



IP 0001/06/B

NON-HAZARDOUS ENGINEERED WASTE LANDFILL AT GHALLIS

ENVIRONMENTAL MONITORING PROGRAMME

Version 4: December 2014



Report Reference:

Adi Associates Environmental Consultants Ltd, 2014. Non-Hazardous Engineered Waste Landfill at Ghallis. Environmental Monitoring Programme required by IPPC permit IP 0001/06/B. San Gwann, December 2014; vii + 61 pp.

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Quality Assurance

Non-Hazardous Engineered Waste Landfill at Ghallis Environmental Monitoring Programme required by IPPC permit IP 0001/06/B June 2014

Report for: **WasteServ Malta Limited**

Revision Schedule

Rev	Date	Details	Written by:	Checked by:	Approved by:
00	Oct 2013	Submission to Client	Rachel Decelis Environmental Consultant	Rachel Xuereb Director	Adrian Mallia Director
01	Dec 2013	Submission to Client	Rachel Decelis Environmental Consultant	Rachel Xuereb Director	Adrian Mallia Director
02	June 2014	Submission to Client	Rachel Decelis Environmental Consultant	Rachel Xuereb Director	Adrian Mallia Director
03	December 2014	Submission to Client	Rachel Decelis Environmental Consultant	Rachel Xuereb Director	Adrian Mallia Director

File ref: G:_Completed Projects\Environmental Management Services\Environmental Monitoring Plans\WSM020 - Ghallis and Zwejra MP - 2013\Monitoring Programme Ghallis (FNL FNL).docx



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I. INTRODUCTION

- I.1. The Malta Environment and Planning Authority (MEPA) issued a permit (Permit number IP0001/06) under Regulation 14 of the Integrated Pollution Prevention and Control Regulations, 2002 to WasteServ Malta Limited (“WasteServ”) for the operation of a non-hazardous waste disposal facility at Ghallis, located in the north east of Malta. The facility comprises an engineered landfill for the disposal of non-hazardous wastes generated on the Maltese Islands. The facility has been developed in five phases consisting of five hydraulically independent cells, each with its own leachate collection and extraction system and physically connected to form an integral common base of the landfill. The facility has a surface water collection system and a gas extraction system with possible utilisation. The gas extraction system is also permitted in the IPPC permit.
- I.2. A renewed and updated permit was issued in June 2013 (IP 0001/06/B) under Regulations 9-11 of the Waste Management (Landfill) Regulations (LN 168 of 2002 as amended) and Regulation 7 of the Industrial Emissions (Framework) Regulations (LN 9 of 2013). Section 1.5.2 to the Permit states that an updated and consolidated Environmental Monitoring Programme is required. This document presents the updated Programme. It takes into account the previous programme as well as relevant comments from the IPPC Committee, and the monitoring results obtained under the previous monitoring programme.
- I.3. WasteServ Malta Limited will endeavour to use EN/ISO standards for monitoring, or their equivalent. Laboratories used for analysis will be accredited to at least ISO 17025:2005.
- I.4. Limits of detection are being included in the monitoring programme where available. In cases where limits of detection are not currently available, WasteServ will communicate them to MEPA once a contractor has been selected.

2. THE SITE

SITE SETTING

- 2.1. The site and its surroundings and the background conditions are described in detail in the Environmental Impact Assessment (EIA) prepared on behalf of WasteServ by SLR Limited¹. Key points only are described here to facilitate an understanding of the conditions and rationale behind the proposed monitoring programme.

GEOGRAPHICAL SETTING

- 2.2. The site is located approximately 2 km to the north of Naxxar and 2 km east of Qawra along the northern coast of Malta. The site is located immediately to the west of a former landfill, the Maghtab landfill, which used to accept a wide range of wastes.
- 2.3. The northern and central parts of the development site extend from a low point of around 30 m AD at the northern and northeastern edges of the area, up to high point of around 50 m AD towards the central part of the site. The northern part of the development site is located on the eastern slopes of a shallow hill and the land predominantly falls to the southeast, east and northeast. These slopes fall beneath the former Maghtab Landfill.
- 2.4. The southern part of the development site consists of the existing main access road to the former Maghtab Landfill, which is currently used to provide access to temporary disposal areas, the Zwejra Disposal areas, two contained cells adjacent to the access road which have been used for the disposal all non-inert waste from Malta and Gozo following the closure of Maghtab Landfill in May 2004. To the southeast, adjacent to southern flanks of the Maghtab landfill, the slopes are generally steeper and represent a shallow valley feature that descends in a northeasterly direction to the sea.

GEOLOGY

- 2.5. The strata at the site and surrounding area are dominated by detrital limestones comprising the Miocene Globigerina Limestone, underlain by the Oligocene Lower Coralline Limestone. There is limited drift cover.
- 2.6. The geological strata are approximately horizontally bedded with a gentle regional dip to the north at between 2 and 3°. In the EIA it is concluded that discontinuities (fractures and joints) and solution type (karst) features are present within the limestone bedrock below the site, inferred from partial or complete loss of drilling fluid returns at various depths during drilling of boreholes.
- 2.7. An east-west trending fault, down thrown to the north, may be present entering the western side of the proposed site. Minor faults are known to be common in this

¹ SLR Ltd (2005) Ghallis – EIA Version 01

area of Malta and are reported to comprise a conjugate set with a general north-south and east-west orientation.

HYDROGEOLOGY

- 2.8. The primary aquifer below the site is developed within the Lower Coralline Limestone Formation and is represented by a thin freshwater lens that overlies brackish/saline groundwater. This is the 'Mean Sea Level Aquifer', as the groundwater elevations lie just above sea level.
- 2.9. Groundwater in the Lower Coralline Limestone Formation beneath the site is shown in the SLR EIA as falling from approximately 1m above mean sea level to the south of the site at the access, falling gently to the north to approximately 0.25 m beneath the northern part of the site.
- 2.10. As the minimum basal elevation of the proposed landfill (Phases 2, 3 and 4) will lie at approximately 16 m above sea level, and a minimum unsaturated zone thickness of approximately 15 m is anticipated.
- 2.11. Primary hydraulic conductivity in the range 2.4×10^{-10} to 2.27×10^{-6} m/s and secondary hydraulic conductivity in the range 2.0×10^{-4} to 1.5×10^{-3} m/s are suggested in the EIA.

HYDROLOGY

- 2.12. The Maltese Islands' climate is a typical Mediterranean one with mild wet winters and hot, dry summers. Precipitation is in the form of rain, hail, dew and soft rime. The average precipitation rate calculated over 30 years (1961-2010) is that of 553.12 mm with a standard deviation of 156.99 mm (28.38 co-efficient of variation) (NSO 2011). The wettest month is typically December, with an average rainfall of 93.7 mm. The driest month is July with an average monthly rainfall of only 0.57 mm. The majority of rainfall takes place between October and March with approximately 85% of the average annual precipitation falling during this part of the year. During April to September, however, rainfall may be significant, with maximum recorded monthly rainfalls for August and September of between 155 mm and 235 mm respectively. Rainfall events are typically characterised by single storms of relatively short duration. This often results in runoff taking place over a short period, during and immediately following the storm event.
- 2.13. There are no permanent surface water features within the site or adjacent surrounding area, reflecting the small catchment size, climatic conditions and the hydraulic conductivity of the underlying limestones.
- 2.14. The design criteria for surface water runoff from the landfill cap are described in the EIA and include peripheral infiltrating drainage ditches (swales) and soakaways to be located on the perimeter of the site. The approximate total capacity required for the swales to accommodate the most intense 24-hour storm recorded over the period 1985 to 2004 and assuming an infiltration rate of 500 mm/h is calculated by SLR Ltd at 13,500 m³. SLR calculated that this total volume could be achieved using ditches of

approximate dimensions 1m deep, 1m bed with side slopes of 1 in 4. The proposed surface water management plan is shown on Drawing AL(2-)08A.

WIND SPEED AND DIRECTION

- 2.15. Prevailing winds blow from the northwest sector for 30% of the time and include the Majjistral and Punent. Winds from the north, northeast, southeast and southwest sectors occur infrequently and calm conditions (wind speeds less than 0.5 m/s) occur for approximately 5.5% of the time.

3. MONITORING OF METEOROLOGICAL DATA

CURRENT MONITORING PRACTICE

- 3.1. Current practice is for meteorological data to be measured at the site office of the adjacent non-hazardous landfill at Zwejra. Parameters measured are wind speed, wind direction, atmospheric pressure, atmospheric temperature, relative humidity and rainfall. Evaporation has also recently started to be measured. Measurements are made on an hourly basis.

LANDFILL DIRECTIVE RECOMMENDATIONS

- 3.2. Annex III of the Landfill Directive (1999/31/EC) indicates that if Member States decide that water balances are an effective tool to evaluate whether leachate is building up in the landfill or whether the landfill is leaking, a number of meteorological parameters should be monitored. Monitoring should be carried out daily for precipitation (volume), temperature, wind (speed and direction), evaporation and atmospheric humidity.

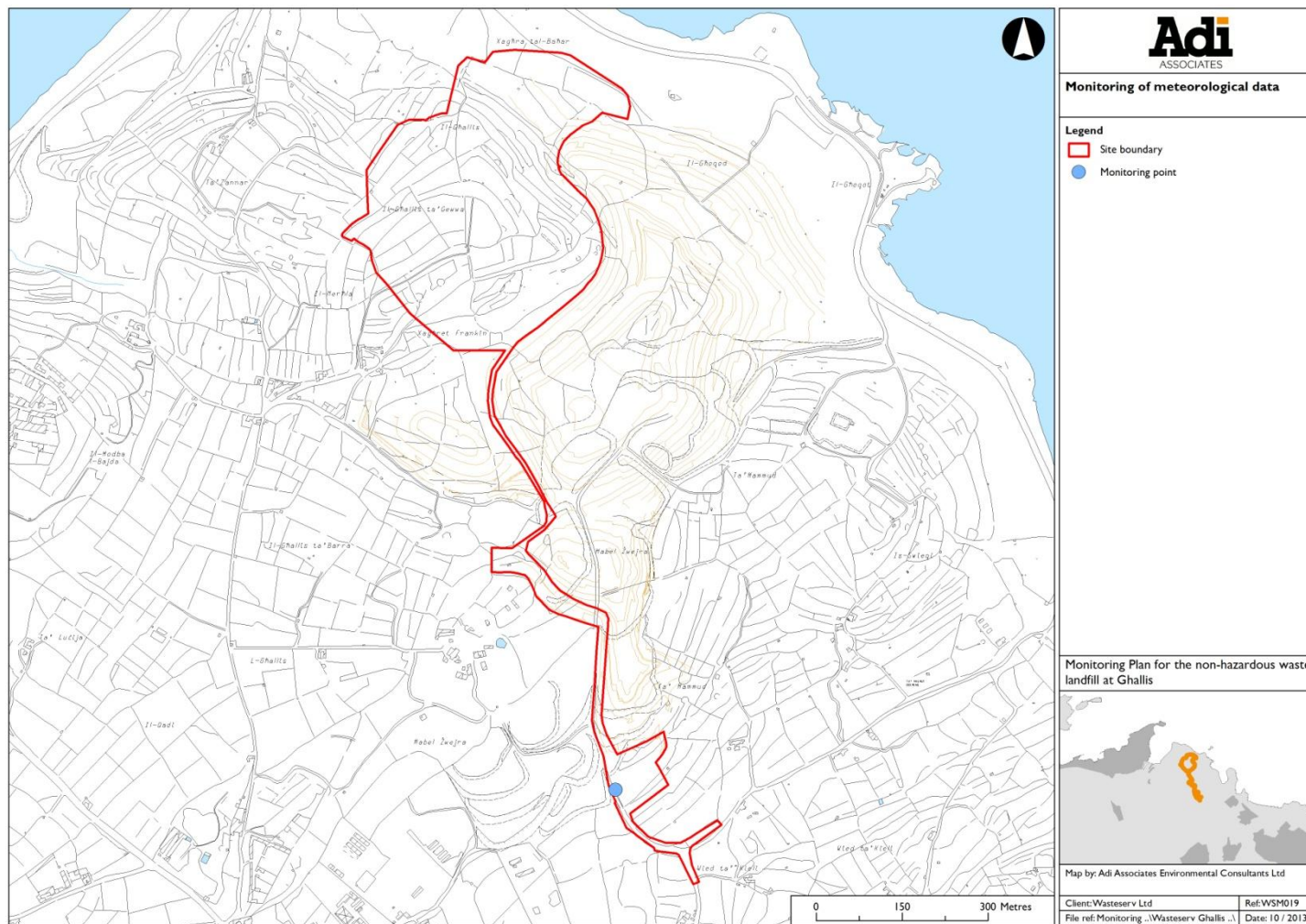
MONITORING STRATEGY

- 3.3. A monitoring plan for the collection of meteorological data is provided in **Table 3.1**. In view of the close proximity of Ghallis landfill to the adjacent Zwejra non-hazardous landfill, the monitoring location will be co-located with the Zwejra landfill's monitoring point.

Table 3.1: Meteorological monitoring

Monitoring location	Parameters	Frequency	Instrument type
Zwejra landfill site office	Precipitation (volume)	Daily	Rain gauge
	Temperature	Daily	Temperature probe
	Wind (speed and direction)	Daily	Wind speed sensor & wind speed direction sensor
	Evaporation	Daily	Evaporation pan & gauge
	Atmospheric humidity	Daily	Humidity probe
	Atmospheric pressure	Daily	Barometric pressure meter

Figure 3.1: Monitoring location for meteorological data



4. LANDFILL GAS AND STACK EMISSIONS MONITORING

CURRENT MONITORING PRACTICE – LANDFILL GAS

- 4.1. With regards to landfill gas monitoring, Section 5 of the Permit states that “*monitoring shall be carried out in accordance with the consolidated Environmental Monitoring Programme for the Permitted Installation, as approved by the Authority*”. Figure 4.1 indicates monitoring points 0, 1, 3 and 4 that are used to monitor on-site ambient air and surface gases.
- 4.2. At surface monitoring points 0, 1, 3 and 4 quarterly measurement of methane concentration/flux, carbon dioxide and oxygen, atmospheric pressure and temperature, flow, meteorological data, general surface type and condition is undertaken. Weekly monitoring is also carried out for methane, carbon monoxide and hydrogen sulphide.
- 4.3. Monitoring is carried out for methane, carbon monoxide and hydrogen sulphide at the ground surface at off-site monitoring points with the results given in parts per million as described in Section 6 of this Programme.
- 4.4. Monthly measurement of methane, carbon dioxide, oxygen, atmospheric pressure, differential pressure temperature and flow is carried out boreholes BH1 to BH5 and MBH 5.
- 4.5. Monthly measurement of methane, carbon dioxide, oxygen, atmospheric pressure, differential pressure and temperature and flow at the leachate monitoring points are undertaken at eight leachate monitoring points (LCPI to 7, with LCP8 having been added recently). New leachate monitoring points are added whenever a new cell is opened.

UK GUIDANCE – LANDFILL GAS

- 4.6. Guidance on the management of landfill gas was provided in the UK in Waste Management Paper 27² (WMP27). In paragraph 2.4, WMP27 states that a control system should be considered effective if the concentration of flammable gas never exceeds 1% by volume and the concentration of carbon dioxide never exceeds 1.5% by volume. Following implementation of the Landfill Directive, new Guidance, TGN03³, has been issued, which updates WMP27. This qualifies the Guidance relating to trigger levels, to 1% methane and 1.5% carbon dioxide above background concentrations. Trigger levels are compliance levels and, in order to meet them, action levels should be set at a level at which the operator can take action to remain compliant. It is proposed that the assessment criteria for landfill gas in the monitoring boreholes are consistent with the trigger levels given in TGN05.

² Department of the Environment (1996). *Landfill Gas*. Waste Management Paper 27, Fourth impression.

³ Environment Agency (2003). “*Guidance on the Management of Landfill Gas*” TGN03.

- 4.7. WMP27 states that monitoring borehole spacing outside the waste is site specific, the spacing related to risk. The Guidance suggests that where development is within 50m to 100m and the strata are uniform, that is no fissures, the spacing should be 50m maximum, dependent on the quantity of gas generated, the risk to development and the type of strata. TGN03 suggests that for fissure or fracture flow dominated permeable strata with development within 250 metres, the maximum spacing should be 50m.
- 4.8. TGN03 describes the pathways through which receptors may be exposed to landfill gas emissions:
- direct release to atmosphere;
 - sub-surface migration through the ground or along service ducts and/or pipelines, etc.;
 - indirect release to atmosphere, e.g. from subsurface landfill gas migration, or dissolution from leachate and condensate;
 - direct release of combustion products to atmosphere, e.g. enclosed flares and engines.
- 4.9. The Guidance describes how any landfill is likely to have a variety of potential release points and fugitive emissions related to landfill gas. For Ghallis landfill, direct release to atmosphere will be possible during the operational phase, but restricted as the site is capped, although this pathway is recognised. The potential for sub-surface migration is recognised, hence the requirement for out of waste landfill gas monitoring points.
- 4.10. Release points/areas considered in the Guidance include:
- freshly deposited wastes;
 - the surface (cap) of the landfill
 - the interface of the landfill with the surrounding geology and engineering features;
 - leaks from the gas and leachate collection systems (pipework, valves, wells);
 - gas and leachate treatment plant;
 - degassing of leachate and condensate during collection and/or treatment;
 - flare stacks;
 - exhaust emissions from utilisation plant; and
 - intermittent emissions during excavations, well drilling, leachate pumping or other engineering works.

4.11. The relative importance of each of these will vary on a site-specific basis. For the Ghallis landfill freshly deposited waste is likely to be a source of landfill gas for in excess of 7 years during the operational and final capping period. There is currently also a flare stack in operation, which could be a source of emissions. The potential for intermittent emissions during replacement gas well drilling is recognised.

4.12. The Guidance states, with respect to surface emissions:

“a qualitative estimate of methane emissions through a surface cap can be made using a hand-held instrument such as a flame ionisation detector (FID). However, very low flux cannot normally be detected and localised on a landfill cap. Extensive research suggests that the flux box is currently the most cost effective technique for the verification of the range of surface emission sources typically found on a landfill site”.

4.13. Further Guidance⁴ states:

“the overall emission assessment procedure has two main stages.

In the first stage, carry out a desk study to determine the main characteristics of the cap. Use this information to then guide a walkover survey of the cap using hand-held gas monitoring equipment to identify where methane emissions are high.

Experience of carrying out flux box surveys, supported by the waste industry’s experience has shown that the walkover survey is the most cost effective means of reducing surface emissions through the landfill cap. The ability to undertake the survey at short notice, with limited resources and costs, makes this a suitable method for identifying uncontrolled landfill gas emissions.

In the second stage, use an array of flux boxes to quantify the rate of emission through capped zones and from identifiable features within the cap. You can then assess the average emission from the whole zone against the relevant standard.

You are required to initially quantify the surface emission of methane from permanently capped areas of your site using a flux box survey as part of a ‘mass balance’ approach to reporting methane emissions and to demonstrate that the permanent cap meets the emission standard.

However providing subsequent annual walkover surveys of that area demonstrate the surface concentration limits in air are less than 100 parts per million by volume (ppmv) immediately above the surface on the main zones of the cap and less than 1,000 ppmv close to any discrete feature, you do not need to carry out subsequent flux box measurements to quantify emissions.

If regular walkover surveys show that the emission of gas is increasing, or you make significant changes to the gas extraction in a permanently capped area, then another flux box survey will be required to quantify the emission rate. For example, if the extraction

⁴ Environment Agency (2010). “Guidance on Monitoring Landfill Gas Surface Emissions”. LFGN 07 V2. (first published 2004, updated 2010)

system has deteriorated or you think that gas production in an area has declined to such an extent that extraction is no longer viable you will need to carry out a flux box survey to ensure that the emission standard is still met.

Temporarily capped areas do not need to be quantified using flux box surveys unless the temporary cap will be in place for longer than 12 months (for example on a long term internal flank). For shorter periods of temporary capping, regular walkover surveys should demonstrate compliance with the surface concentration limits in Section 4.6. Use the emission rate limits in Table 2.1 to calculate the annual emissions from temporarily capped areas”.

Table 2.1 Emission standards for different types of landfill zone

Type of zone	Surface emission standard
Any zone with permanent cap	Methane flux of 0.001 mg/m ² /second
Any zone with temporary or interim cap	Methane flux of 0.1 mg/m ² /second

- 4.14. The Guidance does point out, however, that surface emissions through the main zones cannot be quantified adequately if gas is escaping through major faults in the cap or the gas collection system and states:

“It is therefore essential to identify inadequacies in the gas management system and rectify these before attempting to measure the predominantly diffusive flux of gas emitted through the well-capped surface.

Major faults are easy to find using simple hand-held instruments that measure gas concentrations. You can find lesser faults through a systematic walkover survey while using a hand-held instrument for detecting low concentrations of hydrocarbon gas in air.

Remedying the emission of gas through these features on a capped zone must be a short-term action within your overall gas management plan. You must complete remedial work to prevent significant concentrations of gas being found near the surface before beginning a flux box survey”

- 4.15. In Section 4.6, the guidance states:

“Continue the cycle of walkover surveys followed by remedial action until the gas concentrations your surveys detect are low. The criteria for this will vary depending on local conditions and the scanning procedure you use.

However, as an indication, a quantitative flux box survey will be of little value until the methane concentration in the air is:

less than 100 parts per million by volume (ppmv) immediately above the surface on the main zones of the cap;

less than 1,000 ppmv close to any discrete feature”.

- 4.16. It is clear, therefore, that flux box measurements are suited to very low flux conditions typical of a capped landfill. Alternative strategies, such as the FID, are considered more suitable at the operational phase where there is no cap.

MONITORING STRATEGY – LANDFILL GAS

- 4.17. A consolidated monitoring plan is provided in **Table 4.1** while monitoring point locations are given in **Figure 4.1**.
- 4.18. Background concentrations are taken as those found in groundwater monitoring borehole 2130.
- 4.19. It is recommended that the use of flux box for measuring surface emissions of landfill gas be restricted to those areas of the landfill that have been capped. For those areas operational or with temporary cover, it is recommended that monitoring be carried out using a portable FID. That will not enable flux to be measured on operational areas. It will, however, enable surface emissions and odour monitoring to be co-ordinated (see Section 4, below).
- 4.20. It is recommended that for those areas of the landfill capped, or temporarily capped, and where emissions have been controlled to less than 100 ppmv immediately above the surface, flux box monitoring be carried out in accordance with the Environmental Agency Guidance LFTGN07.
- 4.21. Annex III of the Landfill Directive (1999/31/EC) recommends monthly monitoring of landfill gases. However, where evaluation of monitoring data shows that longer periods are equally effective, monitoring frequencies may be adjusted. An analysis of 2011 and 2012 monitoring data shows that gas concentrations (with the exception of landfill gas surface emissions) are fairly constant for each monitoring point, therefore quarterly monitoring is being recommended for gaseous emissions from the groundwater and leachate monitoring points. However, because some variation has been noted in landfill gas surface emissions, monthly (instead of quarterly) monitoring is recommended at these points. Additionally, annual detailed gas composition and priority trace components analysis is being recommended – the frequency is in accordance with UK Environmental Agency Guidance LFTGN04.⁵
- 4.22. The off-site monitoring of landfill gases (formerly carried out for points 2, 5, 6, 7, 8 and 9) is addressed in Section 6.

⁵ Environment Agency (2011). "Guidance for monitoring trace components in landfill gas." LFGN 04 V3.

Table 4.1: Landfill gas monitoring

Monitoring location (Figure 4.1)	Measured Parameters	Frequency	Instrument type	Assessment levels
Landfill gas surface emission points 0, 1, 3 & 4 (Operational phase)	Methane (flammable gas vapours), methane flux, H ₂ , CO ₂ . General surface type and condition (ground description)	Monthly	Portable Flame Ionisation Detector (FID) calibrated with CH ₄	Not applicable
Landfill gas and groundwater monitoring boreholes (BHI-5, MBH5, 2130)	CH ₄ , CO ₂ , O ₂ , flux, differential pressure flow.	Quarterly	Portable Infra-Red gas analyser	1% CH ₄ , 1.5% CO ₂ above background (i)
Leachate monitoring points (LCPI-8)	CH ₄ , CO ₂ , O ₂ , H ₂ S, flow, differential pressure, flow.	Quarterly	Portable Infra-Red gas analyser	1.0% O ₂ , 0.1% CO.
Gas samples from one leachate monitoring point and one groundwater monitoring borehole	Detailed gas composition and priority trace components (ii)	Annually	Gresham Tube/Tedlar bag and laboratory GCMS for bulk gases. Solid sorbants for priority trace components (iii)	Not applicable
Capped areas	CH ₄ flux (iv)	Annually (v)	Flux box/FID	Permanently capped zone: 0.001 mg/m ² /s Temporarily capped zone: 0.1 mg/m ² /s

Notes:

- (i) Background level to be measured in borehole 2130.
- (ii) See Appendix I.
- (iii) In accordance with methodology in LFTGN04.
- (iv) In accordance with LFTGN07.
- (v) If a cap has previously been shown compliant with the assessment level and there have been no significant physical changes in the gas management during the year, a detailed walkover survey with an FID can be used to demonstrate that the surface emissions are under control. If this survey shows no change in the pattern of methane emission, it may be used as the annual survey.

CONTINGENCY PLAN – LANDFILL GAS

4.23. The following protocol is proposed should methane concentrations exceeding 1% (v/v) and / or carbon dioxide exceeding 1.5% (v/v) in any groundwater or landfill gas monitoring borehole.

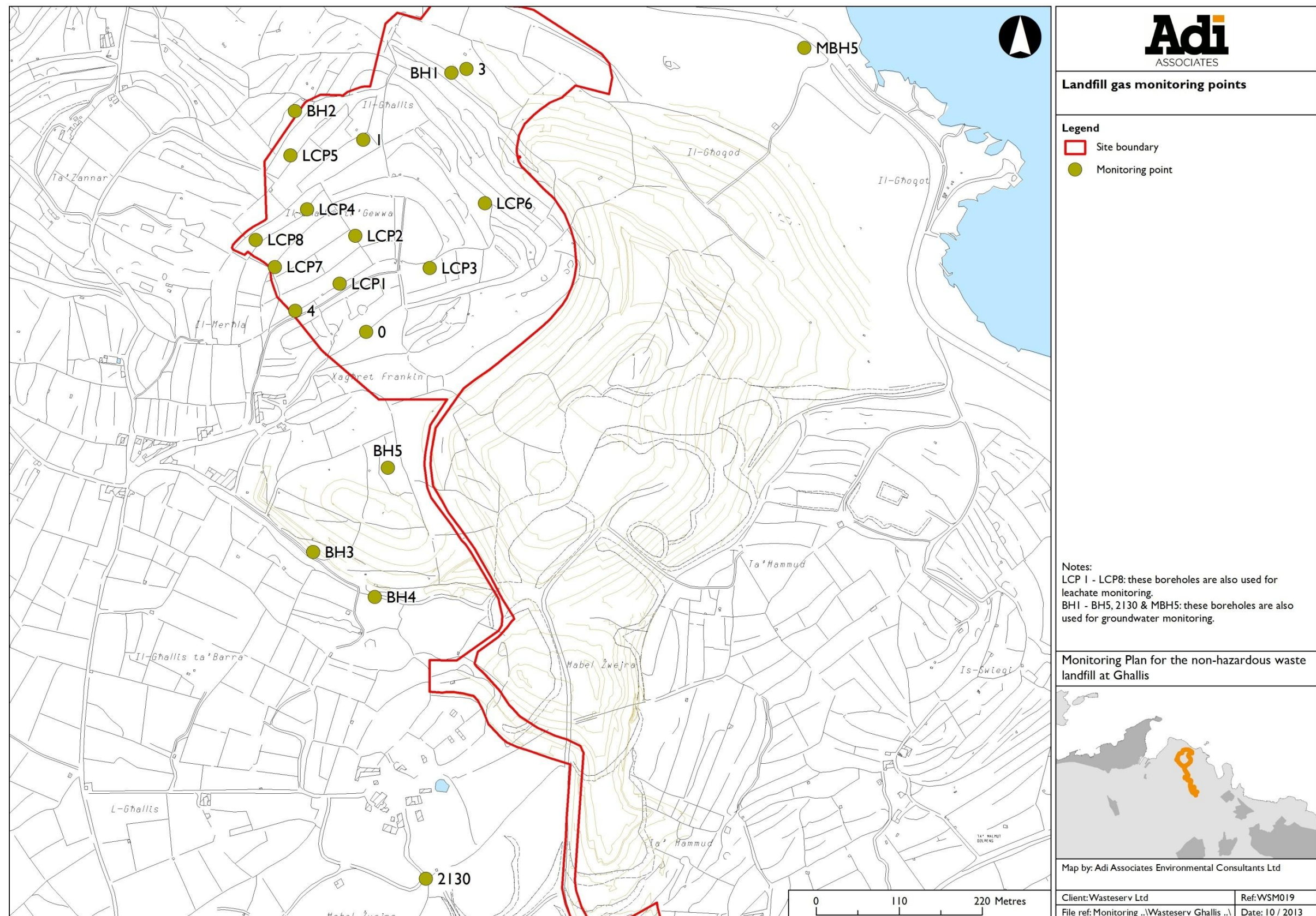
- i. Assess the concentrations of carbon dioxide and methane against background concentrations in borehole 2130;

- ii. If concentrations greater than 1% methane or 1.5% carbon dioxide (v/v), but not greater than background, findings to be reported to MEPA; and
 - iii. If concentrations above 1% methane and 1.5% carbon dioxide greater than background, findings to be reported to MEPA (via fax, phone or e-mail) immediately and confirmed in writing within 3 working days;
 - iv. Increase monitoring of affected and immediately adjacent boreholes to daily;
 - v. Check that the gas extraction system in the vicinity of the affected borehole is operating normally; if not, rectify;
 - vi. Undertake purging of the affected borehole(s) via the gas analyser pump for 15mins recording gas levels at regular intervals (i.e. not greater than 5 minutes) on the same day trigger level breach is noted;
 - vii. If gas concentrations remain largely unchanged following a 15 minute purge, take gas sample(s) from the affected borehole(s) for laboratory analysis by GCMS and initiated monitoring in buildings or services within 250m of affected boreholes using portable FID. If the methane concentrations in any services or property are measured at greater than 5000 ppm (10% of lower explosive limit) the landfill gas risk will be assessed (receptors, ignition source, etc.). If the methane concentration in services or property exceeds 8,000 ppm (16% LEL) ventilation will be increased in affected confined spaces and ignition sources isolated. If the methane concentration in any service or property exceeds 10,000 ppm (20% LEL) evacuation procedures will be initiated;
 - viii. FID monitoring will be repeated twice daily whilst methane or carbon dioxide concentration exceeds assessment levels in any monitoring borehole;
 - ix. If gas concentrations show a marked decrease following a 15 minute purge (step (vi)) repeat step (ii) for 5 consecutive days;
 - x. If gas concentrations remain below assessment levels on 5 consecutive days monitoring, revert to normal;
 - xi. All results will be reported to MEPA on the day taken whilst the methane concentration in boreholes exceed assessment levels.
 - xii. In the event that the result of GCMS analysis of the sample taken in step (vii) is consistent with landfill gas, the gas management system design and operation will be reviewed. If the result is consistent with a non-landfill source of flammable gas or vapours an investigation of source will be initiated.
- 4.24. In the event that the carbon monoxide concentration in any leachate monitoring chamber exceeds the assessment level of 0.1% (100 ppm), temperature measurements will be taken in all leachate monitoring chambers. The temperature in the affected chamber(s) will be compared with that in those chambers in which the carbon monoxide does not exceed the assessment level to establish if the elevated

carbon monoxide is associated with elevated temperature, which may be indicative of combustion. In the event of elevated temperature and carbon monoxide, further investigations will be carried out.

- 4.25. In the event that the oxygen concentration in any leachate monitoring chamber exceeds the assessment level of 1%, the landfill gas extraction system will be checked to ensure that it is balanced to prevent air ingress. If there is no active extraction in operation, potential sources of air ingress such as impaired seals, improperly secured manhole covers, etc. will be assessed.

Figure 4.1: Landfill gas monitoring points



INDICATIVE ONLY - Not to be used for direct interpretation

MONITORING STRATEGY – STACK EMISSIONS

- 4.26. The IPPC permit (Table 5.1.2) gives limit values for emissions from the RTO and CHP plants (Table 4.2 below).

Table 4.2: Limit values for stack emissions from the RTO and CHP plants

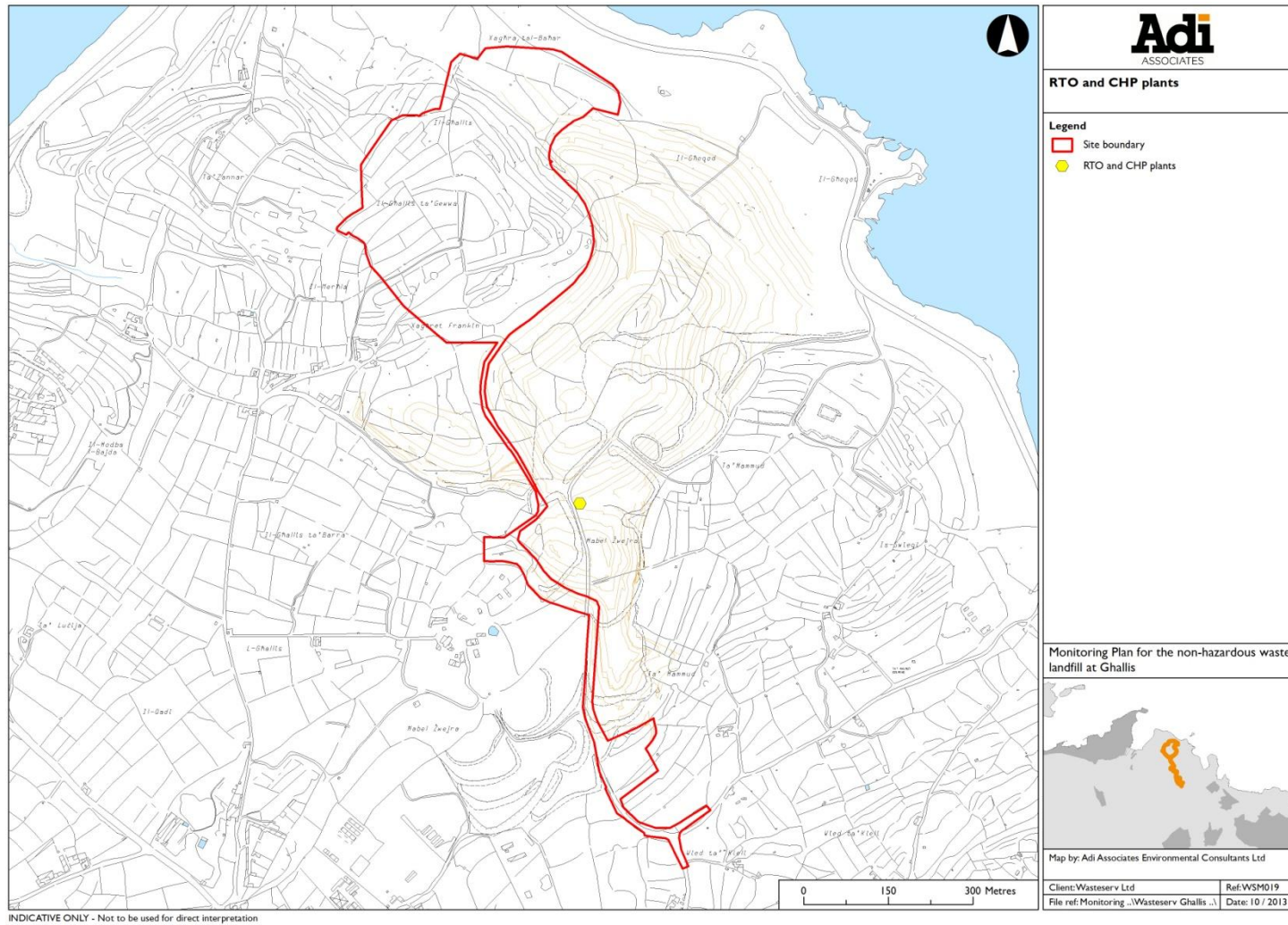
Pollutant	Limit Value
Total dust	5 mg/m ³
Carbon monoxide	80 mg/m ³
Nitrogen dioxide	0.2 g/m ³
Sulfur dioxide	0.35 g/m ³

- 4.27. A monitoring plan is provided in **Table 4.3** while monitoring point locations are given in **Figure 4.2**.

Table 4.3: Monitoring plan for stack emissions from the RTO and CHP plants

Monitoring location (Figure 4.2)	Measured Parameters	Frequency	Detection limit
CHP & RTO plants	Dust	Annual	1 mg/m ³
CHP & RTO plants	CO	Annual	0.01 mg/Nm ³
CHP & RTO plants	NO ₂	Annual	0.56 mg/Nm ³
CHP & RTO plants	SO ₂	Annual	0.56 mg/Nm ³
CHP & RTO plants	PCDD/PCDFs	Annual	0.01 µg/Nm ³
CHP & RTO plants	Flow	Annual	0.01 Nm ³ /h
CHP & RTO plants	Temperature	Annual	0.1 °C
CHP & RTO plants	Moisture	Annual	0.01 mole fraction

Figure 4.2: Monitoring location for stack emissions from the RTO and CHP plants



5. ODOUR MONITORING

PERMIT REQUIREMENTS

- 5.1. Table 5.7.1 to the Permit requires olfactory monitoring of aerial emissions from the site by the site manager or supervisor at least twice per day at the site boundary downwind of the waste operations and by site staff supervising individual waste handling operations.
- 5.2. On detection or notification of odours that are likely to be transported beyond the site boundary and likely to cause pollution, harm to human health or detriment to the amenity, the Permit requires that actions be taken in accordance with an odour management plan approved by MEPA.

UK GUIDANCE

- 5.3. UK Environment Agency Guidance⁶ describes how odour monitoring should be undertaken at a landfill site, with on-site odour assessments carried out, moving from the furthest point downwind from the site relative to the wind direction towards the site boundary or onto the site itself, and in a proximal to distal direction up wind of the site. The persistence of the odour, together with its location from the site boundary, should be noted.
- 5.4. The requirements of the permit are consistent with this Guidance. However, Agency Guidance TGN03 points out that the offensiveness and strength of odours are dependent on factors such as race, gender, age, occupation, health and previous history of odour experiences.

MONITORING PROGRAMME

- 5.5. It is considered that the specification of fixed odour monitoring points will not provide representative or reliable monitoring for odours. Odour migration from the landfill will be affected by wind direction and for localised sources of odour, slight shifts in wind direction can significantly affect the area of influence of the impact of those odours.
- 5.6. Routine monitoring is carried out a minimum of twice a day by a member of staff that does not work at the operational area (people tend to become “accustomed” to smell, such that their perception is less acute than that of other people).
- 5.7. The person responsible for routine monitoring determines the wind direction initially from the site meteorological station. He will then proceed to the site boundary upwind of the operational area. The monitoring personnel will note the strength and characteristics of any odour, likely to be derived from an off-site source.

⁶ Environment Agency (2002) “*Technical Guidance for the Regulation of Odour at Waste Management Facilities*”.

- 5.8. The monitoring personnel proceeds to the landfill boundary downstream of the site and repeats the exercise, moving along the site boundary, such that the 150 m of the boundary downwind and either side of the operational area is traversed.
- 5.9. The monitoring personnel then moves to the immediate vicinity of the working (waste deposition) area to ascertain whether the wastes comprise a source of significant odour. All observations of odour (location, nature of odour, characteristics, “strength”, etc.) are recorded.
- 5.10. In the event of frequent complaint by any member of public, the point on the boundary closest to complainant will be included in all routine odour surveys, irrespective of wind conditions.
- 5.11. The monitoring protocol is summarised in **Table 5.1**.

Table 5.1: Odour monitoring

Monitoring location	Measured Parameters	Frequency	Instrument type	Assessment levels
Site meteorological station	Wind direction	Twice daily	Wind Vane	Not applicable
Landfill boundary upwind of site	Odour	Twice daily	Site staff not normally operating at working area	Discernible odour
Landfill boundary downwind of site	Odour	Twice daily	Site staff not normally operating at working area	Discernible odour
Landfill boundary adjacent to any sensitive receptor/complaint	Odour	Twice daily	Site staff not normally operating at working area	Discernible odour
Site downwind of noted odour, moving upwind in accordance with contingency plan (Section 4.4)	Methane	On detection of discernible odour or complaint	FID	Not applicable

CONTINGENCY PLAN

- 5.12. Odorous wastes are usually easily identifiable due to their characteristic smell. With the exception of illegal or unauthorised deposit of waste, these materials will always be found at the operational area of the landfill.
- 5.13. A common source of odours on landfills is landfill gas. UK Environment Agency Guidance TGN03 points out that a large number of substances are present at trace levels in landfill gas. These compounds contribute significantly to the potential odour and health impacts of the landfill gas. Fugitive emissions of landfill gas may result from inadequate temporary or intermediate cover where operational constraints prevent raising the site to final levels; lack of gas extraction infrastructure or poorly balanced extraction system; breaches in the cap in restored areas; fracture of gas pipelines and

poor seals around gas wells. Because of the correlation between odour and landfill gas, it follows in many instances that the pinpointing of the source of odours can be achieved qualitatively (and more accurately than by the human nose) by tracing the concentration of the carrier gas, methane.

- 5.14. The following protocol is proposed should odours be identified as a result of the olfactory monitoring at the site boundary downwind of the site, or as a result of complaint:
- i. Identify the wind direction from the data provided by the site meteorological station. This will give a broad indication of wind direction, but not necessarily reflect localised conditions, which may vary as a result of surface topography, particularly the Magtab landfill.
 - ii. At the point on the site boundary where the odour is noted, or the nearest point on the boundary upwind of any complaint, measure the methane concentration using a Flame Ionising detector (FID). Move, as far as practically, perpendicular to the wind direction, noting the methane concentration in air measured at approximately 1m from ground surface. Identify the point at which the methane concentration is greatest.
 - iii. From the point of maximum methane concentration identified in (ii) above, determine the wind direction using a hand-held pennant or burgee and move upwind, again measuring the methane concentration by FID. Mark the point at which the methane concentration is greatest using a simple marker such as a cane. It may be necessary to repeat the traverse several times to identify the area of maximum concentration.
 - iv. Repeat the determination of the wind direction and traverse, as far as practical, to left and right perpendicular to the wind direction noting the methane concentration. Identify the point at which the methane concentration is greatest. This should bring the operator in proximity to the source of the landfill gas (and odour) source;
 - v. If the source of landfill gas/odour is not immediately apparent, such as fractured landfill gas pipes, gas well headworks, etc., further localised monitoring at ground level using the FID should be used to pinpoint the source.
 - vi. If the source is from the ground rather than above ground infrastructure (pipes, headworks, etc.), excavation may be necessary to locate below ground gas control infrastructure to identify damage. If the source is spread over a relatively large area, it may be indicative of active methane production and inadequate gas extraction and appropriate measures should be taken, such as the addition of cover, re-balancing of the gas extraction system or installation of additional gas extraction wells.

- vii. Records will be made of any complaint, the location of the complainant in relation to the site, the wind direction prevailing at the time and the nature of wastes being processed and other activities.

6. AMBIENT AIR EMISSIONS MONITORING

CURRENT PRACTICE

- 6.1. The off-site monitoring sites for air quality are points are 2, 6, 7, 8 and 9 (**Figure 6.1**), which are at sensitive environmental receptors such as residences, hotels and tourist resorts.
- 6.2. The permit states that the limits for emissions to air for the parameters set out in the Ambient Air Quality Regulations (LN 478/10) and Tables 1.9.1 and 5.1.1 shall not be exceeded. Table 1.9.1 in the permit sets limit values for carbon monoxide, hydrogen sulphide, methane, benzene, toluene and xylene while Table 5.1.1 sets out target values for dioxins, furans, PCBs and PAHs in particulates less than 10µm in size. Table 6.1 summarises the target values for all the parameters mentioned specifically in the IPPC permit.

Table 6.1: Limit/target values for ambient air specified in the IPPC permit

Pollutant	Limit/Target Value
Carbon monoxide	10 mg/m ³ for a maximum daily 8 hour mean by calculation of 8 hour running averages
Hydrogen Sulphide	0.15 mg/m ³ with an averaging time of 24 hours. To avoid odour annoyance, hydrogen sulphide should not exceed 70µg/m ³ with a 30-minute averaging period.
Methane	10 ppm
Benzene	1 µg/m ³
Toluene	0.26 mg/m ³ as a weekly average
Xylene	10 ppm
PAHs	Benzo (a) Pyrene is an indicator for PAHs and its concentration in the PM ₁₀ fraction must not exceed 1 ng/m ³ averaged over a calendar year.
Dioxins & Furans (PCDDs/PCDFs)	0.1 pg/m ³
PCBs	3 ng/m ³

- 6.3. Monitoring has been carried out for methane, carbon monoxide, carbon dioxide and hydrogen sulphide at the ground surface at off-site monitoring points 2, 6, 7, 8 and 9, although this has since been discontinued. The monitoring carried out to date at those points has not included BTX.
- 6.4. Monitoring is carried out at the Ghallis weighbridge for PAHs, dioxins/furans and PCBs, arsenic, cadmium and nickel. All results have been well below the respective limit values, therefore further monitoring is not recommended. The exception is dioxins/furans, which should start to be measured every six months if gas flaring is carried out.
- 6.5. PM₁₀ and PM_{2.5} have also been monitored on a weekly basis from the Ghallis weighbridge. Some PM₁₀ exceedances have been noted.

- 6.6. Moreover, between February 2011 and June 2012, preliminary characterisation monitoring for aerial emissions (PM_{10} , VOC and CH_4) was conducted at five off-site monitoring locations, as required by the previous approved monitoring programme.⁷ The purpose of this monitoring was to act as a basis on which a risk-based monitoring programme would subsequently be prepared. The report concludes that the values of VOC and methane obtained do not represent critical values at all the sites monitored (always below the respective 10 ppm and 10 mg/m³ assessment levels), and therefore recommends annual monitoring for these parameters during the summer months. However, the PM_{10} daily limit value was exceeded in various samples. Therefore the report recommends that PM_{10} monitoring continues to be carried out quarterly at three monitoring points, with a fourth upwind site being monitored every six months.

UK GUIDANCE

- 6.7. UK Guidance TGN03 states that air quality monitoring on landfill sites will typically consist of odour monitoring (which is considered in Section 4, above) and particulate matter monitoring. It describes how particulates can be present in the landfill gas and are also generated by landfill gas combustion plant.
- 6.8. The Guidance states, with respect to trace components of landfill gas that these:
- “do not usually represent a health hazard following normal atmospheric dilution. However, this should be demonstrated on a site-specific basis through the application of a risk assessment.”*
- 6.9. The Guidance cites the UK Department for Food, Environment and Rural Affairs (Defra), which estimates that fugitive dusts, stockpiles, quarries and construction, together contribute up to 5 µg/m³ towards annual mean background concentrations of the coarse fraction (2.5–10 µm diameter) of particulates in the immediate local areas to sources. The contribution of these sources to the fine fraction (<2.5 µm diameter) is thought not to be significant. It may therefore be anticipated that waste facilities such as landfills will make little contribution to $PM_{2.5}$, as their emissions are likely to consist mainly of coarse particles. The Guidance points out that there is no sharp dividing line between the sizes of suspended particulates and deposited particulates, although particles with diameters >50 µm tend to be deposited quickly and particles of diameter <10 µm have an extremely low deposition rate in comparison.
- 6.10. Information on monitoring of particulate matter in ambient air around waste facilities is given in Technical Guidance Document M17⁸. With regard to background levels it states that these:

⁷ CADA, Ecoserv, 2013. “Period Contract for the Characterisation Monitoring of Aerial Emissions as part of the Ghallis Non-Hazardous Waste IPPC Permit (IP 0001/06).” Technical Summary Report for ambient air monitoring sessions held between February 2011 and June 2012.

⁸ Environment Agency, 2004. “Monitoring of Particulate Matter in Ambient Air around Waste Facilities”. Technical Guidance Document (Monitoring) M17.

“are important when assessing the environmental impact of particulate matter emitted from a particular process or facility. The contribution of the waste facility cannot be considered in isolation, but exactly how the background level is treated may vary according to the objective and application of the monitoring.

The impact of ambient particulate levels will be the sum total of the general background level and the contribution from the waste facility. High background levels may leave little room for additional emissions from future developments in the area. This has implications for the setting of appropriate Action and Trigger Levels for compliance assessment purposes.

Background levels are also important in considering enforcement action. Although there may be no argument about the adverse environmental or health impacts of elevated levels of particulate around a waste facility, the operator’s ability to influence this may be limited if it is due largely to background levels.”

- 6.11. Guidance states that the current focus of health-related sampling of particulate matter is on PM_{10} , or even finer fractions such as $PM_{2.5}$ rather than the inhalable and respirable fractions favoured in occupational exposure monitoring.

MONITORING STRATEGY

- 6.12. Given the opportunity for dilution between the site and the monitoring points, it is considered that monitoring for carbon monoxide off site is of no value. Of all constituents of landfill gas, methane is most likely to be discernible off site due to its far greater concentration at source; hence it is proposed methane be measured off site. Due to the very low concentrations anticipated, it is unlikely that a portable Infra-Red gas analyser normally used for landfill gas determinations, for instance in monitoring boreholes, will be sensitive enough. The portable FID will be used for methane determination. The portable FID proposed to be used for methane determination will respond to any flammable gas; hence provides a “blind test” and will respond to VOCs as well as methane. In the event that significant concentrations are detected, more detailed analysis may be conducted. FIDs can be used for identification of concentration from 1 ppm to 100,000 ppm.
- 6.13. Notwithstanding that fine particles are likely to travel further, given that landfills are not considered a likely source of fine particulates it is considered that off-site monitoring for $PM_{2.5}$ as well as PM_{10} is not justified. However, given that WasteServ have $PM_{2.5}$ and PM_{10} monitors available at the Ghallis weighbridge, it is proposed that $PM_{2.5}$ monitoring is included at this point for the time being as a precautionary measure. Legal Notice 478 of 2010 stipulates an annual limit value for PM_{10} of $40 \mu\text{g}/\text{m}^3$ and a daily limit value of $50 \mu\text{g}/\text{m}^3$, with 35 exceedances of the daily limit being allowed in a year. For $PM_{2.5}$, an annual limit value of $25 \mu\text{g}/\text{m}^3$ is stipulated.
- 6.14. Notwithstanding the proximity of several of the monitoring points to the road system and distance from the landfill boundary, PM_{10} monitoring is recommended, especially in view of the recommendations arising from the preliminary characterisation monitoring report. It is recommended that PM_{10} monitoring will continue at monitoring points 2, 7 and 8, as well as at the Ghallis weighbridge.

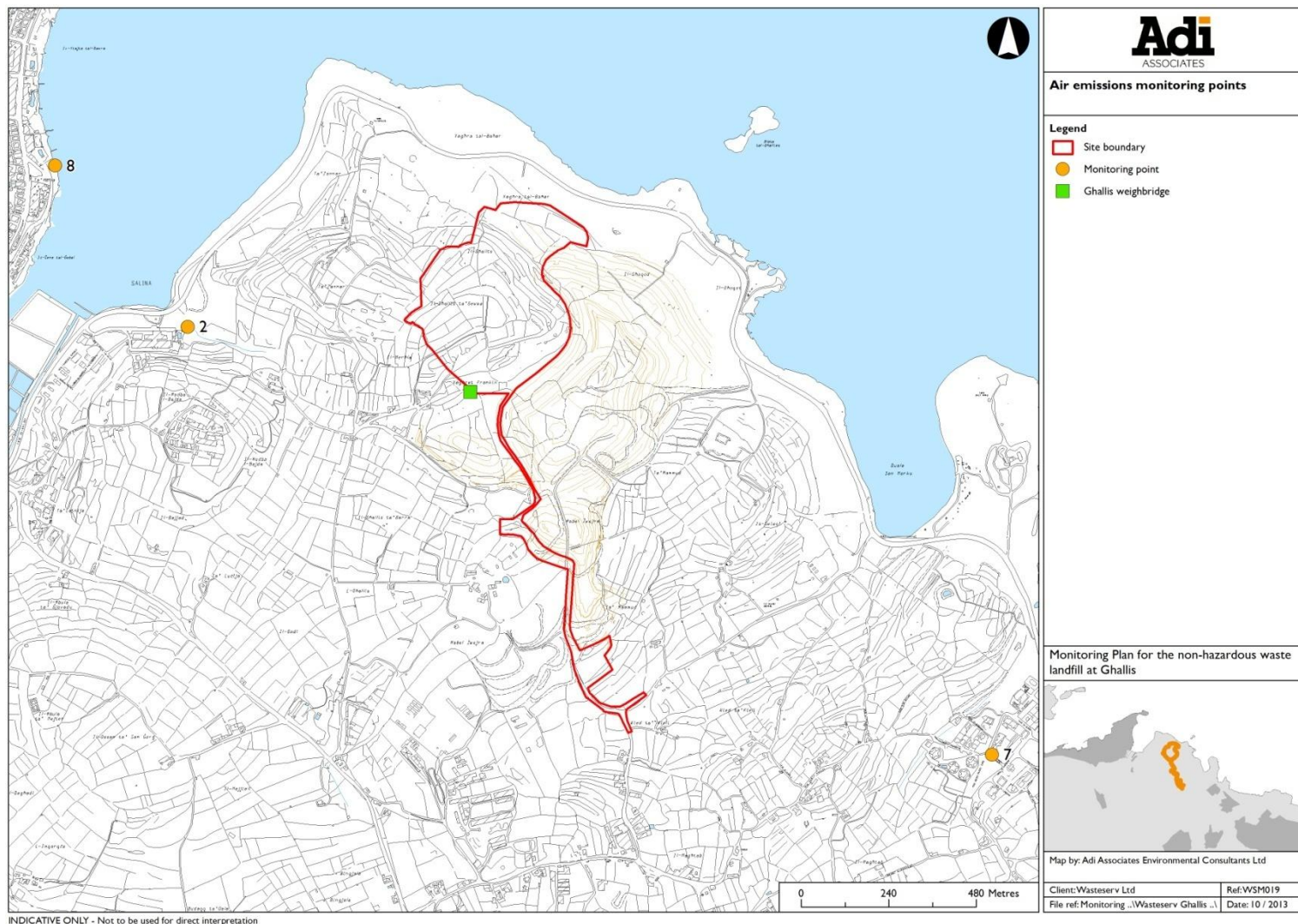
Following a year's monitoring, the data will be evaluated with a view to assessing whether off-site monitoring point 8 is still required.

- 6.15. The preliminary characterisation monitoring report recommends annual monitoring of VOC and CH₄. This will be carried out at one monitoring point (point 7, which is downwind from the landfill). In order to ensure compliance with permit requirements, VOC monitoring will constitute monitoring for individual parameters: benzene, toluene and xylene. The data will be evaluated after two years of monitoring to assess whether further annual monitoring for these parameters should be required.
- 6.16. H₂S may be considered a relevant pollutant from landfills and may cause odour annoyance if detected at certain concentrations. It is recommended that this parameter be monitored quarterly from point 7 (downwind) and point 2 (upwind). The data will be evaluated after one year to assess whether further monitoring should be required.
- 6.17. The proposed ambient air monitoring programme is summarised in **Table 6.2**.

Table 6.2: Ambient air monitoring programme

Monitoring location (Figure 5.1)	Measured Parameters	Frequency
Monitoring points 2 and 7	PM ₁₀	Quarterly
Monitoring point 8	PM ₁₀	Every six months
Ghallis weighbridge	PM ₁₀ PM _{2.5}	Week-long sample once a month
Monitoring points 2 and 7	Hydrogen Sulphide	Quarterly
Monitoring point 7	Benzene	Annual
Monitoring point 7	Toluene	Annual
Monitoring point 7	Xylene	Annual
Monitoring point 7	Methane	Annual
Monitoring point 7	PCDD/PCDF	Every six months

Figure 6.1: Ambient air quality monitoring points



CONTINGENCY PLAN

- 6.18. The following protocol is proposed should an exceedance of any limit/target values for ambient air specified in the IPPC permit be identified:
- i. The site management and MEPA will be advised.
 - ii. The meteorological conditions prevalent during the monitoring period will be identified from the data provided by the site meteorological station. Of particular importance are wind speed and direction, and precipitation.
 - iii. The activities occurring during monitoring will be identified, including whether any abnormal activities were underway during the monitoring period (e.g. maintenance of the CHP/RTO plant, maintenance on gas wells).
 - iv. Where relevant, the operator will determine whether regional events (e.g. transboundary Saharan dust episodes) could have influenced the results. An initial check will be carried out of data from MEPA's monitoring stations to rule out such events; if the data points towards transboundary Saharan events, further analysis using satellite imagery and backward trajectories can be carried out.
 - v. On the basis of the above records, the operator will identify whether a combination of meteorological conditions and activities on site could have caused the exceedance, or whether this is likely to have been caused by activities external to the site.
 - vi. If it results that activities on site could have caused the exceedance, the Operator will, in consultation with MEPA, identify additional mitigation measures to reduce emissions from the site. Where necessary, the site's standard operating procedures will be updated.
 - vii. Monitoring will be repeated once these additional mitigation measures are in place.

7. LEACHATE MONITORING

UK GUIDANCE

- 7.1. The Environment Agency issued new Guidance on monitoring leachate, groundwater and surface water in 2003⁹ to take into account the Landfill Directive. It introduces a risk-based monitoring review and describes characterisation monitoring, indicator monitoring, assessment monitoring and completion monitoring.
- 7.2. The primary purpose of initial characterisation monitoring is to minimise ambiguity in the interpretation of data following commencement of landfill operations. All initial characterisation monitoring measurements should be repeated at least annually within the sequence of routine monitoring programmes to provide a screening check.
- 7.3. Indicator monitoring allows the use of a selected number of determinants and measurements, based on the characteristics of each water body revealed by initial characterisation monitoring. The selection of indicator measurements and monitoring frequencies should be based on knowledge gained from a risk based monitoring review and from the interpretation of initial characterisation monitoring results. Ongoing characterisation measurements are a periodic repeat of the same measurements carried out during the initial characterisation monitoring, but at a lower frequency than for the indicator parameters.
- 7.4. Assessment monitoring is triggered when it becomes apparent that a potential impact from the landfill is occurring. The specification of assessment monitoring schedules should be based on a re-evaluation of the risk using all available relevant monitoring data.
- 7.5. The last stage in the monitoring programme is completion monitoring, carried out to demonstrate that the site is no longer capable of harming human health or the environment. The results of leachate and landfill gas monitoring demonstrate that the site still represents a significant source of contaminants, therefore, completion monitoring is not considered further here.
- 7.6. Example schedules are also given in the new Guidance, but reflect the change in emphasis to risk-based monitoring. A risk-based approach should supersede reliance on model or example monitoring Guidance. Example schedules should not be considered obligatory. Table 6.2 to the Guidance suggests that, for a biodegradable site posing moderate to high risk to groundwater receptors, two leachate level monitoring points per 5ha cell should be provided in addition to leachate extraction points. The current leachate monitoring regime conforms to that suggested. Table 6.5 to the Guidance provides an example of principal chemical composition measurements, but does point out that for all parameters, analyses should be determined on site-specific conditions or for assessment purposes. The monitoring programme proposed in Appendix 3 to the Site Management System includes many

⁹ Environment Agency (2003). "Guidance on Monitoring of Landfill Leachate, Groundwater and Surface Water".

of the parameters included in Table 6.5 to the Guidance, with the addition of naphthalene and toluene, which were identified as List I substances for modelling in the Hydrogeological Risk Assessment carried out as part of the IPPC Permit application process. However, no differentiation is made between characterisation monitoring and indicator monitoring.

- 7.7. The Guidance states that for many non-hazardous biodegradable landfills, initial characterisation monitoring could reasonably be undertaken monthly for physical measurements such as leachate levels, and six-monthly for chemical composition measurements.
- 7.8. The Guidance discusses the use of control and trigger levels and describes how trigger levels have a role both as a performance standard for monitoring and as the success criteria for the risk assessment. The selection of substances should reflect this dual role. The important principle is to select the minimum number of substances that are representative of the compounds present (or predicted to be present) within the leachate. The minimum considered necessary here is that chosen in the Hydrogeological Risk Assessment. However, naphthalene and toluene are being replaced with hydrocarbons (since this parameter is recommended by the Landfill Directive).
- 7.9. With regard to List I and List II substances the Guidance states:

“The GWD prohibits the entry of List I substances into groundwater, and since the Trigger levels for List I substances will generally be very low ... it is unlikely to be practicable to derive Control levels for List I substances in groundwater that can be measured by analytical methods.

It is recommended that, for List I substances, other parameters are considered, such as leachate chemistry and leachate head. Appropriate parameters should be selected having regard to the conceptual model for the site and the outcome of the risk assessment process. In particular, the results of a sensitivity analysis on the predictive modelling of the landfill are likely to be important in identifying those parameters that are likely to have the greatest impact on the rate at which contaminant mass is released from the landfill.

Control levels should be set for relevant parameters at a point that is a significant deviation from the assumed values incorporated within the conceptual model. For example, if leachate is assumed to have a concentration of a List I substance no greater than 250 µg/l, it would be appropriate to set Control levels (applied to leachate monitoring data) at, say, 250 µg/l plus 10%, 20% and 50% (i.e. 275, 300 and 375 µg/l respectively). Increasing levels of contingency action would be instigated at each point.... Additionally, it is recommended that the trend in pollutant concentration over time is reviewed to check whether concentrations are rising towards the values assumed within the conceptual model.

Similarly, if leachate head is a sensitive parameter in the risk assessment and it is assumed within the conceptual model that leachate head will not exceed ... Control levels should be set that will highlight if this is breached. Again, review of trends in monitoring data is important to check whether the levels are likely to be compromised in the near future”.

MONITORING PROGRAMME

- 7.10. A leachate monitoring programme is found in **Table 7.1**; this table also provides the detection limits. **Figure 7.1** shows the leachate monitoring points.
- 7.11. **Table 7.1** includes characterisation and indicator monitoring. The choice of parameters does not include all those parameters identified in the Guidance, as there is no evidence from the Environmental Impact Assessment or Hydrogeological Risk Assessment that all those parameters are critical. Conversely, the list of indicator parameters is more comprehensive than that suggested in the example schedule from the Guidance, as some parameters chosen are indicators of leachate treatability or treatment requirements, as well as polluting potential. The characterisation monitoring parameters are also chosen to reflect the complexity of processes involved in the production and evolution of leachate, with significant variations likely to occur in the composition with time and between different parts of the landfill.
- 7.12. Assessment and compliance levels are also presented in Appendix 3 to the Site Management System. The Control level for leachate head is set at 0.2 m below, and the Trigger level at, the specified maximum level of 1.0 m used in the Hydrogeological Risk Assessment. The chemical quality parameters used are also consistent with those used in the Hydrogeological Risk Assessment. However, the Control levels for the metals are conservatively low, as are the Trigger levels, in comparison with the maximum values used in the risk assessment. The ammoniacal nitrogen and, in particular, chloride assessment and compliance levels are low in comparison with the maximum used in the risk assessment and with measured values in leachate / condensate from the Magtab landfill, with the minimum chloride compliance level being close to the minimum default value used in the risk assessment and less than 20 times the maximum value used, which is based on values from Magtab, and only one quarter of the mode value chosen in the risk assessment. The high chloride levels in Magtab leachate are thought to be more typical of that likely to be found in Malta due to the low rainfall in comparison with the UK where the “default values” used for leachate in the Landsim model used in the risk assessment are derived. Alternative Control and Trigger levels are proposed in **Table 7.1**, based on the mode value used in the risk assessment and the compliance (trigger) level set below the maximum used in the risk assessment. Both values compare reasonably with median and maximum values found for leachates from large landfills with a high waste input and relatively dry waste conditions in a study carried out in the UK¹⁰.
- 7.13. New leachate monitoring points will be added as new cells are added to the landfill.

¹⁰ Robinson H (1995). A Review of the Composition of Leachates from Domestic Wastes in Landfill Sites”. DoE. Report CWM/072/95

Table 7.1: Leachate monitoring programme

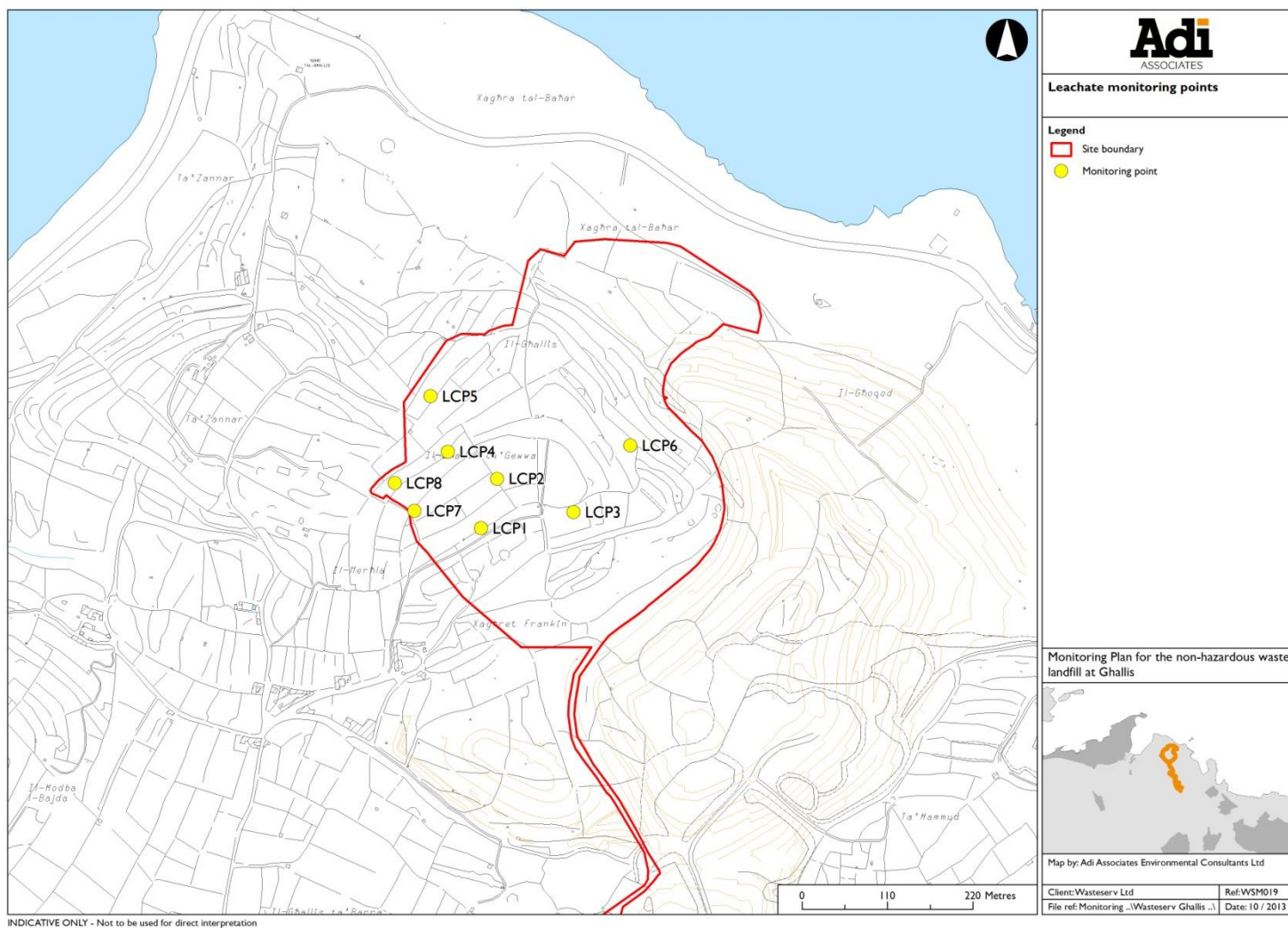
Leachate Monitoring Points LCPI-8					
Determinand	Indicator Monitoring	Characterisation Monitoring	Control level	Trigger Level	Detection Limit
	Frequency (months)				
Water Level	3		0.80 m	1.0 m	
Conductivity	3				±3.4 µS/cm
pH	3				0.1 pH units
TOC	3				0.1 mg/L
NH ₃ -N	3		260 mg/L	1000 mg/L	0.01 mg/L
Cl ⁻	3		1000 mg/L	5000 mg/L	0.05 mg/L
Phenol index	3				0.05 mg/L
F ⁻	3				0.05 mg/L
Fe		12			0.1 µg/L
SO ₄		12			0.05 mg/L
Na		12			0.5 mg/L
K		12			0.5 mg/L
Mg		12			0.05 mg/L
Ca		12			0.05 mg/L
As	3		0.004 mg/L	0.4 mg/L	0.14 µg/L
Ba		12			0.1 µg/L
Cd	3		0.0002 mg/L	0.02 mg/L	0.1 µg/L
Cr	3		0.09 mg/L	0.4 mg/L	0.2 µg/L
Cu	3		0.05 mg/L	0.1 mg/L	0.3 µg/L
Hg		12			0.1 µg/L
Mo		12			1.0 µg/L
Ni	3		0.2 mg/L	0.6 mg/L	0.05 µg/L
Pb	3		0.1 mg/L	0.3 mg/L	0.1 µg/L
Sb		12			0.5 µg/L
Se		12			0.9 µg/L
Zn		12			4.1 µg/L
Hydrocarbons	3				1 µg/L
List I Screen ¹¹		12			

¹¹ See Appendix 2

CONTINGENCY PLAN

- 7.14. In the event that the control level is breached, or a trend in leachate quality leads to the conclusion that the Control or Trigger Level might be breached in the future, the following protocol will be adopted:
- i. The site management and MEPA will be advised.
 - ii. The concentration of those parameters will be re-determined by repeat sampling and analysis.
 - iii. A review of site operations will be undertaken and actions taken to avoid further breach of Control level or potential breach of Trigger level.
 - iv. Increase monitoring frequency to monthly from quarterly to establish if the actions undertaken lead to a stabilization of leachate chemistry, or decline in upward trend in the concentration of the affected parameters.
- 7.15. In the event that the Trigger Level is breached, the following protocol will be implemented:
- i. Review the hydrogeological risk assessment in the light of higher assumed concentrations of the affected leachate parameters and the Control and Trigger levels.
 - ii. If the hydrogeological risk assessment leads to the conclusion that the impact on groundwater quality would be unacceptable, corrective measures will be implemented in agreement with MEPA to reduce the risk.

Figure 7.1: Leachate monitoring points



8. GROUNDWATER MONITORING

CURRENT PRACTICE

- 8.1. Monitoring of groundwater is carried out from boreholes BH1, BH2, BH3, BH4, BH5, MBH 5, 2130, 2041 and, more recently, from borehole 00574 as shown in **Figure 8.1**. Initial characterisation monitoring has been carried out at intervals of three months (and annually for certain parameters) for a period of two years, as per the previous approved monitoring programme.
- 8.2. Prior to sampling groundwater, the depth to the water surface and base of the borehole is measured and the volume of water in the borehole calculated. A minimum volume equivalent to three times that standing in the borehole is purged, either by baler or by dedicated pump to introduce “fresh” groundwater into the borehole. On-site parameters, such as pH, electrolytic conductivity and temperature are measured on completion of purging and observations such as odour, colour and appearance recorded. Sample bottles and tops are rinsed in sample water (unless pre-loaded with preservatives). Sample bottles are filled to the top to minimise air entrapment and the cap screwed firmly on. Sample bottles are labelled and stored in “cool boxes” for shipment to the laboratory.

UK GUIDANCE

- 8.3. The Guidance for groundwater monitoring is taken from the same document as that for leachate monitoring. Table 6.9 to the Guidance gives an example monitoring regime.
- 8.4. Table 6.8 to the Guidance reproduces the minimum monitoring frequency as required by the Landfill Regulations. For groundwater composition, the frequency is site specific.

MONITORING REGIME

- 8.5. The list of parameters, monitoring frequency and associated detection limits are given in **Table 8.1**.
- 8.6. The control and trigger levels as required by the original IPPC permit will be maintained.
- 8.7. For the List I parameters, the Trigger level is the limit of detection (the Discernible Concentration, quoted in the Hydrogeological Risk Assessment). It is, therefore, not possible to set Control levels for List I parameters.
- 8.8. It should be noted that the values for some of the resultant concentrations of contaminants calculated using the Landsim model in the Hydrogeological Risk Assessment are below that found in groundwater in the vicinity of the site. In particular, chloride is widely reported at values significantly greater than the anticipated peak concentration prior to dilution, and above the EU Drinking Water

Standard (DWS), therefore no Control or Trigger levels are proposed for certain parameters.

- 8.9. The Environment Agency Guidance on Hydrogeological Risk Assessment for Landfills states that control levels will typically be set at a level between the predicted concentration in groundwater (i.e. the risk assessment output based on the conceptual model) and the Trigger level (and the compliance limit).
- 8.10. Therefore the control and trigger levels as required by the original IPPC permit (Table 7.2.3.5) will be maintained.

Table 8.1: Groundwater monitoring programme

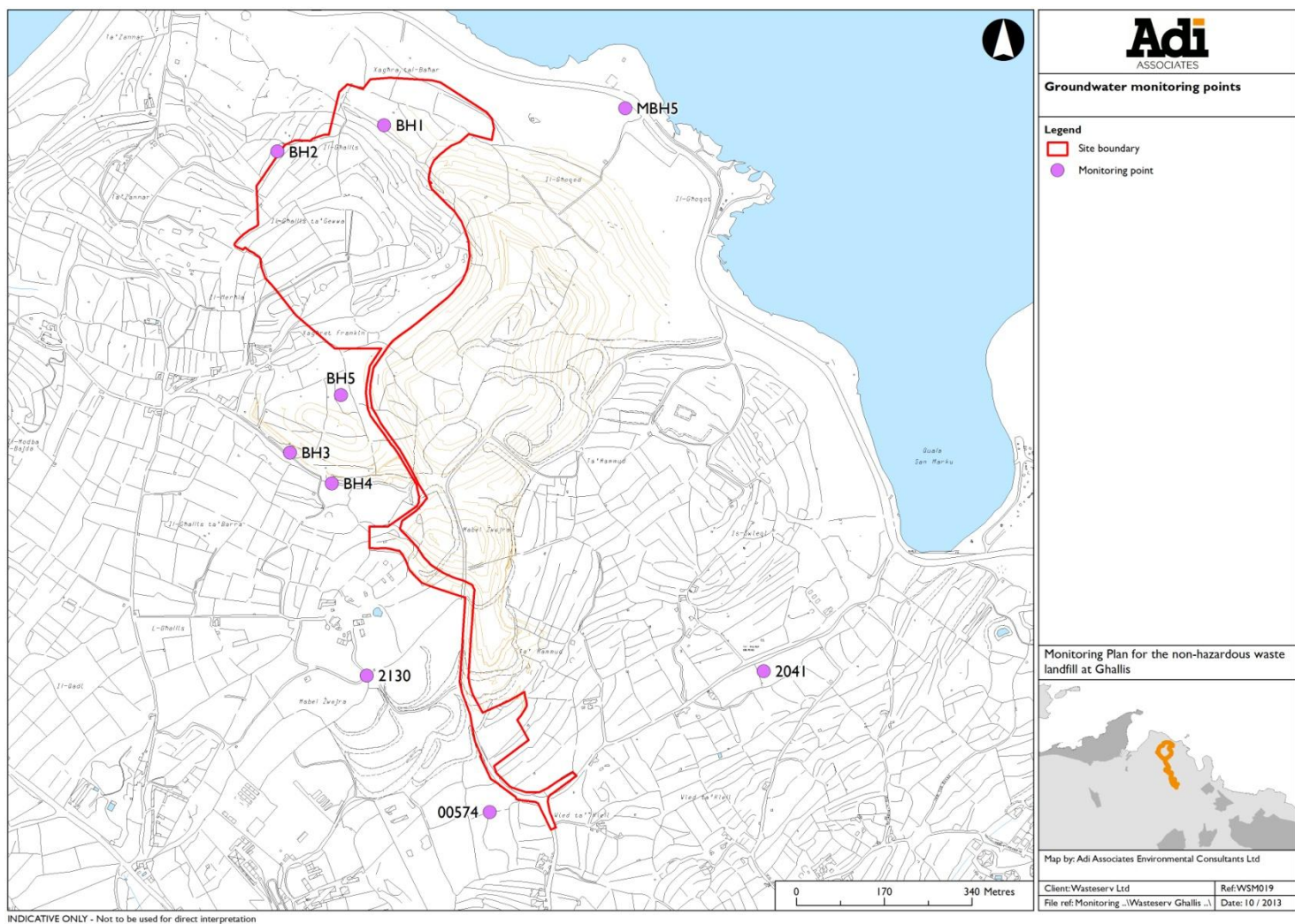
Groundwater Monitoring Points BH1, BH2, BH3, BH4, BH5, MBH5, 2130, 2041 and 00574					
Determinand	Indicator Monitoring	Characterisation Monitoring	Control Level	Trigger Level	Detection Limit
	Frequency (months)				
Water Level	3				
Conductivity	3				±3.4 µS/cm
pH	3				0.1 pH units
TOC	3				0.1 mg/L
NH ₃ -N	3		0.195 mg/L	0.39 mg/L	0.01 mg/L
Cl ⁻	3		N/A	N/A	0.05 mg/L
F ⁻	3				0.05 mg/L
Phenol Index	3				0.05 mg/L
Fe		12			0.1 µg/L
SO ₄		12			0.05 mg/L
Na		12			0.5 mg/L
K		12			0.5 mg/L
Mg		12			0.05 mg/L
Ca		12			0.05 mg/L
As	3		0.0039 mg/L	0.01 mg/L	0.14 µg/L
Ba		12			0.1 µg/L
Cd	3		0.05 µg/L	0.1 µg/L	0.025 µg/L
Cr	3		0.02 mg/L	0.05 mg/L	0.2 µg/L
Cu	3		0.514 mg/L	2.0 mg/L	0.3 µg/L
Hg		12			0.1 µg/L
Mo		12			1.0 µg/L
Ni	3		0.0086 mg/L	0.02 mg/L	0.05 µg/L
Pb	3		0.005 mg/L	0.01 mg/L	0.1 µg/L
Sb		12			0.5 µg/L
Se		12			0.9 µg/L
Zn		12			4.1 µg/L
Hydrocarbons	3				1 µg/L
List I Screen ¹²		12			

¹² See Appendix 2

CONTINGENCY PLAN

- 8.11. In the event that the control level is breached, or a trend in groundwater quality in any borehole leads to the conclusion that the Control or Trigger Level might be breached in the future, the following protocol will be adopted:
- i. The site management and MEPA will be advised;
 - ii. The concentration of those parameters will be re-determined by repeat sampling and analysis;
 - iii. The borehole will be pumped for an extended period in an attempt to increase confidence that the quality is representative of groundwater quality, and not as a result of substances introduced to the borehole from the surface or near surface;
 - iv. A review will be carried out of leachate quality to establish if there is a potential link between trends in leachate quality and groundwater quality, or between background (upstream) groundwater quality and in the affected borehole(s).
 - v. In the event that there is no apparent relationship between leachate quality or upstream groundwater quality and the quality in the affected borehole(s), a review will be carried out of land-use and activities between the landfill boundary and the borehole(s) affected to seek to eliminate external sources of the contaminant(s).
 - vi. In the event that no external source of contaminant(s) is identified, a review of site operations will be undertaken and actions taken to avoid further breach of Control level or potential breach of Trigger level. It is considered likely that actions considered will include, but not necessarily be limited to, the reduction in leachate head within the landfill.
 - vii. The monitoring frequency will be increased to monthly from quarterly to establish if the actions undertaken lead to a stabilization of groundwater quality, or a decline in upward trend in the concentration of the affected parameters.
- 8.12. In the event that the Trigger Level is breached, the following protocol will be implemented:
- i. Review the hydrogeological risk assessment in the light of higher assumed concentrations of the affected leachate parameters and the Control and Trigger levels.
 - ii. If the hydrogeological risk assessment leads to the conclusion that the impact on groundwater quality would be unacceptable, implement corrective measures in agreement with MEPA to reduce the risk.

Figure 8.1: Groundwater monitoring points



9. ON-SITE SURFACE WATER MONITORING

UK GUIDANCE

- 9.1. Guidance for on-site surface water monitoring is taken from the same document as that for leachate and groundwater monitoring. Table 6.8 to the Guidance gives an example monitoring regime, including quarterly indicator monitoring and six monthly characterisation monitoring.

MONITORING REGIME

- 9.2. Given that the perimeter surface water collection system is designed to collect all run-off and there are no other surface water courses in the vicinity of the site, surface water monitoring is carried out only on the perimeter drain, at locations SW1, SW2 and SW3 shown on **Figure 9.1**.
- 9.3. As the entire length of the perimeter surface water drain, as well as the collection ponds, is designed to act as a soakaway, it is considered that accurate measurement of surface water flow is not possible, particularly during low rainfall events. During high rainfall events, estimates of the volume accumulating in the ponds may be made by reference to simple graduated fixed level board placed in the pond and calculation of volume based on the dimensions of the pond and depth of water.
- 9.4. Water samples are collected using bailers or other transfer vessels before pouring water into sample containers. Where the water is deep enough, sample containers are filled directly within the watercourse or pond after rinsing with sample water.
- 9.5. In the previous monitoring programme it was proposed to carry out characterisation monitoring at intervals of 3 months (or following significant rainfall if dry) for a period of twelve months. It was also proposed that this may be reduced to annually after 12 months. Given that the results do not indicate trends of increasing pollutant concentrations, it is considered appropriate for characterisation monitoring to continue at annual intervals. However, indicator monitoring is carried out every 3 months (or following significant rainfall if dry). The list of parameters and detection limits are given in **Table 9.1**. The range of parameters is designed to reflect the leachate indicator monitoring protocol.
- 9.6. As the surface water control system is designed to discharge to the groundwater by infiltration, it is considered that the Control and Trigger levels adopted for groundwater are appropriate for surface water quality.

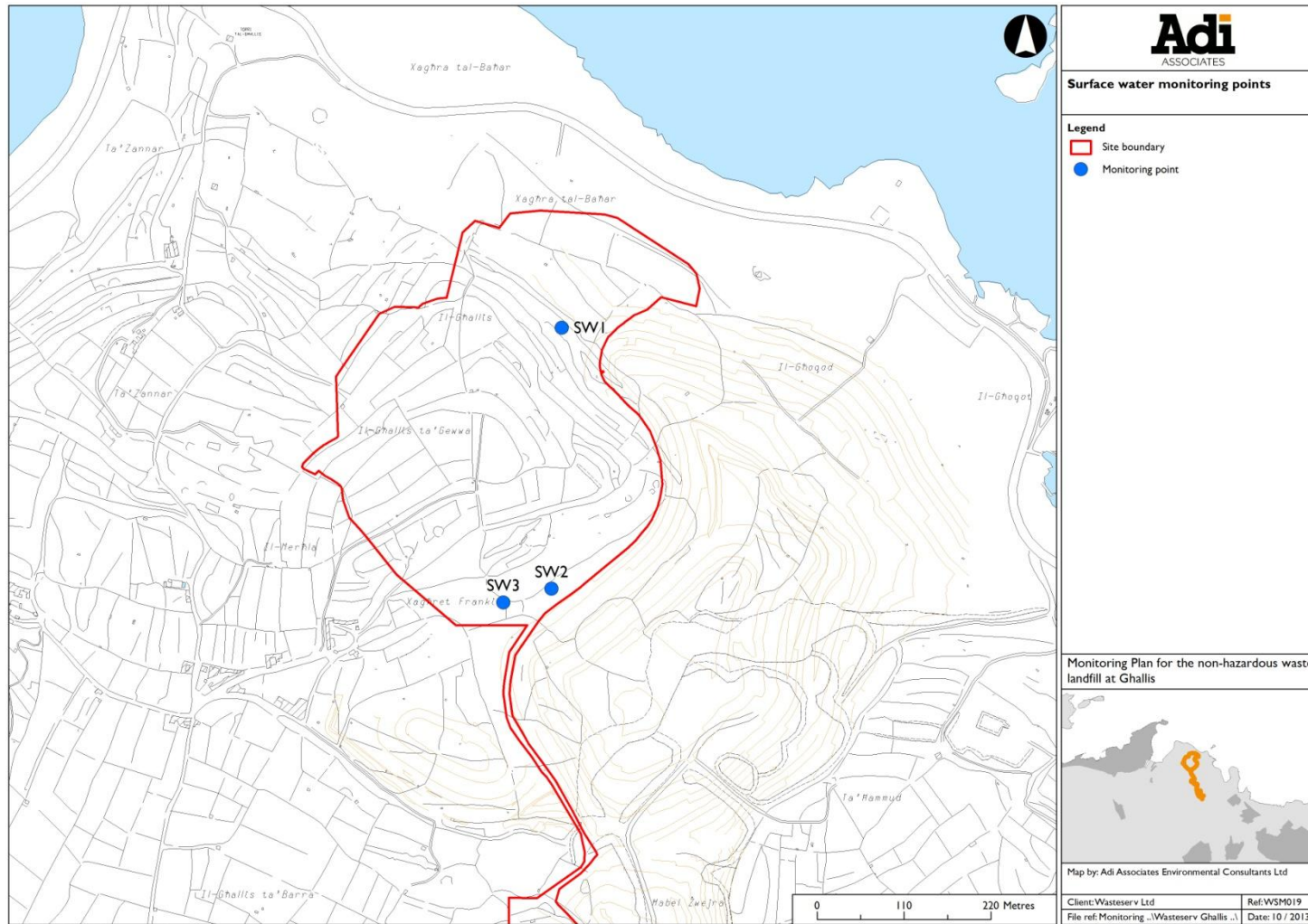
Table 9.1: On-site surface water monitoring

On-site Surface Water Monitoring Points SW1, SW2 and SW3					
Determinand	Indicator Monitoring	Characterisation Monitoring	Control Level	Trigger Level	Detection Limit
	Frequency (months)				
Water Level	3				
Conductivity	3				±3.4 µS/cm
pH	3				0.1 pH units
TOC	3				0.1 mg/L
NH ₃ -N	3		0.195 mg/L	0.39 mg/L	0.01 mg/L
Cl ⁻	3		N/A	N/A	0.05 mg/L
F ⁻	3				0.05 mg/L
Phenol index	3				0.05 mg/L
Fe		12			0.1 µg/L
SO ₄		12			0.05 mg/L
Na		12			0.5 mg/L
K		12			0.5 mg/L
Mg		12			0.05 mg/L
Ca		12			0.05 mg/L
As	3		0.0039 mg/L	0.01 mg/L	0.14 µg/L
Ba		12			0.1 µg/L
Cd	3		0.05 µg/L	0.1 µg/L	0.025 µg/L
Cr	3		0.02 mg/L	0.05 mg/L	0.2 µg/L
Cu	3		0.514 mg/L	2.0 mg/L	0.3 µg/L
Hg		12			0.1 µg/L
Mo		12			1.0 µg/L
Ni	3		0.0086 mg/L	0.02 mg/L	0.05 µg/L
Pb	3		0.005 mg/L	0.01 mg/L	0.1 µg/L
Sb		12			0.5 µg/L
Se		12			0.9 µg/L
Zn		12			4.1 µg/L
Hydrocarbons	3				1 µg/L
List I Screen		12			

CONTINGENCY PLAN

- 9.7. In the event that the control level is breached, or a trend in surface water quality in at any monitoring point leads to the conclusion that the Control or Trigger Level might be breached in the future, the following protocol will be adopted:
- i. The site management and MEPA will be advised;
 - ii. The concentration of those parameters will be re-determined by repeat sampling and analysis (if there is any water remaining – it is anticipated that surface water ponds will be ephemeral, being fed by heavy rainfall events and infiltrating to the groundwater system);
 - iii. A review will be carried out of surface water quality at the different monitoring points to seek to establish at what part of the surface water drain contaminant(s) enter the system.
 - iv. In the event that the review identifies potential sources of contaminated run-off a survey will be carried out of activities on the landfill or potential sources of perched leachate outbreak.
 - v. In the event that no clear source of contaminant(s) is identified, a review of site operations will be undertaken and actions taken to avoid further breach of Control level or potential breach of Trigger level. It is considered likely that actions considered will include, but not necessarily be limited to, the reduction in leachate head within the landfill and cessation of leachate re-circulation in affected areas.
 - vi. The monitoring frequency will be increased to include any significant rainfall event leading to the accumulation of water in the settlement ponds to establish if the actions undertaken lead to a stabilization of groundwater quality, or a decline in upward trend in the concentration of the affected parameters.

Figure 9.1: Surface water monitoring points



10. AGRICULTURE AND SOILS MONITORING

THE EIA FINDINGS

- 10.1. As part of the EIA for the project an agricultural study was carried out incorporating an area of approximately (82.5 ha) and comprising the project area and the immediate surrounds extending approximately 200 m in the south-east, south, south-west, west and north-west directions from the delineated project area.
- 10.2. During the agricultural study 261 land units were identified, of which 205 were identified as agricultural land units, with the majority of plots within the project area being moderately sized units. Most of the agricultural land in the project area consists of shallow terraced land. The majority of cultivated land was cropped with cereals, followed by a smaller area devoted to dryland vegetables. The project area also includes a number of livestock units.
- 10.3. The soils in the project are described as shallow brown coarse loamy carbonatic terraced material. The land has a good soil cover, in 92% of the plots; there is only a limited area (8% of the agricultural land area) that has exposed bare rock. Most of the agricultural land in the project area is cultivated. The majority of cultivated land (77% of land cover) was cropped with cereals, followed by a smaller area devoted to dryland vegetables. Potatoes were being grown in a total of 4 units.
- 10.4. The EIA predicted
- “a slight decrease in the quality of the agricultural produce would be expected as a result of:*
- Aerial deposition of dust and air-borne contaminants on the above-ground parts of vegetation, from vehicle emissions and from any uncontrolled emissions originating from the landfill; and*
- Uptake of soil-borne contaminants transported to the fields through surface runoff or wind-blown deposition.*
- The extent of these impact (sic) will depend upon the standard of operation of the facility. A well operated facility will give rise to minimal such impacts. The change in quality of the agricultural produce in the agricultural area surrounding the facility is a potential risk with a low probability of occurring. Unlike the existing landfill, the controlled waste facility should not be a source of diffuse pollution. This means that the quality of the agricultural produce in the agricultural sphere of influence should not be affected”.*
- 10.5. The surface water management plan incorporates a surface water cut-off ditch design to act as a soakaway facility around the entire perimeter of the landfill. The probability of contamination of adjacent land as a result of surface run-off is, therefore minimal.
- 10.6. The EIA recommended that soils in the area of influence (i.e. within 200 m of the site boundary) should be sampled prior to commencement of works to establish a

baseline soils chemical concentration. Subsequent sampling of soils throughout the construction and operation of the landfill will then be used to establish any impacts of the development and allow necessary measures to reduce effects.

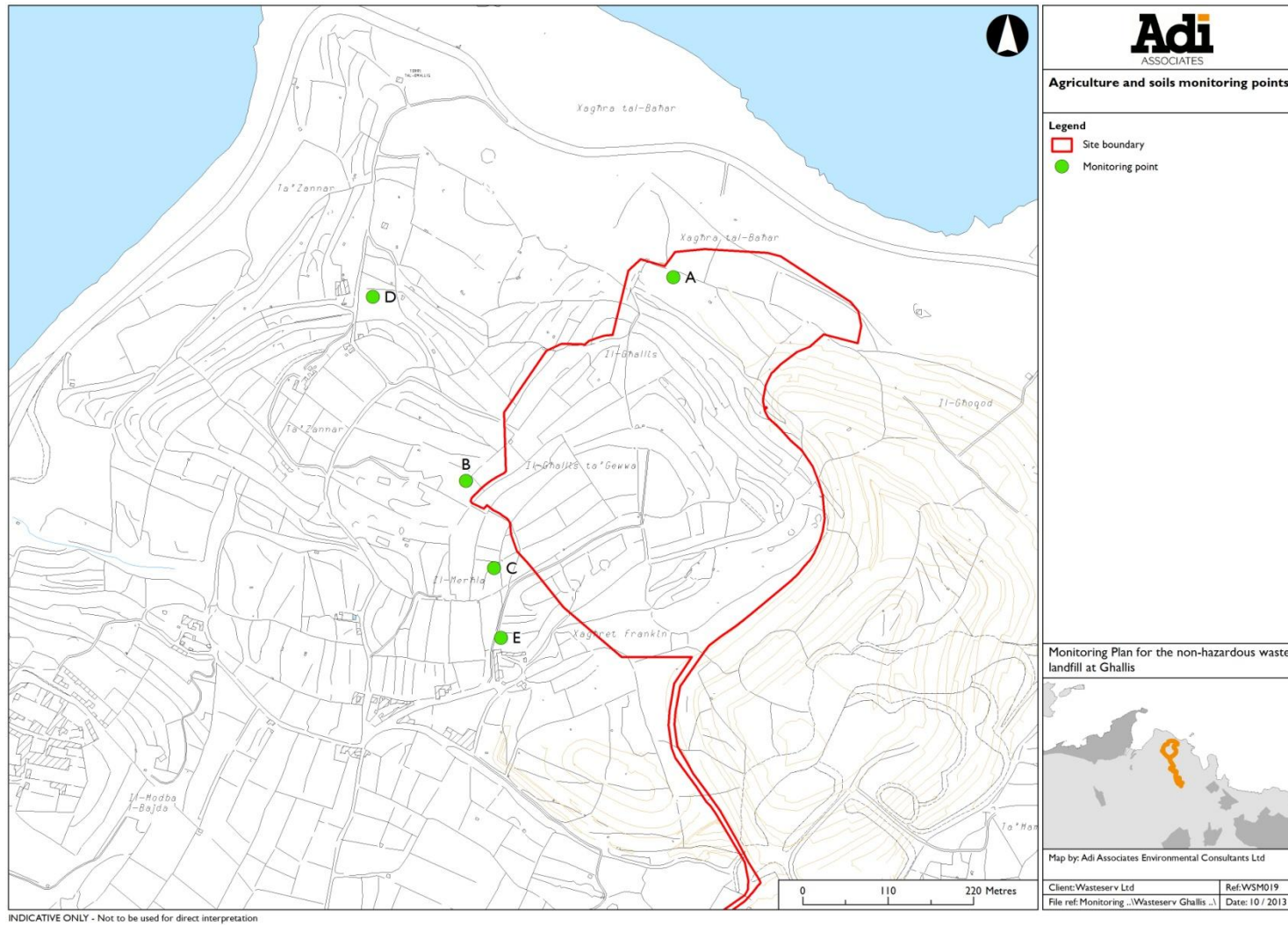
MONITORING PROGRAMME

- 10.7. There are no major run-off routes beyond the site boundary as a result of the surface water management system. The principal soakaways are located on the eastern side of the landfill, adjacent to the former Maghtab landfill. Monitoring is undertaken at Locations A to E as shown in **Figure 10.1**.
- 10.8. The proposed monitoring programme is summarised in **Table 10.1**. For most parameters, quarterly monitoring is being recommended. However, for cyanide, PCBs and dioxins and furans it is recommended that the frequency be reduced to annual, since these parameters have never been detected over the previous monitoring programme (110 samples taken). It is also recommended that aromatic and halogenated hydrocarbon VOCs no longer be measured, as these have also never been detected during the former monitoring in 2011 and 2012, and the landfill is not a clear source of these parameters.
- 10.9. Two samples of soil are taken at each location; one from the top 15 cm of the soils profile and one from between 30 and 40 cm (where soil depth permits). This will provide an indication of “recently” accumulated contaminants and accumulated contaminants leached through the soil. Sampling procedures follow the ISO 10381 series of guidelines.
- 10.10. It is recommended that cereal crops be used as the agricultural product for sampling as it represents the predominant crop type and is likely to enter the food chain either directly by human consumption or as fodder for livestock as is economically the most important crop in the area in terms of land use. Choosing one crop type consistently also minimises the variables in plant uptake that might influence results and hamper the identification in trends that would be more likely to occur if sticking rigidly to a sample location or agricultural plot with, for instance, different vegetable crops, including fruits, roots or tubers.
- 10.11. No Control or Trigger levels are proposed at this stage. It is, however, recommended that the data be reviewed annually to identify trends, not only in the values of contaminants in soils and cereals, but also in their spatial distribution, taking into account weather conditions, in particular winds and rainfall patterns, and other potential sources of contaminants such as the Maghtab landfill.

Table 10.1: Agriculture and soils monitoring

Monitoring location, medium & depth	Parameters	Frequency	Detection Limit
Locations A to E: • Soils at circa 15 cm depth • Soils at 30-40 cm depth • Cereal crop	Nitrogen	Quarterly	0.1 mg/kg
	Phosphorous	Quarterly	0.1 mg/kg
	Potassium	Quarterly	0.1 mg/kg
	Mercury	Quarterly	0.1 mg/kg
	Cadmium	Quarterly	0.1 mg/kg
	Lead	Quarterly	0.1 mg/kg
	Nickel	Quarterly	0.1 mg/kg
	Arsenic	Quarterly	0.1 mg/kg
	Chromium	Quarterly	0.1 mg/kg
	Copper	Quarterly	0.1 mg/kg
	Zinc	Quarterly	0.1 mg/kg
	Tin	Quarterly	0.1 mg/kg
	Boron	Quarterly	0.1 mg/kg
	Fluoride	Quarterly	0.1 mg/kg
	Sulphates	Quarterly	0.1 mg/kg
	Cyanides	Annual	0.1 mg/kg
	PCBs	Annual	0.005 mg/kg
	PAHs	Quarterly	0.01 mg/kg
	Naphthalene	Quarterly	0.01 mg/kg
	Dioxins and Furans	Annual	0.1 µg/kg

Figure 10.1: Agriculture and soils monitoring points



II. COASTAL WATERS AND SEDIMENT

MONITORING LOCATIONS

- II.1. Five monitoring stations are used for water and sediment sampling (A-D, with E included recently). Two of the stations, A and B (**Figure II.1**), are sited in the vicinity of the waste facility and have been selected for the assessment of discharges to coastal water that may potentially originate from the facility. Stations C and D (**Figure II.1**) serve as reference stations from where background physico-chemical data is recorded. Station E was added in accordance with MEPA's requirements.
- II.2. Each station is located at a distance of 10 metres from the shore, however, if it transpires that no sediments are present at this distance from the shore, the location of the station will be adjusted such that the alternative site will be located on a soft bottom but as close as possible to the 10 m horizontal distance mark.
- II.3. The locations of the proposed monitoring station have been carefully selected, such that:
- Stations A, B and E are in the vicinity of the waste facility are located as practically close to it as possible.
 - The two reference stations are located in waters that are relatively free from polluting sources.
 - Incorporating three putatively impacted stations and two reference stations renders the monitoring design sufficiently robust, while enabling rigorous statistical treatment of data, if required.
- II.4. In accordance with the previous monitoring programme, water and sediment samples were collected on a quarterly basis. Results show that it does not appear that the landfill is having a significant impact on the measured concentrations. Therefore it is considered that monitoring of sediments can start to be carried out annually, to allow detection of any long-term changes. This is also in accordance with the MEPA comments on the previous approved monitoring programme for the Zwejra non-hazardous landfill¹³. Quarterly monitoring of coastal water would be maintained as a precautionary measure. Monitoring would be carried out from five locations (A-E). The parameters to be monitored have been updated to reflect the leachate monitoring programme.

LIST OF PARAMETERS

- II.5. The attributes that will be monitored in the water and sediments as part of this coastal water monitoring programme are as given in **Tables II.1 and II.2** below. The parameters have been aligned with the leachate monitoring programme, with

¹³ Adi Associates Environmental Consultants Ltd, 2012. *Monitoring Plan for the Ta' Zwejra Non-Hazardous Engineered Waste Facility*. San Gwann, April 2012; vii + 54pp.

mercury and zinc being monitored quarterly on request from MEPA. The list of parameters (including the List I screen) also includes a number of relevant pollutants arising from Water Framework Directive obligations (Directive 2008/105/EC, Annex I). PCDD/PCDF have been included on request from MEPA.

Table I I.1: Coastal water monitoring programme

Coastal Water Monitoring Points A-E			
Determinand	Indicator Monitoring	Characterisation Monitoring	Detection Limit
	Frequency (months)		
Water Level	3		
Conductivity	3		±3.4 µS/cm
pH	3		0.1 pH units
TOC	3		0.1 mg/L
NH ₃ -N	3		0.01 mg/L
Cl ⁻	3		0.05 mg/L
F ⁻	3		0.05 mg/L
Phenol Index	3		0.05 mg/L
Fe		12	0.1 µg/L
SO ₄		12	0.05 mg/L
Na		12	0.5 mg/L
K		12	0.5 mg/L
Mg		12	0.05 mg/L
Ca		12	0.05 mg/L
As	3		0.14 µg/L
Ba		12	0.1 µg/L
Cd	3		0.025 µg/L
Cr	3		0.2 µg/L
Cu	3		0.3 µg/L
Hg	3		0.05 µg/L
Mo		12	1.0 µg/L
Ni	3		0.05 µg/L
Pb	3		0.1 µg/L
Sb		12	0.5 µg/L
Se		12	0.9 µg/L
Zn	3		4.1 µg/L
Hydrocarbons	3		1 µg/L
PCDD/PCDF		12	0.1 µg/L
List I Screen		12	

Table I I.2: Sediment monitoring programme

Sediment Monitoring Points A-E			
Determinand	Indicator Monitoring	Characterisation Monitoring	Detection Limit
	Frequency (months)		
Granulometry	12		63 μm
TOC	12		
NH ₃ -N	12		0.1 mg/kg
Cl ⁻	12		
F ⁻	12		0.1 mg/kg
Phenol Index	12		
Fe		12	0.1 mg/kg
SO ₄		12	0.1 mg/kg
Na		12	0.1 mg/kg
K		12	0.1 mg/kg
Mg		12	0.1 mg/kg
Ca		12	0.1 mg/kg
As	12		0.1 mg/kg
Ba		12	0.1 mg/kg
Cd	12		0.1 mg/kg
Cr	12		0.1 mg/kg
Cu	12		0.1 mg/kg
Hg		12	0.1 mg/kg
Mo		12	0.1 mg/kg
Ni	12		0.1 mg/kg
Pb	12		0.1 mg/kg
Sb		12	0.1 mg/kg
Se		12	0.1 mg/kg
Zn		12	0.1 mg/kg
Hydrocarbons	12		0.1 mg/kg
PCDD/PCDF		12	0.01 μg/kg
List I screen		12	

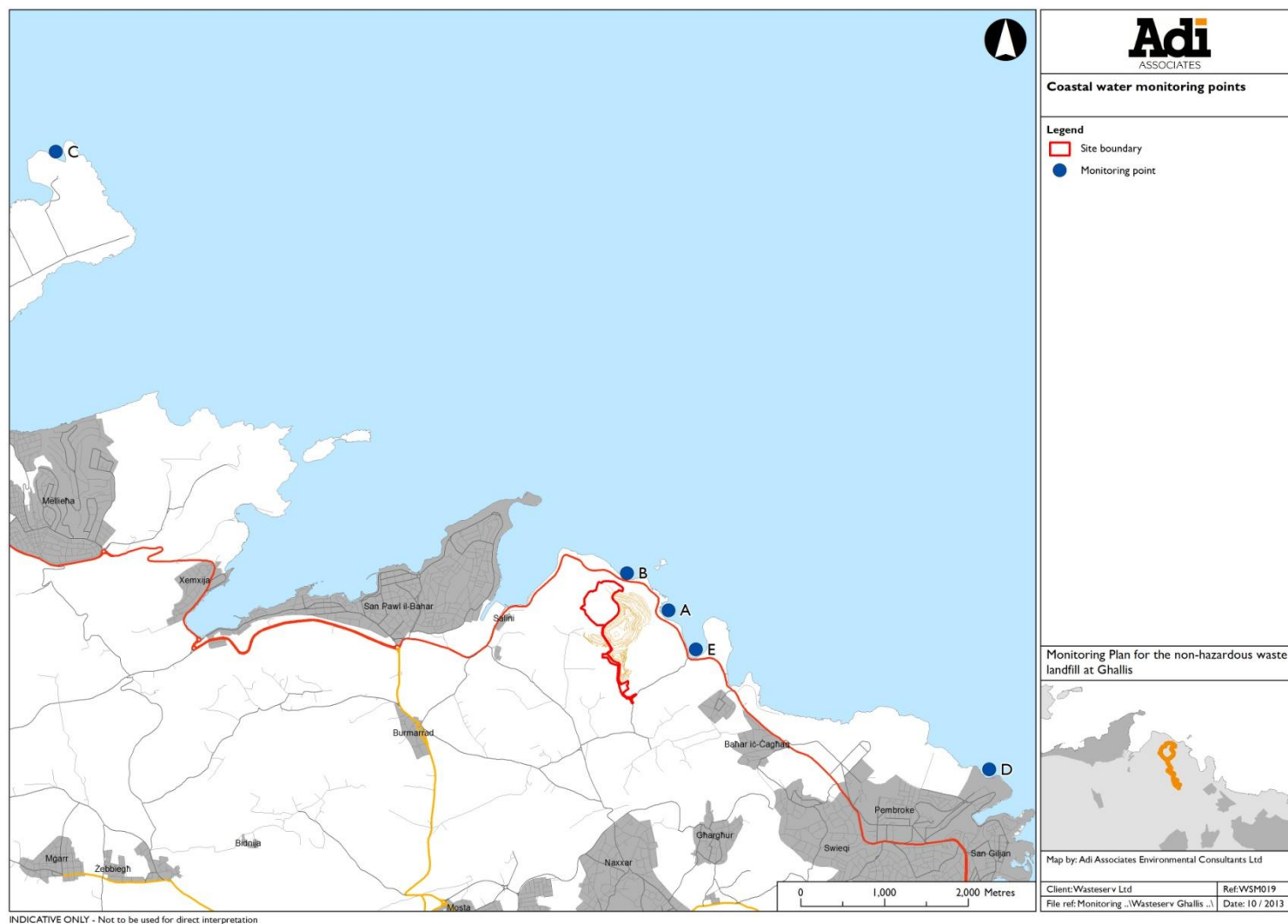
SAMPLING PROCEDURES

- 11.6. To monitor seawater, sampling is carried out at each station at a water depth of 0.5 m below the surface and at a water depth corresponding to a level that is 0.5 m above the seabed. Two replicate samples are collected from each of the two water depths at each of the four stations. Levels of dissolved oxygen and temperature are recorded using an in-situ multi-parameter meter. For the remaining attributes, water samples are collected using a Van Dorn sampler and transferred to polyethylene or glass containers, depending on the attribute to be measured. All water sampling is carried out in accordance with ISO 5667-1:2006 and ISO 5667-3:2003. Sample preservation techniques follow guidance given in ISO 5667-3:2003 for the respective attribute.
- 11.7. Sediment sampling is carried out manually by SCUBA divers. Two replicate samples are collected from each monitoring station using plastic corers. Sediment sampling is carried out in accordance with ISO 5667-12:1995 and ISO 5667-19:2004. Sample preservation techniques follow guidance given in ISO 5667-3:2003 for the respective parameters.

ANALYTICAL METHODOLOGY

- 11.8. For the analysis of chemicals in seawater, the aqueous component is reported. For the analysis of cadmium, lead, mercury and nickel, the water sample will be filtered prior to the analysis through a 0.45 μm filter or any equivalent pre-treatment, such that in accordance with Directive 2008/105/EC, Annex I, Part B, Point 3, the analysis is undertaken on the dissolved phase. For the chemical analysis of sediments, bound fractions are brought into solution by an initial process of acid extraction.
- 11.9. The water and sediment samples should be analysed according to international, European or national standard methodology. The analysis should be carried out by a laboratory accredited according to the ISO 17025:2005 or in the process of achieving such accreditation. The limits of detection for each respective analytical method used for the water and sediment analysis should meet or be lower than the values shown in **Table 11.1** and **11.2**.
- 11.10. The laboratory that will undertake the analysis should provide the details of the methods that would be used, the reference of the method if this is an international or European standard or the principle of the methodology for national standards or in-house methods. The concentration levels of the chemicals parameters recorded for the individual samples are to be reported, including the laboratory certificate for each analysed sample with U = analytical uncertainty, K = coverage factor and R = recovery.

Figure 11.1: Coastal waters monitoring points



CONTINGENCY PLAN

- 11.11. In the event that a trend in sampling points A, B or E suggests that the landfill might be influencing seawater or sediment quality, the following protocol will be adopted:
- i. The site management and MEPA will be advised.
 - ii. The concentration of those parameters will be re-determined by repeat sampling and analysis.
 - iii. A review will be carried out of leachate quality to establish if there is a potential link between trends in leachate quality and seawater/sediment quality.
 - iv. A review will be carried out of reference stations C and D to establish whether background seawater/sediment concentrations have increased.
 - v. In the event that there is no apparent relationship between seawater/sediment quality and leachate quality, and no increase in background concentrations at the reference stations, a review will be carried out of land-use and activities between the landfill boundary and affected sampling point to identify whether external sources of the contaminant(s) could have affected the sample. In particular, if station E is affected, the potential influence of runoff originating from agricultural activities at Maghtab will be examined.
 - vi. In the event that no external source of contaminant(s) is identified, a review of site operations will be undertaken and actions taken to avoid further increases. It is considered likely that actions considered will include, but not necessarily be limited to, the reduction in leachate head within the landfill.
 - vii. The monitoring frequency will be increased to monthly to establish if the actions undertaken lead to a stabilisation of seawater/sediment concentrations, or a decline in upward trend in the concentration of the affected parameters.

12. NOISE

PERMIT REQUIREMENTS

- 12.1. The requirements for the Noise Survey are described in the Terms of Reference provided by MEPA in the IPPC permit; these are reproduced below:

“5.8.3 Monitoring of noise shall be carried out in accordance with the consolidated Environmental Monitoring Programme for the Permitted Installation, as approved by the Authority.

5.8.4 The level of noise emitted from the installation at all operational times shall not exceed the background noise level by more than 5 dB. The locations shall be chosen and the measurements and assessment made according to BS 4142:1997 and ISO 9613-2:1996 or a more recent version replacing these standards.”

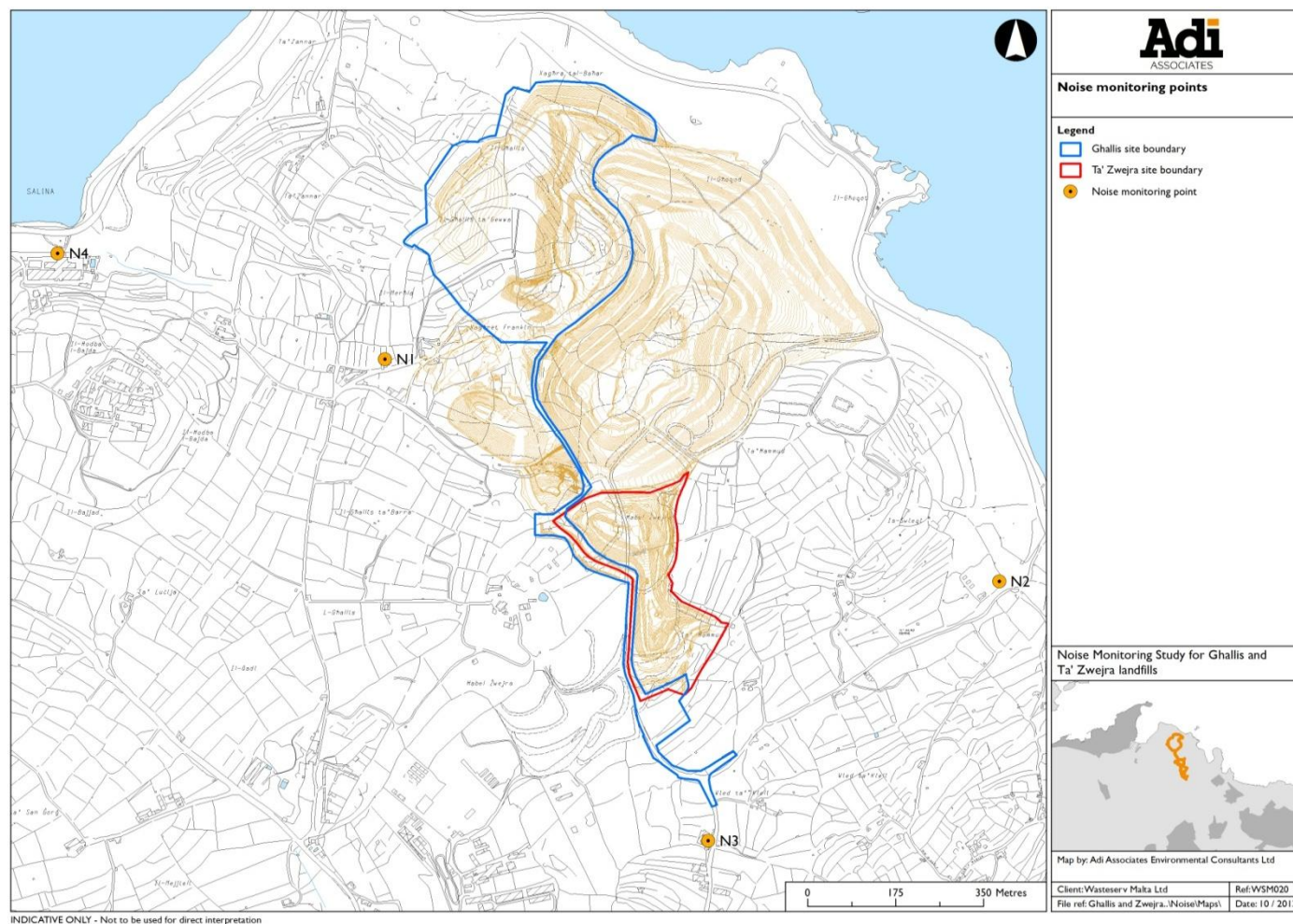
CURRENT PRACTICE

- 12.2. MEPA approved a noise monitoring method statement in March 2014;¹⁴ monitoring on the basis of this method statement was carried out in March and May 2014.¹⁵
- 12.3. Monitoring was carried out at the closest noise-sensitive receptors listed below, and shown in **Figure 12.1**:
- N1: A residence to the west of Ghallis landfill;
 - N2: A residence to the east of Ghallis and Zwejra landfills;
 - N3: A residence to the south of Ghallis and Zwejra landfills; and
 - N4: Coastline hotel to the west of Ghallis landfill.
- 12.4. These monitoring points were consistent with the monitoring points in the previously approved Ghallis monitoring programme, and were co-located with the monitoring points for the Zwejra landfill, since both landfills are considered to have similar sensitive receptors.
- 12.5. Monitoring was carried out during normal daytime operating hours, with a separate single night-time session being conducted at N1 to assess the noise impact of the CHP/RTO plant at night.

¹⁴ Adi Associates Environmental Consultants Ltd, 2013. *Non-Hazardous Engineered Waste Landfills at Ghallis and Ta' Zwejra: Method Statement for Noise Monitoring Programme*. San Gwann, November 2013; v + 23 pp.

¹⁵ Adi Associates Environmental Consultants Ltd, 2014. *Non-Hazardous Engineered Waste Landfills at Ghallis and Ta' Zwejra: Noise Monitoring Report – 2014*. San Gwann, June 2014; vi + 18 pp. + 5 Appendices.

Figure 12.1: Current noise monitoring stations



- 12.6. The monitors made the following observations while measuring the noise environment at these monitoring points:
- With the exception of N1, any noise generated by the Ghallis / Zwejra landfill operations was not distinguishable from other noise sources such as traffic during the morning sessions;
 - Noise generated by the CHP/RTO plant was not audible at N1 at night;
 - Noise generated by traffic sources was particularly frequent at N2, near the junction where Triq ir-Ramla joins the Coast Road, and at N3 where traffic passing through Maghtab Village along Triq ir-Ramla is virtually constant; and
 - Noise measurements taken at N4 during the morning session were mainly the result of noise generated by the Coastline Hotel staff and operations. Noise generated by traffic along the Coast Road (Salini area) was also significant, but to a lesser extent.
- 12.7. Monitoring at the sensitive receptors was followed up by diagnostic monitoring, to allow a more accurate assessment of the individual noise sources under investigation. The results of this assessment were consistent with the field observations made by the monitors, i.e. that none of the activities at the landfills are audible at the noise-sensitive receptors, with the exception of the tipper trucks from N1.
- 12.8. The results of the diagnostic monitoring showed that:
- At stations N2, N3 and N4, the amount of noise generated by the operations of the Ghallis / Zwejra engineered landfills was negligible and inaudible above the general background noise environment;
 - The noise generated by the tipper trucks at N1 was 3 dB above the background noise: this is within the 5 dB limit imposed by the IPPC permit. This value is unlikely to raise complaints; and
 - The CHP/RTO unit results in negligible noise impact on the closest noise sensitive receptor at night, which is assumed to be the time when the receptor is most sensitive.

MONITORING PROGRAMME

- 12.9. The following monitoring programme is recommended, based on the conclusions in the above report:
- An annual noise assessment should be carried out at N1 to ensure that noise generated by the landfills does not change to the detriment of the sensitive receptors;
 - The stations N2, N3, and N4 should be scoped out of future surveys as the noise environment at these locations effectively masks any potential noise generated by

the operations at the Ghallis / Zwejra landfills; and

- The night-time survey at NI to assess the impact of the CHP/RTO unit can also be scoped out in future surveys unless additional plant is added.

12.10. Monitoring is to be carried out in accordance with BS 4142:1997, and using a type 1 sound level meter.

12.11. Since weekday landfill operations represent the worst-case scenario in terms of noise generation, measurements should be made on weekdays during the day (between 7 am and 11 pm).

12.12. A sampling period of one hour is recommended, to be representative of landfill operations.

12.13. Measurements are to be taken as follows:

- Background measurements should be taken at NI when there are negligible noise emissions from the Ghallis and Zwejra landfills. This would be from around 4 pm onwards, at a time when minimal landfill operations are underway and when other noise sources in the surroundings could still be in operation.
- Operational measurements at NI should be taken when normal landfilling operations are underway. Mornings are preferred, since landfilling activities are more intense during this part of the day. It would be preferable to carry out monitoring when activities are underway at both Ghallis and Zwejra, however, it is recognised that this may not be possible due to activities at Zwejra occurring only intermittently.
- Background and operational measurements should be made during similar climatic conditions, to ensure comparable results.

12.14. Diagnostic measurements do not need to be repeated if the source under investigation does not change. In this case the results of the 2014 noise monitoring report can be used, taking into account any changes in the location of the noise source and intervening structures. However, if a change occurs in the landfill noise sources, for example due to the operation of new machinery, diagnostic monitoring is to be carried out in accordance with ISO 1996 and BS4142:1997.

**APPENDIX I:
PRIORITY TRACE COMPONENTS IN LANDFILL GAS**

Detailed Gas Composition	Priority Trace Components
Methane	Benzene, toluene, xylene
Carbon Monoxide	PAHs: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, dibenz(ah)anthracene, benzo[ghi]perylene and indeno(1,2,3-cd)pyrene
Carbon Dioxide	PCBs
Oxygen	Sum dioxins & furans (PCDD/PCDF), expressed in TEQ
Hydrogen Sulphide	Mercaptans: Methanethiol, ethanethiol, 1- butanethiol, 1-propanethiol
Hydrogen	1,2-dichloroethane
	Carbon disulphide
	Dimethyl disulphide
	Aldehydes: Methanal (formaldehyde), Ethanal (acetaldehyde)
	Styrene
	Arsenic, Mercury

**APPENDIX 2:
LIST I SCREEN PARAMETERS**

Parameter
Cyanides
Organic Aromatic Solvents
Benzene
Ethyl benzene
Styrene
Toluene
Para-xylene
Pesticides containing Phosphate
Acephate
Azinphos-ethyl
Azinphos-methyl
Bromophos
Chlorfenvinphos E
Chlorfenvinphos Z
Chlorpyrifos-methyl
Chlorpyrifos
Demeton-O
Demeton-S-methyl
Diazinon
Dimethoate
Eptenofos
Ethion
Fenitrothion
Phosalone
Malaoxon
Malathion
Methidathion
Paraoxon
Paraoxon-methyl
Parathion
Parathion-methyl
Pirimiphos-methyl
Tetrachlorvinfos
Vamidothion
Polycyclic Aromatic Hydrocarbons
Acenaphthene
Acenaphthylene
Anthracene
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(g,h,i)perylene
Benzo(k)fluoranthene
Chrysene
Dibenzo(a,h)anthracene
Fluoranthene
Fluorene
Indeno (1,2,3-c,d) pyrene
Naphthalene
Phenanthrene
Pyrene

Parameter
Carcinogenic Chlorinated Aliphatic Compounds
Chloromethane
Trichloromethane
Vinyl chlorides
1,2-Dichloroethane
1,1-Dichloroethylene
Trichloroethylene
Tetrachloroethylene
Hexachlorobutadiene
Sum of organohalogens
Non-Carcinogenic Chlorinated Aliphatic Compounds
1,1-Dichloroethane
1,2-Dichloroethylene
1,2-Dichloropropane
1,1,2-Trichloroethane
1,2,3-Trichloropropane
1,1,2,2-Tetrachloroethane
Carcinogenic Halogenated Aliphatic Compounds
Tribromomethane (Bromoform)
1,2-Dibromoethane
Dibromochloromethane
Bromodichloromethane
C10-C13 chloroalkanes
Organobromine compounds
Brominated diphenylether
Phthalates
DEHP (di(2-ethylhexyl)-phthalate
Chlorinated aromatic hydrocarbons
Pentachlorobenzene