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TIER 3

ENVIRONMENTAL RISK ASSESSMENT

OF A

FORMER MUNICIPAL LANDFILL

BALLYRAGGET,

COUNTY KILKENNY

VOL 1

Prepared For: -

Kilkenny County Council

Prepared By: -

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December 2017

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1. INTRODUCTION

Kilkenny County Council (KCC) completed a Tier 1 preliminary Environmental Assessment of the closed landfill at Ballyragget in 2010, in accordance with the guidance in the Environmental Protection Agency (EPA) guidance document "Code of Practice Environmental risk Assessment for Unregulated Waste Disposal Sites (CoP)",which was published in April 2007.

The Tier 1 Assessment, ranked the landfill as being of High Risk associated with potential leachate migration to groundwater and surface water. In 2011 URS completed a Tier 2 Risk Assessment, which confirmed the High Risk classification determined in the Tier 1 Assessment and also concluded that there was a Moderate Risk posed by landfill gas to off-site receptors. The Tier 1 and Tier 2 Assessment reports are in Appendix 1.

In November 2017 KCC appointed O'Callaghan Moran & Associates (OCM) to complete a Tier 3 Risk assessment. The Tier 3 included a review of the Tier 1 and Tier 2 Reports, the design and implementation of a site investigation programme, the findings of which formed the basis for the identification of remedial measures.

The site investigations comprised;

- Installation of 3 No. groundwater monitoring wells outside the landfill footprint,
- Collection and analyses of groundwater samples from the three new wells (MW-5, MW-6 and MW-7) and from MW-2 on the landfill footprint,
- Landfill gas monitoring programme,
- Topographic survey.

1.1 Methodology

The site investigation was undertaken in accordance with BS 10175:2001 and 2011 Investigation of Potentially Contaminated Sites-Code of Practice. The risk assessment was completed in accordance with the Code of Practice: Environmental Risk Assessment for Unregulated Waste Disposal Sites (EPA, 2007). The landfill gas risk assessment was completed in accordance with CIRIA 663.

Mr Sean Moran MSc, P.Geol, was the OCM Project Manager with responsibility for the delivery of the project. Mr. Moran a hydrogeologist with more than 28 years' experience in hydrogeological assessment and is certified by the IGI as qualified person in accordance with Section 2.3 of Code of Practice: Environmental Risk Assessment for Unregulated Waste Disposal Sites (EPA, 2007).

2. ENVIRONMENTAL SETTING

2.1 Site Location

The site is 1.5km south-east of Ballyragget in the townland of Donaghmore. c.650m east of the N77 road from Kilkenny to Ballyragget (Figure 2.1). It is is in a former sand and gravel quarry surrounded by agricultural land and access is via a private road that runs along the boundary of the landowner's farmland.

2.2 Site Layout

The site occupies 1.7 hectares (17,000 m^2) and the layout is shown on Figure 2.2. It slopes from south (79mOD) to north-northwest (73mOD). The waste deposition area has been covered with soil and seeded and is currently used to grow grass for animal fodder.

The northern and western boundaries are defined by a tree lined fence. The eastern and southern boundaries are delineated by an electric fence that prevents access by cattle in the surrounding lands. There is a stockpile of soil and stone in the north-west of the site. There are no surface water features either on, or in the vicinity of the site.

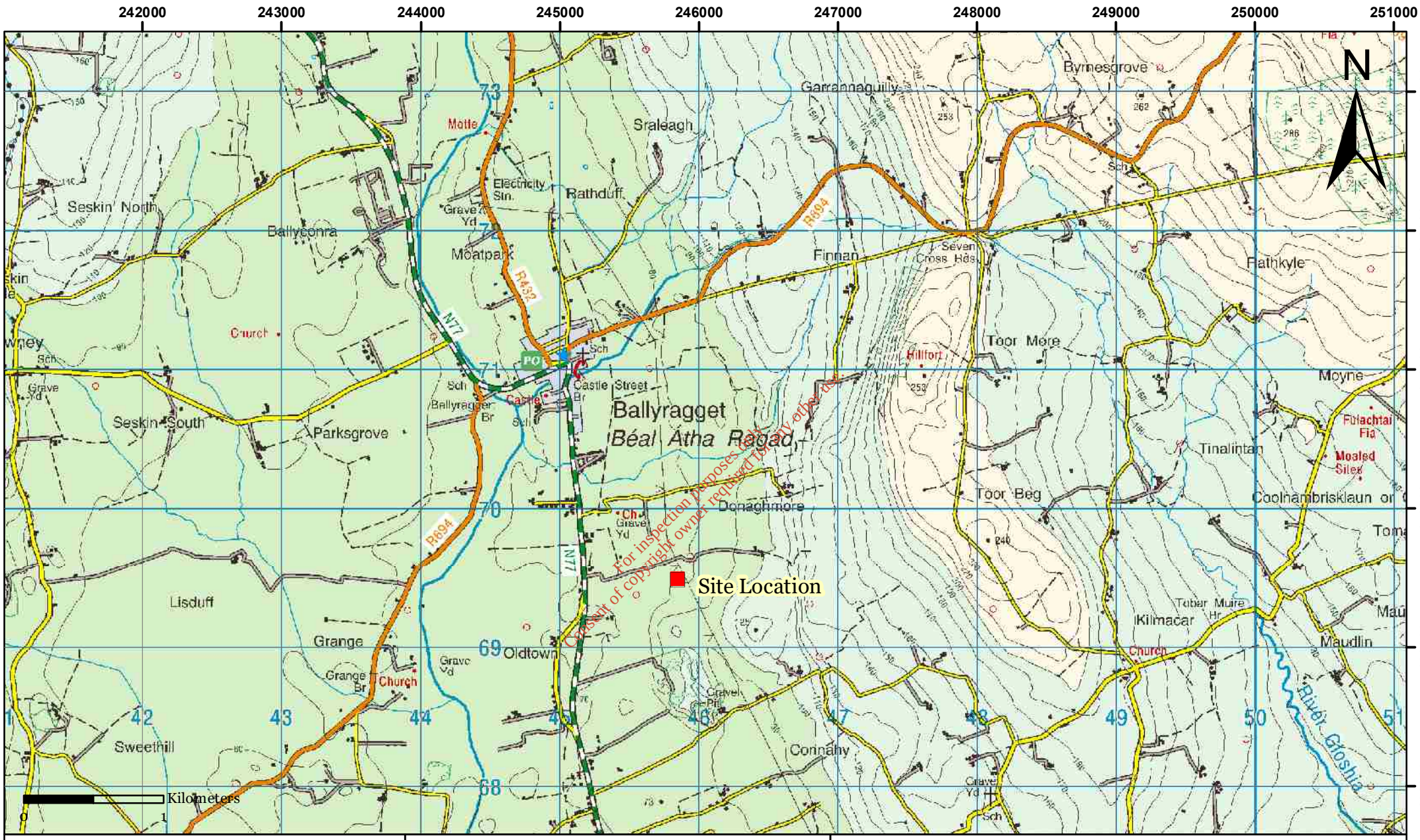
2.3 Surrounding Land Use

The site is c 50m north of a local private road. There are farm roads running along the northern boundary and most of the eastern site boundary. The surrounding land use is mainly agricultural. The closest residential dwelling is approximately 150m to the west. There is a gravel quarry approximately 300m south of the site (Figure 2.3).

2.4 Site History

The site was formerly a sand and gravel quarry, which was used by KCC for the disposal of municipal waste between March 1987 and May 1989. The Tier 2 Assessment estimated that re c40,000m^3 of waste was deposited.

Following closure in 1989, the site was re-instated using imported soil to restore the site to agricultural use. Subsequently the landowner obtained a Waste Facility Permit ref: WMP 24/2005 to import additional soil and stone to level the site; however while the materials were brought to the site they were not spread and were stockpiled in the north-west of the site. The Permit expired in 2008.



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TITLE
Site Location

Details:
Site Location

Figure 2.1

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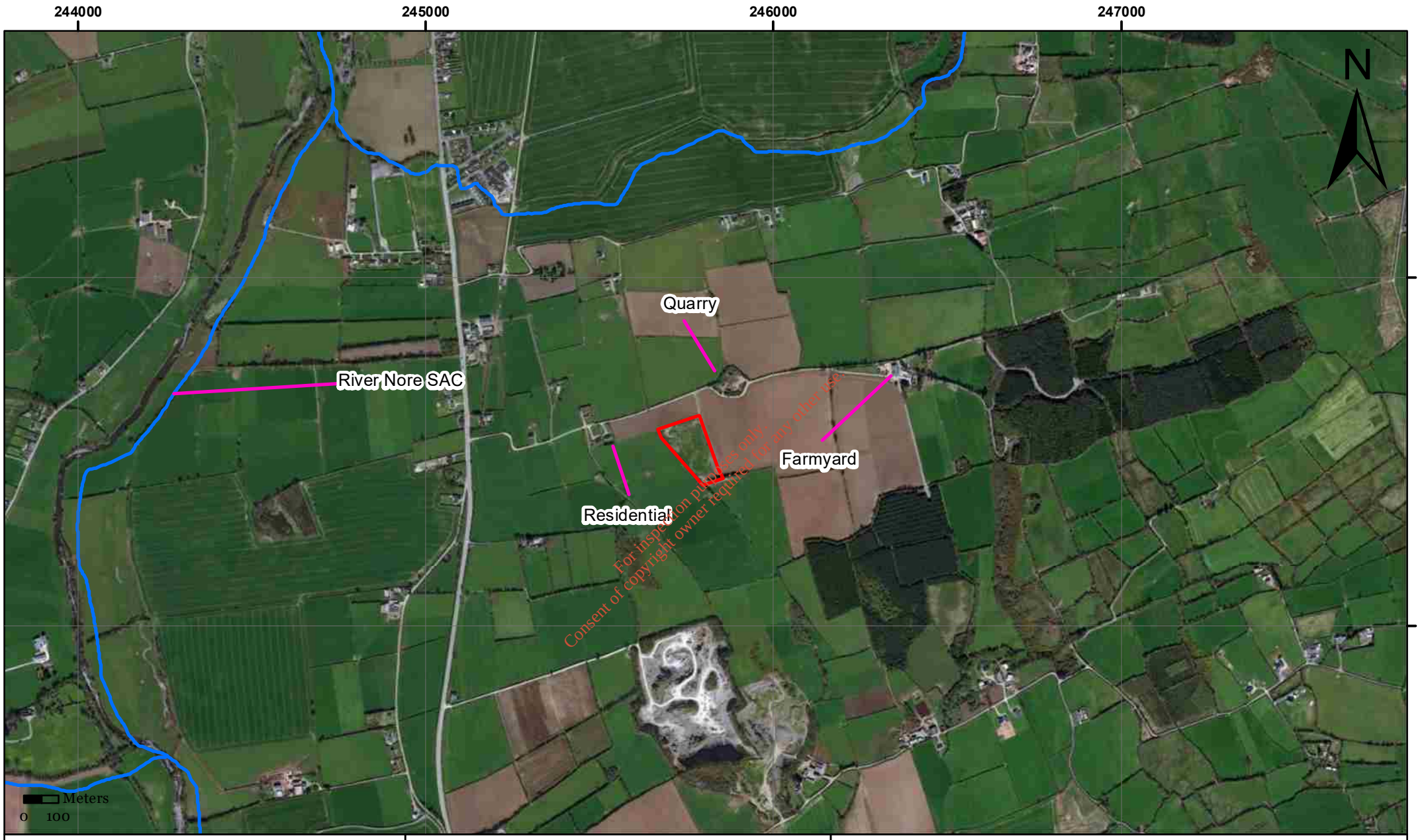
TITLE
Site Layout

Details:
- Trial Pits
- Monitoring Wells
- Site Boundary

Figure 2.2



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TITLE
Surrounding Land Use

Details:
Site Boundary

Figure 2.3

2.5 Hydrology

The nearest surface water feature is the River Finnan, approximately 900m to the north of the site which flows in a westerly direction to join the River Nore approximately 1.5km to the north-west (Figure 2.4). There are no field drains or other surface water features connecting the site to the river.

The site lies within the Lisdowney, Tributary of the Nore Water Body (E_SE_15_479). While the physiochemical status of the water body is good the overall status of this Surface Water Body (SWB) is 'At Risk' due to impacts on ecological receptors. The SWB Report is in Appendix 2.

2.6 Geology & Hydrogeology

Information on the geology was derived from maps prepared by Teagasc and the Geological Survey of Ireland (GSI), and reports on the site investigations conducted by URS and OCM.

2.6.1 Soils and Subsoils

The GSI and Teagasc data bases indicate that the natural soils across the site and surrounding lands comprise limestone sands and gravels (Figure 2.5). The Tier 2 site investigation established there was a layer of soft, brown slightly sandy clay over most of the site. This ranges in thickness from 1.5m in the east of the site to 0.8 in the north-west, and 0.3m in the south-east of the site.

This clay layer overlies the waste, which ranges from 0.6m in the west of the site to 3.3m in the east central portion. Generally the waste body is thickest in the east-central area and thins from here to the north, south and west. The waste is underlain by clayey gravels to a proven depth of between 5-7m below ground level (bgl).

2.6.2 Bedrock

The regional bedrock geology is shown on Figure 2.6. The site is underlain by Crinoidal wackestone/packstone limestone of the Ballyadams Formation. This was confirmed by the Tier 3 site investigations, where the limestone bedrock was encountered at depths ranging from 5m bgl in the south to 7m in the north.

2.6.3 Hydrogeology

The bedrock is classified by the GSI as a Regionally Important Karstified aquifer (RKd) with diffuse flow paths (Figure 2.7). Groundwater recharge is estimated by the GSI to be 466mm per year. The travel paths can range from 100s of metres to >1 kilometre and groundwater levels can change rapidly in response to rainfall recharge, with large fluctuations likely between winter and summer.

Groundwater vulnerability, as defined by the GSI, is the term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities.

The GSI vulnerability classification for the site is classified as 'High' (Figure 2.8). The site investigations indicates a depth to bedrock of c5-7m beneath the landfill. Given that the depth of waste is up to 3.3m the aquifer vulnerability beneath the landfill is considered to be extreme.

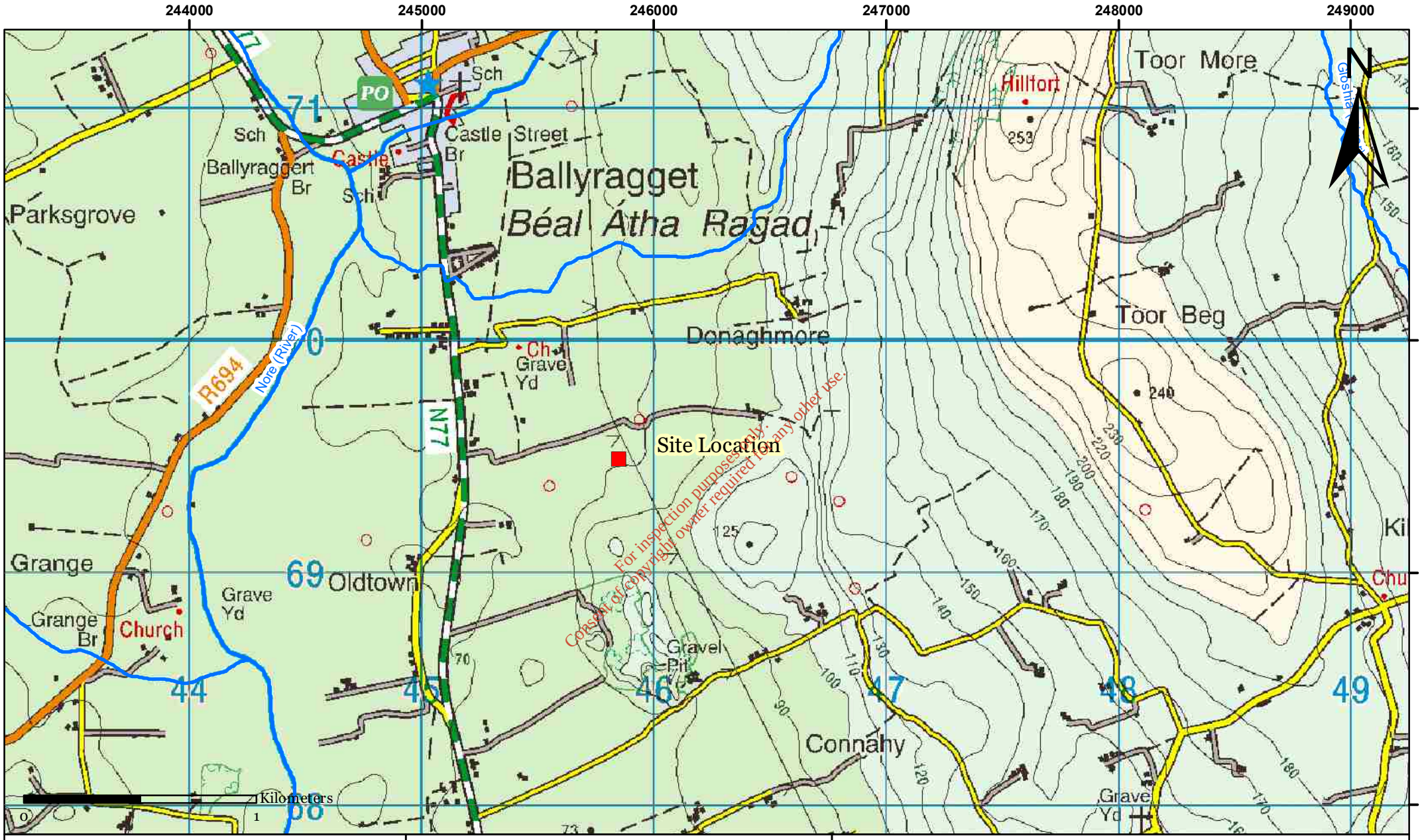
The site lies within the Lisdowney Groundwater Body (GWB) (IE_SE_G_088). The GWB status is rated as 'Good'. The GWB Report is in Appendix 3.

The Ballyconra Public Supply is a groundwater source 2.7km to the north-west of the site and across the River Nore. The GSI have delineated a Source Protection Area (SPA) for this supply source. The site is outside the SPA and the River Nore acts as a hydraulic boundary between the site and the supply well.

The water supply boreholes in the surrounding area are shown on Figure 2.9. The closest down hydraulic gradient well is approximately 450m to the north east (downgradient) of the site. The use of this well is unknown and it is described as a poor yielding well (37 m^3/d).

2.7 Designated Sites

The nearest designated site is River Nore is a designated Special Area of Conservation (SAC) which 1.5km west of the site.



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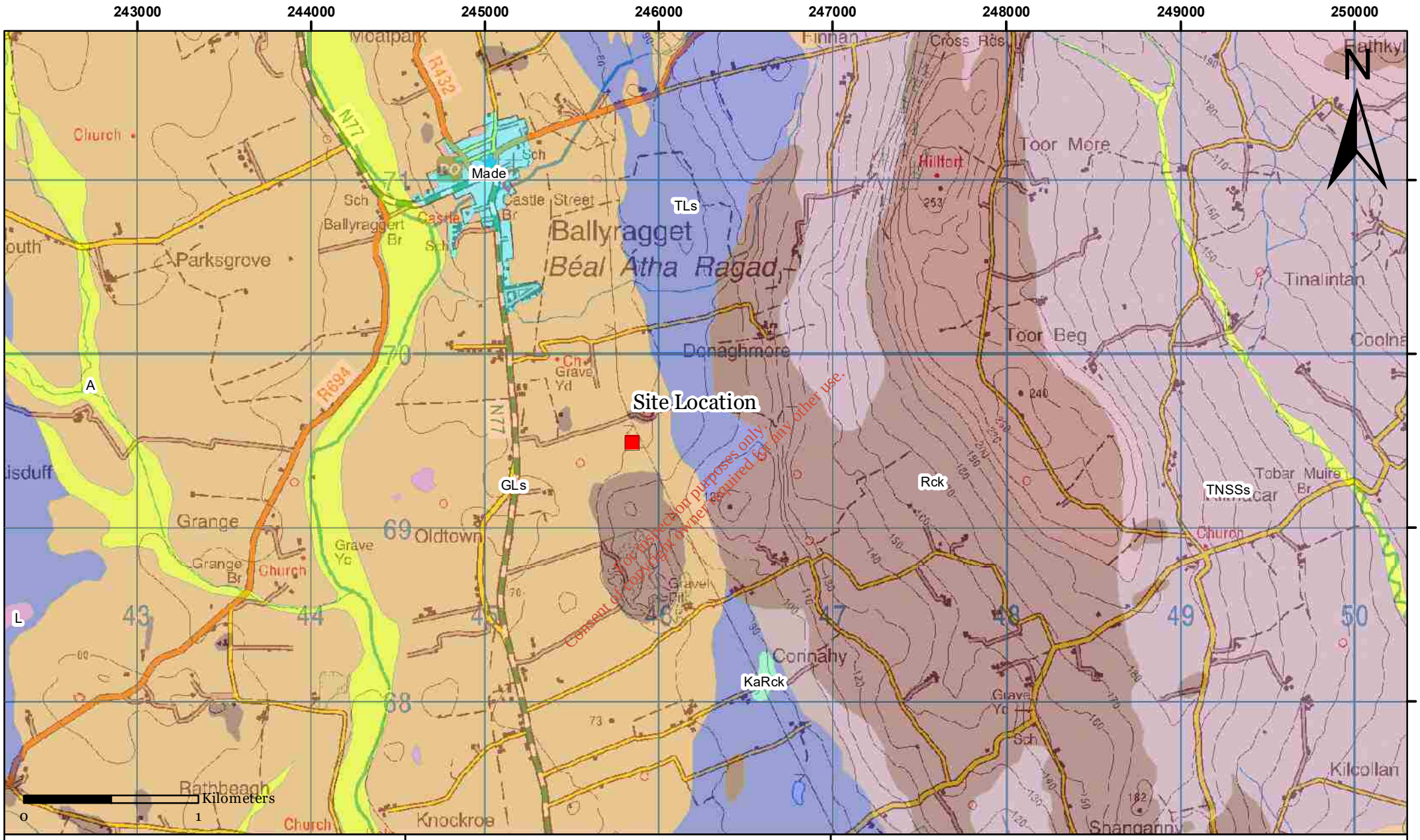
TITLE
Hydrology

Details:
- Site Location
- Rivers

Figure 2.4



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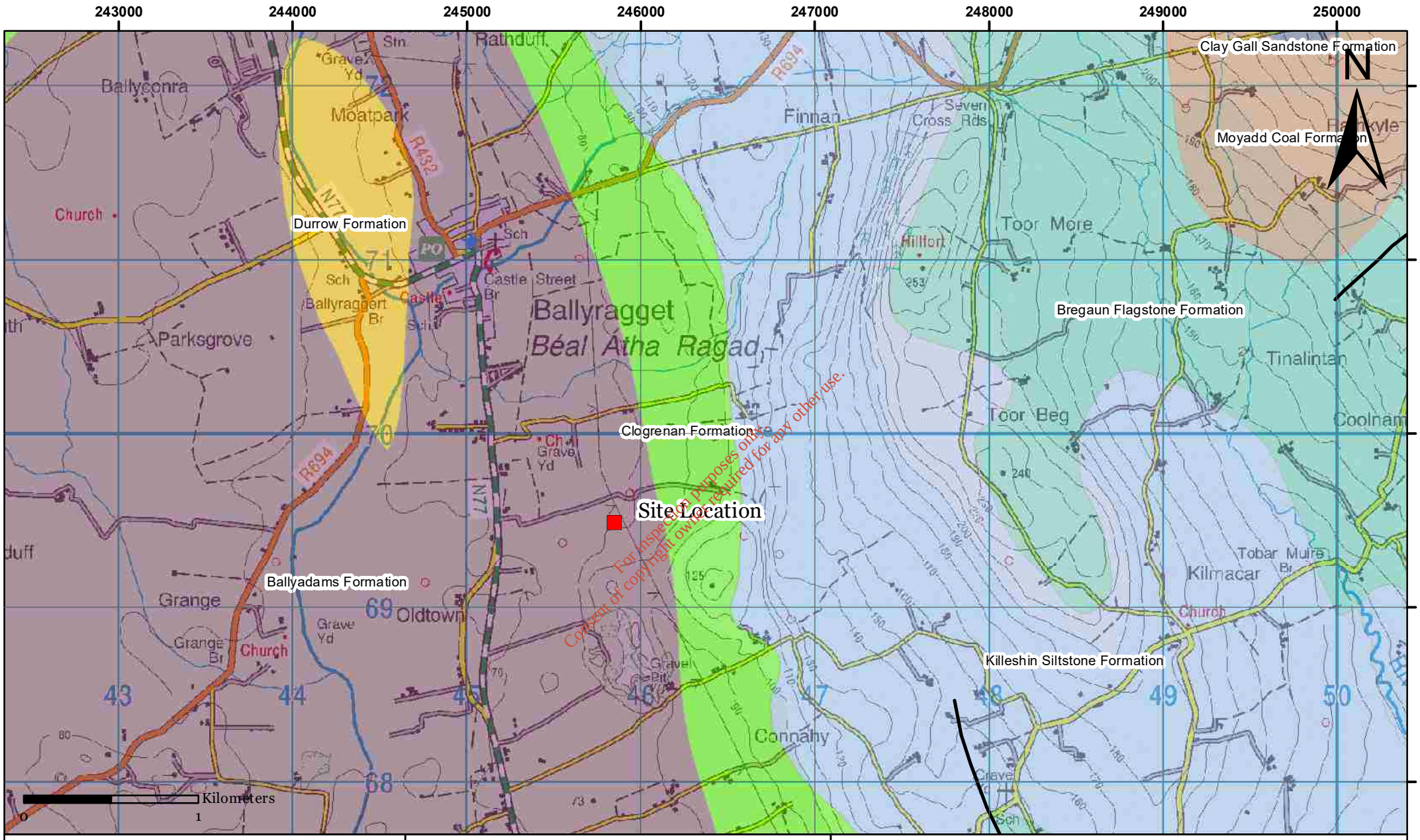
TITLE

Subsoils

Details:

- Site Location
- A - Alluvium undifferentiated
- GLs - Limestone sands and gravels (Carboniferous)
- KaRck-Karstified Rock
- L - Lake sediments undifferentiated
- Made - Made Ground
- Rck - Bedrock at surface
- TLs - Limestone till (Carboniferous)
- TNSSs - Shales and sandstones till (Namurian)

Figure 2.5



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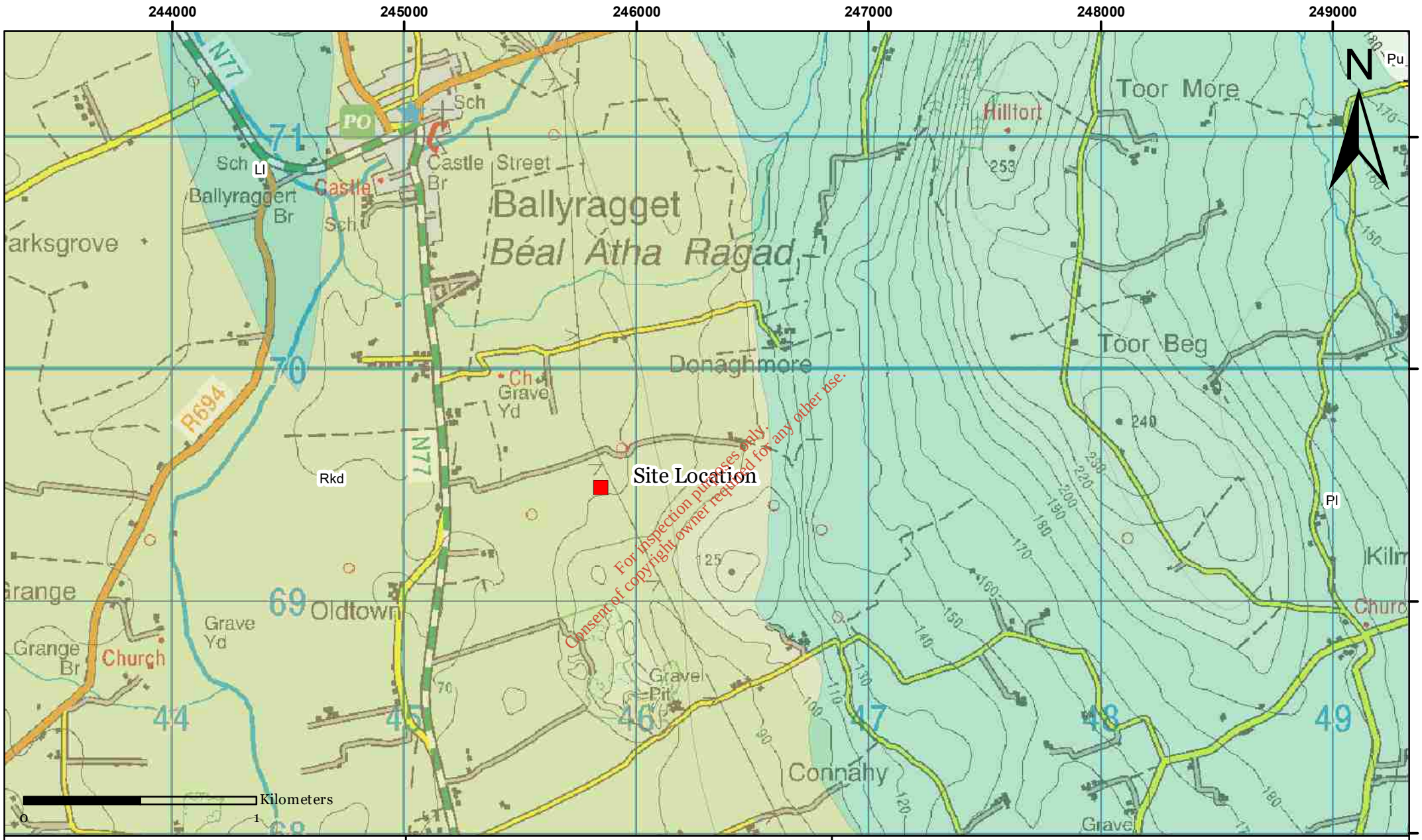
TITLE
Bedrock Geology

Details:
- Site Location
- Faults
- Ballyadams Formation-Crinoidal wackestone/packstone limestone
- Bregaun Flagstone Formation-Thick flaggy sandstone & siltstone-Thick flaggy sandstone & siltstone
- Clay Gall Sandstone Formation-Feldspathic quartzitic sandstone
- Clogrenan Formation-Cherty muddy,calcarentic limestone
- Durrow Formation-Shaly fossiliferous & oolitc limestone
- Killeshin Siltstone Formation-Muddy siltstone & silty mudstone
- Moyadd Coal Formation-Shale,siltstone & minor sandstone

Figure 2.6



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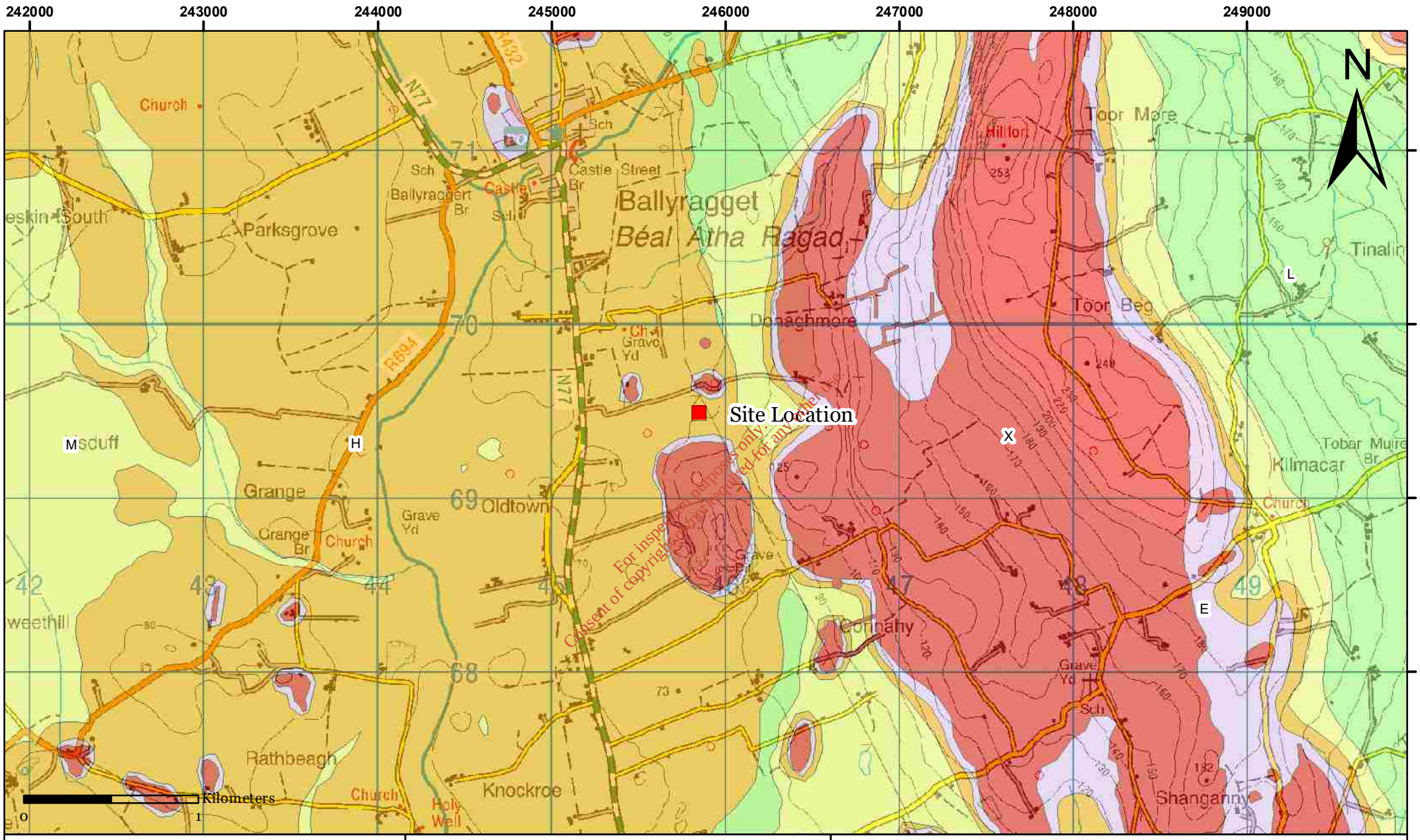
TITLE
Aquifer Classification

Details:
- Site Location
- Ll-Bedrock which is moderately productive only in Local Zones
- Pl - Poor Aquifer. Unproductive except for Local Zones
- Rkd - Regionally Important Aquifer. Karstified Bedrock dominated by diffuse flow

Figure 2.7



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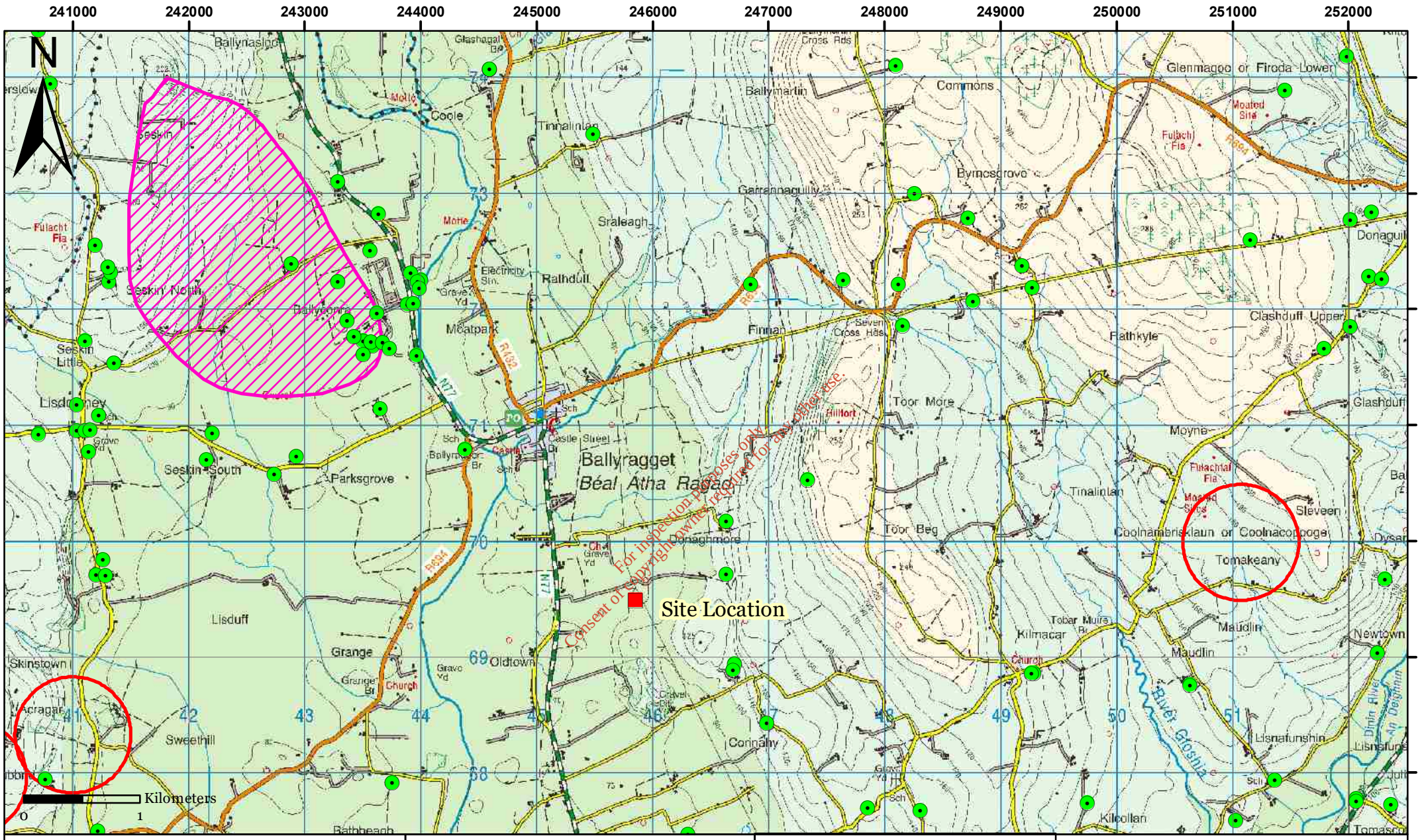
TITLE
Groundwater Vulnerability

Details:

- Site Location
- Bedrock near Surface
- Extreme
- High
- Moderate
- Low

Figure 2.8



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CLIENT
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TITLE
GSI Well Location Data

Details:
Unfortunately many of the borehole logs in the GSI database do not contain accurate location information. The size of the circles shown above is inversely proportional to the accuracy of the well location (i.e. small circles represent high accuracy, where relatively larger circles represent lower accuracy).

- Site Location
- Well Accuracy: 10m to 50m
- Ballyconra Source Protection Area
- Well Accuracy: 500m to 1km

Figure 2.9

3. TIER 3 SITE INVESTIGATIONS

3.1 Objectives

The Tier 2 Assessment Report included recommendations for further site investigations including, but not limited to the installation of further upgradient and downgradient groundwater monitoring wells. The objective of the Tier 3 investigation was to collect sufficient additional information to allow for a complete assessment of the environmental risk posed by the landfill.

3.2 Site Investigation Scope

The Tier 2 site investigation, which was completed in 2011, comprised the excavation of 10 No. trial pits (TP-1 to TP-10) to delineate the lateral and vertical extent of the waste and allow an assessment of the nature of the waste. It also involved the installation of three groundwater monitoring wells (MW-1, MW-2 and MW-3) in the gravels above the bedrock and one landfill gas/leachate well (MW-4) in the waste. MW-1 was located up topographic gradient of the landfill, while the remaining wells were installed on the landfill footprint.

The Tier 3 investigations comprised the installation of three groundwater monitoring wells (MW-5, MW-6 and MW-7). MW-7 is located up gradient of the landfill to replace MW-1, which was dry in 2017. MW-5 and MW-6 were to the north-west and north-east of the landfill to establish groundwater quality down hydraulic gradient of the site.

The locations of trial pits and monitoring wells installed in the Tier 2 and Tier 3 investigations are shown on Figure 3.1.

3.3 Ground Conditions

The landfill is capped with gravelly clay ranging in thickness from 1.5m (TP-5 and TP-6) in the east of the site, to 0.8 m (TP-2) in the north-west of the site and 0.3m (TP-8) in the south-east of the site.

Figure 3.2 which is based on the trial pit data from the Tier 2 site investigation shows the lateral and vertical capping distribution across the site. Figure 3.3 shows the thickness of the waste. The waste is generally thickest in the east central area and thins to the north-west and south. The depth of waste varies across the site from 0.5 m (TP-7) in the west of the site to 3.3 m (TP-6) in the east of the site.

The waste overlies clayey gravels which extend to 5-7m bgl and which are underlain by the limestone bedrock.

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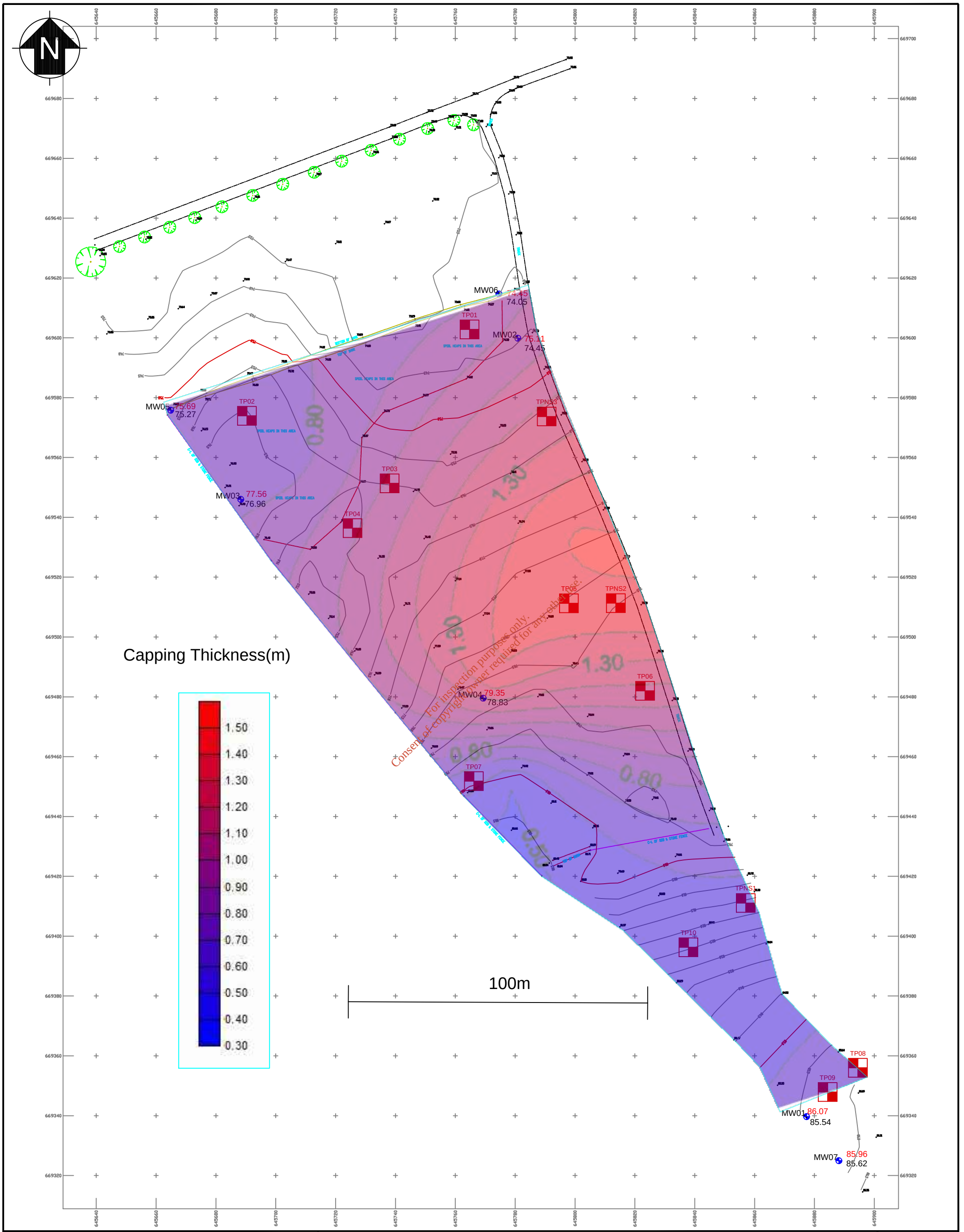
TITLE
Trial Pit & Borehole Locations

Details:
- Trial Pits
- Monitoring Wells
- Site Boundary

Figure 3.1



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	TITLE Capping Depth	SCALE NTS

N

MW06 74.45 74.05

MW02 75.11 74.45

MW05 75.69 75.27

MW03 77.56 76.96

MW04 79.35 78.83

MW01 86.07 85.54

MW07 85.96 85.62

TP01 TP02 TP03 TP04 TP05 TP06 TP07 TP08 TP09 TP10

TPNS1 TPNS2 TPNS3

SPOIL HEAPS IN THIS AREA

Waste Thickness(m)

3.20
3.00
2.80
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40

100m

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CLIENT: Kilkenny County Council

TITLE: MSW Depth

FIGURE No. 3.3

SCALE: NTS

3.3.1 Waste Characterisation

The waste comprises typical municipal solid waste comprising paper, plastic timber in varying stages of degradation interspersed with a gravelly clay matrix. This material may have been intermediate cover used when the landfill was operations. The Tier 2 Assessment estimated that there may be c 40,000m^3 of waste present on the site. This equates to c20,000 tonnes.

3.4 2017 Monitoring Well Installation

The additional groundwater wells were installed to establish groundwater quality up gradient and down gradient of the waste deposition area. The wells were installed by Ground Investigations Ireland Ltd (GII) using a Beretta T51 top drive rotary percussive drilling rig with a 100 mm drilling bit.

The drilling was supervised by an OCM hydrogeologist who logged the borings in accordance with BS 5930 as amended by the GSI, and ensured the wells were installed in accordance with OCM's specification.

3.5 Well Design and Construction

The wells were installed in the bedrock aquifer. MW-5 and MW-6 were drilled to a depth of 14.6 and 15.7 m bgl respectively, while MW-7 was drilled to 25.5 m bgl. Prior to the installation of the well pipes, the boring was cleaned out by airlifting to remove rock chippings and fine silts.

The well pipes comprised high density polyethylene (HDPE) 50 mm diameter standpipes. A gravel filter pack was inserted in the annular space between the boring and the standpipe. Above the gravel filter, the annular space was filled with a 1m bentonite seal. The solid section of the well pipes was brought above the ground level and was fitted with a steel protective well casing. The borehole and well construction logs are in Appendix 4.

3.5.1 Groundwater

Water strikes were encountered during the drilling at 6.8m bgl in MW-5, 6.8m bgl in MW-6 at 5.5mbgl and at 21.2 m bgl in MW-7.

3.5.2 *Visual and Olfactory Evidence of Contamination*

There was no visual or olfactory evidence of contamination in any in the boreholes.

3.5.3 Borehole Development

As referred to above the drilling ended with a short phase of airlift pumping, with the drill tools set just above the bottom of the borehole. The water flow each borehole was completely clear of sediment after the pumping and further development was not necessary.

4. ENVIRONMENTAL MONITORING

4.1 Groundwater

OCM carried out groundwater quality monitoring in MW-2, MW-5, MW-6 and MW-7. MW-2, was installed in the Tier 2 site investigation. No waste was encountered during the drilling but given that it is located in the landfill footprint is likely to be indicative of groundwater quality at the northern down hydraulic gradient section of the landfill.

The monitoring was carried out in accordance with OCM's sampling protocols a copy of which is in Appendix 5.

4.1.1 Field Measurements

Groundwater levels were measured on site prior to sampling. The wells were subsequently surveyed in to Ordnance Datum (OD) in December 2017 and the water levels recorded in the field (meters below top of casing) and the OD levels are shown as shown in Table 4.1.

Table 4.1 Groundwater Levels

Borehole	Top of Casing	Water level	Water level
		20/11/2017	
	mAOD	mbtoc	mAOD
MW-2	75.11	5.44	69.67
MW-5	75.69	7.14	68.55
MW-6	74.45	4.9	69.55
MW-7	85.96	13.43	72.53

Groundwater samples were obtained after either three purge volumes had been removed from the well pipe, or after field parameters stabilised. Stabilisation of field parameters indicates the groundwater in the well pipe is representative of the groundwater formation and not stagnant water in the surrounding gravel pack. The stabilised field measurements are in Table 4.2.

The temperature values are generally within the expected range for groundwater. The pH levels are typically within the expected range for groundwater in a karst limestone environment. Electrical conductivity values were highest in MW-5 and MW-6.

Table 4.2 – Field Measurements 2017

Location	pH	Temperature (°C)	Electrical Conductivity (mS/cm)	Visual Olfactory Description
MW-2	8.33	11.4	853	Clear, no odour
MW-5	8.47	12.6	1319	Clear, no odour
MW-6	8.34	8.34	1027	Clear, no odour
MW-7	8.60	12.7	837	Clear, no odour

4.1.2 Laboratory Analysis

The samples were stored in laboratory prepared bottles and shipped to Jones Environmental Laboratories in the UK, which has an internationally recognised accreditation for the selected range of analyses.

The samples analysed for List 1 and II substances and the parameters specified in Table C2 of the EPA Manual on Landfill Monitoring (2003) which included pH, electrical conductivity, ammonia, nitrate, orthophosphate, potassium, sodium, chloride, sulphate, heavy metals to include(arsenic, antimony, barium, cadmium, chromium, copper, fluoride, mercury, manganese, molybdenum, nickel, lead, selenium and zinc), cyanide Volatile Organic Compounds (VOC), Semi-Volatile Organic Compounds (SVOC), herbicides, pesticides and Total and Faecal Coliforms.. The full laboratory test report is in Appendix 6 and the results are presented in Table 4.4.

The analytical methods were all ISO/CEN approved and the method detection limits(MDL) were all below relevant water quality guide values and limits.

4.1.3 Groundwater Quality

Table 4.4 includes Interim Guideline Values (IGV) published by the EPA and the Groundwater Threshold Values (GTV) set out in the European Communities Environmental Objectives (Groundwater) Regulations (S.I. 9 of 2010). The IGVs are not statutory, but were developed to assist in the assessment of impacts on groundwater quality.

The groundwater samples collected from MW-7, which is located up hydraulic gradient of the landfill, is considered to be representative of background groundwater quality. The ammonium level exceeds the GTV and nitrate and chloride exceed the IGV. These values are most likely indicative of the land-use up hydraulic gradient of the well which is farm animal grazing.

The ammonium, nitrate and nitrite in MW-2, which is installed through the waste body, also exceed the GTV and the levels are significantly higher than those recorded in MW-7. Chloride is also elevated. The ammonium and nitrate exceed the GTV in MW-5 and 6, both of which are downgradient of the waste deposition area. The manganese, zinc, chloride and potassium level also exceed the IGV in both wells and elevated nitrite was detected in MW-5.

Table 4.4 Groundwater Results 2017

Sample I.D. / Sample Date	Units	MW-2 21/11/2017	MW-5 21/11/2017	MW-6 21/11/2017	MW-7 22/11/2017	IGV	GTV
Arsenic	µg/l	4.3	6.3	<2.5	3.4	10	7.5
Boron	µg/l	62	143	76	63	1,000	750
Cadmium	µg/l	<0.5	<0.5	<0.5	<0.5	5	3.75
Chromium	ug/l	<1.5	<1.5	<1.5	<1.5	0.03	NE
Copper	µg/l	<7	<7	<7	<7	30	1500
Lead	µg/l	<5	<5	<5	<5	10	18.75
Manganese	µg/l	<2	272	153	4	50	NE
Mercury	µg/l	<1	<1	<1	<1	1	0.75
Nickel	µg/l	<2	8	7	3	20	15
Phosphorus	ug/l	123	295	52	47	NE	NE
Potassium	mg/l	4	21	8.4	2.8	5	NE
Selenium	ug/l	<3	<3	<3	<3	NW	NE
Sodium	mg/l	11	38	21.9	33.2	150	150
Zinc	µg/l	6	314	486	15	100	75
Chloride	mg/l	34	63.8	47.6	57.2	30	187.5
Cyanide	µg/l	<0.01	<0.01	<0.01	<0.01	10	37.5
Orthophosphate	µg/l	<0.03	<0.03	<0.03	<0.03	30	NE
Sulphate	mg/l	13.9	15.8	13.7	14.4	200	187.5
Ammonium	mg/l	40.42	41.4	10.19	0.27	0.15	0.175
BOD	mg/l	1	3	1	2	NE	NE
COD (Settled)	mg/l	14	15	35	9	NE	NE
TOC	mg/l	<2	4	<2	<2	NAC	NE
Total Dissolved Solids	mg/l	245	417	355	92	1000	NE
Total Oxidised Nitrogen	mg/l	12.2	8	9.5	6.1	NAC	NE
VOCs	µg/l	ND	ND	ND	ND	various	various
sVOCs	µg/l	ND	ND	ND	ND	various	various
PAH	µg/l	ND	ND	ND	ND	0.1	0.075
Nitrate as NO_3	mg/l	53.6	35	41.9	26.8	25	37.5
Nitrite as NO_2	mg/l	0.42	0.34	0.05	0.03	0.1	0.375
Pesticides	ug/l	ND	ND	ND	ND	NE	NE
Total Coliforms	cfu/100 ml	ND	100	ND	ND	0	NE
Faecal Coliforms	cfu/100 ml	ND	100	ND	ND	0	NE

4.1.4 Groundwater Levels

The groundwater levels recorded during the monitoring programme in November were converted to OD and used to generate a groundwater flow direction map for the site (Figure 4.1). The results indicate the groundwater water flow direction is from the south to the north and is generally consistent with the topographic gradient.

4.1.5 Discussion

The groundwater in MW-7, which is the upgradient well, is generally good; however the elevated ammonium and nitrate levels are indicative of an impact from the up gradient agricultural land use.

The results from MW-2, MW-5 and MW-6, which are down gradient of the waste, are indicative of leachate impacts. In MW-5 and MW-6 the results are indicative of with slightly reducing conditions, which are commonly associated with the migration of a leachate plume.

4.2 Leachate Quality

It had been intended to collect a leachate sample from MW-4 in the centre of the landfill but this well was dry during the 2017 monitoring programme.

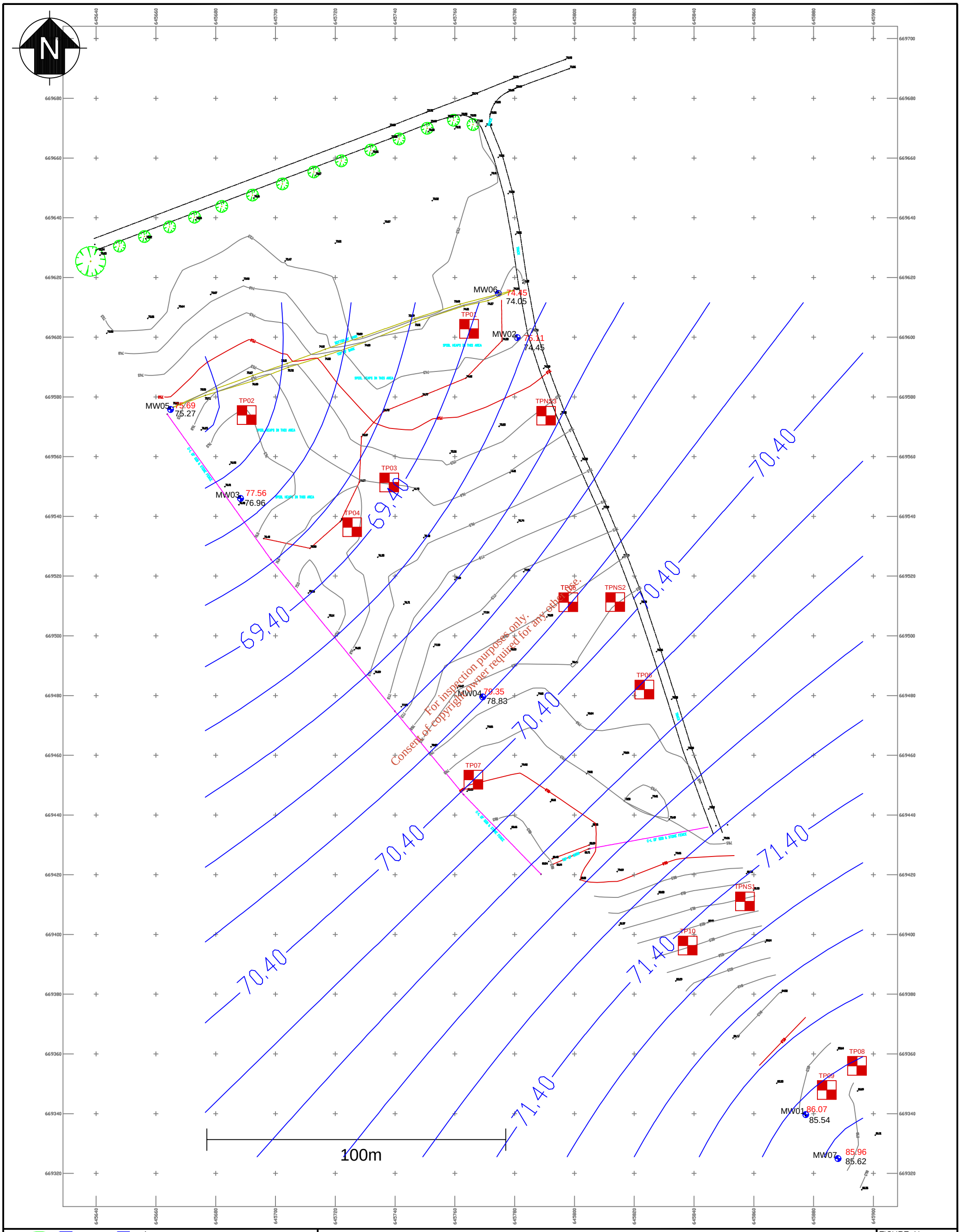
4.3 Landfill Gas Monitoring

Landfill gas monitoring was undertaken in November 2017 in all of the wells installed at the site using a landfill gas analyser. The results are presented in Table 4.2. Monitoring was undertaken for the presence of methane, hydrogen sulphide, carbon dioxide, gas flow rate and atmospheric pressure.

Table 4.2 Landfill Gas Monitoring Results November 2017

Parameter		**Atmospheric Pressure (mb)**	**Flow rate**	**H_2S**	**CH_4 (Peak)**	**CO_2**	**O_2**
Location	**Date / Unit**		**l/h**	**ppm**	**%**	**%**	**%**
MW-1	21/11/2017	996	0.20	0.00	0.10	8.70	8.90
MW-2	21/11/2017	997	-0.10	0.00	0.10	12.00	-
MW-3	21/11/2017	994	0.30	0.00	0.10	8.90	8.90
MW-4	21/11/2017	995	0.00	0.00	64.00	36.00	0.00
MW-5	21/11/2017	996	0.00	0.00	0.00	0.50	20.30
MW-6	21/11/2017	996	0.20	0.00	0.00	0.10	21.20
MW-7	24/11/2017	996	0.10	0.00	0.00	0.10	21.20

Elevated levels of methane and carbon dioxide were detected in MW-4 in the centre of the landfill. The gas flow rate was low indicating that the gas source may be localised and of limited extent. Much lower methane and carbon dioxide levels were recorded in the other wells on the landfill footprint and no evidence of landfill gas was found in MW-6 and MW-7. The carbon dioxide level in MW-5 may be indicative of gas migration but could equally attributable to natural conditions.



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TITLE
Groundwater Contours

FIGURE No.
4.1

SCALE
NTS

5. TIER 3 RISK ASSESSMENT

5.1 Conceptual Site Model

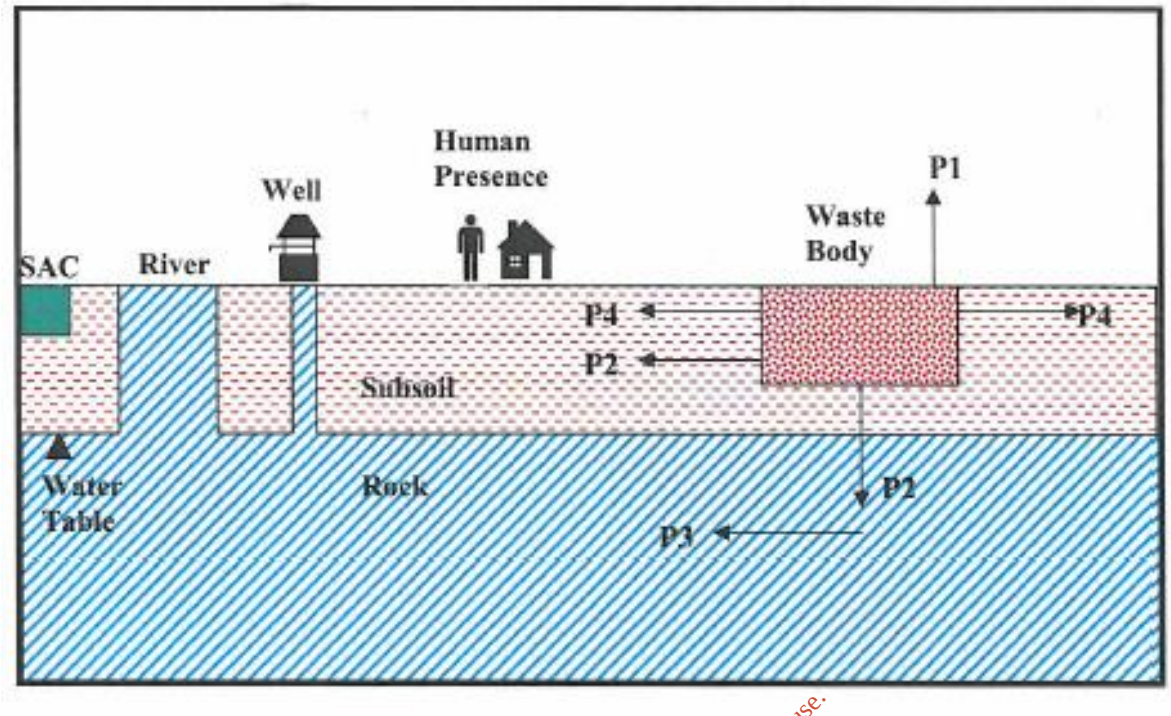
The KCC Tier 1 Risk scores are shown on Table 5.1 with the full Tier 1 Risk and Tier 2 Risk scores in Appendix 1. Both Tier 1 and Tier 2 assessments concluded that the site is a High Risk site due to the leachate migration risk to groundwater.

Table 5.1 Tier 1 Risk Assessment Score

SPR LINKAGE SCORE			MAX LINKAGE SCORE	NORMALISED SCORE
SPR 1	1a X (2a + 2b + 2c) X 3e *7(3+5+0)1*	56	300	18.66%
SPR 2	1a X (2a + 2b + 2c) X 3b (SWDTE) *7(3+5+0)0*	0	300	0%
SPR 3	1a X (2a + 2b) X 3a *7(3+5)1*	56	240	23.33%
SPR 4	1a X (2a + 2b) X 3b *7(3+5)0*	0	240	0%
SPR 5	1a X (2a + 2b) X 3c *7(3+5)5*	280	400	70%
SPR 6	1a X (2a + 2b) X 3d *7(3+5)3*	168	560	30%
SPR 7	1a X (2a + 2b) X 3e *7(3+5)1*	56	240	23.33%
SPR 8	1a X 2c X 3e *7(0)1*	0	60	0%
SPR 9	1a X 2c X 3b (SWDTE) *7(0)0*	0	60	0%
SPR 10	1b X 2d X 3f *7(3)3*	63	150	42%
SPR 11	1b X 2e X 3f *7(5)3*	105	250	42%

The Tier 1 Conceptual Site Model (CSM) is shown in Figure 5.1

Figure 5.1 Tier 1 CSM



5.2 Revised CSM

The COP requires that the Conceptual Site Model (CSM) developed during Tier 1 be refined based on the findings of further site investigations. OCM refined the CSM based on the findings of the Tier 2 and Tier 3 investigations. A schematic of the revised CSM is shown in Figure 5.2. The line of section on which the cross section is based is shown on Figure 5.3.

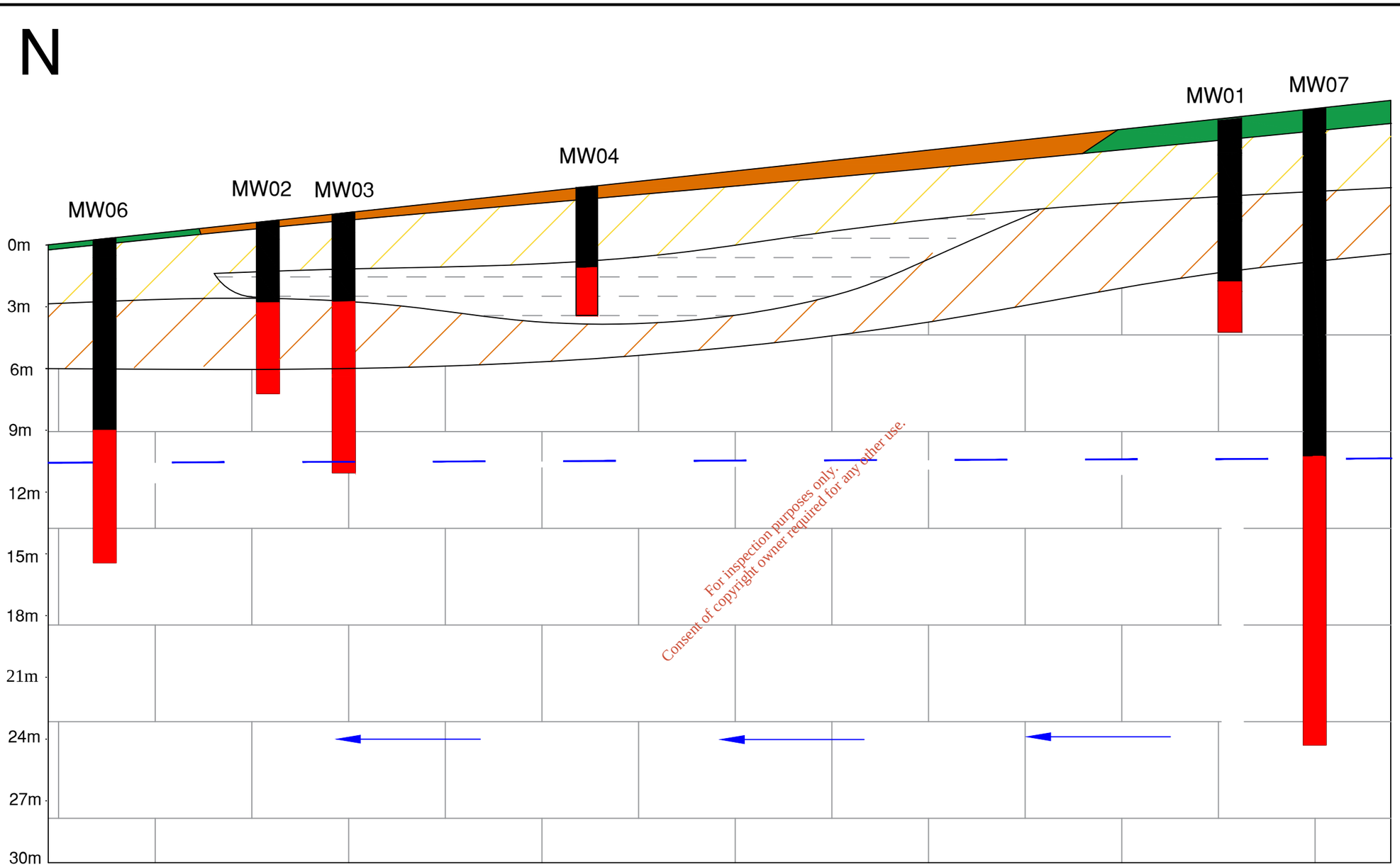
The lateral extent of the waste has been identified and it is contained within the site boundaries. The waste is currently capped with gravelly clay ranging in thickness from 1.5m in the east of the site to 0.8 m in the north-west of the site and 0.3m in the south-east of the site.

The depth of waste varies across the site from 0.5 m in the west of the site to 3.3 m in the east The waste is thickest in the east central area and thins to the north-west and south. The estimated waste volume to be 40,000m^3, which equates to c20,000 tonnes.

The waste is underlain by clayey gravels. The gravels overly the bedrock which is located at c6-7mbgl. The groundwater monitoring results for the down hydraulic gradient wells confirms that leachate migration is occurring from the waste into the underlying bedrock aquifer.

Rainfall recharge to the waste has been reduced by the placement of the clay capping layer. This layer is thickest where the waste is deepest. While some of the potential rainfall recharge runs off the site to the north and north-west, it is likely that there is currently significant rainfall recharge to the waste.

The landfill gas monitoring indicates the presence of elevated carbon dioxide and methane in the centre of the site, but not evidence of landfill gas migration. It is likely that landfill gas vents relatively freely to atmosphere through the cap.



Legend:

- Clay
- Gravel
- Waste Body
- Limestone Bedrock
- Screened Section
- Approximate Groundwater Level
- Cap
- Topsoil

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TITLE
Conceptual Site Model

FIGURE No.
5.2

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TITLE
Line of Section

Details:
- Trial Pits
- Monitoring Wells
- Line of Section
- Site Boundary

Figure 5.3

5.3 Sources

The source is the municipal solid waste which is estimated to be in the region of 20,000 tonnes.

Leachate

While a sample of leachate was not collected the groundwater results indicate that leachate is being generated and is impacting on groundwater quality downgradient of the waste. There is no evidence of leachate break out around the sides of the landfill.

Landfill Gas

Landfill gas is being generated, with elevated methane and carbon dioxide detected in the centre of the site, where the waste is thickest.

5.4 Pathways

5.4.1 Leachate Migration Pathways

Leachate can migrate through the clayey gravels immediately beneath the waste into the karstified limestone bedrock aquifer.

5.4.2 Landfill Gas – Lateral Migration Potential

Landfill gas appears to be venting to atmosphere rather than moving laterally through the surrounding soils. The risk of gas migration risk will increase when the final cap is in place, however the closest residence is c140m to the west of the site.

5.4.3 Surface Water Drainage

There are no surface water drains or streams in the vicinity of the site. The nearest surface water body is the Finnan River located approximately 900m north of the site. It is likely that shallow groundwater discharges to the River Finnan c900 north of the site.

5.5 Receptors

The bedrock aquifer beneath and down hydraulic gradient of the landfill is the primary receptor. There no groundwater supply wells within 450m down hydraulic gradient of the landfill.

The closest dwelling to the site is c140m to the north0west and side gradient of the landfill. Landfill gas monitoring in MW-5 along the northwest site boundary did not detect any landfill gas and landfill gas.

While there are private and a public supply well down hydraulic gradient of the landfill as shown on Figure2.9 all of these wells are located to the northwest of the River Nore which separates the site from these supplies. These wells are not considered to be at risk from leachate migration from the landfill.

Given the results of the groundwater monitoring in the downgradient wells and the distance to the River Finnan, it is extremely unlikely that groundwater discharge is having any discernible impact on the river

5.6 Revised Risk Score

The revised Tier 3 risk scores are summarised on Table 4.2 and are included in full in Appendix 7. The overall risk remains High. The main linkage of concern is leachate migration to the groundwater pathway. The landfill gas risk is low.

Table 4.2 Tier 3 Risk Scores

Calculator	SPR Values	Maximum Score	Linkages	Normalised Score
Groundwater & Surface Water	Groundwater only	Surface water only	Lateral & Vertical	
SPR 1 =	56	300	Leachate => surface water	19%
SPR 2 =	0	300	Leachate => SWDTE	0%
SPR 3 =	112	240	Leachate => human presence	47%
SPR 4 =	0	240	Leachate => GWDTE	0%
SPR 5 =	280	400	Leachate => Aquifer	70%
SPR 6 =	168	560	Leachate => Surface Water	30%
SPR 7 =	56	240	Leachate => SWDTE	23%
SPR 8 =	0	60	Leachate => Surface Water	0%
SPR 9 =	0	60	Leachate => SWDTE	0%
SPR 10 =	31.5	150	Landfill Gas => Human Presence	21%
SPR 11 =	0	250	Landfill Gas => Human Presence	0%
Risk Classification		Range of Risk Scores		
Highest Risk (Class A)		Greater than or equal to 70% for any individual SPR lingage		
Moderate Risk (Class B)		Between 40-70% for any individual SPR linkage		
Lowest Risk (Class C)		Less than or equal to 40% for any individual SPR linkage		
TIER 3 RATING		High Risk (Class A)		

6. REMEDIAL ACTION PLAN

The Risk Ranking for the site is High and is associated with leachate migration to groundwater. The landfill gas risk is considered to be Low. In preparing this Remedial Action Plan (RAP) OCM has considered the proposed future end use for the site, which will be agricultural.

The EPA Landfill Restoration and Aftercare Manual recommends that for Non-Inert Landfill with high amenity sward that a minimum subsoil thickness (after placement) of 700-850mm be placed over the landfill with a 150-300mm top soils layer . The combined thickness should be 1000mm. Non-inert landfills should also be provided with a gas collection and surface water drainage system.

Figure 6.1, 6.2 and 6.3 show outline remedial design for the site to mitigate the environmental risk posed by the site, and to accommodate the proposed end use and EPA Landfill Restoration Manual requirements.

There is currently top soil and grass on the entire landfill and in some areas (central portion) this complies with the EPA recommended cap thickness. The topsoil will have to be stripped to allow additional capping soils to be placed and to allow for grading and compacting the entire capping layer.

The on-site soil stockpile is suitable for use to increase the capping thickness. Additional clay will have to be placed in the south of the site. It may be possible to use surplus soils from the central portion of the site as a source. However it is more likely that additional soil will have brought into the site to achieve the required gradient across the site.

The capping material should be placed, compacted and graded to achieve a fall from south to north consistent with the current topographic slope and also to achieve falls from a central south to north ridge to the east and west at 1:40. A 150mm top soil layer should be placed over the compacted capping layer and should be grass seeded

A surface water collection drain should be installed around the perimeter of the landfill to collect run-off from the compacted clay layer. The drain should be lined with an LDPE membrane and piped to a percolation area located to the north of the landfill.

.

Four gas ventilation wells should be installed, one in each quadrant of the waste, to allow passive ventilation of the gas. The well pipes should be 100mm slotted uPVC and should extend 150mm above the top soil layer. These wells should be fitted with cowls and fenced off to prevent damage by livestock.

N

Percolation Area

MW06 74.45
74.05

MW02 75.11
74.45

MW05 75.69
75.27

Landfill Gas Ventilation Pipe

MW03 77.56
76.96

Surface Water Collection Drain

MW04 79.35
78.83

MW01 86.07
85.54

MW07 85.96
85.62

100m

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FIGURE No.

6.1

TITLE

Remediation Design Drawing

SCALE

NTS

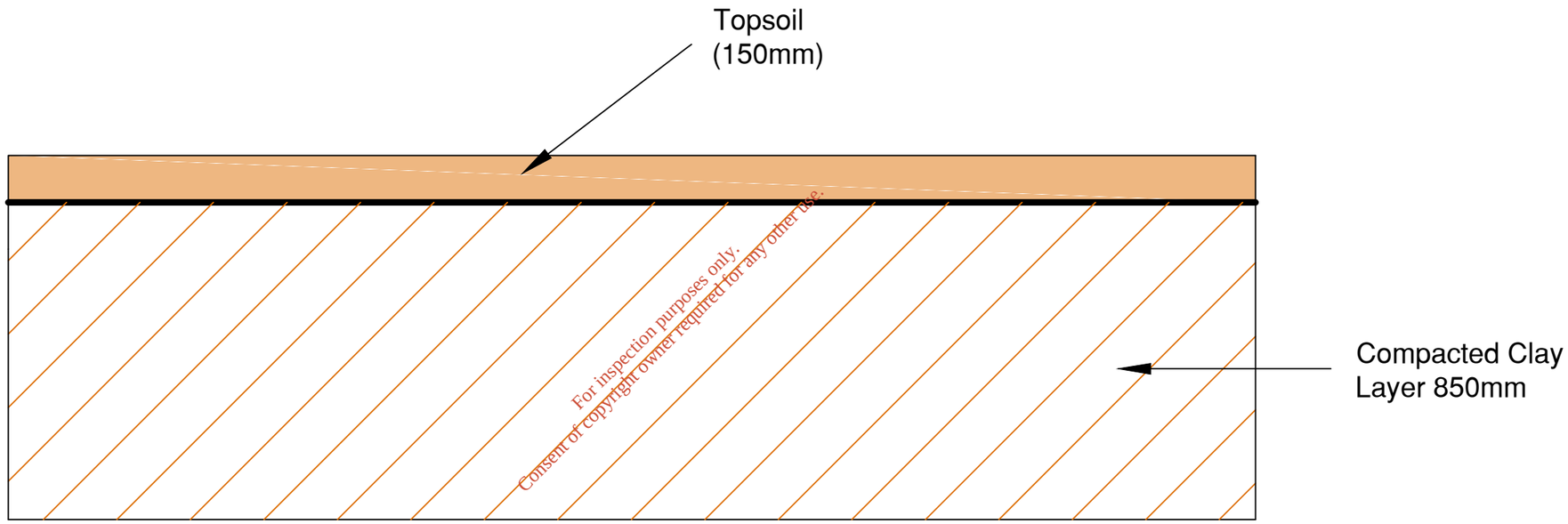

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FIGURE No.
6.2

TITLE

Landfill Capping Detail

SCALE
NTS

REV.
A

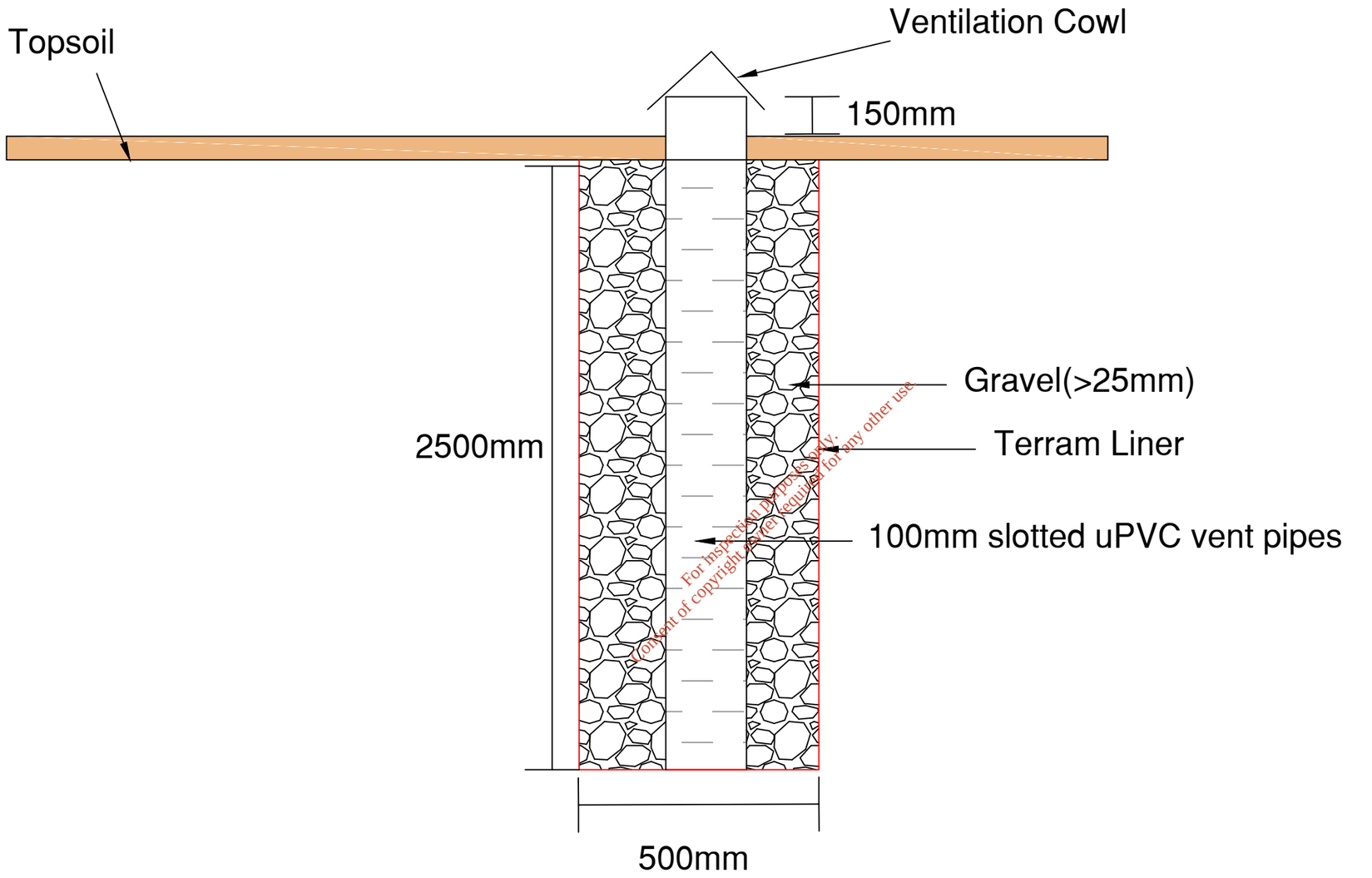

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FIGURE No.
6.3

TITLE

Landfill Gas Ventilation Pipe

SCALE
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A

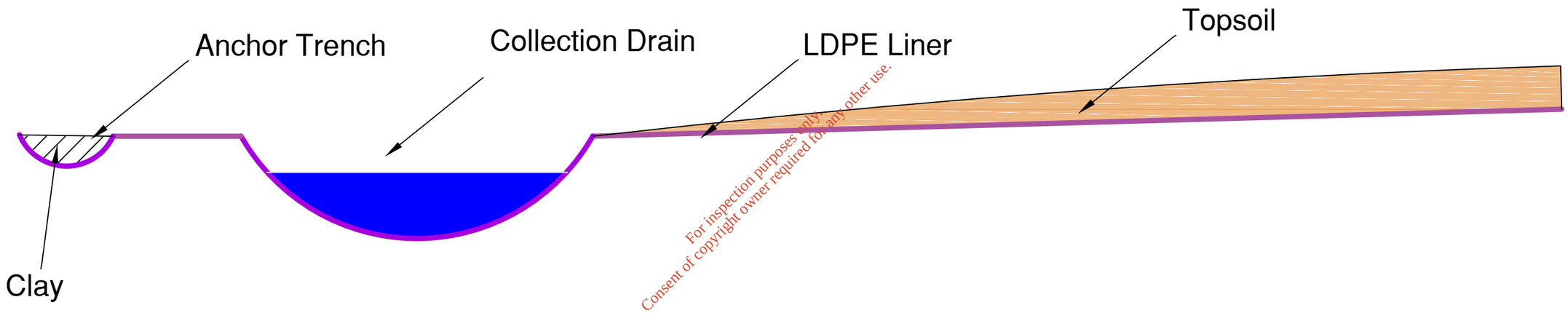

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FIGURE No.

6.4

TITLE

Surface Water Collection Drain

SCALE

NTS

REV.

A

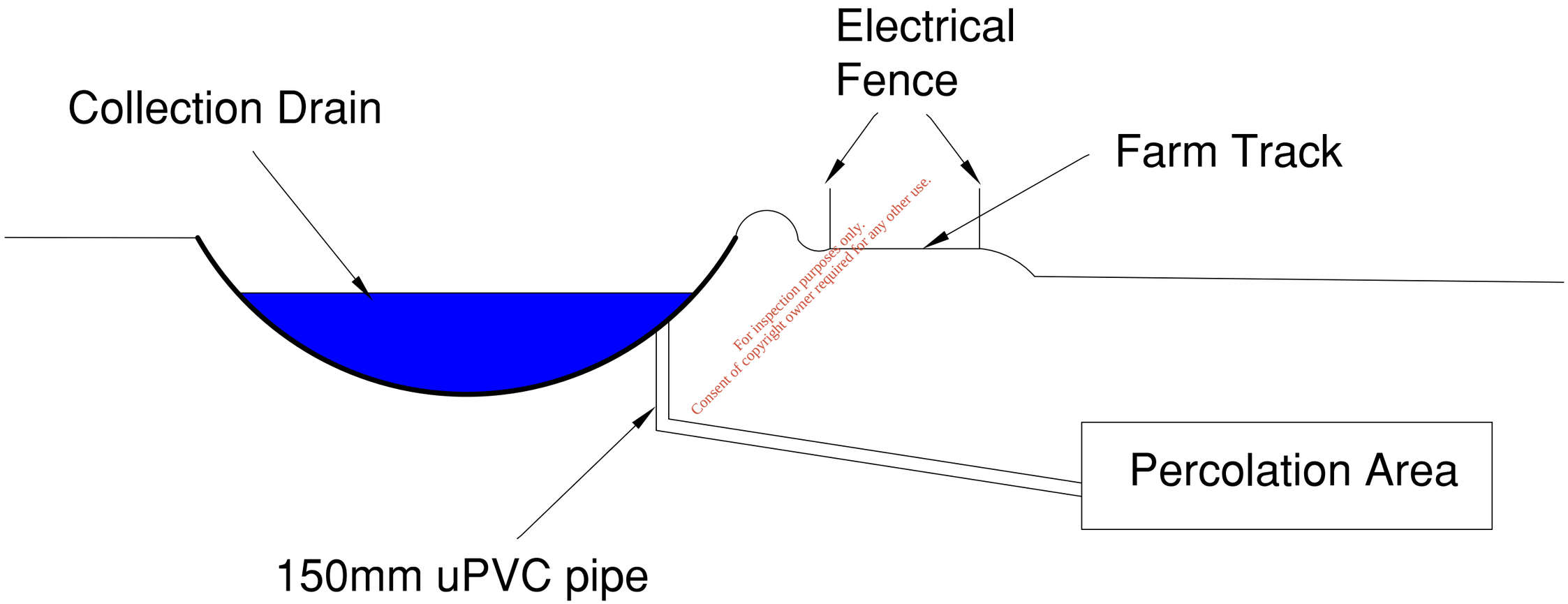

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FIGURE No.

6.5

TITLE

Surface Water Collection Schematic

SCALE

NTS

REV.

A

7. APPROPRIATE ASSESSMENT RISK SCREENING

7.1 AA Risk Screening Process

The Habitats Directive, which is implemented under the European Communities Birds and Natural Habitats) Regulations 2011 (S.I. No 477 of 2011) requires an "appropriate assessment" of the potential impacts any works may have on the conservation objectives of any Natura 2000 site.

Article 6(3) of the Directive stipulates that *any plan or project not directly connected with or necessary to the management of a Natura 2000 site, but likely to have a significant effect thereon…shall be subject to appropriate assessment of its implications for the site in view of the site's conservation objectives.*

Natura 2000 sites are those identified as sites of European Community importance and designated as such under the EU Habitats Directive (92/43/EC) (Special Area of Conservation) or the Birds Directive (Special Protection Areas).

Guidance documents issued by Department of Environment, Heritage and Local Government and the National Parks and Wildlife Services recommend that the assessment be completed in a series of Stages, which comprise:

Stage 1: Screening

The purpose of this Stage is to determine, on the basis of a preliminary assessment and objective criteria, whether a plan or project, alone and in combination with other plans or projects, could have significant effects on a Natura 2000 site in view of the site's conservation objectives.

Stage 2: Appropriate Assessment

This Stage is required if the Stage 1 Screening exercise identifies that the project is likely to have a significant impacts on a Natura 2000 site.

Stage 3: Assessment of Alternative Solutions.

If Stage 2 determines that the project will have an adverse impact upon the integrity of a Natura 2000 site, despite the implementation of mitigation measures, it must be objectively concluded that no alternative solutions exist before the plan can proceed.

Stage 4: Compensatory Measures:

Where no alternative solutions are feasible and where adverse impacts remain but imperative reasons of overriding public interest require the implementation of a project an assessment of compensatory measures that will effectively offset the damage to the Natura site 2000 is required.

The AA screening is required as it is proposed to undertake remedial measures incorporating the stripping off of the vegetation and top soil layer, the placement of additional capping material, grading and compacting the capping layer, installation a surface water collection drain and percolation area gas ventilation wells and the reinstatement of the top soil layer.

7.2 Stage 1 Screening Methodology

The Stage 1 Screening was conducted in accordance with the guidance presented in the "Assessment of Plans and Projects significantly affecting Natura 2000 sites, Methodological Guidance on the provisions of Articles 6(3) and 6(4) of the Habitats Directive 92/43/EEC" (2001); The Department of Environment, Heritage and Local Government (2009, revised February 2010) Appropriate Assessment of Plans and Projects in Ireland and the National Parks and Wildlife Services (2010) Circular NPW 1/10 & PSSP 2/10 Appropriate Assessment under Article 6 of the Habitats Directive: Guidance for Planning Authorities.

Special Areas of Conservation (SAC) are selected for the conservation and protection of habitats listed on Annex I and species (other than birds) listed on Annex II of the Habitats Directive, and their habitats. The habitats on Annex I require special conservation measures. Special Protection Areas (SPA) are selected for the conservation and protection of bird species listed on Annex I of the Birds Directive and regularly occurring migratory species, and their habitats, particularly wetlands.

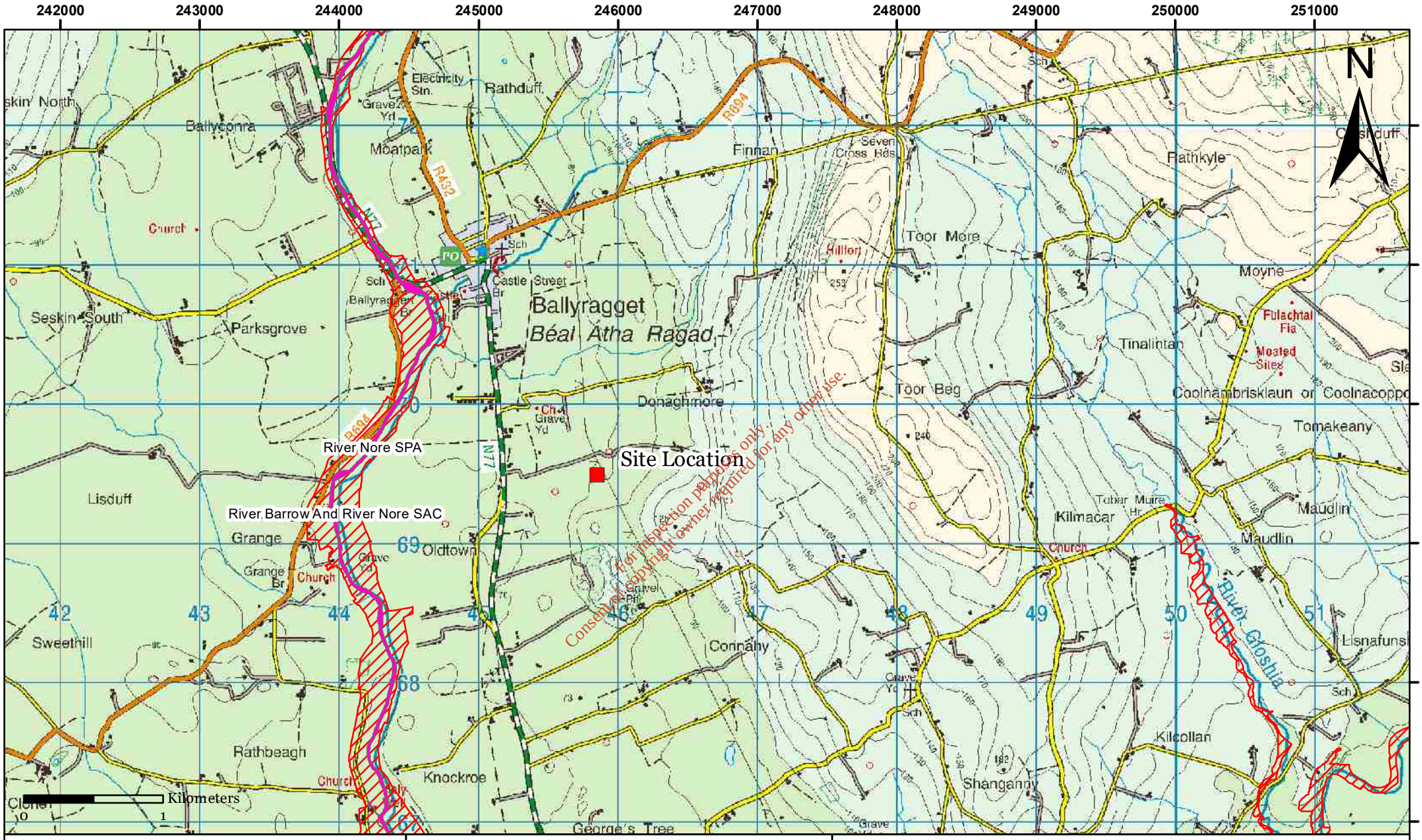
The River Nore is a designated Special Area of Conservation (SAC) approximately 1.5km to the west of the site (Figure 7.1).

The limited remedial works have the potential to general dust emissions in the immediate vicinity of the site when the capping layer is being re-worked and the top soil layer is being placed. There will also be emissions of rainfall run-off collected in the surface water drain to a percolation area to the north of the site.

There is no connection between the SAC and the landfill. While dusts will be generated during the proposed remedial works, given the distance to the SAC they do not present any risk to the SAC.

7.3 Stage 1 Conclusion

As the remedial measures will not impact on the SAC a Stage 2 Appropriate Assessment is not required.



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TITLE
NPWS

Details:
- Site Location
- SPAs
- SACs

Figure 7.1

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

Risk Category

The results of the Tier 3 assessment and the refined SPR conceptual model confirm that the site remains a Class A – High Risk due to the risk posed by leachate migration to groundwater. The landfill gas migration risk to offsite receptors is Low.

Groundwater

While there are private and a public supply well down hydraulic gradient of the landfill as all of these wells are located to the north-west of the River Nore which acts as a hydraulic barrier. These wells are not considered to be at risk from leachate migration from the landfill.

Landfill Gas

The landfill gas risk is low and the remedial measures proposed will mitigate the residual risk

Surface Water

There are no surface water drains or streams in the vicinity of the site. It is likely that shallow groundwater discharges to the River Finnan c900 north of the site. However, it is extremely unlikely that there is any impact on surface water quality when groundwater moving beneath the site discharges to the river.

Ecological Sensitive Sites

The closest site to the landfill is the River Nore (located approximately 1.5km west of the site) is a Special Area of Conservation (SAC). There are no pathways between the landfill and the SAC.

8.2 Recommendations

The remedial measures described in Section 6 of the report should be implemented to mitigate the environmental risk posed by the landfill.

Groundwater monitoring should be undertaken in BH-5, BH-6 and BH-7 annually to establish the effectiveness of the mitigation measures.