REHABILITATION AND RESTORATION OF WIED FULIJA LANDFILL

Project Description Statement

Prepared for: Wasteserv Malta Ltd

SLR Ref: 403.06637.00002
Version No: Final
April 2018

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1.0 Scope of the PDS

In January 2015 Wasteserv Malta Limited (Wasteserv) issued a project Description Statement (PDS) outlining proposals for the rehabilitation and restoration of Wied Fulija Landfill. Since that date further studies have been carried out at the site resulting in a refinement of the proposed design for the rehabilitation and restoration system.

This PDS presents an update to the 2015 document and whilst the core objectives and principles of the project remain unchanged further background information on the site is provided along with more detail on the final design and rehabilitation methodology. This document provides:

- an outline of the past history of the Wied Fulija site, and the past activities that have led to its current contaminated state;
- a review of the environmental situation on site at present; and
- a proposal for the required interventions (detailed design and methodology) required to ensure proper containment of the pollution present on site.

2.0 Details of the Developer

Wasteserv Malta Ltd.
Eko Centre, Latmija Road
Marsascala MSK 4613

Wasteserv Malta Ltd was formed in 2002 as a private company in accordance with the Companies Act 1995 wholly owned by the Government of Malta through Malta Government Investments Limited and Malta Investment Management Company Limited. Wasteserv is responsible for the waste management of all Malta and Gozo.

Its main objectives include:

- The organisation, management and operation of integrated systems for export of waste to destinations outside the Maltese Islands and for waste management, including integrated systems for minimisation, collection, transport, sorting, reuse, utilisation, recycling, treatment and disposal of solid waste and hazardous waste;
- The organisation, management and operation of integrated systems for waste management in accordance with the Laws of Malta and the waste management policy and plan of the Government of Malta, whilst simultaneously observing internationally recognised waste management principles;
- The organisation, management and operation of integrated systems for waste management for other types of waste as may be decided by the Government of Malta or the Ministry responsible for the infrastructure relating to the management of waste; and
- The assistance and supervision of the implementation of waste management policies as developed from time to time by the Government of Malta.

3.0 Introduction

3.1 Żurrieq

Wied Fulija is a small hamlet located on the Southern coast of Malta. It is on the outskirts of Żurrieq, approximately 1.5 km south of the centre. There are a number of villages, including Wied Fulija, that make up the 10.5km² district of Żurrieq. It has a relatively large population of 11,823 as of 2014.[1] At the present time, Żurrieq is predominately a residential area.

It is one of the oldest towns of the Maltese Islands and has a rich history dating back to Bronze, Punic and Roman times. [2] There are a number of historic sites within Żurrieq that can still be visited today, including the Parish Church of St Catherine, the Chapel of the Immaculate Conception, The Xarolla Windmill, The Nigret Palace, The Armoury and The Wardija Tower. [2]

The coastal region of Żurrieq provides access to the Blue Grotto and a number of beautiful diving sites. Wied iz- Żurrieq, located to the South West of the main centre, provides a picturesque area for hiking, rock climbing and swimming.[3] The combination of cultural and natural site located within Żurrieq, attracts large numbers of both locals and tourists to the area.

3.2 Location of Wied Fulija Landfill

The Wied Fulija landfill is located on the edge of Żurrieq, southeast Malta, as shown in Figure 3-1 and Figure 3-2. The GPS co-ordinates of the landfill are 35°48'57.24"N; 14°28'53.72"E. Figure 3-3 shows the site in greater detail with the 100m Area of Influence (AoI) illustrated.

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[1] www.citypopulation.de (2017) https://goo.gl/EsPMww
[2] www.malta.com (2011) https://goo.gl/qnPidu
[3] Malta Tourism Authority (2013) https://goo.gl/T8Prt6

Figure 3-1
Map showing the location of Żurrieq (Source: Google Earth, 2017)

Figure 3-2
Map showing the location of Wied Fulija Landfill

Figure 3-3
Wied Fuljia Landfill and 100m AoI

3.3 Description of the Current State of Wied Fulija Landfill

An aerial photo (dated 2017) of the current state of Wied Fulija Landfill is shown in Figure 3-4.

The landfill at Wied Fulija is no longer active. It commenced operations in 1979 and ceased to accept waste from 1996. In total records indicate that approximately 1.85m tonnes of waste were deposited and it is understood this was a mixture of municipal, construction, demolition and industrial waste . Between 2007 and 2010 records also indicated that approximately 5770 tonnes of glass waste were taken to site for temporary storage.

The site comprises of two separate bodies of waste on the eastern and western sides of Wied il-Ħallelin (Figure 3-5). The seaward side of the site lies within 10-25m off the cliff edge, where there is a sheer drop of around 100m to the sea (Figure 3-6).

The top of the waste is up to 25m above the surrounding natural ground level on the seaward side but is thinner (around 10m) on the landward side. The maximum depth of waste is around 30metres. The total footprint is in the region of 6.5 hectares. Both the eastern and the western plateaus are steep-sided, benched and flat-topped. The top area of the western side is approximately 0.9 hectares and the eastern side about 1.5 hectares. The mounds of waste are composed of a mix of household and industrial waste, construction waste, demolition waste, glass waste, limestone boulders, silt and sand. The valley beneath the two plateaus generally follows the route of Wied il-Ħallelin but contains a limited thickness of waste.

The landfill was mainly founded on rock although some of the waste has been placed on the agricultural fields that surround the site as the landfill has grown. The area surrounding the Wied Fulija landfill mainly consists of the village area of Wied Fulija and the town of Zurrieq to the North, surrounded by local agricultural land and a nearby farm.

A plan of the current Site Layout is shown on the drawings in Appendix A.

Figure 3-4
Aerial Image of Wied Fuljia (2017)

Figure 3-5
Wied Fulija from the North

Figure 3-6
South Part of Wied Fuljia Landfill, near the cliff edge

3.4 Proposed Development

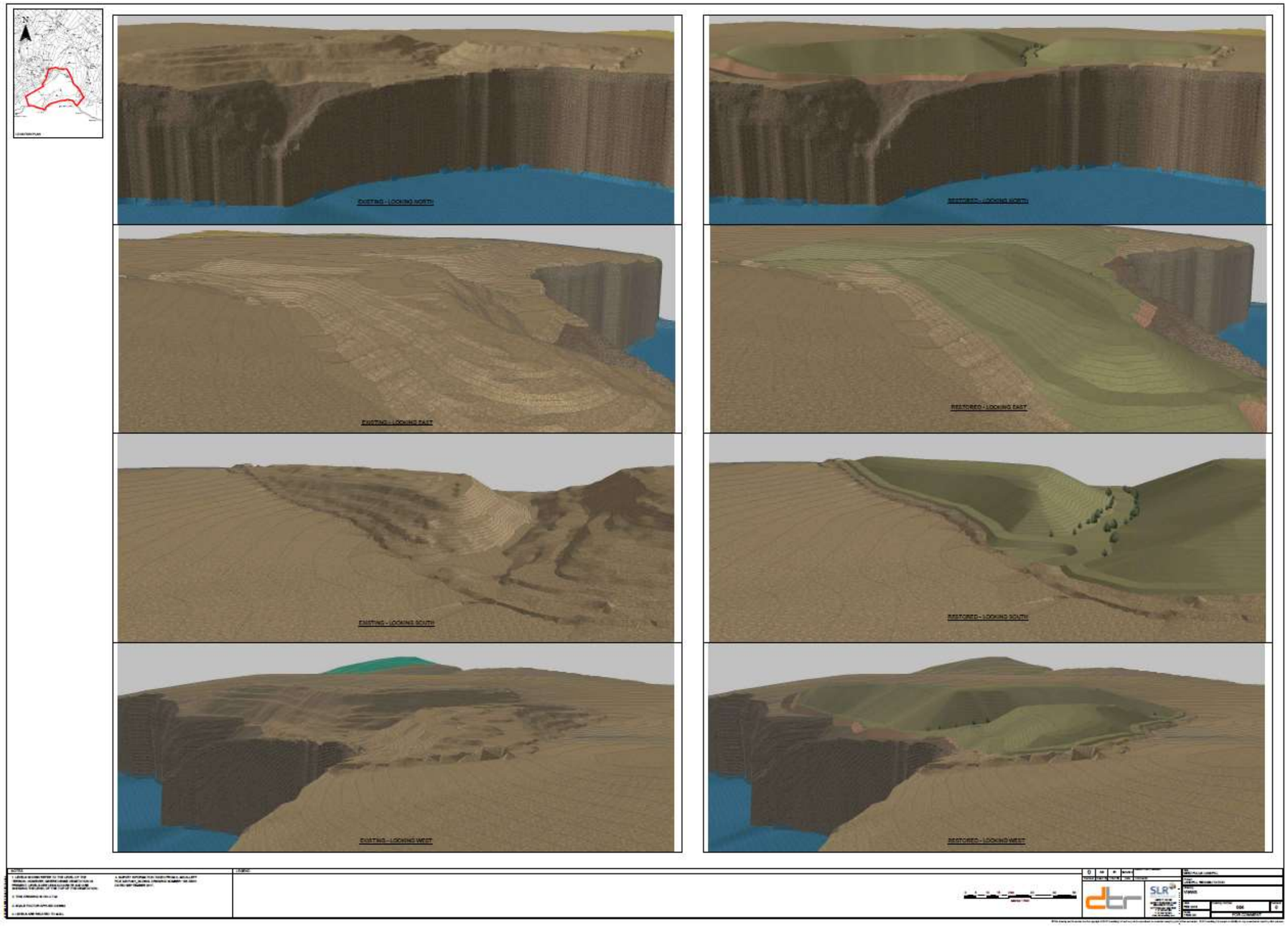
The proposed development will involve the restoration of an area of 6.5ha within the Wied Fuljia Landfill. The two mounds currently located to the west and east of the valley will be reshaped. The valley between the mounds will also be altered. The design of the re-profiling of the mounds ensures that they blend into the surrounding environment as much as possible. A network of access paths will be constructed around the perimeter of the site and on the sides of the mounds, to enable access by foot to the general public. As a key principle the reshaping work helps to stabilise the waste slopes and improve the overall appearance but also aim to minimise excavating the existing waste.

Once reshaped a capping and restoration system will be installed. This will help reduce the adverse effects that the landfill site is currently having on the surrounding environment and make them safe to the general public. A surface water management infrastructure will also be built into the newly profiled mounds.

Once the re-profiling and capping is complete, the area will be landscaped and a range of species of plants will be planted. The planting of vegetation will aid the functioning of the capping system, as well as improving the visual appeal of the current site.

A graphic image of how the Wied Fulija site is expected to change with the development as shown in Figure 3-7. A more detailed description of the proposed project can be found in Section 5.4.

Figure 3-7
Graphic Visualisations of the Changes of Wied Fulija if the Proposed Development is Accepted



3.5 Project Objectives

The solid waste disposal site at Wied Fulija was developed at a time when the full environmental impacts of such operations were not known. As a result, the site has no systems in place for the proper control of landfill leachate or gas. The Ministry for Resources and Infrastructure (later Wasteserv) had expressed concern over the potential human health and environmental impacts of Wied Fulija, and other similar sites, and the need to raise the environmental standards associated with the management of waste in Malta. Movement has been made towards this with the implementation of A SOLID WASTE MANAGEMENT STRATEGY FOR THE MALTESE ISLANDS (2001) and the more recent WASTE MANAGEMENT PLAN FOR THE MALTESE ISLANDS: A RESOURCE MANAGEMENT APPROACH 2014-2020 (2014). The overall objective of this project is to contribute to the implementation of rehabilitation proposals in order to mitigate the prevailing potential hazards at Wied Fulija. It also aims to restore the site to enable the edges of the site to be used for public recreational use as well as promoting increased levels of biodiversity.

Back in 2002, the Ministry for Resources and Infrastructure commissioned Scott Wilson to carry out a study of three landfill sites, including the Wied Fulija landfill. The investigations focused on identifying the hazards to human health and the environment presented by each of the sites. Reference is made to the data collected in his report DEVELOPMENT OF REHABILITATION STRATEGIES MAGHTAB, QORTIN AND WIED FULIJA LANDFILLS (2004) and is now being studied further for the development and implementation of an environmentally sound rehabilitation strategy. More recent geotechnical studies carried out by SLR Consulting Limited (SLR) in 2017 is also being considered in the development plans for the site.

3.6 Related Local Policy

Wied Fulija falls under the SOUTH MALTA LOCAL PLAN (SMLP). The agricultural land in the area surrounding the proposed site is classed as “Protected Agricultural Land” in SMAG 01 of the SMLP (refer to Figure 3-9) and hence needs to be protected from any developments which will affect it adversely.

Along the coast within the AoI of the landfill site there is Rdumijiet ta’Malta: Mix-Xaqqa sal-Ponta ta’ Bengħisa which is a Natura 2000 site. It is a Special Area of Conservation (SAC) and a Special Protection Area (SPA) (refer to Figure 3-8). In the landfill area and its surroundings there are also Areas of Ecological Importance (AEIs) and Sites of Scientific Importance as defined in section SMCO 03 of the SMLP (refer to Figure 3-9). Such areas home a range of endemic and endangered species that are highly sensitive to change and therefore they need be strictly protected to ensure that they are not subject to any adverse impacts that may arise from developments. These areas will be discussed in greater detail in Section 4.3.

The SMLP also highlights the promotion of the creation of “walking and cycle routes and heritage trails in urban and rural areas” in section SMRE 02. Within the Żurrieq area a number of areas are targeted, although none of these are in the AoI, the SMLP states specifically that the list is not exhaustive. The proposed project will help in achieving this aim of opening up the coastline, which is currently not accessible.

Figure 3-8
: Natura 2000 sites of the Maltese Islands. Site 27, Rdumijiet ta'Malta: Mix-Xaqqa sal-Ponta ta' Benghisa is within the AoI (Wied Fulija is highlighted by the red circle)

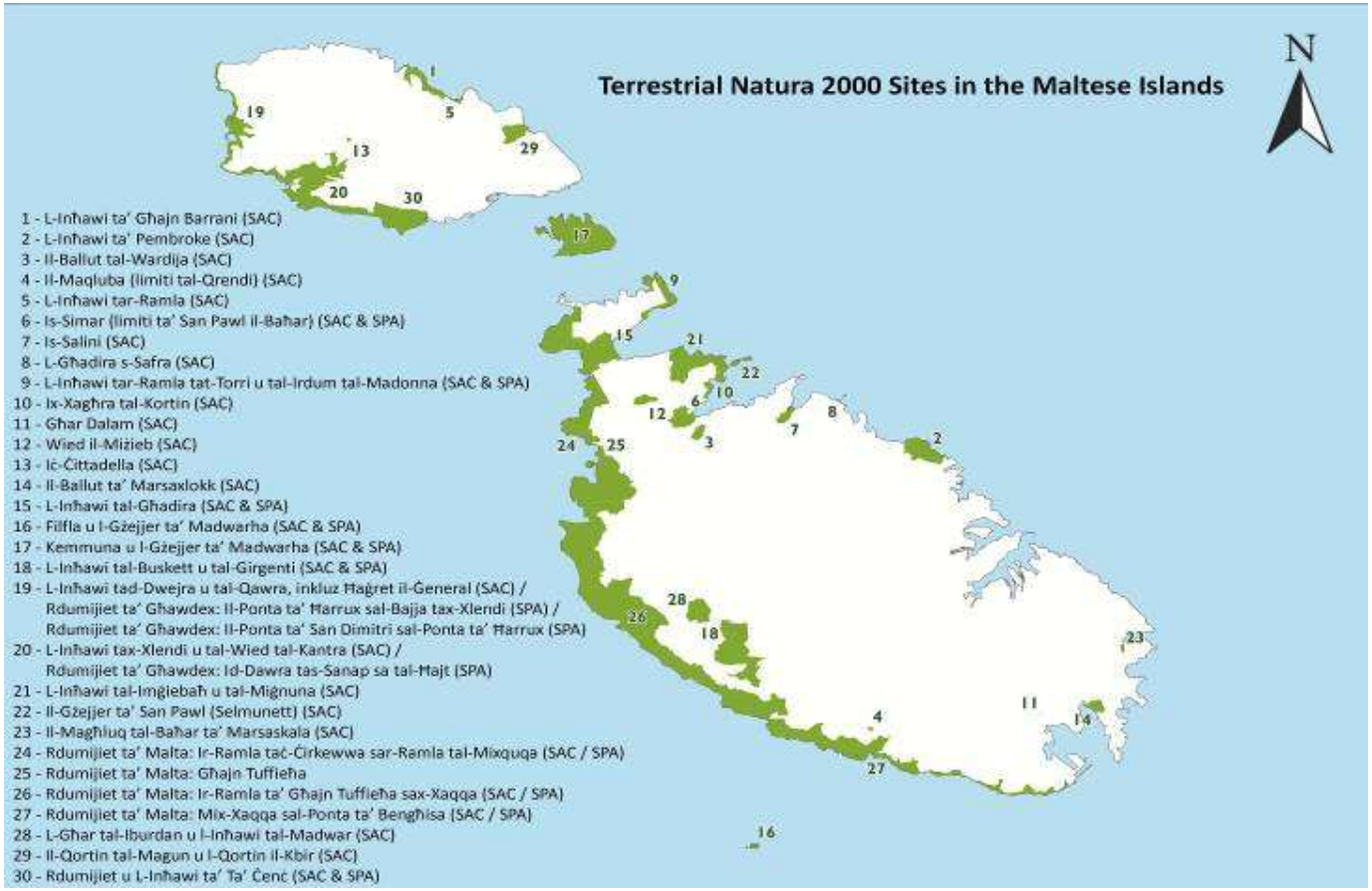
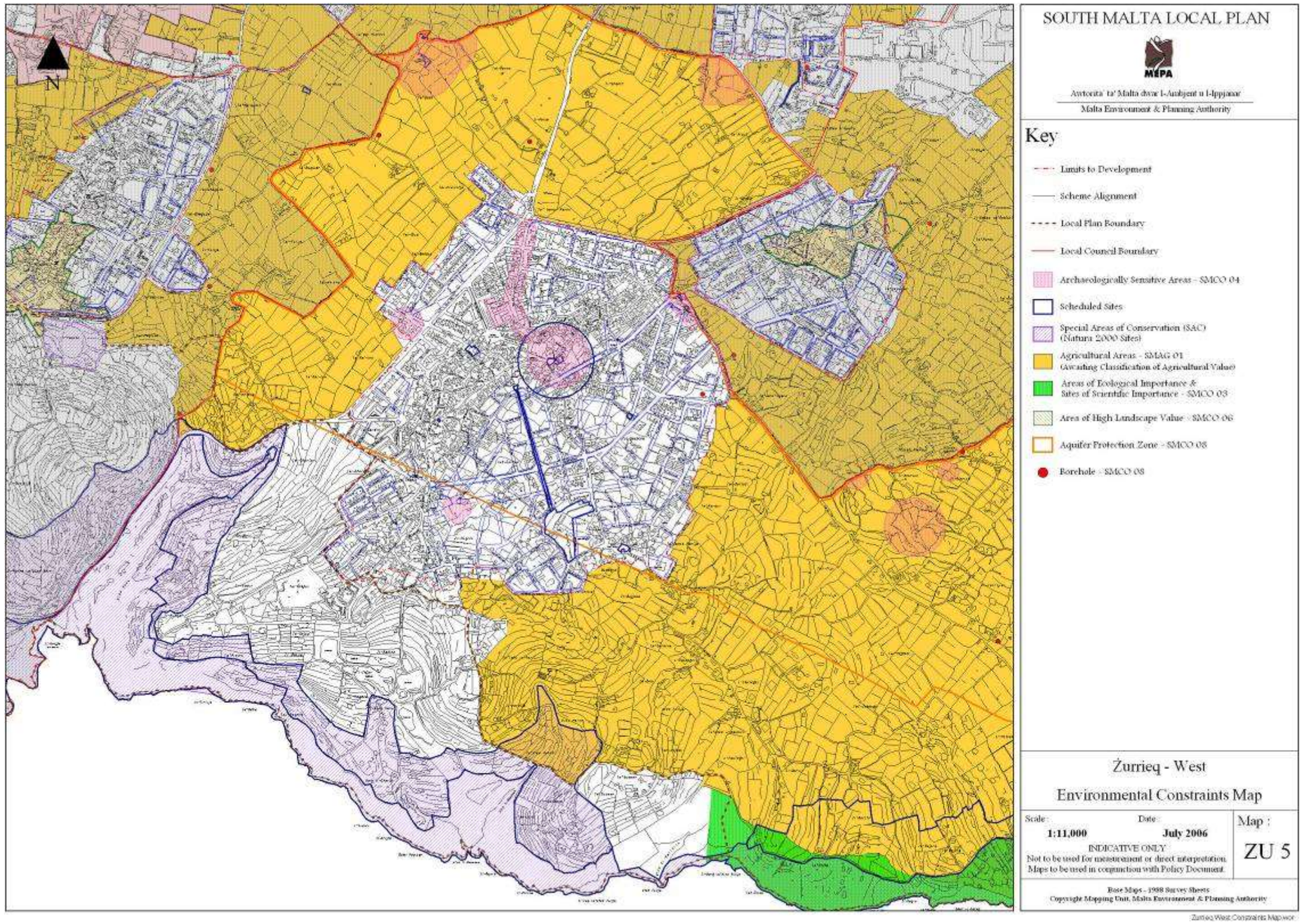


Figure 3-9
: Environmental constraints map for the Żurrieq area, Wied Fuljia is highlighted by the red circle (Source: CMLP)



4.0 Land Uses and Environmental Characteristics

4.1 Land Uses

The land uses with a 100m buffer zone of the Wied Fuljia landfill are mapped in Figure 4-1.

The dominant land use surrounding the landfill is agriculture, found to the East, North and West. Zurrieq is over 700m to the North and North West of the site; a limestone quarry and the Hal Far industrial estate are located over 1km to the east along the cliff, and the Ghar Lapsi reverse osmosis plant is located over 2.4km to the west.

The agricultural fields are divided by the typical and characteristic Maltese rubble walls (Figure 4-2). With the agricultural land to the North East of the site there is an open area that is presently not being used for any specific purpose (Figure 4-3). To the South East of the site there is also an area of abandoned land (Figure 4-4). Located to the North and South East of the landfill there are some residential units (Figure 4-5). To the South of the site there is long stretch of garigue along the cliff tops. The cliff tops are very steep and plunge down into the sea. A narrow strip of the sea is included in the AoI. However, as this area of sea is located at the bottom of the steep cliffs and is small in spatial extent it is considered that no major activities are occurring here.

Figure 4-1
Land Use within the 100m AoI Wied Fulija

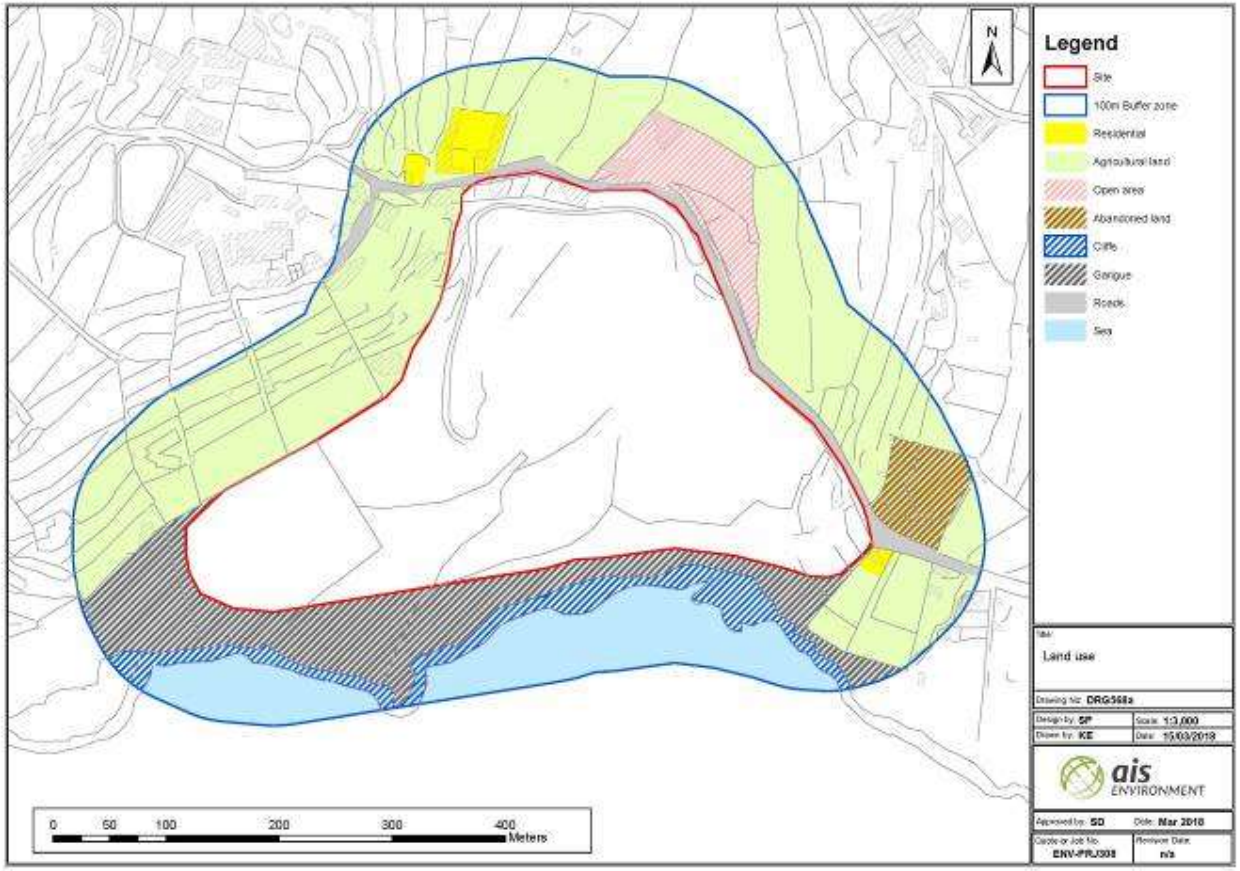


Figure 4-2
Agricultural Fields with Rubble Walls in the 100m AoI (Source Google Earth, 2017)

Figure 4-3
Open area in the 100m AoI (Source: Google Earth. 2017)

Figure 4-4
Abandoned land in the 100m AoI (Source: Google Earth, 2017)

Figure 4-5
Residential Property in the 100m AoI (Source: Google Earth, 2017)

4.2 Geology, Geomorphology and Hydrogeology

4.2.1 Geology and Soil

The landfill and surrounding area is located on the following rock types (refer to Figure 4-6):

- Lower Coralline Limestone Formation:
    - Attard Member: It is grey in colour and composed of detrital coralline algae with scattered, variably developed algal rhodolites. It was deposited in a range of environments from calm lagoons to high energy water conditions during the Chattian age of the Oligocene epoch.
    - Xlendi Member: It is brown to pale grey in colour and is thickly to very thickly bedded biocalarenites and biocalcirudites. The thickness of this member varies across the island from 10 to 15m. It is characterised by coarse cross bedded packstones and grainstones. It was deposited in shallow water, high energy environments during the Chattian age of the Oligocene epoch.
    - Il-Mara Member: It is the youngest of the Lower Coralline members. It is yellow to pale yellow in colour and in some areas white. It can either be massive or laminated and laterally continuous thick to very thick beds of biocalcarenites. This member varies in thickness from 1m up to 20m. The member was deposited in an open marine environment in the fore-slope area in water depths between 5 to 20m during the Chattian age of the Oligocene epoch.
- Globigerina Limestone Formation:
    - Lower Globigerina Member: It is pale yellow in colour with scattered iron stains, with medium-to-fine grains. It varies in thickness from 5m to 110m. It is composed of two main beds: Franka Stone and Soll Bed. It was formed during the Burdigalian age of the Miocene epoch.

The landfill area is located on Xaghra series and L'inglin complex soils. Xaghra soil is a type of terra soil and L'inglin complex soil is a soil complex. A soil map for the AoI is shown in Figure 4-7

Figure 4-6
Underlying geology of the Wied Fulija landfill and AoI

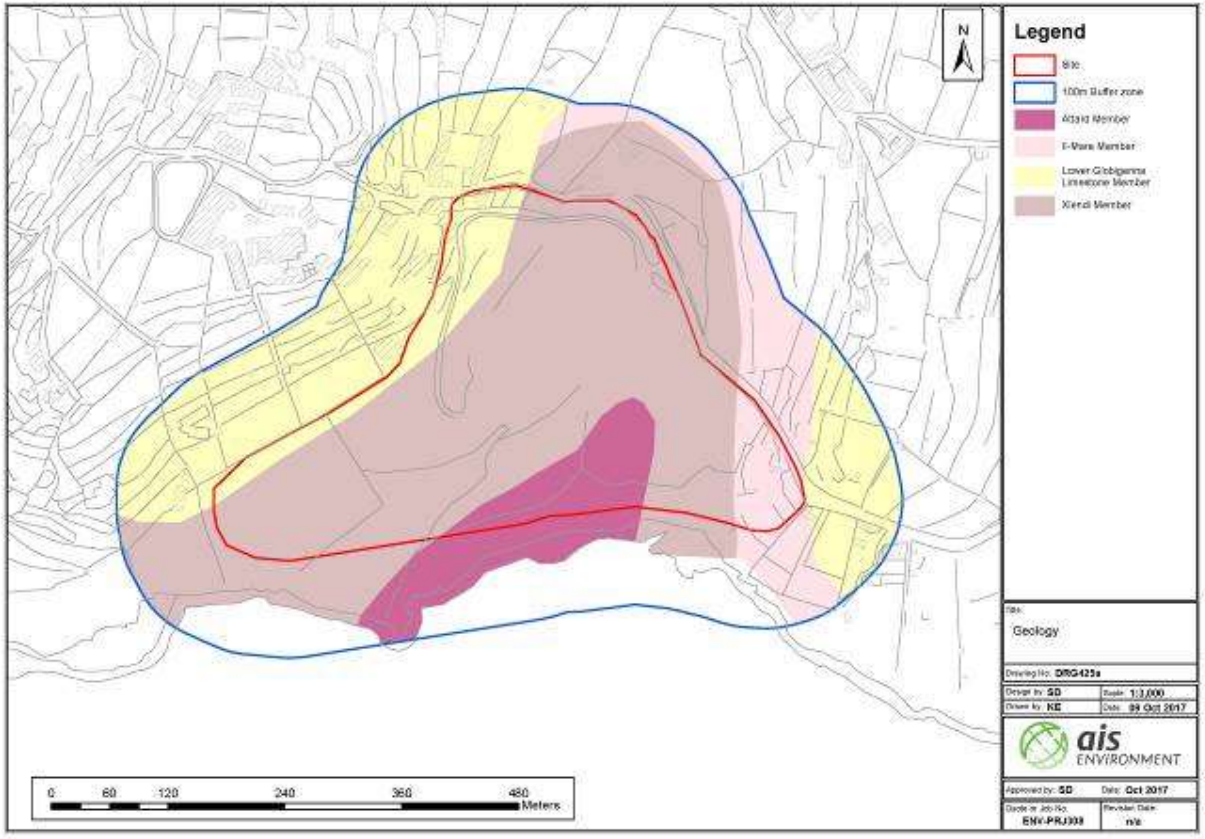
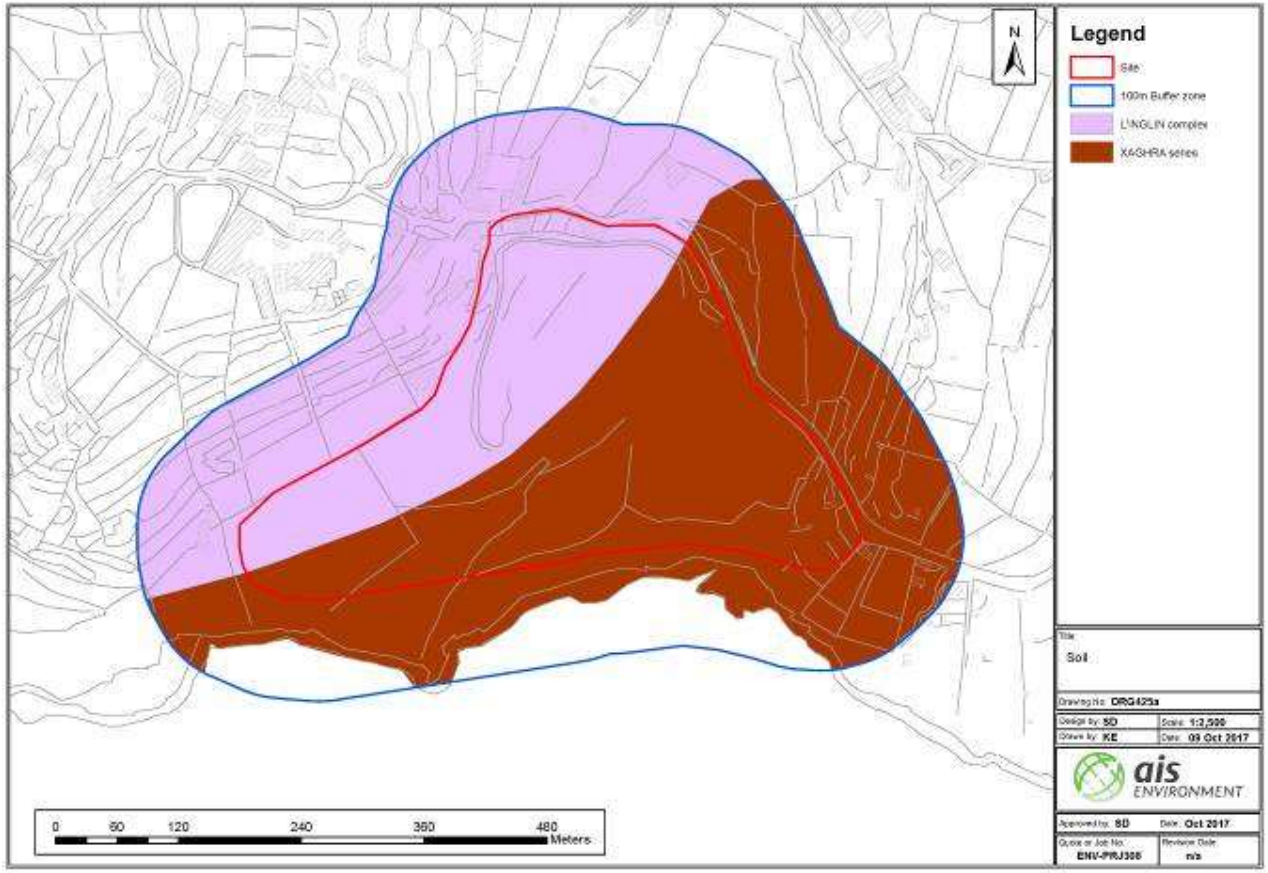


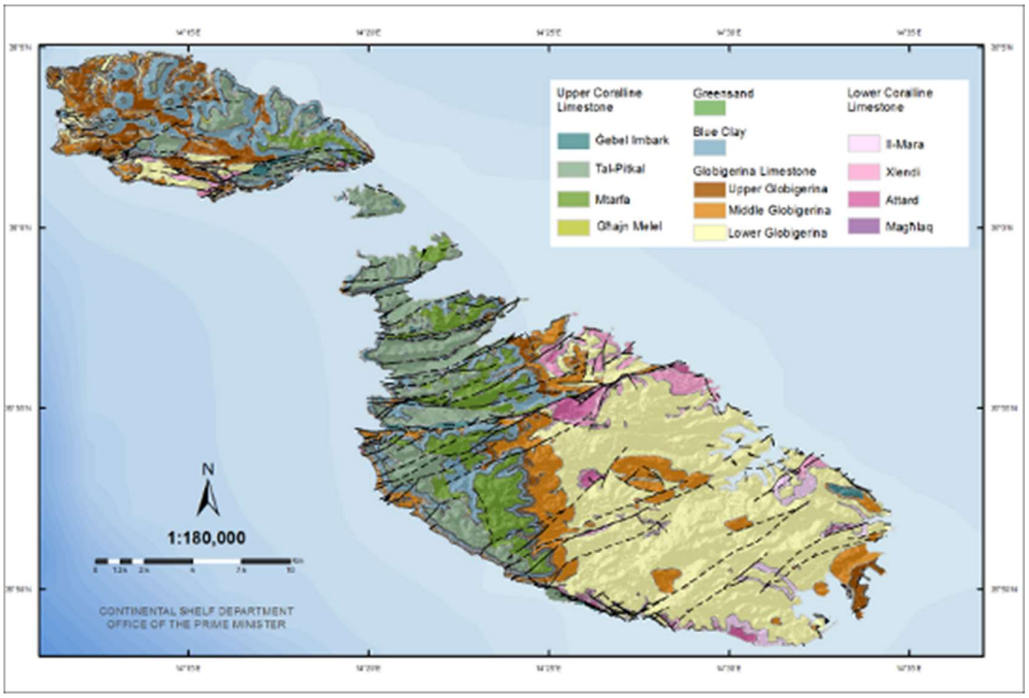
Figure 4-7
Soils of the Wied Fulija landfill and AoI



4.2.2 Geomorphology

The Maltese Islands are dominated by a horst and graben system, which produces areas of high and low lying land. There are also a number of faults which transverse the islands (refer to Figure 4-8). Within the South East area of Malta there is the Magħlaq Fault Zone. The combination of the horst and graben system and the faults results in a number of valley systems. The landfill at Wied Fuljia is located within one of these valleys, Wied il-Ħallelin.

Figure 4-8
Map of the Maltese Islands showing the geology and faults (Source: continentalshelf.gov.mt)



4.2.3 Hydrology

The landfill site is located above the mean sea level aquifer and outside of the aquifer protection zone, which is defined in section SMCO 08 of the SMLP (refer to Figure 4-9). The coastal waters of the AoI are considered to be deep (greater than 50m) and very exposed, according to THE 2ND WATER CATCHMENT MANAGEMENT PLAN FOR THE MALTESE ISLANDS (Figure 4-10).

Figure 4-9
Hydrology of Wied Fulija landfill and AoI (Source: ERA, Natura 2000 Management Plan)

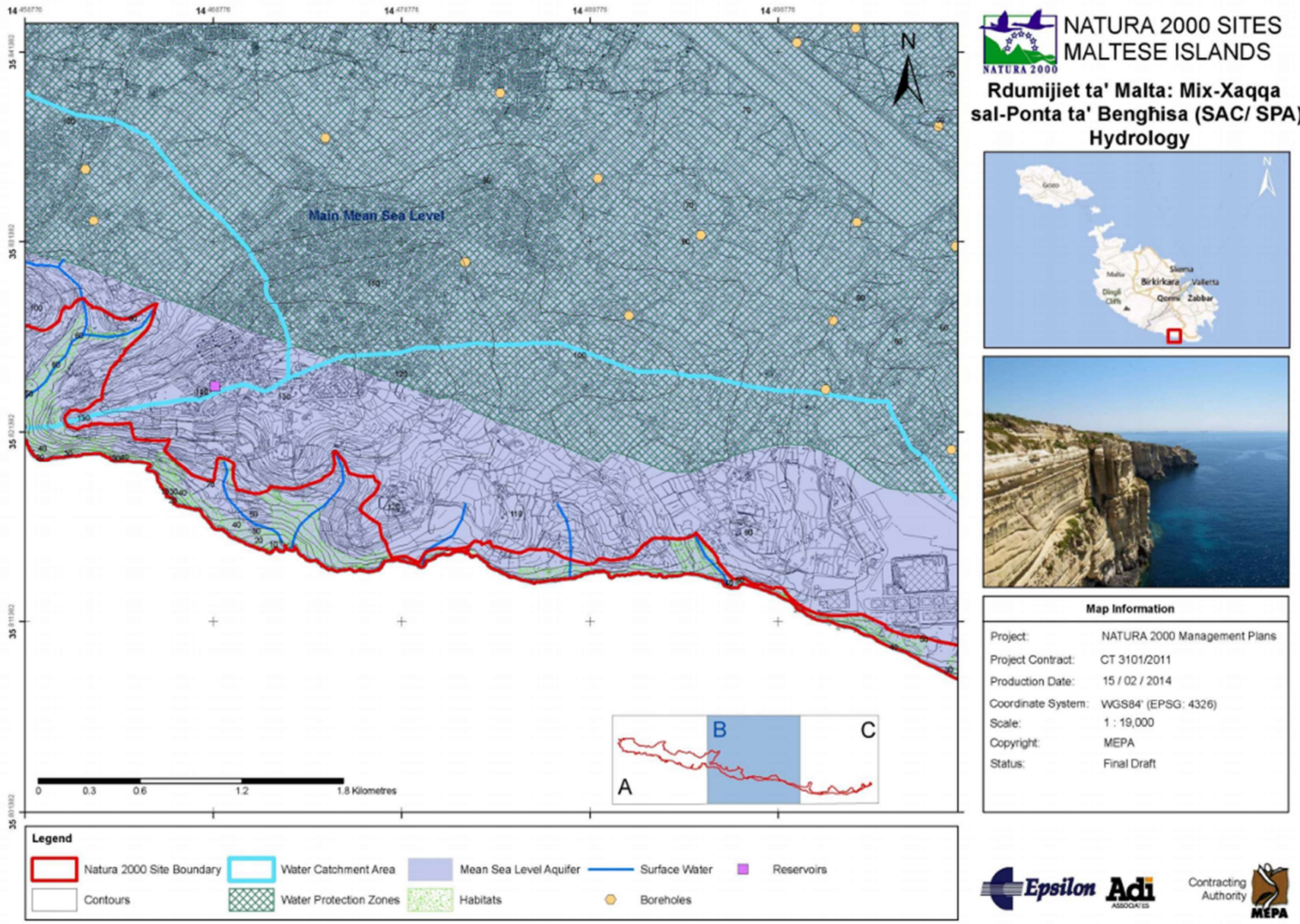
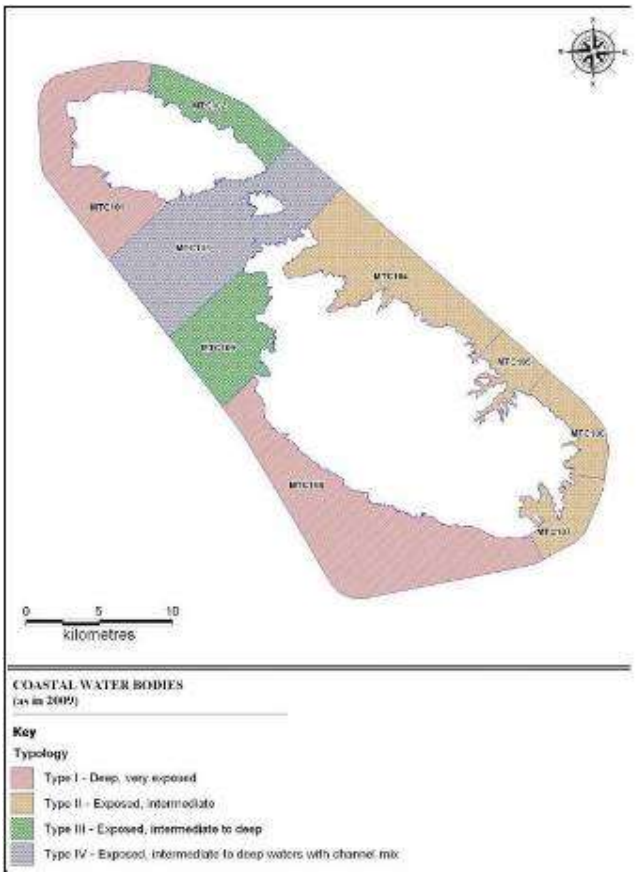


Figure 4-10
Depth and level of exposure of Maltese coastal waters (Source: 2ND WATER CATCHMENT MANAGEMENT PLAN)



4.3 Ecology

The proximity of the Natura 2000 Site, Rdumijiet ta'Malta: Mix-Xaqqa sal-Ponta ta' Benġħisa, needs to be carefully considered in the project development. Figure 4-11 shows the extent of the Natura 2000 site in the locality of the landfill site. It is one of the largest SAC in the Maltese Islands, with an area of over 370 ha.[4] The area is characterised by a number of rare and endangered species. The area is particularly important for seabirds that are known to breed along the steep cliffs. Birds referred to in ARTICLE 4 OF DIRECTIVE 2009/147/EC and listed in ANNEX II OF DIRECTIVE 92/43/EEC found in the area are as follows:

[4] ERA. Rdumijiet ta'Malta: Mix-Xaqqa sal-Ponta ta'Benghisa Management Plan

- *Clandrella brachydactyla* (Short-toed Lark)
- *Calonectris diomedea* (Scopoli's Shearwater)
- *Cettia cetti* (Cetti's Warbler)
- *Cisticola juncidis* (Streaked fantail warbler)
- *Columba livia* (Rock Dove)
- *Larus cachinnans* (Caspian Gull)
- *Milaria calandra* (Corn Bunting)
- *Puffinus yelkouan* (Yelkouan Shearwater)
- *Sylvia conspicillata* (Spectacled Warbler)
- *Sylvia melanocephala* (Sardinian Warbler)

The entire area of Rdumijiet ta'Malta: Mix-Xaqqa sal-Ponta ta' Bengħisa, which extends far beyond the AoI, contains 10 different habitats of importance, as listed in the HABITATS DIRECTIVE ANNEX I:

- Vegetated sea cliffs of the Mediterranean coasts with endemic Sea Lavender species (Habitat 1240)
- Mediterranean salt steppes (Habitat 1510)
- Rock pools of low to moderate nutrient content having clear waters with submerged aquatic plants and algae (Habitat 3140)
- Mediterranean temporary ponds (Habitat 3170)
- Garrigue dominated by Mediterranean shrubby species (Habitat 5330)
- Garrigue/phrygana dominated by the Shrubby Kidney Vetch (Habitat 5410)
- Garrigue/phrygana dominated by the Egyptian St John's Wort (Habitat 5430)
- Steppe communities dominated by the Mediterranean False-Brome (Habitat 6220)
- Cliff communities characterised by many Maltese endemic species and dominated by the Maltese Salt-Tree (Habitat 8210)
- Olive and Carob Forests (Habitat 9320)

Adjacent to the landfill the habitat is described as thermos-Mediterranean and pre-desert scrub and calcareous rock slopes with chasmophytic vegetation (refer to Figure 4-12).

Although, not strictly in the AoI for the proposed development, the Marine Protected Area of Żona fil-Baħar fl-Inħawi ta'Għar Lapsi u ta' Filfla, which is also a Nature 2000 site, is located to the West of the AoI and should also be remembered when evaluating the impacts of the development.

Figure 4-11
The extent of the Natura 2000 site in the locality of the proposed development (Source: ERA, Natura 2000 Management Plan)

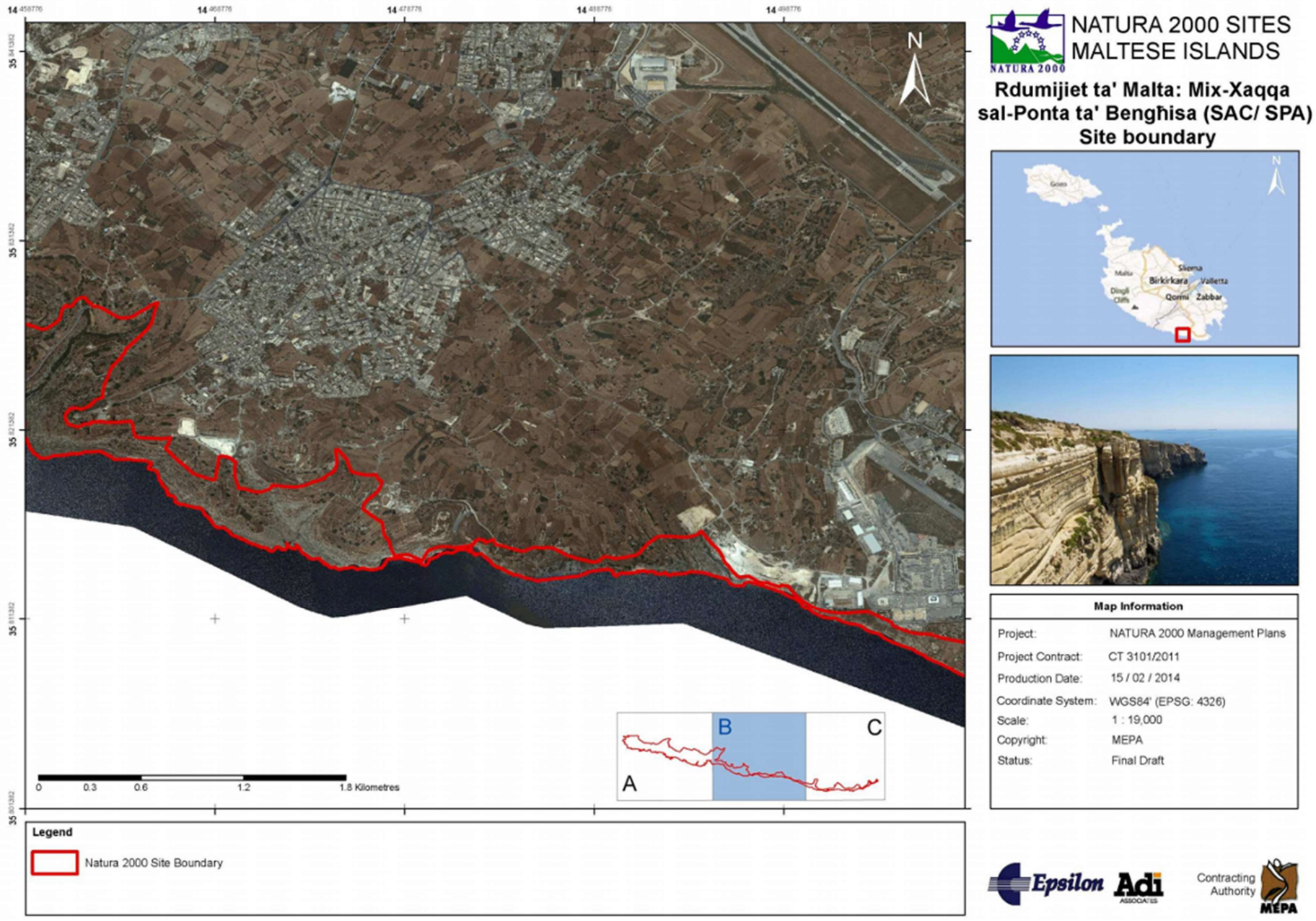
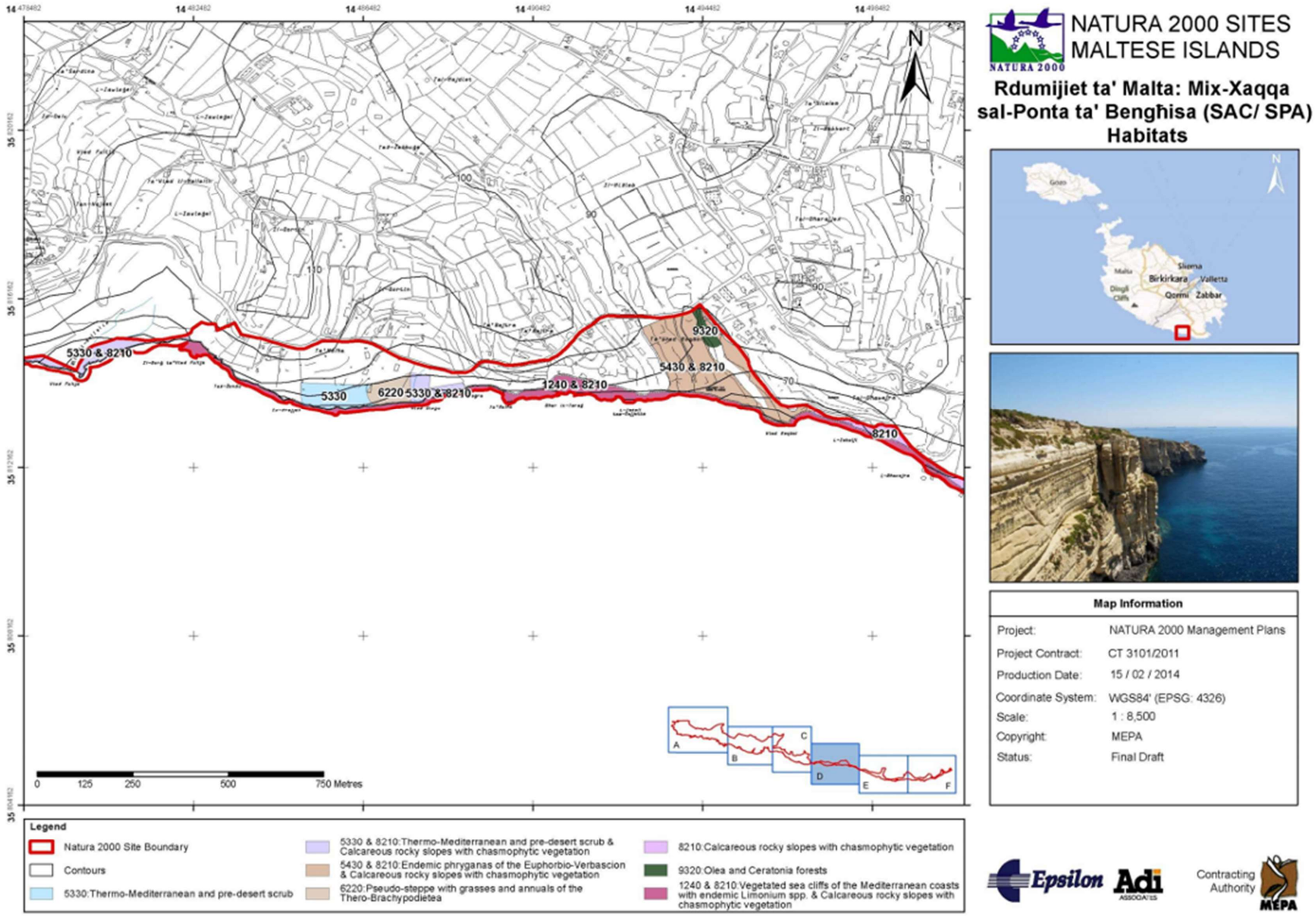


Figure 4-12
Habitat found in the Natura 2000 site adjacent to the proposed development (Source: ERA, Natura 2000 Management Plan)



4.4 Cultural Heritage

The status of the cultural heritage of the buildings within the 100m buffer zone was researched on the PA geoportal website. The 100m zone of influence around the proposed site for the development contains no scheduled buildings. However, the coastal cliffs and Il-Borġ ta'Wied Fulija to Ta'Wied Moqbol are protected as listed natural heritage sites. The coastal cliffs have a Level 2 degree of protection and Il-Borg ta'Wied Fulija to Ta'Wied Moqbol has a Level 3 degree of protection. Although not strictly in the AoI, to the West of the area there is also a buffer zone to protect the coastal cliffs which has a Level 3 degree of protection.

5.0 Rehabilitation Considerations

The restoration and rehabilitation of Wied Fulija landfill is the subject of an application for a planning permit and Wasteserv will seek to obtain European Union (EU) funding to undertake the works.

5.1 Project Summary: The Nature of Opportunities and Problems Addressed

Based on the investigations, surveys and monitoring[5, 6, 7] carried out at Wied Fulija, the main risks identified are:

- Potentially unstable ground surfaces close to the cliff edge;
- Potential instability of the waste mound;
- Subterranean landfill fires;
- Aerial emissions from landfill gas generation; and
- Potential for surface and groundwater contamination.

In order to mitigate these risks and develop the potential for after-use of the site, the following actions are being proposed for the rehabilitation and restoration of the Wied Fulija landfill:

- Re-profiling of the waste mounds including removal of waste where practical from close to the cliff edge, and where this does not affect protected species;
- Installation of a capping and restoration system; and
- Landscaping and creation of public access in selected areas.

5.2 General Design Principles for Capping

The requirements for the contents of a Project Description Statement set out by ERA and the PA require that an assessment of alternatives is included. This would usually contain assessments of alternative sites and alternative technologies or processes. As the proposed development involves the rehabilitation of the existing Wied Fulija Landfill site, it is not necessary to discuss alternative sites. Alternative means of capping or restoration are discussed in the outline below.

The primary function of a landfill rehabilitation system is pollution control. It achieves this by:

- reducing the infiltration of precipitation into the landfill to control leachate generation;
- minimising fugitive emissions of landfill gas through the surface of the cap; and
- separating the waste in the landfill from its surrounding environment.

The history and development of Wied Fulija has led to the selection of a rehabilitation design that is constrained by the presence of steep slopes, a fixed and restricted footprint, possible subterranean fires, difficult and restricted access and the need to achieve acceptable performance in a semi-arid climate. The rehabilitation system comprises two key elements, a capping system and a restoration system.

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[5] Project Task 1a Review of Existing Waste Management Plan for the Maltese Islands, SLR Consulting Limited dated June 2017.
[6] Project Task 1c Reviewing of Existing Studies and Task 2a Desk Study, SLR Consulting Limited dated October 2017
[7] Project Task 2a Site Investigation and Field Study, SLR Consulting Limited dated November 2017.

There are different possible choices for the materials within the capping systems such as the following:

- geosynthetic clay liner (very low permeability);
- bentonite enhanced soil (very low permeability);
- natural mineral liner cap (low permeability)
- evapotranspiration cap (moderate permeability).

Due to the variations of slope across the Wied Fulija Landfill, it is possible that a range of different capping techniques could be used to provide the best overall environmental performance.

Engineered high performance capping systems, such as a low permeability clay or geosynthetic capping systems, are very difficult to install and maintain on slopes steeper than 1:3, due to the risk of veneer failure. In addition to this at Wied Fulija there is also the risk of subsurface landfill fire which could affect an engineered capping system, by either inducing excessive strains in the cap as the combusted waste collapses or in the case of geosynthetic caps affect the integrity of the cap with excessive heat.

In addition, an assessment has been undertaken of the risk that the site presents to groundwater and marine water quality. It is concluded that although the site contains municipal, construction, demolition, and hazardous wastes which represent a potential risk, the thick unsaturated zone at the site (c. 100m), long travel times in the unsaturated zone, the naturally saline character of the groundwater beneath the site and the lack of water interest that rely on groundwater means that the site presents a relatively low risk to the water environment. Furthermore, given that the site does not have an engineered containment system for leachates, the main objective of a remediation strategy would be to prevent further infiltration of water due to precipitation and runoff, thereby limiting the movement of those residual pollutants that have not been leached out over the past decades.

Given the steep slopes at Wied Fulija and the likelihood of subsurface landfill fires, an evapotranspiration cap is considered to be the best option, as the system does not rely upon creating an impermeable layer which may be compromised by site conditions.

5.2.1 Evapotranspiration Capping

Evapotranspiration (ET) systems are increasingly being used to rehabilitate waste disposal sites, including non-hazardous and hazardous waste landfills, in arid climates such as that in Malta. Unlike conventional designs that use materials with low hydraulic permeability caps to minimise the downward migration of water from the restoration soils into the waste, ET cover systems use water balance components to minimise percolation. An ET cover system relies on the restoration soils to store water within it, until it is either transpired through vegetation or evaporated from the soil surface.

ET cover systems use one or more vegetated soil layers to retain water until it is either transpired through vegetation or evaporated from the soil surface. These cover systems rely on the water storage capacity of the soil layer, rather than low hydraulic conductivity materials, to minimize percolation. ET designs are based on using the hydrological processes (water balance components) at a site, which include the water storage capacity of the soil, precipitation, surface runoff, evapotranspiration, and infiltration. By increasing the storage capacity and evapotranspirative properties of the ET system, the potential for percolation of water into the underlying waste is reduced.

Two general types of ET cover systems are monolithic barriers and capillary barriers. Monolithic covers use a single vegetated soil layer to retain water until it is either transpired through vegetation or evaporated from the soil surface. Capillary barrier cover systems consist of a finer grained soil layer (like that of a monolithic cover system) overlying a coarser-grained material layer, usually sand or gravel. The differences in the unsaturated hydraulic properties between the two layers minimize percolation into the coarser-grained (lower) layer under unsaturated conditions. The finer-grained layer of a capillary barrier cover system has the same

function as the monolithic soil layer; that is, it stores water until it is removed from the soil by evaporation or transpiration mechanisms. The coarser-grained layer forms a capillary break at the interface of the two layers, which allows the finer-grained layer to retain more water than a monolithic cover system of equal thickness. Capillary forces hold the water in the finer-grained layer until the soil near the interface approaches saturation.

ET systems are different than the conventional methods of capping landfills, as mentioned above. Instead of using low hydraulic permeability materials, as is used on conventional capping systems, ET systems use water balance components to minimise percolation:

- water storage capacity of the soil;
- precipitation;
- surface runoff
- evapotranspiration; and
- infiltration.

They are considered to be very effective in arid environments. It is important when using an ET system that the soils used on the site can store water within them, as this is the main mechanism to minimise the water percolation. The soil will store water until it is transpired by vegetation or evaporated from the soil surface. The percolation of water into the waste is reduced by increasing the storage capacity of the soil and overall evapotranspiration properties of the ET system.

There are two main types of ET systems:

- Monolithic barriers: composed of one layer of fine
- Capillary barriers: composed of a layer of fine soil overlain by a layer of coarser grained material, typically sand or gravel.

The capillary system is advantageous over the monolithic system as it enables the soil to hold larger volumes of water.

5.2.2 The Chosen System

The final capping system to be chosen for the project needed to be specific to the Wied Fuljia Landfill, reflecting the overall low risk associated with the site. In order to help with the decision of which capping system would be most effective for the site a ground investigation was carried out on the 26th and 27th October, 2017 by SLR. This study built upon the earlier study carried out by Scott Wilson in 2004. It involved the excavation of fourteen trial pits, with a maximum depth of 3.5m below ground level, and surface probe monitoring at certain locations across the surface of the landfill site.

When the results of the 2017 study were compared to the earlier Scott Wilson study, there was very little difference in terms of the gas emissions. In the more recent study the maximum concentrations of carbon monoxide and carbon dioxide have slightly decreased and the hydrogen sulphide levels have slightly increased. These differences are so small they are not considered to be significant. When comparing the two studies based on the maximum temperatures, there was a difference between the two studies. The temperatures are now spread over a smaller range and the maximum temperature is lower than in the 2004 study. Although these differences in temperature were noted they are not considered to represent any change to the condition of the site. The overall results were taken to suggest that subterranean fires are still occurring within the waste.

The 2017 SLR study concluded that there has been no significant change in the conditions of the landfill site since the 2004 study. Although gasses are being emitted from the mounds it is proposed that the volumes are not sufficient enough to warrant the installation of a gas extraction system. Furthermore, given the site is unlined (uncontained) the introduction of a gas extraction system could result in drawing in oxygen to the

waste mass which could increase the risk of further subterranean fires. This could increase emissions and risk undermining interventions intended to stabilise the landfill mass. Based on the characteristics of the landfill and the identified risks it is recommended that an artificial sealing liner is not required for the site.

After extensive consideration of the alternatives and the results of the 2017 study it was decided that an ET capillary barrier system is most appropriate for the site. Details of the capping system are given in Section 5.4

5.3 Description and objectives of selected Capping System

The project will involve the capping of the landfill and re-contouring of the slopes in order to improve environmental control at the site, provide good quality rehabilitation and visually integrate it with the surrounding landscape. Earthworks shall be undertaken first before the capping to achieve an even profile for cap placement.

The capping and restoration system design is intended to achieve the following:

- reduce rainfall infiltration, minimise leachate production and consequent impacts on groundwater quality;
- promote surface water runoff;
- minimise erosion;
- prevent contact with and aerial mobilisation of contaminated materials;
- control gas and odour emissions;
- prevent occurrences of disease vectors and other nuisances;
- limit air ingress into wastes thus reducing the extent of combustion over time;
- prevent the deposit of spilled waste into the sea;
- function with minimum maintenance; and
- meet aesthetics and end-use purposes.

Earthworks shall include clearance of the waste by the cliff edge, pulling back any material spilling onto the cliff edge, and re-contouring of the waste mounds by shifting existing waste material and compacting it to achieve the desired surface. Earthworks shall be carried out in such a manner as to minimise the risk of instability and erosion. Working faces shall be limited to safe slopes and heights, and surfaces shall have sufficient gradients to prevent ponding and to shed water without causing erosion. Particular care will be given when working in those areas in the vicinity of protected species.

The waste mounds will be covered by a layer of inert material which will provide a suitable growing medium for restoration planting and thus allow progressive restoration of the site. Typically this will be 1m thick and may comprise crushed limestone, growing medium and silt-sized material for moisture retention. The capping process and source of inert waste material will follow the same methodology adopted in previous landfill capping and restoration projects, including the landfills at Marsaskala, Magħtab and Qortin. As Wasteserv is continuously striving to implement sustainable development, the possibility of using inert material generated by the excavation of the waste deposits is also being considered. The final specification, including thickness and grain size of the capping material, will depend on the after use/species of planting to be used and will require detailed assessment.

Ultimately it is essential to ensure that the capping and restoration system design:

- is readily ‘constructible’ and can be installed in a safe manner utilising conventional plant, equipment and materials;

- can be constructed in phases and performs satisfactorily with or without vegetation cover;
- satisfies minimum performance requirements in areas where subsurface landfill fires are suspected;
- is aesthetically acceptable;
- is appropriate for the variety of conditions on site, i.e. steep slopes and flat areas;
- adopts 'tried and tested' systems that have proved to perform satisfactorily elsewhere; and
- represents good value for money considering the costs in relation to the environmental benefits.

5.4 Detailed Project Description

A set of site and construction plans for the proposed project are presented in Appendix A. Details of the sizes of areas within the site, the length of walls, ditches and access paths, as well as the volumes of material being used to cut and fill are provided in Table 5-1.

Table 5-1
Areas, lengths and volumes of the different components of the proposed development

Feature	Length / Area / Volume
Insitu exposed rock	3,600m^2
Rip rap lined ditches	3,400m
Wall	1,400m
Access pathways	8,800m^2
Formation Design Cut Volume Fill volume Net	- 84,000m^3 37,000m^3 - 47,000m^3 (Cut)
Overall restoration area (including pathways but excluding boulder and insitu exposed rock)	83,000m^2

5.4.1 Re-Profiling of the Mounds

Both the west and east mounds will be reshaped. The western mound will be approximately 124m high and have a main plateau approximately 110mby 30m wide, with a 180m long ridge that runs northeast to southwest. The mound to the east will be approximately 120m high and have an approximate length of 100m along its east-west axis. The gradient of the steeper perimeter slopes of the mounds varies between 1V:2H 1V:3H, with gentler slopes on the upper sections of the mound and eventually flattening out on the top of the mounds. The valley separating the two mounds will have a length of 150m along its north-south axis and will have slope elevations ranging from 106m in the northern side to 104m in the southern side.

The benches that will be profiled into the mounds will be of a standard size around the whole site. The benches will be 8m wide, measured from the toe to the top soil to the outer edge of the wall and will accommodate an access road and surface water ditches. The wall located at the downslope side of the bench will be 0.5m wide and 1.0m high, with timber railings to act as a safety barrier. Downslope from the wall on the south facing slopes, the slope gradient will be 1V:1H, the face of these slopes shall be supported with boulders.

With respect to the glass deposits located on site (approximately 5770 tomes) a number of alternatives were considered as follows:

- Remove for disposal;
- Remove for recycling;
- Recycle for use in the rehabilitation works; and
- Cover and entomb.

From and environmental point of view excavating and transporting the material to the Ghallis landfill is not considered the best environmental solution. It is also our understanding that Wasteserv was informed that the glass material was unsuitable for recycling. The material also has limited practical use in the rehabilitation works so it is likely the glass will simply be covered and entombed below the capping system. During the rehabilitation works the glass will however be subject to further testing to confirm the material has no recycling or reuse potential.

Plans related to the re-profiled mound can be seen in Figure 5-2 and Appendix A.

5.4.2 The ET Capillary Capping System

The final cover system for Wied Fulija is a capillary design, with the monolithic element formed from the 250mm topsoil and 500mm subsoil layers, and a capillary barrier formed by the 250mm thick regulating layer.

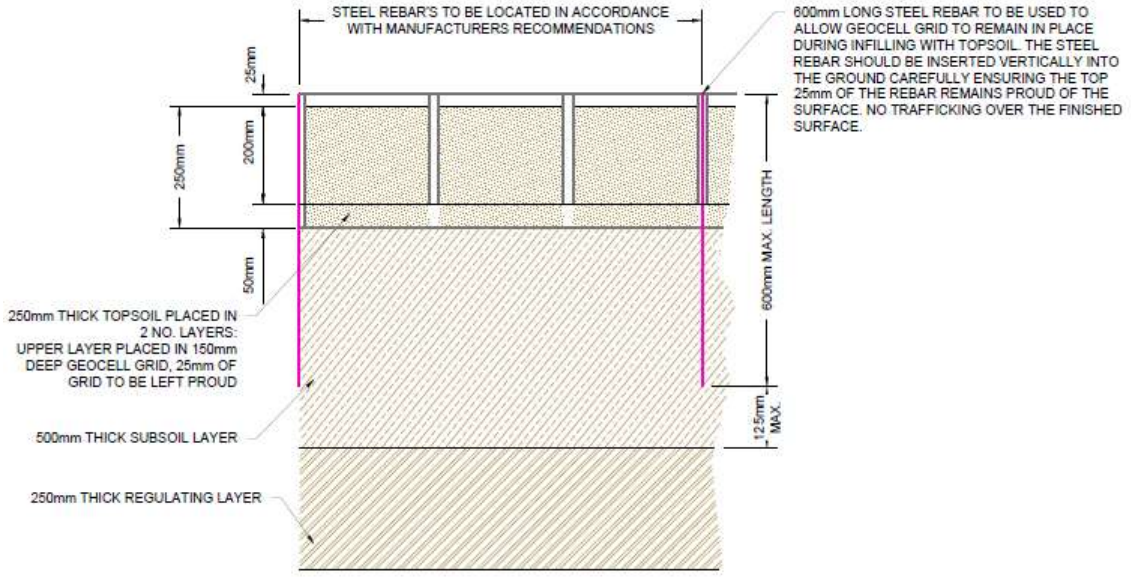
Topsoil and sub soil materials are to be predominantly sourced from inert materials (C&D waste) excavated as part of the re-profiling of the site to achieve the design levels. The excavated soils shall be screened to remove the larger fraction and provide a fine-grained material. In order to increase the organic content of the topsoil and subsoil layers, compost will be imported to the site and mixed with the selected screened material to produce a growth medium for vegetation to establish. The compost will provide nutrients for the vegetation but also increase the fines content of the topsoil and subsoil, increasing the storage capacity of the monolithic element of the system.

The regulating layer will be sourced from the coarser element of the screened material, as described above the high permeability of this layer increases the storage of water in the overlying restoration soils. The coarser soils also have an advantage in that it also provides a barrier to burrowing animals, which may dig through the restoration soils into the underlying waste.

Vegetation for the restoration surface is used not only to promote transpiration but also minimise erosion of the soils. A mixture of native flora will be planted, as they are more tolerant to the climatic conditions on site and less likely to upset the natural ecosystem. The mixture of plants used will be selected to ensure species provide water uptake and promote transpiration throughout the entire year.

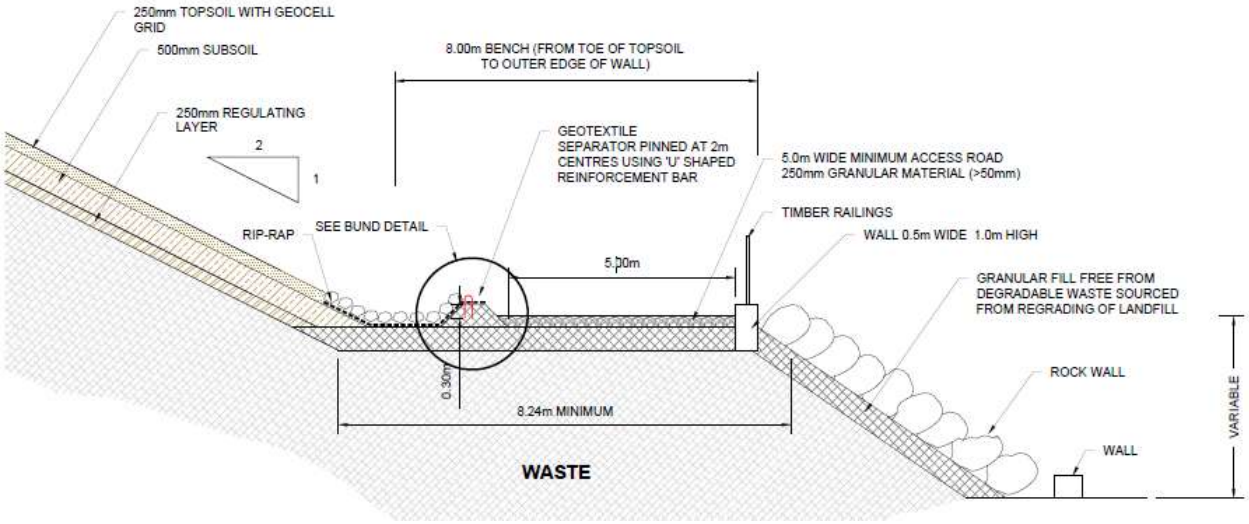
Typical capping details are shown in Figure 5-1 below:

Figure 5-1
Capping Detail for Slopes



As part of the re-profiling and capping works on the waste mounds, benches will have to be constructed to both provide access around the perimeter of the site and allow the surface water to be directed to the desired locations. A typical bench detail showing the arrangement for surface water diversion is shown in Figure 5-2.

Figure 5-2
Typical Arrangement of a Bench



5.4.3 Access Paths

An access path will be constructed around the perimeter of the site. Along the southern boundary of the site this will enable access along the cliff tops. An access path will also be constructed between the two mounds, in the valley, and one path leading up to the top of each mound. The access paths will be raised slightly above the current ground level by the construction of a wall made of rock and then filled with granular material (grain size

greater than 50mm). The infill material will not contain any degradable material, to ensure the integrity and stability of the path over time. They will have a minimum width of 5m and a depth of 250mm. Once the site is in its operational phase access will be by foot only via the designated access paths. Despite the construction of access paths around the perimeter of the site, public access directly over the mounds is not recommended as they are composed of waste material will have relatively steep sides slopes and the proposed landscaping system will require monitoring and maintenance. Vehicles will only be allowed on the site to carry out maintenance work.

5.4.4 Surface Water Management

During storm events, it is expected that there will be increased volumes of surface water runoff. In order to minimise the amount of soil erosion that occurs during such events a network of ditches will be constructed to channel the water away from the site to the edge of the site (in addition to the vegetative cover minimising the scope for erosion). The size of the ditches will be large enough to cope with a 1 in 100year storm event and shall be lined with a geotextile separator and rip rap.

The ditch that will be constructed around the perimeter of the site will discharge on the south side of the site at five locations. At these discharge locations the bund wall will be of a reduced height for a 2m length, so it will be lower that the level of the ditch to allow the water to flow offsite. In order to prevent erosion of fill material a “concrete canvas” will be fitted. There will also be one discharge point to the north east of the site where the water will discharge into a newly constructed reservoir.

A bund will be constructed around the perimeter of the site allow space for a surface water ditch and access pathway. It will have an average height of 0.5m but will vary in some locations. It will have a rock facing to ensure maximum stability. The geotextile separator will be pinned at 2m intervals along the bund using U shaped reinforcement bars.

Plans relating to the surface water management plan are presented in Appendix A. A long term monitoring and maintenance plan will be prepared following construction.

5.5 Execution of Works

The project construction will be carried out by a contractor following a competitive tendering process and the contractor will be responsible for the determination of construction methodology (subject to client approval) However, based on the methods utilised successfully for cappings previously implemented in other landfills, a brief works management plan is outlined hereunder.

The designing process for the rehabilitation of the landfill site was carried out using 3D modelling software. This was to calculate the most appropriate percentages of existing and new materials for the work to minimise the need to bring new material onto the site.

Earthworks comprise the re-contouring of the landfill mass to enhance stability and accessibility, and provide a suitable landform for capping and later on for planting. This involves scarifying surface waste material by bulldozers, processing, transportation by tipper trucks, deposition of material in designated areas and compacting it to achieve the required final surface profiles as indicated on the drawings. However, no deep excavation works are being envisaged. Earthworks in inert material are carried out in a standard way. Areas designated to be excavated are tackled first, with the overburden being loaded on trucks by excavators and carted by dump trucks to those areas designated for filling.

Any material greater than 300mm shall either be used as to form the boulder forming the rock wall supporting the access path, backfilled at depths from the surface profile or otherwise broken down to a maximum particle size not greater than 20mm for use in the capping system. Crushing and grading of material will be carried out by means of a crusher which will be present on site.

Earthworks in material shall be carried out by excavators and shall be carried out in horizontal layers. The contractor shall ensure that prior to the commencement of filling works in a specific area, underlying waste is stable in order to ensure the resultant stability of the overlying fill and cap. The fill will then be deposited and dozed over as evenly as possible and built up in layers of equal thicknesses of 1.5m and compacted to 1m. This will then be topped with 150mm of inert material. By directing earthmoving plant to pass over the area of fill as much as possible, better final compaction of the landfilled material is achieved. The final upper layer of fill areas shall be constructed entirely of inert waste material.

Compaction shall be carried out using a vibratory roller. The compaction plant shall be used in such a way as to compact the underlying material to its optimum density.

In order to minimize the amount of airborne dust which is produced during earthworks, a water bowser with a special nozzle attachment will be deployed during all the works. A fine water mist is sprayed over the material to be moved prior to the start of works. Spraying at regular intervals during works will guarantee that dust generation is kept to a minimum. The use of a wheel washing facility will reduce dust leaving the site by construction traffic. Litter control will be given a priority. Movable screens will be positioned near working areas to control windblown litter if necessary.

All vehicles and equipment will conform to Maltese standards with respect to noise control. Sound reduction equipment will be fixed to power tools, machines and fixed plant. If necessary, acoustic screens will be positioned in critical locations near noise generating equipment. Speed limits imposed on-site will reduce the noise levels produced by vehicles accessing the site. Construction traffic to and from the site will be limited to the delivery of plant and equipment. Vehicles working on site will remain there for the duration of the works.

A full-fledged works management plan will be prepared once the project takes off and there is the required expertise on board.

5.6 Contractor's Personnel to be Employed

- Contractor architect in charge of the project from contractor's side
- Site supervisor to oversee the day-to-day running of the works
- Land surveying team to keep accurate readings and record the works in progress
- Plant operators
- Truck drivers

5.7 Wasteserv Personnel Monitoring the Project

The following would be typical of a project this nature:-

- Project manager
- Landscape designer
- Dust monitoring program agent
- Surveying team
- Quality assurance team

5.8 Contractor's Plant and Machinery

A indicative summary of the machinery to be used throughout the rehabilitation of the site and the quantities are displayed in Table 5-2.

Table 5-2
Summary of the equipment and quantities required for the project

Machine	Quantity
Hydraulic Tracked Excavator	2
Bull Dozer	1
Bobcat	1
Wheel Loader	1
Tracked Shovels	1
Vibrating Drum Roller	1
Crane	
Articulated Tipper Truck	3
8-wheeled Tipper Truck	3
Crushing and Screening Plant	1

In order for the works to be carried out in an efficient manner, the most appropriate machinery will be deployed to carry out the works, complying with EU emission standards and targeting minimum waste generation. These will comprise Euro 4 or Euro 5 compression ignition vehicles including excavators, bulldozers, bobcats, wheel loaders, rollers, cranes and tipper trucks.

Hydraulic tracked excavators can be deployed on higher ground than the dump trucks to be loaded to attain maximum loading rates. Tracked excavators have excellent mobility over rough terrain which gives them a great advantage on this particular site.

Bulldozers can push large quantities of material over short distances on site. A bulldozer is ideal to level large areas with material brought from other parts of the site by dump trucks, slowly building up levels to reach the required heights. It is also capable of compacting the underlying material during its dozing operations. This is due to the high loads and the exerted track action on the material it is being driven on.

Tracked shovels can be used to load dump trucks, push material and arrange slopes and contours.

A mix of dump trucks, having payload capabilities ranging from 17 metric tonnes to 35 metric tonnes, will be deployed in sufficient numbers to reduce excavator and dozer idle times to the least possible amount.

Vibrating drum rollers will be used to achieve the required compaction values of the benches and access routes inside the landfill site.

Oversized materials will be loaded into a crushing and screening plant to produce granular materials suitable for inclusion as the regulating layer (capillary break) or used to construct the rock wall along the south side of the site. Crushed material from the screens will be loaded on to articulated tipper trucks and transported to the works.

Mechanical tipper trailers and eight-wheeler tipper trucks will be used to prevent any road damages while transporting inert material from Għallis to Wied Fulija. Mechanical tipper trailers have a capacity of 26 cubic metres and a gross vehicle mass of 44,000kg. Eight-wheeler tipper trucks have a capacity of 20 cubic metres

and a gross vehicle mass of 42,000kg. It is being estimated that 274,000 cubic metres of inert material will be brought on site from Għallies. This means that approximately 11,913 trips will be required to transport all material on site. With six trucks, each performing an average of six trips per day over a span of 8-10 hours, this volume of material will be transported to the site within one year and four months. The best route to Wied Fulija from Għallis is via Ħal Far.

5.9 Landscaping

Wied Fulija is mainly visible from the northern side and it is understood that following rehabilitation of the site, the principal remaining environmental impact will be the visual impact from the village area of Wied Fulija and the town of Zurrieq. It is therefore envisaged to create screening bunds by means of landscaping along the entire northern edge of the site in order to mitigate this visual impact.

A specialist botanist was consulted to find out the best way to re-vegetate the area. The species of planting to be used will be in accordance with the Guidelines on Trees, Shrubs and Plants for Planting and Landscaping in the Maltese Islands. Due to the exposed character of the site it is important that the vegetation is hardy and robust which can resist the prevailing winds and the salty environment due to the site's proximity to the sea.

The variety of species chosen will ensure that there is sufficient water uptake and transpiration occurring throughout the whole year to maximise the effectiveness of the ET capping system. Furthermore, as the dominant land use around the site is agricultural, the vegetation should reflect this and integrate with the existing agricultural vegetation. For this reason, none of the proposed species are listed in Schedule III of L.N. 200 of 2011, meaning that the chosen species are not considered to be "invasive, alien or environmentally incompatible" with the Maltese Island vegetation. The following species are being proposed:

- *Pinus halepensis*
- *Juniperus phoenicea*
- *Tetraclinis articulata*
- *Quercux ilex*
- *Tamarix africana*
- *Senecio bicolor*
- *Sarcopterium spinosum*
- *Atriplex halimus*
- *Inula crithmoides*
- *Teucrium fruticans*
- *Helichrysum melitense*

Public access will only be granted to the area once the plant communities have established themselves.

6.0 Services

Currently there are no services available at the Wied Fulija Landfill. Once the rehabilitation works are finalised, electrical and water services will be required for regular maintenance.

7.0 Parking Provision

There will be no parking provision on site during execution of the works since the contractor will be bound to bring the workmen on site by means of a collective transport system. Once the works have been completed, the only parking spaces to be provided within the premises are to serve for maintenance purposes only.

8.0 Budget and Timeframe

The general clearing of Wied Fulija, and of the valley in particular, will ideally be bound to the dry season, to ensure that weather will not cause flooding or adversely impact the cleaning process. However, with the exception of extreme weather conditions, the capping process will not be dependent on seasonal changes and can be carried out during any time of the year. On the other hand, planting shall take place in suitable weather conditions during the recognised planting season of Malta. The Contractor shall cease planting when the Engineer is of the opinion that weather conditions will adversely affect the establishment of the planting, for instance, at the height of summer. Care shall also be taken on the type and location of works to ensure that the Cory's Shearwater breeding season is not disturbed. Further to this, working hours will be restricted to daylight hours. No works shall be carried out during the night due to difficult ground conditions.

An initial budget estimate and timeframe have been established for the entire rehabilitation process, based on similar works previously undertaken, procured and estimated for the Maghtab and Qortin landfills. Final Restoration including re-profiling works, installation of capping and drainage systems, and landscaping is estimated to be carried out over a period of 24 months.

9.0 Hazards Related to the Wied Fulija Landfill

The conceptual site model for Wied Fulija is summarised in Table 3 below using a hazard-pathway-receptor framework. This is intended to summarise and present the potential hazards, pathways and receptors, taking into account available information on the landfill itself and the surrounding environment. The potential hazards are discussed in greater detail in the remainder of this section.

Table 9-1
Conceptual Pollution Model for Wied Fulija Landfill

Hazard	Pathway	Current receptors
Leachable contaminants in the waste	Downwards infiltration of rainwater/leachate through waste into underlying bedrock	Groundwater in mean sea level aquifer
		Marine environment (seawater and sediment)
	Rainwater run-off containing dissolved contaminants and suspended solids	Surrounding agricultural land
		Marine environment (seawater and sediment)
Airborne emissions from fires, waste degradation and physical disturbance	Aerial dispersion of gases, dust and particulates	Inhabitants and visitors at: - Wied Fulija - Zurrieq - Local ecology
Toxic waste materials within the waste mass	Ingestion/inhalation/dermal contact	Site workers

There are no formal records of either the type or quantity of waste deposited at Wied Fulija as no weighbridge was installed. However, it is understood that generally the proportion of organic waste is higher than debris waste, perhaps in the ratio 80% to 20% respectively. The percentage of construction and demolition waste increased in more recent years to around 70%, with the remainder comprising predominantly municipal solid waste and trade waste (refer to Figure 9-1). There are also large quantities of glass waste that have been deposited along the valley in between the eastern and western plateaus (Figure 9-2). All waste types produced in Malta, including hazardous wastes, are likely to have been disposed of at this site. The exposed faces appear to contain a significant proportion of partially consolidated municipal solid waste. Thus there is potential for some continued settlement over the next few years and this has to be taken into account in the development of the rehabilitation strategies.

Figure 9-1
Construction and demolition waste at Wied Fulija

Figure 9-2
Glass waste in between the two mounds

9.1 Waste Mass

The presence of significant quantities of domestic and industrial wastes deposited in an uncontrolled manner at Wied Fulija means that the site has the potential to cause a detrimental environmental impact on the surrounding area unless a rehabilitation strategy is implemented. The isolated location of the Wied Fulija landfill effectively limits the significance of most environmental impacts caused by the wastes and the emissions resulting from fires.

The steep slope angles of the waste mound, which range between 31° and 38°, and the proximity of the landfill to the edge of a high sea cliff, could have an impact on the local marine environment and the visual appearance

of the locality in case of sudden collapse and the consequential accidental deposit of spilled waste. However, any such impact may be minor and short-lived as strong sea currents in the area would dilute and disperse much of the debris. Although cliff failure has occurred in the past, there is little to suggest that such collapses are frequent and it is difficult to identify the potential size of any such collapse. However, there is the potential for localised spalling of waste from the surface of the mounds.

Wied Fulija is only visible in the immediate vicinity, thus the negative visual impact is of limited significance. Other environmental impacts are more significant, notably:

- the presence of contaminated and potentially hazardous materials within the dumpsite;
- emissions of potentially toxic fumes from areas of continued combustion;
- aerial emissions of contaminated dusts; and
- emissions to groundwater and the marine environment.

9.2 Surface Contamination

The geology of the site indicates that it is unlikely that there are any significant bodies of leachate within the waste mass. As previously mentioned, the site is located on the Lower Coralline Limestone Formation and lies above the mean sea level aquifer. There are three existing water-monitoring boreholes at Wied Fulija that were drilled in April 1995. Their depths and monitored water levels in 1995 are summarized in Table 4. Of particular note is the significant thickness of limestone strata between the site and water level at mean sea level.

Table 9-2
: Depths and water levels at the Wied Fulija Landfill

	Approximate Ground Level (Masl)	Depth of Borehole (m)	Depth to Water Level (m)	Approximate Water Level (Masl)
1	108	154.7	108.3	0
2	95	123.0	95.7	0
3	102	124.2	101.9	0

The general direction of groundwater flow in the mean sea level aquifer will be toward the coast. A single round of groundwater quality sampling and analysis from one of the existing boreholes (BH3) was undertaken in 1995 by PURA GmbH of Munich, Germany on behalf of the Works Division, Department of the Environment. Although the holes were not purged before sampling (which reduces the confidence that the results accurately reflect groundwater conditions), the samples contained elevated sodium, chloride and sulphate, attributable to saline groundwater, and elevated lead, iron and manganese which may be related to the presence of the landfill.

9.3 Heating/Combustion

The most highly elevated concentrations of carbon monoxide, taken to be indicative of active combustion and causing a low oxygen atmosphere, were observed at the base of the south-eastern corner of the western waste mound. Methane concentrations are generally low, indicating that the anaerobic waste decomposition processes typical of normal landfills are not occurring to a significant extent. Carbon dioxide concentrations were generally high in those areas where elevated temperature and carbon monoxide concentrations were

also recorded. These concentrations confirm that aerobic decomposition of waste predominates within the dumpsite.

9.4 Air Quality

Wied Fulija Landfill has been abandoned since closure and there are no leachate and gas management systems in place. Historically there has been evidence of subterranean fires. Aerial emissions from fires appear to have reduced in recent years as a result of burn-out of organic wastes since new sources of combustible material have not been added since 1996. However, visual evidence of burning implies that fires still occur but are likely to be present at depth. The restoration strategy for Wied Fulija therefore aims to control the aerial emissions from the combusting waste by reducing oxygen availability to the organics present in the waste mass, through the construction of a compacted capping structure as described previously.

Dust generation caused by vehicle movements is not currently a significant problem at Wied Fulija. However, dust generation could become an issue during rehabilitation works.

9.5 The Marine Environment

Given the proximity of Wied Fulija Landfill to the coast at Il-Borg ta' Wied Fulija there is a potential for contaminants to impact on the marine environment. Potential mechanisms by which contamination of near-shore sediments by the landfill could occur are:

- contaminated surface run-off from the landfill entering the sea during heavy rainfall events, or
- direct discharge of contaminated groundwater to the sea.

Both of these are possible. The former is considered likely to be more significant during heavy rainfall as there are no mechanisms in place to direct or divert the drainage channel that seasonally runs through the site along the line of Wied Il-Hallelin. During periods of intense rainfall in the winter, this stream carries significant volumes of water and presumably carries suspended waste materials to the sea. This rehabilitation strategy therefore aims at eliminating the contamination of the marine environment which is currently uncontrolled through the introduction of a storm water management system as described previously.

10.0 Major Environmental Impacts and Mitigation Measures

A preliminary indication of the environmental impacts that are likely to be associated with the scheme are described in this section, and may serve as an initial scoping assessment in the context of Article 6(2) of LN 114 of 2007: *Environmental Impact Assessment Regulations*.

The proposed development involves the re-profiling of the existing Wied Fulija Landfill, the installation of an ET capping system, construction of a surface water management infrastructure and landscaping of the remodeled area.

The potential adverse impacts are expected to relate to the re-profiling of the mounds and the general nuisances related to construction projects on the surrounding natural environment; however, measures are to be taken to eliminate or reduce the residual impact. The potential impacts and their respective mitigation measures are listed Table 5.

Table 10-1
: Summary of expected impacts and mitigation measures

Features Potentially Impacted	Description of Potential Impact	Mitigation Measures
Land Use	**Moderate Beneficial** The current land use of the area is solely as a disused landfill site, the rehabilitation of the area will create a recreational area for the public.	N/A
Agricultural Land	**Minor Adverse** During the rehabilitation of the landfill site litter may be blown into the neighboring areas. Increases in dust emissions are also likely which may affect the quality of the soil and the ability of the plants to photosynthesize. Transport of dirt/mud from the site onto the road network may also pose a risk to the quality of the soil within the neighboring agricultural fields.	Moveable screens will be used during the re-profiling works to help contain any wind-blown litter within the site boundaries. Before any material is moved it will be wetted to minimise the levels of dust dispersal into the surrounding areas. A wheel washing station will be set up at the site exit to keep the amount of sediment being transferred off site to a minimum. Such an impact is expected to be limited to the duration of works.
	Minor Beneficial Improved environmental management of the site, including the stabilization of the waste, capping and surface water management systems will reduce the	N/A

Features Potentially Impacted	Description of Potential Impact	Mitigation Measures
	negative effects that the landfill site currently has upon the surrounding agricultural land.	
Rdumijiet ta'Malta: Mix-Xaqqa sal-Ponta ta' Bengħisa Natura 2000 Site	**Minor Adverse** During the work on the project waste from the site may be blown into the Natura 2000 site. The associated increased levels of dust emissions may also decrease the ability of the plants to photosynthesize.	Movable barriers will be used during the work to prevent any wind-blown litter leaving the site. Any material before being moved will also be wetted to keep dust dispersion to a minimum. Such an impact is expected to be limited to the duration of works.
	Major Beneficial The project involves the removal of waste from the Natura 2000 site; this will restore the area to its natural state and allow appropriate sustainable use of the area.	N/A
Marine Environment	**Minor Adverse** During the re-profiling of the waste mounds and the removal of waste from the cliff tops there is the possibility that waste may fall into the sea.	Care will be taken to minimize the possibility of waste falling over the cliff edge.
	Moderate Beneficial The rehabilitation will stop waste falling over the cliff edge from the landfill into the sea. It will also reduce the volumes of surface water run off that enter the sea, at present this water most likely contains contaminants and also high levels of suspended sediment from the high levels of erosion from the landfill during heavy rainfall events.	N/A
Geology, Geomorphology, Palaenthology, Hydrology, Hydrogeology	**Minor Beneficial** The re-profiling of the mounds and valley will make the waste mounds blend in better with the surrounding natural morphology of the area.	N/A

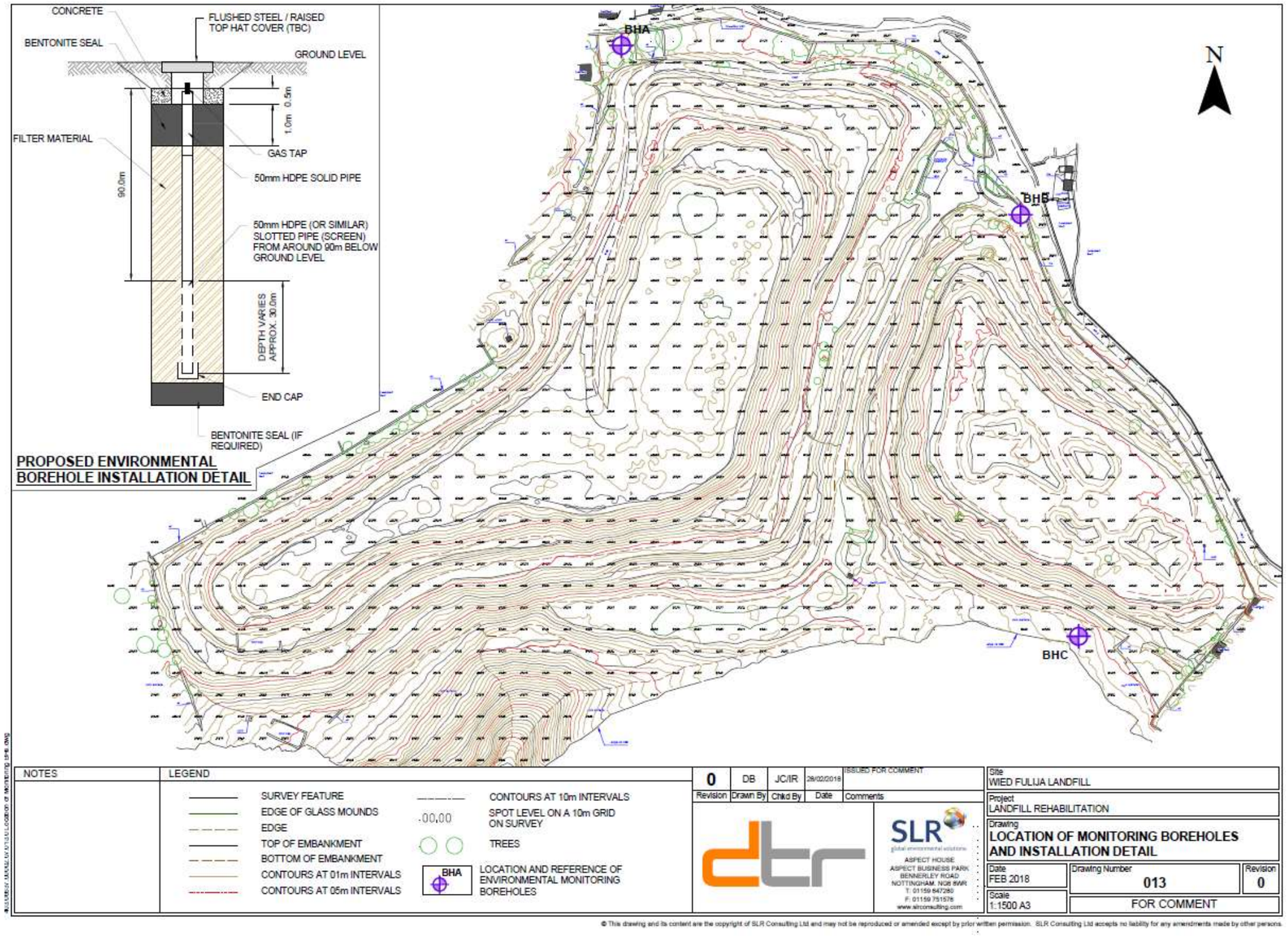
Features Potentially Impacted	Description of Potential Impact	Mitigation Measures
	Major Beneficial The capping work will reduce the amount of contaminated water that enters the mean sea level aquifer located beneath the Wied Fulija Landfill, even though leachate contamination is considered to be very low risk at the site. The surface water management system will also control the water pathways of surface water during rain events.	N/A
Landscape and Visual Impact	**Moderate Beneficial** The restoration of the landfill site and the planting of various types of tress will increase the visual appeal of the area.	N/A
Air Quality	**Moderate Adverse** During to construction phase of the project the crushing and grading of material will occur onsite, which will result in dust being dispersed into the surrounding environment. The re-profiling of the waste and extensive movement of material around the site will also result in dust emissions into the air, which may include contaminants.	Dust dispersal can be reduced by implementing good environmental construction practices, for example wetting roads within the site, wetting material before it is transport and covering any piles of fine grained material with plastic sheets.
	Moderate Beneficial The capping of the waste mounds is expected to reduce the gas emissions from with. It is also expected that the occurrence of fires within the mounds will be reduced, hence reducing the amount of harmful contaminants released into air.	N/A
Noise	**Minor Adverse** The machinery required for the development will produce noise.	Noise pollution will be kept to a minimum by the installation of sound reduction equipment on all machinery to be used on site. When machinery is not in use it will be switched off.
Social Impacts	**Minor Adverse**	Good construction practices

Features Potentially Impacted	Description of Potential Impact	Mitigation Measures
	During the works the usual nuisances associated with construction sites will be a disturbance to locals. The most notable problem will be the relatively high frequency of vehicles using the local roads in the transporting of material from Għallies to Wied Fulija. The vehicles entering and leaving the site on a regular basis will transfer sediment/mud from the site onto the public roads.	will be implemented to reduce the negative impact upon locals, including the use of a wheel washing station. The vehicles that will be used on site will remain on site throughout the duration of the project and the workers will use collective transport to and from the site on a daily basis. Work will only be carried out during daylight hours. Such an impact is expected to be limited to the duration of works.
	Moderate Beneficial The current Wied Fuljia Landfill is an eye sore and hazardous to the public, as well as producing an unpleasant odour. The rehabilitation will improve the visual appeal of the site, reduce the hazardous nature of the area and overall improve the natural environment. The opening up of the cliff tops is also a significant benefit to the public as it will allow access along the coastline.	N/A

The impacts described above are transient in nature, and on conclusion of works result in improved containment of the pollution currently present on site, and mitigation of the visual impact that exists at present. For these reasons, the cumulative impact of the proposal is ultimately beneficial.

If the proposed project is accepted, it is recommended that monitoring is carried out to assess the performance and success of the rehabilitation project. It is suggested that monitoring should focus on surface water; landfill gas and air quality; and settlement behaviour. In order to carry out such monitoring it is recommend that 3 boreholes are used within the site, the location of which is shown in Appendix A.

Figure 10-1
Location of monitoring boreholes



11.0 Conclusion

Wied Fulija is currently causing a detrimental impact to its surroundings. The principal receptors at risk, particularly from aerial emissions, include local agricultural land to the east, the village area of Wied Fulija to the north and the town of Zurrieq to the north. The Project Description Statement gives an overview of the technical aspects of the proposed capping and restoration works as well as the objective implications and impacts of such a project.

Based on the assessment of the impacts and mitigation measures related to the rehabilitation of Wied Fulija Landfill it is considered that the project will in the long term be beneficial to the local community and natural environment, most notably the Natura 2000 site. Any adverse impacts are associated with the construction work and are therefore, only temporary. Therefore, this proposal is a positive one, as it will rehabilitate the Wied Fulija landfill which currently generates an environmental concern to the Maltese Islands.

This rehabilitation strategy which forms part of a string of projects embarked by WasteServ is aimed at mitigating and reducing to the bare minimum the negative environmental impacts which resulted from the uncontrolled dumping at Wied Fulija, to create an environment that is safe and has potential for a beneficial future use. The proposed intervention is therefore not only meant to address and reduce such negative environmental impacts but goes further by seeking to enhance the overall environment in the area once the works are completed.

Thus, this rehabilitation strategy will ultimately improve the current situation by implementing site specific requirements, eliminating most of the negative impacts to surrounding areas and simultaneously contributing towards reaching the national Europe 2020 targets for Energy Efficiency, Renewable Energy and Greenhouse Gas Emission Reduction. WasteServ Malta Ltd therefore seeks to undertake the works to reinstate Wied Fulija back into beneficial use and to derive environmental benefits from a site that is currently dilapidated and unusable.

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