.07.09	1.20/ 198.80	0.55/ 199.45	27.96/ 220.54	13.75/ 237.25	
23.07.09	1.20/ 198.80	0.55/ 199.45	27.96/ 220.54	13.75/ 237.25	10.7/ 189.30 ¹
28.07.09	1.20/ 198.82				1.20/ 198.80
30.07.09	1.20/ 198.81	0.74/ 199.26	26.81/ 221.69	11.43/ 239.57	1.32/ 198.68
13.08.09	1.20/ 198.79		27.68/ 220.82	11.53/ 239.47	

Notes: ¹. Level taken at completion of drilling and therefore water levels had not recovered to static levels due to low permeability of rock.

4.5 Aquifer Properties

4.5.1 Site Testing

A pump test was conducted to estimate the aquifer properties of T and S. The test was conducted within the quarry pit piezometers. P2 was pumped for a period of 4 hrs at a near constant rate of 0.078 L/s. This maintained a drawdown of approximately 7.5 m in the pumping well. The response was measured in P5. P1 showed no response. The aquifer's response to pumping followed the Theis type curve (Figure 3) and therefore pump test data analysis was undertaken using the Theis method. Results indicate a K value of 0.09 m/d and an S value of 0.0005. This S value is indicative of a confined aquifer and therefore may be indicative of an initial semi-confined/confined response.

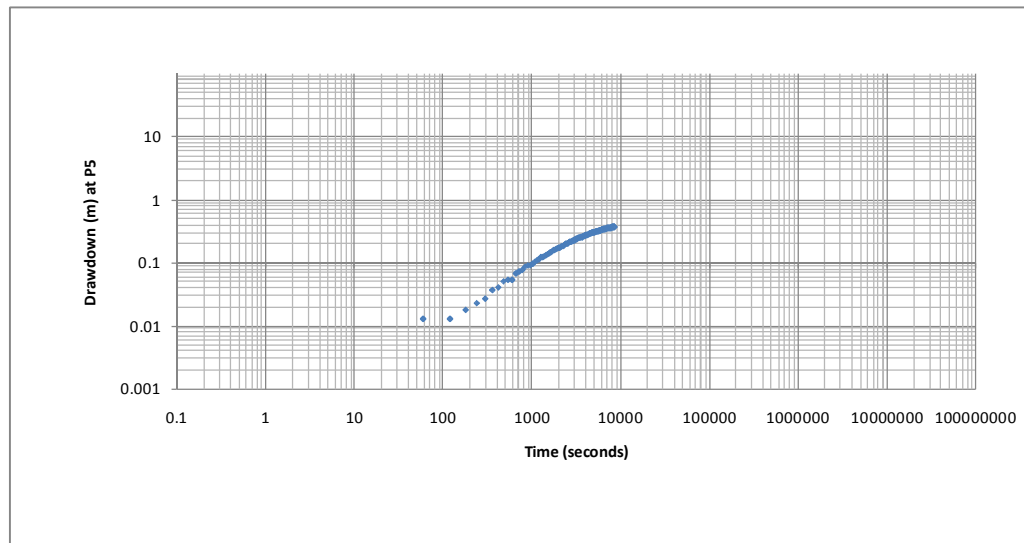


Figure 3: Drawdown versus time data from the pump test.

In addition to the above, slug tests were also conducted to provide further estimates of K. Results of aquifer testing to date are summarised in Table 3.

Table 3: Summary of aquifer testing data.

Borehole	Test Type	Date	K (m/d)	S _y
P5	Pump Test – Theis analysis	30.07.2009	0.09	0.0005
P2	Slug Test	30.07.2009	0.11	-
P3	Slug Test	13.08.2009	0.04	-
P4	Slug Test	13.08.2009	0.14	-
Geomean			0.09	-
Adopted Aquifer Pre-calibration K Value			0.09	0.04

4.5.2 Review of Site Testing Results

K values estimated from site testing compare well with one another and with typical published values for the region (Section 3.4). Therefore, the median site testing value for K of 0.09 m/d was adopted as a pre-calibration aquifer value for the groundwater model.

The S value derived from site testing is atypically low being a more typical S value for confined aquifers. This value is not suitable for use as a site design value where the groundwater system is modelled as a single regional unconfined aquifer, therefore, a design value for specific yield S_y of 0.04 has been adopted (for transient analysis only). The actual hydrogeological system is likely to be comprised of an initial

unconfined aquifer underlain by semi-confined/confined layers. This degree of complexity is difficult to model and not required to achieve model objectives. The S_y value of 0.04 was adopted based on typical values for unconfined sandstone rock aquifers and also based on the method outlined in Section 4.6. The S_y value was utilised in the analytical transient analysis in Section 4.6. The MODFLOW model developed for impact assessment was steady-state and therefore required no storage input.

4.6 Existing Drawdown

The existing drawdown resulting from the current quarry pit level (approximately 200 mAHD) was measured based on groundwater levels within site piezometers. Based on an assumed homogenous local groundwater level of 240 mAHD, a homogenous natural ground level of 250 mAHD and the relationship between groundwater levels and distance from the existing pit perimeter (Figure 4), the distance to 1 m drawdown contour is likely to be in the order of 400 m.

In addition to the above the Theis well function was used to confirm conceptual aquifer property values. S was varied iteratively until the resulting 1 m drawdown extent was approximately 400 m (i.e representative of the observed existing drawdown). T was kept constant based on a K of 0.09 m/d (derived from site testing) and aquifer depth of 35 m. The pumping rate used in the Theis equation to represent pit dewatering was estimated based on the Dupuit-Forchheimer method which assumed excavation area was 6.075 ha. Steady state conditions were assumed to exist after 1 year. The theoretical drawdown curve provided a curve similar to that of the observed drawdown curve (i.e 1m drawdown at 400 m) with an S value of 0.04.

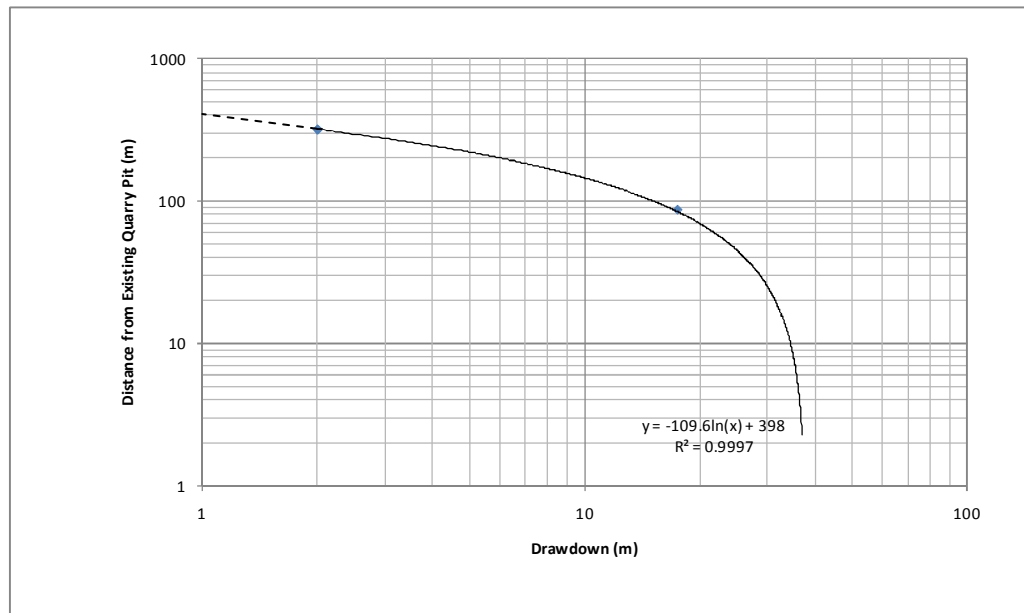


Figure 4: Plot of existing drawdown versus distance from existing excavation perimeter based on measured levels within piezometers.

4.7 Conceptual Hydrogeological Model

The conceptual hydrogeological model that provided the basis for the construction of the numerical Modflow model is based on the following assumptions:

- A single unconfined layer of Hawkesbury Sandstone to a level of 0 mAHD with a homogeneous K value.
- Surface topography as defined from the 1:25,000 topographic map.
- A homogeneous recharge value.
- No groundwater extraction (other than the quarry).
- Aquifer discharge within drainage lines. This represents base-flow to drainage lines and also groundwater discharge at springs.

Like any conceptual model the key aquifer processes which are outlined above are a simplification of a highly complex system. Based on the data available and the model's primary objectives the above conceptualisation is considered suitable for application within a numerical model.

5 Hydrogeological Model

5.1 Overview

The finite difference groundwater flow model 'Modflow' was utilised within Visual Modflow to develop a numerical steady-state groundwater model to assess groundwater related impacts associated with the project.

Primary objectives of the model were to quantify dewatering rates associated with the proposed expansion of extractive operations and to determine likely drawdown impacts. The flow engine 'USGS Modflow 2000' was used in the model.

Model set-up, aquifer properties, boundary conditions and calibration is outlined in Attachment D.

5.2 Modelling Scenarios

The following scenarios were modelled:

1. Current-development – quarry in its approximate current state with active extraction pit level at 200 mAHD.
2. Ultimate Approved-development – quarry at its ultimate approved state being extraction to the practical limit of 120 mAHD.
3. Proposed-development – the quarry as per Scenario 1 but with the extraction pit to a level of 190 mAHD comprising both the existing approved pit area and the proposed expansion site.

Details of model set-up, aquifer properties, boundary conditions and calibration are provided in Attachment D.

5.3 Model Results

Modelled groundwater inflows for each modelling scenario and the radius of influence for Scenarios 2 and 3 are summarised in Table 4. Results for drawdown for all licensed wells within the model domain are summarised in Table 5. Model outputs for Scenarios 1 to 3 showing groundwater head contours, drawdown contours and the model domain are in Attachment E.

Table 4: Summary of steady-state modelling results.

	Scenario 1	Scenario 2	Scenario 3
Groundwater Inflow (m³/d) ¹	277	806	404
Radius of Influence	-	1000 m m contour) ²	(10 500 m (10 m contour) ³

Notes: ¹. Groundwater inflows assume no evaporative losses. ². Finer contour resolution causes contours to extend outside of model domain. ³. Drawdown to 1 m contour is 1,285 m.

Table 5: Model output of drawdown in licensed bores from existing-development piezometric surface for scenarios 2 and 3.

Groundwater Bore Number	Scenario 2	Scenario 3
GW105609	14.32	11.75
GW104167	19.76	1.23
GW104097	8.31	0.31
GW102423	27.36	26.52
GW101930	49.92	8.46
GW101920	8.92	3.29
GW101916	9.59	0.34
GW101915	8.28	-0.66
GW101664	8.32	0.32
GW101511	8.21	0.22
GW100835	25.68	22.43
GW100786	0.47	0.03
GW100681	17.72	8.08
GW100238	84.39	5.75
GW067551	9.54	6.28
GW066918	38.67	9.60
GW065892	22.82	15.12

GW065477	1.68	0.96
GW065458	99.19	5.35
GW063850	51.04	3.56
GW062121	5.72	1.87
GW056649	16.20	10.23
GW056451	9.68	0.50
GW054992	48.28	40.98
GW053607	10.11	5.64
GW051998	48.01	37.44
GW051774	-0.39	-0.41
GW051443	-0.90	-1.09
GW049304	9.64	0.34
GW049244	9.83	0.40
GW047695	20.80	0.14
GW047267	26.73	3.70
25 th %ile	8.32	0.33
median	12.22	3.42
75 th %ile	26.89	8.74

Results indicate that the existing development (Scenario 1) has the lowest groundwater inflow rate into the excavation pit. The ultimate approved - development (Scenario 2) has the highest groundwater inflows and drawdown. Groundwater inflow rates and drawdown are markedly lower for the proposed development (Scenario 3) when compared to the ultimate approved - development (Scenario 2).

Negative drawdown indicates that the model is over-predicting the groundwater head in certain areas as introducing the DRAIN boundary condition (used to simulated the quarry pit) for Scenarios 2 and 3 should theoretically reduce heads inside the radius of influence and leave heads unchanged outside of the radius of influence. However,

these instances are isolated and the model is adequate for assessment purposes.

6 Groundwater Impact Assessment

6.1 Overview

The following potential impacts are assessed in light of the proposed expanded quarry on the site.

1. Reduced yield at neighbouring bores.
2. Groundwater quality changes.
3. Altered Groundwater Dependent Ecosystem (GDE) Habitat.

6.2 Impact Assessment

6.2.1 Reduced Yield at Neighbouring Bores

The maximum yield of neighbouring bores may reduce from existing conditions as the development progresses. Continued aquifer drawdown will reduce the saturated thickness of bores which are located within the excavation's radius of influence. The drawdown of local aquifer due to the completion of the ultimate approved - development (Scenario 2) is very much greater than both the existing - development (Scenario 1) and the proposed-development (Scenario 3).

Comparison of drawdown between the ultimate approved-development (Scenario 2) and the proposed-development (Scenario 3) is shown in Table 6. Median change to drawdown is -8.0 m whilst the 25th percentile value is -12.56 m. Drawdown associated with the proposed-development (Scenario 3) is lower than that associated with the ultimate approved-development (Scenario 2) for all bores. For the majority of bores the reduction to drawdown associated with the proposed-development is substantial. This means that the groundwater head in bores will be higher under the proposed-develop than under the ultimate approved-development.

Based on this analysis the proposed quarry shall have substantially reduced local aquifer drawdown effects than the currently approved form. Therefore, further mitigation works are not considered warranted.

Table 6: Modelled changes to drawdown between ultimate approved-development (Scenario 2) and proposed-development (Scenario 3) for off-site bores.

Groundwater Number	Scenario 2 (ultimate approved-development) Drawdown (A)	Scenario 3 (proposed-development) Drawdown (B)	Changes to Drawdown (A)-(B)
GW065458	99.19	5.35	-93.83
GW100238	84.39	5.75	-78.64
GW063850	51.04	3.56	-47.48
GW101930	49.92	8.46	-41.46
GW066918	38.67	9.60	-29.07
GW047267	26.73	3.70	-23.03
GW047695	20.80	0.14	-20.67
GW104167	19.76	1.23	-18.52
GW051998 ¹	48.01	37.44	-10.57
GW100681	17.72	8.08	-9.64
GW049244	9.83	0.40	-9.43
GW049304	9.64	0.34	-9.30
GW101916	9.59	0.34	-9.25
GW056451	9.68	0.50	-9.18
GW101915	8.28	-0.66	-8.94
GW101664	8.32	0.32	-8.00
GW104097	8.31	0.31	-7.99
GW101511	8.21	0.22	-7.99
GW065892	22.82	15.12	-7.70
GW054992 ¹	48.28	40.98	-7.30
GW056649	16.20	10.23	-5.97
GW101920	8.92	3.29	-5.64

GW053607	10.11	5.64	-4.48
GW062121	5.72	1.87	-3.85
GW067551	9.54	6.28	-3.26
GW100835	25.68	22.43	-3.25
GW105609	14.32	11.75	-2.57
GW102423	27.36	26.52	-0.84
GW065477	1.68	0.96	-0.72
GW100786	0.47	0.03	-0.44
GW051443	-0.90	-1.09	-0.20
GW051774	-0.39	-0.41	-0.02
25th %ile	8.32	0.33	-12.56
median	12.22	3.42	-8.00
75th %ile	26.89	8.74	-3.70

Notes: 1. Bore located within proposed expansion site. 2. Negative change to drawdown corresponds with an increase in groundwater head.

6.2.2 Groundwater Quality Changes

Changes to groundwater quality are unlikely to result from quarrying activities. Preparation of site plans to ensure appropriate management of hydrocarbons and other potential contaminants along with suitable spill containment measures are likely to be sufficient to reduce the potential risk of contaminating the aquifer(s). No further mitigation measures are required.

6.2.3 Altered GDE Habitat

The ecological assessment for the project undertaken by RPS Harper Somers O'Sullivan (2009) indicates that the closest GDE's are present approximately 500 m to the south and south east of the proposed expansion site. These GDE's are classified as Sandstone Hanging Swamp and Hawkesbury Banksia Scrub. GDE's comprised of Sheltered Rough-barked Apple Forest and Sheltered Blue Gum Forest also exists adjacent to Mooney Creek (approximately 1 km west of site) (RPS Harper Somers O'Sullivan, 2009).

Drawdown results from the groundwater model indicate the following:

- The ultimate approved-development drawdown encroaches upon the mapped GDE's within RPS Harper Somers O'Sullivan (2009) comprised of Sandstone Hanging Swamp, Hawkesbury Banksia Scrub, Sheltered Rough-barked Apple Forest and Swamp Mahogany.
- The proposed-development drawdown encroaches upon the mapped GDE's within RPS Harper Somers O'Sullivan (2009) comprised of Sandstone Hanging Swamp, Hawkesbury Banksia Scrub, Sheltered Rough-barked Apple Forest and Swamp Mahogany. Mapped GDE's are subjected to less drawdown under the proposed than the ultimate approved-development.

Based on the above analysis the habitat of GDE's will be subjected to less drawdown under the proposed-development compared to the ultimate approved-development and therefore potential impacts will be less.

Mooney Mooney Creek and its tributaries are also likely to be GDE's as baseflow is likely to be required in times of low rainfall to maintain ecosystem health. If impacts to baseflow eventuate then impacts will be lower under proposed-development conditions compared to ultimate approved-development conditions based on analysis of drawdown results.

Conclusion

A groundwater assessment was undertaken to assess the impacts of the proposed boundary readjustment and expansion of the resource extraction operations of the existing Somersby Quarry (Central Coast Sands) into the proposed expansion site.

Potential impacts were assessed using a calibrated steady-state numerical Modflow groundwater flow model. Primary objectives of the model were to assess drawdown and groundwater ingress rates into the extraction pit for existing-approved and proposed-development scenarios.

Aquifer testing on the site including slug tests and a pump test produced a median K test value of 0.09 m/d. Final calibrated horizontal K values used in the groundwater model varied from 0.001 to 0.5 m/d with the majority of the model domain assigned a value of 0.0073 m/d. This value is in line with typically cited K values for the aquifers in the Somersby region and for aquifers within Hawkesbury Sandstone. Following model calibration recharge was determined to be 130 mm/yr on the ridge tops and surrounding areas and 40 mm/yr in steep hill slope areas and in depressions where groundwater discharge is likely to dominate. The groundwater model was calibrated to existing-development conditions/observations.

Results indicate that the steady-state groundwater inflow into the extraction pit is currently of the order of 277 KL/d, under the currently approved-development groundwater inflows shall be of the order of 806 KL/d. Groundwater inflows for the proposed-development shall be of the order of 404 KL/d.

The proposed lateral expansion of the quarry will result in reduced impact when compared to the ultimate approved-development due to the following:

- Groundwater extraction rates are modelled as approximately 50% lower (404 KL/d compared to 806 KL/d).
- Drawdown levels will be lower at all bores, that is the groundwater table will be closer to the ground surface under the proposed - development than under the ultimate approved - development. Modelling indicates that the proposed development will result in a reduction to median drawdown of approximately 8 m.

- Groundwater Dependent Ecosystems (GDEs) will experience less impact under the proposed – development compared to the ultimate approved – development. In particular GDEs adjacent to Mooney Mooney Creek are outside of the zone of influence of the proposed – development but are within the zone of influence of the ultimate approved – development.

Aquaterra (May, 2008), *Calga Sand Quarry Hydraulic Testing Program*.

Hitchcock. PW (1995), The Hydrogeology of the Newcastle-Gosford Region, *Engineering Geology of the Newcastle-Gosford Region*: Allman MA and Sloan SW (Eds), Australian Geomechanics Society.

Martens and Associates (July, 2008), *Preliminary Surface and Groundwater Assessment; Hanson Somersby Quarry Project*.

Merrick. N and Alkhatib. M (November, 2006), Groundwater Simulation and Optimisation Modelling of the Kulnura – Mangrove Mountain Aquifer Systems.

NSW DWE (2003), *Water Sharing Plan for the Kulnura Mangrove Mountain Groundwater Sources*.

Robert Carr and Associates Pty Ltd (1996), Draft Report on the Impact of the Proposed Somersby Sand Quarry on Regional Groundwater Flow Patterns – prepared for CSR Readymix.

RPS Harper Somers O'Sullivan (July, 2009), Draft Ecological Assessment for Central Coast Sands Quarry, Somersby.

9 Attachment A – Site Plan



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CLIENT/ PROJECT	TITLE		DESIGNED: BR	DATUM: AHD	SHEET 1 OF 1 SHEETS	REV. 1	DESCRIPTION FINAL	DATE 28.09.2009	ISSUED BR
HANSON CONSTRUCTION MATERIALS PTY LTD/ SOMERSBY QUARRY	SITE PLAN: QUARRY LAY-OUT, PROPOSED EXPANSION SITE AND LOCATION OF EXISTING PIEZOMETERS.		DRAWN: BR	HORIZONTAL RATIO: 1:5000 @ A3 1:2500 @ A1					
THIS PLAN MUST NOT BE USED FOR CONSTRUCTION UNLESS SIGNED AS APPROVED BY PRINCIPAL CERTIFYING AUTHORITY All measurements in multiples of 50mm specified	PROJECT MANAGER: MR ANDREW NORRIS	DRAWING NUMBER: P070194.9JD03_V1_SHEET1	REVIEWED: AN	VERTICAL RATIO: 1:5000 @ A3 1:2500 @ A1	PAPER SIZE: A1 / A3				

10 Attachment B – Borehole Logs and Rock Core Log

CLIENT		Hansen Construction Materials Pty Ltd		COMMENCED		21/07/09		COMPLETED		21/07/09		REF		BH1			
PROJECT		Hydrogeological Investigation		LOGGED		BR		CHECKED		AN		Sheet 1 of 1					
SITE		Somersby Quarry		GEOLOGY		Sandstone		VEGETATION		NA		PROJECT NO. P0701949					
EQUIPMENT			Auger			EASTING			-			RL SURFACE			253m AHD		
EXCAVATION DIMENSIONS			Ø 90mm X 1.45m depth			NORTHING			-			ASPECT			South		
SLOPE			5%														

EXCAVATION DATA					MATERIAL DATA					SAMPLING & TESTING				
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS	
A	Nil	N	M	0.5			SM	SILTY SAND – Dark grey.		-				
A	Nil	N	M	0.7			SP	SAND – Red, iron stone gravels (10-20mm, 50%).		-				
A	Nil	N	M	1.0			SC	CLAYEY SAND – Light yellow.		-				
				1.45				Borehole terminated at 1.45m on extremely weathered sandstone.						
				2.0										
				3.0										
				4.0										
				4.5										

EQUIPMENT / METHOD		SUPPORT		WATER		MOISTURE		PENETRATION		CONSISTENCY		DENSITY		SAMPLING & TESTING		CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION	
N	Natural exposure	SH	Shoring	N	None observed	D	Dry	VS	Very Soft	VL	Very Loose	A	Auger sample	pp	Pocket penetrometer	Y	USCS
X	Existing excavation	SC	Shotcrete	X	Not measured	M	Moist	S	Soft	L	Loose	B	Bulk sample	S	Standard penetration test	N	Agricultural
BH	Backhoe bucket	RB	Rock Bolts	W	Water level	W	Wet	F	Firm	MD	Medium Dense	U	Undisturbed sample	VS	Vane shear		
E	Excavator	Nil	No support	Wp	Plastic limit	H	High	St	Stiff	D	Dense	D	Disturbed sample	DCP	Dynamic cone penetrometer		
HA	Hand auger			WI	Liquid limit	R	Refusal	VSt	Very Stiff	VD	Very Dense	M	Moisture content	FD	Field density		
S	Hand spade							H	Hard			Ux	Tube sample (x mm)	WS	Water sample		
PT	Push tube							F	Friable								
A	Auger																
CC	Concrete Corer																

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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CLIENT		Hansen Construction Materials Pty Ltd				COMMENCED		21/07/09		COMPLETED		21/07/09		REF		BH2	
PROJECT		Hydrogeological Investigation				LOGGED		BR		CHECKED		AN		Sheet 1 of 1			
SITE		Somersby Quarry				GEOLOGY		Sandstone		VEGETATION		NA		PROJECT NO. P0701949			
EQUIPMENT				Auger				EASTING		-		RL SURFACE		248m AHD			
EXCAVATION DIMENSIONS				Ø 90mm X 2.0m depth				NORTHING		-		ASPECT		South		SLOPE 5%	
EXCAVATION DATA						MATERIAL DATA						SAMPLING & TESTING					
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.				CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS	
A	Nil	N	M	0.3			SP	SAND – Yellow.					-				
A	Nil	N	M	0.76			SC	CLAYEY SAND – Light brown.					-				
A	Nil	N	M	1.0 1.4 1.5			CL	SANDY CLAY – Yellow.					-			Groundwater observed at 1.4m bgl	
A	Nil	Y	W	2.0			EW	EXTREMELY WEATHERED SANDSTONE – Red, sugary.					-				
				3.0 4.0 4.5				Borehole terminated at 2.0m on extremely weathered sandstone.									
EQUIPMENT / METHOD		SUPPORT	WATER	MOISTURE	PENETRATION	CONSISTENCY	DENSITY	SAMPLING & TESTING		CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION							
N	Natural exposure	SH	Shoring	N	None observed	D	Dry	VS	Very Soft	VL	Very Loose	A	Auger sample	pp	Pocket penetrometer	Y	USCS
X	Existing excavation	SC	Shotcrete	M	Moist	S	Soft	L	Loose	B	Bulk sample	S	Standard penetration test	VS	Vane shear	N	Agricultural
BH	Backhoe bucket	RB	Rock Bolts	W	Wet	F	Firm	MD	Medium Dense	U	Undisturbed sample	D	Disturbed sample	DCP	Dynamic cone penetrometer		
E	Excavator	Nil	No support	Wp	Plastic limit	St	Stiff	D	Dense	M	Moisture content	Ux	Tube sample (x mm)	FD	Field density		
HA	Hand auger			WI	Liquid limit	VSt	Very Stiff	VD	Very Dense					WS	Water sample		
S	Hand spade					H	Hard										
PT	Push tube					F	Friable										
A	Auger																
CC	Concrete Corer																
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS																	
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CLIENT		Hansen Construction Materials Pty Ltd			COMMENCED		21/07/09		COMPLETED		21/07/09		REF		BH3				
PROJECT		Hydrogeological Investigation			LOGGED		BR		CHECKED		AN		Sheet 1 of 1						
SITE		Somersby Quarry			GEOLOGY		Sandstone		VEGETATION		Grass		PROJECT NO. P0701949						
EQUIPMENT				Auger			EASTING		-		RL SURFACE		250m AHD						
EXCAVATION DIMENSIONS				Ø 90mm X 2.3m depth			NORTHING		-		ASPECT		South		SLOPE 5%				
EXCAVATION DATA						MATERIAL DATA						SAMPLING & TESTING							
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.			CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS				
A	Nil	N	M	0.3			SM	SILTY SAND – Brown.				-							
A	Nil	N	M	0.7			SC	CLAYEY SAND – Reddish brown, ironstone gravels (10-20mm, 25%).				-							
A	Nil	N	M	1.0			SC	CLAYEY SAND – Yellow tending to dark yellow with depth.				-							
A	Nil	N	M	2.0			SC												
A	Nil	N	M	2.3			EW	EXTREMELY WEATHERED SANDSTONE – Dark yellow.											
				3.0				Borehole terminated at 2.3m on extremely weathered sandstone.											
				4.0															
				4.5															
EQUIPMENT / METHOD				SUPPORT		WATER		MOISTURE		PENETRATION		CONSISTENCY		DENSITY		SAMPLING & TESTING		CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION	
N	Natural exposure	SH	Shoring	N	None observed	D	Dry	L	Low	VS	Very Soft	VL	Very Loose	A	Auger sample	pp	Pocket penetrometer	Y	USCS
X	Existing excavation	SC	Shotcrete	X	Not measured	M	Moist	M	Moderate	S	Soft	L	Loose	B	Bulk sample	S	Standard penetration test	N	Agricultural
BH	Backhoe bucket	RB	Rock Bolts	W	Water level	W	Wet	H	High	F	Firm	MD	Medium Dense	U	Undisturbed sample	VS	Vane shear		
E	Excavator	Nil	No support	Wp	Plastic limit	R	Refusal	St	Stiff	D	Dense	D	Disturbed sample	DCP	Dynamic cone penetrometer				
HA	Hand auger			WI	Liquid limit			VSt	Very Stiff	VD	Very Dense	M	Moisture content	FD	Field density				
S	Hand spade							H	Hard	Ux	Tube sample (x mm)	WS	Water sample						
PT	Push tube							F	Friable										
A	Auger																		
CC	Concrete Corer																		
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS																			
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CLIENT		Hansen Construction Materials Pty Ltd		COMMENCED		21/07/09		COMPLETED		21/07/09		REF		BH4			
PROJECT		Hydrogeological Investigation		LOGGED		BR		CHECKED		AN		Sheet 1 of 1					
SITE		Somersby Quarry		GEOLOGY		Sandstone		VEGETATION		Grass		PROJECT NO. P0701949					
EQUIPMENT			Auger			EASTING			-			RL SURFACE			245m AHD		
EXCAVATION DIMENSIONS			Ø 90mm X 1.9m depth			NORTHING			-			ASPECT			South		
SLOPE												5%					

EXCAVATION DATA					MATERIAL DATA					SAMPLING & TESTING				
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS	
A	Nil	N	M	0.5			SM	SILTY SAND – Brown, red sandstone, gravels (10-15mm, 5%).						
A	Nil	N	M	1.0			SC	CLAYEY SAND – Honey brown.						
A	Nil	N	M	1.7			EW	EXTREMELY WEATHERED SANDSTONE.						
				2.0				Borehole terminated at 1.9m on extremely weathered sandstone.						
				3.0										
				4.0										
				4.5										

EQUIPMENT / METHOD		SUPPORT		WATER		MOISTURE		PENETRATION		CONSISTENCY		DENSITY		SAMPLING & TESTING		CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION	
N	Natural exposure	SH	Shoring	N	None observed	D	Dry	L	Low	VS	Very Soft	VL	Very Loose	A	Auger sample	pp	Pocket penetrometer
X	Existing excavation	SC	Shotcrete	X	Not measured	M	Moist	M	Moderate	S	Soft	L	Loose	B	Bulk sample	S	Standard penetration test
BH	Backhoe bucket	RB	Rock Bolts	W	Water level	W	Wet	H	High	F	Firm	MD	Medium Dense	U	Undisturbed sample	VS	Vane shear
E	Excavator	Nil	No support	Wp	Plastic limit	Wp	Plastic limit	R	Refusal	D	Dense	D	Disturbed sample	DCP	Dynamic cone penetrometer		
HA	Hand auger			WI	Liquid limit	WI	Liquid limit			VSt	Very Stiff	VD	Very Dense	M	Moisture content		
S	Hand spade									H	Hard			Ux	Tube sample (x mm)	FD	Field density
PT	Push tube									F	Friable					WS	Water sample
A	Auger																
CC	Concrete Corer																

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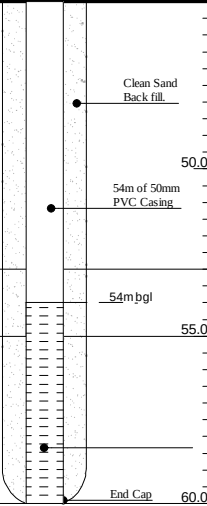
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Engineering Log - Borehole

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

CLIENT	Hansen Construction Materials Pty Ltd			COMMENCED	21/07/09		COMPLETED	21/07/09		REF BH5							
PROJECT	Hydrogeological Investigation			LOGGED	BR		CHECKED	AN		Sheet 1 of 1							
SITE	Somersby Quarry			GEOLOGY	Sandstone		VEGETATION	NA		PROJECT NO. P0701949							
EQUIPMENT		Auger			EASTING		-		RL SURFACE		248m AHD						
EXCAVATION DIMENSIONS		Ø 90mm X 0.7m depth			NORTHING		-		ASPECT		South						
SLOPE					5%												
EXCAVATION DATA					MATERIAL DATA					SAMPLING & TESTING							
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.		CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS			
A	Nil	N	M	0.3			SM	SILTY SAND – Brown, red sandstone, gravels (10-15mm, 5%).			-						
A	Nil	N	M	0.7			SC	CLAYEY SAND – Honey brown.			-						
				1.0				Borehole terminated at 0.7m on reddish brown residual soil.									
				2.0													
				3.0													
				4.0													
				4.5													
EQUIPMENT / METHOD		SUPPORT	WATER	MOISTURE	PENETRATION	CONSISTENCY	DENSITY	SAMPLING & TESTING		CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION							
N	Natural exposure	SH	Shoring	N	None observed	D	Dry	VS	Very Soft	VL	Very Loose	A	Auger sample	pp	Pocket penetrometer	Y	USCS
X	Existing excavation	SC	Shotcrete	X	Not measured	M	Moist	S	Soft	L	Loose	B	Bulk sample	S	Standard penetration test	N	Agricultural
BH	Backhoe bucket	RB	Rock Bolts	W	Water level	W	Wet	F	Firm	MD	Medium Dense	U	Undisturbed sample	VS	Vane shear		
E	Excavator	Nil	No support	Wp	Plastic limit	H	High	St	Stiff	D	Dense	D	Disturbed sample	DCP	Dynamic cone penetrometer		
HA	Hand auger			WI	Liquid limit	R	Refusal	VSt	Very Stiff	VD	Very Dense	M	Moisture content	FD	Field density		
S	Hand spade							H	Hard			Ux	Tube sample (x mm)	WS	Water sample		
PT	Push tube							F	Friable								
A	Auger																
CC	Concrete Corer																
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS																	
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CLIENT		Hansen Construction Materials Pty Ltd			COMMENCED		21/07/09		COMPLETED		21/07/09		REF		BH P1	
PROJECT		Hydrogeological Investigation			LOGGED		BR		CHECKED		AN		Sheet 1 of 1			
SITE		Somersby Quarry			GEOLOGY		Sandstone		VEGETATION		NA		PROJECT NO. P0701949			
EQUIPMENT				Down Hole Hammer			EASTING		-		RL SURFACE		200m AHD			
EXCAVATION DIMENSIONS				Ø 120mm X 40.0m depth			NORTHING		-		ASPECT		North West		SLOPE 0-2%	
EXCAVATION DATA					MATERIAL DATA					SAMPLING & TESTING						
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS			
A	Nil	Y	W	2.0				SANDSTONE – White/red, tending to reddish pink colour at 1m.			B	1.0	1949/P1/1.0	 Lockable Raised Well monument		
A	Nil	Y	W	3.0				SANDSTONE – Red.			B	3.0	1949/P1/3.0	Concrete		
A	Nil	Y	W					SANDSTONE – With clay seam, high proportion of clay.			B	4.9	1949/P1/4.9			
A	Nil	Y	W	8.0				SILTSTONE – Grey.			B	7.0	1949/P1/7.0	34m of 50mm PVC Casing		
A	Nil	Y	W	9.0				SANDSTONE – Blue/grey/white, coarse grained, high quartz grains.			B	8.5	1949/P1/8.5			
A	Nil	Y	W	12.0				SILTSTONE – Grey.						Clean Sand Back fill.		
A	Nil	Y	W	26.0				SANDSTONE – Light grey/blue/white, coarse grained, quartz grains.			B	26.0	1949/P1/26.0			
A	Nil	Y	W	34.2				SANDSTONE – Grey, fine grained.			B	32.0	1949/P1/32.0	34mbgl		
A	Nil	Y	W	36.0				SANDSTONE – Grey, coarse grained.			B	35.0	1949/P1/35.0	6.0m of 50mm screen covered in filter sock		
A	Nil	Y	W	40.0				SANDSTONE – Grey, fine grained.			B	40.0	1949/P1/40.0	End Cap		
								Borehole terminated at 40.0m on sandstone.								
EQUIPMENT / METHOD				SUPPORT	WATER	MOISTURE	PENETRATION	CONSISTENCY	DENSITY	SAMPLING & TESTING		CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION				
N Natural exposure				SH Shoring	N None observed	D Dry	L Low	VS Very Soft	VL Very Loose	A Auger sample		pp Pocket penetrometer		Y USCS		
X Existing excavation				SC Shotcrete	X Not measured	M Moist	M Moderate	S Soft	L Loose	B Bulk sample		S Standard penetration test		N Agricultural		
BH Backhoe bucket				RB Rock Bolts	Water level	W Wet	H High	F Firm	MD Medium Dense	U Undisturbed sample		VS Vane shear				
E Excavator				Nil No support	Water outflow	Wp Plastic limit	R Refusal	D Dense	VD Very Dense	D Disturbed sample		DCP Dynamic cone penetrometer				
HA Hand auger					Water inflow	WI Liquid limit		VSt Very Stiff		M Moisture content		FD Field density				
S Hand spade								H Hard		Ux Tube sample (x mm)		WS Water sample				
PT Push tube								F Friable								
A Auger																
CC Concrete Corer																
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS																
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CLIENT	Hansen Construction Materials Pty Ltd			COMMENCED	21/07/09		COMPLETED	21/07/09		REF BH P3						
PROJECT	Hydrogeological Investigation			LOGGED	BR		CHECKED	AN		Sheet 2 of 2						
SITE	Somersby Quarry			GEOLOGY	Sandstone		VEGETATION	Grass		PROJECT NO. P0701949						
EQUIPMENT		Down Hole Hammer			EASTING		-		RL SURFACE		248.5m AHD					
EXCAVATION DIMENSIONS		Ø 120mm X 60.0m depth			NORTHING		-		ASPECT		South					
									SLOPE		5-10%					
EXCAVATION DATA					MATERIAL DATA					SAMPLING & TESTING						
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS			
								Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.								
A	Nil	Y	W	50.0				SANDSTONE – Reddish pink/brown, coarse grained, high quartz content.								
				53.0												
A	Nil	Y	W	55.0				SANDSTONE – Grey, decreased quartz content, fine grained.								
				55.0												
A	Nil	Y	W	60.0				SANDSTONE – Reddish brown, high quartz content, coarse grained.								
				60.0												
				65.0				Borehole terminated at 60.0m on sandstone.								
				70.0												
				75.0												
				80.0												
				85.0												
				90.0												
EQUIPMENT / METHOD		SUPPORT	WATER	MOISTURE	PENETRATION	CONSISTENCY	DENSITY	SAMPLING & TESTING		CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION						
N	Natural exposure	SH	Shoring	N	None observed	D	Dry	VS	Very Soft	VL	Very Loose	A	Auger sample	pp	Pocket penetrometer	YUSCS N Agricultural
X	Existing excavation	SC	Shotcrete	M	Moist	L	Low	S	Soft	L	Loose	B	Bulk sample	S	Standard penetration test	
BH	Backhoe bucket	RB	Rock Bolts	W	Wet	F	Firm	MD	Medium Dense	MD	Medium Dense	U	Undisturbed sample	VS	Vane shear	
E	Excavator	Nil	No support	Wp	Plastic limit	St	Stiff	D	Dense	D	Dense	D	Disturbed sample	DCP	Dynamic cone penetrometer	
HA	Hand auger			WI	Liquid limit	VSt	Very Stiff	VD	Very Dense			M	Moisture content	FD	Field density	
S	Hand spade					H	Hard					Ux	Tube sample (x mm)	WS	Water sample	
PT	Push tube					F	Friable									
A	Auger															
CC	Concrete Corer															
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS																
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CLIENT		Hansen Construction Materials Pty Ltd				COMMENCED		21/07/09		COMPLETED		21/07/09		REF		BH P4	
PROJECT		Hydrogeological Investigation				LOGGED		BR		CHECKED		AN		Sheet 2 of 2			
SITE		Somersby Quarry				GEOLOGY		Sandstone		VEGETATION		Grass		PROJECT NO. P0701949			
EQUIPMENT		Down Hole Hammer				EASTING		-		RL SURFACE		251.0m AHD					
EXCAVATION DIMENSIONS		Ø 120mm X 60.0m depth				NORTHING		-		ASPECT		South		SLOPE		3%	
EXCAVATION DATA						MATERIAL DATA						SAMPLING & TESTING					
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA		CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS			
A	Nil	Y	W	50.0				SANDSTONE – Reddish brown, medium quartz content, variable colours.				B	49.0	1949/P4/ 49.0			
				55.0								B	57.0	1949/P4/ 57.0			
				60.0				Borehole terminated at 60.0m on sandstone.									
				65.0													
				70.0													
				75.0													
				80.0													
				85.0													
				90.0													
EQUIPMENT / METHOD		SUPPORT	WATER	MOISTURE	PENETRATION	CONSISTENCY	DENSITY	SAMPLING & TESTING		CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION							
N Natural exposure		SH Shoring	N None observed	D Dry	L Low	VS Very Soft	VL Very Loose	A Auger sample		pp Pocket penetrometer							
X Existing excavation		SC Shotcrete	X Not measured	M Moist	M Moderate	S Soft	L Loose	B Bulk sample		S Standard penetration test							
BH Backhoe bucket		RB Rock Bolts	▽ Water level	W Wet	H High	F Firm	MD Medium Dense	U Undisturbed sample		VS Vane shear							
E Excavator		Nil No support	⚠ Water outflow	Wp Plastic limit	R Refusal	St Stiff	D Dense	D Disturbed sample		DCP Dynamic cone							
HA Hand auger			⚡ Water inflow	Wl Liquid limit		VSt Very Stiff	VD Very Dense	M Moisture content		penetrometer							
S Hand spade						H Hard		Ux Tube sample (x mm)		FD Field density							
PT Push tube						F Friable				WS Water sample							
A Auger																	
CC Concrete Corer																	
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS																	
								MARTENS & ASSOCIATES PTY LTD 6/37 Leighton Place Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767 mail@martens.com.au WEB: http://www.martens.com.au									
Engineering Log - Borehole																	

CLIENT	HANSON QUARRIES		COMMENCED	30/7/09	COMPLETED	30/7/09	REF BH6							
PROJECT	GEOTECHNICAL INVESTIGATIONS		LOGGED	JSF	CHECKED	DMM	Sheet 1 of 10							
SITE	SOMERSBY		GEOLOGY	SANDSTONE	VEGETATION	-	PROJECT NO. P0701949							
EQUIPMENT	TRUCK MOUNTED RIG		EASTING	NA	RL SURFACE	-								
DRILLING FLUID	Water		NORTHING	NA	ASPECT	-	SLOPE	-						
DRILLING DATA			MATERIAL DATA			SAMPLING & DEFECT DATA								
METHOD	WATER	TCR	RQD (SCR)	DEPTH (M)	GRAPHIC LOG	DESCRIPTION OF STRATA Type, texture, structure, mottling, colour, oxidation, particle characteristics, organics, secondary & minor components, fill, contamination, odour.	WEATHERING	INFERRED STRENGTH Is ₅₀ MPa	DEFECT DESCRIPTIONS AND ADDITIONAL OBSERVATIONS	AVERAGE DEFECT SPACING (mm)				
				0.5m										
				1.0m										
				1.5m										
				2.0m										
				2.5m										
				3.0m										
				3.5m										
				4.0m										
				4.5m										
				5.0m										
				5.5m										
				5.8m										
				6.0m										
				6.5m										
				7.0m										
				7.5m										
				8.0m										
				8.5m										
				9.0m										
EQUIPMENT / METHOD N Natural exposure X Existing excavation HQ Diamond Core - 63 mm NMLC Diamond Core - 52 mm NQ Diamond Core - 47 mm A Auger			WATER N None observed X Not measured ▽ Water level △ Water outflow ▽ Water inflow			WEATHERING Rs Residual Soil EW Extremely Weathered HW Highly Weathered MW Moderately Weathered SW Slightly Weathered Fr Fresh Rock			CORE DATA TCR Total Core Recovery (%) RQD Rock Quality Designation (%) SCR Solid Core Recovery (%)			ROCK STRENGTH TEST RESULTS ▼ Point load strength Index (Is50) - axial test (MPa) ► Point load strength Index (Is50) - diametral test (MPa) ● Unconfined compressive strength (UCS) (MPa)		
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS														
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CLIENT	HANSON QUARRIES		COMMENCED	30/7/09	COMPLETED	30/7/09	REF BH6			
PROJECT	GEOTECHNICAL INVESTIGATIONS		LOGGED	JSF	CHECKED	DMM	Sheet 2 of 10			
SITE	SOMERSBY		GEOLOGY	SANDSTONE	VEGETATION	-	PROJECT NO. P0701949			
EQUIPMENT	TRUCK MOUNTED RIG		EASTING	NA	RL SURFACE	-				
DRILLING FLUID	Water		NORTHING	NA	ASPECT	-	SLOPE	-		
DRILLING DATA			MATERIAL DATA				SAMPLING & DEFECT DATA			
METHOD	WATER	TCR	RQD (SCR)	DEPTH (M)	GRAPHIC LOG	DESCRIPTION OF STRATA Type, texture, structure, mottling, colour, oxidation, particle characteristics, organics, secondary & minor components, fill, contamination, odour.	WEATHERING	INFERRED STRENGTH Is ₅₀ MPa	DEFECT DESCRIPTIONS AND ADDITIONAL OBSERVATIONS	AVERAGE DEFECT SPACING (mm)
				9.5m						
				10.0m						
				10.5m						
				11.0m						
				11.5m						
				12.0m						
				12.5m						
				13.0m						
				13.5m						
				14.0m						
				14.5m		SANDSTONE - Moderately to slightly weathered, highly fractured.				
				14.8m						
				15.0m						
				15.5m						
				16.0m		SANDSTONE - Medium grained, slightly weathered, slightly fractured.				
				16.5m						
				17.0m						
				17.5m						
				18.0m						
EQUIPMENT / METHOD			WATER		WEATHERING		CORE DATA		ROCK STRENGTH TEST RESULTS	
N Natural exposure			N None observed		Rs Residual Soil		TCR Total Core Recovery (%)		▼ Point load strength Index (Is50) - axial test (MPa)	
X Existing excavation			X Not measured		EW Extremely Weathered		RQD Rock Quality Designation (%)		► Point load strength Index (Is50) - diametral test (MPa)	
HQ Diamond Core - 63 mm			▽ Water level		HW Highly Weathered		SCR Solid Core Recovery (%)		● Unconfined compressive strength (UCS) (MPa)	
NMLC Diamond Core - 52 mm			△ Water outflow		MW Moderately Weathered					
NQ Diamond Core - 47 mm			▽ Water inflow		SW Slightly Weathered					
A Auger					Fr Fresh Rock					
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS										
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CLIENT		HANSON QUARRIES		COMMENCED		30/7/09		COMPLETED		30/7/09		REF		BH3					
PROJECT		GEOTECHNICAL INVESTIGATIONS		LOGGED		JSF		CHECKED		DMM		Sheet 3 of 10							
SITE		SOMERSBY		GEOLOGY		SANDSTONE		VEGETATION		-		PROJECT NO. P0701949							
EQUIPMENT			TRUCK MOUNTED RIG			EASTING			NA			RL SURFACE			-				
DRILLING FLUID			Water			NORTHING			NA			ASPECT			-				
DRILLING DATA					MATERIAL DATA							SAMPLING & DEFECT DATA							
METHOD	WATER	TCR	RQD (SCR)	DEPTH (M)	GRAPHIC LOG	DESCRIPTION OF STRATA Type, texture, structure, mottling, colour, oxidation, particle characteristics, organics, secondary & minor components, fill, contamination, odour.	WEATHERING	INFERRED STRENGTH Is ₅₀ MPa						DEFECT DESCRIPTIONS AND ADDITIONAL OBSERVATIONS	AVERAGE DEFECT SPACING (mm)				
								EW	0.03	0.1	0.3	1	3		10	100	1000	10000	-10
				18.5m		SANDSTONE - Fine to medium grained, slightly weathered, slightly fractured.													
				19.0m															
				19.5m															
				20.0m															
				20.5m															
				21.0m															
				21.5m															
				22.0m															
				22.5m		SANDSTONE - Medium grained, slightly weathered, highly fractured.													
				22.9m															
				23.0m															
				23.5m		SANDSTONE - Moderately to slightly weathered, highly fractured.													
				23.9m															
				24.0m									(Highly fractured from 24.05 - 24.10m)						
				24.5m		SANDSTONE - Fine grained, slightly weathered, slightly fractured.													
				25.0m															
				25.1m		SANDSTONE - Slightly weathered, highly fractured.													
				25.5m		SANDSTONE - Fine grained, slightly weathered, fractured.													
				26.0m															
				26.5m		SANDSTONE - Medium grained, slightly weathered, slightly fractured.													
				27.0m															
EQUIPMENT / METHOD N Natural exposure X Existing excavation HQ Diamond Core - 63 mm NMLC Diamond Core - 52 mm NQ Diamond Core - 47 mm A Auger				WATER N None observed X Not measured Water level Water outflow Water inflow				WEATHERING Rs Residual Soil EW Extremely Weathered HW Highly Weathered MW Moderately Weathered SW Slightly Weathered Fr Fresh Rock				CORE DATA TCR Total Core Recovery (%) RQD Rock Quality Designation (%) SCR Solid Core Recovery (%)				ROCK STRENGTH TEST RESULTS Point load strength Index (Is50) - axial test (MPa) Point load strength Index (Is50) - diametral test (MPa) Unconfined compressive strength (UCS) (MPa)			
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS																			
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CLIENT		HANSON QUARRIES		COMMENCED		30/7/09		COMPLETED		30/7/09		REF		BH6			
PROJECT		GEOTECHNICAL INVESTIGATIONS		LOGGED		JSF		CHECKED		DMM		Sheet 4 of 10					
SITE		SOMERSBY		GEOLOGY		SANDSTONE		VEGETATION		-		PROJECT NO. P0701949					
EQUIPMENT			TRUCK MOUNTED RIG			EASTING			NA			RL SURFACE			-		
DRILLING FLUID			Water			NORTHING			NA			ASPECT			-		
DRILLING DATA					MATERIAL DATA							SAMPLING & DEFECT DATA					
METHOD	WATER	TCR	RQD (SCR)	DEPTH (M)	GRAPHIC LOG	DESCRIPTION OF STRATA Type, texture, structure, mottling, colour, oxidation, particle characteristics, organics, secondary & minor components, fill, contamination, odour.	WEATHERING	INFERRED STRENGTH Is ₅₀ MPa	DEFECT DESCRIPTIONS AND ADDITIONAL OBSERVATIONS				AVERAGE DEFECT SPACING (mm)				
				27.5m		SANDSTONE - Medium grained, slightly weathered, slightly fractured.			(With some coarse grained section)								
				28.0m													
				28.5m													
				29.0m													
				29.5m		SANDSTONE - Coarse grained, slightly weathered, highly fractured.			(Joint observed from 29.5 - 30.3m, 75-80°)								
				30.0m													
				30.4m													
				30.5m		SANDSTONE - Medium grained, slightly weathered, slightly fractured.											
				31.0m													
				31.5m													
				32.0m													
				32.5m		SANDSTONE - Moderately weathered, fractured.											
				32.6m													
				33.0m													
				33.5m													
				34.0m		SANDSTONE - Medium grained, grading to coarse grain with depth, slightly weathered, slightly fractured.											
				34.25m													
				34.5m													
				34.65m													
				35.0m		SANDSTONE - Medium grained, slightly weathered, slightly fractured.											
				35.5m													
				36.0m													

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
HQ Diamond Core - 63 mm
NMLC Diamond Core - 52 mm
NQ Diamond Core - 47 mm
A Auger

WATER
N None observed
X Not measured
 Water level
 Water outflow
 Water inflow

WEATHERING
Rs Residual Soil
EW Extremely Weathered
HW Highly Weathered
MW Moderately Weathered
SW Slightly Weathered
Fr Fresh Rock

CORE DATA
TCR Total Core Recovery (%)
RQD Rock Quality Designation (%)
SCR Solid Core Recovery (%)

ROCK STRENGTH TEST RESULTS
 Point load strength Index (Is50) - axial test (MPa)
 Point load strength Index (Is50) - diametral test (MPa)
 Unconfined compressive strength (UCS) (MPa)

Quality Sheet No. 5

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Engineering Log -

Cored Borehole

CLIENT		HANSON QUARRIES		COMMENCED		30/7/09		COMPLETED		30/7/09		REF		BH6			
PROJECT		GEOTECHNICAL INVESTIGATIONS		LOGGED		JSF		CHECKED		DMM		Sheet 5 of 10					
SITE		SOMERSBY		GEOLOGY		SANDSTONE		VEGETATION		-		PROJECT NO. P0701949					
EQUIPMENT			TRUCK MOUNTED RIG			EASTING			NA			RL SURFACE			-		
DRILLING FLUID			Water			NORTHING			NA			ASPECT			-		
DRILLING DATA			MATERIAL DATA						SAMPLING & DEFECT DATA								
METHOD	WATER	TCR	RQD (SCR)	DEPTH (M)	GRAPHIC LOG	DESCRIPTION OF STRATA Type, texture, structure, mottling, colour, oxidation, particle characteristics, organics, secondary & minor components, fill, contamination, odour.		WEATHERING	INFERRED STRENGTH Is ₅₀ MPa		DEFECT DESCRIPTIONS AND ADDITIONAL OBSERVATIONS			AVERAGE DEFECT SPACING (mm)			
				36.5m													
				37.0m													
				37.5m													
				38.0m													
				38.5m													
				39.0m													
				39.5m													
				40.0m													
				40.5m													
				41.0m													
				41.5m													
				42.0m													
				42.5m													
				42.7m													
				43.0m													
				43.5m													
				43.6m													
				44.0m													
				44.5m													
				45.0m													
EQUIPMENT / METHOD		WATER		WEATHERING		CORE DATA		ROCK STRENGTH TEST RESULTS									
N	Natural exposure	N	None observed	Rs	Residual Soil	TCR	Total Core Recovery (%)	▼ Point load strength Index (Is50) - axial test (MPa)									
X	Existing excavation	X	Not measured	EW	Extremely Weathered	RQD	Rock Quality Designation (%)	► Point load strength Index (Is50) - diametral test (MPa)									
HQ	Diamond Core - 63 mm	△	Water level	HW	Highly Weathered	SCR	Solid Core Recovery (%)	● Unconfined compressive strength (UCS) (MPa)									
NMLC	Diamond Core - 52 mm	▽	Water outflow	MW	Moderately Weathered												
NQ	Diamond Core - 47 mm	▽	Water inflow	SW	Slightly Weathered												
A	Auger			Fr	Fresh Rock												
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS																	
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CLIENT		HANSON QUARRIES		COMMENCED		30/7/09		COMPLETED		30/7/09		REF		BH6			
PROJECT		GEOTECHNICAL INVESTIGATIONS		LOGGED		JSF		CHECKED		DMM		Sheet 6 of 10					
SITE		SOMERSBY		GEOLOGY		SANDSTONE		VEGETATION		-		PROJECT NO. P0701949					
EQUIPMENT			TRUCK MOUNTED RIG			EASTING			NA			RL SURFACE			-		
DRILLING FLUID			Water			NORTHING			NA			ASPECT			-		
DRILLING DATA					MATERIAL DATA							SAMPLING & DEFECT DATA					
METHOD	WATER	TCR	RQD (SCR)	DEPTH (M)	GRAPHIC LOG	DESCRIPTION OF STRATA Type, texture, structure, mottling, colour, oxidation, particle characteristics, organics, secondary & minor components, fill, contamination, odour.	WEATHERING	INFERRED STRENGTH Is ₅₀ MPa	DEFECT DESCRIPTIONS AND ADDITIONAL OBSERVATIONS			AVERAGE DEFECT SPACING (mm)					
				45.5m		SANDSTONE - Medium to fine grained, slightly weathered, slightly fractured.			(Quartz layer at 45.5 - 45.52m)								
				46.0m													
				46.5m													
				47.0m													
				47.1m		CRUSHED SANDSTONE SEAM.											
				47.5m		SANDSTONE - Medium to fine grained, slightly weathered, slightly fractured.											
				48.0m													
				48.5m													
				49.0m													
				49.5m		SANDSTONE - Medium to fine grained, slightly weathered, slightly fractured.											
				50.0m													
				50.5m													
				51.0m													
				51.5m		SANDSTONE - Medium grained, moderately weathered, highly fractured.											
				51.8m													
				52.0m													
				52.5m													
				53.0m		SANDSTONE - Medium grained, slightly weathered, slightly fractured.											
				53.5m													
				54.0m													

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
HQ Diamond Core - 63 mm
NMLC Diamond Core - 52 mm
NQ Diamond Core - 47 mm
A Auger

WATER
N None observed
X Not measured
 Water level
 Water outflow
 Water inflow

WEATHERING
Rs Residual Soil
EW Extremely Weathered
HW Highly Weathered
MW Moderately Weathered
SW Slightly Weathered
Fr Fresh Rock

CORE DATA
TCR Total Core Recovery (%)
RQD Rock Quality Designation (%)
SCR Solid Core Recovery (%)

ROCK STRENGTH TEST RESULTS
 Point load strength Index (Is50) - axial test (MPa)
 Point load strength Index (Is50) - diametral test (MPa)
 Unconfined compressive strength (UCS) (MPa)

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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**Engineering Log -
Cored Borehole**

CLIENT		HANSON QUARRIES		COMMENCED		30/7/09		COMPLETED		30/7/09		REF		BH6						
PROJECT		GEOTECHNICAL INVESTIGATIONS		LOGGED		JSF		CHECKED		DMM		Sheet 7 of 10								
SITE		SOMERSBY		GEOLOGY		SANDSTONE		VEGETATION		-		PROJECT NO. P0701949								
EQUIPMENT			TRUCK MOUNTED RIG			EASTING			NA			RL SURFACE			-					
DRILLING FLUID			Water			NORTHING			NA			ASPECT			-					
DRILLING DATA					MATERIAL DATA							SAMPLING & DEFECT DATA								
METHOD	WATER	TCR	RQD (SCR)	DEPTH (M)	GRAPHIC LOG	DESCRIPTION OF STRATA Type, texture, structure, mottling, colour, oxidation, particle characteristics, organics, secondary & minor components, fill, contamination, odour.	WEATHERING	INFERRED STRENGTH Is ₅₀ MPa						DEFECT DESCRIPTIONS AND ADDITIONAL OBSERVATIONS	AVERAGE DEFECT SPACING (mm)					
								BW	-0.03	WI	-0.1	SW	-0.3		WS	-1	SS	-3	SS	-10
				54.5m		SANDSTONE - Medium grained, slightly weathered, slightly fractured.														
			55m																	
			55.5m																	
			55.9m																	
				56.0m		SILTSTONE - Slightly weathered.														
				56.4m		SANDSTONE - Medium grained, slightly weathered, slightly fractured.														
				56.45m		SILTSTONE - Slightly weathered.														
				56.5m																
				57.0m		SANDSTONE - Medium to coarse grained, slightly weathered, fractured.														
				57.45m																
				57.5m		SILTSTONE - Slightly weathered.														
				58.0m																
				58.5m		SANDSTONE - Medium grained, slightly weathered, slightly fractured.														
				58.8m																
				59.0m		SANDSTONE - Medium grained, slightly weathered, fractured.														
				59.5m																
				60.0m		SANDSTONE - Fine to medium grained, slightly weathered, slightly fractured.														
				60.5m																
				61.0m																
				61.5m																
				62.0m																
				62.5m																
				63.0m																
EQUIPMENT / METHOD		N Natural exposure		WATER		N None observed		WEATHERING		Rs Residual Soil		CORE DATA		TCR Total Core Recovery (%)		ROCK STRENGTH TEST RESULTS		▼ Point load strength Index (Is50) - axial test (MPa)		
X Existing excavation				X Not measured		EW Extremely Weathered		EW Highly Weathered		MW Moderately Weathered		RQD Rock Quality Designation (%)		SCR Solid Core Recovery (%)		► Point load strength Index (Is50) - diametral test (MPa)				
HQ Diamond Core - 63 mm				Water level		SW Slightly Weathered		Fr Fresh Rock								● Unconfined compressive strength (UCS) (MPa)				
NMLC Diamond Core - 52 mm				Water outflow																
NQ Diamond Core - 47 mm				Water inflow																
A Auger																				
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS																				
		MARTENS & ASSOCIATES PTY LTD 6/37 Leighton Place Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767 mail@martens.com.au WEB: http://www.martens.com.au										Engineering Log - Cored Borehole								

CLIENT	HANSON QUARRIES		COMMENCED	30/7/09	COMPLETED	30/7/09	REF BH6										
PROJECT	GEOTECHNICAL INVESTIGATIONS		LOGGED	JSF	CHECKED	DMM	Sheet 9 of 10										
SITE	SOMERSBY		GEOLOGY	SANDSTONE	VEGETATION	-	PROJECT NO. P0701949										
EQUIPMENT	TRUCK MOUNTED RIG		EASTING	NA	RL SURFACE	-											
DRILLING FLUID	Water		NORTHING	NA	ASPECT	-	SLOPE	-									
DRILLING DATA			MATERIAL DATA			SAMPLING & DEFECT DATA											
METHOD	WATER	TCR	RQD (SCR)	DEPTH (M)	GRAPHIC LOG	DESCRIPTION OF STRATA Type, texture, structure, mottling, colour, oxidation, particle characteristics, organics, secondary & minor components, fill, contamination, odour.	WEATHERING	INFERRED STRENGTH Is ₅₀ MPa	DEFECT DESCRIPTIONS AND ADDITIONAL OBSERVATIONS	AVERAGE DEFECT SPACING (mm)							
				72.5m		SANDSTONE - Fine to medium grained, fresh, slightly fractured.											
				73m													
				73.5m													
				74.0m													
				74.5m													
				75.0m													
				75.5m													
				76.0m													
				76.5m													
				77.0m		SANDSTONE - Medium grained, slightly weathered, fractured.											
				77.5m													
				78.0m													
				78.5m													
				78.7m													
				79.0m		CONGLOMERATE - Slightly weathered, quartz gravels (5-10mm), fractured.											
				79.5m													
				79.6m													
				80.0m		SANDSTONE - Fine to medium grained, slightly weathered, slightly fractured.											
				80.5m													
				81.0m													
EQUIPMENT / METHOD N Natural exposure X Existing excavation HQ Diamond Core - 63 mm NMLC Diamond Core - 52 mm NQ Diamond Core - 47 mm A Auger			WATER N None observed X Not measured Water level Water outflow Water inflow			WEATHERING Rs Residual Soil EW Extremely Weathered HW Highly Weathered MW Moderately Weathered SW Slightly Weathered Fr Fresh Rock			CORE DATA TCR Total Core Recovery (%) RQD Rock Quality Designation (%) SCR Solid Core Recovery (%)			ROCK STRENGTH TEST RESULTS Point load strength Index (Is50) - axial test (MPa) Point load strength Index (Is50) - diametral test (MPa) Unconfined compressive strength (UCS) (MPa)					
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS																	
 Martens						MARTENS & ASSOCIATES PTY LTD 6/37 Leighton Place Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767 mail@martens.com.au WEB: http://www.martens.com.au						Engineering Log - Cored Borehole					

CLIENT	HANSON QUARRIES		COMMENCED	30/7/09		COMPLETED	30/7/09		REF BH6			
PROJECT	GEOTECHNICAL INVESTIGATIONS		LOGGED	JSF		CHECKED	DMM		Sheet 10 of 10			
SITE	SOMERSBY		GEOLOGY	SANDSTONE		VEGETATION	-		PROJECT NO. P0701949			
EQUIPMENT		TRUCK MOUNTED RIG		EASTING	NA		RL SURFACE		-			
DRILLING FLUID		Water		NORTHING	NA		ASPECT		-			
DRILLING DATA			MATERIAL DATA				SAMPLING & DEFECT DATA					
METHOD	WATER	TCR	RQD (SCR)	DEPTH (M)	GRAPHIC LOG	DESCRIPTION OF STRATA Type, texture, structure, mottling, colour, oxidation, particle characteristics, organics, secondary & minor components, fill, contamination, odour.	WEATHERING	INFERRED STRENGTH Is ₅₀ MPa		DEFECT DESCRIPTIONS AND ADDITIONAL OBSERVATIONS	AVERAGE DEFECT SPACING (mm)	
				81.5m		SANDSTONE - Fine to medium grained, slightly weathered, slightly fractured.						
				82m								
				82.5m								
				83.0m								
				83.5m								
				84.0m		SANDSTONE - Coarse grained, slightly weathered, slightly fractured.						
				84.1m								
				84.5m		SANDSTONE - Fine to medium grained, slightly weathered, slightly fractured.						
				85.0m								
				85.5m								
				86.0m								
				86.5m								
				87.0m		END OF CORED BOREHOLE AT 86.0m.						
				87.5m								
				88.0m								
				88.5m								
				89.0m								
				89.5m		END OF CORED BOREHOLE AT 86.0m.						
				90.0m								
EQUIPMENT / METHOD		WATER		WEATHERING		CORE DATA		ROCK STRENGTH TEST RESULTS				
N Natural exposure		N None observed		Rs Residual Soil		TCR Total Core Recovery (%)		▼ Point load strength Index (Is50) - axial test (MPa)				
X Existing excavation		X Not measured		EW Extremely Weathered		RQD Rock Quality Designation (%)		► Point load strength Index (Is50) - diametral test (MPa)				
HQ Diamond Core - 63 mm		Water level		HW Highly Weathered		SCR Solid Core Recovery (%)		● Unconfined compressive strength (UCS) (MPa)				
NMLC Diamond Core - 52 mm		Water outflow		MW Moderately Weathered								
NQ Diamond Core - 47 mm		Water inflow		SW Slightly Weathered								
A Auger				Fr Fresh Rock								
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS												
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						Engineering Log - Cored Borehole						

11 **Attachment C – Local Bore Data Summary**

Groundwater Bore No. on Figure 1	Groundwater Number	LIC-Number	Authorised Purposes	Yield (L/S)	Salinity (mg/L)	Location (northing, easting)	Distance from subject site (km)	Bore depth (m)	Bore surface level (mAHD)	Standing water level (mBGL/mAHD)	Water bearing zones (mBGL)
1	GW080166	-	Monitoring (DWE)	0.5	80	6303107, 338124	1.40	40.50	208	19.15/188.85	16.00-18.00, 34.00-37.00
2	GW056451	20WA100737	Stock	0.10	'good'	6303628, 338565	1.00	66.00	200	14.00/186.00	36.00-37.00
3	GW101915	20WA100361	Domestic Industrial Stock	0.80	'fresh'	6303777, 338359	0.90	61.00	208	9.00/199.00	35.80-37.20, 54.80-56.50
4	GW049244	20WA100361	Domestic Industrial Stock	-	-	6303846, 338742	0.81	38.10	230	-	19.80-20.00, 26.00-26.10, 30.00-30.50
5	GW101916	20WA100828	Domestic Stock	0.25	'fresh'	6303615, 339032	0.94	78.00	210	16.70/193.30	40.30-42.80, 71.50-73.20
6	GW049304	20WA100728	Domestic Stock	-	'good'	6303821, 339053	0.78	45.80	230	-	19.80-20.00
7	GW104167	20BL159919	Test Bore	0.34	'fresh'	6304211, 338665	0.56	91.00	238	-	52.10-52.80
8	GW047695	20WA100781	Domestic Stock	-	'good'	6304219, 338943	0.53	61.00	231	-	21.00-30.00, 53.00-54.00
9	GW063850	20WA100763	Domestic	-	-	6304527, 338938	0.31	55.00	238	-	24.40-25.40, 42.60-43.60
10	GW047267	20WA100746	Domestic Farming	-	0-500ppm	6304443, 339430	0.47	30.50	238	-	29.00-30.00
11	GW100238	20WA100800	Domestic Stock	-	-	6304793, 339041	0.10	30.00	245	-	-
12	GW065458	-	Domestic	-	'fresh'	6304837, 339010	0.10	51.00	244	-	16.80-17.00, 40.90-41.20
13	GW104097	20CA100357	Domestic Industrial	0.19	-	6304697, 339631	0.53	91.44	241	-	-

Irrigation Stock											
14	GW066918	-	-	0.25	'fresh'	6304814, 339502	0.40	-	260	-	28.80-29.00, 42.10-42.40
15	GW101511	20WA100359	Domestic Industrial Stock	5.00	'fresh'	6304072, 340338	1.25	66.00	210	18.00/192.00	32.00-33.00, 50.10-50.90, 63.00-63.80
16	GW101664	20WA100833	Domestic Stock (Test Bore)	0.63	'fresh'	6304431, 340062	0.90	90.00	230	27.00/203.00	60.50-61.20, 73.10-74.00, 85.60-86.80
17	GW100681	20WA100823	Domestic Stock	-	'fresh'	6304950, 339937	0.72	61.00	251	-	8.00-8.40, 44.50-45.00
18	GW101920	20WA100830	Domestic Stock	0.36	'fresh'	6305140, 340288	1.30	66.00	250	20.00/230.00	24.20-26.00, 61.60-63.90
19	GW062121	20CA100325	Industrial	-	-	6305295, 340631	1.28	43.00	261	-	14.80-15.10, 36.70-38.80
20	GW065892	-	Domestic	-	'fresh'	6305220, 339805	0.59	34.00	260	-	8.00-8.20, 29.80-30.40
21	GW056649	20WA100739	Domestic	-	'unknown'	6305283, 339933	0.70	46.00	260	-	18.20-18.50, 30.30-30.80, 41.70-42.00
22	GW053607	20WA100761	Domestic Stock	-	'fresh'	6305348, 340139	0.87	62.00	260	-	18.10-18.20, 41.60-42.00, 56.80-56.90
23	GW067551	-	Domestic	-	'fresh'	6305515, 340096	0.84	34.00	255	-	17.80-18.10, 29.90-31.60
24	GW100835	20WA100363	Domestic Stock	0.33	-	6305412, 339724	0.51	61.00	258	-	-
25	GW054992	20WA100736	Domestic Stock	-	'good'	6305460, 339439	0.28	68.00	250	-	21.00-24.00, 51.00-53.00
26	GW051998	20WA100734	Domestic Stock	-	'good'	6305552, 339412	0.28	45.00	251	-	19.00-20.00, 35.00-38.00
27	GW102423	20WA100835	Domestic	0.00	-	6305587, 339644	0.47	18.29	253	3.05/249.95	-

28	GW105609	20BL162049	Domestic Stock	-	-	6305801, 339759	0.58	-	246	-	-
29	GW101930	20WA100367	Domestic Industrial	0.37	'fresh'	6305876, 339121	0.20	64.00	236	10.00/226.00	13.30-15.00, 46.80-49.10
30	GW100786	20WA100786	Domestic Stock	0.33	'fresh'	6305778, 338049	0.59	61.00	90	7.00/83.00	18.10-18.30, 36.30-36.70
31	GW065477	20WA100333	Domestic Industrial	-	-	6306254, 339590	0.66	92.00	217	4.00/213.00	-
32	GW051443	20WA100735	Stock	-	'unknown'	6306357, 339631	0.69	36.00	210	-	17.40-18.00, 29.60-30.00
33	GW051774	20WA100732	Domestic Stock	-	'fresh'	6306921, 340216	1.34	42.00	250	-	26.40-26.70
34	GW103340	20WA100843	Domestic Stock	-	'fresh'	6307292, 339860	1.36	73.00	267	-	19.60-21.10, 70.10-70.50
35	GW061190	20WA100757	Domestic	-	'fresh'	6307159, 339695	1.25	31.00	269	-	18.20-18.50, 27.40-27.90
36	GW059946	20WA100749	Domestic Stock	-	'fresh'	6307156, 339540	1.17	42.00	260	-	2.90-4.10, 36.20-36.80
37	GW052895	20WA100725	Domestic Stock	-	'good'	6307277, 339383	1.22	62.60	248	-	29.00-30.00, 35.00-36.00, 50.00-51.00
38	GW066915	-	-	-	-	6307338, 339356	1.25	-	245	-	-
39	GW066914	-	-	-	-	6307430, 339355	1.31	-	245	-	-
40	GW105691	20WA100848	Domestic Stock			6307555, 339044	1.37	-	222	-	-

12 Attachment D – Model Set-up, Aquifer Properties, Boundary Conditions and Calibration

Model Domain

Spatial and temporal discretisation of the model domain is summarised in Table 7 with the model domain shown in Figure 6.

Table 7: Temporal and spatial discretisation details for the amended MODFLOW groundwater model.

Temporal Discretisation	
Model type	Steady State
Simulation Time	365 days (for mass balance calculations)
Spatial Discretisation	
Model Origin – easting, northing (AMG)	337000, 6303800
Model Upper Right Corner – easting, northing (AMG)	341000, 6306800
Grid Size (m)	uniform: 20 x 20 m
Rows/Columns	150/200
Model Area (ha)	1200 (4000 m x 3000 m)
Layers	
1	Considered to represent a single unconfined layer of Hawkesbury Sandstone with the base level set at 0 mAHD.

Aquifer Properties

Final calibration involved multiple K zones where vertical conductivity (K_v) was assumed to be an order of magnitude lower than horizontal conductivity ($K_{x,y}$). Final calibrated K zones and values are outlined in Figure 5. K zones and values were assigned iteratively until best calibration results were achieved. Calibration was undertaken manually.

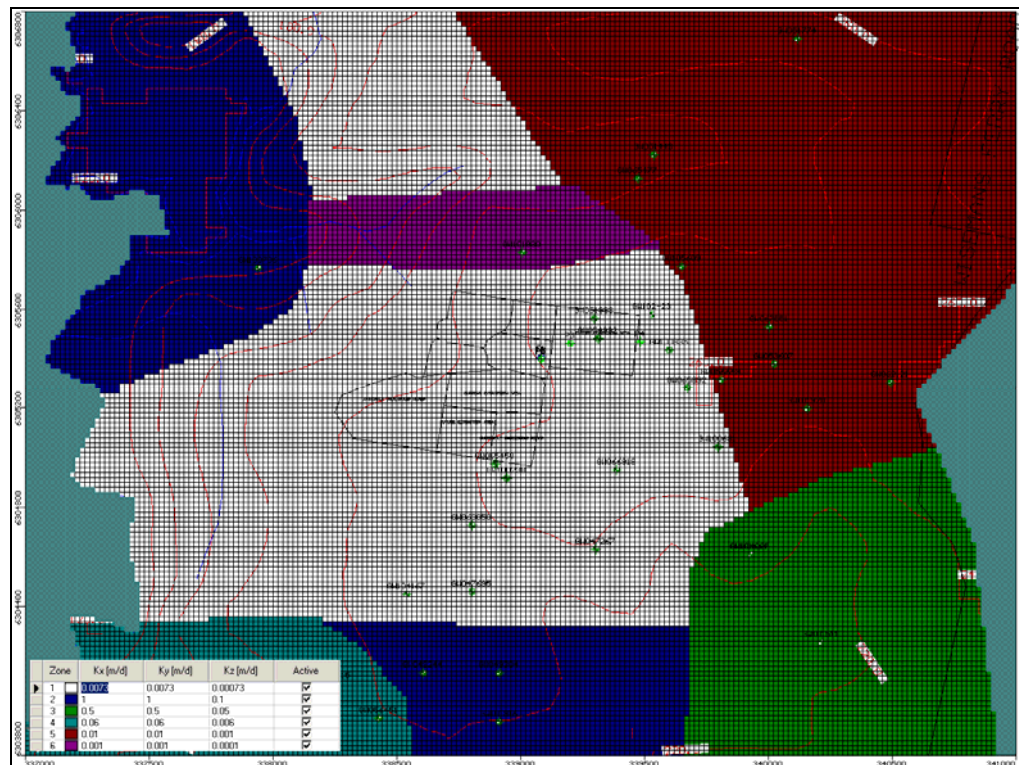


Figure 5: Calibrated K zones and values.

Boundary Conditions

Boundary conditions used in the model are summarised below and depicted in the model extract along with boundary condition input parameters (Figure 6).

1. Inactive flow – this was used to represent areas within the model domain to the west of Mooney Creek and also areas to the east of the ridge near Wisemans Ferry Road.
2. Path-line boundary – this was used to border the northern and southern edges of the model domain. A path-line boundary can be used normal to the groundwater head contours. In this case the model domain represents the edge of the path-line boundary.
3. River boundary – this was used to represent Mooney Creek. The dam area was assigned a river stage of 100 mAHD, riverbed bottom of 98 mAHD and a conductance of 4 m²/d. The reach downstream of the dam had the same conductance value but river stage and riverbed bottom were reduced lineally.
4. Drain boundary – this was used to represent base-flow or spring-flow in the vicinity of two drainage lines. The drains representing

these drainage lines were assigned an elevation of 1 mBGL and a conductance of 8 m²/d. This has the effect of removing water from the model once the head in a cell becomes higher than the drain elevation in the cell.

A drain boundary was also used to represent the existing extraction pit as this allowed existing dewatering volumes and drawdown to be quantified. This drain was applied over the current quarry pit. The drain for the pit was assigned an elevation of 200 mAHD and a very high conductance value to reduce the groundwater head to the level of the drain (200 mAHD).

5. Recharge – recharge was determined to be 130 mm/yr on the ridge tops and surrounding areas and 40 mm/yr in steep hill slope areas and in depressions where groundwater discharge is likely to dominate. Evapotranspiration (ET) was not modelled as the recharge applied in the model was net recharge.

The above boundary conditions were kept constant for all simulations except for the drain boundary which was used to represent the active quarrying pit. Consequently, the location and area of this drain was varied based on the simulation. The hydraulic properties of the drain were kept constant with the exception of the drain level which varied depending on the simulation.

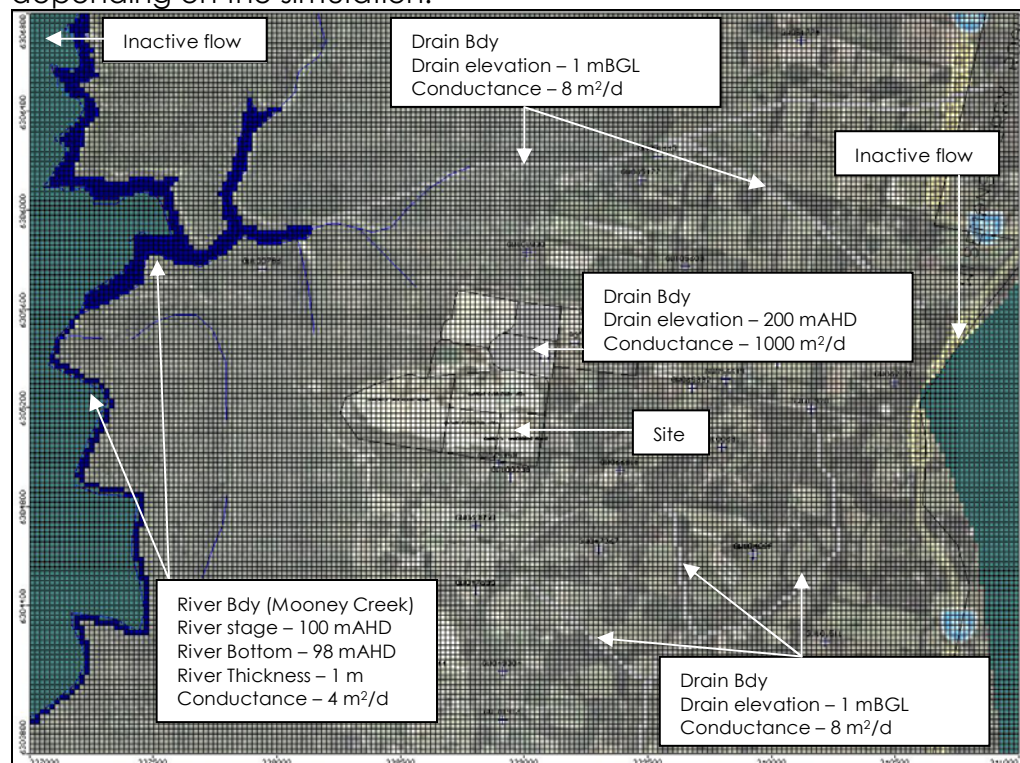


Figure 6: Boundary conditions used in existing development model.

Observation Wells

32 of the 40 observation wells within Attachment C were inserted into the model to provide a means of drawdown assessment. The remaining 8 wells were outside of the model domain.

Calibration

Of the observation wells outlined in Attachment C, the wells with available head measurements were used for calibration without verification. Because the model is steady state, using these levels for calibration inherently assumes:

- Head observations were taken during steady state conditions.
- Head observations were taken at the same time.
- Head observation levels have not been influenced by nearby pumping as the model assumes no groundwater extraction within the model domain apart from within the study site.
- Head observation levels have come from a single unconfined layer.

Given the various assumptions outlined above, unverified head observation values were not relied up too heavily. Efforts were focused on trying to replicate verified head levels taken from within the bores on the site and proposed expansion site.

Calibration results for all wells with head observations are outlined in Figure 7. The normalised RMS of 5% is lower than the typically tolerated maximum value of 10%. The standard error of the estimate is 2.10 m. Calibration results for verified head observations (head observations taken within bores on the site and proposed expansion site) are in Figure 8.

With the exception of observations from within site piezometers, observation data is unverified and taken from a variety of different times and is therefore inherently somewhat unreliable for calibration of a steady-state model. Despite this, calibration results are adequate and indicate that the model is deemed suitable for predictive use.

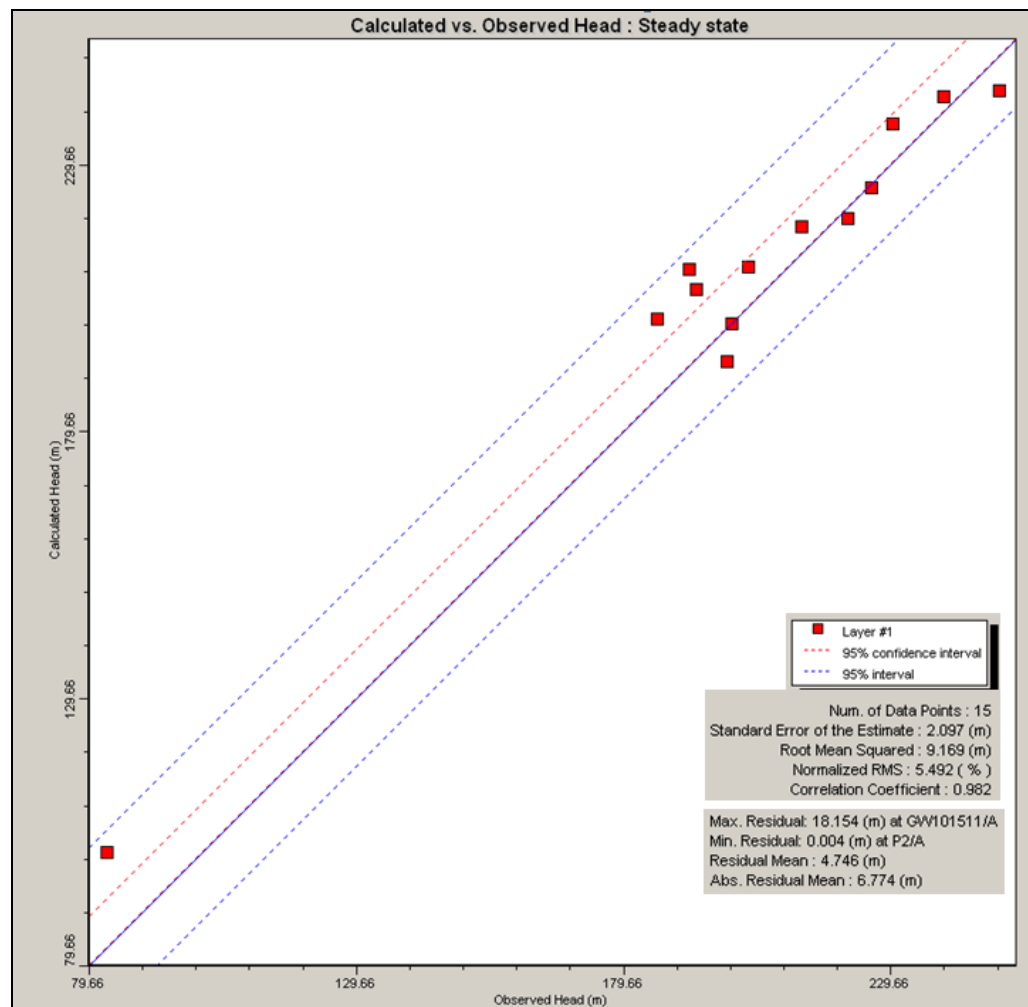


Figure 7: Calibration results for all bores with head observations.

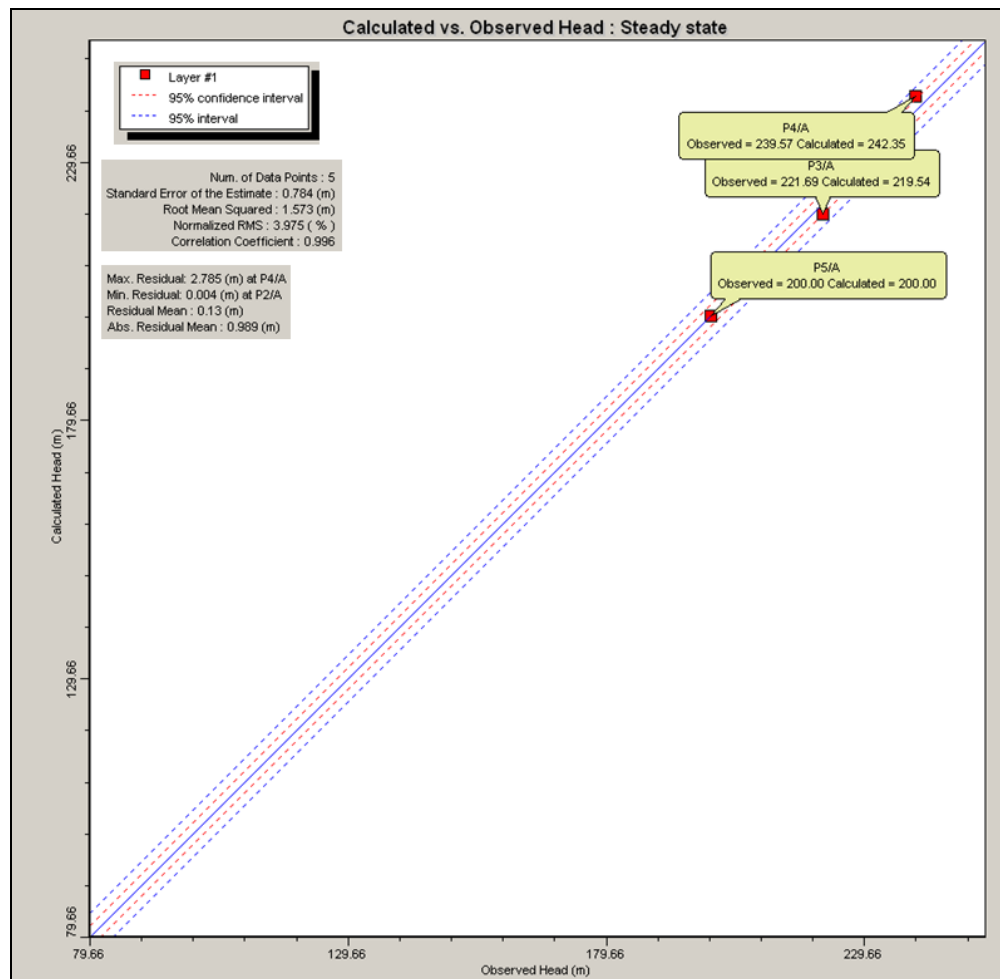
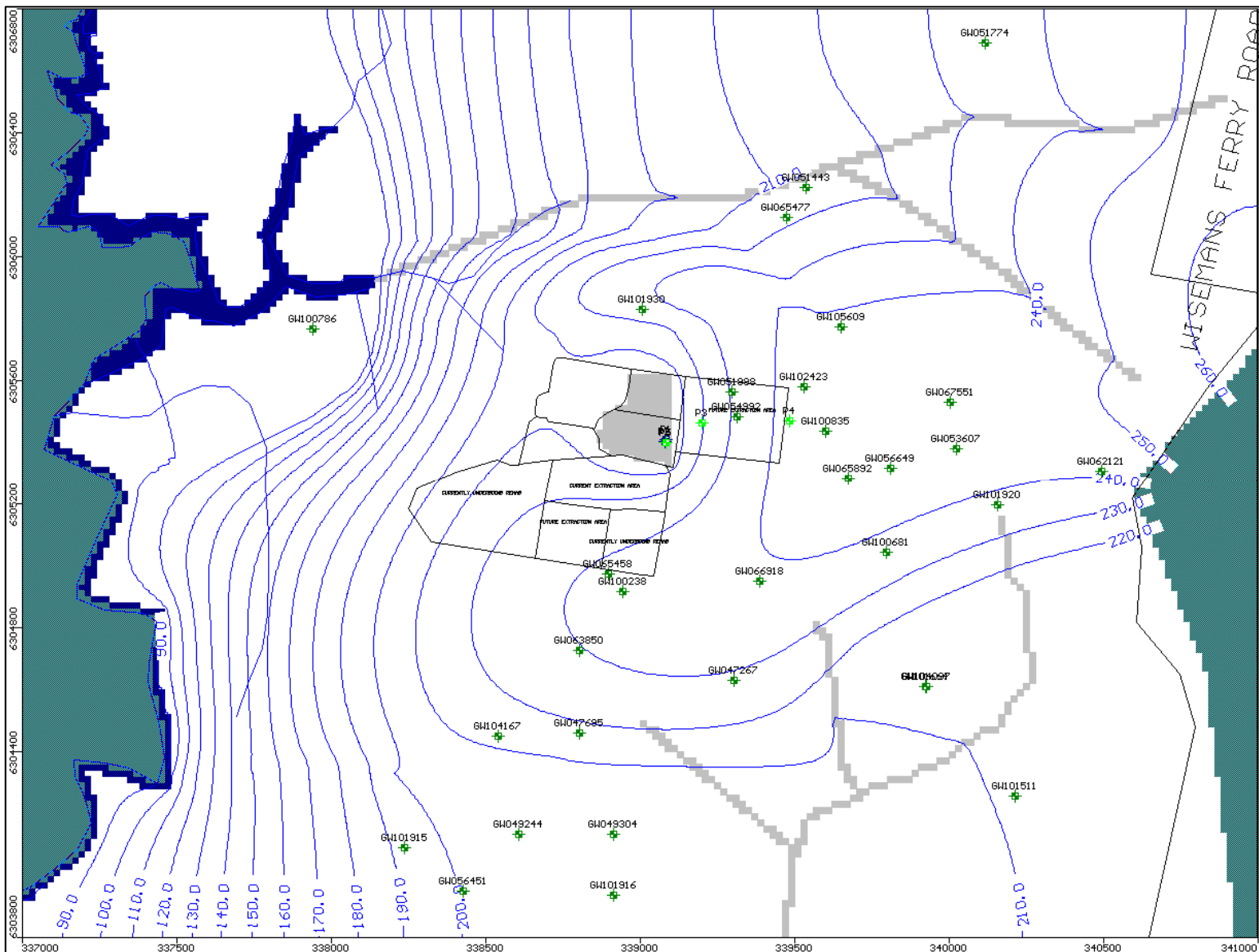


Figure 8: Calibration results for all bores with verified head observations (ie bores on the site and proposed expansion site).

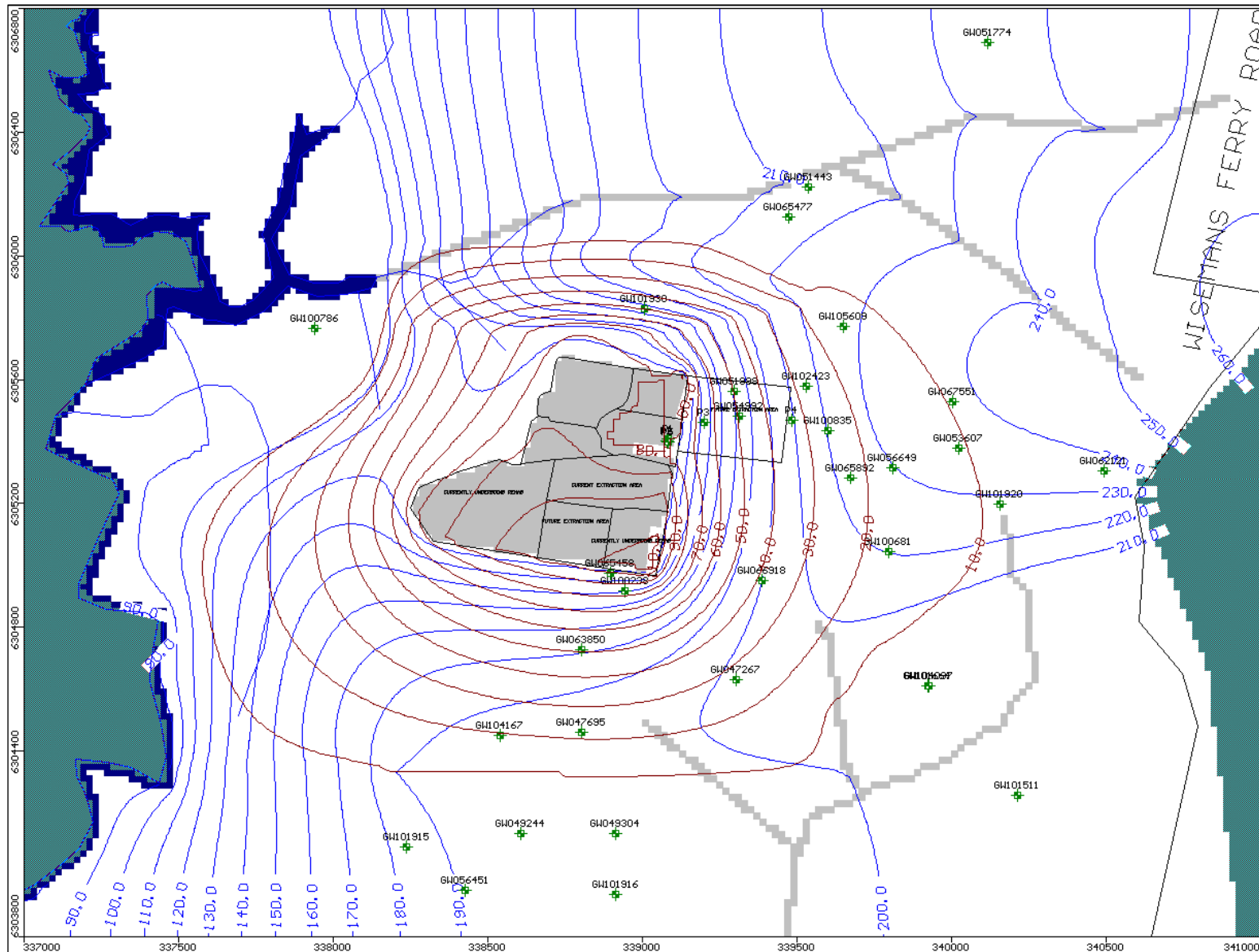
13 **Attachment E – Model Outputs**



Key:
 Blue lines – groundwater head contours
 Dark blue areas – river boundary
 Grey areas – drain boundary
 Aqua areas – inactive model domain



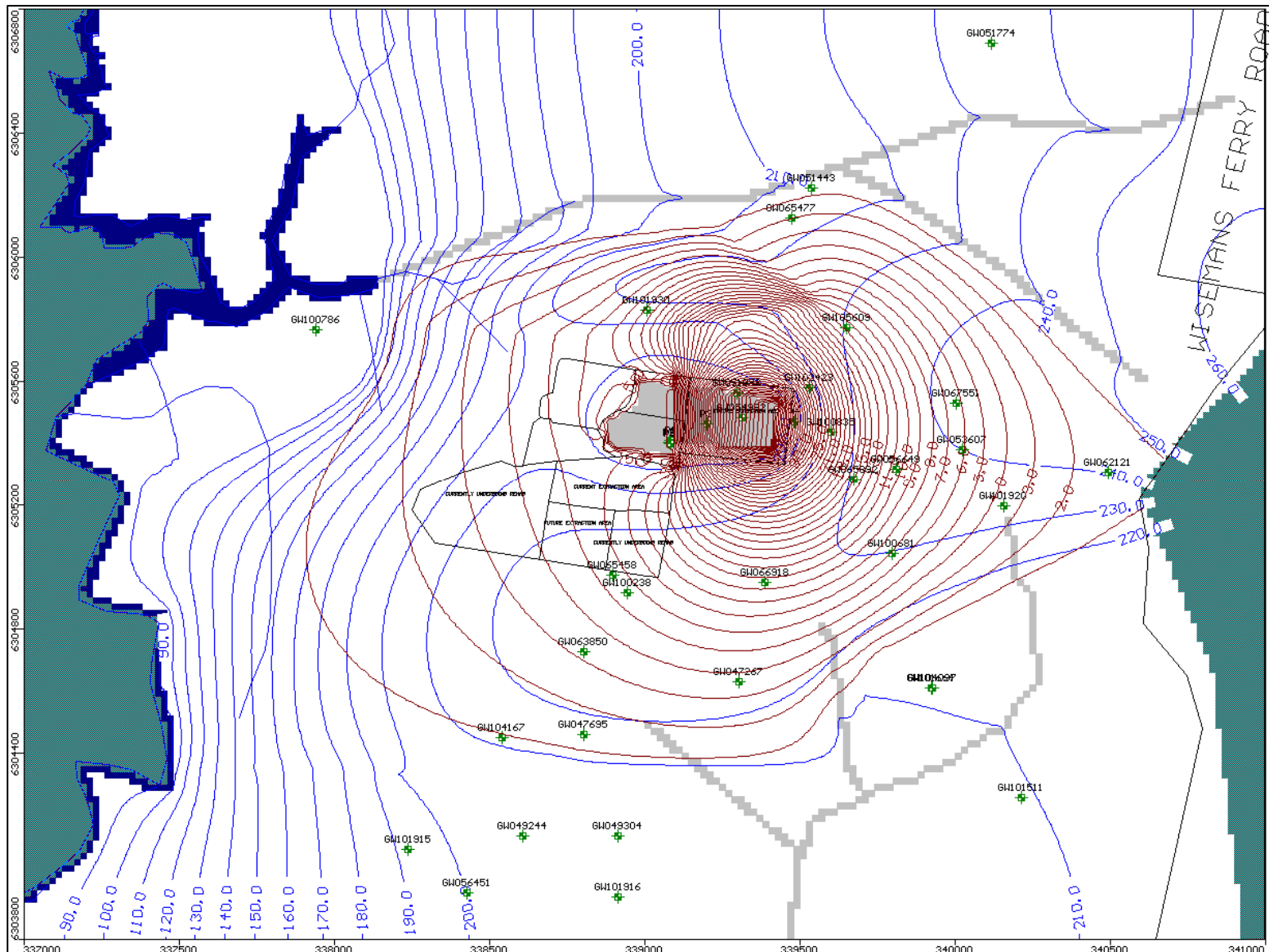
Martens & Associates Pty Ltd ABN 85 070 240 890		Environment Water Wastewater Geotechnical Civil Management	
Drawn:	BJR	MODEL OUTPUT FOR SCENARIO 1 (I.E EXISTING-DEVELOPMENT)	Drawing No:
Approved:	ASN		ATTACHMENT E - 1
Date:	24.12.2009		
Scale:	1:23,250 (approx)		Job No: P0701949



Key:
 Blue lines – groundwater head contours
 Brown lines – drawdown contours
 Dark blue areas – river boundary
 Grey areas – drain boundary
 Aqua areas – inactive model domain



Martens & Associates Pty Ltd ABN 85 070 240 890		Environment Water Wastewater Geotechnical Civil Management	
Drawn:	BJR	MODEL OUTPUT FOR SCENARIO 2 (I.E ULTIMATE APPROVED-DEVELOPMENT)	Drawing No:
Approved:	ASN		ATTACHMENT E - 2
Date:	24.12.2009		
Scale:	1:20,000 (approx)		Job No: P0701949



Key:
 Blue lines – groundwater head contours
 Brown lines – drawdown contours
 Dark blue areas – river boundary
 Grey areas – drain boundary
 Aqua areas – inactive model domain



Martens & Associates Pty Ltd ABN 85 070 240 890		Environment Water Wastewater Geotechnical Civil Management	
Drawn:	BJR	MODEL OUTPUT FOR SCENARIO 3 (I.E PROPOSED-DEVELOPMENT)	Drawing No:
Approved:	ASN		ATTACHMENT E - 3
Date:	24.12.2009		
Scale:	1:19,850 (approx)		Job No: P0701949