



Request for Renewal of IP 0001/05 (IPPC Permit for Ta' Zwejra)

Consolidated Application

December 2012

ANNEX 1

IP 0001/05
Ta' Zwejra Non-Hazardous Waste Landfill
Condition 3.13 - Improvement Programme
Status - September 2010

No.	Reference	Requirement	Date	Compliance
1	Several	Review and confirmation of a holistic environmental monitoring programme related to the operation of the site (groundwater, surface water, gaseous emissions and ambient air quality)	To be submitted within 1 month from issue of permit	Submitted April 2006
2	1.1.28	Location of any point discharges to surface waste	All details will be provided within 1 month of issue of permit as in 1.1.26	Submitted April 2006
3	1.2.26	Triggers level for dioxins, PAHs and heavy metals	All details will be provided within 1 month of issue of permit. Contingency plans which will be put into effect when the trigger level is reached are to be submitted within 6 months.	Feedback provided in submission dated June 2009.

4	2.3.18	Dissolved gas content control	To be provided within 1 month of leachate detection	As referred in SMS document section 6.6.7 page 38, dissolved gas content control would be relevant should on-site leachate treatment be established. To date the current practice is that leachate is recirculated onto the landfill.
5	2.3.22	Performance parameters for leachate treatment off-site	To be submitted within 1 month from issue of permit	Not applicable at the moment
6	2.3.33	Leachate quality monitoring	Sampling procedure and equipment used for monitoring to be provided within 1 month of issue of permit	Submitted April 2006
7	2.2.34	Run off monitoring	Details of system monitoring (volume, meteorological conditions and quality) to be provided within 1 month of issue of permit.	Submitted April 2006
8	2.3.35	Flood action plan	Will be submitted within 1 month of issue of permit	Submitted with application

9	2.3.37	Run off monitoring		Number and location of points, sampling procedure and equipment, methodology and all other relevant information will be communicated within 1 month of issue of permit.	Submitted April 2006
10	2.3.38	Run off monitoring parameters		To be provided within 1 month	Submitted April 2006
11	2.3.39	Surface water monitoring		Number and location of points, sampling procedure and equipment, methodology and all other relevant information will be communicated within 1 month of issue of permit.	Submitted April 2006
12	2.3.46/2.3.48	Landfill gas management plan		To be submitted within 6 months of issue of permit	Submitted

13	2.3.63	Contingency plan for landfill gas monitoring	To be submitted within 6 months of issue of permit	Submitted
14	2.3.64	Security arrangements on installation	To be provided within 1 month of issue of permit	Submitted April 2006
15	2.3.67	Inspection and maintenance contract	To be submitted within 6 months	This relates to pipework, etc. in connection with the landfill gas management system. Since this is not yet in place an inspection and maintenance contract is not yet in place.
16	2.3.75	Odour monitoring points	All details are to be specified within 1 month of issue of permit	Submitted April 2006
17	2.3.75	Odour monitoring	Within 6 months	Submitted April 2006
18	2.3.87	Submission of noise monitoring plan	To be submitted within 1 month from issue of permit	Submitted April 2006
19	2.3.88	Details of noise and vibration monitoring points: determinands, frequency, etc.	Noise monitoring plan to be provided within 1 month of issue of permit	Submitted April 2006
20	2.4.4	Continuous supply of water	To be submitted within 1 month from issue of permit	Submitted April 2006

21	2.4.8	Meteorological monitoring points	To be submitted within 6 months of issue of permit	Meteorological monitoring is conducted by means of a station located on the weighbridge office.
22	2.5.5	Final version of closure plan	Within 1 month	The closure of the Ta Zwejra landfill is included within the scope of PA 02342/06 which is currently being processed by MEPA.
23	4.4.7	Further updates regarding continuous professional development of employees	To be submitted within 6 months of issue of permit	Details submitted as part of submission dated June 2009
24	4.1.2-4.1.21	Submission of Environment Management System	To be submitted within 6 months of issue of permit	Work is underway to implement an EMS for this facility. A detailed plan is included.

Clarifications on Annex 1 submitted to MEPA in May 2011

Most of the requirements of the improvement programme have already been addressed, in particular through a series of correspondence between WasteServ and MEPA and submissions made by WasteServ.

The following are the remaining pending issues related to the improvement programme (Condition 3.13.1 of IP 0001/05):

No.	Requirement	Deadline	Current status	IPPC Committee response 2 February 2011	WasteServ response May 2011
3	Trigger levels for dioxins, PAHs and heavy metals	November 2005	<p>AER for 2009 was submitted in April 2010. Results summarised below.</p> <p>Dioxin & furan measurements at weighbridge were 0.0055 pg/m³ in 2008 and <0.0051 pg/m³ in 2009.¹</p> <p>PAH measurements: 0.0265 ng/m³ in 2008; <2.75 ng/m³ in 2009. The ELV is 1 ng/m³, therefore the limit of detection (LOD) is not</p>	<p>These dioxin levels are far lower than the ELV of 0.1 pg/m³. Therefore removal of monitoring requirement is justified.</p> <p>Dioxins and furans however have the potential to arise from combustion of landfill gas (flaring).^{2,3} Therefore the removal of the monitoring requirement should only be valid as long as no flaring takes place.</p> <p>Trigger levels for PAHs need to be proposed by WasteServ.</p> <p>Measurements need to be carried out with a method having an appropriate</p>	<p>WasteServ has commissioned Messers Adi Associates to compile a review of the monitoring requirements in the current IPPC permit for Ta' Zwejra and to propose a monitoring plan for the facility. This proposed draft monitoring plan is included as Appendix 1 for consideration by the IPPC committee.</p> <p>WasteServ has commissioned Messers Adi Associates to compile a review of the monitoring requirements in the current IPPC permit for Ta' Zwejra and to propose a monitoring plan for</p>

¹ Section S2.4.1 gives dioxin & furan emissions as <0.0051 pg/m³ for 2009, whereas the following two measurements are given in the raw data sheet: 6 fg/l-TE/m³ and 11 fg/l-TE/m³, which would average out to 0.0085 pg/m³. WasteServ has confirmed (email of 12 January 2011) that the raw data is for Għallis.

² UK Environment Agency & Scottish Environment Protection Agency. (2002). *Guidance on Landfill Gas Flaring*. Available [online](#).

³ Department for Environment, Food and Rural Affairs. (2004). *Review of Environmental and Health Effects of Waste Management: Municipal Solid Waste and Similar Wastes*. Available [online](#).

No.	Requirement	Deadline	Current status	IPPC Committee response 2 February 2011	WasteServ response May 2011
			sufficient.	LOD.	the facility. This proposed draft monitoring plan is included as Appendix 1 for consideration by the IPPC committee.
			As, Cd, Ni levels lower than ELVs for 2008; while the method used in 2009 was not suitable for metals, reference was made to raw data for Ghallis. ⁴	WasteServ is to ensure that measurements for metals are carried out according to the IPPC permit. Trigger levels for metals need to be proposed by WasteServ.	WasteServ has commissioned Messers Adi Associates to compile a review of the monitoring requirements in the current IPPC permit for Ta' Zwejra and to propose a monitoring plan for the facility. This proposed draft monitoring plan is included as Appendix 1 for consideration by the IPPC committee.
3	Contingency plans which will be put into effect when the trigger level is reached	April 2006		Contingency plans for PAHs and metals to be submitted by WasteServ.	WasteServ has commissioned Messers Adi Associates to compile a review of the monitoring requirements in the current IPPC permit for Ta' Zwejra and to propose a monitoring plan for the facility. This proposed draft monitoring plan is included as Appendix 1 for consideration by the IPPC committee.
17	Odour monitoring	April 2006	2009 AER does not include odour monitoring results.	Odour monitoring results to be submitted by WasteServ.	WasteServ has commissioned Messers Adi Associates to compile a review of the monitoring requirements in the current IPPC permit for Ta' Zwejra and to propose a monitoring plan for the facility. This proposed draft monitoring plan is included as Appendix 1 for consideration by the IPPC committee.
22	Final version of	November	Detailed closure plan not	Comments regarding the closure plan	The closure plan is specified by means

⁴ MEPA is currently awaiting submission of an updated Annual Environmental Report for 2009 for Żwejra (as per email dated 24 January 2011).

No.	Requirement	Deadline	Current status	IPPC Committee response 2 February 2011	WasteServ response May 2011
	closure plan	2005	submitted.	summary submitted as part of PA 02342/06 are enclosed (Annex III). Detailed closure plan addressing these comments to be submitted by WasteServ.	of two documents, namely (1) Ta' Zwejra Landfill – Closure Plan – Gas Collection System – Specification and Construction and Quality Assurance Plan and (2) Ta' Zwejra Landfill - Closure Plan – Intermediate Capping - Specification and Construction and Quality Assurance Plan. These are attached as Appendices 2 and 3 respectively.
24	Submission of environment management system	April 2006	EMS not submitted to date. <i>October 2010:</i> Further to what was reported in submission dated June 2010, WasteServ is in the process of engaging an officer to implement this task. The task shall be implemented during 2011.	A plan for implementation of the EMS is to be submitted, with the various tasks required to be carried out being given specific timeframes.	WSM is in the process of engaging an officer to implement this task. The task shall be implemented during 2011.

Other pending requirements of IP 0001/05

Condition	Requirement	Timeframe	WasteServ response	IPPC Committee response 2 February 2011	WasteServ response May 2011
3.15	Weekly monitoring for Volatile Organic Compounds (Benzene, Toluene, Xylene), barometric pressure and temperature	Quarterly reporting	<i>July 2009:</i> Not available due to lack of appropriate equipment.	Monitoring to start being carried out and reported.	WasteServ has commissioned Messers Adi Associates to compile a review of the monitoring requirements in the current IPPC permit for Ta' Zwejra and to propose a

					monitoring plan for the facility. This proposed draft monitoring plan is included as Appendix 1 for consideration by the IPPC committee.
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2012												December		
	January	February	March	April	May	June	July	August	September	October	November			
9001	Maghtab Waste Management Complex (inc. Zwejra and Ghallis)			Key process identification	Build & draft Systems Manual	(1) Drafting, Implementation and fine tuning of procedures (2) Training of Employees						Internal Audits	Management review	Certification
14001	Maghtab Waste Management Complex (inc. Zwejra and Ghallis)	Key process identification			(1) Drafting, Implementation and fine tuning of procedures (2) Training of Employees						Internal Audits	Management review	Certification	

APPENDIX 1

Clarifications on Consolidated Environmental Monitoring Programme

Monitoring	Assessment of proposal	Further submissions/clarifications required	Adi Associates comments
Landfill gas surface emissions	<p>Parameters proposed are more appropriate to landfill gas monitoring, frequency and methodology takes into account whether landfill has been capped.</p> <p>However, recommendations in Annex III of Directive 1999/31/EC regarding meteorological monitoring are not all included.</p> <p>Monitoring of H₂ as per Annex III of Directive 1999/31/EC is not included.</p> <p>Acceptable, subject to at least weekly monitoring of wind direction and force, evaporation and atmospheric humidity, and at least monthly monitoring of H₂.</p>	<ol style="list-style-type: none"> 1. Section 3.19 includes measurements of CO. Table 3.1 to be updated accordingly. 2. Fig 3.1 to be updated with borehole labelling. 3. Additional meteorological monitoring to be included. 4. Monitoring of H₂ to be included. 	<ol style="list-style-type: none"> 1. CO added to table 2. This has been updated. 3. Included in para 3.19 and updated Table 3.1 4. Included in para 3.19.

Monitoring	Assessment of proposal	Further submissions/clarifications required	Adi Associates comments
Gas flare	Acceptable.	Input the contents of Table 7.2.1.3 in the final monitoring programme, since the existing permit and reference will be superseded upon renewal.	No further changes required.
Ambient air	Same sensitive receptors as Ghallis. Acceptable.	Note: This data is to be reported in both the Żwejra and Ghallis AERs.	No further changes required.
Odour	Goes beyond existing permit. Acceptable.		No further changes required.
Leachate	Goes beyond existing permit. Acceptable.		No further changes required.
Groundwater	Location of samples and measurement are risk-based, however only 1 of the 4 points is downstream of landfill. Acceptable, subject to inclusion of an additional monitoring point downstream of the landfill (this may replace one of the perpendicular sampling points).	Updating of sampling points. Note: Data from co-located monitoring points is to be reported in both the Żwejra and Ghallis AERs.	Another sampling point added.

Monitoring	Assessment of proposal	Further submissions/clarifications required	Adi Associates comments
Surface water	Location of samples and measurement are risk-based and linked to groundwater monitoring. Acceptable.		No further changes required.

Monitoring	Assessment of proposal	Further submissions/clarifications required	Adi Associates comments
<p>Coastal water and sediment</p>	<p>Impact from Żwejra is expected to be adequately assessed through this monitoring. However, dioxins/furans are to be included, in line with the approved Ghallis monitoring programme, and some other parameters in view of new Water Framework Directive Obligations.</p> <p>Acceptable, subject to the following changes:</p> <p>(1) Inclusion of dioxins/furans (PCDDs/PCDFs) monitoring in sediment and water.</p> <p>(2) Inclusion of brominated diphenylether, C10-C13 chloroalkanes, DEHP (di(2-ethylhexyl)-phthalate), fluoranthene, pentachlorobenzene and five PAHs in sediment (as per Directive 2008/105/EC, Annex I).</p> <p>(2) Addition of Qalet Marku as a monitoring point (this can be carried out instead of point D; the interpretation of the results from this point can also take into account input from agricultural sources).</p> <p>(3) Inclusion of the updated monitoring points on a close-up map of the area, including coordinates, superimposed on main water catchment of the area.</p> <p>Additional notes:</p> <p>(1) Annual sediment monitoring is sufficient, to be carried out in the same time of year if annual.</p> <p>(2) Quarterly water analysis is sufficient.</p> <p>(3) Agreed with inclusion of recommended physico-chemical parameters.</p>	<p>Proposal to be updated accordingly.</p> <p>Note: This data is to be reported in both the Żwejra and Ghallis AERs.</p>	<ol style="list-style-type: none"> 1. Dioxins and furans added in Tables 9.1, 9.3 and 9.4. 2. Included in Table 9.1. 3. Moving Station D to Qalet Marku is not advisable as this means that only one reference site (Station C) will be left outside the potential influence of the Landfill. Consequently, if there will some problem at Station C, it will not be possible to compare the results obtained from Stations A, B and C to an alternative reference site. The supporting rationale for this may be found in Underwood A. J. (1997), Experiments in Ecology, Cambridge University Press. If the MEPA require monitoring inside Qalet Marku, this should be achieved by adding a monitoring station at that site. For this reason we are proposing a fifth station, Station E (refer to updated Figure 9.1).

Monitoring	Assessment of proposal	Further submissions/clarifications required	Adi Associates comments
Noise	<p>Same sensitive receptors; however Coastline has been excluded due to current levels (baseline) being above limit value in permit. Current practice is to issue limit values of 5 dB above background and the IPPC permit will be revised accordingly.</p> <p>Acceptable, subject to inclusion of Coastline monitoring point.</p>	Proposal to be updated accordingly.	Coastline has been included as a monitoring point.

**Ta' Zwejra Non-Hazardous Engineered Waste Facility
I/o Maghtab, Maghtab**

IPPC Permit Application: IP0001/05

Monitoring Plan for the Non-Hazardous Waste Landfill at Ta' Zwejra

Version 3: April 2012

adi
ASSOCIATES
ENVIRONMENTAL
CONSULTANTS



Report Reference:

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

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Quality Assurance

IP0001/05 - Ta' Zwejra Non-Hazardous Engineered Waste Facility Monitoring Plan April 2012

Report for: Wasteserv Ltd

Revision Schedule

Rev	Date	Details	Report authored by:	Checked by:	Approved by:
00	April 2011	Submission to client	Dr Patrick Collison Consultant	Krista Farrugia Consultant	Rachel Xuereb Director
1.0	June 2011	Submission to client	Dr Patrick Collison	Krista Farrugia	Rachel Xuereb
2.0	April 2012	Submission to MEPA	Dr Patrick Collison	Krista Farrugia	Rachel Xuereb

File ref: G:\ADI\Monitoring (post-decision)\Ta' Zwejra Monitoring Plan\Adi Associates Monitoring Report Ta Zwejra_3.doc



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adi
ASSOCIATES
ENVIRONMENTAL
CONSULTANTS

**Kappara Business Centre
113 Triq Birkirkara
San Gwann SGN 4197**

**Tel. / Fax: 21378172 - 77 – 80
Email: info@adi-associates.com
Web: www.adi-associates.com**

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APPENDICES

Appendix I: Summary of Responses to Permit Improvement Programme

I. INTRODUCTION

- I.1. The Malta Environment and Planning Authority (MEPA) issued a permit, number IP 0001/05, under Regulation 14 of the Integrated Pollution Prevention and Control Regulations 2002 to WasteServ Malta Limited for the operation of a non-hazardous waste disposal facility at Ta' Zwejra, located adjacent to the former Maghtab landfill 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 three phases consisting of 3 hydraulically independent cells.
- I.2. Section 7 to the Permit sets out environmental monitoring requirements for different environmental media. The Improvement Programme specified in Table 3.13 to the Permit, requires the submission of a review and confirmation of a holistic environmental monitoring plan for the site, including groundwater, coastal water, gaseous emissions and ambient air quality.
- I.3. In response to the requirements of the Improvement Programme, WasteServ submitted comments, to which MEPA has responded. The submissions and current status are summarised in **Appendix I** to this report. This report addresses those general and detailed comments relating to leachate, groundwater, surface water, landfill gas and ambient air monitoring.

2. THE SITE

SITE SETTING

- 2.1. The site and its surroundings and the background conditions are described in the hydrogeological risk assessment¹ prepared on behalf of WasteServ in support of the IPPC application and from an Environmental Impact Assessment (EIA) prepared by SLR Limited² on behalf of WasteServ for the Ghallis landfill. 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 2km to the north of Naxxar and 2km east of Qawra along the northern coast of Malta. The site is located immediately to the south of a former landfill, the Maghtab landfill, a non-engineered landfill, which, it is understood, accepted a wide range of wastes.
- 2.3. The site lies to the east of the existing main access road to the former Maghtab Landfill and current Ghallis landfill. The Ta' Zwejra disposal areas were used for the disposal of all non-inert waste from Malta and Gozo following the closure of Maghtab Landfill in May 2004. The land falls to the south towards a shallow valley feature that descends in a northeasterly direction to the sea.

GEOLOGY

- 2.4. 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.
- 2.5. The geological strata are approximately horizontally bedded with a gentle regional dip to the north at between 2 and 3°. In the Ghallis EIA it is concluded that discontinuities (fractures and joints) and solution type features (karst) 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.
- 2.6. A north-south trending fault, down thrown to the east, may be present in the vicinity of the site³. Minor faults are known to be common in this area of Malta and are reported to comprise a conjugate set with a general north-south and east-west orientation.

¹ SLR Ltd Ta' Zwejra Non-hazardous Landfill Facility Hydrogeological Risk Assessment

² SLR Ltd (2005) Ghallis – EIA Version 01

³ Oil Exploration Directorate, Office of the Prime Minister (1993). Geological Map of the Maltese Islands, Sheet 1, Malta.

HYDROGEOLOGY

- 2.7. 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 locally known as the 'Mean Sea Level Aquifer', as the groundwater elevations lie just above sea level.
- 2.8. Groundwater in the Lower Coralline Limestone Formation beneath the site is shown on Drawing RA5 to the Ghallis IPPC permit application as falling from approximately 1.0m above mean sea level to the south of the site at the access, falling gently to the north to approximately 0.5m to the north of the Ta' Zwejra site.
- 2.9. As the minimum basal elevation of the proposed landfill lies at approximately 30m above sea level, a minimum unsaturated zone thickness of approximately 30m is anticipated.
- 2.10. Primary hydraulic conductivity in the range 2.4×10^{-10} to 2.27×10^{-6} m/sec and secondary hydraulic conductivity in the range 2.0×10^{-4} to 1.5×10^{-3} m/sec are suggested in the EIA.

HYDROLOGY

- 2.11. The mean rainfall for the period 1841 to 2000 is 501mm. The maximum recorded annual rainfall for the same period is reported as 1009mm and the minimum recorded annual rainfall over the same period was 224mm. The wettest month is typically December, with an average rainfall of 93.7mm. The driest month is July with an average monthly rainfall of only 0.57mm. 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 155mm and 235mm 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.
- 2.12. 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 limestone.
- 2.13. The design criteria for surface water runoff from the landfill cap are described in the Hydrogeological Risk Assessment and include peripheral infiltrating drainage ditches (swales) and soakaways to be located on the perimeter of the site. These will be designed with a capacity to attenuate runoff from the facility during 1:100 year rainfall events.

WIND SPEED AND DIRECTION

- 2.14. 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 0.5m/sec) occur for approximately 5.5% of the time.

3. LANDFILL GAS MONITORING

PERMIT REQUIREMENTS

- 3.1. Section 7.2.1 to the permit requires landfill gas surface emissions from 6 locations listed in Table 7.2.1 to the permit, namely monitoring points referenced 1, 2, 3, 5, 9 and 11 shown on Drawing ZW014/004 submitted with the permit application.
- 3.2. Table 7.2.1.3 to the permit specifies the parameters to be monitored and the air emission limits. The parameters include particulate matter, VOCs as TOC, hydrogen chloride, carbon monoxide, sulphur dioxide, oxides of nitrogen, ammonia, nitrous oxide, PCBs and dioxin/furans. Although methane would be included in VOCs, it is not singled out as a monitoring parameter although it does comprise the largest component of landfill gas; nor is carbon dioxide, the second largest component. It appears that the range of parameters for on site emissions monitoring is taken from Section 1.3 and Table 2 to the Gas Risk Assessment (GRA) submitted with the IPPC application. In fact that monitoring is proposed for emissions from the gas treatment plant (flare) and is appropriate for combustion products arising from landfill gas flaring and is not designed for fugitive emissions from the landfill surface (see Section 4.1.1).
- 3.3. There are no specific permit requirements for landfill gas monitoring in boreholes external to the landfill. Paragraph 7.2.1.8 refers to “other kinds of monitoring” and Table 7.2.1.8 refers to Page 69, 12.3.3 Perimeter Gas Monitoring, which is a reference to the Site Management System document, submitted with the IPPC application. However, that document does not provide locations for gas monitoring boreholes.
- 3.4. Table 3.13, Improvement Programme Requirements, Item 13, requires a contingency plan related to landfill gas monitoring to be submitted.

CURRENT MONITORING REGIME

- 3.5. The concentration of methane, carbon dioxide, oxygen, hydrogen sulphide and carbon monoxide have been measured approximately weekly at sampling points 1 to 10 (shown on drawing ZW014.004) for the period from December 2006 to date. Monitoring is carried out using a portable gas analyser, as described in Section 3.4.4 to the GRA.
- 3.6. From February 2008, the same parameters have been measured at monitoring points Z2, Z3, ZE1, ZE2, Z1A and Z1B. The latter series of monitoring points are leachate collection chambers.
- 3.7. There are no landfill gas monitoring boreholes outside the site specifically installed for the Ta' Zwejra landfill, although they are included in the monitoring regime for the Ghallis landfill⁴.

⁴ ADI Associates environmental consultants Ltd (2010). “Monitoring Plan for the Non-hazardous Waste Landfill at Ghallis”.

UK GUIDANCE

- 3.8. Following implementation of the Landfill Directive, guidance in the UK, TGN03⁵ 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; and
 - Direct release of combustion products to atmosphere, e.g. enclosed flares and engines.
- 3.9. The guidance describes how any landfill is likely to have a variety of potential release points and fugitive emissions related to landfill gas. For Ta' Zwejra landfill, direct release to atmosphere will be possible until capping is completed, 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 must be considered. Direct release of combustion products at the Ta' Zwejra landfill will not currently occur as no landfill gas combustion currently takes place, although there is provision for flaring in the future.
- 3.10. 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.

⁵ Environment Agency (2003). "Guidance on the Management of Landfill Gas" TGN03.

3.11. The relative importance of each of these will vary on a site-specific basis. For the Ta' Zwejra landfill, deposited waste is likely to be a source of landfill gas until final capping is complete. There are currently no active leachate or gas treatment plants, flare stacks or utilisation plants. The potential for intermittent emissions during installation of gas well drilling is recognised.

3.12. 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.

3.13. Further guidance⁶ states:

Monitoring will not normally proceed to the quantitative flux survey until a systematic walkover survey demonstrates that the concentration of methane 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 such as a leachate well or wellhead.

3.14. 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 where there is no cap. Under these conditions the principle objective is to minimise odour emissions.

3.15. Guidance on the management of landfill gas was provided in the UK in Waste Management Paper 27⁷ (WMP27). 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. Following implementation of the Landfill Directive TGN03⁸ updated WMP27. TGN03 suggests that for fissure or fracture flow dominated permeable strata with development within 250 metres, the maximum spacing should be 50m.

3.16. 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

⁶ Environment Agency (2004). Guidance on Monitoring Landfill Gas Surface Emissions". LFGN 07.

⁷ Department of the Environment (1996). Landfill Gas". Waste Management Paper 27, Fourth impression.

⁸ Environment Agency (2003). "Guidance on the Management of Landfill Gas" TGN03.

of carbon dioxide never exceeds 1.5% by volume. TGN03 qualifies the guidance relating to trigger levels, to 1% methane and 1.5% carbon dioxide above background concentrations in monitoring boreholes. 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.

PROPOSED LANDFILL GAS MONITORING STRATEGY ON AND WITHIN THE LANDFILL

- 3.17. Consolidated monitoring proposals to reflect the permit requirements and current guidance are given in **Table 3.1**. The monitoring proposals closely reflect the requirements of the permit. However, it is considered that some amendments are appropriate, as discussed below.
- 3.18. Landfill gas surface emissions at monitoring locations 1, 2, 3, 5 and 9 are considered appropriate for monitoring landfill gas surface emissions from the landfill (see **Figure 3.1**). Location 11 is considered appropriate for monitoring background ground level concentrations in air as it is located upwind during the majority of meteorological conditions. Monitoring at locations 4, 6, 7 and 8, as currently carried out, is considered appropriate for monitoring of surface emissions on the former Maghtab landfill, but should not be reported within the results for Ta' Zwejra. Monitoring surface emissions at location 10 is unlikely to be of relevance as it is beyond the landfill boundary.
- 3.19. It is considered that measurement of methane, carbon dioxide, oxygen, hydrogen sulphide and carbon monoxide by portable instrument, as currently used, is appropriate as an indicator of landfill gas surface emissions. Monthly monitoring of hydrogen will also be carried out. It is considered that the measurement of particulate matter, VOCs and hydrogen chloride are not appropriate for monitoring landfill gas surface emissions. Weekly monitoring of wind direction and force, evaporation and atmospheric humidity will also be undertaken.
- 3.20. 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 **Chapter 4**).
- 3.21. 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.
- 3.22. It is recommended that monitoring of methane, carbon dioxide, oxygen, hydrogen sulphide and carbon monoxide in leachate chambers reference Z1, Z2, Z3, Z4, Z5, and Z6 is appropriate, as it allows an assessment of landfill gas production at source. Leachate monitoring points are shown in **Figure 6.1**.

Table 3.1: Proposed landfill gas monitoring regime

Landfill Gas Monitoring				
Monitoring location	Measured Parameters	Frequency	Instrument type	Assessment levels
Landfill gas surface emission points 1, 2, 3, 5, 9 and 11 (Operational phase)	CH ₄ , CO ₂ , O ₂ , CO, H ₂ S. Meteorological data (i) General surface type and condition	Weekly	Portable Infra-Red gas analyser	Not applicable
Capped areas	CH ₄ flux (vi)	Annually (v)	Flux box/FID	Permanently capped zone: 0.001 mg/m ² /s Temporarily capped zone: 0.1 mg/m ² /s
Leachate monitoring points Z1, Z2, Z3, Z4, Z5 and Z6 (see Figure 6.1)	CH ₄ , CO ₂ , O ₂ , H ₂ S Meteorological data (i)	Monthly	Portable Infra-Red gas analyser	1.0% O ₂ , 0.1% CO.
Gas samples from one leachate monitoring point and one gas monitoring borehole	Detailed gas composition and priority trace components	Bi-annually	Gresham Tube/Tedlar bag and laboratory GCMS for bulk gases. Solid sorbants for priority trace components (iii)	Not applicable
Landfill gas and groundwater monitoring boreholes (see Figure 3.1)	CH ₄ , CO ₂ , O ₂ , flux, differential pressure, flow. Meteorological data (i)	Monthly	Portable Infra-Red gas analyser	1% CH ₄ , 1.5% CO ₂ above background (ii)

Notes:

- (i) Meteorological data includes wind direction and force, evaporation and atmospheric humidity atmospheric pressure, temperature and rainfall, measured at site office.
- (ii) Background level to be measured in boreholes and 2130.
- (iii) In accordance with methodology in LFTGN04.
- (iv) In accordance with LLFGN07.
- (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.

PROPOSED PERIMETER LANDFILL GAS MONITORING STRATEGY

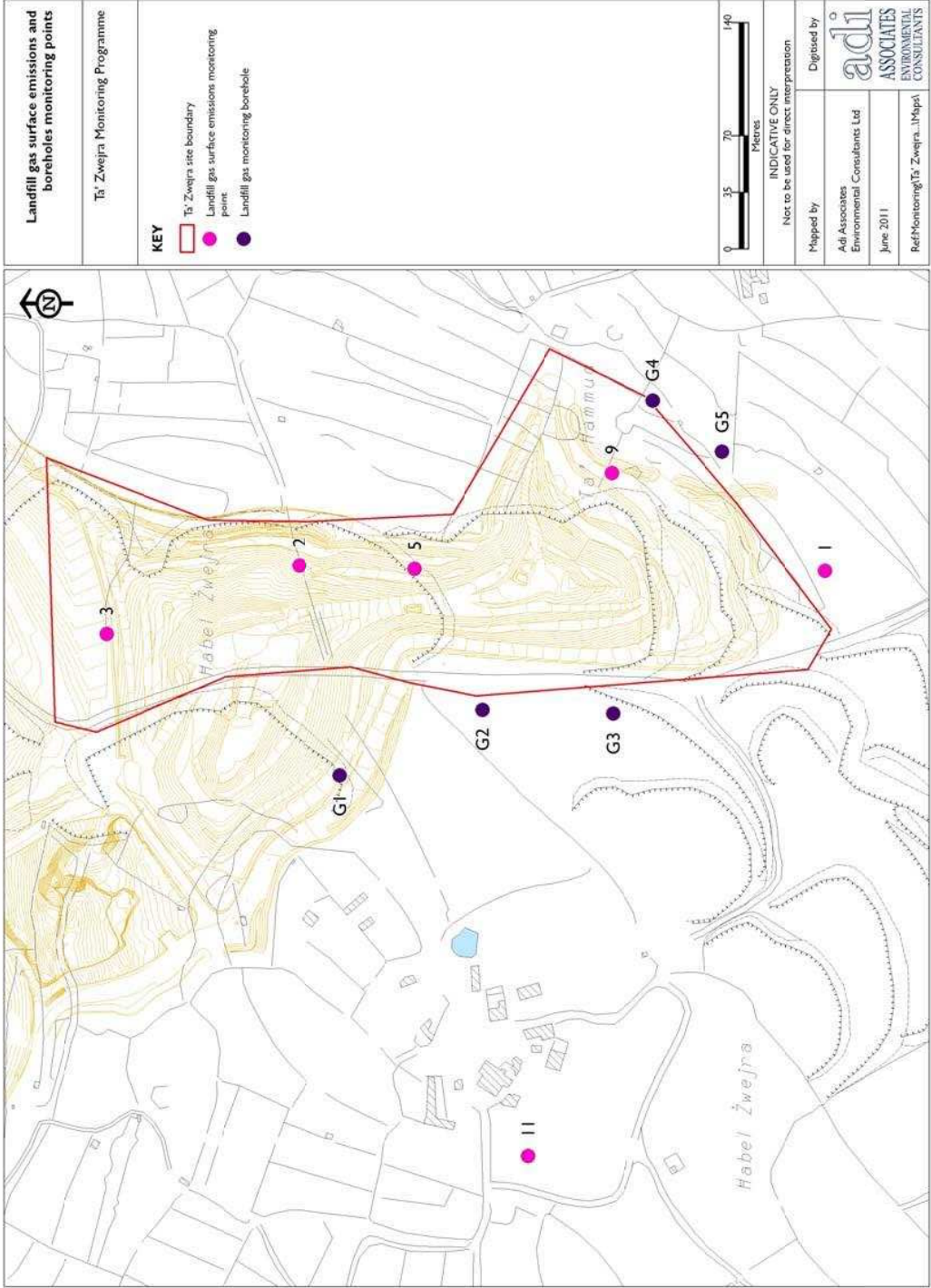
- 3.23. There is one isolated property adjacent to the western boundary of the site within 250m. There are currently no landfill gas monitoring boreholes between the site and the property, although agricultural borehole 2130 is located at a similar distance from the landfill as the property, and is included in the landfill gas monitoring regime for Ghallis landfill. Groundwater monitoring borehole MBH2 shown on Drawing ZVW008/004 lies close the landfill boundary between the site and the property, and it is recommended that the accessibility and construction details be investigated to assess the suitability of this borehole for monitoring landfill gas. In the event that MBH2 is inaccessible or its construction is unsuitable for monitoring landfill gas, it is recommended that a replacement borehole be installed at or close to that location. It is also recommended that one borehole in addition to those proposed be installed approximately 50m to the south of that location to bring the spacing in line with guidance (see **Figure 3.1**). There is also an isolated property to the south east of the site. It is recommended that two boreholes be installed along the south eastern boundary at approximately 50m spacing to monitor for landfill gas at the locations shown on **Figure 3.1**.
- 3.24. It is recommended that background concentrations for methane and carbon dioxide be taken as those found in groundwater monitoring borehole 2604, which is situated on the Lower Coralline Limestone and borehole 2013 situated on the Globigerina Limestone, both of which are remote from the landfill (subject to the construction being suitable for, or capable of modification for, landfill gas monitoring).
- 3.25. Consolidated monitoring proposals to reflect the permit requirements and current guidance are given in **Table 3.1**.

CONTINGENCY PLAN

- 3.26. The following protocol is proposed should methane concentrations exceeding 1% (v/v) and / or carbon dioxide exceeding 1.5% (v/v) be recorded in any groundwater or landfill gas monitoring borehole:
- Assess the concentrations of carbon dioxide and methane against background concentrations in boreholes 2041 and 2130;
 - If concentrations greater than 1% methane or 1.5% carbon dioxide (v/v), but not greater than background, are recorded findings to be reported to MEPA;
 - If concentrations above 1% methane and 1.5% carbon dioxide greater than background are recorded, findings to be reported to MEPA (via fax, phone or e-mail) immediately and confirmed in writing within 3 working days;
 - Increase monitoring of affected and immediately adjacent boreholes to daily;
 - 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 5000ppm (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 8,000ppm (16% LEL) ventilation will be increased in affected confined spaces and ignition sources isolated. If the methane concentration in any service or property exceeds 10,000ppm (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; and
 - 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;
- 3.27. In the event that the carbon monoxide concentration in any leachate monitoring chamber exceeds the assessment level of 0.1% (100ppm), 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.
- 3.28. In the event that the oxygen concentration in any leachate monitoring chamber exceeds the assessment level of 1%, the landfill gas extraction system (when installed and operational) 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 3.1: Landfill gas surface emissions and boreholes monitoring points



4. AIR EMISSIONS MONITORING

PERMIT REQUIREMENTS

- 4.1. Section 7.2.5, Fugitive Emissions to Air, specifies particulate monitoring at the monitoring points set out in Table 7.2.1.3. The same table lays down parameters and monitoring requirements for air emissions. However, the monitoring points specified are monitoring points for landfill gas surface emissions. As discussed in **Chapter 3**, above, the monitoring parameters specified were proposed in the gas risk assessment for emissions from gas treatment plant and are appropriate for combustion products arising from landfill gas flaring or engines used for the generation of electricity from landfill gas. The monitoring parameters are not appropriate to monitoring points 1, 2, 3, 5, 9 and 11 specified in table 7.2.1 and 7.2.1.3.
- 4.2. Section 7.2.5.3.2 makes reference to off-site monitoring sites to be set up by the operators and states that these shall consist of sensitive receptors in the immediate vicinity (hotels, residences, and tourist resorts).

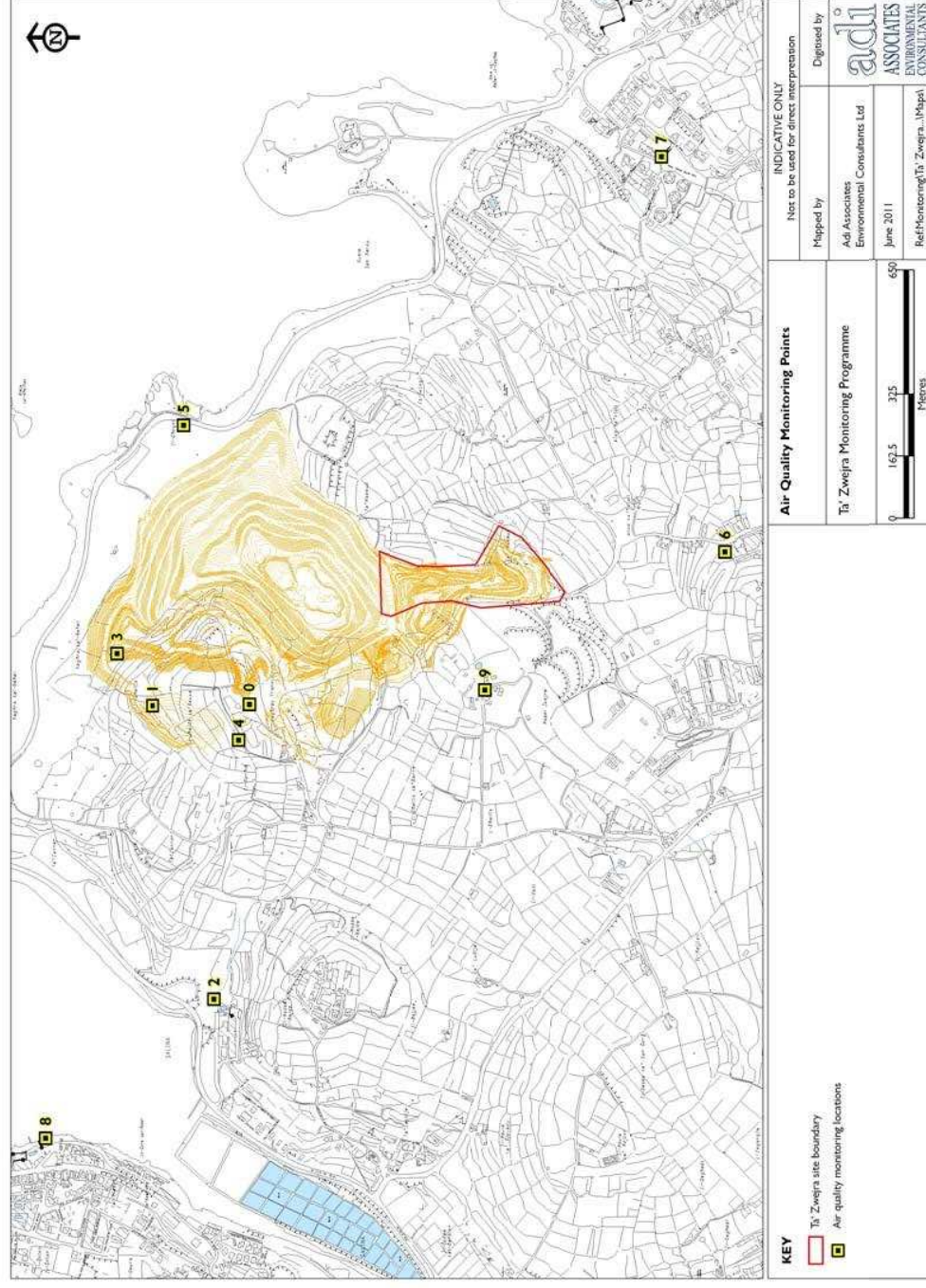
PROPOSED MONITORING STRATEGY

- 4.3. In the event that landfill gas flares and engines are utilised, it is recommended that routine monitoring of the parameters set out in Table 7.2.1.3 at emission sources (e.g. flares or engine exhausts).
- 4.4. Section 3.16 to Permit IP0001/06 for the Ghallis non-hazardous landfill located to the north of the Ta' Zwejra site requires the establishment of off-site monitoring sites for air quality at 6 air monitoring locations, which are at sensitive environmental receptors such as residences, hotels and tourist resorts. Due to the close proximity of the Ta' Zwejra site to both the Ghallis and Maghtab landfills, the sensitive receptors are the same. It is therefore considered that the air emissions monitoring programme put forward to satisfy the conditions of the Ghallis permit is appropriate for the Ta' Zwejra landfill. These monitoring points are shown in **Figure 4.1**.

CONTINGENCY PLAN

- 4.5. In the event of discernible increase in pollutant levels at any of the off-site air monitoring locations, further investigation will be required to identify the source of pollutants. Because of the proximity of and intimate relationship between the Ta' Zwejra, Ghallis and Maghtab landfills, including shared gas collection infrastructure, it is recommended that a list of likely emission points be compiled. This list will include such points as landfill gas flares, engines, infrastructure (pipework and manifolds) and earthworks. It is recommended that this list be updated regularly to recognise changes to the system and operations such as maintenance and extension to gas collection infrastructure and earthworks on site (e.g. capping).

Figure 4.1 : Air quality monitoring points



5. ODOUR MONITORING

PERMIT REQUIREMENTS

- 5.1. Table 7.2.8 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. Table 3.13 to the Permit (Improvement Programme Requirements) requires the submission of odour monitoring point locations.
- 5.3. 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 the Authority.

UK GUIDANCE

- 5.4. UK Environment Agency guidance⁹ 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.
- 5.5. 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.

PROPOSED MONITORING PROGRAMME

- 5.6. 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.
- 5.7. It is proposed, therefore, that routine monitoring be 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

⁹ Environment Agency (2002) “Technical Guidance for the Regulation of Odour at Waste Management Facilities”.

- that of other people). A suitable member of staff would be, for instance, one who normally works at the site office or weighbridge.
- 5.8. The person responsible for routine monitoring will determine the wind direction initially from the site meteorological station. He/she 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.
 - 5.9. The monitoring personnel will proceed to the landfill boundary downstream of the site and repeat the exercise, moving along the site boundary, such that the 150m of the boundary downwind and either side of the operational area is traversed.
 - 5.10. The monitoring personnel will then move 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) will be recorded.
 - 5.11. 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.
 - 5.12. The proposed monitoring protocol is summarised in **Table 5.1**.

Table 5.1: Proposed odour monitoring programme

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	Methane	On detection of discernible odour or complaint	FID	Not applicable

CONTINGENCY PLAN

- 5.13. 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.
- 5.14. A common source of odours on landfills is landfill gas. 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.
- 5.15. 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 Maghtab 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; and
- 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 at the site.

6. LEACHATE MONITORING

PERMIT REQUIREMENTS

- 6.1. There are no specific permit requirements for leachate monitoring. However, the Management Plan and application document make reference to leachate monitoring specifications in accordance with section 1.1.6 of the application document. This, in turn makes reference to Drawing ZW008/04 and ZW009/04.

GUIDANCE

- 6.2. The UK Environment Agency issued guidance on monitoring leachate, groundwater and surface water in 2003¹⁰ 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.
- 6.3. 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.
- 6.4. 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 lesser frequency than for the indicator parameters.
- 6.5. 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.
- 6.6. 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.
- 6.7. 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

¹⁰ Environment Agency (2003). "Guidance on Monitoring of Landfill Leachate, Groundwater and Surface Water".

- 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.
- 6.8. 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.
- 6.9. 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.
- 6.10. 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.

PROPOSED MONITORING PROGRAMME

- 6.11. A leachate monitoring programme is proposed in **Table 6.1** and proposed monitoring points are shown in **Figure 6.1**. This 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.
- 6.12. Control and Trigger levels are proposed in **Table 6.2** and **Table 6.3**, 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 UK¹¹.

¹¹ Robinson H (1995). A Review of the Composition of Leachates from Domestic Wastes in Landfill Sites". DoE. Report CWM/072/95

Table 6.1: Proposed leachate monitoring programme

Leachate Monitoring Points Z2, Z3, ZE1, ZE2, Z1A and Z1B				
Determinand	Indicator Monitoring	Characterisation Monitoring	Control level	Trigger Level
	Frequency (months)			
Water Level ¹²	3		0.80m	1.0m
Conductivity ¹³	3			
pH	3			
TOC	3			
NH ₃ -N	3		260mg/l	1000mg/l
Cl ⁻	3		1000mg/l	5000mg/l
F ⁻		12		
Fe		12		
SO ₄		12		
Na		12		
K		12		
Mg		12		
Ca		12		
As	3		0.004mg/l	0.4mg/l
Ba		12		
Cd	3		0.0002mg/l	0.02mg/l
Cr	3		0.09mg/l	0.4mg/l
Cu	3		0.05mg/l	0.1mg/l
Hg		12		
Mo		12		
Ni	3		0.2mg/l	0.6mg/l
Pb	3		0.1mg/l	0.3mg/l
Sb		12		
Se		12		
Zn		12		
List I Screen		12		
Naphthalene	3		0.05mg/l	5mg/l
Toluene	3		0.8mg/l	1.2mg/l

¹² Leachate collection points and leachate monitoring points

¹³ Leachate quality monitoring in leachate collection points (LMP) only

Table 6.2: Proposed groundwater monitoring programme

Groundwater Monitoring Points MBH1, MBH3, BH4 & 2130				
Determinand	Indicator Monitoring	Characterisation Monitoring	Control level	Trigger Level
	Frequency (months)			
Water Level	3			
Conductivity	3			
pH	3			
TOC	3			
NH ₃ -N	3		0.36mg/l	0.39mg/l
Cl ⁻	3		N/A	N/A
F ⁻		3 ¹⁴ (12)		
Fe		3 (12)		
SO ₄		3 (12)		
Na		3 (12)		
K		3 (12)		
Mg		3 (12)		
Ca		3 (12)		
As	3		0.002mg/l	0.01mg/l
Ba		3 (12)		
Cd	3		N/A	0.1µg/l
Cr	3		0.01mg/l	0.05mg/l
Cu	3		0.018	2.0mg/l
Hg		3 (12)		
Mo		3 (12)		
Ni	3		0.005mg/l	0.02mg/l
Pb	3		0.009mg/l	0.01mg/l
Sb		3 (12)		
Se		3 (12)		
Zn		3 (12)		
List I Screen		12		
Naphthalene	3		N/A	0.01µg/l
Toluene	3		N/A	4.0µg/l

¹⁴ 3 monthly for the first year, then every 12 months

Table 6.3: Proposed surface water monitoring programme

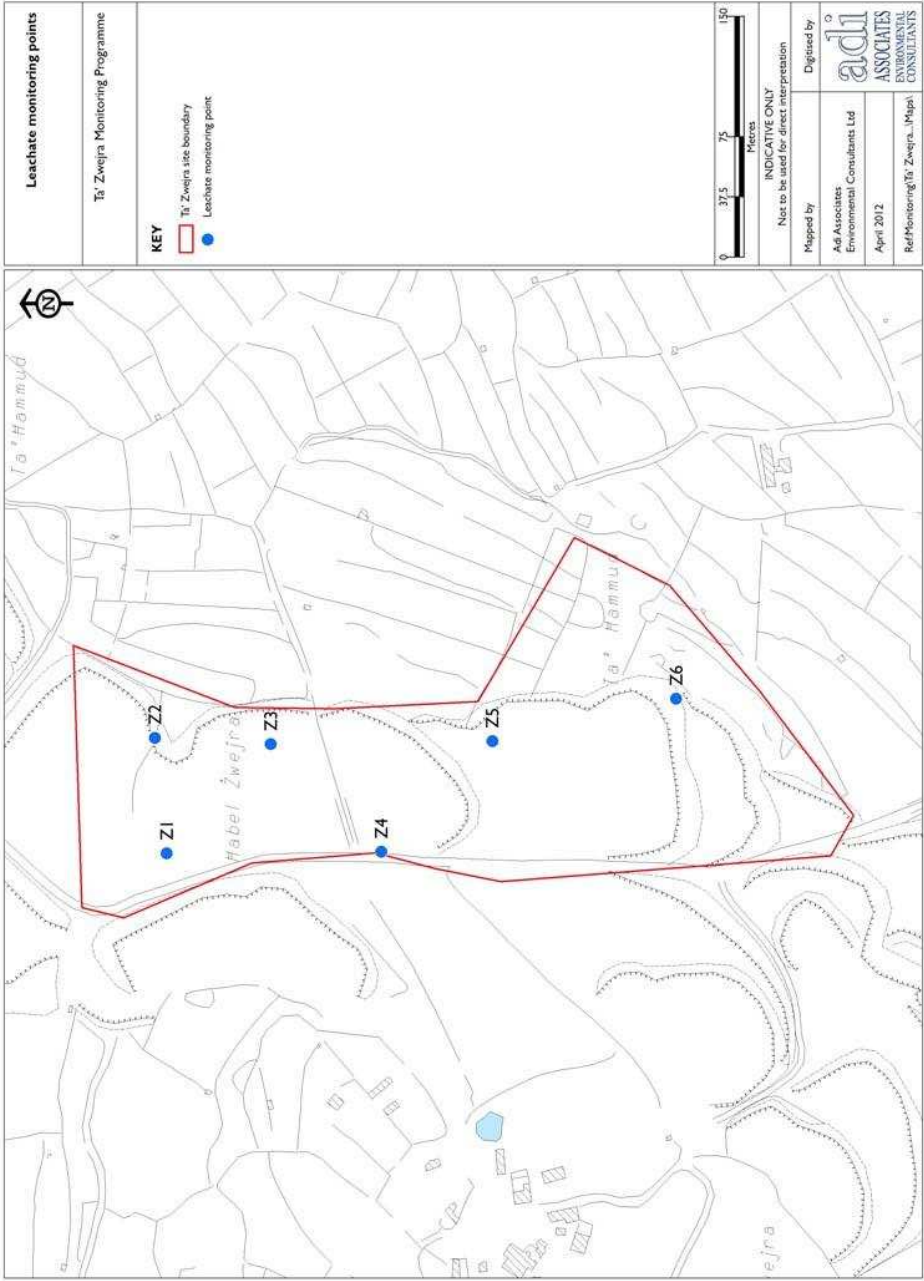
Surface Water Monitoring Points SW1, SW2 and SW3				
Determinand	Indicator Monitoring	Characterisation Monitoring	Control level	Trigger Level
	Frequency (months)			
Water Level	3		N/A	N/A
Conductivity	3			
pH	3			
TOC	3			
NH ₃ -N	3		0.36mg/l	0.39mg/l
Cl ⁻	3		N/A	N/A
F ⁻		3 ¹⁵ (12)		
Fe		3 (12)		
SO ₄		3 (12)		
Na		3 (12)		
K		3 (12)		
Mg		3 (12)		
Ca		3 (12)		
As	3		0.002mg/l	0.01mg/l
Ba		3 (12)		
Cd	3		N/A	0.1µg/l
Cr	3		0.01mg/l	0.05mg/l
Cu	3		0.018	2.0mg/l
Hg		3 (12)		
Mo		3 (12)		
Ni	3		0.005mg/l	0.02mg/l
Pb	3		0.009mg/l	0.01mg/l
Sb		3 (12)		
Se		3 (12)		
Zn		3 (12)		
List I Screen		12		
Naphthalene	3		N/A	0.01µg/l
Toluene	3		N/A	4.0µg/l

¹⁵ 3 monthly for the first year, then every 12 months

CONTINGENCY PLAN

- 6.13. 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; and
 - iv. Increase monitoring frequency to monthly from quarterly to establish if the actions undertaken lead to a stabilisation of leachate chemistry, or decline in upward trend in the concentration of the affected parameters.
- 6.14. 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; and
 - 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 6.1: Leachate monitoring points



7. GROUNDWATER MONITORING

PERMIT REQUIREMENTS

- 7.1. Table 7.2.4.3 the permit requires that the operator carries out monitoring at 9 points identified on Drawing ZW008/004. Table 7.2.4.3 specifies the parameters to be monitored and the accuracy (limit of detection). The frequency is specified as quarterly for all parameters. Table 7.2.4.4 specifies the trigger levels for 9 parameters.

CURRENT MONITORING REGIME

- 7.2. Groundwater monitoring has been carried out in 5 boreholes, HBH1, MBH3, MBH4, MBH5 and MBH6 intermittently through the period 2005 to 2009.
- 7.3. Borehole MBH1 lies to the south of the site, upstream of the site anticipated from the hydrogeological risk assessment carried out for the Ghallis landfill.
- 7.4. MBH3 lies to the north east of Ta' Zwejra Cell I, and is anticipated to be downstream of the site, although in close proximity to the south eastern flank of the former Maghtab landfill.
- 7.5. MBH4 and MBH5 lie further to the north east than MBH3 and, although anticipated to be downstream of the Ta' Zwejra landfill, also lie downstream and closer to the former Maghtab landfill and closer to the current Ghallis landfill. It is likely, therefore, that it would be difficult to distinguish changes in groundwater quality in MBH4 and MBH5 resulting from Ta' Zwejra engineered landfill and the former Maghtab uncontained landfill. MBH5 is incorporated into the monitoring regime for the Ghallis landfill.
- 7.6. MBH6 lies to the north west of the site, perpendicular to the anticipated groundwater flow beneath the site and approximately 650m from the site boundary. Given the distance and direction from the site, it is considered that this borehole will not provide good and timely data for changes in groundwater quality arising from the Ta' Zwejra landfill.
- 7.7. The parameters tested for are in compliance with the requirements of Table 7.2.4.3, although ammoniacal nitrogen, naphthalene and toluene have only been included in the more recent sampling exercises.
- 7.8. There are other boreholes in proximity to the site that are not incorporated into the monitoring regime for the Ta' Zwejra landfill, but are incorporated into the monitoring regime for the Ghallis landfill, these include 2130, an agricultural borehole on the western boundary of the site and BH4 located to the south of the hazardous waste cell, in a similar orientation to the site as MBH6, but significantly closer at approximately 200m distance.

BACKGROUND GROUNDWATER QUALITY

- 7.9. Groundwater monitoring results for boreholes MBH1, 3, 4, 5 and 6 for the period 2005 to 2009 show saline or brackish conditions, although apparently variable. An example of the extreme variability is provided by the results for MBH1, where chloride concentration varies from 3mg/l in August 2008 to 15120mg/l in February 2005. A similar range is found in borehole MBH3 (0.18mg/l in March 2009 to 22,000mg/l in August 2006) and MBH 6 (20mg/l in August 2008 to 19100mg/l in August 2006). Interestingly, the corresponding conductivity values do not show the same variation. Given the saline nature of the aquifer, it would be expected that there would be reasonable correlation between chloride and conductivity values. No measurements are given of water level, therefore it is not possible to assess whether there were any changes in water table between those dates of extreme values in chloride which could indicate that a lower salinity lens of water had been sampled.

UK GUIDANCE

- 7.10. 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.
- 7.11. 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. The permit requires quarterly monitoring.

PROPOSED MONITORING REGIME

- 7.12. It is noted that of those boreholes monitored to date, with the exception of borehole MBH1, all other boreholes lie upstream of the site or perpendicular to flow taking into account the groundwater contours interpreted as part of the Ghallis Hydrogeological Risk Assessment and identified on Drawing RA5. MBH5 to the north east of the landfill is incorporated in the regime for Ghallis landfill, and as is likely it will be heavily influenced by saline water and possibly by the Maghtab landfill, it is recommended that this and MBH 4 be removed from the monitoring regime for Ta' Zwejra. Although borehole BH 4 and agricultural borehole 2130 are included in the monitoring regime for Ghallis, they are included as upstream boreholes for that monitoring regime and it is recommended that the results for those boreholes be reviewed when considering the impact of Ta' Zwejra, as they lie close to the site. Although the latter two boreholes lie perpendicular to the inferred groundwater flow, it must be recognised that the hydraulic gradient is very shallow and local variations are likely. In summary, it is recommended that monitoring boreholes MBH1, MBH3, 2130 and BH4 be included in the monitoring regime for Ta' Zwejra landfill. The selected groundwater monitoring points are illustrated in **Figure 7.1**.
- 7.13. It is recommended that, prior to sampling groundwater, the depth to the water surface and base of the borehole be measured and the volume of water in the borehole calculated. A minimum volume equivalent to three times that standing in the borehole will be purged, either by baler or by dedicated pump to introduce

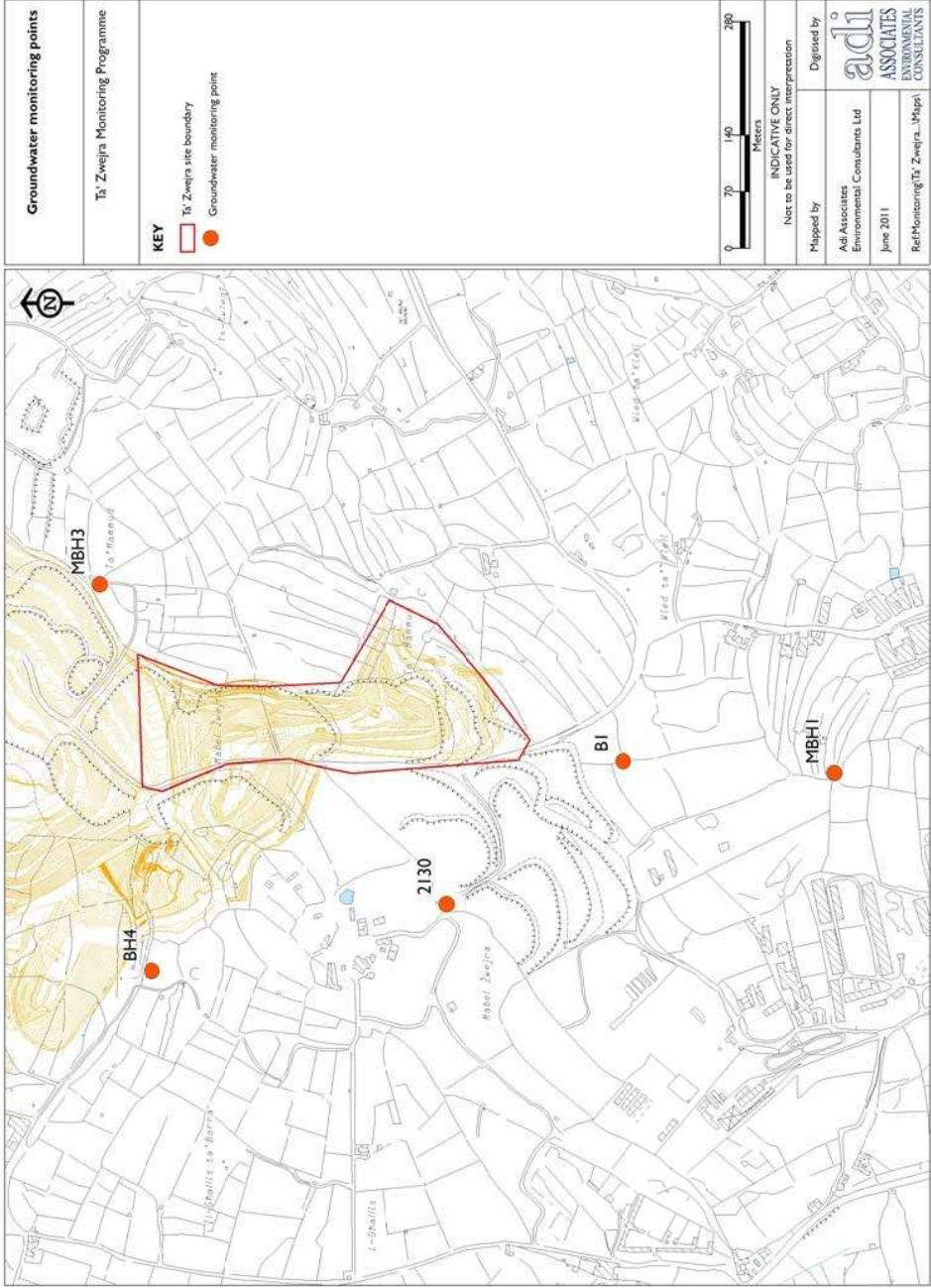
- “fresh” groundwater into the borehole. On-site parameters, such as pH, electrolytic conductivity and temperature will be measured on completion of purging and observations such as odour, colour and appearance recorded. Sample bottles and tops will be rinsed in sample water (unless pre-loaded with preservatives). Sample bottles will be filled to the top to minimise air entrapment and the cap screwed firmly on. Sample bottles will be labelled and stored in “cool boxes” for shipment to the laboratory.
- 7.14. It is proposed that initially characterisation monitoring be carried out at an interval of three months for a period of twelve months. This may be reduced to annually after a period of twelve months or when it has been established that reasonably stable conditions have been achieved. Indicator monitoring is proposed every 3 months. The list of recommended parameters is given in **Table 6.2**. The range of parameters extends beyond that specified in the Permit and is designed to reflect the leachate indicator monitoring protocol.
- 7.15. Control and Trigger levels are proposed for those parameters used in the hydrogeological risk assessment. For the List I parameters, the Trigger level is assumed to be the limit of detection (the Discernible Concentration, quoted in the Hydrogeological Risk Assessment). It is, therefore, not possible to set Control levels. 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.
- 7.16. The UK 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 EAL (or the Trigger level). Until representative groundwater quality data are obtained, from which background quality can be assessed, it is proposed that the Control level adopted be the 95 Percentile Resultant Peak Concentration at the downstream boundary determined in the Hydrogeological Risk Assessment, for those parameters modelled. It is recommended that the Control levels be re-assessed following the collection of one year’s groundwater monitoring data.

CONTINGENCY PLAN

- 7.17. 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:
- The site management and MEPA will be advised;
 - 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; and
 - vii. The monitoring frequency will be increased to monthly from quarterly to establish if the actions undertaken lead to a stabilisation of groundwater quality, or a decline in upward trend in the concentration of the affected parameters.
- 7.18. 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; and
 - 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 7.1: Groundwater monitoring points



8. SURFACE WATER MONITORING

PERMIT REQUIREMENTS

- 8.1. Item 7 and 9 of Table 3.13 to the permit requires details of system monitoring (volume, meteorological conditions and quality), number and location of points, sampling procedure and equipment, methodology and all other relevant information to be provided within 1 month of issue of permit.

UK GUIDANCE

- 8.2. Guidance for 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.

PROPOSED MONITORING REGIME

- 8.3. Given that the perimeter surface water collection system is designed to collect all run-off and there are no other surface watercourses in the vicinity of the site, surface water monitoring is proposed only on the perimeter drain.
- 8.4. 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.
- 8.5. Water samples may be collected using bailers or other transfer vessels before pouring water into sample containers. Where the water is deep enough, sample containers may be filled directly within the watercourse or pond after rinsing with sample water.
- 8.6. It is proposed that initially characterisation monitoring be carried out intervals of 3 months (or following significant rainfall if dry) for a period of twelve months. This may be reduced to annually after 12 months. Indicator monitoring is proposed every 3 months (or following significant rainfall if dry). The list of parameters is given in **Table 6.3**. The range of parameters is designed to reflect the leachate indicator monitoring protocol.
- 8.7. 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.

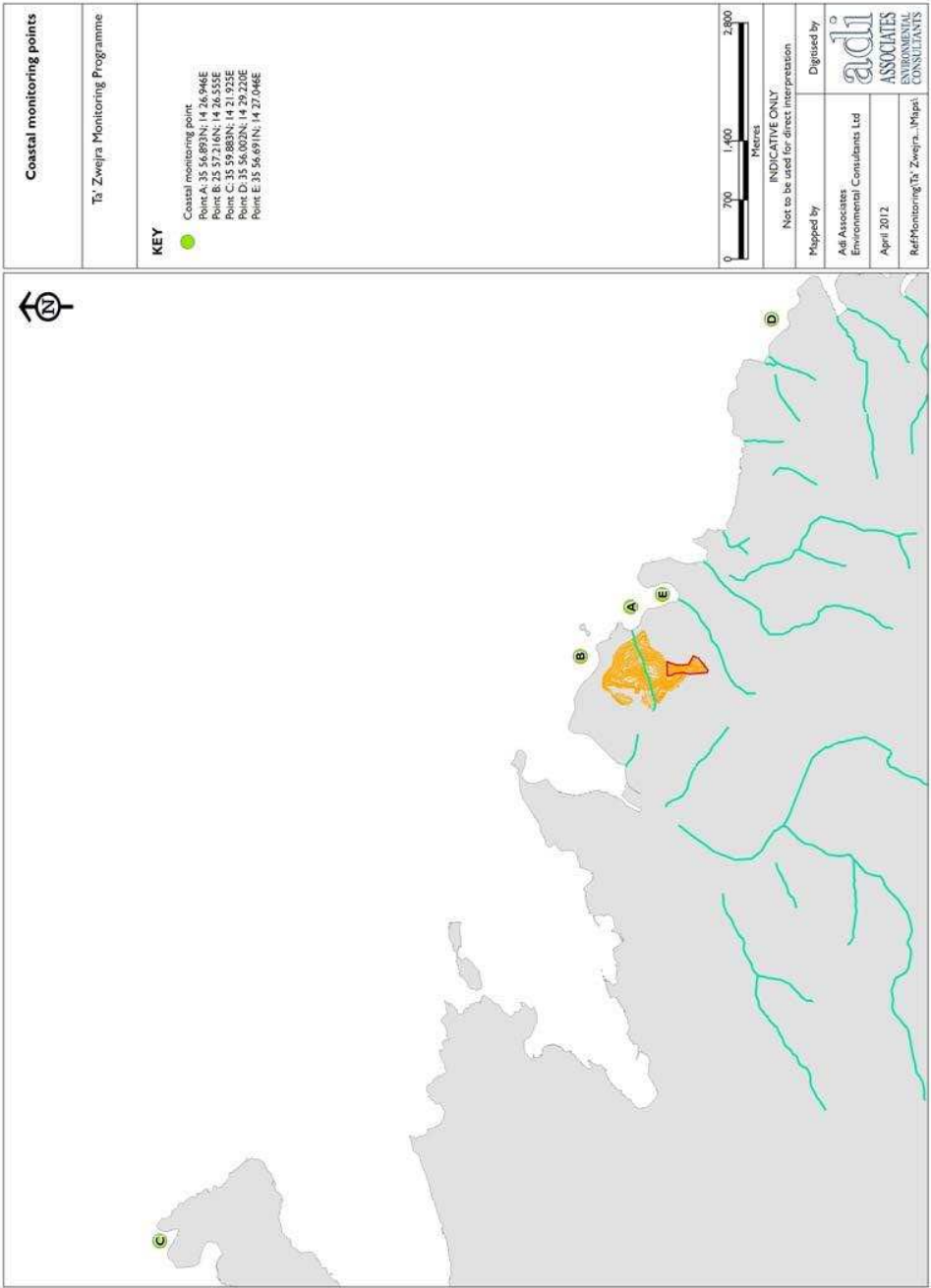
CONTINGENCY PLAN

- 8.8. 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; and
 - 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 stabilisation of groundwater quality, or a decline in upward trend in the concentration of the affected parameters.

9. COASTAL WATERS

- 9.1. As indicated above WSM is undertaking a monitoring programme for coastal waters in relation to the Ghallis Non-Hazardous Landfill. This programme includes 4 monitoring stations for sampling of water and sediments. Since the Ta' Zwejra Landfill is located in the immediate vicinity of the Ghallis landfill any runoff transporting potential pollutants from the former landfill will, as in the case of the adjacent Ghallis landfill, be expected to impact the Qalet Marku marine area. Given this, it is proposed that the same 4 monitoring stations currently used in the Ghallis Non-Hazardous Landfill monitoring programme for coastal waters be used for water and sediment sampling in relation to the current proposal for the Ta' Zwejra Landfill (see **Figure 9.1**).
- 9.2. The location of the current monitoring stations is adequate for the Ta' Zwejra Landfill particularly since two of the stations, A and B (in **Figure 9.1**), are sited in the vicinity of the waste facility and are thus well located for assessment of discharges to coastal water that may potentially originate from the landfill. Stations C and D, which are also already used as reference stations in the same Ghallis Non-Hazardous Landfill monitoring programme will also serve well as reference stations for the present Ta' Zwejra Landfill monitoring proposal. These stations may be used to collect background physico-chemical data for comparison with the putatively impacted sites (Stations A and B).
- 9.3. The collection of data from the same stations that are being monitored as part of the Ghallis monitoring programme will reduce unnecessary additional costs of sampling and analysis. Furthermore, a comprehensive data set has already been collected from the Ghallis Non-Hazardous Landfill monitoring programme, which can be used in comparative analysis and to show temporal and spatial trends, where present.
- 9.4. In summary the locations of the existing monitoring stations are appropriate for use in the Ta' Zwejra landfill monitoring programme for coastal waters, since:
- Stations A and B in the vicinity of the waste facility are located as practically close to the landfill site as possible. Locating monitoring stations in Qalet Marku should be avoided, since recent pollution studies in the area have highlighted potential contamination of the inlet by runoff originating from the agricultural activities at Maghtab.
 - The two reference stations are located in waters that are relatively free from other polluting sources.
 - Incorporating two putatively impacted stations and two reference stations will render the monitoring design sufficiently robust, while enabling rigorous statistical treatment of data, if required.

Figure 9.1: Proposed coastal monitoring points



FREQUENCY OF SAMPLING

- 9.5. It is recommended that water and sediment samples will be collected from each of the four monitoring stations at least on a quarterly basis. This will give adequate time coverage to detect potential trends in contamination.

LIST OF PARAMETERS

- 9.6. The IPPC permit gives a list of chemical parameters that should be analysed in coastal water and sediments (see **Table 9.1**). This list is quite exhaustive and includes chemical parameters listed in European and national legislation related to discharges in the marine environment. These parameters should be measured in both water and sediments, the latter being considered as 'sinks' where concentrations of potential contaminants tend to accumulate, therefore providing useful information on potential pollution patterns.
- 9.7. It is recommended that, during for the first year of monitoring, all these parameters will be included in the monitoring programme to establish a baseline against which to compare future monitoring results. In itself, the baseline study will also identify potential pollutants that may be already present and which may have originated from a different source (e.g. the Ghallis landfill).
- 9.8. Following the first year, the list of parameters can be revised, in consultation with MEPA, taking into account the results obtained from the baseline session. Another possibility would be to retain regular monitoring of groups of substances (e.g. total pesticides, total polyaromatic hydrocarbons) instead of individual chemicals within the group. In any case, it is recommended that monitoring of selected parameters be undertaken at least annually.

Table 9.1: List of chemical parameters to be included in the surface water (and sediment) monitoring (extract from IPPC permit)

Marine water	Marine sediments
Chemical Oxygen Demand (COD)	Chemical Oxygen Demand (COD)
Total Nitrogen	Total Nitrogen
Biological Oxygen Demand (BOD5)	Biological Oxygen Demand (BOD5)
Total Phosphorus	Total Phosphorus
Total Suspended Solids	Total Suspended Solids
Mercury	Mercury
Cadmium	Cadmium
Lead	Lead
Nickel	Nickel
Arsenic	Arsenic
Chromium	Chromium
Copper	Copper
Zinc	Zinc
Silver	Silver
Tin	Tin
Malathion	Malathion

Dichlorvos	Dichlorvos
Hexachlorocyclohexane	Hexachlorocyclohexane
Polychlorinated biphenyls (PCB)	Polychlorinated biphenyls (PCB)
1,2 Dichloroethane	1,2 Dichloroethane
Carbon tetrachloride	Carbon tetrachloride
Pentachlorophenol PCP	Pentachlorophenol PCP
Hexachlorobenzene HCB	Hexachlorobenzene HCB
Hexachlorobutadiene	Hexachlorobutadiene
Trichlorobenzene TCB	Trichlorobenzene TCB
Chloroform (Trichloromethane)	Chloroform (Trichloromethane)
Perchloroethylene (Tetrachloroethylene)	Perchloroethylene (Tetrachloroethylene)
Petroleum Hydrocarbons	Petroleum Hydrocarbons
Tributyltin compounds	Tributyltin compounds
Cyanides	Cyanides
Fluorides	Fluorides
Benzene	Benzene
Naphthalene	Naphthalene
Simazine	Simazine
Trifluralin	Trifluralin
Triphenyltin and its derivatives	Triphenyltin and its derivatives
Boron	Boron
Parathion	Parathion
Aldrin	Aldrin
Dieldrin	Dieldrin
Endrin	Endrin
Isodrin	Isodrin
DDT (Dichlorodiphenyltrichloroethane)	DDT (Dichlorodiphenyltrichloroethane)
Heptachlor	Heptachlor
Toxaphene (Campheclor)	Toxaphene (Campheclor)
Chlordane	Chlordane
Alachlor	Alachlor
Anthracene	Anthracene
Atrazine	Atrazine
Chlorfenvinphos	Chlorfenvinphos
Chlorpyrifos	Chlorpyrifos
Endosulfan	Endosulfan
alpha-Endosulfan	alpha-Endosulfan
Isoproturon	Isoproturon
Dioxins & Furans (PCDDs/PCDFs)	Dioxins & Furans (PCDDs/PCDFs)
	Brominated diphenylether
	C10-C13 chloroalkanes
	DEHP (di(2-ethylhexyl)-phthalate)
	Fluoranthene
	Pentachlorobenzene
	Benzo(a)pyrene
	Benzo(b)fluor-anthene
	Benzo(k)fluor-anthene
	Benzo(g,h,i)-perylene
	Indeno(1,2,3-cd)-pyrene

- 9.9. In addition to the list of chemical parameters for coastal water and sediments given in **Table 9.1**, it would also be appropriate to include other physico-chemical parameters in the monitoring programme (see **Table 9.2**), since these would provide additional useful information on coastal water and sediment quality which would aid in the interpretation of the results obtained. Some of these additional parameters are ones that are also required in monitoring carried out to satisfy the requirements of the Water Framework Directive (WFD) for monitoring in coastal waters, and include physical characteristics that would be measured in-situ (temperature, salinity, dissolved oxygen), chemical parameters indicative of organic enrichment (nitrates and phosphates) and an indicator for phytoplankton growth (chlorophyll *a*).

Table 9.2: Recommended list of physico-chemical parameters to include in the surface water and sediments monitoring programme.

Marine water	Marine sediments
<p>General parameters</p> <p>Temperature Salinity Dissolved oxygen Nitrates Phosphates Chlorophyll a</p> <p>Specific Chemical Parameters (see list in Table 9.1)</p>	<p>Granulometry</p> <p>Specific Chemical Parameters (see list in Table 9.1, excluding the parameters COD and BOD5, which would only be applicable to water samples)</p>

SAMPLING PROCEDURES

- 9.10. To monitor seawater, samples may be collected at each station from 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. At least two replicate samples should be collected from each of the two water depths at each of the four stations. Replicate measurements (at least 2) of temperature, salinity and dissolved oxygen may be recorded using an *in-situ* multi-parameter meter. For the remaining attributes, water samples (at least 2 replicates) should be collected from each identified depth using a Van Dorn sampler and transferred to polyethylene or glass containers, depending on the attribute to be measured. All water sampling should be carried out in accordance with ISO 5667-1:2006 and ISO 5667-3:2003. Sample preservation techniques should follow guidance given in ISO 5667-3:2003 for the respective attribute.
- 9.11. Sediment sampling may be carried out manually by SCUBA divers. At least two replicate samples should be collected from each monitoring station using PVC and metal corers, depending on the targeted parameter to be tested; PVC corers should be used to collect samples intended for analysis of metals, and metal corers should be used to collect samples intended for analysis of organic compounds. Sediment sampling should be carried out in accordance with ISO 5667-12:1995 and ISO 5667-19:2004. Sample preservation techniques should follow the guidance given in ISO 5667-3:2003 for the respective parameters.

ANALYTICAL METHODOLOGY

- 9.12. The water and sediment samples should be analysed according to international, European or national standard methodology. For the analysis of chemicals in seawater, the aqueous component should be reported. For the chemical analysis of sediments, bound fractions should be brought into solution by an initial process of acid extraction. The analysis should preferably be carried out by a laboratory that is

accredited according to the ISO 17025:2005 standard. 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 9.3** and **Table 9.4** below. The laboratory that will undertake the analysis should provide the details of the method 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.

Table 9.3: Analytical methodology and limits of detection to be applied for the analysis of coastal water

Parameter	Analytical Methodology	Limits of Detection for WATER analysis
Temperature	Thermistor sensor probe	- 5 to 70 °C
Salinity	Electrometry	0.01 ppt
Dissolved oxygen	ISO 5814:1990	0 - 500 % air saturation
Nitrate	ISO 7890-3:1988	0.2 mg N-NO ₃ /L
Phosphate	ISO 6878:2004	0.03 µg P-PO ₄ /L
Total suspended solids	APAT CNR IRSA 2090 Man 29 2003	2 mg/L
Chemical Oxygen Demand (COD)	APAT CNR IRSA 5130 Man 29 2003	5 mg/l
Total Nitrogen	APAT CNR IRSA 5030 Man 29 2003 + APAT CNR IRSA 4040 A I Man 29 2003 + APAT CNR IRSA 4050 Man 29 2003	0.01 mg/l
Biological Oxygen Demand (BOD ₅)	APHA Standard Methods, ed 21 th 2005, 5210 D	5 mg/l
Total Phosphorus	APAT CNR IRSA 4110 Man 29 2003	0.01 mg/l
Total Suspended Solids	APAT CNR IRSA 2090 B Man 29 2003	0.01 mg/l
Mercury	UNI EN ISO 17294-02:2005	0.05 µg/l
Cadmium	APAT CNR IRSA 3020 Man 29 2003	0.1 µg/l
Lead	APAT CNR IRSA 3020 Man 29 2003	1 µg/l
Nickel	APAT CNR IRSA 3020 Man 29 2003	1 µg/l
Arsenic	APAT CNR IRSA 3020 Man 29 2003	1 µg/l
Chromium	APAT CNR IRSA 3020 Man 29 2003	1 µg/l
Copper	APAT CNR IRSA 3020 Man 29 2003	1 µg/l
Zinc	APAT CNR IRSA 3020 Man 29 2003	1 µg/l
Silver	APAT CNR IRSA 3020 Man 29 2003	1 µg/l
Tin	APAT CNR IRSA 3020 Man	0.01 µg/l

Parameter	Analytical Methodology	Limits of Detection for WATER analysis
	29 2003	
Malathion	APAT CNR IRSA 5100 Man 29 2003	0.01 µg/l
Dichlorvos	EPA 3510C 1996 + EPA 8270D 2007	0.001 µg/l
Hexachlorocyclohexane	EPA 3510C 1996 + EPA 8270D 2007	0.001 µg/l
Polychlorinated Biphenyl (PCB)	EPA 3510C 1996 + EPA 8270D 2007	0.001 µg/l
1,2 Dichloroethane	EPA 5030C 2003 + EPA 8260C 2006	0.01 µg/l
Carbon tetrachloride	EPA 5030C 2003 + EPA 8260C 2006	0.01 µg/l
Pentachlorophenol (PCP)	APHA Standard Methods, ed 21 th 2005, 6410 B	0.001 µg/l
Hexachlorobenzene (HCB)	EPA 3510C 1996 + EPA 8270D 2007	0.001 µg/l
Hexachlorobutadiene	EPA 5030C 2003 + EPA 8260C 2006	0.01 µg/l
Trichlorobenzene (TCB)	EPA 3510C 1996 + EPA 8270D 2007	0.001 µg/l
Chloroform (Trichloromethane)	EPA 5030C 2003 + EPA 8260C 2006	0.1 µg/l
Perchloroethylene (Tetrachloroethylene)	EPA 5030C 2003 + EPA 8260C 2006	0.01 µg/l
Petroleum Hydrocarbons	APHA Standard Methods, ed 21 th 2005, 5520 F	[n-hexane] 50 µg/l
Tributyltin compounds	UNI EN ISO 17353:2006	0.01 µg/l
Cyanides	APAT CNR IRSA 4070 Man 29 2003	0.1 µg/l
Fluorides	EPA 300.1 1999	0.05 µg/l
Benzene	EPA 5030C 2003 + EPA 8260C 2006	0.01 µg/l
Naphthalene	APAT CNR IRSA 5080 Man 29 2003	0.001 µg/l
Simazine	PAT CNR IRSA 5060 Man 29 2003	0.01 µg/l
Trifluralin	EPA 3510C 1996 + EPA 8270D 2007	0.001 µg/l
Triphenyltin and its derivatives	UNI EN ISO 17353:2006	0.01 µg/l
Boron	APAT CNR IRSA 3020 Man 29 2003	1 µg/l
Parathion	APAT CNR IRSA 5100 Man 29 2003	0.01 µg/l
Aldrin	EPA 3510C 1996 + EPA 8270D 2007	0.001 µg/l
Dieldrin	EPA 3510C 1996 + EPA 8270D 2007	0.001 µg/l
Endrin	EPA 3510C 1996 + EPA 8270D 2007	0.001 µg/l
Isodrin	EPA 3510C 1996 + EPA 8270D 2007	0.001 µg/l

Parameter	Analytical Methodology	Limits of Detection for WATER analysis
DDT (Dichlorodiphenyltrichloroethane)	EPA 3510C 1996 + EPA 8270D 2007	0.001 µg/l
Heptachlor	EPA 3510C 1996 + EPA 8270D 2007	0.001 µg/l
Toxaphene (Campheclor)	EPA 3510C 1996 + EPA 8270D 2007	0.001 µg/l
Chlordane	EPA 3510C 1996 + EPA 8270D 2007	0.001 µg/l
Alachlor	EPA 3510C 1996 + EPA 8270D 2007	0.001 µg/l
Anthracene	APAT CNR IRSA 5080 Man 29 2003	0.001 µg/l
Atrazine	EPA 3510C 1996 + EPA 8270D 2007	0.001 µg/l
Chlorfenvinphos	APAT CNR IRSA 5100 Man 29 2003	0.01 µg/l
Chlorpyrifos	APAT CNR IRSA 5100 Man 29 2003	0.01 µg/l
Endosulfan	EPA 3510C 1996 + EPA 8270D 2007	0.001 µg/l
alpha-Endosulfan	EPA 3510C 1996 + EPA 8270D 2007	0.001 µg/l
Isoproturon	APAT CNR IRSA 5050 Man 29 2003	0.1 µg/l
Dioxins & Furans (PCDDs/PCDFs)	EPA 8280A 1996 GC-MS	0.1 µg/l

Table 9.4: Analytical methodology and limits of detection to be applied for the analysis of marine sediments.

Parameter	Analytical Methodology	Limits of Detection for SEDIMENT analysis
Total Nitrogen	CNR IRSA 6 Q 64 Vol 3 1985	0.01%
Total Phosphorus	CNR IRSA 9 Q 64 Vol 3 1985	0.01%
Mercury	EPA 3051A 2007 + EPA 6010C 2007	0.1 mg/kg
Cadmium	CNR IRSA 10 Q 64 Vol 3 1985 + APAT CNR IRSA 3020 Man 29 2003	0.1 mg/kg
Lead	CNR IRSA 10 Q 64 Vol 3 1985 + APAT CNR IRSA 3020 Man 29 2003	0.1 mg/kg
Nickel	CNR IRSA 10 Q 64 Vol 3 1985 + APAT CNR IRSA 3020 Man 29 2003	0.1 mg/kg
Arsenic	CNR IRSA 10 Q 64 Vol 3 1985 + APAT CNR IRSA 3020 Man 29 2003	0.1 mg/kg
Chromium	CNR IRSA 10 Q 64 Vol 3 1985 + APAT CNR IRSA 3020 Man 29 2003	0.1 mg/kg
Copper	CNR IRSA 10 Q 64 Vol 3 1985 + APAT CNR IRSA 3020 Man 29 2003	0.1 mg/kg
Zinc	CNR IRSA 10 Q 64 Vol 3 1985 + APAT CNR IRSA 3020 Man 29 2003	0.1 mg/kg
Silver	CNR IRSA 10 Q 64 Vol 3 1985 + APAT CNR IRSA 3020 Man 29 2003	0.5 mg/kg
Tin	CNR IRSA 10 Q 64 Vol 3 1985 + APAT CNR IRSA 3020 Man 29 2003	0.1 mg/kg

Parameter	Analytical Methodology	Limits of Detection for SEDIMENT analysis
Malathion	EPA 3550C 2007 + EPA 3630C 1996 + EPA 8270D 2007	0.01 mg/kg
Dichlorvos	EPA 3550C 2007 + EPA 3630C 1996 + EPA 8270D 2007	0.01 mg/kg
Hexachlorocyclohexane	EPA 3541 1994 + EPA 3630C 1996 + EPA 8081B 2007	0.001 mg/kg
Polychlorinated Biphenyl (PCB)	EPA 3541 1994 + EPA 3630C 1996 + EPA 8082A 2007	0.005 mg/kg
1,2 Dichloroethane	EPA 5021A 2003 + EPA 8260C 2006	0.01 mg/kg
Carbon tetrachloride	EPA 5021A 2003 + EPA 8260C 2006	0.01 mg/kg
Pentachlorophenol (PCP)	EPA 3550C 2007 + EPA 3630C 1996 + EPA 8270D 2007	0.001 mg/kg
Hexachlorobenzene (HCB)	EPA 3550C 2007 + EPA 3620C 2007 + EPA 8270D 2007	0.001 mg/kg
Hexachlorobutadiene	EPA 5021A 2003 + EPA 8260C 2006	0.01 mg/kg
Trichlorobenzene (TCB)	EPA 3550C 2007 + EPA 3620C 2007 + EPA 8270D 2007	0.01 mg/kg
Chloroform (Trichloromethane)	EPA 5021A 2003 + EPA 8260C 2006	0.01 mg/kg
Perchloroethylene (Tetrachloroethylene)	EPA 5021A 2003 + EPA 8260C 2006	0.01 mg/kg
Petroleum Hydrocarbons	EPA 5021A 2003 + EPA 8260C 2006 + EPA 3541 1994 + EPA 8270D 2007	0.1 mg/kg
Tributyltin compounds	UNI EN ISO 17353:2006	0.01 mg/kg
Cyanides	EPA 9010C 2004 + EPA 9014 1996	0.1 mg/kg
Fluorides	CNR IRSA 14 Q 64 Vol 3 1996	0.1 mg/kg
Benzene	EPA 9010C 2004 + EPA 9014 1996	0.1 mg/kg
Naphthalene	CNR IRSA 14 Q 64 Vol 3 1996	0.1 mg/kg
Simazine	EPA 5021A 2003 + EPA 8260C 2006	0.01 mg/kg
Trifluralin	EPA 3541 1994 + EPA 3630C 1996 + EPA 8270D 2007	0.01 mg/kg
Triphenyltin and its derivatives	UNI EN ISO 17353:2006	0.01 mg/kg
Boron	CNR IRSA 11 Q 64 Vol 3 1988	0.5 mg/kg
Parathion	EPA 3550C 2007 + EPA 3630C 1996 + EPA 8270D 2007	0.01 mg/kg
Aldrin	EPA 3541 1994 + EPA 3630C 1996 + EPA 8081B 2007	0.001 mg/kg
Dieldrin	EPA 3541 1994 + EPA 3630C 1996 + EPA 8081B 2007	0.001 mg/kg
Endrin	EPA 3541 1994 + EPA 3630C 1996 + EPA 8081B 2007	0.001 mg/kg
Isodrin	EPA 3541 1994 + EPA 3630C 1996 + EPA 8081B 2007	0.001 mg/kg
DDT (Dichlorodiphenyltrichloroethane)	EPA 3541 1994 + EPA 3630C 1996+ EPA 8081B 2007	0.001 mg/kg
Heptachlor	EPA 3541 1994 + EPA 3630C 1996 + EPA 8081B 2007	0.001 mg/kg
Toxaphene (Campheclor)	EPA 3550C 2007 + EPA 3630C 1996 + EPA 8270D 2007	0.01 mg/kg
Chlordane	EPA 3541 1994 + EPA 3630C 1996+ EPA 8081B 2007	0.001 mg/kg
Alachlor	EPA 3541 1994 + EPA 3630C 1996+ EPA 8081B 2007	0.001 mg/kg
Anthracene	EPA 3541 1994 + EPA 3630C 1996+	0.001 mg/kg

Parameter	Analytical Methodology	Limits of Detection for SEDIMENT analysis
	EPA 8081B 2007	
Atrazine	EPA 354I 1994 + EPA 3630C 1996 + EPA 8081B 2007	0.001 mg/kg
Chlorfenvinphos	EPA 3550C 2007 + EPA 3630C 1996 + EPA 8270D 2007	0.01 mg/kg
Chlorpyrifos	EPA 3550C 2007 + EPA 3630C 1996 + EPA 8270D 2007	0.01 mg/kg
Endosulfan	EPA 354I 1994 + EPA 3630C 1996 + EPA 8081B 2007	0.001 mg/kg
alpha-Endosulfan	EPA 354I 1994 + EPA 3630C 1996 + EPA 8081B 2007	0.001 mg/kg
Isoproturon	EPA 354I 1994 + APAT CNR IRSA 5050 Mar 29 2003	0.1 mg/kg
Dioxins & Furans (PCDDs/PCDFs)	EPA 8280A 1996 GC-MS	0.01 µg/kg
Brominated diphenylether	EPA 1614:2007 + EPA 3545:2007	100 ng/kg
C10-C13 chloroalkanes	EPA 354I 1994 + EPA 3630C 1996 + EPA 8270D 2007	0.01 mg/kg
DEHP (di(2-ethylhexyl)-phthalate)	EPA 354I 1994 + EPA 3620C 2007 + EPA 8270D 2007	0.01 mg/kg
Fluoranthene	EPA 354I 1994 + EPA 3630C 1996 + EPA 8270D 2007	0.01 mg/kg
Pentachlorobenzene	EPA 3550C 2007 + EPA 3620C 2007 + EPA 8270D 2007	0.001 mg/kg
Benzo(a)pyrene	EPA 354I 1994 + EPA 3630C 1996 + EPA 8270D 2007	0.01 mg/kg
Benzo(b)fluor-anthene	EPA 354I 1994 + EPA 3630C 1996 + EPA 8270D 2007	0.01 mg/kg
Benzo(k)fluor-anthene	EPA 354I 1994 + EPA 3630C 1996 + EPA 8270D 2007	0.01 mg/kg
Benzo(g,h,i)-perylene	EPA 354I 1994 + EPA 3630C 1996 + EPA 8270D 2007	0.01 mg/kg
Indeno(1,2,3-cd)-pyrene	EPA 354I 1994 + EPA 3630C 1996 + EPA 8270D 2007	0.01 mg/kg

CONTINGENCY PLANS

- 9.13. Regular monitoring should establish the levels, if any, of the specified pollutants and parameters listed in tables above. If a particular trend is established upon the collection of a series of data sets, measures on the operation and management of the facility need to be put in place.

10. NOISE

PERMIT REQUIREMENTS

- 10.1. The proposal for monitoring noise has been based on the requirements for monitoring noise (Section 7.8) of the IPPC permit. A copy of the relevant extract (7.8) from the permit is reproduced hereunder:

The Permitted Installation shall be designed, operated and maintained so as to avoid reasonable cause for annoyance from noise or vibration, in particular by:

- *equipment maintenance e.g. fans, pumps, motors, conveyors and mobile plant;*
- *use and maintenance of appropriate attenuation e.g. silencers, barriers, enclosures;*
- *timing and location of noisy activities and vehicle movements;*
- *periodic checking of noise emissions, either qualitatively or quantitatively; and*
- *maintenance of building fabric.*

Provided always that the techniques used by the operator shall be no less effective than those described in the application, where relevant

Emergency generators/alarms/sirens/release valves shall only be tested between the hours of 10.00 and 17.00 Monday to Friday and not on any Public Holiday

The level of noise emitted from the installation at all operational times shall not exceed 55 dB, expressed as an LAeq,1 hour, between 0600 hrs and 1900 hrs Monday to Saturday, and between 0700 hrs and 1100 hrs, or 1200hrs (according to conditions 3.3.2.1 and 3.3.2.4 of this permit) on Sundays and Public Holidays, as measured, or assessed at the specified boundary locations of the installation on plan reference 148/04 attached to this Permit. The locations shall be chosen and the measurements and assessment made according to BS 4142:1997.

No work will be permitted on Sundays and Public Holidays. The working hours from Mondays to Saturdays is from 6.00 – 19.00.

Noise monitoring is to be carried out on a regular basis to ensure that the above limits are not exceeded.

PROPOSED MONITORING PROGRAMME

- 10.2. This monitoring programme is required to identify monitoring locations. It is good practice to identify locations that are sensitive receptors. This exercise was carried out as part of the EIA prepared for the Ghallis engineered landfill. Given the proximity of the Ta'Zwejra Facility with the Ghallis Non-Hazardous Engineered Landfill, it is proposed to use two of the same monitoring points proposed in the Ghallis Monitoring Programme; a third point to the east of Ta Zwejra is also included. These are:
- The adjacent hamlet (see **Figure 10.1**);
 - The adjacent house to the south of the hazardous treatment area (see **Figure 10.1**); and
 - The property south of the site entrance (see **Figure 10.1**).
- 10.3. The Coastline Hotel **was not** selected as a monitoring location because the baseline noise level is over the level set in the permit that of 55dBA. Since the baseline level is 56dBA this point cannot be used. If the permit condition were rephrased stating that the noise level should not be greater than 10dBA for example, then the Coastline Hotel would be included. Monitoring shall be carried out annually.

Noise monitoring points

Tŷ Zwegra Monitoring Programme

KEY

Tŷ Zwegra site boundary

Noise monitoring point

INDICATIVE ONLY
Not to be used for direct interpretation

0 120 240 480
Metres

Maped by
adi ASSOCIATES
Environmental Consultants Ltd
April 2012
Ref: Monitoring/Tŷ Zwegra... Map

APPENDIX I SUMMARY OF RESPONSES TO PERMIT IMPROVEMENT PROGRAMME

No.	Requirement	Deadline	WasteServ response	Previous MEPA comments	Current status	IPPC Committee response 2 February 2011
3	Trigger levels for dioxins, PAHs and heavy metals	November 2005	June 2009: Requested waiving of dioxin & furan monitoring in absence of clear source.	October 2009: One-time monitoring results requested, following which request may be evaluated.	<p>AER for 2009 was submitted in April 2010. Results summarised below.</p> <p>Dioxin & furan measurements at weighbridge were 0.0055 pg/m³ in 2008 and <0.0051 pg/m³ in 2009.¹⁶</p> <p>PAH measurements: 0.0265 ng/m³ in 2008; <2.75 ng/m³ in 2009. The ELV is 1 ng/m³, therefore the limit of detection (LOD) is not sufficient.</p> <p>As, Cd, Ni levels lower than ELVs for 2008; while the method used in 2009 was not suitable for metals, reference</p>	<p>These dioxin levels are far lower than the ELV of 0.1 pg/m³. Therefore removal of monitoring requirement is justified.</p> <p>Dioxins and furans however have the potential to arise from combustion of landfill gas (flaring).^{17,18} Therefore the removal of the monitoring requirement should only be valid as long as no flaring takes place.</p> <p>Trigger levels for PAHs need to be proposed by WasteServ.</p> <p>Measurements need to be carried out with a method having an appropriate LOD.</p> <p>WasteServ is to ensure that measurements for metals are carried out according to the IPPC permit.</p>

¹⁶ Section S2.4.1 gives dioxin & furan emissions as <0.0051 pg/m³ for 2009, whereas the following two measurements are given in the raw data sheet: 6 fg/l-TE/m³ and 11 fg/l-TE/m³, which would average out to 0.0085 pg/m³. WasteServ has confirmed (email of 12 January 2011) that the raw data is for Ghallis. MEPA is therefore currently awaiting the submission of the 2009 raw data for Zwejra.

¹⁷ UK Environment Agency & Scottish Environment Protection Agency. (2002). *Guidance on Landfill Gas Flaring*. Available [online](#).

¹⁸ Department for Environment, Food and Rural Affairs. (2004). *Review of Environmental and Health Effects of Waste Management: Municipal Solid Waste and Similar Wastes*. Available [online](#).

No.	Requirement	Deadline	WasteServ response	Previous MEPA comments	Current status	IPPC Committee response 2 February 2011
					was made to raw data for Ghallis. ¹⁹	Trigger levels for metals need to be proposed by WasteServ.
3	Contingency plans which will be put into effect when the trigger level is reached	April 2006	As per previous comment.	As per previous comment.		Contingency plans for PAHs and metals to be submitted by WasteServ.
17	Odour monitoring	April 2006		October 2009: No response provided.	2009 AER does not include odour monitoring results.	Odour monitoring results to be submitted by WasteServ.
22	Final version of closure plan	November 2005	Partial (Cell 1) closure plan submitted in April 2006. June 2009: The closure of the Ta' Zwejra landfill is included within the scope of PA 02342/06 which is currently being processed by MEPA. A detailed closure plan of the Ta' Zwejra landfill is currently being developed and shall be submitted to MEPA in the coming weeks.	October 2009: Noted.	Detailed closure plan not submitted.	Comments regarding the closure plan summary submitted as part of PA 02342/06 are enclosed (Annex III). Detailed closure plan addressing these comments to be submitted by WasteServ.

¹⁹ MEPA is currently awaiting submission of an updated Annual Environmental Report for 2009 for Żwejra (as per email dated 24 January 2011).

