



LTD "SOLID WASTE MANAGEMENT
COMPANY OF GEORGIA"

**GEORGIA:
KVEMO KARTLI SOLID WASTE MANAGEMENT PROJECT**

PROJECT IMPLEMENTATION SUPPORT SERVICES



**DETAIL DESIGN
TECHNICAL REPORT 1: LANDFILL DESIGN**



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1. INTRODUCTION

1.1 GENERAL DATA

During the implementation of the Initial Project and after the review of the environmental impact assessment study by all competent authorities, new requirements emerged. A state decision was taken to upgrade a military airfield located near the proposed landfill site to civil airport.

In compliance with the International Civil Aviation Organisation (“ICAO”) standards and requirements, a 13 km buffer zone around the airfield must be kept. The initial location of the landfill fell within the minimum safety distance from the airfield, which would have been a breach of the ICAO guidelines.

As a result, a decision was made by the Government of Georgia to change the location of the new landfill for Kvemo Kartli region. This change of location required carrying out new site investigation.

All different aspects of evaluation (based on the principles of Multi-Criteria Analysis (MCA)) were considered to select the site near Tsintskaro village as the most appropriate site for the Landfill.

1.2 SCOPE OF THE PRESENT REPORT

The purpose of the present Final Detailed Design is to provide a detailed description of the construction works and operational guidelines (operation manual) for the new sanitary landfill of Kvemo Kartli and also provide a solid basis in order for the tender documents to be elaborated for the future procurement of the works.

Ltd “Solid Waste Management Company of Georgia” with financial support of the European Bank for Reconstruction and Development (EBRD) is planning to implement the project – “Kvemo Kartli Solid Waste Management, which implies construction of a new regional sanitary landfill in Kvemo Kartli region that will serve to the following Municipalities: Marneuli, Bolnisi, Dmanisi, Tetritskaro, and Tsalka. The scope of the new landfill design is to assist in improving the currently problematic waste management conditions of the area.

The controlled disposal of wastes in the new sanitary landfill will minimize any negative impacts to the environment and human health and will serve better the needs for waste management in the area.

When preparing the new landfill design the Consultant has considered all environmental, technical, economic and social aspects and the expressed views and opinions of all the stakeholders involved in the Project.

The landfill construction works and site protection design described in the present report includes the following tasks:

- Landfill Formation
 - Earthworks for Bottom basin formation and embankment fills

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- Bottom basin sealing system
- Leachate and biogas management
- Operational procedures
- Installation of top cover system
- Site protection
 - Construction of flood protection and stormwater drainage infrastructures
 - Construction of utilities (e.g road works, fire protection)
 - Environmental monitoring program

The landfill is designed in compliance with internationally established practices and the relevant Georgian Legislation on waste management.

The data taken into account in the present landfill final detail design were derived from the onsite surveys conducted by the Consultant and include the morphology of the landscape, the geological and soils characteristics, the quality and quantity of surface and ground water and the biogas levels in the atmosphere.

1.3 LEGISLATION

The design of the landfill has been carried out based on the design criteria defined in:

1. Georgian legislation and specifically in “Technical Regulation on The Construction, Operation, Closure and After-care of Landfills” as approved by the Government of Georgia with Resolution № 421 and for the areas not covered by Georgian legislation,
2. The EU Directive 99/31/EC on the Landfill of Waste,
3. EU Waste Directive 2008/98/EC on waste,
4. EU Industrial Emissions Directive (integrated pollution prevention and control) 2010/75/EU.

1.3.1 EU Landfill Directive 99/31/EC

This Directive aims to provide for measures, procedures and guidance to prevent or reduce as far as possible the negative effects on the environment from landfill waste. It applies to all landfills and provides certain exclusion from the scope of the Directive. The key requirements that need to be met to minimise the potential environmental impacts from the construction and operation of a landfill are summarised below.

Classes of landfill

Every landfill must be classified as receiving either hazardous, non-hazardous or inert waste.

Waste not accepted in landfills

The following wastes are not accepted in landfills:

- Liquid waste, unless authorised for disposal at inert landfill sites;

- Waste which, in the conditions of the landfill, is explosive, corrosive, oxidising, highly flammable, or flammable (as defined in Annex 3 of Directive 91/689/EEC, on hazardous waste);
- Hospital and other clinical waste from medical or veterinary establishments which are defined as infectious under Directive 91/689/EEC;
- Whole used tyres and shredded used tyres (excluding bicycle tyres and those with an outside diameter above 1,400 mm); and
- Any other type of waste that does not fulfil the acceptance criteria determined in accordance with Annex 2.

There are also targets for the reduction of biodegradable waste going to landfill.

Permit to operate a landfill

A permit to operate a landfill must be obtained from the relevant authority, the Directive describes the required information that must be provided by an applicant to allow an application to be determined, including where an impact assessment is required under Directive 85/337/EEC);

Waste acceptance procedures

Prior to accepting waste landfill site operators are to ensure that:

- The waste in question can be accepted at that site according to the conditions set out in the permit and that waste fulfils the acceptance criteria set out in Annex 2;
- The following acceptance procedures are observed:
 - Checking of waste documentation;
 - Visual inspection of the waste at the entrance and the point of deposit and, where appropriate verification conformity with the description provided in the documentation. Provision is made for sampling and analysis; and
 - Keeping a register of the quantities and characteristics of the waste deposited, indicating origin, date of delivery, identity of the producer (municipal waste) and, in the case of hazardous waste the precise location on the site.
- Written certification of each delivery is provided; and
- The competent authority is notified in the event of the non-acceptance of waste.

Control and monitoring procedures in the operational phase

Control and monitoring procedures in the operational phase must meet at least the following requirements:

- Operator carries out a control and monitoring program as specified in Annex 3 of the Directive;

- Operator notifies the competent authorities of any significant adverse environmental effects revealed by the control and monitoring procedures and follow any decision about corrective measures to be taken. Such measures will be at the expense of the operator; and
- Quality control of the analytical operations of the control and monitoring procedures.

Closure and after-care procedures

The full costs of landfill are to be reflected in the charges for waste acceptance. This must include the costs of closure and aftercare for at least 30 years.

1.3.2 EU Waste Directive 2008/98/EC

Directive 2008/98/EC, on waste (the revised Waste Framework Directive), sets out measures to minimise the negative effects of the generation and management of waste on human health and the environment and aims to reduce the use of resources through the development of a waste policy, which should help move the EU closer to a 'recycling society'. The Directive does this by establishing the following waste hierarchy, which will apply as a priority order in waste prevention and management legislation and policy:

- Prevention;
- Preparing for re-use;
- Recycling;
- Other recovery, for example, energy recovery; and
- Disposal.

A list of wastes is established by Decision 2000/532/EC. This contains the current version of the European Waste Catalogue. This catalogue provides codes allowing consistent identification of types of waste for accurate characterisation, monitoring and recording of waste generation, transfer and ultimate destination.

1.3.3 EU Industrial Emissions Directive (integrated pollution prevention and control) 2010/75/EU

The Industrial Emissions Directive (integrated pollution prevention and control) (IE-IPPC) represents a combined approach to managing the environmental impacts of industry, including the waste management industry. It sets out measures designed to prevent and reduce emissions in the air, water and land from such activities in order to reach a high level of protection of the environment. Through a single permitting process, operators must apply best available techniques (BAT) and meet various requirements, whilst taking into account local factors. The operator must apply for a permit from the national competent authority who will assess the application and if proposals are deemed appropriate, issue a permit containing conditions to protect to environmental and monitoring the operation of the facility under those conditions.

The European Commission has not produced a best available techniques reference document (BREF) for landfill. Instead, the Landfill Directive described above provides certain technical standards for landfill sites.

Guidance provided by the European Commission, explains the interface between the IPPC and Landfill Directives.^{1,2} With respect to the technical requirements for landfills, the guidance explains, that the provisions of the Landfill Directive are considered to take the place of the provisions of Article 9(4) of the IPPC Directive. That part of the IPPC Directive requires, that emission limit values and the equivalent parameters and technical measures are based on best available techniques (BAT). Where the Landfill Directive does not provide the relevant technical requirements, then the general principles of the IPPC Directive and BAT must be applied.

¹ Environmental Permitting Guidance, The Landfill Directive For the Environmental Permitting (England and Wales) Regulations 2010 Updated March 2010 Version 3.1, Department for Environment, Food and Rural Affairs

² Guidance on Interpretation and Implementation of the IPPC Directive http://ec.europa.eu/environment/archives/stationary/ippc/general_guidance.htm

2. LANDFILL DESIGN PARAMETERS

2.1 SITE LOCATION AND MORPHOLOGY

The Kvemo Kartli region is located in the southern part of Georgia within an area of valleys and relatively low hills surrounded by high mountain ranges including the Trialeti, the Javakheti, and the Bambak-Erevano ranges.

Kvemo Kartli covers an area of 6,528 km² (9% of Georgia's area) and shares its borders with the following Georgian regions: Samtskhe-Javakheti, Shida Kartli, Mtskheta-Mtianeti, Tbilisi and Kakheti, as well as Armenia and Azerbaijan.

The main land use in the Kvemo Kartli region is for agricultural activities. At present Tetritskaro municipality is known as an agricultural region. Main fields of agriculture are: livestock and dairy products (45%), grain production (30%), gardening (20%).

The current land use of the proposed Solid Waste Landfill site, owned by Solid Waste Management Company of Georgia (Ministry of regional Development and Infrastructure of Georgia), is for agriculture. The borders of the site are as follows:

- Western border: Agricultural area;
- Northern border: Agricultural area;
- Eastern border: dirty road and former water pipeline and a pump station (including three abandoned buildings);
- Along the eastern side: electric transmission line (as described below); and
- Southern border: Agricultural area.

The wider area has been used in the past for the cultivation of various plants. In recent years, mainly for economic reasons (profitability), no agricultural activities is taking place in the area (neither on the proposed landfill site).

The landfill area is situated on the Tetritsqaro Municipality at an altitude of approximately 720 m above sea level. The surrounding area is fairly flat with carved river valleys. The plateau shows typical vegetation with shrubs and trees.

The main river in the area of interest is the Algeti River. The Algeti River is coming from the south from Trialeti range, which is its origin. In the south part of Tetritskaro municipality, Khrami River is located, with a well-defined canyon of 20 km length.

Around the site where the landfill will be constructed, there are also other various streams, lakes and ponds.

Table 1: Site's general characteristics

Parameter	
Coordinates	41°32'38.56" N ; 44°39'42.30" E
Area (ha)	21.5 (3 different parcels)
Distance from nearest settlement (km)	2
Distance from main road (km)	1.35
Distance from natural area (km)	0.87
Land use category	Agricultural
Property	Municipality

Parameter	
Major infrastructure (e.g. pipeline, high voltage power line)	High voltage power line
Distance from surface water body (km)	< 500 m

The main findings of the visit are presented, inter alia, in the following chapters.



Figure 2-1: Landfill area

2.2 HYDROGEOLOGICAL CONDITIONS

The hydrographic network of the study area is quite rich and it comprises of various rivers, streams, ponds (both natural and artificial). The site area belongs to the flat plains of River Khrami, which is sloping slightly to the South-East direction.

The relevant hydrogeological information is based in available maps and summarized in the following table.

No of Map	Title of map	Info
1	Geological map of Marneuli-Gardabani artesian well	General: Upper Miocene-Pliocene-dolerite and basaltic covers/surface Tsinskaro area: Lower and Middle Oligocene-clay gypsum-bearing clays with interbeds of argillaceous sandstones
2	Geological map	The upper sub-division of the Pliocene-Middle Quaternary unit. Flows of lavas of dolerites (basalts) of a bundle and

No of Map	Title of map	Info
		lenses of volcanic ashes (sands) of various broken unconsolidated terrigenous formations of a motley composition and their mixed varieties
3	Hydrogeological map of Marneuli-Gardabani artesian well	General: Aquiferous complex volcanogenic and continental sediments of the Upper Miocene-Pleiocene, dolerites (basalts) Tsinskaro area: Sporadic and saturated sediments of the Lower Eocene and Paleocene. Conglomerates, pebbles, limestones
4	Hydrogeological map	General: The area of the Miopleistocene feeding area of waterproof and less water-permeable rocks with high-salinity water content, for which the calculations of groundwater operating reserves have not been made. Tsinskaro area: The aquifer of floodplain and modern river-bed sediments. Boulder - pebbles with sandy aggregate (comment: nearby Tsinskaro)
5	Schematic hydrogeological map	The aquifer of the Upper Pliocene and Quaternary dacite, andesite-dacite, andesite, andesite-basaltic and basaltic lavas.
6	Tectonic map	Quaternary dolerite lavas.
7	Underground water supplies	The area of the Miopleistocene feeding area of waterproof and less water-permeable rocks with high-salinity water content, for which the calculations of groundwater operating reserves have not been made.

The most important feature of the hydrographic network of the area is Algeti River, and is direct distanced at more than 1,24 km from the boundaries of the site.

According to the above-mentioned maps, the geological structure of project area consists of continental alkali basalts of upper Pliocene - late Quaternary, dolerites, andesite-basalts, conglomerates, sand stones and clay.

Lava layers are covered by 0.5-3.0 meter of delluvial deposits, in some places by prolluvial clay materials, common inclusions of fragmented loose rock filled with clay-loam, grit and common inclusions of large rocks. Some sections of the modern Quaternary layer are rinsed out and completely removed and fractured basalts are showing from the surface.

According to the Hydrological map of Georgia, the territory belongs to a region of ground water accumulated in rock discontinuities (joins, fractures, etc) on the east slope of Javakheti Range in the groundwater district of Artvin-Bolnisi Belt.

Extremely fractured lava layers are permeable to water. Atmospheric precipitation that leaks down to the discontinuities is usually gathered on the bottom of lava flows, on the surface of waterproof Tyrone-age rock layers or, on the top of middle layers of inner-igneous loams and are appeared as springs at lower levels of slopes of erosive ravines and rivers.

Ground water, discharged from basalt layers is well filtered, clean and clear. This water is used for drinking as well as agricultural purposes.

Groundwater level measurements from piezometers, taken on 02.08.19 (end of fieldworks), 19.09.19, 27.11.19, 06.02.20, 01.07.20, 24.02.21 are presented and analyzed in Table 3.3 of Technical Report 2 (Geotechnical investigation study). The analysis reveals that, at the locations of the piezometers the fluctuation of ground water table during the eighteen (18) month monitored period varied from 0.10m to 0.68m. Accordingly, in the design of the proposed landfill, the minimum elevation of excavations across the area, is about 2m higher than the maximum elevation of ground water table.

2.3 SEISMICITY

According to the seismic hazard map of Georgia, the proposed site belongs to magnitude 8.0 earthquake zone and has dimensionless coefficient of horizontal ground acceleration equal to 0,14.

It is expected that earthquakes and tremors will be experienced at a low intensity at the site during the landfill construction, operation and post-operation life, as these frequently occur in Georgia. However, overall there is a very low risk of an earthquake that may cause disruption or damage to the proposed landfill site because of the low intensity of historic tremors and the low lying, solid base engineering of the facility.

According to the above data, it can be mentioned that there are not any geological or tectonic risks in the proposed study. There is not a significant shallow aquifer or any tectonic restrictions which could pose a risk or require special design and construction.

2.4 PROTECTED AREAS

According to the Agency of Protected Areas of Georgia (<http://www.apa.gov.ge/en/>) and the available data, there is not any natural protected area in the vicinity of the site.

The area of Algeti National park is located at a distance more than 35 km from the site (Tsintskaro).

3. DESCRIPTION OF THE LANDFILL DESIGN

3.1 GENERAL DESCRIPTION OF LANDFILL DESIGN

The new landfill will be developed near Tetriskardo village having an area of approximately 20.8 ha.

The Kvemo Kartli new landfill design is in line with EU regulations (Council Directive 1999/31/EC/25.04.1999) and international best practices for non hazardous landfills.

Landfill bottom basin is divided by berms into two distinct phases of operation and two sub cells for each phase which will be filled gradually starting from the east part of the site and moving towards the west.

The landfill will have a bottom sealing system that will ensure collection of all produced leachate. The leachate collection system consists: i) of a leachate drainage layer 0,50m thick covered on both sides by geotextile and ii) a leachate collection pipe network that is described in the detail in the attached Technical Report 4 (Surface Water-Flood management).

After filling all the available landfill area a proper top cover system will be placed, in order to isolate all deposited wastes, facilitate biogas collection and avoid adverse effects to human health and the environment.

The final closed landfill site will be covered with vegetative soil and planted with properly selected plants to fit and grow in the conditions of the area.

A ground water, surface water and biogas monitoring system will be installed in order to monitor the site during operation and after its closure. Due to the relative large thickness of the deposited wastes, a settlement monitoring system will also be installed. Specifically upon completion of the landfill operation the following will continue to operate and apply:

- Leachate collection and treatment system (leachate recirculation in waste volume and periodic removal),
- Biogas collection and flare system,
- The environmental monitoring program (e.g. air, groundwater quality),
- Settlements monitoring program and
- Vegetation maintenance.

3.2 CONSTRUCTION WORKS AND LANDFILL OPERATIONAL SEQUENCE

3.2.1 General

The landfill construction works in the landfill will be performed in a specific sequence.

For an efficient landfill management, the new landfill bottom basin will be divided into 4 cells that will be gradually used for waste disposal.

- a. Construct the perimeter road, the embankment and the fencing that surrounds the footprint of the landfill site. The perimeter road, fencing and the

embankment must be founded on natural soils after removal of any wastes, roots, shrubs and any loose soils.

- b. Grade the site properly to create the relief of the basin of the landfill. Grading may start from the east side of the landfill and gradually will continue to the west.

Cuts in the natural soils are anticipated to be done mostly by usual mechanical plants (bulldozers, excavators, etc,) and only locally, where rocky formations may be present, excavation may require hydraulic hammer.

Where fill is required (for roads, perimeter embankment, bottom of landfill, etc) it will be engineered, using natural clean soils, from on-site cuts, clear of deleterious materials (shrubs, roots, waste, etc). Prior to fillings, the fill area, as well as the entire area of the footprint of the landfill, will be stripped at an average thickness of 0,61m (min=0,20m, max=1,2m, sdev=0,30m), and will be inspected and approved by the inspector of the project. Stripped clean soils can be piled for future use during landfill operations (daily cover, etc).

- c. Following the bottom basin sealing layer will be placed consisting of: the geological barrier 0,50m thick, the Geosynthetic Clay Liner (GCL) to form an impermeable barrier, the artificial sealing layer (HDPE geomembrane), the leachate collection system (leachate drainage layer 0,50, thick & pipe network) and finally a protection geotextile will be installed.
- d. On top of the protection geotextile, municipal waste can be deposited taking care not to damage the lining system of the landfill. This can be accomplished by placing on top of the base lining system, municipal waste with relatively small grain size, and without sharp edges.
- e. In parallel with waste deposition the biogas collection wells will also be placed within the waste mass.

Action	Duration (days)	Start	End
Site Preparation works and services	61	Oct-22	Dec-22
Design & obtaining of permits and approvals	242	Febr-22	Oct-22
Construction phase	426	Oct-22	Dec-23
Mobilization & preliminary works (Mobilization of contractor equipment and personnel, Site clearance and marking, construction of temporary roads, ramps and plateaus)	92	Oct-22	Jan-23
Earth works and drainage works	90	Dec-22	Mar-23
Bottom lining system	153	Mar-23	Aug-23
Roads (internal & access road)	151	Jan-23	Jun-23
Buildings	183	Jun-23	Dec-23

LANDFILL DESIGN

Action	Duration (days)	Start	End
Services	181	Feb-23	Aug-23
Leachate Treatment Plant	92	May-23	Aug-23
Gas extraction system	92	Jun-23	Sep-23
Other facilities (access gate, site lighting, fire protection system, CCTV, etc)	184	May-23	Nov-23
Fencing, landscaping and Surface drainage	62	Jul-23	Sep-23
Equipment and installation	153	Mar-23	Aug-23

When waste deposition reaches the landfill's closure relief, the final cover gradually can be installed. In this manner the non-covered surface area of the landfill is kept to a minimum, thus minimizing leachate production.

The landfill will be constructed in two phases. Phase I and Phase II. Phase I is divided to sub-phases "cell 1" and "cell2" and Phase II is divided to sub-phases "cell 3" and "cell4".

The total planned area for disposal is **9.62** ha, **4.97** ha for Phase I (cell1 and cell 2) and **4.65** ha for Phase II (cell 3 and cell 4).



Figure 3-1: Layout of Phase I



Figure 3-2: Layout of Phase II

3.2.2 Landfill operational sequence

The landfill will be constructed in two phases. Phase I and Phase II.

Phase I is divided to sub-phases “cell 1” and “cell2” and Phase II is divided to sub-phases “cell 3” and “cell4”.

The total planned area for disposal is **9.62 ha**, **4.97 ha** for Phase I (cell1 and cell 2) and **4.65 ha** for Phase II (cell 3 and cell 4).

Phase I

The planned area for disposal during Phase I is **4.97 ha**. During the construction of Phase I disposal area, a dyke will be constructed, dividing the whole phase into 2 cells (Cells 1&2). At the west side of Phase I a berm (dyke) is being constructed, in order at first to be used as a temporary part of circumferential road of Phase I and secondly to separate Phase I from Phase II.

LANDFILL DESIGN

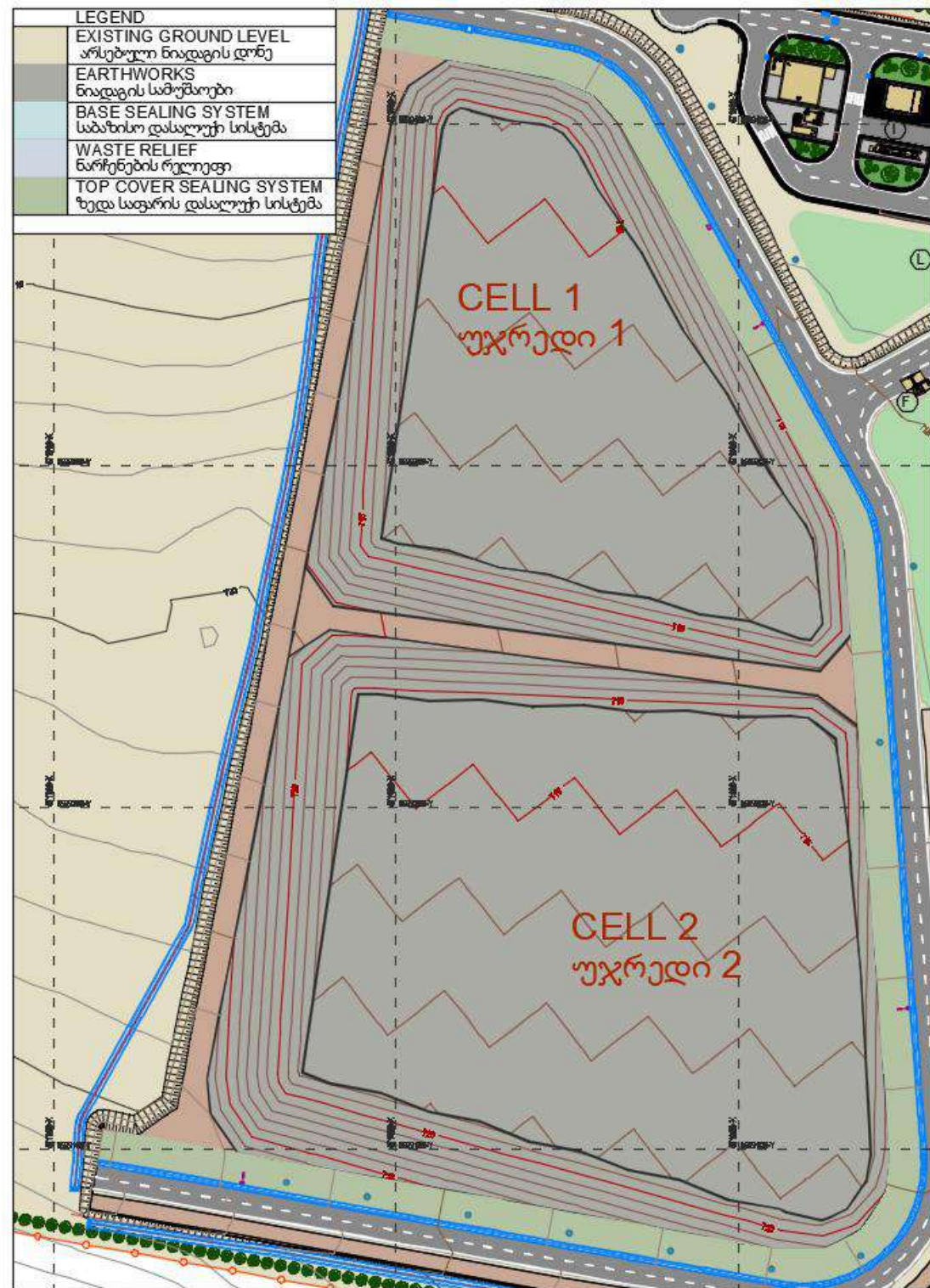


Figure 3-3: Cells 1 and 2 -Earthworks

LANDFILL DESIGN

After the construction of earthworks of cell 1 and cell 2, a liner system (base sealing system) along with leachate collection and transfer network of cells 1 and 2 is being constructed.

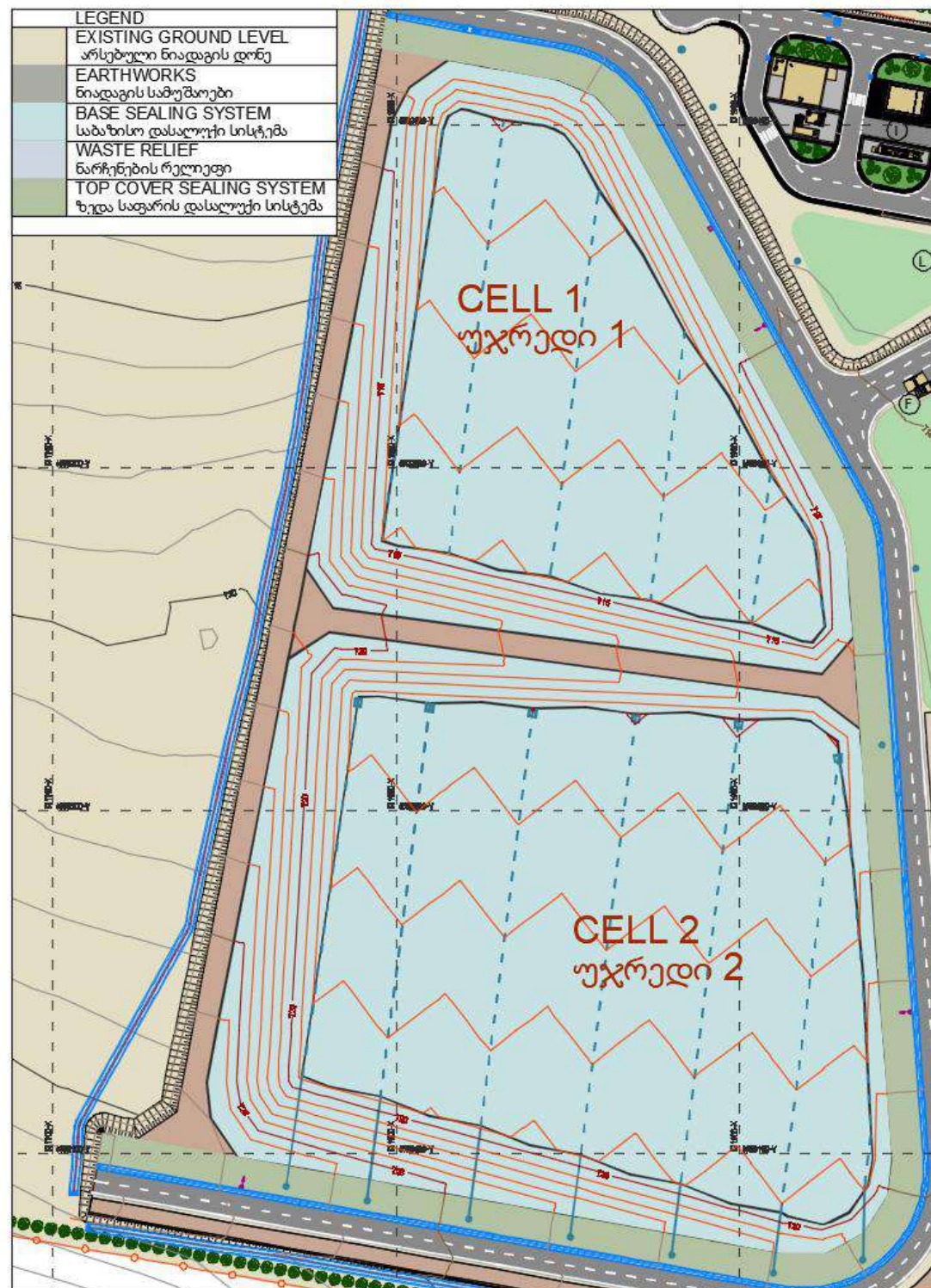


Figure 3-4: Cells 1 and 2- Liner system & Leachate collection system

LANDFILL DESIGN

Disposal of solid waste procedure begins in cell 1 and the leachate collection system of cell 1 is used for leachate collection, while at the same time the leachate collection system of cell 2 is being used to collect and pump out of cell 2 rainwater.

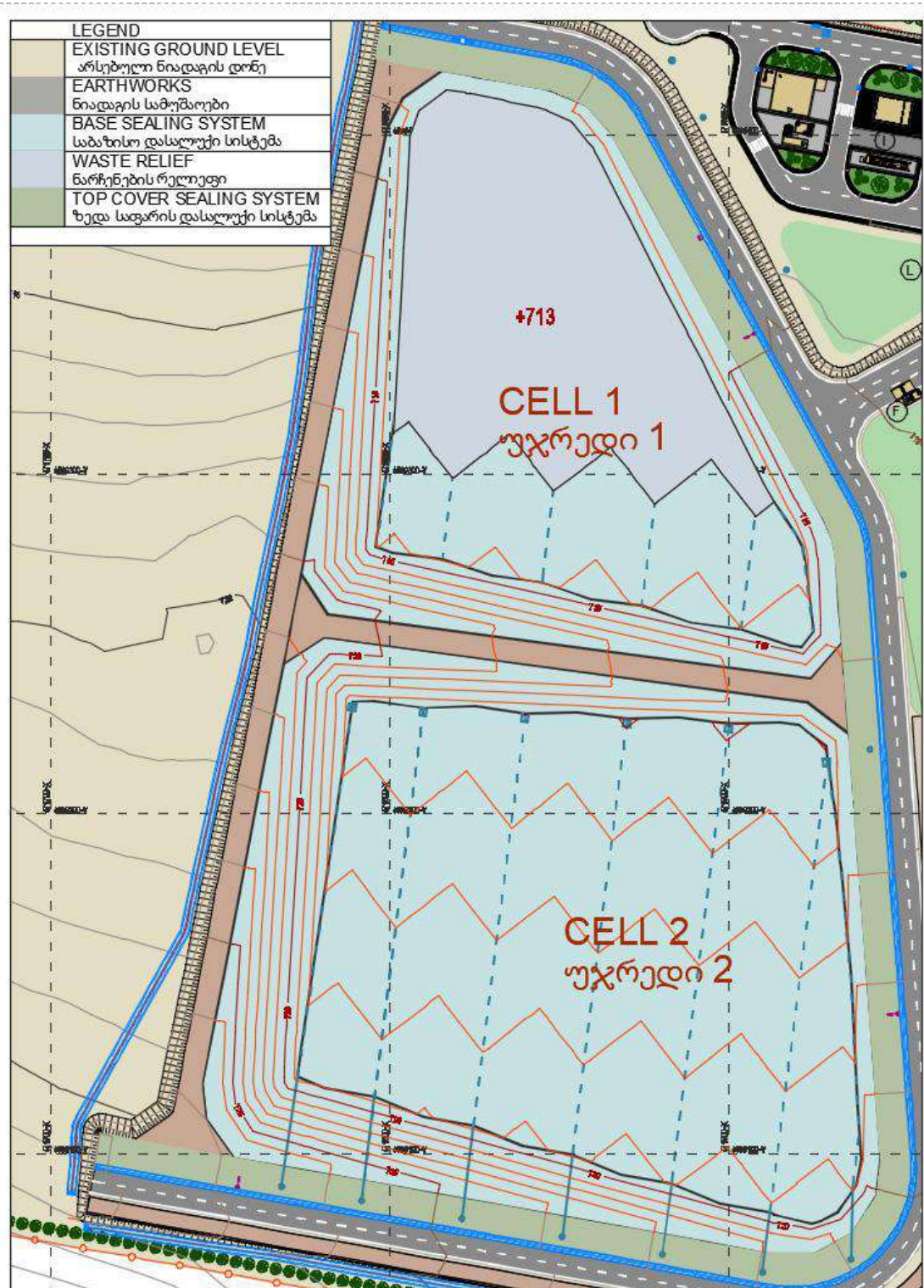


Figure 3-5: Beginning of disposal in cell 1

LANDFILL DESIGN

After waste relief in cell 1 reaches level +721 m, waste disposal is taking place only in cell 2, and so at that point leachate collection system of cell 2 is also being used for leachate collection.

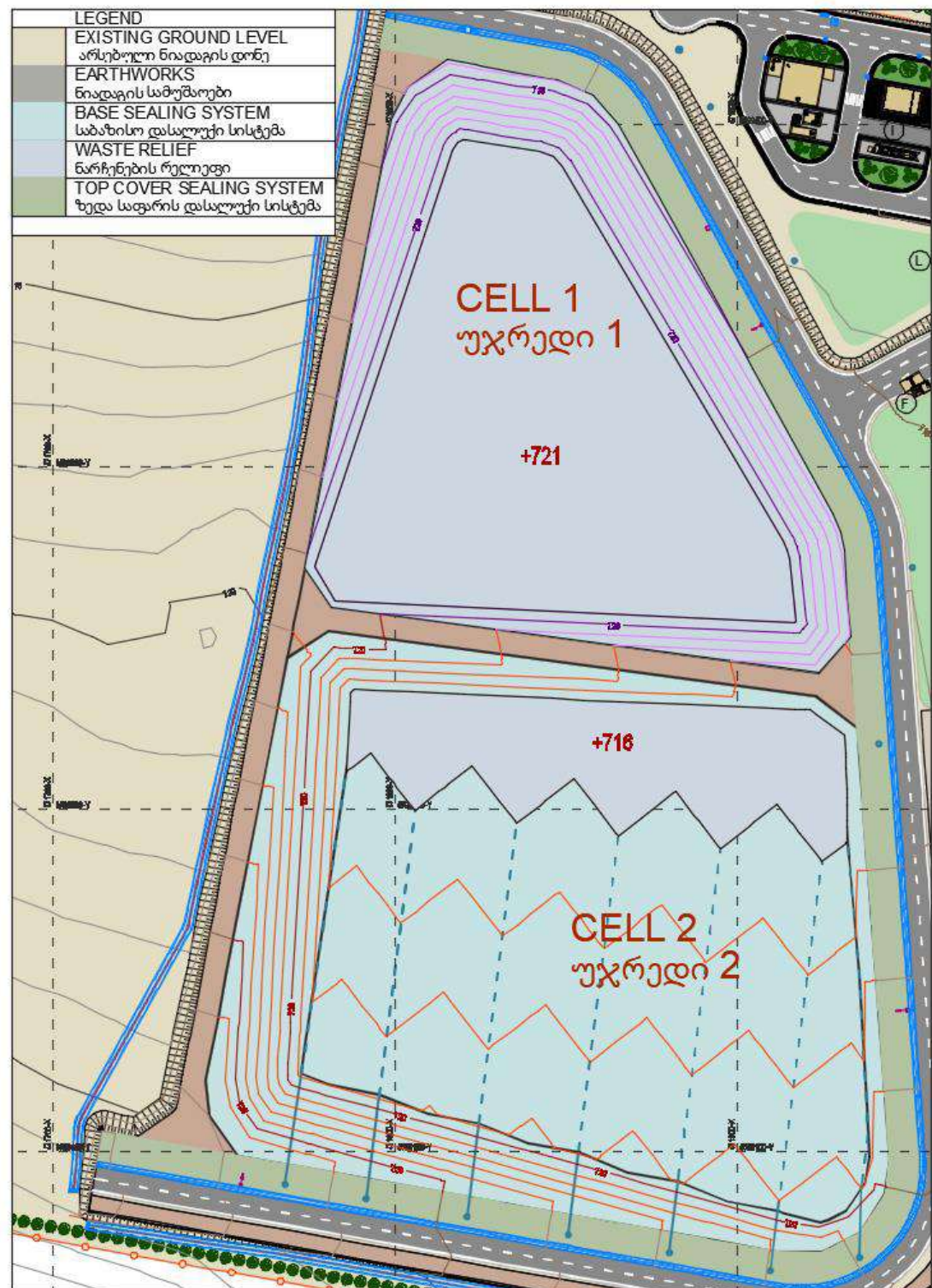


Figure 3-6: Beginning of disposal in cell 2

LANDFILL DESIGN

Waste disposal is taking place only in cell 2 until waste relief reaches the altitude of waste relief of cell 1. Then the disposal is taking place in both cells 1 and 2

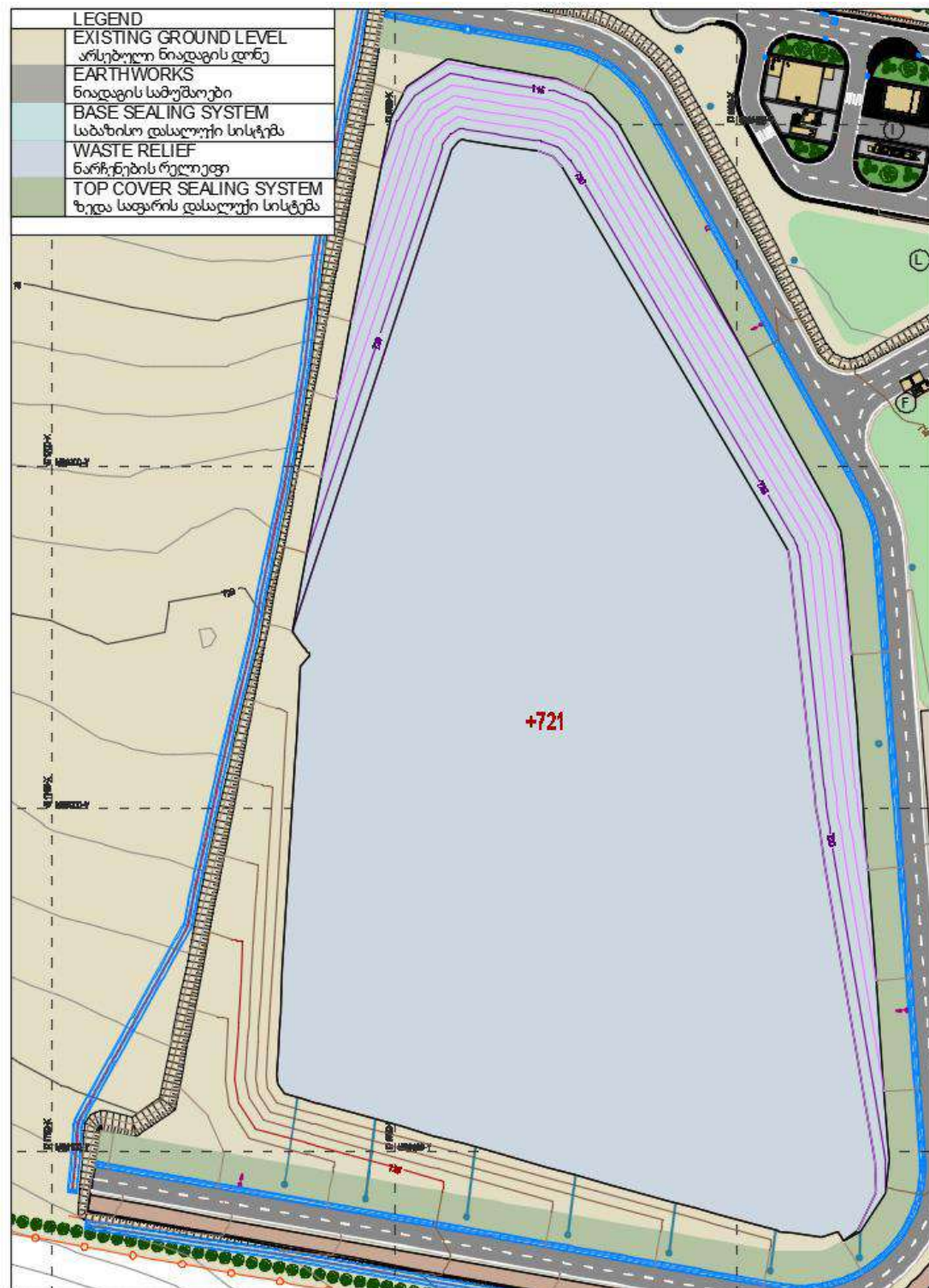


Figure 3-7: Beginning of disposal in both cells 1 and 2

LANDFILL DESIGN

Until waste relief of Phase I reaches its temporary plateau, earthworks for the construction of Phase II cells is taking place.

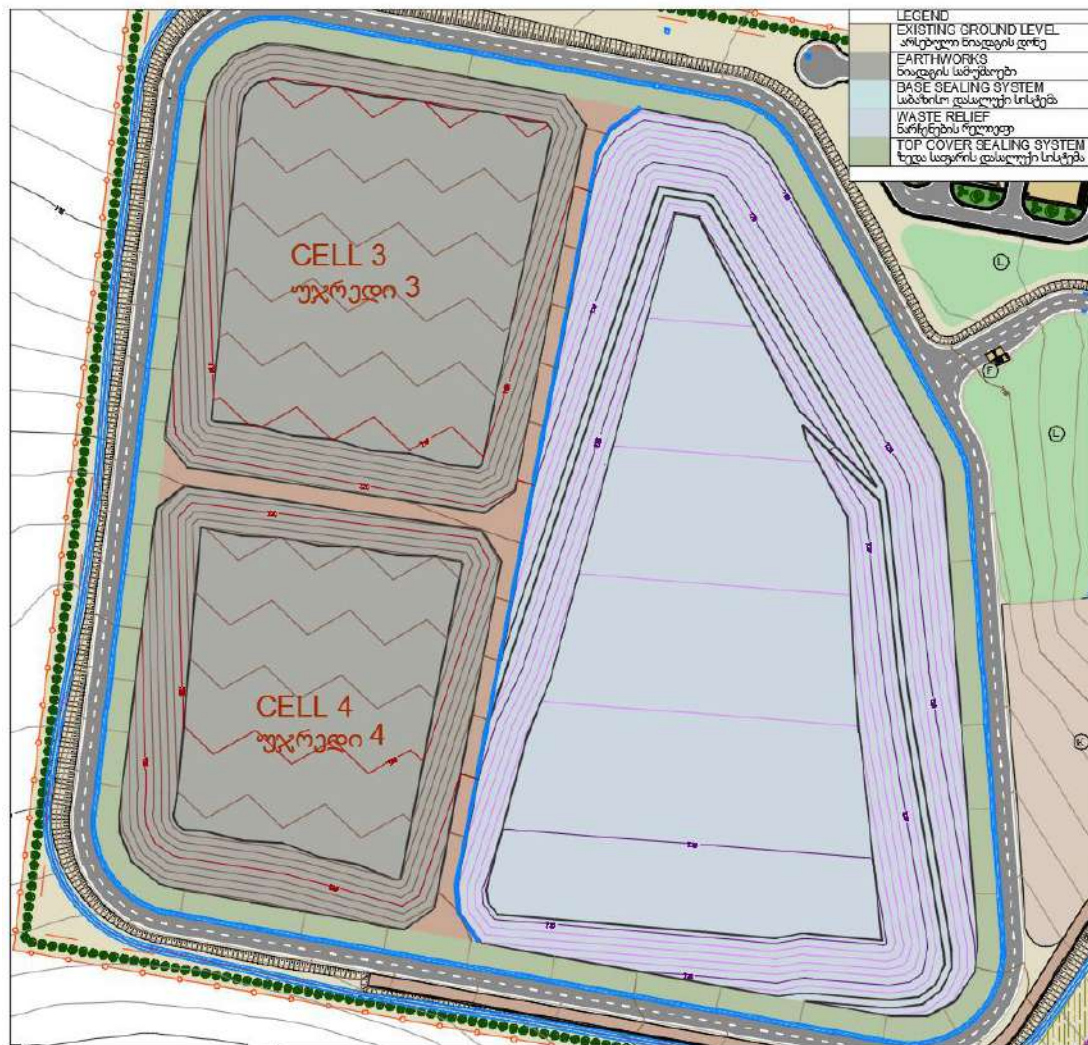


Figure 3-8: Phase I temporary plateau & Cells 3 and 4 -Earthworks

Phase II

The planned area for disposal during Phase II is **4.65** ha. During the construction of Phase II disposal area, a dyke will be constructed, dividing the whole phase into 2 cells (Cells 3&4).

By the time waste relief of Phase I reaches its temporary plateau, a liner system (base sealing system), along with leachate collection and transfer network of cells 3 and 4, is already being constructed.

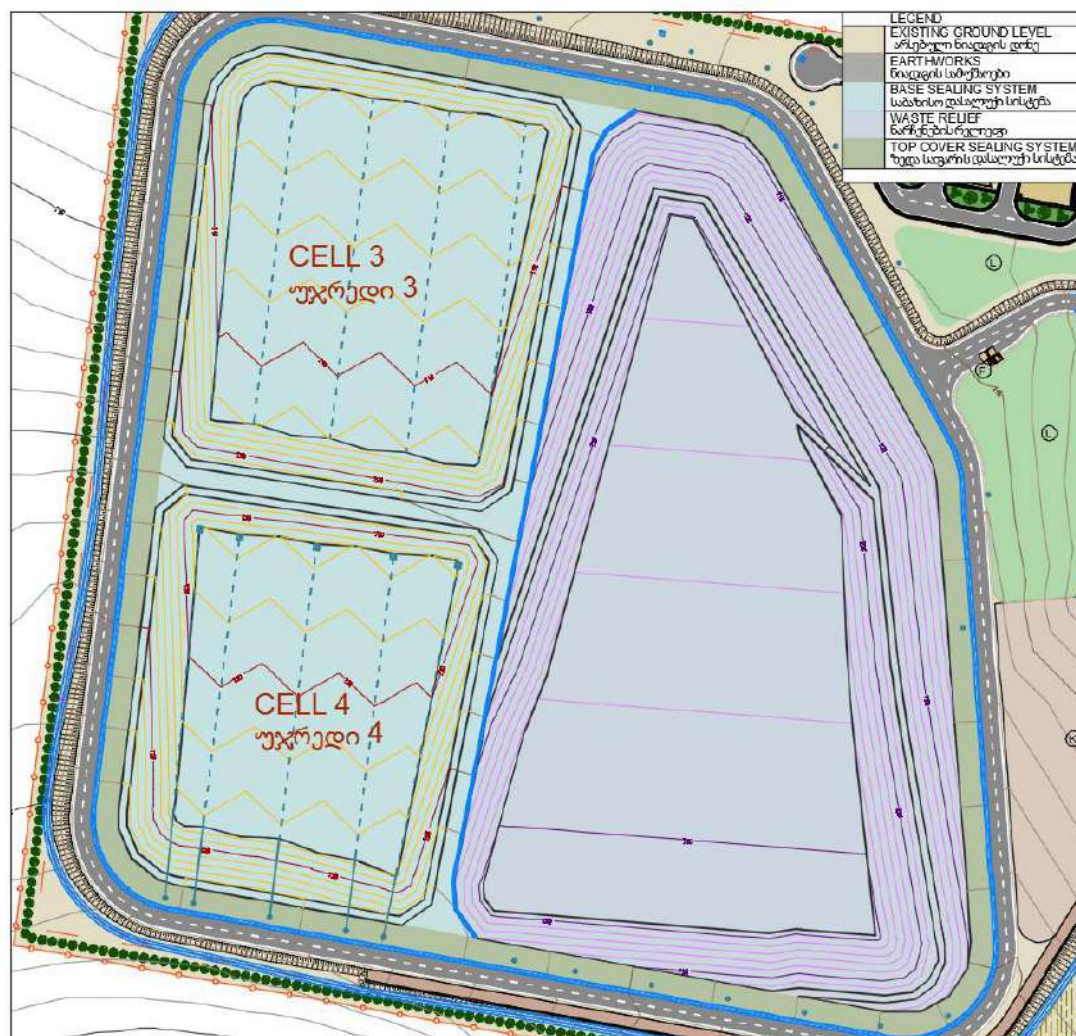


Figure 3-9: Cells 3 and 4- Liner system & Leachate collection system

LANDFILL DESIGN

Disposal of solid waste procedure begins in cell 3 and the leachate collection system of cell 3 is used for leachate collection, while at the same time the leachate collection system of cell 4 is being used to collect and pump rainwater out of cell 4.

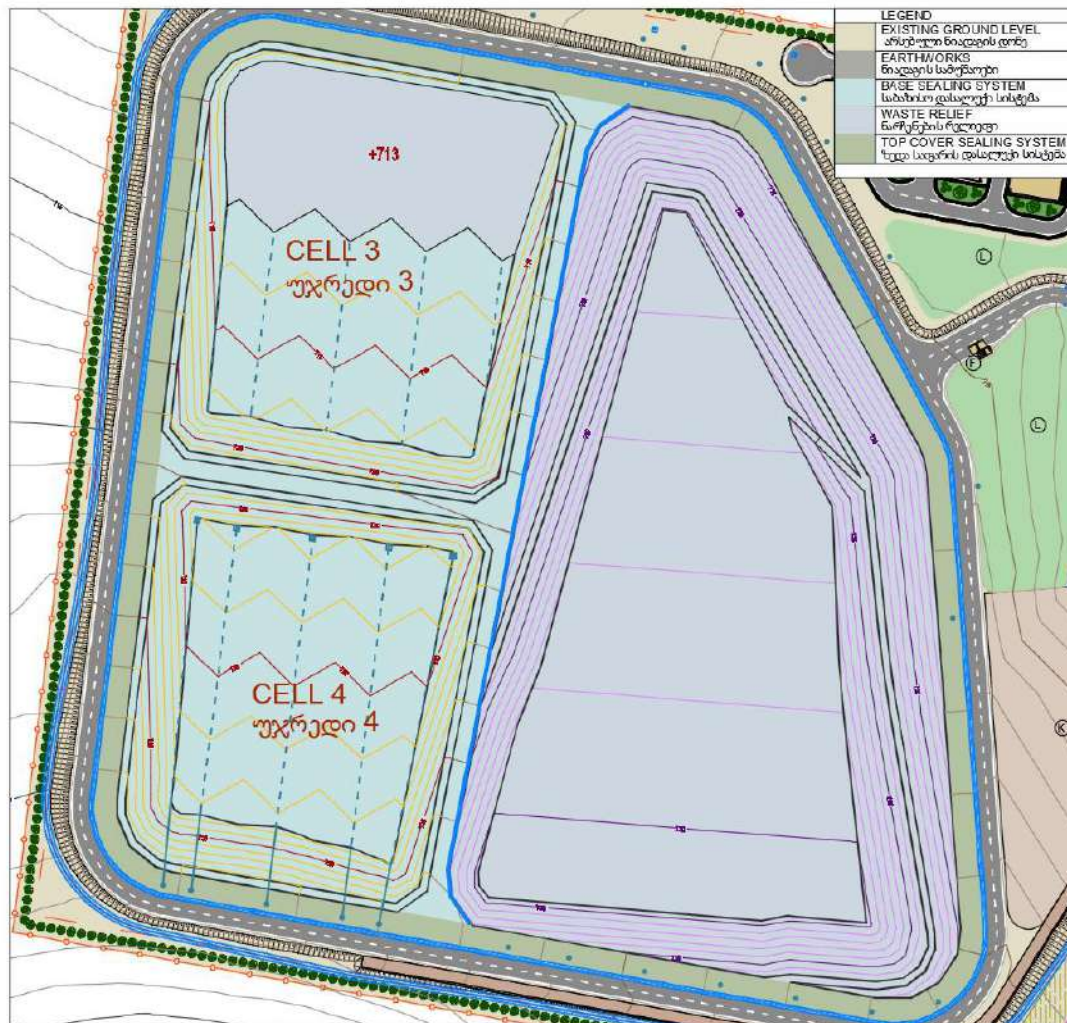


Figure 3-10: Beginning of disposal in cell 3

LANDFILL DESIGN

After waste relief in cell 3 reaches level +722 m, waste disposal is taking place only in cell 4, and so at that point leachate collection system of cell 4 is also being used for leachate collection.

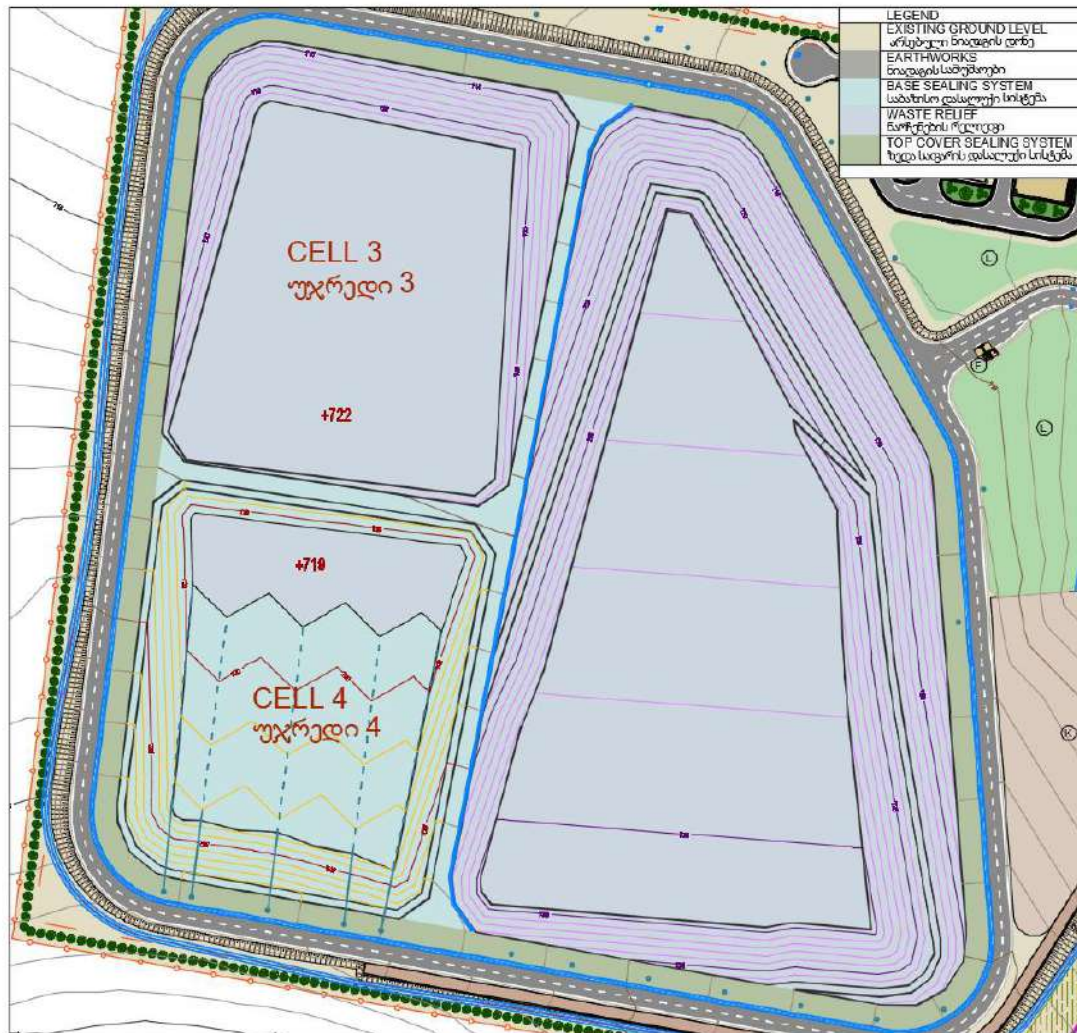


Figure 3-11: Beginning of disposal in cell 4

LANDFILL DESIGN

After waste relief in cell 4 reaches level +722 m, waste disposal is taking place in both cells 3 and 4 until waste relief level reaches level +731m.

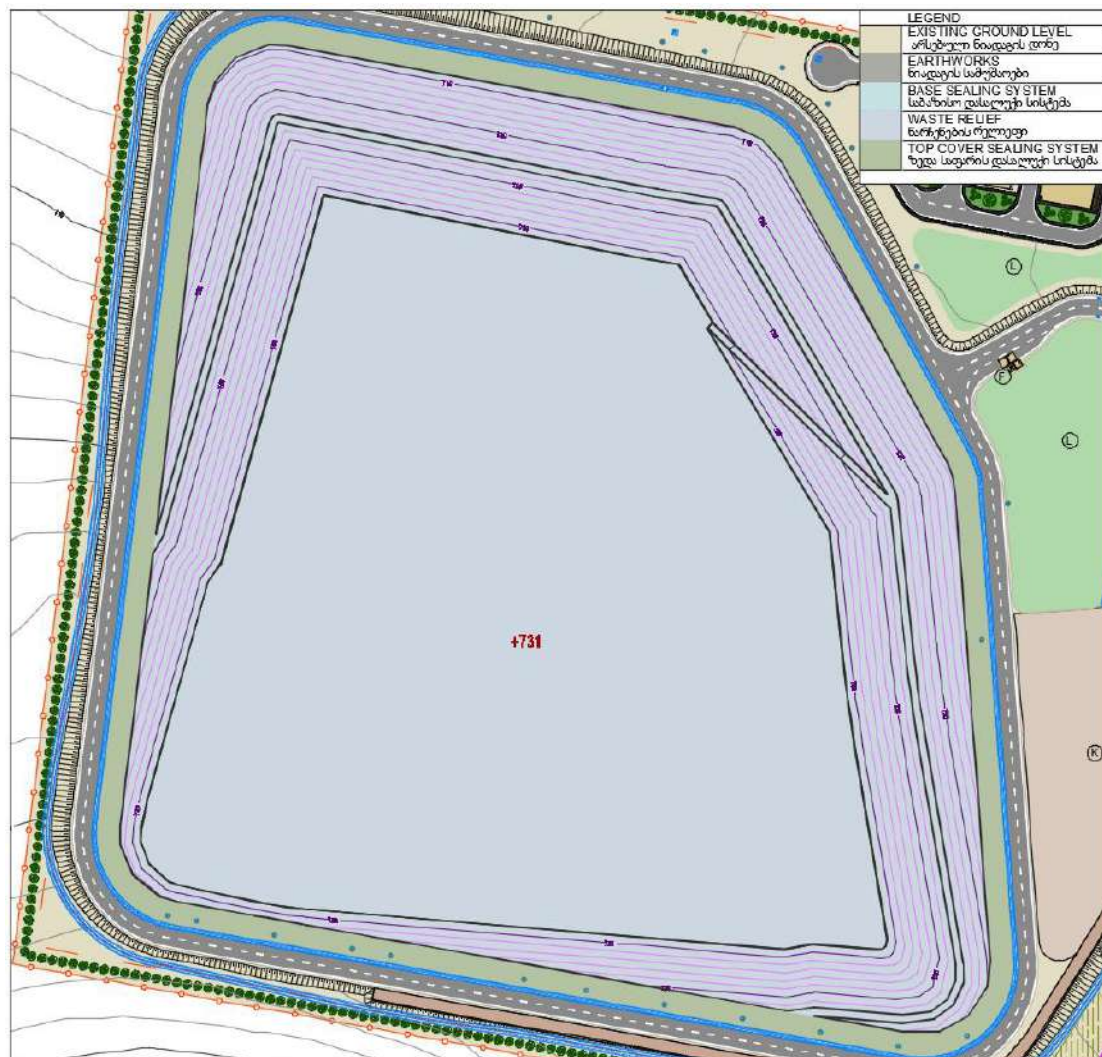


Figure 3-12: Beginning of disposal in both phases I&II

LANDFILL DESIGN

After waste relief reaches level +731m, waste disposal is taking place in both phases I and II until waste relief reaches its final level.

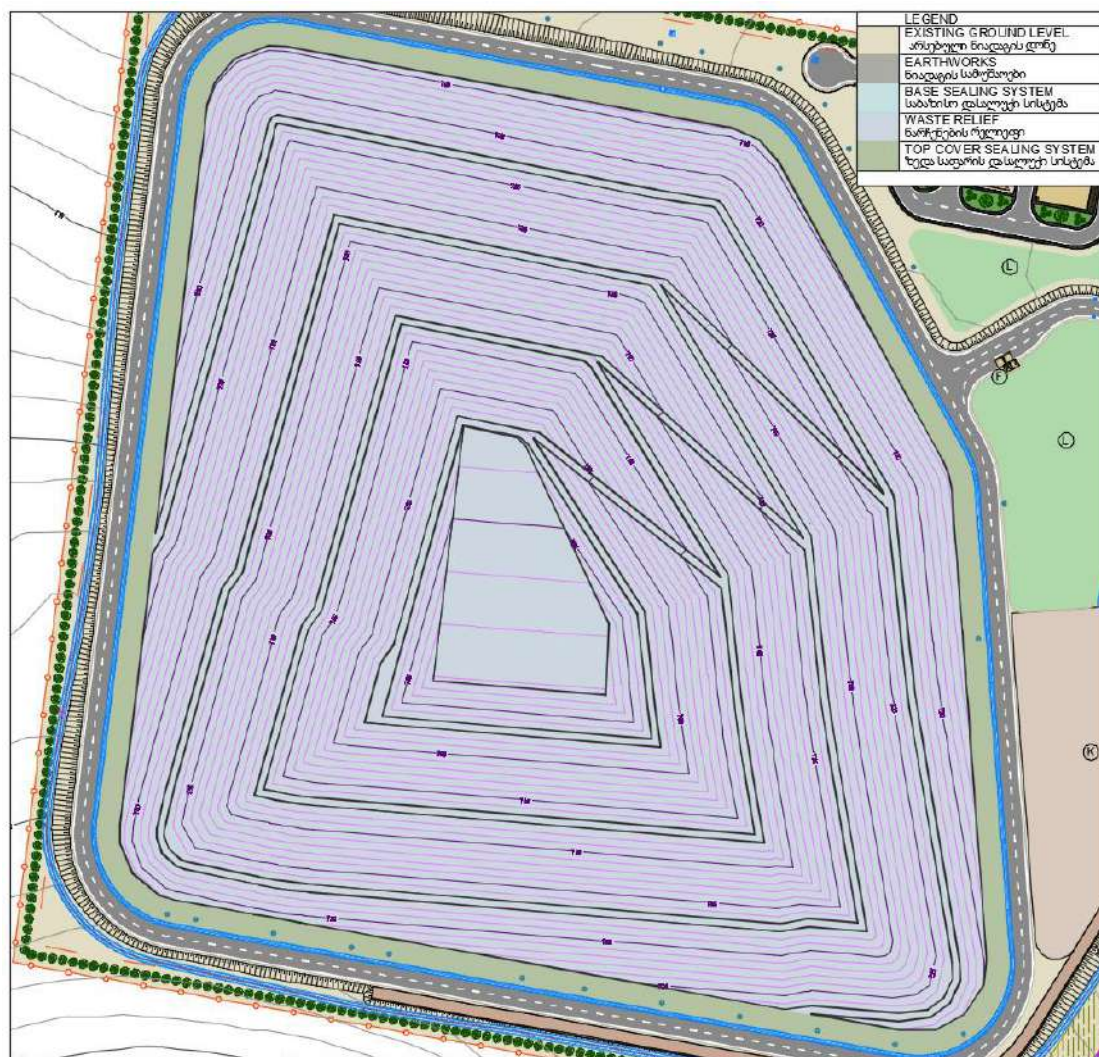


Figure 3-13: Waste relief final level

After waste relief reaches its final level, top cover sealing system is being constructed



Figure 3-14: Final cover levels

In the following scheme (Section1), presented both phases of construction and landfilling (see also Drawing DDFE.06.2).

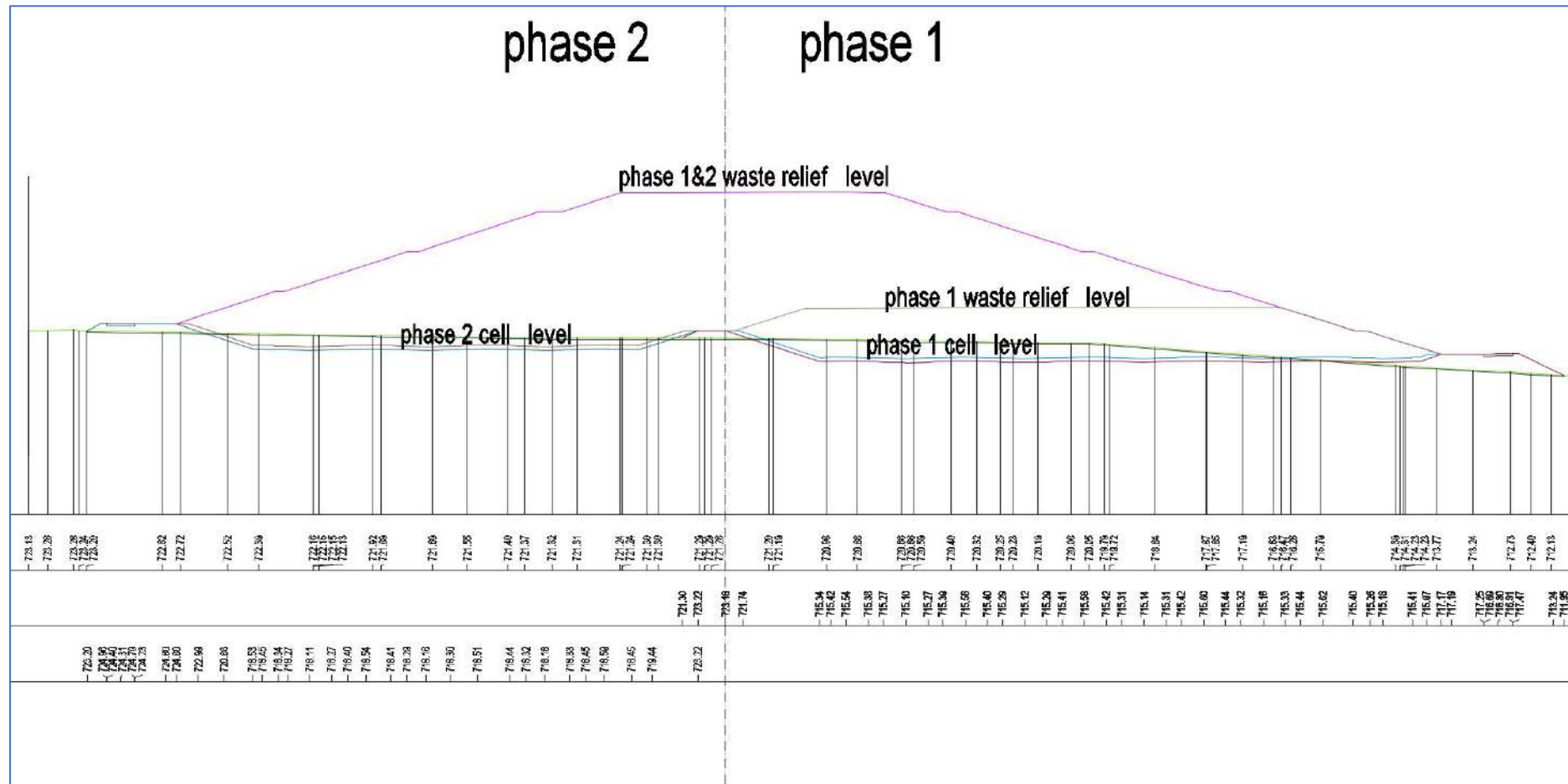


Figure 3-15: Section of both phases

3.3 LANDFILL OPERATION LIFETIME

The total lifetime of the landfill is expected to be more than 7 years for Phase I and over 20 years for Phase II, assuming a waste density of 0.8 t/m³ and daily cover contribution for 10 % of the volume.

The calculation was based on the assumptions made in COWI's Baseline Report and Project Proposal report by taking into account a more conservative waste density (0.8 instead of 1.0 t/m³) and the new design of the landfill basin prepared by HPC.

Duration	m ³ of waste per year
Years 1-12	50,160
Years 13-17	41,360
Years 18-22	54,560
Years 23-30	56,320
TOTAL (29 years+11 months)	1,582,000

The landfill will be able to accommodate additional units for waste treatment facilities. There are areas/sections developed during the construction phase prepared for additional future waste handling activities such as crushing and screening of construction and demolition waste, composting facility or temporarily storage of hazardous waste.

Further, based on settlement calculations presented in Technical Report (TR) 2 (Geotechnical investigation study), the depositional life of the landfill may be extended by 20% to 25% of the aforementioned landfill life.

4. LANFILL FORMATION - EARTHWORKS

As mentioned above, the landfill will be constructed in two phases, Phase I and Phase II, but as shown in the respective drawings, the majority of earthworks takes place during Phase I.

4.1 PHILOSOPHY DESIGN

As mentioned above, the landfill will be constructed in two phases. Phase I and Phase II. All the configurations have been decided based on the following principles (having in mind the existing terrain):

- Easy leachate collection, avoiding mixture with the rain water
- Avoiding - as much as possible - large volume of excavations, since the groundwater table is high
- Easy accessibility of the garbage trucks to the bottom of the basin
- Construction of a circumferential road and trench for runoff of the rain water
- Easy accessibility of all buildings and infrastructure areas
- Construction of Phase II without interruption of Phase I operation procedure
- Easy stormwater collection, reducing the need for several structures

The total area of earthworks of both phases is aprox. **16.88** ha. Earthworks are divided into the following main categories:

- Excavation of top soil;
- Earthworks for landfill cells;
- Earthworks for roads (including roadside constructions);
- Earthworks for auxiliary infrastructures, planting areas etc.;
- Earthworks for the formation of waste relief.

4.2 EARTHWORKS PER PHASE

Phase I

As shown in the respective drawings, the majority of earthworks takes place during Phase I, as Phase I includes the construction of the entire internal road network (except circumferential road of Phase II), the construction of all auxiliary infrastructures and also the landfill cells 1 and 2. The total area of earthworks of Phase I is aprox. **11.04** ha.



Figure 4-1: Phase I General Layout

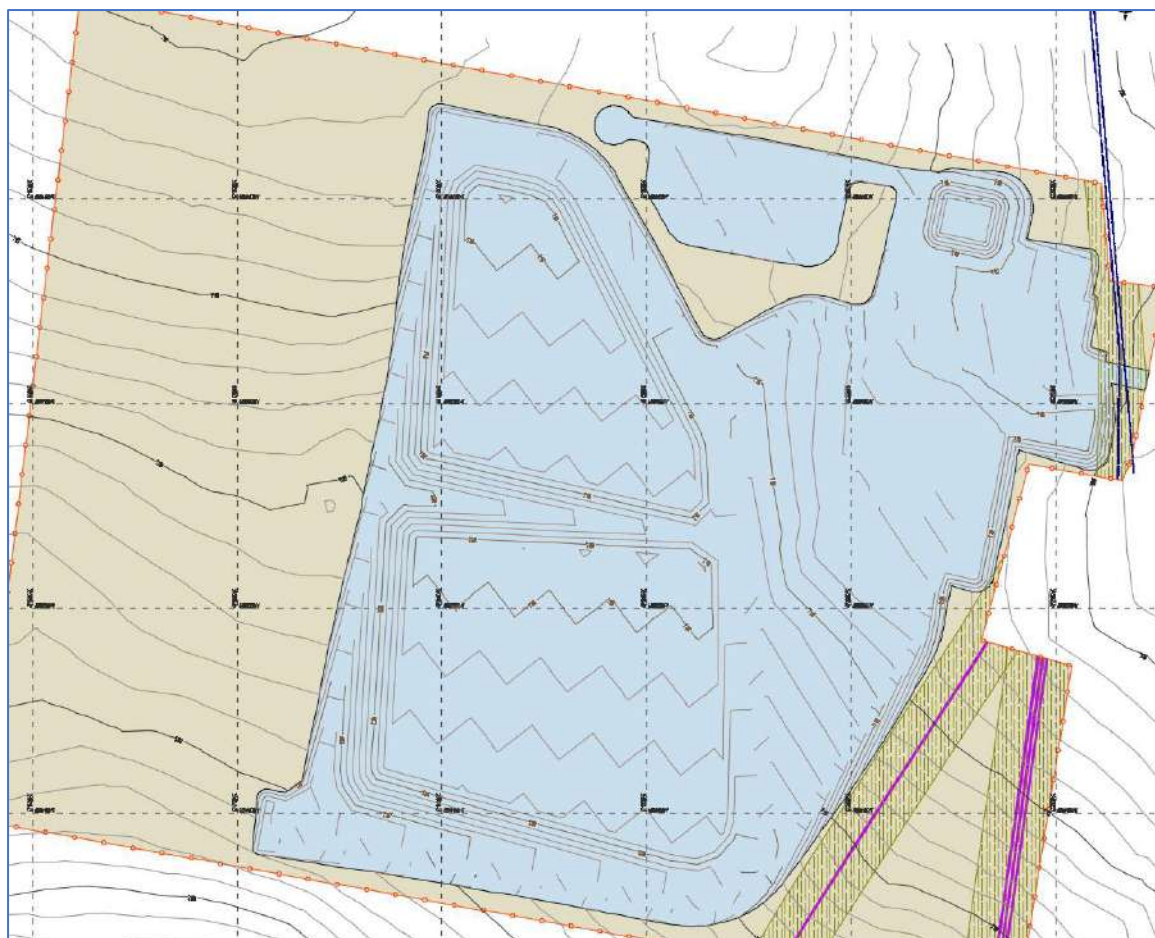


Figure 4-2: Phase I Earthworks total area

Phase II

Phase II earthworks includes the construction of cells 3 and 4 along with the rest of the circumferential road and ditch. The total area of earthworks of Phase II is aprox. 5.84 ha.

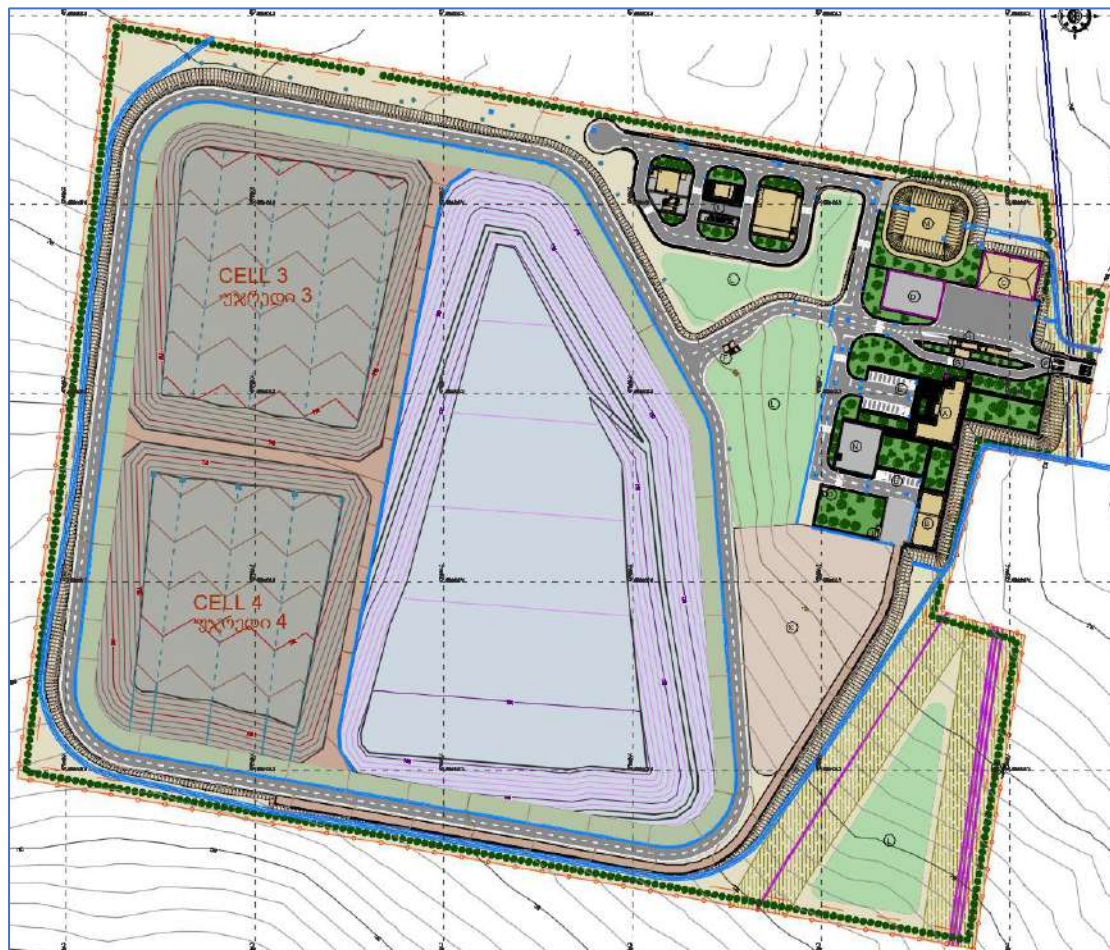


Figure 4-3: Phase II General Layout



Figure 4-4: Phase II Earthworks total area

Earthworks are divided into four main categories

- Excavation of top soil;
- Earthworks of landfill disposal area (cells);
- Earthworks of roads (including roadside constructions) and
- Earthworks of auxiliary infrastructures, etc.

4.2.1 Top soil

Top soil shall mean the top layer of soil which can support vegetation, and shall be removed and disposed of. The topsoil shall be removed from the area of the corks prior to commencement of the general earthworks, the surface thus formed being defined as the natural foundation. The top soil layer to be excavated shall have an average thickness of 0.61 meters. Top soil piles should be 2-3 meters high, and sides with a 45 degree slope.

Phase I

As mentioned above, the majority of earthworks along with construction of access road will take place during Phase I and as a result 70% of total (for both access road and phases I & II) top soil volume will be excavated during Phase I.

So, during Phase I top soil will be have to disposed:

- Partially on a temporary area (only during Phase I) located in the area where cell 4 is going to be constructed. This area will be aprox 1.2 ha and
- Partially on the L areas (as shown on general layout drawings) until the final stages of final cover construction works of Phase II.

Top soil stored on the temporary area will be used for the gradual construction of slopes of Phase I final cover.

Phase II

During earthworks of Phase II top soil will be disposed only on L areas.

Top soil of L areas will be used for the gradual construction of the rest of slopes and plateau of final cover of Phase II.

Table 2: Top soil volume

TOP SOIL VOLUME TABLE	
Phase I (including access road works)	+77,346.00
Phase II	+35,608.00
Total	+112,954.00
Recultivation layer (of final cover) needs	-107,100.00
BALANCE	+5.854

4.2.2 Landfill disposal area (cells)

Cells are designed in such way so as to fulfill certain requirements and needs of Landfill operation and meet legislation requirements. The bottom of the cell (basin) has been configured in the shape of W.

A W shape basin is designed in a way that low altitude points are being constructed every 30 meters. In order to achieve this type of formation, every 15 meters a slope of 3% is being constructed from the low altitude point to the high one and vice versa, so the peaks' altitude is 0.45m higher than the bottoms' one.



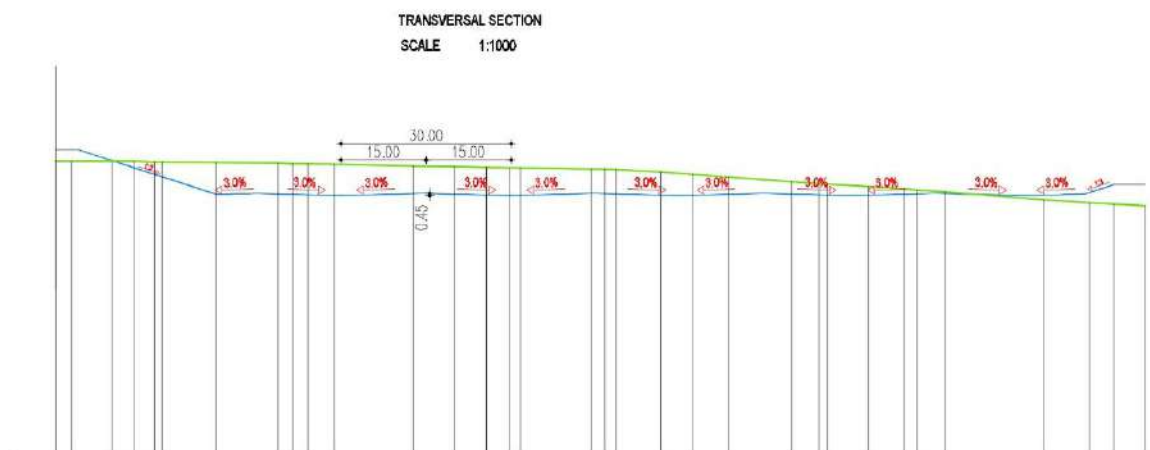


Figure 4-5: Transversal section of a W shaped basin cell

Advantages of a W shape basin are the following:

- Fulfillment of legislation requirement that distance between leachate collection pipes cannot exceed 30m;
- Additional protection for leachate collection pipes;
- Better distribution of leachate for each collection pipe and
- Reduction of earthworks cut/fill quantities.

Phase I – Cells 1 and 2:

The planned area for disposal during Phase I is **4.97** ha. Phase I disposal area is being divided to two distinct cells by an internal berm (dyke). Before constructing cells, an intermediate land area (zone) between the road and the basin, is reserved for the slopes of final cover layers. This zone has a standard width of 8,854m.

During the construction of Phase I disposal area, a dyke will be constructed, dividing the whole phase into 2 cells (Cells 1&2). This dyke will be constructed over the excavated area and the lining layers of the landfill will be installed over the dyke, following its shape. At the west side of Phase I, a berm (dyke) is being constructed in order at first to be used as a temporary part of circumferential road of Phase I and secondly to separate Phase I from Phase II. The dyke's maximum height will be 9m, the minimum width of its crest 7m and the slopes will be of maximum 1(v):3(h)

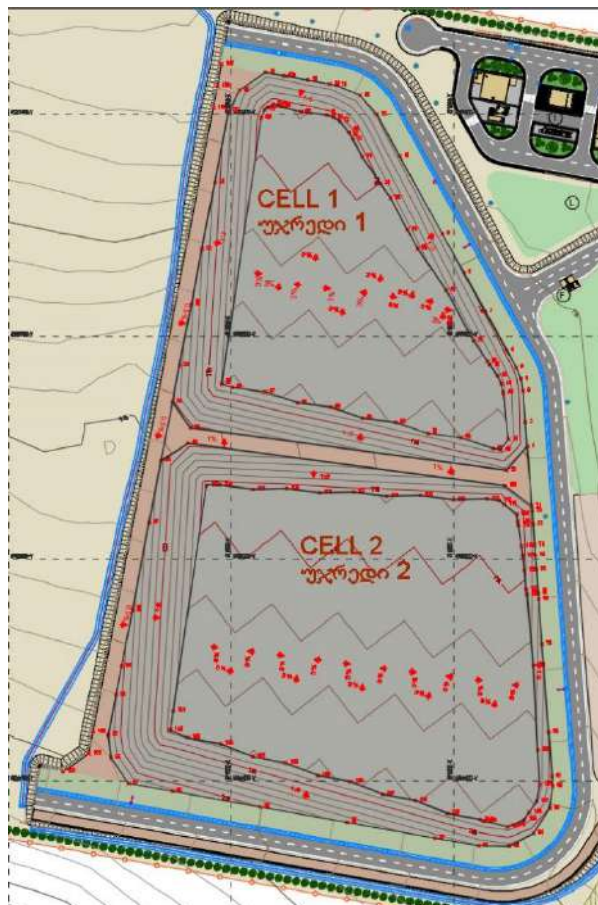


Figure 4-6: Design elements of Phase I (disposal area – Cells 1 & 2)

The division of the phase will assist the landfill operator to separate the leachate (produced from the waste volume) from the pure water coming from the rainfall into the non-active cell (cell 2). In order for the rainwater not to get in touch with the waste, which will result in leachate production, it will be pumped out of the non-active cell using mobile pump. The dyke's maximum height will be 6m, the width of the top 7m and the slopes will be of maximum 1(v):3(h).

Cell 1 is the first “active” (in terms of solid waste disposal) cell of Phase I. That means that operation of landfill (day 1) will start from cell 1 where the first disposal of solid waste will take place.

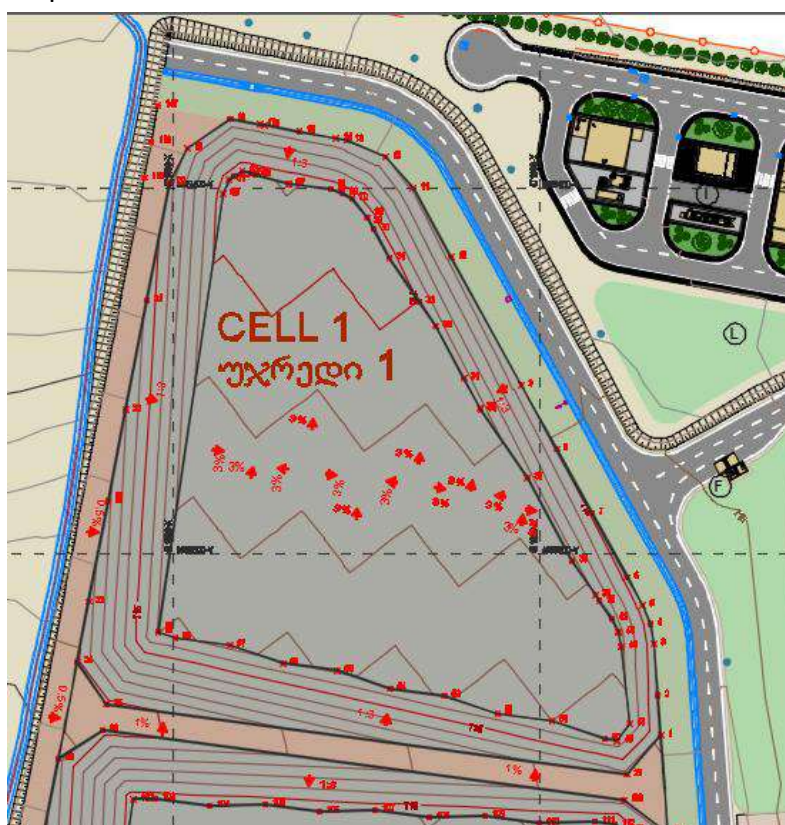


Figure 4-7: Design elements of Phase I (disposal area – Cells 1)

Cell 1 is located on the northeastern part of available total disposal area. The total planned area for Cell 1 is **1.9 ha**, of which 1.16ha the area of the basin and 0.74ha the area of the circumferential slopes. Main principle while designing Cell 1 was the need to avoid - as much as possible - large volume of excavations, since the groundwater table is high. At the same time, it was also critical to avoid large embankment slopes of the circumferential road of Phase I, especially at the south part of phase one where Cell 2 is located. Taking into consideration all the above, the longitudinal grade of the basin was designed with the minimum acceptable value of 3%, while the circumferential slopes will be of maximum 1(v):3(h). Its bottom base will be at elevation ranging from +708.9m to +713.5m.

Cell 2 is the continuation of Cell 1 and the second cell to be activated after cell 1 reaches a certain level of waste relief.

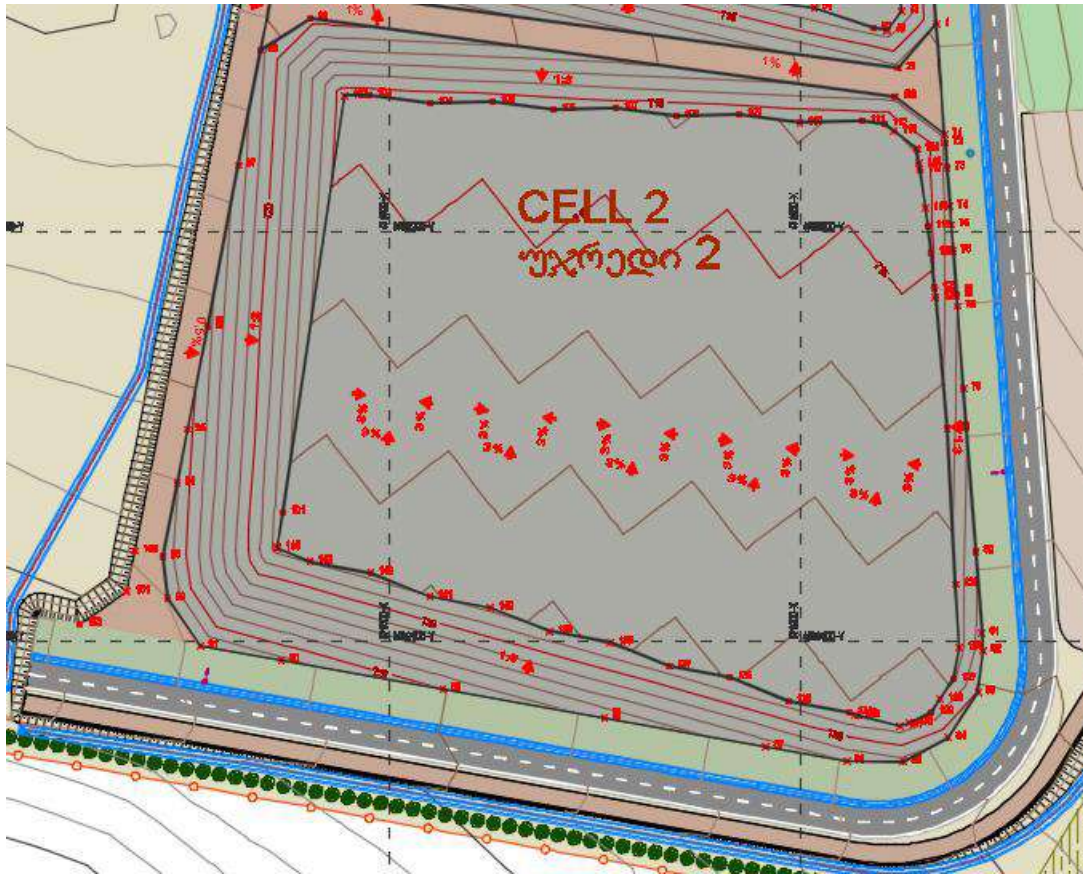


Figure 4-8: Design elements of Phase I (disposal area – Cells 2)

Cell 2 is located on the southeastern part of available total disposal area. The planned area for Cell 2 is **3.07** ha of which 2.02ha the area of the basin, 0.91ha the area of the circumferential slopes and 0.14ha the area of the crest of the internal berm (dyke). For the reasons mentioned above, the longitudinal grade of the basin of Cell 1 and in extension the basin of Cell 2 was designed with the minimum acceptable value of 3%. while the circumferential slopes will be of maximum 1(v):3(h). Its bottom base will be at elevation ranging from +713.8m to +718.6m.

Phase II – Cells 3 and 4

The planned area for disposal during Phase II is **4.65** ha. Phase II disposal area is being divided to two distinct cells by an internal berm (dyke). Before constructing cells, an intermediate land area (zone) between the road and the basin, is reserved for the slopes of final cover layers. This zone has a standard width of 8,854m. During the construction of Phase II disposal area, a dyke will be constructed, dividing the whole phase into 2 cells (Cells 3&4). This dyke will be constructed over the excavated area and the lining layers of the landfill will be installed over the dyke, following its shape.

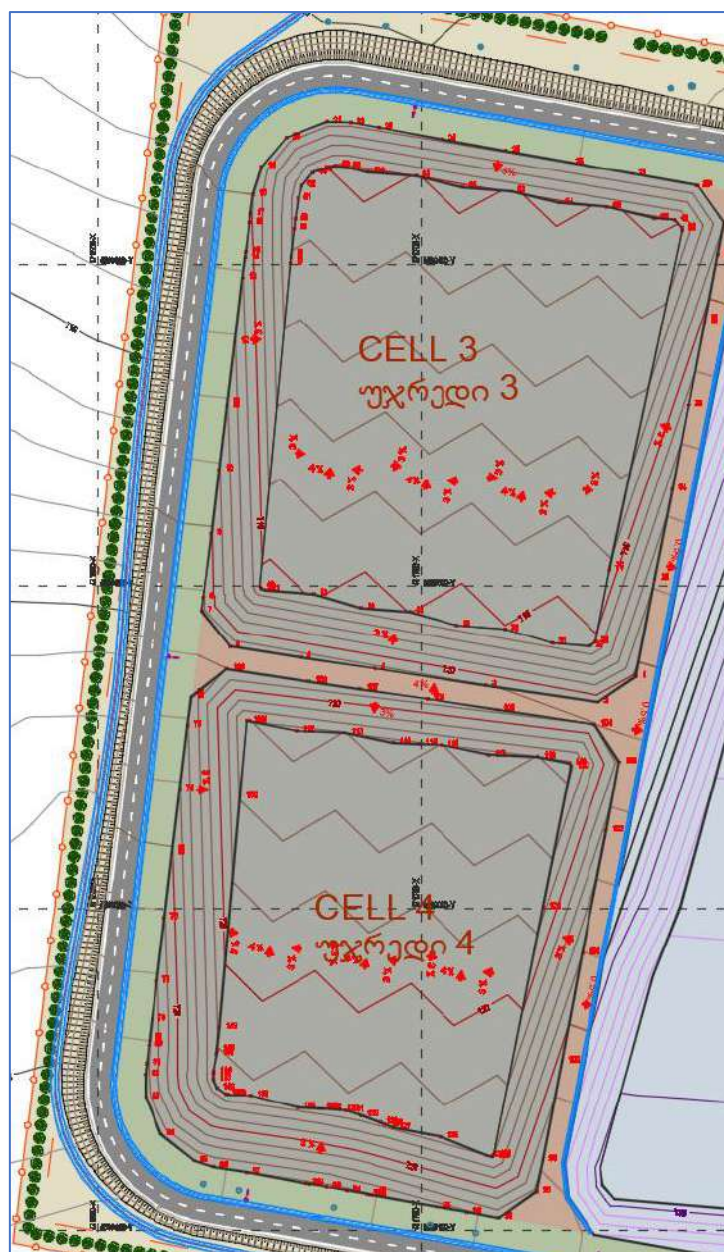


Figure 4-9: Design elements of Phase II (disposal area – Cells 3 & 4)

The division of the phase will assist the landfill operator to separate the leachate (produced from the waste volume) from the pure water coming from the rainfall into the non-active cell (cell 4). In order for the rainwater not to get in touch with the waste, which will result in leachate production, it will be pumped out of the non-active cell using mobile pump. The dyke's maximum height will be 6.5m, the width of the top 7m and the slopes will be of maximum 1(v):3(h).

Cell 3 is the first “active” cell of Phase II and the third in sequence, after Phase I reaches a certain level of waste relief.

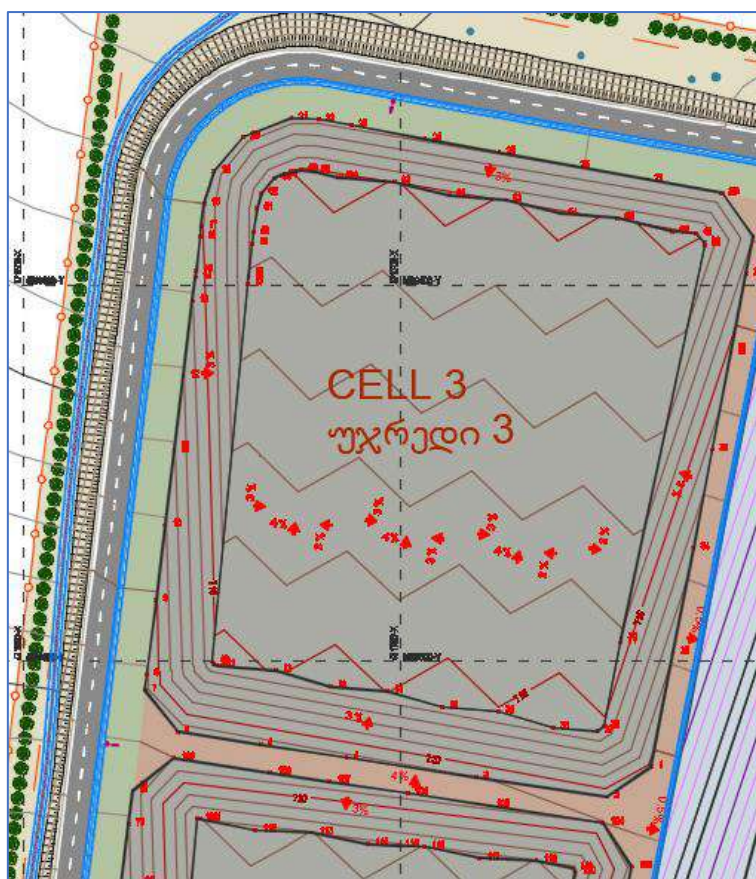


Figure 4-10: Design elements of Phase II (disposal area – Cell 3)

Cell 3 is located on the northwestern part of available total disposal area. The total planned area for Cell 3 is **2.3** ha, of which 1.5ha the area of the basin and 0.80ha the area of the circumferential slopes.

Main principle while designing Cell 3 was the need to avoid - as much as possible - large volume of excavations, since the groundwater table is high. At the same time, it was also critical to avoid large embankment slopes of the circumferential road of Phase II. Taking into consideration all the above, the longitudinal grade of the basin was designed with the value of 4%, while the circumferential slopes will be of maximum 1(v):3(h). Its bottom base will be at elevation ranging from +709.6m to +715.6m.

Cell 4 is the continuation of Cell 3 and the last cell to be activated after cell 3 reaches a certain level of waste relief.



Figure 4-11: Design elements of Phase II (disposal area – Cell 4)

Cell 4 is located on the southwestern part of available total disposal area. The planned area for Cell 4 is **2.35** ha of which 1.12ha the area of the basin, 0.85ha the area of the circumferential slopes and 0.38ha the area of the crest of the internal berm (dyke). For the reasons mentioned above, the longitudinal grade of the basin of Cell 3 and in extension the basin of Cell 4 was designed with the value of 4%. while the circumferential slopes will be of maximum 1(v):3(h). Its bottom base will be at elevation ranging from +716.6m to +722.0m.

4.2.3 Rest of earthworks

Technical specifications and detailed reports about earthworks taking place for the construction of roads, as well for auxiliary infrastructures, planting areas, are described in the corresponding annexes. Especially:

- Earthworks for roads (including roadside constructions) and landfill cells and
- Earthworks for auxiliary infrastructures, planting areas etc.

Phase I:

Roads

- The majority of internal road network will be constructed during Phase I.
- The internal road network consists of eight (9) distinct roads.
- All the necessary design data and technical features are listed in the corresponding section for Internal Roads
- Nevertheless, both road and cell earthworks are considered as one task to be constructed and calculated as one volume for each of fill and cut works.

- Fill slopes are designed 1:2 and cut slopes 1:1
- Total planned area of road surface along with roadside constructions is **1,654ha**

Buildings and planting areas

- As shown on general layout plan, an area of aprox. 1.21 ha is planned for buildings and planting areas.
- The volumes presented for these areas on the soil cut and fill volume table, are not detailed but an estimation depending on the near road levels, before the constructions of buildings.

Phase II:

Roads

- Internal road network of Phase II, includes the construction of 600m of Road 2.
- All the necessary design data and technical features are listed in the corresponding section for Internal Roads
- Nevertheless, both road and cell earthworks are considered as one task to be constructed and calculated as one volume for each of fill and cut works.
- Fill slopes are designed 1:2 and cut slopes 1:1
- Total planned area of road surface along with roadside constructions is **1,04ha**

Buildings and planting areas

- As shown on general layout plan, the majority of buildings and all of the planting areas will be constructed during Phase I.

All areas for additional auxiliary infrastructures for Phase II, are already planned during Phase I.

4.2.4 Earthworks Volume

The following table presents in detail the quantities of earthworks of Phase I and Phase II.

Table 3: Earthworks' quantities

EARTHWORKS - PHASE I		
TASK	CUT(m³)	FILL (m³)
Top soil (not included in balance)	67,34400	
Earthworks	+122,416.00	-140,867.00
BALANCE	-18,451.00 m³	
EARTHWORKS - PHASE II		
TASK	CUT(m³)	FILL (m³)
Top soil (not included in balance)	35,608.00	
Earthworks	+62,479.00	-57,149.00
BALANCE	+5,330.00 m³	

**Estimation before final constructions of buildings and planting areas*

4.2.5 Waste relief formation

Waste disposal is taking place under the following specifications:

- Waste relief side slopes 1:3
- Waste relief longitudinal slope (plateau) is:
 - 2% for temporary plateau of Phase I
 - 5% for final plateau of both Phases I and II

As waste relief rises, every 10m of altitude a berm is being constructed. Berms are used to improve waste relief stability and also to provide access to the majority of waste relief area.

Berms are connected to road 2 (via the intermediate zone). For those berms on a high altitude, access to road 2 is provided via berms of lower altitude by constructing an access road between them.

Berm has minimum width of 3m. Berm's crossfall is 4% directing to the outer limit of the waste relief so that stormwater is heading to the perimetric ditch.

Phase I

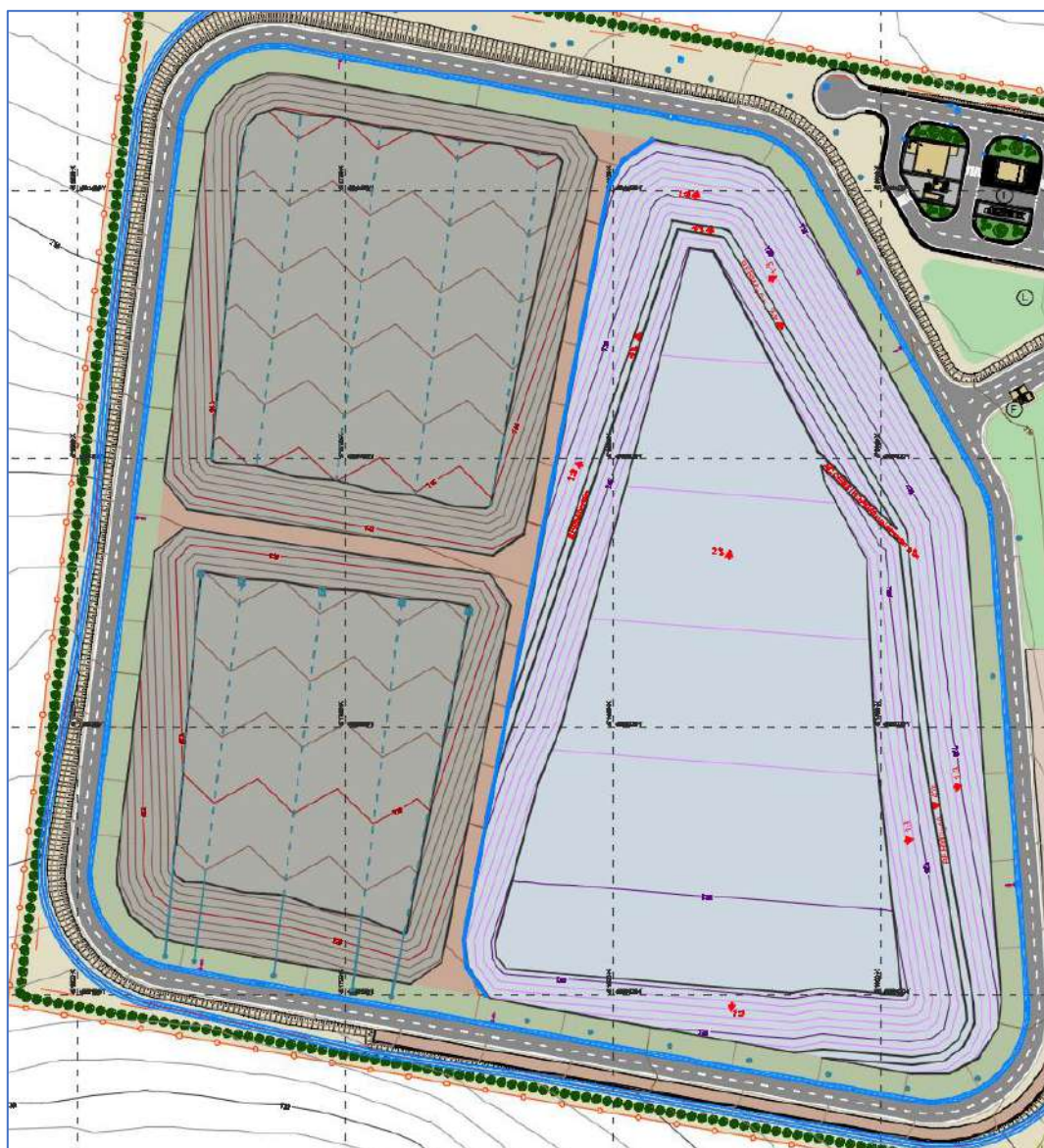


Figure 4-12: Waste relief - Phase I

As mentioned above, waste relief side slopes are 1:3 until they reach the temporary plateau with a longitudinal slope of 2%.

Waste relief during Phase I reaches the level +731.00m.

Phase II

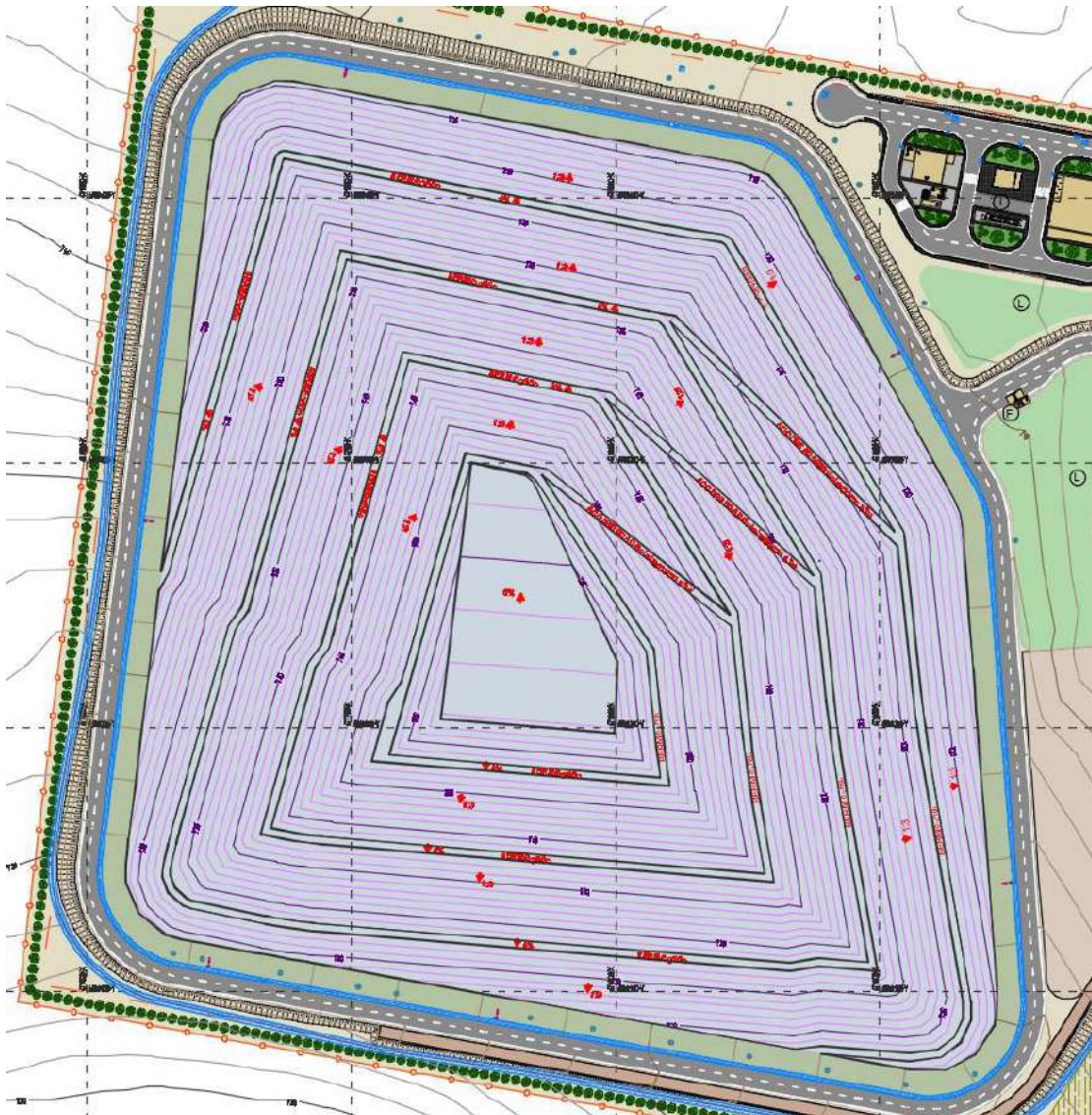


Figure 4-13: Waste relief - Phase I&II

After waste relief in Phase I reaches the level +731.00m. waste disposal is taking place in cell 3, then in cell 4 and when both reach level +731, then waste relief starts rises in both phases.

As waste relief rises, every 10m of altitude a berm is being constructed. Berms are used to improve waste relief stability and also to provide access to the majority of waste relief area.

Berms are connected to road 2 (via the intermediate zone). For those berms on a high altitude, access to road 2 is provided via berms of lower altitude by constructing an access road between them.

Berm has minimum width of 3m. Berm's crossfall is 4% directing to the outer limit of the waste relief so that stormwater is heading to the perimetric ditch.

Waste relief reaches the final plateau that has a longitudinal slope of 5%.

Highest altitude of waste relief is +758.00m

Table 4: Waste relief volume

WASTE RELIEF VOLUME		
TASK	Solid waste (m ³)	Daily cover soil(m ³) (10%)
Phase I	427,000	43,000
Phase I&2	1,582,000	158,000
TOTAL LANDFILL VOLUME	1,740,000 m³	

4.2.6 Slopes and Stability

For the construction of the proposed landfill, two types of slopes will be created namely: i) the slopes at the sides for the landfill base (cells), and ii) the slopes at the sides of the finally closed landfill.

The stability of these slopes in shallow and deep seated circular type failure is analyzed using the computer program SLIDE, developed by Rocscience. This program has the capability to perform slope stability calculations of shallow and deep circular modes of failure, as well as planar (noncircular) modes of failure.

The results of slope stability analyses at the sides of the landfill base, in circular and planar failure modes are summarized in Table 6.2 of Technical Report (TR) 2 (Geotechnical investigation study). The detailed stability calculations are presented in Annex V of the aforementioned Technical Report. Based on the results of stability calculations shown in aforementioned Table 6.2, the sides of the landfill base are stable, under the examined cases and assumptions.

The sides of the top cover are sloping generally at 1v:3h, with 3m wide benches every about 10m in height, and its upper plateau has a slope of 5.0%. For the entire landfill the maximum elevation difference between the perimeter embankment and the upper plateau is about 47m. The results of slope stability analyses at the sides of the top cover system, in circular and planar failure modes are summarized in Table 6.3 of Technical Report (TR) 2 (Geotechnical investigation study). The detailed stability calculations are presented in Annex V of the aforementioned Technical Report. Based on the results of stability calculations shown in Table 6.3, the sides of the sides of the closed landfill are stable, under the examined cases and assumptions.

4.2.7 Intermediate Cells Formation

The layout of the base of the proposed landfill is shown in Drawing DDGT.6.1 of Technical Report (TR) 2 (Geotechnical investigation study), where the locations of the relevant geotechnical design cross sections (Drawings DDGT.6.3 and Drawing DDGT.6.4) are also shown. In total, four (4) cells are formed for deposition of waste.

The sides of the perimeter and interior embankments of the landfill are sloping generally at 1v:3h and its base has a slope of 4.0%.

The sequential phases of development of the entire landfill, the functionality of the various systems in the landfill (leachate collection and treatment, biogas collection and management, surface water management, etc) are described in the TR 2.

Several intermediate embankments will be constructed at the landfill basin that will divide the area in 4 cells. These embankments will be created in order to retain the

new waste deposits and the leachate of landfill, and at the same time to manage on site runoffs. The embankments will consist of structural fill (clean soil).

4.2.8 Landfill Base Sealing System

Based on the geotechnical analysis presented in Section 6 of Technical Report 2 (Geotechnical investigation study), the typical section of the base sealing system of the landfill is presented below, and is consistent with the requirements of technical regulations.

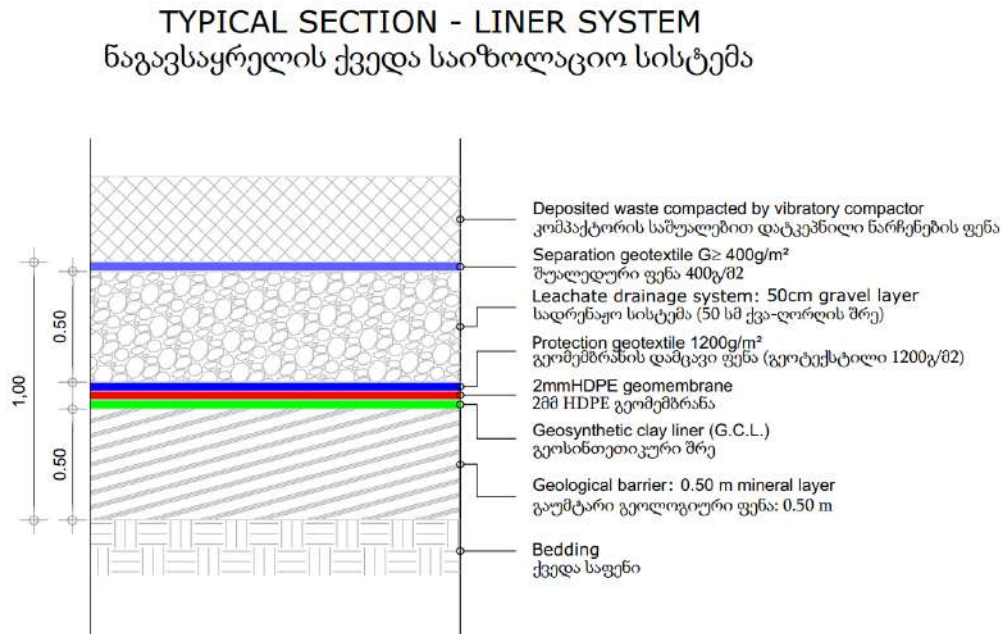


Figure 4-14: Landfill bottom sealing system

The landfill base sealing system will be constructed under QA/QC procedures that will be described in the tender documents, and its details are presented in TR 2 and in geotechnical design gross sections in the relevant Drawing DDGT.6.3 and Drawing DDGT.6.4. of the aforementioned Technical Report.

The base sealing system consists of the following elements from its bottom to the top.

- a) **Geological barrier.** The geological barrier of the base sealing system, will consist of onsite excavated soils that will be produced during development of the landfill, and its minimum thickness will be 0.50m. The geological barrier will be placed on natural onsite soils that will be graded as shown in the drawings, will be continuous at the base and the side slopes of the perimeter and interior embankments, and ultimately will extend to cover entirely the base of the landfill.
- b) **Geosynthetic clay liner (GCL).** The GCL may be a Maccaferri type "MACLINE GCL W 22" or equivalent. After inspection and removal of any stones ($d_{\text{max}} > 3\text{cm}$) from the final surface of the geological barrier that has been proof rolled by a smooth drum compactor, the GCL is placed on the geological barrier. The GCL will be placed continuously at the base and the side slopes of the perimeter and interior embankments and ultimately will extend to cover entirely the base of the landfill. Adjacent panels of GCL will be connected following the instructions of its manufacturer. The ends of the panels will be

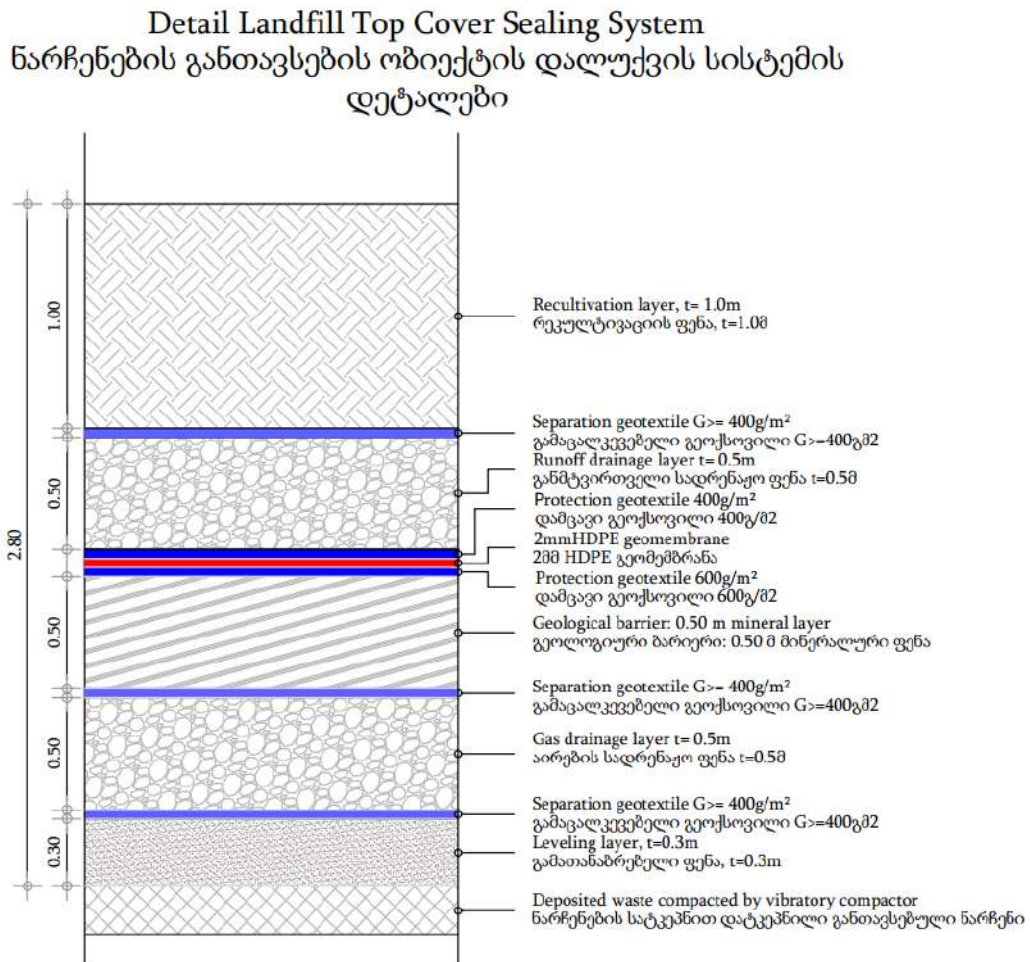
anchored as necessary in anchor trenches at the crest of the embankments, as shown typically in Drawing DDGT.6.2.1 of TR 2.

- c) **HDPE geomembrane liner.** The geomembrane liner will consist of an HDPE geomembrane having thickness 2mm, (Maccaferri type "MACLINE RDH, 2mm" or equivalent) and will be placed on top of the GCL. To increase the frictional resistance to sliding, the HDPE geomembrane will be textured on both sides, at the side slopes of the landfill cells, and smooth geomembrane will be placed at the base of the cells. The geomembrane will be continuous at the base and the side slopes of the perimeter and interior embankments and ultimately will extend to cover entirely the base of the landfill. Adjacent panels of geomembrane will be connected by fully proofed welding following the instructions of its manufacturer. The ends of the panels will be anchored as necessary in anchor trenches at the crest of the embankments as shown typically in the details in Drawing DDGT.6.2.1 of the TR 2.
- d) **Protection geotextile above geomembrane.** The protective geotextile will be a nonwoven, polypropylene needle punched, geotextile (Maccaferri type "MACTEX PN 700.1, 1200gr/m² or equivalent) that serves the purpose of protecting the underlying geomembrane from the "sharp" particles of the drainage layer. The geotextile is placed on the geomembrane. The geotextile will be placed continuously at the base and the side slopes of the perimeter and interior embankments and ultimately will extend to cover entirely the base of the landfill. Adjacent panels of the geotextile will be connected by overlapping, following the instructions of its manufacturer. The ends of the panels will be anchored as necessary in anchor trenches at the crest of the embankments as shown typically in the details in Drawing DDGT.6.2.1. of the TR 2.
- e) **Leachate drainage system.** The leachate drainage system serves the purpose of collecting effectively all leachate generated by the waste. It will be placed on top of the aforementioned protection geotextile, and will consist of a drainage layer and a perforated pipe network, etc., as described in the detail design report of this study. The drainage layer will be 0.50m thick and will consist of gravel (gradation 16/32), with CaCO₃ content not exceeding 20% by weight, and may be supplied by quarries that operate within the region. The drainage layer will be placed continuously at the base and the side slopes of the perimeter and interior embankments and will ultimately extend to cover entirely the base of the landfill.
- f) **Separation geotextile.** The separation geotextile will be a nonwoven, polypropylene needle punched, geotextile that serves the purpose of avoiding clogging of the underlying leachate drainage system by the file particle of the waste. The geotextile is placed on the leachate drainage layer. The geotextile will be placed continuously at the base and the side slopes of the perimeter and interior embankments and will ultimately extend to cover entirely the base of the landfill. Adjacent panels of the geotextile will be connected by overlapping following the instructions of its manufacturer. The ends of the panels will be anchored as necessary in anchor trenches at the crest of the embankments as shown typically in the details in Drawing DDGT.6.2.1 of the TR 2.

4.2.9 Landfill Top Cover Sealing System

The sides of the top cover are sloping generally at 1v:3h, with 3m wide benches every about 10m in height, and its upper plateau has a slope of 5.0%. For the entire landfill the maximum elevation difference between the perimeter embankment and the upper plateau is about 47m.

The typical section of the capping sealing system of the landfill is presented below, and is consistent with the requirements of technical regulations.



The top cover sealing system of the landfill will be constructed under QA/QC procedures that will be described in the tender documents, and its details are presented in section 5.2 and in geotechnical design gross sections in Drawing DDGT. 6.5 and Drawing DDGT.6.6.

The top cover system consists of the following elements from its bottom to the top.

- Leveling soil layer.** This soil layer is used to form the final grading of the completed landfill according to the grades shown in Drawing DDGT. 6.2 of TR 2, and will be about 0.30m thick.
- Separation geotextile below gas drainage system.** The separation geotextile will be a nonwoven, polypropylene needle punched, geotextile that serves the purpose of avoiding clogging of the overlying gas drainage system by the fines of the leveling soil layer. The geotextile is placed continuously on the leveling layer. Adjacent panels of the geotextile will be connected by overlapping

following the instructions of its manufacturer. The ends of the panels will be anchored in anchor trenches as necessary at the crest of the perimeter embankments, as shown typically in the details Drawing DDGT.6.2.1 of TR 2. In the upper plateau and the benches of the final closure sealing system, depending on geosynthetic installation conditions (length, etc), shallow trenches (depth ~0.30m) may be used to anchor the geosynthetic layer.

- c) **Gas drainage system.** The landfill gas drainage system serves the purpose of collecting effectively all gas generated by the deposited waste. It will be placed on top of the aforementioned separation geotextile, and will consist of a drainage layer and a perforated pipe network e.tc., as described in the detail design report of this study. The drainage layer will be 0,50m thick and will consist of gravel (gradation 16/32), with CaCO₃ content not exceeding 20% by weight, and may be supplied by quarries that operate within the region. The drainage layer will be placed continuously on the top of the underlain separation geotextile.
- d) **Separation geotextile above gas drainage system.** The separation geotextile above the gas drainage system is the same as the separation geotextile below the gas drainage system described in paragraph (b) above, and will be placed in similar manner.
- e) **Geological barrier.** The geological barrier of the top cover sealing system may consist of onsite excavated soils that will be produced during development of the landfill, and its minimum thickness will be 0,50m. The geological barrier will be placed on the separating geotextile, will be continuous at the upper plateau and the side slopes of the top cover system.
- f) **Protection geotextile bellow geomembrane.** The protection geotextile will be a nonwoven, polypropylene needle punched, geotextile that serves the purpose of protecting the overlying geomembrane. After inspection and removal of any stones (d_{max}>3cm) from the final surface of the geological barrier, that previously has been proof rolled by a smooth drum compactor, the geotextile is placed on the geological barrier. The geotextile will be placed continuously at the upper plateau and the side slopes of the top cover system. Adjacent panels of the geotextile will be connected by overlapping following the instructions of its manufacturer. The ends of the panels will be anchored in anchor trenches as necessary at the crest of the perimeter embankments, as shown typically in the details Drawing DDGT.6.2.1 of TR 2. In the upper plateau and the benches of the final closure sealing system, depending on geosynthetic installation conditions (length, etc), shallow trenches (depth ~0.30m) may be used to anchor the geosynthetic layer.
- g) **HDPE geomembrane liner.** The geomembrane liner will consist of an HDPE geomembrane having thickness 2mm, and will be placed on top of the protection geotextile. To increase the frictional resistance to sliding, the HDPE geomembrane will be textured on both sides, at the side slopes of the top cover system, and smooth geomembrane will be placed at the upper plateau. The geomembrane will be continuous at the upper plateau and side slopes of the top cover system. Adjacent panels of geomembrane will be connected by fully proofed welding, following the instructions of its manufacturer. The ends of the panels will be anchored in anchor trenches as necessary at the crest of

the perimeter embankments, as shown typically in the details Drawing DDGT.6.2.1 of TR 2. In the upper plateau and the benches of the final closure sealing system, depending on geosynthetic installation conditions (length, etc), shallow trenches (depth ~0.30m) may be used to anchor the geosynthetic layer.

- h) **Protection geotextile above geomembrane.** The protective geotextile will be a nonwoven, polypropylene needle punched, geotextile that serves the purpose of protecting the underlying geomembrane from the “sharp” particles of the drainage layer. The geotextile is placed on the geomembrane. The geotextile will be placed continuously at the upper plateau and the side slopes of the top cover system. Adjacent panels of geotextile will be connected by overlapping following the instructions of its manufacturer. The ends of the panels will be anchored in anchor trenches as necessary at the crest of the perimeter embankments, as shown typically in the details Drawing DDGT.6.2.1 of TR 2. In the upper plateau and the benches of the final closure sealing system, depending on geosynthetic installation conditions (length, etc), shallow trenches (depth ~0.30m) may be used to anchor the geosynthetic layer.
- i) **Runoff drainage system.** The runoff drainage/collection system serves the purpose of collecting effectively all precipitation water, that may percolate through the recultivation layer and otherwise could accumulate on top of the geomembrane liner, jeopardizing thus the stability of the recultivation layer. It will be placed on top of the aforementioned protection geotextile, and will consist of a drainage layer and a perforated pipe network, etc., as described in the detail design report of this study. The drainage layer will be 0,50m thick and will consist of gravel (gradation 16/32), with no CaCO₃ content constrains. The drainage layer will be placed continuously on the top of the protection geotextile. The perforated pipe network will be installed within the runoff drainage layer. The runoff drainage/collection system is described in the detail design report of this study.
- j) **Separation geotextile above runoff drainage system.** The separation geotextile above the runoff drainage system is the same, and will be placed in similar manner as the separation geotextile below the gas drainage system.
- k) **Recultivation layer.** The recultivation layer will have thickness $t=1\text{m}$ and will be placed on top of the separation geotextile. The quality of recultivation layer will be such that it can maintain local vegetative species. The recultivation layer material may be obtained from the excavation of the surficial humus layer (top soil).

A top soil at an average thickness of 0,61m (min=0,20m, max=1,2m).

5. AUXILIARY INFRASTRUCTURE

The facilities that will be constructed for the landfill, reception area and connected activities in Phase I of the Project are mentioned before. The facilities are described in more detail hereafter.

5.1 ACCESS ROAD

Access Road Starts At Marneuli – Tetritskaro – Tsalka Internal Road. The Road was designed in such way, so as to ensure access to Landfill Area safely and serve. Minimum width of road is 7m. Speed limit for all kinds of vehicles Up to 100 meters before entrance is set to 60 km/hr, near Landfill Entrance speed limit set to 20 km/hr.

EARTHWORKS -ACCESS ROAD		
TASK	CUT(m ³)	FILL (m ³)
Top soil (not included in balance)	9,921.00	
Earthworks	+10,690.00	-18,390.00
BALANCE	-7,700.00 m³	

- Access Road - Horizontal Alignment
 - Total length of Road is 1804m
 - Minimum width is 7m.
 - Minimum Radius of horizontal curve is 30m.
- Access Road - Profile
 - Maximum longitudinal slope (gradient) of road is 7.96%
 - Minimum longitudinal slope is 0.57%.
 - Minimum vertical curve radius is 1000m and maximum is 3000m.
- Access Road - typical cross section - pavement
 - The minimum width for Access Road pavement is 7m.
 - Crossfall is set to 2.5% for right side and 2.5% for left side. on Curves used superelevation with 4% slope and widening.
 - Shoulders constructed with width 1.5m Left and 1m Right.
 - Access Road will be constructed based on typical road pavement of thickness d=0.62 m.

Typical pavement thickness consists of:

- 5 cm of asphalt concrete ac-16 surface
- 7 cm of bituminized crushed stone ac-32 base

- 20 cm unbound granulated stone material 0-40mm
- 30 cm sand-gravel material sub base cbr >80%
- Utility Crossings

Designed Access Road is Crossing Some utilities listed below:

- Ch 0+23 d-150mm - Gas Pipe,
- Ch 6+88 – ch 6+92 2Xd-1.2 m - Water Pipe,
- ch 15+32 – ch 15+36 2Xd-1.2m - Water Pipe.

To Cross Them Safely and Not to Damage Them During Construction in Design Provided Casing pipes.

- Drainage
 - Designed Access Road is Crossing Ravines,
 - for Water Crossing Designed Reinforced Concrete Culverts
 - ch 3+20 d-1.5m L=11.0 m,
 - ch 6+20 d-1.5m L=13m,
 - ch 17+20 d-1.5m L=20m.

5.2 JUNCTION ROADS - INTERCHANGE

Designed access road uses part of existing local road, so in order to ensure access to local roads and facilities served by the existing road, two junctions are being constructed.

The first junction (Junction Road#1) is located at landfill access road ch 16+70, designed to provide access to the existing facility.

The second junction starts at landfill access road ch 17+91.56, designed to provide access to the local road network. Minimum width of road is 5m.

Speed limit for all kinds of vehicles is set to 20km/hr.

5.2.1 JUNCTION ROAD #1

The first junction (Junction Road#1) is located at landfill access road ch 16+70, designed to provide access to the entrance gate of the existing facility. Minimum width of road is 5m. Speed limit for all kinds of vehicles is set to 20km/hr.



Figure 5-1: Junction Road

- Junction Road #1 - Horizontal Alignment
 - Total length of Junction Road#1 is 83m.
 - Minimum width is 5m.
 - Minimum Radius of horizontal curve is 50m.
- Junction Road #1 - Profile
 - Maximum longitudinal slope (gradient) of road is 4.34%
 - Minimum longitudinal slope is 0.59%.
 - Minimum vertical curve radius is 450m and maximum is 600m.
- Junction Road #1 - typical cross section - pavement
 - The minimum width for Access Road pavement is 5m.
 - Crossfall is set to 2.5% for right side and 2.5% for left side.
 - shoulders constructed with 1m width.

Access Road will be constructed based on typical road pavement of thickness $d=0.62$ m.

- Typical pavement thickness consists of:
 - 5 cm of asphalt concrete ac-16 surface
 - 7 cm of bituminised crushed stone ac-32 base
 - 20 cm unbound granulated stone material 0-40mm
 - 30 cm sand-gravel material sub base cbr >80%
- Junction Road #1 Drainage
 - Designed Junction Road is Crossing Ditches from Landfill,
 - a Reinforced Concrete Culvert is being constructed located at ch 0+10 (d-1.5m L=13m).

5.2.2 JUNCTION ROAD #2

The second junction (Junction Road#2) starts at landfill access road ch 17+91.56, designed to provide access to the local road network. The local road network is used by locals to reach their villages and farmers that own land plots near Landfill facility. Minimum width of Junction Road#2 is 5m. Speed limit for all kinds of vehicles is set to 20km/hr.

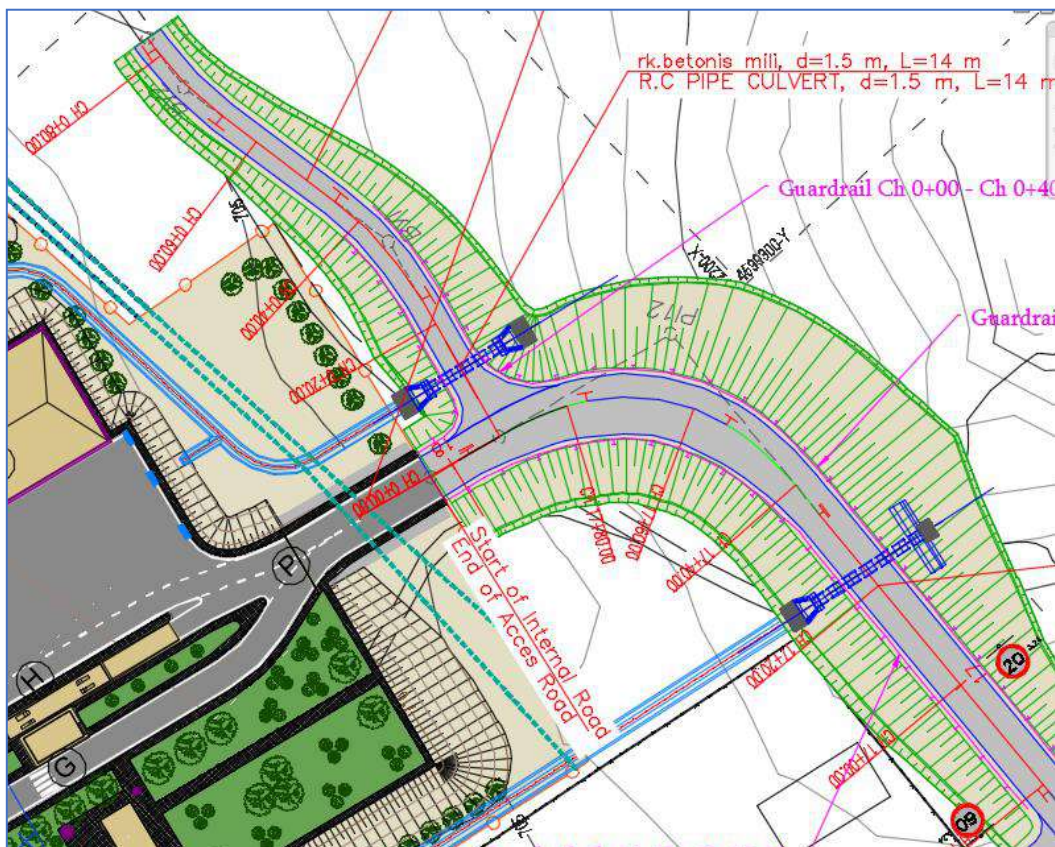


Figure 5-2: Junction Road #2

- Junction Road #2 - Horizontal Alignment
 - Total length of Junction Road#2 is 12.5 m

- Minimum width is 5m.
 - Minimum Radius of horizontal curve is - m.
- Junction Road #2 - Profile
 - Maximum longitudinal slope (gradient) of road is 19.7%
 - Minimum longitudinal slope is 19.7 %.
 - Minimum vertical curve radius is 60 m and maximum is 60 m.
- Junction Road #2 - typical cross section - pavement
 - The minimum width for Access Road pavement is 5m.
 - Crossfall is set to 2.5% for right side and 2.5% for left side.
 - shoulders constructed with 1m width.

Access Road will be constructed based on typical road pavement of thickness d=0.62 m.

- Typical pavement thickness consists of:
 - 5 cm of asphalt concrete ac-16 surface
 - 7 cm of bituminised crushed stone ac-32 base
 - 20 cm unbound granulated stone material 0-40mm
 - 30 cm sand-gravel material sub base cbr >80%
- Drainage
 - Designed Access Road is Crossing Ravines,
 - for Water Crossing Designed Reinforced Concrete Culverts ch 0+10 d-1.5m L=14.0 m.

5.2.3 INTERCHANGE #3

The main Interchange is located On Marneuli – Tetrtskaro – Tsalka Internal Road.

The interchange is being constructed in order for Access Road to connect existing main road network with the Landfill facility. The Access Road will be used by heavy trucks.

So according to the legislation acceleration and deceleration lanes must be constructed on the existing road. In order create a safe interchange, additional lanes must be constructed, and therefore widenings must be designed for the existing road and appropriate markings on the road surface. All the required geometrical design elements, coordinates etc are being presented in respective drawings.

5.5 WEIGHBRIDGE

One "Build-in" weighbridge is proposed installed in front of control office.

Three lanes are proposed at the entrance area. The weighbridge will be installed in the middle lane.

Specification of weighbridge: 50 tonnes capacity and with a length/width of 18 x 3 m. The weighbridge will be with automatic registration system including card reader at weighbridge, suitable computer with software package, printer (of bills) etc. The registration system will include software to generate weekly, monthly and annual reports including statistics etc.

Weighbridge is presented with "H" in the General Layout (e.g. Drawing DDLF.02.1.). Its structure is planned to be a rectangular shape, with measurements 18.64x3.64 and the capacity of 50 tons.

The weighbridge represents the mon. r/c pit, foundation tile - 40 cm thick and walls - 30 cm thick. The bottom of the building has a two-way slope to the middle, where a special drainage pit is arranged. At the bottom, 4 units of special base will be arranged, where a mon. r/c platform will be laid. The technological gap between the platform and the monolithic outer frame should remain in the light - 2 cm on the perimeter.

5.6 CONTROL OFFICE FOR THE WEIGHBRIDGE – GUARD HOUSE

The site entrance can be attended from the control office/guard house, which is presented with symbol G in the General Layout (e.g. Drawing DDLF.02.1.). The structure will be a rectangular building 8.0m x 4.0m. There is a 0.15 m height stair step in the main entrance. Floor is elevated by 0.45 m. Monolithic reinforced concrete blind side on the outside perimeter of the building with the width of 1.00 m will be arranged.

The main entrance has a metal door, which will be painted with double layer oil paint. The windows on the outer perimeter are arranged in white metal-plastic with double glazing, with inner shelves and outer waterproof tin sheets. The wall filling blocks will be sanded with a solution of cement, then spackle-sanded and painted with moisture-resistant paint. The wall thickness is 0.3 m.

Suspended Armstrong ceilings will be installed in the building. Interior and exterior wall colors as well as other decorative elements and furniture details will be agreed with the Company.

The foundation of the building with a constructive solution is mon. r/c type, up to the floor level mon. r/c walls will be arranged. For the roof mon. r/c beam and roofing tile will be used.

Room	Facilities and staff for landfill operation	m ²
Control office for weighbridge – Guard House	2 (1 guard and 1 for weighbridge operation)	26.82
1 WC		1.12

5.7 HANGAR FOR STORAGE OF RECYCLABLE MATERIALS – SAMPLING AREA

North of the weighbridge area, lies a large asphalt paved manoeuvring area (30mx20m) in order to serve the procedures for sampling area and accessing the hangar for temporary storage of recyclable and other waste streams. This area is accessed by the lane that bypasses the weighbridge.

One hangar will be constructed which will be used for temporary storage of recyclables and the future housing of waste treatment equipment (shredder, compactor etc).

The building will be an on-site construction building and the load bearing structure preferably by composite concrete and iron (rust and fire resistant).

Sampling area will be concrete paved with slopes toward the stormwater collection manholes constructed in the middle area. The leachate gathered by this area will be transferred to the leachate collection system.

5.8 ADMINISTRATION, LABORATORY, STAFF FACILITIES INCLUDING SANITARY FACILITIES

It will be constructed one staff building at the landfill site which will include all required rooms including control room and laboratory.

The Administration Building, is presented with symbol A in the General Layout (e.g. Drawing DDLF.02.1.) and is planned to be a complex rectangular shape structure (34.0 m x 21.05 m) with total area of 393.71 m². In the main entrance lies a 0.15 m height stair step and floor level is elevated by 0.45 m from the ground level. Next to the stairs lies a ramp adapted for disabled people. There is monolithic reinforced concrete (mon. r/c) blind side on the outside perimeter of the building with 1.00 m width.

The building is designed with the corridoral system. On the lower side of the left corner of the building bathrooms and Technical Laboratory are situated. On the lower side of the right corner administration and archive rooms are located. On the top side of the building from right to left are located the control room, kitchen, department of finance, secretary room, site manager's room, and conference room. Women's and men's isolated changing rooms and bathrooms with showers, together with the recreational room are situated on the right side of the building.

Main and additional entrances are arranged with sash (glass) doors. Main entrance is covered with an eave console. A decorative wall will also be arranged.

Interior office doors are designed with MDF closed texture, (color will be agreed with the client), and in washrooms white metal-plastic doors will be used set. Windows on the outer perimeter will be made of white metal-plastic with double glazing, with inner shelves and outer waterproof tin sheets. The floor of the corridor and rooms will be covered with sand-cement mortar and laminated parquet, and the bathrooms

will have ceramic tiles. The wall filling blocks will be sanded with a solution of cement, then spackle-sanded and painted with moisture-resistant paint.

Suspended Armstrong ceilings are installed in the building, and moisture-resistant plastic tiles are installed in the bathrooms. Interior and exterior wall colors as well as other decorative elements and furniture details will be agreed with the Company.

The foundation of the building with a constructive solution is mon. r/c type, up to the floor level mon. r/c walls are arranged. Building framework is made of monolithic reinforced concrete with columns and beams. Mon. r/c tile is arranged on the flat roofing, on which hydro isolated layer is set. Stainless steel gutters and intake pipes are arranged on the perimeter of the roof.

Table 5: Administration building's rooms and relevant staff

Room	Facilities and staff for landfill operation	Facilities and staff for waste transfer activities
<i>Number of staff</i>	Regional Manager: 1 Financial Administrator: 1 Secretary: 1 Foreman: 1 Weighbridge Operator: 2 Vehicle operators: 3 Guard at gate: 1 Laboratory: 1 Unskilled workers: 3	Transfer Manager: 1 Foreman: 1 Drivers: 2
Administration office	For 2 persons (12.83 m ²)	-
Site manager office	For 1 person (17.82 m ²)	
Secretary of site manager	For 1 person (13.63 m ²)	
Department of finance	For 2 persons (13.73 m ²)	
"Kitchen/Recreational Room/Cafe" (Room with table, chairs, small facility for storage and preparation food/coffee)	For 12 persons (32.83 m ²)	+4 persons
Changing room and bathing facilities (for men)	For 12 persons (26.45 m ²)	+2 persons
Changing room and bathing facilities (for women)	For 6 persons (22.92 m ²)	(Included for landfill staff)

Room	Facilities and staff for landfill operation	Facilities and staff for waste transfer activities
Toilet facility for trucks drivers and visitors etc.	For 1 person (2.88 m ²)	(Included for landfill staff)
Toilet facility for staff	For 2 persons (2.42 m ² & 3.84 m ²)	
Laboratory	For 1 person (27.59 m ²)	-
Entrance room, storage room, corridors etc.	As required	As required
Conference room	For 12 persons (27.69 m ²)	As required
Control room	As required (22.33 m ²)	
Archive	As required (6.34 m ²)	

No facilities for waste collection staff (municipality responsibility) or for administration staff from SWMCG (except for specific landfill staff and waste transfer staff mentioned above) will be included in administration building. The administration building can later be extended towards north or east if required.

5.9 GARAGE AND WORKSHOP FOR MACHINERY AND STORAGE ROOMS

The garage/workshop (element B of the General Layout) that will be constructed will include all necessary equipment for the maintenance of landfill operation equipment including storage room and workshop facilities.

According to the plan the building is of rectangular shape, with measurements of 27.80m x 11.00m. On the front facade there are 3 units of two-winged metal doors, with the size of 5.00m x 5.00m. There is one additional unit of one-winged door and another two-winged door, which will be painted with two layers of oil paint. The floor level is 0.10 m above the ground level, a 1.00 m wide monolithic reinforced concrete blind side is arranged on the outer perimeter of the building.

In the left part of the building restrooms, warehouses and technical rooms are located, while a garage for vehicles is situated in the right part. The windows on the outer perimeter are arranged in white metal-plastic with double glazing, with inner shelves and outer waterproof tin sheets. The wall filling blocks are sanded with a solution of cement, then spackle-sanded and painted with moisture-resistant paint.

Interior and exterior wall colors as well as other decorative elements and furniture details will be agreed with the client.

The foundation of the building is 30 cm thick mon. r/c foundation walls and floor tile. Mon. r/c frame with columns and beams will be constructed, on which a roof tile will

be attached on two different heights - +4.20 and +5.20. For the roof a 80cm high parapet and stainless steel culverts will be used.

In connection to the garage a fuel tank and pumping facility (element "J" at the General Layout) will be constructed for landfill machinery. It is recommended to install an outdoor semi-permanent tank system with a metallic or concrete leakage safety basin as shown in the relevant drawing. The pump will have a manual pump system to be used during power failure.

An outdoor 10 m³ tank on a steel frame located in a confined metallic or concrete structure with required spill capacity (1 m³) or with double-walled tank and an electrical pump device with fuel meter will be installed. The tank and pump will be equipped with an antifreeze system (tracing).

Outside the garage an area for parking of machines, waste transfer collection trucks, containers is established.

5.10 WHEEL WASH FACILITY

A wheel wash facility, including disinfection facilities, will be established on the exit lane while exiting the disposal area in order to secure that trucks stay clear of possible waste and sludge residues. Trucks required for wheel cleaning have to pass the wheel wash facility prior exit from the site and prior the weighbridge if reweighing is required.

5.11 WATER (DRINKING/RAW WATER), SEWAGE WATER AND ELECTRICITY, COMMUNICATION

The Administration building (A), the Garage building (B), the Entrance guard building (G), and the Sludge building, the Reverse Osmosis Unit and the pH Adjustment Unit of Leachate Treatment Plant, will be supplied with potable water. Also an outdoor water tap will be placed in the Area of Gas Collection and Flaring.

The facilities' potable water needs will be met by the construction of a concrete tank. The capacity of the tank will be about 12.5 m³. A pump station for the supply of potable water will be placed next to the tank. Water supply of the tank will be by tank trunk.

The plant will work in 2 shifts with 17 persons as staff and about 8 visitors per shift. Taking into account that all the above mentioned 50 persons/day will consume 70 lt/d potable water, the daily demand is estimated to 3.50 m³/d. Taking into account the simultaneous use of water outlets for such kind of enterprises a peak hourly flow is estimated to 3.6 m³/h. Thus the pump station will consists of 2 pumps (1+1 backup) with capacity Q=3.6 m³/h and Hm=50 m.

The potable water network will be constructed of HDPE PE100, PN16 atm, pipes suitable for water (blue color), that will be connected at the entry point of the internal water installations of the buildings.

The main pipeline from pump station up to Administration building pipes will be DN50 and will continue to Entrance guard building with DN25 pipe. The connections from main pipeline to Administration building and the Garage will be with DN25 pipe as well.

The pipeline from pump station to Leachate Treatment Plant and the connections to the buildings of the Leachate Treatment Plant as well to the outdoor tap will be from DN25 pipe.

The pipelines will be placed in a 1.0 m deep trench.

For irrigation purposes and other industrial use, the treated leachate as well as the Retention Pond can be used.

The **sewage** comes from the Garage building (B), the Administration building (A) and the Entrance guard building (G).

The plant will work in 2 shifts with 17 persons as staff and about 8 visitors per shift. Taking into account that all the above mentioned 50 persons/day will use the hygiene and kitchen facilities and produce 50 lt/d waste water, the daily inflow is estimated to 2.50 m³/d. Taking into account the simultaneous use of use of toilet and shower facilities a peak hourly flow is estimated to 4.0 m³/h.

The construction of a sewage network is foreseen. The sewage network will lead the sewage to a precast pump station (Figure 5-4). From the pump station, the sewage will be pumped to Leachate Treatment Plant through a HDPE – PE100 – DN40 – PN16atm pipe, 255 m in length. In pump station will be placed two (1+1backup) submerged pumps with capacity Q=4 m³/h and Hm=45 m.

The sewage network will be constructed of u-PVC SDR41 pipes, DN125. Prefabricated inspection manholes, from PEMD, DN/OD 1000/1200 (Figure 5-2) will be placed at the change of direction points. The slope of the pipes is predicted to be 1.5%. The pipes will be placed in trench 0.50 m width (Figure 5-3).



Figure 5-4: Pump station

Figure 5-5: Manhole

Figure 5-6: Trench

There is an existing electricity grid in the area but it is assumed that connection to a transformer will be in the nearest settlement approximately 5.0 km towards southwest or the existing substation in the adjacent plot (its status cannot be assessed at this phase of the study). An alternative as an initial facility or for emergency a diesel generator could be established and this option is not included in the present study.

Phone and Internet communication will be established by a wireless (mobile) communication.

5.12 FIRE PROTECTION SYSTEM

In area of Kvemo Kartli landfill will be installed one complete fire protection system as shown on the drawings of Technical Report TR-06 (Electro-mechanical Works), including the following:

- Fire protection booster pumps set;
- Sufficiently large water reservoir;
- Piping system including fire hose cabinets and
- Portable fire extinguishing equipment.

The system shall be completed with all piping hose racks, hose cabinets, Siamese fittings, valves, fittings, fire pump, jockey pump, controls, and other required appurtenances, connected as shown.

Unless otherwise indicated, the installations shall conform to the latest edition of the relevant standards and codes.

- International Codes and
- National Fire Protection Regulations (NFPA).

The firefighting water needs, are covered by the tank (retention pond) of treated leachates, with total capacity of more than 800 cubic meters (m3).

The Booster Pumps set will draw water from the treated water tank and through a network of pipes will discharge water to the fire hoses cabinets network.

A connection pipe PE DN125mm to the manifold, which results in two 65 mm diameter orifices offsite, is required in order to supply the system from the fire trucks in case of emergency.

It has to be mentioned that stored soil (not top-soil) will be used also for firefighting purposes.

5.13 ADDITIONAL AUXILIARY SYSTEMS

Additional auxiliary systems will be established in order to facilitate the operation of the installation and protecting the environment. Indicative:

LANDFILL DESIGN

- Bird deterrent;
- Weather station;
- Fire alarm;
- Security camera and server;
- Portable radiation detection equipment;
- Chemical lab equipment, etc.

6. INTERNAL ROAD NETWORK

6.1 INTRODUCTION

Internal road network consists of nine (9) distinct roads. The network was designed in such way, so as to ensure access to all areas of the facility safely and serve all of auxiliary infrastructure operation. Minimum width of all roads is 4.5 m and maximum is 7m.

Speed limit for all kinds of vehicles is set to 20km/hr.





Figure 6-1: Internal Road network

6.2 ROAD 1

Road 1 constitutes the main road of the facility for both phases I and II. It serves on the one hand the entrance area operation, and on the other hand ensures the access to the perimeter road (road 2) of phases I and II, but also to the rest of the auxiliary infrastructure by the central intersection with roads 3 and 5.

At the entrance area Road 1 has 3 lanes, two for each direction and one for accessing the weighbridge area.

At station 0+133.341 Road 1 reaches the main intersection of the facility. While reaching Road 2 an extra lane is being constructed in order to serve trucks using the wheel wash plant area .



Figure 6-2: Road 1

Road 1 - Horizontal Alignment

- The starting point of Road 1 is at the entrance of the facility (end of access road) and the end of it, the intersection with road 2.
- Total length of Road 1 is 228.199m
- Minimum width is 7m.
- Radius of horizontal curve is 20m.

Road 1 - Profile

- Maximum longitudinal slope (gradient) of road is 6.15%
- Minimum longitudinal slope is 2.49%.
- Minimum vertical curve radius is 450m and maximum is 500m.

Road 1 - typical cross section - pavement

- The minimum width for Road 1 pavement is 7m.
- Crossfall and superelevation is set to -1% for right side and +1% for left side (acceptable due to low-speed limit).

- Curbs and Gutters are being used, at one hand in order to serve stormwater drainage management and on the other hand due to the pedestrian pavements (sidewalks) that need to be constructed.
- Road 1 will be constructed based on typical road pavement of thickness $d=0.62$ m.
- Typical pavement thickness consists of:
 - ✓ 5 cm of asphalt concrete ac-16 surface
 - ✓ 7 cm of bituminized crushed stone ac-32 base
 - ✓ 20 cm unbound granulated stone material 0-40mm
 - ✓ 30 cm sand-gravel material sub base cbr >80%

6.3 ROAD 2

Road 2 constitutes the perimeter road of both phase I and phase II cells of the landfill. It will be constructed in two phases as well. Road 2 can be accessed from site entrance via Road 1.



Figure 6-3: Road 2

Road 2 - Horizontal Alignment

Starting point of the road section that corresponds to phase I, is located at the southwestern edge of cell 2 and the final point is located at the northwestern edge of cell 1 (chain. +689.563 – cross section 42).

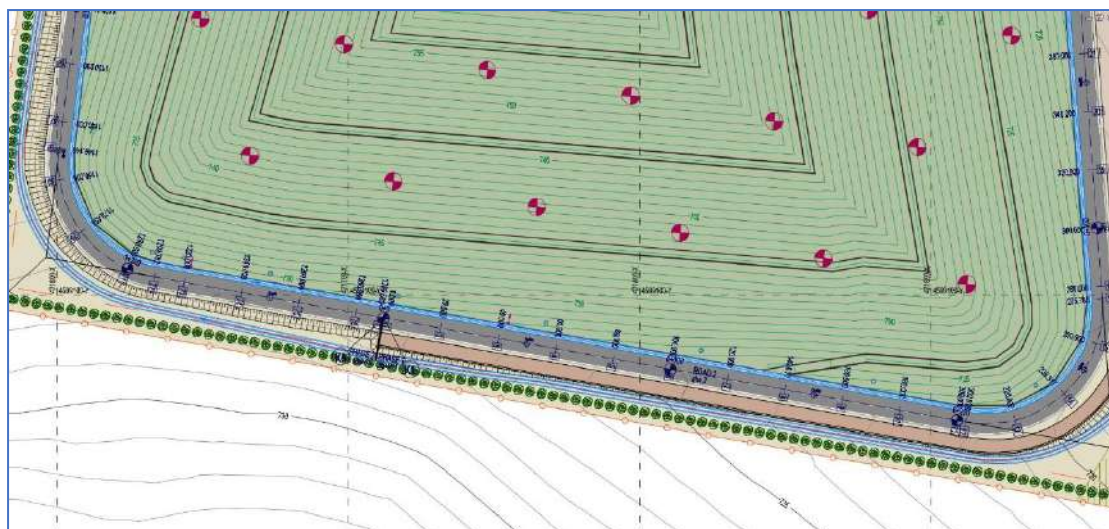


Figure 6-4: Road 2 phase I starting point

Starting point of the road section that corresponds to phase II, is located at the northwestern edge of cell 1 or northeastern edge of cell 3 (chain. +689.563 – cross section 42) and the final point is located at the southwestern edge of cell 2 or southeastern edge of cell 4 (chain. +1289.563 – cross section 77 or cross section 1 – chain. 0+000).



Figure 6-5: Road 2 phase II starting point

- Total length of Road 2 is 1,289.563m, 689.569m for phase I and 600m for phase II.
- Minimum width is 7m.
- Radius of horizontal curve is 40m.

Road 2 - Profile

- Maximum longitudinal slope (gradient) of road is 5%
- Minimum longitudinal slope is 0.5%.
- Minimum vertical curve radius is 500m and maximum is 1,500m.

Road 2 - typical cross section - pavement

- The minimum width for Road 2 pavement is 7m.
- Crossfall and superelevation is set to 2.5% for right side and -2.5% for left side (acceptable due to low-speed limit), except of the area of intersection with road 1 where values are set to -2.5% for both sides.
- Curbs and Gutters are being used on the outer side of the road, at one hand in order to serve stormwater drainage management and on the other hand to separate road surface from possible future roadside constructions and also to keep vehicles within road limits (acceptable due to low-speed limit).
- On the inner side of the road a ditch is being constructed.
- Road 2 will be constructed based on typical road pavement of thickness $d=0.62$ m.
- Typical pavement thickness consists of:
 - ✓ 5 cm of asphalt concrete ac-16 surface
 - ✓ 7 cm of bituminized crushed stone ac-32 base
 - ✓ 20 cm unbound granulated stone material 0-40mm
 - ✓ 30 cm sand-gravel material sub base cbr >80%

6.4 ROAD 3

Road 3 constitutes the road that provides access to Road 4 and to surface water pond area. Road 3 can be accessed from site entrance via Road 1.



Figure 6-6: Road 3

Road 3 - Horizontal Alignment

- Total length of Road 3 is 76.033m.
- Minimum width is 7m.
- No horizontal curves

Road 3 - Profile

- Maximum longitudinal slope (gradient) of road is 4% (intersection area)
- Minimum longitudinal slope is 1%.
- No vertical curve

Road 3 - typical cross section - pavement

- The minimum width for Road 3 pavement is 7m.
- Crossfall and superelevation is set to -1% for right side and +1% for left side (acceptable due to low-speed limit), except of the area of intersection with Road 1 where values are set to -4% for right side and +4% for left side.
- Curbs and Gutters are being used, at one hand in order to serve stormwater drainage management and on the other hand due to the pedestrian pavements (sidewalks) that need to be constructed.
- Road 3 will be constructed based on typical road pavement of thickness $d=0.62$ m.
- Typical pavement thickness consists of:
 - ✓ 5 cm of asphalt concrete ac-16 surface
 - ✓ 7 cm of bituminized crushed stone ac-32 base
 - ✓ 20 cm unbound granulated stone material 0-40mm
 - ✓ 30 cm sand-gravel material sub base cbr >80%

6.5 ROAD 4

Road 4 constitutes the road that provides access to Road 8 that serves the Leachate Treatment Plant area. Road 4 can be accessed from site entrance via Road 1 and Road 3. At the end of Road 4 a U-turn area will be constructed in order to provide the suitable space for vehicles to return back to Road 3 or Road 8.

- ✓ 30 cm sand-gravel material sub base cbr >80%

6.6 ROAD 5

Road 5 constitutes the road that provides access to Road 6 and to Road 7. Road 5 can be accessed from site entrance via Road 1.



Figure 6-8: Road 5

Road 5 - Horizontal Alignment

- Total length of Road 5 is 87.289m.
- Minimum width is 7m.
- No horizontal curves

Road 5 - Profile

- Longitudinal slope (gradient) of road is 1%
- No vertical curve

Road 5 - typical cross section - pavement

- The minimum width for Road 5 pavement is 7m.
- Crossfall and superelevation is set to -1% for right side and +1% for left side (acceptable due to low-speed limit), except of the area of intersection with Road 1 where values are set to -4% for right side and +4% for left side.
- Curbs and Gutters are being used, at one hand in order to serve stormwater drainage management and on the other hand due to the pedestrian pavements (sidewalks) that need to be constructed.
- Road 5 will be constructed based on typical road pavement of thickness $d=0.62$ m.

- Typical pavement thickness consists of:
 - ✓ 5 cm of asphalt concrete ac-16 surface
 - ✓ 7 cm of bituminized crushed stone ac-32 base
 - ✓ 20 cm unbound granulated stone material 0-40mm
 - ✓ 30 cm sand-gravel material sub base cbr >80%

6.7 ROAD 6

Road 6 constitutes the road that provides access to Administration Building area. North and south of Road 6 a parking area on each side are being located to serve personnel parking demands. The parking area provides 18 parking spaces, two of which reserved for persons with disabilities

Road 6 can be accessed from site entrance via Road 1 and Road 5.



Figure 6-9: Road 6

Road 6 - Horizontal Alignment

- Total length of Road 6 is 42.40m.
- Minimum width is 7m.
- No horizontal curves

Road 6 - Profile

- Longitudinal slope (gradient) of road is 1%
- No vertical curve

Road 6 - typical cross section - pavement

- The minimum width for Road 6 pavement is 7m.

- Crossfall and superelevation is set to -1% for right side and +1% for left side (acceptable due to low-speed limit).
- Curbs and Gutters are being used, at one hand in order to serve stormwater drainage management and on the other hand due to the pedestrian pavements (sidewalks) that need to be constructed.
- Road 6 will be constructed based on typical road pavement of thickness $d=0.62$ m.
- Typical pavement thickness consists of:
 - ✓ 5 cm of asphalt concrete ac-16 surface
 - ✓ 7 cm of bituminized crushed stone ac-32 base
 - ✓ 20 cm unbound granulated stone material 0-40mm
 - ✓ 30 cm sand-gravel material sub base cbr >80%

Road 7

Road 7 constitutes the road that provides access to Garage area by connecting it with Road 5. North of Road 7 a parking area is being located to serve both Garage and Gas and flaring collection area. The parking area provides 8 parking spaces, one of which reserved for persons with disabilities. Road 7 can be accessed from site entrance via Road 1 and Road 5.



Figure 6-10: Road 7

Road 7 - Horizontal Alignment

- Total length of Road 7 is 55.149m.
- Minimum width is 7m.
- No horizontal curves

Road 7 - Profile

- Longitudinal slope (gradient) of road is 1%
- No vertical curve

Road 7 - typical cross section - pavement

- The minimum width for Road 7 pavement is 7m.
- Crossfall and superelevation is set to -1% for right side and +1% for left side (acceptable due to low-speed limit).
- Curbs and Gutters are being used, at one hand in order to serve stormwater drainage management and on the other hand due to the pedestrian pavements (sidewalks) that need to be constructed.
- Road 7 will be constructed based on typical road pavement of thickness $d=0.62$ m.
- Typical pavement thickness consists of:
 - ✓ 5 cm of asphalt concrete ac-16 surface
 - ✓ 7 cm of bituminized crushed stone ac-32 base
 - ✓ 20 cm unbound granulated stone material 0-40mm
 - ✓ 30 cm sand-gravel material sub base cbr >80%

6.8 ROAD 8

Road 8 constitutes the road that provides access to each facility of Leachate Treatment Plant area. Road 8 Axis begins and ends at Road 4 Axis. Road 8 can be accessed from site entrance via Road 1, Road 3 and Road 4.



Figure 6-11: Road 8

Road 8 - Horizontal Alignment

- Total length of Road 8 is 166.58m.
- Minimum width is 5.5m.
- Radius of horizontal curve is 10.75m.

Road 8 - Profile

- Maximum longitudinal slope (gradient) of road is 1,2%
- Minimum longitudinal slope is 1%.
- Maximum vertical curve radius is 10,000m and minimum vertical curve radius is 1,800m

Road 8 - typical cross section - pavement

- The minimum width for Road 8 pavement is 5.5m.
- Crossfall and superelevation value is set to 1% (acceptable due to low-speed limit).
- Curbs and Gutters are being used, at one hand in order to serve stormwater drainage management and on the other hand due to the pedestrian pavements (sidewalks) that need to be constructed.
- Road 8 will be constructed based on typical road pavement of thickness $d=0.62$ m.
- Typical pavement thickness consists of:
 - ✓ 5 cm of asphalt concrete ac-16 surface
 - ✓ 7 cm of bituminized crushed stone ac-32 base
 - ✓ 20 cm unbound granulated stone material 0-40mm
 - ✓ 30 cm sand-gravel material sub base cbr >80%

6.9 ROAD 9

Road 9 constitutes the gravel road that provides access to garage area from the cells area. This road is only to be used by the landfill compactor or possible other heavy machinery that operates inside the landfill cells. In this way garage area may be reached by the landfill machinery for maintenance or repairs, without using the rest of internal road network preventing at the same time any possible damage on asphalt roads. Road 9 can serve both Phases I and II as it is located opposite the central gravel berm.



Figure 6-12: Road 9

Road 9 - Horizontal Alignment

- Total length of Road 9 is 432.642m.
- Minimum width is 4.5m.
- Radius of horizontal curve is 46m and 50m.

Road 9 - Profile

- Maximum longitudinal slope (gradient) of road is 6%
- Minimum longitudinal slope is 1%.
- Vertical curve radius is 500m and minimum vertical curve radius is 1,800m

Road 9 - typical cross section - pavement

- The minimum width for Road 8 pavement is 4.5m.
- Crossfall and superelevation value is set to 1% (acceptable due to low-speed limit).
- Road 9 will be constructed based on typical road pavement of thickness $d=0.3$ m.
- Typical pavement thickness consists of:
 - ✓ 30 cm sand-gravel material cbr >80%

Garage plateau area - pavement

- Garage plateau will be constructed based on typical road pavement of thickness $d=0.78$ m.
- Typical pavement thickness consists of:
 - ✓ 28cm concrete layer
 - ✓ 20cm crashed material base cbr >80%
 - ✓ 30 cm sand-gravel material sub base cbr >80%

Internal beam – temporary road of phase I - pavement

- Internal beam used as a temporary road during phase I will be constructed based on typical road pavement of thickness $d=0.3$ m.
- Typical pavement thickness consists of:
 - ✓ 30 cm sand-gravel material cbr >80%

7. LEACHATE MANAGEMENT

7.1 GENERAL ISSUES

Leachate can be attributed to many factors including the water generated as a product of refuse decomposition. However, the main factor contributing to leachate quantity is the inflow water from surface water sources, such as rainfall.

Since at our case, there will not be direct contact between the sanitary landfill and local ground-water, the primary source of water for leachate production will be infiltration of rainfall.

Therefore minimizing the rainfall infiltration into the sanitary landfill the leachate quantity collected and led to leachate treatment will be also minimized.

A basic characteristic of leachate is that they are variable in quantity and quality.

Therefore, a highly polluted liquid, such as leachate, it is required to be treated before discharged to any receiving body (soil, water, etc)

It should be noted here, that the leachate flow is not continuous for all year but periodic. This is very important factor in choosing the proper leachate treatment.

In order to achieve the goals of leachate management in the landfill:

1. The input amount of rainwater must be reduced. Circumferential ditches will be developed in order to prevent the stormwater from entering into the landfill's body. These works are fully described in Technical Report 04 (flood protection works).
2. Also a top cover will be constructed after the closure of each cell, as it is being described in Technical Report (TR) 01: Landfill Design.
3. The collection system will ensure long-term collection of the total quantity of leachate and exclude any admixture with rainwater.

For the determination of the volume, the rate of production and the qualitative composition of leachate, the following information will be used:

- the intensity, frequency and duration of precipitation;
- runoff of surface liquids;
- the filtration of water inside the body of the landfill;
- the frost;
- the average air temperature;
- evaporation from the surface of the landfill, especially during its operation period;
- the composition and density of the waste;
- the initial moisture content;
- the quality and humidity of the coating material;
- the characteristics of landfill and the spatial development of the cells.

7.2 LEACHATE MANAGEMENT SYSTEM OVERVIEW

The leachate drainage system serves the purpose of collecting effectively all leachate generated by the waste.

Specifically, the leachate drainage system is designed in order to:

- be able to drain down leachate within the landfill such that the saturated thickness of leachate above the bottom liner is less than any specified level.
- be strong enough to withstand physical damage due to the loading imposed by the waste, and any compaction equipment working over the system.
- be able to accommodate the predicted settlement at the base of the landfill under the applied loads and foundation conditions.
- be resistant to microbiological and chemical attacks in the corrosive environment of the landfill.
- be able to function in spite of unavoidable incrustation processes during and after the operational life of the landfill.
- be capable of inspection and maintenance until such time as the system is no longer required to function.
- incorporate a suitable level of "redundancy" in the design to take account of failure of parts of the system and provide alternative drainage routes to collection points.

The leachate drainage system consists of the drainage layer and the drainage pipes (perforated HDPE pipe network) and it is placed on top of the protection geotextile.

The design of the leachate drainage system is summarized under the following general design features:

- The leachate drainage system will extend over the entire base of the landfill and will extend up its sloping side walls.
- The drainage layer will consist of granular materials.
- The bottom liner will be profiled to have sufficient gradient to promote efficient drainage to the drainage pipes. The drainage pipes will have sufficient longitudinal slope to reduce sedimentation.
- The network of perforated drainage pipes will be laid within the drainage layer with continuous gradients towards the leachate collection point(s) and will be capable of being inspected and maintained.
- Leachate removal from a common collection point will be capable of continuous and automatic functioning.
- The system will be inspected regularly and cleaned out accordingly.

The rain water percolating through the covered sanitary landfill cells, as well as the rainwater percolating through the open cells (in operation) will be collected through a drainage system underlying the landfill and directed to the leachate treatment area.

The rain water collected in the sampling area, the wheel wash plant and wastewater from the building will also be directed to the leachate treatment.

The rain water on the unpolluted part of the empty cells will be pumped to the circumferential ditch and to the stormwater retention pond.

The general layout of leachate collection system and its design details are presented in Technical Report (TR) 04: Surface Water Management & Flood Protection Works.

7.3 DESIGN PARAMETERS FOR LEACHATE TREATMENT PLANT DESIGN

7.3.1 Quality

As far as leachate quality is concerned, leachate is heavily loaded with organic and inorganic pollution and its quality characteristics depend on the landfill's refuse composition, as well as its degradation stage.

Leachate contains suspended solids, soluble waste components, soluble decomposition products and microorganisms. Most leachate components have the potential to be toxic and could cause the heavy pollution of river or lake, directly (through toxins and BOD₅) or indirectly (via eutrophication). They can also contaminate drinking water, in case it is disposed to drinking water resource. Therefore, under no circumstances should the leachate be discharged to surface and underground water. The composition of the leachate produced in a landfill, depends on the type, composition and age of waste, the degree of compression in landfills, etc. A typical composition of the leachate produced from domestic waste landfills are given in the table below.

Table 6: Composition of produced leachate

Parameter	Concentration limits (mg/l)	Typical concentration (mg/l)
BOD ₅	2,000 – 30,000	10,000
TOC	15,000 – 20,000	6,000
COD	3,000 – 45,000	18,000
Total Suspended Solids	200 – 1,000	500
Organic nitrogen	10 – 600	200
Ammonia nitrogen	10 – 800	200
Nitrates	5 – 40	25
Total phosphorus	1 – 70	30
Orthophosphoric	1 – 50	20
Alkalinity (CaCO ₃)	1,000 – 10,000	3,000
pH	5.3 – 8.5	6
Total hardness (CaCO ₃)	300 – 10,000	3,500
Calcium	200 – 3,000	1,000

Magnesium	50 – 1,500	250
Potassium	200 – 2,000	300
Sodium	200 – 2,000	500
Chlorine	100 – 3,000	500
Sulphur	100 – 3,000	500
Total iron	50 – 600	60

7.3.2 Quantity

Leachate flow is not continuous throughout the year, but periodic and therefore, calculations have been performed based on the following assumptions as described in the next Tables.

Since, the landfill is going to operate in different Phases (Phase I and Phase II), which are subject to different design characteristics, different assumptions for each Phase have been taken into account.

The calculations have been performed for the whole of each phase (Phase I and Phase II) and do not take into account the sub-phases (cell 1 and cell 2/ cell 3 and cell 4). However, calculations are performed for:

1. *Phase I – daily cover*: after solid waste disposal has started in cell 1 and cell 2 and while landfilling of Phase I is reaching the top disposal level, but it is not yet covered with final cover.
2. *Phase II – daily cover*: after solid waste disposal has started in cell 3 and cell 4 and while landfilling of Phase II is reaching the top disposal level, but it is not yet covered with final cover.
3. *Phase II – final cover*: After the end of the total lifetime of the landfill.

In the following Tables the leachate quantity results according to the above-mentioned assumptions are being presented.

Specifically, each Table registers the values of each month corresponding to the mean monthly values for the total of all operating years. The first column registers the reference month. The second column of each table registers the sum leachate production for each month (in mm), while the third column registers it in m³ (by multiplying it with the corresponding area). The fourth column registers the average monthly leachate production (in m³) and the fifth registers the max monthly leachate production (in m³) (It is assumed that the max monthly production is not observed in a single day of a month, but that it is observed in a continuity of X consecutive days). The last column registers the peak daily leachate production (in m³) which corresponds to the maximum value of all the max monthly leachate production (fifth column).

(1) PHASE I – daily cover

Mean values for 7 years, Area: 4,97 Ha

Month	Sum monthly production (mm)	Sum monthly production (m ³)	Average monthly production (m ³)	Max monthly production (m ³ /mo)	Peak daily production (m ³ /d)
1	39.26	1951.43	62.95	150.19	23.3
2	19.14	951.13	33.97	163.06	
3	10.17	505.26	16.30	111.94	
4	10.59	526.47	17.55	153.05	
5	3.25	161.32	5.20	13.36	
6	2.03	101.06	3.37	6.15	
7	1.54	76.37	2.46	3.90	
8	1.20	59.45	1.92	2.76	
9	0.94	46.71	1.56	2.11	
10	0.82	40.99	1.32	1.94	
11	4.30	213.52	7.12	103.71	
12	27.25	1354.37	43.69	156.23	

The maximum production of leachate as it was calculated is: $Q \cong 23.3 \text{ m}^3/\text{day}$

(2) PHASE II – daily cover

Mean values for 30 years, Area: 10.7 Ha

Month	Sum monthly production (mm)	Sum monthly production (m ³)	Average monthly production (m ³)	Max monthly production (m ³ /mo)	Peak daily production (m ³ /d)
1	34.29	3669.48	118.37	340.94	53.82
2	20.35	2177.77	77.78	376.78	
3	10.20	1091.64	35.21	293.68	
4	9.29	994.24	33.14	354.73	
5	3.56	381.24	12.30	87.82	
6	2.27	242.80	8.09	40.23	
7	1.52	162.66	5.25	15.71	
8	1.09	117.13	3.78	7.95	
9	0.83	88.63	2.95	5.24	
10	0.69	74.23	2.39	3.89	
11	4.54	485.97	16.20	310.18	
12	20.50	2193.75	70.77	346.26	

The maximum production of leachate as it was calculated is: $Q \cong 53.82 \text{ m}^3/\text{day}$

This quantity is selected for the design of the leachate treatment plant the peak(maximum) flow as design flow.

(3) PHASE II – final cover

Mean values for 30 years, Area: 10,7 Ha

Month	Sum monthly production (mm)	Sum monthly production (m ³)	Average monthly production (m ³)	Max monthly production (m ³ /mo)	Peak daily production (m ³ /d)
1	0.021	2.257	0.073	0.127	0.018
2	0.021	2.284	0.082	0.134	
3	0.024	2.605	0.084	0.135	
4	0.022	2.306	0.077	0.102	
5	0.022	2.361	0.076	0.104	
6	0.022	2.328	0.078	0.099	
7	0.023	2.410	0.078	0.098	
8	0.022	2.406	0.078	0.098	
9	0.022	2.315	0.077	0.098	
10	0.022	2.354	0.076	0.093	
11	0.020	2.185	0.073	0.086	
12	0.021	2.251	0.073	0.103	

Concluding, for the design of the treatment facility, the following design parameters have been considered.

Table 7: Total Design quantity of Leachate

Landfill Leachate		
Daily average Flow	m ³ /d	53.82
Hours of leachate PS operation per day	h	4
Hourly average Flow	m ³ /h	13.5

7.4 EFFLUENT QUALITY STANDARDS

The treated leachate quality will be in accordance:

A) to EU Directive 91/271/EEC (Annex I, Table 1)

Biochemical oxygen demand (B.O.D ₅)	≤ 25 mg/l
Chemical oxygen demand (COD)	≤ 125 mg/l
Total suspended solids (SS)	≤ 35 mg/l
Total phosphorus (P)	≤ 2 mg/l
Total Nitrogen (N)	≤ 15 mg/l

B) to the Georgian Legislation for disposal of treated effluent to surface water.

- Discharges of effluents from wastewater systems, are regulated by Regulation # 431, GOG, 20/08/2018.
- Maximum allowable concentrations of discharging effluent into receiving water bodies is regulated by regulation # 17 GOG 03/01/2014.
- Maximum allowable concentrations (see table below) for regulations 431, 17 and Approximate Working Range regarding UWSCG norms.
- Regulation N 425 (31.12.2013) of Government of Georgia on Approval of Technical Regulation for Protection of Surface Water from Pollution.

Maximum allowable concentrations, as presented at TR 03, will be met with the proposed treatment procedure.

7.5 LEACHATE TREATMENT SYSTEM

There are many advantages and drawbacks of the various treatments are discussed under the items: (a) leachate transfer, (b) biodegradation, (c) chemical and physical methods, and (d) membrane processes.

Several sources permit to review and summarize each treatment efficiency depending on operating conditions. Finally, considering the hardening of the standards of rejection, conventional landfill leachate treatment plants appear under-dimensioned or do not allow them to reach the specifications required by the legislator.

So that, new technologies or conventional ones improvements have been developed and tried to be financially attractive. Today, the use of membrane technologies, more especially reverse osmosis (RO), either as a main step in a landfill leachate treatment chain or as a single post-treatment step has shown to be an indispensable means of achieving purification (S. Renou, 2007).

Once the leachate is properly collected, it is driven to the leachate treatment plant, before the final effluent disposal and/or reuse.

To meet the effluent quality requirements, the Reverse Osmosis (RO) treatment method was selected, following pretreatment for maximum solids removal.

This proposed leachate treatment plant consists of:

- a. Screw screen with compactor
- b. Equalization tank with aeration and pH adjustment
- c. Sedimentation Tank with Lamella
- d. Sludge Storage Tank
- e. High pressure pumping units
- f. Sand & Pressure filter
- g. RO unit
- h. Treated Water Storage tank and back washing pumps
- i. Concentrate Water pumps drive the stream to active cells in landfill
- j. Polyelectrolyte Unit

- k. Static Mixer
- l. Centrifugal
- m. Drainage pumps drive the stream to Equalization tank

The RO method is recommended internationally for leachate treatment by new (modern) sanitary landfills, with relatively low leachate flows. It is relatively cheap for construction, it renders excellent effluent quality, requires no special attendance, it is easy to be expanded, and fully automated. However, it has high operational and maintenance cost, due to high required energy input and to the replacement of the “aging” or worked out membranes (in average, membrane replacement: 1 per 3 years).

All design details are presented to TR 03.

7.6 FUTURE EXPANSION OF THE LEACHATE TREATMENT SYSTEM

The composition and quantity of leachate are expected to evolve over time, depending on the development of the landfill.

The treatment plant is designed to cover also the 2nd phase of the landfill. Nevertheless, there will be a need to replace equipment after the 1st phase completion.

The future expansion of the leachate treatment system is proposed to include the Replacement of R/O filters and membranes.

7.7 EFFLUENT QUALITY AND SUITABILITY FOR DRINKING AND DOMESTIC WATER USAGE

The quality of effluent at the exit of the leachate treatment plant is compared to Regulation N 425 (31.12.2013) of Government of Georgia on Approval of Technical Regulation for Protection of Surface Water from Pollution.

Table 8: Quality of effluent and corresponding limit values

Parameter	Permeate water quality	Maximum permissible concentration for drinking and domestic water usage	Units
BOD ₅	1.5	6	mg/l
TOC	4.8	-	mg/l
COD	5.8	30	mg/l
Total Suspended Solids	0.0	0.75	mg/l
NH ₄ ⁺	0.39	0.39	mg/l
K ⁺	19.53		mg/l
Na ⁺	155.20		mg/l

Parameter	Permeate water quality	Maximum permissible concentration for drinking and domestic water usage	Units
Mg ⁺²	5.68		mg/l
Ca ⁺²	22.44		mg/l
Sr ⁺²	0.00		mg/l
Ba ⁺²	0.00	0.1	mg/l
CO ₃ ⁻²	20.72		mg/l
HCO ₃ ⁻	410.50		mg/l
NO ₃ ⁻	6.56	45	mg/l
Cl ⁻	230	350	mg/l
F ⁻	0.11	0.05	mg/l
PO ₄ ⁻³	1.46	3.5	mg/l
SO ₄ ⁻²	71.05	500	mg/l
SiO ₂	0.00		mg/l
Boron	0.00	0.5	mg/l
CO ₂	0.94		mg/l
Est.Cond.µS/cm	990.00		mg/l
TDS	763.20		mg/l
pH	7.00	6.5-8.58	mg/l

From the above comparison, it is evident that water standards are not exceeded.

8. BIOGAS MANAGEMENT

Detailed design of biogas management system at Kvemo Kartli Landfill includes the collection, transmission, and flaring / utilization system.

LFG control systems consist of collection, conveyance, and treatment components and are designed to be either passive or active. A passive system allows the landfill gas to exit the collection system without mechanical assistance, whereas an active system uses mechanical assistance, such as blowers, to extract gas. Depending on the potential impacts of the landfill gas and local regulatory criteria, gas is either dispersed into the atmosphere or collected and treated.

Taking into consideration biogas quantities etc. calculated above, the method that is going to be applied shall concern active expansion vertical networks and flaring system.

The detailed design of collection systems, conveyance piping, and treatment are described in the next chapters.

Briefly, the detailed design of all components consists of the following:

- Vertical collection wells
- Heads of collection wells
- Piping Network for the transmission of biogas to the central station of collection and processing (Header Piping)
- Siphons of water removal
- Flare combustion

In general, biogas recovery systems consist of several subsystems, which can operate independently. Thus, a possible failure of an individual sub-system shall have only a small impact at the operation of the whole system.

The design of the biogas collection is based on the recoverable quantity of biogas from the landfill, taking under consideration a representative safety factor. The maximum design flow is calculated as follows:

Maximum network design flow (m^3/h): $Q_{\text{design}} = Q_{\text{recovered}} \times 1.50 = 870,21 \text{ (m}^3/\text{h)}$.

Furthermore, all the proposed equipment shall be suitable for operation in climate conditions at the site; temperature range of 5°C below the minimum, to 5°C above the maximum temperatures recorded in the area.

All the machinery described below and piping is selected to minimize costs. All of it will be new, unused and will be the most recent or current design and specification.

The equipment will be CE marked, to show conformance with relevant Georgian and European Legislation and Standards, including the Machinery, Low Voltage and Electromagnetic Compatibility Directives, and Pressure Equipment Directive.

All design details of the biogas management is presented in Technical Report (TR) 5: Biogas Management

The estimation of landfill gas generation on the landfill is based on the following assumptions:

Disposal period:	2023-2052	
Waste amounts:	37,600– 51,200 ton/year (Total 1,582,000 m ³)	
Composition of waste ³ :	Paper and textiles	17.5%
	Garden waste etc.	1%
	Food waste	30%
	Wood and straw	1%
	Inorganic waste	50.5%
Methane correction factor (MCF):	(Managed landfill with more than 5 m depth)	1.0
Fraction of organic waste dissimilated:	(IPCC default value)	0.77

Based on the above assumptions of waste composition and amounts of waste disposed on the landfill the estimated landfill gas generation is resented in the next table.

Table 9: LFG Production

Years	Total produced landfill gas (m³/year)	Total produced landfill gas (m³/hr)	Recoverable landfill gas 70% (m³/hr)	Recoverable landfill gas with safety factor 1.5 (m³/hr)
2023	0,00	0,00	0,00	0,00
2024	445.900,54	50,90	35,63	53,45
2025	870.054,26	99,32	69,52	104,29
2026	1.273.521,76	145,38	101,77	152,65
2027	1.657.311,91	189,19	132,43	198,65
2028	2.022.384,40	230,87	161,61	242,41
2029	2.369.652,10	270,51	189,36	284,03
2030	2.699.983,34	308,22	215,75	323,63
2031	3.014.204,15	344,09	240,86	361,29
2032	3.313.100,22	378,21	264,75	397,12
2033	3.597.418,96	410,66	287,46	431,20
2034	3.867.871,31	441,54	309,08	463,61
2035	4.125.133,55	470,91	329,63	494,45
2036	4.291.620,79	489,91	342,94	514,41
2037	4.449.988,35	507,99	355,59	533,39
2038	4.600.632,24	525,19	367,63	551,45
2039	4.743.929,13	541,54	379,08	568,62
2040	4.880.237,36	557,10	389,97	584,96
2041	5.127.240,00	585,30	409,71	614,57
2042	5.362.196,18	612,12	428,49	642,73

³ Waste types used in IPCC landfill gas First Order Decay (FOD) model

LANDFILL DESIGN

Years	<i>Total produced landfill gas (m³/year)</i>	<i>Total produced landfill gas (m³/hr)</i>	<i>Recoverable landfill gas 70% (m³/hr)</i>	<i>Recoverable landfill gas with safety factor 1.5 (m³/hr)</i>
2043	5.585.693,42	637,64	446,35	669,52
2044	5.798.290,56	661,91	463,33	695,00
2045	6.000.519,22	684,99	479,49	719,24
2046	6.208.530,70	708,74	496,12	744,17
2047	6.406.397,35	731,32	511,93	767,89
2048	6.594.613,92	752,81	526,97	790,45
2049	6.773.651,07	773,25	541,27	811,91
2050	6.943.956,47	792,69	554,88	832,32
2051	7.105.955,97	811,18	567,83	851,74
2052	7.260.054,67	828,77	580,14	870,21
2053	6.905.977,63	788,35	551,85	827,77
2054	6.569.169,12	749,91	524,93	787,40
2055	6.248.786,97	713,33	499,33	749,00
2056	5.944.030,03	678,54	474,98	712,47
2057	5.654.136,26	645,45	451,81	677,72
2058	5.378.380,78	613,97	429,78	644,67
2059	5.116.074,06	584,03	408,82	613,23
2060	4.866.560,18	555,54	388,88	583,32
2061	4.629.215,24	528,45	369,91	554,87
2062	4.403.445,75	502,68	351,87	527,81
2063	4.188.687,17	478,16	334,71	502,07
2064	3.984.402,48	454,84	318,39	477,58
2065	3.790.080,88	432,66	302,86	454,29
2066	3.605.236,46	411,56	288,09	432,13
2067	3.429.407,00	391,48	274,04	411,06
2068	3.262.152,85	372,39	260,67	391,01
2069	3.103.055,77	354,23	247,96	371,94
2070	2.951.717,96	336,95	235,87	353,80
2071	2.807.760,97	320,52	224,36	336,55
2072	2.670.824,86	304,89	213,42	320,13
2073	2.540.567,19	290,02	203,01	304,52
2074	2.416.662,27	275,87	193,11	289,67
2075	2.298.800,26	262,42	183,69	275,54
2076	2.186.686,45	249,62	174,74	262,10
2077	2.080.040,49	237,45	166,21	249,32
2078	1.978.595,72	225,87	158,11	237,16
2079	1.882.098,47	214,85	150,40	225,59
2080	1.790.307,44	204,37	143,06	214,59
2081	1.702.993,12	194,41	136,08	204,13
2082	1.619.937,16	184,92	129,45	194,17
2083	1.540.931,89	175,91	123,13	184,70

LANDFILL DESIGN

Years	<i>Total produced landfill gas (m³/year)</i>	<i>Total produced landfill gas (m³/hr)</i>	<i>Recoverable landfill gas 70% (m³/hr)</i>	<i>Recoverable landfill gas with safety factor 1.5 (m³/hr)</i>
2084	1.465.779,76	167,33	117,13	175,69
2085	1.394.292,84	159,17	111,42	167,12
2086	1.326.292,37	151,40	105,98	158,97
2087	1.261.608,33	144,02	100,81	151,22
2088	1.200.078,97	137,00	95,90	143,85
2089	1.141.550,42	130,31	91,22	136,83
2090	1.085.876,35	123,96	86,77	130,16

9. DRAINAGE/FLOOD PROTECTION WORKS

The following paragraphs describe briefly the surface water management process at the landfill site and the flood protection works. All design details are presented in Technical Report (TR) 4: Surface Water Management & Flood Protection Works.

9.1 SURFACE WATER MANAGEMENT

Storm water, from the surrounding area of the landfill, will be collected and diverted through ditches positioned around the landfill area.

Non-polluted surface water consists of rain water, (1) that is collected from the covered landfill surfaces, (2) from the landfill areas, which are not in operation (surfaces under construction or surfaces which are temporarily covered with cover sheets) and (3) from the circumferential to landfill basin road.

This type of surface water (non-polluted) will be collected in a lined ditch placed along the circumferential road. Non-polluted surface water will be diverted, from the lowest point of the ditch, through a culvert, which will be crossing the circumferential road and subsequently through a sewer and stored in a retention pond. Once the storm event is over, pond drainage may occur through evaporation and percolation into the soil. The retention pond will be equipped with a gated discharge pipe and overflow spillway, in order to overcome extremely storm events.

In addition to the primary purpose of the retention pond, which is to reduce peak flows of the stormwater, the pond can be adapted to enhance stormwater quality, providing time for particulate pollutants to settle down. Furthermore, the pond will be used as water storage, for internal operation purposes e.g. firefighting water, irrigation of plants and trees, cleaning of roads, spraying of roads against dust.

Surface water, from the roads of the facilities area, will be collected through a drainage system, consisting of gully-holes and sewers.

Surface water, from areas where the risk of oil spillage is high (e.g. washing and fuel filling area in front of garage), will pass from an oil separator, before being discharged in the drainage system.

Surface water, from the Sampling area and Wheel wash plant, will be discharged to the leachate collection system.

9.2 FLOOD PROTECTION WORKS

The flood protection works, for the site area, consist of the following works:

- Outer ditch along the foot of landfill embankment, for the diversion of storm water, from external catchment area to the final receptors.
- Ditch along the circumferential road of landfill basin.
- Culvert, for the outflow of the circumferential ditch, passing under the circumferential road.
- Ditch from culvert to stormwater retention pond.
- Retention pond with overflow and drainage system.
- Drainage system for the roads of facilities area.

The overall design of the flood protection works is presented in the general layout (Drawing DDHY.02.1 of TR 4).

10. LANDSCAPE DESIGN-PLANTATION

It is noted that the re-vegetation proposed herein concerns the final closed landfill. This will allow for the settlements in the waste mass to take place. During the gradual closing of the cells, a temporary non-vegetated layer will be applied according to the specifications described in previous chapters.

10.1 SOIL TYPE

The acquisition of new soil is essential for successful revegetation projects. In general, the underlying problems of soils can be reduced down to four. These four aspects reflect the very simple needs of plants for: 1) a medium into which they are physically able to root, 2) an adequate water supply, 3) an adequate nutrient supply and 4) lack of toxicity (Wong and Bradshaw 2002).

Soils needs to: (1) have a healthy layer near the surface; (2) be tested as necessary for pH, nitrogen, phosphorus, conductivity, bulk density, organic matter, and other nutrients; and (3) be treated as necessary.

The following aspects must be noted for the soils used for the vegetative cover:

- **Depth:** According to literature, topsoil depth should in any case be over 30 cm and preferably between 45-60 cm. Topsoil depth for the closed landfill site will be 50 cm (minimum). This will ensure the successful establishment of the proposed plants (no deep rooted species are proposed), protection from potential runoff and will allow for additional depth to prevent excess humidity from reaching the cap.
- **Acidity:** Soils with an extreme acidic pH should be treated with lime before they are spread over the landfill surface. A neutral or slightly alkaline pH is adequate for revegetation. In case that the soil is found to be acidic, proper treatment should be applied.
- **Organic matter:** Typical soils in the greater area have low organic matter and as such they should be treated before plantation. Soils could be amended by incorporating composted organic matter into the top from one to several weeks before planting.
- **Nutrients:** An initial treatment with fertilizers should be considered however this should not be a permanent measure. Subsequent needs of nutrients will be covered naturally as the plant community will further establish.
- **Texture:** Stones and cobbles should be removed from soil before the application. As seen from the surveys and relative literature, in the greater area are generally fine to medium grained.

The final soil surface should be loosely distributed during landscaping and should not be compacted with heavy equipment (Wong and Bradshaw 2002). It should be spread evenly over the surface. The application of topsoil in strips along the contour is recommended especially when the topsoil supply is limited (DERM, 1995).

10.2 VEGETATION SPECIES

An artificial community consisting of carefully selected species can cover these aspects and achieve:

1. Environmental restoration: the plant community established on the restored sites will lead through ecological functions (nutrient recycling, gas absorption, soil stabilization) to a more stable environment.
2. Aesthetic/ landscape upgrading: by using plant communities on the surface of a restored landfill the surrounding area becomes more appealing and is available for more possible after uses.

In order to select the plant species to be used on the sites the following aspects are considered:

- Adaptability to local environmental conditions.
- Avoidance of alien species. This is a general approach used globally. Although a variety of plant species can be used on a landfill surface, native plants are recommended when possible. Planting native species that have been selected over thousands of years in that area are best adapted to disturbances and climate change. It is noteworthy though that non harmful species from different regions that have exceptional phytoremediation properties may be used if necessary. In the current project, non native species are not necessary.
- Preference for species that can establish in new soils (pioneer species)
- Adaptability to anaerobic soil conditions (ie helophytes)
- Species that are easily flammable will not be selected.
- If conditions allow (soil depth, inclination etc) 3 storeys of vegetation will be preferred. It is estimated though that this approach will not be followed for this landfill, since a 3rd storey of vegetation (trees) is not in general present in the area, and the soil depth will probably be smaller than required. The resulting restored site will comprise of 2 storeys (herbaceous understory and a second storey pf woody plants).
- Species that are not highly competitive, in order to achieve the desired diversity in the restored community.
- Easy to cultivate species.
- Species with fast growth rates.

In practice, no single species can achieve all of the above. A combination of species is proposed instead.

It is noted that a common practice for landfill revegetation is to exclude tree and shrubs species, in order to ensure no cap penetration by their rooting systems. In particular for the project site it is noted that:

- Trees are not naturally present on the site or near it. Tree plantations would alter the ecology and the landscape profile of the area.
- Trees and large shrubs need greater soil depth and less inclination, compared to the proposed herein.

- Taking into consideration the climatic conditions of the area, trees would have greater needs in irrigation.
- Tree and large shrub roots would pose a greater risk to cap integrity than grasses and small bushes.

It is important to add that, while the proposed species are adequate for the site, a surveying of the greater area is recommended before the final restoration of the site and species are selected in consultation with local experts.

10.3 PRACTICAL GUIDELINES FOR THE RE-VEGETATION OF THE SITE

10.3.1 Topsoil

Topsoil shall have a neutral or slightly alkaline pH. In case the topsoil is extremely acidic, it shall be treated with lime before application. In case the topsoil has low organic matter, it shall be treated with composted organic matter at least for at least a week before application. In case the topsoil is nutrient poor, fertilisers shall be applied. Soil depth shall be at least 50 cm. Samples analysis shall be submitted to and be approved by the Supervisor of the works before revegetation work is commenced.

10.3.2 Grass Sowing

Species shall be chosen according to the specifications detailed in the previous paragraphs. All grass seed shall be appropriate to the area and shall be proposed by the Contractor and approved by the Supervisor.

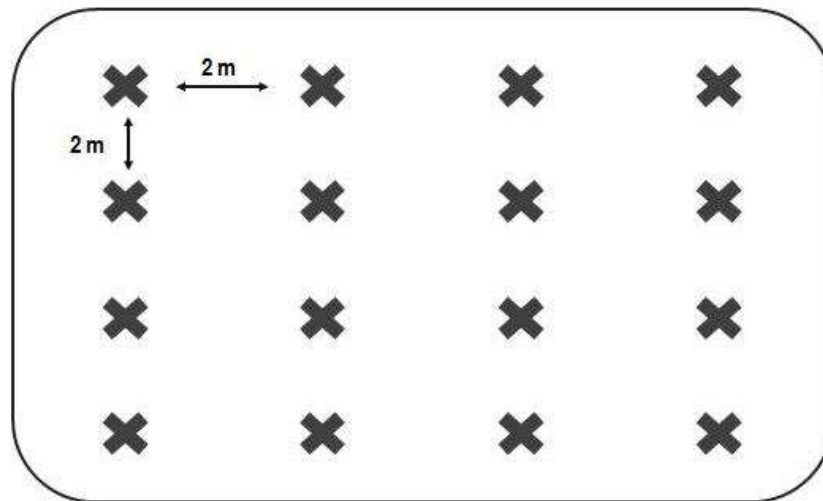
After the preparation and establishment of top-cover soil the sowing takes place. It is proposed that sowing will be performed immediately so that the topsoil does not remain uncovered and exposed for a long time. The herbaceous plants should complete a growing period and then be cut, leaving the litter (green waste) on ground.

Sowing density shall be 10-20 gr/m².

10.3.3 Shrub Planting

The appropriate shrub shall be chosen and planted according to the specifications detailed in the present study. The individuals shall be planted when they have reached 1-2 years of age.

Plantation should be in a row with 2 m between each individual. Rows should be 2 m apart as shown in the following diagram.



If supplementary plantations are needed, a more natural spatial arrangement may be chosen.

10.4 IRRIGATION

Irrigation shall be applied during the first 2 years of the revegetation and consequently will be reevaluated. The irrigation procedure shall be implemented during the 5 driest months (May-September) of each year.

Midday application and application in days that wind is over 5 Bf should be avoided.

Irrigation rate is estimated at 0.75 lt/m².

11. OPERATIONAL & PROCEDURES MANUAL

11.1 LANDFILL OPERATIONS & MAINTENANCE MANUAL

11.1.1 Operations Manual

11.1.1.1 Waste deposition

Generally, filling of the site begins in one corner and moves outward. Waste is generally placed in lifts, or thin layers of waste. The area in which the waste is currently being unloaded, placed, and compacted is called the working face. The working face must be large enough to allow for unloading of several vehicles simultaneously. Typically, 4 to 6 m is required per vehicle.

The first layer placed consists of preselected waste, with sharp and heavy objects removed, and is placed directly above the leachate collection system. It must be placed and compacted in a manner in which all equipment is kept from damaging the leachate collection system.

During waste deposition, it is important and critical to follow good depositional practices: deposition of waste from the bottom of the cell towards the top of the landfill (at the prescribed crest elevation), in inclined lifts with maximum slope of 1v:3h that does not exceed 2 m to 3 m in thickness, use of compacted daily soil cover, etc). Good depositional practices enhance the active volume of the landfill, provide adequate strength in the deposited waste mass that is necessary for the required stability, and also minimize short and long term settlements that are detrimental to the final cover and the after closure integrity of the landfill.

The disposed waste will be transferred to the work front by the trucks using specific internal service roads. These service roads will be frequently maintained to facilitate the passage of the heavy vehicles.

The unloading of waste will be done as close as possible to the waste front. The waste has to be laid (from bottom to top) in layers, as thin as possible in order for better compaction to be achieved. The laid waste will then be compacted using bulldozers achieving a final density of waste at least 550kg/m³.

Periodic soil cover will be placed on top of the disposed waste (using onsite excavated soil materials), as needed to provide a working surface for the waste transfer and placement process (truck access etc).

The side slopes of the shaped waste mount will be 1v:3h and will be also covered with the same soil material.

As cover soil material it is proposed to use the clayey soils that exist onsite and will result from the excavations for the area formulation.

During the laying of each waste layer special care should be taken in creating a surface with a small slope opposite to the work front. In this manner rainwater will not pass through the work front but will be diverted in the perimeter of the site. The produced leachate will be collected in the leachate collection trench from where they will be pumped and recirculated within the waste mass.

11.1.1.2 Compaction

The waste has to be laid in layers, as thin as possible from bottom to top, in order better compaction to be achieved. Reasonable standard is to use single layers, each layer some 0.5 - 1m (considering that wastes undergo minimum compaction in the waste collection vehicles). After compaction (the compactor has to pass up to 25 times) the layer is compacted to some 0.2 to 0.3 m. Then the next layer is added until the package of compacted layers is 2-3 m in total. The area of the work each day must extend accordingly in order for the compacted waste laid in the same day to have a total height of 2-3m. After the end of each day, the freshly deposited waste must be covered by a layer of soil at least 0.10m thick. By using special compactors with steel tooth on the wheel drums, the density of the compacted waste of a 0.5m thick layer is approximately 0.9-0.95 t/m³. For thicker layers (2.5m) the density is lower (~0.85t/m³). As the months pass the density of waste increases by a percentage of 20%.

For reasons of better compaction, the waste must be laid **from the bottom to top** and not unloaded at the top of the existing waste mount as it is currently done.

The uniform and effective compaction of waste is extremely important for the following reasons:

1. Reduction of risk of ignition and landfill fires
2. Better stability of the waste mass and aversion of relevant accidents
3. Uniform settlement which protects all future installations on the waste mass
4. Improved traffic flow and turnaround time
5. Reduced space and food for vermin
6. Improved control of water flows
7. Controlled gas production and minimizing of odors
8. Faster stabilization of waste
9. Less cover soil required for an even surface
10. Less airborne debris

11.1.1.3 Temporary cover

As it was mentioned above, at the end of each day, all the deposited waste must be covered with temporary cover material which will be at least 0.10m thick. This is very important for the stability of the waste relief, the reduction of the airborne debris and odours, as well as the reduction of the vermin.

The temporary cover must leave water to pass into the waste mass and help biodegradation processes, as well as not to gather in the work front and create mud-lakes. For this reason inert material from construction/demolition material of medium grain size can be used for temporary cover.

It is advisable that during the operation, each layer of waste to have a small slope towards the general slope of the landfill and opposite from the waste front in order storm water not to accumulate to the work front. In general the working face must be kept well drained.

A crucial condition for the proper landfill operation is the slope of free surfaces so as prevent the retention of water in hollows. Water can impede working face activity by slowing truck movement in muddy conditions and can cause traction problems for landfill equipment. It can promote mud-tracking problems and will attract vectors. A general rule is to avoid flat areas on a landfill, promoting drainage away from the working face at all times.

The slope of the vertical sides of the daily cell must be maximum 1:3 (height: width).

In order these operations to be performed by the personnel, the supplier of the new equipment will train accordingly all the personnel involved in landfilling.

It must be noted here that there is a second type of temporary cover which is used when a 15m height layer of waste has been laid. This temporary cover is 0.30m thick and is utilized for the temporary closure of the cells that have filled up to the certain level. More specifically, the waste in the landfill, due to geotechnical restrictions, will be laid in layers 15m thick. So, when in a cell the waste reaches the maximum height of the phase, it must be closed temporarily and move on to the next cell. It is easily deduced from the above that after the temporary closure of a cell, this has to stay for some years with the temporary cover. For this reason this temporary cover must be thicker and better constructed than the daily cover, in order to be resistant enough to erosion and reduce effectively the quantity of stormwater entering the waste mass and consequently producing leachate.

11.1.1.4 First layer of waste

The first layer is very crucial for the landfill operation. During the placement of the first layer, the following problems may occur:

- Damage to the lining system of the landfill.
- Disruption of the leachate collection system of the landfill.

The procedure for the right construction of the first layer is the following:

- The access road to the working face must be constructed from the top to the bottom in a way that ensures that the landfill vehicles will roll on soil ramps instead of the bottom of the landfill.
- At the end of the access road a relatively wide temporary area must be constructed for the manoeuvring of the trucks.
- The first trucks must dispose of the waste at the end of the access road or the temporary movement area on the landfill bottom.
- Bulky and wastes capable of puncturing the liner must be removed.
- The first waste should be disposed, at a vertical height of about 80 cm and **must not be compacted**, so as to constitute a protection – layer of the liner system.

The above procedure will cease when the whole area of the landfill bottom is covered with waste at a vertical height of about 80 cm, so that no landfill equipment will roll onto the liner or the drainage system of the landfill.

11.1.1.5 Danger of explosion

During all operations in the waste front which involve digging in the waste (landfilling, drillings etc.) the area around the working front must be monitored for methane concentrations higher than the Lower Explosive Limit (LEL). LEL for any gas is the lowest concentration of that gas in air that can result in an explosion if an ignition source is present. The LEL for methane is 4.4% in air (by volume). When this critical concentration of methane is reached, we say that 100% of the LEL has been reached and that there is immediate concern that an explosion could occur, particularly if the concentration develops inside a building or other confined space where ignition sources could be present. Ignition sources could be e.g. the hitting of the blade of the compactor on a metallic object. Usually, all operations in the landfill are stopped far below 4.4 % is reached.

11.1.1.6 Litter control

Litter must also be controlled and is the main complaint of nearby residents. Litter results from delivery of uncovered loads, wind, and operational practices. The most common control method is the placement of portable screens near the working face. Other mitigation methods may include more frequent covering of waste on windy days, requiring all delivered loads to be covered, collecting litter as necessary, unloading waste on a minimal surface area, and operating the working face so as to minimize wind disturbance (creating it in the opposite direction of the wind). Whenever fences are used, frequent cleaning of the fences is needed in order to minimize their vulnerability to being damaged from strong winds.

11.1.1.7 Dust control

Dust problems are caused by earthmoving and compaction activities, wind, and traffic on roadways. Excessive dust can cause health problems for landfill employees (allergic reactions), increases in equipment maintenance costs and frequency, and nuisances for nearby residents. The most common control measure is to spray access roads with water.

Other methods to control dust include using dust-free roads (i.e. asphalt), enforcing speed limits via speed bumps, using vegetation to reduce wind speed at ground level, and selecting an appropriate time to move soils to minimize the amount of dust (McBean et al., 1995).

11.1.2 Maintenance Procedures

Mechanical equipment:

All mechanical equipment must be maintained according to the specifications described in their operation manuals that will be provided to the operator by the Contractor. The Contractor will be responsible for the proper training of the employees of the Operator on the use of the particular equipment.

Bottom Lining:

The lining system can be affected very easily by various environmental factors such as the sun, the wind and also by strain caused by differentiations settlements or bruises by mechanical equipment. For these reasons proper care of the lining system must be taken in order to avoid its destruction.

In case a torn part is encountered, there must be enough material properly stored in the site for the repair of the damage.

Hydraulic systems operation and maintenance:

All ditches, pipes and manholes must be inspected regularly (twice per month during rainy periods and once per two months the arid season). If debris and other material is found they must be cleaned thoroughly in order to avoid clogging.

11.2 ENVIRONMENTAL MONITORING & POST-CLOSURE CARE PLAN

11.2.1 General Description

Post-closure care involves the routine inspection of the closed landfill site, maintenance of the infrastructure, and environmental monitoring.

The environmental monitoring actions are related to the environmental control that should be exercised on the responsibility of the Managing Agency of the landfill during the period of Operation and Post-closure care.

The sanitary landfill site must be monitored both during operation and for many years after its closure. Monitoring is based on observation of the correct operation of all infrastructure and the possible effects on the surrounding areas and population. In terms of the monitoring, a minimum program of measurement of parameters (during operation and after closure) is determined. Monitoring ensures the effective protection of the environment by the landfill infrastructure and it can help prevent the spreading of pollution or contamination if an unexpected event happens.

The overall monitoring system of the landfill will consist of the following parts:

- Groundwater monitoring system (vadoze zone & groundwater)
- Surface water monitoring system
- Air quality monitoring system
- Settlements monitoring system.

The monitoring of the relevant parameters will show the condition of the aforementioned areas of interest and the frequency of the sampling is shown in the table below:

Table 10: Environmental monitoring program

	POST CLOSURE CARE ACTIONS	MONITORING FREQUENCY
1	Leachate volume	every six months
2	Leachate composition	every six months
3	Surface water quality	every six months
4	Groundwater level	every six months
5	Groundwater quality	every six months

	POST CLOSURE CARE ACTIONS	MONITORING FREQUENCY
6	Gas emissions (CH ₄ , CO ₂ , O ₂ , H ₂ S, H ₂) and atmospheric pressure	every six months

All data collected from the monitoring systems must be kept in appropriately organized records, reviewed and analyzed regularly, in order to take promptly appropriate remedial measures.

It is proposed by the Consultant that the implementation of the environmental monitoring program will begin together with the initiation of construction works in order to collect data on the existing conditions of the environment prior to the operation of the new landfill site.

11.2.2 Air Quality Monitoring

As described in previous chapters of the present report, the proposed biogas collection and management system ensures that no uncontrolled escape of landfill gas to the atmosphere will take place.

However, landfill gas levels should be measured at the landfill area as well as in the surrounding area taken by using portable gas detectors, to monitor biogas levels in the air and minimize the possibility of unforeseen situations (e.g. explosions). The gas detecting devices should be appropriate for use for gas controlling in landfills. It should detect gases such as methane, CO₂, CO etc in range 0-5% and provide accurate measurements even in the presence of other gases.

At the landfill area the biogas levels will be measured at the location of the monitoring wells that have been installed onsite during the geotechnical campaign conducted by the Consultant. In addition air quality measurements should be taken at the area around the landfill to ensure that no migration of any possible biogas quantities has occurred.

11.2.3 Ground Water Monitoring

Groundwater quality could be controlled by taking samples from the nearest irrigation and water supplying wells located upstream and downstream of the site.

The water samples analysis ~~will be~~ will be conducted in accredited private laboratories or competent state agencies properly equipped. The analysis will include the following parameters:

- pH
- COD
- BOD
- Conductivity
- Turbidity
- Temperature
- Phenols
- As

- Cd
- Cu
- Hg
- Zn
- Volatile cyanides
- Fluorides
- Total Phosphorus
- Nitrogen
- Total, suspended and dissolved solids

A strict protocol will be followed during the sampling / measurement / analysis of groundwater levels & quality according to international standards. All data and procedures will be recorded and kept in organized files.

It is very important that the personnel responsible for collecting and handling samples maintain protocols for ensuring that the water samples do not degrade while they are being transported to the laboratory.

11.2.4 Surface Water Monitoring

The monitoring of surface water quality, as well as of all the other parameters, will be exercised by the Managing Agency of the new landfill site by taking samples from the perimetric stormwater drainage ditch of the landfill in at least two points, one upstream and one downstream of the site. The monitoring frequency will be every six months, and the control parameters are identical to those of groundwater described above.

11.2.5 Waste relief settlements monitoring

Settlement is an important parameter to monitor because of its impact on landfill cap integrity. The cap functions to ensure long-term integrity and to support post-closure uses of the landfill site, such as maintaining a vegetative layer. The cap must be maintained to prevent loss of soil via an effective stormwater management plan.

In order to measure settlements, the so-called “settlement plates” are installed on the waste surface (in the areas where final waste height has been reached).

The number of required settlement indicators at the cap of the new landfill site is 4.

These plates include a steel plate (square 1m x 1m x 4 mm thickness) where a steel pipe (2” diameter) is welded. The base of the settlement plates is installed 0.5 m underneath the final surface of the final cover, secured in its position by a layer of concrete (thickness 20 cm).

The iron pipe is used to measure height reduction. The elevation of the pipes is measured and compared with the elevation of stable points.

A section of the settlement plate to be used on site is presented in the following figure.

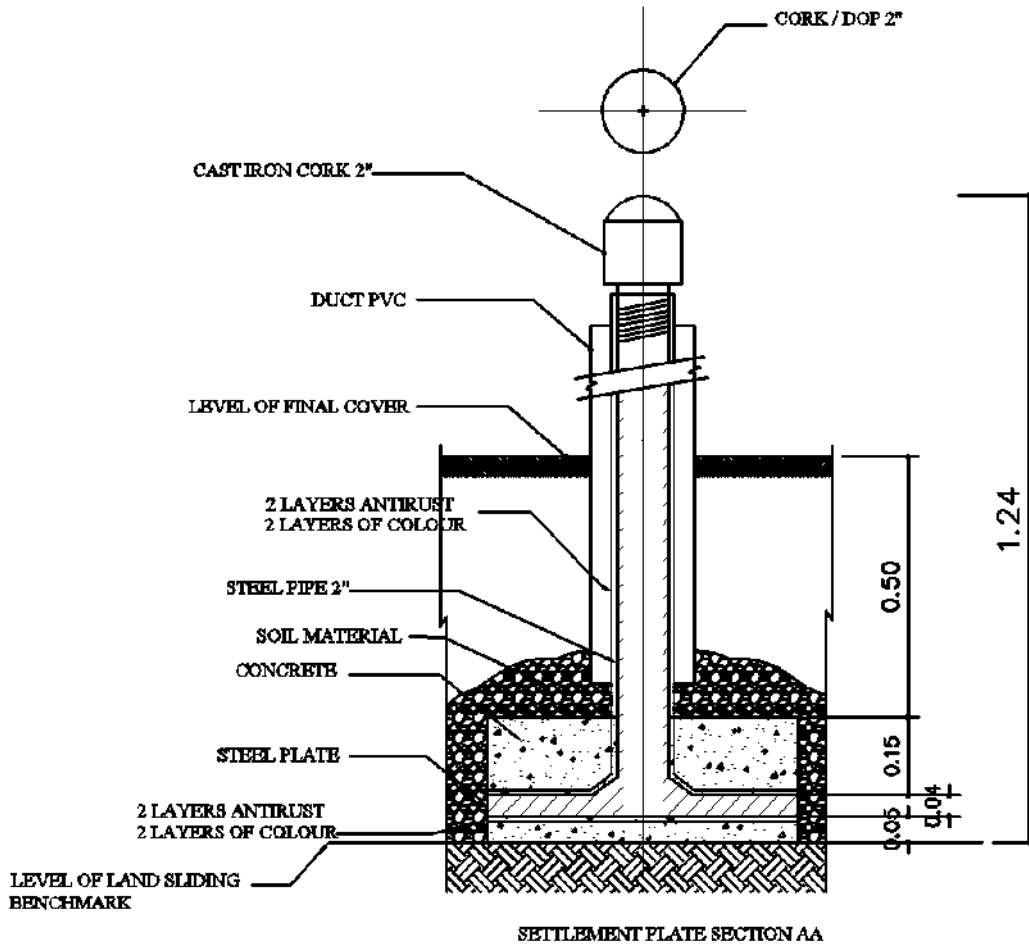


Figure 11-1: Section of settlement plate

11.2.6 Vegetation Post Closure Care Actions

First of all, it is of substantial importance to note that grazing shall be prohibited at the entire revegetated area. Grazing animals should be fenced off the restored landfill, as grazing will enhance instability and erosion of the topsoil. In addition, several of the plant species may not be suitable for pasture. Furthermore, vehicle and pedestrian access should be also restricted while restoration is in progress.

For at least two to three years after revegetation, the landfill facility should be checked periodically to ensure vegetation reestablishment and to monitor any erosion or settling of the final cover. Evaluation for establishment can start at any time during the second growing season.

To be considered established, a grass plant must have a well-developed root system and should exhibit signs of tillering (shoot growing from the base of a stem, especially the stem of a grass) or rhizome (thick underground horizontal stem that produces roots and has shoots that develop into new plants) development.

A sustainable monitoring target is a goal for total vegetation groundcover of 70% (including litter cover and current year live vegetation basal cover). It has been seen that at 70% groundcover the following parameters are met:

- Runoff water loss = 10mm per year.

- Soil loss = 0.3mm per year.
- Good plant production and sustainability.
- High green leaf and plant vigor.
- High water infiltration.
- Plant bases protected from temperature extremes.
- High litter levels.
- Good microbial activity.
- High organic matter content.
- Good soil structure and soil surface.

In addition to the general target of 70% total groundcover, a minimum of 30% relative foliar cover of live desired species (seeded or nonseeded native species) must be met. Relative cover is defined as the percentage of cover of a given species divided by the total amount of vegetation cover present. A minimum of 50% of the seeded native species will be present at the revegetation site. No single species will contribute more than 45 percent of the relative foliar cover.

In case of poor vegetation establishment, soil pH, organic matter, humidity, nutrients and potential aggressive invasive species will need to be examined and treated with the appropriate measures (soil enhancement, irrigation, additional seed sowing).

One aspect that needs to be thoroughly checked and revised in case of poor vegetation establishment is biogas production. Despite the fact that a biogas management system is planned, gas might be produced in uncontrolled manner (e.g. in case of slits in the sealing cover) and contribute to erosion, soil runoff and the establishment of anaerobic conditions in the soil. If such case occurs, biogas management should be revised and revegetation procedures should be repeated where needed.

The closed landfill should continue to be monitored on a less frequent basis for 5-10 years after site closure, particularly after significant rainfall events. These inspections also are needed to check for dead or stressed vegetation due to landfill gas, leachate seepage, significant erosion, etc.

11.2.7 Restriction of Further Waste Disposal

Signs, lighting, and barriers can restrict unauthorized waste dumping in a given area. In addition, a security system has to be in place that will operate after closure of the site in order to prevent entrance of unauthorized vehicles. Also a plan needs to be in place to maintain the area and to promptly remove any materials that are dumped.

The adoption of certain measures is very important in order to prevent the pollution. These measures have to deal with all sources and all causes of pollution, because the most feasible option is prevention and not rehabilitation. The E.U. experience on the subject will be very useful to Georgia for the solution of this problem. E.U. bases its strategy and practice to the "Polluter Pays" principle. This means that the polluter, whichever he is (industries, municipalities, businesses etc) has to contribute financially to the management of the waste that he produces and to the mitigation of the adverse effects of the pollution he produced. This principle together with a strict legal framework and the funding of relevant public agencies or authorities which will

enforce the aforementioned rules will avert drastically the uncontrolled and illegal dumping of waste all over the country.

Consequently the State must take measures for creating the required infrastructure for integrated solid waste management and on the same time to create a mechanism for the prevention, detection and punishment of illegal polluters.

11.3 HEALTH AND SAFETY MANUAL

11.3.1 Introduction

This section sets out the basic requirements of the effective control of health and safety at the site. It constitutes general guidance which should be considered and enacted by site operators.

The works described in the present study shall be executed in a safe manner, according to the laws and decrees of Georgia, as well as the relevant international standards for safe operations in landfill construction sites.

Accidents can be minimized by the implementation of safety and training programmes and by effective site management. These programmes should include the following:

- identification of potential sources of risk;
- assessment of the degree of risk from these sources;
- determination of procedures for addressing the risks;
- development of procedures to minimize accident/risks when they occur; and
- on-going monitoring to ensure proper implementation of safe working procedures.

More specifically, the dangers for the personnel working on site have to do with:

1. Waste handling and moving (risk for explosion, risks for contamination after direct contact with waste etc) and
2. Excavation works and operation of large vehicles (collisions, crushing accidents etc)

11.3.2 Accidents related to Excavation Works

➤ Fatalities

A significant number of deaths and injuries in landfill site construction are directly related to excavation and trenching.

Trenching fatalities are mainly caused by cave-ins. Death occurs by suffocation or crushing when a worker is buried by falling soil.

Over half of all powerline contacts involve buried cable. Before excavating, the gas, electrical, and other services in the area must be accurately located and marked. If the service poses a hazard, it must be shut off and disconnected.

➤ Injuries

The following are the main causes of lost-time injuries in the excavation works:

- materials and equipment falling into a trench

- slips and falls as workers climb on and off equipment
- handling and placing pipe and other heavy materials
- being struck by moving equipment
- falls as workers climb in or out of an excavation
- falling over equipment or excavated material
- falling into a trench

11.3.3 Protection against Cave-Ins

There are three basic methods of protecting workers against trench cave-ins:

- sloping
- trench boxes
- shoring

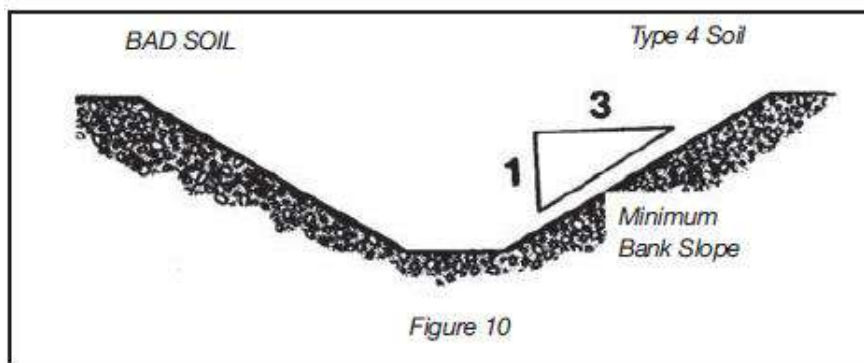
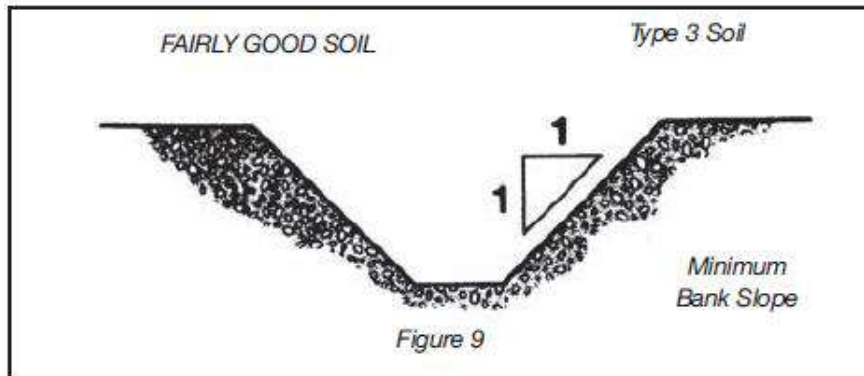
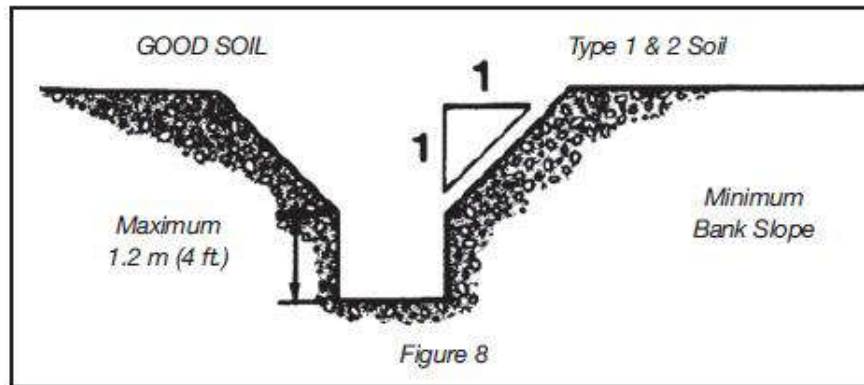
Most fatal cave-ins occur on small jobs of short duration such as service connections and excavations for drains and wells. Too often people think that these jobs are not hazardous enough to require safeguards against collapse.

Unless the walls are solid rock, never enter a trench deeper than 1.2 metres (4 feet) if it is not properly sloped, shored, or protected by a trench box.

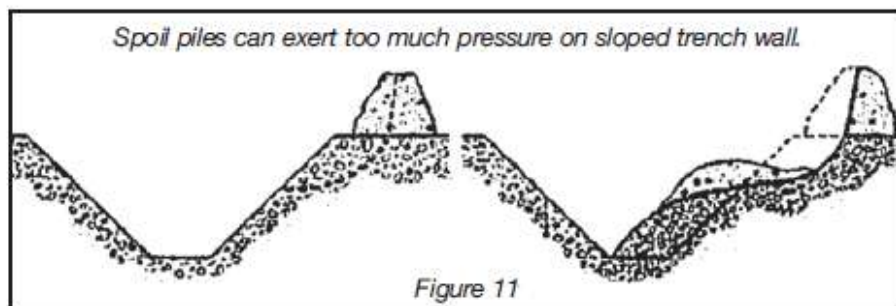
- Sloping:

One way to ensure that a trench will not collapse is to slope the walls.

Where space and other requirements permit sloping, the angle of slope depends on soil conditions (see following figures).



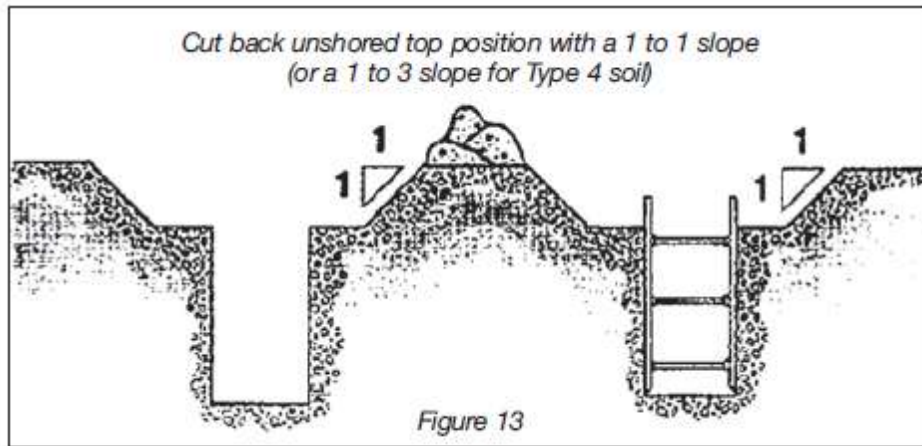
Although sloping can reduce the risk of a cave-in, the angle must be sufficient to prevent spoil not only from sliding back but also from exerting too much pressure on the trench wall (see figure 11 below).



Sloping is commonly used with shoring or trench boxes to cut back any soil above the protected zone. It is also good practice to cut a bench at the top of the shoring or trench (Figure 12).

Moisture affects stability, especially where heavy rainfall has occurred.

If sloping is to be used above a trench box, the top portion of the cut should first be sloped 1 to 1 (or 1 to 3 for bad soil — see previous page). Then the box should be lowered into the trench (Figure 13).



- Trench boxes

Trench boxes are not usually intended to shore up or otherwise support trench walls. They are meant to protect workers in case of a cave-in.

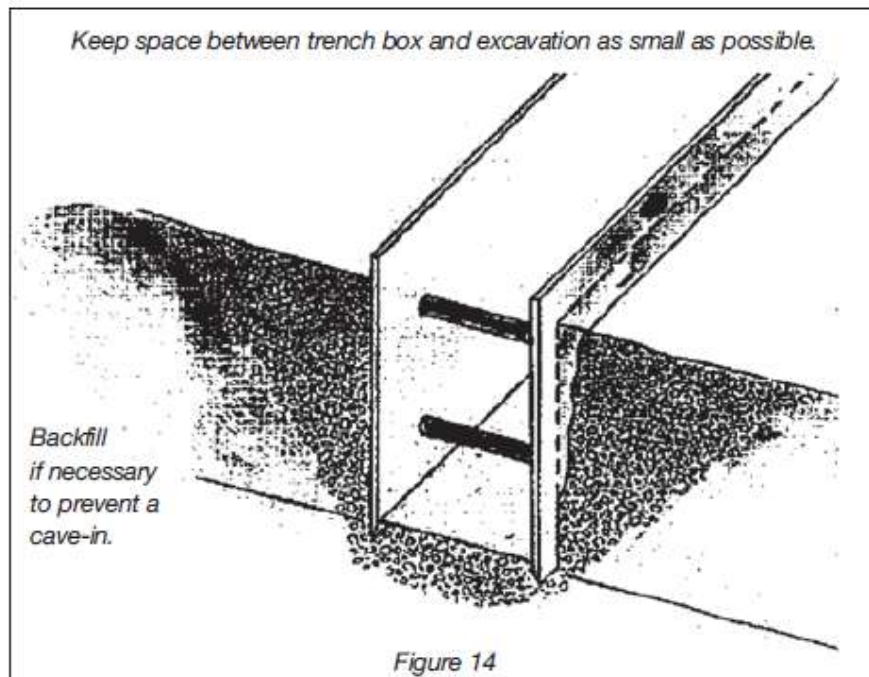
Design drawings and specifications for trench boxes must be signed and sealed by the professional engineer who designed the system and must be kept on site by the constructor.

Boxes are normally placed in an excavated but unshored trench and used to protect personnel. A properly designed trench box is capable of withstanding the maximum lateral load expected at a given depth in a particular soil condition.

Trenches near utilities, streets, and buildings may require a shoring system.

As long as workers are in the trench they should remain inside the box. Workers must not be inside the trench or the box when the box is being moved. A ladder must be set up in the trench box at all times.

Excavation should be done so that the space between the trench box and the excavation is minimized (Figure 14).



The two reasons for this are:

- 1) allowing closer access to the top of the box
- 2) limiting soil movement in case of a cave-in.

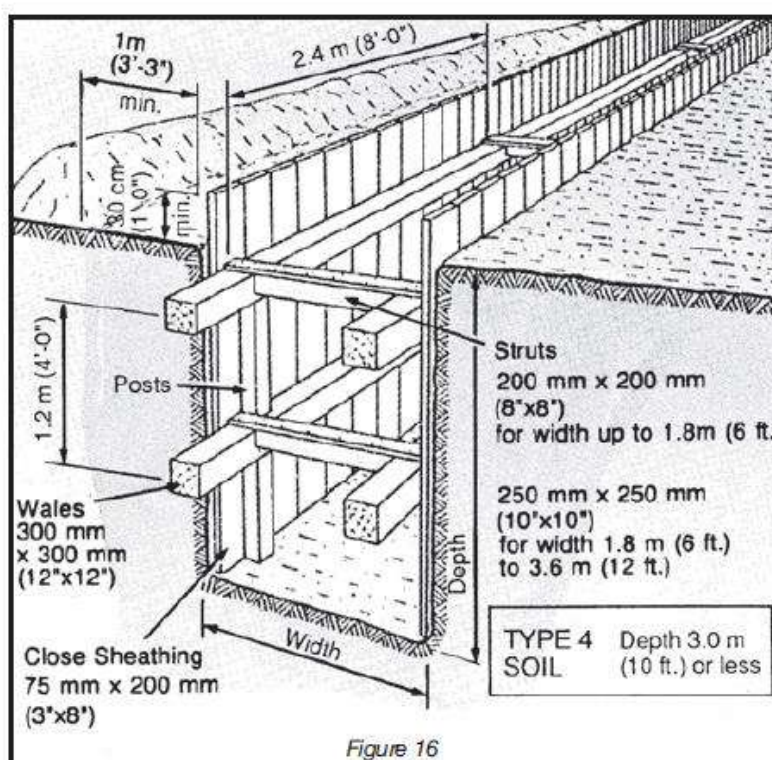
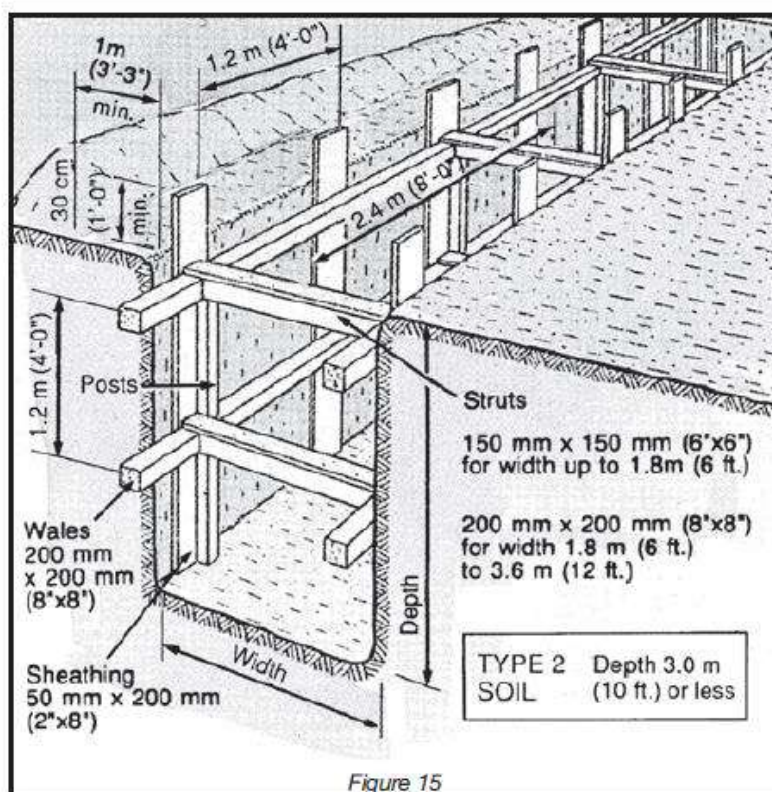
- Shoring

Shoring is a system which “shores” up or supports trench walls to prevent movement of soil, underground utilities, roadways, and foundations.

Shoring should not be confused with trench boxes. A trench box provides worker safety but gives little or no support to trench walls or existing structures such as foundations and manholes.

The two types of shoring most commonly used are timber and hydraulic. Both consist of posts, wales, struts, and sheathing.

Figures 15 and 16 identify components, dimensions, and other requirements for timber shoring in some typical trenches.



Keep space between trench box and excavation as small as possible.

11.3.4 Other Hazards and Safeguards

Injuries and deaths are also related to six other major areas:

- personal protective equipment;

The PPE will be distributed to the personnel before they take on their duties. The distribution of the PPE requires authorization by the supervising engineer. The on-site Safety Managers will supervise the use of the PPE and any problems will be reported. During the distribution, the employees will be informed about the risks that face, as well as about the use, maintenance, storage, replacement and final delivery of the PPE.

The conditions under which personal protective equipment is used, especially in respect with the time during which the employee must wear this equipment, are determined by the severity of the risk, the frequency of exposure to the risk, the characteristics of each employee's work position, as well as by the efficiency of the personal protective equipment. The use of PPE is mandatory (in work positions where the use of PPE is stipulated) and in case it is not used, the reason will be analyzed and investigated, in order for the problem to be solved.

For the proper selection of personal protective equipment, the risk, the duration of the employees' exposure to the risk and the exposure duration must be specified beforehand with accuracy.

All equipment must be used according to the manufacturer's instructions. All instructions are clear concise with user-friendly instructions understood by all personnel required to use this equipment.

The Contractor H&S engineer will inspect the quality and functions of the equipment and inform personnel regarding any deficiencies. If equipment is unsuitable it is immediately exchanged for new equipment. He will also be responsible for training and proper use of the health and safety equipment. Below is a partial list of the health and

- Half face mask respirator
- Full face mask respirator
- Protective gloves
- Protective glasses
- Tyvek protective working suits
- Jackets and pants with reflective colors
- Protective helmets
- Protective boots
- Protective belts
- Safety goggles
- Safety shoes
- Portable gas detectors

Everyone on a construction project must wear safety boots certified. They should have steel toecaps and have a steel insert in the sole to resist injury from projections of glass, metal or other items in the deposited wastes.

It is mandatory for everyone on a construction project to wear head protection in the form of a hard hat that complies with the current Regulations.

Eye protection is strongly recommended to prevent injuries from construction operations such as chipping and drilling and site conditions such as dust.

Personnel exposed for long periods to noisy equipment should wear hearing protection.

Work in confined spaces such as manholes and valve chambers may require respiratory protection against hazardous atmospheres. See the paragraph on protection against explosion for more information.

High visibility clothing should be provided and worn by all site staff and visitors.

Gloves should be issued as required. The type of glove should be puncture resistant and should be suitable for the relevant task, eg litter collection, vehicle fuelling, cold weather conditions.

Operatives at landfill sites work in all weather conditions and will need to be provided with suitable windproof wet weather clothing.

ii. Underground utilities

Services such as gas, electrical, telephone, and water lines must be located by the utility before excavation begins.

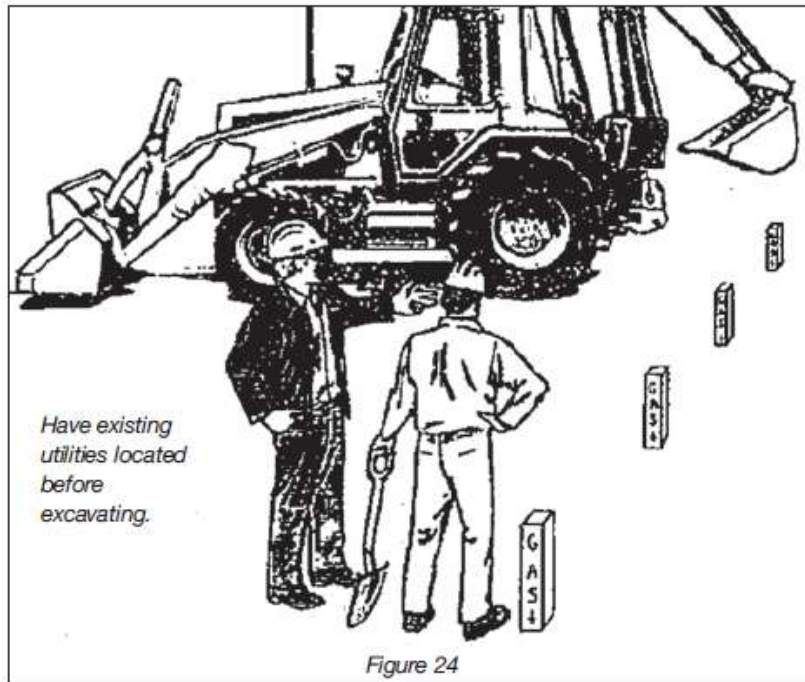
Request locates for all the underground utilities in the area where excavation will be taking place. The contractor responsible for the work must contact the owners of any underground utilities that may be in that location.

The service locate provided by the utility owner should indicate, using labeled stakes, flags, and/or paint marks, the centre line of the underground utility in the vicinity of the proposed excavation.

The excavator should not work outside of the area covered by the locate stakeout information without obtaining an additional stakeout.

Locate stakeout accuracy should be considered to be 1 metre on either side of the surface centre line locate unless the locate instructions specifically indicate other boundary limits.

Where the underground utility cannot be located within the locate stakeout limits, the utility owner should be contacted to assist with the locate.



Mechanical excavation equipment should not be used within the boundary limits of the locate without first digging a hole or holes using the procedure below to determine the underground utility's exact centre line and elevation.

Test holes should, in general, be excavated by one of the following methods:

(a) machine excavation immediately outside the boundary limits and then hand digging laterally until the underground utility is found; or

(b):

(i) hand excavation perpendicular to the centre line of the locate in cuts of at least 1 foot in depth;

(ii) mechanical equipment can then be used carefully to widen the hand-dug trench to within one foot of the depth of the hand-dug excavation;

(iii) repeat steps (i) and (ii) until the utility is located; or

(c) a hydro-excavation system — acceptable to the owner of the utility — which uses high-pressure water to break up the cover material and a vacuum system to remove it can be used to locate the underground utility. See the next section for more information about hydro excavation.

Centre line locates should be provided and test holes dug where a representative of the utility identifies:

(a) alignment changes and

(b) changes in elevation.

Where an underground utility may need support or where it may shift because of disturbance of surrounding soil due to excavation, guidelines for excavation and support should be obtained from the owner of the utility.

iii. Hydro excavation — Precautions

- Before starting work, use barricades and signs to inform unauthorized personnel to keep out.
- Employers must ensure that workers are properly trained on the machine they are using.
- When exposing underground power utilities the operators should use bonding mats.
- Use a fall-protection system when required.
- Keep clear of the vacuum. It is powerful and can cause serious injury or even death if you are caught in the tube.
- Some utility owners set limits for the water pressure that can be used near their buried plan. Check with the utility owner before excavating.
- Keep away from the operation if you are not directly involved in the work.
- Wear hearing protection if working in vicinity of the hydrovac truck.
- Be aware of the hazards, such as slips from the runoff water and ice during the winter.
- Wear appropriate eye and face protection such as safety glasses and faceshields. They will protect you from getting any airborne debris (caused by splashing) in your eyes.
- Keep clear of the vacuum. It is powerful and can cause serious injury or even death if you are caught in the tube.

iv. Materials handling

Many lost-time injuries in landfill construction sites involve materials handling. Moving rock and soil, lifting pipe and manhole sections, laying down bedding material, or lowering pumps and compactors into the trench can all be hazardous.

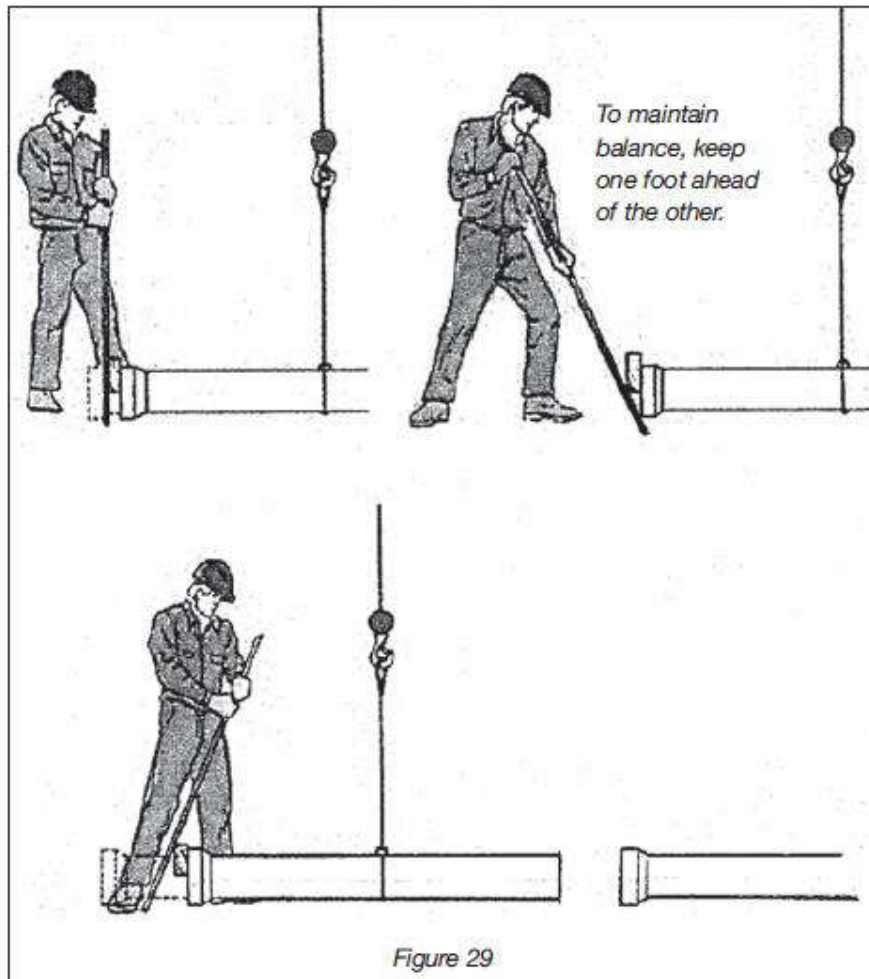
Pipe — Trucks should always be on level ground when pipe is unloaded. Pipe should be chocked or staked before tie-downs are released. These measures will reduce the risk of sections rolling off the truck.

Plastic and small diameter pipe is often banded with metal straps. Be careful cutting the straps. They are under tension and can fly back and hit you.

Personnel often injure fingers and hands when laying and joining sections of pipe. While sections are suspended from hoisting equipment, keep hands away from slings or chokers in tension.

When guiding and pushing sections together by hand, never curl fingers around ends or flanges. As pipe is placed along the trench, each section should be blocked or set so that it cannot roll and cause injury.

Back injuries can occur when small-diameter pipe is being hoisted into position (Figure 29).



The worker pushing the bar should place his feet directly in front of the pipe with one foot ahead of the other.

Large-diameter pipe should be placed with pipe pullers (Figure 30).

v. Bedding material — Personnel shovelling

Bedding material in the trench are usually working in a confined area where footing is muddy and uneven.

The result can be overexertion or slips and falls leading to back and other injuries. Mechanical equipment can significantly reduce this hazard. For instance, bedding material can be put in the excavator bucket with a front-end loader, then spread evenly along the trench bottom.

Rigging is essential to safe, efficient materials handling since pipe, manhole sections, and equipment are lowered into the trench by cranes or other hoisting devices. Rigging these loads properly can prevent injury.

When using wire rope slings, inspect for broken wires, worn or cracked fittings, loose seizings and splices, flatening, and corrosion.

Knots or kinks indicate that wire rope slings are permanently damaged and should not be used.

Damage most often occurs around thimbles and fittings. Don't leave wire rope lying on the ground for any length of time in damp or wet conditions.

vi. Housekeeping

Accident prevention depends on proper housekeeping at the site.

At the top of heights the area must be kept clear at least 1 metre (3 feet) away from the edge in order, sections of pipe, unused tools and timber, piles of spoil, and other material not to fall.

The slips and falls common on excavation projects can be reduced by cleaning up scrap and debris. Trenches should also be kept as dry as possible. Pumps may be required.

Proper housekeeping is especially important around ladders. The base and foot of the ladders should be free of garbage and puddles. Ladders should be tied off at the top, placed in protected areas, and inspected regularly for damage.

vii. Heavy equipment

Excavators, backhoes, and other heavy equipment can cause injuries and fatalities to operators and personnel on foot.

Reversing vehicles and equipment on construction projects pose a serious problem for personnel on foot. Fatal accidents resulting from workers being backed over by dump trucks and other equipment occur all too frequently. Anyone on foot in the vicinity of reversing vehicles and equipment is at risk.

The main problem with reversing vehicles and equipment is the driver or operator's restricted view. Around dump trucks and heavy equipment such as bulldozers and graders there are blind spots where the operator has no view or only a very limited view.

The operator may not see someone standing in these blind spots. Anyone kneeling or bending over in these areas would be even harder to see.

Consequently the driver or operator must rely on mirrors or signallers to back up without running over someone or into something. The figure in the following page shows the blind spots for common types of construction equipment.

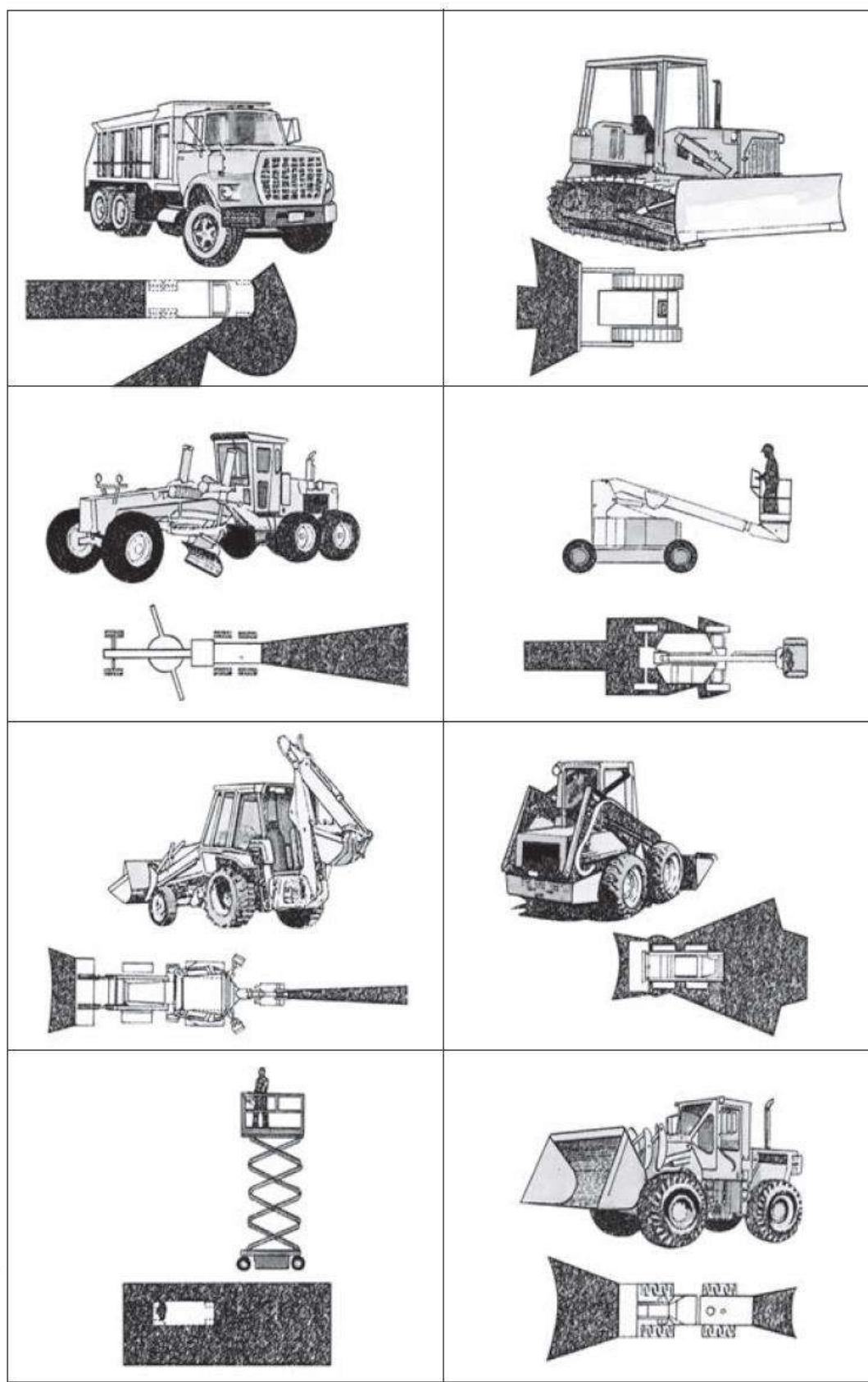


Figure 11-3: Blind spots for various equipment

Dump trucks and cranes are the kinds of equipment that hit overhead power lines most often. Beware of power line contact whenever a crane, dump truck, or other vehicle is going to be operated near an overhead electrical conductor. If equipment operates within reach of (and could therefore encroach on) the minimum permitted distance from an overhead power line, the constructor is required to have written procedures in place to prevent the equipment from encroaching on the minimum distance.

Back-up alarms are required on dump trucks and recommended for all moving equipment. Where vehicles have to operate in reverse, warning signs must be conspicuously posted.

Ground rules for truck drivers

- Understand and obey the signaller at all times.
- Remain in the cab where possible.
- Ensure that mirrors are clean, functional, and properly adjusted.
- Do a circle check after being away from the truck for any length of time (walk around the truck to ensure the area is clear before moving).
- Stop immediately when a signaller, worker, or anyone else disappears from view.

On most instances, a signaller or spotter must be present when:

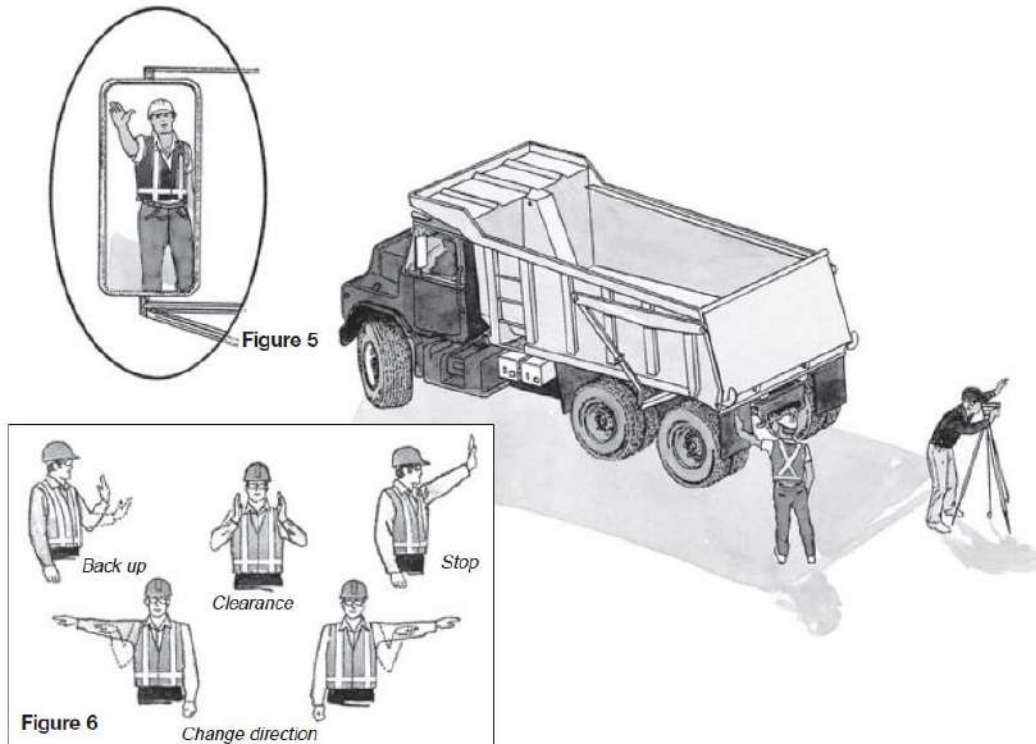
- a) a vehicle or equipment operator's view of the intended path of travel is obstructed
- b) a person could be endangered by the operation of the vehicle or equipment, or by its load
- c) any part of the equipment could encroach on the minimum distance to an overhead power line.

A signaler must be a competent worker and must not have any other duties to fulfill while acting as a signaler. Before a worker can act as a signaler, the employer must ensure that the worker has been given adequate oral and written instructions in a language that he understands. The employer must keep, on site, a copy of the written instructions and a record of the training.

A signaler must wear a garment – usually a nylon vest – that is fluorescent or bright orange, with 2 vertical 5- centimeter-wide yellow stripes on the front and 2 similar stripes forming a diagonal "X" pattern on the back. These stripes must be retro-reflective and fluorescent. The vest must have an adjustable fit and have a front and side tearaway feature.

If a signaller has to work during the night, he must wear retro-reflective silver stripes around each arm and leg. The signaller must maintain clear view of the path that the vehicle, machine, or load will be travelling and must be able to watch those parts of the vehicle, equipment, or load that the operator cannot see. The signaller must maintain clear and continuous visual contact with the operator at all times while the vehicle or equipment is moving, and must be able to communicate with the operator using clearly understood, standard hand signals. The signaller must warn other

workers on foot of the approaching vehicle or equipment, and must alert the operator to any hazards along the route.



Workers on foot — Personnel on foot are frequently stuck by machine attachments such as excavator buckets and bulldozer blades when they stand or work too close to operating equipment, especially during unloading and excavation.

Workers on foot are also injured and killed by equipment backing up.

Ground rules for workers on foot

- Beware of common operator blind spots.
- Stay alert to the location of equipment around you.
- Avoid entering or standing in blind spots.
- Always remain visible to the operator. Make eye contact to ensure that you are seen.
- Never stand behind a backing vehicle.
- Remember — the operator may be able to see you while you are standing but not when you kneel down or bend over.

viii. Vehicle traffic

The maximum velocity allowed at the work sites, for vehicles owned by the Contractor and his sub-contractors is 10 km/h.

ix. Danger of explosion

During all operations in the waste area which involve digging in the waste (moving of waste, drillings etc.) the area around the working front must be monitored for methane concentrations higher than the Lower Explosive Limit (LEL). LEL for any gas is the lowest concentration of that gas in air that can result in an explosion if an ignition source is present. The LEL for methane is 4.4% in air (by volume). When this critical concentration of methane is reached, we say that 100% of the LEL has been reached and that there is immediate concern that an explosion could occur, particularly if the concentration develops inside a building or other confined space where ignition sources could be present. Ignition sources could be e.g. the hitting of the blade of the compactor on a metallic object. Usually, all operations in the landfill are stopped far below 4.4 % is reached.

All site staff should be made aware of the possible hazards from landfill gas. Smoking on site should be forbidden except in designated areas in the site cabins. Buildings and other enclosed structures located at the landfill should be designed to prevent the accumulation of flammable gas within them.

Facilities to permit the free circulation of fresh air will generally be required, particularly under floors. It is imperative that all cabins, other store rooms and voids such as those below weighbridges and cabins should be regularly monitored for the presence of flammable gas. All service duct entries to buildings should be seen as possible gas pathways and hence appropriately monitored.

Where it has been established that concentrations of landfill gas are above 20% of the lower explosive limit (LEL), the relevant building should be evacuated. Where this level has been observed within site buildings, the installation of continuous landfill gas monitors and an audible alarm is essential. Extreme care should be taken when reentering buildings which have been previously evacuated. Procedures for the evacuation and reentry of buildings when significant amounts of landfill gas have been observed should be contained in the operator's safety statement.

The unnecessary creation of enclosed spaces on site, such as by inversion of a skip for maintenance, should be avoided on all landfills. Lighting columns may permit the accumulation of landfill gas. Hence they should be sealed at the base and should contain intrinsically safe electrical equipment. Health and safety issues should have particular priority where any site works involves the disturbance of filled areas. In particular, drilling in deposited wastes may give rise to the evolution of noxious and/or combustible gases. Hence regular checks on gas build-up should be made as drilling proceeds. Similarly, any trenches constructed for the purposes of gas collection pipes will need to be physically stable and also monitored for landfill gas.

On no account should persons enter trenches or other confined spaces without gas monitoring, rescue and other appropriate safety measures. All contractors should be aware of the hazards of working on landfill sites and be suitably experienced to address them.

Instructions should be issued to all employees that no-one should enter any confined space below ground level, such as culverts and manholes, unless an appropriately authorised person has certified that it is safe to do so. Safety precautions for areas where gas may accumulate require that:

- only persons with appropriate experience and training should be involved in entering confined spaces or providing back-up on the surface;
- smoking should not be allowed;
- persons entering a manhole should be equipped with self-contained breathing apparatus;
- persons entering a manhole should have a safety harness and appropriate line manned by at least two other employees;
- other employees at the surface should have spare breathing apparatus and the requisite training in its use; and
- lights or tools to be used in manholes should be intrinsically safe.

If there is any doubt as to safety of an enclosed space, it should not be entered.

11.3.5 Common Landfill Operations

A. Site entrance

Safety measures during waste trucks' entrance in the landfill involve employees and third persons. Measures include:

- Keeping track records of vehicles entering and leaving the site.
- Being aware of pedestrians and vehicles that use the site at the time.
- Following signage or traffic instructions within the site.
- Making sure the vehicle is safely placed on the weighbridge
- No unauthorized persons allowed entering the vehicle cabin.
- Vehicle cabin doors shall remain closed
- Vehicles shall move slowly to the unloading area only when drivers are instructed to. Otherwise they do not move the vehicles inside the landfill site.
- Safety closures of vehicles shall not be unlocked in the weighbridge area.
- Vehicles with containers will perform loading maneuvers only in specially designated areas.

B. Working Front

Safety measures during waste deposition at the active zone involve vehicle drivers and machine operators.

Measures for drivers include:

- Drivers will drive the vehicle at a speed 20 km/h or less, depending on road conditions.
- Drivers should expect instructions before arriving at the active zone.
- Drivers will keep their priority.

- Drivers will stop the vehicle at least two meters from working front.
- When drivers place the vehicle they shall leave adequate distance from other vehicles and pedestrians.
- The vehicles will be located in secure locations with raised handbrake and neutral gear.
- The driver shall exit the cab of the vehicle and unbar the rear only when vehicle is immobilized and secured.
- The drivers will not drive the vehicle to the work front with elevated superstructure (in case of non-compacting).
- Drivers will return slowly to the work front and will not be tilted out of the cabin door after unloading to inspect the rear of the vehicle.
- Drivers shall move at least 5 meters from the work front, snap the closures of the vehicle and then leave the area.
- If the vehicle is stuck during unloading, the driver will inform an instructor or the nearest operator.
- Special caution is demanded during night operations because of insufficient lighting.
- Drivers shall be responsible to report any suspicious and hazardous wastes, as well as any other particularity that can create problems in the disposal process (liquids, powders, etc.).

Measures for machine operators include:

- Operators should avoid the use of dozers or other laying – compacting machinery at steep slopes and especially downwards, because there is danger of tipping.
- Operators should work in a closed cabin so that the air supply is made through a special filter.
- Operators should use steps and handles for entering and exiting the machine
- Operators should maintain steps clean because there is a risk of slipping during the exit from machine and will not jump out of it.
- No one should ever get on a moving vehicle.
- Only authorized persons are allowed in the cabins of machines.
- Operators should keep the buckets and blades of machinery close to the ground when moving and lower them to the ground during parking
- Operators should avoid driving on the side surfaces of the landfill
- Operators should not crush sealed containers

C. Workshop Operations

Safety measures for employees working at the workshops include:

- Not using tools that do not have safety devices on.

- Wearing goggles when there is danger of splashing substances.
- Protecting cables from oils, chemicals and hot surfaces.
- Wearing appropriate personal protective equipment and suitable work clothing.
- Do not use a machine unless they are trained to.
- Always use the proper tools to perform their jobs.
- Storing cylinders containing flammable gases in a safe place.
- Driving the machinery or truck to the maintenance ramp under the supervision of a technician.
- Performing maintenance only while the vehicle is stationary and insured.
- Not smoking when handling or using flammable materials.
- Maintaining the workplace clean from oil residues to prevent falls.
- Taking precautions when handling compressed air devices.

11.3.6 Emergency Procedures

Emergency telephone numbers — ambulance, fire, police, local utilities, senior management, should be posted in the field office for quick reference.

If someone is seriously injured, take the following steps.

- 1) Protect the area from hazards.
- 2) Prevent further injury to the casualty.
- 3) Administer first aid.
- 4) Call an ambulance or rescue unit.
- 5) Have someone direct the ambulance or rescue unit to the accident scene.

All projects must have a person qualified and certified to provide first aid.

Cave-ins - It is natural to try to rescue casualties caught or buried by a cave-in. But care must be taken to prevent injury and death to rescuers, whether from a further cave-in or other hazards.

The following procedures may be suitable, depending on conditions.

- 1) To get down to the casualty, use a tarpaulin, fencing, plywood, or similar material that can cover the ground and will ride up over any further cave-in.
- 2) Sometimes a further cave-in can be prevented by placing a backhoe bucket against the suspected area or excavating it.
- 3) Rescue workers should enter the trench with ropes and wear rescue harnesses if possible.
- 4) To prevent further injury, remove the casualty by stretcher whenever possible. Tarps or ladders can be used as a makeshift stretcher.
- 5) Stabilize the casualty.

Breathing — Ensure that the casualty is breathing. If not, open the airway and start artificial respiration immediately. Mouth-to-mouth is the most efficient method.

Bleeding — Control external bleeding by applying direct pressure, placing the casualty in a comfortable position, and elevating the injured part if possible.

Unconsciousness — This is a priority because it may lead to breathing problems. An unconscious person may suffocate when left lying face up. If injuries permit, unconscious persons who must be left unattended should be placed in the recovery position.

11.3.7 Training

Contracting company should provide suitable training and instruction to site employees, both full time and part time. The operator should also ensure that any contractor working on site is also informed of the hazards and the necessary precautions. There is also a responsibility for persons employing contractors to ensure that the latter are able to act as competent project supervisors in relation to the safety aspects of the relevant design and construction elements of their work.

All site personnel should be familiar with contingency procedures in the event of accident, injury, fire etc. The locations of emergency equipment should be identified during routine employee training. Phone numbers for local police, fire and ambulance services should be prominently displayed for use in the event of an emergency.

11.3.8 Staffing Levels

All staff and users of the site should be effectively supervised. No site open to receive waste should be manned by one member of staff working on their own. Similarly no unloading of vehicles should occur in the absence of site staff or out of their immediate view.

11.3.9 Medical Care

Good personal hygiene is essential to workers on landfill sites and hence hot and cold washing facilities must be provided. All workers at landfill sites, including those employed temporarily by the operator or by contractors working on the site, should have adequate protection against tetanus. This protection must be kept up to date, with boosters given at 10 yearly intervals. The onus should be on the employer to ensure that these injections have been received by employees and to require appropriate assurances from contractors working on the site.

11.3.10 First Aid

A first aid box should be available on site in a clearly marked location. The contents of the box should be monitored for use, so that supplies are checked regularly by a named individual responsible for its upkeep. Eye wash facilities also should be available: these should either employ running water or involve non-reusable eye wash bottles. Any bottle with a broken seal must be disposed of immediately and replaced. The operator should arrange for recognized occupational first aid training, with a minimum of one person with a first aid qualification normally present on site. All staff should be familiar with the first aid facilities available on site.

11.3.11 Site Infrastructure, Signs and Barriers

Steep gradients and sharp curves on site access roads should be avoided. If this is not possible warning signs and crash barriers must be provided. Speed limits should be displayed and enforced by the site operator. Vehicles should not travel over unstable areas on a landfill surface. Neither should they travel with their vehicle bodies raised up or being lowered.

Sites should be provided with adequate lighting to allow for safe and efficient operation at the tipping area at dawn and dusk in the winter period. Trenches and lagoons used for liquid or sludge disposal should be fenced or be clearly marked with poles and bunting and each trench should be labeled to indicate the type of wastes allowed to be deposited. When filled, trenches should be covered immediately. After filling, it may be desirable that the position of trenches remains clearly marked. Their soft nature, particularly when sludges have been deposited, may make them a hazard to site workforce, users and trespassers. Hazard notices should be utilised on the site in relation to deep water, leachate lagoons or steep faces. Physical barriers should be in place to prevent unauthorised access to culverts and other confined spaces. Culverts on landfill sites may be attractive to children and must be subject to adequate security measures to prevent entry.

11.3.12 Hazardous Substances

The operator should ensure that exposure of persons at a landfill to hazardous substances, is minimised or, where exposure cannot be avoided, adequately controlled. Employees should be trained regarding:

- potential risks;
- associated preventative measures and precautions;
- existence of occupational exposure limits;
- actions to be taken;
- hygiene requirements; and
- personal protective equipment.

Landfills represent working environments where employees could be potentially exposed to a variety of different substances. Operators should assess the types of substances likely to be received at their sites and identify the risks they pose. Where known hazardous substances such as asbestos are deposited, clear procedures and supervision should be undertaken as part of the safety statement for the site.

Table 11: Dangers due to encounter of various chemicals

Hazard/Risk	Mitigation
Asbestos materials	Shall be managed by the Contractor, only if he has a relevant permission to do so. In case that during the works, asbestos is found in high concentration, all works must stop and the Contractor shall notify the Engineer. All necessary actions for the safe removal of asbestos must then be taken by the Contractor.

<p>Mercury vapour</p> <p>Mercury is a very toxic material (inhalation/skin absorption hazard, skin sensitizer, reproductive hazard). Mercury poisoning causes irreversible brain, liver and kidney damage</p>	<p>Unprotected persons should avoid all contact with mercury including contaminated environment.</p> <p>Wear the recommended protective equipment (chemical protective respirators, goggles, gloves, coveralls, boots, hard hats).</p> <p>Do not eat, drink or smoke in work areas.</p> <p>Wash hands thoroughly after handling contaminated material.</p> <p>Use corrosion-resistant transfer equipment.</p> <p>Immediately report leaks, spills or other failures. Ongoing monitoring</p>
<p>Chlorine</p> <p>Respiratory irritant can cause serious skin injury. High concentration can result in lung damage and death.</p>	<p>Wear required personal protective equipment (use chemical protective gloves, coveralls, boots) including respirators with special cartridges.</p> <p>Have additional SCBA/escape packs available for use in emergencies.</p> <p>Use Emergency Response trained people on site.</p> <p>Have safety shower/eye-wash kits readily available in the immediate work area.</p>
<p>Unidentified chemicals</p> <p>Chemicals can be dangerous. How dangerous depends on the type of substance, the way it enters the body and the amount of substance that enters the body.</p>	<p>Correctly wear the recommended personal protective equipment. equipment.</p> <p>Never taste or allow unknown products to come into contact with your skin.</p> <p>Never look up if a drip from a leak hits you - move away first</p> <p>Do not eat, drink or smoke while working with hazardous substance.</p> <p>Do not keep food or drink near the substance.</p> <p>Wash your hands and face and other exposed areas with soap and water before going to the toilet or eating and drinking.</p> <p>The appropriate MSDS should be available near the work area for consultation when needed.</p>

11.3.13 General Responsibilities of Contractor/ Employees

A. Responsibilities of the Contractor

The contractor constructing or operating the site has the following obligations:

- To take any measure required in order all the employees and third parties that work or visit the site to be protected against any danger that can threaten their safety.
- To comply to the suggestions of all health and safety engineers and the relevant authorities. The contractor must facilitate their audits and their work in general.
- To supervise the proper implementation of the workspace health and safety measures.

- To take collective protection measures.
- To inform all employees and visitors to the sites about the dangers of their work in the site.
- To encourage the training of the employees in health and safety issues and inform them about the relevant legislation and its implementation.
- To implement a program of preventive actions against accidents and improvement of the working conditions.
- To keep a special file for the registration of any accident (causes and description).

B. Employee's Obligations

The employees at the landfill site have the following obligations:

- Implement the health and safety measures
- Use personal protective equipment
- Comply with the provisions and security mechanisms
- To attend relevant seminars on health and safety.

11.3.14 Risk Assessment and Mitigation

In the present paragraph, the most important risks are being summarized and the relevant mitigation measures are being described.

Table 12: Dangers during site investigation

	Hazard/Risk	Mitigation
High	Moving vehicles Collisions with people / animals High risk of collisions when reversing	Personnel to wear yellow jackets at all times Observe speed limits and good driving code at all times Use headlights whenever moving Only trained personnel to drive vehicles Personnel to assist reversing vehicles
Medium	General machinery risks Limbs caught in moving parts	Only trained operators to use machines Sufficient number of personnel on site Wear appropriate PPE
Medium	Rotating machinery Clothes can get caught and drag limbs into machinery	Wear proper PPE. Avoid loose sleeves, unfastened clothes Never use hands to slow down or stop a machine in motion
High	Trial pits and excavations (Animals & people falling in, sides collapsing on workers)	Follow established safe work practice. Wear the recommended personal protective equipment Personnel should be informed and trained in safe work procedures and specific site hazards.
High	Lifting heavy materials Muscle strains, injuries	Only lift comfortable weights, using more than one person when necessary. Use proper slings and grips with smooth or damp items.

	Hazard/Risk	Mitigation
		Use a winch or crane when necessary Follow correct lifting procedures
Low	Use of sharp tools Cuts and abrasions	Wear safety gloves Train personnel in the correct use of tools
Medium	Noise Damage to hearing organs	Wear hearing protection when working near machinery
High	Chemicals and contamination Toxic effects	Wear appropriate PPE obtain data sheets on all chemicals used, and follow manufacturers recommendations Alert supervisor if contamination is discovered
Medium	Underground cables, pipes, etc. Electric shock, gas fires / explosions, wastewater releases	Investigate the possibility of buried services

Table 13: Dangers during remediation activities

Significance	Hazard/Risk	Mitigation
Medium	Contact with overhead obstructions	Specify height restrictions for equipment Use "goal-posts" Map out safety routes
Medium	Noise Damage of hearing organs	Using ear protection Never remove your hearing protection in a noisy area.
Medium	Heavy equipment Body injuries	Follow established safe work practice
Medium	Power tools body injuries	Training on power tools Regular inspection of equipment
Medium	Lifting and moving drums/containers body injuries	Follow established safe work practice
Medium	Electrical hazard body injuries	Mark buried cables and electrical lines Check insulation

Table 14: Dangers during waste moving operations

Significance	Hazard/Risk	Mitigation
High	Excavations with steep slippery slopes.	Follow established safe work practice Trench sides can collapse suddenly whatever the nature of the soil. Any excavation deeper than 1.2 m must have the sides sloped or supported Dig well away from underground services such as electricity cables, gas pipes etc. if it is necessary to work near services use service plans, locators and safe digging practice to avoid danger
High	Burns and electric shock from membrane welding and testing equipment	Employ only trained personnel. Use correct equipment Restrict use in wet weather
High	Collision of heavy machines with personnel	Personnel wear reflective jackets Audible reversing alarm Plan night-time working carefully Work area controls
High	Bites of poisonous animals and insects	Train personal avoid contacts with animals Wear required clothes and footwear In the case of accident obtain proper treatment from the First Aid or Medic
Medium	Lifting heavy items (membrane rolls, sand bags)	Use crane Have sufficient numbers of personnel on site Training in lifting techniques
Medium	Holes and ditches	Follow established safe work practice
Medium	Unstable surfaces	Follow established safe work practice Keep the workplace tidy. In case of spill anything clean it up immediately Report damages or obstructions to ground surfaces
Medium	Heat stress	Train personal that will wear PPE Carefully schedule work and rest periods Drink plenty of fluids
Medium	Cold exposure	Restrict work under below zero temperature Monitoring of air temperature treat sufferers immediately
Low	Dust	Wear masks Keep access tracks damp

Table 15: Dangers during transportation of various loads

Significance	Hazard/Risk	Mitigation
High	Road accidents	<p>Keep safety rules:</p> <p>Use of visibility clothing by all personnel</p> <p>Where necessary use, audible alarms, and lighting both of the workplace and on vehicles</p> <p>Make sure visiting drivers follow the Project rules</p> <p>Check vehicles daily and have faults rectified promptly</p> <p>Keep your vehicle tidy and free from tools or personal property etc, which may obstruct the controls</p> <p>Check that the tire pressures are correct, that there are no oil leaks and the brakes, clutch and steering are effective before starting work</p> <p>Always obey the traffic rules and regulations</p> <p>Never use a vehicle for anything other than its designed use</p> <p>DO NOT:</p> <p>Let unauthorized people drive</p> <p>Let passengers ride on the vehicle unless it is designed for this</p>
High	Accident at canal crossing (impact on drinking water supply)	<p>Only trained, competent, authorised personnel will be allowed to drive vehicles</p> <p>Provide extra training to drivers</p> <p>Equip crossing area with additional traffic signs, traffic lane markings etc</p> <p>Immediately inform canal administration and state regulatory bodies about any accident</p> <p>Prepare emergency action plan for this case</p>
High	Health hazard from handling materials	<p>Training to provide information for reducing personal risk when handling chemicals.</p> <p>Load and unload materials safely, e.g. ensure safe access onto vehicles for loading and sheeting. Materials should be safely secured against possible movement.</p> <p>If a person feel unwell, when working with materials go out into the fresh air and report to supervisor</p> <p>Procedures</p>

12. LANDFILL EQUIPMENT

Equipment falls into three functional categories: 1) waste movement and compaction, 2) earth cover transport and compaction, and 3) support functions. Selecting the type, size, quantity and combination of machines required to move, spread, compact and cover waste depends on:

- Waste amount and type;
- Weather conditions;
- Site and soil conditions: topography, soil moisture and difficulty of excavation;
- The distance the cover material must be transported;
- Amount and type of soil cover;
- Compaction requirements; and
- Supplemental tasks, such as maintaining roads, assisting in vehicle unloading, and moving other materials and equipment around the site.

In this paragraph the technical specifications of the proposed equipment for landfill operation are presented.

Table 16: Proposed equipment for Landfill Operation

Equipment	Quantity	Description
Weighbridges	1	
Landfill compactor	1	medium heavy (30 tons operating weight)
Crawler Bulldozer	1	
Wheel Loader	1	
Dumper	1	medium heavy, payload 15 - 25 tons (10 - 15 m ³)
Backhoe loader with wheels	1	
Methane Detectors	2	portable

Steel-wheeled compactors are designed specifically for compacting solid wastes. Wheels are studded with load concentrators of various designs. This equipment gives maximum compaction of solid wastes. Steel-wheeled compactors are best suited to medium or large sanitary landfills.

The excavators will be used in the work for handling of soil at the landfill filling area, for shaping the landscape and for loading dumpers and trucks where waste and soil shall be moved.

A major issue in modern landfill operation is handling of soil and securing supply of soil for daily and final cover of the waste. The dumpers will be allocated for the soil

works and used for internal transport of waste at the landfill site and possibly also for transport of soil to the landfill from areas outside the landfill site, if needed.

Any goods which provide performance at least substantially equivalent to those specified in the Technical Specifications can be acceptable.

Wherever reference is made in the Technical Specifications to specific standards and codes to be met by the goods and materials to be furnished or tested, the provisions of the latest current edition or revision of the relevant standards in effect, shall apply, unless otherwise stated in the Contract. Where such standards and codes are national or relate to a particular country or region, other authoritative standards that ensure substantial equivalence to the standards or codes specified will be acceptable.

13. BOQ AND BUDGET

PHASE I/CAPEX

#		თავების, ობიექტების, სამუშაოების და დანახარჯების დასახელება / Name of chapters, units, works and expenses	საერთო სახარჯთ. ღირებულება ლარი / Total Cost Estimate EUR
1		3	4
		1. Construction part	
1	Calc. N1	General construction works	530,783.405
2	Calc. N2	Internal water supply	2,048.312
3	Calc. N3	Internal sewerage	922.571
4	Calc. N4	Internal Electrical Supply	11,027.828
5	Calc. N5	Ventilation	7,149.916
6	Calc. N6	Heating Cooling	8,927.365
7	Calc. N7	Weak currents, computer and telephone networks	2,807.274
8	Calc. N8	Fire alarm	2,299.622
9	Calc. N9	Grounding	325.188
10	Calc. N10	Lightning Protection	305.325
11	Calc. N11	Arranging of power network	108,582.050
12	Calc. N12	Access road and bridge	507,778.119
13	Calc. N13	Internal roads	508,821.017
14	Calc. N14	Surface and drainage systems	367,272.850
15	Calc. N15	Leachate Water collection System	2,262,021.667
16	Calc. N16	External sewer network	11,524.842
17	Calc. N17	Landscaping and lighting of the area	340,989.574
18	Calc. N18	Gas collection system	256,540.675
19	Calc. N19	Sludge water treatment plant	576,064.323
20	Calc. N20	Outdoor and internal fire-fighting System	48,085.095
21	Calc. N21	Landfill cells earthworks	199,440.752
22	Calc. N22	Earthworks built-plant areas	49,727.601
		Sum of part 1	5,803,445.37
		2. Other expenses	

LANDFILL DESIGN

#		თავების, ობიექტების, სამუშაოების და დანახარჯების დასახელება / Name of chapters, units, works and expenses	საერთო სახარჯთ. ღირებულება ლარი / Total Cost Estimate EUR
1		3	4
	СНП IV-9-82 პუნქტი 48	Temporary construction buildings 4.2%	243,744.71
		Connection to the power grid	135,000.00
		Connection to the water supply network	85,000.00
		Office Furniture and Equipment	40,000.00
		Publicity	55,000.000
		Additional investigations	40,000.000
		QA/QC	35,000.000
		Sum of part 2	633,744.706
		ჯამი/Sum	6,437,190.08
		გაუთვალისწინებელი ხარჯები / Contingency 10%	643,719.01
		ჯამი/Sum	7,080,909.08
		VAT18%	1,274,563.64
		ჯამი/Sum	8,355,472.72

LANDFILL DESIGN

PHASE II/CAPEX

#		თავების, ობიექტების, სამუშაოების და დანახარჯების დასახელება / Name of chapters, units, works and expenses	საერთო სახარჯთ. ღირებულება ლარი / Total Cost Estimate EUR
1		3	4
		1. Construction part	
1	Calc. N13	Internal roads	159,124.01
2	Calc. N14	Surface and drainage systems	99,853.30
3	Calc. N15	Leachate Water collection System	1,879,607.54
4	Calc. N17	Landscaping and lighting of the area	34,384.75
5	Calc. N18	Gas collection system	2,919,329.63
6	Calc. N19	Leachate Treatment Plant	87,590.67
6	Calc. N20	Outdoor fire-fighting System	14,910.32
7	Calc. N21	Landfill cells earthworks	134,824.42
		Sum of part 1	5,329,624.65
		2. Other expenses	
	СНП IV-9-82 პუნქტი 48	Temporary construction buildings 4.2%	223,844.24
		Sum of part 2	223,844.24
		ჯამი/Sum	5,553,468.88
		გაუთვალისწინებელი ხარჯები / Contingency 10%	555,346.89
		ჯამი/Sum	6,108,815.77
		VAT18%	1,099,586.84
		ჯამი/Sum	7,208,402.61

LANDFILL DESIGN

PHASE I /ANNUAL OPERATION AND MAINTENANCE COSTS

Item	Unit	Nos.	Unit price		Sub-total		TOTAL	
			€	GEL	€	GEL	€	GEL
Fixed O&M costs								
Maintenance, civil works	%	2	5,803,445	19,292,973.79	116,069	385,859		
Maintenance, equipment	%	5	670,703	2,229,685.03	33,535	111,484		
					149,604	497,344		
Contingencies	%	10			14,960	49,734		
subtotal					164,564	547,078	164,564	547,078
Variable O&M costs ⁵⁾								
Salaries								
<i>Landfill Manager</i>	no.	1	902	3,000	902	3,000		
<i>Foreman / Deputy site manager</i>	no.	1	752	2,500	752	2,500		
<i>Communication Specialist</i>	no.	1	361	1,200	361	1,200		
<i>Accountant/Finance</i>	no.	1	421	1,400	421	1,400		
<i>Laboratory Assistant / Environmental Expert</i>	no.	1	421	1,400	421	1,400		
<i>Gas System Technician / Electrician</i>	no.	2	361	1,200	722	2,400		
<i>Wastewater treatment technician</i>	no.	2	361	1,200	722	2,400		
<i>Workshop manager</i>	no.	1	421	1,400	421	1,400		
<i>Workshop technicians</i>	no.	1	301	1,000	301	1,000		
<i>Workshop support staff</i>	no.	1	301	1,000	301	1,000		
<i>Warehouse worker</i>	no.	1	301	1,000	301	1,000		
<i>Weighbridge operator</i>	no.	3	301	1,000	902	3,000		
<i>Compactor / Machine driver</i>	no.	2	451	1,500	902	3,000		
<i>Driver of auxiliary equipment</i>	no.	3	421	1,400	1,263	4,200		
<i>Support Staff (Workers)</i>	no.	4	271	900	1,083	3,600		
<i>Security</i>	no.	3	271	900	812	2,700		
<i>Cleaner</i>	no.	2	241	800	481	1,600		
Social contribution	%	17			1,910	6,348		

LANDFILL DESIGN

Item	Unit	Nos.	Unit price		Sub-total		TOTAL	
			€	GEL	€	GEL	€	GEL
Power	kWh	25,000	0.06	0.20	1,500	4,987		
Fuel	l	50,000	0.80	2.66	40,000	132,976		
Water and waste water	m ³	1,000	1.50	4.99	1,500	4,987		
Handling of leachate	m ³	1,000	2.50	8.31	2,500	8,311		
Monitoring costs (Sampling 4 time/year)	no.	4	5,000.00	16,622.00	20,000	66,488		
Insurance	Lump sum				3,500	11,635		
					81,979	272,532		
Contingencies	%	15			12,297	40,880		
subtotal					94,276	313,411	94,276	313,411
Total O & M costs (rounded)					260,000	860,000	260,000	860,000

Depreciation								
Civil works and buildings	4%	30	5,803,445	19,292,973.79	335,614	1,115,715		
Equipment	4%	15	670,703	2,229,685.03	60,324	200,540		
					395,938	1,316,255	400,000	1,320,000

Total O & M costs							660,000	2,180,000
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LANDFILL DESIGN

PHASE II /ANNUAL OPERATION AND MAINTENANCE COSTS

Item	Unit	Nos.	Unit price		Sub-total		TOTAL	
			€	GEL	€	GEL	€	GEL
Fixed O&M costs⁴								
Maintenance, civil works	%	2	5,329,625	17,717,804	106,592	354,356		
Maintenance, equipment	%	5	87,707	291,572	4,385	14,579		
					110,978	368,935		
Contingencies	%	10			11,098	36,893		
subtotal					122,076	405,828	122,076	405,828
Variable O&M costs⁵⁾								
Salaries								
<i>Landfill Manager</i>	no.	1	902	3,000	902	3,000		
<i>Foreman / Deputy site manager</i>	no.	1	752	2,500	752	2,500		
<i>Communication Specialist</i>	no.	1	361	1,200	361	1,200		
<i>Accountant/Finance</i>	no.	1	421	1,400	421	1,400		
<i>Laboratory Assistant / Environmental Expert</i>	no.	1	421	1,400	421	1,400		
<i>Gas System Technician / Electrician</i>	no.	2	361	1,200	722	2,400		
<i>Wastewater treatment technician</i>	no.	2	361	1,200	722	2,400		
<i>Workshop manager</i>	no.	1	421	1,400	421	1,400		
<i>Workshop technicians</i>	no.	1	301	1,000	301	1,000		
<i>Workshop support staff</i>	no.	1	301	1,000	301	1,000		
<i>Warehouse worker</i>	no.	1	301	1,000	301	1,000		
<i>Weighbridge operator</i>	no.	3	301	1,000	902	3,000		
<i>Compactor / Machine driver</i>	no.	2	451	1,500	902	3,000		
<i>Driver of auxiliary equipment</i>	no.	3	421	1,400	1,263	4,200		
<i>Support Staff (Workers)</i>	no.	4	271	900	1,083	3,600		
<i>Security</i>	no.	3	271	900	812	2,700		
<i>Cleaner</i>	no.	2	241	800	481	1,600		

⁴ O&M costs of Phase I are not included

LANDFILL DESIGN

Item	Unit	Nos.	Unit price		Sub-total		TOTAL	
			€	GEL	€	GEL	€	GEL
Social contribution	%	17			1,910	6,348		
Power	kWh	25,000	0.06	0.20	1,500	4,987		
Fuel	l	50,000	0.80	2.66	40,000	132,976		
Water and waste water	m ³	1,000	1.50	4.99	1,500	4,987		
Handling of leachate	m ³	1,000	2.50	8.31	2,500	8,311		
Monitoring costs (Sampling 4 time/year)	no.	4	5,000.00	16,622.00	20,000	66,488		
Insurance	Lump sum				3,500	11,635		
					81,979	272,532		
Contingencies	%	15			12,297	40,880		
subtotal					94,276	313,411	<i>94,276</i>	<i>313,411</i>
Total O & M costs (rounded)					220,000	720,000	220,000	720,000

Depreciation								
Civil works and buildings	4%	30	5,329,625	17,717,804.17	308,213	1,024,622		
Equipment	4%	15	87,707	291,572.06	7,888	26,224		
					316,101	1,050,847	320,000	1,050,000

Total O & M costs							540,000	1,770,000
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