**Ministry of Environment and Physical Planning**

**Republic of Macedonia**

**City of Skopje**

# Study to Finance, Build and Operate a Wastewater treatment plant in the City of Skopje

## ESIA Study

**January, 2017**

The Study to Finance, Build and Operate a WWTP in the City of Skopje is financed by the Ministry of Finance, Economy and Industry – Republic of France. The project is implemented by Egis Eau form France in cooperation with the local partner BAR E.C.E. Skopje.

In line with defined project activities the local consultant is responsible for preparation of the EIA Study for the project for construction of the WWTP in the City of Skopje.

Considering that the activity is listed in Annex I-paragraph 11 of the Decree determining the projects and the criteria on the basis that will establish the need to implement the procedure for assessment of environmental impact (O.G. No. 74/05, 109/09 and 164/12): "Treatment plants for waste water, with a capacity exceeding the equivalent of 10,000 inhabitants", i.e. projects that necessarily need to carry out the procedure for the assessment of environmental impacts, the City of Skopje as the implementer of the project, on 17.11.2015 (ref.no 17-241/15), submitted a letter of intent for realization of the Project - "Construction of a wastewater treatment plant in the territory of Skopje" to the Ministry of Environment and Physical planning.

In the procedure, established by law, the Ministry issued Decision no. 11-8709/2 that an EIA procedure should be conducted for the activities dated 22.01.2016, and issued The Opinion for the scope of work no 11-1260/2 dated 08.03.2016.

**NOTES:**

**The Updated Draft ESIA Study is based on the findings and results from the Design Works Report and Technical Drawings for the selected wastewater treatment plant for the City of Skopje.**
**The Study for the Skopje WWTP prepared by Tehnolab, Skopje in 2008, as a part of the Project: Wastewater Management in Skopje in the Republic of Macedonia funded by Japanese Government is taken as a basic document, preliminary approved by the City of Skopje.**

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**List of abbreviations**

| | |
|---|---|
| **ATEX** | Explosive environment |
| **BAT** | Best Available Technique |
| | |
| **BOD** | Biochemical Oxygen Demand |
| **BREF** | Best Available Technique Reference Document |
| **CAPEX** | Capital Expenses |
| **CBA** | Cost Benefit Analysis |
| **CCTV** | Closed Circuit TeleVision |
| **CD** | Capacity Development |
| **CHP** | Combined Heat & Power Plant |
| **COD** | Chemical Oxygen Demand |
| **DGT** | Direction Générale du Trésor Public – France |
| **DS** | Dry Solids |
| **EA** | Extended Aeration |
| **EIA** | Environmental Impact Assessment |
| **EU** | European Union |
| **FS** | Feasibility Study |
| **GDP** | Gross Domestic Product |
| **GIS** | Geographic Information System |
| **GUP** | General Urban Plan |
| **GWP** | Global Warming Potential |
| **HMI** | Hydro Meteorological Institute |
| **IPPC** | Industrial Pollution Prevention Control |
| **JASPERS** | Joint Assistance to Support Projects in European Regions |
| **MEPP** | Ministry of Environment & Physical Planning |
| **MKD** | Macedonian Denar |
| **OPEX** | Operation Expenses |
| **OG** | Official Gazette of the Republic of Macedonia |
| **PCE** | Public Communal Enterprise |
| **p.e.** | Population Equivalent |
| **PIU** | Project Implementation Unit |
| **PLC** | Programmable Logic Controller |
| **PPP** | Public Private Partnership |
| **Ppm** | Part per million |
| **PSP** | Private Sector Participation |
| **PU** | Public Utilities |
| **RES** | Renewable Energy Source |
| **SNCR** | Selective Non-Catalytic Reduction |
| **SS** | Suspended Solids |
| **SSO** | State Statistics Office |
| **SEA** | Strategic Environmental assessment |

| | |
|---|---|
| **TOC** | Total Organic Carbon |
| **UV** | Ultra Violet |
| **VSS** | Volatile Suspended Solids |
| **WWTP** | Wastewater Treatment Plant |
| **m** | meter |
| **s** | second |
| **m.a.s.l.** | meters above sea level |
| **ha** | hectar |
| **d** | day |
| **y** | year |
| **kg** | kilogram |
| **$Nm^3$** | normal cubic meter |

# 1 INTRODUCTION

## 1.1 General information

| | |
|---|---|
| **Project** | Study to Finance, Build and Operate a WWTP in the City of Skopje |
| **Referent number** | EUR 41 267 W |
| **Project title** | ESIA Study of the project to Finance, Build and Operate a WWTP in the City of Skopje |
| **Status** | Updated Draft version -2 |
| **Date** | June 2016 |
| **Beneficiary** | Ministry of environment and physical planning and City of Skopje |
| **Prepared by** | ■ Aleksa Tomovski- authorized EIA expert<br>■ Vesna Ickovska; B.Sc.Environmental engineer<br>■ Darko Stojanovski, B.Sc. Civil engineer<br>■ Mihajlo Sahinov, B.Sc.Mechanical engineer<br>■ Dragana Ilijevska, B.Sc. Civil engineer<br>■ Afërdita Haxhijaha Imeri, Social Expert |
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| **Signatory of the Study** | Aleksa Tomovski, EIA Expert |

## 1.2 Overall context of the project

One of the key segments for implementation of the EU standards is environmental management. This is related not only to the compliance and implementation of one of the most complex and financially “most heavy” chapters of the EU legislation; it is also related to the environmental protection and rational use of natural resources as one of the main pillars of the sustainable development.

Integrated water management based on the principles of sustainable development, is one of the important national priorities. Increase investments in environmental infrastructure, with particular emphasis on the collection and treatment of wastewater and drinking water supply, constitute obligations of the country to the principles, priorities and conditions in the Accession Partnership laid down in Council Decision 2008/212/EC of 18 February 2008.

Implementation of the legal requirements and achievement of the standards especially in regard of the UWWT Directive (91/271/EEC) and Drinking Water Directive (98/83/EC) is a huge challenge for the country as far as investments are concerned. In this regard in Macedonia only 15% of the country is covered with WWTP (mechanical and biological). Bigger cities still discharge untreated waste water directly to water bodies.

On September 2014 the Kick of Meeting was organized with the main aim to introduce and inform relevant stakeholders and general public with the main project activities, goals to be achieved taking into consideration environmental protection.

The Public debate related to the recommended solutions for wastewater and sludge treatment took place on 30$^{th}$ of October 2015. The main aim of this debate was to introduce

the beneficiary, relevant stakeholders, NGO's and general public with the pros and cons of the recommended solutions, including the impact on the environment. Discussions were mainly oriented towards environmental protection.

## 1.3 Project objectives

The project area covers 9 of 10 municipalities in the City of Skopje. Municipality of Saraj is excluded as several small WWTP are planned for construction in this municipality. Currently one WWTP is under construction that will improve the quality of river Treska being one of the main tributaries of Vardar River. In the north, part of the Municipality of Gorce Petrov small WWTP is also under construction and in the settlement Dracevo the existing WWTP should be reconstructed. On the other hand, municipality of Sopiste will be included in the project as the newly constructed collection system will be connected to the one of the main collectors.

Population projections to the target year 2045 are prepared based on the last census 2002 (506,926 inhabitants) and population projections for the period 2012/2013 provided by the State Statistical Office. With the adopted average rate of population growth of 0.50% per year, population number will reach 588,000 by 20130 and 633,700 by 2045**.** Population to be served with the WWTP in 2030 amounts to 490,000 and 518,000 in 2045. Besides, the WWTP will accept the sludge generated from 30,000 inhabitants in 2020, and it will be reduced in 2045 to 12,700. Industries within the project area providing appropriate effluent quality in the sewerage system according to national standards will also use wastewater services. Other industries should provide their own treatment prior to discharging in the recepients.

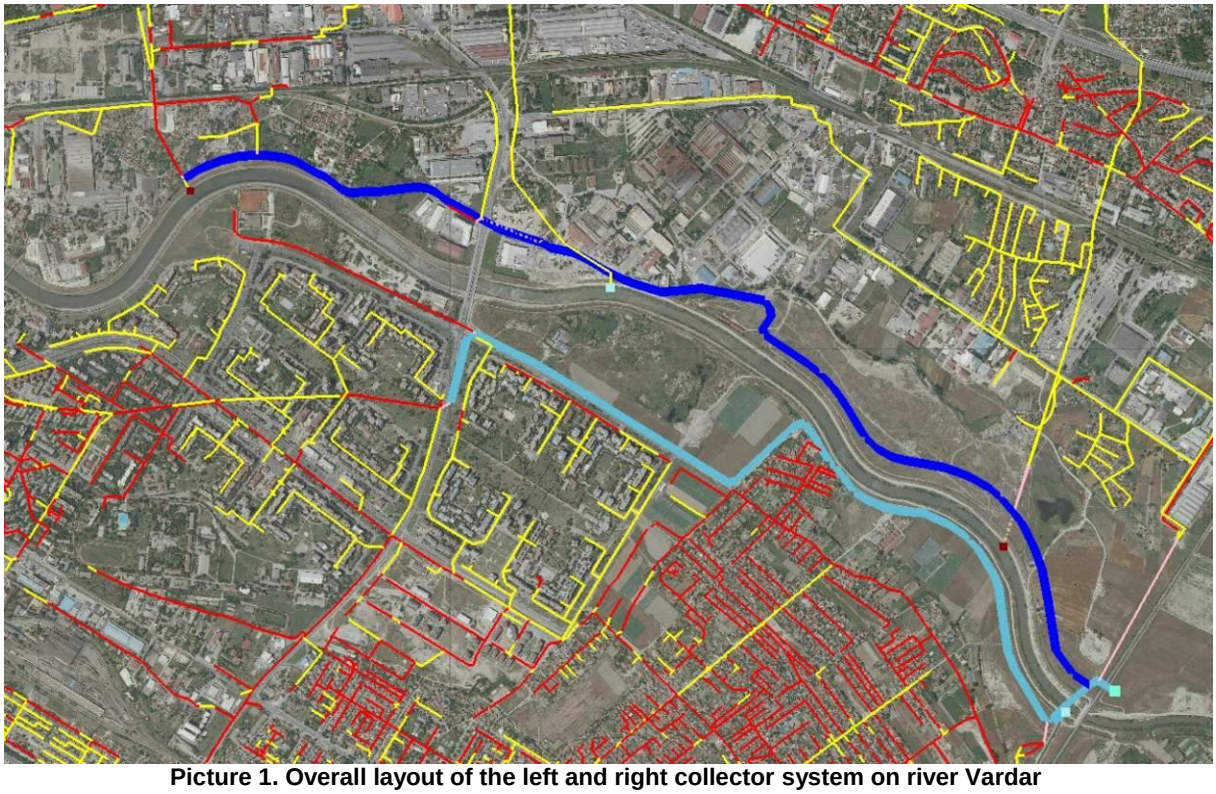
The design horizon for the Study in the first phase of the project implementation will be the year 2030. Secondary treatment will be provided to the diverted wastewater flow to the plant, with special consideration to: sludge by-product disposal, optimization of energy consumption and air quality protection against possible emissions from the plant. Tertiary treatment with the reduction of Nitrogen & Phosphorous concentrations in the treated effluent is foreseen at the second stage of the project, by 2045. The treated effluent will be discharged into the Vardar River which is expected to be declared as a sensitive area in the future.

The 2045 horizon will also be the target year for taking a decision regarding the provision of an appropriate physical and chemical treatment for the storm water drainage flow which may remain entering the wastewater collection system of the served area in rainy periods. The presence of such additional flow in the future will depend on the progress to be achieved for the provision of an adequate separation between the collected sewage flow and storm water drainage flow along the existing sewer collection system.

The main aim of the Study is to provide optimal and sustainable solutions for the water line and sludge line that will achieve the standards of the Urban WWTP Directive and standards for elimination of sludge. On long-term basis, this will ultimately improve the Vardar river quality. Implementation of the project will provide positive impacts on the quality of life, and achievement of better socio-economic climate as base for improvement of the economic standard, new employment for the local population, better condition for foreign investments in the country.

## 1.4 OTHER DEVELOPMENT PROJECTS IN THE PROJECT AREA

In parallel with the investment measure for construction of the WWTP for the City of Skopje the project for improvement of the wastewater collection system in the City of Skopje cofinanced by IPA Funds is underway. The project area covers the city district from where wastewater by gravity is conducted to the future WWTP. With the construction of left main collector and right main collector on river Vardar wastewater will be conducted to the WWTP. Also, it is planned to divide the storm. water from the communal wastewater and continuation of construction of a separate storm water system in the City of Skopje.



**Picture 1. Overall layout of the left and right collector system on river Vardar**

## 1.5 EIA procedure

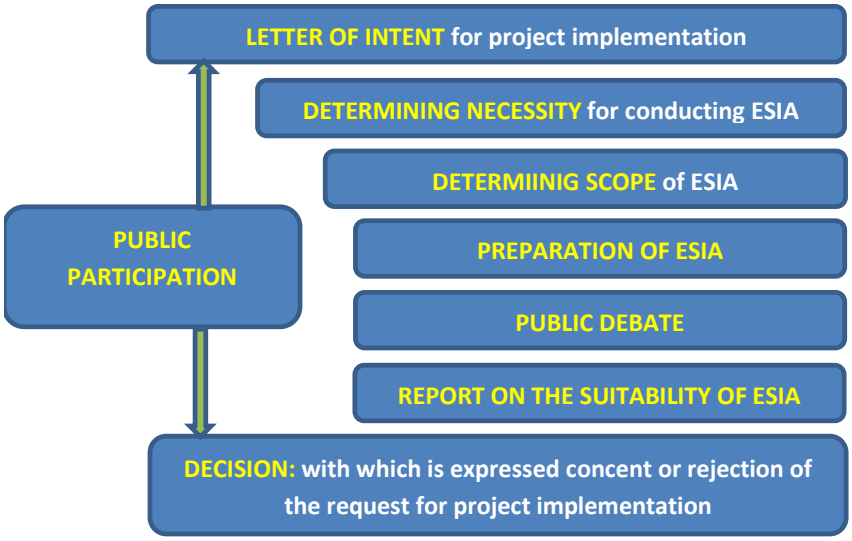
In the Law on Environment (O.G. No. 53/05 81/05, 24/07, 159/08, 83/09, 48/10, 124/10, 51/11, 123/12, 93/13, 187/13 and 42/14), in which the requirements of the EU Directive for EIA are transposed (85/337/EEK), the procedure for Environmental Impact Assessment is defined.

The Decree determining the projects and the criteria based on the need to implement the procedure for assessment of environmental impact (O.G. No. 74/05,109/09 and 164/12) gives the list of projects subject to the environmental impact assessment procedure.

The project of Construction of waste water treatment plant for the City of Skopje falls under the Annex I paragraph 11 of the Decree: „Wastewater treatment plants for waste water, with a capacity over 10,000 p.e.", i.e. – projects that require the preparation of an EIA Study.

The main objective of the EIA study is to determine the possible impacts of the project on construction of the WWTP Skopje on the environment and determine appropriate mitigation measures during construction, operation and closure of the station.

The procedure for conducting an EIA Study is shown on the following diagram.




**Picture 2.EIA Procedure**

# 2 LEGAL AND ADMINISTRATIVE FRAMEWORK

The Constitution of R.M provides the basic principles of environmental protection, and sets this issue as high priority. The Constitution stipulates that one of the basic principles of fundamental values is regulation and humanization of space, the protection and improvement of the environment and nature. Also, one of the fundamental freedoms and human rights is the right to a clean and healthy environment, but it is also the obligation of the citizens to promote and protect the environment, while the country is obliged to provide the exercise of this guaranteed right of the citizens (Article 43).

The key national legislation, EU directives and international standards relevant to the preparation of the study to assess the environmental impact of the implementation of the Project “Study to finance, build and operate a WWTP for the City of Skopje” are presented in table 1.

The contents of the EIA study was prepared in accordance with the national legislation and EU guideline for preparation of EIA (JASPERS Sectoral Guidences for WWTP and Incineration). In order to assess the environmental impact from construction of the infrastructure for wastewater treatment in the City of Skopje, description is provided for:

- Legislation (EU legislation and national legislation) relevant to this project;
- Project location for construction of the treatment plant;
- The proposed project;
- Main alternatives considered;
- Existing environmental situation;
- Significant impact on the mediums and environmental areas as well as socio-economic impacts. Mitigation and elimination measures are defined, based on the identified environmental impacts;
- Management Plan and Environmental Monitoring Program, aimed at assessing the degree of realization of the project and the effects of the implementation of the measures to mitigate the impacts.

**Table 1. Legal Framework**

| Aspects of the environment/society | Relevant National Legislation, Regulations, Decrees, Rulebooks | Relevant EU legislation / Best Practices / Experiences |
|---|---|---|
| **General** | ■ Constitution (O.G. of RM No. 52/91, 01/92, 31/98, 91/01, 84/03 and 107/05);<br>■ Law on Local Government (O.G. No. 5/2002);<br>■ Law on Construction (O.G. No. 130/2009, 124/10, 18/11, 36/11, 54/11, 13/12 and 144/12);<br>■ Law on general administrative work (O.G. No. 38/2005);<br>■ Law on Agricultural Land (O.G. No. 25/1998; 18/1999; 02/2004);<br>■ Law on Financing of Units of Local Government (O.G. No. 61/2004, 96/2004, and 67/2007);<br>■ Expropriation Law (O.G. No. 33/1995, 20/1998, 40/1999, 31/2003 and 46/2005);<br>■ Law on Forests (O.G. No. 64/2009, 24/2011 and 53/2011); | ■ 1996/82/EC: Council Directive on the prevention and control of major accidents in the presence of dangerous substances SEVESO-II;<br>■ 2008/1/EC: Council Directive of January 2008 concerning integrated pollution prevention and control of pollution; |
| **Procedure for EIA** | ■ Law on Environment (O.G. No.53/05, 81/05, 24/07, 159/08, 83/09, 48/10, 124/10, 51/11, 123/12 , 93/13, 187/13 and 42/14);<br>■ Decree determining the projects and the criteria on the basis of which it is needed to implement the EIA (O.G. No. 74/05, 109/09 and 164/12);<br>■ Rulebook on the information contained in the notification of the intention to implement the project and the procedure for determining the need for impact assessment of the project on the environment (O.G. No. 33/06);<br>■ Rulebook on the content of the publication of the notice of intention to implement the project, the decision on the need to assess the impact of the project on the environment, the study to assess the impact of the project on the environment, the report on the adequacy of the assessment study impact of the project on the environment and the decision to approve or reject the project implementation, as well as methods of public consultation (O.G. No. 33/06);<br>■ Rulebook on the requirements to be fulfilled by the study to assess the impact of the project on the environment (O.G. No. 33/06);<br>■ Rulebook on the form, content, procedure and manner of | ■ EIA Directive (85/337/EEC), in force since 1985 and applies to defined public and private projects in Appendix 1 (mandatory EIA procedure) and Appendix 2 (discretionary right of Member States). This Directive was amended three times, in 1997, 2003 and 2009, and in the Macedonian legislation is transposed in Chapter XI of the Law on Environment and relevant regulations.<br>■ Directive 2011/92/EU, last modified in 2014 by Directive 2014/52/EU<br>■ EU Instructions for EIA;<br>■ Experience and recommendations of other countries for EIA;<br>■ JASPERS guidelines. |

| | | |
|---|---|---|
| | preparation of the report on the adequacy of the study for assessment of the project on the environment, and the procedure for authorization of persons from the list of experts to assess the environmental impact, that will prepare the report (O.G. No. 33/06);<br>■ Rules of the costs for conducting the assessment of the project's impact on the environment by the Investor (O.G. No. 116/09). | |
| **Access to information regarding Environment and public participation in the deciding for the environment** | ■ Law on Environment (chapter refers to the EIA procedure and the cross-border context and diffusion of information, public participation and access to justice requirements) (O.G. No. 53/05, 81/05, 24/07, 159/08, 83/09, 124/10, 51/11);<br>■ Espoo Convention was ratified by Macedonia (O.G. No. 44/99);<br>■ The Aarhus Convention was ratified by Macedonia (O.G. No. 40/99). | ■ Directive on access to environmental information (2003/4/EC);<br>■ Directive on public participation in connection with the preparation of certain plans and programs relating to the environment and amending with regard to public participation and the directives of the Council on access to justice 85/337/EEC and 96/61/EC (2003/35/EZ);<br>■ Council Directive 2001/42/EC of 27 June 2001 on the assessment of the effects of certain plans and programs on the environment;<br>■ Convention on Environmental Impact in a Transboundary Context (Espoo, February 1991);<br>■ Convention on Access to Information, Public Participation in Decision-making and Access to Justice courses in Environmental Matters (Aarhus Convention, June 1998); |
| **Water** | ■ Law on Waters (O.G. No. 87/08, 6/09, 161/09, 83/10, 51/11, 44/12, 23/13, 163/13 and 180/14);<br>■ Law on Water Economy (O.G. No. 85/03, 95/05, 103/08);<br>■ Law on the supply of drinking water and disposal of urban waste water (O.G.N. 68/04, 28/06, 103/08, 17/11, 18/11, 54/11 and 163/13);<br>■ Decree on water classification (O.G. No. 18/99);<br>■ Decree on categorization of watercourses, lakes, reservoirs and | ■ Water Framework Directive (2001/60/E3), as amended by Decision 2455/2001/EC and Directive 2008/32/EC, 2008/105/EC, 2009/31 / EC and 2013/39/EC;<br>■ Directive on treatment of urban waste water (91/271/EEC) in addition to Directive 98/15/EC and Regulation (E3) 1882/2003 and EC 1137/2008 and Decision 93/481/EEC; |

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| | groundwater (O.G. No.18 / 99 and 71/99);<br>■ Rulebook on the content and manner of preparation of plans for river basin management (O.G. No.148/09);<br>■ Rules on the methodology for assessment of river basins (O.G. No. 148/09);<br>■ Rulebook on the requirements for collection, disposal and treatment, the manner and conditions for design, construction and exploitation of systems and plants for purification of urban waste waters, as well as technical standards, parameters standards and emission standards for quality of pre-treatment, disposal and purification of waste waters, taking into account the load and the method of treatment of urban waste waters discharged into sensitive Fields of discharge of urban waste water (O.G. No. 73/11)<br>■ Rulebook on the conditions, manner and maximum allowable concentrations of values and parameters of treated wastewater for re-use (O.G. No. 73/11);<br>■ Rulebook on the conditions, manner and emission limit values for discharges of wastewater in their treatment, the method of their calculation, taking into account the specific requirements for the protection of the protection zones (O.G. No. 81/11);<br>■ Rulebook on the methodology, reference measurement methods, manner and parameters for monitoring of wastewater, including sewage sludge from the treatment of urban waste water (O.G. No. 108/11);<br>■ Rulebook on hazardous and harmful substances and their emission standards that can be discharged into the sewer or drainage system, in surface or underground water bodies as well as coastal lands and wetlands (O.G. No.108/11);<br>■ Rulebook on the transmission of information from the monitoring of wastewater discharged, and the form and content of the form for submission of data (O.G. No. 108/11);<br>■ Rulebook on the form and content of the application for non-issuance of a license or failure to issue a decision rejecting the application for a license to discharge (O.G. No. 129/11);<br>■ Rulebook on the criteria for determining the areas vulnerable to | ■ Directive on nitrates (91/676/EEC) as amended by Council Regulation EC 1882/2003 and EC 1137/2008;<br>■ Directive 2008/105/EC on environmental quality standards in the field of water policy;<br>■ Directive on the protection of groundwater against pollution and deterioration (2006/118/EC);<br>■ Directive 2006/11/EC on pollution caused by certain dangerous substances discharged into the aquatic environment;<br>■ Directive 76/464/EEC on the discharge of dangerous substances into water, the legislation oriented to the control of emissions;<br>■ Directive 80/68/EEC on the protection of groundwater from pollution caused by certain dangerous substances;<br>■ Directive 86/278/EEC on the protection of the environment, especially the soil when using sludge in agriculture;<br>■ Directive on the quality of water intended for consumption by people (Directive on drinking water) (98/83/E3), as an amendment to Regulation (EC) 1882/2003 and 1882/2003 and EC Decision 95/337/EC. |

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| | discharges of urban waste water (O.G. No. 131/11);<br>■ Rulebook on the manner and procedure for the use of sludge, the maximum values of concentrations of heavy metals in the soil in which the sludge is used, values of concentrations of heavy metals in the sludge in accordance with its purpose and the maximum annual quantities of heavy metals that can be put in the soil (O.G. No. 73/11);<br>■ Rulebook on the manner and procedure for the use of sludge, the maximum values of concentrations of heavy metals in the soil in which the sludge is used, values of concentrations of heavy metals in the sludge in accordance with its purpose and the maximum annual quantities of heavy metals that can be put in the soil (O.G. No. 73/11). | |
| **Waste management** | ■ Law on Waste Management (O.G. No. 68/04, 71/04,107/07, 102/08, 134/08, 124/10, 51/11, 123/12, 147/13, 163/13 and 27/14);<br>■ Law on Ratification of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (O.G. No. 48/97);<br>■ Law on management of electrical and electronic equipment and waste from electrical and electronic equipment (O.G. No. 6/12 and 163/13);<br>■ Law on Management of Batteries and Accumulators and Waste from Batteries and Accumulators (O.G. No. 140/10, 47/11, 148/11, 39/12 and 163/13);<br>■ Law for menagment of packaging and waste packaging (O.G. No.161/09);<br>■ List of types of waste (O.G. No. 100/05);<br>■ Rulebook on Procedures and manner of collection, transportation, processing, storage, treatment and disposal of waste oils, the manner of keeping records and submission of data (O.G. No. 156/07 and 109/14);<br>■ Rulebook on emission limit values during waste incineration and combustion processes, conditions and manner of work for installations for incineration and combustion. (O.G. No.123/09<br>■ Rulebook on the form and content of the application and the license | ■ Waste Framework Directive (2006/12/EC);<br>■ Hazardous Waste Directive (91/689/EEC);<br>■ Directive on waste oils (75/439/EEC);<br>■ Decision 2000/532/EC establishing a list of wastes;<br>■ Directive 86/278/EEC on the protection of the environment, especially the soil when using sludge in agriculture. |

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| | for the use of sewage sludge as well as the issuance of the license for the use of sewage sludge (O.G. No. 60/11);<br>■ Rulebook on the form, content, and manner of submission of data and the type of information using sludge from the treatment of urban waste water in accordance with its purpose, treatment, composition and location of its use (O.G. No. 60/11);<br>■ Rulebook on common rules for municipal and other non-hazardous waste (O.G. No. 147/07);<br>■ Rulebook on the form and content of the application for non-issuance of a license or failure to issue a decision rejecting the application for a license for collection and transportation of municipal and other types of non-hazardous waste (O.G. No. 146/11);<br>■ Rulebook on the form and content of the permit for collection and transportation of hazardous waste (O.G. No. 118/10);<br>■ Rulebook on the form and content of the application for permit for processing, treatment and/or storage of waste, the form and content of the license and the minimum technical requirements for the activity of processing, treatment and/or storage of waste (O.G. No. 23/07, 76/07, 122/08, 126/12 and 9/13);<br>■ Rulebook amending the Regulation on the form and content of the license application and the register of issued licenses to trade with non-hazardous waste, manner and procedure for issuing a license, the manner of keeping records and the conditions on the manner of conducting trade activity with non-hazardous waste (O.G. No. 55/12);<br>■ Rulebook on the manner of functioning of the integrated network of waste disposal (O.G. No. 7/06);<br>■ Rulebook on the form and content of the application, the form and content of the permit for collection and transportation of municipal and other types of non-hazardous waste and the minimum technical requirements for performing collection and transportation of municipal and other types of non-hazardous waste (O.G. No. 8/ 06 and 133/07);<br>■ Rulebook on the amount of biodegradable components in the | |

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| | waste that can be deposited (O.G. No. 108/09 and 142/09). | |
| **Air quality** | ■ Law on air quality (O.G. No. 67/04 with amendments no. 92/07, 35/10 and 47/11);<br>■ Law on Ratification of the Framework Convention of the United Nations on Climate Change (O.G. No. 61/97);<br>■ Law on Ratification of the Kyoto Protocol to the Framework Convention of the United Nations on Climate Change (O.G. No. 49/04);<br>■ Decree on limit values of levels and types of pollutants in ambient air and alert thresholds, deadlines for reaching the limit values, margins of tolerance for the limit values, target values and long-term goals (O.G. No. 50 / 05, and 4/13);<br>■ Rulebook on quantities of limit values for the emissions of polluting substances in order to determine projections for a period of time relating to the reduction in the quantity of emissions of pollutants per year (O.G. No. 2/10, 156/11 and 111/14);<br>■ Rulebook on methodology, manners, procedures, methods and means to measure emissions from stationary sources (O.G. No. 11/12);<br>■ Rulebook on limit values for permissible emission levels and types of pollutants in waste gases and vapours emitted from stationary sources into the air (O.G. No. 141/10);<br>■ Rulebook on the methodology for inventory and determining the level of emissions of pollutants into the atmosphere in tonnes per year for all activities, and other data for the submission of a monitoring program of air in Europe (EMEP) (O.G. No. 142/07);<br>■ List of zones and agglomerations for ambient air quality (O.G. No. 23/09)<br>■ Rulebook on quantities of limit values of emissions of polluting substances in order to determine projections for a period of time relating to the reduction in the quantity of emissions of pollutants per year (O.G. No. 2/10);<br>■ Rulebook on quality of liquid fuels (O.G. No. 88/07, 91/07,97/07, 105/07, 15/08, 78/08, 156/08 and 81/09);<br>■ Rulebook on the content and method of transmission of data and | ■ Framework Directive on ambient air quality (2008/50/E3);<br>■ Directive on limit values for benzene and carbon monoxide in ambient air 2000/69/E3;<br>■ Directive 2002/3/EC on ozone in ambient air;<br>■ Directive 1999/30/EC on limit values for sulphur dioxide, nitrogen dioxide and nitrogen oxides, suspended solids and lead in ambient air;<br>■ Directive 2004/107/EC relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air. |

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| | information on the situation in the management of air quality (O.G. No. 138/09);<br>■ When implementing the project, it should be taken into account, the findings of the National Plan for Ambient Air Protection in the Republic of Macedonia for the period 2013-2018 year (O.G. No. 170/12). | |
| **Noise and Vibrations** | ■ Law on the Protection of the Environment from noise (O.G. No. 79/07, 124/10, 47/11 and 163/13);<br>■ Rules for the application of noise indicators, additional noise indicators, the method of measuring the noise assessment methods with indicators of noise in the environment (O.G. No. 107/08);<br>■ Regulation on limit values of the noise level in the environment (O.G. No. 147/08);<br>■ Rulebook on conditions for the necessary equipment that authorized professional organizations and scientific institutions and other legal entities and individuals should possess to perform specified duties to monitor noise (O.G. No. 152/08);<br>■ Rulebook on specific types of noise sources and conditions to meet the plants, equipment, installations and devices used in open space in terms of emitted noise standards for noise protection (1) (O.G. No. 142/13);<br>■ Rules of the locations of measuring stations and measuring points (O.G. No. 120/08);<br>■ Decision on determining in which cases and under what conditions is considered that the peace of citizens is disturbed from harmful noise (O.G. No. 1/09). | ■ Directive 2002/49/EC on the assessment and management of environmental noise;<br>■ Directive 2000/14/EC on noise emissions from outdoor equipment. |
| **Protected Areas and Biodiversity** | ■ Law on Nature Protection (O.G. No. 67/06, 14/06, 84/07, 35/10, 47/11, 148/11, 59/12, 13/13, 163/13, 27/14 and 41/14);<br>■ Legal acts for proclamation of protected areas in accordance with the Law on Nature Protection;<br>■ Law on Ratification of the Bonn Convention on the Conservation of Migratory Species of Wild Animals (O.G. No. 38/99);<br>■ Law on Ratification of the Berne Convention on the Conservation of European Wildlife and Natural Habitats (O.G. No. 49/97); | ■ Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora;<br>■ Directive 2009/147/EC on the conservation of wild birds;<br>■ Convention on Biological Diversity (Rio de Janeiro) in 1992;<br>■ Convention on the Conservation of Migratory Species of Wild Animals (Bonn), 1979; |

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| | ■ Law on Ratification of the Convention on International Trade in Endangered Species of Wild Fauna and Flora - CITES Convention (O.G. No. 82/99);<br>■ Law on ratification of the London Agreement on the Conservation of Bats in Europe (O.G. No. 38/99);<br>■ Decree on the ratification of the Convention for the protection of wetlands of international importance for the protection of aquatic birds (RAMSAR) (O.G. No. 9/77). | ■ Convention on Wetlands of International Importance, especially as wetlands (Ramsar), 1971;<br>■ Convention on the protection of wild flora and fauna in Europe and Natural Habitats (Bern), 1972;<br>■ Convention on International Trade in Endangered Species of Wild Fauna and Flora (Washington-CITES Convention), 1973<br>■ Agreement on the Conservation of Bats in Europe (London), 1991. |
| **Protection of soil** | Soil protection in Republic of Macedonia is regulated by the application of laws and regulations relating to the environment, water, nature, forests, waste and construction. | |
| **Protection of Cultural Heritage** | ■ Law on Protection of Cultural Heritage (O.G. No. 20/04, 71/04, 115/07, 18/11, 148/11, 23/13, 137/13, 164/13, 38 /14 and 34/14);<br>■ Law on Ratification of the Framework Convention of the Council of Europe of the importance of cultural heritage in the society (O.G. No. 25/11);<br>■ Law on Ratification of the Convention for the Safeguarding of the Intangible Cultural Heritage (O.G. No. 59/06). | ■ Convention on the Protection of the World Cultural and Natural Heritage, UNESCO, 1972. |
| **Health and Safety and Health at Work** | ■ Law on Health Protection (O.G. No. 43/12, 145/12, 87/13, 164/13, 39/14, 43/14 and 132/14);<br>■ Law on Safety and Health at Work (O.G. No 92/07, 136/11, 23/13, 25/13, 137/13, 164/13 and 158/14);<br>■ Decree on the type, method, volume and pricing of medical examinations of employees (O.G. No. 60/13 and 168/14);<br>■ Rulebook on minimum requirements for safety and health of employees at work (O.G. No. 154/08);<br>■ Rulebook on personal protective equipment used by workers at work (O.G. No. 116/07);<br>■ Rulebook for Safety and Health at Work on equipment for work (O.G. No.116 / 07);<br>■ Rulebook on safety and health at work of employees at risk of noise (O.G. No. 21/08). | ■ Framework Directive on Safety and Health at Work (89/391 / EEC);<br>■ Directive 89/654/EEC on the minimum requirements for safety and health in the workplace;<br>■ Directive 2009/104/EC on the use of work equipment;<br>■ Directive 89/656/EEC on the use of personal protective equipment;<br>■ Directive 89/654/EC on the basic requirements to meet the workspace. |

# 3 DESCRIPTION OF THE PROJECT

## 3.1 Area served by the project

The city of Skopje is located in the center of the Skopje region, which coincides with the natural geographic boundaries of the Skopje valley, which is a large area in the upper part of the river Vardar. It is surrounded by high mountains from all sides. The City lies over an area of 1818km$^2$, 23km long and 9km wide. Skopje extends from 42°00' north latitude and 21°26' east longitude, at 230-240m a.s.l.

As a special administrative unit in the country, the City of Skopje consists of 10 municipalities: Aerodrom (2345.90ha), Butel (5455.49ha), Gazi Baba (11238.74ha), Gorce Petrov (6696.55ha) Karposh (3433.23ha), Kisela Voda (3143.93ha), Sarai (23089.13ha), Center (721.40ha), Chair (319.95ha), Suto Orizari (752.98ha). According to the number of inhabitants, the largest municipality is Gazi Baba 72,222 inhabitants and the least inhabited is Suto Otizari with 22,017 inhabitants. By area the largest municipality in Skopje is Saraj with an area of 229km$^2$, and the smallest is the Chair 4km$^2$.


**Picture 3. Territorial Organization of the City of Skopje**

Based on the analysis of information on the current population and forecasted population growth, as well as type of the industrial and economic activities in the area and land projection for its future development, the capacity of the WWTP is estimated at 650.000 p.e.

The boundary of the territory of Skopje agglomeration including 10 municipalities defined the agglomeration, yet the legislation for establishing and defining of agglomerations at national level are pending.

Boundaries of the agglomeration are proided below.


**Picture 4. City of Skopje aglomeration**

The territory served by the future WWTP includes all municipalities constituting the City of Skopje, except Saraj municipality where several small WWTP will be constructed. On the other hand, recent development suggests the inclusion of two new collectors to the central WWTP Project, starting from Sopiste and connects Soncev Grad and other settlements subject to rapid infrastructure development.

## 3.2 Existing water supply system

Main structures of the water supply system providing production and distribution of water in the City are as presented in the following table 2:

**Table 2. Main structures of water supply system**

| Name | Installed capacity ($m^3/s$) | Exploitation capacity ($m^3/s$) |
|---|---|---|
| Rasce 1 | 4.00 | 2.00-4.00 |
| Rasce 2 | 2.00 | 1.00 |
| Well area – Nerezi (4 wells) | 0.76 | 0.57 |
| Well area Lepenec (3wells) | 0.69 | 0.69 |
| Watersupply line Zelezara | 1.2 | 1.2 |
| TOTAL | 8.65 | 5.46-7.46 |

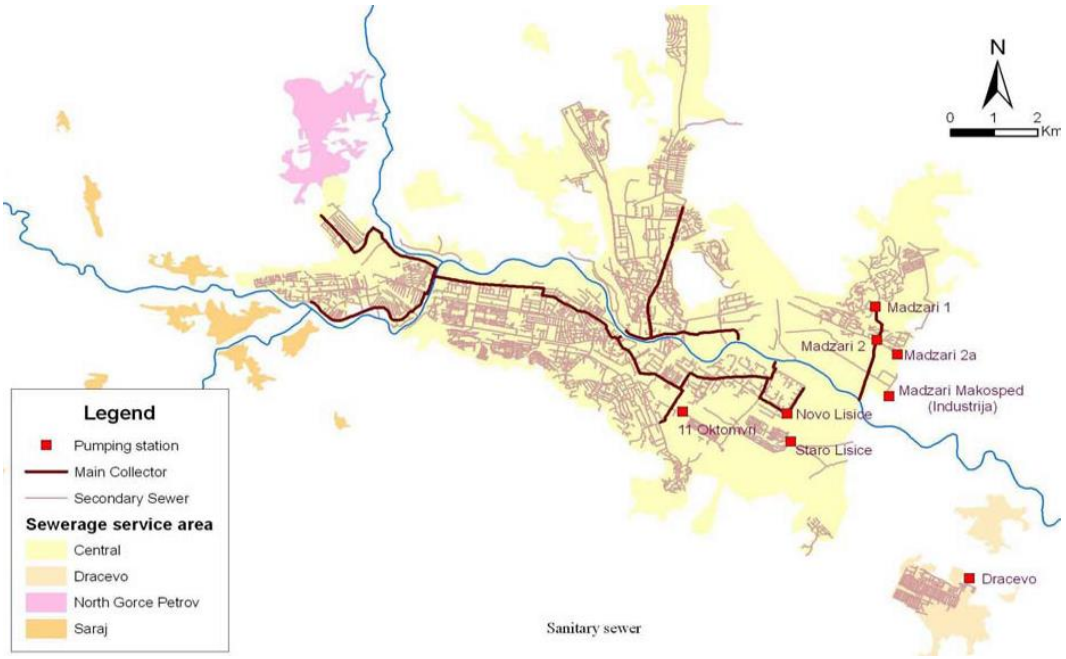
*Source: "PU Vodovod and kanalizacija" Skopje*

The quality of the spring water is constantly monitored and the results confirmed that physical, chemical and bacteriological safety of drinking water meets the national and EU quality standards and the water is not subject to any additional treatment except preventive chlorination.

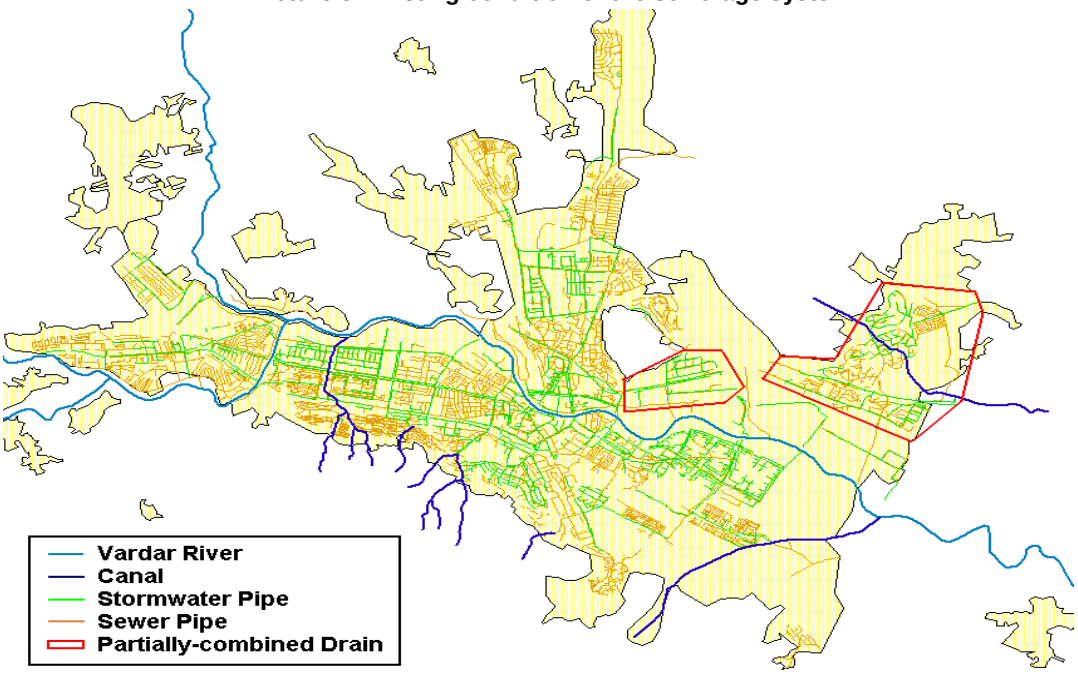
The total lentght of water supply network in 2014 was 1085 km. Diameters of pipes ranging from D2 to D1600mm are mostly made of cast iron, and a small percentage of other materials like: zinc, steel, plastic and asbestos-cement that is gradually replaced due to their negative environmental impact.

## 3.3 Existing sewerage system

The sewage system drains communal and industrial wastewater from the City of Skopje and its suburbs, with the exception of the industrial complex Zelezara and Ohis that have their own sewage systems and WWTP. Separate entity is also the sewerage system in Dracevo with old WWTP. The total length of sewerage network in 2014 was 1.021km out of which 719km is communal sewerage network and 302km is storm water system.




**Picture 5. Existing condition of the sewerage system**




**Picture 6. Existing storm water network**

Combined (storm water and communal) network, although cheaper, causes functional problems during wet weather, namely flooding of the streets with waste water that are potential danger to public health but also an additional burden for the future WWTP. For this

reason, the storm water network should be separated from the sewerage network and new storm water separate infrastructure should be constructed in future, as to provide fully detached atmospheric and sewage system, with low infiltration. Parts of the city not covered with the storm water system, are faced with problems related to occurrence of heavy and intensive rains. Water accumulated on the ground surface, slowly drains into the system for wastewater collection.
In majority of the city (7,287ha) the storm water flow is diverted to the existing sewage system, thus additionally overloading the system.

## 3.4 Description of the project site

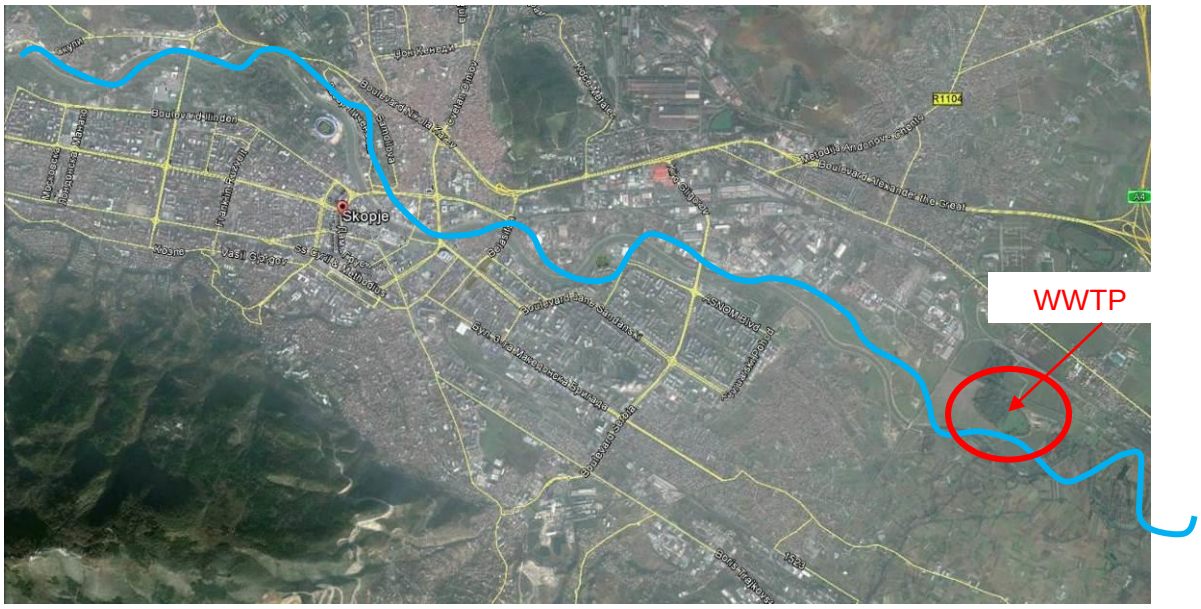
### Existing conditions and land use

The location of the future WWTP is set out in the GUP (General Urban Plan) of the City of Skopje from 2012 to 2022. The planning document is supported with the relevant SEA procedure. According to national regulations, none of the governmental officials are entitled to make changes in the planning documents.

**Note: Within the frames of the predvious Study for WWTP (2008 prepared by Tehnolab, ownership of the Municipality of Skopje) analysis of four alternative location options was performed. The seleted location approved by the relevant institutions remains the same both for the previous and current Study – namely the location included in GUP 2012-2020.**

The WWTP is located on the left side of Vardar River, within municipality of Gazi Baba Baba – KP Trubarevo, in the eastern part of Skopje valley and the City.

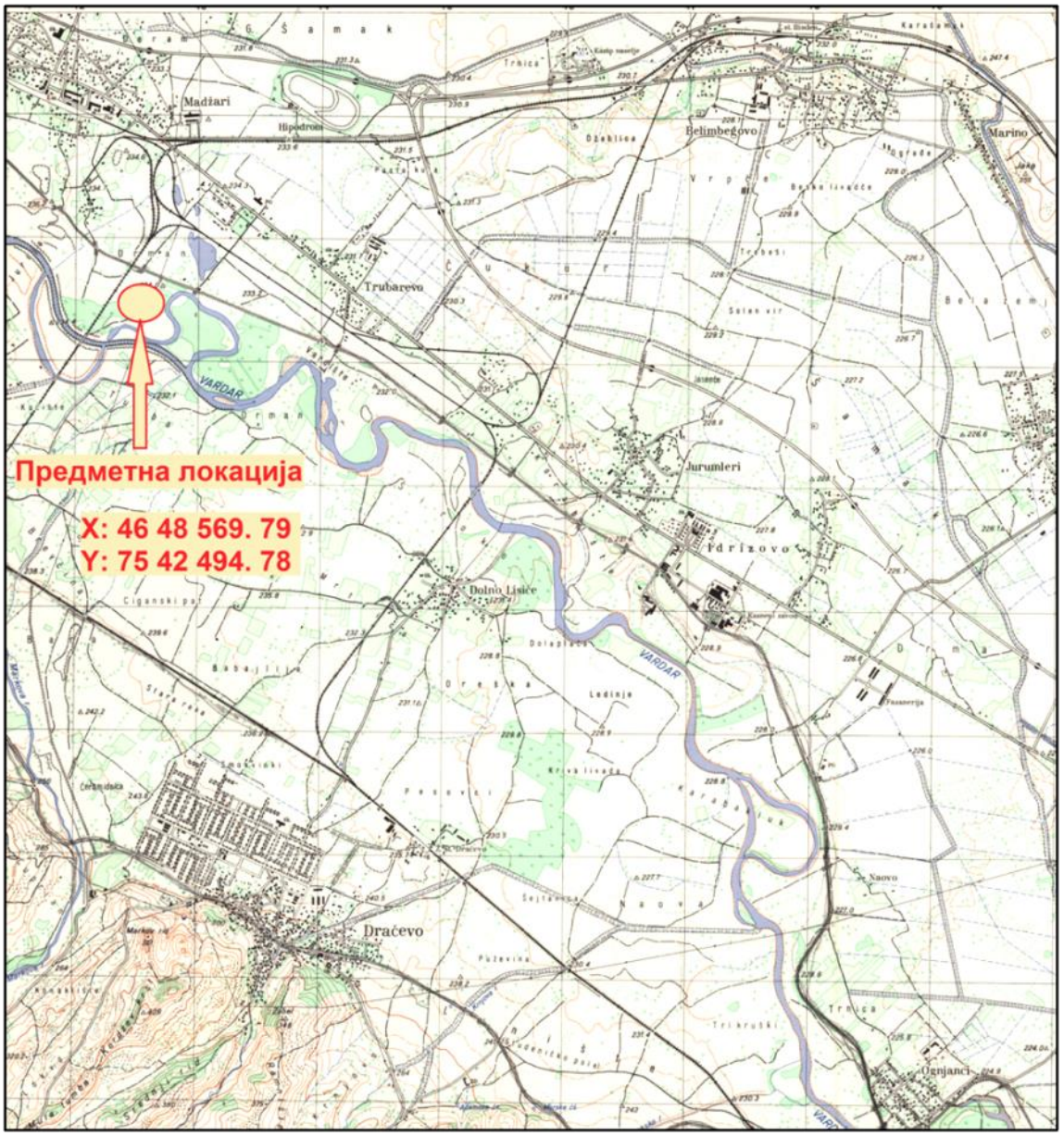
Municipality of Gazi Baba covers an area of 92km$^2$. Trubarevo is on the lowest elevation, at 225m.a.s.l.




**Picture 7. General location of the WWTP- Municipality of Gazi Baba**

The location selection is justified since the terrain configuration is good, land area corresponds to the project need, the proximity to the river and the ability of connection to the main interceptors planned to integrate all collateral lines in the city of Skopje.

The following figure shows the planned location for construction of a water treatment station on a topographic map showing the coordinates of the same points.




**Picture 8. Topographic map- location of the WWTP**

According to the cadastral data, the area is 91.90ha of agricultural land. The land consists of several cadastral plots most of them ownership of the Republic of Macedonia. Only one plot is privately owned with an area of 0.53ha (out of 23 plots) while 6.70ha are given under concession. Within the project area the site Ostrovo (20ha) is also included, demarcated by the old meandering riverbed of Vardar which is completely filled and dried after performing the melioration of the Vardar river bed. The eastern side of the site is marshy and the area is flat with an average height of 234m.a.s.l. The lowest point of the site is within a protected area and it is 232m a.s.l. whereas the highest point is in the north where the altitude is 235m. Along the banks of the Vardar River, the natural elevation of the land is 233m.

In the immediate surroundings of the location of the future treatment plant there are no housing structures. Closest to the site are houses in the settlement Inzikovo located at distance of 2,5km from the site, Settlements Dracevo and Dolno Lisice are located at distance of 3,5km and 3km. The industrial complex Zelezara is located at 5km from the

station. The facility for separation of sand and concrete production is located 1km from the site.

The total land area required by the ultimate year 2045 is estimated at 13ha out of which the land development requirements will be limited to 8.50ha**.**

## 3.5 Existing on site facilities/structures:

The site is limited by the railway to the west, the local road Skopje – Petrovec to the North, the Vardar River left bank to the South and a track separating a flat agricultural land from a trees and shrubs land to the east until the River bank which turns 90° in the north direction (refer to figure below).

The site is accessible at its north western corner from Industriska 1 Road. This will be considered as a main access to the WWTP in the future.

According to the existing topographical survey, the eastern part of the site is rather marshy and the whole area is flat with an average elevation of 234m.a.s.l.

The lowest point, of the site, is located within the protected zone Ostrovo, where contours are indicating the elevation of 232m.a.s.l. Highest points are to the north where elevations of 235m.a.s.l. are observed. Along the River Bank, natural ground elevation is averaging at 233m.a.s.l.


**Picture 9. Site map photo**

The site is crossed in the middle from South to North by a high voltage 110kV power line located at a distance varying between 235 and 350m from the railroad alignment. Another high voltage line of the same voltage and connecting to the previous one crosses the site perpendicularly in the direction of the railway. The position of this high voltage line is to be considered as a midway between the site's northern borders and the Vardar River to the south. In parallel, at approximately 70m to the north, a 35kV low voltage line is also crossing the site before turning south to pass above the watercourse in the direction of the neighboring Aerodrom Municipal area.

An underground ND400mm gas line under 40bar, which is a main feeder to Skopje from Bulgaria is also running, inside the site next to the railroad embankment. Inclined 16$^{o}$ as compared to the railway centerline direction to the north of the site, it remains parallel to the railroad when crossing the site. The gas line, inside the WWTP site, is located at 15-18m distance from the ballast of the railroad embankment. The line goes round the existing dike along the Vardar and crosses the watercourse in the direction of the Aerodrom Municipality.

Safety measures should strictly be implemented as required for any work within the protection zone of the pipeline.
According to the City GUP for 2012-2022; a peripheral road is planned across the plant site at 300m distance from the railroad embankment. It is close to the high-voltage line crossing the site in the direction from south to north. The road will be 25m wide but its right of way could be larger. Although the site is large enough for the implementation of wastewater facilities to cater for more than 80% of the Skopje City population and economy users in the served area for the project horizon 2045 several existing constraints must be considered when preparing the design of the projected wastewater treatment works.

**View from the embankment on Vardar river**

**View of the location from the railroad with the power line**

**Embankment on the left bank of Vardar river**

**Vardar river view from the bridge on the railroad**

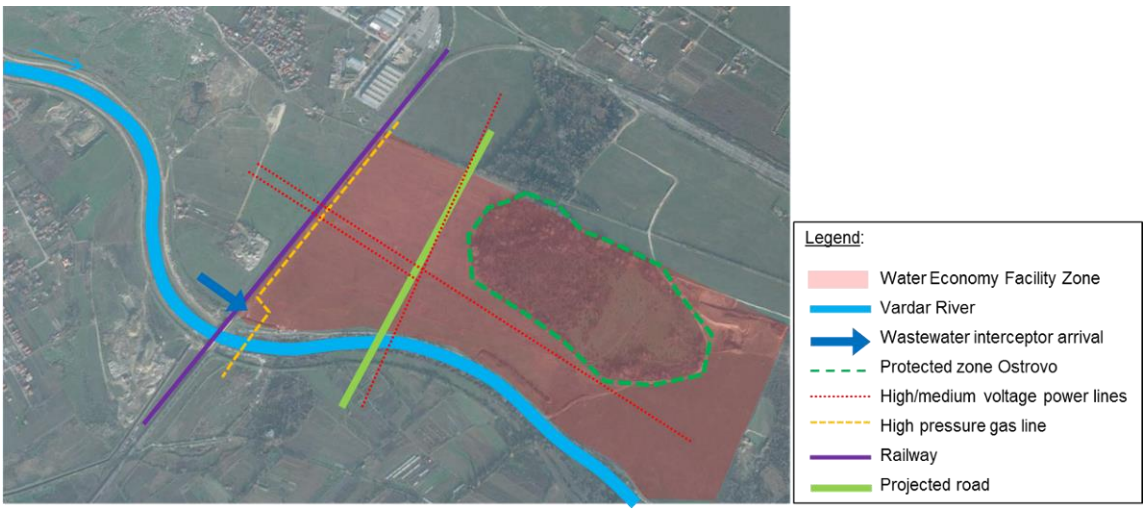
**Picture 10. Photos from the location**

## 3.6 Site constraints

Although the site is large enough for the implementation of the projected wastewater facilities until the ultimate horizon at least, several existing constraints are to be considered when preparing the design works of the WWTP as listed below:

- Flooding risks from the nearby Vardar River in the south;
- A biodiversity protection zone (Ostrovo) in the middle of the site which is almost covering 25% of the whole area;
- Electric poles with 3 overhead high voltage lines crossing the site in two directions;
- A high pressure underground gas pipe line;
- A double line railroad along the western limit of the site;

- A planned 25m wide road, scheduled in the General Urban Plan for 2002–2022 period in the north south but not yet implemented;
- The position of the incoming gravity sewer main to the projected WWTP which implies the provision of a deep structure for the collection and the lifting of the wastewater flow to the facility inlet;
- Environmental constraints along the watercourse which prevent from the construction of works close to the water body.




**Picture 11. Characteristics and limitations**

Last but not least, environmental constraints along the watercourse request a free space of 50m to be made available between the highest level of the flowing water and construction works to be envisaged in the vicinity. The width of such free area can be reduced, upon request of the Municipality, after MEPP approval. In this approach to address design area allocation issue, it is suggested that the total width of the restricted area along the watercourse where construction works will be envisaged for the WWTP, will be limited to 17m only. Such area can also be used for the construction of protection works along the watercourse as well as for the provision of a service road to replace an existing earth made one mainly used for trucks circulation.

## 3.7 Flood Protection measures for the site

The land allocated to the project is apparently prone to floods from possible overflowing of the watercourse. The flatness of the site is also adding difficulties for securing an adequate drainage of the storm water runoff flow to the watercourse. Levels for 1,000 and 300-year return floods of the Vardar River, as well as the corresponding flows which have been recorded, are presented in the table below:

**Table 3. Vardar river flood levels and corresponding flows**

| Flood return period | Flood level | Flow |
|---|---|---|
| 300 years | 233.30m a.s.l. | 1,420m$^3$/s |
| 1,000 years | 235.00m a.s.l. | 1,694m$^3$/s |

Control works along the upstream section of the river and its tributaries, including the provision of water storage reservoirs for various purposes, are supposed to decrease flood risks appreciably.

The beginning of the dike starting at the railway bridge has a top width of 3m with 236.00m.a.s.l. elevation. It very likely plays a key role in the protection of the bridge against the scouring effects of the River.

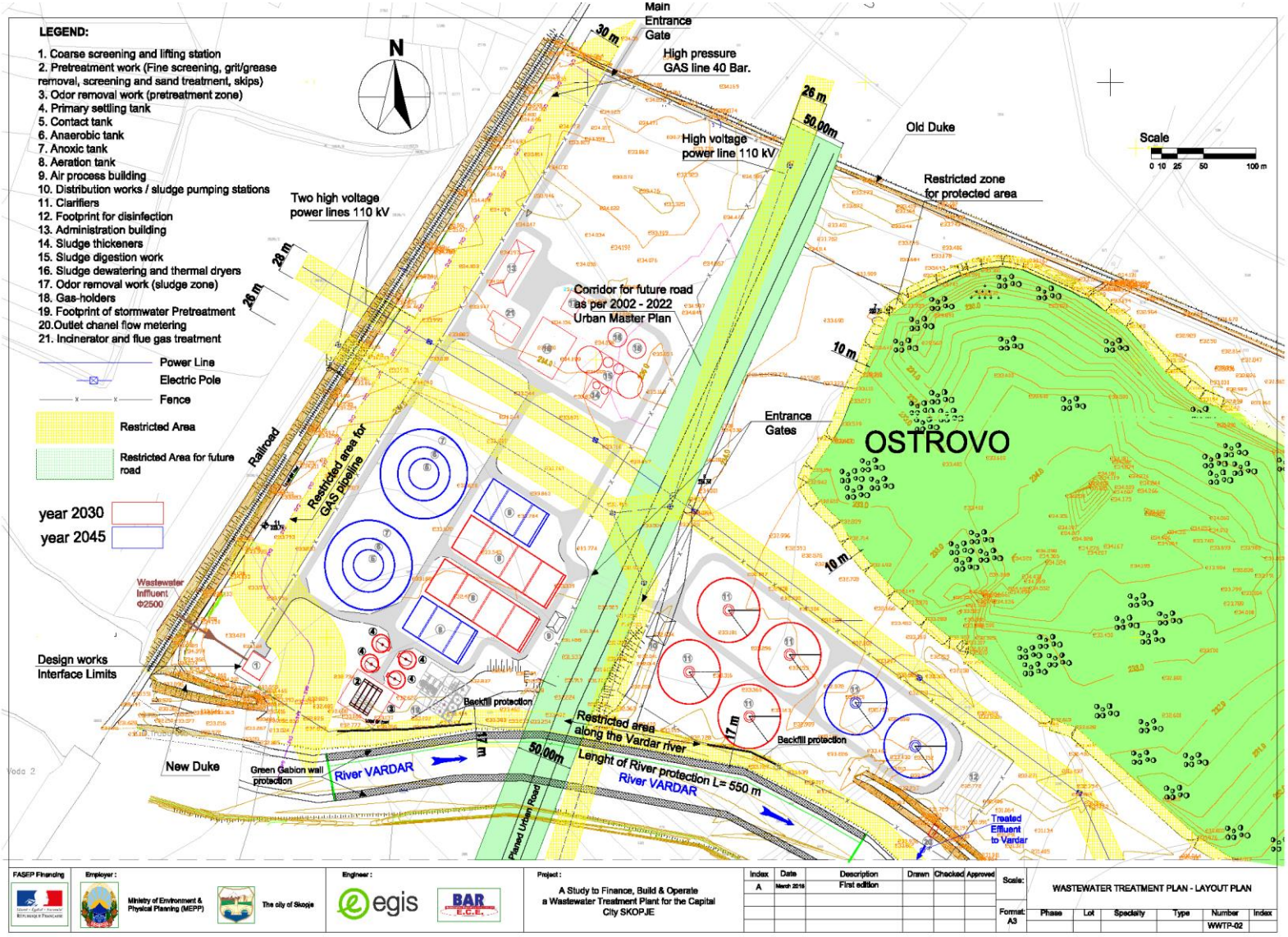
The construction of treatment facilities on adequately sized and compacted earth fill is selected as flood protection solution. Compacted fill will be provided all over the plant, as a plateau, to enhance stormwater drainage and flood protection considering the 1000-year returns period.

It is supposed that one third of the earth fill volume required will come from excavation works for the construction of the different structures of the project.

## 3.8 Impact of identified constrains on the WWTP layout

The land to be used for the implementation of the projected wastewater treatment works is definitely of limited extent in comparison with the overall size of the identified site that can be made available for the project (91.80ha).

Due to above mentioned site restrictions, WWTP works will be implemented in three different areas. Two of the areas along the Vardar River will be separated by the reservation required for the north south power line, while the third area, further to the north will be located on the northern side of the two power lines running in the east west direction. The WWTP layout shows that water treatment line will be installed in the south part of the allocated site along the Vardar River, with west-east orientation. An area, next to inlet pre-treatment works for the raw sewage flow, will be provided for a possible implementation of storm water treatment works in the future (2045 horizon). Moreover, enough area will be kept free for the development of the second phase of works.




**Picture 12. Layout of the project component location with restricted areas**

## 3.9 Description of the design loads

### Basic parameters for assessment of the WWTP capacity

### Population projection

The calculations of the population growth up to 2045 was done according to the data from the last census and the projections up to 2013 done by the State Statistical Office. According to estimation in 2030 the number of population is 588,000 and 633,700 for 2045.

The WWTP will accept the sludge generated from 30,000 inhabitants in 2020, and it will be gradually decreased to 12,700 in 2045.

### Wastewater generation

The population to be served by the Central WWTP was estimated on the basis of the number of beneficiaries already connected to the wastewater collection system.

Using this number, the water demand rates already defined (based on starting figures by 2015: 150l/capita/d for private and 100l/capita/d for other users as recomended by the Public water and sewerage utility, as well as a conversion factor water consumption/sewage production of (0.90); the wastewater generation rates for users connected will be as 230l/s for 2030 and 241l/s for 2045.

The table below shows the evolution of the infiltrated flow into the sewer system (from underground and from ground surface) as well as the incoming flow at the central wastewater treatment facilities until the project targeted year 2045:

**Table 4. Wastewater quantities at Central WWTP inlet and dilution rates all through the Project Period**

| Year | 2013 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 |
|---|---|---|---|---|---|---|---|---|
| Population that can be served by the Central WWTP (Rounded Figures) | | 456 000 | 467 000 | 478 000 | 490 000 | 500 000 | 510 000 | **518 000** |
| Household / domestic water consumption (l/capita/day) | 150 | 150 | 140 | 145 | 150 | 152 | 155 | 157 |
| Institutional / commercial / industrial water consumption (l/capita/day) **(*)** | 100 | 100 | 100 | 100 | 105 | 108 | 110 | 111 |
| Total water consumption (l/capita/day) | 250 | 250 | 240 | 245 | 255 | 260 | 265 | 268 |
| Average rate of diversion to the sewage flow | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| Rate of connection to the sewage system in served area | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Discharged sewage flow into the wastewater collection system ($m^3$/day) | 101 470 | 102 487 | 100 872 | 105 311 | 112 098 | 116 600 | 121 238 | **125 083** |
| **Wet weather flow** | | | | | | | | |
| Infiltration water rate into the sewage system (%) **(**)** | 100% | 100% | 60% | 50% | 45% | 42% | 39% | 37% |
| Average wastewater flow reaching the Central WWTP ($m^3$/day) | **202 939** | **204 974** | **161 395** | **157 967** | **162 542** | **165 572** | **168 521** | **171 363** |
| Average flow (l/day/capita) | 450 | 450 | 346 | 331 | 333 | 332 | 332 | 330 |
| Peak flow at WWTP ($m^3$/s) | | 3.32 | 2.79 | 2.78 | 2.89 | 2.96 | 3.02 | 3.08 |

| Dry weather flow | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Infiltration water rate into the sewage system (%) **(**)** | 69% | 70% | 29% | 21% | 17% | 15% | 13% | 12% |
| Average wastewater flow reaching the Central WWTP ($m^3$/day) | **171 939** | **173 974** | **130 395** | **126 967** | **131 542** | **134 572** | **137 521** | **140 363** |
| Average flow (l/day/capita) | 381 | 382 | 279 | 266 | 269 | 270 | 271 | 271 |
| Peak flow at WWTP ($m^3$/s) | | 2.96 | 2.43 | 2.43 | 2.53 | 2.60 | 2.67 | 2.73 |

***(*)*** *Excluding users treating their own effluent*
***(**)*** *Including storm water drainage runoff*

## Pollution loads

In dry weather conditions, two major types of pollution can be observed in the wastewater flow generated from the urban areas of cities:

- The domestic pollution generated by private (households), institutions and commercial activities;
- The industrial pollution generated by industries which are generally located in industrial zones.

According to the already established rates for sizing and load from households and other users including load from the sludge from the unserved population the following table provides the total load from households at the entrance of the WWTP.

**Table 5. Estimated total domestic pollution loads at the Central WWTP inlet (Rounded Figures)**

| Year | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 |
|---|---|---|---|---|---|---|
| Served Population | 467,000 | 478,000 | 490,000 | 500,000 | 510,000 | 518,000 |
| $BOD_5$ (kg/d) | 28,300 | 28,900 | 29,500 | 30,050 | 30,600 | 31,200 |
| COD (kg/d) | 56,600 | 57,800 | 59,000 | 60,100 | 61,200 | 62,600 |
| SS (kg/d) | 33,200 | 33,900 | 34,600 | 35,200 | 35,800 | 36,500 |
| Total N (Kjeldahl) (kg/d) | 5,200 | 5,300 | 5,420 | 5,500 | 5,620 | 5,730 |
| Total P (kg/d) | 860 | 870 | 890 | 900 | 920 | 940 |

Considering that all discharging industries into the municipal wastewater collection system will be securing a domestic type of sewage flow, as required by EU Directives and Macedonian Standards, the pollution key parameters to be considered are based on the observed pollution load of the industrial effluent expressed in $BOD_5$ concentration. The concentration rates for other parameters, expressed in % of the $BOD_5$ load, will be as follows:

**Table 6. Industrial pollution load rates to be considered for sizing the projected treatment facilities**

| Parameters | In % of $BOD_5$ rate |
|---|---|
| $BOD_5$ | As established in existing study for each industry discharging into the sewer system |
| COD | 250% |
| SS | As established in existing study for each industry discharging into the sewer system |
| Total Nitrogen N by Kjeldahl Method | 10% |
| Total Phosphorous P | 2% |

Taking into consideration the latest figures on water demand for industries together with estimated future projections, the industrial pollution load for 2020, the beginning of the project period, will be:

$BOD_5$ =5,400 kg/d
SS =9,200 kg/d

As the future quality of the generated industrial wastewater is expected to improve with the implementation of IPPC requirements for Class “A” & Class “B” industries, which include among other things, the execution of the Clean Production Plan, the following reduction for the projected industrial flow pollution is expected later and until the targeted year 2045:

| Year | 2025 | 2030 | 2035 | 2040 | 2045 |
|---|---|---|---|---|---|
| Reduction % | 6.5 | 12 | 13.9 | 15.7 | 17.6 |

The following additional pollution load from storm water runoff of paved areas will be considered in wet weather conditions:

BOD5: 3,410kg/d
SS: 12,400kg/ d

For the COD pollution parameter; the same rate as for the suspended solids concentration may apply while for Total Nitrogen and Total Phosphorous; a rate equivalent to 12.50% and 1.25% of the $BOD_5$ load will be used respectively and the following will be considered:

COD: 12,400kg/d
NK : 400kg/d
P : 40kg/d

**Table 7. Total pollution load figures at the Central WWTP Inlet (Rounded Figures)**

| Year | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 |
|---|---|---|---|---|---|---|
| Population in the served area | 470,000 | 480,000 | 490 000 | 500 000 | 510 000 | 518 000 |
| **Dry weather pollution loads (domestic + industrial + on-site sanitation)** | | | | | | |
| BOD5 (kg/d) | 33,700 | 33,900 | 34,200 | 34,700 | 35,100 | 35,600 |
| COD (kg/d) | 42,400 | 42,600 | 42,500 | 43,100 | 43,500 | 44,200 |
| SS (kg/d) | 70,600 | 70,900 | 71,200 | 72,000 | 72,800 | 73,700 |
| Total N (Kjeldahl) (kg/d) | 5,700 | 5,800 | 5,900 | 6,000 | 6,100 | 6,200 |
| Total P (kg/d) | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 |
| **Wet weather pollution loads** | | | | | | |
| BOD5 (kg/d) | 37,100 | 37,300 | 37,600 | 38,100 | 38,500 | 39,000 |
| COD (kg/d) | 54,800 | 55,000 | 54,900 | 55,500 | 55,900 | 56,600 |
| SS (kg/d) | 83,000 | 83,300 | 83,600 | 84,400 | 85,200 | 86,100 |
| Total N (Kjeldahl) (kg/d) | 6,100 | 6,200 | 6,300 | 6,400 | 6,500 | 6,600 |
| Total P (kg/d) | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 |

**Based on these parameters, the Central WWTP will be sized to cater for 650,000 p.e. (population-equivalent) by the ultimate year 2045.**

## 3.10 Treated water quality targets

The quality of the treated water will meet two wastewater treatment levels in order to meet the directive 91/271/EEC at the ultimate phase of the project at least:

- Short/medium term (year 2030) treatment target assuming that water quality requirements in sensible areas are not applied;
- Long term (year 2045) treatment target in compliance with the European Community requirements for sensitive areas.

The table below shows the two targets of the treated effluent quality; the short/medium term target without considering the receiving water body as sensitive area and the long term target with a receiving water body classified as sensitive area with the need to meet the European Community Directives in this regard:

**Table 8. Proposed treated water quality targets**

| Parameters | Short/medium term target (to year 2030) | | Long term target (to year 2045) | |
|---|---|---|---|---|
| | Maximum concentration (mg/l) | Minimum percentage of reduction | Maximum concentration (mg/l) | Minimum percentage of reduction |
| $BOD_5$ | 25 | 70-90 | 25 | 70-90 |
| COD | 125 | 75 | 125 | 75 |
| TSS | 35 | 90 | 35 | 90 |
| N total | 40 (1) | - | 10 | 70-80 |
| P total | 5 (1) | - | 1 | 80 |

# 4 DESIGN OF THE WASTEWATER AND SLUDGE TREATMENT PROCESS

## General design criteria

The projected Central WWTP will be designed and built into two phases:

- Phase 1: short/medium term corresponding to target year 2030, assuming that water quality requirements in sensitive areas (receiving water body) are not applied.
- Phase 2: long term corresponding to target year 2045, in compliance with the European Community requirements for sensitive areas.

Water treatment facilities will be designed to essentially remove carbon pollution in phase 1, and then to remove carbon, nitrogen and phosphorous pollution in phase 2.

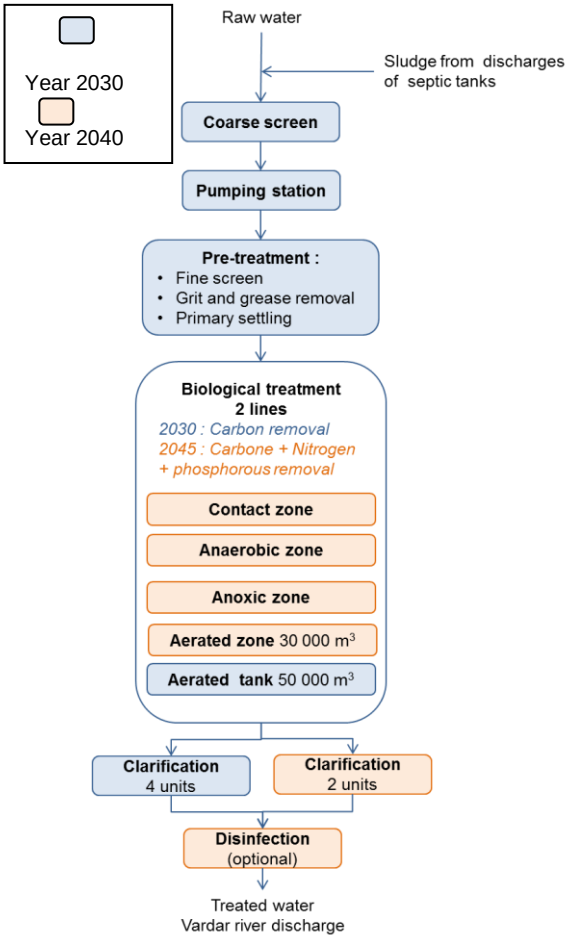
Pre-treatment head works, at the WWTP inlet, as well as sludge treatment facilities will be designed in a single phase to meet the long term target by the year 2045. This will cover civil works and the major parts of equipment to be ready for the first phase of the plant operation.

**Table 9. Resume of loads and treatment levels**

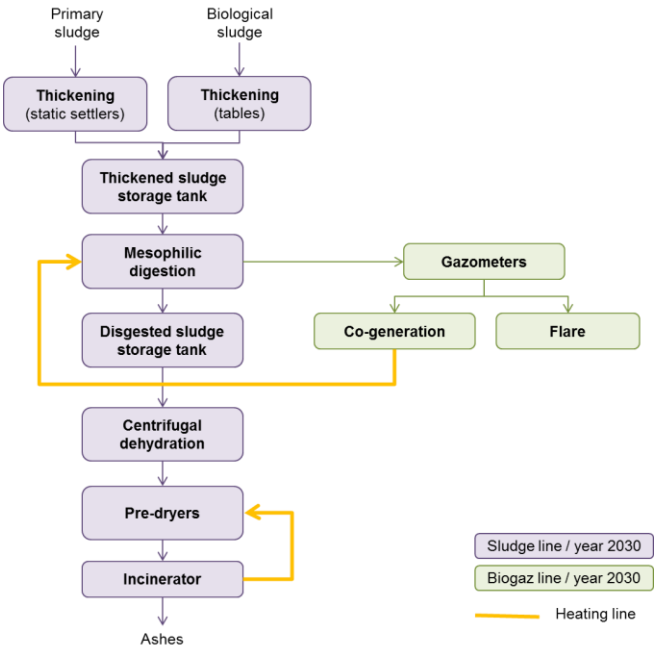
| **Year** | **2030** | | **2045** | |
|---|---|---|---|---|
| **Parameters** | Flow / pollution loads | Maximum concentration in treated water (mg/l) (*) | Flow / pollution loads | Maximum concentration in treated water (mg/l) (*) |
| **Dry weather** | | | | |
| Average daily flow | **131 542 $m^3$/d** | **/** | **140 363 $m^3$/d** | **/** |
| Peak flow | 2.53 $m^3$/s | / | 2.73 $m^3$/s | / |
| BOD5 | 34,200 kg/d | 25 | 35,600 kg/d | 25 |
| COD | 42,500 kg/d | 125 | 44,200 kg/d | 125 |
| SS | 71,200 kg/d | 35 | 73,700 kg/d | 35 |
| Total N (Kjeldahl) | 5,900 kg/d | 40 | 6,200 kg/d | 10 |
| Total P | 1,000 kg/d | 5 | 1,000 kg/d | 1 |
| **Wet weather** | | | | |
| Average daily flow | **162 542 $m^3$/d** | **/** | **171 363 $m^3$/d** | **/** |
| Peak flow | 2.89 $m^3$/s | / | 3.08 $m^3$/s | / |
| BOD5 | 37,600 kg/d | 25 | 39,000 kg/d | 25 |
| COD | 54,900 kg/d | 125 | 56,600 kg/d | 125 |
| SS | 83,600 kg/d | 35 | 86,100 kg/d | 35 |
| Total N (Kjeldahl) | 6,300 kg/d | 40 | 6,600 kg/d | 10 |
| Total P | 1,000 kg/d | 5 | 1,000 kg/d | 1 |

Also, an additional separate physical-chemical treatment line can be provided, if required, by 2045, to treat the exceeding storm water flow during wet weather conditions (flow exceeding the threshold of 3.08$m^3$/s, which corresponds to the peak daily flow in dry weather conditions).

The addopted water and sludge treatment solutions are presented in the diagrams below:




Picture 13. Wastewater treatment diagram




Picture 14. Picture 13: Sludge treatment diagram

## 4.1 Waste water treatment process

The wastewater treatment line to be provided include: coarse screen and an inlet lift station for the raw sewage flow, pre-treatment works, including fine screens, grit/grease removal and primary settling tanks, biological treatment aeration tanks, clarification tanks with finally a metered outlet before the discharge of the treated effluent into the Vardar.

Provisions are made, in the 2045 horizon projections, to increase of the treatment capacity of the WWTP with additional units to be built in parallel to the existing ones. This will be more particularly the case of the biological treatment and the clarification. Moreover, the implementation of tertiary treatment facilities for Nitrogen and Phosphorous removal in the second stage of the project (horizon 2045) will also be considered. For this purpose, contact, anaerobic and anoxic tanks will be built to the upstream side of the biological treatment facilities. As for disinfection, this will not be required for 2030 but provision will also be made for the construction a contact tank and a chlorine disinfection unit to meet 2045 requirements if necessary.

## Efluent inlet

The main collector will connect the two projected main interceptors of D1800mm each to be located one on both sides of the Vardar River. These two interceptors will also be joined by a D1000mm gravity main to connect the discharge manhole of the existing Makosped pumping station serving the nearby Madzari industrial area. A main gravity collector of D2500mm diameter, where the three above mentioned interceptor will be discharging, is expected to cross underneath the existing railroad fill at the southwest side of the project site to reach the WWTP inlet at +227.59m a.s.l.

Before the construction of the wastewater treatment plant, the projected D1800mm two main interceptors as well as the existing D1,000mm Makosped gravity line will all be discharging temporarily into the Vardar.

With the construction of the first stage of the WWTP (year 2030 horizon), all the three temporary discharge lines will be equipped with overflow weirs in order to divert the collected wastewater flow to the plant in dry weather and very likely the early part of the rainfall period. Overflow weir levels for each one of the three wastewater interceptors are expected to divert flows in excess to the Vardar River during the rainy period.

With the implementation of the second stage of the WWTP to meet the year 2045 requirements, two possibilities can be envisaged:

**The first possibility** will relate to successful efforts in securing a separate type of wastewater and storm water drainage interception in the served area. Overflow weirs elevation will be kept as established for the first phase of the WWTP implementation (year 2030) and no pre-treatment works for storm water flow will be envisaged within the plant site.

**The second possibility** will apply to combined type of sewage flow conditions (wastewater+storm water) remaining beyond the 2030 horizon. In this case, overflow weirs height will be increased further in order to allow the diversion of a diluted flow to the treatment plant inlet during wet weather, and the crest level will correspond to 300 year return period.

In any case and as safety measure, an emergency overflow should also be provided at the inlet pumping station. It will be directed to the Vardar River. The crest level of the weir will be at +233.30m.a.s.l. that corresponds to the 300 year return period.

### Reception of sludge from septic tanks

Sludge from septic tank will be transferred to the WWTP by trucks and discharged into a concrete storage tank to be located close to the plant inlet, just before the coarse screening step.

### Coarse screening

The coarse screen will be installed at in a channel at the plant inlet to prevent large floating objects to enter the plant and to protect the lifting pumps at the downstream side as well.

The coarse screen is designed for the maximal flow i.e. peak wet weather flow of target year 2045. Three automatically cleaned vertical grids will be provided, two in operation and one in stand-by, all installed in three parallel concrete channels. The bar spacing will be 25mm.

### Grit refusal

The wastes retained by the grid are automatically evacuated to a screw compactor in order to reduce their volume and secure their dehydration (minimal dryness of 25%). Compacted wastes are stored in two containers of 25m$^3$ capacity each in order to be transferred, to the Drisla landfill, which is the only authorized site to receive such waste. The maximum generated quantity of waste from the coarse screen is: 14,324kg/d for 2030 and 15,120kg/d for 2045, and maximum compacted waste for 2030 amount to 17.9m$^3$/d and 18.99m$^3$/d for 2045.

### Raw water pumping station

The facility will be located at the head of the water treatment plant will secure a gravity-feed treatment for the whole WWTP.The pumping station is designed to cater for the maximal flow i.e. peak wet weather flow of the target year 2045. Four submersible pumps will be provided: three for operation and a fourth one as stand-by. However, due to uncertainties on the intercepted wastewater flow, a provision for the installation of a fifth pump in the lift station structure can be envisaged.

## Pre-treatment

Fine screening

The purpose of the fine screen step is to remove fine solids from the raw wastewater in order to avoid damages for the subsequent treatment process equipment. Fine screen operates similarly to the coarse screen. It is designed for the maximal flow i.e. peak wet weather flow for target year 2045. Three automatically screens will be provided, two in operation and one in stand-by, all installed in three independent concrete channels in parallel. The bar spacing of screens will be 6mm.

Sand, fat, oil and grease removal

Sand and grease removal are carried out simultaneously in a specific reactor (concrete construction) designed for the maximal flow i.e. peak wet weather flow for target year 2045.

Four identical tanks in parallel will be provided. Each tank will be equipped with a submersible turbine for aeration, to help grease to float, and a superficial scraper to collect floated grease.

Valves will be provided on the inlet and outlet pipes of each tank in order to be able to isolate it in case of maintenance.

### Grit treatment

After sedimentation, grit will be extracted from the bottom of the tanks. Then it will be drained and washed in grit classifiers, in order to remove organic matters. Washed grit with grease will be stored into two skips of 10m$^3$ capacity each before their transfer to the Drisla landfill site. Maximum grit production for 20,103 is 4,876kg/d /and duration of storage in the containers is 6.1 day. The quantity for 2045 is kg/d and storage duration of 5.9 days.

### Collected grease

Grease, removed by flotation, will be collected by a scraper at the surface of the tanks and stored in a pit before its transfer to final disposal (sanitary landfill), or

Grease can also be digested together with the generated sludge in the plant, in accordance with the sludge digestion process developed.

## Primary settling

The primary settling facility is located between pre-treatment works and aeration tanks and consists of a physical settling treatment tank.

This primary treatment aims at removing easily settleable carbon matters in order to reduce the quantity of the carbon to be removed in biological tanks and, consequently, to reduce the size of aeration tanks.

The primary settling facility will be designed for the maximum flow i.e. peak wet weather conditions flow for the target year 2045. Four identical concrete tanks will be provided.

The main characteristics of the primary settling tanks are given in the following table:

**Table 10. Design of primary settling tanks**

| Parameters | Units | Values | |
|---|---|---|---|
| | | 2030 | 2045 |
| Peak wet weather flow | $m^3/s$ | 2.89 | 3.08 |
| Type of settling tanks | - | Circular lamellar | |
| Number of tanks | Unit | 4 | |
| Diameter (internal) | m | 16 | |
| Total mirror area | $m^2$ | 700 | |
| Maximum velocity with N unit | m/h | 15 | 16 |
| TSS removal efficiency | % | 45% | 45% |
| BOD removal efficiency | % | 23% | 23% |
| COD removal efficiency | % | 25% | 25% |
| Maximum primary sludge production | kg/d | 26,700 | 27,400 |
| Volatile substance (VS) | % | 53% | 53% |
| Average primary sludge production | kg/d | 22,450 | 23,150 |
| Volatile substance (VS) | % | 56% | 54% |

Primary sludge will be extracted on daily basis from the bottom of each primary settling tank and, it will be transferred to the sludge treatment facilities.

## Biological treatment – Activated sludge process

Biological water treatment is based on the use of microorganisms for assimilating the organic pollution in wastewater. Activated sludge is an aerobic process in which water to be treated is brought into contact with a bacterial flock in the presence of oxygen. This process simply replicates a natural phenomenon to an industrial scale.

Carbon pollution removal

For the purpose of carbon removal, the liquor is aerated for a certain period of time. During aeration activated sludge organisms use the available organic matter as food to produce stable solids and to generate more organisms which are both to be considered as part of activated sludge.

The implementation of an activated sludge process for carbon removal requires the following facilities:

- Aeration tank;
- Device for oxygen supplying;
- Stirring device to ensure an optimal contact between bacteria and substrate and an equal oxygen distribution in the tank, and to prevent sludge deposits
- Clarifier (secondary settler), for the separation of treated water and biomass;
- Recirculation device;
- Device for the extraction of excess sludge.

Nitrogen pollution removal

If required by the treated water quality targets, activate sludge process enables also to remove nitrogen pollution. Nitrogen pollution removal requires the development of specific bacteria which can be done under specific conditions. Nitrogen removal is performed in two successive steps:

**Nitrification and Denitrification:**

The implementation of an activated sludge process concomitant carbon and nitrogen pollution removal requires additional facilities than those describes below. For that purpose, the biological tank should be provided with 3 additional zones upstream the aeration tank:

- Contact zone: this is a non-aerated zone in which the recirculated effluent is brought in contact and mixed with pre-treated effluent in order to prepared optimal conditions;
- Anaerobic zone: this is a strictly non-aerated zone which enables the development of anaerobic bacteria for nitrogen (and also phosphorous) biological treatment;
- Anoxic zone: in the anoxic zone, no aeration is provided, but oxygen is present in the oxidized forms of nitrogen (nitrites and nitrates). In this zone occurs the denitrification process.

The minimal commonly accepted temperature for the design of biological treatmentd is 12°C.

The common range for sludge age for a conventional activated sludge plant is between 3 and 20 days and depends on the treatment target.

The sludge age for nitrogen removal is around 20 days.

Classification of activated sludge processes

The various types of activated sludge treatment can be classified according to the following parameters at which they operate:

**Table 11. Classification of Activated Sludge Processes**

| Type of process | F/M ratio<br>kg BOD5/kg TSS/d | BOD loading (Cv)<br>kg $BOD_5/m^3/d$ | Sludge age<br>days | BOD5 removal efficiency |
|---|---|---|---|---|
| Low loading process | F/M < 0.15 | Cv < 0,40 | 10 - 30 | > 90%<br>+ possibility of nitrogen removal |
| Medium loading process | 0.15 < F/M < 0.4 | 0.5 < Cv < 1.5 | 4 – 10 | 80 – 90%<br>+ possibility of nitrogen removal at high temperature |
| High loading process | 0.4 < F/M < 1.2 | 1.5 < Cv < 3 | 1.5 - 4 | < 80%<br>No nitrogen removal |

## Sizing of Biological Tanks

According to the treated water quality targets, the biological tanks will be designed for carbon pollution removal in phase 1 (target year 2030) and for concomitant carbon and nitrogen pollution removal in phase 2 (target year 2045).

Consequently, the biological process will be of medium loading type for target year 2030 and low loading type for target year 2045.

The biological tank will be constituted of the following tanks:

- Target year 2030: aeration tank only;
- Target year 2045: contact tank+anaerobic tank+anoxic tank+aeration tank.

For more flexibility in operation and maintenance, the biological treatment will be constituted of two identical lines operating in parallel.

## Aeration of activated sludge

Oxygen is required for the aeration tank as to provide following biological activities.

- Bacterial sintesis with assimilation of organig carbon supstrate
- Endogenous respiration of the biomass
- Nitrification.

According to the calculations, the total oxygen required in maximal conditions amounts to 20,207kg/d in 2030 and 37,760 kg/d for 2045.

Aeration system provides the aerobic microorganisms with the oxygen they need. Oxygen is generally taken from the ambient air.

Compressed air will be supplied by blowers installed in a specific soundproof building near the aeration tank. An acoustic hood will be provided for each blower in order to reduce the noise.

## Physical – Chemical Treatment of Phosphorous

In order to comply with the treated water quality targets for 2045 concerning phosphorous parameter, a physical-chemical treatment of phosphorous will be necessary.

This treatment will be achieved by injection of iron salt (ferric chloride–$FeCl_3$) in the aeration tank in order to precipitate the dissolved phosphorous.

The design of this physical-chemical treatment is shown in the following table:

**Table 12. Design of phosphorous physical-chemical treatment**

| Parameters | Units | Values – 2045 |
|---|---|---|
| Pure $FeCl_3$ treatment rate | mg/l | 15 |
| $FeCl_3$ commercial solution (42%) daily consumption | $m^3$/d | 6.9 |
| Number of storage tank | - | 2 |
| Volume of each storage tank | $m^3$ | 50 |
| Total storage volume | $m^3$ | 100 |
| Autonomy of storage | day | 14 |

For security reasons, ferric chloride solution will be stored in double-walled HDPE tanks or simple-walled tank with concrete retention in case of leak. Its injection will be achieved by 2 dosing pumps (1+1 stand-by) for each aeration tank and regulated according to the water flow to be treated.

## Clarification

This is the final treatment stage along of the water treatment line. Clarification aims at separating the activated sludge from the treated water by settling. Treated water is collected in the top of the clarifier by means of a peripheral channel while settled sludge is extracted in the bottom of the tank.

### De-aeration and distribution chamber

A distribution chamber will be provided between the aeration tanks and the clarifiers in order to equally distribute the flow to all the clarifiers in operation.

Such facility will be built for the target year 2030 with provisions for the distribution to additional clarifiers to meet the long-term target year 2045 requirements.

This distribution chamber will also operate as a de-aeration chamber, to enable the removing of gas bubbles from the activated sludge in order to improve sludge settling conditions in the clarifiers. This is particularly required in target year 2045 with the provision of tertiary treatment facilities.

### Clarifiers

Clarifiers are located at the downstream side of the distribution chamber.

Clarifiers will be of circular shape concrete tanks. Four identical tanks will be provided for the target year 2030 and space for two additional tanks of same size and shape will be available for the target year 2045. Clarifiers will be equipped with a suction scraper bridge for sludge scraping and floating materials collection.

## Sludge recirculation

For sludge recirculation purposes, two recirculation chambers will be provided: one for each biological treatment line, each equipped with two submersible type recirculation pumps: one for operation and another one as stand-by.

## Desinfection

Disinfection will be achieved by chlorination of treated water, which needs the construction of a contact tank with capacity of 10,170$m^3$ and the average rate of treatment with chlorine is 10mg/l.

Sufficient area will be preserved for a future implementation of disinfection treatment facilities. Moreover, the possibility of this optional treatment is taken into account for establishing the hydraulic profile of the WWTP.

## Treated effluent discharge to the river

Treated water will be discharge to the river Vardar. Precautions will be taken to enable the discharge of treated water even in case of river flood. The 300-year return flood will be considered for the discharge of treated effluents to the Vardar, which correspond to a level of

+233.30m.a.s.l. The treated effluent flow will be regulary measured, and in this regard, Venturi channel + ultrasonic level sensor will be installed.

## 4.2 Sludge treatment

The part in excess of the recirculated sludge extracted from clarifiers and pumped back to the biological aeration tanks will be diverted to the sludge treatment line process by: thickening, mesophilic or anaerobic digestion, centrifugal dehydration followed by a pre-drying of the sludge before its diversion to the incinerator. The heat generated by the burned sludge in the incinerator will be used to dry the dehydrated sludge in the pre-drying units.

The methane gas or biogas produced by sludge digesters will be directed on power and thermal energy co-generation. The thermal energy will be used to heat digesters.

### Sludge production

#### Primary sludge production

Primary sludge will result from settling materials in the primary settlers. The primary sludge production, for target years 2030 and 2045 and for average and peak conditions, is presented in the table below:

**Table 13. Primary sludge production**

| Parameters | Units | Values – target year 2030 | | Values – target year 2045 | |
|---|---|---|---|---|---|
| | | Average | Peak | Average | Peak |
| Primary sludge production | kgSS/d | 22,450 | 26,700 | 23,150 | 27,400 |
| Volatile substance (VS) | % | 56% | 53% | 54% | 53% |

#### Secondary Biological sludge production

Secondary sludge result from the biological treatment in activated sludge process.

**Table 14. Biological sludge production**

| Parameters | Units | Values – target year 2030 | | Values – target year 2045 | |
|---|---|---|---|---|---|
| | | Average | Peak | Average | Peak |
| Am | kg/kg | 0.565 | 0.529 | 0.569 | 0.526 |
| B | $day^{-1}$ | 0.054 | 0.046 | 0.057 | 0.054 |
| DBO5 removed | kg/d | 25,809 | 27,322 | 27,412 | 28,950 |
| Sludge age | day | 4 | 4 | 19 | 19 |
| $S_{BOD5}$ | kgSS/d | 11,992 | 12,207 | 7,488 | 7,516 |
| k3 | kg/kg | 1.082 | 1.028 | 0.879 | 0.856 |
| Mineral matter at the inlet of the tank | kg/d | 3,864 | 6,473 | 4,599 | 6,564 |
| $S_{min}$ | kgSS/d | 4,181 | 6,654 | 4,042 | 5,619 |
| k4 | kg/kg | 0.553 | 0.506 | 0.546 | 0.503 |
| Volatile substance (VS) at the inlet of the tank | kg/d | 22,971 | 25,572 | 23,105 | 26,421 |
| $S_{hard}$ | kgSS/d | 14,141 | 11,691 | 14,426 | 11,555 |
| k6 | kg/kg | 0.245 | 0.111 | 0.112 | 0.245 |
| Nitrogen to nitrify | kg/d | 131 | 154 | 4,468 | 4,524 |
| $S_N$ | kgSS/d | 38 | 496 | 507 | 32 |
| Sludge from biological phosphorous removal | kg/d | 0 | 0 | 1,517 | 1,119 |
| Sludge from physical-chemical phosphorous removal | kg/d | 0 | 0 | 299 | 1,335 |
| $S_P$ | kgSS/d | 0 | 0 | 1,816 | 2,454 |
| Produced sludge | kg/d | 27,760 | 33,041 | 25,533 | 30,521 |
| **Excess Activated Sludge Production** | **kgSS/d** | **26,200** | **30,800** | **23,750** | **28,600** |
| Volatile substance (VS) | % | 85% | 80% | 77% | 73.5% |

## Static thickening

For primary sludge, static thickening is the most appropriate and the less expensive solution. In static thickeners, solids matter settles according to its weight under gravity action only. Two identical concrete tanks willl be constructed.

Thickener will be provided with a mechanical rotating bottom scraper, which aims at transferring the settled sludge to the central sludge pit and facilitate the release of interstitial water.

Thickened sludge has a concentration of around 50gSS/l and still remains liquid and can be pumped.

As primary sludge is fermentable, static thickeners will be covered and ventilated. Extracted air will be transfer to the odour treatment system.

Sludge thickening tank

Thickened primary sludge and thickened biological sludge are mixed and stored in a thickened storage tank. The volume of this tank will be sufficient to ensure a buffer volume of thickened sludge to feed with a constant flow rate the digestion downstream.

## Sludge Digestion

Principle

The purpose of sludge stabilization through digestion is to reduce its pollution potential, through the reduction of the following parameters:

- Quantity of sludge,
- Microbiological pollution due to the presence of micro-organisms,
- Odours due to the putrid fermentation of the sludge biodegradable part.

The production of biogas from digestion is due to the conversion of organic matters into methane gas.

The sources of volatile matters are: Primary sludge and Biologic sludge

Inlet sludge feeding

A key issue for digestion is the maintaining of a constant sludge feeding flow rate all through the digestion process. The sludge discharge line enters a feed tank located close to the digester. The feed tank is kept under low vacuum condition.

Sludge Digester

Anaerobic digestion is processed inside 2 digestion tanks. Volatile solids reduction in the anaerobic digestion process is in the range of 55%. Digesters are designed on the basis of 20 days of sludge retention time under average conditions (5 dry weather days+2 wet weather days per week). Anti-foam agent and ferric chloride injections will be provided to control foam production and $H_2S$ release.

The performance of the digestion process depends on:

- The applied load expressed in kg VSS/m³ of digester capacity,
- The retention time,
- The sludge quality (nature of VSS, presence of inhibition compounds, etc.).

The main parameters for the digestion step design are stated in the following table:

**Table 15. Sludge digestion design criteria**

| Parameters | Units | Value |
|---|---|---|
| Inlet Sludge Characteristics | | |
| Inlet Sludge nominal flow | kg DS/d | 46,220 |
| Inlet Sludge VM content | % DS | 71.6 |
| Inlet Sludge Concentration | g/l | 50 |
| Digesters Characteristics | | |
| Digester Temperature | °C | 36 |
| Number of digesters | | 2 |
| Retention time in digesters | days | 20 |
| Volume of each digester | $m^3$ | 9,100 |
| Volatile matter removal efficiency | % | 55 |
| Total Biogas production | $Nm^3$/unit | 15,400 |
| Thermal needs | kW Th | 1,270 |
| Inlet Sludge Characteristics | | |
| Digested sludge Quantity | kgDS/d/unit | 28,800 |
| Digested sludge concentration | gDS/l | 31.8 |
| Volatile Fraction outlet | % dry matter | 52% |

Digester heating

The mesophilic anaerobic biological reaction is considered as optimal between 33°C and 37°C temperature. In order to keep a stable temperature within the digester, whatever the recorded feed or the outside temperature, it would be necessary to insulate the digester and to warm it up.

Cogeneration unit, coupled with a stand-by boiler, supplies the hot water heated by the biogas.

Digested sludge extraction

Each digester is in connection with an outlet chamber, and is is operated at constant level, i.e. the fresh sludge inlet flow rate is equal to the digested sludge volume at the outlet. From each outlet chamber, the digested sludge flows to the digested sludge storage tank. Besides other equipment, each outlet tank is provided with safety valve equipped with a flame arrester device.

## Digested sludge storage tank

The digested sludge storage tank receives digested sludge from mesophilic digesters. The tank content is mixed to allow sludge homogenization. From this digested storage tank, sludge is pumped to the sludge centrifuger for dewatering. This tank is ventilated and extracted air is sent to odour treatment. Due to $CH_4$ presence in this tank, due safety measures will be provided.

## Dehydradation

Dehydration of digested sludge aims at increasing the suspended solids concentration by removing water from sludge. It is a necessary step before the sludge pre-drying and incineration. Dehydration is carried out with mechanicals devices-centrifuges. Centrifuges enable effective solids-liquid separation even on very difficult sludge. Three identical centrifuges will be provided (2 in operation+1 stand-by). The dewatered sludge will reach a dryness of around 27% and will be stored in two parallel storage tanks in order to ensure a buffer volume to feed the pre-dryers downstream. The centrifuged water (centrate) will be collected into a pit to return to the entrance of the WWTP.

The machines will be installed in a specific soundproofing building. Moreover, each machine will be equipped with a protective and soundproofing hood.

To avoid odour nuisance, the centrifuges will be equipped with a whole hood and waste air will be extracted from the hood to the odour treatment system.

Centrifuges will operate automatically six days a week and up to 16h/d.

## Pre-drying

To ensure a subsequent self-thermal incineration, it is necessary the sludge to be dryed previously.

The pre-dryer is heated mainly by steam, generated from the flue gas stream behind the incinerator. The dewatered sludge is dried to a DS-concentration that ensures an auto-thermal incineration of the sludge in a fluidized bed incineration.

The drying system includes all necessary mechanical equipment for condensing the steam generated by the drying process and for the transfer of the partially dried sludge to the inlet of the incinerator or alternatively to an emergency hauling by trucks.

The evaporated water from the sludge drying process leaves the head of the dryer as saturated steam and it is directed to a condenser. The condensate, generated in the condensing system, is collected in a holding tank, also called condensate tank, similar to the one used for the centrifuged water.

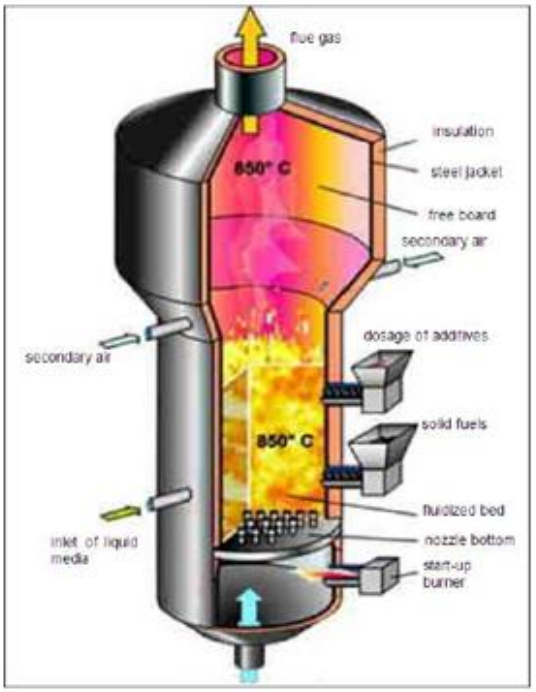
## Incineration of sewerage sludge

In order to maintain good operational control over the sewerage sludge incinerator and thereby minimise and control its emissions and residues, BAT is to maintain the effective combustion performance of the sewage sludge incineration plant by using fluidised bed technology because of the higher combustion efficiency and lower flue-gas volumes that generally result from such systems.

The general plant concept for the sludge incineration is based on a continuous incineration process without adding any primary energy, e.g. gas or oil, in combination with an energy recovery from the flue gases drying the dewatered sludge to the level of self-thermal combustion**.**

**The fluidized bed type incinerator**

The fluidized bed incineration consists of the incinerator itself, the heating-up burning chamber and the necessary fan for generating the fluidized bed inside the incinerator as shown in the figure below:




**Picture 15. Principle construction of a fluidized-bed firing system**

The incineration plant is made of one line incineration and consists of the following main section:

- wind box with connected heating up combustion chamber,
- fluidized bed area,
- freeboard (post combustion zone),
- Incinerator head with connecting flange to the waste recovery system.

Combustion temperature is in the range of 850 – 870°C.

The construction of the incinerator ensures an incineration process, which minimize the generation of NOx in the flue gases without adding any ammonia solution (SNCR-process).

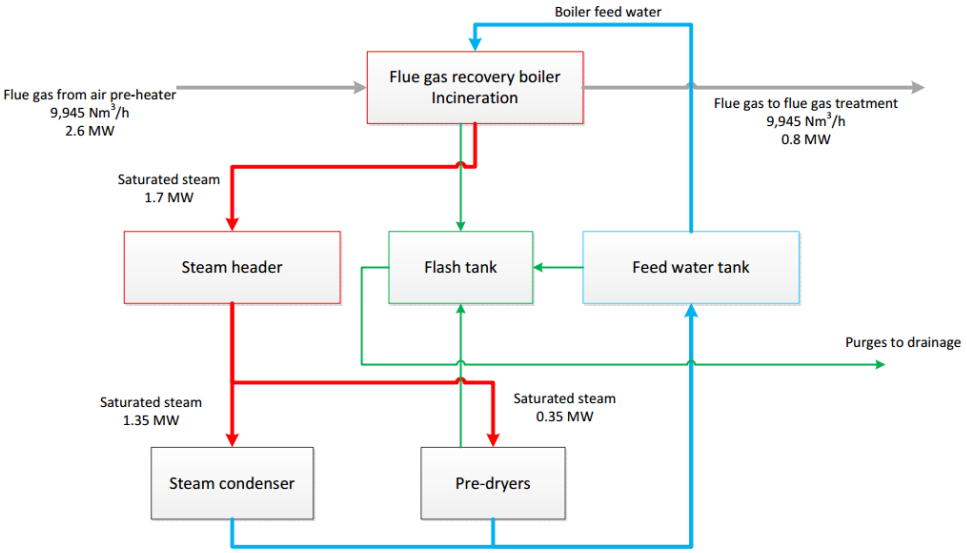
The main characteristics of the incinerator are described in the following table:

**Table 16. Incinerator design values**

| Parameters | Unit | Value |
|---|---|---|
| Inlet Sludge nominal flow | kg DS / d | 26,700 |
| Inlet Sludge VM content | % DS | 55 |
| Inlet Sludge DS content | % | 37 |
| Incinerator operating time | hr/d | 20 |
| Incinerator operating time | d/week | 6 |
| Incinerator diameter | M | 4.3 |
| Incinerator freeboard temperature | °C | 850 - 870°C |

## Waste Heat Recovery System

The sludge treatment plant incorporates a heat recovery system which recovers heat from the flue gases, used for generating steam for dryer heating. Steam is generated from the hot flue gases behind the incinerators.




**Picture 16. Thermal balance of the Skopje WWTP pre-drying-incineration stage**

## Flue gas treatment

Flue gas from the incinerators pass through air pollution control systems designed to remove ash and pollutants before it is discharged into the atmosphere.

Emission limits (see table below) have to be achieved during 24-hr operation mode.

**Table 17. Daily average emission limit values for the polluting substances**

| Parameters | Units | Daily average | 30 min Average (100%) | 30 min average (97%) |
|---|---|---|---|---|
| Total Dust | mg/Nm$^3$* | 10 | 30 | 10 |
| Gaseous and vaporous organic substances, expressed as TOC | mg/Nm$^3$* | 10 | 20 | 10 |
| Hydrogen chloride (HCl) | mg/Nm$^3$* | 10 | 60 | 10 |
| Hydrogen fluoride (HF) | mg/Nm$^3$* | 1 | 4 | 2 |
| Sulphur dioxide ($SO_2$) | mg/Nm$^3$* | 50 | 200 | 50 |
| Nitrogen monoxide (NO) and nitrogen dioxide ($NO_2$), expressed as $NO_2$ | mg/Nm$^3$* | 200 | 400 | 200 |
| Carbon monoxide | mg/Nm$^3$* | 50 | 100 | 150 (10-min average) |
| Dioxines and furanes (sampling period 6-8 hr) | ng/Nm$^3$* | 0.1 | | |
| Mercury (Hg) | mg/Nm$^3$* | 0.05(**) | | |
| Total Cadmium (Cd) and Thallium (Tl) | mg/Nm$^3$* | 0.05(**) | | |
| Total Heavy Metals (including Antimony (Sb), Arsenic(As), Lead (Pb), Chromium (Cr), Cobalt (Co), Copper (Cu), Manganese (Mn), Nickel (Ni), Vanadium (V)) | mg/Nm$^3$* | 0.5(**) | | |

The flue gas leaving the waste heat steam boiler shall be completely de-dusted and cleaned from harmful components. The whole flue gas purification system is of dry type with only dry discharge products. The flue gas temperature at the boiler exhaust amounts to 200 °C approximately.

A portion of flying ashes precipitates in the boiler. The final de-dusting is effected by means of electrical precipitator.

Electrostatic precipitator is equipped with conical bottom for collecting the dust and a rotary valve at each bottom outlet flange for mechanical discharge of the collected ashes. The ashes are then discharged into a storage silo whit a direct loading of the waste product to trucks. The ashes in most cases can be reused in road construction, concrete works or even used in the cement plants.

The flue gases are treated from any basics components and heavy metals by means of a special dry cleaning system, consisting on a reactor and followed by a bag filter.

Inside the reactor, sodium bicarbonate and activated carbon are injected into the flue gas for binding the harmful components. The sodium bicarbonate injection in the reactor removes the remaining acid & sulphurous pollutants and the activated carbon injection removes mercury, dioxins and furans.

Bag filtration systems ensure the emission limits. Therefore, bag filters are usually installed as final process step behind the reactor, for separating the reaction products. The reaction product (residues) is collected in the bottom of the bag filter and then discharged into any separated large-bags.

A cooling air injection is provided upstream the reactor in order to decrease the flue gas temperature down to 200°C in case of any dysfunction for constant optimum reaction conditions with activated carbon and in order to protect the bag filters.

**Table 18. Flue gas treatment values**

| Parameters | Units | Value |
|---|---|---|
| Inlet | | |
| Flue gas flow | $m^3/h$ | 9,950 |
| Flue gas temperature at the inlet of the electrostatic precipitator | °C | 200°C |
| Electrostatic | | |
| Electrostatic precipitator efficiency | % | 99,9% |
| Ashes hourly production | kg/h | 727 |
| Ashes week production | t/w | 87 |
| Ashes density | - | 0,6 |
| Storage volume for 1 week | $m^3$ | 150 |
| Big Bag precipitator | | |
| Sodium Bicarbonate hourly consumption | kg/h | 123.6 |
| Storage volume for 1 month | $m^3$ | 70 |

| | | |
|---|---|---|
| Activated Carbon hourly consumption | t/w | 0.21 |
| Bag Filter efficiency | % | 99,9% |
| Residues week production | t/w | 13.0 |
| Residues density | - | 0,55 |
| Exhaust | | |
| Maximal Treated Flue gas flow (with cooling air) | $m^3/h$ | 10,650 |
| Chimney diameter | M | 0.75 |

## 4.3 Biogas line

### Overall Biogas Line Description

Biogas is collected from mesophilic digesters and sent through a condensate trap provided to collect condensed water droplets. Then, biogas is either stored in gasholders or directly sent to the cogeneration building for the production of electricity and/or thermal energy. If needed, biogas can also be burnt on the flare, as an ultimate discharge path. Before the reuse of the gas in the cogeneration engine, biogas needs to be treated: pressure is increased through centrifugal blowers, then hydrogen sulphide ($H_2S$) is removed by means of a wet scrubber before treatment on active carbon for removal of siloxanes and further removal of $H_2S$ gases.

The biogas network is constituted of:

- CHP Unit: To convert biogas in heat and power;
- Condensate trap: To dry biogas and to catch condensate;
- Flare: To burn biogas in excess;
- Gasholder: To store biogas and to maintain it under pressure;
- Blowers: To increase biogas pressure in order to be used for cogeneration (or boiler);
- $H_2S$ and siloxanes treatment/removal unit: To protect cogeneration;
- Boiler: To provide heating production in case of CHP Unit failure or during the start-up of the process.

### Condensate trap

Before using the biogas, it is important to make sure that the liquid concentrated part is removed and collected at the lowest point of the network or the circuit. That is the purpose of the condensate trap which is located upstream of the gasholder tank.

As this is the only path for the produced biogas, the condensate trap is provided along with a manual by-pass for maintenance purposes.

### Gasholders

In order to buffer the variations between the biogas production and consumption, 2 gasholders will be provided. The gasholder will also control the biogas pressure and keep it at 25-30mbar in the dome of the digesters and in the network, up to the blowers. This system ensures a natural protection of the digesters, both in overpressure and in depression by means of a pressure/vacuum relief valve. For an easier maintenance purposes, the selected technology for gas holding consists of a double membrane spherical type holder. Each gasholder is protected against overpressure with a hydraulic seal that acts as a safety valve.

**Picture 17. Gasholder**

Each gasholder, among other, includes:

- Air blowers for a constant inflation of the structure coupled with a pressure measurement;
- Hydraulic seal to protect the gasholder;
- Pressure retaining valve;
- Ultrasonic level transmitter at the top.

## Flare

The biogas cogeneration units are designed to handle the entire average biogas production. However, in case one or several engines are not available or out of order, biogas must be burnt in a low elevation hidden flame flare. This avoids discharging methane gas into the atmosphere whose global-warming potential (GWP) is 56 times higher than the carbon dioxide.

## Biogas treatment

### Biogas blowers

After the storage stage, the biogas needs to be boosted in order to go through a wet scrubber, the routing circuit before reaching the engines with enough pressure. The temperature increase due to the adiabatic compression on the blower generates a decrease of the relative humidity of the biogas and limits further condensation in case of low outdoor temperature.

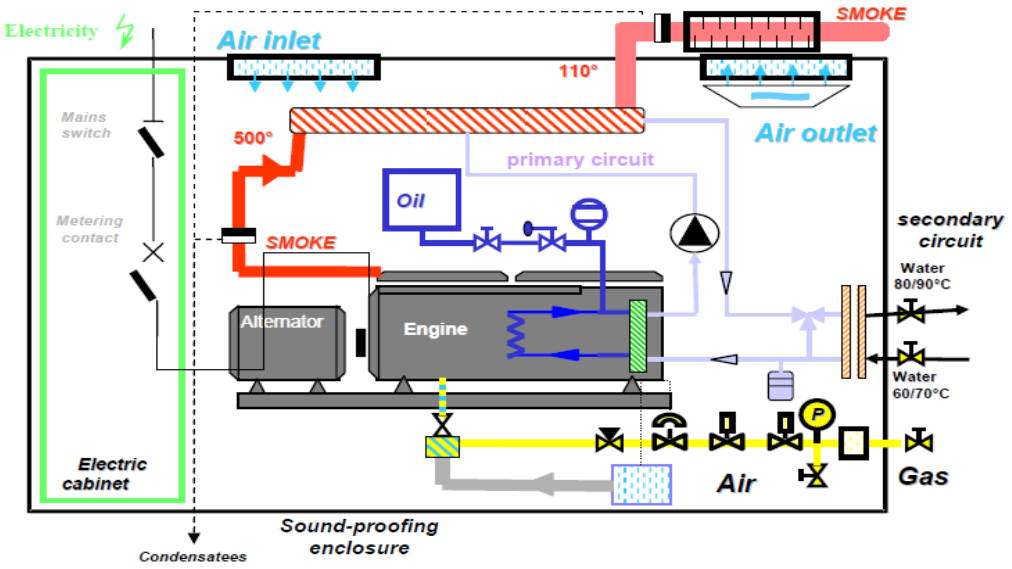
### $H_2S$ and siloxanes removal

During the exploitation phase of the thermal engine, hydrogen sulphide can react with water and form sulphuric acid which leads to corrosion problems. $H_2S$ is first removed from the biogas by gas washing in a wet scrubber. A second stage will also be included for biogas treatment, by means of active carbon. This second treatment will allow siloxanes removal to a concentration of less or equal to 5ppm. It will also allow further removal of $H_2S$ down to less or equal to 1ppm.

## Co-generation

A cogeneration (Combined Heat and Power, CHP, Unit) allows producing two usable secondary energies (mechanical and thermal) from a primary fuel source. In case of the project, the primary fuel source is biogas from sludge digestion. The mechanical energy is

converted into electrical power by an alternator. The thermal energy, recovered from the alternator supplies the energy necessary for the heating of the sludge in the digestion.




**Picture 18. Diagram of a co-generation unit**

The cogeneration unit includes one thermal engine coupled with a three-phase alternator. The entire group is assembled on vibration absorbers and a flexible coupling avoids any vibration on the external structures. The engine/alternator couple and peripheral equipment are installed in a dedicated sound/noise-protected room or container.

In case of failure of the CHP Unit or during start-up, a stand-by boiler can provide the heat quantity necessary to warm the digester's sludge, using the biogas.

**Table 19. Cogeneration figures**

| Parameters | Units | Value |
|---|---|---|
| Biogas Dry flow rate | Nm³/d | 26,700 |
| CHP electrical efficiency | % | 36 |
| CHP thermal efficiency | % | 42 |
| Electricity production capacity | kWe | 1,400 |
| Electricity produced (generator capacity) | kWe | 1,300 |
| Heat produced | kW th | 1,675 |

## 4.4 Solid Waste Disposal

Solid wastes produced from the plant include screenings, grits and the sludge generated from the biological treatment.

### Screenings and Grits

Retained screenings and grits will be removed and disposed of independently from the treated sludge in excess.

For grits, particles settling in the sedimentation tank will be drained and washed to remove sticking organic matters before their hauling to the sanitary landfill or their incineration. If necessary, grits can also be lime stabilized before their hauling and disposal in the sanitary landfill.

In case screenings and grits will be disposed of in Drisla landfill site, they should preferably be compacted in the plant before their hauling to the landfill site.

Washed and drained grits can also be transported as public works material for trench backfilling for instance.

There will be also grease which is to be removed from the settling tank by flotation and surface scrapping. Since the plant will be equipped with a sludge incinerating facility, the removed grease will be mixed to the dewatered sludge before its incineration.

### Ashes from Sludge Incinerator

The digested and mechanically dried sludge will be burned in the incineration facilities to be provided. Ashes average production of 106 tons per week is expected for the 2030 horizon. By the 2045 horizon, ashes production is expected to reach 116 t/w.

With an ashes density of 0.6t/$m^3$, ashes production would be totaling 175$m^3$ per week or 9,000$m^3$/y in 2030.

Ashes storage either on the plant site or elsewhere would necessitate their protection by means of humidification and the provision of a tarpaulin cover in order to prevent their spreading and dispersal.

Ashes disposal can be secured at Drisla landfill site as well as in abandoned quarries in the vicinity.

Ashes transportation should be done either by a tank truck or by a dumper truck. For the latter, ashes should be covered by a tarpaulin to avoid their dispersal.

Another solution with ashes reuse would consist in using them in public works and for some specific constructions. The addition of some reagents can convert ashes into granular shape solids which are considered as more adapted for carrying out some specific field works (filling, foundation material, etc.).

## 4.5 Odor treatment

The wastewater treatment process could generate bad odours that should be taken to limit odour emission. For that purpose, the following works and devices will be covered and ventilated:

- Coarse screens;
- Raw water pumping station;
- Fine screens;
- Static thickeners;
- Biological excess sludge tank;
- Gravity belt thickeners;
- Thickened sludge tank;
- Digested sludge tanks;
- Centrifuges.

The waste air extracted from these works is transfered to the air treatment facilities before being discharged to the atmosphere.

The main air pollutants, to be removed, will be:

- Hydrogen Sulphide ($H_2S$),

- Ammonia ($NH_3$),
- Mercaptans,
- Amines.

Considering the high estimated airflow to be treated (100,000$m^3$/h), and the good efficiency of physical-chemical treatments on a wide range of odorous compounds, the selected air treatment for Skopje WWTP is: physical-chemical treatment of air.

Removal of harmful substances in the gaseous products of the gas line is also dealing with odors.

The physical-chemical treatment consists in 3 scrubbing towers in series. The 3 towers will be of the following types:

- Tower 1 will be a sulphuric acid ($H_2SO_4$) scrubbing to remove nitrogen compounds (mainly ammonia and amines) according to an acid-base reaction;
- Tower 2 will be an oxidising scrubbing using sodium hypochlorite (NaClO) to remove reduced sulphur compounds (hydrogen sulphide and mercaptans);
- Tower 3 will be an alkaline scrubbing using sodium hydroxide (NaOH) to remove reduced sulphur and volatile fatty acids.

The design of physical-chemical scrubbers is stated in the following table:

**Table 20. Design of physical-chemical scrubbers**

| Parameters | Units | Value |
|---|---|---|
| Estimated air flow to be treated | $m^3$/h | 100,000 |
| Number of lines | unit | 1 |
| Number of scrubbers | unit | 3 |
| Scrubber unit diameter | m | 4,5 |
| Tower 1 | - | - |
| $H_2SO_4$ average consumption (96%) | l/h | 1,4 |
| $H_2SO_4$ storage | $m^3$ | 1,0 |
| Storage autonomy | D | 30,0 |
| Tower 2 | - | - |
| NaOH average consumption (30%) | l/h | 16,8 |
| NaOH storage | $m^3$ | 15,0 |
| Storage autonomy | D | 30,0 |
| Tower 3 | - | - |
| NaOCl average consumption | l/h | 43,0 |
| NaOCl consumption (48°) | $m^3$ | 15,0 |
| Storage autonomy | d | 14,0 |

## 4.6 Storm water treatment

For target year 2030, no specific treatment will be forecasted; storm water exceeding the design flow of the WWTP will be discharged to the River.

On the contrary, for target year 2045, a specific treatment will be provided to cope with this storm water overflow. So for target year 2030, a sufficient area will be preserved for a future implementation of storm water treatment facilities near the pre-treatment works.

For target year 2045, the storm water treatment will be design according the parameters provided in the Technical report.

## 4.7 Buildings & offices

Technical & administration buildings will be provided, as part of the WWTP, including electrical houses, air blowers building for aeration/biological tanks, sludge treatment building to house belt thickeners and dewatering centrifuges, workshop with store area. The administration building will include, among other things, a fully equipped laboratory. The new WWTP will be provided with several technical and administrative buildings.

## 4.8 Power reguirement

Taking into consideration power co-generation in the plant, the total external power demand is expected to reach some 6,050MWh/y in the first phase of the project (year 2030).

Main power consuming units in the plant are: the inlet lift station, air blowers, sludge recirculation pumps, dewatering machines and incineration/flue gas treatment.

As far as power supply to the WWTP and for safety purpose, two identical transformers in parallel will be provided for the water/wastewater treatment line as well as for the sludge treatment line. Transformers capacity will be:

- Wastewater treatment line 2 x 2,500kVA
- Sludge treatment line 2 x 1,000kVA

Standby generators will also be provided with 1,000kVA for the wastewater treatment line and 800kVA for the sludge treatment line.

## 4.9 Description of civil works

The present part of the report addresses the different issues related to civil works.

- Existing geotechnical conditions,
- Riverbank protection,
- Impact of seismic tremor on structural design and stability of site,
- Design criteria used in the sizing of water and non-water structures,

### Fill Areas

Due to site development constraints, the provision of fill to meet the requirement of the hydraulic profile of the plant and to provide appropriate storm water drainage for the developed area will be limited to three separate areas which constitute the project site:

- The inlet works, physical and biological treatment area;
- The clarifiers area and;
- The sludge treatment and the Administration area.

The compacted fill height around the different project structures will vary between 1.00 and 1.80m and enough settlement can be secured through an early backfilling of the land. Such arrangement can be achieved by allowing the contractor to start preparatory works including filling works the earliest possible. A gap of six to eight months between the spreading and the compaction of the earth fill and the beginning of the construction works will be required.

## The Road Network

The access road to the site will connect Industriska 1 to the northern side of the existing earth dike. The entrance road is expected to run parallel to the existing industries railroad and at more than 30m from the existing high pressure underground gas pipe.

Roads will have the size of double carriage way (two lanes of 3.60m each) with one meter shoulder on each side. This is the case of the following road sections:

- Access road to the Administration Building, Stores and Workshop;
- Road serving inlet works including raw water lift station, pre-treatment units and sludge treatment area;
- The central road connecting the main entrance road to aeration tanks and clarifiers area.

All other roads will be of one lane type with a total width of 6m including shoulders.

## Fencing

All the project area including the free land between the existing northern dike and the site entrance, where the administration building will be located, will be fenced, some 2,900m in total.

Taken into consideration site restrictions, two fence areas can be identified:

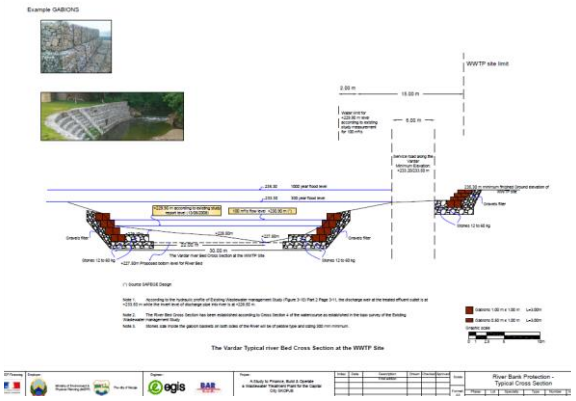
- The area located to the western side of the projected road corridor and covering 14.20ha and
- The eastern side area of 5.50ha where clarifiers and the footprint for disinfection facilities have been located

## River Bank Protection

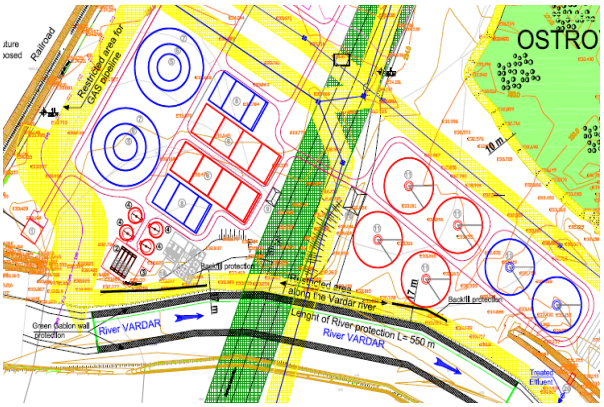
River bank protection, to be made of gabions of 1.00m x 1.00m cage section, will be provided up to 4m total high and along 550m of the project site. Protection works are expected to limit the scouring effects of the River flow and to protect the project site against erosion.

Based on the comparison of different methods for riverbank protection, the selected solution is construction of Green Gabion Wall for Slope Protection and Reno Mattresses for Toe Protection.

In order to meet the above design requirement and level of safety, a typical cross section illustrating the constructive measures of riverbank protection is shown in the figure below:



Picture 19. Typical cross section of river bank protection




Picture 20. Location and length of riverbank to be protected

The quantities of riverbanks and structures of wastewater treatment plant protection will amount to 7,560m$^3$.

### Type of foundations to be envisaged and recommendations

At the present stage of the project, the soil of WWTP site is classified into medium compacted one. Shallow foundation is deemed appropriate. However, prior to the commencement of works on site, the Contractor should carry out complementary geotechnical investigations on site.

### Macedonian Seismic Standards requirements

The Plant is located in an area where the expected seismic intensity for a 500-year return period is of 9 degrees in accordance with MCS Based on the seismic map of Macedonia, the different structures of WWTP are located in a highly seismic area and should be designed to withstand the strongest expected earthquake intensity.

Seismic design of the entire facility shall fit to both Eurocodes and national design criteria.

## 4.10 Main activities

### Construction phase

The construction phase covers:

- Preparatory works (removal of vegetation, removal of humus layer, excavation/backfilling ground leveling.);
- Accommodation facilities for the construction yard: water supply (domestic and technological if any), discharge of waste water and installations for treatment and/or removal of liquid effluents, where appropriate, electric supply, waste disposal etc.;
- Storage facilities for the building materials;
- Parking and maintenance of the equipment used for construction activities;
- Fencing of construction yard;
- Access roads;
- Construction of the water line and sludge line (civil works, excavation, pipes, heavy machinery) and construction of the incineration plant;
- Activities for flood protection and river bank protection;
- Installation of the equipment;
- Use, storage, transport and handling of materials and waste.

### Operational Phase

- Technological operations required for the WWTP operation;
- Quality control - the efficiency of the waste water and sludge treatment processes;
- Maintenance operations;
- Technological operations required for the sludge facilities operation;
- Transport, storage and handling of the wastes resulted from WWTP operation.

### Commissioning / decommissioning

Commissioning of the Plant is a process under the responsibility of the Contractor / Operator. It is iniated once the construction phase is completed and all equipment installed. The commissioning is technical step under the responsibility of skilled personnel, under terms defined and confirmed by the involved project players.

Precommissioning is a mandatory step where he Plant structures are checked and confirmed in regard to their technical properness and basic functionality, thus ultimately including validation of working and environmental parameters of the structures and equipment based on the manufacturer's documentation, performed tests during construction and other associated means of verification. Once the precommissioning is accepted and approved, commissioning may take place.

The process of commissioning also includes training of the personnel. Transfer of know-how is important not only to achieve proper run of the Plant, but also to deal with improved energy efficiency, reduced GHG emmissions, as well as to educate the personnel in regard to measures of prevention of environmental damages under planned and unforeseen occasions.

The initial commissioning of the Plant begins with introduction of clear water. Such an approach is taken due to the necessity all installed running, signaling and steering appliances to be brought to the state of coordinated function, as required with design.

Activities the Plant to achieve its working profile are subject of separate methodology accepted for implementation. This also includes the time span necessary for establishment of the processes, regulation of dosing of chemicals, under standing control of the working parameters and analyses of the produced effluent. The methodology must include the aspect of amle and skilled intervention during the process, would any irregularity occur, especially in registering of leakages, increased noise, sufficiency of disposal facilities, storring and handling of materials an other.

During commissioning, the guaranteed environmental impact of the installed machinery must be verified by the authorized entities prior to hand over of the Plant by the Contractor to the Operator.

Means of continuous monitoring, such as laboratory, field metering equipment, networking of data collection represents part of the commissioning. Separate documentation on proper functionality, along with the accepted protocols of data presentation shall be delivered.

Commissioning shall contain establishment of real time monitoring of the data to authorized persons, and futher to the relevant stakeholders, including public. Access to this data will be previously defined/accepted.

Decommissioning of the Plant or its parts must be also subject to decommisioning-rehabilitation plan accepted prior to activation of such a step. Decommissioning of some parts of the Plant can also mean that there are improvements defined that require outdated parts of the Plant to be demolished or/and removed.

Structures, buildings, machinery, installations subject to decommissioning must be clearly noted and potential environmental damages identified. Only authorized entities are allowed to deal with decommissioning.

Areas of demolition and clearance of decommissioned works shall be brought to the state defined and approved in the Plan. If residuals of the process are subject to any special activity, such as remediation, this step is considered to be a part of particular analyses and approval, including acceptance of decommissioning activities.

Analyses of soil and ground water are required after the decommissioning, as a means of verification that no harmful materials are present on the siete where the Plant or its parts used to operate.

## 4.11 Raw materials, construction materials and equipment

### Construction phase

Commonly used construction materials for the WWTP include: concrete, brick, steel and stainless steel and other masonry material; asphalt, welding materials, pipes of different materials, filter materials, electrical materials and other.

Commonly used construction equipment and heavy vehicles: compressor, excavator, compactor, concrete mixer, concrete vibrator, crane, mobile crane, bulldozer, generator, drill, pneumatic tools, chainsaw and others will be employed during the construction.

### Operation phase

**Table 21. Expected waste quantities**

| Source | Waste | Code | Quantity |
|---|---|---|---|
| Mechanical coarse and fine screening | Inert waste | 19 08 01 | 2030 -14342 kg/d<br>2045 – 15120 kg /d |
| Removal of gravel and grease | Inert waste | 19 08 02 | 2030 – 4876 kg /d<br>2045 – 5141 kg /d |
| Ashes production | Insineration waste | 10 01 15 | 2030 – 106t/w<br>2045 - 116 t/w |
| Flying ashes from inceneration different than 10.01.016 | Incineration waste | 10.01.17 | Not defined |
| Send from fluidiezed bed cover | Incineration waste | 10.01.24 | Not defined |
| Ash residue not mentioned in 19.01.11 | Incineration waste | 19.01.12 | 13 t/w |

**Table 22. Reagents / chemicals to be used during operation**

| Reagents | Storage Condition | Process stage utilization | Quantity (2030) t/y | Quantity (2045) t/y |
|---|---|---|---|---|
| $FeCl_3$ commercial solution (42%)daily consumption | HDPE tanks (2x 50$m^3$)/simple walled tankwith concrete retention in case of leak | Physical-chemical treatment of phosphorous | - | 6.9$m^3$/d |
| $H_2SO_4$ Average consumption (96%) | Storage tank | Physical-chemical treatment of air | l/h | 1.4 |
| NaOH average consumption (30%) | Container | Physical-chemical treatment of air | l/h | 16.8 |
| NaOCl consumption (48%) | Storage tank | Physical-chemical treatment of air | $m^3$ | 15 |
| Active carbon consumption | Cassete in box | Biogas treatment | t/w | 0.21 |
| Bicarbonate | Storage tank | IBiogas treatment | Kg/h | 123.6 |

# 5 DESCRIPTION OF MAIN PROJECT ALTERNATIVES

Taking into consideration the limitations of the project location and basic data relevant for dimensioning of the WWTP capacity, including possible effects on the environment, the FS provided several different water line and sludge line solutions. Each solution is with different technical approach and different financial parameters for their implementation.

Different options take into account the requirements for output parameters of the treated wastewater, according to the national legislation that fully transpose the requirements of the EU UWWT Directive.

## 5.1 Do nothing scenario

If “Do nothing scenario” remains in force in future deterioration of the environment and society is unavoidable. This scenario will “improve” the following trends in regard to:

**Environment**

- Further deterioration of the quality of Vardar River and quality of ground water bodies due to enormous discharge of untreated water until it become eutrophic – Dead River.
- Failure to comply with applicable regulatory requirements
- Huge impact on the aquatic flora and fauna

**Socio-economic aspect**

- Increased number of acute infective intestinal diseases caused by increased number of coliform bacteria in 1l, increased number of aerobic bacteria in 1l and increased number of fecal bacteria (E. coli, E coli TT, Enterococcus, Enterobacter spp) in Vardar River.
- Economic loss of the farmers – reduced quality and quantity of the crops irrigated with polluted water
- Economy development and new employment

## 5.2 Description of alternative processes

### Identification and analysis of possible solutions for water line

Various existing and mostly long-tested processes are considered as able to treat $BOD_5$, COD and SS of urban wastewater effluents up to the above proposed targets. The preliminary analysis of available solutions was done according to the following criteria:

- Land or space requirement;
- Suitability of the process with respect to the required treatment level for short, medium and long term considerations;
- Impact on environment;
- Raw wastewater influent characteristics to the plant;
- Existing applications for similar treatment capacity;
- Sludge production.

In this regard following options were suggested:

- Extended Aeration (EA);

- Activated sludge with prior settling, also called Conventional Activated Sludge Process or CASP;
- Membrane Bioreactor (MBR) process;
- Oxygen Activated Sludge (OAS) process;
- Sequencing Batch Reactor (SBR) process;
- Moving Bed Biofilm Reactor (MBBR) process;
- Aerated Lagoon (AL) process;
- Biological Filtration (BF) process;
- Conventional Trickling Filter (CTF) process.

The assessment of the various processes according to the above selected criteria is shown on the following table.

**Table 23. Assessment of existing water treatment processes according to the project requirements**

| Process | Land space requirement | Suitability for short term and long term required level treatment | Impact on environment | Influent characteristics impact on the process | Existing applications for similar treatment capacity |
|---|---|---|---|---|---|
| Extended activated sludge (EAS) | Compatible with site availability | All quality requirements are achievable | Unpleasant smell. Odour removal treatment may be required especially in sludge area | Compatible with influent characteristics | The most common process (with CASP) for WWTP in any size |
| Activated sludge with primary settling (ASPS) | Compatible with site availability | All quality requirements are achievable | | Compatible with influent characteristics | The most common process (with EA) for WWTP in any size |
| Membrane Bioreactors (MBR) | Compatible with site availability (very compact process) | All quality requirements are achievable | | Compatible with influent characteristics | Many applications for all size WWTP |
| Oxygen activated sludge (OAS) | Compatible with site availability | All quality requirements are achievable | | Not recommended for highly diluted influent as is the case of the Project | Mainly used for industrial wastewater treatment or upgrading of existing urban WWTP |
| Sequencing batch reactors (SBR) | Compatible with site availability | All quality requirements are achievable | | Not recommended for highly diluted influent as is the case | Many applications but more suitable for small or medium size WWTP |
| Moving Bed Biofilm Reactors (MBBR) | Compatible with site availability | All quality requirements are achievable | | Compatible with influent characteristics | Mainly used to upgrade existing urban plants Few application for new big WWTP |
| Aerated lagoon (AL) | Non compatible | Quality requirements | | Compatible with influent | Few application for bid WWTP (at least in |

| | | | | | |
|---|---|---|---|---|---|
| | with the size of the site (required water area > 150 ha) | for BDO5, TSS and CDO hardly achievable Quality requirements for N and P are not achievable | | characteristics | Europe) |
| Conventional trickling filter (CTF) | Compatible with site availability | Quality requirements for N and P are not achievable, and should net the addition of works based on another process (BF) | Little smell Attracts mosquitos and birds | Compatible with influent characteristics | Less used for large WWTP because of its relatively low efficiency |
| Biological filtration (BF) | Compatible with site availability (very compact process) | All quality requirements are achievable | Unpleasant smell. Odour removal treatment may be required especially in sludge area | Compatible with influent characteristics | Many applications for all size WWTP |

## Alternatives excluded from further evaluation

- Oxygen Activated Sludge (OAS) process is not suitable as the projected WWTP will receive domestic type of sewage exclusively. No industrial wastes with high organics concentrations are expected.
- Sequencing Batch Reactor (SBR) process is a highly efficient process; but it is preferably used to treat highly concentrated wastewater which is not the case of the project where high infiltration into the sewer system is increasing the wastewater flow dilution.
- Moving Bed Biofilm Reactor (MBBR) process is also a highly efficient process. However it is mainly used for upgrading the capacity and/or the efficiency of existing small and medium size WWTPs. It is not commonly used for large size new plants still need to be built.
- Aerated Lagoons (AL) process is not appropriate as it requires large areas (more than 150 ha in water surface in the case of the projected Central WWTP) without reaching the water quality requirements.
- Conventional Trickling Filter (CTF) process is not a relevant solution due to its insufficient efficiency as compared to the water quality requirements.

## Alternatives selected for further evaluation

Aditional technical and financial comparison between the 4 remaining option shows that option 3 – membrane bioreactors and option 4 Bio filtration as compared to option 1 Extended Aeration (EA) and option 2. Activated sludge with prior settling, are with higher investment costs and the rate of produced sludge is higher compared to option 1 and 2.

Comparison of option 1 and option 2 is based on the above criteria, including CAPEX (investments) and OPEX (running) costs

These criteria are applied in a form of SWOT matrix which shows for each one of the two selected WWTP solutions positive and negative effects.

**Table 24.SWOT Matrix**

| | POSITIVE EFFECTS | | NEGATIVE EFFECTS | |
|---|---|---|---|---|
| | **S –Strengths** | | **W – Weaknesses** | |
| **INTERNAL FACTORS** | **Solution 1 : Extended Activated Sludge** | **Solution 2: Activated Sludge with Primary Settling Tank (conventional AS)** | **Solution1 : Extended Activated Sludge** | **Solution 2: Activated Sludge with Primary Settling Tank (Conventional AS)** |
| | **General strengths** | | **General Weaknesses** | |
| | Good efficiency for the removal of all pollutants as per EU requirements and Macedonian Standards<br><br>Compatibility with load variations due to low F/M ratio (0,5 to 0,6 kg$BOD_5$/kgDSS)<br><br>No important environmental impact (odour and noise pollution can be controlled)<br><br>Land requirement no larger than 15 ha in the western part of the project earmarked area (Water Zone). Available area for future possible extension | | Sensitivity to unexpected flow variation<br><br>Attention should be paid to sludge dispersion caused by excessive aeration and lowered sludge activity<br><br>Possibility of further expansion of the plant in the land located East of the existing North-South Overhead power lines and with possible constraint from the projected road (as per GUP)<br><br>Due to the sludge chain mainly (except for option c: Lime Treatment with Power & Heat Cogeneration; staff with high qualification is required | |
| | Low sludge production compared to solution 2<br><br>Operation is simplified due to only one quality of sludge production | Primary sludge allows to produce a larger quantity of biogas and electricity compared to solution 1<br><br>Primary settling allows a better flexibility in operation | | |
| | **Sludge option strengths** | | **Sludge option weaknesses** | |
| | <u>Solution 1 and solution 2 - option “a” (sludge drying)</u><br><br>Low quantity of sludge to be eliminated (10,000 to 12,000 tons/year)<br><br>Sludge is sanitised and stabilised<br><br><u>Solution 1 and solution 2 - option “b” (incineration + cogeneration)</u><br><br>Low quantity of sludge by-products to be evacuated to landfill site (5,500 to 6,800 tons/year)<br><br>Favourable energy balance. Better for solution 2<br><br><u>Solution 1 and solution 2 - option “c” (lime treatment+ cogeneration)</u><br><br>Among all sludge options, the most favourable energy balance. Better for solution 2<br><br>Lower global expenditures | | <u>Solution 1 and solution 2 - option “a”: (drying)</u><br><br>No energy generation resulting in bad energy balance<br><br><u>Solution 1 and solution 2 - option “b”: (incineration +cogeneration)</u><br><br>High $CO_2$ impact<br><br><u>Solution 1 and solution 2 - option “c” (lime treatment + cogeneration)</u><br><br>Very large quantity of sludge to be hauled (38,000 to 45,000 tons/year) | |

| | | |
|---|---|---|
| | Solution 1 and solution 2 - option "d" (hydrolysis + cogeneration)<br>Favourable energy balance. Better for solution 2<br>Sludge is sanitised and stabilised<br><br>Solution 1 and solution 2 - option "e" (hydrolysis + cogeneration + 50% drying)<br>Favourable energy balance. Better for solution 2<br>Sludge is sanitised and stabilised<br>Half of sludge is dried (possible reuse in the cement factory)<br>Lower quantity of sludge to be hauled compared to option "d" (15,500 to 20,000 t/year) | Incomplete stabilisation and sanitation<br>Only one possible way for sludge elimination: sludge conditioning (except temporary landfilling)<br><br>Solution 1 and solution 2 - option "d" (hydrolysis + cogeneration)<br>Large quantity of sludge to be hauled (23,000 to 30,000 tons/year) |
| **COSTS** | **S1:** CAPEX (2030/2040): 6.5/7.2 Billion MD<br>**S2:** CAPEX (2030/2045) : 6.5/7.4 Billion MD | CAPEX 2040 + 20 years OPEX: 18.8 Billion MD<br>CAPEX 2040 + 20 years OPEX : 17.3 Billion MD |

| | **O – Opportunities** | **T – Threats** |
|---|---|---|
| **EXTERNAL FACTORS** | Solution 1 and solution 2 option "a" (drying)<br>Various possibilities for sludge elimination according to opportunities: soil conditioning (subject to suitable sludge quality), reusing in cement factory (subject to sludge quality and dryness level), co-incineration, landfilling (temporary). Due to the sludge quality and quantity, landfilling could also be envisaged as a perennial solution<br>Solution 1 and solution 2 option "a" (incineration)<br>Possibility to reuse ashes in public works<br>Solution 1 and solution 2 - option "c" (lime treatment + heat and power cogeneration)<br>Possibility to reuse sludge for soil conditioning provided that sludge quality responds to farming demand<br>Solution 1 and solution 2 option "d" (hydrolysis + cogeneration)<br>Various possibilities for sludge elimination according to opportunities: soil conditioning (subject to sludge quality), co-incineration with other wastes, landfilling (temporary)<br>Solution 1 and solution 2 option "e": (hydrolysis + cogeneration + 50% drying)<br>Various possibilities for sludge elimination according to opportunities: soil conditioning (subject to sludge quality), co-incineration, reuse in cement factory for the part of the sludge which has been dried (subject to sludge quality), temporary landfilling. Due to the sludge quality and quantity, landfilling could also be envisaged as a perennial solution | Solution 1 and solution 2 - option a (drying)<br>No energy generation resulting in bad energy balance. Expenses costs sensitive to possible increasing of the energy cost. Harder treat for solution 1.<br>Solution 1 and solution 2 - option b (incineration + cogeneration)<br>More stringent regulations on CO2 emissions<br>All solutions and options except incineration, more particularly lime treatment option<br>For the time being, there is an uncertainty as far as the feasibility of sludge reuse for soil conditioning:<br>– uncertainty as far as sludge quality due to possible if not certainly the presence of heavy metals (Lead, Zinc, etc…) due to industries discharging into the sewer system, resulting in unsuitability of sludge for agricultural use<br>– uncertainty as far as sludge demand from farmers<br>If the quality of sludge is not suitable for soil conditioning (all options except "b") or reuse in cement factory (options "a" and "e"), the only elimination solution should be a perennial landfilling (or co-incineration), except in option "b" (incineration). |

**The selected option is option 2: Activated sludge with primary settling commonly known as conventional activated sludge**

## Selection of the sludge treatment options

The following criteria are taken into consideration in selection of the sludge treatment:

- To produce energy from sludge process in order to save operation energy costs;
- To reduce the quantity of sludge resulting from primary and biological waste water treatment for the two following reasons: firstly, no solution for reusing or elimination of sludge can be considered with certainty as feasible for the time being, secondly it is a priority, in any case, to save transportation costs to elimination or reusing site;
- To make possible the development of several solutions for reusing or elimination of the treated sludge, either alternatively or in a complementary way.

Five options have therefore been selected to allow an informative comparison and to secure a wide range of possible solutions. They can be summarised as follows:

- **Option a**: digestion, dewatering and thermal drying with a 90% dryness as well as reusing of methane gas to heat driers and hot water vapour from driers to heat sludge digesters. This option allows envisaging various ways of sludge reuse or elimination providing that chemical quality of sludge proves to be acceptable: soil improvement, reuse as fuel for cement plant, temporary landfilling;
- **Option b**: incineration of digested and pre-dried sludge in the WWTP with reuse of methane gas to heat digesters through co-generation energy and reuse of incinerator heat to cater for pre-driers energy demand. This option is the only one which does not require to haul sludge out of the WWTP;
- **Option c**: digestion and dewatering of sludge followed by lime injection, gas methane produced by digestion being used to heat digesters through the co-generated heat. This option is the less expensive in terms of CAPEX and is particularly suitable for the reuse of the sludge as soil conditioner;
- **Option d**: digestion enhanced by means of thermal hydrolysis and dewatering, gas methane produced by digestion being used to heat the thermal hydrolysis and digestion through co-generated heat. Potential solutions for sludge reuse or elimination are the same as the ones mentioned in Option a above;
- **Option e**: Same as option d but with the use of dryers in order to get further reduction of the quantity of solid sludge produced.

Taking into consideration the above mentioned criteria for selection the options the most suitable one will remain the option which shows a good power production/consumption balance for the plant. Therefore, options with thermal dry (a), incineration (b) or hydrolysis with thermal drying up to 50% of the sludge production (e), are considered as the most suitable ones.
Fluidised bed inceneration of the sludge is adopted as a most modern and efficient technology, recommended by corresponding Bref / BAT, having most suitable environmental profile.

**Table 25. Comparison of incinerators types**

| Parameters | Multiple-hearth furnace | Fluidised bed incinerator |
|---|---|---|
| Heat transfer | Poor | Excellent |
| Mixing | Poor | Intense |
| Excess air | High | Low |
| Bio solids detention time | Long (0.5 – 3 hours) | Short (1 – 5 minutes) |
| Gases detention time | Short (1 – 2 seconds) | Long (6 – 8 seconds) |
| Heat recovery system | Rather low | Very suitable |
| Maintenance | Rotating device to be controlled | No rotating device |
| Fuel consumption | Higher than Fluidised bed incinerator | - |

## Sellected technology:

- Water line solution – Option 2 Conventional Activated Sludge with primary treatment due to: lowest costs (CAPEX & OPEX), lowest sludge production, flexibility in operation and better electric power production/consumption balance whatever the sludge treatment/disposal option to be selected.
- Sludge management - option b Incineration due to: low costs, low solid waste quantities for disposal and independence from other actors.

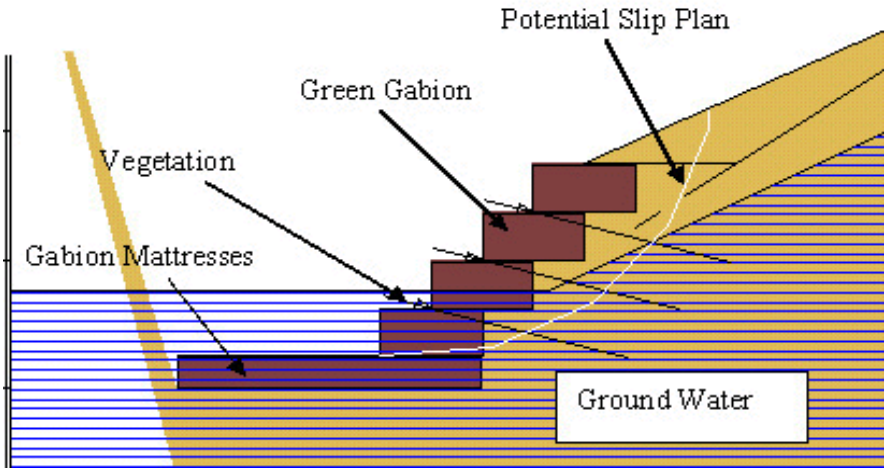
## Alternatives for riverbank protection

The different methods for keeping Vardar Riverbanks healthy before excessive erosion occurs during the flood period are outlined below. These methods describe the riverbank protection in general terms and propose the most appropriate solution in terms of durability and low maintenance cost for such protection.

With all the environmental aspects of this project, the selection of material is considered very important for perfect integration of works with the surrounding environment. To achieve this objective, several types of materials are recommended that can offer strength, resistance, and natural integration: Green Gabion made of PVC coated woven wire mesh, block paving, mortared stone pitching, Coconut fiber Mesh and Wooden Piles.

Three possibilities have been envisaged:

**Solution 1: Green gabion wall protection and renomattres for toa protection**




**Picture 21. Cross Section of Gabion Wall**

**Advantages**

- Good stability where flow velocities are too high,
- Can be stacked on relatively steep slopes to resist river flows and unstable banks,
- Adapted to soil settlement,
- Allow for natural vegetation growth,
- Record of satisfactory performance and,
- Aesthetically pleasing.

**Disadvantages**

- Labour intensive

**Solution 2. Reno mattress protection**

**Advantages:**

- Holds soil in place to protect Riverbank and toe slope from erosion,
- Good stability where flow velocities are too high,
- Shaped into shallow, broad baskets,
- Tied together side by side to form continuous blanket of protection,
- Easy adaptation for soil settlement,
- Placed on a smoothly graded riverbank slope,
- Allow for natural vegetation Growth,

**Disadvantages**

- Labour intensive

**Solution 3. Block paving with hollow concrete blocks.**

**Advantages**

- Openings allow vegetation to grow so that the root structure can strengthen the bank
- Durable, less susceptible to freeze/thaw,
- Sufficiently flexible to conform to changes in bank shape,
- Can be used with a filter if erosion is a concern,

- Easy pedestrian access to river,
- Sufficient flexibility to conform to minor changes in bank shape.

**Disadvantages**

- Susceptible to excess hydrostatic pressure,
- Uniformly sized – may require a filter material,
- Vulnerable to environmental hazards.

The recommended / sellected is option 1.

# 6 DESCRIPTION OF THE EXISTING ENVIRONMENT

## 6.1 Topography

Planned location of Waste water treatment plant for Skopje is on the south-east part of Skopje Valley, in Trubarevo within municipality Gazi Baba. The municipality Gazi Baba spreads on the east part of the Skopje valley and the City of Skopje, and covers 92($km^2$).

The lowest part of Gazi Baba is the village Trubarevo with altitude 225m above sea level, and the highest part is on 1,626m altitude above sea level.

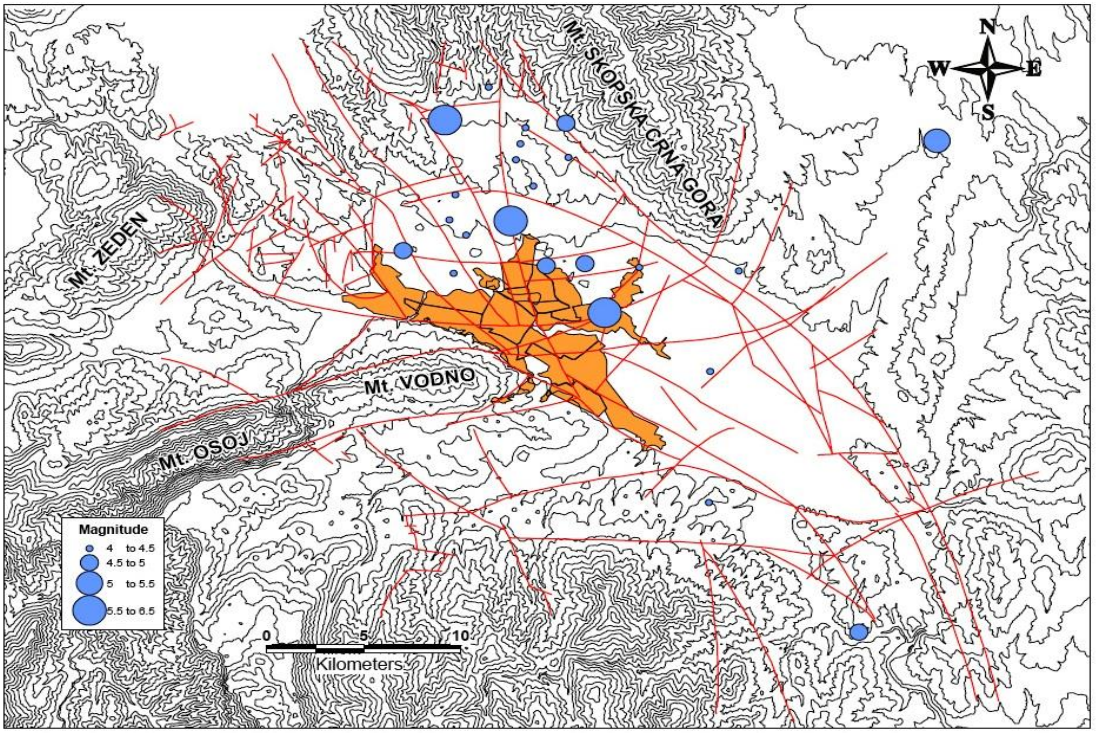
According the relief, it is an area, whose most part (central, south-west and the south) is situated in a valley. 65% from the area is fertile land. The rest of the territory covers several hills: in the north part there is characteristic landscape–the forest Gazi Baba, in the central part is the location Kamnik, and in the east–the mountain part of Skopska Crna Gora. The relief of the municipality consists from several different morphological elements and shapes. The hills in the alluvial valley are: Gazi Baba, Kamnik and Krst, constructed from marl and dusty-clay sediments. As micro-relief forms they are relatively small and located on the left side of the river Vardar.

## 6.2 Soil and geology

According to the regional geological research data presented on the Basic Geological Map, scale 1:100.000 for Skopje, the soil of Skopje basin is made of masses of rocks from the Paleozoic and Mesozoic complex. Basic geological ambience on the wide-spread area of Skopje basin is Neogene - Pliocene sediments and Quaternary-alluvial deposits. The basic rock masses are the Pliocene lake sediments taking about 700 meters, covered with Quaternary mostly alluvial-terrace sediments. Characteristics of the Quaternary sediments of upper layers were determined basically as gravel and sand and clay layers up to the terrain surface. Their genesis is connected with the alluvial flows of the river Vardar, as well as the flood deposits from the surrounding river basins.

The Paleozoic complex encompasses: schist, marble and quartzite, which altogether spread from north-east to south-west.

From seismic and tectonic aspect of the region, the location belongs to the Vardar seismic zone, where the Skopje epicenter area is affected by the level of the earthquake destructive effects. These aspects should be taken into consideration when seizing the structural elements, in order to provide a seismic protection and i stability in case of earthquake with anticipated intensity. The seismic of the Skopje region including tectonic processes caused catastrophic earthquakes in the past. The maximal expected magnitude is 6.5 and seismic intensity is IX (EMS-98), defined using data of all earthquakes in this region. Exceeding of these values is not expected. Below is provided the seismo'tectonic map of Skopje region with marked and relevant magnitudes.



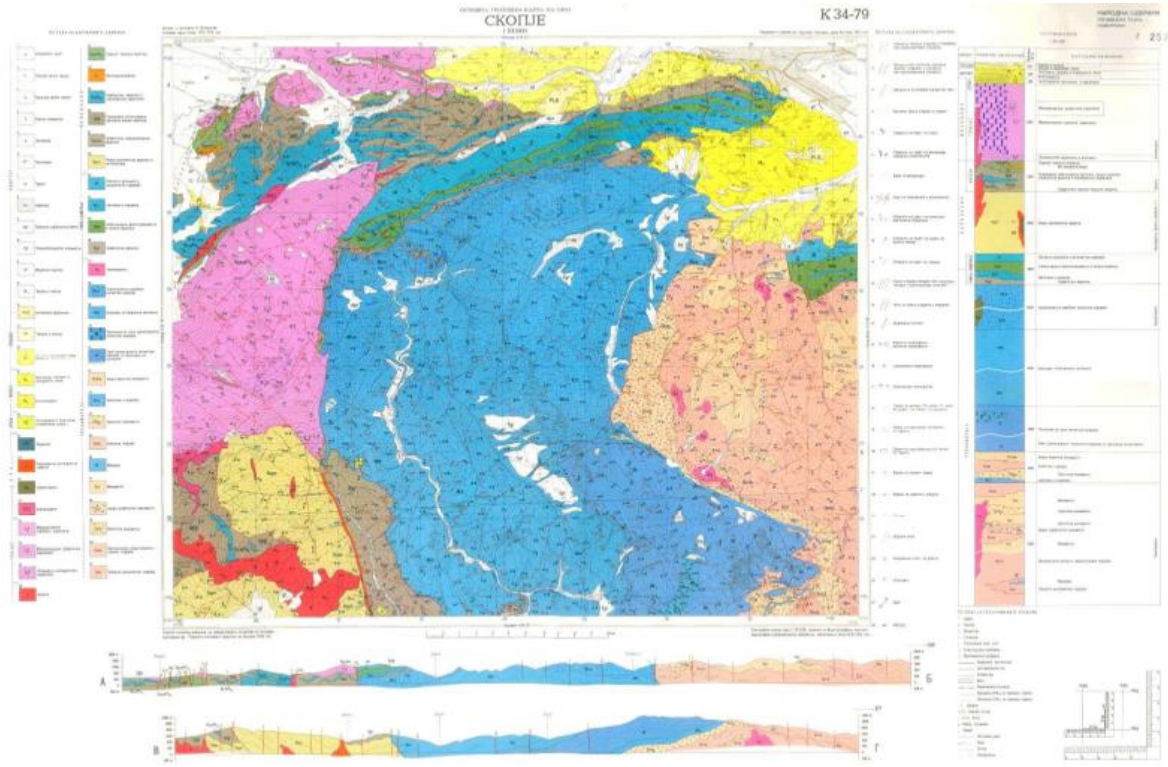

**Picture 22. Seismic Map of Skopje Region**

Under super position, the marble appears next as interstratifications or in bands in the schist masses. They are mostly gray and white, or with striped, on some places with schist texture and significant percentage of mica, which point out the gradual transition with the surrounding mica schist.

According to their presence in the Paleozoic complex, the biotite and quartz-sericite schist represent the basic mass. Mostly they are in a tectonic relation with the rest of the litostratigraphic members. They are clay-sand products, which, during the process of metamorphose in the long geological history, transformed into different varieties of schist. Their color is gray and brown, their surface is mostly degraded and dilapidated (frail), striped and with extended schists-like characteristic.

Generally, the soil on the location is composed of proluvial deposits represented by ffine'grained clay mixtures and gravel ingredients. The geo-mechanical features of these deposits are relatively low due to thenarrow anles of internal friction and low modules of pressure. Therefore, such layers can be used only for low specific loads. Under this layer there is a layer of gravel deposits and sandy mixtures including small particles, very compact. Geo -mechanical features of the layer can be used as direct foundation base. Geological map for Skopje region is provided below.

Pedological composition of Skopje Valley is homogeneous. Different soil types are represented: regosoils, coluvial, deluvial soils, vertisoils, chromium cambosoils (cinamonic forest soils), cambosoils (brown forest soils), fluvisoils (alluvion soils), fluvial-meadow soils (humus flovsoils) etc.




**Picture 23. Geology map of the City of Skopje**

Generaly, the ground down to 12.0m is composed of the following substances:

- Humus soil;
- Soil with small particles and silt, medium solid consistency, very confined, dark-brown colored;
- Clay flour, small and coarse sand and gravel and organic ingredients, medium plastic, medium solid consistency, brown color;
- Small to coarse gravel, sandy, medium to thick concentration with presence of silt, oscillating percentage of granules Dmax 50–60mm unconfined, reddish and brown.

Urban development and industry on the territory of Skopje Valley makes impacts to soil quality.

The whole territory of the municipality Gazi Baba was flooded from the former Skopje Lake (Oligocene lake). The relief, abrasive terraces and surfaces kept their horizontal position. Because of the tectonic movements and the big seismic instability, as well as the frequent earthquakes with epicenter in the Skopje valley and especially in the east part (the location of the municipality), resulted in leaking of the lake, rhythmically, with holding on to several levels, which formed the Skopje valley.

The whole low land of the municipality is covered with fluvial sediments, represented by silt, sand and gravel. Besides that, there is Neogenic Lake–sandy clay sediments, which are visible 2 to 5m depth. That is why the low lands provided favorable conditions for quality agricultural crops. Also, in the low lands the erosion is weak, which minimizes the negative consequences.

The resins are present on the east slopes of Gazi Baba and Kamnik. They are developed over different neogenic sediments. Larger areas southeast from Kamnik are formed with

resins, characterized with high productive ability. The alluvial-sandy soils are spread around Trubarevo and are used for intensive gardening, vine and fruit production.

The resins are present on the east slopes of Gazi Baba and Kamnik. They are developed over different neogenic sediments. Larger areas southeast from Kamnik are the resins, which characterize with high productive ability. The alluvial-sandy soils are spread around Trubarevo and are used for intensive gardening, vine and fruit production.

The meadow soils, formed under the influence of the high underground waters, spread on the east from the settlements Chento, the village Singelich, Indzikovo, and on the southeast towards the village Trubarevo and municipality Ilinden. The alluvial-sandy soils are spread around Trubarevo and are used for agriculture.

## 6.3 Ground Waters

The area of the Skopje region has extraordinary good hydrographic- hydrological features. Available water resources are manifested with ground and surface waters. The alluvial plain land in parts, especially around larger watercourses, has large reserves of ground water. Torrents and soil erosion as hydrographic problems are the result of geological and climatic peculiarities of the Skopje region and the destruction of the forest.

Two main aquifers characterize the ground water in Skopje valley: high yield semi-confined aquifer of superficial sand and gravel with clay horizons and low yield aquifer in underlying marls.

The superficial aquifer is in direct connection with the River Vardar, being within the alluvial plain of the river. The depths of groundwater level vary depending on the local conditions, flowing in general in direction towards the river and downstream. The upper aquifer stretching along upper part of Skopje valley consists of compacted alluvial sand and gravel on both sides of the river. The thickness varies from 4-5m in the western part to up to 144m in Trubarevo. The hydraulic conductivity also varies. Data from existing wells shows K from $1.80*10^{-5}$ to as high as $3.60*10^{-2}$m/s (Trubarevo). The depths are from- 4.0m in the upper (western) part to - 12.0m from surface in the east industrial area.

In the industrial area there are number of boreholes for supplying industry with water. Measurements of the ground water are not continuous. In the lower part of Skopje valley the same aquifer – compacted alluvial sand and gravel- continues with reduced thickness and similar conductivity. The groundwater level is artificially kept bellow the surface of the terrain by drainage network and pumping into the River Vardar before Taor gorge.

In 2008, near the location of the WWTP 12 boreholles were drilled and detailed geotechnical investigation were performed. According to the results of drillings, features of the lithological units were defined. Layers of fine'grained and gravel sand that formed part of the alluvial sediments are layers of varying thickness and porosity and quite high permeability.

The aquifer is formed of in unconsolidated sediments with free level where the pressure of the ground water is same as the atmospheric and with primary permeability (intergranular porosity and permeability. Ground water flow is following the flow direction of Vardar River as both ground and surface water flows through alluvial environment composed of fractions of gravel sand with high inter granulometric porosity. Permeability and hydraulic conductivity were defined according to the previously defined granulometric curve.

Considering the abowe mentioned characherictics of the ground water problems during excavation works may occur due to the high groundwater level. In this regard, special attention should be paid to the groundwater drainage measures during the excavation, foundation and during construction works.

The following table provides overview of the maximum monthly ground water level – measurement point Trubarevo (N 41º 58' 45'' / E 21 º 31' 49'') for the period 2001- 2010.

**Table 26. Monthly Ground Water Maximal Level – Measurement Point Trubarevo**

| Year | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | $H_{max}$(cm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2001** | 446 | 448 | 436 | 387 | 380 | 412 | 440 | 465 | 495 | 500 | 498 | 439 | 380 |
| **2002** | 488 | 490 | 465 | 423 | 432 | 430 | 473 | 459 | 447 | 385 | 421 | 358 | 358 |
| **2003** | 278 | 286 | 332 | 352 | 359 | 380 | 415 | 468 | 472 | 460 | 453 | 439 | 278 |
| **2004** | 430 | 430 | 408 | 400 | 406 | 400 | 427 | 448 | 457 | 445 | 426 | 418 | 400 |
| **2005** | 408 | 389 | 350 | 369 | 371 | 373 | 406 | 457 | 453 | 429 | 414 | 360 | 350 |
| **2006** | 280 | 283 | 265 | 298 | 333 | 362 | 375 | 423 | 438 | 438 | 437 | 429 | 265 |
| **2007** | 420 | 404 | 420 | 419 | 430 | 424 | 447 | 472 | 470 | 423 | 424 | 438 | 404 |
| **2008** | 425 | 402 | 412 | 434 | 438 | 442 | 467 | 495 | 465 | 468 | 456 | 457 | 402 |
| **2009** | 425 | 431 | 412 | 370 | 343 | 438 | 391 | 406 | 420 | 426 | 442 | 410 | 343 |
| **2010** | 350 | 325 | 297 | 263 | 261 | 279 | 350 | 381 | 404 | 377 | 335 | 295 | 261 |
| **$H_{max}$(1-10)** | 278 | 283 | 265 | 263 | 261 | 279 | 350 | 381 | 404 | 377 | 335 | 295 | 261 |

## 6.4 Hydrology and surface water

### Vardar River – receiving water course

The River Vardar is the largest river in the Republic of Macedonia with catchment area of 22,290 $km^2$, which covers nearly 80% of total land area (25,713 $km^2$) of the country.

Within the Republic of Macedonia, the river has a length of 301 km, while in Greece the length is about 80km. Its spring is near the village of Vrutok at 683m a.s.l. and after running through central part of Macedonia, the River Vardar inflows into Aegean Sea.

The main tributaries of the River Vardar are: Treska, Lepenec (coming from Kosovo), Pcinja, Bregalnica, Crna Reka and Bosava.

The average annual flow for the period 1960-1991 at the border with Greece (Gevgelija) is 144.9$m^3$/s, while the average annual volume of discharged water at the same location is about 4.56 billion $m^3$.

The River Vardar within the Study area is one tenth of total length and located in the upper stretch. Some general information is given in following Table.


**Picture 24. Map of the river basin districts**

River Vardar within the Study area is one tenth of total length and located in the upper stretch. Some general information is given in following Table.

**Table 27. General information of Vardar River**

| Hydrological station | Skopje – zelezen most | Unit |
|---|---|---|
| River | Vardar | |
| Station code | 63050 | |
| Coordinates | N 41º 59' 41"/E 21º 26' 50" | |
| Altitude | 239.55 | a.s.l. |
| Catchment area A | 4.650.0 | $km^2$ |
| Average rainfall: $P_o$ | 788 | mm |
| Average annual flow $Q_{sr}$ | 57.7 | $m^3/s$ |
| Average multi annual module Mo | 12.40 | $l/s/km^2$ |
| Min flow (1990) $Q_{smin}$ | 5,2 | $m^3/s$ |
| Max. flow (1963) $Q_{smax}$ | 1080 | $m^3/s$ |
| Max, Flow with probability of occurrence once in 1000 year $Q_{0,1\%}$ | 1694 | $m^3/s$ |
| Max, Flow with probability of occurrence once In 300 y. $Q_{0,3\%}$ | 1420 | $m^3/s$ |
| Max Flow with probability of occurrence once in 100 | 1162 | $m^3/s$ |
| 10 years – $Q_{10\%}$ | 632 | $m^3/s$ |
| Volume $W_o$ | 1.820.086.378.0 | $m^3$ |
| Module coefficient $C_m$ | 10.497 | |

*Source AHMW: 2015 year*

## Water levels

Using data from the AHMW, the following table presents the trends of increase-dicreased water levels of Vardar River, measurement point Zelezen most for 2001-2013.

**Table 28. Monthly Water Level of Vardar River**

| | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | Annually cm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2013** | | | | | | | | | | | | | |
| Max | 71 | 133 | 143 | 139 | 183 | 127 | 79 | 81 | 92 | 90 | 83 | 121 | 112 |
| Min | 50 | 58 | 80 | 100 | 103 | 76 | 68 | 66 | 96 | 51 | 61 | 78 | 74 |
| **2012** | | | | | | | | | | | | | |
| Max | 110 | 100 | 115 | 138 | 135 | 103 | 70 | 114 | 104 | 89 | 110 | 106 | 108 |
| Min | 62 | 51 | 65 | 95 | 82 | 60 | 52 | 50 | 53 | 40 | 59 | 57 | 58 |
| **2011** | | | | | | | | | | | | | |
| Max | 136 | 133 | 132 | 120 | 118 | 130 | 120 | 89 | 110 | 109 | 106 | 104 | 117 |
| Min | 78 | 98 | 95 | 84 | 83 | 90 | 81 | 55 | 44 | 41 | 66 | 62 | 69 |
| **2010** | | | | | | | | | | | | | |
| Max | 105 | 155 | 160 | 185 | 165 | 148 | 120 | 107 | 112 | 138 | 140 | 204 | 145 |
| Min | 105 | 112 | 127 | 115 | 132 | 98 | 71 | 71 | 72 | 75 | 92 | 122 | 99 |
| **2009** | | | | | | | | | | | | | |
| Max. | 172 | 86 | 151 | 170 | 152 | 146 | 115 | 105 | 83 | 80 | 160 | 136 | 130 |
| Min | 66 | 60 | 65 | 100 | 109 | 90 | 62 | 63 | 41 | 41 | 75 | 73 | 53 |
| **2008** | | | | | | | | | | | | | |
| Max | 112 | 102 | 110 | 92 | 101 | 78 | 61 | 53 | 72 | 80 | 80 | 135 | 90 |
| Min | 65 | 61 | 54 | 63 | 70 | 51 | 32 | 35 | 51 | 53 | 46 | 55 | 53 |

## Water quality in Vardar River

Vardar River is generally classified in Class II, except downstream parts in the city of Skopje classified as class III. Downstream Skopje at measurement point Taor the quality of Vardar River belongs to class IV-V. According to the Decree on water classification the water quality is classified from I to V, where Class II means:

- Very clean, mesotrophic water, which in its natural state can be used for bathing and recreation, water sports, production of other types of fish, or which can be used – after usual methods of purification / coagulation, filtration, disinfection etc./–for drinking and production and processing of food products.

## Existing impact from wastewater discharge

Based on the data of Vodovod i Kanalizacija results of pollution loads measured on samples collected at six strategic points along the wastewater collection system for the three last year period (2012-2014 inclusive). These points correspond to the discharge, into the Vardar and its main confluent, of six sewer interceptors for the domestic wastewater. Four of these points are located in Gazi Baba Municipal area with one of the points on the right bank of the River (Bliznak Bridge point) and the remaining three (Keramidnica, Novo Lisice pumping station and Vardariste points) on the left bank of the watercourse. The two other points are located downstream from the project location (Hipodrom point within Aerodrom Municipality and Dracevo point in Dracevo settlement part of Kisela Voda Municipality).

Measurements have been done on a monthly random checking basis and on one collected sample from each one of the six discharge points. This exercise is usually repeated 10 out of 12 months of the year (no samplings and analysis are done in July-August period). Suspended solids concentration has been measured after 30 minutes settling.

Results show that the discharged wastewater flow from urban areas of Skopje City is highly diluted since maximum $BOD_5$ concentration rate observed is averaging at less than 200mg/l at Novo Lisice pumping station and it is lower than 100mg/l at Vardariste and Hipodrom points. This is an indication that water infiltration into the wastewater collection system, either in dry or in wet weather conditions, is quite high. In this regard, it is to be noted that the correlation of such rates with recorded figures on water consumption as available to Vodovod i Kanalizacije would indicate that water infiltration flow into the sewage system in Skopje City is exceeding 100% of the estimated average wastewater flow (150% can be considered as average in wet weather conditions).

On the other hand, the ratio of $BOD_5$/COD is averaging at 2.0 to 2.1 for the six measuring points which is to be considered as quite normal for a domestic type of wastewater flow with a limited presence of industrial effluent.

It is also to be noted that extreme values for $BOD_5$ concentration have been recorded at the checked discharge points all through the year. The results are summarized in the table below:

**Table 29. Extreme values of $BOD_5$ Loads for years 2012, 2013 & 2014**

| Discharge Point | 2012 | | | | 2013 | | | | 2014 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $BOD_5$ (mg/l) | Min. | Month | Max | Month | Min. | Month | Max | Month | Min. | Month | Max | Month |
| Keramidnica | 24.99 | May | 149.35 | Oct. | 33.37 | June | 448.35 | Dec. | 44.65 | Sep. | 202.56 | May |
| Bliznak Bridge | 33.85 | June | 170.00 | Nov. | 35.30 | Jan. | 266.58 | Sep. | 54.19 | Apr. | 145.54 | Sep. |
| Novo Lisice P/S | 118.65 | May | 907.32 | Nov. | 34.07 | June | 332.74 | Nov. | 77.64 | Apr. | 199.51 | May |
| Vardariste | 44.51 | Oct. | 193.00 | Feb. | 25.41 | Feb. | 191.77 | Jan. | 42.75 | Sep | 101.29 | Feb. |
| Dracevo | 38.00 | May | 261.00 | Feb. | 45.24 | Sep. | 195.16 | Nov. | 156.87 | Jan | 209.55 | Sep. |
| Hipodrom | 17.00 | Feb. | 151.25 | May | 16.20 | Mar. | 199.55 | Sep. | 43.22 | May | 153.71 | Jan. |

*Source: Vodovod i Kanalizacija*

Results indicate that pollution loads varies widely all over the year within selected discharge points. This is very likely due to the additional storm water flow in rainy weather. They also vary from a year to another as well as from a discharge point to another one.

In the absence of information on the discharged flow, a wider period of observation with a periodic and uninterrupted sampling and analysis exercise, these results would remain difficult to use for developing the basic design parameters of the projected WWTP.

As for suspended solids concentration, results are also confirming that wastewater effluents are highly diluted as figures obtained for suspended solids are equal or even lower than what has been obtained for $BOD_5$ concentration, while they are generally 10 to 15% higher, in urban areas.

**Table 30. Average values for wastewater parameter measurement (mg/l) throughout years 2012 to 2014**

| | Keramidnica | Bridge Bliznak | PS Novo Lisice | Vardariste | Dracevo | Hipodrom |
|---|---|---|---|---|---|---|
| **$BOD_5$** | **108.78** | **113.03** | **192.22** | **88.16** | **149.19** | **81.51** |
| **COD** | **234.17** | **224.31** | **377.78** | **180.08** | **318.66** | **174.87** |
| **COD/$BOD_5$** | **2.22** | **2.03** | **1.95** | **2.03** | **2.12** | **2.18** |
| **SS** | **109.46** | **116.96** | **106.42** | **53.62** | **102.62** | **81.90** |
| **Total N** | **26.04** | **79.04** | **67.80** | **25.73** | **73.27** | **19.67** |

*Source: Vodovod i Kanalizacija*

The Central Laboratory, performing analysis on heavy metal concentration on the 6 main wastewater discharge points into the Vardar River, on 14th October 2014 confirmed that:

- The diluted character of the sewage flow. $BOD_5$ concentrations varied from 49.38 mg/l for Hipodrom sewer discharge point to 142.50mg/l for Dracevo discharge point in Kicela Voda Municipality.
- The presence of zinc concentration above tolerated limits (2.48 to 3.56mg/l depending on the tested discharge point).

Within Skopje City, a total number of 58 discharging sewer collectors, have constituted the targeted sampling points of the Laboratory. They can be distributed as follows:

- Storm water drainage system: 34
- Wastewater collection system: 17
- Industrial sewage system (used exclusively or predominantly by industries): 7

Among industries that have their own sewer system, the following can be identified: Technicki Gasovi, Skopski Leguri, Arcelor Mittal, Makstil and Concrete production units. Moreover, sewer collectors from three existing dump sites along the River have also been considered.

Results indicate that for 18 of the discharge points; organic pollution ($BOD_5$ and/or COD) is exceeding tolerated limits according to EU Directives and as adopted by Macedonian Standards as far as liquid discharges into surface water. However, such pollution remains below the threshold that can be accepted for discharges into wastewater collection systems generally limited, unless otherwise indicated, to 250mg/l for $BOD_5$ and 700mg/l for COD.

Six (6) of storm water discharge points are indicating an organic pollution higher than acceptable for the discharge of a wastewater flow into a surface water body, and two of them have the organic pollution concentration comparable to the one of a wastewater flow. This indicates that in some areas; the storm water drainage system may also be used inadvertently, for the discharge of wastewater flow.

As for wastewater system discharge points; a high dilution of the organic pollution can be noticed with the exception of the following four discharge points, which are not among the six points regularly tested by the Central Laboratory: UN Bridge, the railway station D500mm diameter collector, the Pension Insurance D300mm diameter collector and Zelezara sewerage system. Organic pollution concentrations for these points are well indicative of a domestic type of wastewater flow.

Heavy metal concentration tests have excluded: aluminium, mercury, arsenic and selenium while zinc and cadmium tests were not done for all the checked discharge points and more particularly along the downstream section of the investigated area.

Heavy metal concentrations above tolerated rates; were found at 35 discharge points covering both storm water and wastewater systems. Heavy metal concentrations, above tolerated limits, are mainly related to Zinc, Nickel and Lead. Discharge points where heavy metal concentrations were found above normal rates include a number of storm water drainage outlets. This may be considered as an indication that contaminated soils in some industries may also be affecting the characteristics of the storm water runoff flow in these areas.

## 6.5 Climate and Meteorology

The territory of the Republic of Macedonia, Skopje Region in particular, is under the influence of the modified Mediterranean type of climate resulting from the Continental, Middle European and Dry Eastern, mountain climate, as well as the secondary factors – relief and elevation.

Water resources in the country are vulnerable to climate change regarding both the quality and quantity. According to the third national climate change report, total average rainfalls are expected to decrease some 8% by 2075 and 13% by 2100. The expected decrease of the available surface water for Vardar river is estimated at 7,6% in 2025 and 18,2% in 2100. Besides, the groundwater charging in the Vardar River Basin will constantly decrease reaching app 57,6% of the current level.

### Temperature

The average annual temperature in the municipality of Gazi Baba is 12,5$^0$C. Average monthly temperature in the winter period is above zero, coldest month is January with average temperature value 0.4$^0$C. Annual max. temperature is 42,4$^0$C. Average annual summer days amounts to 117.

The temperature air inversions appear every month, but they are most present during the winter. The lowest temperatures during the days when temperature inversions are present are in the low parts of the valley, while the temperature gets higher at the higher parts. The difference in the temperature in occassions of inversion between the lowest parts of the valley and the surrounding high areas during winter can exceed 10ºC, depending on the inversion intensity.

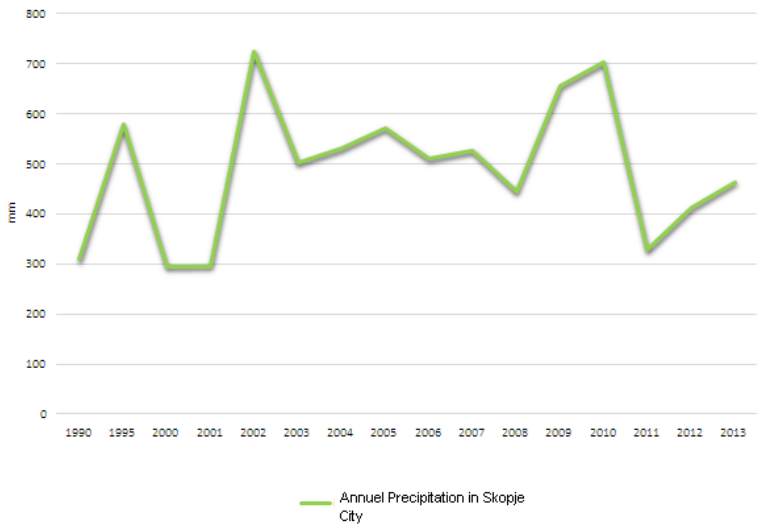
Average period with ice lasts 84 days. During the summer period the rate of electricity consumption increases due to high temperature. On the other hand, the heating season lasts 6 months. The minimal annual temperature of the air is - 22,9$^0$C.

Average annual relative humidity of the air is 70%. Lowest relative humidity is registered in July and august - from 54% to 69%. Average annual number of clear sky days is 70, and on cloudy days 107.

Based on the basic climate elements (air temperature and precipitation) and its features, the climate of this site can be defined as moderate with changed Mediterranean influence and pluviometric regime.

## Precipitation

Precipitation is unevenly distributed during the year (monthly and seasonal). Intensive rain occurs in May and October. Minimum values are registered in February and July. According to ombrographic measurements in the Skopje valley precipitation are more frequent in the afternoon than in the morning. During the hot period of the year, intensive rains are rather frequent with different intensity and duration.




**Picture 25. Precipitation in mm for the City of Skopje (1990-2013)**

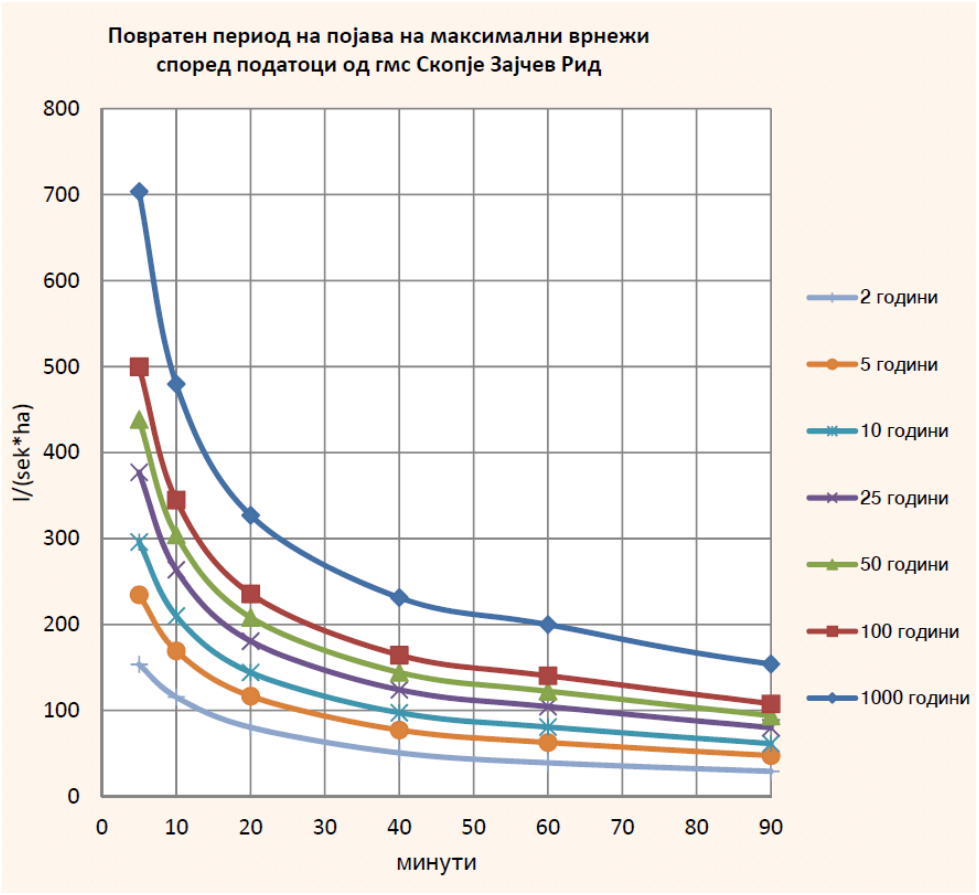
The following table presents the monthly sum in mm for the period 2003-2013, measurement station Zajcev rid. Analysed data shows that annual precipitation varies between 400mm - 700mm, whilst average annual precipitation sum for 2003-2013 is 512mm.

**Table 31. Precipitation in mm for the City of Skopje**

| MP Skopje Zajcev rid | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2013** | 25.1 | 66.1 | 25.7 | 36.4 | 64.5 | 61.3 | 19.0 | 8.4 | 56.5 | 20.5 | 30.1 | 0.8 | 414.4 |
| **2012** | 30.9 | 43.9 | 16.o | 52.0 | 108.2 | 11.7 | 6.8 | 4.2 | 11.1 | 49.0 | 36.1 | 31.8 | 412.7 |
| **2010** | 28.2 | 63.7 | 69.6 | 63.8 | 38.6 | 57.5 | 53.2 | 3.5 | 37.3 | 144 | 81 | 64.8 | 704.1 |
| **2009** | 72.8 | 12.2 | 69.6 | 65.3 | 70.2 | 104.3 | 10.2 | 50.2 | 11.1 | 52.9 | 56.1 | 79.6 | 653.6 |
| **2008** | 7.7 | 0.5 | 20.8 | 18.7 | 40.7 | 46.9 | 57.8 | 24.8 | 78.5 | 27.3 | 37.5 | 68.3 | 438.5 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2007** | 30 | 21 | 31 | 7.8 | 96.2 | 34.8 | 1.2 | 52.7 | 27.2 | 140 | 69.4 | 15.7 | 527 |
| **2006** | 51.2 | 56 | 58.1 | 23.8 | 19.2 | 94.7 | 39 | 29.2 | 43.3 | 56.9 | 13.2 | 10.4 | 495 |
| **2005** | 44 | 22.8 | 39 | 22.7 | 72.4 | 38.4 | 36.9 | 73.3 | 34.2 | 50.1 | 39.3 | 101.3 | 447.8 |
| **2004** | 36.7 | 20.7 | 26.0 | 55.4 | 47.4 | 43.3 | 27.4 | 34.6 | 37.9 | 47.3 | 37.3 | 56.7 | 531.7 |
| **2003** | 113 | 16.3 | 1.7 | 31.6 | 93 | 6.23 | 2.3 | 11.8 | 21.3 | 91 | 25.9 | 27.1 | 497.1 |
| **Average values** | 44 | 32 | 36 | 38 | 65 | 50 | 25 | 30 | 36 | 68 | 43 | 45 | 512,14 |

*Source: AHMW*




**Picture 26. Return period of occurrence of the maximum rainfall with short duration at the measuring point Zajcev Rid.**

## Wind

In the Skopje valley the wind flows from the north and south quadrant are most frequent. Yet the orographic conditions have great impact on the wind paths.

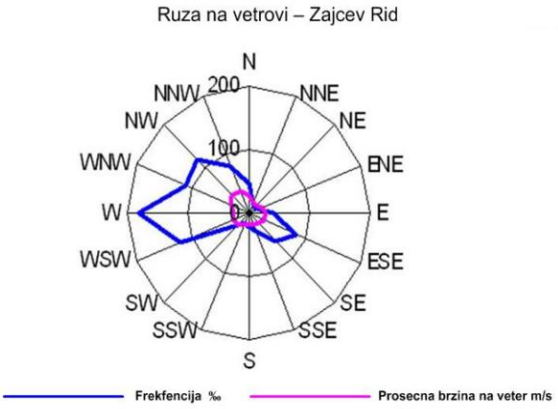
The average monthly and annual wind speeds in m/sec for the period 1971-2000 are presented in the Table below:

**Table 32. Average monthly and annual wind speeds m/sec**

| Monitoring Station | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Skopje – Petrovec | 1.2 | 1.6 | 1.8 | 1.8 | 1.6 | 1.6 | 1.7 | 1.5 | 1.4 | 1.2 | 1.1 | 1.1 | 1.5 |
| Skopje - Zajcev Rid | 2.2 | 2.7 | 2.9 | 2.9 | 2.7 | 2.7 | 2.7 | 2.7 | 2.6 | 2.3 | 2.4 | 2.3 | 2.6 |

In the area of Gazi Baba following winds are most common: Povardarec, Jugo, and wind from north-west direction.

The wind rose for MM Skopje–Zajcev rid indicate that the wind spead and direction are distributed on certain location.




**Picture 27. Wind Rose - Zajcev Rid**

In the open east part of the Skopje valley, the regime of the winds is quite different from the one in the city. Most presents are the north wind with an average of 142‰/year and middle year speed of 3,9 m/s. It is present during the whole year, but it appears to be most frequent in July-210‰, middle speed 4,6m/sec, and least frequent in May-109‰ and middle speed 1,8m/s. After the north wind, the most frequent is the wind from the north-east path with an average of 120‰/year and average speed of 3,3m/s. It is also present during the whole year, but most frequent is in March-154‰ and middle month speed of 3,1m/s, and least frequent in October and November with 95‰ and 98‰ with middle speed 3,3m/s.

In the east part of the valley for this period, the north wind has the highest average speed without considering the month-3,5m/s, than the north-east with 3,3m/s and the south-east with 1,8m/sec. The south-west, north-west and the west wind have a speed of 2,7 m/sec, and the south 2,2m/s. Considering the month, the highest speed of the wind is in February and March-4,6m/s. The winds in the Skopje valley have their distinct and their daily path. In the mornings, the west and north-west winds are dominating, while the south-east winds are quite rare.

## Insolation

According to the data presented in the below Table, for both monitoring stations in Skopje the maximum insolation hours are recorded in July and August, while on annual level more sunshine hours (2226,2) are recorded for Skopje–Zajcev Rid.

**Table 33. Average monthly and annual number of days expressed in hours**

| Station | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Skopje - Petrovec | 53,4 | 89,1 | 135,5 | 167,8 | 231,9 | 256,9 | 286,7 | 277,2 | 206,7 | 161,3 | 103,7 | 69,9 | 2013,1 |
| Skopje - Zajcev rid | 82,2 | 114,8 | 155,8 | 188,1 | 235,4 | 282,6 | 318,9 | 302,5 | 234,4 | 161,4 | 90,6 | 59,6 | 2226,2 |

### Fog

Fog appears mostly in the winter period, from October to March. On average, for the period 2010-2013, 15.5 days with fog are registered at the measurement point Skopje Zajcev rid, station Skopje –Petrovec, while 20 days at the monitoring station Skopje – Zajcev Rid. The number of days in months and annual sum are presented in the Table 5.10.

**Table 34. The number of days in months with fog and annual sum**

| Station Skopje-Zajcev Rid | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2013** | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 12 | 20 |
| **2012** | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 5 | 11 |
| **2011** | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 3 | 13 |
| **2010** | 1 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 4 | 7 | 18 |
| **Total** | 2,75 | 1,5 | 0,5 | 0,25 | 0 | 0 | 0 | 0 | 0,25 | 1 | 2,5 | 6,75 | 15,5 |

*Source: AHMW*

### Cloudiness

The records of average monthly and annual cloudiness for the monitoring station Skopje-Petrovec are given in the Table below.

**Table 35. Average monthly and annual cloudiness**

| Station | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Skopje -Petrovec | 6,5 | 5,8 | 5,6 | 5,5 | 5,1 | 4,0 | 3,1 | 2,9 | 3,7 | 4,7 | 6,1 | 6,7 | 5,0 |

## 6.6 Waste management

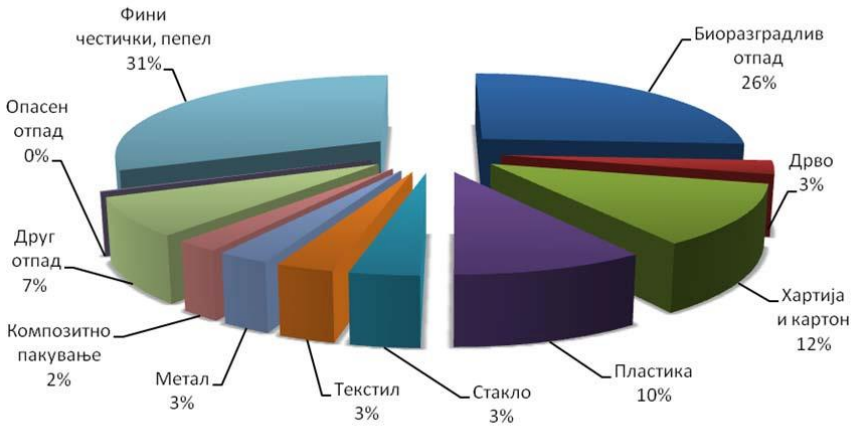
The waste management plan for the City of Skopje covers the period 2010-2015. It provides directions for waste management in line with the national legislation, recognizing the need for regional waste management and gradual reduction of waste quantities.

Communal waste refers to waste collected from households including waste from streets and parks, commercial – institutional sector and industrial waste with characteristics of communal waste. Hazardous waste from households is related to: batteries containing heavy metals and acid, medical leftovers, pesticides, etc. Waste services are provided by PU “Komunalna Higiena” Skopje.

**Table 36. Coverage rate for waste services collection, transport and landfilling),**

| | |
|---|---|
| Number of population | 506,926 |
| Number of population provided with the service | 448,697 |
| Number of population without services provided | 58,229 |
| Rate of coverage with the service [%] | 88,5% |

Municipal solid waste described above is a main stream of generated waste. The rate of different types of municipal waste is presented in the figure and it varies from 253 – 313 kg/p/y.




**Picture 28. Estimated quantities and composition of municipal waste in the region of Skopje 2009**

According to the PE "Communal Hygiene" on the territory of Skopje quantities of waste over the years shows increasing trend, namely in 2011 it was 133,068t, then in 2012 declined slightly and amounted to 128,850t. Total municipal waste in 2013 amounted to 133,271t compared to 2012 it increases for 3.43 %. The total amount of collected municipal waste and transported to the landfill Drisla declined by 3.17 %.

Collected waste quantity from municipality of Gazi Baba follows the increasing trend of the City of Skopje. The composition of waste collected in Gazi Baba is different in comparison to the city of Skopje, as it contains quantities of industrial waste from the industries. The average quantities of waste collected in Gazi Baba represent 12.53% of the total quantities of waste for the City of Skopje.

Estimated quantities of generated inert waste for Macedonia are around 230-250 kg/capita/y.

According to the National waste management plan (2006 – 2012), 26% of the generated waste is biodegradable, or the average production of this type per inhabitant is 53.71 kg/y.

From the data obtained from the A and B IPPC permits major industrial installations in the Municipality of Gazi Baba, the total amount of non-hazardous industrial waste generated is 150,830t/y, whereas the quantity of hazardous waste generated from installations around 5,435t/y.

Medical waste is incinerated at the Drisla landfill. According to available information 35% of the total hazardous medical waste is incinerated.

## 6.7 Air Quality

Ambient air pollution in the City originated from different types of sources, methodologicaly classified as stationary (point and surface), mobile and fugitive sources.

The table below (expressed in MW presents the stationary sources of pollution of the ambient air quality in the City of Skopje. It is more than obvious that diffuse sources of pollution are dominant pollutants of the air compared to the surface (collective) pollutants.

**Table 37. Installed Capacity of Stationary Sources of Ambient Air in Skopje**

| City | Collective (MW) | Point (MW) | Total (MW) |
|---|---|---|---|
| Skopje | 89.38 | 1298.95 | 1388.33 |

*Source: LEAP City of Skopje 2011*

According to data from the Cadaster of polluters and pollutants in Skopje there are 276 registered businesses (152 non-productive and 142 productive) emiting pollutants in the ambient air. According to the same source, the number of outlets or sources in these business entities is 698, with 234 surface and 464 point sources. It points that the number of outlets from power plants is almost double compared to outlets from industrial facilities.

### Air quality monitoring

Assesment of the ambient air quality in the territory of the Republic Macedonia for each pollutant is carried out within the zones and agglomerations established by a special bylaw , under which the municipality of Gazi Baba belongs to Skopje agglomeration. Under this Act, Skopje agglomeration consists of the City of Skopje or the municipalities within the boundaries of the city and the areas of the municipalities of Aracinovo, Zelenikovo, Ilinden, Petrovac, Sopiste, Studenicani and Cucer Sandevo.

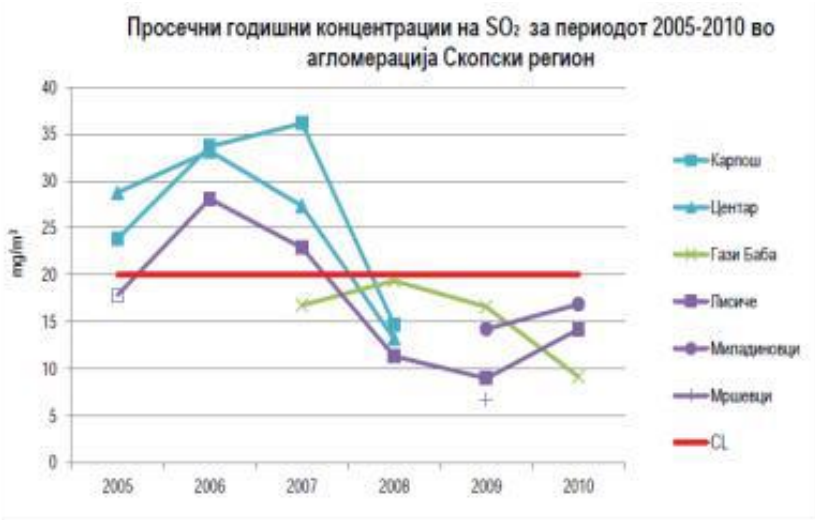
The monitoring is performed by the following public institutions:

- Ministry of environment and physical planning managing the State automatic system for air quality;
- Administration for Hydro-meteorological works and
- Institute for Public Health and Centre for public health in Skopje. The ministry of environment manages 15 monitoring stations.

### Baseline condition of the ambient air quality in the municipality of Gazi Baba

The review of the state of air quality in the municipality of Gazi Baba is based on data from the automatic monitoring station located in the municipality, which monitors the cumulative effect of all sources. They also provide the assessment report on the ambient air quality in the municipality. The station in Gazi Baba is located on a hill in the north-western part of the city, near the university campus.

In Zelezara area, north-west from the monitoring station, at distance of 2km, there is the steel factory, which is a main polluter of the air.




**Picture 29. Annual average concentrations in the period 2005-2010 for the $SO_2$ in the agglomerations**

A review of data from existing reports on the quality of ambient air from AMS Gazi Baba show a downward trend in average annual concentrations of $SO_2$ in the period 2008-2012 as shown in the following table:

**Table 38. Average annual concentrations of $SO_2$**

| Average annual concentrations of $SO_2$ (µg/m$^3$) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** |
| **AMC Gazi Baba** | / | / | / | / | / | 20 | 17 | 8 | 7 | 6 |

Monitoring results of the ambient air quality in 2014 for $SO_2$ shows that no exceedance of the MAC is registered. As for the $NO_2$, in the Skopje region (2002-2008) exceedance of the maximum allowable concentrations is registered at all stations. Biggest quantities of emissions of $NO_2$ are emitted from heat production industries (60%) and the share of the road traffic is 29%

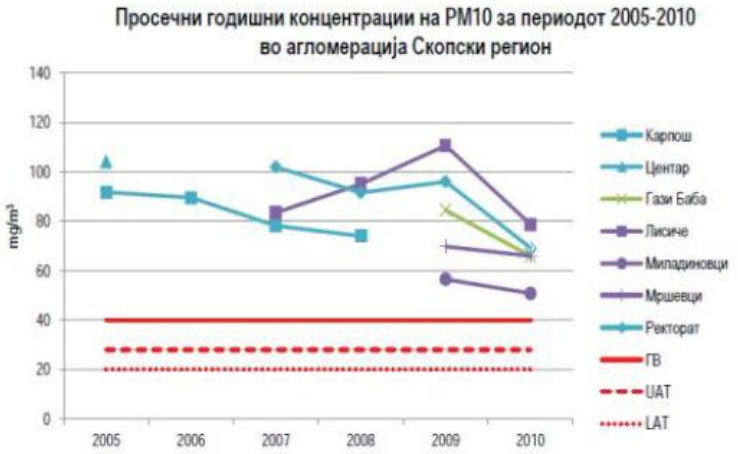

***Picture 30. Average annual concentration in the period 2005-2010 for NO2**

Average annual concentrations of $NO_2$ in the period 2012-2003 are presented in the annual reports from the AMS Gazi Baba.

**Table 39. Average annual concentrations of $NO_2$ in the period 2012-2003**

| Average annual concentration of $NO_2$ (µg/m$^3$) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Година** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** |
| **AMS Gazi Baba** | / | 43 | / | / | 23 | 27 | 16 | 22 | / | / |
| **Annual limit value** | | | | | 60 | 56 | 52 | 48 | 44 | 40 |

According to the measured concentrations for the period 2005-2010, the particulate matter (PM10) in Skopje agglomeration is shown in the following figure.




**Picture 31. Average annual concentration in the period 2005-2010 for $PM_{10}$ in Skopje, agglomeration**

The analysis of the measured concentrations compared to assessment thresholds are carried out against daily and annual average value. The measured levels of assessment thresholds for annual and daily limit value shows that the levels of upper threshold evaluation for the period 2005-2010 was exceeded at all measuring stations, including in Gazi Baba.

The highest percentage (50%) of emissions of particulate matter derives from combustion, construction activities, industrial processes, and transformation of energy. Furthermore, a significant proportion in the emissions derived from non-industrial combustion plants (24%) and production processes with 21% including emissions from motor vehicles and dust rises from unpaved surfaces and wood burning small-scale households.

Fluctuations are evident mostly due to changes in the operation of major industrial facilities in the country.

Data from measurements show exceeding of the annual limit value of 40 µg/m³ in all stations in Skopje agglomeration. During the calm cold winter days, the meteorological situation called inversion causes episodes of high concentrations of this pollutant.

In terms of annual average concentrations of particulate matter (PM10) in the period from 2003 to 2012 measured in Gazi Baba, the situation is shown in the following table.

**Table 40. Average annual concentration of PM10(µg/m$^3$)**

| Year | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| AMS Gazi Baba | / | / | / | / | / | / | 84 | 66 | / | 100 |
| Annual limit value | | | | | 60 | 54 | 47 | 40 | 40 | 40 |

Analysis of data from the reports on the work of AMC Gazi Baba showed great lack of data on measured values, yet the measured data explicitly show that exceedance of the allowable values and trend growth is evident. In relation to the past in 2013, the analysis of available data again indicates erratic operation of automatic monitoring station (out of function from September to December). Data for the remaining period (January-August) still show a total of 110 exceedences of 24-hour limit values (50 µg/m$^3$), versus total allowed number of 35 exceeding the allowable annual limit value for $PM_{10}$.

**Table 41. Measured exceedance per month AMS Gazi Baba**

| Measured exceedance per month AMS Gazi Baba | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 27 | 16 | 1 | 21 | 12 | 15 | 17 | 5 | / | / | / | / |

The results from the monitoring of the ambient air quality in the city of Skopje for 2014 - pollutant smoke show those only 4 samples exceed the limit values.

The average annual concentration of smoke in Skopje in 2014 is very low - 0,0085µg/m$^3$ and 5.8 times lower than the MAC=0,05µg/m$^3$. Compared to the measurement results for the period 2004-2013 is an evident trend of reducing the concentration of smoke in Skopje.

The center for Public health during 2014 measured the Pb concentrations. Results show that in 2014 none of the samples exceed the allowed value.

**Table 42. Pesults for the ambient air quality – pollutant aero-sediment**

| Public health centers | Number of measurement points | Number of samples | Average annual concentration (mg/m$^2$) | Min/max (mg/m$^2$) | Number of samples above the MAC* |
|---|---|---|---|---|---|
| Skopje | 30 | 357 | **177,2** | 12,8-862,9 | **57** |

*Source: Centar for public health*

Compared with the results from 2003-2013 the concentration for aero sediment decreases.

## 6.8 Noise

Level of noise is monitored by following institutions

- Central laboratory of MOEPP provide ad-hoc measurement upon request,
- The centre for Public Health and its regional branches.

Measurement of noise levels are not performed in the City of Skopje. Thus, data from the scientific investigations study for the effects on the population during exposure to noise in the City of Skopje prepared by the IPH.

The noise monitoring is conducted in the areas of II and III level of protection.

**Table 43. Values of indicators Lday and Lnight in areas with II degree of protection**

| Municipality | Measurement point | Lday dB(A) | Lnight dB(A) |
|---|---|---|---|
| Gorce Petrov | St Dauticaв | 54 | 44 |
| Aerodrom | st.abojmija 2 | 56 | 48 |
| Aerodrom | St..Kosta novakovic 48 | 58 | 51 |
| Aerodrom | st.Mite Bogoevski | 58 | 52 |
| Aerodrom | st. Vidoe Smilevski Bato 22 | 59 | 51 |
| Kisela voda | st.Hristo Tatarcev | 57 | 48 |
| Karpos | st.Dragisa Misovic | 58 | 50 |
| Gazi Baba | st. Karl Hron 86 | 53 | 37 |
| Gazi Baba | st. Karl Hron 26 | 48 | 36 |
| Average value ) | | **56 (±4)** | **46 (±7)** |

*Source: Institute of Public Health*

The results of the study show that the noise in residential areas are maintained within limits, but in mixed residential and business zones in the central area and beyond, where there is intense traffic, day and night noise levels exceed the limit values for 9-15dB(A). The analysis shows that the construction activities, transport, catering and shopping facilities and a number of people gathered in one place are the dominant sources.

Despite the mandatory obligation for preparation of noise strategic maps and noise action plan, they are still pending.

## 6.9 Flora and fauna

The primary vegetation in the wider area is Querco-Carpinetum orientalis, yet today it is almost completely destroyed. The same area is covered with anthropogenic plantations with large number of indigenous and non-indigenous woody species. According to the literature there are 109 known plant species including:

- Species that are on the CORINE list of Europe: Silene vulgaris (Moench) Garcke and
- Species of the Republic of Macedonia that have a limited expanse (up to five locations), and connect at the area of Gazi Baba: Amaranthus deflexus L., Convolvulus betonicifolius Miller, Foeniculum vulgare Miller and Rhagadiolus stellatus (L.) Gaertn

As for fungi in the area of Gazi Baba the total number is about 140 species. Most of the species were collected in the planted (anthropogenic) deciduous and coniferous forests, and a smaller part of meadow species. In the terms of taxonomic affiliation, there are mostly

representatives of the type Basidiomycota. Most of the recorded species belong to the *genus Amanita, Russula and Suillus. From lignicolous species, are mostly scavengers that develop on dry branches, stumps and fallen trees from various species of trees and shrubs. More than a dozen types can be used for human consumption. These are: meadow, forest and field champignon (Agaricus arvensis, A. campestris and A. silvicola); the "wood ear" (Auricularia auricula-judae); poplars (Agrocybe cylindracea); bloody milk cap (Lactarius sanguifluus); fairy ring champignon (Marasmius oreades); pored mushroom (Suillusgranulatus and S. fluryi); grey knight (Tricholoma terreum) and others. Poisonous species: Agaricus xanthodermus, Stropharia coronilla, Coprinus micaceus, Lepiota cristata and others. Rare species of special importance is the type Campanella caesia which is indigenous to Gazi Baba.

The fauna of invertebrates of Gazi Baba is poorly studied. Best explored are the day-time butterflies and very little data exists for locust. From butterflies there are 56 species registered, including no significant species. Among the more significant are Iphiclides podalirius, Papilio machaon and Vanessa Atalanta. From the straight winged insects there are 12 known species. In Gazi Baba there are no appropriate conditions for the development of significant populations of amphibians due to the absence of ponds and streams.

The fauna of reptiles is poor and there is only a handful of data. Gazi Baba distinguishes the following types of reptiles: Testudo hermanni, Cyrtodactylus kotschyi, Lacerta viridis, Podarcis erhardii and Coluber caspius. The most significant, from an international aspect is the presence of the hilly turtle, which is affected globally but widespread and common in Macedonia.

The fauna of birds is well studied, but also the richest. Registered presence of at least 87 species, but this number is probably higher. No globally affected species, but the presence of eight species concentrated in Europe and unfavorable conservation status (Stork - passer; Green Woodpecker; Forest Lark - winter guest; Wood Warbler - migratory; Woodchat Shrike, the Common Linnet and Corn Bunting). Several species such as (stork, peregrine falcon - passer, Syrian woodpecker, middle spotted woodpecker, forest lark, collared flycatcher - migratory and the Red-backed Shrike) are considered Emerald species.

The fauna of mammals is also poorly studied; the most important is the presence of at least four bat species, all included in Annex IV of the Habitats Directive (strictly protected species in the EU). The most important species is the squirrel. There is an expected presence of many species, especially of bats and rodents.

In the current territorial borders of the municipality of Gazi Baba are the localities Ostrovo Arboretum and Ezerce. The area of the localities Ezerce, Arboretum and Ostrovo represent an Integral environmental ecosystem, established at the confluence of the river Vardar at Trubarevo, Gazi Baba, Skopje. In order to protect its natural values, especially of biological diversity that are of significant importance for nature conservation they have been declared protected areas category III Natural Monument. The total area of the three sites in IEE Ostrovo-Trubarevo is 29ha of which the Ostrovo locality covers 20ha, Dendro-Park Arboretum occupies 3ha and Ezerce 6ha.Management of the protected area is entrusted to the forest research unit within the Faculty of forestry.

### Ostrovo

The locality Ostrovo is a relict of the former island which naturally was formed by the River Vardar, which in this area is separated into two flows and stepped Islands. Today, on this

terrain fossil beds are perseved on both sides of the river, but they are covered with humus layer and overgrown with grassy compound and shrub vegetation. Therefore, Ostovo is scientifically treated as s fossil Island of Vardar River. The area of the site is characterized with high ground water level.

**Picture 32. Protected area Ostrovo, wood vegetation**

At the locality there are two separate types of biotopes: grassland and arboreal type. Despite their artificial formation there is a process of natural renewal of dendro-flora. At the site in the ground floor there are grassland species, (Poaceae), and other floral elements.

On the site weed, and ruderal vegetation (aCM. Geranio-Sylibetum mariani) are covering the overall flora vegetation diversity in this area' Wood vegetation is presented with: black ash, elderberry, rosehip, elm, maple, acacia, populous alba populous nigra, Acer negundo, Salix alba, heath, white willow, and other hops.

Butterflies on the site have been poorly studied. In the summer (July-August 2008) Initial inventory of the fauna was made (Micevski, B, 2008). The research registered 10 butterfly species and two species of dragonflies. Other insects are common: great zhegach and 22 species of grasshoppers. From molluscs there are 3 types of land snails, of which one species is Balkan endemic. Herpetofauna (amphibians and reptiles) in the locality is represented by six species. The avifauna of the locality is represented by 55 species of birds that can be found throughout the year, but there are migratory birds (in spring, autumn and winter migration period). Mammals in the site are represented by 20 species of which 14 species are mammals' micro (lilaci potkovichari, nightgown, Evening) and 5 types of macro mammals (patterned marten, badger, wild cat, Slender, squirrel and hedgehog).

According to the international status of the species diversity, it is determined that the locality of Ostrovo has fauna species that are important for biodiversity in Macedonia and wider, European and global level. Namely, from 6 herpetofauna species status of protected species in European terms. In the Bern Convention annex II are four types; III in annex II of the same convention there two types, and from the list of CORINE biotopes are three types. From terofaunata the locality is inhabited by14 species of international importance, and in the world list of threatened wild species are 11 species, in annex II of the Bern Convention are three types, in annex III are 4 types, and in CORINE list 11 species. Namely, the status of threat or vulnerability 9 bat species and two species of mammals. From avifauna in the site are allocated 27 bird species of international importance. In Spec. Category 2 are 6 types, Spec. Category 3 are 10 species in spec. Category 4 are 9 species.

In 1976 Ostrovo was declared as a protected area in the category of Natural Monument due to its important educational value. As a concequence, the site Ostrovo is a protected area and construction constraits should be implemented in the vicinity as per the law on environment.

## Arboretum

Arboretum was established in 1953 by the Forestry Faculty. It is located in the alluvial plain of Skopje Valley, around the village Trubarevo and covers an area of 3 hectares. Actually arboretum is a continuation of the vegetation forming localities Ostrovo and the eastern side of locality Ezerce. In arboretum are planted woody species and shrub dendroflora and other indigenous species of all continents, especially in Europe, Asia and North America. The total number of wood and shrub species in Arboretum is about 600 species. The Dendro-park serves as environmental monitoring, scientific research of forest experimental station Trubarevo and instruction for students at Skopje Faculty of Forestry.

**Picture 33. Arboretum within the Faculty of Forestry, located near the future WWTP**

## Ezerce

The locality is characterized with significant environmental, educational and recreative values. It was declared as protected area in the category nature momentum. The locality Ezerce is under water throughout the year, while during summer the water sustains only at lower levels. The surface is humid throughout the year which is the reason for development of typical mud vegetation with domination of the reed. At the surface of the lake lemna is dominant. At the locality representatives from shrubs and wood vegetation species are present.

Dominant species are: white willow, brittle willow, white poplar, black poplar, elm, and encountered: heath, maple, acacia and elderberry.

**Lemna sp. Is dominant at the surface of the lake, while Typha latifolia is present at the underground layers**

**Marsh vegetation at the locality Ezerce**

**Picture 34. Ezerce locality**

According to the international status of the species diversity on the site, following groups were selected: 8 types of herpetofauna with status of protected species in European terms (Berne Convention Annex II there are 4 types, in attachment III 2 species in the bed sheets 3 types). From avifauna in the site are allocated 21 bird species of international importance: the Spec. Category 2 are 2 types, Spec. category 3 are 12 species in Spec. category 4 are 7 species; in favor of the EU Birds Directive 13 species of birds.

In the Bern Convention annex II there are 18 types and in annex III there are 3 types; in Appendix II of the Bonn Convention type 10 and 15 species in the CORINE list.

From terofaunata the site is allocated 14 species of international importance, and in the world list of threatened wild species are 11 species in Appendix II of the Bern Convention are 3 types in Annex III are 4 types, and in troughs list 11 species. The status of threat or vulnerability for 9 species of bats.

A database which includes a full list of types of project area (Trubarevo), has been made for the purpose of the EIA study in 2008. In this Study was treated in detail floristic diversity and the diversity of habitats.

## Fauna of the project area

### Fishes

**Table 44. Evaluation of fishes**

| SCIENTIFIC NAME | | LEGAL PROTECTION | | IUCN global category of threat | PREVALENCE |
|---|---|---|---|---|---|
| | | 92/43 | BERN | | |
| Pisces (Fishes) | | | | | |
| 1. | Eudontomyzon mariae | II | III | - | - |
| 2. | Anguilla anguilla | - | - | CR | - |
| 3. | Rhodeus meridionalis | II | - | - | r. Vardar |
| 4. | Gobio balcanicus | II | - | - | South I Balkan |
| 5. | Romanogobio elimeius | II | - | - | r. Vardar |
| 6. | Barbus balcanicus | II | III | - | Balkan |
| 7. | Barbus macedonicus | II | III | - | r. Vardar |

| | | | | | |
|---|---|---|---|---|---|
| 8. | Cyprinus carpio | - | - | VU | - |
| 9. | Cobitis vardarensis | II | III | - | r. Vardar |
| 10. | Sabanejewia balcanica | II | III | - | SI Balkan |
| 11. | Zingel balcanicus | II | II | - | r. Vardar |

Out of the total number of recorded 11 species of fish only two have the status of threatened species: Anguilla Anguilla and Cyprinus carpio (**IUCN global category of threat).**

The white barbel (Barbus macedonicus) and the Vardar ray-finned fish (Cobitis vardarensis), species are protected by law.

**Amphibians and reptiles**

**Table 45. Evaluation of amphibians and reptiles**

| SCIENTIFIC NAME | | LEGAL PROTECTION | | IUCN global category of threat | PREVALENCE |
|---|---|---|---|---|---|
| | | 92/43 | BERN | | |
| Amphibia (Amphibians) | | | | | |
| 1. | Triturus macedonicus | II/IV | II | - | SW Balkan |
| 2. | Triturus karelinii | II/IV | II | - | Balkan |
| 3. | Pelobates syriacus | IV | II | - | SE Balkan |
| 4. | Bufo viridis | IV | II | - | Central and SE Europe |
| 5. | Hyla arborea | IV | II | - | Euroasia |
| 6. | Rana dalmatina | IV | II | - | Europe |
| Reptilia (Reptiles) | | | | | |
| 1. | Testudo hermanni | II/IV | II | LR/nt | Mediterian |
| 2. | Testudo graeca | II/IV | II | VU | South Europe |
| 3. | Emys orbicularis | II/IV | II | LR/nt | Europe |
| 4. | Lacerta trilineata | IV | II | - | Balkan |
| 5. | Podarcis taurica | IV | II | - | SE Europe |
| 6. | Podarcis erhardii | IV | II | - | Balkan |
| 7. | Coluber caspius | IV | II | - | SE Europe |
| 8. | Elaphe quatuorlineata | II/IV | II | - | SE Europe |
| 9. | Natrix tessellata | IV | II | - | SE Europe |
| 10. | Vipera ammodytes | IV | II | - | Balkan |

The species Macedonian crested newt (Triturus macedonicus) and Balkan newt (Triturus karelinii) included in the list of Annex II, which means that these species are of interest to the community, whose preservation requires special declaration of conservation areas. Both types newts are regional endemic species vulnerable to extinction due to their small area of distribution which is limited to wetland ecosystems, disjunctively spread across certain parts of the Balkan Peninsula. These species are registered in the small marsh of Ezerce.

As for reptiles, within the test area there are 13 registered reptile species, of which ten species included in Annex II (strictly protected species).

Of amphibians and reptiles registered within the tested area, only the spur-thighed tortoise (Testudo graeca) is included in the list of species under global threat, the category VU (vulnerable species), while species hilly turtle (Testudo hermanni) and pond turtle (Emys orbicularis) are included in the category NT (near threatened species).

## Birds

**Table 46. Evaluation of birds**

| SCIENTIFIC NAME | | SPECs CATEGORY | LEGAL PROTECTION | | | IUCN global category of threat |
|---|---|---|---|---|---|---|
| | | | 79/409 | BERN | BON | |
| **Aves (Birds)** | | | | | | |
| 1. | Phalacrocorax pygmaeus | 1 | I | II | II | NT |
| 2. | Cosmerodius albus | - | I | II | II | - |
| 3. | Egretta garzetta | - | I | II | - | - |
| 4. | Nycticorax nycticorax | 3 | I | II | - | - |
| 5. | Botaurus stellaris | 3 | I | II | II | - |
| 6. | Ixobrychus minutus | 3 | I | II | II | - |
| 7. | Ciconia ciconia | 2 | I | II | II | - |
| 8. | Mergus albellus | 3 | I | II | II | - |
| 9. | Accipiter gentilis | - | - | II | II | - |
| 10. | Accipiter nisus | - | - | II | II | - |
| 11. | Accipiter brevipes | 2 | I | II | II | - |
| 12. | Buteo buteo | - | - | II | II | - |
| 13. | Circus aeruginosus | - | I | II | II | - |
| 14. | Circus cyaneus | 3 | I | II | II | - |
| 15. | Falco peregrinus | - | I | II | II | - |
| 16. | Falco subbuteo | - | - | II | II | - |
| 17. | Falco tinnunculus | 3 | - | II | II | - |
| 18. | Falco naumanni | 1 | I | II | I | VU |
| 19. | Charadrius dubius | - | - | II | II | - |
| 20. | Vanellus vanellus | 2 | II | III | II | - |
| 21. | Recurvirostra avosetta | - | I | II | II | - |
| 22. | Actitis hypoleucos | 3 | - | II | II | - |
| 23. | Bubo bubo | 3 | I | II | - | - |
| 24. | Asio otus | - | - | II | - | - |
| 25. | Otus scops | 2 | - | II | - | - |
| 26. | Athene noctua | 3 | - | II | - | - |
| 27. | Caprimulgus europaeus | 2 | I | II | - | - |
| 28. | Alcedo atthis | 3 | I | II | - | - |
| 29. | Merops apiaster | 3 | - | II | II | - |
| 30. | Coracias garrulus | 1 | I | II | II | EN |
| 31. | Upupa epops | 3 | - | II | - | - |
| 32. | Dendrocopos major | - | - | II | - | - |
| 33. | Dendrocopos medius | - | I | II | - | - |
| 34. | Dendrocopos minor | - | - | II | - | - |
| 35. | Picus viridis | 2 | - | II | - | - |
| 36. | Lullula arborea | 2 | I | III | - | - |
| 37. | Hirundo rustica | 3 | - | II | - | - |
| 38. | Delichon urbica | 3 | - | II | - | - |
| 39. | Riparia riparia | 3 | - | II | - | - |
| 40. | Anthus pratensis | - | - | II | - | - |
| 41. | Anthus campestris | 3 | I | II | - | - |
| 42. | Anthus spinoletta | - | - | II | - | - |
| 43. | Anthus trivialis | - | - | II | - | - |
| 44. | Motacilla alba | - | - | II | - | - |
| 45. | Motacilla flava | - | - | II | - | - |
| 46. | Motacilla cinerea | - | - | II | - | - |
| 47. | Lanius collurio | 3 | I | II | - | - |
| 48. | Lanius excubitor | 3 | - | II | - | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| 49. | Locustella luscinioides | - | - | II | II | - |
| 50. | Acrocephalus scirpaceus | - | - | II | II | - |
| 51. | Acrocephalus | - | - | II | II | - |
| 52. | Cettia cetti | - | - | II | II | - |
| 53. | Sylvia communis | - | - | II | II | - |
| 54. | Phylloscopus collybita | - | - | II | II | - |
| 55. | Phylloscopus sibilatrix | 2 | - | II | II | - |
| 56. | Muscicapa striata | 3 | - | II | II | - |
| 57. | Erithacus rubecula | - | - | II | II | - |
| 58. | Luscinia megarhynchos | - | - | II | II | - |
| 59. | Parus caeruleus | - | - | II | - | - |
| 60. | Parus palustris | 3 | - | II | - | - |
| 61. | Parus major | - | - | II | - | - |
| 62. | Troglodytes troglodytes | - | - | II | - | - |
| 63. | Miliaria calandra | 2 | - | III | - | - |
| 64. | Emberiza citrinella | - | - | II | - | - |
| 65. | Carduelis carduelis | - | - | II | - | - |
| 66. | Carduelis cannabina | 2 | - | II | - | - |
| 67. | Oriolus oriolus | - | - | II | - | - |

From Birds, registered within the examined area, the species pygmy cormorant (Phalacrocorax pygmaeus), European roller (Coracias garrulous) and lesser kestrel (Falco naumanni) are included in category SPEC 1 species under global threat. In the category SPEC 2 (group of species with unfavorable conservation status, whose global populations are concentrated in Europe) included 10 species of birds and 20 species belong to the category SPEC 3 (group of species with unfavorable conservation status. Whose global populations are not concentrated in Europe). In the IUCN Red List species under global threat (2007.), In the categories of species under threat involved the European roller (Coracias garrulous) in category EN (endangered species) and the lesser kestrel (Falco naumanni) in the category VU (vulnerable species) while the pygmy cormorant (Phalacrocorax pygmaeus) is included in the category NT (near threatened).

### Mammals

**Table 47. Evaluation of mammals**

| SCIENTIFIC NAME | | LEGAL PROTECTION | | | IUCN global category of threat | PREVALENCE |
|---|---|---|---|---|---|---|
| | | 92/43 | BERN | BON | | |
| Mammals (Mammals) | | | | | | |
| 1. | Rhinolophus ferrumequinum | II/IV | II | II | LR/nt | Ecozone paleoarktik |
| 2. | Rhinolophus hipposideros | II/IV | II | II | VU | Western paleoarktik |
| 3. | Myotis myotis | II/IV | II | II | LR/nt | Western paleoarktik |
| 4. | Eptesicus serotinus | IV | II | II | - | Paleoarktik |
| 5. | Nyctalus noctula | IV | II | II | - | Paleoarktik |
| 6. | Pipistrellus pipistrellus | IV | III | II | - | Paleoarktik |
| 7. | Pipistrellus nathusii | IV | II | II | - | Europe – Asian Turkey |
| 8. | Plecotus austriacus | IV | II | II | - | Paleoarktik |
| 9. | Miniopterus schreibersi | II/IV | II | II | LR/nt | Euroasia, Africa |
| 10. | Spalax leucodon | - | - | - | VU | South-east Europe |
| 11. | Vormela peregusna | - | II | - | VU | Euroasia |
| 12. | Lutra lutra | II/IV | II | - | NT | Paleoarktik |
| 13. | Felis silvestris | IV | II | - | - | Western paleoarktik |

Of the total number of registered mammals in the examined area, IUCN's Red List includes 3 types that are under global threat (IUCN 2007), The lesser horseshoe bat (Rhinolophus hipposideros), The lesser mole-rat (Spalax leucodon) The marbled polecat (Vormela peregusna), which are included in the category-VU (Vulnerable species).

The management of the integral ecosystem in Trubarevo is delegated to the forestry research unit within the faculy of forestry.

## 6.10 Landscape and visual effects

From a biogeographic standpoint, Macedonia is located in the zonobiom of the sub-Mediterranean Balkans forests (Matvejev, 1995).

According to the classification of the European landscapes, Macedonian zonobiom belongs to landscape types – Mediterranean open surfaces (Stanners and Bordeau 1995).

Therefore, concerning landscape in Skopje City as result of the action and interaction of natural and/or human factors (geological structure, relief structure, climate, hydrography, pedological composition), the city enrols among cities with specific landscapes. As protected landscapes in Skopje according IUCN (Category V), are: Katlanovo Wetland (faunal features), Rusica (dendrologic/forestry features; under IUCN Category IV, as dendrologic forestry features are Vodno and Kozle.

Landscapes and visual values were taken into consideration in this study as the WWTP will be constructed in Trubarevo – Municipality of Gazi Baba. The municipality spreads on the eastern part of Skopje valley, 65% of the total territory is fertile land, and the rest is highest areas. On fertile territory different crops are grown (wheat, ray, barley, corn) as well as gardening culture (peppers, tomatoes, onions, garlic, leek, potatoes, water melons etc).

On the territory of the municipality exists the forested area Park forest Gazi Baba which declared as characteristic landscape. The location Gazi Baba is unique of the type on the Balkan region and represents true green treasure. In the Gazi Baba forest, there are many wood types and bushes, and from the conifer types, most found is the black pine. Near this location on east the Zelezara, metal complex is located. The botanic garden within the Institute for Biology is also located in Gazi Baba municipality, and as well as Dendro-park of the Faculty for Agriculture and Forestry, Skopje, Arachinovo marsh (1 $km^2$, south from Arachinovo. With unique values for the bio-diversity, and the marsh ecosystems).

The proposed location of the WWTP is in Trubarevo settlement, which is the lowest part of Municipality Gazi Baba. Thus, landscape characteristics surrounding this part of Trubarevo include: meadows, un-fertile lands, water areas, roads and railway line pass near the location.

However, within this zone is the natural heritage Ostrovo, and outside is Arboretum as well as area considered as natural protected monument. No settlements exist within the boundary of the proposed sites. This area serves only for scientific and educational purposes.






**Picture 35. Site pictures**

## 6.11 Description of nature, cultural and historic heritage

Concerning natural conditions in the Republic of Macedonia, the country enrols among rare European countries with rich diversity of flora and fauna habitats, and great protected network. Thus, Macedonia covers 74 items of nature, with an area of 187,770ha, or 7.11% of the total surface area of the country. Republic of Macedonia also is rich in immovable cultural heritage of exceptional cultural, historical and artistic values, confirming the existence, the continuity and the identity of Macedonian people. According to official records kept in the national organization responsible for cultural heritage conservation and its local units, there are 11,200 immovable monuments of culture registered in the Republic of Macedonia. The latest Spatial Plan of the Republic of Macedonia provided a list of protected areas in the municipality.

Table 56 gives an overview of the protected areas concerning City of Skopje and the relevant locations of the proposed project. Hence, these areas are protected by Macedonian's laws and also under the City of Skopje.

**Table 48. Monuments of nature (IUCN category III) at the site location**

| no | Name | Region | Area (ha) | Protected | Descrition | Characteristics |
|---|---|---|---|---|---|---|
| 1. | Trubarevo | Skopje | 3.3 | 1965 | Arboretum | Dendrologic/forest characteristics |
| 2. | Ostrovo | Skopje | 20 | 1976 | Unique Bird settlemrnt in Skopje region | Faunal characteristics. |

*Source: Classification of the World Conservation Union (IUCN - Union of Conservation of Nature and Natural Resources)*

The following picture presents the ecosystem of Trubarevo including protected areas Ostrovo, Arboretum and Ezerce.


**Picture 36. Ecosystem Trubarevo with protected areas**

The municipality of Gazi Baba, has a quite impressive number of cultural and historical monuments. One of the oldest settlements in Macedonia and the Balkan region, is the Neolithic settlement Tumba Madzari (located between the settlements Madjari Cento), with the famous ceramic statue of the "Great Mother" and prehistoric cemeteries with urns near the Hippodrome.

Within the urban area of Gazi Baba, tthere are several churches: "St. Archangel Michael "(with the British and Serbian graves), the Turbe of Aslik Celebi 1572; Turbe of King K 'zi from XV century; archaeological sites, village Madzari and other. Anyhow, none of thies historical and cultural monuments are located near the project area.

## 6.12 Social and economic aspects

The city of Skopje is an administrative, economic, cultural and educational center of Republic of Macedonia. As a separate unit of the local self- government it consists of ten municipalities and they are as follows: Aerodrom, Butel, Gazi Baba, Gjorce Petrov, Karpos, Kisela Voda, Centar, Chair, Shuto Orizari and Saraj.

Skopje as a city represents a complex socio-demographic, spacious–physical, economic and ecological unity. The city as a whole, or some of its separate components, zones or areas are resulting from the overall socio-economic development as well as from the social relations, which have been established in a natural way. In such settings, the activities related to the quality of environment in Skopje and generally related to the quality of the life in the city are closely tied to the quality of the social elements of the environment.

According to official data from the State Statistical Office, the population living in the city of Skopje amounts to 506,926 inhabitants (distributed in 10 municipalities) with different ethnic backgrounds. The number of inhabitants, distributed by municipalities, as well as the ethnicity of the population is shown in the following table:

**Table 49. Population – distribution in line with the ethnic background**

| Ethnic background | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Municipality | Total | Macedonian | Albanians | Turks | Roma population | Aroman | Serbs | Bosnian | Other |
| Aerodrom | 72,009 | 64,391 | 1,014 | 430 | 580 | 501 | 3,085 | 538 | 1,470 |
| Butel | 36,154 | 22,506 | 9,107 | 1,304 | 561 | 120 | 1,033 | 970 | 553 |
| Gazi Baba | 72,617 | 53,497 | 12,502 | 606 | 2,082 | 236 | 2,097 | 710 | 887 |
| Gorce petrov | 41,634 | 35,455 | 1,597 | 368 | 1,249 | 109 | 1,730 | 489 | 637 |
| Karpos | 59,666 | 52,810 | 1,952 | 334 | 615 | 407 | 2,184 | 98 | 1,266 |
| Kisela voda | 57,236 | 52,478 | 250 | 460 | 716 | 647 | 1,426 | 425 | 834 |
| Center | 45,412 | 38,778 | 1,465 | 492 | 974 | 459 | 2,037 | 108 | 1,099 |
| Cair | 64,773 | 15,628 | 36,921 | 4,500 | 3,083 | 78 | 621 | 2,950 | 992 |
| Suto orizari | 22,017 | 1,438 | 6,675 | 56 | 13,342 | - | 67 | 177 | 262 |
| Saraj | 35,408 | 1,377 | 32,408 | 45 | 273 | - | 18 | 1,120 | 167 |
| Total | 506,926 | 338,358 (66,75%) | 103,891 (20,49%) | 8,595 (1,7%) | 23,475 (4,63%) | 2,557 (0,5%) | 14,298 (2,82%) | 7,585 (1,5%) | 8,167 (1,61%) |

According to the available data for Skopje region it can be stated that this region differs from the other regions in Macedonia with huge absolute population growth rate of 43%. The population density in Skopje region varies in different urban areas of the City. Population

density is 146 inh/ha, yet, in the central area population density is 455 inh/ha. The birth rate in Skopje Region is 14.2 promile, while the rate of natural growth in the Skopje region is 6.1 $\%_0$.

The age pyramid in the Skopje region show equal representation of both sexes. Their distribution by age groups is relatively equal to the age group over 55 years of age. In this and all subsequent age groups of female representation increased to reach nearly the double value in the age group over 80 years.

**Table 50. Population in Skopje region per sex, and five years age groups**

| **Skopje region** | | | |
|---|---|---|---|
| **Age** | **Total** | **Man** | **Woman** |
| **Total** | **617 646** | **304 192** | **313 454** |
| 0 | 8 126 | 4 229 | 3 897 |
| 1 - 4 | 31 686 | 16 428 | 15 258 |
| 5 - 9 | 37 045 | 19 003 | 18 042 |
| 10 - 14 | 36 290 | 18 587 | 17 703 |
| 15 - 19 | 36 941 | 19 019 | 17 922 |
| 20 - 24 | 41 199 | 21 097 | 20 102 |
| 25 - 29 | 44 473 | 22 398 | 22 075 |
| 30 - 34 | 47 990 | 23 769 | 24 221 |
| 35 - 39 | 48 277 | 24 027 | 24 250 |
| 40 - 44 | 45 322 | 22 517 | 22 805 |
| 45 - 49 | 42 808 | 21 242 | 21 566 |
| 50 - 54 | 38 774 | 19 169 | 19 605 |
| 55 -59 | 37 980 | 18 270 | 19 710 |
| 60 - 64 | 37 341 | 17 373 | 19 968 |
| 65 - 69 | 30 425 | 13 977 | 16 448 |
| 70 - 74 | 21 963 | 9 963 | 12 000 |
| 75 - 79 | 16 445 | 7 324 | 9 121 |
| 80 - 84 | 9 453 | 3 873 | 5 580 |
| 85 and more | 5 030 | 1 910 | 3 120 |
| Unknown age | 78 | 17 | 61 |

Regarding the type of households, almost 90 % of the households in the municipality represent the individual family households. In terms of the number of family members, household with 4 members are predominant, which is 1/3 of the total number of individual family households. The other categories (2 members with 3 members and 5 or more family members) accounted for 22-23% of the overall structure of the individual family.

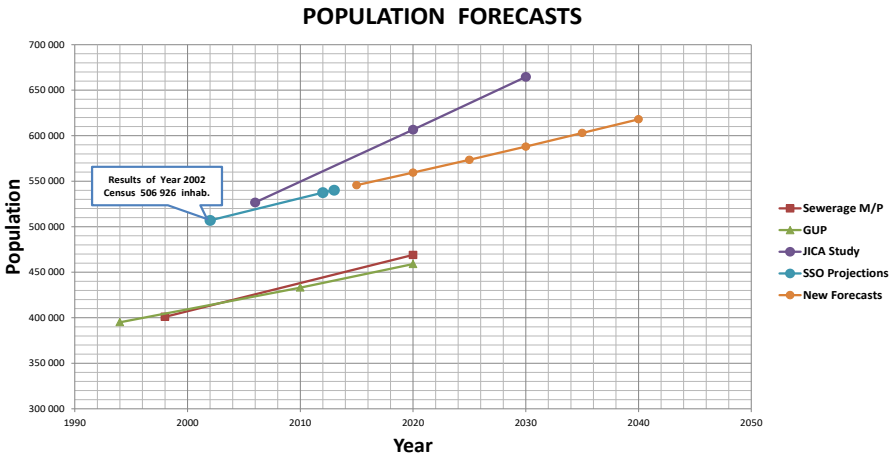
Detailed overview of the demographic characteristics of the municipality of Gazi Baba is given in the table below.

**Table 51. Demographic profile of Gazi Baba Municipality**

| Demographic profile of Gazi Baba Municipality | |
|---|---|
| Number of settlements | 26 |
| Area | 92 $km^2$ |
| Population number | 72.617 inhabitants |
| Population density | 789 inhabitants /$km^2$ |
| Population density in RM | 82 inhabitants /$km^2$ |
| Number of apartments | 22.815 |
| Number of households | 20.336 |
| Average number of members per household | 3,57 |

*Source: LEAP Gazi Baba 2013-2019*

Due to the lack of recent official census data the most suitable t way to address the issue of population growth, it is to follow the annual growth of population in the City of Skopje according to the State Statistical Office. The growth rate from 0.50% per year can be taken as optimum for the entire project period, given that according to the UN report major increase in population in the country in this period is not to be expected. By 2040, it is expected that the number of inhabitants increased to approximately 620,000 (30% of the country's population).




**Picture 37. Population Forecasts**

## Population covered with WWTP

According to the data from the PU Vodovod and Kanalizacija in the period 2009 – 2013, 96% of the population is covered with water supply services and 83% of the population is covered with wastewater collection services.

Number of population connected to the WWTP per municipality is as follows:

**Table 52. Population connected to the WWTP per municipality**

| No | Municipality | Percentage of population connected to sewerage system | Number of population connected to sewerage system, |
|---|---|---|---|
| 1 | Centar | 100% | 45 412 |
| 2 | Gazi Baba | 77% | 56 094 |
| 3 | Aerodrom | 92% | 66 409 |
| 4 | Cair | 100% | 64 773 |
| 5 | Kisela voda | 80% | 46 516 |
| 6 | Butel | 100% | 36 154 |
| 7 | Suto orizari | 94% | 20 577 |
| 8 | Karpos | 94% | 56 069 |
| 9 | Gorce Petrov | 75% | 31 226 |
| 10 | Saraj | 0% | 0 |
| **2002** | | 83% | **423 229** |
| **2012** | | 83% | **448 737** |
| **2013 with Sopiste** | | 83% | **450 976** |

It is expected that 83% of the population will be connected to the WWTP up to 2045, assuming that the envisaged extension of the wastewater collection network will be provided.

## Migration trend

The highest rate of total immigrants was recorded in the municipality of Aerodrom, which also has the highest rate of total emigrants. In 2015 ithe number of imigrants in the City of Skopje amounts to 2658 and the number of emigrants is 1786. Regarding the municipality of Gazi Baba the number of imigrants is 254 and emigrants 263.

## Economic context

## General trends

Most of the industrial, commercial and service facilities are located in Skopje region. According to the data provided from the State statistical office, out of 6805 newly established enterprises in 2013 at national level, 2489 are located in Skopje region (6.1%)

Also the number of active business entities in the country in 2014 was 70 659. The data on the structure of active business entities by regions shows that the highest share belongs to Skopje Region with 38.0% ie 26 848 active business entities.

The municipality of Gazi Baba has a biggest concentration of large Industrial companies at state level. More than 5.066 bussines entities are registered according to the central Registar of RM. The number of the active Active companies on municipal level is 2.986, or municipality of Gazi Baba participate with 4.1% in the total number of active business entities. The micro bussines entities dominate in with 67%. Most important industries are: metal processing, metallurgy, food processing, production of non-alcoholic drinks and bear, etc. As a biggest industrial zone in the City of Skopje and RM it generates 1/3 of the GDP in the Country.

In terms of number of companies in their activity, most of the companies are dealing with wholesale and retail trade and repair of motor vehicles (38%) followed by the manufacturing industry with 13% of the Municipality, as well as transport and storage with 14%.

## Economic state of households in the project location

The economic indicators are a necessary precondition for general conception of the effective policy and future development activities, which in its essence must respect the principles of sustainability. Economic assessment is presented with the gross domestic product and labor / employment.

**Table 53. Current GDP per person for 2010, 2011, 2012**

| Year | 2010 | 2011 | 2012 |
|---|---|---|---|
| RM | 212 795 | 225 493 | 226 440 |
| Skopje region | 308 467 | 319 717 | 327 989 |

*Source: State Statistical office, region in Macedonia, 2015*

In the municipality of Gazi Baba, 34% of the population over 15 years is employed, out of which 60% are male and 40% are female. Within the structure of active employees most dominant are people over 40 years with 53-56% employment rate. Followed by the most influential age group 25-39 years, with 40% of the representatives employed. Lastly the youngest age group 15-24 years with 7% of the representatives employed.

Among the employed, commerce employes 17%, followed by mining and construction occupations with 16% of the employed, 15% technicians, occupations related to handling machines and plants with 13%, 12% public servants, then elementary occupations 11%. In the municipality, experts and scientists are represented by 9%.

Industrial employment covers, the manufacturing industry with 26%, followed by trade with 16%, transport and communications with 10%, public administration and defense with 9%, construction 8% health by 7% and Education 6%, real estate and business activities 4%, communal, cultural and other service activities also 4%, financial intermediation 2% and Electricity, gas and water by 2%. The percentage of employees in the industry of the municipality is equally reflected at the level of the City of Skopje and nationally.

Data related to average household iincome are still pending on national level. This data usually derived from approximate indicators. In this regard the average household income for most of the families is in the range of 14,000-35,000 denars/month.

Data for available incomes should take into account the level of gray economy as a common alternative used for generation income or additional income. According to the pilot research

for the household income covering 403 families from the City of Skopje, following results were obtained.

**Table 54. Income per family**

| Income group (mkd/month/family) | Number of families | % of total number |
|---|---|---|
| up to 8,000 | 57 | 14.1% |
| 8,001-14,000 | 76 | 18.9% |
| 14,001-18,000 | 66 | 16.4% |
| 18,001-24,000 | 81 | 20.1% |
| 24,001-35,000 | 58 | 14.4% |
| 35,001-50,000 | 32 | 7.9% |
| over 50,000 | 16 | 4.0% |
| did not answer | 17 | 4.2% |
| Total | 403 | 100.0% |

## Agriculture and irrigation

**Table 55. Census (2007)**

| | Number of individual agricultural household | Total available area ha | Total used area | Own land | Taken as rent | Rented to others |
|---|---|---|---|---|---|---|
| RM | 192378 | 321813.70 | 264338.58 | 222819.95 | 46720.93 | 5202.29 |
| Skopje region | 19065 | 25297.03 | 21289.01 | 17771.01 | 3787.99 | 269.9 |
| Skopje | 9148 | 9392.71 | 7932.23 | 6904.42 | 1126.63 | 98.82 |
| Aerodrom | 724 | 556.95 | 489.73 | 449.91 | 47.86 | 8.04 |
| Butel | 1056 | 1510.81 | 1352.79 | 1010.51 | 349.05 | 6.78 |
| Gazi Baba | 2370 | 2942.00 | 2370.81 | 2065.70 | 342.02 | 36.9 |
| Gorce Petrov | 921 | 530.45 | 404.58 | 379.98 | 41.37 | 16.77 |
| Karpos | 555 | 541.82 | 486.15 | 353.69 | 133.20 | 0.75 |
| Kisela voda | 1018 | 683.44 | 625.44 | 565.36 | 77.44 | 17.37 |
| Saraj | 2238 | 2321.40 | 1933.62 | 1866.24 | 70.09 | 2.71 |
| Centar | 28 | 20.66 | 13.27 | 11.26 | 2.56 | 0.55 |
| Cair | 25 | 36.61 | 35.49 | 30.57 | 8.00 | 3.08 |
| Suto orizari | 213 | 248.58 | 220.37 | 171.19 | 55.03 | 5.85 |

Due to the construction of the WWTP, 9148 individual agricultural users will benefit from the improved water quality for irrigation.

The table below provides data on categories of used agricyltural land in Skopje region.

**Table 56. Categories of used agricultural land in Skopje region**

| | Total | Cultivate land, gardens | Meadows | Pastures | Orchards | Vineyards | Nurseries |
|---|---|---|---|---|---|---|---|
| RM | 264338.58 | 190725.88 | 31557.41 | 15402.47 | 9418.51 | 17160.42 | 73.90 |
| Skopje region | 21289.01 | 17231.66 | 2215.06 | 601.94 | 438.70 | 795.84 | 5.82 |
| City of Skopje | 7932.23 | 6828.17 | 350.60 | 110.96 | 210.00 | 431.38 | 1.12 |

## Land ownership

The available land for the WWTP consists of several cadaster plots generally owned by RM, only one plot is a private property with an area of 0.53 ha, whilst 6.70 ha are under concession.

If necessary, the private property could be expropriated following the legally binding procedure.

## Public services and amenities in the project location

## Health care and health issues

Although there are no data directly connecting the quality of environment and public health, the occurrence and the number of diseases in the City of Skopje, clearly indicate air pollution and water pollution pose threat to the human health.

Most common infective deseases realted to water pollution are: acute infective intestinal desease, hepatit A, enterocollit, infections caused by E.Colli, other bacterial alimented intoxications, salmonellosis, etc.

Health protection in the City of Skopje is organized at three levels: primary, secondary and tertiary, both in public and private organizations. Besides, there are other existing forms within primary protection related to public health such as: 20 counseling centers for pre-school children (84 RM); 16 dispensaries for children of school age from 7-19 years (63 PM); 1 family planning counseling center (25 RM).

Secondary protection is more specialized form of public health protection. The same is organized in medical centers including polyclinics and general hospitals. In the City of Skopje there is one specialized hospital, one Institute for Public healt and three centers for rehabilitation.

Tertial level of health protection is done in Skopje, as for this type of treatment request specialized doctors and special institutions. This level of protection is realized in 48 health institutions (clinics and institutes).

In the municipality of Gazi Baba there is one private hospital, one polyclinic and one public health institution.

### Social protection

Social protection in Macedonia is still centralized function which is implemented through inter-municipal centers for social protection. In 2014 at state level are registered 37,083 adult recipients of social assistance, out of which the city of Skopje has the highest number of

users of social support-14223 persons. The largest share goes to people with physical disabilities wich makes this category of users (8741 persons) the most numerous.

## Education

The largest number of educational and pedagogical institutions in the country is located in the City of Skopje. According to available data, there are 59 kindergadens and 13 specialized schools.

Public and private education is organized at all levels (primary, secondary, undergraduate, postgraduate studies). Primary and secondary education is compulsory. In the City of Skopje there are 101 primary schools out of which 15 are located in Gazi Baba. Out of 31 secondary schools in Skopje 6 are located in Gazi Baba. Primary and secundary education is mandatory.

Higher education is provided at the State University "St. Cyril and Methodius", and other four private universities. Macedonian Academy of Sciences and Arts is the highest scientific and research institution in the country. The educational network is complemented with the functioning of the National University Library "St. Kliment Ohridski" and the city library, Youth Cultural Center - Karposh Cultural and Information Center -KIC.

## Road network and traffic conditions

Skopje is the main traffic node whereas railway and air traffic traverses. Regarding traffic circulation, there are problems with the frequent traffic congestions in the city, which are occurring especially at the crossroads. The undone primary traffic network in the city has been a problem as well as it is the partial realization of the fast main roads. The nonexistence of main roads and condensing roads is also a problem which bears a key significance pertaining to the connection of the western to the central part of the city and certain localities in the southern industrial zone, as well as there is lack of an alternative. The length of the planned traffic network is 267.92km (GUP 2002 yaer).

Public transportation is organized in terms of distance such as long distance, suburban, urban and taxi transportation of travelers. Buses are the major means of transportation. The network comprises 27 urban lines and 25 suburban lines. The primary traffic network in Municipality of Gazi Baba has been categorized in to two categories: main streets (with speed limit of 60 km/h) and condensing streets. The primary street network in Municipality of Gazi Baba is adjoining the primary network of Skopje City as well as the exterior road network Republic wide. The local road network is covering almost all populated areas. Exempting some rural areas, the road network generally consists of quality build asphalt paved roads.

## Local self-government

A multifaceted one-level system of local self-government is functioning in the city of Skopje, represented by two equal types of local self-government units: the city and the municipalities.

The City Committee of Urbanism, Communal-Housing Affairs, Traffic and Environment is divided into six organizational units/departments and accordingly it is accountable for these matters.

Local self-government units (the municipalities) are in charge of the protective and preventive measures regarding water pollution, air pollution, soil pollution, protection of the Nature’s Heritage, noise and nonionic radiation protection, as well as they have

competences regarding communal sphere, urban and rural planning and other areas related to the Environment and nature. Municipality's Council is the highest decision making body. Principal Act of the municipality is the Statute, which determines the working bodies and decision making procedures related to all issues of citizen's concern.

# 7 DESCRIPTION OF THE POSSIBLE ENVIRONMENTAL IMPACTS AND APPROPRIATE MITIGATION MEASURES

The EIA regulation stipulates that all environmental impacts should be identified and assessed, for all environmental media and all project stages. Effects are further evaluated in regard to the standards and legislation (wherever possible), otherwise the assessment will be based on the established quantitative and qualitative analysis and expert judgement.

Generally, the implementation of the project for construction of the WWTP, including the on-site processing of sludge is characterized with significant positive effects, related to:

- Improvement of the Vardar River quality, thus enabling its reuse for irrigation, better conditions for aquatic flora and fauna and minimization of the health risks related to water with substandard quality.

Sludge processing will provide following positive effects related to:

- Postive effects on environment trough reduction of the quantities of disposed waste by incineration of sludge;
- Postive effect on reduction of greenhouse gasses (methane) by sludge digestion and use of generated methane for production of heat and electricity;
- Postive visual effects, without on site storage of disposed waste.

However, despite positive (regional) aspects, (local) negative implication from the projects should be dully considered.

Assesment is based on normal working conditions, in case of extraordinary conditions, in case of accidents with assessment of risk and area of potential influence.

Measures proposed for reduction of impacts are effective only if the same are implemented and if upon implementation are periodically monitored to assure that that the results are providing the desirable effects.

Environmental impacts expected from the project for construction of WWTP in the City of Skopje are related to impacts on:

- Surface and ground water
- Soil and geology
- Air
- Waste generated
- Odour
- Biological diversity
- Population

Eventual changes because of the project implementation are based on the analysied current state of the environment.

**The impact assessment is based on the following steps:**

- Description and characterization of the state of the environment–receptor of impacts;
- Assessment of environmental changes (imacts resulting with project implementation);
- Determination of the impact significance;
- Providing preventive measures and/or control measures.

Determining the significance of impacts is a function of the sensitivity of the receptor and the magnitude of the impact.

Thus, the assessment is related to:

- Determing the sensitivity of the receptor and magnitude of impact;
- Determing the significance;
- Cumulative impact;
- Transboundary impact.

Sensitivity of receptor/environmental component is valued as very high, heigh, medium, low and negligible depending on the significance (inernational, national, regional, local).

Magnitude can be:

- Heigh related to the loss of quality/quantity of resources (negative) or high level of improvement (positive).
- Medium related to partial damages of key elements and characteristics or improvement of the quality.
- Low related to measurable changes of elements and characteristics.
- Negligible related with very small losses or adverse changes.

The matrix for assessment of the impact significance as function of receptor sensitivity and magnitude is used for valuation of the impacts.

| **Magnitude of imact** | **Impact significance** | | |
|---|---|---|---|
| Heigh | Moderate | Moderate or heigh | Heigh |
| Medium | Low /moderate | Moderate | moderate / heigh |
| Low | Low | Moderate | Moderate |
| Negligible | Low/no impact | Low or moderate | Low or moderate |
| Sensitivity of the receptor | LOW | MEDIUM | HEIGH |

Determination of the impact significance is a result of the analysis of parameters that are limited with legislation related to environmental emissions and current emission levels. In case if the legislation is pending, expert judgement is use.

Categories of significant impact in terms of decision-making.

- Heigh impact significance: negative impacts of national regional significance. Measures for improvement are mandatory;
- Moderate significance of the impact related to positive/negative impacts –not crucial for decion making, yet on the other hand cumulative effects may influence the desion making if overall negative impact on a particular resource is detected;

- Low impact significance: positive/negative impacts of local character that has no influence on decision making;
- No impact: impacts within the frame of normal limit values of variation.

## 7.1 Surface and ground water

### Construction phase

Source of emissions as a result of:

- Removal of the vegetation and humus layer;
- Excavation, soil handling;
- Construction of structures and facilities of the WWTP;
- Flood protection structures;
- Handling of construction material and waste at the location;
- Rinsing the location after heavy rain;
- Storage of fuels, chemicals and waste;
- Uncontrolled leakage of fuel, oils from construction vehicles and machinery and other dangerous substances used during construction phase such as: lubricants, paints, solvents etc.

Impact on quality of surface and groundwater may occur in the following cases: improper management of waste water that will be generated by workers involved in construction activities; inadequate management of excavated material, temporary disposed on the construction site or near the shore line of Vardar River, that can be rinsed by heavy rains or dispersed by wind causing deposition of sediments in the river.

### Operational phase

Following impacts on surface and ground water are expected during the operational phase:

- Possible incidents caused by improper maintenance of the syphon connecting the left and right collector, and possible defects of certain WWTP units resulting with discharge of effluent with inappropriate quality in the recipient;
- Uncontrolled spilling of liquids, i.e. foul water, oils and lubricants;
- Inappropriate treatment and handling of excess sludge generated, inadequate management and storage of chemicals, oils, and improper management of waste that will be generated as a result of the operation of the WWTP and incinerator.

**Note:** Selected measures are in line with the following low and appropriate by lows.

- Law on Waters ("O.G." no. 87/08, 6/09, 161/09, 83/10, 51/11, 44/12, 23/13, 163/13 and 180/14);
- Rulebook on the requirements for collection, disposal and treatment, the manner and conditions for design, construction and exploitation of systems and plants for purification of urban waste waters, as well as technical standards, parameters standards and emission standards for quality of pre-treatment, disposal and purification of waste waters, taking into account the load and the method of treatment of urban waste waters discharged into sensitive Fields of discharge of urban waste water (O.G. No. 73/11);

- Rulebook on the conditions, manner and emission limit values for discharges of wastewater in their treatment, the method of their calculation, taking into account the specific requirements for the protection of the protection zones ("O.G." no. 81/11);
- Rulebook on the methodology, reference measurement methods, manner and parameters for monitoring of wastewater, including sewage sludge from the treatment of urban waste water ("O.G." no. 108/11);

| SURFACE AND GROUND WATER | |
|---|---|
| IMPACTS | MITIGATION MEASURES |
| CONSTRUCTION PHASE | |
| NOTE: The Contractor is obliged, and will submit Environmental Management Plan (EMP) during the construction phase, subject to approval of the Engineer. | |
| Disturbance of groundwater level as a result of excavation works; | Safe drainage and evacuation of the pumped groundwater, in order to avoid possible suffusion phenomena; |
| Modifications of surface water flow sections through:<br>■ soil wash and rocks displacing into the surface water body<br>■ stability degradation of surface water body banks because of placement or operation of construction equipment in the area | Timing of construction activities and avoidance of the execution works under aggressive weather conditions (rains, strong winds);<br>■ Construction works for stream and river crossings during low-flow periods;<br>■ Use of special construction techniques in areas of steep slopes, exposed to erosion phenomena; also, in the areas of stream crossings; |
| Pollution of surface water body through the runoff of sediment - in the case of erosion or of landslides | ■ Avoidance of performing the construction works simultaneously on both river banks;<br>■ Avoidance of creating excessive slopes in the vicinity of river banks;<br>■ Measures for protection against erosion, corresponding to the characteristics of the working area;<br>■ limitation of the excavations size within the 100-year floodway of the surface water bodies. |
| Pollution of Vardar river due to discharge of communal, sanitary and wastewater from cleaning the equipment and machinery, and pollution of surface water bodies by rain water runoff from construction yard and/or working site | ■ Wastewater generated on the site must not be discharged in water bodies or channels, located near the project site. Mobile toilets will be placed on the site. They will be regulary managed and controlled by an athorized company. Mobile toilets should be placed at the distance greater than 100m from the drainage infrastructure or surface water body ;<br>■ Euipment and vehicles used during construction shall be cleaned outside of building site, or on site, upon particular approval of handling of produced foul waters. |
| Pollution of surface water bodies through rain water runoff from construction yard and/or working site, in case of inappropriate facilities for storage of construction materials, hazardous substances, fuel, lubricants and waste. | ■ Procedures for the storage and handling construction materials, hazardous substances, fuel, lubricants and waste;<br>■ Storage fuels, lubricants and chemicals in proper storage facilities (restricted access, sealed packages);<br>■ Tanks for fuel storages leak-proofed and installed on impermeable surface; in the case of incidental spills collecting recipients, absorbent material and fire fighting equipment shall be provided;<br>■ Covering construction material stockpiles (with tarpaulin or similar). |
| Groundwater pollution through the infiltration of accidental spills (e.g. fuel and lubricants, hazardous substances) because of improper storage facilities, refuelling operations or handling operations. | ■ Storage of fuels, lubricants and chemicals in proper storage facilities (restricted access, sealed packages);<br>■ Procedures for storage and handling of the construction materials, hazardous substances, fuels;<br>■ Fuelling of the vehicles and equipment at workshops/sites with adequate leakage prevention (e.g. impermeable surface, settlers and oil separator);<br>■ Emergency procedures and contingency plans for accidents, breakdowns, spills, etc.; |

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| Wastage of drinking water resources. | ■ Use of low quality water for sprinkling for dust prevention at the construction yard and work sites. |
| Accidental spills of machine oils | ■ Designation of area allocated for small repairs on the equipment with adequate reservoir for woked out oils;<br>■ Regular servicing and maintenance of the machinery to be used during construction activities, (implemented off site by the contracted, authorized service provider)<br>■ Vehicles and mobile machinery should be parked on waterproof base whenever out of opreation;<br>■ In case of accidental leakage, collection containers should be provided as well as absorption material and fire equipment |
| Improper storage and handling of dangerous substances or waste with dangerous/hazardous characteristics. | ■ Substances and waste, which possess hazardous characteristics should be stored in properly labeled containers that will prevent their leakage. They should be protected from rinsing and stored on a waterproof base.<br>■ Generated hazardous waste will be handed over to the authorized company that holds a license for collection and transportation of hazardous waste<br>■ Following procedures for the storage and handling construction materials, hazardous substances, fuel, lubricants and waste;<br>■ Application of measures stipulated in the:Soil management plan, waste management plan, plan for management of dangerous substances and control of leakage, Emergency plan |
| Water pollution as a result of collector pipe breaks, improper maintenance of the syphon (clodging) and in case of defects of certain units of the WWTP. | ■ Regular inspection, timely detection of any faults and mistakes and taking appropriate remedial measures;<br>■ Plan for emergencies and incidental damage to structures, platforms, pipes, etc. |
| Servicing and washing vehicles | ■ Servicing and washing vehicles is performed regularly at locations designated for this purpose provided with waterproof base and a system of channels to collect waste water. Servicing and washing vehicles is recommended to be done off-site. |
| Groundwater pollution through infiltration of leakages as a result of damage occurrence of civil structures, platforms, pipes etc., which are located at the site of the WWTP | ■ Regular inspections in order to timely detect any failures, and take appropriate remedial action;<br>■ An emergency plan for accidental pollution events and damages on civil structures, platforms, pipes;<br>■ Compliance with construction requirements for sludge storage location, and those related to water impermeable basis;<br>■ A monitoring programme for groundwater (water table) in the WWTP area; generally it is recommended to have at least two monitoring wells, placed up and downstream the WWTP location, considering water movement direction of groundwater. |
| OPERATIONAL PHASE | |
| In the case of new WWTP in service for a new residential area/agglomeration, the effluent discharge is a source of pollutants for the receiving water body. | ■ Selected apropriate wastewater treatment process providing natural regeneration capacity of surface water. |

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|---|---|
| Pollution of receiving water body because of waste water treatment failure, which can be caused by:<br>■ Increased loads of pollutants in WWTP influent through exceeded polluted waste water from industrial users, commercial users and other users non-domestic waste water);<br>■ Malfunctioning of WWTP because of failure of electric supply, failure of electrical and mechanical equipment, improper operation of WWTP equipment. | Assessment on the reducing measures, for discharges from industry, commercial users, etc. into waste water collecting system connected to the WWTP. The framework of these activities should be included in an action plan that will establish the measures for limiting the potential negative impact on the WWTP treatment process. The main measures recommended to be included in the action plan will refer to:<br>■ Full inventory (quantitative and qualitative) of industrial effluents as well as drainage systems that should be accompanied with suspiciousness of identified potential pollution, as well as where polluting episodes were recorded, by a sampling and analysis campaign;<br>■ Where the above mentioned effluent inventory indicates a risk that the limit values of waste water parameters could not be met (or could not be met at all times), special conditions have to be applied by the WWTP operator to the industrial companies (compliance with the discharge limit values in the sewerage system);<br>■ Developing and implementing of emergency response programme for the wwtp operation, which will address issues such as: emergency backup power; operational monitoring programme and procedures for WWTP operation;<br>■ Inspection and control programme implementation by the Inspectorate to industrial companies (e.g. pre-treatment facilities, the need of upgrading pre-treatment facilities, waste water flows metering, self monitoring), according to approved adjustment plan, if any;<br>■ Emergency plan for accidental pollution events on industrial companies locations. |
| Water discharges from the cleaning of flue gases from the inceneration process | ■ During operational phase all generated wastewater will be discharged to the WWTP providing that all discharged parametars are in compliance with the Rulebook on emission limit values during waste incineration and combustion processes, conditions and manner of work for instalations for incineration and combustion. (Of.Gazzete no.123/09). |
| Groundwater pollution through infiltration of leakages as a result of damage occurrence of civil structures, platforms, pipes etc., which are located at the site of the WWTP | ■ Regular inspections in order to timely detect any failures, and take appropriate remedial action;<br>■ An emergency plan for accidental pollution events and damages on civil structures, platforms, pipes;<br>■ Compliance with construction requirements for sludge storage location, and those related to water impermeable basis; and ground water monitoring plan.<br>■ A monitoring programme for groundwater (water table) in the WWTP area; generally it is recommended to have at least two monitoring wells, placed up and downstream the WWTP location, considering water movement |
| Residuals | ■ Under normal operating conditions, if all the measures are implemented residual impacts are not expected. |

## 7.2 Soil and geology

Generally, established construction zones and construction activities may affect the soil quality as well as surface and groundwater quality only in case of incidents and improper management and handling of materials and equipment.

During the preparatory work minimal negative impact is expected as a result of removal of the humus layer and leveling of the the ground provided for construction of the structures and facilities of the WWTP. Material from the excavation will be reused to raise the plateau of the station app 90000m$^3$.

Negative impacts are expected in the construction phase as a product of operational equipment. Given the presence of construction machinery, machines and other equipment on site, possibilities for spills of oil and oil derivatives increased resulting in their infiltration into the soil and groundwater.

These impacts are moderate and limited during construction.

In extraordinary circumstances, spillage of hydraulic oil may be expected. In such case the top layer of the contaminated land will be removed and transported to the designated site for this type of material.

Generally, established construction zones and construction activities may affect the soil quality as well as surface and groundwater quality only in case of incidents and improper management and handling of materials and equipment.

### Construction phase

Construction activities can disturb the geological characteristics of the soil and cause degradation and erosion of soil and rocks/sediments.

Possible negative impacts on soil and geology of the project area as a result of activities in the construction phase are:

- Degradation of soil due to the removal of the topsoil;
- Temporary change of land use;
- Temporary soil erosion due to excavation of sites for the WWTP near unstable surfaces;
- Soil compaction, and thus reduced capacity for infiltration of precipitation;
- Erosion due to the removal of vegetation, earthworks and the use of heavy machinery during construction activities in or near the riverbed of Vardar;
- Soil pollution by accidental spills of fuels, oils and chemicals (eg, lubricants, paints, solvents, resins, acids, etc.), as well as accidental spills in the process of refueling and oil equipment and machinery at a construction site;
- Pollution of soil, infiltration of leachate from uncontrolled waste disposal and construction material;
- Major accident or damage to infrastructure, such as steel or concrete foundations, due to the corrosive nature of soils; and
- Soil contamination as a result of sedimentation or previously contaminated soils (location previously been in agricultural use, so presence of pesticides and other chemicals is to be expected) Soil pollution can affect water flows in the project area (surface and groundwater), and surrounding fertile land.

## Operational phase

During the operational phase following impacts may occur:

- Soil erosion and landslides phenomena in sloping areas, caused by run-off to surface waters and/or by the removal of vegetation.
- Soil pollution at the location through leakages because of damage of certain structers, pipes.etc.

During the operation/functioning of the WWTP, the soil can be contaminated by accidental leaks of leachate from the locations for temporary storage of sludge from wastewater treatment plants in the processes.

**Note:** Soil protection in Republic of Macedonia is regulated by the application of laws and regulations relating to the environment, water, nature, forests, waste and construction.

| SOIL AND GEOLOGY | |
|---|---|
| IMPACTS | MITIGATION MEASURES |
| CONSTRUCTION PHASE | |
| Soil degradation as a result of humus layer removal | ■ Topsoil removal and storage in separate piles and reinstallation after refilling of the trenches, to enable natural revegetation; Soil stripping and clearance of vegetation to be done parallel to contour lines, starting from high to low ground; Utilisation of appropriate machinery for land clearing to minimize disturbance to the soil.<br>■ Utilisation of appropriate machinery for land clearing to minimize disturbance to the soil. |
| Soil compaction on working site, and consequently, reduced capacity for infiltration of the precipitation | ■ Perform construction works during low-flow periods; provision of the perimeter drains to intercept storm-runoff from outside the working site; in severe situations: sand/silt traps and sediment basins to be provided; At the completion of the works: ripping of the soil, re-application of the top soil and establishment of vegetation cover. |
| Temporary land use change | ■ Restoring the site upon the completion of work. |
| Pollution of soil by infiltration of leachate from uncontrolled waste disposal and construction material | ■ Appropriate procedures and plans for the management and storage of materials, waste and hazardous waste (batteries, accumulator, chemicals) |
| Soil erosion due to:<br>- excavation works;<br>- leading to soil instability and landslides;<br>- removal of vegetation, earthworks and the use of heavy machinery during construction activities. The removal of vegetation, earthworks and the use of heavy machinery during construction activities in or near the riverbed of Vardar. | ■ Performance of major earthworks to be constricted as much as possible to the dry season;<br>■ Construction of drainage system to accept and conduct the storm water from the site<br>■ Application of appropriate erosion-protection measures: sequence of works to avoid areas subject to erosion during severe storm events, execution of silt screens, in particular where it concerns works situated in sloping areas and in riverbanks;<br>■ Implementation of active revegetation programme at work sites, including in particular erosion-prone areas (e.g. hill sides and riverbanks);<br>■ Establishment of the vegetation cover |
| Soil pollution at the location of the construction yard and work sites because of the accidental spillage of fuels and lubricants at parking areas, fuelling and cleaning of vehicles and equipment used for construction activities. | ■ Parking area arrangements for equipment and vehicles involved in construction activities (e.g. impermeable surface);<br>■ Mainntenance, fuelling and cleaning of vehicles and equipment done at workshops/sites with adequate leakage prevention (e.g. impermeable surface, settlers and oil separator);<br>■ Storage of the fuels, lubricants and chemicals in appropriate storage facilities (restricted access, sealed packages);<br>■ Tanks for the fuel storages leak-proofed, and installed on impermeable surface; in the case of incidental spills collecting recipients, absorbent material and fire fighting equipment shall be provided;<br>■ Proper maintenance of the transport and construction equipment;<br>■ Clean up procedures for the construction equipment. |

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|---|---|
| Soil pollution - at the construction yard and working sites - due to accidental spillage of chemicals, and by infiltration of leachate from uncontrolled deposits of waste. | ■ Storage of fuels, lubricants and chemicals in proper storage facilities (restricted access, sealed packages);<br>■ Fuelling of the vehicles and equipment at workshops/sites with adequate leakage prevention impermeable surface, settlers and oil separator);<br>■ Emergency procedures and contingency plans for accidents, breakdowns, spills, etc. |
| OPERATIONAL PHASE | |
| Spill out of waters washing the concrit plateau | Internal sewage network will be constructed leading collected site waters to the inlet structures for treatment. |
| Occurrence of soil erosion and landslides phenomena in sloping areas, caused by run-off to surface waters and/or by the removal of vegetation. | ■ Implementation of active revegetation programme on works sites, including in particular erosion-prone areas;<br>■ Application of appropriate erosion-protection measures, according to the characteristics of affected area. |
| Soil pollution at the WWTP location, through leakages because of damage to certain pipes, basins, structures. | ■ Regular inspections in order to timely detect any failures, and take appropriate remedial action;<br>■ An emergency plan for accidental pollution events and damages on civil structures, platforms, pipes;<br>■ Compliance with construction requirements for sludge storage location, and those related to water impermeable basis; |
| Residuals | Under normal operating conditions, residuals are not expected |

## 7.3 Air and climate

### Construction phase

Construction activities related to the Proposed Project will result in moderate air quality impacts. There will be fugitive dust generated during the site preparation and construction phases of the Project. The potential impact from fugitive dust emissions will be minimized by appropriate preventive measures. Vehicular emissions from construction equipment and vehicles are anticipated to have moderate impacts. In general, the above-mentioned emissions will generate moderate impact during construction.

Due to the combustion of oil products- petrol in vehicle engines, exhausted gases are released in the atmosphere with content of app. 180 organic components as harmful substancies. The content of Pb in petrol amounts to 0,6 g/l. Approximately 75% of the Pb content is emitted through exhausted gases and around 95% of the sulfur content is converted to $SO_2$.

The following table presents the contents of the emitted harmful substances:

**Table 57. Emitted harmful substances**

| Compound | Petrol engine | Dizel engine |
|---|---|---|
| | g/l | g/l |
| $SO_2$ | 0,4 | 4,5 |
| NO | 20 | 90 |
| Organic volatile | 40 | 110 |
| TSS | 3 | 15 |
| CO | 220 | 90 |
| Pb | 0,45 | 0 |
| Benzopiren | 20 $\mu g/m^3$ | 10 $\mu g/m^3$ |

The rate of emissions and potential impacts depend on the number of used machines and vehicles, and the power of engines, fuel quality and condition of the engine, i.e. the level of maintenance. Use of approved engines only, following the EU class for diesel engines shall be respected.

These emissions will not result in high concentrations that will have long-term effects in the environment surrounding the project and beyond.

The emergence and importance of the generation of dust depends on the meteorological conditions of the area and the soil conditions in the period when construction activities are taking place, and the location where they take place. However, under normal weather conditions, the impact of dust should be limited to within a few meters from the area where construction activities are conducted.

## Operational Phase

The only long-term air quality impact that may be created by the Proposed Project results from the potential increase in project-related vehicular exhaust emissions. The primary pollutants associated with vehicular exhaust emissions are $NO_x$ and CO. The Proposed Project will not increase traffic volumes, reduce source-receptor distances or change other existing conditions to such a degree as to increase air pollutants emissions. Moderate impact on air quality anticipated.

The potential sources of of air emissions would be the air emissions from the stack of incineration process. Air pollution control and stack monitoring system will be installed to ensure that the emissions from the stack will meet the stringent target emission limits equivalent to those stipulated in national and EU regulation for waste incineration. Besides, all the potential odour emissions associated with the operation of the STF will be collected and destroyed by the incineration process or ventilated to deodorizer before discharge to the atmosphere.

In case of failure of the public grid, diesel electric electricity generators shall operate. These engines shall comply with the contemporary emissions requirements.

With the implementation of practicable air pollution control system, adverse cumulative air quality impacts at all air sensitive receivers in the vicinity of the Project site will be negligible.

### Odor pollution

Odour pollution is a threat not just to human health and welfare, but also to air quality, as it contributes to photochemical smog formation and particulate secondary contaminant emissions. Odour from wastewater treatment plants is caused by emissions, such as VOC and sulfur compounds. This type of pollution was traditionaly considered as low priority. However due to the more stringhtened environmental legislation and more freaquent compliances from the near by population this issue is reised to a higher level.

In a WWTP, the main sources of emission of odorous compounds generally concern the pretreatment works and sludge treatment facilities. Thus, in the case of Skopje WWTP, the following works and devices will be covered and ventilated. The waste air extracted from these works is transfered to the air treatment facilities before being rejected to the atmosphere.

The mains air pollutants, to be removed, are: Hydrogen Sulphide ($H_2S$), Ammonia ($NH_3$), Mercaptans, Amines. The physical-chemical technologies remove bad smelling by changing them with chemical srubbers.

Adverse environmental impact is not be expected during the construction phase with the approved methods to handle, transport and dispose the waste and the recommended good site practices being strictly followed.

Greenhouse gases

Wastewater treatment is performed to remove organic matter through biological processes of microorganisms that use organic materials for maintenance and growth. These microorganisms can perform the decomposition of organic matter under aerobic and anaerobic conditions. If the

degradation of organic substances is carried out under, anaerobic conditions generate greenhouse gases: methane ($CH_4$), nitrogen dioxide ($N_2O$) and carbon dioxide ($CO_2$). Nitrogen oxide ($N_2O$) can be generated during the nitrification and denitrification. Emissions of greenhouse gases in the operational phase are expected to be generated from the exhaust of vehicles that will be used to transport sludge, waste, supply of raw materials and chemicals, etc.

**Note:** Selected measures are in line with the following low and appropriate by lows.

- Law on air quality (O.G. no. 67/04 with amendments no. 92/07, 35/10 and 47/11);
- Rulebook on emission limit values during waste incineration and combustion processes, conditions and manner of work for installations for incineration and combustion. (Of. Gazzete no.123/09);
- Decree on limit values of levels and types of pollutants in ambient air and alert thresholds, deadlines for reaching the limit values, margins of tolerance for the limit values, target values and long-term goals ("O.G." no. 50 / 05, and 4/13);
- Rulebook on methodology, manners, procedures, methods and means to measure emissions from stationary sources ("O.G." no. 11/12);
- Rulebook on limit values for permissible emission levels and types of pollutants in waste gases and vapours emitted from stationary sources into the air ("O.G." no. 141/10);

| AIR AND CLIMATE | |
|---|---|
| IMPACTS | MITIGATION MEASURES |
| CONSTRUCTION PHASE | |
| Air pollution-fugitive dust emissions during construction activities through entraining dust from the working site by vehicles, earthworks, and due to the wind erosion from open areas and stockpiles | Prevention of the dust through sprinkling, during periods of dry weather; the water should not be applied in excess, otherwise runoff and mud resulted from the site could be transferred onto public roads by vehicles;<br>■ Daily cleaning of the access ways - in the neighbourhood of the construction yard and working sites (removal of the earth and sand to prevent dust);<br>■ Mandatory tires full cleaning prior to leaving the site to the public roads and streets. |
| Emissions of dust generated during handling of construction, materials | ■ Appropriate procedures for handling of construction materials;<br>■ Implementation of good construction practice. |
| Air pollution through emissions from motor vehicles, transport and construction motor equipment | ■ Supervisor's approval for use of each particular engine on compliance with EU class;<br>■ Regular inspections of the vehicles and equipment;<br>■ Limitation of working hours for the works located in sensitive locations. |
| Residual impact | In normal working conditions, residual are not expected. |
| OPERATIONAL PHASE | |
| Discharge gasses and their odour by Incineration of sludge | There will be three odour treatment scrubbing towers, to remove: nitrogen compounds; tower 2 for removal of hydrogen sulphides and mercaptans; tower 3 for removal of reduced sulphur and fatty acids. The removal process is based on addition of adequate chemicals. |
| Air pollution of flue gasses of incineration | Incineration process includes addition of chemicals that are reducing the existence of nitrogenous and sulphur oxides in the flue gasses, as well as sandy material that is preventing harmful substances to join the flying ash.<br>Inside the reactor, sodium bicarbonate and ammonia are injected into the combustion chamber to prevent forming of flue gas harmful components.<br>Special dry cleaning system shall be installed.<br>It consists of electrostatic precipitator, bag filters with efficiency of 99.9%. |
| Electric generators flue gasses emission | The generators diesel engines shall comply with the EU regulation regarding diesel engines, i.e. EU 6 generation. |
| Emission of NOx in flue gases at the stack of the | For reducing the NOx-level in the flue gases at the stack, an ammonia solution is injected in the head of the |

| AIR AND CLIMATE | |
|---|---|
| IMPACTS | MITIGATION MEASURES |
| Incinerator | incinerator by using special spray nozzles. The dosing system is operated automatically and regulated by NOx |
| $H_2S$ release from sludge digester | Anti-foam agent and ferric chloride injection will be provided to control foam production and $H_2S$ release. $H_2S$ is first removed from the biogas by gas washing in a wet scrubber. A second stage will also be included for biogas treatment, by means of active carbon. This second treatment will allow siloxanes removal to a concentration of less or equal to 5 ppm. It will also allow further removal of $H_2S$ down to less or equal to 1 ppm. |
| Odor generated during the wastewater treatment process | ■ Regular monitoring of the WWTP function;<br>■ Minimizing the settling time of the sludge in the primary settler;<br>■ Control of the sludge treatment process;<br>■ Regular monitoring of the parametres deriving from the sludge tretman process;<br>■ Control of the wastewater flow and aeration process;<br>■ Compensatory planting of vegetation (trees and plants of varying heights forming a windbreaker) at the borders of the WWTP site;<br>■ Inlet structures, including pumping station and grit removal will be accommodated in the enclosed rooms, ventilated, with air discharge throughout an absorbing filter;<br>■ Settling tanks will be covered with polyester roof, with forced air take out and discharge throughout absorbing filter;<br>■ Sludge thickening process shall be in the enclosed space with forced ventilation and discharge of air throughout absorbing filter. |
| Odor from transportation of sludge and other wastes | ■ Avoid movements in the urban area;<br>■ Defining alternative transport routes for the sludge;<br>■ Covering the vehicles during transport;<br>■ Preparation of the sludge management plan. |
| Residual impact | Minor residual impacts |

## 7.4 Noise and vibrations

### 7.4.1 Construction Phase

The WWTP is located outside the boundaries of the urban area. Near settlements are at distance of 2.5-3.5km. The area belongs to the IV th level of noise protection, namely it is an area where construction activities can be performed considering that the area is without apartments, and area aimed for industrial, and other similar production activities, transport activities, storage services and service activities and communal activities generating higher level of noise.

According to the level of noise protection, the limit values of the basic noise indicators must not exceeded the following values:

**Table 58. Noise limit values**

| Area according to the level of noise protection | Noise level dB(A) | | |
|---|---|---|---|
| | Ld | Le | Ln |
| First degree area | 50 | 50 | 40 |
| Second degree area | 55 | 55 | 45 |
| Forth degree area | 70 | 70 | 60 |

The biggest impacts of noise emissions are expected during construction of the WWTP. Most sensitive receptors are residents in the nearest vicinity of the location, employees who will be engaged in the construction phase. Increased noise levels are expected to cause disturbance of the fauna species in the immediate environment.

The following table provides levels of sound pressure generated by the construction machinery, which is expected to be used in the construction phase:

**Table 59. Levels of sound pressure generated by the construction machinery**

| Type of euipment | Typical noise level dB(A) at 15 m | Noise level at 240 m |
|---|---|---|
| Air compressor | 75-87 | 51-63 |
| Digger | 71-92 | 47-69 |
| Compactor | 72 | 48 |
| Concrete mixer | 75-88 | 51-64 |
| Loader | 72-81 | 48-58 |
| Generator | 72-82 | 48-58 |
| Grejder | 80-93 | 56-69 |
| Pumps | 70-90 | 44-66 |
| Stone breaker | 85-95 | 61-74 |
| Tractor | 78-95 | 54-74 |
| Truck | 83-93 | 59-69 |
| Concrete vibrator | 68-81 | 44-57 |

The impacts of noise on sensitive receptors will depend on the timing of the construction activities, the duration of the construction phase, the type of machinery and equipment to be

used, the topography of the terrain, etc. Vibrations during construction activities will be generated by the presence of mechanization, construction, excavation, compaction of material. Significant impacts from vibrations due to the type of construction work to be performed on the ground are not expected.

## Operational phase

The operational phase is not expected to generate higher levels of noise. Near the WWTP location other sensitive receptors, except fauna species does not exist. The main sources of noise in the operational phase are the vehicles transporting the waste from the site. The operation of WWTP may result in minor noise generation. .

Although high noise level is not expected, special attention should be paid to the possible disturbance of the fauna species and habitats within the protected area Ostrovo.

The impacts of noise and vibration during operational phase will depend on the type of equipment that will be installed in the WWTP. All equipment generating noise is installed in specific sound proofing buildings. Part of the equipment is assembled on vibration absorbers and flexible couplings, thus avoiding vibration of external structures.

**Note:** Selected measures are in line with the following low and appropriate by lows.

- Law on the Protection of the Environment from noise ("O.G." no. 79/07, 124/10, 47/11 and 163/13);
- Rules for the application of noise indicators, additional noise indicators, the method of measuring the noise assessment methods with indicators of noise in the environment ("O.G." no. 107/08);
- Regulation on limit values of the noise level in the environment ("O.G." no. 147/08);
- Decision on determining in which cases and under what conditions is considered that the peace of citizens is disturbed from harmful noise ("O.G." no. 1/09).
- Rulebook on conditions for the necessary equipment that authorized professional organizations and scientific institutions and other legal entities and individuals should possess to perform specified duties to monitor noise ("O.G." no. 152/08); Rules of the locations of measuring stations and measuring points ("O.G." no. 120/08);

| NOISE and VIBRATION | |
|---|---|
| IMPACTS | MITIGATION MEASURES |
| CONSTRUCTION PHASE | |
| Disturbance of the local population, biodiversity as a result of increased noise levels. Local workers will be also exposed to noise | ■ Preparation and implementation of the Traffic management plan and Plan for management of the building site;<br>■ Limitation of the vehicle speed in the settlements;<br>■ The construction equipment has to be in compliance with the Directive 2000/14/EC for noise emissions generated from outdoor equipment;<br>■ Construction works will take place in the period 07.00-19.00h with respect to the resting period from 15:00 to 18:00 and weekend;<br>■ The equipment will be provided with devices for noise stifling thus reducing the noise level;<br>■ Regular maintenance of the equipment and mechanization;<br>■ Avoidance of the equipment with noise level above 90dB. |
| Residual impact | None |
| OPERATIONAL PHASE | |
| Vibration generated by equipment of the cogeneration unit | Equipment of the cogeneration unit is assembled on vibration absorbers and a flexible coupling avoids any vibration on the external structures. |
| Noise generated by engine/alternator | The engine/alternator couple and peripheral equipment are installed in a dedicated sound/noise-protected room or container. |
| Noise generated by centrifuges used in dehydration of digested sludge | The machines will be installed in a specific soundproofing building. Moreover, each machine will be equipped with a protective and soundproofing hood. |
| - Noise generated from the WWTP equipment (generator, pumps, ventilation)<br>- Noise generated from the STF (Incinerator) | ■ The equipment that generate higher noise levels should be placed in closed structures;<br>■ Provision of anti-vibration base for specific parts of the equipment generating noise that will reduce vibration and noise;<br>■ Planting vegetation within the frames and around the location site;<br>■ All noise generating activities will be enclosed within building structures. |
| Residual impacts | None |

## 7.5 Impacts from waste generation

### 7.5.1 Construction phase

Main source in the construction phase are:

- Excavation activities
- Construction activities for the WWTP
- Communal waste
- Packaging waste – wood, plactic, paper and cardboard.
- Packaging waste - paints, varnishes, greases and oils, chemicals, hazardous waste.

The waste generated on the site is classified as inert waste. Workers on the site will generate communal waste.

Treatment of waste generated during the construction phase will be consistent with the rules for handling the waste arising from the hierarchy of waste management. In order to ensure proper management of each type of waste, future Contractor will have to enter into agreement with waste management companies specialised in transport, treatment and / or disposal of such waste.

### 7.5.2 Operational phase

Sources:

- WWTP process including mechanical treatment, grit and grese removal, separation of oil and send, and save handling of raw materials.
- Sludge treatment process

During operational phase large amounts of sludge will be generated. Sludge will be incinerated on site. Ash and residuals will be appropriately stored and disposed.

Expected waste quantities are provided in the Table below:

**Table 60. Expected waste quantities**

| Source | Waste | Code | Quantity |
|---|---|---|---|
| Mechanical coarse and fine screening | Inert waste | 19 08 01 | 2030 -14342 kg/d<br>2045 – 15120 kg /d |
| Removal of send and grease | Inert waste | 19 08 02 | 2030 – 4876 kg /d<br>2045 – 5141 kg /d |
| Ashes production | Insineration waste | 10 01 15 | 2030 – 106t/w<br>2045 - 116 t/w |
| Flying ashes from inceneration different than 10.01.016 | Incineration waste | 10.01.17 | Not defined |
| Send from fluidized bed cover | Incineration waste | 10 01 24 | Not defined |
| Ash residue not mentioned in 19.01.11 | Incineration waste | 19.01.12 | 13 t/w |
| Packaging Waste from chemicals | | | / |

**Table 61. Quantity of reagens/chemicals to be used in the operational phase for different processes**

| Reagents | Storage Condition | Process stage utilization | Quantity (2030) *t/year* | Quantity (2045) *t/year* |
|---|---|---|---|---|
| $FeCl_3$ commercial solution (42%)daily consumption | HDPE tanks (2x 50$m^3$)/simple walled tankwith concrete retention in case of leak | Physical-chemical treatment of phosphorous | - | 6.9. $m^3$/d |
| $H_2SO_4$ Average consumption (96%) | Storage tank | Physical-chemical treatment of air | l/h | 1.4 |
| NaOH average consumption (30%) | Container | Physical-chemical treatment of air | l/h | 16.8 |
| NaOCl consumption (48%) | Storage tank | Physical-chemical treatment of air | $m^3$ | 15 |
| Active carbon consumption | Cassete in box | Biogas treatment | t/week | 0.21 |
| Bicarbonate | Storage tank | Biogas treatment | Kg/h | 123.6 |

The Contractor should provide the implementation of the environmental protection measures through implementation of the waste management plan including:

- Identification of all types of waste generated during construction and quantities generated
- Handling of different types of waste in line with the basic hierarchy of waste management as to provide possibilities for waste quantity reduction and waste removal.
- Determination of places and storage conditions
- Determination of the manner and frequency for take over and removal
- Records on generated and removed waste
- Regular controls of the construction zone as to provide compliance with with the requirements stipulated in the waste management plan.
- Safe handling of chemicals.

**Note:** Selected measures are in line with the following low and appropriate by lows.

- Law on air quality (O.G. no. 67/04 with amendments no. 92/07, 35/10 and 47/11);
- Rulebook on emission limit values during waste incineration and combustion processes, conditions and manner of work for installations for incineration and combustion. (Of. Gazzete no.123/09);
- Decree on limit values of levels and types of pollutants in ambient air and alert thresholds, deadlines for reaching the limit values, margins of tolerance for the limit values, target values and long-term goals ("O.G." no. 50 / 05, and 4/13);
- Rulebook on methodology, manners, procedures, methods and means to measure emissions from stationary sources ("O.G." no. 11/12);

- Rulebook on limit values for permissible emission levels and types of pollutants in waste gases and vapours emitted from stationary sources into the air ("O.G." no. 141/10);

| WASTE | |
|---|---|
| IMPACT | MITIGATION MESURE |
| CONSTRUCTION PHASE | |
| Impact on biodiversity, surface and ground water quality and soil, human health, landscape due to generation of different types of waste | Preparation of the waste management plan during construction and operation before the construction starts, that will include the following:<br>■ Identification of different types of waste and waste quantities expected to be generated on the site in line with the List of Waste Types (Of. Gazzete 100/05);<br>■ Selection and classification of different waste types and their handover to the authorized companies;<br>■ Defining the manner of handling different types of waste;<br>■ Procedure for waste management;<br>■ Defining the number /type of waste containers and location for waste storage;<br>■ Defining the time for collection and transport of the generated waste out of the site.<br>■ Reuse of excavated land and construction waste as much as possible<br>■ Reuse of other waste types;<br>■ Assessed value of waste to be used, reused or recycled.<br>■ Regular evidence of types and quantities of generated waste, and preparation of annual reports of waste quantities handed over to authorized companies.<br>■ Manner of monitoring for measures taken for waste management.<br>■ Preparation of the waste management plan in case of incidental spillage of waste with hazardous characteristics.<br>■ Training of personal on proper waste handling;<br>■ Nomination of responsible person for waste management;<br>■ Implementation of the waste management plan including signing contracts with authorized companies for collection, transport and treatment of waste. |
| Residual influence | None |
| OPERATIONAL PHASE | |
| Solid waste generation as refusals from course screen | Grit and other refusals will be disposed of in Drisla landfill site; They will be compacted and stored in skips of in the plant before their hauling to the landfill site. |
| Solid waste generation from fine screen | Grit refusals will be disposed of in Drisla landfill site; They will be compacted and stored in two skips of 25m$^3$ in the plant before their hauling to the landfill site. |
| Solid waste generation by settling of sand | After sedimentation, sand will be extracted from the bottom of the tanks. Then it will be drained and washed, in order organic matters to be removed. Washed sand with grease will be stored into skips before their transfer to the Drisla landfill site.<br>Washed and drained grits can also be transported as public works material for trench backfilling or other reuse. |

| | |
|---|---|
| Oils and Grease | Oils and grease removed with flotation will be collected by a scraper at the surface of the tanks and stored in a pit prior to the disposal to Drisla landfill or they will be digested and incinerated. |
| Ashes emission | The ashes are stopped to exit the flue system by the electrostatic filters.<br><br>They discharged into a storage silo where a direct loading of the waste product to trucks is possible. Silo is equipped with mechanical discharge back up and all necessary facilities for safe silo ventilation, product discharge, control and maintenance works. The ashes in most cases can be reused in road construction, concrete works or even used in the cement plants. |
| Solid waste from Incineration process | Flue gasses are treated by bag filters.<br>The reaction product (residues) is collected in the bottom of the bag filter and then discharged into any separated large-bags.<br>Ashes storage would necessitate their protection by means of humidification and the provision of a tarpaulin cover in order to prevent their spreading and dispersal.<br>Ashes shell be disposed at Drisla landfill site as well as in abandoned quarries in the vicinity or ashes maybe be reused in public works and for some specific constructions. The addition of some reagents can convert ashes into granular shape solids which are considered as more adapted for carrying out some specific field works (filling, foundation material, etc.).<br>Ashes transportation should shell be done either by a tank truck or by a dumper truck. |
| Pollution by combustion process storage | No storage of the combustion process is envisioned on the Plant. All quantities of generated solid waste shall be taken out of the site to the agreed locations (Drisla, or sites for reuse). |
| Impact on biodiversity, surface and ground water quality and soil, human health, landscape due to generation of different types of waste | Implementation of the activities stipulated in the waste management plan genereteted in the operational phase including all items including the Wsate management plan for the construction phase.<br>Signing contracts with authorized companies for collecton, transport and treatment of different type of wastes. |

## 7.6 Population

### Construction phase

### Socio-Economic aspects

Influence on the economic activities of local companies during the construction some of the local business may face problems, in their everyday work, due to the implementation of construction activities.

### Health and safety of the local population

Construction area

There is a potential security risk to the local population acceding to the construction areas (open drains and excavated parts). Most of the incidents are related to the illegal presence of human or at site. Access to construction sites can endanger personal health and safety and the health and safety of workers involved in the construction process.

Fear for personal health and safety due to the increased volume of traffic

The increased intensity and volume of traffic may obstruct normal traffic regime in the project area. The increased presence of heavy vehicles as well as increase of the volume of traffic on local roads can cause the growth of the local rate of traffic accidents.

### Health and Safety of the workers

Engagement of non-qualified workers and low-qualified workers may lead to potential threat of the process itself as well as for the workers, population, and environment.

Risk for the workers

Solid practices from industrial operation and/or liquid chemical aerosols may cause visual impairments reflected as eye injuries and permanent blindness

Threatened workers' health due to the use of rotating equipment and movable equipment.

Injury or death can occur if the employee is captured, entangled, or struck by machine parts due to unexpected starting of the equipment or unusual movement during operations.

Endangered health of workers during handling of heavy vehicles and traffic within the site.

Poorly trained or inexperienced drivers industrial vehicles represent an increased risk of accidents with other vehicles, pedestrians, and equipment. Industrial vehicles and delivery vehicles, as well as private purpose vehicles also represent a potential risk.

Stress and threat to personal security caused by climate conditions in the workplace

Local climate can reach extreme weather conditions, which causes deterioration of working conditions. It often occurs during the summer when temperatures are above 30$^{o}$C and when the condition lasts ten or more days. The same can temporarily worsen the efficiency of labor, endangering the lives of employees and thereby caused the delay time of the realization of the planned activities

Stress caused by emissions of exhausted gases in the working environment

Construction workers working in an environment where machines and vehicles use diesel as fuel are exposed to the exhaust gases for a certain period of time.

Endangered health of workers caused by diseases transmitted by vector through insect bites.

The immediate vicinity of the drains and other water surfaces may be a home to various types of vector insects that easily transmitted diseases.

Health impacts on personal during explosion and fire.

Fires and explosions resulting from ignition of flammable materials or gases can lead to loss of property or deaths among workers engaged in construction activities.

### Operational phase

### Health and safety of the local population

Endangered health of the local community caused by diseases transmitted through insect bites.

WWTP will provide ground for increased presence of mosquitoes at the site. Mosquitoes are vector agents that carry diseases, viruses and parasites from person to person. Occurrance of serious infectious diseases is not expected.

- Pollution of agricultural land non-agriculture land during incidents

The transfer of wastewater goes through pipelines that have a certain lifespan. After a certain period leaks may occur that will contaminate active agricultural areas. Thus polluted areas, if not treated properly, may negatively impact agricultural products, and income from agricultural activity. The overflow of wastewater near the settlements is particularly high risk to children, pets and livestock.

- Transport, handling and storage of chemicals

During the work, the plant would use chemicals and substances that are harmful for the population and his environment. Any negligence in the transport, handling and storage can cause an incident with major consequences for human health.

### Health and Safety of the workers

- Stress caused by emissions of exhausted gases in the working environment

Construction workers working in an environment where machines and vehicles use diesel as fuel are exposed to the exhaust gases for a certain period of time. Additionally, the specificity of the workplace in such facility assumed increased amounts of volatile gases from the wastewater treatment and sludge treatment.

- Endangered health of workers exposed to biological hazard

The work in the WWTP, maintenance works, and disposal of sludge, poses a high risk from infections due to microorganisms, viruses, toxins.

- Endangered health of workers exposed to chemical hazard

In the process of wastewater treatment chemical compounds are used which, if carelessly transferred, handled and used can be dangerous not only for the health of the worker, but also to local population.

**Note:** Selected measures are in line with the following laws.

- Law on Safety and Health at Work ("O.G." No 92/07, 136/11, 23/13, 25/13, 137/13, 164/13 and 158/14);

- Law on Health Protection ("O.G." no.43/12, 145/12, 87/13, 164/13, 39/14, 43/14 and 132/14);.

| POPULATION | |
|---|---|
| IMACTS | MITIGATION MEASURES |
| CONSTRUCTION PHASE | |
| SOCIO-ECONOMIC ASPECTS | |
| Traffic disruptions, resulting in nuisance and interruption of commercial and social activities | Preparation of a traffic management plan which will address aspects related to following issues:<br>■ phasing of construction activities, rerouting of the traffic; scheduled construction activities for minimisation disruption of existing traffic patterns to residential and businesses areas; establishment of temporary access ways (with collaboration and with assistance of local traffic police authorities),Parking restriction of construction vehicles in front of access points and/or business parking areas; Informing the local communities of the construction programme, for example, through local newspapers;Temporary covering of open trench segments to allow residents and service vehicles to access driveways. Limitation of any temporary interference with private property (e.g. pipeline crossings over private lands);Limitation of the length of trenches at one time as much as possible - period estimation of construction works will be done; Restriction of materials delivery or removal during peak traffic hours along major road arteries.presentation of the traffic plan to the general public. |
| Potential security risk to the local population acceding to the construction areas | ■ Protection (fencing) and signalling of work sites (especially excavation works), in particular during the night, with clear marking of the safety border of the works perimeter (main locations will be specified on a map);<br>■ Restricting access to working sites for other persons than authorised workers (places occupied by operation mechanical and electric equipment, open trenches). |
| Disturbances and nuisances to the public, through air emissions (dust produced at work sites, as well as resulted from the transport of raw and waste materials) and odour from waste stored at work sites | Same as mesures stipulated in 6.2.3. |
| Discomfort for the inhabitants due to the noise generated by construction activities | ■ Interdiction of construction activities at night and restrictions on limits on hours of rest in sensitive neighbourhoods (e.g. hospitals); Noise mitigation measures e.g. noise barriers, use of electrical equipment/ installation rather gasoline/diesel-powered; Restrictions of speed limit and of tonnage for heavy vehicles passing through residential areas; Proper maintenance of equipment for quiet operation. |
| OPERATION PHASE | |
| Disturbances and nuisances to the public, through the offensive odour generated by the operation of the WWTP, WWPS or waste water network | Same as mesures stipulated in 6.2.3. |
| HEALTH AND SAFETY OF LOCAL POPULATION | |

| | |
|---|---|
| Active construction sites | Proper fencing of the site, placing a sign prohibiting entry into construction and other signs for danger in line with the national and EU legislation |
| Fear for personal health and safety due to the increased volume of traffic | ■ Preparation and implementation of the traffic plan and actively communicated with the local community e<br>■ All critical points must have adequate traffic control during the construction phase and the speed limit that will meet the requirements of the new temporary situation. |
| Residual impact | None |
| HEALTH AND SAFETY OF WORKERS | |
| Engagement of non-qualified workers and low-qualified workers | ■ Proper verification of the qualification and experience of workers hired;<br>■ Appropriate additional training on health and safety at work should be organized by the contractor, in order to minimize the risk of accidents;<br>■ proper personal protective equipment will be provided by the employer to all workers |
| Risk of visual impairments | ■ Use of personal protective equipment<br>■ Compliance with local labor law and EU directives on health and safety and the use of personal protective equipment 89/654 / EEC , 89/656 / EEC , 89/686 / EEC and 2009/104 / EC . |
| Health risk due to the use of rotating equipment and movable equipment | ■ Using machines that eliminate the danger of the existence of a trap, and ensure that limbs are kept out of danger under normal operating conditions. Where the machine or equipment has exposed moving part that may endanger the safety of any worker, it should be equipped with, device that prevents access to the slide, or projecting point. Visors should be designed and installed in compliance with relevant safety standards of the machine. |
| Endangered health of workers during handling of heavy vehicles and traffic within the site. | ■ Training and licensing of operators of industrial vehicles for safe handling of specialized vehicles such as forklifts, including safe loading / unloading, limit load, etc.;<br>■ The mobile equipment with limited visibility must be equipped with audible alarms;<br>■ Compliance with local labor laws and EU directives on health and safety |
| Stres as result of the exhausted gases in the working environment | ■ In line with **national law and EU directives 89/654/EEC, 89/656/EEC, 89/686/EEC и 2009/104/EC.** |
| Impared workers health due to vector borne deseases | ■ Regular medical checks. |
| Impared workers heath due to fire and explosions | ■ Use of personal protective equipment;<br>■ And takes place away from sources of sparks and oxidizing materials. |
| Rezidual impact | Possible residual impact |

## 7.7 Biodiversity

In the current territorial borders of the municipality of Gazi Baba are the localities Ostrovo Arboretum and Ezerce. The area of the localities Ezerce, Arboretum and Ostrovo represent an Integral environmental ecosystem, established at the confluence of the river Vardar at Trubarevo, Gazi Baba and Skopje. In order to protect its natural values, especially of biological diversity that are of significant importance for nature conservation they have been declared protected areas category III Natural Monument. Management of the protected area is entrusted to the Forest research unit within the Faculty of forestry

### Construction phase

Possible impacts during the construction phase

- Removal of the humus layer and the surface of the project area

The surface layer of soil is especially important for wildlife. It is composed of inorganic, organic and incompletely degraded organic (humus) materials. On the other hand, this part of the soil is the habitat of a number of soil organisms. By removing this layer, these groups of living organisms will be removed from this area. Significant effects are not expected.

- Disturbance to the Vardar River aquatic ecosystems

Increased turbidity of Vardar river as a result of construction activities may pose temporary impact to the aquatic ecosystem expecially on the white barbel (Barbus macedonicus) and the Vardar ray-finned fish (Cobitis vardarensis), species protected by law and on Anguilla Anguilla and Cyprinus carpio (IUCN global category of threat).

- Harassment

During the work the construction activities will generate increased intensity of noise within the project area. The increased intensity of noise will affect especially birds in the project area. The impact of noise can cause migration of these groups of animals, and can also have an impact on the reproductive process of the animals. Special attention will be paid to the the species pygmy cormorant (Phalacrocorax pygmaeus), European roller (Coracias garrulous) and lesser kestrel (Falco naumanni) that are included in category SPEC 1 species under global threat.

- Fragmentation of habitats

Improper wastewater management and improper hendling of waste affect the environmental quality (water and soil) which are habitats of many plants and the animals. Changes in the habitats of species can lead to their disappearance or reduction in number of species populations. The intensity of the impacts will depend on the duration of the construction phase, period and time of implementation of works.

Attention should be paid to the following mammals registered in the protected area: The lesser horseshoe bat (Rhinolophus hipposideros), the lesser mole-rat (Spalax leucodon), The marbled polecat (Vormela peregusna), which are included in the category - VU (Vulnerable species).

Amphibia species Macedonian crested newt (Triturus macedonicus) and Balkan newt (Triturus karelinii) are included in the list of Annex II. Both types of newts are regional endemic species vulnerable to extinction. These species are registered in the small marsh of Ezerce.

From the reptiles registered in the protected area only the spur-thighed tortoise (Testudo graeca) is included in the list of species under global threat, the category VU (vulnerable species), while species hilly turtle (Testudo hermanni) and pond turtle (Emys orbicularis) are included in the category NT (near threatened species).

Generally, impact is classified as moderate to high.

### Operational phase

Direct effects in the operational phase are less destructive and damaging to the proceedings in the construction phase.

The WWTP will have a large positive effect on the quality of the surface and ground water as it will significantly reduce or completely eliminate discharges of untreated wastewater into surface and groundwater, Aquatic ecosystems, in particular Vardar River ecosystems and biodiversity will benefit from this improvement.

Certain adverse effects initiated during the construction phase, will affect the terrestrial ecosystems. They include principally: permanent fragmentation of habitats and biocorridors, disturbance caused to the wildlife from WWTP functionning (dust emissions, noise, lighting, car trafic), but also from possible pollution of air, water and soil caused by improper implementation of the Plan for waste management, natural disasters (earthquakes, floods), accidental events (fires, spills of untreated wastewater, fats and oils) that may affect biodiversity.

These impacts should be of low intensity due to the implementation of BAT (Best Available Techniques) in the operation of a future treatment plant.

**Note:** Selected measures are in line with the following law.

- Law on Nature Protection ("O.G." no. 67/06, 14/06, 84/07, 35/10, 47/11, 148/11, 59/12, 13/13, 163/13, 27/14 and 41/14);

| BIODIVERSITY | |
|---|---|
| IMPACTS | MITIGATION MEASURES |
| CONSTRUCTION PHASE | |
| ■ Loss of vegetation as a result of clearing the project area;<br>■ Destruction of habitats by removing<br>■ humus layer of soil and vegetation removal | ■ -The contractor in close cooperation with the Forest research unit within the Faculty of forestry.) that manages the protected areas within the site should prepare management plans for clearing of vegetation by assessing the quantity and type of timber and other plants that need to be removed from the respective location, providing sustainable logging of trees and vegetation.<br>■ Reuse of the top layer of soil removed (which will temporarily be removed) for arranging the green spaces within the site.<br>■ If nests of birds or reptile, eggs or young are found on the location, they should be transferred to other suitable location defined bu the forest research unit. |
| Impacts on the process of photosynthesis from emissions of fugitive dust. | Measures for reduction of the emissions in the ambient air - 6.1.3. point |
| Harassment of biodiversity by<br>generating increased noise levels and increased presence of people and machinery | ■ Measures for reduction of emission of noise<br>■ Limitation of the construction works during breeding season<br>■ Construction works are forbidden during spawning season<br>■ Use of technically correct machinery that provide lower level of emission of harmful products of combustion, noise and vibration. |
| Affecting fauna species that have a seasonally variable vulnerability due to, breeding, critical feeding times or seasonal migrations | ■ Manual execution of works through elimination of using any equipment and vehicles in protected sites or sensitive areas;Restriction of construction works during the breeding seasons |
| Change of the covert and food places for fauna species, with habitat in the works area, because of disturbance produced by construction activities | ■ Limiting the speed of the heavy vehicles in sensitive areas;<br>■ Workers' training regarding the provisions of the biodiversity protection legislation, and the appropriate mitigation measures. |
| Limiting the speed of the heavy vehicles in sensitive areas; | ■ Provide bio-corridors/unhindered passages for fauna species;<br>■ Workers training regarding the provisions of the biodiversity protection legislation, and the appropriate mitigation measures. |

| | |
|---|---|
| Total or partial destruction of the vegetation in works areas (soil stripping, vegetation cuttings and clearness); and low ability to recover of the fauna species (either naturally or with assistance) from the habitat disturbance. | ■ Conservation of trees and other vegetation as much as possible; ;<br>■ Removal of trees and replanting, avoiding from cutting them down; clearing and cutting of trees shall only occur with the appropriate authority's consent;<br>■ An inventory of trees to be cut down shall be made and a plan for replanting will be developed and implemented;<br>■ After any intervention that may disturb natural sites: ecological restoration through environmental engineering (restorations, rehabilitation) shall be undertaken, including restoration of top soils and (re-) introduction of genetic species to re-establish the natural local ecology;<br>■ Restriction/control of any fertilizers used during vegetation restoration on affected areas |
| Aquatic environment alteration due to the changes of water characteristics (physical, chemica, and biological), caused by water body pollution (the causes for pollution described above see subsection 6.2.1 and 6.2.2) | ■ See recommended mitigation measures in subsection 6.2.1 and 6.2.2 – for construction phase |
| Residual impact | Minor |
| OPERATIONAL PHASE | |
| Alteration of habitats or the species, modification or destruction of migration routes for terrestrial and aquatic fauna because of the land use change | Compensatory planting or restocking of indigenous species; Carry out the efficient elimination of any eventual spreading of the dangerous invasive species; Creating opportunities for fauna migration or provision of new habitat; Monitoring the affected protected area for a certain period (e.g. 2-3 years), recommended at the beginning and at the end of vegetation period; if any restoration of the flora elements failed, certain corrections and additional planting plan should be started. |
| Residual impact | None |

## 7.8 Landscape, visual effects

### Construction phase

In the construction phase of the project some activities may cause negative impacts on the landscape and visual effects. The area of the site for construction of the future WWTP does not possess significant features. Impacts in the construction phase are mainly related to the presence of heavy machinery, equipment vehicles and staff, piles of vegetation cleared, dug and stored building materials. Changes in the landscape may affect local residents, owners of agricultural land near the construction site, passers-by, tourists and others.

The number of buildings, their size and architecture, which will be defined in the technical documentation for construction, can cause changes in the aesthetic features of the landscape. The location of the predicted WWTP is located away from the local and regional road and is not expected to be visible for a number of passers-by and local residents. The impacts will be of low intensity, local and of short duration.

### Operational phase

During the operational phase, impacts on landscape and visual aspects are associated with the presence of facilities and equipment for waste water treatment. In addition, adjacent to the location area is unurbanized. Given the relatively large distance of the structures of WWTP from the nearest settlement and lack of attractive spaces and tourist facilities in the nearby surroundings, they will have small visual impact. Also despite the fact that during the operational stage, area will be permanently altered, horticultural arrangement of space should give positive effects in visual perception by receptors (Pedestrians, farmers etc.). Thus it is considered that the impacts on the landscape in the operational phase will be of low intensity and local.

| LANDSCAPE AND VISUAL IMPACTS | |
|---|---|
| POSSIBLE IMPACTS | MITIGATION MEASURES |
| CONSTRUCTION PHASE | |
| Disruption of the landscape and visual characteristics from the construction activities on site. | ■ Limitation of the size of the construction site within the frams of the cadaster lot;<br>■ Adequate organization, maintaining the site and its fencing<br>■ Remediation of the situ after construction including cleaning of earth piles , construction material and other construction residues |
| Residual impact | Not expected |
| Operational phase | |
| Impacts on visual characteristics of the area . | ■ Adequate design of civil structures (WWTP, WPS, WWPS) to ensure that it blends into the surrounding environment; Planting of native trees and other vegetation on the location of the WWTP, which will encompass the boundaries of the location.<br>■ Aesthetic design of inceneration facade, stack and associated structures to harmonize with the surrounding setting. Shrub and climbing planting to soften structures.<br>■ Tree planting to screen STF |
| Residual impacts | None |

## 7.9 Material assets

### Construction phase

Following impacts are likely to occur during construction phase:

- Possible damage to underground infrastructure

During the construction of structures and facilities of the WWTP underground infrastructure may be damaged. The Contractor shall reimburse the damage

- Influence on the quality of roads used for transport of construction materials

The transfer of materials and people to the construction sites will have to be done by existing roads. Not all roads are with good quality that can withstand the transportation of materials to the desired destination. Some of the roads are in poor condition. Intensive use of the existing road network can lead to deterioration of the infrastructure. Mitigation and or compensation measures should be foreseen in this regard by the project owner, in coordination with local authorities.

- Impact on the local development

| MATERIAL GOODS | |
|---|---|
| IMPACTS | MITIGATION MEASURES |
| CONSTRUCTION PHASE | |
| Possible damage to underground infrastructure | ■ Contractor must provide the necessary documentation and data from all relevant institutions responsible for underground infrastructure in the project area in order to avoid incidents of disruption of water supply, electricity, and other underground infrastructure<br>■ Claims incurred must be paid in full by the Contractor |
| Influence on the quality of roads used for transport of constructiona materials | After completion of construction works contractor will have to repair roads damaged during transportation of materials and people for this project. |
| Temporary disturbance to residential and other sensitive receptors (hospitals, schools etc.) through generation of noise;<br>Traffic disruption because of construction/ rehabilitation activities (mainly those related to the water distribution network). | See mitigation measures recommended in subsection 6.2.4 Human Beings |
| Temporary interference with private property (e.g. pipeline crossings over private lands) | Where private land or other property is affected, or where there is loss of income as a result of the project activities, it should be agreed on mitigation or compensation measures with the affected population prior to the start of construction |
| Damages to civil works (because of vibration) | Identification of vulnerable civil works placed in the immediate proximity of construction sites and use of safety methods and equipment;<br>Elimination the use of equipment that may generate dangerous vibrations;<br>If significant damage can occur, it is recommended to change the location of works. |
| Residuals | Minor |
| OPERATIONAL PHASE | |
| No expected impact on material good during the operational phase of the WWTP | / |

## 7.10 Cultural heritage

### Construction phase

Potential destruction and loss of undiscovered archaeological site

On the project site there are no significant archeological or cultural sites. Therefore, no impacts are expected from this project on cultural heritage.

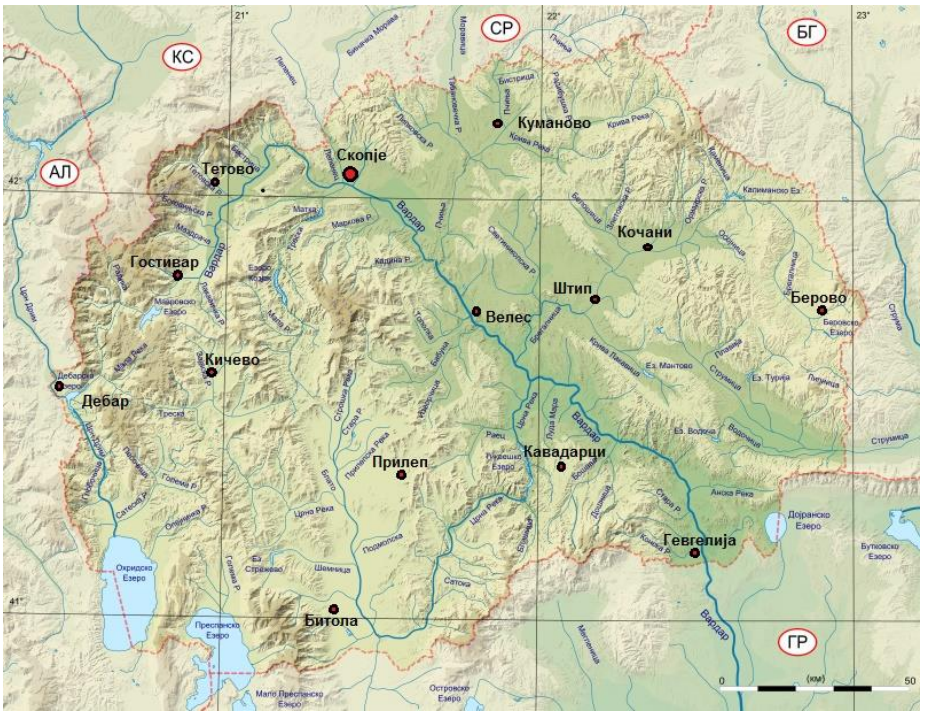
In case if new archeological sites or valuable archeological evidence are found during construction, the same will be immediately reported to the relevant instititutions and the Ministry of culture, accordfing to the Law on Protection of Cultural Heritage (O.G. No.20/04, 71/04, 115/07, 18/11, 148/11, 23/13, 137/13, 164/13, 38/14 and 34/14);

## 7.11 Transboundary impact of Vardar River

Vardar River flows into the North Aegean Sea as Axios river in Greece. Axios is also one of the most important transboundary rivers in Greece, mainly because of the use of waters for irrigation in the fertile plain of Thessaloniki. The river forms a very rich ecological delta (protected RAMSAR site) before discharging into the Bay of Thermaikos.

The integrity Axios basin ecosystem depends on the quality of water that enters from Macedonia. Yearly average flow of Vardar River in Skopje is 57.7m$^3$/s; whilst in Gevgelija, on the Greek border, it is 145m$^3$/s.

Considering the rapid implementation of the WWTP projects in Macedonia in the biggest cities located in the Vardar river basin, namely Gostivar, Tetovo, Skopje, Veles, Kavadarci, Bitola, Prilep and Gevgelija, the quality of Vardar River at the border with Greece will be improved, thus providing positive effects also for the greek side.




**Picture 38. Republic of Macedonia, borders, and Vardar River**

## 7.12 Risk cases

Generally, the occurrence of incidents and impacts is related to the following sources of risks:

- Seismic risk;
- Flood risk;
- Risk from improper handling of materials;
- Risk from fire;
- Impacts in Case of environmental accidents.

**Seismic risk**

The future wastewater treatment plant is located in an area where the expected seismic intensity for a 500-year return period is of 9 degrees in accordance with MCS Based on the seismic map of Macedonia, the different structures of WWTP are located in a highly seismic area and should be designed to withstand the strongest expected earthquake intensity.

According to the Macedonian standard, the civil structures of Wastewater Treatment plants in Skopje are categorized in two separate categories II and III. The first one, category II, concerns the structures where it is expected human activities whilst category III concerns the tanks and equipment.

In case of significant soil seismic degradation, the water contained in the tanks, and elsewhere in the Plant can be spilled around affecting soil and groundwaters.

**Flood risk**

During the last century in Skopje valley were registered floods from 1916 – 1979. The biggest flood is registered in 1962 and the flow assessed at 1310 $m^3/s$, and the floded area was 6751 ha.

The flood in 1979 floded 7550ha and the registered flow was 980$m^3/s$.

Critical flooding points

Based on the hydraulic calculations of the flow rate of the river bed and experience from previous flood events, several critical points where flood may occur are detected, namely:

- Cut section near Taor village – Gazi Baba Municipality – Vardar River

Due to the low flow rate backwater flow occur and the water level raises thus posing serious threat for perforation of the left protection embankment. During 1979 flood at this profile the registered flow was 60$m^3/s$, that is significantly less than waters flowing to Vardar river. The water diference outflows and it was accumulated in Skopsko Pole.

- Left bank of the trial section and bridge of the classification yard Trubarevo

Due to the unfinished left river bed melioration works and low flow capacity rate of the bridge, there is a possibility for replication of the 1979 flood.

The land allocated to the project is prone to floods from possible overflowing of the Vardar river. The flatness of the site is also adding difficulties for securing an adequate drainage of the storm water runoff flow to the watercourse. Levels for 1,000 and 300-year return floods of the Vardar River, as well as the corresponding flows which have been recorded, are presented in the table below:

Table 3 Vardar river flood levels and corresponding flows

| Flood return period | Flood level | Flow |
|---|---|---|
| 300 years | + 233.30m a.s.l. | 1,420 $m^3/s$ |
| 1,000 years | + 235.00m a.s.l. | 1,694 $m^3/s$ |

Control works along the upstream section of the river and its tributaries, including the provision of water storage reservoirs for various purposes, are supposed to decrease flood risks appreciably.

The construction of treatment facilities on adequately sized and compacted earth fill is selected as flood protection solution. Compacted fill will be provided all over the plant, as a plateau, to enhance stormwater drainage and flood protection considering the 1000-year returns period.

**Risks from fire**

As a preventive measure for the project, activities related to protection and rescue from fire, explosion and dangerous substances will be implemented. Appropriate assesment of possible threats to the human helth and safety will be carried out. Besides, the organizational structure will be defined and a set of operational procedures for implementation of the measures for protection and rescue from fire, explosion and dangerous substances will be prepared and strickly followed.

During the construction phase the impact may occure due to: improper handling of machinery, welding activities, spontaneous combustion of stockpiled waste, and incidents/disturbance on the public gasline. However, during the construction phase the impact is not large as the construction is not related with dangerous and flammable materials.

The main risk is related to the biogas line generated from the digestor. Each improper handling or mistake during the operation is related to certain level of risk.

**Measures**

The contractor should follow the standards and requirements stipulated in the following national legislation:

- Law on protection and rescue consolidated version (“Official Gazette” of RM No.93/12).
- Law on storage and protection from flammable liquids and gasses (“Official Gazette” of RM No.15/76)
- Ordinance for implementation of the measure for protection and rescue from fire, explosion and hazardous substances, (“Official Gazzete” of RM No.100/10).
- Rulebook for fire protection measures, explosions and hazardus substances (“Official Gazette” of RM No.32/11).
- Rulebook on technical norms for hydrant network for fire extinguishing (“Official Gazette” of RM No.31/06).
- Rulebok for equipment and protection systems intended for use in potentional explosive atmosphere, (“Official Gazzete” of RM No.64/06).

During the construction phase following fire reduction measures are recommended:

- Where necessary the high and dry vegetation from working spots should be removed.
- Use of fire extinguish equipment placed on the site during construction.
- In case of welding preventive measures are necessary.

**Operational phase**

Due to the low flash point of the biogas, the biogas circuit and buildings have to be submitted to an ATEX study which will establish the necessary precautions to be taken in order to limit fire risk in case of biogas leak or release.

A fire detection and alarm system within WWTP buildings will consist of a fire alarm and alert panel, audible alarms (horns) and break glass units. Additionally, in places where a fire may lead to substantial damage, smoke detectors will be installed at the ceiling level of the area. The fire alarm system will be controlled continuously and will have extendible features, to allow for phase 2 extension and for process changes.

Electrical instalations will be specified as anti-explosive.

Beside the general direction for fire management based on the law, it is of utmost importance to provide regular trainings related to: fire protection, management of the biogas system, preparation and implementation of the standard set of working procedures, use of fire protection systems.

**Risk from improper management of materials**

The risk impacts from improper management of materials may affect the environment in any way. During the construction the material is related to construction activities. Following materials will be used: finished concrete mass, asphalt, oils and lubricants. Improper handling and management may produce certain impacts and the same will be significant at the location due to the vicinity of Vardar River. Considering that concrete and asphalt material is not prepared on the site negative impacts are not expected. Besides, repairements or keeping the mechanization for a longer period at the location including storage of fuels or other dangerous supstances is not an option.

**Measures**

The existence of standard operational procedures during the operation of the WWTP and incineration means high professional level of work. This includes procedures and activities related to management of different processes in the treatment facility. The personal should be informed about the standard operational procedures, scheduled trainings and clearly placed notifications and warnings in the facility. Timely and adequate response in case of disaster depends on the instruction provided in emergency procedures, including: identification of all risks, establishing priorities and delegation of responsibilities to persons to be engaged during the accidents.

**Impacts in Case of environmental accidents**

Possible spillage of untreated wastewater in the recipient or soil in the vicinity of the plant caused by power supply outage, major failures of equipment, or shut down of the individual facilities.

In order to avoid untreated wastewater discharge in the event of power outages, a stand by generator with sufficient capacity to ensure emergency operation is provided. By pass line with adequate capacity will enable disconnecting of individual facilities in case of failure or shut down.

Sludge treatment in case of failures of the parts of the treatment line.

Outages of some of the equipment may occur during the operation of the Plant, due to periodical maintenance, or other reasons of stoppage. In such case, the Plant has to operate without a need of storage of sludge surplus.

No storage of sludge is envisioned in the Plant, other than quantities under treatment.

The technical solution of the Plant is such that whenever failures are existent in the bio digester, dryers, or incinerator, the delivery of sludge to these parts is blocked by the steering and controlling system, SCADA and PLCs.

The biogas cogeneration units are designed to handle the entire average biogas production. However, in case one or several engines are not available or out of order, biogas must be burnt in a low elevation hidden flame flare. This avoids discharging methane gas into the atmosphere.

Due to $CH_4$ presence in the digested storage tank, a dedicated safety study will be carried out to determine the required ventilation volume.

**Table 62.Summary table: Description of identified impacts and impact significance**

| Potential influence on environmental components | Sensitivity of receptor | Magnitude of the impact | Impact significance |
|---|---|---|---|
| **Surface and ground water** | **Construction phase** | | |
| | Low | Negligible | Low or no impact |
| | **Operational phase** | | |
| | Low | low | Low |
| **Soil and geology** | **Construction phase** | | |
| | Medium | low | moderate |
| | **Operational phase** | | |
| | Low | low | Low |
| **Air and climate** | **Construction phase** | | |
| | Medium | Low | moderate |
| | **Operational phase** | | |
| | Medium | Low | moderate |
| **Noise** | **Construction phase** | | |
| | Medium | Medium | Moderate |
| | **Operational phase** | | |
| | Low | Negligible | Low |
| **Waste generated** | **Construction phase** | | |
| | Low | Low | Low |
| | **Operational phase** | | |
| | Low | Negligible | Low/negligible |
| **Biological diversity** | **Construction phase** | | |
| | Heigh | Medium | Moderate or heigh |
| | **Operational phase** | | |
| | Low | Medium | Low or moderate |
| **Landscape and visual effects** | **Construction phase** | | |
| | Medium | Medium | Moderate |
| | **Operational phase** | | |
| | Low | Negligible | Low/no impact |
| **Material assets** | **Construction phase** | | |
| | Low | Low | Low |
| | **Operational phase** | | |
| | Low | Negligible | Low/no impact |

### Environmental monitoring

Environmental monitoring will be required to manage the effectiveness of the mitigation measures and to report to the regulatory authorities. Most if not all avoidable adverse impacts from the construction and operation of the WWTP in the City of Skopje can be prevented through sound environmental management.

An environment-monitoring plan has been developed for managing environmental as well as health and safety issues associated to the project.

### Project Construction Phase

The most severe environmental impacts of any development occur during the construction stage. The construction environmental management plan will contain on-site guidelines for contractors specifying appropriate construction practices pertaining to the following:

- Occupational health and safety hazards;
- Generation of dust from excavated soil and air borne cement particles;
- Generation of noise by machinery and other equipmwnt used at the site;
- Carrying off of materials (excavated soil, construction wastes and materials) by surface water run off;
- Generation and disposal of solid waste.

### Project Operational Phase

The operation of the proposed developments will be guided by environmental management systems. Environmental plans will be developed for all entities of the township. In addition, each precinct head will be responsible for implementation of these plans. The main focus in developing these plans will be on:

- Energy conservation;
- Water conservation;
- Minimising waste generation;
- Waste disposal;
- Sewage treatment;
- Occupational health and safety hazards that workers may be exposed to
- Preventive maintenance;
- Emergency response planning.

### Monitoring of wastewater and sludge

Responsibility of the WWTP operator for monitoring of wastewater, including sludge is defined in the Rulebook on the methodology, reference measurement methods, manner and parameters for monitoring of wastewater, including sewage sludge from the treatment of urban waste water (O.G. No.108/11).

At the WWTP facility, testing of samples are performed evenly on flow or time, during 24 hourly distance, from the same marked spot at the entrance of the plant. If needed and in order to establish the achieved reduced loading (%), in the same manner measurements at the entrance of the plant may be performed.

Minimal number of samples on annyal level are provided in the Rulebook on the requirements for collection, disposal and treatment, the manner and conditions for design, construction and exploitation of systems and plants for purification of urban waste waters, as well as technical standards, parameters standards and emission standards for quality of pre-treatment, disposal and purification of waste waters, taking into account the load and the method of treatment of urban waste waters discharged into sensitive area of discharge of urban waste water (O.G. No.73/11).
The WWTP for Skopje is equipped with automatic monitoring. Test results will be delivered in a manner provided manner provided in the Rulebook on the transmission of information from the monitoring of wastewater discharged, and the form and content of the form for submission of data (O.G. No.108/11).

Maximum number of samples that may exceed the limit values for $BOD_5$ and COD provided in the rulbook on urban wastewater are provided - Annex 1.

Extreme values of the wastewater should not be considered if they are result of unusual situation such as intensive rains.

Wastewater generetaded from flue gas treatment will be measured in line with the Rulebook on emission limit values during waste incineration and combustion proces, conditions and manner of work for installations for incineration and combustion (O.G. No.123/09).
Emissions from stationary sources will be measured in line with the Rulebook on methodology, manners, procedures, methods and means to measure emissions from stationary sources (O.G. No.11/12).
Permissible emission levels and type of pollutans in waste gases and vaporous emitted from stationary sources into air is regulated with the Rulebook on limit values for permissible emission levels and types of pollutants in waste gases and vapours emitted from stationary sources into the air (O.G. No.141/10).

# 8 ENVIRONMENTAL MONITORING PROGRAM

| Receptor/Parameter to be controlled | Monitoring requirements | Manner of monitoring | Frequency of monitoring | Reason for monitoring | Responsibility |
|---|---|---|---|---|---|
| PREPARATORY PHASE | | | | | |
| Review of the management plans and prepared check lists | In the premises of the contractor and relevant institutions | Review of the documents | Prior to commencement of construction activities | Enabling Smooth project implementation – in line with the national and EU requirements | City of Skopje, MEPP State Inspectorate |
| Issued permits and approvals | In the premises of the contractor /contractor | Visual review | Prior to commencement of construction activities | Cross checking of the issued documents to confirm that all requirements are in line with national/EU legislation | City of Skopje, MEPP State Inspectorate |
| CONSTRUCTION WORKS | | | | | |
| Implementation of measures provided in the management plans | At the Project site and its surrounding | At the location review of the reports, cross checking , activities and measures | On daily basis – Contractor and audit – once per month. | Appropriate project implementation and timely implementation of the mitigation measures proposed in the EMP in line with national and EU standards | Contractor, Audit, City of Skopje, MEPP State Inspectorate |
| Implementation of measures stipulated in the EMP – operational phase | At the project site and its surrounding | At location – review reports, check lists ) | Monthly | Control of the WWTP system efficiency and environmental protection | City of Skopje, Selected operator in cooperation with the state environmental inspectorate and municipal environmental inspectorate |

| Receptor/Parameter to be controlled | Monitoring requirements | Manner of monitoring | Frequency of monitoring | Reason for monitoring | Responsibility |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| SURFACE AND GROUND WATERS | | | | | |
| CONSTRUCTION PHASE | | | | | |
| Measurement of the surface water quality, pH, flow, turbidity, dissolved oxugen and other parameters | Upstream and downstream points of the river Vardar where main construction activities will be implemented | Sampling and laboratory analysis of physical and chemical water characteristics | Once prior to commencement of construction activities, than once per month or in a shorter period of time if necessary. | Identification of sources of pollution, evaluation of the impact and and implementation of mitigation measure. | Contractot/sub-contractor, monitored by City of Skopje and MEPP State Inspectoratye |
| Measurement of the quality and ground water level | At the location of the WWTP at different distances from Vardar river | Laboratory analysis of samples collected with piezometer | Once per month | Analysis and documentation of the ground water regime in the project area. Identification of pollution sources | Contractor/sub-contractor |
| OPERATIONAL PHASE | | | | | |
| Quantity and quality of the inlet wastewater BOD, COD, SS, pH, $NH_4$- N, $NO_2$-N, $NO_3$-N, $N_{вк}$, $P_{вк}$, Haevy metals, organic matters turbidity etc. | At the entrance point of the WWTP | Monitoring with adequate equipment and laboratory analysis | In line with the national requirements (twice per month) | Documenting the status of the wastewater at the entrance point | WWTP Operator |
| Quantity and quality of the effluent BOD, COD, SS, pH, $NH_4$- N, $NO_2$-N, $NO_3$-N, $N_{вк}$, $P_{вк}$, Haevy metals, organic matters turbidity etc. , | Downstream from the outlet point of the effluent discharge | Sampling and laboratory analysis | Once prior to commencement data of the WWTP. Once per month during the operation or if necessary more frequent checking | Documenting the status of Vardar River prior to the commencement date; Regular control of the water quality to address improvement or problerms during the operational phase. | WWTP operatior and State Environmental Inspectorate |
| Receptor/Parameter to be controlled | Monitoring requirements | Manner of monitoring | Frequency of monitoring | Reason for monitoring | Responsibility |

| | | | | | |
|---|---|---|---|---|---|
| Measurement of the ground water quality and level | At the location site at different distances from Vardar river | Laboratory analysis | Once per month | Documenting the status of ground water and implementation of the envisaged mitigation measures in the EMP | WWTP operatior and State Environmental Inspectorate |
| SOIL AND GEOLOGY | | | | | |
| CONSTRUCTION PHASE | | | | | |
| Soil condition in regard to engineering and geology processes | At the site locations affected (by erosion, landslide, etc0 as defined in geotechnical and hydro technical investigations and on sites where stored earth is placed | Following the measures and recommendations provided in the geotechnical documentation and visual monitoring during the construction phase | On a daily basis during construction and during preparatory and construction activities and immediately after heavy rain | Implementation of measures that will provide stability and and protection of the soil and minimization of eventual geological processes | Contractot/sub-contractor, monitored by City of Skopje and MEPP State Inspectorate |
| Soil pollution | Contaminated soil at location | Soil sampling and laboratory analysis | During the construction phase indication | To avoid further pollution and to protect public health | Contractot/sub-contractor, monitored by City of Skopje and MEPP State Inspectorate |
| Quality and soil condition | All storage points for chemicals , fuels and waste Points | Visual control | Monitoring on daily basis during preparatory and construction phase. Regular laboratory analysis in case of incidents | Documenting the status of the soil and implementation of the envisaged mitigation measures in the EMP | Contractot/sub-contractor, monitored by City of Skopje and MEPP State Inspectorate |
| OPERATIONAL PHASE | | | | | |
| Soil pollution caused by uncontrolled discharges | All points for storage of chemicals, fuel, waste and sludge and spillage of wastewater | Visual control | Regular laboratory analysis in case of accidents and spillage | To avoid soil pollution from different sources and pollution of surface and ground water | WWTP operator in cooperation with relevant institutions |
| Receptor/Parameter to be controlled | Monitoring requirements | Manner of monitoring | Frequency of monitoring | Reason for monitoring | Responsibility |

| | | | | | |
|---|---|---|---|---|---|
| AIR AND CLIMATE | | | | | |
| CONSTRUCTION PHASE | | | | | |
| Dust and exhausted gases in the ambient area | At the limits of the construction site and in the vicinity of the site. | Visual control of the working conditions and used construction practices on the site<br><br>Measurements of dust and exhausted gases in the ambient air | Daily visual control during preparatory and construction phase ,<br><br>Once per month | To comply with the standards for air quality and minimization of the impacts on sensitive receptors. | Contractor/Audit, city of Skopje, MEPP |
| OPERATIONAL PHASE | | | | | |
| Unpleasent small from the treatment processes of water and sludge. | Athe WWTP boundaries and around the boundaries | Appropriate laboratory analysis and monitoring .using tests to define the sensitivity toward odor. | Continuously | Documenting the status of the dispersion of odour and implementation of mitigation measures | WWTP Operator and the relevant institutions and environmental inspectors |
| NOISE AND VIBRATION | | | | | |
| CONSTRUCTION PHASE | | | | | |
| Level of noise and vibration | At the location and in the surrounding. | Appropriate measurement equipment | According to the national legislation – once per month If subsequent monitoring prove that there is no exceedance of the limit values measurements will be done as needed . | To reduce the noise and vibration level from construction activities. Compliance with relevant standards | Contractor, Audit, MEPP, City of Skopje, environmental inspectorate |
| Receptor/Parameter to be controlled | Monitoring requirements | Manner of monitoring | Frequency of monitoring | Reason for monitoring | Responsibility |

| | | | | | |
|---|---|---|---|---|---|
| OPERATIONAL PHASE | | | | | |
| Level of noise and vibration | At the location and in the surrounding. | Appropriate measurement equipment | According to the national legislation. If levels of noise and vibration are below limit values , monitoring will be done once per year | Reduction of levels of noise and vibrations from the operation activities for WWT and compliance with national/EU standards | WWTP operator , Audit, MEPP, City of Skopje , environmental inspectorate |
| BIODIVERSITY | | | | | |
| CONSTRUCTION PHASE | | | | | |
| Terestrial and aquatic flora and fauna, habitats | Monitoring will be provided at the location site near the protected area Ostrovo. Monitoring will be provided along the Vardar river | Monitoring will be defined in line with the Valorization existing valorization report and in close cooperation with the entity responsible for management of the protected area | Frequency will be defined in cooperation with the entity responsible for management of the protected area Ostrovo | To provide efficient protection of the biodiversity | Contractor, Audit. MEPP, City of Skopje, Municipality of Gazi Baba , entity responsible for management of the protected area |
| OPERATIONAL PHASE | | | | | |
| Terestrial and aquatic flora and fauna, habitats | Monitoring will be provided at the location site near the protected area Ostrovo. Monitoring will be provided along the Vardar river | Monitoring needs and methodology will be defined based on the consultations prior to the construction phase | Frequency will be defined in cooperation with the entity responsible for management of the protected area Ostrovo | To provide efficient protection of the biodiversity | WWTP Operator in cooperation with MEPP, and the entity responsible for management of the protected area Ostrovo. |

| Receptor/Parameter to be controlled | Monitoring requirements | Manner of monitoring | Frequency of monitoring | Reason for monitoring | Responsibility |
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| LANDSCAPE AND VISUAL EFFECTS | | | | | |
| CONSTRUCTION PHASE | | | | | |
| Landscape characteristics Construction activities, storage of materials and waste , | Whole area | Visual control | On a daily basis during the construction phase | To provide efficient protection of the landscape | Contractor, Audit, MEPP, City of Skopje , environmental inspectorate |
| WASTE | | | | | |
| CONSTRUCTION PHASE | | | | | |
| Waste management | Whole area | Visual control , review of the documents and plan for waste management | On the daily basis | To provide efficient waste management practices | Contractor, Audit, MEPP, City of Skopje , environmental inspectorate |
| OPERATIONAL PHASE | | | | | |
| Waste management | Whole area | Visual control , review of the documents and plan for waste management | Periodically during the operational phase | To provide efficient waste management practices | WWTP Operator |
| Sludge quantity and content of dry matters, heavy metals pH | Primary and secondary settler during the digestion process and at the exit point of stabilized sludge | Appropriate measurement equipment and laboratory analysis | Once per month | Documenting the status of the sludge treatment and compliance with the environmental standards | WWTP Operator. MEPP State Inspectorate |
| POPULATION | | | | | |
| CONSTRUCTION PHASE | | | | | |
| Review of the qualifications of workers to be included in this project | Contractor premises | Documents review | Prior to construction activities | Determine the need for qualified and experience staff for implementation of the project | Contractor |

| Receptor/Parameter to be controlled | Monitoring requirements | Manner of monitoring | Frequency of monitoring | Reason for monitoring | Responsibility |
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| Management plan for the WWTP Skopje | Contractor premises | Documents review | Prior to construction activities | To cover all aspects of the construction prior to the start up of the construction activities. | Contractor |
| Safety and Health Plan including a mechanizam for complaints | Contractor premises | Review of documents | Prior to commencement of construction activities | Health protection provided to workers on the site and local inhabitants and protection of material goods | Contractor |
| Public informations related to the time frame for implementation of construction activities as part of the WWTP Construction plan | Review of documents, arhive documents and on site activities | Prepared list of communicated people, Photos , media | Each 3 months during the construction phase | Determine whether all stakolders are informed and communicated | Contractor |
| Training on safety and helth issues for the employed staff вработените | Contractor premises | Photos, materials provided | At the beginning of the construction phase | Determine whether all workers obtain adequate knowledge | Contractor |
| Specific trainings related to handling of flammable, explosive materials and chemical /biological agens | Contractor premises | Photos, materials provided | At the beginning of the construction phase | Determine whether all responsible persons at construction sites are introduced with methods, techniques and training needs | Contractor |
| Secured construction site and visible warning signs | On site | Photos of location | Monthly | Reduced health and safety threats to local population and workers | Contractor |