E4281 v2

Adriatic Sea Environmental Pollution Control Project (I)
Croatia and Bosnia and Herzegovina

# ENVIRONMENTAL MANAGEMENT PLAN

## MOSTAR LANDFILL
## SOLID WASTE LEACHATE (WASTEWATER) TREATMENT PLANT

**June, 2013**

# List of Abbreviations

| | |
|---|---|
| ASEPCP | Adriatic Sea Environmental Pollution Control Project |
| BiH | Bosnia and Herzegovina |
| EIA | Environmental Impact Assessment |
| ELV | Emission Limit Values |
| EMP | Environmental Management Plan |
| ESMF | Environmental and Social Management Framework |
| EU | European Union |
| FBiH | Federation of Bosnia and Herzegovina |
| GEF | Global Environment Facility |
| HPP | Hydro Power Plant |
| MoFTER | Ministry of Foreign Trade and Economic Relations of BiH |
| MBR | Membrane Bio Reactor |
| MRF | Materials Recovery Facility |
| PEHD | Polyethylene High-Density (or HDPE - High-Density Polyethylene) |
| PUC | Public Utility Company |
| WWTP | Waste Water Treatment Plant |

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# 1 INTRODUCTION

## 1.1 Background information

Bosnia and Herzegovina (hereinafter BiH) together with the Republic of Croatia (hereinafter Croatia) applied for the Global Environment Facility (GEF) grant to support the Adriatic Sea Environmental Pollution Control Project (I) (hereinafter ASEPCP or the Project) which the Ministry of Foreign Trade and Economic Relations of BiH (hereinafter MoFTER) plans to implement in BiH. The objective of the Project is nutrient pollution reduction in selected hot-spots of the Eastern Adriatic Sea.

ASEPCP would involve implementation of selected demonstrative priority pollution control investment sub-projects (Component 1) and regional Technical Assistance (Component 2), to address key issues affecting the environmental sustainability of the Adriatic Sea, including: municipal wastewater and solid waste treatment; protection of karstic groundwater; improvement of coastal water monitoring, and preparation of investments.

Under Component 1 - demonstrative investments, two proposed sub-projects related to solid waste leachate treatment (Mostar in Bosnia and Herzegovina and Zadar in Croatia) would be financed within the ASEPCP.

This Environmental Management Plan (EMP) for the construction of a wastewater treatment plant (WWTP) at “Uborak” landfill in Mostar was developed as demonstration draft EMP, as part of the Environmental and Social Management Framework (ESMF) for the ASEPCP. It was developed based on the available information; however it will need to be updated later on during the project preparation/implementation when more information on design and alternatives would be provided. At this stage of project preparation, the Public Utility Company “Deponija” (PUC “Deponija”) needs to obtain notification of the competent ministry on the need for EIA. If the EIA would be required, the ToR for EIA will be updated to include the EMP, and this demonstration draft EMP will be updated.

## 1.2 Project context

The sanitary landfill “Uborak” in Mostar has been designed and constructed to meet stringent European requirements for landfill construction.

Its leachate treatment system is, at the present, envisaged as a leachate recirculation system with sprinklers. This recirculation system is in place, but is not yet operating, as the landfill is not receiving waste. This system consists of an open lagoon whose dimensions are approx. 1 700 $m^3$, drainage PEHD pipes for collection of leachate from the disposal area and two pumps for recirculation of leachate into the disposal area.

The landfill operator has planned to use this system in the first several years of landfill operation, until the means are created for construction of a wastewater treatment plant at the landfill.

In order to comply with the Decree on Conditions for Discharge of Wastewater into Natural Recipients and Public Sewer Systems (Official Gazette of FBiH", No. 6/12), prior to discharge of used waters into recipients, they have to be treated.

This is why the landfill operator envisaged constructing a wastewater treatment plant as the final option for treatment of leachate. The design of the envisaged WWTP is provided in the Main design of the landfill. However, due to lack of funds, this WWTP has not yet been constructed.

As this sanitary landfill has not yet begun operations, it may prove to be a unique opportunity to construct a WWTP prior to commissioning of landfill thus enabling full compliance to EU standards regarding landfill construction and operation and preventing any possible risk of environmental contamination due to eventual malfunction of the lagoon, or oversaturation of the landfill with rainwater which may cause leachate contamination of the surrounding area.

The following sections provide the project description pertaining to the proposed upgrade of the leachate system at “Uborak” landfill with the baseline environmental conditions in the project area.

Potential environmental and social impacts regarding the construction of the WWTP at the landfill have also been identified which are related to the construction phase of the proposed facility as well as during its operation phase. Good construction practices have been proposed and mitigation measures identified.

The EMP, which consists of a Mitigation and Monitoring Plan, is provided in table form, taking into account key environmental issues which should be managed and mitigation measures to manage each specific impact. The Monitoring Plan describes the necessary actions to monitor the implementation of the mitigation measures proposed in the Mitigation plan.

# 2 PROJECT DESCRIPTION

The landfill operator possesses the Preliminary design for construction of sanitary landfill Uborak (drafted by the design bureau “Hercegovina”) which was adopted by the Town council assembly on 8 November 2007, the Main design which consists of two projects – Main design: Complex of structures for the town landfill Uborak, dated April 2009 and Main design: Facility for treatment of waste Uborak, dated June 2010, which had to be revised due unsolved expropriation issues of the surrounding land causing the change in placement of the landfill facilities within the landfill area.

The landfill operator PUC “Deponija” commissioned the revision of the aforementioned designs. These revisions were undertaken by the design bureau IPSA Institute., Sarajevo in 2012.

The revised Main design consists of the following elements:

- Book 1 General part
- Book 2 Regulation of Sušica Stream – km 0+0,000 to 1+599,07
- Book 3 Regulation of Sušica Stream – km 1+599,07 to 2+656,28
- Book 4a Entry zone – architecture
- Book 4b Entry zone – traffic
- Book 4c Entry zone – water supply and sewage
- Book 5 Administrative building (Architecture, structure, water supply)
- Book 6a Landfill disposal zone
- Book 6b Treatment of leachate water from the disposal area, MRF, leachate recirculation, connection of treated water to regulated watercourse Sušica
- Book 6c Hydrant network
- Book 7 Materials recovery facility MRF (Architecture, structure, water supply and electrical installations)
- Book 8a Relocation of transmission line DV 10 kV Institute – Predionica located on the territory of landfill Uborak in Mostar
- Book 8b Prefabricated substation 10 (20) / 0.4 kV, 400kVA Uborak III – Mostar
- Book 8c Low voltage switchgear and exterior lighting of landfill Uborak in Mostar
- Book 8d Administration facility, gate booth, garage, sanitary facility, ancillary construction for vehicle washing, scale house – electrical installations

This documentation was made available to the Consultant during the drafting of this EMP.

Of interest to this project, within its parent landfill project is Book 6b which provides a detailed overview of the leachate treatment system with design specifications, hydraulic calculations and cost estimates.

The specifications of the foreseen treatment system and the treatment process are described below.

**Foreseen wastewater treatment plant**

The designed WWTP is envisaged as a multi-phase facility which includes mechanical, biological and chemical treatment of leachate water.

Leachate form the lagoon is transported to the reception chamber via pipeline DN 100 and two pumps (1x PMP 2,2 kW) from where it is dosed into the separator – precipitator with volume of 20 000 L.

The separator – precipitator is used for gravity induced separation of greasy components from the water, and at the same time for sedimentation of sand and soli. The facility has connections for placing dispensing devices for coagulants and necessary chemicals for reduction of TLV. The top of the separator has three revision shafts for control and servicing. One third of the separator volume is foreseen for sedimentation of heavy particles, after which the water is transported via gravitation to the area for separation of light particles and liquids from the wastewater. Following the process of separation, the water is transported to the patented system for reduction of organic pollution in wastewater, the biorotor BRT 400 for aerobe biological treatment. The technological procedure of this treatment consists of the following: aeration by pumps and bioactivation; biological purification in biosections of biorotor; aeration by blowers; and final settlement in outlet chamber with recirculation of active sludge. Following the biological treatment, water flows to the system for disinfection by chlorine. This is a plant of 12 $m^3$ with automated chlorination system.

After chlorination, the treated effluent flows to the control shaft for sampling and then to the main shaft which is a reinforced concrete chamber whose dimensions are 8x8x3 m and which also serves for collection of rainwater from the cells that are not in use.

This water is finally drained toward the regulated watercourse Sušica via gravitation using PVC pipes approx. 250 m long.

This system was selected based on its cost, as the landfill operator is not able to provide funds for a more sophisticated design.

It is advisable to foresee a more advanced WWTP system during the implementation of this project, for example Membrane Bio Reactor (MBR) technology or similar. This technology relies on microfiltration or ultra filtration membranes to separate the activated sludge from the treated water. The effluent of this process is of excellent quality in terms of total suspended solids and microorganisms. Further, the required footprint for this process is smaller than for a conventional activated sludge process.

Therefore, the EMP describes the possible impacts arising from construction and operation of a wastewater treatment plant using either of the above mentioned technologies.

## 2.1 Description of the construction site location

The municipal solid waste landfill “Uborak” is located north of Mostar town at a mildly sloping terrain, approximately 12 km from the town centre. It is well connected with the town via main road Sarajevo – Opuzen M17 which is located in its immediate vicinity, and to which it is connected by a local asphalt road.

This landfill site is completely constructed and is capable of receiving waste for the next five years at its three cells of approx. 2 ha, after which a phase enlargement is anticipated. This landfill site has not yet begun its operation, i.e. it is still not receiving waste.

The landfill currently occupies an area of approximately 3.8 ha and is located between the periodically occurring watercourse Sušica (which has been regulated and is within a closed

concrete channel in the entire length of its border with the landfills) to its east and south and a military complex to the north.

It borders with the existing landfill site “Uborak” on its eastern side and is divided from it by the aforementioned watercourse.

Within this site, there is an area of approx. 1.2 ha foreseen for the placement of a composting area and covering material, part of which may be used for placement of the WWTP. These 1,2 ha of space are sufficient for the placement of all these elements, and in the future, if there is need for extra space for the composting area and covering material, the landfill has manoeuvring area for adequate expansion.

The wider area of the construction site which is located within the new sanitary landfill Uborak (shown in green) is depicted in the following figure:

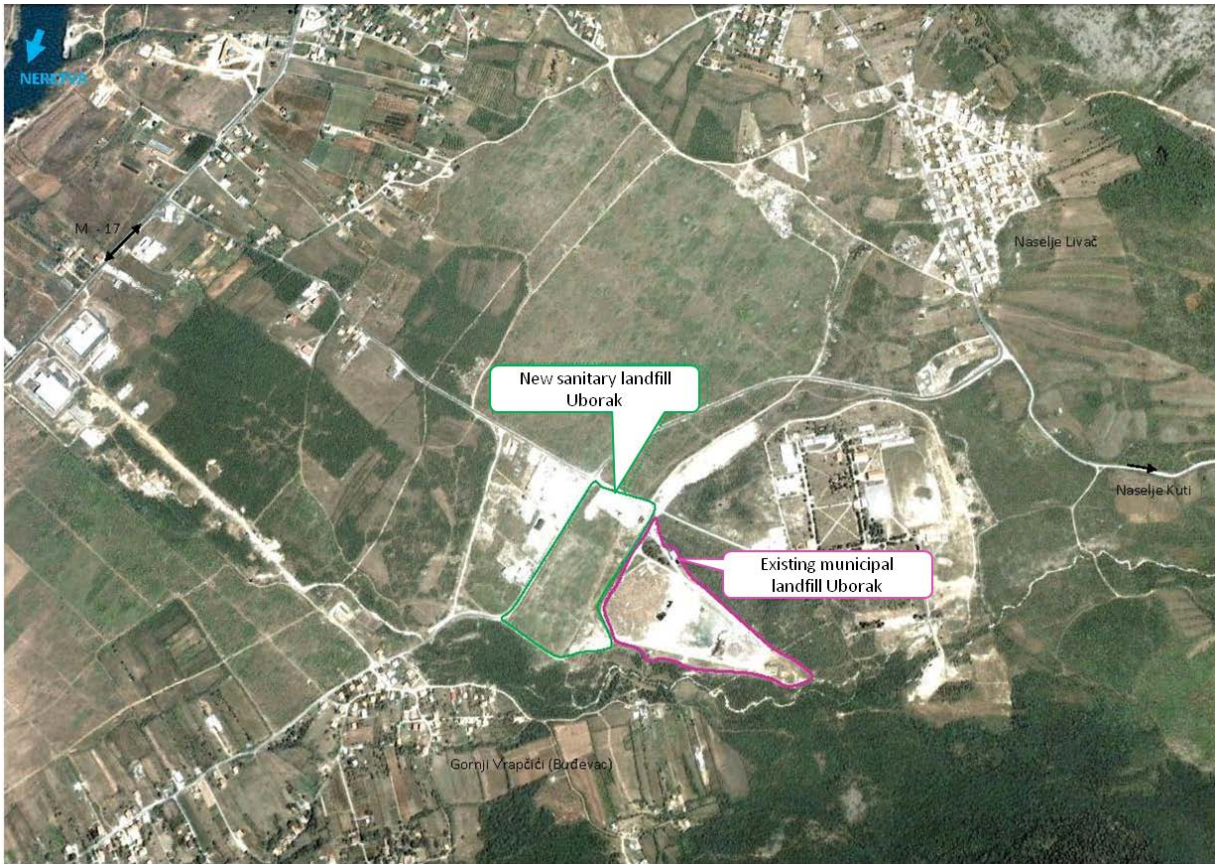


**Figure 1:** Wider location of the construction site – orto-photo image

## 2.2 Information on operator

The existing landfill “Uborak” was operated by PUC “Komos”, Mostar until 27 November 2006 when the newly formed PUC “Uborak”, took over operations. They ceased to be the operator of the landfill in 2008.

On 27 February 2008 a new company was registered under the name PUC “Deponija” which was registered in the court Register under the number 1-12216. This company now operates the new landfill “Uborak”. The main activity of this company is listed under the code 90.020 – Collection and treatment of other waste and the main activities of the company include:

- 37.100 Recycling of ferrous remains and waste
- 37.200 Recycling of non-ferrous remains and waste
- 74.840 Other business activities
- 90.000 Removal of waste waters, transport of waste and similar activities
- Treatment of waste by incineration or by other means
- Disposal of waste on terrain or covering or ploughing
- Treatment of liquid waste.

## 2.3 Pre-rehabilitation and rehabilitation/construction activities

Disposal of waste at this location began in 1960 in an unplanned manner, by dumping waste into a natural sinkhole whose area was approximately 1.5 ha at terrain level. After the sinkhole was filled above terrain level, and following the usual occurrences of wild fires and foul smells characteristic of wild dumps, the local population pressurized the administration into rehabilitation of this area and closure of the dumpsite. During 1991 the landfill was rehabilitated and prepared for closure.

However, in 1995 it was decided by the EU Administration of Mostar to reactivate the closed dumpsite in order to solve the problem of non-existence of adequate landfill for this town.

For this purpose, a main design was prepared and subsequently the landfill was extended to ensure approx. 335 990 $m^3$ (or approx. 200 000 tonnes) which would suffice for 10 – 15 years of disposal. The landfill was put in operation in 1997 and has been in use ever since with a total of 345 650 tonnes of disposed waste, exceeding the designed capacity by approximately 150 000 tonnes.

For this reason, the construction of a new landfill was foreseen and the administration of Mostar town commissioned the drafting of Preliminary and Main designs.

Following these designs, the new sanitary landfill was constructed in the immediate vicinity of the existing municipal non-sanitary landfill, which will ensure approx 11.5 ha of landfill space in its final stage.

The newly constructed disposal zone is located in the northern part of the landfill site and covers an area of approx. 2 ha. It is divided into three cells which ensure about 160.000 $m^3$ of readily available disposal volume.

The main features of this landfill and its facilities, including the leachate treatment system are described in the following paragraphs.

## 2.4 Staffing and support

The company currently employs 26 employees. The organizational chart of PUC “Deponija”, Mostar is provided below:

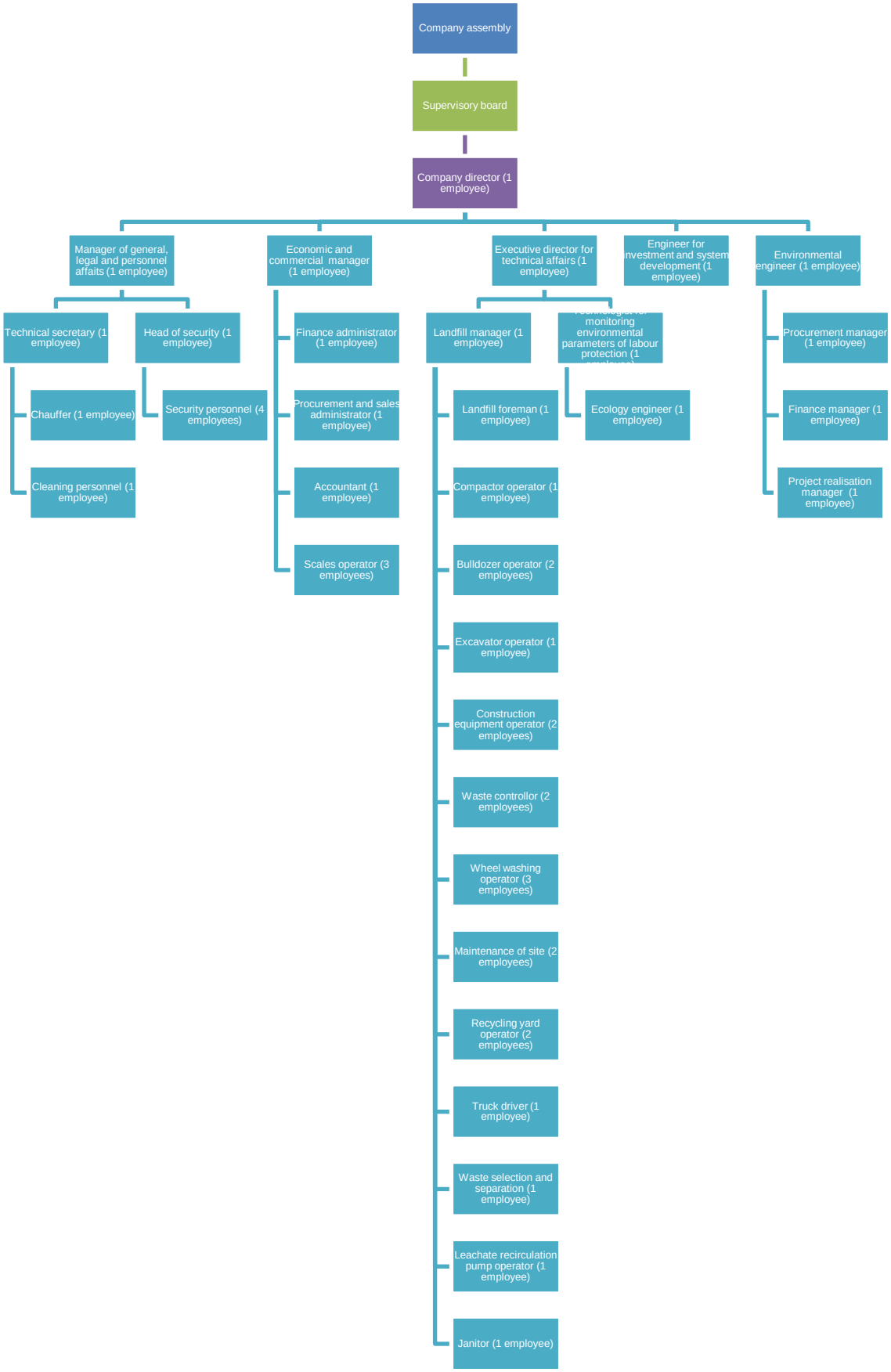


**Figure 2:** Organizational chart of PUC “Deponija”

## 2.5 Facilities and services

The total fenced area of the landfill is 131 526 $m^2$ which includes the disposal area, protection zone and ancillary facilities. These facilities include access roads, technological roads inside the disposal zone, materials recovery facility (MRF), area for composting, administrative building, entry zone, cells for waste disposal, system for collection and treatment of leachate and system for collection of landfill gas.

As previously stated, in its current condition, the landfill has a capacity of approx. 160 000 $m^3$ which is sufficient for five years of disposal. However, with expansion which is expected to occur in four basic phases, it will be possible to use this landfill for a period of thirty years to come.

**Access road**

The landfill site is well connected via a branch of local asphalt road to the main road M 17. Access is also possible via local road passing through settlement “Vrapčići”.

**Entry zone**

The entry zone consists of the following elements which ensure adequate control and procedures of incoming waste and trucks that leave the landfill are satisfied:

- Manipulative area – this space is reserved for movement of full and empty vehicles and areas for their parking as well as weighing scales, disinfection basin, washing plateau, fuel station, etc.;
- Administrative building - a two-storey building with all the necessary facilities for daily operations (offices, toilets, kitchen and laboratory);
- Garage for mechanization – this area is reserved for storage of mechanization and minor repairs.

**Water supply**

Supply of sanitary and technical water to the landfill is ensured through the public water supply system whose main connection for supply of settlement “Vrapčići” passes in the immediate vicinity of the landfill.

**Sewage system**

Wastewater from the facilities used by the staff is separated from the systems for collection of rainwater and leachate.

There is no public sewer system in the vicinity of the landfill, and wastewater from the administrative building and other facilities used by the staff is drained into the biological cleaning device (treatment plant) for purifying of wastewater “Regeneracija”. Waters treated in this manner are then discharged into the regulated riverbed of Sušica watercourse.

The landfill is surrounded by an embankment, and thus surrounding surface waters do not pose a threat to the landfill and its disposal area.

Rainwater from the entry zone, washing plateau, disinfection basin is collected by a sewage system, drained into an oil and grease separator and finally discharged into the regulated riverbed of Sušica watercourse.

**Supply of electricity**

For supply of electricity to the landfill, a 50 kW substation was put in place which will ensure supply for the administrative building, scale, proper illumination, etc.

**Leachate collection system and basin**

Leachate is to be collected and drained by a drainage system which consists of drainage PEHD pipes DN 250 mm. This system is connected to manholes. Full PEHD pipes are used for drainage of leachate from the last manhole to the leachate lagoon.

For collection of leachate at the landfill, a lagoon is foreseen, with a total volume of 1 700 $m^3$, whose construction and layers will ensure water tightness.

The construction consists of a 10 cm layer of sand upon which a multi-barrier protection system is placed which, in turn, is covered by another layer of sand 30 cm thick on which concrete octogens are placed and filled with gravel.

Once the WWTP is commissioned, the leachate collection and recirculation system will not cease to operate. In the summer period, when there is little precipitation, this will be the primary method for leachate treatment. The WWTP will remain operational at reduced capacity when it will treat only the waste waters from the MRF, which is planned to be constructed in the intermediate future and connected to the WWTP. This will ensure savings in power consumption. During periods of heavy rainfall, the WWTP will be used for treatment of leachate from the landfill and the leachate collection basin.

**Fence**

The fence is placed around the landfill to ensure that unauthorized access is restricted, animals are prevented from entering and reduces optical visibility of the landfill interior.

**Cells for disposal of waste**

In order to ensure water tightness, the cell is constructed in the following manner (bottom up):

- after excavation to the foreseen level, levelling and compaction is performed of the cell surface, to which a 10 cm layer of sand is applied and compacted;
- the surface is thus prepared for placement of the multi-barrier protection system which consists of the following materials and layers:
    - GCL (bentonite layer)
    - HDPE geomembrane min. 2.5 mm thick
    - geotextile 500 g/$m^2$ to protect the geomembrane
- On the finishing layer of geotextile, drainage PEHD pipes are placed and the entire surface is covered with natural gravel 8-32 mm which serves as a drainage layer and protection of the multi-barrier system.

**Composting area and area for covering material**

This area is located south of the disposal zone, in the centre of the landfill complex. It covers an area of approx. 1.2 ha and is currently not in use, i.e. no facilities of any kind are located in this area. Therefore, the wastewater treatment plant may be placed in this zone, as it provides natural inflow of the leachate waters from the disposal area, leachate basin and MRF which is located to its east.

The landfill has sufficient space according to its Main design for expansion if the need for extra space arises for the composting area and materials storage.

## 2.6 Operation and maintenance

The landfill is fenced and has an entry zone with restricted access.

The foreseen working hours of the landfill are between 07:00 and 17:00 every day during the winter period and 06:00 and 20:00 every day in the summer period. During this period, entrance is allowed only to authorized staff and vehicles of the public utility companies registered for collection and transport of waste.

The landfill has not yet been commissioned, but the following operations are foreseen:

At the entry zone, weighing and control of the incoming waste is performed, and a register is kept. The entry zone serves for examination of the waste prior to its acceptance and disposal. Within this area there is a washing and disinfection station where trucks are washed prior to leaving the landfill. The used water is drained to the primary precipitator from which it is led to the oil and grease separator.

Landfilling is composed of the following basic operations:

- dumping of waste on the active cell of the landfill;
- spreading of waste in layers with a dozer and compactor;
- compaction of waste with a dozer and compactor;
- daily covering of waste with an inert layer at the end of working day, and after the cell is filled to the foreseen capacity covering with a thicker layer of inert material;
- planting greenery on top of the closed cell.

As this landfill is classified as non-hazardous waste landfill, it is obliged to receive waste classified under Chapter 20 – “Municipal Wastes (Household waste and similar commercial, industrial and institutional wastes) Including separately collected fractions” of the European Waste Catalogue (“EWC”)which is in accordance with the “Regulation on waste categories with lists” (“Official Gazette of FBiH”, No. 9/05), whilst other non-hazardous waste will be received only if there is no other environmentally feasible solution for its disposal. This primarily relates to non-hazardous waste from the industrial sector which may be accepted in small quantities and under a special contract of temporary nature.

The landfill will temporarily storage hazardous waste listed under Chapter 20 -entries are marked in the EWC 2002 and Regulation with an asterisk (*). This waste will be stored in the recycling plateau.

All waste foreseen for recycling and hazardous waste is to be handed to authorised operators for further treatment, according to contract.

The landfill will use a compactor, caterpillar bulldozer and loader in its daily activities. For basic maintenance of this mechanization, the garage which is located in the entry zone will be used.

Major mechanization maintenance is to be undertaken at authorized service providers which handle all waste arising from these maintenance activities in an appropriate manner.

## 2.7 Required off-site investments

At this stage of the project, no off-site investments are expected, as the landfill has full infrastructure and connectivity to the surrounding area.

# 3 ENVIRONMENTAL BASELINE CONDITIONS

The considered area is located in the north of the town of Mostar, at approximately 12 km from the urban zone. It lies in the immediate vicinity of the main road M-17.

## 3.1 Geology and Soil Characteristics

The area of Mostar valley belongs to the geotectonic unit of the Outer Dinarides. The basic features of the regional geology and structure and geomorphologic configuration of the Outer Dinarides is reflected in the development of lithofacies of stratigraphic members and their highly complex mutual spatial arrangement. The sedimentation process is continuous from the Triassic up to Late Cretaceous through the sedimentation of shallow Carbonate Sediments (limestones and dolomites).

The orogenic movements at the fringes of the Late Cretaceous lead to elevation of the terrain and transgressive deposition of Palaeogene sediments across the Late Cretaceous. Following the Palaeocene, the Orogeny processes, such as faulting, overthrusts, uplifting etc. have been manifesting themselves in varying intensity until today.

At the beginning of the orogenesis the geosyncline development of the region ends and further development of the terrain is linked to continental development, by the formation of the Mostar lake basin where mostly clastic sediments (marl, breccia, and clay with coal) are deposited. They have been faulted and lowered to great depth by post-Miocene tectonics, whilst on the other side the surrounding terrains have been elevated to considerable heights.

Exploration drilling and geophysical measurements in the area north of Mostar called Bijelo Polje, has made possible the determination of the following:

- The contact between the orogeny basin and its rim is of tectonic character;
- The thickness of Quaternary formations ranges between 30 and 40 m and they consist of glacio-fluvial terrace sediments, diluvial clayey debris, and scree material;
- Beneath the Quaternary formations significant layers of Neogene sediments may be found, which consist of marl, sandstone, marl clay and coal;
- The Neogene formations possess fault lines along which there were occurrences of tectonic movement of certain blocs.

The geological base of the landfill is diluvium, which covers a significant area of the BijeloPolje area. The landfill “Uborak” was formed in these layers, and there is a significant occurrence of fractionating of the vertical geological-lithological column. In its reconstruction, information obtained from exploratory drilling nearby the “Uborak” location was used, as well as from drilling performed in the intermediate vicinity of the location.

These sediments are characterised by vertical alternation of several lithological series which differ from borehole to borehole only slightly, which may be attributed to permissible error during the core determination.

A generalized cross section of these layers is presented in the Table 1.

**Table 1:** Description of layers obtained by investigative drilling

| Depth (m) | Description |
|---|---|
| 0 -10 | Well clayed large and small debris with a small content of partially round fractions |
| 10 - 15 | Compacted and consolidated clay with variable content ofdebris of different granulation |
| 15 - 25 | Pure debris with smaller content of larger blocs, partially coherent with carbonate binder such as breccia |
| 25 - 30 | Very compacted clay with small debris |
| 30 | Grey marl clay |

The soils in the immediate vicinity of the landfill “Uborak” are mostly anthropogenised, and are therefore humic and contain a lot of physiologically active phosphorus and potassium. Based on the results of the soil survey performed in 1954, it was visible that most of the land was covered by pastures in that period, whilst the 1975 survey showed that these areas have become almost completely anthropogenised and placed under a certain agricultural crop (grape vine, vegetables or fruits).

## 3.2 Meteorological Conditions

Mostar and its surrounding areas belong to the altered Mediterranean climate. The basic characteristics of this climate are mild and short winters and very warm summers.

The mean annual air temperature is 14.8 C, the highest temperature reaches values of 43 ºC and the absolute minimum recorded was - 11 ºC. The hottest month is July, with an average temperature of 25.13 ºC and the coldest is February with average daily temperature range of 5-12 C.

The mean relative humidity does not drop below 50% during any month, but the minimum values vary between 9 and 20%.

This area is exposed to frequent and very strong winds. During spring and summer, winds of the southern quadrant occur mostly, and during the autumn and winter of the northern quadrant.

The most frequent wind is northern with frequency of 31% and an average speed of 21 kilometres per hour, while the maximum speed exceeds 100 kilometres per hour.

Rainfall in this area occurs in the form of rainstorms and strong rain downpours. They are characterised by great variability, equally the sum of annual and monthly precipitation. The average annual amount of rainfall is 1 573 mm. Distribution of rainfall per months of the year is very uneven. They are unevenly distributed even when their mean values are analysed. For example, the mean monthly rainfalls are highest in December (220 mm) and the lowest in July (52 mm), meaning that December has 4.23 times more rain than July.

## 3.3 Current Environmental State

### 3.3.1 Hydrology and Hydrogeology

In the area of “Uborak” there are no water sources or continuous watercourses. The stream “Sušica” flows in the immediate vicinity, in which flow occurs only during heavy rainfall. For

the purpose of the landfill expansion it was necessary to relocate this occasionally appearing stream, so that it does not cross the landfill surface.

This construction procedure was completed during the construction phase of the landfill, according to the Main design of the landfill of which regulation of Sušica Stream is a part of. The construction works ensure that waters from the landfill cannot be accidentally spilled or discharged into this stream.

During 1989 and 1991, when activities on the closure of the existing municipal landfill were underway, certain research was carried out on the effects of the landfill on the environment, primarily on its impact on the quality of groundwater.

In order to define the impacts, the flow dynamics of groundwater had to be determined first based on continuous monitoring of groundwater levels within a ring of piezometers.

Monitoring was conducted continuously during two periods: prior to the construction of HPP "Mostar" which is located approximately 4 km north of Mostar, in the vicinity of the landfill, and after the formation of the reservoir and commissioning of the HPP. Therefore the movement of groundwater was defined for two boundary conditions:

- Groundwater dynamics in the conditions prior to the construction of the reservoir for HPP "Mostar";
- Groundwater dynamics in the conditions following to the construction of the abovementioned reservoir.

The results of monitoring were represented as isolines of groundwater levels for mean levels during perennial monitoring. As groundwater movement occurs perpendicularly to the groundwater isolines, it is clear that groundwater from the landfill area flowed directly toward Neretva River towards the north-west, in the conditions prior to the construction of the HPP.

After the formation of the reservoir, groundwater from the landfill area moves to the north-west, parallel to the Neretva River, to the alluvial gravels where a mighty freatic aquifer has formed with primary inflows from the reservoir and secondary from the direction of the broken karst source of Velež massif.

Even though these investigative works were carried out for the purpose of determining the impact of the HPP on groundwater movement, it is significant to know the direction of groundwater flow as it is the main transmitter of potential pollution arising from leachate in order to determine where the main impacts might occur due to leachate contamination.

The groundwater level is at a depth of 20 – 25 m from terrain level which depends on the hydrological regime.

### 3.3.2 Water Quality

Based on the groundwater movement measuring locations have been selected for groundwater sampling and physical and chemical analysis. Parallel to sampling of groundwater, two boreholes have been drilled in the existing landfill for sampling of leachate water. The following table shows the results of those analyses.

**Table 2:** Physical and chemical characteristics of the leachate from "Uborak" landfill and groundwater in the landfill vicinity

| No. | Physical and chemical parameters | Control point | | Emission limit values (ELVs) for industrial wastewater discharged into natural recipients[1] |
|---|---|---|---|---|
| | | Landfill „Uborak" | Piezometer 300 m from landfill | |
| 1. | temperature ($^0$C) | 54 -73 | 12,50 | 30 |
| 2. | *pH* | 8,45 – 8,60 | 7,95 | 6,5 – 9,0 |
| 3. | conductivity (µS/20°C) | 9800 – 25000 | 510 | - |
| 4. | turbidity (FTU) | 1000 – 2200 | 0 | - |
| 5. | colour ($^0$Pt-Co scale) | 150 | 6 | - |
| 6. | dissolved oxygen | 2,35 | 10,50 | - |
| 7. | $BOD_5$($mgO_2$/l) | 222 -2469 | 1,1 | 25,00 |
| 8. | $KMnO_4$consumption ($mgO_2$/l) | 1362 -3458 | 3,57 | - |
| 9. | ammonia ( $mgNH_4$/l ) | 25 -280 | 0,05 | 10,00 |
| 10. | nitrates ($mgNO_2$/l) | 0,005 -5000 | 10 | - |
| 11. | nitrites ($mgNO_3$/l) | 300 | 0,5 | 10,00 |
| 12. | phenols (mg/l) | 1,46 -11,56 | - | 0,1 |
| 13. | detergents (mg/l) | 0.175 -5800 | - | 1,0 |
| 14. | calcium ($mgCaCO_3$/l) | 841 -1441 | 56 | - |
| 15. | potassium (mg/l) | 536 -1880 | 0,82 | - |
| 16. | sodium (mg/l) | 988 -1960 | 2,92 | - |
| 17. | magnesium ($mgCaCO_3$/l) | 160 -559 | 230 | - |
| 18. | Iron - total (mg/l) | 10900 -22000 | 1713 | - |
| 19. | bicarbonates ($mgCaCO_3$/l) | 150,0 -12444,0 | 317,8 | - |
| 20. | total hardness ($mgCaCO_3$/l) | 1400 -1680 | 286 | - |
| 21. | chlorides (mg/l) | 4472 -6991 | 5,83 | 250 |
| 22. | sulphates (mg/l) | 1000 -1180 | 24,8 | 200 |
| 23. | silicates (mg/l) | 105 -274 | 5,44 | - |
| 24. | orthophosphates (mg/l) | 17,52 – 35,80 | 0,20 | - |

This data was obtained in 1999 during chemical analyses of the leachate samples taken from boreholes in the existing (old) landfill body. For parameters not stated in the rightmost column of the above table, there is no limit value set in this Decree.

The new landfill has not yet begun receiving waste, so the total expected annual volume of leachate was determined using empirical equations and the water balance equation for the landfill.

According to the Main design (Book 1), the annual generation of leachate and necessary basin volume was calculated for the determined phases of landfilling and assumption that

[1] According to the provisions of the Decree on Conditions for Discharge of Wastewater into Natural Recipients and Public Sewer Systems (Official Gazette of FBiH ", no. 6/12)

leachate will be recirculated minimally 20 times per year. These results are shown in the following table:

**Table 3:** Average annual leachate generation at the landfill

| Phase of landfill operation | Area (ha) | Annual leachate generation ($m^3$) | Necessary basin volume ($m^3$) |
|---|---|---|---|
| Existing | 3,95 | 7.158 | 357,9 |
| Phase I | 5,53 | 10.009 | 500,5 |
| Phase II | 8,51 | 15.403 | 770,2 |

### 3.3.3 Air Quality

The negative impact of the existing landfill, which adjacent to the new one, on the air ,is reflected in the spread of odours due to gas development as a result of aerobic and especially anaerobic decomposition of waste in the landfill but this phenomenon is mostly confined to an intermediate area surrounding the landfill.

The nearest settlements are located approx. 300 – 500 m from the existing landfill site, so during windy periods, it is expected that odours can be felt in these areas.

The prevailing winds of this area are northern winds which occur in the winter period, whilst the second most occurring winds of the southern direction occur mainly in autumn and spring.

According to measurements of wind characteristics carried out in 2008 on the mountain massif Velez, surrounding Mostar, the wind rose at two measuring stations (MS Poljice located east of Mostar and MS Plocno located to the north-east of Mostar), is depicted in the following figure:

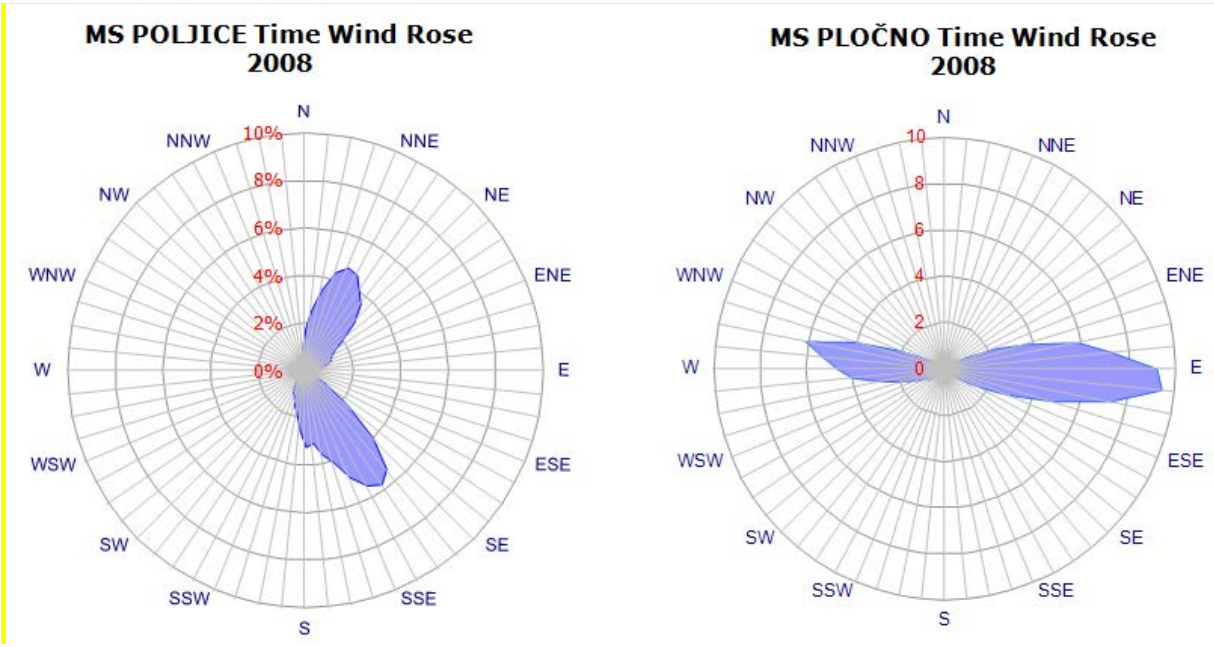


**Figure 3:** Wind rose for the area of Mostar in 2008 (Source:Powerpoint presentation "Experiences from research and design of wind turbines in complex terrains", Suad Zalihic, Elvir Zlomusica, International conference ENERGA June 2012, Tuzla)

The full negative impacts of this old municipal landfill occurred in the period 1988 – 1990 when the waste reached terrain level.

Fires break out often at this site, and foul odours can be felt all the way to Mostar. Wind carries light materials such as paper, nylon and bags and scatters them in the intermediate surroundings of the landfill.

### 3.3.4 Flora and Fauna, Rare or Endangered species

The wider area is characterized by a degraded vegetation cover, with dominant tertiary vegetation systems (orchards, vineyards and fields).

Primary vegetation is non-existent in this area, except in the northern slopes towards Velež Mountain. In terms of proximity, it is not in the immediate vicinity of the considered area, but its presence is significant as it forms the major part of the basin that borders with the “Uborak” landfill.

Secondary vegetation is made up of elements of underbrush, hornbeam, bramble and blackberries. The last two vegetation elements are predominant in the landfill area.

Human factor has caused negative effects on the vegetation as its destruction has enabled more pronounced erosion factors of water and winds.

There are no registered rare or endangered species in this area.

### 3.3.5 Landscape and Sensitive Habitats

Impacts of the existing municipal landfill on the surrounding landscape can manifest themselves through the accumulation of dust, vapour and aerosol dispersion due to wind. This effect depends on the wind direction and velocity. Given that within the radius of dominant flue products and other factions spread, there is arable land, there is a possibility of contamination of arable land surrounding the landfill. Also, considering that the waste is disposed of in an inadequate way, there is a possibility that it reaches surfaces surrounding the landfill which can have a negative impact on this land.

## 3.4 Socio-cultural Environment

The Project location is in the City of Mostar, which consists of 43 local communities. According to the last official census from the year 1991, Mostar's population was 125.061. According to the estimates provided by the Statistics Agency of the Federation of BiH from the year 2009, the City of Mostar has a population of 111.186.

The landfill is located within the local community of Vrapcici, app. 12 km from the city centre. According to the most recent official census from 1991, Vrapcici has a population of 3.450, with 985 households.

Settlements in proximity to the landfill are Livac, Kuti and Budevac. The first two settlements are 500 m away from the landfill, while the nearest houses in part of the settlement Budevac are app. 300 m away.

In the wider area of the landfill, there are no cultural or natural heritage sites.

# 4 POTENTIAL ENVIRONMENTAL AND SOCIAL IMPACTS

The construction of a WWTP will have a number of positive and possibly some minor negative impacts, particularly during plant operation. However, some impacts are also expected during construction, mainly due to civil works.

The need for construction of a WWTP at the landfill is reflected in the fact that during periods of heavy rainfall, in order to minimise the risk of spilling of toxic leachate and overloading the current leachate recirculation system, the landfill operator considers discharge of the treated leachate water into Neretva River via Sušica Stream a more sound option. Additionally, this would enable connection to the wastewater treatment system of the materials recovery facility located at the landfill.

Experience from the existing municipal landfill shows that it becomes extremely saturated with water every year during the winter period of heavy rainfall. Therefore, it is expected that this will occur with the new landfill as well, which will require not only that recirculation is suspended during this period, but also to drain excess water from the landfill itself and to soundly discharge it into the environment.

Overall, this would contribute to reduction of pollutant loads discharged into karstic groundwater of Neretva River which discharges into the Adriatic Sea.

## 4.1 Impacts on Surface and Underground Water Quality

The impacts on the quality of both groundwater and surface waters are expected to be positive, as treatment of leachate will minimise the risk of it contaminating the environment. However, in case of plant failure, some negative impacts, reflected in deteriorated effluent quality are expected. These impacts may be mitigated using appropriate housekeeping practices.

**Construction**

Negative impacts, short - term in character, which might occur during construction of the WWTP are mostly due to excavation works with occurrences of substrate erosion from working areas to the nearby periodically occurring stream Sušica. However, this watercourse has been regulated in the course of construction activities at the sanitary landfill and is located in a closed concrete channel, so these impacts are not likely and are minimal. This can be mitigated using good construction practices such as stockpiling excavated soil along the side of trenches; protecting the stockpiles from dust and wind erosion, with the use of covers or the application of water; and protecting stockpiles from vehicle movements. Where it is possible, existing roads will be used to move vehicles and equipment around the construction area.

Excess excavated soil that is not put back in place after the construction of the WWTP may be used as inert covering material for the landfill.

Contamination of surface and groundwater might occur as a result of accidental release or spilling of oils, fuels, grease and other pollutants pertaining to the mechanization and vehicles. Special care should be taken to ensure spills are promptly contained and cleaned up and vehicles and machinery properly maintained.

**Operation**

The impacts of the WWTP are expected to be positive, as its commissioning will enable treatment of excess water that saturates the landfill during periods of heavy rain (November – March). Even though the lagoon was designed to receive the reasonably anticipated quantities of leachate (see Table 3), during this period, it is not recommendable to recirculate leachate, which means that the waters from the lagoon have to be drained elsewhere. Therefore the recirculation lagoon will also be connected to the WWTP, which will provide treatment, thus the water may be safely discharged to the Sušica Stream.

However, in case of failure, precautionary steps need to be taken to ensure minimal risk to the environment. This includes providing standby generators in case of power failure to generate power. In case of mechanical failure of the plant, additional chlorination may be introduced to the recirculation lagoon to reduce pathogenic bacteria of the leachate prior to its discharge into the effluent, if the lagoon exceeds its capacity during periods of heavy rain. This ensures a better scenario than “do-nothing”, i.e. discharge of untreated leachate into the recipient.

Adequate warning notices need to be given to local authorities of the communities affected by deterioration of the water quality, i.e. downstream users.

Maintaining equipment in good working order is also important for preventing equipment malfunction, thus reducing the risk of surface and groundwater contamination caused by mechanical failure.

The positive effects are reflected in connecting the MRF to the WWTP which will decrease the pressure load on the existing sewerage system in place at the landfill.

There is a possibility of connecting the leachate system of the old landfill to the WWTP which will significantly improve the conditions of the groundwater, as this leachate system in place is not operated to required standards. This may be the subject of a separate agreement between the two landfills and their operators.

In case an agreement is made with the operators of the old landfill on the treatment of this leachate at the WWTP, a special dynamic plan of leachate intake from the old landfill will be drafted by the WWTP operator.

## 4.2 Impacts on Soil Quality

**Construction**

Construction works related to the removal of superficial layer of humus, excavation of the ground, as well as the presence of mechanization units and workers on the construction sites will cause appearance of certain negative impacts on soil. However, as construction will take place within the landfill area, these impacts are limited only to the limited area of the landfill and are not considered of high risk. Good engineering practices, like separate storing of topsoil need to be adhered to. Topsoil reutilization should be done using the best available procedures and techniques. Before construction works, the topsoil should be removed and stored beside the excavation site to avoid loss and/or degradation. After the construction works have been completed, the soil should be replaced and pre-construction conditions reinstated.

Mechanical impacts during excavation works which result from the presence of mechanization units, vehicles and workers on the construction sites might be mitigated with good working practice. If proposed mitigation measures are properly implemented, impacts on land will not be significant.

After the construction works have been completed, the soil should be replaced and pre-construction conditions reinstated.

Spare soil and other inert waste that needs to be disposed of could be used as cover or as reinstatement material at the landfill site.

**Operation**

The impact of the WWTP on soil conditions during operation can have indirect effects on public health and the environment. Sludge is an unavoidable by-product of biological wastewater treatment plants, and can be handled in several ways (disposal at landfill, incineration and agriculture use following its pre-treatment).

Independent of the type of disposal, it first has to be stabilised, which means that little biodegradable material is left in the sludge. As a consequence, the sludge does not emit strong odours.

For the area of Mostar, several sludge stabilization options may be considered, which are presented in the table below.

**Table 4:** Comparison of sludge stabilization processes

| Sludge stabilization process | Description | Advantages | Disadvantages |
|---|---|---|---|
| Aerobic digestion | Activated sludge is kept relatively long in the biological treatment (approx. 25 days) – extension of the activated sludge aeration process | Biologically stable end product which is odourless<br>Relatively cheap construction of aerobic digestion tanks<br>Easier to operate than more complex anaerobic form – requires less skilled labour | High power costs<br>Variable solids reduction efficiency with varying temperature changes<br>Possibility of odours |
| Anaerobic digestion | Sludge digestion is carried out in the absence of free oxygen by anaerobic organisms. | Energy production<br>Good dewatering of sludge | Complex process<br>High safety requirements |
| Chemical stabilization | The sludge is treated with chemicals in different ways to stabilize the sludge solids. | May be used for agricultural use | Increased sludge amount<br>Unsuitable for disposal in landfill |
| Constructed wetlands | Sludge stabilization is carried out over a period of 10 years in constructed beds populated with reeds which break down biosolids and dewater sludge. | Cheap to construct and operate (very low energy consumption)<br>Simple process<br>High levels of mineralization and dewatering of sludge<br>No odour | Requires large footprint |

At this stage, the most appropriate method for sludge stabilization for the area of Mostar would be constructed wetlands. This method does not generate odour during sludge stabilization, which is a significant consideration due to strong winds that characterize this area. Sludge stabilized in this manner may be soundly disposed of at the sanitary landfill Uborak, which is at this moment the most viable solution for final sludge disposal.

However, the relatively long buffering time of the sludge also allows other sludge disposal alternatives to be explored in the intermediate future such as sludge incineration which is preferred over disposal at landfill due to spatial considerations. However, the final sludge treatment needs to be addressed in line with concepts on national and regional level that would specify clear disposal routes in the future.

Sludge reuse, when possible, is prescribed by the Decree on Conditions for Discharge of Wastewater into Natural Recipients and Public Sewer Systems (Official Gazette of FBiH ", no. 6/12). However, it must meet certain criteria which make it harmless to the environment, which are prescribed by the “Regulation on Animal Waste and Other Non – hazardous Materials of Natural Origin Which May Be Used for Agricultural Purposes” (Official Gazette of FBiH, no. 8/08). This should be considered accordingly during the development of any sludge management procedures.

## 4.3 Impacts on Air Quality

**Construction**

During the construction phase, some of the main sources of pollution are linked to traffic and dust arising from construction activities. The areas expected to be affected will be within several hundred meters of the working area. As previously mentioned, the nearest settlements are approx. 300 – 500 m distant from the construction area, and may be impacted by construction activities. These are not significant impacts provided the proposed mitigation measures such as dust suppression techniques (e.g. soil damping, truck covering, etc.) are properly implemented. Such impacts will be short term and neither significant influence on local population nor pollutant emissions above the values set by legislation in force, are expected. Emissions from diesel engines will be kept to a minimum by ensuring regular maintenance and use of high quality fuels as well as shutting equipment down when not in use.

**Operation**

During the WWTP lifecycle, emissions pertaining to its operation (biological treatment) are unavoidable. Several emissions may occur, including greenhouse gasses and aerosols which in the air have direct and indirect effects to the atmosphere. Bad odour may occur if the WWTP is not operated according to projected parameters or due to extremely high temperatures. The location of WWTP is planned in the area relatively distant from the urban part of Mostar (approx. 12 kilometres), with a small number of inhabitants in its relative vicinity (some of the settlements of the Vrapcici local community - Gornji Vrapcici) and the army barracks “Miralem Jugo”.

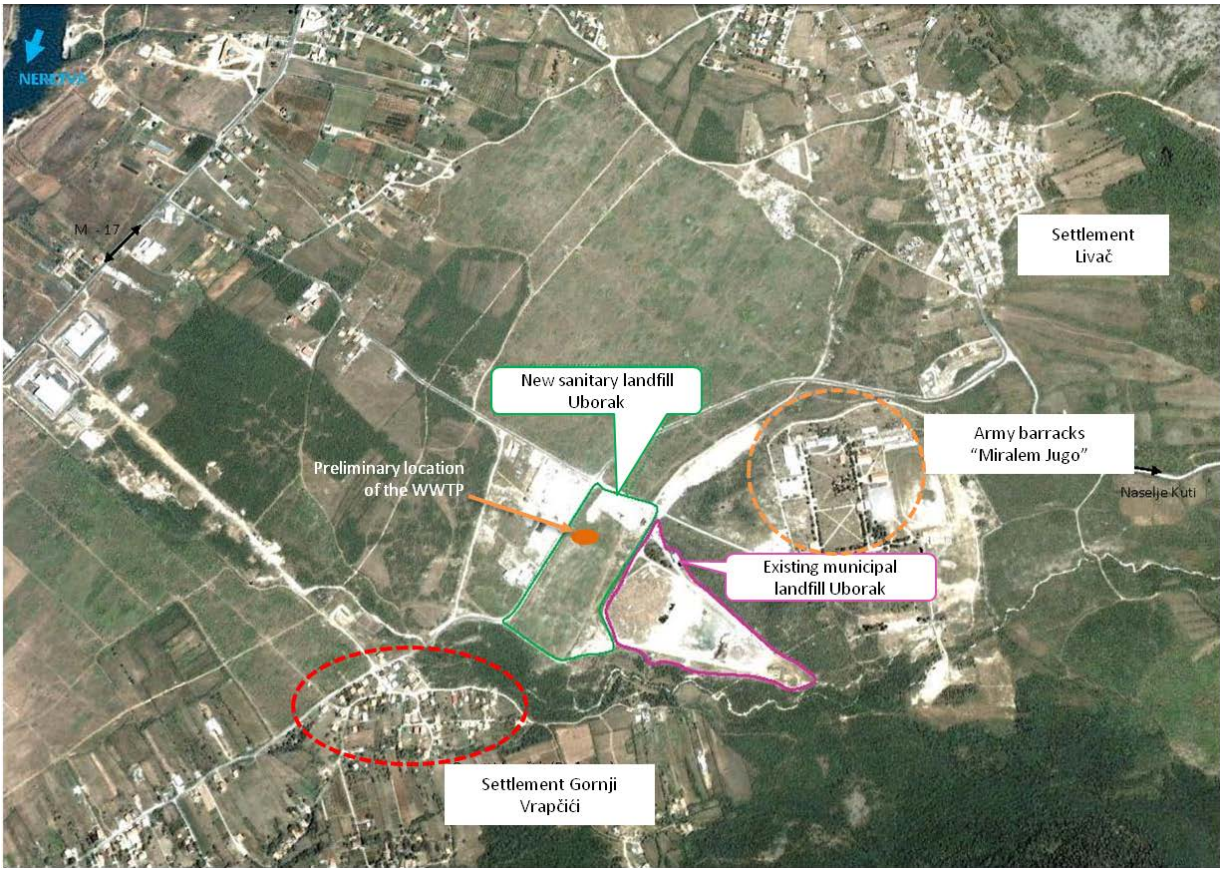


**Figure 4:** Preliminary location of the WWTP and position of the nearest households (marked in red dotted line)

It is necessary to undertake mitigation measures which include placing facilities which are the main sources of odour/gas emissions in closed units or buildings; installation of gas and odour control devices; and adherence to good housekeeping procedures. This will ensure that no negative impacts are felt by the local population closest to the WWTP (approx. 300 – 500 m away).

## 4.4 Impacts from Noise and Vibration

**Construction**

Construction works may result in significant, but temporary increase in noise levels as a result of presence of people and vehicles and operation of mechanical units, such as compaction, excavation, drilling or mechanical digging. However, this effect is short-term and unavoidable and may be considered of moderate significance, as the landfill is located 300 – 500 m to the nearest residential area.

The FBiH and the EU have legislation in force regulating the levels of permissible noise from mobile plants and machinery. These limits shall be respected in the course of any construction activities through the implementation of mitigation measures which include scheduling construction activities so those which generate noise and vibration are operated separately and during normal daytime periods; use of noise control devices.

An increase in traffic is expected arising from construction machinery entering and leaving the site. However, all construction traffic will be scheduled to occur during normal working

hours, which will ensure that these impacts are acceptable. Equipment and vehicles will be operated in a sympathetic manner, i.e. not left idling.

**Operation**

Noise may be generated during operation of the WWTP. Potential noise sources include the preliminary treatment facility, pumping station, compressor station, etc., depending on the selected type of plant. Mitigation measures to minimize such impacts include placing facilities or motors which emit high noise levels in closed buildings or units; regular maintenance and inspection of all plant facilities; adopting good housekeeping procedures and the use of noise control equipment, i.e. mufflers, enclosures etc. The WWTP is located in a rural area away from densely populated areas (approx. 300 – 500 m from the closest settlements). Therefore, noise impacts associated with plant operation are not considered significant.

## 4.5 Impacts on Ecology and Biotic Resources

**Construction**

The proposed location of the WWTP is located within the landfill site, therefore no significant impacts on ecology or biotic resources are expected.

**Operation**

It is not expected that the WWTP will have any significant impact on vegetation and animal life during normal operation. As stated earlier, it is expected that the treatment of leachate will have a positive impact on the Neretva River, including downstream recipients.

## 4.6 Impacts on Local Population

**Construction**

No significant negative impacts on the health of the local population are envisaged because of the project. Although the construction works will take place within the new landfill area, increased traffic on access roads may occur mainly due to the transport of equipment and construction material for the WWTP. However, speed limits will be strictly enforced to minimise generation of dust from vehicles transporting material and all construction activities will be limited to normal daylight working hours. Mitigation measures proposed in the environmental mitigation plan of this EMP (see Chapter 5.1) are considered appropriate to avoid impacts associated with public health and safety.

Potential health and safety impacts may only be expected in the early phases of project construction, and mainly refer to the people working on site. These impacts include:

- Pollution and deterioration of the soil from harmful substances spilling (fuel, oil, etc.);
- Air pollution due to dust due to construction works, and gases from the machinery and vehicles used during the construction;
- Noise and vibration from the construction machinery during the construction and during the deployment period of the WWTP;
- Pollution of ground water due to spillage and trickling of fuel, oil and other pollutants;
- Health and safety hazard for construction workers from open channels and trenches deposited and temporarily stored materials, manoeuvring with the construction machinery.

These impacts may be mitigated using good housekeeping practices referred to in Chapter 5.1 of this EMP.

**Operation**

It is expected that the implementation of this Project will have significant positive social impacts, as wastewater treatment plants generally create positive social benefits.

The major identified positive impact includes the elimination of discharged waste water to ground water and the river Neretva, which is of crucial importance to human health primarily, due to elimination of any potential dangers/risks to potable water in individual water wells used by the local population as well as to agricultural land and crops in the proximity of the landfill.

Negative impacts associated with the operation of the WWTP include hazard risks to plant employees from daily maintenance of the plant facilities (i.e. taking samples, sludge removal, plant cleaning etc.) and exposure to the various gases released during wastewater treatment (CO, $SO_2$, $NO_x$). If not properly managed, these substances can result in sickness and chronic medical problems in the future. Mitigation measures have been proposed to avoid such impacts, which include training and education programs for all employees; periodical medical checkups; the implementation of good housekeeping procedures; and the use of gas and odour control devices and/or closed units/buildings for facilities emitting harmful chemicals. Through proper care and management, such impacts are not considered significant.

## 4.7 Impacts on Land Use

No impacts on land use are expected during Project implementation.

## 4.8 Resettlement and/or Economic Displacement

No resettlement of households/businesses or acquisition of private land is expected during Project implementation.

## 4.9 Impacts on traffic infrastructure

**Construction**

As the WWTP is to be constructed within the landfill site, the only possible impacts on traffic may be reflected in local disruptions of traffic within the technical roads inside the landfill. However, as the landfill on which the WWTP is to be located is not yet receiving waste, no traffic aside from the construction traffic is expected within the landfill, i.e. the construction site of the WWTP.

No significant amount of traffic is expected to be disrupted in the area of the construction site, as it is located near a local road used only by the local population of the Vrapcici local community. Adequate planning of the construction site activities and movement of mechanization will ensure that no disruptions occur to the local roads.

**Operation**

No impacts are expected during the operation phase.

# 5 ENVIRONMENTAL MANAGEMENT PLAN

## 5.1 Environmental Mitigation Plan

| Activity | Expected environmental impact | Proposed measure for mitigation | Responsibility for implementing mitigation measure | Period of implementing mitigation measure | Cost associated with implementation of mitigation measure |
|---|---|---|---|---|---|
| **Design and Construction Phase** | | | | | |
| Delay in construction and commissioning of the WWTP | Health and environmental risk | Obtainment of all necessary permits and approvals | Landfill operator/ owner of landfill | Prior to design | Depending on type of permit/approval necessary |
| Plant design and infrastructure | Health and environmental risk | A high standard of quality will be maintained during project design and preparation to minimize any environmental risks.<br>It will be ensured that all noise/odour/air polluting units are placed in closed areas with adequate air treatment devices. | Design company | During design | Included in design costs |
| Emissions from construction equipment and vehicles | Air pollution | Equipment and vehicles will be regularly maintained in-line with manufacturers' recommendations to minimise polluting exhaust emissions.<br>All new equipment and vehicles will meet the relevant national regulations and EU directives for emissions standards.<br>Vehicles and equipment will be turned off when not in use.<br>Construction equipment and vehicles | Construction contractor | During construction | Minor/Included in construction costs |

| Activity | Expected environmental impact | Proposed measure for mitigation | Responsibility for implementing mitigation measure | Period of implementing mitigation measure | Cost associated with implementation of mitigation measure |
|---|---|---|---|---|---|
| | | will be monitored periodically to ensure they meet the agreed standards. | | | |
| Noise and vibration from construction works | Noise pollution and vibration | Construction activities will be limited to normal daylight working hours.<br>A works schedule will be followed and/or other specific restrictions on works will be established.<br>All construction equipment and vehicles will be in good working order and maintained in line with manufacturers' recommendations.<br>Noise control engineering techniques will be in use where practical i.e. the use of mufflers, silencers, enclosures etc.<br>Noise emissions will be monitored against set control targets to meet required standards for industrial zones:<br>Daytime (07.00-22.00) – 70 dB (A)<br>Night-time (22.00-07.00 – 70 dB (A) | Construction contractor | During construction | Minor/Included in construction costs |
| Construction activities incl. excavation, stockpiling or backfilling of excavated material | Sedimentation and surface run-off | Dust suppression techniques (i.e. the application of water, spraying the site with water mist) will be used.<br>Excavated materials will be stockpiled on the hill side of the trench.<br>Stockpiles will be protected from vehicle movements.<br>The rinsing of sediment off site will be prohibited to avoid sediment reaching storm drains.<br>Equipment tires will be rinsed before | Construction contractor | During construction | Minor/Included in construction costs |

| Activity | Expected environmental impact | Proposed measure for mitigation | Responsibility for implementing mitigation measure | Period of implementing mitigation measure | Cost associated with implementation of mitigation measure |
|---|---|---|---|---|---|
| | | leaving site to avoid trailing sediment off site or onto roadways.<br>Topsoil is to be handled and stored separately to avoid any contamination. | | | |
| Waste generation from construction activities (including hazardous waste) | Soil and water pollution | All waste material will be transported and disposed of accordingly at the landfill.<br>Hazardous wastes (oils and grease from grease trap) will be collected in closed tanks, temporarily stored in the recycling area and handed over to an authorized company for final treatment/disposal. | Construction contractor.<br>Environmental inspector must ensure all regulations and procedures are followed. | During construction | Minor/ Should be included in construction costs;<br>Cost estimate:<br>2 BAM/t – for transport;<br>50 BAM/t – for disposal |
| Execution of works | On-site installation damage | Contractors will protect existing installations and buildings from potential damage during the execution of works.<br>In the event of damage, the contractor is obliged to undertake repairs | Construction contractor | During construction | Minor/Included in construction costs |
| Use of construction vehicles and equipment | Soil and water pollution | Stringent on-site pollution control measures will be applied to prevent soil and water contamination from oil and fuel.<br>Condition of vehicles and equipment will be periodically checked.<br>Equipment and vehicles will be regularly maintained in line with manufacturers' recommendations.<br>Any spills will be contained and cleaned up.<br>All vehicles will carry absorbing pads.<br>Protective equipment and trays will be | Construction contractor | During construction | Minor/Included in construction costs |

| Activity | Expected environmental impact | Proposed measure for mitigation | Responsibility for implementing mitigation measure | Period of implementing mitigation measure | Cost associated with implementation of mitigation measure |
|---|---|---|---|---|---|
| | | used when refuelling or changing oil on vehicles and equipment.<br>Designated areas will be defined for the storage of fuel, lubricants, coolants, paint, solvents etc. | | | |
| **Operation Phase** | | | | | |
| Wastewater collection system (WCS) | Soil and water pollution | All sewers, collection channels and manholes should be kept watertight.<br>Ongoing inspection and maintenance of the WCS should be performed to monitor leaks, pipe corrosion etc. | Operator, WWTP maintenance | During operation | Included in maintenance costs |
| Discharge of effluent to recipient rivers | Water quality degradation | Effluent will be regularly monitored to ensure water quality standards prescribed by the Decree on Conditions for Discharge of Wastewater into Natural Recipients and Public Sewer Systems (Official Gazette of FB&H ", no. 6/12) are met. WWTP will operate at an optimum efficiency level. | Operator, WWTP maintenance | During operation | 1 500 BAM/measurement |
| Disposal of residual solid products (sludge) from mechanical, chemical and/or sludge treatment | Soil and water pollution | Sludge will be stabilized in constructed wetlands.<br>Safety procedures for transportation and disposal of stabilized sludge will be established.<br>The sanitary landfill will be used for disposal of stabilised sludge in the immediate and intermediate future, and other viable options may be considered in the future if conditions for such arise. | Operator, WWTP maintenance | During operation | Included in maintenance costs |

| Activity | Expected environmental impact | Proposed measure for mitigation | Responsibility for implementing mitigation measure | Period of implementing mitigation measure | Cost associated with implementation of mitigation measure |
|---|---|---|---|---|---|
| Inefficient WWTP operation | Inadequate effluent quality | WWTP operation will be regularly monitored.<br>Regular screening of inflowing wastewater will be conducted.<br>Effluent quality from the WWTP will be controlled.<br>WWTP condition will be periodically checked. | Operator, WWTP maintenance | During operation | 1 500 BAM/measurement |
| Chemical additives | Environmental pollution | All chemical substances used during the chemical treatment phase or other phases (such as adding catalysts to increase sludge drying etc.) will be appropriately stored and handled as hazardous materials. | Operator, WWTP maintenance | During operation | Included in maintenance costs |
| Filter backwashing | Water pollution | Backwash wastewater should be recycled into the system and treated | Operator | During operation | Included in maintenance costs |
| Waste disposal from preliminary and mechanical treatment, chemical residues etc. | Environmental pollution | Waste management plan should be established.<br>Non-hazardous wastes should be disposed of within the sanitary landfill.<br>Wastes deemed as hazardous shall be stored separately until handled over to an authorized company for their final treatment/disposal. | Operator | During operation | Included in maintenance costs |
| WWTP operation | Health and safety hazard for personnel | Personnel of the WWTP should have periodical medical checks to ensure no negative impacts arise from their employment at the WWTP.<br>Sanitary and safety facilities will be maintained. | Operator | During operation | Included in maintenance costs |

| Activity | Expected environmental impact | Proposed measure for mitigation | Responsibility for implementing mitigation measure | Period of implementing mitigation measure | Cost associated with implementation of mitigation measure |
|---|---|---|---|---|---|
| | | Training and education programs will be organized for employees. | | | |
| **Incident situations** | | | | | |
| Pump failure | Outflow of wastewater | To prevent the flow of water out of the pumping station, due to pump failure spare pumps will be installed. | Operator, WWTP maintenance | During construction | Included in construction costs |
| Power outage | Malfunctioning of plant | In order to ensure that power is available to the plant at all times, ancillary power generators will be put in place in case of electrical outage. | Operator, WWTP maintenance | During construction | Included in construction costs |
| Incident discharge of leachate to surrounding area | Water quality degradation | Regular monitoring of meteorological parameters will be carried out to ensure the landfill and leachate lagoon is adequately drained to the WWTP in conditions of heavy rainfall and that the WWTP is operating to designed standards.<br>In case of discharge, adequate notice will be given to the local authorities of all settlements and inhabitants located downstream of the plant to ensure measures against possible human and animal contamination. | Operator | During operation | Minor/ Included in maintenance costs |
| Plant operation | Fire | Fire extinguishers of the “dry” type will be provided in all buildings containing electro-mechanical equipment and electrical installations, which are in-line with applicable standards.<br>An outdoor hydrant network will be | Construction contractor; Fire Inspector | During construction | Included in construction costs |

| Activity | Expected environmental impact | Proposed measure for mitigation | Responsibility for implementing mitigation measure | Period of implementing mitigation measure | Cost associated with implementation of mitigation measure |
|---|---|---|---|---|---|
| | | constructed at the plant, in accordance with the appropriate regulations. | | | |
| **Decommissioning Phase** (these measures refer only to the decommissioning of the WWTP which is expected to occur simultaneously with the decommissioning of the landfill and will form part of the mitigation measures for the landfill closure which are to be drafted separately) | | | | | |
| Decommissioning activities | Traffic disruptions and congestion of local roads | Warning/informative signs will be clearly displayed around the construction area.<br>Works will be limited to regular time intervals.<br>Temporary traffic lights will be in use where appropriate i.e. when alternating by-passing traffic. | Decommissioning contractor | During decommissioning | Included in decommissioning costs |
| Generation of dust from decommissioning activities and truck traffic | Air pollution from dust generation | Closed or covered trucks will be used to transport material, where possible.<br>Dust suppression techniques will be adopted where activities generate airborne dust or when working in dry soils i.e. application of water, the use of protective covers or screens etc.<br>Activities which generate airborne dust will be prohibited during high wind periods.<br>Speed limits for all vehicles will be strictly enforced on site to 25 km/hour | Decommissioning contractor | During decommissioning | Included in decommissioning costs |
| Noise and vibration from decommissioning activities | Noise pollution and vibration | Decommissioning activities will be limited to normal daylight working hours.<br>A works schedule will be followed and/or other specific restrictions on works will be established.<br>All equipment and vehicles will be in good working order and maintained in | Decommissioning contractor | During decommissioning | Included in decommissioning costs |

| Activity | Expected environmental impact | Proposed measure for mitigation | Responsibility for implementing mitigation measure | Period of implementing mitigation measure | Cost associated with implementation of mitigation measure |
|---|---|---|---|---|---|
| | | line with manufacturers' recommendations. | | | |
| Decommissioning process | Pollution of recipient watercourse | Pipes and the overall effluent release mechanism needs to be sealed or completely removed to prevent leaks and spills into the recipient river, after the WWTP is closed. | Decommissioning contractor, WWTP Maintenance Crew | During decommissioning | Included in decommissioning costs |

## 5.2 Environmental Monitoring Plan

| **WHAT** *parameter is to be monitored?* | **WHERE** *is the parameter to be monitored?* | **HOW** *is the parameter to be monitored (type of monitoring equipment)?* | **WHEN** *is the parameter to be monitored (timing and frequency)?* | **BY WHOM** *is the parameter to be monitored (responsibility)?* | **HOW MUCH** *is the cost associated with implementation of monitoring?* |
|---|---|---|---|---|---|
| **Baseline** | | | | | |
| Physical and chemical properties of groundwater and nearby recipients:<br>▪ Water temperature ( □C)<br>▪ pH<br>▪ diluted oxygen concentration (mg $O_2$/l)<br>▪ dispersed matter concentration (mg/l)<br>▪ BOD (mg $O_2$/l)<br>▪ COD (mg $O_2$/l)<br>▪ Total nitrogen concentration (mg N/l)<br>▪ Total phosphorus concentration (mg P/l)<br>▪ Total oil and grease concentration (mg/l)<br>▪ Mineral oil concentration (mg/l)<br>▪ Salinity (%)<br>▪ Turbidity (m)<br>▪ Ammonia (mg N/l)<br>▪ Nitrite (mg N/l)<br>▪ Nitrate (mg N/l)<br>▪ Orthophosphate (mg P/l)<br>▪ Chlorophyll “a” (mg/$m^3$)<br>▪ Copper (µg Cu/l)<br>▪ Zinc (µg Zn/l) | At outlet and upstream and downstream of the outlet (The best and exact position will be determined by the operator). | Laboratory testing | Water samples to be taken prior to commissioning of WWTP. After commissioning, samples will be taken in periods prescribed by the Decree on Conditions for Discharge of Wastewater into Natural Recipients and Public Sewer Systems (Official Gazette of FBiH, No. 6/12) | Authorised laboratory/ Operator | 5 000 BAM/ measurement |

| **WHAT** *parameter is to be monitored?* | **WHERE** *is the parameter to be monitored?* | **HOW** *is the parameter to be monitored (type of monitoring equipment)?* | **WHEN** *is the parameter to be monitored (timing and frequency)?* | **BY WHOM** *is the parameter to be monitored (responsibility)?* | **HOW MUCH** *is the cost associated with implementation of monitoring?* |
|---|---|---|---|---|---|
| ▪ Cadmium (µg Cd/l)<br>▪ Lead (µg Pb/l)<br>▪ Total coli forms (b.c./100 ml)<br>▪ Faecal coli form FC (f.c./100 ml)<br>▪ Faecal coli form FS (f.s./100 ml) | | | | | |
| Physical and chemical properties of leachate (if landfill starts operation prior to commissioning of WWTP) | Bottom of disposal cell | Laboratory testing | Water samples to be taken prior to commissioning of WWTP once per week | Authorised laboratory/ Operator | 5 000 BAM/ measurement |
| Noise level<br>70 dB (A) by day and night (industrial zone) | Plant boundary | Measurement devices | Prior to plant operation, then twice a year following commissioning. | Operator | 500 BAM/ measurement |
| Meteorological parameters:<br>▪ Precipitation (mm/min) | Plant boundary/ nearest meteorological station | Measurement devices | Daily | Operator | - |
| Air quality:<br>▪ Level of dust (amounts of sediment particles and airborne particles)<br>▪ Exhaust emissions from vehicles and equipment | Working area | Measurement devices<br>Visual inspection, check vehicle and equipment service history | If needed (will be decided upon visual inspection) | Construction contractor | 3 000 BAM/ measurement |
| **Construction Phase** | | | | | |
| Air quality:<br>▪ Level of dust (amounts of sediment particles and | Working area | Measurement devices<br>Visual inspection, | Once a month in the dry season during construction, and after complaints or due to | Construction contractor | 3 000 BAM/ measurement |

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|---|---|---|---|---|---|
| airborne particles)<br>▪ Exhaust emissions from vehicles and equipment | | check vehicle and equipment service history | replacement of construction equipment | | |
| Noise level<br>70 dB (A) by day and night (industrial zone) | Plant boundary | Measurement devices | Regularly during construction, as appropriate, or upon complaints from citizens | Construction contractor | 500 BAM/ measurement |
| Waste generation and management | Working area | Visual inspection, disposal records | Regularly during construction, as appropriate.<br>Amount and disposal records internal reports will be made daily and monthly | Construction contractor | Included in construction costs |
| Water tightness | Collectors, pipes and WWTP facilities | Test certificate; visual inspections | During construction | Construction contractor | Included in construction costs |
| Leaks/spills of fuel, lubricants, paints, solvents | On site, around site | Visual inspection | Regularly during construction, daily or weekly as appropriate | Construction contractor | Included in construction costs |
| **Operation Phase** | | | | | |
| Wastewater chemical and physical parameters:<br>▪ total suspended substance mg/l<br>▪ pH, conductivity<br>▪ total suspended solids<br>▪ BOD (mg $O_2$/l<br>▪ COD (mg $O_2$/l)<br>▪ total phosphorus concentration (mg P/l)<br>▪ total oil and grease | Plant inlet and outlet | Laboratory testing | Once per month, in the first year, following commissioning. If the test results are satisfactory, i.e. comply with Decree on Conditions for Discharge of Wastewater into Natural Recipients and Public Sewer Systems (Official Gazette of FBiH, No. 6/12), testing can be reduced to 4 | Authorised laboratory/ Operator | 5 000 BAM/ measurement |

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|---|---|---|---|---|---|
| concentration (mg/l)<br>▪ mineral oil concentration (mg/l)<br>▪ anionic detergent<br>▪ total phenols<br>▪ heavy metals (Pb, Ni, Zn, Cu, Cd, Cr, Hg, As) | | | times a year. | | |
| Sludge quality:<br>▪ daily quantity of treated and dewatered sludge ($m^3$/d)<br>▪ daily sludge dry substance content (l/d)<br>▪ total nitrogen concentration (mg N/kg D.S.)<br>▪ total phosphorus concentration (mg P/kg D.S.)<br>▪ total potassium concentration (mg K/kg D.S.)<br>▪ total cadmium concentration (mg Cd/kg D.S.)<br>▪ total chromium concentration (mg/l Cr/kg D.S.) | Stabilized and dewatered sludge tank | Laboratory testing | 12 times a year, (equally distributed throughout the year) | Authorised laboratory/ Operator | 5 000 BAM/ measurement |
| Air quality parameters:<br>▪ Wind direction and speed (m/s)<br>▪ Air temperature ( □C) | Plant boundary | Air quality meters | Twice a year (conducted during a 10 day period, in cold and warm periods) | Operator | 4 000 BAM/ measurement |

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|---|---|---|---|---|---|
| ▪ Air humidity (%)<br>▪ Precipitation (mm/min)<br>▪ Ammonia (µg $NH/m^3$)<br>▪ Hydrogen-sulphide (µg $H_2S/m^3$)<br>▪ Mercaptans (µg $C_2H_5SH/m^3$) | | | | | |
| Noise levels<br>< 70 dB (A) day and night (the permissible level for industrial land use) | Plant boundary | Measurement devices | Twice a year (conducted during a 5 day period) | Operator | 500 BAM/ measurement |
| Leaks/spills of fuel, lubricants, paints, solvents | On site, around site | Visual inspection; accident reports | Regularly during operation, daily or weekly as appropriate | Operator/WWTP Maintenance crew | Included in operation costs |
| Compliance with legal regulations and internal procedures for safe material handling | On site | Visual inspection, regular reports | Daily | Operator/WWTP Maintenance crew | Included in operation costs |
| **Decommissioning Phase** | | | | | |
| Traffic disruptions and congestion of local roads | On site, around site | Visual inspection, complaints from neighbours and traffic participants | Regularly during decommissioning, daily or weekly as appropriate | Decommissioning contractor | Included in decommissioning costs |
| Air Quality<br>Level of dust<br>Exhaust emissions from vehicles and equipment | Working area | Visual inspection, check the service history of vehicles and equipment | Regularly during decommissioning as appropriate | Decommissioning contractor | 4 000 BAM/ measurement |
| Noise levels | Plant boundary | Measurement | Regularly during | Decommissioning | 500 BAM/ |

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|---|---|---|---|---|---|
| < 70 dB (A) day and night (the permissible level for industrial land use) | | devices | decommissioning as appropriate | contractor | measurement |
| Leaks/spills of fuel, lubricants, paints, solvents | On site, around site | Visual inspection; accident reports | Regularly during decommissioning, daily or weekly as appropriate | Decommissioning contractor | Included in decommissioning costs |
| Leaks/discharges through the effluent release system | At the effluent release points, disassembling points | Visual inspection | Daily during decommissioning works | Decommissioning contractor | Included in decommissioning costs |
| Filling in of open areas, pits, sumps and sinks | On site | Visual inspection | Daily during decommissioning works | Decommissioning contractor | Included in decommissioning costs |