Project Description Statement

To amend permit PA 964/11 and alter the internal lateral landfill profile to increase volume capacity on Ghallis non-hazardous landfill, while retaining site area.

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Cover image from Google Earth (2017)

Introduction

1. Wasteserv Malta Ltd. have submitted a development permit application to amend PA 00964/11 (Tracking Number 201018), so as alter the internal lateral landfill profile, with the objective of increasing volume capacity on the Ghallis non-hazardous landfill. The proposal is limited to the existing site area of the Ghallis non-hazardous landfill, and will not involve any interventions beyond the boundaries indicated within PA 00964/11.

2. The limited void space available at the Ghallis non-hazardous landfill is the most significant waste management issue at the national level. This facility is the only disposal option – barring export at a prohibitive cost – for non-hazardous waste streams where diversion to recovery or recycling is not an option. Remaining approved landfill void space as at March 2017 is estimated[1] at 1,000,000m^3. The remaining landfill void space is expected to be filled rapidly, given current waste deposition rates (an average of 21,500 tonnes per month during 2016).

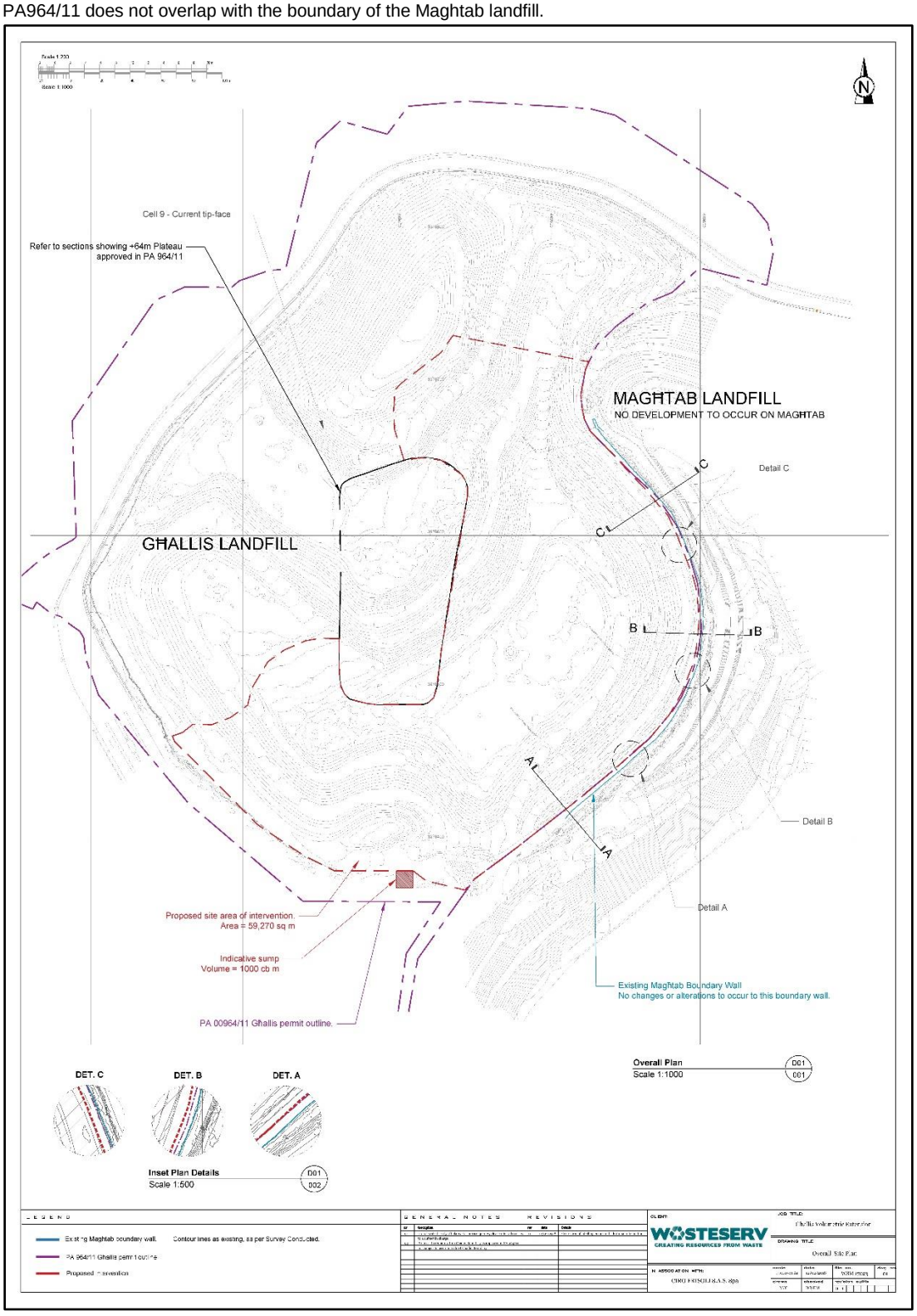
3. Proposals for landfill extension, as well as alternative disposal technologies such as waste to energy are still under development. To allow for sufficient time to develop such waste management options, obtain the required regulatory permits, and construct the required infrastructure, it is imperative that the lifetime of the Ghallis landfill be extended as far as possible. This is essential if alternatives are to be operational before available landfill void space is exhausted.

4. This project involves the use of compacted waste, using lining materials and engineered reinforcement, to create a free-standing, retaining wall. This wall would have a steeper profile than that currently implemented, and extend along the Ghallis landfill in the area identified in Plan 1. The retaining wall would not involve any interventions in the old Maghtab landfill, and would provide the Ghallis landfill with a capping layer as required by the Landfill Directive 1999/31/EC. No increase in height beyond the permitted limits is being contemplated.

5. These engineering works would extend the Ghallis landfill life time by around 9 to 12 months, by increasing void space by circa 350,000m^3. Implementation of the project would be carried out by *geom. Ciro Frisoli & C. S.a.s.*, an Italian company specialised in landfill engineering, and that owns the patents pertaining to the technologies that allow the construction of such retaining walls in landfills. This technology has been implemented successfully in the Pariti 2 and the Passo Breccioso Landfills in Foggia (see Appendix A).

[1] This estimate subtracts the approximate volume occupied by the basal lining layers and assumes a 10% daily cover.

Plan 1: location of proposed project indicated in red; the boundary of the Ghallis non-hazardous landfill, as indicated by PA964/11 does not overlap with the boundary of the Maghtab landfill.



6. The potential of this technology is illustrated in the following images 1 and 2, showing the Pariti 2 landfill in Foggia, where an existing landfill was engineered to stabilise the poorly designed and compacted landfill mass, and increase landfill volume.

Image 1: Pariti 2 landfill, Foggia before stabilisation

Image 2: Pariti 2 landfill, Foggia after consolidation using Frisoli technology

Site description and context

7. The Ghallis Non-Hazardous Landfill consists of an engineered landfill facility for the disposal of non-hazardous wastes, and forms part of the Maghtab waste management complex. The latter is dedicated to the disposal needs of all non-hazardous waste streams generated in Malta, or to the diversion of waste streams to recovery or recycling processes in other permitted facilities.

8. This facility was designed as a disposal facility that implements the requirements of Directive 1999/31/EC on the landfill of waste as transposed by Legal Notice 168 of 2002 Waste Management (Landfill) Regulations. The landfill facility was originally approved for development by PA 04834/04 after an Environmental Impact Assessment process. Various development permits were required to permit various modifications and upgrades; these included PA 00964/11, which defined the boundary of the Ghallis non-hazardous landfill. The latter development permit applications formed part of a Master Plan for the Maghtab Environmental Complex, which was assessed via an update to the original EIS (GF 00121/06).

9. The operations of this facility were originally permitted on the 6th April 2007 through the issue of the integrated pollution prevention and control permit IP001/06/A; the renewal of this permit was decided on 31st January 2013 through the issue of IP001/06/B, that was eventually extended to January 2018.

10. Construction of the landfill proceeded in phases consisting of independent cells, and certified via Construction Quality Assurance reports that were prepared during the construction of each cell. The engineering specifications were derived from the results of hydrogeological, landfill gas and stability risk assessments, to ensure that operations at the installation would not result in an adverse effect on the surrounding environment. Each cell has its own leachate collection/extraction system, as well as a gas extraction system connected to a central gas management facility. At present, the construction of the final cell is currently being completed, and the gas extraction system that was the subject of the IPPC permit renewal in 2013 is being implemented.

11. The location for the proposed development is over 1km south of Qawra, which is located on the further side of Salina Bay. Most of the immediately adjacent areas are predominantly agricultural fields bounded by rubble walls. Public access to the site (and to the Maghtab Environmental Complex generally) is precluded by various security measures.

12. The surrounding land uses have been surveyed in terms of nature and extent in the *Master Plan for the Maghtab Environmental Complex - Environmental Impact Statement Update prepared in support of development permit Application No. PA 02342/06 (*Adi Associates Environmental Consultants Ltd, 2011). Current surrounding land uses include:

    i. The adjacent waste management facilities forming part of the Maghtab Environmental Complex, including the Civic Amenity site, the Malta North Waste Treatment Plant, and the Zwejra and Maghtab landfills;
    ii. The Salini Resort (Coastline) hotel at a minimum of 700m to the west;
    iii. Various residences to the west and the south;
    iv. A private waste management facility to the south, including small settlements such as Maghtab;
    v. Natural habitats in the vicinity of the Maghtab landfill that have been studied as part of previous Environmental Impact Assessments;
    vi. Small farmhouses and ancillary buildings, including an adjacent cow farm; and
    vii. Roads, including access roads to the Maghtab complex to the south, and the Coast Road to the west.

    The various EIA studies carried out for developments related to the Maghtab Environmental Complex have included various studies on the cultural, archaeological and environmental characteristics of the areas surrounding the site.

Project Description

13. The landfill area where this project is proposed is located along the eastern side of the Ghallis landfill, which faces the western aspect of the Maghtab landfill. Plan 1 illustrates the site boundary of the Ghallis non-hazardous landfill, as permitted via development permit PA 00964/11. The boundary of the Maghtab landfill is immediately adjacent to the Ghallis landfill boundary; the interventions proposed by this project, including the laying of foundations, will not involve any interventions on the Maghtab landfill as indicated in the detail of Plan 1.

14. The project design has given due consideration to the configuration and topography of the gap between the two landfills, to mitigate the impact of this intervention from the vantage points along the Ghallis perimeter and surrounding areas. Photomontages as per the Planning Authority's *Best Practice Guide - Visual Simulations* are included in a separate section on visual impact.

15. Plan 2 is a design highlighting the basic features forming part of the retaining wall structure. A typical cross-section of the proposal superimposed on the Ghallis landfill is provided in Plan 3, which allows comparison of the existing landfill profile with that which is being proposed. The boundaries of the Ghallis and Maghtab landfills are illustrated, though the distance between them is expected to vary as per Plan 1. This reprofiling will not compromise the permitted pre-settlement height limit of 64m above sea level as per development permit. The total waste fill capacity gained as a result of the re-engineering would be approximately 300,000m^3.

16. Further technical detail regarding the structures are provided in Plan 2. The following structures should be noted:

- **Compacted wastes form an integral part of the retaining wall structure;** these will be rejects from the Malta North plant, which will not include any biodegradable fractions. No chemical or binding agents will be used in the compaction process, and compacting will take place on site at the point of deposition. The waste shall be deposited in layers of one metre, and enveloped in geonets that are linked structurally with electro-welded steel mesh; HDPE monofilament nets are used to provide support to soil capping structures.
- **Foundation structures for the retaining wall structure:** layers of sand and compacted inert material shall be placed on top of the liner materials, so as to provide a base for the retaining wall, and protect the underlying liner layers. A layer of gravel wrapped in woven geotextile will be included to facilitate movement of leachate and landfill gas. These layers will be covered with a geological barrier, and a further layer of inert material sealed in woven geotextile.
- **Prefabricated concrete wall:** the function of this is to serve as an anchor point for the various bottom liners (2mm HDPE and Geosynthetic Clay Liner), as well as the non-woven geotextiles used to protect the underlying liner materials. This wall has no structural function besides acting as a demarcation line and anchor point.

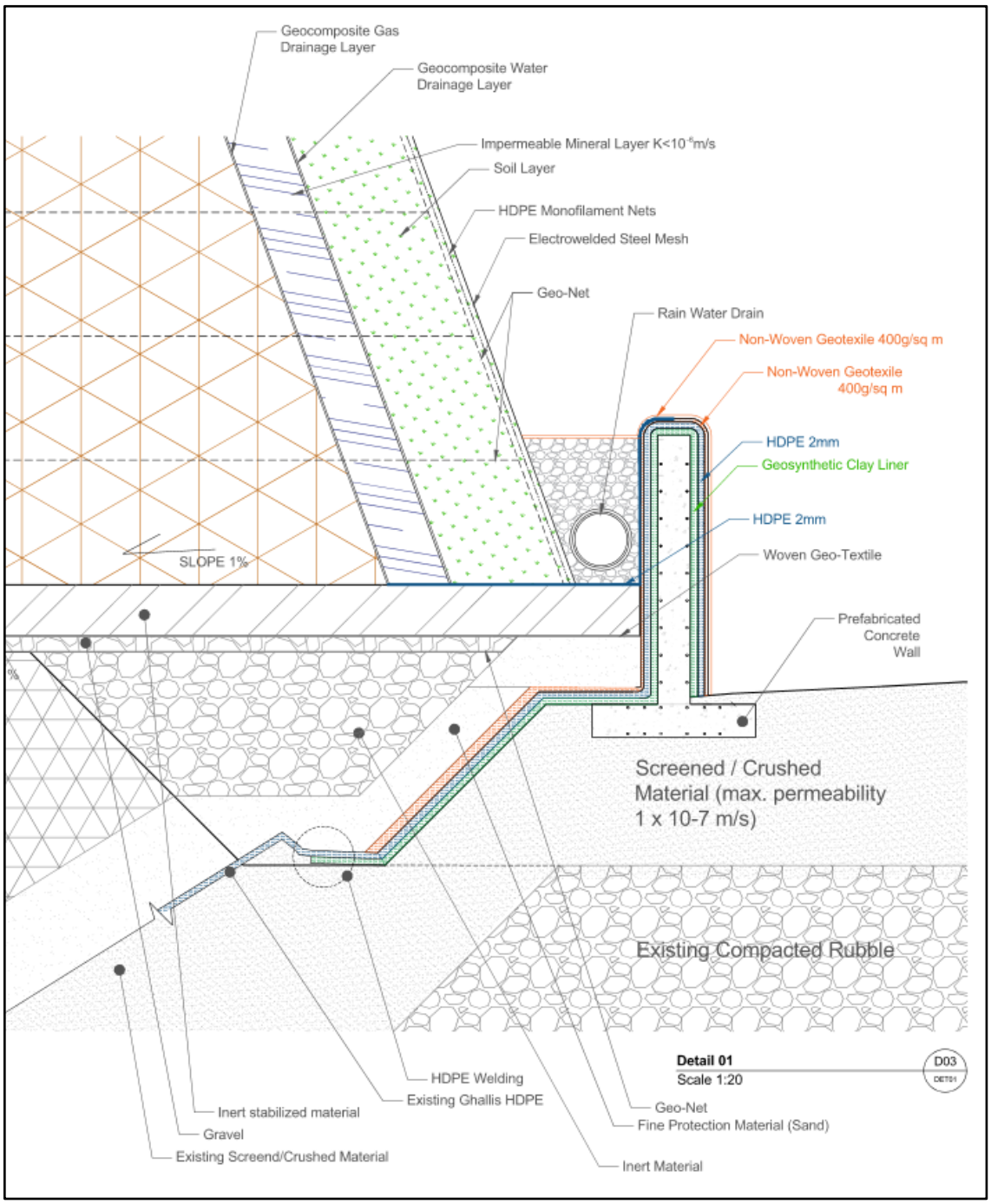
17. **Bottom liner and geological barrier:** as described in the following sections describing the construction processes, the bottom liner and geological barrier shall be laid as per the requirements of the Landfill Regulations S.L. 549.29, where the mineral layer shall be of a minimum of 50cm, and have the required permeability of 1.0×10^{-9} m/s. The existing Ghallis HDPE liner will be track welded with the new liner, followed by a Geosynthetic Clay Liner. A non-woven geotextile (400g/sq.m) will be laid on top, and form the base on which the foundations (described above) will be laid.
The geological barrier of 50cm height will be constructed on top of the foundation layer including 50cm of inert material wrapped in woven geotextile and HDPE of 2mm thickness between the two layers. These layers will be given a gradient of 1% to both the upper and lower surfaces, such that any leachate or gas generated by the deposited waste is directed back into the core of the landfill mass. A layer of gravel will be included to facilitate permeation of leachate and landfill gas.

18. **Gas and leachate collection:** the new retaining system will allow for continued use of the existing gas and leachate collection systems; an increase in height will be required for leachate connection points 4,5, and 7; the existing gas collection system will require redeployment to prevent it from being damaged during preparation of the retaining walls, and infilling of additional void space.

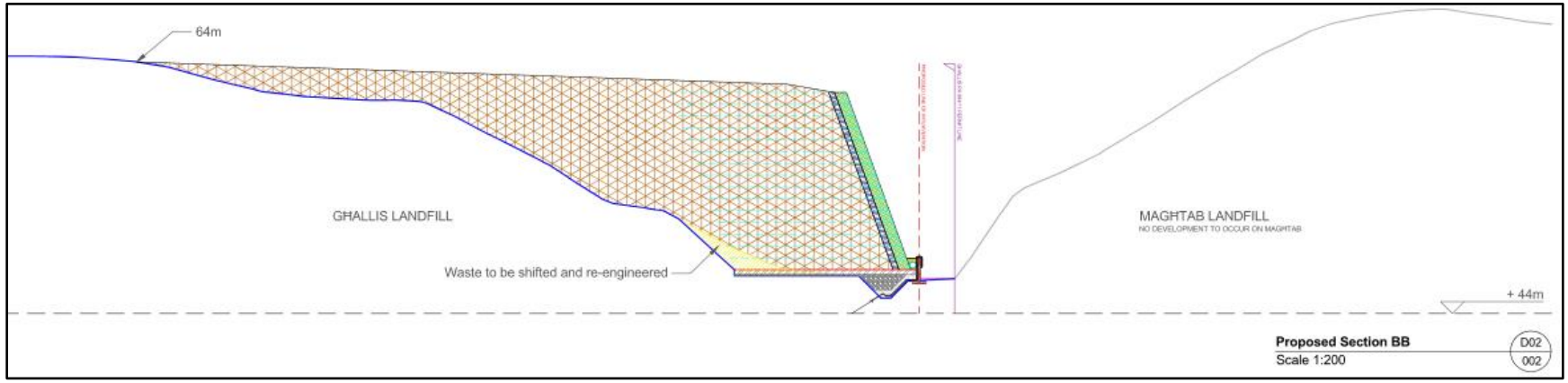
19. **Landfill capping:** the area covered by the new retaining wall will include the following capping materials, as per the requirements of the European landfill directive: a multilayer outer portion consisting of an outer covering layer (soil: 100 cm), a geocomposite drainage layer for rainwater (1 cm), an impermeable mineral layer, and an inner geocomposite drainage layer for landfill gas. These layers will be integrated into the retaining structures using the geonet structures and electro-welded steel mesh layers described above.

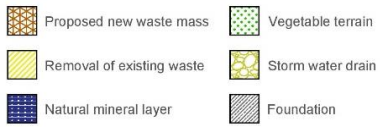
20. **Services, water, foul water sewers, surface water drainage (including storm water drainage), and energy sources**: this project shall not involve any changes in existing services, foul water management, and energy sources barring equipment used for construction. Storm water management is incorporated in the project design; a pipeline for capture of storm waters will be laid over the surface structures. and shall be linked up with existing provision on site as considered within IP0001/06/B.

Plan 2: conceptual comparison of existing and proposed landfill profiles and engineering works - detail provided by Frisoli



Plan 3: typical section through the Maghtab and Ghallis landfills, illustrating the manner in which the conceptual design in Plan 2 is superimposed on the existing profile of the Ghallis landfill.





Process of Construction and Project Duration

21. The construction of the retaining wall shall involve the following processes:

    i. **Process 1:** re-engineering of the Ghallis eastern face, including shifted of excavated waste, in preparation for foundations;
    ii. **Process 2:** extension of the existing basal liner by welding to extend containment, and laying of foundations; and
    iii. **Process 3:** recontouring of Ghallis landfill profile, resulting in an angle of 70° using reinforced compacted waste; placing of geotextile and capping materials satisfying the requirements of the Landfill Directive 1999/31/CE, allowing for proper drainage and biogas collection.

22. **Process 1:** The area covered by foundations will be of approximately 10,000m^2. The foundation will be constructed all along the perimeter of the project area, for a length of about 650m and width of 15m, within the perimeter of the Ghallis facility. Typical preparations of foundations are illustrated in images 3 and 4 overleaf. This process will include the following steps:

    - In order to guarantee the continuity of the liner of the existing cell with the new construction, the existing HDPE will be unearthed by careful excavation.
    - Re-engineering of the existing eastern cell side slope by trimming a section of the existing Ghallis landfill, approximately triangular in section, to create the necessary space for the construction of the retaining structures - removed waste material will need to be deposited at the existing tip face currently being used at the Ghallis landfill;
    - Engineering the side slopes of the excavated area to conform to a 3:1 grade to ensure stability during works; and
    - Installation of a prefabricated T-wall, to serve as an anchor point for the various layers of the liner systems.

23. **Process 2:** The new cell volume will be constructed above the base of the existing basal liner system of Ghallis landfill, as follows:

    - A Geosynthetic Clay Liner (GCL) will be laid under the HDPE liner, where the continuity of the HDPE within the old and the new cell is maintained through double track fusion welding for long straight seams with free flaps on each side of the weld (where possible), or with HDPE extrusion welding;
    - GCL and HDPE are covered with a non-woven geotextile, and all layers are draped over the prefabricated concrete T-wall;
    - Compacted inert material are then used to create a foundation for the retaining wall, and a layer of sand placed as protection of the liner against puncturing;
    - A further geological barrier of 0.5m thickness will be laid over the foundation, and covered with 2mm HDPE; and
    - A layer of inert material of 0.5m thickness will be laid over the HDPE, and will be wrapped in impermeable geotextile. (Both upper and lower sides of the geological barrier and inert

layer are given a gradient of 1%, to ensure that leachate and gas generated are directed into the landfill mass.)

24. **Process 3:** Preparation of foundations and laying of the basal liner is followed by the placing of the waste retaining structures. The stability of the slope is facilitated by compacting masses of waste in layers, where each layer of the retaining wall is enveloped in a geonet, and integrated with other retaining structures, particularly the electro-welded steel mesh. Once the construction of the retaining wall is in place and additional void space becomes available, any wastes removed to allow preparation of foundations – as well as fresh MSW – will be deposited in the new void space created. The construction steps are as follows:

- Placing of steel frames on the foundation bed, at the outer boundary of the retaining wall;
- Laying of the bottom geogrid layer;
- Inclusion of vertical reinforcements (electro-welded steel mesh) as support for the outer mineral liner;
- Draping of geocomposite materials used for gas drainage (on the inner side of the landfill capping structures) and water drainage (on the outer side of the landfill capping structure);
- Outer capping soil and mineral clay layers laid, and with HDPE monofilament net used to retain the finer soil particles;
- Waste laid in a one metre thick layer, compacted, and covered with a geogrid as required by calculations concerning stability; and
- The above process repeated as necessary until the required heights are achieved.

Image3 3 & 4: Preparation of foundations and laying of basal liner

25. **Implementation phases – raw materials, energy, employment:** no raw materials will be used besides the liners and geocomposite materials described above, and the waste mass itself. Energy consumption will be limited to the fuel needed for the heavy vehicles required to trim, move and compact the wastes. This project is expected to involve between 7 – 10 people, who would be involved throughout all the processes described above. Machinery to be used will be excavators, trucks, and compaction vehicles.

26. **Access requirements:** these will be serviced by internal roads currently available within the Maghtab complex. The project may involve the creation of additional access routes traversing the waste mass itself, as is currently required by logistic requirements of the waste deposition process.

27. **Project duration:** total duration of works is expected to be of about four years (see Gantt chart in Table 1). Works on site will be carried out by Frisoli, given their expertise and experience in the re-engineering of landfills. The process of construction of the retaining wall will proceed in parallel with the infilling, given that waste will be required to create the retaining structures and infill. Inert material will be used as daily cover, and recovered on a daily basis as per current practice. It is expected that the final capping process will be concluded in the same period when other capping activities will be taking place i.e. towards 2021 when the point of closure of the Ghallis landfill is expected to be due.

Table 1: proposed project duration

		Month 1				Month 2				Month 3				Month 4				2018				2021				Days
1	**Site preparation - underpinning**																									
1.a	Pre-foundation levelling and excavation of waste at the eastern side of Ghallis landfill																									30
1.b	Search of the existing HDPE																									21
1.c	Installation of prefabricated walls																									10
1.d	HDPE welding and laying of the basal liner																									21
1.e	Testing and trials on HDPE welding																									1
1.f	Filling excavations performed (sand and inert material)																									15
1.g	Final test of the works																									1
2	**Foundation**																									
2.a	Implementation of the foundation of the retaining structures																									30
3	**Retaining structures for waste - Frisoli's technique**																									
3.a	Implementation of retaining structures for landfills with Frisoli's technique																									720

Environmental Risks, Impacts & Mitigation

28. An environmental impact may be positive, neutral or negative, depending on the effect a causative agent would have on the environment. Impacts from this project can arise from either of two stages:

    A. the ***operational stage***, which is that where the landfill is being recontoured and waste infilled, and
    B. the ***post-operational stage*** where the landfill mass has been formed and capped, and is being maintained.

29. The environmental risks associated with the various operational phases are listed in Table 2 overleaf, together with the mitigation measures that are proposed to manage and mitigate such impacts. These may be summarised as follows:

- **Emissions**: these are expected to be comparable to those of the existing landfill operations currently approved – this impact is expected to be **neutral** over the longer term, with the exception of emissions during the re-engineering phase, where emissions may be **slightly negative**.
- **Generation of leachate**: these are expected to be comparable to those of the existing landfill operations currently approved; the lack of permeability of the outer landfill layers, together with the steeper profile, will decrease penetration of the landfill mass by rainfall, resulting in reduced generation of leachate - this impact is expected to be **positive**.
- **Ground contamination**: the construction process would not result in any damage to the existing landfill liner, and the retaining structures are expected to increase potential for containment - this impact is expected to be **neutral** over the longer term.
- **Waste management**: the objective of this proposal is the gain in void space at the Ghallis landfill, which would allow for the development of further waste management solutions for non-hazardous waste streams currently being deposited in this site - this impact is expected to be **strongly positive** over the longer term.
- **Stability**: this project proposal is underpinned by a Stability Risk Assessment (prepared by the contractor, with the assistance of Mr. Barry Gore as external consultant) that directed the development of project parameters; consequently, this impact is expected to be **neutral** over the longer term. An overview of the issues considered in terms of stability are given in the following sections of this document.
- **Visual impact**: the extent to which interventions on the Ghallis landfill would be visible from external viewpoints would be limited, given that interventions are limited to the area between the Ghallis and Maghtab landfills. This impact is expected to be **slightly negative** over the longer term – see following sections for a more detailed assessment with photomontages.

30. **Cumulative impacts:** the operational risks detailed above are expected to be transient, and reversible in that they are limited in duration to the engineering works involved in creating the retaining wall, and the infilling operations. The environmental impacts created are expected to be consistent with those currently experienced at the landfill, with the exception of the phase involving trimming of the waste mass, given the risks indicated in Table 2. However, application of the mitigation measures indicated above should serve to mitigate these risks.

31. **Environmental monitoring**: this will be required through all stages. The current monitoring programme includes H_2S, CH_4, VOCs, PMs, etc. A review of the monitoring programme indicates that the monitoring parameters employed are compatible with the monitoring requirements of this proposal. However, a review will be required to ensure that monitoring effort captures all activity taking place.

32. The above environmental risks shall also be managed through the following:

- Health and safety risk assessments
- Method statements for the various processes
- Stability assessments
- Fire risk assessment and management plan

Table 2: environmental risks posed during the development and operational processes, and relevant mitigation measures

Process	Risk	Mitigation measure
1. Re-engineering of Ghallis eastern face, as preparation for engineering works	Destabilisation of Ghallis landfill mass	• Stability Risk Assessment prior to excavation works to identify risk areas • Method statement for excavation and laying of foundations, to avoid destabilisation, stipulating excavation process required to control areas at risk of destabilisation e.g. trimming in tiered benches rather than exposure of vertical faces • Works during rainy periods will be avoided to minimise potential destabilisation caused by wetting of the landfill mass
	Elevated risk of dust and odours	• Specific environmental monitoring is required here to monitor impacts on the environment, and health and safety during works • Monitoring of wind speed and direction prevalent in the works area • Use of fog cannon on site during works as dust abatement • Wastes will be covered with daily cover: either inert material or a geosynthetic layer
2. Preparation of foundations and extension of the basal liner by welding to existing landfill liner to extend containment	Integrity of basal landfill liner, compromising leachate retention systems	• Careful exposure of landfill liner, as has been current practice when extending landfill through construction of adjacent cells • CQA reporting
3. Building of modular free-standing wall sections inclined at an angle of 70° with reinforced compacted waste	Integrity of basal landfill liner, compromising leachate retention systems	• Careful deposition of foundation materials, preventing heavy vehicles from driving directly on liner • CQA reporting
4 & 5. waste infilling and placing of geotextile and capping materials	Destabilisation of landfill mass	• Deposition of waste in layers and compaction, as per current landfill practice

Process	Risk	Mitigation measure
All processes	Generation of dust and odour	• Dust and odour are expected to be equivalent to that of current landfill operations during infilling operations; the use of daily cover is essential. For trimming operations see above.
	Water containment	• Containment of waters is expected to use the existing systems on the Ghallis landfill • Trimming works will be avoided during rainy periods (as per above) • Frisoli system includes a system of ducts to collect rainwater from the surface of the sloping free standing wall (which is impermeable to any water)
	Fire & exposure of potential hotspots	• Assessment of risk through visual inspection and thermographic cameras to detect hotspots • Hotspot management using leachate and/or water to dissipate heat in buried landfill mass • Fire management plan • Maintenance of stockpiles of inert material and necessary plant to respond to fire risk
	Loss of containment	• The preparation of good foundations and implementation of leachate collection systems
	Reduced waste permeability prolonging lifespan of landfill and creating possibility of eventual contamination in the event of failure	• Extreme compaction of wastes is expected to be for the layers forming the retaining wall. Recirculation of leachate in the main waste mass will not be affected; nevertheless, this point highlights the importance of leachate recirculation and treatment, to remove the contaminants from the system.
	Traffic & Logistics – management of concurrent operation of two tip-faces	• Issues with regards to having two tip faces at any one time; including traffic management, risk assessment and mitigation measures necessary

33. The **post-operative phase** will involve the following impacts:

- **Emissions**: these are expected to be comparable to those of the final landfill form currently approved – this impact is expected to be **neutral** over the longer term.
- **Generation of leachate**: the lack of permeability of the outer landfill layers, together with the steeper profile, will decrease penetration of the landfill mass by rainfall, resulting in reduced generation of leachate - this impact is expected to be **positive** over the longer term.
- **Ground contamination**: the construction process would not result in any damage to the existing landfill liner, and the retaining structures are expected to increase potential for containment - this impact is expected to be **neutral** over the longer term.
- **Waste management**: the objective of this proposal is the gain in void space at the Ghallis landfill, which would allow for the development of further waste management solutions for non-hazardous waste streams currently being deposited in this site - this impact is expected to be **strongly positive** over the longer term.
- **Visual impact**: the extent to which interventions on the Ghallis landfill would be visible from external viewpoints would be limited, given that all interventions are limited to the gap between the Ghallis and Maghtab landfills. This impact is expected to be **slightly negative** over the longer term (see following sections on visual impact).

Stability

34. Landfill stability has been assessed as part of a Stability Risk Assessment (SRA) carried out in parallel with the development of this project proposal. This SRA considered the original studies carried out for the Ghallis landfill by SLR in 2004, and considered the behaviour of the proposed structures in conjunction with the findings of the 2004 studies, and additional data collected in terms of the 'as built' drawing provided by Wasteserv Malta Ltd.

35. The SRA included the development of a Conceptual Stability Site Model, that considered the following:

    i. **Basal Sub-Grade Model** that evaluates the stability of the foundations and underlying substratum (rock), where settlement is expected to be minimum and negligible;
    ii. **Basal Lining System Model** that evaluates the extension of the existing lining systems to ensure continuity with the proposed structures, and evaluates the risks in terms of ensuring continued containment;
    iii. **Waste Mass Model** which evaluates the behaviour of the waste mass as part of the structure, in terms of the quality of the waste and the tendency with respect to settlement, where the compacted waste used as part of the retaining structure will be pre-treated via sorting at Mechanical Treatment Plants (MTP), or digestate from the anaerobic treatment plant, to where the organic fractions prone to biological degradation and settlement has been removed; and
    iv. **Capping System Model & Side Slope Lining System Model** which sets the parameters that need to be met by the structures being proposed, in terms of stability and containment.

36. The various models described above were screened in terms of risk as part of assessment process. Risks identified were correlated with mitigation measures that would be required either in terms of management of operations, or design of structures. Structural designs were evaluated in terms of the reinforcements required (as described in the plans presented previously), and the physical properties pertinent to the various materials. Relevant calculations were carried out using ReSSA 3.0 as developed by ADAMA Engineering for use by US State Highway Agencies and by US Federal agencies.

Visual Impact

37. The nature and extent of visual impacts arising from the Maghtab national waste management complex have been evaluated previously in the *Master Plan for the Maghtab Environmental Complex - Environmental Impact Statement Update prepared in support of development permit Application No. PA 02342/06 (*Adi Associates Environmental Consultants Ltd, 2011). The process of development of the proposed extension to the Ghallis landfill has considered the results of the above study; further studies have been conducted to direct the development of the final form of the project, so as to optimise mitigation of visual impact as far as possible during the design phase.

38. The study carried out in 2011 defined a Zone of Visual Influence (see Plan 4) to assess the impact of the Maghtab Environmental Complex as approved by PA 02342/06 and PA 00964/11. This Zone of Visual Influence (ZVI), and viewpoints selected on this basis of this ZVI, were reused to generate a further set of photomontages that would allow assessment of visual impact. The photomontages were generated as required by the Planning Authority's *Best Practice Guide - Visual Simulations* by Perit Joseph Pace of Virtual Reality Studios Ltd., and these are attached as Appendix B.

39. A list of viewpoints is provided in Table 3, which itemises the various locations from which the photographs were taken, and describes the extent to which the proposed extension is visible in the photomontages provided. Appendix B includes:

    - Photographs of all viewpoints listed in Table 3 in their present form (labelled as existing);
    - Photomontages (labelled as wireframe) showing superimposed 3D models generated via a Digital Terrain Model, where the remaining approved void space is shown in green, and the proposed extension is shown in pink; and
    - Photomontages (labelled proposed) of the final proposed landfill terrain (showing both approved and proposed landfill infill), with a render derived from that of the Maghtab landfill.

40. The proposed extension to the landfill is visible from the following points:

- Point 1. Wardija: view of St. Paul's Bay and Burmarrad plains, with Maghtab landfill in the distance
- Point 2. Triq il_Qawra Promenade, Bugibba
- Point 3. Triq il_Luzzu, Qawra, facing Salina Bay
- Point 4. Adjacent to Coastline Hotel
- Point 5. Farm to the north of Ghallis landfill
- Point 6. North part of Coast Road Y
- Point 13. Triq John Adye, T'Alla u Ommu: rural landscape surrounding Maghtab Environmental Complex and industrial development
- Point 14 Triq l_Imsaqqfin, Mosta: rural landscape surrounding Maghtab Environmental Complex and industrial development

The proposal is not visible from the Gharghur viewpoints, where the visual impact is deemed to be neutral.

41. **Viewpoints where Maghtab is a backdrop:** the proposed development has the Maghtab landfill as a backdrop for viewpoints 1, 2, 3 & 6 (i.e. Wardija, Qawra viewpoints and the northern part of the Coast Road). While the extension will be visible in terms of line of sight, these would not be immediately obvious given the existing Maghtab landfill mass in the background. Although the rural setting of these viewpoints is deemed sensitive, the changes would be restricted to the view of the Maghtab waste management complex. Given a final finish that is comparable to that of the existing landfill masses, the overall changes to the landscape would be imperceptible, and consequently the visual impact would not be significant.

42. **Viewpoint where Maghtab is a backdrop, and impinges slightly on the skyline in terms of height:** the proposed development has the Maghtab landfill as a backdrop for viewpoints 4, 5 & 6 from immediately around Ghallis (i.e. from near the Coastline Hotel, the Coast Road, and from the north). While the extension will be visible in terms of line of sight, this will be restricted to a limited elevation of the existing landfill mass against the skyline. Although the setting of this viewpoint is generally rural, the existing mass of the Maghtab waste management complex is a dominant backdrop. Given a final finish that is comparable to that of the existing landfill masses, the overall changes to the landscape would be a slight increment over the existing situation, and consequently the visual impact would not be significant.

43. **Viewpoint where proposed development impinges on the skyline in terms of lateral extension**: with respect to viewpoints 13 & 14 (from T'Alla u Ommu and Mosta) the extension will be visible in terms of line of sight, this will consist of an elevation of the existing landfill mass against the skyline. The panoramic views are considered sensitive, even though the general rural is dominated by the Maghtab landfill and industrial development in the foreground. Given a final finish that is comparable to that of the existing landfill masses, the overall change to the landscape would be an increment of the existing visual impact, is deemed moderate in terms of magnitude and extent.

Plan 4: Zone of Visual Influence as defined in the EIA update carried out by Adi Associates Environmental Consultants Ltd, (2011). *Master Plan for the Maghtab Environmental Complex. Environmental Impact Statement Update prepared in support of development permit Application No. PA 02342/06.*

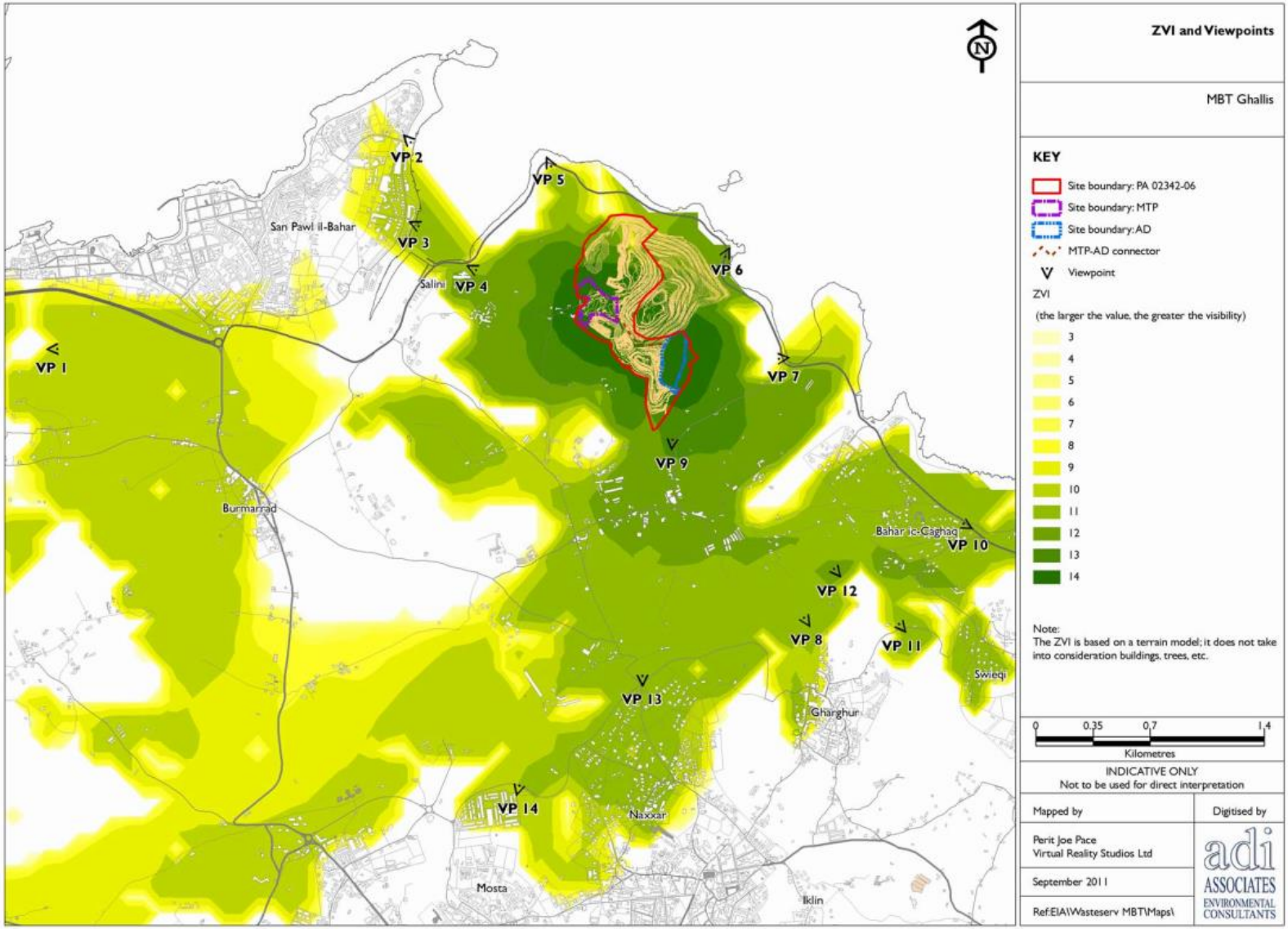


Table 3: list of viewpoints and description of impact of existing approved landfill, and proposed landfill extension

Viewpoint	Location	Visible (Y/N)	Description of Impact of approved landfill	Description of Impact of proposed extension
1.	**Wardija**: view of St. Paul's Bay and Burmarrad plains, with Maghtab landfill in the distance	Y	Approved landfill mass extends further to the north in terms of impact on the skyline.	Proposal has Maghtab as a backdrop; visible extent of extension is limited.
2.	**Triq il_Qawra Promenade, Bugibba**: view of sea, and coastal area dominated by Maghtab landfill	Y	Approved increase in landfill mass has Maghtab as a backdrop.	Proposal has Maghtab as a backdrop; visible extent of extension is limited.
3.	**Triq il_Luzzu, Qawra, facing Salina Bay**	Y	Approved landfill mass extends further to the eastern side of Salina Bay in terms of impact on the skyline.	Proposal has Maghtab as a backdrop; visible extent of extension is limited.
4.	**Adjacent to Coastline Hotel**	Y	Approved landfill mass extends further to the eastern side of Salina Bay in terms of skyline.	Proposed visible extent of landfill mass extends in the direction of the eastern side of Salina Bay in terms of impact on the skyline. Approved landfill mass as a backdrop.
5.	**Farm to the north of Ghallis landfill**	Y	Not visible	Proposed landfill mass is Incremental increase over existing.
6.	**North part of Coast Road**	Y	Approved landfill mass increases existing massing of landfill	Proposal has approved landfill mass as a backdrop; visible extent of extension is limited.
8.	**Sqaq tax-Xaqquf, Gharghur**: view of Burmarrad with St. Paul's Bay in the distance; Maghtab landfill	N	Behind Zwejra landfill – change is barely perceptible	Behind Zwejra landfill – change is barely perceptible
12.	**Triq Ghaxqet l-Ghajn, l/o Gharghur**: view of Maghtab and rural surroundings, with Maghtab landfill and St. Paul's bay in the distance	N	Behind Zwejra landfill	Behind Zwejra landfill – photomontage is to indicate location of intervention behind Zwejra landfill
13.	**Triq John Adye, T'Alla u Ommu:** rural landscape surrounding Maghtab Environmental Complex and industrial development	Y	Behind Zwejra landfill – Malta North visible	Proposed landfill mass extends incrementally further to the north in terms of skyline.
14.	**Triq l_Imsaqqfin, Mosta:** rural landscape surrounding Maghtab Environmental Complex and industrial development	Y	Behind Zwejra landfill – Malta North visible	Proposed landfill mass extends incrementally further to the north in terms of impact on the skyline, but is superimposed on approved landfill mass (see detail).

Appendix A – Case Studies

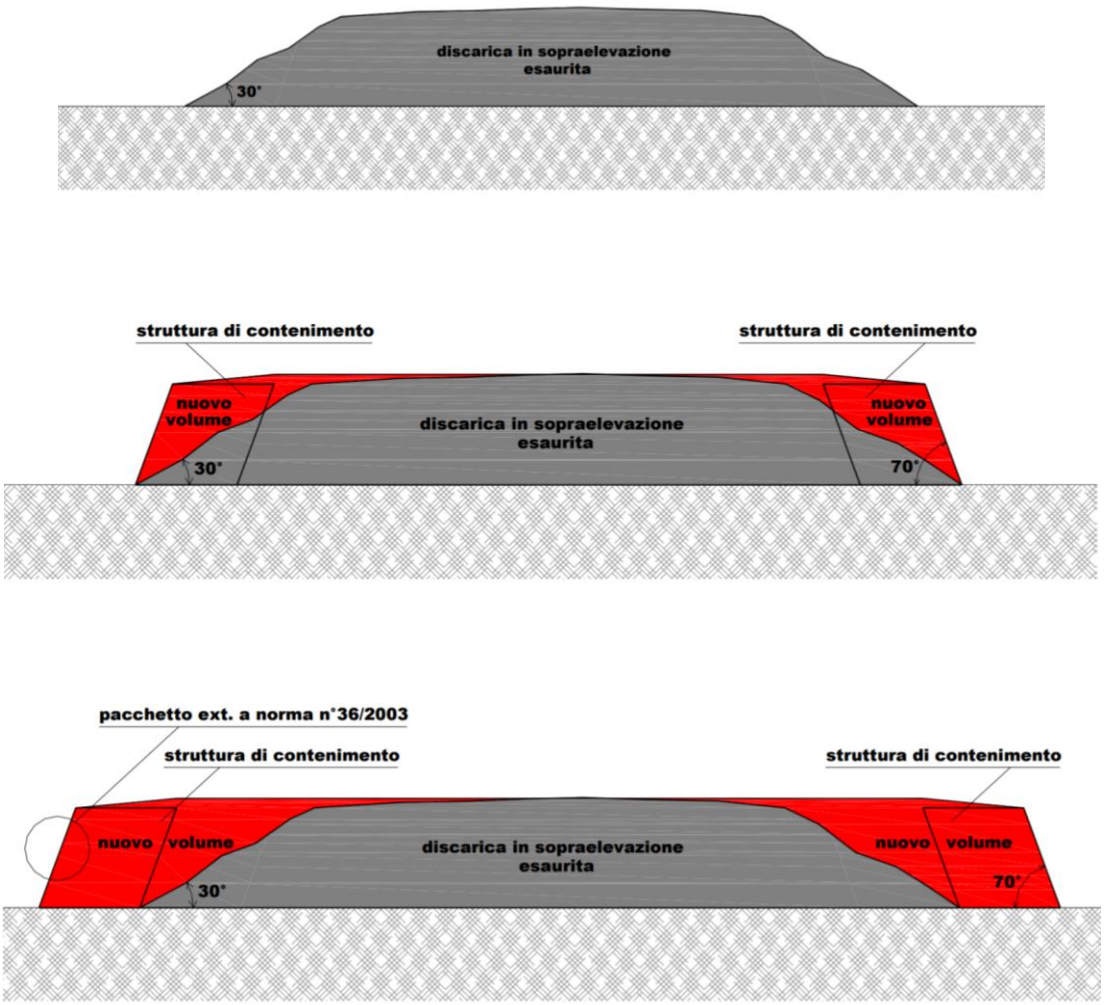
“Passo breccioso” landfill, Foggia (FG), Italy

“Passo breccioso” landfill is located close to the industrial area of the city of Foggia. It has a total surface of 10 hectares (about 35 acres) and is divided in two lots.

Figure 1: GPS view of "Passo breccioso" landfill

The work focused on an area of 4.5 hectares, in which the company was able to recover 575,000 cubic meters thanks to the construction of the patented structures. Figure 2 illustrates the various phases of construction that have been used to stabilise the pre-existing landfill mass, and recover additional landfill volume.

Figure 2: from top to bottom: pre-existing landfill, and sections of final landfill form.



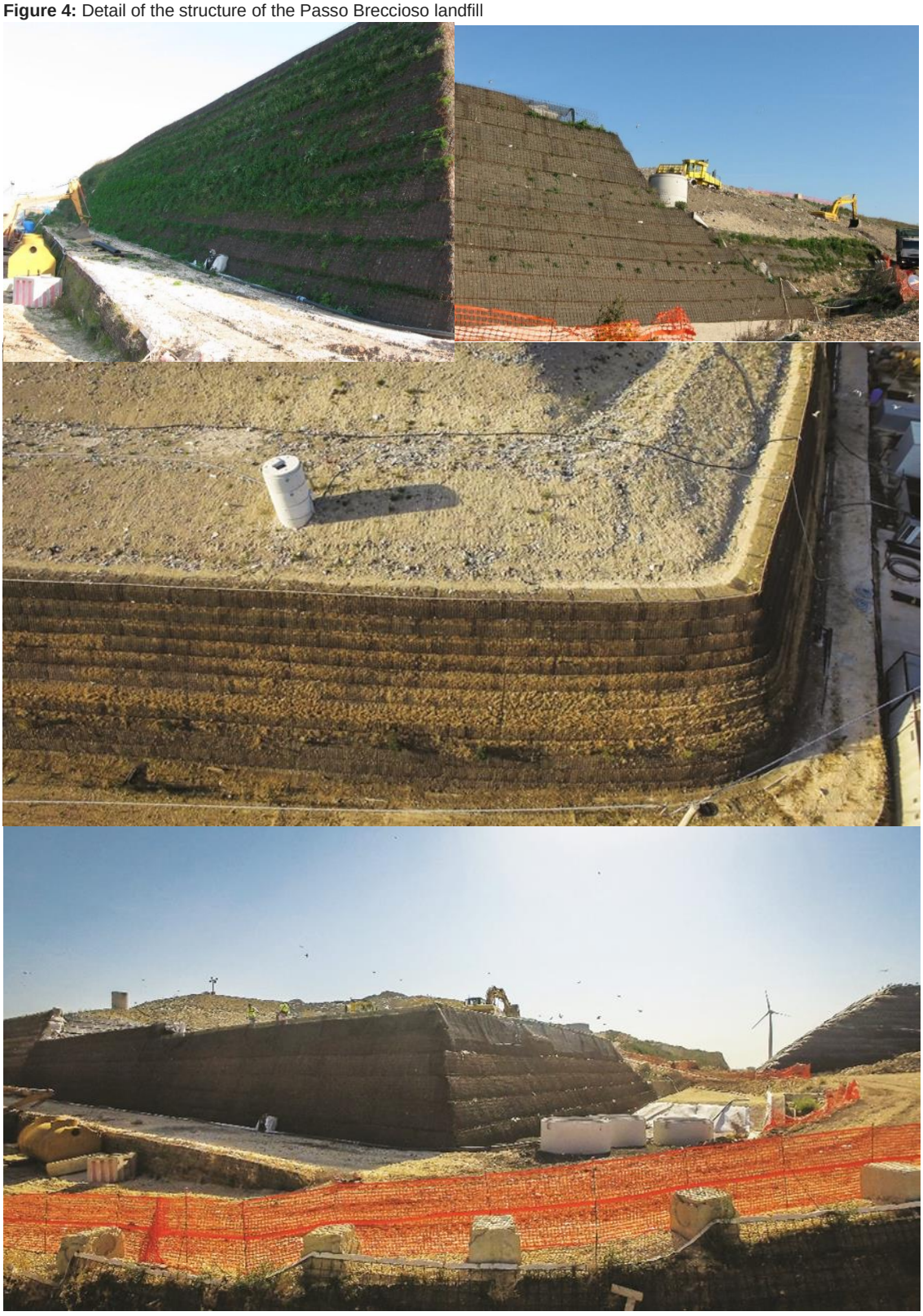
The previous figures depict the development of the landfill through the years, where the red sections represent the obtained recovered volume, and the retaining structures have a height of 12 meters. Moreover, the gradual and natural settlement of the landfill, due to waste decomposition, has allowed to build structures, over the years, more than 12 meters high (on average 2 meters above the expected and/or existing walls), which has permitted an even greater recovery of volume.

Operations required for these works included improvement of waste compaction, optimizing the available space and further stabilizing the structure. The limited organic content of these wastes has limited settlement over a period of almost 15 years; the compacted wastes, together with the reinforcements inside the structures, have proved to be stable, with an average reduction of the angle of the walls (from 2% to about 4% on average). A reduction in leachate production was also detected, as the high inclination of the walls and the external capping contributed to limit the infiltration of rainwater inside the landfill.

Additionally, the company, in partnership with the “University of Bari” has experimented with plantings above the landfill cover, using native species of the south-east Italy named *Inula viscosa* or *Dittrichia viscosa*. The plant served to limited visual impact, rendering the landfill less intrusive in terms of effect on the landscape. This plant is a highly branching perennial plant common throughout the Mediterranean Basin; it is a hardy species, very resistant to adverse conditions and degraded environments like landfills. *Inula viscosa* does not need any particular watering or climatic conditions and can be planted in every season.

Figure 3: "Passo breccioso" landfill

Figure 4: Detail of the structure of the Passo Breccioso landfill



“Pariti 2” landfill, Manfredonia (FG), Italy

“Pariti 2” landfill was a dumpsite characterized by a strong instability. The landfill, built in an old quarry, was exhausted and located in a mountainous area, which made the design and the execution of the embankments more difficult. Figure 5 shows the original condition of the landfill before the company intervention.

Figure 5: "Pariti 2" landfill (before)

The consolidation with recovery of volume of the landfill was achieved using the patented structures in benches. These benches have a limited height due to the small size of the landfill and the limited proper space. Despite this constraint, it is estimated that the total recovered volume stands at approximately 160,000 cubic meters over an area of 1,025 hectares (about 3 acres).

Figure 6: "Pariti 2" landfill (after)

The landfill design is similar to an amphitheatre, was constructed in benches at the bottom of the landfill, which has allowed stabilisation of the structure, and adaptation of the walls to the local topography. The waste utilized for the structures was unprocessed municipal waste; consequently, his resulted in a more substantial settlement of the landfill (about 20%) at the end of the intervention.

“Masseria campana” landfill, Deliceto (FG), Italy

Figure 7: "Masseria campana" landfill (East side)

Figure 7 shows the consolidation with recovery of volume of the East side of the “Masseria campana” landfill during its execution. The ordinary size of the landfill did not justify the costs of a traditional expansion with embankments using by soil; the technique, instead, has made possible the implementation of the project, with a volumetric recovery of about 60.000 m^3.

Appendix B - Photomontages

VIEWPOINT REFERENCE 1 Distance to proposed development: 3.35 Km Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1206 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

EXISTING VIEW

VIEWPOINT REFERENCE 1 Year 0 / 10 Distance to proposed development: 3.35 Km Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1206 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

WIRELINE VIEW

VIEWPOINT REFERENCE 1 Year 0 / 10 Distance to proposed development: 3.35 Km Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1206 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

PROPOSED VIEW

The image contained on this page is not representative of scale and distance from the actual viewpoint and shows the proposed development in its context only

VIEWPOINT REFERENCE 2 Distance to proposed development: 1.47 Km Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1226 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

EXISTING VIEW

VIEWPOINT REFERENCE 2 Year 0 / 10 Distance to proposed development: 1.47 Km Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1226 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

WIRELINE VIEW

VIEWPOINT REFERENCE 2 Year 0 / 10 Distance to proposed development: 1.47 Km Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1226 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

PROPOSED VIEW

The image contained on this page is not representative of scale and distance from the actual viewpoint and shows the proposed development in its context only

VIEWPOINT REFERENCE 3 Distance to proposed development: 1.19 Km Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1234 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

EXISTING VIEW

VIEWPOINT REFERENCE 3 Year 0 / 10 Distance to proposed development: 1.19 Km Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1234 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

WIRELINE VIEW

VIEWPOINT REFERENCE 3 Year 0 / 10 Distance to proposed development: 1.19 Km Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1234 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

PROPOSED VIEW

The image contained on this page is not representative of scale and distance from the actual viewpoint and shows the proposed development in its context only

VIEWPOINT REFERENCE 4 Distance to proposed development: 698 m Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1244 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

EXISTING VIEW

VIEWPOINT REFERENCE 4 Year 0 / 10 Distance to proposed development: 698 m Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1244 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

WIRELINE VIEW

VIEWPOINT REFERENCE 4 Year 0 / 10 Distance to proposed development: 698 m Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1244 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

PROPOSED VIEW

The image contained on this page is not representative of scale and distance from the actual viewpoint and shows the proposed development in its context only

VIEWPOINT REFERENCE 5 Distance to proposed development: 329 m Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1336 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

EXISTING VIEW

VIEWPOINT REFERENCE 5 Year 0 / 10 Distance to proposed development: 329 m Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1336 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

WIRELINE VIEW

VIEWPOINT REFERENCE 5 Year 0 / 10 Distance to proposed development: 329 m Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1336 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

PROPOSED VIEW

The image contained on this page is not representative of scale and distance from the actual viewpoint and shows the proposed development in its context only

VIEWPOINT REFERENCE 6 Distance to proposed development: 329 m Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1259 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

EXISTING VIEW

VIEWPOINT REFERENCE 6 Year 0 / 10 Distance to proposed development: 329 m Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1259 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

WIRELINE VIEW

VIEWPOINT REFERENCE 6 Year 0 / 10 Distance to proposed development: 329 m Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1259 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

PROPOSED VIEW

The image contained on this page is not representative of scale and distance from the actual viewpoint and shows the proposed development in its context only

VIEWPOINT REFERENCE 8 Distance to proposed development: 2.31 Km Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1359 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

EXISTING VIEW

VIEWPOINT REFERENCE 8 Year 0 / 10 Distance to proposed development: 2.31 Km Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1359 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

WIRELINE VIEW

VIEWPOINT REFERENCE 8 Year 0 / 10 Distance to proposed development: 2.31 Km Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1359 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

PROPOSED VIEW

The image contained on this page is not representative of scale and distance from the actual viewpoint and shows the proposed development in its context only

VIEWPOINT REFERENCE 12 Distance to proposed development: 2.15 Km Camera height: 1.5m Date / time of photograph: 19-Jun-2017 ; 1433 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

EXISTING VIEW

VIEWPOINT REFERENCE 12 Year 0 / 10 Distance to proposed development: 2.15 Km Camera height: 1.5m Date / time of photograph: 19-Jun-2017 ; 1433 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

WIRELINE VIEW

VIEWPOINT REFERENCE 12 Year 0 / 10 Distance to proposed development: 2.15 Km Camera height: 1.5m Date / time of photograph: 19-Jun-2017 ; 1433 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

PROPOSED VIEW

The image contained on this page is not representative of scale and distance from the actual viewpoint and shows the proposed development in its context only

VIEWPOINT REFERENCE 13 Distance to proposed development: 2.36 Km Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1318 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

EXISTING VIEW

VIEWPOINT REFERENCE 13 Year 0 / 10 Distance to proposed development: 2.36 Km Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1318 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

WIRELINE VIEW

VIEWPOINT REFERENCE 13 Year 0 / 10 Distance to proposed development: 2.36 Km Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1318 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

PROPOSED VIEW

The image contained on this page is not representative of scale and distance from the actual viewpoint and shows the proposed development in its context only

VIEWPOINT REFERENCE 14 Distance to proposed development: 3.1 Km Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1324 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

EXISTING VIEW

VIEWPOINT REFERENCE 14 Year 0 / 10 Distance to proposed development: 3.1 Km Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1324 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

WIRELINE VIEW

VIEWPOINT REFERENCE 14 Year 0 / 10 Distance to proposed development: 3.1 Km Camera height: 1.5m Date / time of photograph: 29-Sept-2017 ; 1324 Camera type: EOS 5DS; VFOV: 27deg HFOV: 39.6deg Sheet number: NA

PROPOSED VIEW

The image contained on this page is not representative of scale and distance from the actual viewpoint and shows the proposed development in its context only

Detail from Viewpoint reference 14