Tier 2 Exploratory Site Investigation Former Landfill at Tipperary Town

Prepared For:

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1. INTRODUCTION

O'Callaghan Moran & Associates (OCM) was appointed by Tipperary South Riding County Council (the Council) to complete a Tier 2 environmental risk assessment of the closed Tipperary Town Landfill.

1.1 Background

The Council completed a Tier 1 Assessment of the landfill in accordance with the "Code of Practice Environmental risk Assessment for Unregulated Waste Disposal Sites (CoP)" published by the Environmental Protection Agency (EPA). The Assessment concluded that the site was a Class A – High Risk site, due to the risk to humans from landfill gas and the potential for leachate migration to surface water.

In September 2009, the EPA prepared guidance on the completion of Tier 2 Site investigations in which it was recommended that the investigations be completed in two phases. Phase 1 should consist of Exploratory Works, following which the initial Tier 1 assessment should be revised and the need for and/or extent of a Phase 2 Detailed Site Investigation. This Report documents the findings of the Exploratory Phase..

1.2 Work Scope

The EPA guidance states that trial and trench site investigations and an assessment of the nature of the waste is a mandatory in the Exploratory Phase. Testing of the surrounding soil, waste and where possible leachate, surface and groundwater is recommended as is a topographic and GPS survey.

Following a review of the Tier 1 Assessment, a site inspection and experience of the implementation of Tier 2 Assessments, OCM concluded that the Exploratory Phaes should include;

- Geophysical Survey,
- Waste and Soil Characterisation,
- Waste Testing
- Surface Water Monitoring.

As there were no landfill gas, leachate or groundwater monitoring wells installed at the site, monitoring for these elements was not completed.

OCM concluded that given the high risk ranking, that a geophysical site survey be included in the Exploratory Phase, although this is not recommended in the EPA guidance. Completing the survey at this stage would ;

- A more comprehensive delineation of the lateral and vertical extent of the waste
- Identify possible leachate plumes migrating to surface and or groundwater
- Identify potential anomalous zones in the waste such as buried drums or areas where drilling might prove difficult,
- Establish total thickness of waste,
- Establish thickness of subsoil beneath the waste and depth to bedrock.

This information would then be used to amend the Conceptual Site Model and develop the scope of the Detailed Site Investigation. For example, if the groundwater pathway is not significant there may not be need to install bedrock groundwater monitoring wells. Alternatively if the subsoil thickness beneath the waste is thin or absent it would provide justification for installing deeper bedrock groundwater monitoring wells. This is particularly important in Karst Limestone aquifers where flow paths can be several kilometres in length.

OCM did not include a topographic survey at this stage as experience has shown that this survey should be completed at the end of Phase 2 so that all landfill gas and groundwater monitoring points, trial pits and surface water monitoring locations can be surveyed in at one time, thereby avoiding remobilising a survey crew.

2. SUMMARY OF TIER 1 ASSESSMENT

The site is in the Townland of Carrownreddy and is accessed by the Lake Road off the R610 Tipperary to Dundrum Road and is within the Tipperary Environs area Figure 2.1). It served as the landfill for Tipperary Town from circa 1940, until it closed l in 1990. The site is currently used by Tipperary Town Council as a Depot for road maintenance materials and machinery.

The site is approximately 1.8 hectares and within this area is a fenced off area of 0.2 hectares, which was apparently used exclusively for wastewater sludge. The southern, and part of the eastern and western site perimeter is fenced, but there is no visible boundary, other than the raised landfilled area, marking the northern boundary. The waste body is understood to be between 9-12meters thick. In addition to the sludges, the other wastes accepted are most likely to have been commercial and domestic.

The southern part of the site has a hardcore surface and is used for storing road maintenance materials and machinery. There is also a storage shed site, and a portacabin with toilet facilities for staff. The remainder of the site, north of the shed is covered with a considerable volume of miscellaneous wastes, including large mounds of construction & demolition waste, waste tyres (partially burned), household waste, white goods (fridges, washing machines etc) and green waste.

The underlying aquifer beneath is classified as being Regionally Important and the vulnerability rating is High. There are no groundwater, leachate or landfill gas monitoring wells and it is understood that surface water run-off from the site discharges to the Town's drainage system.

2.1 Surrounding Land Use

The adjoining lands are currently used primarily for low intensity agriculture, (grazing horses). Immediately to the north is a marshy area (once known as the Lake). There are residences within 250m of the site. A residential development (~250 houses) is under construction approximately 200m to the northeast of the site and it is the intention to develop the land between landfill and the residential estate for light industrial warehousing.

The lands to the south are currently used for grazing, but it is intended to develop these lands for social housing and light industrial use. There are currently no proposals to develop the lands to the west, but there are plans to extend the Lake Road west to link up with the R497, the Donohill Road.

Tipperary Town Council intend to move the Depot to an alternative location to enable the investigation and remediation of the site. In the longer term, the Council intends to develop a Civic Amenity Site at the site.

3. EXPLORATROY PHASE SITE INVESTIGATION

3.1 Site Inspection

OCM completed a site inspection on October 27th 2009 accompanied by the Council's Ms Ruth Hennessy and Mr John O'Sullivan. Ms. Hennessy had completed the Tier 1 assessment and Mr.O'Sullivan (Ruth to confirm name?) is the local area Engineer who had a detailed knowledge of the site history and surrounding land use. The objective of the visit was confirm the location of sensitive receptors, the surrounding land use and surface water drainage.

3.2 Trial Pitting and Trench Investigations

The investigations were undertaken on November 2nd and 3rd 2009 in accordance with BS10175, 2001, Investigation of Potentially Contaminated Sites - Code of Practice and were supervised by OCM personnel experienced in the investigation of landfills and contaminated lands.

A tracked excavator, capable of travelling on variable terrain, with a reach of 6 metres below ground level was used to excavate the trial pits. The excavations were logged in accordance with BS5930. The trial pit locations are shown on Figure 3.1 and a complete set of photographs and trial pit logs will be included in the Detailed Site Investigation Report. A selection of photographs are included below for reference purposes.

3.2.1 Lateral Extent of the Waste

The lateral extent of the waste is clearly defined by the difference in level between the fill area and the surrounding natural ground. The lands on the eastern, western and northern boundaries are at least 6m, 5m and 3m (respectively) higher than the surrounding lands. The northern boundary is defined by a wetland area. .

Excavations were carried out at the northern, western and eastern boundaries to confirm that the toe of the slope marked the lateral extent of the waste. Excavations along the southern boundary indicated that the waste extended to the road way that runs along the southern site boundary.

The natural ground surrounding the landfill comprises saturated lacustrine sediments overlying gravely clay till, which appears to be of moderate to low permeability and was moist to dry in the top 2-3 metres.

3.2.2 Vertical Extent of Waste

The full thickness of the waste was defined along the margins, but it was not possible to establish the full depth in the central portion of the site, because the waste extended beyond the reach of the excavator. The average depth of the excavations was six metres.

Based on the difference in levels between the fill area and the surrounding lands, it is estimated that in the central area the waste is on average 12m deep. The geophysical survey indicates the waste ranges from 6-7m up to 17m in the northern section of the landfill. The geophysical survey is discussed in more detail below in Section 3.4

3.2.3 Waste Characterisation

There is a variation in the waste types across the site. The wastes in the northern, western and eastern edges of the site consist of mainly Construction and Demolition (C&D) waste comprising soils and stone, with minor amounts of rubble. The central section contains more domestic and commercial types

The municipal waste comprises a mix of plastic and glass bottles, occasional empty flattened steel drums, empty plastic drums, concrete pipes, steel, papers, tyres, tyre tubes, timber and trees, all of which were supported by a sandy gravelly clay matrix. It ranged from damp to dry with some minor seeps of water in the upper 2m.

It is assumed that the sandy clay was used as cover material when the site was operational, but no discrete layers were noted. No datable materials (newspapers, stationary) which could be used to establish the age of the waste found. There was no evidence of any significant amounts of hazardous waste (e.g. oils, solvents), staining or odours. Strong putrescible odours were only detected in two trial pits TP-9 and TP-10, which are in the western section of the site.

The area north of the on site building and road maintenance materials is covered in soils and stone mixed with minor amounts of what appears to be C&D waste. This material is on average 1.5m to 2.5m thick. This material appears to have been brought onto site after the facility officially closed and has not been graded

Photo 1 Waste in TP-1.

Photo 2 Waste in TP-3.

Photo 8 Waste in TP-11

Photo 3 Waste in TP-10

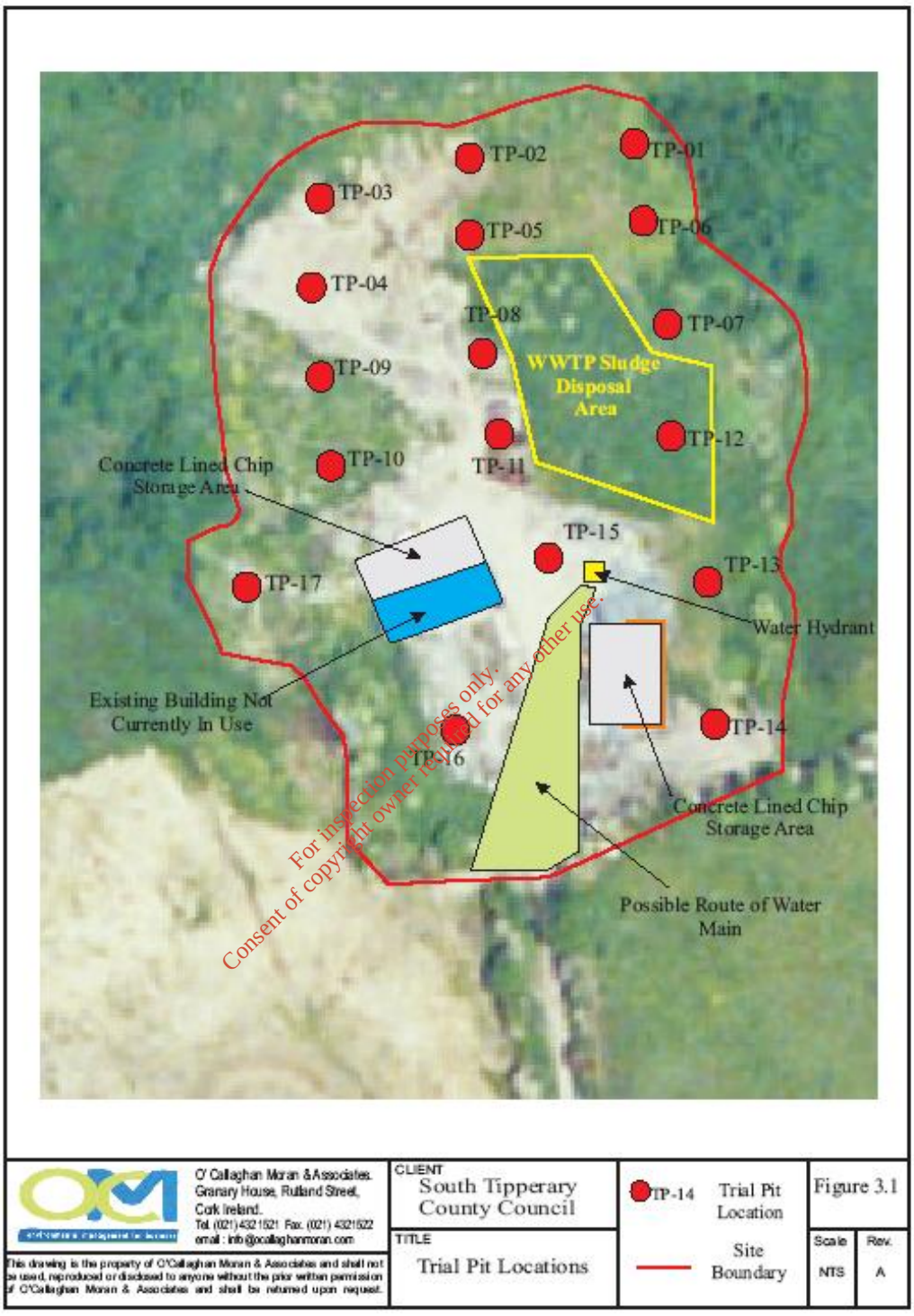
Photo 4 Waste in TP-13

Photo 5 Waste in TP-15

Photo 6 Waste in TP-17

3.2.4 Waste Sampling Programme

Composite samples of the waste were collected in accordance with OCM's sampling protocol. The samples were field screened for the presence of volatile organic compounds (VOC) using a photo ionisation detector (PID). The PID readings are included in the trial pit logs. PID readings ranged from non detect to 10 ppm and were not considered to be indicative of the presence of significant levels of VOCs. The samples were placed in laboratory prepared containers and stored in coolers prior to shipment to Jones Environmental Forensics in the UK.



3.3 Surface Water

A surface water drain flows from the site to the east for 150m. The drain then turns south towards the access road. From the access road, it is piped through the Town and eventually discharges to the River Ara. A surface water sample was collected from the drain approximately 50m from the landfill on the 3rd November 2009.

3.3.1 Laboratory Analysis

Two samples were selected to be analysed for the parameters set out in the EU Council Decision establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC (Council Decision).

The Council Decision sets threshold limits for a range of inorganic and organic parameters, which define whether a waste is suitable for disposal to an inert, non-hazardous or hazardous waste landfill. Based on field observations it was considered the parameters specified in the Council Decision were appropriate for assessment purposes. However, depending on the test results, additional analyses may be carried out.

The solid samples were tested for Total Organic Carbon (TOC), BTEX (benzene, toluene, ethylbenzene and xylene) Polychlorinated biphenyls (PCB), Mineral Oil and Polycyclic Aromatic Hydrocarbons (PAH). Leachate generated from the waste samples were tested for metals (arsenic, barium, cadmium, chromium, copper, mercury, molybdenum, nickel, lead, antimony, selenium and zinc), chloride, fluoride, soluble sulphate, phenols, dissolved organic carbon (DOC) and total dissolved solids (TDS). The laboratory methodologies were all ISO approved or equivalent and the method detection limits (MDL) were all below the relevant guidance limit.

The results of the laboratory analysis were not be available at the time of the preparation of this report. However, based on OCM experience, the waste is considered to be typical of that found in small scale municipal landfills. No significant zones of potentially contaminated or hazardous waste were identified.

The surface water samples were collected in accordance with OCM sampling protocols and were placed in laboratory prepared containers and stored in a cooler. Field measurement and observations recorded at the time of sampling are presented in Table 3.5. The samples were sent for analyses to Jones Environmental Laboratory in the UK. The Chain of Custody documentation will be included in the detailed site investigation report.

3.4 Geophysical Site Investigation

The geophysical survey was completed by Apex Geoservices Ltd on the 29th and 30th October 2009. The full Apex report is presented in Appendix 1 and summarised below.

The objectives of the survey was to:

1. Determine the sub-surface conditions including thickness and extent of the buried waste, nature of subsurface material and depth to bedrock.
2. Identify leachate plumes into surface drains or underlying karstic limestone.
3. Locate any local anomalies (buried drums, etc) within the waste material.

The geophysical methods employed were:

1. EM31 Conductivity mapping to provide information on variations in the bulk conductivity value which reflects variation in the composition of the material in the top 6m of the subsurface.
2. 2-D Resistivity Profiles to provide information on the nature and thickness of the deposit, the extent of capping material and the nature of the underlying soils and rock.

The survey findings are shown on the APEX Drawing in Appendix 1. The survey concluded that:

- The lateral extent of the landfill is defined by the steep slopes of its boundary.

- The fill comprises organic waste and C&D waste, which typically includes a cap of C&D material and mixed C&D and organic waste material up to 6m thick underlain by organic waste material over lacustrine sediments and sandy gravelly silt/clay.

- The combined thickness of the landfill material ranges from 6.7m on Profile R2 to possibly up to 17m on R4.

- Localized increases in resistivity values across the site indicate an increase in the C&D content and a decrease in the organic waste content of the fill.

- In the fill area, the resistivity contrast between leachate saturated lacustrine sediments and the waste is poor. This indicates that leachate from the waste has most likely migrated into the underlying lacustrine sediments

- Beneath the lacustrine sediments is a layer of sandy gravelly silty clay of medium to low permeability (Bounder Clay). The thickness of this layer could not be established in the centre of the site because of the thickness of the waste mass. However the depth to bedrock and hence thickness of the boulder clay above the bedrock was established at the edges of the fill. This indicates that the waste mass is not in direct contact with the bedrock and that there may be 3-4m of subsoil above the bedrock.

- The resistivity values of the rock are relatively low (<400 Ohm-m) indicating that it is likely to be argillaceous/shaly and therefore is unlikely to be prone to extensive karstification. This indicates that the boundary between the Regionally Important Karstified Limestone (RKd) aquifer and the Locally Important Ll a Shaly limestone is either further north or south, but not underneath the site.

- The resistivity data also indicate a possible leachate zone, where the fill and outlet stream meet. This indicates a possible preferential flow path toward the surface water system for leachate collecting in the landfill.

- Areas of possible buried metal have been identified

3.5 Landfill Gas Risk

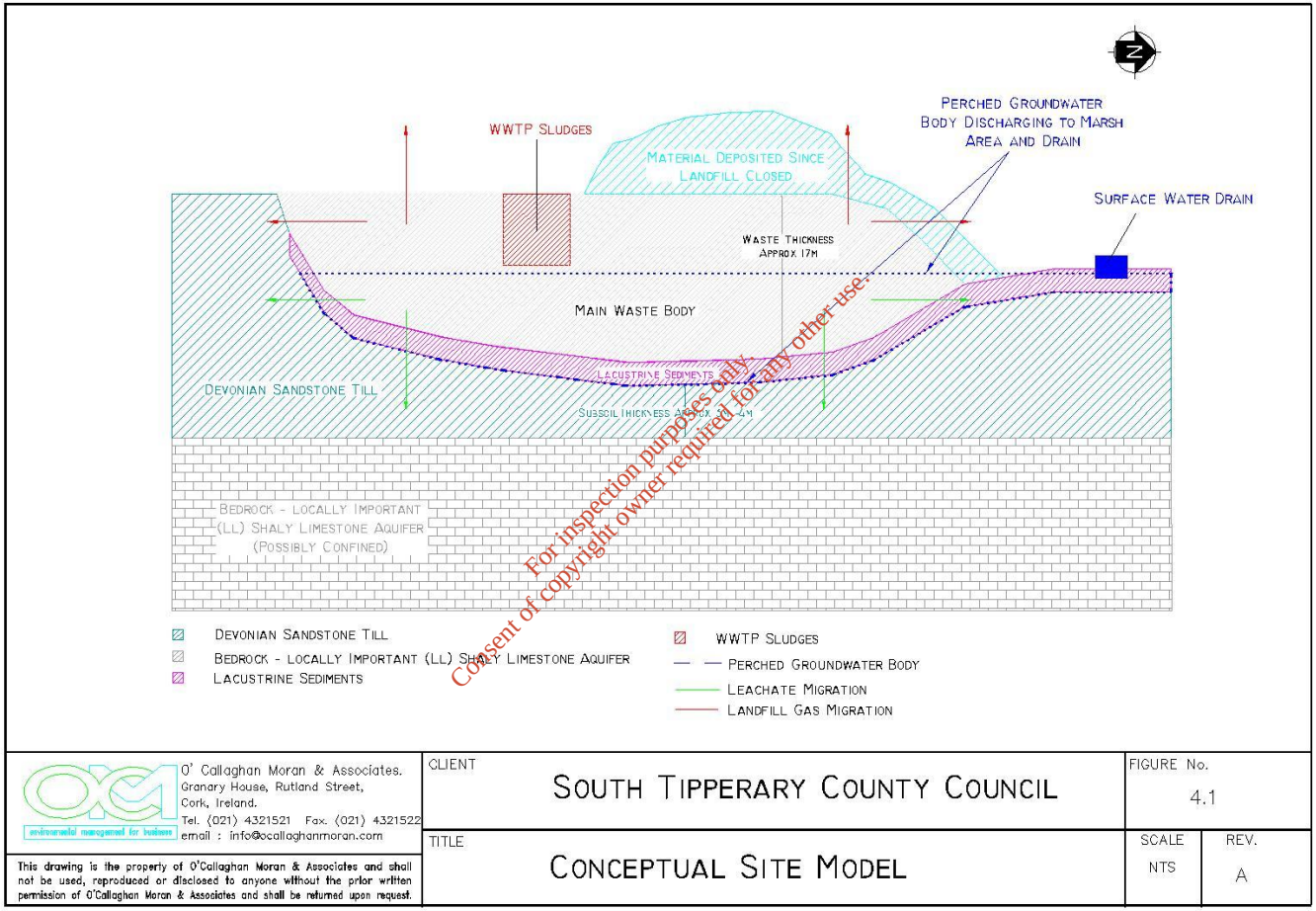
There are no landfill gas monitoring wells on the site. During the initial site inspection OCM were informed that the on-site building is no longer used and it is planned to demolish the structure in the near future. It is reasonable therefore to assume that the risk to users of the building in the medium to long term will be eliminated and the landfill risk assessment should therefore be reassessed.

OCM observed that lands beyond the marsh area to the north and northwest approximately 200 - 300m away have been reclaimed with construction demolition waste as part of the planned future development of these lands for residential and or commercial purposes. It is also possible that the lands immediately to the east and west of the site could be developed for residential and/or commercial purposes. The risk therefore to potential off-site receptors remains significant and needs to be assessed in the Detailed Site Investigations.

4. REVISION OF TIER I RISK ASSESSMENT & CONCEPTUAL SITE MODEL

4.1 Revised Conceptual Site Model

A revised conceptual Site Model is presented on Figure 4.1 below. This model illustrates the presence of low –to moderate permeability boulder clay and Ll aquifer beneath the site. The Leachate beneath the landfill is likely to perched above the boulder clay with preferential discharge to the surface water system.



4.2 Risk Assessment

OCM has modified the original risk assessment on the basis of the findings of the Exploratory Phase and the changes are highlighted in blue.

Table 6

Ref	**Source**	*Score*	*Rational*
1a	Leachate	7	▪ <5 hectares ▪ Waste likely to be both municipal & industrial
1b	Gas	7	▪ <5 hectares ▪ Highest rating given as proportion of municipal: industrial wastes is not known.

Table 7

Ref	**Pathways**	*Score*	*Rational*
2a	Groundwater vulnerability	2	▪ GSI data states that the site is rated as having high vulnerability.
2b	Groundwater flow regime	1	▪ Bedrock was originally considered to be karst. The geophysical survey indicates that bedrock is not karst and is likely to be Shaley Limestone i.e Ll Aquifer. Score reduces from 5 to 1.
2c	Surface water drainage	2	▪ Landfill is reportedly connected to town surface water drainage system
2d	Landfill gas lateral migration	3	▪ Residences not currently within 250m of site, but will be within 5 years ▪ Karst bedrock
2e	Landfill gas vertical migration	0	▪ Building on site not occupied and will be removed risk score reduces from 5 - 0

Table 8

Ref	**Receptors**	*Score*	*Rational*
3a	Human presence (leachate)	2	▪ Currently no houses within 250m, there will be within 5 years ▪ Note: All houses will be served by public water
3b	Protected areas	1	▪ No protected areas within 1 km of site ▪ The marsh area has been considered as an undesignated GWDTE, precautionary approach. ▪ No consultation with the NPWS has taken place.
3c	Aquifer category	5	▪ Locally Important Ll aquifer underlies the site, score reduces from 5 to 3
3d	Public water supply	3	▪ Public water supply is greater than 1km away (Cordangan) ▪ Karst bedrock – but different geological formation ▪ Precautionary approach assumed
3e	Surface water bodies	3	▪ Surface water drain within 50m of site boundary
3f	Human presence (gas)	0	▪ Building on site unoccupied and to be removed

			score reduces from 5 to 0

The revised risk assessment indicates that the site remains High Risk. However, the High Risk categories no longer include a landfill gas risk to site occupants or nearby residents. The risk posed by landfill gas to nearby residences is now considered to be Moderate Risk.

The risk posed by leachate migration to the surface water system is the primary High Risk Driver. The fill area is underlain by lacustrine sediments and moderate to low permeability glacial till, which is estimated to be 3-4m thick.

While leachate may have saturated the lake sediments, the tills are likely to limit the vertical migration toward the bedrock aquifer. The aquifer appears to be a shaley limestone (Ll) aquifer. Such aquifers tend to have short flow paths with discharge to the local surface water system. It is highly likely, based on the findings of the Geophysical Survey, that there is preferentially flow laterally toward the surface water system.

Note: The table below represents the Tier 1 Risk rating for this site. SPR1 to 9 represent the leachate risk scores. SPR10 & 11 represent Landfill Gas Risk. The migration pathways are colour coded as follows:

Groundwater & Surface Water	Groundwater only	Surface water only	Lateral & Vertical

Calculator		SPR Values	Maximum Score	Normalised Score
SPR1	1a x (2a + 2b + 2c) x 3e	105	300	35.00%
SPR2	1a x (2a + 2b + 2c) x 3b	35	300	11.67%
SPR3	1a x (2a + 2b) x 3a	42	240	17.50%
SPR4	1a x (2a + 2b) x 3b	21	240	8.75%
SPR5	1a x (2a + 2b) x 3c	63	400	15.75%
SPR6	1a x (2a + 2b) x 3d	63	560	11.25%
SPR7	1a x (2a + 2b) x 3e	63	240	26.25%
SPR8	1a x 2c x 3e	42	60	70.00%
SPR9	1a x 2c x 3b	14	60	23.33%
SPR10	1b x 2d x 3f	63	150	42.00%
SPR11	1b x 2e x 3f	This linkage is not present due to no receptor above the source		
Overall Risk Score		105		**70.00%**
				A

Risk Classification	Range of Risk Scores
Highest Risk (Class A)	**Greater than 70 for any individual SPR linkage**
Moderate Risk (Class B)	**40-70 for any individual SPR linkage**
Lowest Risk (Class C)	**Less than 40 for any individual SPR linkage**

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The Exploratory Phase has confirmed that the site is a Class A High Risk Site. However the highest risk is posed only by leachate migration to the surface water system. The risk posed by landfill gas to site users has been eliminated as the onsite buildings will be demolished. The risk posed to nearby residences has reduced from High to Moderate Risk based on strong evidence for the presence of an Ll aquifer beneath the site.

It is likely that leachate migration is occurring from the site toward the marsh wetland area and into the drain, which ultimately discharges to the River Ara several kilometres downstream of the site. The surface water sampling results will assist in determining if leachate is impacting on water quality in the drain.

5.2 Recommendations

OCM recommend that a Detailed Risk Assessment of the site be undertaken to assess the risk posed by leachate and landfill gas migration from the site.

5.2.1 Leachate Risk

5.2.1.1 Surface Water

OCM recommend that the results of the surface water sampling form the basis for the assessment of the risk to surface water. If an impact is confirmed there may be a need for further assessment of the surface water system as part of the detailed site assessment.

5.2.1.2 Groundwater

OCM recommend that three groundwater monitoring wells be installed around the perimeter of the site in the subsoil formation above the bedrock to establish if leachate migration is reaching an/or migrating through this layer.

One well will if possible be installed up hydraulic gradient of the landfill site to the north or northeast depending on site conditions. Currently this area is under water as it is part of the old marsh. Two wells will be installed down hydraulic gradient of the site. One to the east of the landfill, between the landfill and the surface water drain through which all surface water appears to discharge form the landfill catchment. One well to the west of the site to establish if leachate is migrating away from the site in that direction.

5.2.1.3 Leachate

OCM recommend that three internal leachate wells be installed at locations identified in the geophysical site investigation. These wells will also be used to monitoring landfill gas. . The wells will extend to the base of the waste.

5.2.2 Landfill Gas

OCM recommend that six (6 no.) landfill gas wells be installed around the perimeter of the landfill site. Three of the (3) the landfill gas wells located outside the fill area will be used to monitor groundwater quality in the shallow subsurface, where flow may contribute to the local surface water drainage system.

The wells will be located adjacent to the closest sensitive receptors (the halting site to the west and the residential development site to the northeast. Gas monitoring wells will also be located adjacent to the site entrance to the south and to the east and west because these lands are zoned for residential development in the future.

The landfill gas levels in the wells should be monitored weekly intervals over the following three weeks. The monitoring will include methane, carbon dioxide and hydrogen sulphide pressure and flow rates.