SURFACE WATER AND GROUNDWATER 6

CONTENTS

TABLES

FIGURES

APPENDICES

INTRODUCTION

6.1 This Environmental Impact Statement (EIS) is prepared to accompany a planning application for the continuance of use of the existing quarry at Huntstown, County Dublin submitted to Fingal County Council by Roadstone Wood Ltd. This EIS has been prepared by SLR Consulting Ireland for Roadstone Wood Ltd.

6.2 The site is a large operational limestone rock quarry situated in north county Dublin. The quarry is operated by Roadstone Wood Ltd. (hereafter referred to as RWL).

6.3 The planning application area of the quarry is approximately 167.5 hectares, and there have been four discrete areas of excavation at the site, with a total extraction area of 55.9 hectares. The remaining area within the landholding is used for value-added activities (e.g. concrete batching, tar plant, etc.), a power station, and agricultural land.

Outline of the Scope of Works

6.4 The EIS has been prepared to accompany a planning application for the continued operation and development of the quarry. The scope of this section includes:

- an assessment of the existing surface water and groundwater conditions at and close to the site;
- an assessment of the impact of the quarry development on surface water and groundwater conditions;
- a recommendation of mitigation measures to reduce or eliminate any potential impacts.

Project Team

6.5 This section of the EIS was prepared by SLR Consulting Ireland / Eugene Daly Associates. The project team consists of:

- Oliver Higgins MSci., Dip. GIS
- Les Brown Ph.D., M.Sc. B.Sc.
- Peter Glanville Ph.D., MSc.

Information Sources

6.6 As part of the study process, the organisations shown on Table 6.1 over were consulted and relevant information obtained.

Table 6-1
List of Organisations Providing Information

Organisation	Address
Geological Survey of Ireland	Beggars Bush, Haddington Rd, Dublin 4.
Met Eireann	Glasnevin, Dublin 9.
Environmental Protection Agency	Headquarters, PO Box 3000, Johnstown Castle Estate, Co Wexford.
Teagasc	Oak Park, Carlow
OPW	51 St. Stephen's Green, Dublin 2
Water Framework Directive Resource	www.wfdireland.ie

Methodology

6.7 The methodology used in the investigation follows the guidelines and advice notes provided by the Environmental Protection Agency on environmental impact assessments and the Institute of Geologists of Ireland's (IGI) guide on Geology in Environmental Impact Statements, with additional reference to the IGI guidance on Quarry EISs.

6.8 The methodology involved in the assessment of the hydrogeology and hydrology at the site can be summarised as follows:

- A desk study, in which existing data, and relevant regional data sources for the area were examined.
- Field visits, in which aspects of the sites hydrology and hydrogeology were assessed.
- A programme of monitoring well installation to characterise the hydrogeology of the strata at the site.
- Analysis of the information gathered and assessment of the potential impacts of the development.

6.9 The desk study involved the examination of several datasets to determine the geological and hydrogeological setting of the area, as detailed in Table 6.2.

Table 6-2
Regional Data Consultation

Data Theme	Dataset	Scale / Resolution
Agricultural Soils	An Foras Taluntais Mapping	1:126,720
Glacial Drift		
Subsoil Geology	Teagasc Database	1:35,000
Solid Geology	GSI Bedrock Geology	1:100,000
	GSI Historical Bedrock mapping	1:10,560
Aquifer Classification	GSI bedrock and gravel aquifer maps	1:100,000
Elevation	OSI Discovery Mapping	1:50,000

6.10 Field visits were undertaken during 2009, 2010 and 2011. The fieldwork undertaken as part of the hydrogeological characterisation included:

- A walkover survey of the site and surrounding area
- Catchment delineation and flow measurement
- Installation of monitoring wells
- Sampling of quarry discharge, surface water and groundwater for laboratory analyses
- Measurement of discharge flows
- Monitoring of groundwater levels

EXISTING DEVELOPMENT

6.11 The quarry landholding lies within an area enclosed to the south by the M50, to the east by the N2 dual carriageway (and its predecessor, the R135), and to the north and west by the Cappagh Road. The Cappagh road is a distributor road connecting Finglas with various industrial estates around Ballycoolin, and linking with the R135 at Kilshane, north of the site.

6.12 Huntstown quarry is a large operational limestone rock quarry situated in north Dublin. There are four excavation areas referred to as north, west, central and south. Current quarry depths and maximum expected working levels based on geometry and geology for the current licenced extraction areas are detailed below:

- The North quarry has an existing extraction level of c.39mOD with a maximum potential depth to c.23mOD;
- The Central quarry has an existing extraction level of c.58mOD with a maximum potential depth to c.25mOD;

- The West quarry has been stripped of overburden but rock extraction has not commenced. The final extraction level of the West Quarry is expected c.18mOD; and
- The South quarry has an existing extraction level of c.33mOD and has a maximum potential depth to -65mOD.

6.13 A waste licence application has been submitted to the Environmental Protection Agency (EPA) to restore part the North Quarry to its original ground level using imported inert fill, soil and stones.

6.14 RWL currently carry out limestone bedrock extraction (through blasting), crushing and screening at the site. Value added asphalt, concrete and block manufacturing is also carried out at the site. The application provides for the continuance of the quarry operations, and sets out the quarry development plan. Excavation is carried out beneath the water table and groundwater is encountered at quarry faces within all three pits. A discharge licence has been in place for the northern part of the site since 1987 (Ref. No. WPW/1/87), which includes for the continued removal / treatment of this water from the sump in the northern quarry floor. This licence is currently under review by Fingal County Council. A discharge licence for the southern part of the site has also been submitted to Fingal County Council.

6.15 The existing water management system is an integral part of the quarry operation. The water management system is divided into six main components, which are detailed below:

1. Two surface watercourses drain from the site. One stream drains the southern part of the site to the Tolka River and the other stream drains the northern part of the site to the River Ward.
2. Rainfall infiltrates to ground across the majority of the site. Rainfall from roadways, hard standing and roof areas all run-off is allowed to infiltrate to ground. Rainfall incident to the quarry excavations is routed via channels to main quarry sumps. Some rainfall incident with excavations infiltrates to ground.
3. Groundwater input to excavation areas is routed by channels and collected central sumps. From the sumps water is pumped to settlement lagoons for treatment prior to being discharged.
4. Process water is used in crushers to assist crushing and prevent dust generation. Process water for crushing, screening and washing and is sourced at the quarry sumps. Process water for concrete products is sourced from the northern surface water discharge.
5. An existing proprietary treatment system and percolation area treats foul water from the site. It is proposed to continue using this wastewater treatment system for the development.
6. General water supply for the quarry offices and canteen facilities is from a mains supply.
7. An oil interceptor (Klargester 10,000L Forecourt Enviroceptor Class 1 & Class 2) has been installed adjacent to the bunded fuel storage in the central processing area, with the clean outfall directed to the central quarry void area.

6.16 At present there are c.49 people directly employed at the quarry (with a further c.12-15 indirectly employed in support and transportation according to market demand).

DESCRIPTION OF THE ENVIRONMENT

Topography, Physical Features and Landuse

6.17 Natural ground levels in the area generally flat lying with a range in natural topography between c.70 – 95 mOD. The lowest extraction floor is approximately 27 mOD in the southern quarry.

6.18 The site is drained by two surface water catchments: the northern half is part of the River Ward, and the southern half is part of the River Tolka.

6.19 Landuse at the site comprises of quarrying, areas of scrubland vegetation and areas of agricultural land. The agricultural land comprises both for grazing and for crops.

6.20 There are a number of residences around the development. A well survey was undertaken of residences within 500 m of the site. Details of the well survey are included in the appendices.

Rainfall

6.21 North County Dublin is one of the driest parts of the country, receiving an average of less than 800 mm of rainfall annually (1961 - 1990). Average monthly and recent rainfall results are shown in Table 6-3. The rainfall results are from the Met Eireann Dublin Airport synoptic weather station (elevation 71 mOD) which is located approximately 2km east of the study area. The average value for rainfall is for the period 1961 – 1990 (Fitzgerald & Forrestal, 1996).

6.22 It can be seen from the table that over the course of monitoring at the site, rainfall amounts were significantly higher in 2009, and appear to be relatively (at least 20% higher) than the average results.

6.23 Rainfall values for one-hour and two-day events of 5-year return period intensity are 16 mm and 55 mm respectively (Met Eireann, 2010)

Table 6-3
Local Rainfall and Evapotranspiration (mm) for Dublin Airport

	Rainfall			Potential Evapotranspiration (Penman)			Effective Rainfall		
	Average	**2009**	**2010**	**Average**	**2009**	**2010**	**Average**	**2009**	**2010**
Jan	70	62	45	17	13	9	52	49	36
Feb	50	56	37	22	18	7	28	38	30
Mar	54	26	55	36	36	34	17	0	21

Apr	51	71	27	52	47	55	0	24	0
May	55	76	38	73	71	72	0	5	0
Jun	56	64	50	81	88	88	0	0	0
Jul	50	165	79	86	78	83	0	87	0
Aug	71	70	48	71	70	-	0	0	-
Sep	66	24	104	48	47	-	18	0	-
Oct	70	63	30.8	29	26	-	41	37	-
Nov	64	171	100	17	16	-	48	155	-
Dec	76	69	58.1	15	9	-	61	60	-
Annual	733	918	671	548	519	-	184	456	-

6.24 The average value for evapotranspiration (Table 6-3) is based on the period 1981 - 2000. Potential Evapotranspiration (PE) is estimated to be of the order of 500mm/yr around North Co. Dublin, and Actual Evapotranspiration (AE) is about 425mm/yr. Therefore, the average potential recharge at the site is about 308mm/yr.

6.25 At the existing quarry, the AE will be much lower due to the absence of significant vegetation cover and therefore the AE is assumed to be approximately 50mm/yr and therefore potential aquifer recharge at the quarry void is approximately 683mm/yr.

6.26 The long term actual evapotranspiration rate is far greater in the April to September period inclusive, when the temperature is higher, daylight periods are longer and plant growth rates are high, than in the October to March period inclusive when the opposite scenario is the case.

Local Quaternary and Bedrock Geology

6.27 The superficial deposits at the site and surrounding area are underlain by bedrock of several lower Carboniferous Formations (refer to Figures 5.3 and 5.4 in Chapter 5 of this EIS). Regional geological maps indicate that there are four bedrock formations recorded across the Huntstown Quarry complex. These are:

- The Boston Hill Formation: described as a rather uniform, thick successions of nodular diffusely bedded, argillaceous fossiliferous limestones (and their dolomitised equivalents) and subordinate thin shales. Improved understanding of local structural geology means that this formation is now recognised as part of the Malahide Formation.
- The Waulsortian Limestone is described as mainly pale grey biomicrite.
- The Tober Colleen formation described as very gradationally-interbedded calcareous mudstone and very argillaceous micrite. It overlies, and fills in the gaps between depressions of the Waulsortian Limestones.

- The Malahide Formation: at its top, is described as a fossiliferous limestone and shale with some oolites and sandstone, biomicrites and biosparites.

Local Geology

6.28 Six groundwater monitoring wells (designated GW01 – GW06) were installed across the Huntstown Quarry complex in July 2010. The locations of these monitoring wells are shown in Figure 6-1. The well construction records are presented in Appendix 6-A.

6.29 The monitoring wells were constructed using rotary percussion drilling techniques, and therefore only general descriptions were obtained of bedrock encountered. Where not affected by quarrying activities, the depth to bedrock across the quarry complex ranges from 1.9m to 13m. The boreholes were drilled to a final depth of between 49m and 80.5m. Groundwater monitoring piezometers were installed so that specific response zones could be isolated from other water ingress.

Agricultural Soils

6.30 The Environmental Protection Agency (EPA) website publishes soils and subsoils maps created by the Spatial Analysis Unit, Teagasc in collaboration with the Geological Survey of Ireland. These maps indicate that the application site at Huntstown and the surrounding area is typically underlain by deep well drained mineral soils. These soils are derived from the underlying glacial till which extends across the North Dublin region. The glacial till is derived from limestone parent material (refer to Figures 5.1 and 5.2 in Chapter 5 of this report).

Surface Water – Hydrology

6.31 The Huntstown quarry complex straddles two river catchments, that of the Ward River and that of the Tolka River, with approximately equal areas of the landholding in each, as shown in Figure 6-2. The North, Central and West quarries lie in the northern part of the landholding, entirely within the Ward River catchment. The South quarry lies in the southern part of the landholding, entirely within the Tolka River catchment.

Local Hydrology: Quality

6.32 The northern portion of the River Ward (known as the Ballystrahan sub-catchment) is classified in the latest assessment of Ireland's rivers (EPA, 2010) as being at 'Poor' status. The River Ward itself has a median Q-rating of 3 (unsatisfactory). Siltation by agriculture and urban wastewater discharges are believed to be the principal contributors to reduced water quality in the stream.

6.33 The Tolka River is classified as in the latest assessment of Ireland's rivers (EPA, 2010) as being of 'Poor' status. The Tolka itself has a median Q-rating of 2-3 (unsatisfactory). The Tolka catchment is partly urbanised and the upper reaches of the catchment is characterised by relatively intensive agricultural practices. A combination of both factors contribute to the overall status of the river with

siltation by agriculture and urban wastewater discharges are believed to be the principal contributors to reduced water quality in the river.

6.34 The Draft River Basin Management Plan, as prepared for as part of Ireland's obligations under the Water Framework Directive, reported the status of the Ward River sub-catchment as 'Poor'. In other parts of the Ward catchment, the status of sub-catchments range from 'Moderate' to 'Bad'. The status of the Tolka River is also 'Poor' while only the very upper reaches of the catchment is of 'Moderate' status.

Local Hydrology: Flows

6.35 The EPA hydrometric website indicates that there was a hydrometric station on the River Ward at Owens Bridge, approximately 4.5 km north-east of the Huntstown Quarry complex. The hydrometric station is no longer in operation. It had recorded flow from a catchment area of approximately 36 km^2, but this does not include the Ballystrahan sub-catchment

6.36 The EPA hydrometric website indicates that there are two hydrometric stations on the Tolka river at Finglas and Glasnevin (Botanic Gardens), approximately 4km south-east of the Huntstown Quarry complex. The hydrometric station at Glasnevin records the flow from a catchment area of 138km^2, which includes the southern part of the Huntstown Quarry complex. The small stream which flows from Huntstown discharges into the Tolka River immediately upstream of the gauge station at Glasnevin.

6.37 As part of work for the Water Framework Directive, the EPA has prepared an internet-based model for the calculation of ungauged catchments (http://watermaps.wfdireland.ie/HydroTool/). For the Ballystrahan catchment at St. Margaret's, area c. 7km^2, the stream flows have been calculated and are shown in Table 6-4. In the River Tolka catchment a sub-catchment, area c. 8km^2, at Finglas (stream ID 09_1512), the flows have been estimated, see Table 6-5. (Note that the error associated with the model can be in the region of 50%, but is an improvement on other desk-based methods).

Table 6-4
Flows Estimated for the Ballystrahan Sub-Catchment at St. Margarets

Flows equalled or exceeded for the given percentage of time (litres/sec)										
5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%
317	209	131	92	71	66	50	36	25	15	11

Table 6-5
Flows Estimated for the Unnamed Sub-Catchment at Finglas (Stream ID 09_1512)

Flows equalled or exceeded for the given percentage of time (litres/sec)										
5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%
364	241	151	106	98	49	37	27	38	29	25

Discharge Consents

6.38 There are four monitoring locations and two discharge points at the Huntstown Quarry complex. In addition the Huntstown Power Station has an adjacent discharge. The monitoring locations and discharge points are shown on the schematic representation of the surface water management system presented in Figure 6-3 and described below:

- Discharge point DP.1 is the way leave for water draining to the Ward catchment. Water discharged at DP.1 comprises of incident rainwater and influent groundwater from the North quarry and Central quarry as well as treated wastewaters from the concrete/asphalt production plant. Water pumped from the North quarry and the concrete/asphalt plant is treated by dedicated settlement ponds. Water quality from the North quarry, Central Quarry and concrete plant is measured at point W1 and water quality from the Central quarry is monitored at W2 (Existing Discharge Licence No. WPW/F/008-01).
- Discharge Point DP.2 is the way leave for water draining to the Tolka catchment. Water discharged at DP.2 comprises of water pumped from the South quarry, which is treated by dedicated settlement ponds in the southern part of the site. Water quality from the South quarry is measured at W3.
- A discharge from Huntstown Power Station, which discharges to the stream. This is designated HPW1.

Locations of surface water monitoring points are identified on Figure 6-4.

6.39 Water quality will be monitored at W4 when the waste licence to infill the North quarry with inert soil/stones is granted.

Ward Catchment

6.40 The quality of the combined quarry discharges to the Ward River catchment, W1 and W2, are summarised in Table 6-6.

Table 6-6
Average / Median Quarry Discharge Quality Monitoring Results for the North Quarry at W1 and Central Quarry at W2 (ceased in 2010).

	Year	Number of Samples	pH	BOD*	Suspended Solids	Temperature	Ammonia (NH4)*	Calcium	Phosphorus*	Sulphate
W1	2002	17	7.99	<2	13.9	11.3				
	2003	23	7.98	<2	9.4	10.9	<0.1	122	<0.05	161
	2004	21	8.08	<2	12.0	11.5	<0.1	140	<0.05	193
	2005	13	8.04	<2	16.9	10.8	<0.1	137	<0.05	213
	2006	11	8.01	<2	12.1	12.0	<0.1	152	<0.05	214
	2007	11	8.04	<2	20.5	12.8	<0.1	180	<0.05	235
	2008	12	7.97	<2	18.0	10.3	<0.1	160	<0.05	248
	2009	11	7.75	<2	17.9	11.7	<0.1	146	<0.05	236
	2010	12	8.12	<2	8.0	10.0	<0.1	141	0.074	219
	2011	6	8.0	<2	6.0	8.8	<0.1	147	0.07	214
W2	2003	38	8.15	<2	11.2	10.8	<0.1	160	<0.05	171
	2004	36	8.16	<2	13.2	11.2	<0.1	147	<0.05	160
	2005	25	8.12	<2	16.0	10.3	<0.1	152	<0.05	136
	2006	24	8.17	<2	30.3†	12.4	<0.1	149	<0.05	129
	2007	23	8.22	<2	16.2	14.2	<0.1	162	<0.05	142
	2008	24	8.07	<2	27.9†	13.4	<0.1	131	<0.05	148
	2009	13	7.84	<2	28.2	13.3	<0.1	142	<0.05	168

All values are in mg/l except for pH, which is in pH units
* - Median Values, since most values were below the detection limit

6.41 It can be seen that the discharge quality monitoring results from W1 and W2 are, on average, of acceptable quality. Monitoring of existing discharges from the Huntstown quarry complex is continuing.

6.42 Water quality at both the central and northern quarry sumps has been monitored. The results are presented in Table 6-7, along with the discharge licence limits for the North quarry.

Table 6-7
Water Quality for Northern Quarry and Central Quarry Sumps. (06/08/2010)

	Central Sump	Northern Sump	Discharge Limits
Temperature	13.9	16.4	25
pH	7.04	7.11	6 – 9
Conductivity	227	329	-
Sodium	12.56	20.54	-
Potassium	1.21	4.89	-

Calcium	54.3	102.4	-
Magnesium	0.95	3.25	-
Chloride	24.7	30.21	-
Sulphate	8.16	19.27	-
Total Alkalinity	151	209	-
Total Hardness	330	430	-
Nitrate	4.66	3.27	-
Nitrite	0.05	<0.05	-
Ammoniacal Nitrogen	0.04	0.02	1
Iron	<0.001	0.016	-
Manganese	<0.001	0.002	-
Orthophosphate	0.07	0.04	-
BOD	2	1	20
DRO	<0.01	<0.01	-
Mineral Oil	<0.01	<0.01	-
Suspended Solids	N/T	N/T	30

Note: Suspended solids were not analysed as tested samples were grab analyses from the top of the sump, (and are not therefore representative of pumped water).

6.43 The quantity of water pumped from the northern quarry is not monitored but estimations have been made at several stages in the history of the quarry, and a flow measurement was made for the purposes of this project. Flow estimates and/or measurements at W1 are indicated on Table 6-8.

Table 6-8
Discharge Estimates and Measurements at W1 (Northern Quarry)

	Discharge amount (m^3/day)
1999 Average Estimate	1,870
2003 Average Estimate (half of maximum estimate)	3,710
2009 Average Estimate	2,600
2010 Measurement (February)	1,470

6.44 In recent years, it has been observed that groundwater inflow at the northern quarry has reduced as development of the southern quarry has expanded and deepened below the level of the northern quarry.

6.45 The monitoring of discharge from Huntstown Power Station is regulated by the EPA under IPPC licence P0777-01. The average discharge parameters are indicated in Table 6-9.

Table 6-9
Average Power Station Discharge Quantity and Quality Monitoring Results (HPW1)

Parameter	Unit	Average Value	Licence Limit
Discharge volume	m^3/day	99.96	600
Total Suspended Solids	mg/l	11.32	30
Nitrate	mg/l NO_3	2.62	-
BOD	mg/l	1.01	20
COD	mg/l	10.31	50
Total Dissolved Solids	mg/l	784.5	2000
Total Nitrogen	mg/l N	1.49	-
Total Phosphorus	mg/l P	0.028	0.1
Ammonia	mg/l NH_3	0.16	1.5

6.46 It can be seen that the flow quantities from the power station average <3% to 7% of the total quarry related flow. Flows from the power station contribute to a marginal increase in ammonia, but are within licence limits.

Tolka Catchment

6.47 The water quality from the South quarry is presented below in Table 6-10. Settlement ponds (3,500m^3 capacity) were installed in 2009 and as a result there was a dramatic improvement in water quality with regard to suspended solids.

Table 6-10
Average / Median Quarry Discharge Quality Monitoring Results for W3

	Year	Number of Samples	pH	BOD*	Suspended Solids	Temperature	Ammonia (NH4)*	Calcium	Phosphorus*	Sulphate
W3	2002	11	8.1	<2	5.5	13.1	-	-	-	-
	2003	23	7.8	<2	8.5	10.9	<0.1	133.9	<0.05	169.2
	2004	22	8.0	<2	3.6	11.5	<0.1	120.9	<0.05	157.7
	2005	15	8.0	<2	5.5	11.0	<0.1	120.2	<0.05	146.4
	2006	9	7.8	<2	3.2	12.3	<0.1	127.7	<0.05	133.1
	2007	11	8.0	<2	4.5	13.1	0.20	137.8	<0.05	149.4
	2008	12	8.0	<2	15.1	10.4	0.22	134.4	<0.05	180.0
	2009	6	7.6	<2	35.5	12.2	0.69	126.8	<0.05	178.7
	2010	8	8.2	<2	7	11	<0.1	118	0.07	170
	2011	4	8.0	<2	6	10	<0.1	130	0.06	177

All values are in mg/l except for pH, which is in pH units
* - Median Values, since most values were below the detection limit

6.48 It can be seen that the discharge quality monitoring results are, on average, of acceptable quality. Monitoring of existing discharges from the Huntstown quarry complex is continuing.

6.49 The quantity of water pumped from the southern quarry is routed through settlement ponds prior to discharge. As part of recent hydrogeological assessment for the site as part of the project a flow monitoring station was constructed down gradient of the settlement ponds. Data recorded during the summer of 2010 shows discharges between 1,000-5,400m^3/d. The lower range of these flow measurements is considered to represent the groundwater component of the water pumped from the quarry sump.

6.50 In recent years, it has been observed that groundwater inflow at the northern quarry has reduced as development of the southern quarry has expanded and deepened below the level of the northern quarry.

Flooding

6.51 The Office of Public Works website (www.floodmaps.ie) indicates that there is a record of one historic flood event in the vicinity of Huntstown, at Kilshane Cross in November 2002. This flood was attributed to 'runoff from adjacent grasslands', and was not related to quarrying activities at Huntstown.

6.52 Surface water run-off and discharges at the Huntstown Quarry complex are managed on a continual basis so that they do not increase the risk of flooding in the surrounding area.

FIELD SURVEYS

6.53 Site visits and inspections of the application site were undertaken by an SLR senior hydrogeologist during 2010. Field visits were made to site during July 2011. The key objective of these site visits was to assess the existing hydrological and hydrogeological environment and establish existing surface water management activities.

6.54 During site visits, several minor groundwater inflows into the north quarry and south quarry were observed from fractures in the quarry faces. Photographs of features of note at the North Quarry are presented as plates at the end of this chapter.

LIMITATIONS

6.55 The assessment of the hydrological and hydrogeological environment presented above is based on visual observations from site visits, available monitoring records, published information and discussions with personnel employed on site. It should be viewed as a largely qualitative assessment.

Groundwater – Hydrogeology

Aquifer Characteristics and Groundwater Vulnerability

6.56 The site is located within the Dublin Groundwater Body (GWB), which extends from Kilcock in the west to the Dublin coastline, and from the foothills of the Dublin Mountains in the south, to Dublin Airport in the North. There are no major abstractions for groundwater supply from the Dublin GWB. The source protection area for a wellfield at Dunboyne extends marginally into the groundwater body. The source protection zone for this wellfield is 8.5 km from the Huntstown Quarry complex. Huntstown Quarry itself is most likely the largest groundwater abstraction from the Dublin GWB.

6.57 The bedrock geology of the Huntstown area is complex. It has however been extensively studied and is the subject of published research, summarised in Section 5 of this report. The predominant bedrock at Huntstown is limestone, grouped into the Waulsortian, Malahide (Boston Hill) and Tober Colleen Formations, as previously described. As is typical of Irish bedrock, groundwater flow through these formations is controlled by secondary fissure permeability. The bulk permeability of the formations is relatively high, with groundwater storage and movement mainly constrained to the upper weathered horizons of each unit and to discontinuities (such as such as joints, fractures and faults).

6.58 Bedrock aquifer maps published on the GSI website indicate that the Huntstown Quarry complex straddles bedrock formations which are generally considered to be locally important karstified aquifers. Of the three bedrock formations exposed at Huntstown, both the Waulsortian and Malahide (Boston Hill) Formations are considered to be locally important aquifers, while the Tober Colleen Formation is considered to be a poor aquifer. An extract of the bedrock aquifer map is presented as Figure 6-5.

6.59 The subsoil deposits that overlie the bedrock at Huntstown tend to be relatively thin but play an important role in groundwater recharge. Where the subsoil comprises sand and gravel deposits, it permits a high level of recharge and can provide additional storage to the underlying bedrock aquifer. In the Huntstown area however, the extent and thickness of sand and gravel deposits is insufficient for it to be considered an aquifer in its own right.

6.60 A review of the GSI karst database indicates that there are no karst landforms or features within 5 km of the Huntstown Quarry complex.

6.61 Groundwater vulnerability maps published on the GSI website indicate that the Huntstown Quarry complex is located within an area with high to extreme groundwater vulnerability status. This is principally due to the fact that subsoil has been removed over virtually the entire site. An extract of the groundwater vulnerability map is presented as Figure 6-6. The groundwater vulnerability reflects the exposed nature of the quarry area, owing to the removal of subsoils.

6.62 The quarry excavations have intersected the groundwater table and lowered it around the periphery with the excavation of each quarry bench. There are minor groundwater inflows to each of the quarries that drain to the quarry floor, where they are contained. Water is pumped from the quarry floor as and when required in order to maintain dry conditions on the floor. When pumps are active, the northern quarry has an estimated discharge rate of around 20l/sec.

Recharge Mechanisms

6.63 Dublin Airport meteorological monitoring station receives a mean annual rainfall of 732 mm (based on the 1961 – 1990 average). The potential groundwater recharge is obtained by taking the rainfall and subtracting the actual evaporation/evapotranspiration (AE). In the Dublin area, potential groundwater recharge to the aquifer ranges from 325mm/yr to 550 mm/yr.

6.64 The Water Framework Directive's Working Group on Groundwater (2005) however has suggested that a reasonable 'cap' on recharge to locally important aquifers would be 150mm/year to 200 mm/year and that any incident rainfall in excess of this will be rejected as run-off. The bulk of this groundwater recharge would be likely to occur between late October and early March.

6.65 At the existing quarry, the AE will be much lower due to the absence of significant vegetation cover and therefore the AE is assumed to be approximately 50mm/yr and therefore potential aquifer recharge at the quarry void is approximately 682mm/yr.

Groundwater Levels and Flow

6.66 The published geological memoir reports that across the eastern region of Ireland, groundwater is generally within 10m of the surface and has an annual fluctuation of less than 5m.

6.67 During the groundwater well installation works in July 2010, groundwater strikes were recorded at all wells during drilling. A summary of water strikes is presented in Table 6-111 below, along with other pertinent information:

Table 6-11
Groundwater Strikes Recorded during Well Drilling

Borehole Name	Well depth (m)	Water Strike (mbgl)	Water Strike (mOD)	Water Depth (mbTOC) 05/08/10	Water Level (mOD) 05/08/10
GW01	61	54	26.98	25.47	56.27
GW02	55	32	49.51	11.99	70.34
GW03	49	31	46.94	20.46	58.01
GW04	61	54	26.88	29.59	52.14
GW05	55	14.5	70.01	10.81	74.52
GW06	80.5	49	33.16	40.46	42.32

6.68 Water levels presented here were recorded on the 5 August 2010, approximately three weeks after the completion of drilling and groundwater monitoring well installation. Groundwater level monitoring is on-going on at least a monthly frequency. Water level data recorded at the site by RWL as part of the ongoing EMS is presented in Table 6-12.

Table 6-12
Groundwater Levels Recorded for the Site EMS

HUNTSTOWN QUARRY GROUNDWATER MONITORING LEVELS							
Hole ID		GW01	GW02	GW03	GW04	GW05	GW06
Easting		311785	311157	311274	310466	310272	310847
Northing		240902	241167	241774	241917	241374	240362
Top of Casing (Steel) Elevation (mOD)		81.74	82.33	78.47	81.73	85.33	82.78
Water Depth (mbTOC)	05-08-10	25.47	11.99	20.46	29.59	10.81	40.46
Water Elev. (mOD)		56.27	70.34	58.01	52.14	74.52	42.32
Water Depth (mbTOC)	19-08-10	25.79	6.95	20.81	30.3	11.34	40.94
Water Elev. (mOD)		55.95	75.38	57.66	51.43	73.99	41.84

Water Depth (mbTOC)	16-09-10	-	13.09	20.58	30.84	9.04	40.21
Water Elev. (mOD)		-	69.24	57.89	50.89	76.29	42.57
Water Depth (mbTOC)	20-09-10	25.83	10.54	20.47	-	10.54	41.05
Water Elev. (mOD)		55.91	71.79	58	-	74.79	41.73
Water Depth (mbTOC)	29-09-10	25.7	5.67	20.86	-	8.29	39.25
Water Elev. (mOD)		56.04	76.66	57.61	-	77.04	43.53
Water Depth (mbTOC)	04-11-10	26.1	-	21.4	-	8.7	40.9
Water Elev. (mOD)		55.64	-	57.07	-	76.63	41.88
Water Depth (mbTOC)	17-11-10	25.71	5.48	20.48	-	5.69	38.91
Water Elev. (mOD)		56.03	76.85	57.99	-	79.64	43.87
Water Depth (mbTOC)	01-12-10	23.69	4.7	18.57	-	4.01	37.4
Water Elev. (mOD)		58.05	77.63	59.9	-	81.32	45.38
Water Depth (mbTOC)	27-01-11	23.69	4.7	18.57	-	4.01	37.4
Water Elev. (mOD)		58.05	77.63	59.9	-	81.32	45.38
Water Depth (mbTOC)	25-May-11	26.89	10.56	22.12	-	9.68	41.18
Reduced Level		54.85	71.77	56.35	-	75.65	41.6
Water Depth (mbTOC)	14-Jul-11	27.51	12.18	22.22	30.73	11.27	41.72
Reduced Level		54.23	70.15	56.25	51	74.06	41.06
Maximum Groundwater Level		58.05	82.33	59.9	52.14	81.32	45.38
Minimum Groundwater Level		54.23	69.24	56.25	50.89	73.99	41.06
mbTOC = metres below Top of Casing (steel)							

6.69 Groundwater contours based on the rest levels recorded in the groundwater monitoring wells have been used to determine groundwater flow contours, which are presented on Figure 6-1. These data indicate that the groundwater flow

direction across the Huntstown Quarry complex site, from north to south. These data indicate that the floor of the deepest quarry (the South quarry floor at 33mOD) is 15 m below the groundwater table at a distance of 80m (i.e. from GW06).

6.70 The depths to groundwater indicate that the existing dewatering operations at the site have lowered groundwater levels over a significant area. Based on the distance-drawdown method, it is estimated that a reduction of 2m in groundwater levels extends c.1.1 km from the South and North quarries. Beyond this distance the water level drawdown will merge with the natural seasonal fluctuation in groundwater levels.

Groundwater Abstractions: Use and Quality

6.71 The GSI national well database records indicate that there are 12 wells or drill holes within 1 km of the Huntstown Quarry complex. Of these, only 2 appear to be wells used for groundwater abstraction: one is in the Waulsortian Limestone Formation to the west of the site, and one, also in Waulsortian Formation is to the south of the site.

6.72 The potable water demand at Huntstown Quarry is satisfied by a Local Authority mains supply. All other water requirements at the site (i.e. for concrete, aggregated washing and processing) are sourced from sumps on the quarry floor which collect groundwater ingress and run-off water. The adjoining Huntstown Power Station sources approximately 150m^3/day of water from an on-site well for operational use.

6.73 Under Ireland's obligations for the Water Framework Directive, the status of groundwater bodies nationally has been assessed, both on the basis of their quality and availability. This information is only currently available in draft form, but for the Dublin GWB, it suggests the following:

- That it is at significant risk from point source pollution (risk category 1a);
- That it is probably at significant risk from diffuse source pollution (risk category 1b); and
- That it not at significant risk from abstraction and saline intrusion (risk category 2a).

The overall risk category for the GWB is therefore set at '1a'. However, because the Dublin GWB is situated beneath a large urban area, it is likely to be subject of less stringent management objectives (in the river basin management plan) than other areas.

6.74 At the quarry itself, water abstraction for the concrete, aggregate washing and processing is sourced from sumps on the quarry floor that collect groundwater ingress and run-off water. These sumps are pumped when required to maintain dry conditions on the quarry floor.

6.75 Groundwater samples were obtained from all six groundwater monitoring wells (identified as GW01 – GW06) in August 2010 and forwarded for hydrochemical analysis. All wells were purged prior to sampling. Additionally, a water sample was collected from the surface watercourse to the north of the site, adjacent to

Kilshane Cross. All samples were sent to an independent accredited laboratory for analysis. A summary of water quality test parameters is presented in Table 6-13 below. Detailed results are presented in Appendix 6-B.

Table 6-13
Summary of Groundwater Quality (August 2010)

	GW01	GW02	GW03	GW04	GW05	GW06	IGV*
pH	7.34	6.84	7.46	7.32	6.86	7.12	6.5 -9.5
Conductivity	114	229	376	512	681	354	1000
Sodium	24.52	17.89	28.62	25.42	16.89	18.45	150
Potassium	3.54	2.99	4.01	3.12	1.58	2.57	5
Calcium	80.7	75.45	92.52	85.42	68.57	78.45	200
Magnesium	17.54	15.42	20.27	19.85	14.56	20.12	50
Chloride	19.23	24.68	43.11	27.49	19.51	34.16	30
Sulphate	48.96	12.09	17.24	36.11	24.66	18.71	200
Total Alkalinity	301	292	351	332	247	313	NAC
Total Hardness	340	352	440	494	220	252	200
Nitrate	18.66	12.45	24.77	16.62	9.32	6.44	25
Nitrite	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1
Ammoniacal Nitrogen	0.02	0.01	0.04	0.02	0.01	<0.01	0.15
Iron	0.006	<0.001	0.052	<0.001	<0.001	0.067	0.2
Manganese	0.001	<0.001	0.013	<0.001	<0.001	0.021	0.05
Orthophosphate	0.1	0.09	0.06	0.02	<0.01	0.01	0.08
Total Organic Carbon	4.1	4.4	1.5	0.5	3.2	9.9	NAC

Shaded — Maximum admissible concentration exceeded
IGV — Interim Guideline Value for groundwater, as set out in the EPA Publication 'Towards setting Guideline values for the Protection of Groundwater in Ireland'.

6.76 The groundwater quality data presented above indicate that the groundwater at Huntstown can be considered to be of good status. Virtually all parameters analysed had ion concentrations lower than the Interim Guideline Values (IGV) set out in the EPA Publication '*Towards setting Guideline values for the Protection of Groundwater in Ireland*'. The guideline value for chloride was exceeded at two locations, but this is likely to be due the slightly higher concentration of chloride in rainfall due to the close proximity to the coast (12-km). All samples exceeded the guideline for hardness, but it should be noted that hardness occurs naturally at high concentrations in limestone bedrock: about 65% of all groundwater samples from the recent national database have hardness in excess of 200 mg/l. Values of

orthophosphate exceeding the guideline value are likely to be the result of local fertiliser application.

6.77 The hydrochemistry of the groundwater samples indicate hard calcium-magnesium-bicarbonate waters with moderately low sodium and magnesium. This type of water is typical of groundwater from a dolomitised limestone aquifer. Potassium, chloride, ammoniacal nitrogen, nitrite and nitrate are moderate indicating minimal organic contamination. The higher nitrate level at GW01, although still low, is most likely due to its closer proximity to agricultural land. There are a small number of hydrochemical variations between samples taken up gradient and down gradient of the quarried sites. However these are within the normal expected range for this type of aquifer.

SITE BASELINE SUMMARY

6.78 Huntstown Quarry has four excavation areas:

1. The North quarry is currently being considered by the planning authority for use by RWL as an inert landfill;
2. The Central quarry;
3. The West quarry; and
4. The South quarry is active and has been deepened to 27mOD.

6.79 Detailed hydrogeological investigations have been undertaken at this site, these include the installation of six (no) groundwater monitoring boreholes and a flow recording device to measure discharge to the Tolka River from southern discharge.

6.80 The limestone bedrock at the site is generally considered to be locally important karst aquifers. Typical of Irish aquifers groundwater flow is almost entirely by secondary fissure permeability. There are no recorded karst landforms within 5km of the site.

6.81 The subsoils in the site area comprise of glacial till that is derived from limestone parent material. The overlying soils comprise of well drained mineral soils.

6.82 The limestone bedrock in the quarry area is considered to have relatively high bulk permeability, with low storage. Permeability and storage will reduce with depth with the upper weather bedrock having the highest aquifer properties.

6.83 The well drained nature of the soils will allow significant recharge but the glacial till subsoil is likely to restrict flow through to the bedrock. Where subsoils are thicker then runoff will occur.

6.84 Discharge from the northern quarry has reduced in volume from an average of 2,600m^3/d (2009) to a winter flow of 1,470m^3/d (February 2010). The average groundwater flow for 2010 is estimated to be 750m^3/day.

6.85 The central quarry no longer intercepts groundwater and all rainfall infiltrates to ground.

6.86 Direct rainfall to the south quarry excavation and intercepted groundwater inflow is directed to the central sump, and from here it is be pumped to settlement

lagoons for treatment. Discharge from the south quarry is estimated to range from a summer average of c.2,000m^3/d to a winter average of c.3,500m^3/d. Of this volume an annual average of c.1,000m^3/d is intercepted groundwater.

6.87 The seasonal fluctuation in the water table at the site area ranges from about 1.5 m to 5 m. A groundwater cone of depression surrounds the site, which is deeper surrounding the South and North quarries.

6.88 Groundwater flows in the region will have a generally southern direction. Drawdown from the South and North quarries extends for 1.1km at drawdown of c.2m.

6.89 Water supply in the region is mainly from mains supply. A well survey has identified three local groundwater supplies, including the supply Huntstown power station.

WATER MANAGEMENT

6.90 As discussed, there are several elements of water management necessary during the operational phase of the quarry. These are: natural surface water channels, influent water (groundwater), incident water (rainfall), process water, wastewater and potable water. Each of these elements is discussed here.

Influent Groundwater

6.91 The influent groundwater at the site is collected at the lowest point in each the quarry sump.

6.92 Influent groundwater is largely derived from fractures in the bedrock. The average amount of groundwater encountered at the site during 2010-11 was 750m^3/d from the North and central quarries combined and 1,000m^3/d from the South quarry. It is estimated that the summer groundwater inflows are approximately 500m^3/d from the combined North and Central quarries and 750m^3/d from the South quarry.

Incident Rainfall and Stormwater Attenuation

6.93 The extraction areas, for the purposes of stormwater attenuation, are regarded as enclosed basins. The current extraction areas for each quarry are:

North quarry	4.2ha.
West quarry	10.3ha.
Central quarry	16.4ha.
South quarry	25.0ha.

6.94 Within each extraction area, incident rainfall and groundwater flows are captured in a series of dug channels on the quarry floor. These channels direct all water to a sump, before being pumped for treatment by settlement lagoons.

Water Balance

6.95 All rainwater falling within the operational quarry areas is directed to the sump within the footprint of the quarry, and a water balance is presented here for the main quarry operational area. Water in the sump either evaporates or is discharged from the site. Areas not being quarried will not have their natural drainage systems altered, and so are not included in the water balance calculations. The water balance for the excavation areas are summarised in Table 6-14 and 6-15. The calculations for these volumes are presented in Appendix 6-C.

Table 6-14
Water Balance: Summary Results Ward Catchment North, Central & West Quarries

Phase		Run-Off generated by Average Annual Rainfall (1961-1990)	Run-Off generated during wettest Month – December (av. 76 mm)	Run-Off generated by 48hr. Storm Event – 5 year (55mm)	Run-Off generated during driest Month – July (av. 50 mm)
Existing	Surface Water	572 m^3/day	701 m^3/day	7,650 m^3/day	346 m^3/day
	Ground water	750 m^3/day	1000 m^3/day	1000 m^3/day	500 m^3/day
	TOTAL	1,322 m^3/day	1,701 m^3/day	8,650 m^3/day	846 m^3/day
35-year extent	Surface Water	572 m^3/day	701 m^3/day	7,650 m^3/day	346 m^3/day
	Ground water	1,000 m^3/day	1,500 m^3/day	1,500 m^3/day	750 m^3/day
	TOTAL	1,572 m^3/day	2,201 m^3/day	9,150 m^3/day	1,096m^3/day

Table 6-15
Water Balance – Summary Results Tolka Catchment (South quarry)

Phase		Run-Off generated by Average Annual Rainfall (1961-1990)	Run-Off generated during wettest Month – December (av. 76 mm)	Run-Off generated by 48hr. Storm Event – 5 year (55mm)	Run-Off generated during driest Month – July (av. 50 mm)
Existing	Surface Water	466 m^3/day	573 m^3/day	6,250 m^3/day	282 m^3/day
	Ground water	1,000 m^3/day	1,500 m^3/day	1,500 m^3/day	750 m^3/day
	TOTAL	1,466 m^3/day	2,073 m^3/day	7,750 m^3/day	1,032 m^3/day
35-year extent	Surface Water	466 m^3/day	573 m^3/day	6,250 m^3/day	282 m^3/day
	Ground water	2,000 m^3/day	3,000 m^3/day	3,000 m^3/day	1,000 m^3/day
	TOTAL	2,466 m^3/day	3,573 m^3/day	9,250 m^3/day	1,282 m^3/day

6.96 The continuation of use will lead to a moderate increase in discharge from the site. The increase in discharge is estimated to be 20% for the northern site and 60% from the southern site. The increase in discharges is entirely due to the increase groundwater inflows as the quarry floors deep. There will be no increase in surface water run-off as a result of continuation of use.

6.97 The current water treatment system (comprising of primary settlement in the quarry sumps and secondary treatment by dedicated settlement ponds) will remain in operation for the continuance of use. The size of the settlement ponds are adequate to provide 24 hours attenuation during an average December (based upon 30-year average rainfall data)

6.98 On occasion, peak storm events may cause water to on the quarry floors to back-up. At these times parts of the quarry will be flooded temporarily as the water management system works to deal with the excess water. During these times the flooded areas will be cordoned off.

Process Water

6.99 The site requires water for a number of different operations, including;

- Aggregate processing and dust control;
- Dust Suppression.

Aggregate Processing and Dust Control

6.100 Dust suppression is carried out in two ways at the site

- There is one static dust suppression area, at the entrance of the quarry near the weighbridge. This drains towards the central working area of the quarry, and dissipates on the hard standing there.
- A tractor and bowser with a spray bar carry out dust suppression at the remainder of the upper working area during the summer months. Water used in this process generally evaporates after a short time, and no drainage is necessary.

6.101 The daily water requirements for aggregate processing and the canteen/office facilities are shown in Table 6-16. Dust suppression will only be required on an intermittent basis during periods of dry weather.

Table 6-16
Estimate Daily on-Site Water Requirement at Huntstown Quarry

Operation	Requirement (m^3/day)	Requirement (m^3/hr) *
Aggregate processing	60	6
Concrete consumption	60	6
Dust suppression (seasonal)	30	3
Total	**150**	**15**

** based on a 10 hour working day*

6.102 The water requirements are satisfactorily met by the ingress of water into the quarry from rainfall and groundwater. The quarry is a net exporter of water.

Water Supply

6.103 The drinking, canteen and welfare water supply for the site is sourced from mains water.

Wastewater Management

6.104 Wastewater generated at the site is directed to the existing septic tank and percolation area located near the site office.

Fuel/Chemical Storage

6.105 Fuel storage takes place at a bunded tank near the concrete plant on site. The only chemicals to be stored on site that have the potential to cause water pollution are lubricating and hydraulic oils, and these will be stored in an enclosed container or on spill pallets.

ASSESSMENT OF IMPACTS

Evaluation Methodology

6.106 The impacts of the proposed quarry development on the local surface water and groundwater environment are assessed in this section. The methodology applied here is a qualitative risk assessment methodology in which the probability of an impact occurring and the magnitude of the impact, if it were to occur, are considered. This approach provides a mechanism for identifying the areas where mitigation measures are required, and for identifying mitigation measures appropriate to the risk presented by the development. This approach allows effort to be focused on reducing risk where the greatest benefit may result.

6.107 The assessment of risk is based on the matrix outlined in Table 6-17 below.

Table 6-17
Matrix Used to Assess Potential Impacts

Probability of Occurrence	Magnitude of Potential Impacts			
	Severe	Moderate	Mild	Negligible
High	High	High	Medium	Low
Medium	High	Medium	Low	Near Zero
Low	Medium	Low	Low	Near Zero
Negligible	Low	Near Zero	Near Zero	Near Zero

6.108 The assessment of likely magnitude of potential impacts in relation to hydrogeology and hydrology is assessed in accordance with criteria detailed in Table 6-18.

Table 6-18
Magnitude of Potential Hydrological and Hydrogeological Impacts

Magnitude	Potential Impact
Negligible	No alteration or very minor changes with no impact to watercourses, hydrology, hydrodynamics, erosion and sedimentation patterns; No alteration to groundwater recharge or flow mechanisms; and No pollution or change in water chemistry to either groundwater or surface water.
Mild	Minor or slight changes to the watercourse, hydrology or hydrodynamics; Changes to site resulting in slight increase in runoff well within the drainage system capacity; Minor changes to erosion and sedimentation patterns; and Minor changes to the water chemistry of surface runoff and groundwater. .
Moderate	Some fundamental changes to watercourse, hydrology or hydrodynamics; Changes to site resulting in an increase in runoff within system capacity; Moderate changes to erosion and sedimentation patterns; and Moderate changes to the water chemistry of surface runoff and groundwater.
Severe	Wholesale changes to watercourse channel, route, hydrology or hydrodynamics; Changes to site resulting in an increase in runoff with flood potential Significant changes to erosion and sedimentation patterns; and Major changes to the water chemistry or hydro-ecology.

6.109 In addition to their nature and significance, the potential impacts will be assessed in terms of their duration, whether they are direct or indirect impacts, and also if the impacts will be cumulative.

6.110 The following sections identify the potential impacts of the proposed development on the hydrogeological and hydrological environments. It also assesses the likelihood of occurrence of each identified impact in accordance with Table 6-17 and Table 6-18. It should be noted that the impacts are initially assessed with no mitigation or design measures incorporated to reduce the risk.

6.111 Surface runoff generated within the quarry is the main factor requiring management by the water management system. Continued groundwater management will also be necessary.

Potential Impacts on Groundwater

6.112 The proposed inert waste recovery facility has the potential to impact on groundwater in terms of both the groundwater quality and the groundwater flow regime. The potential impacts are considered qualitatively here.

Impact on Quantity and Groundwater Levels

6.113 During the development of the site there is a risk of a reduction in groundwater quantity and levels outside of the quarry void.

6.114 A radius of groundwater influence currently extends from the footprint of the excavations, with the deepest cone of depression from the South and North quarries. In general the cone of depression extends up to approximately 1.1km from the site. The cone is at its steepest within 400m of the North and South quarries where the drawdown is estimated to be 10m. The drawdown gradient rapidly reduces outwards from the site so that beyond 1.1km the levels are drawdown by less than 2m. Interaction between each extraction area drawdown has lowered groundwater levels across the site.

6.115 Over the 35-year development of the site it is proposed to deepen the quarry floors towards their maximum extents. The most significant deepening will occur in the South quarry, which has a potential depth of -65mOD. The South quarry will remain the deepest of the four quarries and as such it will remain as the main drawdown point for the site. The three other quarries (North, Central and West) will intersect groundwater, however, these waters will largely be peripheral to these excavation and not the deeper groundwater intersected by the South quarry.

6.116 There will be a steepening of the drawdown cone as the south quarry deepens and based on estimations the 2m drawdown contour will extend outwards from 1.1km to approximately 2km over the 35year period. There will be a slight extension in drawdown cone of depression westwards as the West Quarry deepens. However, as groundwater levels are already depressed in the area due to ongoing dewatering from the South quarry and North quarry the quantities of water to be abstracted from the West quarry will remain low until such a time that it deepens below the level of the North quarry.

6.117 Groundwater monitoring data demonstrates that the drawdown within the aquifer at the site has occurred due to dewatering by Huntstown Quarry. A cone of drawdown has developed that extends below the Huntstown Power Station and its groundwater supply.

6.118 There is a low risk of groundwater levels being further lowered outside of the quarry void. The potential for increased impact on groundwater levels is considered to be '**low**' as the magnitude of the impact is considered to be '**mild**' and the probability of occurrence is '**medium**' to '**low**'.

6.119 There are no proposed increases in the extent of the quarry areas as part of this application and therefore the potential impact on groundwater quantity is considered to be '**low**' as the magnitude of the impact is considered to be '**mild**' and the probability of occurrence is '**medium**'.

6.120 There are no groundwater dependant designated ecological receptors nearby. Therefore, the potential impact on groundwater quantity is considered to be '**near zero**' as the magnitude of the impact is considered to be 'negligible' and so too is the probability of occurrence.

Impact on Quality

6.121 The continued removal of the protective layer of unsaturated soil and subsoil overlying the bedrock increases the vulnerability of groundwaters beneath the site. Consequently, a potential exists to cause a reduction in the groundwater quality arising from operational activity at the site.

6.122 During the development and operation of the site, there is a risk of groundwater pollution from the following potential sources:

- accidental spillage of fuels and lubricants by operating plant; and
- suspended solids entering groundwater during extraction.

6.123 Without mitigation, the probability of occurrence of spillage of fuels, lubricants and other potentially contaminative liquids is '**medium**' due to the area of the site and number of vehicles that will use the site. The magnitude of such an impact would be '**moderate**'. Therefore, the overall risk to groundwater, without mitigation, is '***medium***'.

6.124 There is low risk of excessive suspended solids impacting groundwater quality as mobilisation and transport of suspended solids requires a flow velocity greater than that usually achievable in the groundwater environment. The magnitude of impact is '***mild***', the probability of occurrence is '**low**' and therefore the overall risk is considered to be '***low***'.

Potential Impacts on Surface Water

6.125 There are several permanent surface water features within the Huntstown Quarry complex including natural or modified watercourses and artificial features such as ditches, temporary channels, sumps and/or settlement ponds required for surface water management. Without mitigation measures there is the potential for the pollution of these surface water courses with hydrocarbons and suspended solids. The potential for pollution is considered to be '**medium**', the magnitude of impact is '**moderate**' and the probability of occurrence is '**medium**'.

6.126 There is a low risk of an increase in surface water flow in adjoining surface water courses to the site without mitigation measures arising from the continued discharge of water from the quarry voids. Without mitigation measures the potential impact is considered to be '**medium**' as it is considered that the magnitude is '**mild**' and the probability of occurrence is '**high**'.

List I and II Substances

6.127 There are a number of potential sources of List I and II substances at the site including petroleum products, Alkalis, Eutrophicants and Ammonia based reagents. These substances could arise from plant and machinery at the site, storage facilities, concrete plant, traffic, cement and explosives. Without mitigation measures at the site potential impact is considered to be '**high**' as the magnitude of the potential impact is '**moderate**' and the probability of occurrence is '**high**'.

Summary of Potential Impacts

6.128 A summary of potential impacts *without mitigation* is presented in Table 6-19.

Table 6-19
Summary of Unmitigated Risk and Magnitude of Potential Impacts at Huntstown

Potential Impact	Spatial Impact, Duration, Direct/Indirect	Probability of Occurrence	Magnitude of Impact	Significance of Impact	Mitigation Required?
Groundwater Quantity and Groundwater Levels					
Reduction in Groundwater Levels	Local, long term, Direct	Medium	Low	Low	No
Groundwater Quantity	Local, long term, Direct	Medium	Mild	Low	No
Groundwater Quality					
Spillages of fuel	Local, Short Term, Direct	Medium	Moderate	Medium	Yes
Suspended solids	Local, Short-Term, Direct	Low	Mild	Low	No
Surface Water Quality and Quantity					
Spillages of fuel	Local, Short Term, Direct	Medium	Moderate	Medium	Yes
Suspended solids	Local, Short and Long Term, Direct	Medium	Moderate	Medium	Yes
Increased flow in streams	Local, Short and Long Term, Direct	High	Mild	Medium	Yes

6.129 The summary of potential impacts above indicates that if no mitigation measures are incorporated into the proposed development then there is the potential for detrimental and direct impacts to local groundwater and surface water.

6.130 The potential impacts are considered to be local and range from short-term to long-term. If the identified potential impacts on either groundwater quality or groundwater flow were all to occur there would be a cumulative effect, which would increase the significance of the impacts.

6.131 It is therefore recommended that the mitigation measures outlined in the following section are incorporated into the development proposal to reduce the potential impacts.

DO NOTHING SCENARIO

6.132 The site currently comprises a number of large quarry voids, which are actively dewatered. Planning conditions preclude the restoration of the site through water-table rebound and the creation of a man-made lake.

6.133 Open water bodies attract bird populations that would pose a risk to air traffic at the adjacent Dublin Airport. To do nothing with the existing site would therefore result in only a limited natural colonisation and re-vegetation of slopes, and would require dewatering in perpetuity.

6.134 Ongoing vigilance would also be required to ensure no potential contaminating activities occur on or in the vicinity of the quarry floor.

INTERACTIONS

6.135 It is considered that the groundwater and surface water at Huntstown are not interconnected at the present time (while dewatering continues), and that the local tributaries of the Ward and Tolka Rivers are not in continuity with the regional groundwater at the site.

6.136 There are currently surface water discharges from the site to the Ward and Tolka river catchments.

MITIGATION MEASURES

6.137 Measures are in place / proposed at the quarry to prevent any reduction in the quality of the local aquatic environment. These mitigation measures are in accordance with the “best practice / possible mitigation measures” set out in Section 3.4 of the DoEHLG (2004) Quarries and Ancillary Activities: Guidelines for Planning Authorities, and are also designed to comply with the discharge licence requirements.

6.138 In order to mitigate against the risk of pollution to groundwater and surface water occurring during quarrying operations at the site, the following management measures would be included:

- surface water channels are constructed within the quarry to collect surface water runoff on site and any perched groundwater seepage to prevent erosion/gullying. The channels are cleaned out regularly. Any fine sediment removed is buried on site. Where this fine material is used in restoration works, i.e. in new bunds, it should be capped with topsoil or coarser material to prevent erosion;
- fuel is stored in a designated bunded area at the site;
- all chemicals and petroleum-based products and chemicals are to be stored on spill pallets or similar;
- wherever possible a traffic management system would be put in place to reduce the potential conflicts between vehicles, thereby reducing the risk of a collision;
- a site speed limit would be enforced to further reduce the likelihood and significance of collisions;
- all plant would be regularly maintained and inspected daily for leaks of fuels, lubricating oil or other contaminating liquids/liquors;
- refuelling of vehicles would either be undertaken at a surfaced area from a fuel tank(s) that is bunded or from a mobile double skinned fuel bowser in order to minimise the risk of uncontrolled release of polluting liquids / liquors;
- maintenance of plant and machinery would be undertaken within existing site maintenance sheds or off-site, as appropriate, to minimise the risk of uncontrolled release of polluting liquids;
- spill kits would be made available on-site to stop the migration of any accidental spillages, should they occur (see Appendix 6-D for details of spill kit);
- diverting all surface water run-off collected in sumps via settlement ponds and/or interceptor tanks prior to discharge to surface watercourses in order to reduce concentration of suspended solids;
- settlement ponds for the treatment of waters that are discharged at locations W1 and W3 of the site have been designed to settle suspended solids to acceptable levels (25 mg/l), in accordance with the requirements of the discharge licence;
- use of quarry floor sumps, areas of the quarry floor and ponds to provide for the short term and temporary attenuation for water to be discharged from the quarry voids; and
- In the unlikely event that the quarry operations are demonstrated to have an adverse impact on third party water supply wells the operator will undertake appropriate remedial measures to restore / replace the water supply at their own expense.

6.139 These mitigation measures would reduce the potential impacts outlined in Table 6-19 above of:

- spillage of fuels and lubricants from '***medium***' to '***low***';
- an increase in suspended solids from '***medium***' to '***low****';* and
- increased stream flow from '***medium***' to '***low***'.

RESTORATION / AFTERUSE

6.140 After closure, all chemicals, petroleum based products, mechanical and electrical equipment shall be removed prior to closure of the site.

6.141 It is proposed to infill all of the quarry void areas with inert soils / stones in the long term. Due to the close proximity to Dublin Airport, the Dublin Airport Authority do not wish the quarry voids to be allowed to fill with water and form lakes which could attract large numbers of birds to the site and therefore pose a hazard to aircraft taking off and landing at the main runway (10/28) at the airport.

MONITORING

6.142 A number of measures are proposed in order to monitor any potential impact of the proposed development on groundwater at the site or surface water in the immediate vicinity of the site.

Groundwater Monitoring

6.143 Groundwater sampling and testing is undertaken on a bi-annual basis at the 6 No. groundwater monitoring wells installed around the Huntstown Quarry complex. Groundwater levels in the wells will be recorded on a quarterly basis and submitted annually with the annual environmental report for the facility.

6.144 The existing groundwater monitoring well locations at the Huntstown Quarry complex are shown on Figure 6-1.

6.145 Groundwater samples are tested for a range of physical and chemical parameters in order to assess water quality. The groundwater quality in the monitoring wells will be tested for the following parameters:

- Conductivity;
- pH value;
- Total Coliforms cfu/100mls;
- Ammonia mg/l NH_3-N;
- Nitrate mg/l NO_3;
- Nitrite mg/l;
- Ortho Phosphate / Ortho Phosphate mg/l as P;
- TPH mg/l;
- PRO mg/l; and
- DRO mg/l.

Surface Water Monitoring

6.146 As part of the compliance with the discharge licence for the quarry regular water quality monitoring of the discharge locations takes place. The monitoring results are submitted to Dublin County Council on a regular basis.

6.147 Surface water at the site is currently tested for a range of physical and chemical parameters in order to assess water quality and detect possible contamination at the site.

6.148 Surface water quality is currently tested at the discharge points to the Ward and Tolka Rivers from the north quarry and south quarry respectively. The surface water monitoring locations across the Huntstown Quarry complex are shown on Figure 6-4.

6.149 Surface water samples are tested in order to assess water quality and detect possible contamination at the site. The test parameters will be as for groundwater, with the following additional parameters:

- BOD mg/l;
- COD mg/l; and
- Suspended Solids mg/l.
- Sulphates mg/l.

6.150 The surface water monitoring regime will remain in place for the duration of the proposed development and for a short period thereafter.

RESIDUAL IMPACTS

6.151 A summary of the proposed mitigation methods, together with the predicted effects and residual impacts is presented in Table 6-20.

6.152 Examination of Table 6-20 confirms that there are no significant residual impacts with respect to groundwater and/or surface water provided the appropriate mitigation measures outlined above are implemented at the site. It is therefore considered that the proposed development, with mitigation measures, will have no significant adverse impact on groundwater and/or surface water.

Table 6-20
Summary of Mitigation and Residual Impacts at Huntstown

Potential Impact	Spatial Impact, Duration, Direct/Indirect	Probability of Occurrence	Magnitude of Impact	Significance of Impact	Mitigation Required?	Mitigation Measures	Mitigated Probability of Occurrence	Mitigated Magnitude of Impact	Residual Magnitude of Impact
Groundwater Quantity and Groundwater Levels									
Reduction in Groundwater Levels	Local, long term, Direct	Medium	Low	Low	No				
Groundwater Quantity	Local, long term, Direct	Medium	Mild	Low	No				
Groundwater Quality									
Spillages of fuel	Local, Short Term, Direct	Medium	Moderate	Medium	Yes	Traffic systems, maintenance, bunding and spill kits	Medium	Mild	Low
Suspended solids	Local, Short-Term, Direct	Low	Mild	Low	No				
Surface Water Quality and Quantity									
Spillages of fuel	Local, Short Term, Direct	Medium	Moderate	Medium	Yes	Traffic systems, maintenance, bunding and spill kits	Medium	Mild	Low
Suspended solids	Local, Short and Long Term, Direct	Medium	Moderate	Medium	Yes	Surface water management measures	Medium	Mild	Low
Increased flow in streams	Local, Short and Long Term, Direct	High	Mild	Medium	Yes	Surface water management measures	High	Negligible	Low

REFERENCES AND SOURCES OF INFORMATION

AGMET group, 1996. ***Agroclimatic Atlas of Ireland***, James F. Collins & Thomas Cummins Editors, Dublin.

Conry, M. J. And Ryan, P., 1967. **Soils of County Dublin**. National Soil Survey of Ireland, An Foras Taluntais.

DoEHLG, 2004, **Quarries and Ancillary Activities: Guidelines for Planning Authorities.**

Environmental Protection Agency, 2002. ***Guidelines on the Information to be Contained in Environmental Impact Statements.*** Environmental Protection Agency.

Environmental Protection Agency, 2006**.** ***Environmental Management Guidelines – Environmental Management in the Extractive Industry (Non-Scheduled Minerals).*** Environmental Protection Agency.

Environmental Protection Agency /Teagasc **EPA Soil and Subsoil Mapping Project**, 2005.

European Commission (2010) **Report from the Commission to the Council and the European Parliament on the implementation of Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources based on Member State reports for the period 2004-2007.** European Commission.

Fetter, C. W. (1988). **Applied Hydrogeology** (second edition). Macmillan Publishing Company.

Fitzgerald, D. and Forrestal, F. **Monthly and Annual Averages of Rainfall for Ireland 1961-1990**. Met Eireann.

Geoffrey Walton Practice (1988). ***Technical review of the stability and hydrogeology of mineral workings for the Department of the Environment.*** HMSO.

Geoffrey Walton Practice (2007). ***Handbook of methods for controlling surface waters in and around aggregate quarries*****.** Accessed 30 September 2009 through parent URL: www.sustainableaggregates.com.

Institute of Geologists of Ireland (2002). ***Geology in Environmental Impact Statements – A Guide***. Institute of Geologists of Ireland.

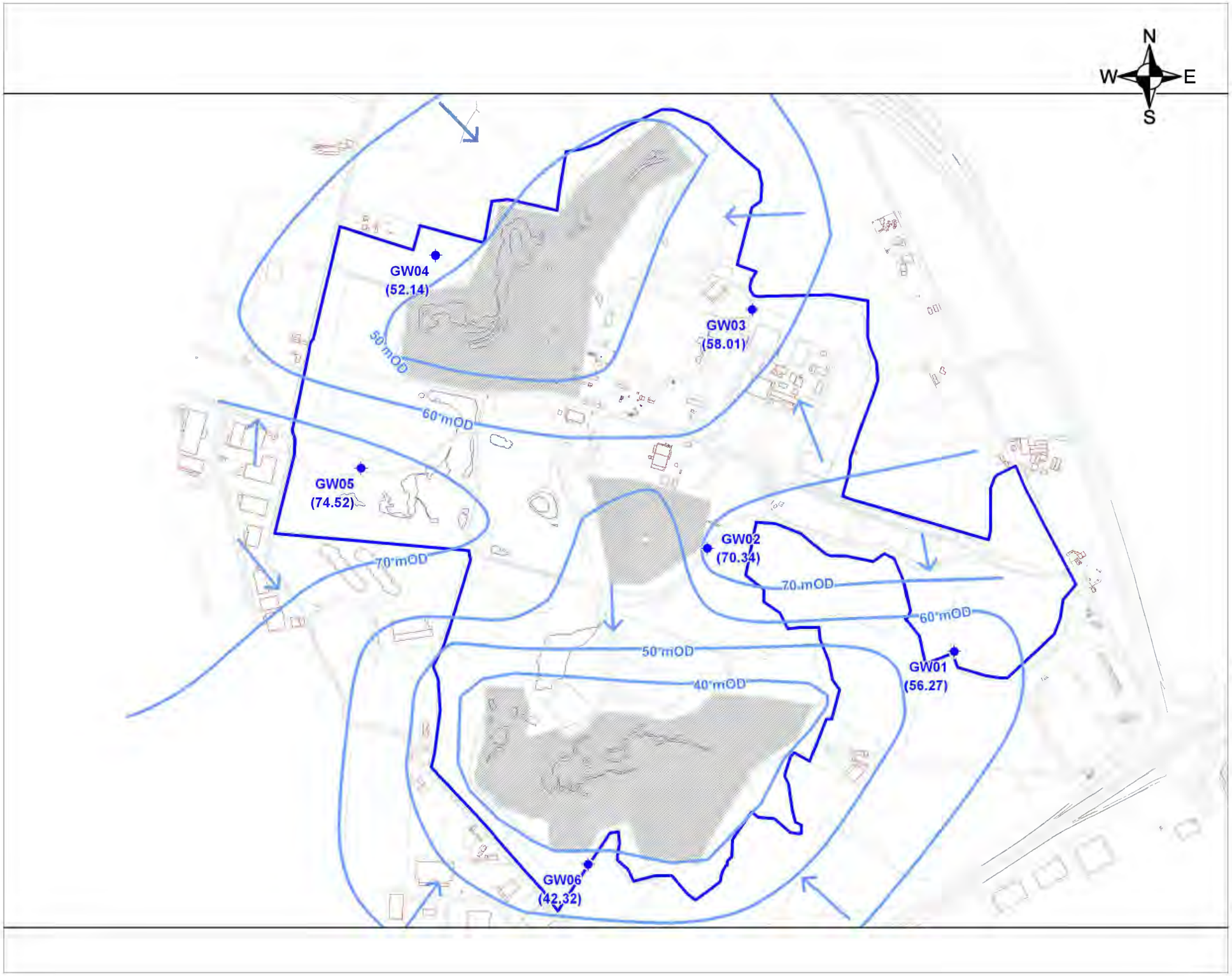
Institute of Geologists of Ireland (2007). ***Recommended Collection, Presentation and Interpretation of Geological and Hydrogeological Information for Quarry Developments*****.** Institute of Geologists of Ireland.

Geological Survey of Ireland, 2001. ***A geological description to accompany the bedrock geology 1:100,000 Map Series. Geology of Meath, Sheet No 13.*** Geological Survey of Ireland.

Geoloical Survey of Ireland, 1999. ***Geology of Meath, 1:100,000 Map Series, Sheet 13***. Geological Survey of Ireland.

Preene, M., Roberts, T. O. L., Powrie, W. And Dyer, M. R. ***Groundwater Control – Design and Practice.*** CIRIA, Publication C515.

FIGURES



0 100 200 300 400m 600 800 1000

Metres
1:10,000

LEGEND

- Site Boundary
- Quarried Areas
- Monitoring Wells (Groundwater Elevation on 05 Aug 10)
- Groundwater Flow Direction
- Contours of Equal Groundwater Elevation

Roadstone Wood
The Right Choice

SLR CONSULTING IRELAND
7 DUNDRUM BUSINESS PARK
WINDY ARBOUR
DUBLIN 14
T: +353-1-2964667
F: +353-1-2964676
www.slrconsulting.com

ROADSTONE WOOD LTD.

HUNTSTOWN QUARRY,
NORTH ROAD, FINGLAS, DUBLIN 11

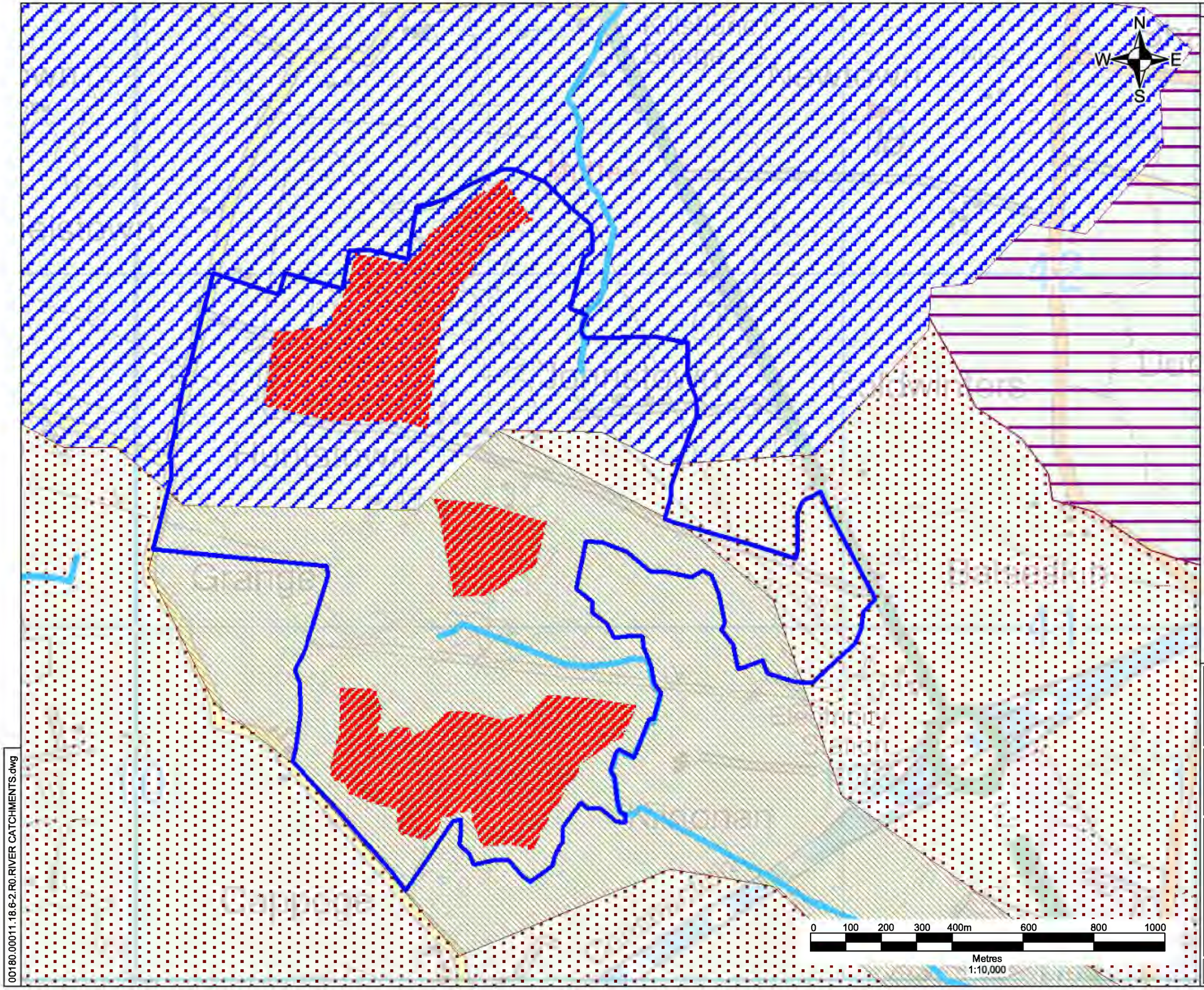
GROUNDWATER MONITORING LOCATIONS AND GROUNDWATER LEVEL CONTOURS

FIGURE 6-1

Scale: 1:10,000 @ A3

Date: FEBRUARY 2012

00180.00011.18.6-1.R0.GROUNDWATER CONTOURS.dwg



LEGEND

- Site Boundary
- Active Areas

Catchments

- Finglas Stream Subcatchment
- Tolka River Catchment
- Ward River Catchment
- Mayne Stream Catchment
- Santry Stream Catchment
- Watercourses

Roadstone WOOD
The Right Choice

SLR CONSULTING IRELAND
7 DUNDRUM BUSINESS PARK
WINDY ARBOUR
DUBLIN 14
T: +353-1-2964667
F: +353-1-2964676
www.slrconsulting.com

ROADSTONE WOOD LTD.
ENVIRONMENTAL IMPACT STATEMENT

WASTE RECOVERY FACILITY,
HUNTSTOWN QUARRY,
NORTH ROAD, FINGLAS, DUBLIN 11

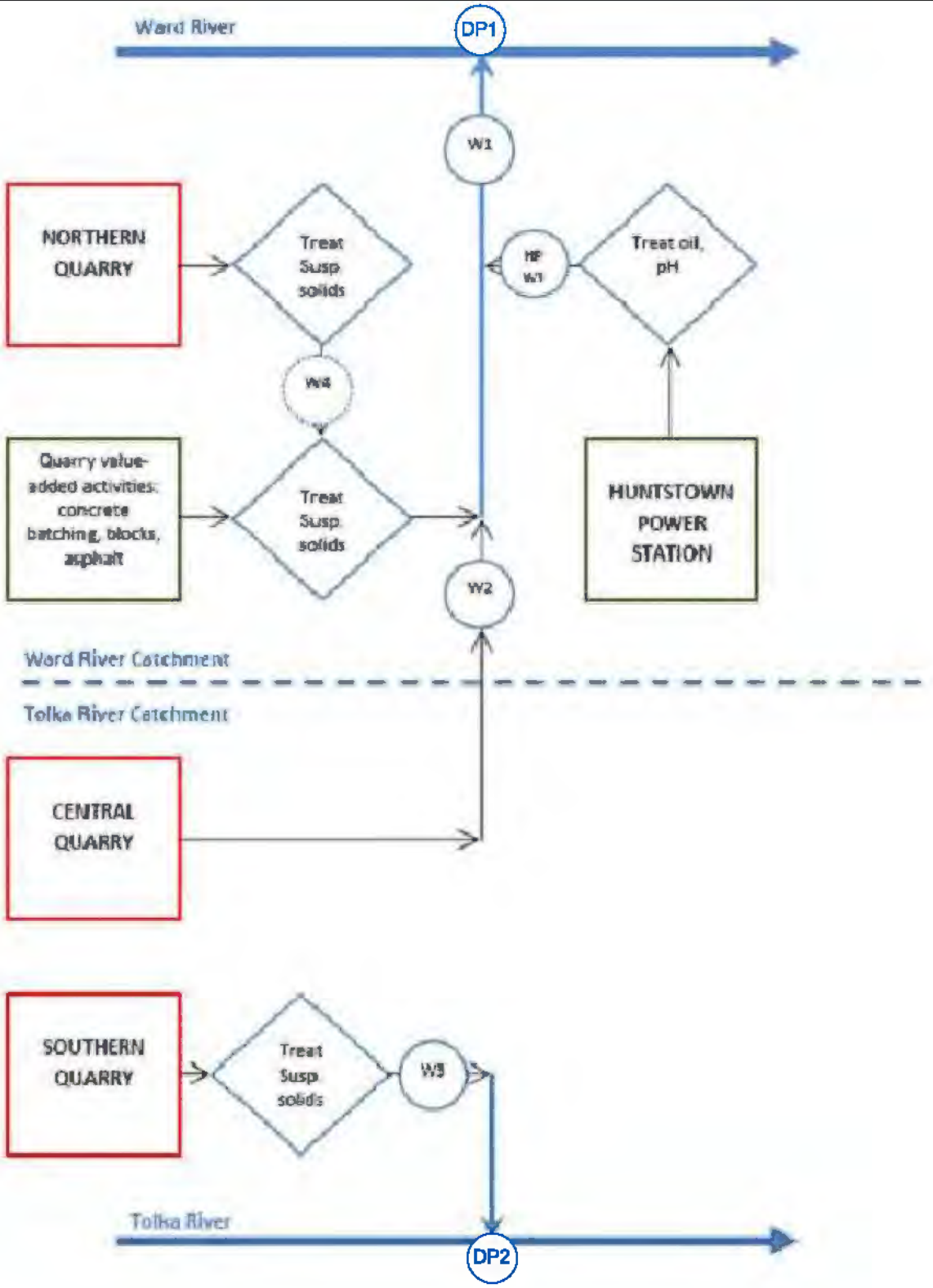
RIVER CATCHMENTS MAP

FIGURE 6-2

Scale: 1:10,000 @ A3

Date: FEBRUARY 2012

00180.00011.18.6-2.R0.RIVER CATCHMENTS.dwg



SLR CONSULTING IRELAND
7 DUNDRUM BUSINESS PARK
WINDY ARBOUR
DUBLIN 14
T: +353-1-2964667
F: +353-1-2964676
www.slrconsulting.com

ROADSTONE WOOD LTD.
ENVIRONMENTAL IMPACT STATEMENT

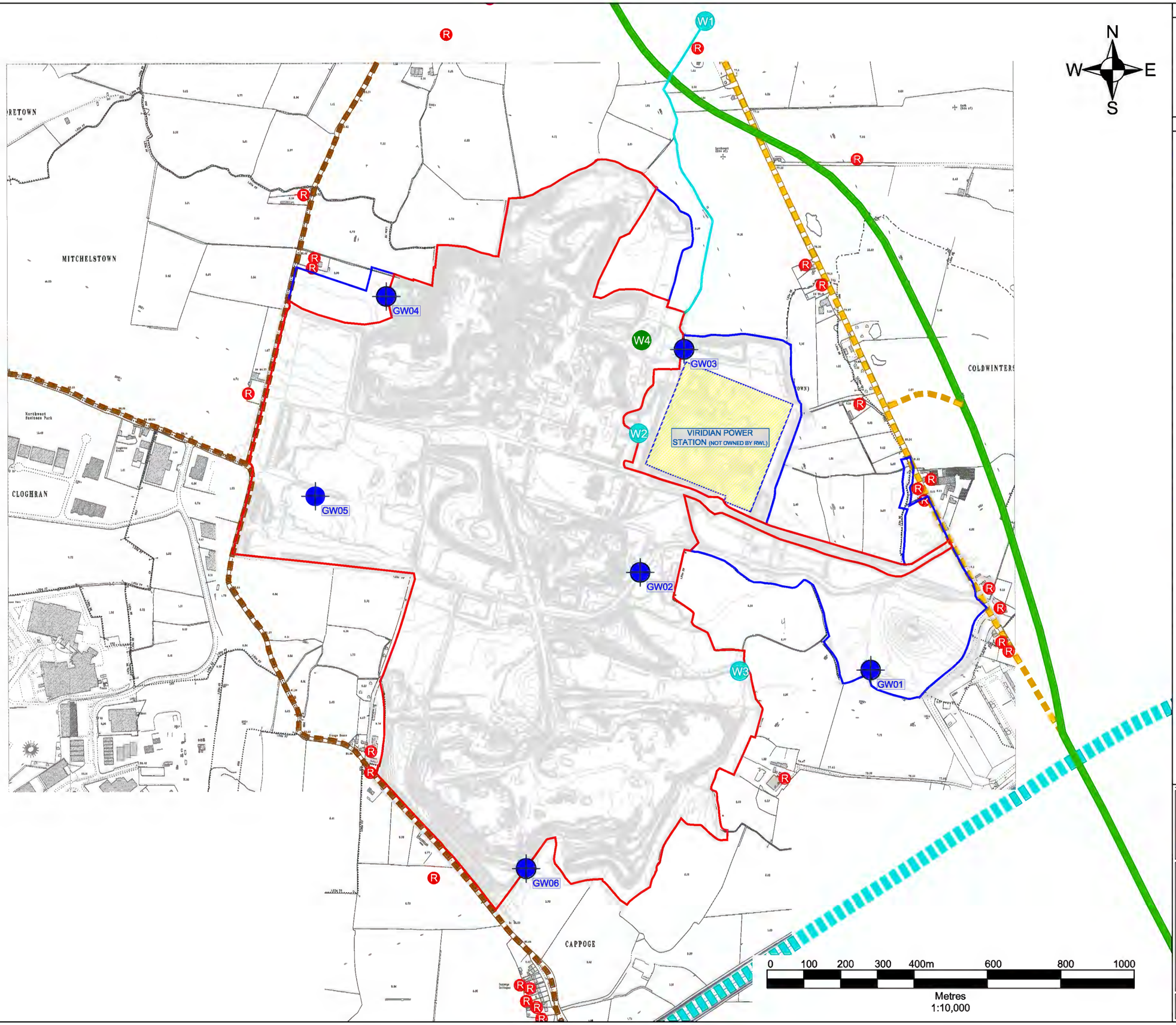
HUNTSTOWN QUARRY,
NORTH ROAD, FINGLAS, DUBLIN 11

SURFACE WATER MANAGEMENT SYSTEM

FIGURE 6-3

Scale	Date
NOT TO SCALE	FEBRUARY 2012

Roadstone WOOD
The Right Choice



N
W E
S

NOTES

1. EXTRACT FROM 1:2,500 ORDNANCE SURVEY DIGITAL SHEET NO'S. 3062-A, 3062-B, 3062-C, 3062-D, 3063-A, 3063-C, 3130-A & 3130-B

2. ORDNANCE SURVEY IRELAND LICENCE NO. SU 0000712 (C) ORDNANCE SURVEY & GOVERNMENT OF IRELAND

LEGEND

- ROADSTONE WOOD LTD. LANDHOLDING (c. 211 ha)
- PLANNING APPLICATION AREA (c.167.5 ha)
- N2 DUAL CARRIAGEWAY
- NORTH ROAD (R135)
- LOCAL ROAD
- M50 MOTORWAY
- LOCATION OF NEAREST RESIDENCES
- GROUNDWATER MONITORING WELL LOCATION
- SURFACE WATER MONITORING LOCATION
- PROPOSED SURFACE WATER MONITORING LOCATION

Roadstone WOOD
The Right Choice

SLR CONSULTING IRELAND
7 DUNDRUM BUSINESS PARK
WINDY ARBOUR
DUBLIN 14
T: +353-1-2964667
F: +353-1-2964676
www.slrconsulting.com

ROADSTONE WOOD LTD.
ENVIRONMENTAL IMPACT STATEMENT

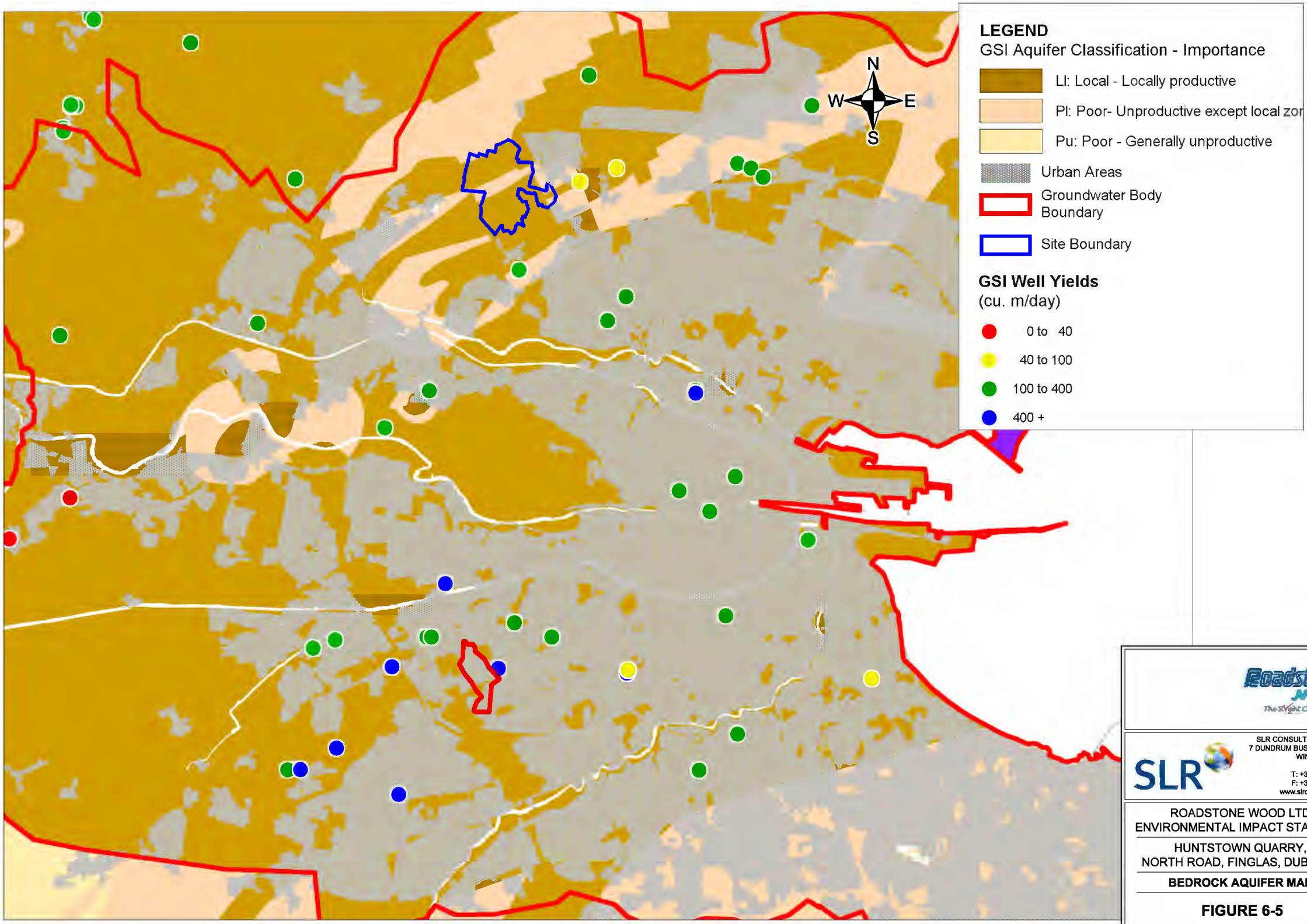
HUNTSTOWN QUARRY,
NORTH ROAD, FINGLAS, DUBLIN 11

WATER MONITORING MAP

FIGURE 6-4

Scale	Date
1:10,000 @ A3	FEBRUARY 2012

00180.00011.18.6-4.R0.WATER MONITORING MAP.dwg



Roadstone WOOD
The Right Choice

SLR CONSULTING IRELAND
7 DUNDRUM BUSINESS PARK
WINDY ARBOUR
DUBLIN 14
T: +353-1-2964667
F: +353-1-2964676
www.slrconsulting.com

ROADSTONE WOOD LTD.
ENVIRONMENTAL IMPACT STATEMTN

HUNTSTOWN QUARRY,
NORTH ROAD, FINGLAS, DUBLIN 11

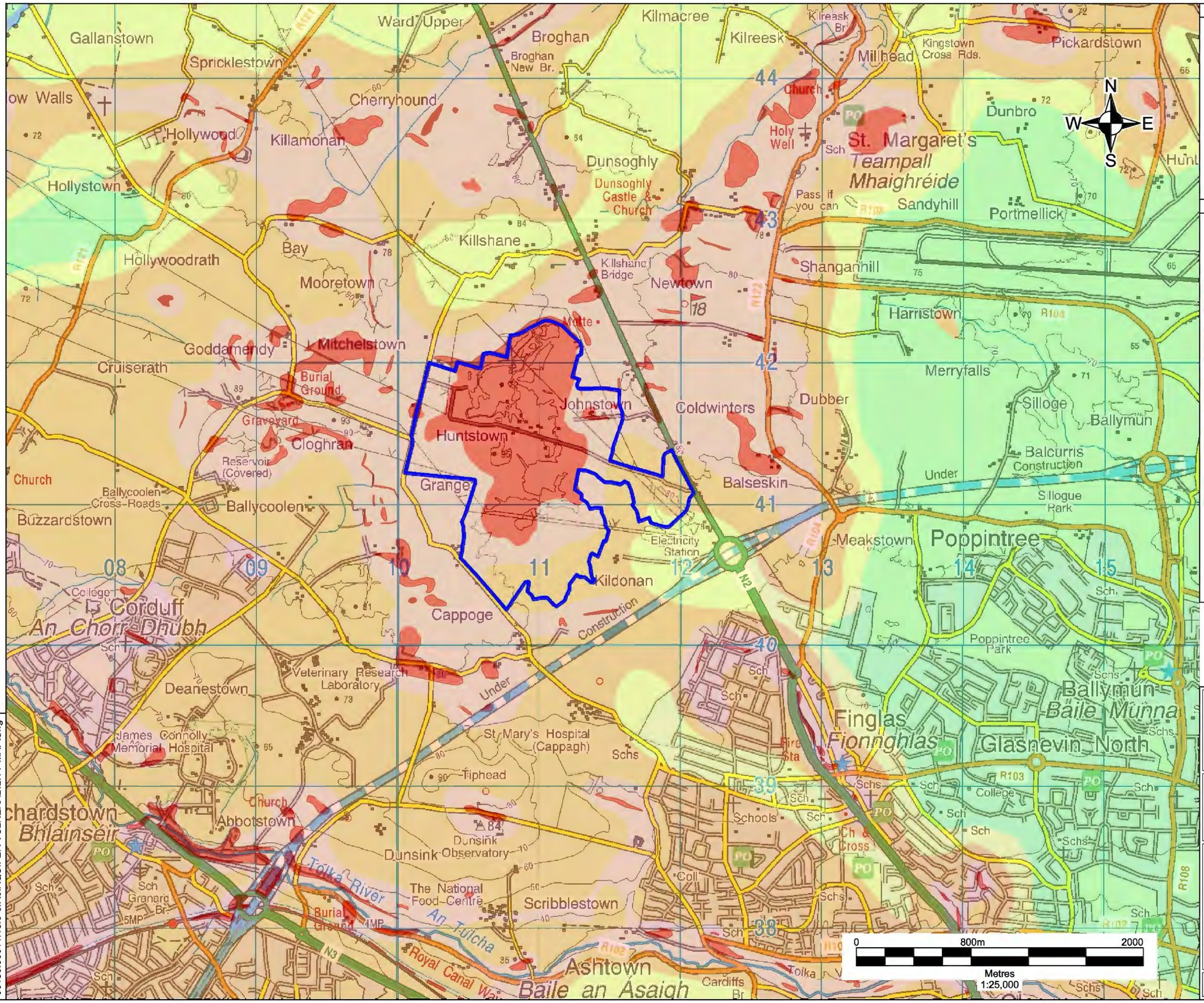
BEDROCK AQUIFER MAP

FIGURE 6-5

Scale: No Scale @ A3

Date: FEBRUARY 2012

00180.00011.18.6-5.R0.BEDROCK AQUIFER MAP.dwg



NOTES

1. EXTRACT FROM 1:50,000 ORDNANCE SURVEY DISCOVERY SERIES MAP NO. 56

2. ORDNANCE SURVEY IRELAND LICENCE NO. SU 0000712 (C) ORDNANCE SURVEY & GOVERNMENT OF IRELAND

LEGEND

- ROADSTONE WOOD LTD. LANDHOLDING (c. 211 ha)
- EXTREME (ROCK AT OR CLOSE TO SURFACE)
- EXTREME
- HIGH
- MODERATE
- LOW

Roadstone WOOD
The Right Choice

SLR CONSULTING IRELAND
7 DUNDRUM BUSINESS PARK
WINDY ARBOUR
DUBLIN 14
T: +353-1-2964667
F: +353-1-2964676
www.slrconsulting.com

ROADSTONE WOOD LTD.
ENVIRONMENTAL IMPACT STATEMENT

HUNTSTOWN QUARRY,
NORTH ROAD, FINGLAS, DUBLIN 11

AQUIFER VULNERABILITY MAP

FIGURE 6-6

Scale: 1:25,000 @ A3

Date: FEBRUARY 2012

00180.00011.18.6-6.R0.AQUIFER VULNERABILITY MAP.dwg

APPENDICES

Appendix 6-A
Groundwater Well Construction Records

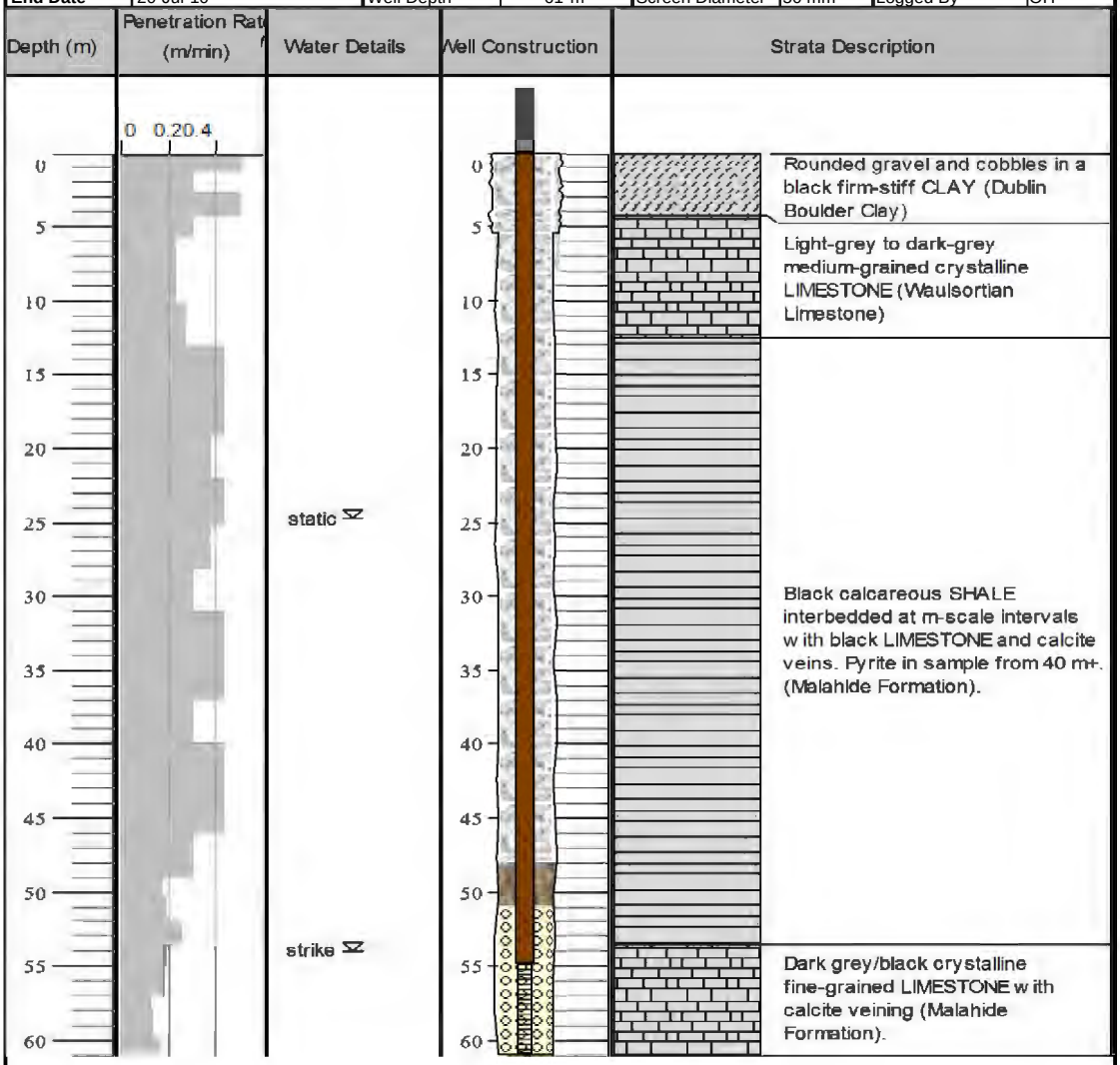
Appendix 6-B
Water Quality Results

Appendix 6-C
Site Water Balance

Appendix 6-D
Spill Kit Details

Appendix 6-A
Groundwater Well Construction Records

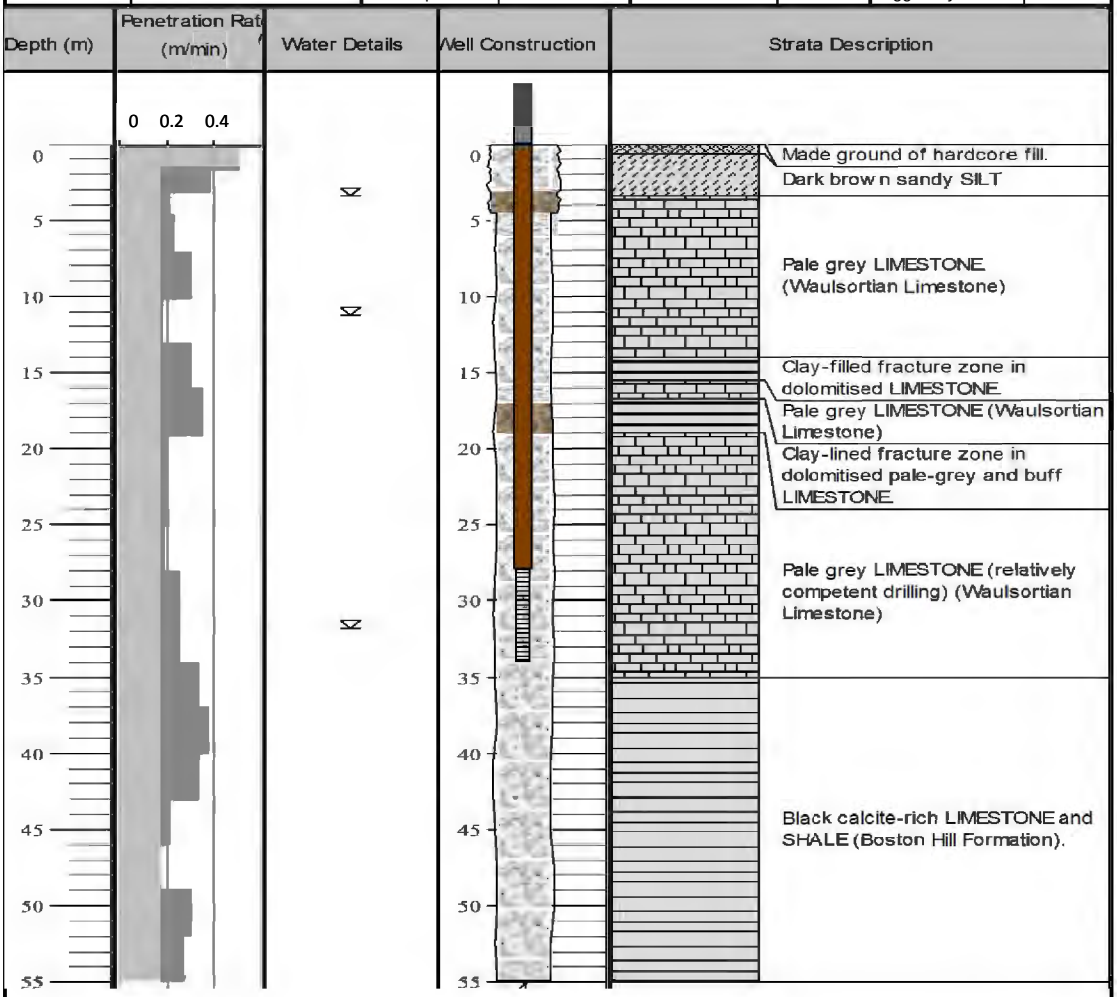
Project Name	Huntstown Quarry PA	**WELL LOG**		SLR Consulting (Ireland) Ltd.			
Client	Roadstone Wood Ltd.	Well Name	GW01	7 Dundrum Business Park			
Project No.	501.0180.00011			Windy Arbour			
Location	Huntstown, County Dublin	Easting	311785.7	Dublin 14			
Contractor	Petersen Drilling Services	Northing	240902.1	T: 01 2964667 F: 01 2964676			
Drill Rig	Knebel	Elevation (gl)	80.98 mOD	Casing Length	55 m	Hole ID	170 mm
Drill Method	Symmetrix and DTH Air	Elevation (TOC)	81.74 mOD	Casing Diameter	50 mm	Static Level	24.7 mbgl
Start Date	17-Jul-10	Boring Depth	61 m	Screen Length	6 m	Depth to Bedrock	4.3 mbgl
End Date	20-Jul-10	Well Depth	61 m	Screen Diameter	50 mm	Logged By	OH



Drilling Diameters			**Steel Support Casings**			Driller Yield Estimate:
Diameter	From	To	Diameter	From	To	Development Time:
0.17	0	5.5				
0.14	5.5	61				

Other Remarks:

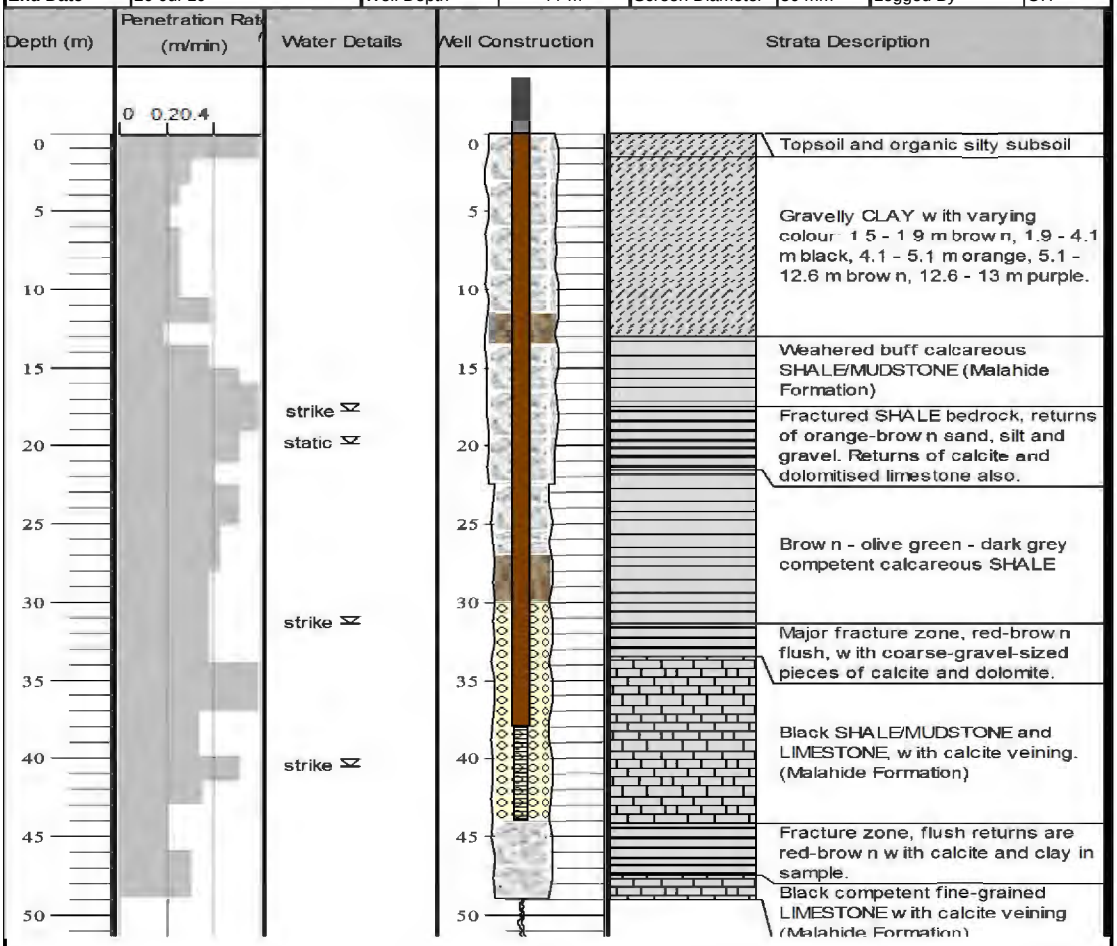
Project Name	Huntstown Quarry PA	**WELL LOG**		SLR Consulting (Ireland) Ltd.			
Client	Roadstone Wood Ltd.	Well Name	GW02	7 Dundrum Business Park			
Project No.	501.0180.00011			Windy Arbour			
Location	Huntstown, County Dublin	Easting	311158.0	Dublin 14			
Contractor	Petersen Drilling Services	Northing	241167.5	T: 01 2964667 F: 01 2964676			
Drill Rig	Knebel	Elevation (gl)	81.51 mOD	Casing Length	28 m	Hole ID	170 mm
Drill Method	Symmetrix and DTH Air	Elevation (TOC)	82.33 mOD	Casing Diameter	50 mm	Static Level	11.2mbgl
Start Date	17-Jul-10	Boring Depth	55 m	Screen Length	6 m	Depth to Bedrock	3.4 mbgl
End Date	20-Jul-10	Well Depth	34 m	Screen Diameter	50 mm	Logged By	OH



Drilling Diameters			**Steel Support Casings**			Driller Yield Estimate:
Diameter	From	To	Diameter	From	To	Development Time:
0.17	0	4.5				
0.14	4.5	55				

Other Remarks:

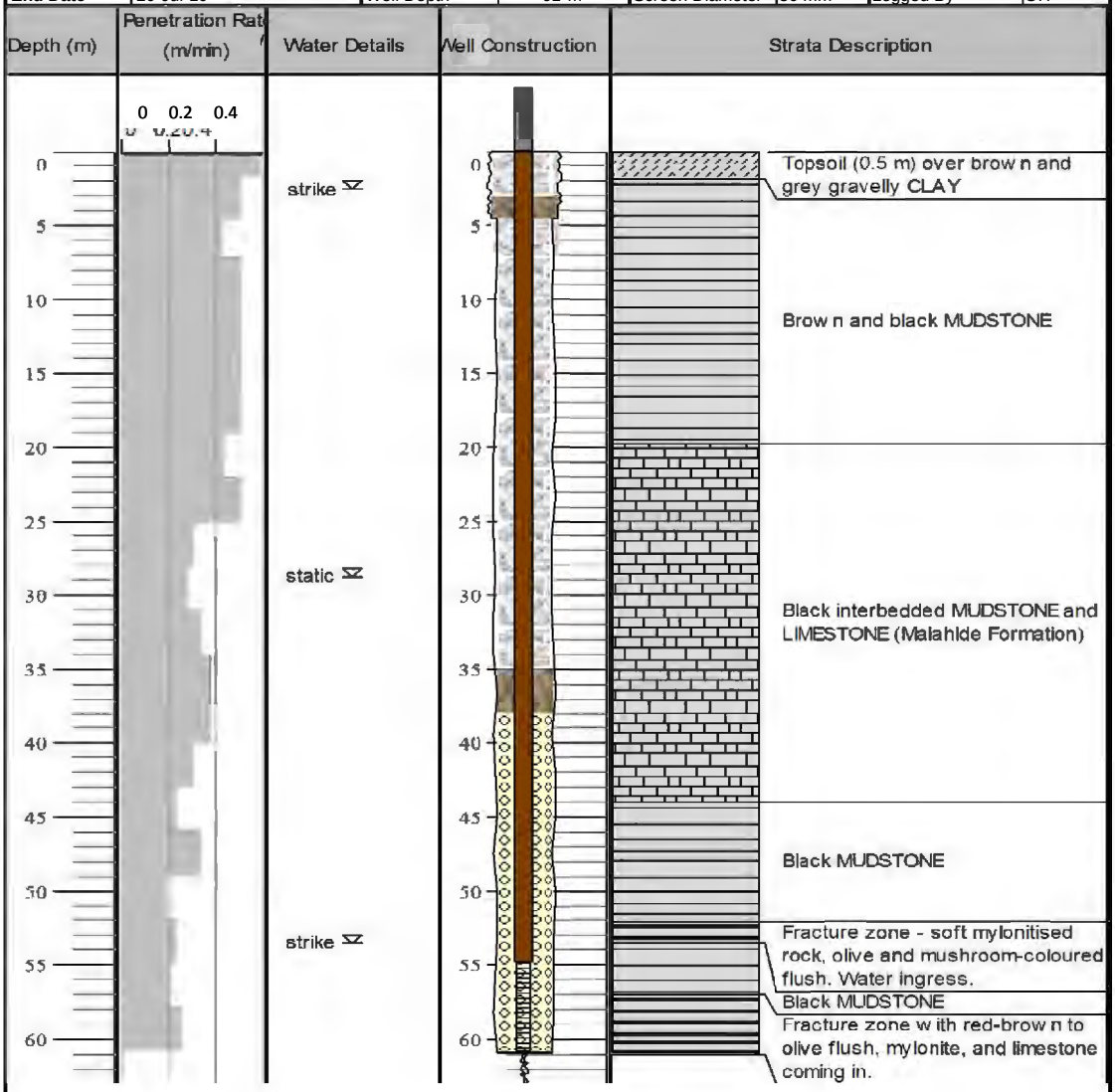
Project Name	Huntstown Quarry PA	**WELL LOG**		SLR Consulting (Ireland) Ltd.			
Client	Roadstone Wood Ltd.	Well Name	GW03	7 Dundrum Business Park			
Project No.	501.0180.00011			Windy Arbour			
Location	Huntstown, County Dublin	Easting	311274.1	Dublin 14			
Contractor	Petersen Drilling Services	Northing	241775.0	T: 01 2964667 F: 01 2964676			
Drill Rig	Knebel	Elevation (gl)	77.94 mOD	Casing Length	38 m	Hole ID	170 mm
Drill Method	Symmetrix and DTH Air	Elevation (TOC)	78.47 mOD	Casing Diameter	50 mm	Static Level	19.9 mbgl
Start Date	17-Jul-10	Boring Depth	49 m	Screen Length	6 m	Depth to Bedrock	13 mbgl
End Date	20-Jul-10	Well Depth	44 m	Screen Diameter	50 mm	Logged By	OH



Drilling Diameters			**Steel Support Casings**			Driller Yield Estimate:
Diameter	From	To	Diameter	From	To	Development Time:
0.17	0	22.5				
0.14	22.5	49				

Other Remarks:

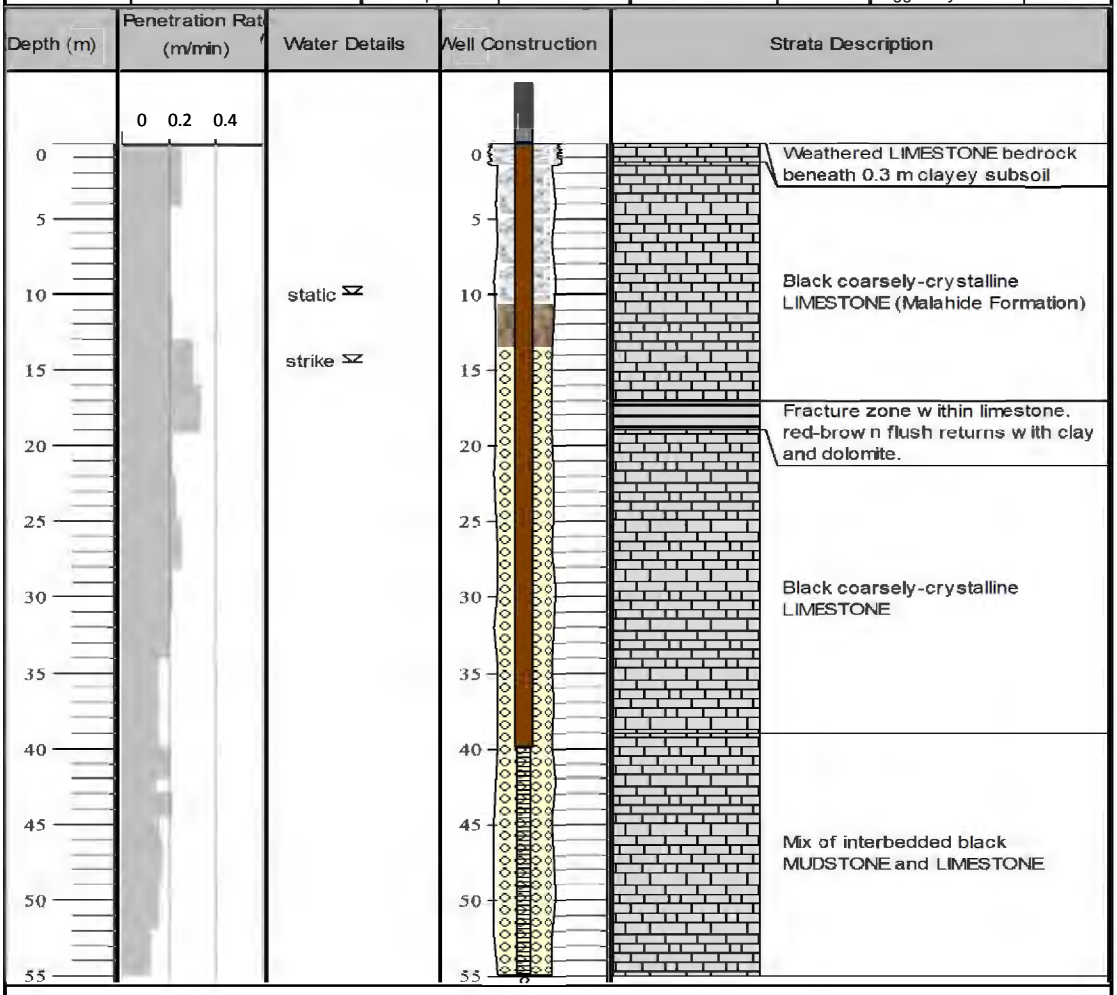
Project Name	Huntstown Quarry PA	**WELL LOG**		SLR Consulting (Ireland) Ltd.			
Client	Roadstone Wood Ltd.	Well Name	GW04	7 Dundrum Business Park			
Project No.	501.0180.00011			Windy Arbour			
Location	Huntstown, County Dublin	Easting	310466.2	Dublin 14			
Contractor	Petersen Drilling Services	Northing	241917.7	T: 01 2964667 F: 01 2964676			
Drill Rig	Knebel	Elevation (gl)	81.21 mOD	Casing Length	55 m	Hole ID	170 mm
Drill Method	Symmetrix and DTH Air	Elevation (TOC)	81.73 mOD	Casing Diameter	50 mm	Static Water Level	28.7 mbgl
Start Date	17-Jul-10	Boring Depth	61 m	Screen Length	6 m	Depth to Bedrock	1.9 mbgl
End Date	20-Jul-10	Well Depth	61 m	Screen Diameter	50 mm	Logged By	OH



Drilling Diameters			**Steel Support Casings**			Driller Yield Estimate:
Diameter	From	To	Diameter	From	To	Development Time:
0.17	0	4.5				
0.14	4.5	61				

Other Remarks:

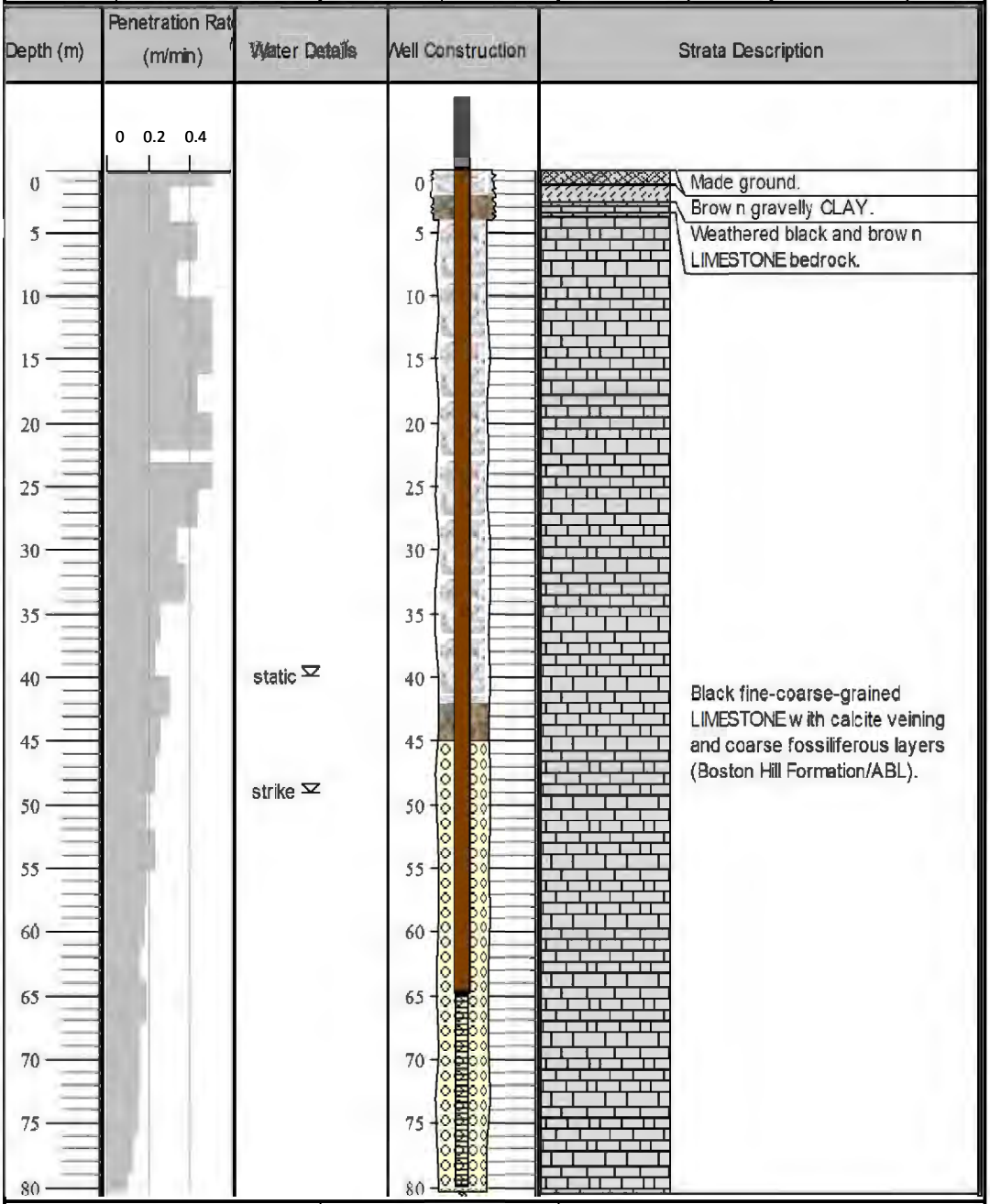
Project Name	Huntstown Quarry PA	**WELL LOG**		SLR Consulting (Ireland) Ltd.			
Client	Roadstone Wood Ltd	Well Name	GW05	7 Dundrum Business Park			
Project No.	501.0180.00011			Windy Arbour			
Location	Huntstown, County Dublin	Easting	310273.0	Dublin 14			
Contractor	Petersen Drilling Services	Northing	241374.9	T: 01 2964667 F: 01 2964676			
Drill Rig	Knebel	Elevation (gl)	84.95 mOD	Casing Length	40 m	Hole ID	170 mm
Drill Method	Symmetrix and DTH Air	Elevation (TOC)	85.33 mOD	Casing Diameter	50 mm	Static Level	10 mbgl
Start Date	17-Jul-10	Boring Depth	55 m	Screen Length	15 m	Depth to Bedrock	0.3 mbgl
End Date	20-Jul-10	Well Depth	55 m	Screen Diameter	50 mm	Logged By	OH



Drilling Diameters			**Steel Support Casings**			Driller Yield Estimate:
Diameter	From	To	Diameter	From	To	Development Time:
0.17	0					
0.14						

Other Remarks:
Approximately 2.5 m of soil and subsoil have been stripped from this area.

Project Name	Huntstown Quarry PA	**WELL LOG**		SLR Consulting (Ireland) Ltd.			
Client	Roadstone Wood Ltd	Well Name	GW06	7 Dundrum Business Park			
Project No.	501.0180.00011			Windy Arbour			
Location	Huntstown, County Dublin	Easting	310847.3	Dublin 14			
Contractor	Petersen Drilling Services	Northing	240902.1	T: 01 2964667 F: 01 2964676			
Drill Rig	Knebel	Elevation (gl)	82.16 mOD	Casing Length	65.5 m	Hole ID	170 mm
Drill Method	Symmetrix and DTH Air	Elevation (TOC)	82.78 mOD	Casing Diameter	50 mm	Static Level	39.8 mbgl
Start Date	17-Jul-10	Boring Depth	80.5 m	Screen Length	15 m	Depth to Bedrock	2.5 mbgl
End Date	20-Jul-10	Well Depth	80.5 m	Screen Diameter	50 mm	Logged By	OH



Drilling Diameters			**Steel Support Casings**			Driller Yield Estimate:
Diameter	From	To	Diameter	From	To	Development Time:
0.17	0	4				
0.14	4	80.5				

Other Remarks:

Appendix 6-B
Water Quality Results

BHP/CL/02C

24 AUG 2010

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: **SLR Consulting Ireland**
7 Dundrum Business Park
Windy Arbour
Dublin 14

FTAO: Oliver Higgins

BHP Ref. No.: 94060.1
Order No.:
Date Received: 06/08/10
Date Completed: 20/08/10
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	Central Sump			
pH		-	7.04	APHA-4500-H^+-B
Electrical Conductivity		μScm^{-1}	227	APHA - 2510 - B
Sodium		mg/l	12.56	APHA - 3120 - B
Potassium		mg/l	1.21	APHA - 3120 - B
Calcium		mg/l	54.3	APHA - 3120 - B
Magnesium		mg/l	0.95	APHA - 3120 - B
Chloride		mg/l	24.7	APHA - 4110 - B
Sulphate (as SO_4)		mg/l	8.16	APHA - 4110 - B
Total Alkalinity (as $CaCO_3$)		mg/l	151	APHA - 2320 -B
Total Hardness (as $CaCO_3$)		mg/l	330	APHA - 2340- B
Nitrate (as NO_3)		mg/l	4.66	APHA - 4110 - B
Nitrite (as NO_2)		mg/l	<0.05	APHA - 4110 - B
BOD		mg/l	2	APHA - 5210 - B
Diesel Range Organics		mg/l	<0.01	GC-FID
Mineral Oils		mg/l	<0.01	GC-FID

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

P. O Sul

Pat O'Sullivan
Issue Date : 20/08/2010

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: **SLR Consulting Ireland**
7 Dundrum Business Park
Windy Arbour
Dublin 14

FTAO: Oliver Higgins

BHP Ref. No.: 94060.1
Order No.:
Date Received: 06/08/10
Date Completed: 20/08/10
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	Central Sump			
Ammoniacal Nitrogen (as NH_3-N)		mg/l	0.04	APHA -4500- NH_3-D
Iron		mg/l	<0.001	APHA - 3120 - B
Manganese		mg/l	<0.001	APHA - 3120 - B
OrthoPhosphate (PO_4-P)		mg/l	0.07	APHA - 4110 - B

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

P. O'Sul

Pat O'Sullivan
Issue Date : 20/08/2010

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: **SLR Consulting Ireland**
7 Dundrum Business Park
Windy Arbour
Dublin 14

FTAO: Oliver Higgins

BHP Ref. No.: 94060.2
Order No.:
Date Received: 06/08/10
Date Completed: 20/08/10
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	Northern Sump			
pH		-	7.11	APHA-4500-H^+-B
Electrical Conductivity		μScm^{-1}	329	APHA - 2510 - B
Sodium		mg/l	20.54	APHA - 3120 - B
Potassium		mg/l	4.89	APHA - 3120 - B
Calcium		mg/l	102.4	APHA - 3120 - B
Magnesium		mg/l	3.25	APHA - 3120 - B
Chloride		mg/l	30.21	APHA - 4110 - B
Sulphate (as SO_4)		mg/l	19.27	APHA - 4110 - B
Total Alkalinity (as $CaCO_3$)		mg/l	209	APHA - 2320 -B
Total Hardness (as $CaCO_3$)		mg/l	430	APHA - 2340- B
Nitrate (as NO_3)		mg/l	3.27	APHA - 4110 - B
Nitrite (as NO_2)		mg/l	<0.05	APHA - 4110 - B
BOD		mg/l	1	APHA - 5210 - B
Diesel Range Organics		mg/l	<0.01	GC-FID
Mineral Oils		mg/l	<0.01	GC-FID

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 20/08/2010

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: **SLR Consulting Ireland**
7 Dundrum Business Park
Windy Arbour
Dublin 14

FTAO: Oliver Higgins

BHP Ref. No.: 94060.2
Order No.:
Date Received: 06/08/10
Date Completed: 20/08/10
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	Northern Sump			
Ammoniacal Nitrogen (as NH_3-N)		mg/l	0.02	APHA -4500- NH_3-D
Iron		mg/l	0.016	APHA - 3120 - B
Manganese		mg/l	0.002	APHA - 3120 - B
OrthoPhosphate (PO_4-P)		mg/l	0.04	APHA - 4110 - B

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 20/08/2010

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: **SLR Consulting Ireland**
7 Dundrum Business Park
Windy Arbour
Dublin 14

FTAO: Oliver Higgins

BHP Ref. No.: 94060.3
Order No.:
Date Received: 06/08/10
Date Completed: 20/08/10
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	SW01			
pH		-	6.96	APHA-4500-H^+-B
Electrical Conductivity		μScm^{-1}	459	APHA - 2510 - B
Sodium		mg/l	31.2	APHA - 3120 - B
Potassium		mg/l	3.12	APHA - 3120 - B
Calcium		mg/l	80.4	APHA - 3120 - B
Magnesium		mg/l	2.45	APHA - 3120 - B
Chloride		mg/l	56.74	APHA - 4110 - B
Sulphate (as SO_4)		mg/l	20.4	APHA - 4110 - B
Total Alkalinity (as $CaCO_3$)		mg/l	210	APHA - 2320 -B
Total Hardness (as $CaCO_3$)		mg/l	424	APHA - 2340- B
Nitrate (as NO_3)		mg/l	11.24	APHA - 4110 - B
Nitrite (as NO_2)		mg/l	<0.05	APHA - 4110 - B
BOD		mg/l	1	APHA - 5210 - B
Diesel Range Organics		mg/l	<0.01	GC-FID
Mineral Oils		mg/l	<0.01	GC-FID

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 20/08/2010

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: **SLR Consulting Ireland**
7 Dundrum Business Park
Windy Arbour
Dublin 14

FTAO: Oliver Higgins

BHP Ref. No.: 94060.3
Order No.:
Date Received: 06/08/10
Date Completed: 20/08/10
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	SW01			
Ammoniacal Nitrogen (as NH_3-N)		mg/l	0.01	APHA -4500- NH_3-D
Iron		mg/l	<0.001	APHA - 3120 - B
Manganese		mg/l	<0.001	APHA - 3120 - B
OrthoPhosphate (PO_4-P)		mg/l	0.08	APHA - 4110 - B

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

P. o Sul

Pat O'Sullivan
Issue Date : 20/08/2010

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: **SLR Consulting Ireland**
7 Dundrum Business Park
Windy Arbour
Dublin 14

FTAO: Oliver Higgins

BHP Ref. No.: 94060.4
Order No.:
Date Received: 06/08/10
Date Completed: 20/08/10
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	GW01			
pH		-	7.34	APHA-4500-H^+-B
Electrical Conductivity		μScm^{-1}	114	APHA - 2510 - B
Sodium		mg/l	24.52	APHA - 3120 - B
Potassium		mg/l	3.54	APHA - 3120 - B
Calcium		mg/l	80.7	APHA - 3120 - B
Magnesium		mg/l	17.54	APHA - 3120 - B
Chloride		mg/l	19.23	APHA - 4110 - B
Sulphate (as SO_4)		mg/l	48.96	APHA - 4110 - B
Total Alkalinity (as $CaCO_3$)		mg/l	301	APHA - 2320 -B
Total Hardness (as $CaCO_3$)		mg/l	340	APHA - 2340- B
Nitrate (as NO_3)		mg/l	18.66	APHA - 4110 - B
Nitrite (as NO_2)		mg/l	<0.05	APHA - 4110 - B
Total Organic Carbon		mg/l	4.1	APHA - 5310 - C

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 20/08/2010

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: **SLR Consulting Ireland**
7 Dundrum Business Park
Windy Arbour
Dublin 14

FTAO: Oliver Higgins

BHP Ref. No.: 94060.4
Order No.:
Date Received: 06/08/10
Date Completed: 20/08/10
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	GW01			
Ammoniacal Nitrogen (as NH_3-N)		mg/l	0.02	APHA -4500- NH_3-D
Iron		mg/l	0.006	APHA - 3120 - B
Manganese		mg/l	0.001	APHA - 3120 - B
OrthoPhosphate (PO_4-P)		mg/l	0.1	APHA - 4110 - B

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 20/08/2010

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: **SLR Consulting Ireland**
7 Dundrum Business Park
Windy Arbour
Dublin 14

FTAO: Oliver Higgins

BHP Ref. No.: 94060.5
Order No.:
Date Received: 06/08/10
Date Completed: 20/08/10
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	GW02			
pH		-	6.84	APHA-4500-H^+-B
Electrical Conductivity		μScm^{-1}	229	APHA - 2510 - B
Sodium		mg/l	17.89	APHA - 3120 - B
Potassium		mg/l	2.99	APHA - 3120 - B
Calcium		mg/l	75.45	APHA - 3120 - B
Magnesium		mg/l	15.42	APHA - 3120 - B
Chloride		mg/l	24.68	APHA - 4110 - B
Sulphate (as SO_4)		mg/l	12.09	APHA - 4110 - B
Total Alkalinity (as $CaCO_3$)		mg/l	292	APHA - 2320 -B
Total Hardness (as $CaCO_3$)		mg/l	352	APHA - 2340- B
Nitrate (as NO_3)		mg/l	12.45	APHA - 4110 - B
Nitrite (as NO_2)		mg/l	<0.05	APHA - 4110 - B
Total Organic Carbon		mg/l	4.4	APHA - 5310 - C

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 20/08/2010

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: **SLR Consulting Ireland**
7 Dundrum Business Park
Windy Arbour
Dublin 14

FTAO: Oliver Higgins

BHP Ref. No.: 94060.5
Order No.:
Date Received: 06/08/10
Date Completed: 20/08/10
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	GW02			
Ammoniacal Nitrogen (as NH_3-N)		mg/l	0.01	APHA -4500- NH_3-D
Iron		mg/l	<0.001	APHA - 3120 - B
Manganese		mg/l	<0.001	APHA - 3120 - B
OrthoPhosphate (PO_4-P)		mg/l	0.09	APHA - 4110 - B

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 20/08/2010

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: **SLR Consulting Ireland**
7 Dundrum Business Park
Windy Arbour
Dublin 14

FTAO: Oliver Higgins

BHP Ref. No.: 94060.6
Order No.:
Date Received: 06/08/10
Date Completed: 20/08/10
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	GW03			
pH		-	7.46	APHA-4500-H^+-B
Electrical Conductivity		μScm^{-1}	376	APHA - 2510 - B
Sodium		mg/l	28.62	APHA - 3120 - B
Potassium		mg/l	4.01	APHA - 3120 - B
Calcium		mg/l	92.52	APHA - 3120 - B
Magnesium		mg/l	20.27	APHA - 3120 - B
Chloride		mg/l	43.11	APHA - 4110 - B
Sulphate (as SO_4)		mg/l	17.24	APHA - 4110 - B
Total Alkalinity (as $CaCO_3$)		mg/l	351	APHA - 2320 -B
Total Hardness (as $CaCO_3$)		mg/l	440	APHA - 2340- B
Nitrate (as NO_3)		mg/l	24.77	APHA - 4110 - B
Nitrite (as NO_2)		mg/l	<0.05	APHA - 4110 - B
Total Organic Carbon		mg/l	1.5	APHA - 5310 - C

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 20/08/2010

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: **SLR Consulting Ireland**
7 Dundrum Business Park
Windy Arbour
Dublin 14

FTAO: Oliver Higgins

BHP Ref. No.: 94060.6
Order No.:
Date Received: 06/08/10
Date Completed: 20/08/10
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	GW03			
Ammoniacal Nitrogen (as NH_3-N)		mg/l	0.04	APHA -4500- NH_3-D
Iron		mg/l	0.052	APHA - 3120 - B
Manganese		mg/l	0.013	APHA - 3120 - B
OrthoPhosphate (PO_4-P)		mg/l	0.06	APHA - 4110 - B

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 20/08/2010

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: **SLR Consulting Ireland**
7 Dundrum Business Park
Windy Arbour
Dublin 14

FTAO: Oliver Higgins

BHP Ref. No.: 94060.7
Order No.:
Date Received: 06/08/10
Date Completed: 20/08/10
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	GW04			
pH		-	7.32	APHA-4500-H^+-B
Electrical Conductivity		μScm^{-1}	512	APHA - 2510 - B
Sodium		mg/l	25.42	APHA - 3120 - B
Potassium		mg/l	3.12	APHA - 3120 - B
Calcium		mg/l	85.42	APHA - 3120 - B
Magnesium		mg/l	19.85	APHA - 3120 - B
Chloride		mg/l	27.49	APHA - 4110 - B
Sulphate (as SO_4)		mg/l	36.11	APHA - 4110 - B
Total Alkalinity (as $CaCO_3$)		mg/l	332	APHA - 2320 -B
Total Hardness (as $CaCO_3$)		mg/l	494	APHA - 2340- B
Nitrate (as NO_3)		mg/l	16.62	APHA - 4110 - B
Nitrite (as NO_2)		mg/l	<0.05	APHA - 4110 - B
Total Organic Carbon		mg/l	0.5	APHA - 5310 - C

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 20/08/2010

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: **SLR Consulting Ireland**
7 Dundrum Business Park
Windy Arbour
Dublin 14

FTAO: Oliver Higgins

BHP Ref. No.: 94060.7
Order No.:
Date Received: 06/08/10
Date Completed: 20/08/10
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	GW04			
Ammoniacal Nitrogen (as NH_3-N)		mg/l	0.02	APHA -4500- NH_3-D
Iron		mg/l	<0.001	APHA - 3120 - B
Manganese		mg/l	<0.001	APHA - 3120 - B
OrthoPhosphate (PO_4-P)		mg/l	0.02	APHA - 4110 - B

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 20/08/2010

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: **SLR Consulting Ireland**
7 Dundrum Business Park
Windy Arbour
Dublin 14

FTAO: Oliver Higgins

BHP Ref. No.: 94060.8
Order No.:
Date Received: 06/08/10
Date Completed: 20/08/10
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	GW05			
pH		-	6.86	APHA-4500-H^+-B
Electrical Conductivity		μScm^{-1}	681	APHA - 2510 - B
Sodium		mg/l	16.89	APHA - 3120 - B
Potassium		mg/l	1.58	APHA - 3120 - B
Calcium		mg/l	68.57	APHA - 3120 - B
Magnesium		mg/l	14.56	APHA - 3120 - B
Chloride		mg/l	19.51	APHA - 4110 - B
Sulphate (as SO_4)		mg/l	24.66	APHA - 4110 - B
Total Alkalinity (as $CaCO_3$)		mg/l	247	APHA - 2320 -B
Total Hardness (as $CaCO_3$)		mg/l	220	APHA - 2340- B
Nitrate (as NO_3)		mg/l	9.32	APHA - 4110 - B
Nitrite (as NO_2)		mg/l	<0.05	APHA - 4110 - B
Total Organic Carbon		mg/l	3.2	APHA - 5310 - C

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 20/08/2010

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: **SLR Consulting Ireland**
7 Dundrum Business Park
Windy Arbour
Dublin 14

FTAO: Oliver Higgins

BHP Ref. No.: 94060.8
Order No.:
Date Received: 06/08/10
Date Completed: 20/08/10
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	GW05			
Ammoniacal Nitrogen (as NH_3-N)		mg/l	0.01	APHA -4500- NH_3-D
Iron		mg/l	<0.001	APHA - 3120 - B
Manganese		mg/l	<0.001	APHA - 3120 - B
OrthoPhosphate (PO_4-P)		mg/l	<0.01	APHA - 4110 - B

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 20/08/2010

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: **SLR Consulting Ireland**
7 Dundrum Business Park
Windy Arbour
Dublin 14

FTAO: Oliver Higgins

BHP Ref. No.: 94060.9
Order No.:
Date Received: 06/08/10
Date Completed: 20/08/10
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	GW06			
pH		-	7.12	APHA-4500-H^+-B
Electrical Conductivity		μScm^{-1}	354	APHA - 2510 - B
Sodium		mg/l	18.45	APHA - 3120 - B
Potassium		mg/l	2.57	APHA - 3120 - B
Calcium		mg/l	78.45	APHA - 3120 - B
Magnesium		mg/l	20.12	APHA - 3120 - B
Chloride		mg/l	34.16	APHA - 4110 - B
Sulphate (as SO_4)		mg/l	18.71	APHA - 4110 - B
Total Alkalinity (as $CaCO_3$)		mg/l	313	APHA - 2320 -B
Total Hardness (as $CaCO_3$)		mg/l	252	APHA - 2340- B
Nitrate (as NO_3)		mg/l	6.44	APHA - 4110 - B
Nitrite (as NO_2)		mg/l	<0.05	APHA - 4110 - B
Total Organic Carbon		mg/l	9.9	APHA - 5310 - C

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 20/08/2010

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: **SLR Consulting Ireland**
7 Dundrum Business Park
Windy Arbour
Dublin 14

FTAO: Oliver Higgins

BHP Ref. No.: 94060.9
Order No.:
Date Received: 06/08/10
Date Completed: 20/08/10
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	GW06			
Ammoniacal Nitrogen (as NH_3-N)		mg/l	<0.01	APHA -4500- NH_3-D
Iron		mg/l	0.067	APHA - 3120 - B
Manganese		mg/l	0.021	APHA - 3120 - B
OrthoPhosphate (PO_4-P)		mg/l	0.01	APHA - 4110 - B

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 20/08/2010

Appendix 6-C
Site Water Balance

Climate Data		
Average Annual Rainfall (AvgR)	733	mm
Potential Evapotranspiration (PE)		mm
Actual Evapotranspiration (AE)	425	mm
Effective Rainfall (ER)	308	mm
Wettest Winter Month (December) rainfall	76	mm
Driest Summer Month (July) rainfall	50	mm
Wettest Winter Month (December) AE (Gnfld/Rstrd.)	11	mm
Driest Summer Month (July) AE (Gnfld/Rstrd.)	86	mm
Wettest Winter Month (December) AE (Operational)	5	mm
Driest Summer Month (July) AE (Operational)	15	mm
Annual AE greenfield/restored areas	467	mm/yr
Annual AE operational areas	50	mm/yr
5 yr return period: 48 hr event	50	mm
5 yr return period: 1 hr event	15	mm

Site Operational Sizes (ha.)	**North quarry**	**West quarry**	**Central quarry**	**South quarry**
Operational	3.9	10.3	16.4	25.0
Greenfield				
Restored				

AVERAGE ANNUAL POTENTIAL RUNOFFS	**North quarry**	**West quarry**	**Central quarry**	**South quarry**
Operational Area				
Average daily rainfall (P) (Operational) (cu. m/day)	78.3	206.7	329.1	501.7
Av. Daily AE (Operational) (cu. m/day)	5.3	14.1	22.5	34.2
Av. potential runoff from operational area (ER)	**72.9**	**192.6**	**306.7**	**467.5**
Av. potential runoff from operational area (ER) (l/sec)	**0.8**	**2.2**	**3.5**	**5.4**
Greenfield/Restored Area				
Average daily rainfall (P) (Greenfield) (cu. m/day)	0.0	0.0	0.0	0.0
Average daily rainfall (P) (Restored) (cu. m/day)	0.0	0.0	0.0	0.0
Average Daily AE (Greenfield/restored)(cu. m/day)	0.0	0.0	0.0	0.0
Average potential runoff from gnfld/rstrd area (ER)	0.0	0.0	0.0	0.0
Average potential runoff (Gnfld./rstrd.)(ER) (l/sec)	0.0	0.0	0.0	0.0
Combined Areas				
Average Potential Runoff from site (cu. m/day)	72.9	192.6	306.7	467.5
Average Potential Runoff from site (l/sec)	0.8	2.2	3.5	5.4

WETTEST/DRIEST MONTHLY POTENTIAL RUNOFFS				
WETTEST WINTER MONTH (DECEMBER)	**North**	**West**	**Central**	**South**
Operational Area	**quarry**	**quarry**	**quarry**	**quarry**
Average daily rainfall (P) (Operational) (cu. m/day)	95.6	252.5	402.1	612.9
Average Daily AE (Operational) (cu. m/day)	6.3	16.6	26.5	40.3
Average potential runoff (operational) (ER)	**89.3**	**235.9**	**375.6**	**572.6**
Average potential runoff (operational) (ER) (l/sec)	**1.0**	**2.7**	**4.3**	**6.6**
Greenfield/Restored Area				
Average daily rainfall (P) (Greenfield) (cu. m/day)	0.0	0.0	0.0	0.0
Average daily rainfall (P) (Restored) (cu. m/day)	0.0	0.0	0.0	0.0
Average Daily AE (Greenfield/restored)(cu. m/day)	0.0	0.0	0.0	0.0
Average potential runoff from gnfld/rstrd area (ER)	0.0	0.0	0.0	0.0
Average potential runoff (Gnfld./rstrd.)(ER) (l/sec)	0.0	0.0	0.0	0.0
Combined Areas				
Average Potential Runoff from site (cu. m/day)	89.3	235.9	375.6	572.6
Average Potential Runoff from site (l/sec)	1.0	2.7	4.3	6.6

DRIEST MONTH	**North**	**West**	**Central**	**South**
Operational Area	**quarry**	**quarry**	**quarry**	**quarry**
Average daily rainfall (P) (Operational) (cu. m/day)	62.9	166.1	264.5	403.2
Average Daily AE (Operational) (cu. m/day)	18.9	49.8	79.4	121.0
Av. potential runoff from operational area (ER)	**44.0**	**116.3**	**185.2**	**282.3**
Av. potential runoff from operational area (ER) (l/sec)	**0.5**	**1.3**	**2.1**	**3.3**
Greenfield/Restored Area				
Average daily rainfall (P) (Greenfield) (cu. m/day)	0.0	0.0	0.0	0.0
Average daily rainfall (P) (Restored) (cu. m/day)	0.0	0.0	0.0	0.0
Average Daily AE (Greenfield/restored)(cu. m/day)	0.0	0.0	0.0	0.0
Average potential runoff from gnfld/rstrd area (ER)	-	-	-	-
Average potential runoff (Gnfld./rstrd.)(ER) (l/sec)	-	-	-	-
Combined Areas				
Average Potential Runoff from site (cu. m/day)	44.0	116.3	185.2	282.3
Average Potential Runoff from site (l/sec)	0.5	1.3	2.1	3.3

PEAK FLOWS	**North**	**West**	**Central**	**South**
5 yr:48 hr duration	**quarry**	**quarry**	**quarry**	**quarry**
Flow on operational area (cu. m/day)	**975**	**2575**	**4100**	**6250**
Flow on operational area (l/sec)	**11**	**30**	**47**	**72**
Flow on greenfield area (cu. m/day)	0	0	0	0
Flow on restored area (cu. m/day)	0	0	0	0
Total Flows (cu. m/day)	975	2575	4100	6250
5 yr:1 hr duration				
Flow to operational area (cu. m/hr)	**400.4**	**1057.5**	**1683.8**	**2566.7**
Flow on greenfield area (cu. m/hr)	0	0	0	0
Flow on restored area (cu. m/hr)	0	0	0	0

Run-off Summary

	Ward Catch North quarry	West quarry	Central quarry	
av an	72.9	192.6	306.7	572.2
wetest m	89.3	235.9	375.6	700.8
48hr st	975	2575	4100	7650.0
dry	44.0	116.3	185.2	345.5

	Tolka South quarry
av an	467.5
wetest m	572.6
48hr st	6250
dry	282.3

Appendix 6-D
Spill Kit Details

Safety Storage Systems Ltd.
- Spill Kit Details

Emergency Spill Response Kits designed to tackle chemical spills which occur outside bunded areas. Contents include Absorbent Socks, Mats, Pads, Instructions, Disposal Bags and PPE.

Supplied in highly visible mobile wheeled Bins.

Spill Kit type: General Purpos.

250 Litre Spill Kit
1 250 Litre Wheeled Bin
4 Socks (3m x 8cm)
20 Cushions
140 Pads (Double Weight)
1 Plug Rug (61cm X 40cm)
1 5Kg Plugging Granules
1 Caution Tape
4 Disposal Bags and Tie
1 Instruction Sheet