[English translation. Original Summary is in Ukrainian]

Enabling Transboundary Cooperation and Integrated Water Resources Management in the Dniester River Basin

Research on the Current State of Tailings Storage Facilities in the Dniester River Basin

SUMMARY
ON TAILINGS STORAGE FACILITIES INVENTORY IN THE DNIESTER RIVER BASIN

Kyiv – 2020

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Acknowledgements for significant contribution at the first stage of the project:
Dr. Hryhorii Shmatkov, Dr. Serhii Chumachenko, Dr. Kateryna Okhotnyk.

The research on the current state of Tailings Storage Facilities (TSFs) in the Dniester River Basin was carried out in the framework of the GEF/ UNDP/ OSCE/ UNECE project "Enabling Transboundary Cooperation and Integrated Water Resources Management in the Dniester River Basin" (hereinafter "the GEF Project"). The project beneficiary is the Ministry of Environmental Protection and Natural Resources of Ukraine.

The project expresses its sincere gratitude for support of the project activities and assistance in research to representatives of state authorities: Mykola Kuzio (Deputy Minister for European Integration, the Ministry of Environmental Protection and Natural Resources of Ukraine), Roman Mykhailiuk (Head of the Dniester Basin Water Administration), Liliia Hrychulevych (Head of the Basin Water Administration of the Black Sea Rivers and the Lower Danube), Volodymyr Bilokon (Project Manager for Sustainable Use of Water Resources, Reform Support Team, the Ministry of Environmental Protection and Natural Resources of Ukraine), and representatives of TSF operators.

This Summary presents the main findings of the research, which are set out in detail in the Reports for each company – TSF operator.

The list of references to the data sources used in the research (company documentation, state registers, information system data, regulations, etc.) is provided in the Reports that is available upon the request.

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SUMMARY TARGET AUDIENCE

The recommendations of the research are intended to be presented to TSF operators and competent authorities of Ukraine: Ministry of Environmental Protection and Natural Resources of Ukraine, State Emergency Service of Ukraine, State Agency of Water Resources of Ukraine, Dniester Basin Water Administration, State Environmental Inspectorate of Ukraine, State Labor Service of Ukraine, Verkhovna Rada Committee on Environmental Policy and Nature Management, Regional State Administrations (Department of Ecology and Department of Civil Protection), local governments (district, city, village councils); and competent authorities of the Republic of Moldova.

The developed measures to maintain TSF safety are divided into two categories:

- measures recommended for implementation by TSF operators (Section II and Subsections 1-11 for each company)
- legislative and regulatory, organizational recommendations for competent authorities (Section V).

The developed recommendation package is designed to systematically improve the level of environmental and technogenic safety, prevent accidents, and reduce the risks of water pollution in the transboundary Dniester River Basin. The proposed recommendations can be used in the drafting of the Dniester River Basin Management Plan (RBMP) and other relevant programs in the region.

The prevention of transboundary water pollution in the event of TSF accidents should become an important part of the Dniester RBMP. This issue was recommended for consideration by the Joint River Commission as the responsible agency for intergovernmental cooperation between Ukraine and the Republic of Moldova – the Commission on Sustainable Use and Protection of the Dniester River Basin (the Dniester Commission)[1].

The purpose of this Summary is, first of all, to inform competent authorities and international organizations about the existing hazards of TSF operation in the Dniester River Basin as well as to call for considering the opportunities and resources to prevent environmental disasters of national and transboundary scale through the "state-business" interaction

[1] The Dniester Commission web-site

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LIST OF ABREVIATIONS

ALEP – Accident Localization and Elimination Plan

BWA – Basin Water Administration

CHPP – combined heat and power plant

CJSC – Closed Joint Stock Company

CMU – Cabinet of Ministers of Ukraine

CPS – Cluster Pump Station

CPS-2 ND – Cluster Pump Station 2 North Dolyna

DBN – State construction codes of Ukraine

DPSIR – analytical framework to describe interaction of the society and the environment (Driver – Pressure – State – Impact – Response)

DSTU – State Standard of Ukraine

EIA – Environmental Impact Assessment

EU – European Union

GEF – Global Environment Facility

GTI – group technological installation

HS – hydraulic structures

LLC – limited liability company

MAC – maximum allowable concentration

OGPD – Oil And Gas Production Department

OJSC – Open Joint Stock Company

OPPS – oil preparation and pumping shop

OR – Oil Refinery

OSCE – Organization for Security and Co-operation in Europe

PJSC – Private Joint Stock Company

RBMP – River Basin Management Plan

SE – State Enterprise

SES of Ukraine – State Emergency Service of Ukraine

pHMWB – preliminary heavily modified water body

SMW – solid municipal waste

SPE – Scientific and Production Enterprise

SWB – surface water body

TPP – thermal power plant

TSF – tailings storage facility

UkrCPRI – Ukrainian Civil Protection Research Institute

UNDP – United Nations Development Programme

UNECE – United Nations Economic Commission for Europe

WDF – Waste Disposal Facility

INTRODUCTION

TSFs are the facilities of potentially hazard for water resources of Ukraine – these are earthen reservoirs, natural or artificially made in the natural environment, for industrial waste disposal which is transported from its production sites mainly by hydraulic means through pipelines and stored in a liquid, sludge- and paste-like state.

When any TSF system fails, the liquid component of the waste penetrates the protective functions of the enclosing structures, comes out and causes destruction. The most large-scale accidents occurred at TSFs of a mining company in Brumadino, Brazil (2019), Ridder Mining and Processing Plant "Kazzinc" LLC, Kazakhstan (2016), Talvivaara in Finland (2012), an aluminum production sludge storage facility in Colontar, Hungary (2010), and a storage facility in Baia Mare, Romania (2000)[2].

Fig. 1. The moment of the tailings dam failure, Brazil, 2019. Photo: The Guardian News, video snapshot

In Ukraine, TSF accidents occurred at the extractive and chemical company "Polimineral" (1983), the potassium plant in Kalush (2008) causing industrial waste escape into the Dniester River, and at the TSF of the alumina plant near Mykolaiv (2001), with the spread of fine-waste particles (red dust) across dozens of square kilometers[3].

The international community has been making significant efforts to improve TSF safety. The legal framework for measures to reduce the risk of transboundary water pollution as a result of industrial accidents is laid down in two UNECE treaties, namely: the Industrial Accidents Convention[4] and the Water Convention[5]. The conventions promote cross-border cooperation in the field of sustainable use of water resources, prevention of industrial accidents, as well as preparedness and response to such accidents.

[2] Based on the website materials of the "The Global Tailings Review" initiative and the document "Safety Guidelines and Good Practices for Tailings Management Facilities"
[3] The accidents are stated in the "Methodology for Comprehensive Evaluation of Tailings Management Facilities Safety".
[4] Full title "Convention on the Transboundary Effects of Industrial Accidents"; the information is posted on UNECE website
[5] Full title "Convention on the Protection and Use of Transboundary Watercourses and International Lakes", the information is posted on the UNECE website

Thus, in 2008, within the framework of these Conventions, the Joint Expert Group on Water and Industrial Accidents, with support of the UNECE Secretariat, developed "Safety Guidelines and Good Practices for Tailings Management Facilities"[6] (hereinafter "the UNECE Guidelines") updated in 2014.

From 2013 to 2017 two international projects were implemented in Ukraine to develop and test the "Methodology for Comprehensive Evaluation of Tailings Management Facilities Safety" (hereinafter "the Methodology") based on the UNECE Guidelines, with financial support from the German Environment Agency[7] and leading experts in the area[8]. And starting 2019, the International Commission for the Protection of the Danube River has been implementing the international project "Improving the Safety of Tailings Management Facilities in the Danube River Basin" using the developed Methodology[9].

Following a large-scale TSF accident in Brazil in 2019, that same year the UN Development Program, International Council on Mining and Metals, and Principles for Responsible Investment initiated the development of a "Global Industry Standard on Tailings Management" aimed at preventing catastrophic accidents at such facilities[10].

TSFs are complex structures with long-term functionality, exposed not only to the natural environment, but also to many socio-political and economic factors (for example, policies of nearby companies and local authorities, quality of legislative regulation and methodological support, allocation of responsibilities in case of emergencies, human factor, etc.). Thus, **TSF management is a dynamic, complex, and interconnected system that requires a comprehensive "state-business" approach for environmental protection from the devastating consequences of accidents throughout TSF entire life cycle.**

[6] Safety guidelines and good practices for Tailings Management Facilities
[7] Umweltbundesamt (UBA)
[8] 2013-2015 project "Improving the Safety of Tailings Management Facilities Based on the Example of Ukrainian Facilities". 2016-2017 project "Raising Knowledge among Students and Teachers on Tailings Safety and Its Legislative Review in Ukraine"
[9] Information is on the ICPDR website
[10] More information at Global Tailings Review website

ABOUT THE PROJECT

The issue of TSF environmental safety should be considered both nationally and internationally in terms of the potential threat posed by such facilities. The national part is related to the continuous accumulative environmental impact due to long-term storage of waste containing toxic substances and its potential impact in case of accidents. The likely transboundary impact of such facilities poses hazard to the neighboring countries. An accident or pre-emergency state of facilities can cause the escape of toxic waste substances into transboundary rivers. One of such rivers is the Dniester River flowing through two countries – Ukraine and the Republic of Moldova.

As of 2019, there are 465 TSFs storing over 6 bln tons of waste from various industries[11] of Ukraine (Fig. 2).

Violation of TSF operation rules causes large-scale accidents with uncontrolled emissions of pollutants. Due to the anthropogenic pressure on the quantitative and qualitative status of surface and groundwater, TSFs are categorized as sources of water body pollution, namely:

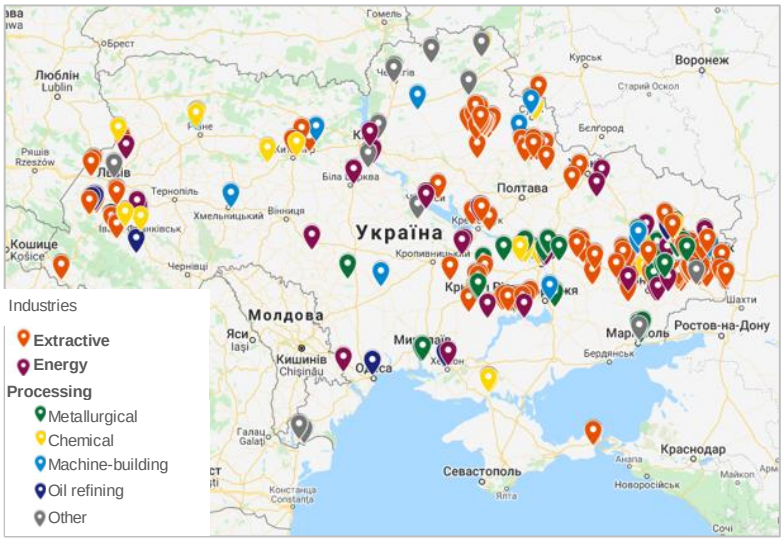

Fig. 2. Map of the Tailings Storage Facilities in Ukraine

- **point sources of surface water pollution with hazardous substances[12]** – in the case of drainage or return waters discharge from a TSF
- **sources of accident-induced pollution and impact by contaminated areas[15] on surface and groundwater** – in case of structures' integrity failure.

The **research of TSFs in the Dniester River Basin** was performed during 2018-2020 under the GEF/ UNDP/ OSCE/ UNECE project "Enabling Transboundary Cooperation and Integrated Water Resources Management in the Dniester River Basin". The study included TSF identification and inventory.

[11] Identification of 465 TSFs in Ukraine was carried out within the framework of this GEF Project supported by the Ministry of Environmental Protection and Natural Resources of Ukraine. Data sources: information received from the State Regional Administrations (2018-2019). The database and the map of the TSFs in Ukraine were submitted to the GEF Project beneficiary – the Ministry of Environmental Protection and Natural Resources of Ukraine

[12] The term is in accordance with the "Procedure for Development of the River Basin Management Plan", approved by the Cabinet of Ministers of Ukraine Resolution No. 336 of 18 May 2017 and "Guidelines for determining the main anthropogenic pressures and their impacts on the status of surface waters"

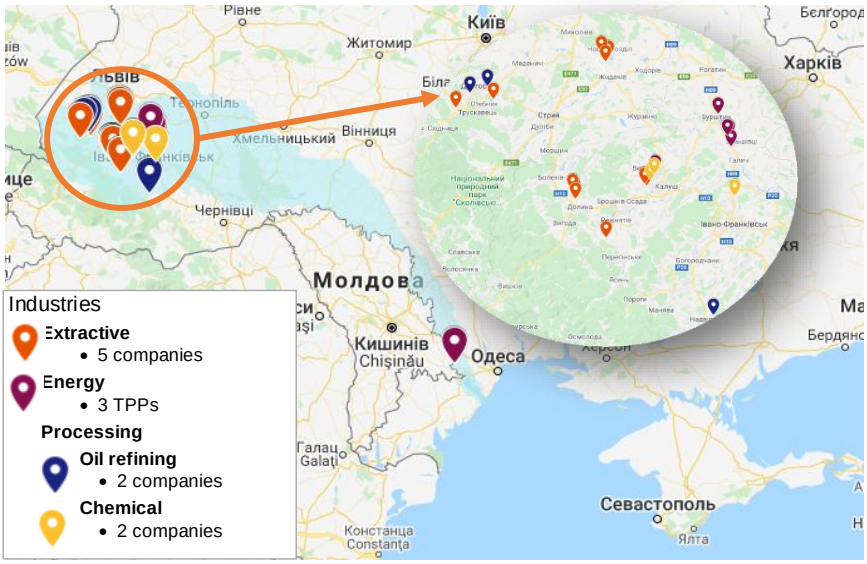

Fig. 3. Tailings Storage Facilities in the Dniester River Basin The river basin boundaries are marked in blue

The Dniester River Basin area covers the territories of 7 Regions of Ukraine – Lviv, Ivano-Frankivsk, Chernivtsi, Ternopil, Khmelnytskyi, Vinnytsia, and Odesa Regions, with companies of various industries.

The study identified 32 TSFs with 162 mln tons of waste in the Dniester River Basin, which are owned by 12 companies.

According to the administrative-territorial allocation, the facilities are located in the Ivano-Frankivsk, the Lviv, and the Odessa Regions (Fig. 3). **The list of TSFs in the Dniester River Basin is provided in Annex 1.**

In-depth TSF inventory was conducted through observations – site visits, visual inspections, and analytical work – data analysis of companies documents and staff interviews, using European methodological tools:

- The "Methodology for Comprehensive Evaluation of Tailings Management Facilities Safety"[13] (an adapted version was used, according to the requirements of Ukrainian legislation)
  - based on the provisions of the UNECE document "Safety Guidelines and Good Practice for Tailings Management Facilities"[14].
- Guidelines for Determining the Main Anthropogenic Pressures and their Impacts on the State of Surface Waters[15]
  - developed in the framework of implementing basin-specific European approaches to integrated water resources management[16].

In result of the TSF inventory 11 reports were prepared for each operator of the 31 TSFs in the Dniester River Basin[17].

[13] The "Methodology for Comprehensive Evaluation of Tailings Management Facilities Safety" in English is posted on the German Environmental Protection Agency (UBA) website.
[14] The "Safety Guidelines and Good Practices for Tailings Management Facilities" is published on the UNECE website.
[15] The Guidelines were approved by Protocol No. 2 at the Scientific and Technical Council meeting of the State Water Agency of Ukraine on 27 November 2018
[16] Common Implementation Strategy for the Water Framework Directive (2000/60/EC). Guidance document No. 3. Analysis of Pressures and Impacts. Available in English
[17] The companies that did not provide sufficient openness in cooperation with the GEF Project:
- PJSC "Barva" Fine Organic Synthesis Plant refused to cooperate with the project
- SD Burshtyn TPP of JSC DTEK Zakhidenergo refused to provide documentation, but agreed the site visits to the TSFs
- PJSC NPK-Galychyna did not provide the permission on visual inspection of one TSF identified during the research

This Summary presents the consolidated overview of the TSF research and includes 11 sections for each company with the following information:

- amount and hazard class of the waste stored, toxic effects of the substances contained in waste
- TSFs location in relation to the hydrographic network with determination of the nearest surface water bodies (SWB)
- natural conditions in TSF location territory as the main external hazard drivers during their operation (of a climatic, hydrological, geological, and seismic nature)
- TSF safety assessment with identification of significant non-compliances that require relevant response, in particular:
  - ensuring proper TSF operation
  - conducting systematic control and monitoring of the current facilities state
  - proper closure of inactive TSFs and rehabilitation of disturbed lands
  - TSF emergency preparedness of the companies
  - maintenance of operational records.

Following a comprehensive study of the anthropogenic pressures posed by TSFs on water bodies, an expert opinion was provided on TSFs as potential sources of SWB pollution and sources of impact by contaminated areas. The result is shown in the analytical scheme: "Driver – Pressure – State – Impact – Response"[18] **(Annex 2)**.

In expert opinion, the SWBs in the Dniester River Basin, listed in the table below, are at risk of failing to achieve environmental goals[19] due to pressure and potential accident impact posed by TSFs.

[18] According to the "Guidelines for determining the main anthropogenic pressures and their impacts on the status of surface waters", approved by Protocol No. 2 at the Scientific and Technical Council meeting of the State Water Agency of Ukraine on 27 November 2018

[19] The term is in accordance with the "Guidelines for determining the main anthropogenic pressures and their impacts on the status of surface waters"

Table 1. SWBs in the Dniester River Basin, that are under the pressure by TSFs

SWB ID	SWB name	SWB ID	SWB name	SWB ID	SWB name
UA_M5.2_0006	the Dniester River	UA_M5.2_0151	the Klodnytsia River	UA_M5.2_0375	the Hnyla Lypa River
UA_M5.2_0007	the Dniester River	UA_M5.2_0281	the Lushchava River	UA_M5.2_0376	Burshtyn Reservoir
UA_M5.2_0089	the Tysmenytsia River	UA_M5.2_0309	the Syvka River	UA_M5.2_0377	the Hnyla Lypa River
UA_M5.2_0090	the Tysmenytsia River	UA_M5.2_0310	the Kropyvnyk River	UA_M5.2_0432	the Vorona River
UA_M5.2_0097	the Ratochyna River	UA_M5.2_0311	the Frunyluv River	UA_M5.2_1114	Kuchurhan Reservoir
UA_M5.2_0099	the Slonytsia River	UA_M5.2_0359	the Duba River	UA_M5.2_1115	the Kuchurhan River

Fig. 4. GEF Project activities: site visits, working meetings

The joint events with Moldovan party of the GEF Project were organized in the framework of the TSF research: visit to ones of the most emergency-state TSFs in the Dniester River Basin (July 2019, Kalush), visit to the Ash-and-slag Storage Facility located in the Transnistrian segment of the Ukrainian-Moldovan border (October 2019, Odesa Region). Interim results of the TSF inventory in the Dniester River Basin were presented to all the parties of the GEF Project at the workshop on TSF safety (January 2019, Kyiv) and at the Second Meeting of the Dniester Commission (April 2019, Kyiv)[20].

Fig. 5. Cross-border cooperation – joint activities organized by the Ukrainian party of the GEF Project

[20] Publication on the Dniester Commission website

I. OVERVIEW OF THE POLICY ON EMERGENCY PREVENTION AND RESPONSE AT TAILINGS STORAGE FACILITIES

A complex of special facilities and equipment for accumulation of large amounts of industrial waste, explosiveness and toxicity of the substances contained in this waste pose hydrodynamic, fire, chemical and environmental hazards. These types of hazards can cause accidents that will lead to escape of pollutants into surface and groundwater, including to the transboundary Dniester River, given the hydrographic network of the facilities' location. This can result in poisoning of the natural environment components, flooding, destruction of residential and industrial buildings and transport infrastructure elements.

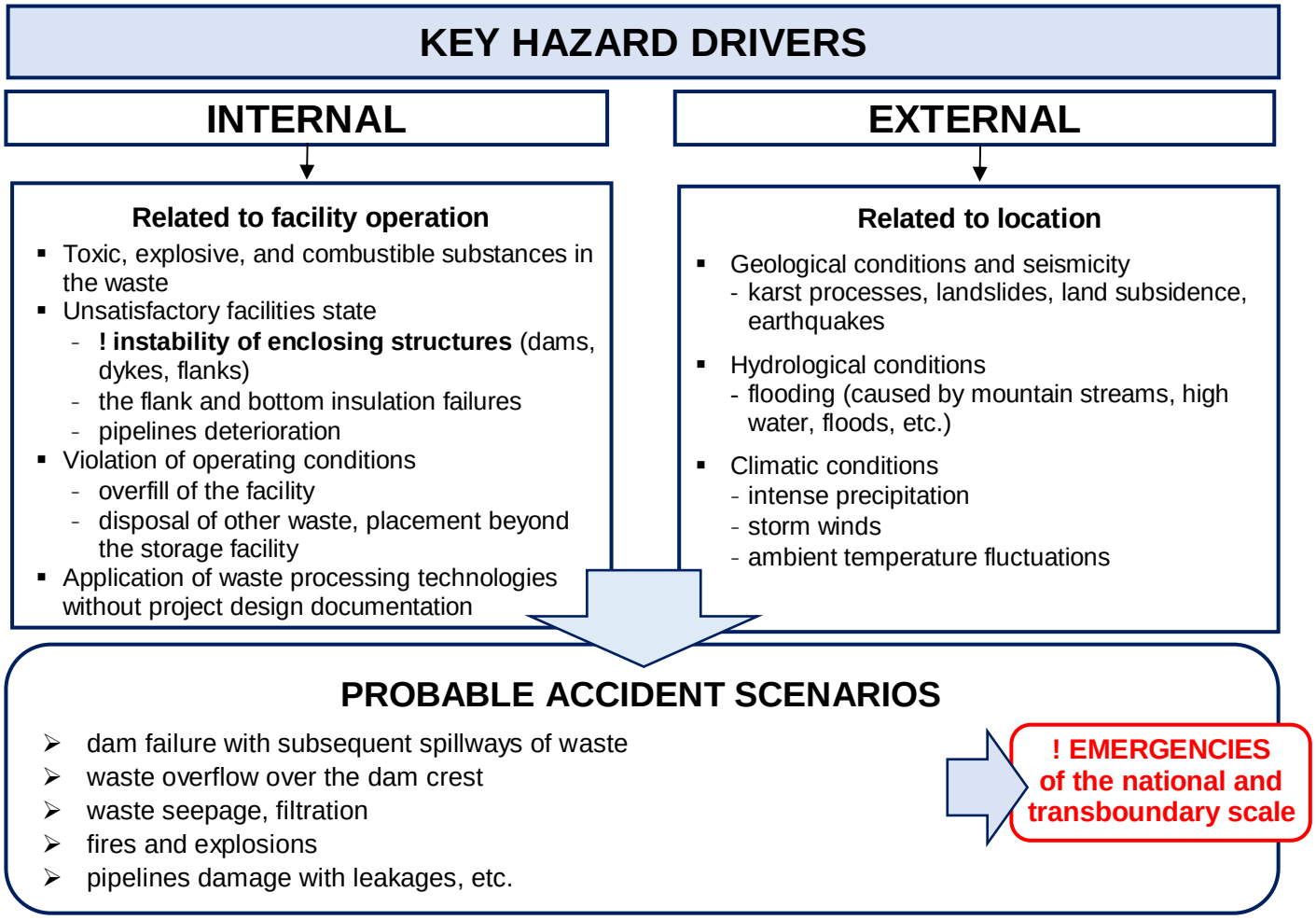

Fig. 6. Main hazard drivers of TSF operation[24]

[21] The chart was formed using the terms set forth in the "Methodology for Identification of Potentially Hazardous Facilities" approved by the Ministry of Emergency of Ukraine Order No. 98 dated 23.02.2006 and "Regulation on Certification of Potentially Hazardous Facilities" approved by the Ministry of Emergency of Ukraine Order No. 338 dated 18.12.2000

The indications of unsatisfactory structures' condition and operation of TSFs containing toxic substances revealed during the research testify to **internal hazard drivers**, which in combination with **external hazard drivers** – proximity to water bodies and hazardous natural phenomena – significantly increase the risk of accidents of various scale.

Accidents at TSFs can cause multi-million losses, and the cost of responding the consequences of accidents almost invariably exceeds the cost of ensuring proper facility safety and development of emergency prevention and response measures[22].

During the research on the current state of TSFs in the Dniester River Basin, TSF operators' internal emergency planning was reviewed. The analysis of the operational documentation showed that the companies are not prepared for accidents at such potentially hazardous facilities as TSFs.

The company emergency response documentation (accident localization and elimination plans, emergency response plans) does not take into account all the existing potential hazards with consideration of probable accident scenarios at TSFs, and such Plans have not been developed at all at some companies (see section Inventory results for each company).

Thus, the emergency preparedness of the companies in the Dniester River Basin area where TSFs are located is unsatisfactory. It is necessary to determine the list of possible emergencies at TSFs taking into account the natural features of the area and the facilities' safety level, including risk analysis of such accidents. Operational documentation must clearly define the personnel actions. Special attention should be paid to assessing the consequences of possible accidents for the environment, developing appropriate response measures, and measures to prevent accidental transboundary water pollution.

External emergency response planning is carried out by executive authorities and local governments and includes development of Emergency Response Plans at the level of Ukraine, industry, region, city, district, business entity (Emergency Response Plans)[23].

Also, for each region as an administrative-territorial unit, a "Technogenic and Natural Emergencies Risk Passport" is drawn up and maintained. According to the Passport form provided in the document "Interim Procedure for Passportization of Territories regarding Technogenic and Natural Emergencies Risks"[24], such a passport should contain, inter alia, information on TSFs that characterizes the regions' technogenic hazard, including estimates of the probable flooding area, number of communities and population in the probable catastrophic flooding area, as well as facility's problematic issues.

[22] For more information see the UNDP Report 2017 "Mine Tailings Storage: Safety Is No Accident"
[23] Per Art. 130 of the Civil Protection Code of Ukraine and the Procedure for Development of Activity Plans for the Integrated State Civil Protection System approved by the Cabinet of Ministers Resolution No. 626 dated 9 August 2017
[24] Approved by the Order of the Ministry for Emergency Situations and Affairs of Population Protection Against Consequences of Chornobyl Accident dated 24.09.2007, No. 659 "On Improving Passportization of Territories for Emergency Risks"

In December 2018 the GEF Project sent **request letters to the territorial bodies of the State Emergency Service (SES) of Ukraine** within the framework of the research on the current state of TSFs in the Dniester River Basin: Main Department of SES of Ukraine in the Lviv Region and Department of SES of Ukraine in the Ivano-Frankivsk Region. Request on **sharing information about TSFs**:

- "Technogenic and Natural Emergencies Risk Passports" in the Ivano-Frankivsk and the Lviv Regions, and
- "Potential Hazardous Facility Passports" for the companies in the Ivano-Frankivsk and the Lviv Regions, which own TSFs.

The above documents were not provided in response to the requests. The official response of the Main Department of the SES of Ukraine in the Lviv Region provides general information about the Region's TSFs without explaining the reasons for absence of the requested documents. No official response has been received from the Department of the SES of Ukraine in the Ivano-Frankivsk Region.

The SES of Ukraine implements the State Policy of Emergency Prevention and Response, including organization of **methodological support for** emergency planning. Discussions by the GEF Project parties of the practical planning issues and the results of the review of the "Guidelines for Development of Civil Protection Plans" (Ukrainian Civil Protection Research Institute, 2015) identified the shortcomings of the existing methodological approaches. There are gaps in the following areas during the preparation of the relevant Emergency Response Plans and Accident Localization and Elimination Plans at High-Risk Facilities (ALEP):

- **consideration of all the probable accident scenarios, including:**
  - **external and internal hazard drivers during TSF operation**
  - **flood risk assessment in case of an emergency (modelling of the dam failure or overflow scenario)**
  - **domino effect**
- **prevention of accidental transboundary water pollution.**

It is necessary to improve the methodological approaches of all the probable accident scenarios consideration and taking into account the issues related to prevention of accidental transboundary water pollution. This will help both competent authorities (central and local executive bodies, local governments) and TSF operators (as business entities) to develop their emergency response plans.

Prevention of transboundary water pollution should be a mandatory component of the emergency response planning. To date, this aspect is insufficiently reflected at the national legislative level based on the comparative analysis of the relevant national and European standards[25] using the "Checklist for

[25] The analysis of the requirements to consider the aspect of transboundary water pollution was performed in the framework of the "Research of the Donbas TSFs Current State and Their Possible Emergency Impact on Water Bodies under the Military Actions", the project of the OSCE Project Coordinator in Ukraine "Assistance in the Donbas Environmental Monitoring System Expansion", 2019

Contingency Planning for Accidents Affecting Transboundary Waters (for Competent Authorities)"[26]. Industrial accidents at TSFs can lead to pollution of transboundary rivers, including the Dniester River. Therefore, given Ukraine's intention to accede to the UNECE Convention on the Transboundary Effects of Industrial Accidents[27], it is advisable to take into account the issues related to prevention of accidental transboundary water pollution both in legislative acts and in the guidelines to increase the efficiency of emergency planning, response and interaction of the neighboring countries.

It is necessary to emphasize the importance of joint and coordinated emergency planning between Ukraine and the Republic of Moldova. In 2006-2008, in the framework of the international project "Transboundary Risk Management in the Dniester River Basin", a draft document "International Plan for Hazard Prevention and Warning in the Dniester River Basin" was developed. This document is intended for installation of emergency notification system in case of accidental water pollution in the Dniester River Basin. This draft document, as well as international experience in other river basins[28], can be used as a basis for further development and implementation of the emergency notification system by the Dniester Commission, which is the responsible body for intergovernmental cooperation between the Republic of Moldova and Ukraine in the area of protection, sustainable use, and development of the Dniester River Basin.

Also, the Conference of the Parties to the Convention on the Transboundary Effects of Industrial Accidents introduced the UNECE Industrial Accident Notification System[29] in 2000, through which countries, including Ukraine, can report such accidents and receive information from other countries, regularly publish updates, as well as request (mutual) assistance in case of any accidents (not only transboundary).

Industrial accidents at TSFs can pose devastating transboundary effects. Thus, the key elements of improving the emergency prevention and response policy in the Dniester River Basin include the interaction between the civil defense authorities and the business entities, and transboundary emergency response planning by the neighboring countries.

[26] Checklist for contingency planning for accidents affecting transboundary waters (for competent authorities). Posted on the UNECE website

[27] The Draft Law of Ukraine "On Ukraine's Accession to the Convention on the Transboundary Effects of Industrial Accidents" was published on 23 April 2019 on the SES of Ukraine website in the section "Electronic Public Consultations"

[28] For example, a draft Joint Emergency Response Plan in the Danube Delta region for the Republic of Moldova, Romania, and Ukraine was developed under the "Project on Hazard and Crisis Management in the Danube Delta" (2011-2015)

[29] United Nations Industrial Accident Convention's Notification System website. The system is accessible to each communication point of a registered country. The information and instructions on using the system are available at the link

II. RESULTS OF TSF INVENTORY IN THE IVANO-FRANKIVSK REGION

TSF operators

1. **Oriana-ECO LLC**
2. **Karpatnaftokhim LLC**
3. **State Enterprise Kalush Combined Heat and Power Plant-Nova**
4. **PJSC Naftokhimik Prykarpattia**
5. **Dolynanaftogaz Oil and Gas Production Department of PJSC Ukrnafta**
6. **Burshtyn Thermal Power Plant Separate Division of JSC DTEK Zakhidenergo**

1. Oriana-ECO LLC

Oriana-ECO LLC is an extractive industry company on potassium-magnesium ores extraction and enrichment located in the Kalush District of the Ivano-Frankivsk Region. The company owns **three TSFs – facilities of the research, and the Dombrovskyi Quarry**.

Since 2001, TSF operator has not been pursuing its main business activity – extraction of mineral raw materials for the chemical industry and production of mineral fertilizers. The TSFs are inactive.

Three TSFs store 26 mln m^3 of potassium-magnesium ore extraction and enrichment waste – brines represented by sodium, magnesium, and potassium chlorides and sulfates. The Dombrovskyi Quarry is filled with 22 mln m^3 of brines. Proper closure of the facilities and rehabilitation of disturbed lands have not been done. The waste hazard class has not been identified and there is no waste passportization and accounting. The substances contained in waste are characterized by toxic effects, mainly due to their irritating properties. This can be manifested in reduced hydrobionts population and species composition, increased respiratory and digestive diseases, and mineral metabolism disruption in the human body.

Fig. 7. Location of Oriana-ECO TSFs relative to the hydrographic network

The shortest distance from the TSFs to water bodies: 1.15 km from the Syvka River SWB (UA_M5.2_0309, UA_R_16_M_2_Si) – a right tributary of the Dniester River, 60 m from the Kropyvnyk River SWB (UA_M5.2_0310, UA_R_16_S_2_Si) – a left tributary of the Syvka River, and 530 m from the Frunyluv River SWB (UA_M5.2_0311, UA_R_16_S_2_Si; Fig. 7). Linear hydrographic network of the TSFs location: the Frunyluv River – the Kropyvnyk River – the Syvka River – the Dniester River. In case of accidents at the TSFs, pollutants can reach the transboundary Dniester River.

The climatic, hydrological, geological conditions and seismicity of the site of Oriana TSFs are considered as the main external natural hazard drivers of TSF operation, namely:

- climatic hazard driver: the site of the TSFs is the humid zone with significant amount of precipitation that can aggravate the dam erosion, seepage and washing of salts from the TSFs and adjacent territories with inevitable escape of toxic waste into water bodies
- hydrological hazard driver: the TSFs are located within the boundaries of the river with a potential flooding ability (based on the preliminary assessment of the flooding risks of the Dniester River Basin area)
- geological hazard driver: the Kalush-Holyn deposit belongs to the areas of modern karst process activation, which poses a threat of waste entering the voids during land subsidence under the TSFs
- seismicity of the area: the TSFs are located in a seismically hazardous area (the background seismic intensity is 7 points[30]). This can adversely affect the stability of TSF dams and other structures, which in turn increases the risk of accidents.

Fig. 8. Aerial photo of the TSF location area, the closest in the picture is TSF 1, then TSF 3 and TSF 2

[30] The DSTU B.V.1.1-28 scale for average soil conditions and 5% probability of exceeding the regulatory seismic intensity over 50 years (Map ZSR-2004-B). According to DBN B.1.1-12: 2014. Construction in seismic areas of Ukraine. State Construction Codes of Ukraine

The location area of the TSFs suffers from a combination of negative changes in the natural environment, which are studied and well known to industry experts and public authorities. In 2010, by the Decree of the President of Ukraine No. 145/2010 of 10.02.2010 and the Law of Ukraine on its approval No. 1885-VI of 12.02.2010, the Kalush area was officially declared an “environmental emergency zone” for 90 days. In pursuance of this Decree, the Cabinet of Ministers of Ukraine approved the relevant Program and List of Urgent (Priority) Activities and Measures (CMU Ordinance No. 381-r of 02.03.2010). As of 2018, the environmental emergency response measures envisaged at the state level have not been fully implemented.

According to the state monitoring, the excessive concentrations of chlorides and dry residue in the surface water of the Syvka and the Kropyvnyk Rivers and increased concentrations of chlorides in the groundwater are continuously recorded in the area of the TSFs.

The Ivano-Frankivsk Region Development Strategy Implementation Plan for 2015-2017 envisaged the implementation of the project “Development of an Automated System for Remote Monitoring and Forecasting of the Brines Level and Concentration in the Dombrovskyi Quarry and of the Salinization of the Kalush Industrial Area”. The project includes the installation of the operating monitoring wells network. However, as of 2018, the activities have not been performed.

The research on the current state of the three Oriana TSFs in 2018 showed that the facilities operation level does not meet the requirements of the environmental and technogenic safety standards. In particular, the following significant non-compliances have been identified:

- **TSF 1 closure and rehabilitation of disturbed lands was done partially: the land has not been leveled, so precipitation gathers in places of surface roughness, due to this the slopes are exposed to water erosion and there is a brines seepage through TSF dam.**

Fig. 9. Accumulation of precipitation on the surface of TSF 1, July 2018

Fig. 10. The area between TSF 2 and 3. Signs of soil salinization, July 2018

- **a critical filling level and brine seepage through the dam is observed at TSF 2**
- **progressing brines filtration through the dams of TSF 1 and 2. This indicates the integrity failure of the hydraulic structures complex and causes soil, surface and groundwater salinization**
- **TSF 1, 2, and 3 drainage and water discharge systems have been destroyed**
- **there are no warning signs to prevent unauthorized access to the facilities. According to the interview, locals use TSF 3 as a bathing pond**
- **the technical state of all the three TSF structures has not been monitored**
- **no environmental impact monitoring**
- **TSF emergency preparedness of the company is not ensured:**
  - **there is no information on identification and passportization of the TSFs as Potentially Hazardous Facilities**
  - **Emergency Response Plans for the TSFs have not been developed**
- **there are no key safety documents – design documentation, passports of hydraulic structures, passports of waste disposal facilities, monitoring procedures and others.**

Fig. 11. TSF 3. Photo by Google service user Liudmyla Yakoviv, August 2017

Fig. 12. Seepage of salts through the TSF 1 dam, July 2018

The above key non-compliances in the operation of such potentially hazardous facilities need to be addressed to minimize their impact on the environment and to prevent accidents. Relevant recommendations are provided in the section below.

The Dombrovskyi Quarry. Additionally, the visual inspection of the TSFs included a visual observation of a flooded quarry. It is not a standard TSF, thus making it impossible to apply methodological tools to take an in-depth inventory. The visual inspection of the Dombrovskyi Quarry showed a critical filling level and landslides, which are signs of existing active geological processes occurring in the hard rock of the quarry flanks. There is flanks destabilization risk due to the ongoing hydrogeological processes in the quarry area. The 2009 project of the Dombrovskyi Quarry and TSFs 1 & 2 conservation[31] indicates the surface and groundwater inflow into the quarry. The quarry washing out by the Syvka River, whose bed was artificially diverted during facility construction , combined with the influence of the underground aquifer, increase the water flow pressure on the quarry flanks.

The natural conditions of the facility site, listed at the beginning of this section, pose a risk of intense precipitations, flooding by river waters and seismic hazard to the quarry. All these processes decrease stability of the quarry flanks and develop cracks. This in turn can lead to brine coming out through the destroyed flanks, which are natural barriers and retain brines inside the pond, with disastrous flooding of the surrounding area and escape of contaminants into the hydrographic network of the transboundary Dniester River.

Fig. 13. The Dombrovskyi Quarry, landslides, July 2018

[31] Conservation project of the Dombrovskyi Quarry with reclamation of external Dumps 1, 4 and TSFs 1, 2. OJSC “Mining and Chemical Industry Institute”, OJSC “Oriana” SE “Potash Plant”. Lviv, 2009

The expert opinion on the possibility of the Dombrovskyi Quarry technogenic hazard reduction was formed based on the interviews, document review and visual inspection. The most efficient way to prevent a large-scale accident due to the quarry flanks failure is to reduce the internal pressure of the fluid on the quarry enclosing structure, namely brines removal from the quarry pond. The options may include the brines reprocessing or reuse for industrial purposes, for example, in the oil extracting industry for well plugging. Or other ways reducing the quarry fluid volume.

Fig. 14. Aerial photo of the Dombrovskyi Quarry, July 2018

The results of the “Methodology for Comprehensive Evaluation of Tailings Management Facilities Safety” application, based on the analysis of the visual observation, staff interviews, and documentation analysis, showed a most unsatisfactory level of ensuring proper operation of the TSFs (Table 2) – the compliance with the safety criteria is below 50% in all the categories.

Table 2. Results of the categorial evaluation of Oriana TSFs operation

No.	Category	Safety criteria compliance level, %			Category significance (critical – extremely important)[32]
		TSF 1	TSF 2	TSF 3	
I	Geological, climatic and local conditions	38.6	47.4	31.6	non-critical
II	TSF location plan	22.9	35.4	16.7	non-critical
III	Substances (waste volume and toxicity)	41.0	41.0	30.8	critical
IV	Dam and screens	17.3	34.5	29.8	critical
V	Transport and infrastructure	9.5	9.5	9.5	critical
VI	Water flow management	6.7	6.7	3.7	critical
VII	Environmental Impact Assessment	17.5	17.5	14.3	critical
VIII	Emergency Response Plan	10.2	20.4	10.2	critical
IX	Monitoring	0.0	0.0	0.0	critical
X	Training and personnel	0.0	0.0	0.0	non-critical
XI	Verification and reporting	23.0	36.8	9.2	non-critical
XII	Closure and rehabilitation	28.2	28.2	28.2	critical
Overall result		**17.9**	**23.1**	**15.3**	–

As of 2018, Oriana-ECO LLC has not been pursuing its main business activity, resulting in lack of financial, technical and human resources to properly manage such potentially hazardous facilities as TSFs and a quarry. The company has a growing debt to reimburse preferential pensions for the previous periods and the rent for the land under the waste storage facilities from past production.

The list of TSF operation non-compliances identified during the research and the measures to maintain the facilities safety are provided in the Report in the tabular form according to the pattern: “identified non-compliance” – “legislative criteria” – “corresponding recommendation”. Below are provided the recommendations, the implementation of which is critical for safe operation of the TSFs.

[32] Critical categories are extremely important TSF safety categories, which relate mainly to technical aspects of facility operation and safety maintenance. Detected non-compliances with the safety requirements in these categories require mandatory urgent action. Non-critical categories relate to issues mostly concerned with documentation management and reporting, and the facility personnel qualification level

Measures recommended for implementation by Oriana-ECO LLC

1. **Address the emergency condition of TSFs 1, 2 and 3, take action to prevent escape of waste to the environment and further pollutants migration into water bodies**
   - 1.1. Restore drainage and water discharge systems of three TSFs
   - 1.2. Closure of TSF 1 and full rehabilitation of disturbed lands
   - 1.3. Restore dams integrity of TSFs 1 & 2 to eliminate the progressing brines filtration and consider the technical possibilities of arranging the following at the facilities:
     - protective screens and a surface cover, a drainage system
     - emergency reservoirs for waste capture
   - 1.4. Install the appropriate warning signs in the area of the TSFs (“danger zone”, “unauthorized passage and entry prohibited”, “no swimming”)
2. **Perform regular control and monitoring of the TSFs current state**
   - 2.1. Perform regular visual and instrumental observations
   - 2.2. Regularly monitor the environmental impact of the facilities, in particular arrange the monitoring wells network to control the groundwater level and pollution, and the quality of surface water and soils
   - 2.3. Perform control checks of the hydraulic structures readiness for safe operation during floods and autumn/winter periods at least twice a year
   - 2.4. Perform scheduled survey and passportization of the hydraulic structures at least once every three or five years (depending on the facilities construction class)
   - 2.5. Perform the regular survey of the TSFs at least once a year
3. **Ensure the company’s emergency preparedness at the TSFs**
   - 3.1. Develop Emergency Response Plans for three TSFs in accordance with the regulatory requirements, including consideration of all the probable accident scenarios and flood risk assessment in case of an emergency (modelling of the dam failure or overfill scenario of the TSFs)
   - 3.2. Perform identification and passportization of the TSFs as Potentially Hazardous Facilities in accordance with the current legislation requirements
4. **Ensure the maintenance of the operational documentation for the TSFs**
   - 4.1. Develop documentation on facilities operation
     - operating manual
     - Hydraulic Structure Passports for the TSFs, and

Measures recommended for implementation by Oriana-ECO LLC

- ensure availability of technical documentation with the design parameters of the TSF structures

4.2. Develop documentation on waste management

- Waste Passports with definition of the composition, properties, and hazard class of the waste stored in the TSFs
- Passports for the Waste Disposal Facilities
- Waste Management Plans
- Procedure for environmental monitoring of the TSFs, and
- ensure statistical reporting on waste management.

5. In expert opinion, the best way to prevent the anthropogenic pressure posed by inactive TSFs of Oriana-Eco LLC on the SWB in the Dniester River Basin is the maximum recycling of accumulated waste, further closure of the TSFs and rehabilitation of disturbed lands

2. Karpatnaftokhim LLC

Karpatnaftokhim LLC is a major industrial company for production of petrochemical and chemical products. It is located near the Kalush town, Ivano-Frankivsk region, in the area of the Kalush Mining Complex (Fig. 15). The company owns **two TSFs**: a sludge storage facility of hypochlorite effluents treatment (in this Summary the term is “TSF 1”[33]), and a sludge storage facility of industrial water treatment (in this Summary the term is “TSF 2”[34]).

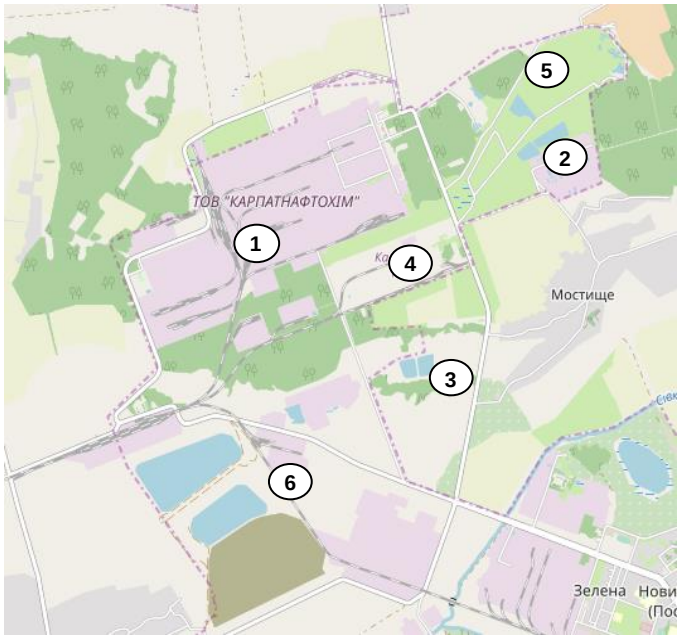

Fig. 15. Company layout map. Legend: 1 – Karpatnaftokhim LLC site, 2, 3 – Karpatnaftokhim TSFs, 4 – Kalush Combined Heat and Power Plant-Nova site, 5 – TSF of Kalush Combined Heat and Power Plant-Nova, 6 – three TSFs of Oriana-ECO

The company was established in 2004 on the basis of OJSC Oriana property complex. KARPATY CHEMICAL B.V., the Netherlands, is the only member of the company. The business entity resumed its production in 2017, after a downtime since 2012. Main products: ethylene, propylene, benzene, C9 fractions (a mixture of hydrocarbons), polyethylene, caustic soda, and polyvinyl chloride suspension. Karpatnaftokhim LLC provides the drinking and industrial water to its own production and to the organizations and business entities of Kalush town. The company treats its return water (industrial and household) at a full-cycle biological treatment complex and discharges it into the Dniester River.

The total amount of waste as of 2018 in TSF 1 was **836.658 tons** and in TSF 2 – **9,189.635 tons**. The structures’ filling level is 10% of the design volume. The hypochlorite wastewater treatment sludge is composed of water (80%), copper and nickel hydroxides, and clay. The industrial water treatment sludge consists of dry residue, solid phase – aluminum and iron hydroxides, calcium oxide, silicon dioxide, the rest being water (98%). TSF 1 contains decomposed hypochlorite wastewater, which is characterized by high alkali content and poses a risk of chemical burns on exposed parts of the human body. Sodium hypochlorite is an active disinfectant with high antibacterial activity; at the same time, when in contact with water bodies, it interacts with other substances and disrupts trophic connections in aquatic ecosystems.

[33] Full title of the facility: Sludge storage facility of the Neutralization and Treatment of Industrial Wastewater Shop
[34] Full title of the facility: Sludge storage facility of the Water Supply and Sewerage Shop

TSF 1 is located in 1.1 km from the SWB of the Kropyvnyk River (UA_M5.2_0310, UA_R_16_S_2_Si) and 750 m from the Sapohiv stream. TSF 2 is located in 200 m from the Frunyluv River (UA_M5.2_0311, UA_R_16_S_2_Si) and 80 m from the Kropyvnyk River, the distance to the bypass canal flowing into the Kropyvnyk River is 50 m (Fig. 16). Linear hydrographic network: the Frunyluv River – the Kropyvnyk River – the Syvka River – the Dniester River. In case of accidents at the TSFs, pollutants can reach the transboundary Dniester River.

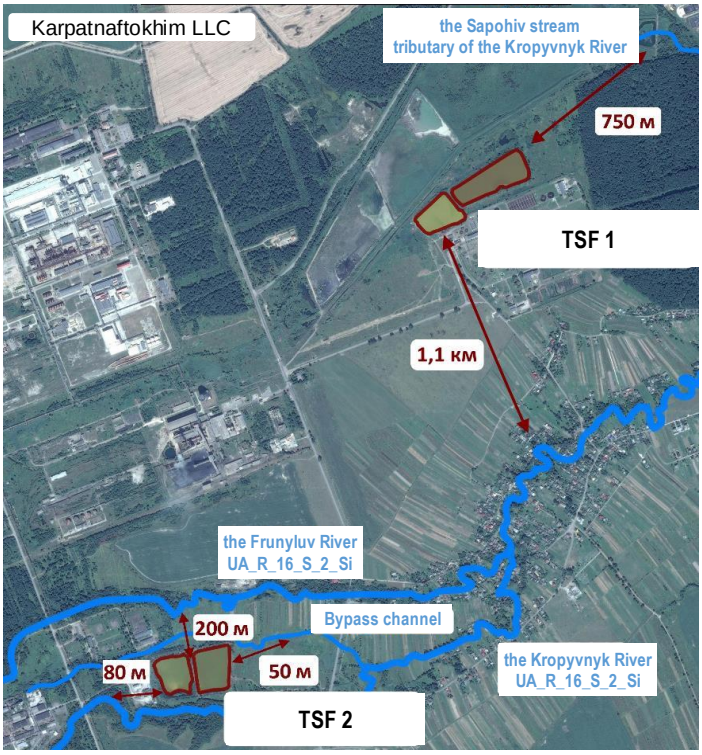

Fig. 16. Location of Karpatnaftokhim TSFs relative to the hydrographic network

The climatic, hydrological, geological conditions and seismicity of the site of Karpatnaftokhim TSFs are considered as the main external natural hazard drivers of TSF operation, namely:

- climatic hazard driver: the area of the TSFs is the humid zone with significant amount of precipitation, which may cause overfilling of the facilities, with waste overflowing the dam crest
- hydrological hazard driver: the TSFs are located within the boundaries of the river with a potential flooding ability (based on the preliminary assessment of the flooding risks of the Dniester River Basin area)
- geological hazard driver: the Kalush-Holyn deposit, within the area of which the TSFs are located, belongs to the areas of modern karst process activation, which poses a threat of waste entering the voids during land subsidence under the facilities
- seismicity of the area: the TSFs are located in a seismically hazardous area (the background seismic intensity is 7 points[35]). This can adversely affect the stability of TSF dams and other TSF structures, which in turn increases the risk of accidents.

[35] The DSTU B.V.1.1-28 scale for average soil conditions and 5% probability of exceeding the regulatory seismic intensity over 50 years (Map ZSR-2004-B). According to DBN B.1.1-12: 2014. Construction in seismic areas of Ukraine. State Construction Codes of Ukraine

Fig. 17. TSF 1 of Karpatnaftokhim. View from the TSF of Kalush CHPP-Nova

TSF 1 is located in close proximity to the TSF of Kalush Combined Heat and Power Plant-Nova (hereinafter Kalush CHPP-Nova). This creates preconditions for the domino effect – the probability of occurrence or successive occurrence of accidents at facilities located in close proximity to each other.

The research on the current state of two Karpatnaftokhim TSFs in 2018 showed that **the TSFs, upon visual inspection, were in satisfactory condition, there were no signs of obvious issues and operational violations, but the operation level of the facilities partially fails to meet the requirements of the environmental and technogenic safety standards.** In particular, the following non-compliances were identified:

- **signs of land subsidence near the reserve section of TSF 1, which may indicate a threat of flooding the territory of neighboring treatment facilities**
- **environmental impact monitoring of the TSFs is carried out not in full. In particular the following is missing:**
  - **monitoring of the soils and groundwater quality in the area of TSF 2**
  - **surface water quality monitoring in the location of both TSFs (the Sapohiv stream and the Kropyvnyk River)**
- **TSF emergency preparedness of the company is not fully ensured**
  - **the Karpatnaftokhim Accident Localization and Elimination Plan does not consider accidents at the TSFs**
  - **the Operating Instructions for TSFs describing safety requirements in emergency fail to take into account all the existing TSF potential hazards. For example:**
    - **dam integrity and/or stability failure (breakthroughs, landslides, cracks, washing out, etc.)**
    - **pipeline failure**
    - **fire at the TSF 1 site**
    - **emergencies at nearby facilities/enterprises – the domino effect**

Fig. 18. TSF 1. General view and warning sign [Caution. Poison. Technical reservoir], November 2018

Fig. 19. TSF 2, general view, November 2018

The above key non-compliances in the operation of such potentially hazardous facilities need to be addressed to minimize their impact on the environment and to prevent accidents. Relevant recommendations are provided in the section below.

The results of the “Methodology for Comprehensive Evaluation of Tailings Management Facilities Safety” application, based on the analysis of the visual observation data, staff interviews, and documentation analysis, showed a partially unsatisfactory level of ensuring proper operation of the TSFs (Table 3).

Table 3. Results of categorial evaluation of Karpatnaftokhim TSFs operation (below 50% are highlighted)

No.	Category	Safety criteria compliance level, %		Category significance (critical – extremely important)[36]
		NTIWW shop SF	WSS shop SF	
I	Geological, climatic and local conditions	**33.3**	57.4	non-critical
II	TSF location plan	61.5	84.6	non-critical
III	Substances (waste volume and toxicity)	83.3	96.3	critical
IV	Dam and screens	50.6	87.7	critical
V	Transport and infrastructure	50.0	79.2	critical
VI	Water flow management	**46.4**	59.7	critical
VII	Environmental impact assessment	**25.4**	52.4	critical
VIII	Emergency Response Plan	**30.1**	**31.4**	critical
IX	Monitoring	64.3	**31.0**	critical
X	Training and personnel	**20.4**	**20.4**	non-critical
XI	Verification and reporting	**48.1**	92.6	non-critical
XII	Closure and rehabilitation	58.3	58.3	critical
Overall result		**47.6**	**62.6**	–

The list of TSF operation non-compliances identified during the research and the measures to maintain the facilities safety are provided in the Report in the tabular form according to the pattern: “identified non-compliance” – “legislative criteria” – “corresponding recommendation”. Below are provided the recommendations, the implementation of which is critical for safe operation of the TSFs.

[36] Critical categories are extremely important TSF safety categories, which relate mainly to technical aspects of facility operation and safety maintenance. Detected non-compliances with the safety requirements in these categories require mandatory urgent action. Non-critical categories relate to issues mostly concerned with documentation management and reporting, and the facility personnel qualification level

Measures recommended for implementation by Karpatnaftokhim LLC

1. **Ensure proper operation of the TSFs**
   - 1.1. Inspect the technical state of the TSF 1 structures to identify the threat level of flooding the neighboring treatment facilities and develop appropriate preventive measures
2. **Perform regular control and monitoring of the TSFs current state**
   - 2.1. Regularly monitor the environmental impact of the TSFs. In particular:
     - soils and groundwater quality in the area of TSF 2
     - surface water quality in the location of both TSFs (the Sapohiv stream and the Kropyvnyk River)
   - 2.2. Perform scheduled survey and passportization of the hydraulic structures of two TSFs at least once every three or five years (depending on the facilities construction class)
   - 2.3. Perform the regular survey of two TSFs at least once a year
3. **Ensure the company's emergency preparedness at the TSFs**
   - 3.1. Develop the Emergency Response Plans for two TSFs in accordance with the regulatory requirements, including consideration of all the probable accident scenarios at the TSFs and flood risk assessment in case of an emergency (modelling of the dam failure or overfill scenario of the TSFs)
4. **Ensure the maintenance of the operational documentation for the TSFs**
   - develop a Hydraulic Structure Passport for TSF 1
   - ensure availability of the technical (design) documentation with design parameters of TSF 1
   - update and approve by the head of the company the Hydraulic Structure Passport for TSF 2
   - update Operating Instructions for the TSFs with consideration of all the probable accident scenarios at the TSFs
   - develop Waste Management Plans
5. **In expert opinion, the best way to prevent the anthropogenic pressure posed by the TSFs of Karpatnaftokhim LLC on the SWB in the Dniester River Basin is to ensure proper operation of the facilities, reduce the level of waste production, and search for the ways of maximum recycling of accumulated waste**

3. State Enterprise Kalush Combined Heat and Power Plant-Nova

State Enterprise Kalush Combined Heat and Power Plant-Nova (hereinafter Kalush CHPP-Nova) belongs to power complex companies of the Ministry of Energy of Ukraine. It is located in 4 km from the Kalush town, Ivano-Frankivsk Region, in the area of the Kalush mining complex (see Fig. 15 in the previous section). The CHPP ash-and-slag waste is disposed to a TSF – **the ash-and-slag storage facility** (in this Summary the term is "TSF").

Fig. 20. View of the CHPP site from the ash-and-slag dump, November 2018

The electricity produced at the enterprise is used for its own needs and is supplied to the power system of Ukraine. Thermal energy is supplied to external consumers – Kalush housing and utilities, industrial enterprise Karpatnaftokhim LLC, as well as for its own needs.

The TSF of Kalush CHPP-Nova has been in operation since 1968. As the CHPP operated on gas for a long period, the TSF was not filled with waste until 2013. As of 2018, Kalush CHPP-Nova had accumulated **1.913 mln tons of waste**, IV Hazard Class, of which there were 1.601 mln tons of ash and 0.312 mln tons of fuel slag.

Two sections of the TSF are in operation as of 2018 (slag section and ash section 1), the remaining two sections (emergency section and ash section 2) do not have shaft spillways and a drainage system. The company developed Technical Project Documentation on TSF reconstruction in 2018 to extend the TSF operational lifetime and ensure the proper operational condition of the existing facilities.

The predominant minerals in the ash-and-slag waste are silicon, aluminum, and iron oxides, and in small quantities there are calcium, magnesium, potassium, sodium, and sulfur oxides. The ash slags contain, but in much smaller quantities, heavy metals in the form of low-solubility and insoluble compounds. Such wastes can cause degradation of hydrobionts, flora and fauna, and adversely affect human health. Toxic effects of substances contained in waste are manifested mainly in irritation of mucous membranes, chronic damage of the respiratory tract, and deposition of highly dispersed particles in the lungs, causing delayed pathological changes.

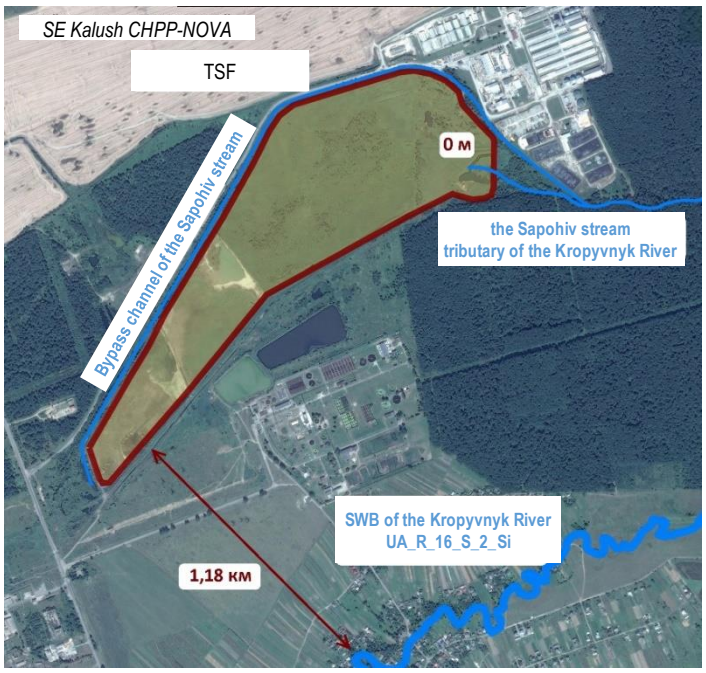

Fig. 21. Location of Kalush CHPP-Nova TSF relative to the hydrographic network

The TSF is located in the floodplain of the Sapohiv stream, which is a tributary of the Kropyvnyk River, and in 1.18 km from the Kropyvnyk River SWB (UA_M5.2_0310, UA_R_16_S_2_Si; Fig. 21). Linear hydrographic network: the Spohiv stream – the Kropyvnyk River – the Syvka River – the Dniester River. In case of accidents at the TSF, pollutants can reach the transboundary Dniester River.

The climatic, hydrological, geological conditions, and seismicity of the site of SE Kalush CHPP-Nova TSF are considered as the main external natural hazard drivers of TSF operation, namely:

- climatic hazard driver: heavy rains that may fall in the area of the TSF can cause dam erosion and overfilling of the TSF if its sections are filled to a critical level
- hydrological hazard driver: there is no the flooding hazard driver – the TSF is located beyond the boundaries of any rivers with a potential flooding ability (based on the preliminary assessment of the flooding risks of the Dniester River Basin area)
- geological hazard driver: the Kalush-Holyn deposit, within the area of which the TSF is located, belongs to the areas of modern karst process activation, which poses a threat of waste entering the voids during land subsidence under the facility
- seismicity of the area: the TSF is located in a seismically hazardous area (the background seismic intensity is 7 points[37]). This can adversely affect the stability of TSF dams and other structures, which in turn increases the risk of accidents.

[37] The DSTU B.V.1.1-28 scale for average soil conditions and 5% probability of exceeding the regulatory seismic intensity over 50 years (Map ZSR-2004-B). According to DBN B.1.1-12: 2014. Construction in seismic areas of Ukraine. State Construction Codes of Ukraine

The TSF of Kalush CHPP-Nova is located in close proximity to the TSF of Karpatnaftokhim, which contains decomposed hypochlorite wastewater (see Section 2 of this Summary). This creates preconditions for the domino effect – the probability of occurrence or successive occurrence of accidents at facilities located in close proximity to each other.

The research on the current state of the Kalush CHPP-Nova TSF in 2018 showed that the facility operation level does not meet the requirements of the environmental and technogenic safety standards. In particular, the following significant non-compliances were identified:

- **abandoned condition of emergen**
  TSF: minor flooding, the
  vegetation
- **dry areas of the ash-and-slag bea**
  poses a threat of ash-and-slag m
  beyond the TSF in the dry season
- **no operational road to ash section**
- **abandoned condition of drainag**
  clarified water and the bypass ch
  cleared up in some places and blo
  capacity is reduced

Fig. 22. Minor flooding in the area of the TSF emergency section

Fig. 23. TSF ash section 1, dry beach area

Fig. 24. Operational road

- **the operational control over the condition of TSF hydraulic structures is not fully performed: there is no test equipment at the facility (piezometers, sedimentary surface marks), thus the instrumental monitoring of dam stability is not performed.**
- **TSF emergency preparedness of the company is not ensured:**
  - **there is no information on identification and passportization of the TSF as a Potentially Hazardous Facility**
  - **the Accident Localization and Elimination Plan of Kalush CHPP-Nova does not consider accidents at the TSF**
  - **The Operating Instruction of the TSF does not contain a TSF emergency response plan**
- **there are no warning signs to prevent unauthorized access to the facility**
- **the operational documentation is maintained with non-compliances: there are no annual "Action Plans to Ensure Reliable Operation of the Ash and Slag Removal and Storage System", Waste Management Plans; the Operating Instruction for the hydraulic ash removal system needs to be supplemented.**

The above key non-compliances in the operation of such a potentially hazardous facility need to be addressed to minimize its impact on the environment and to prevent accidents. Relevant recommendations are provided in the section below.

Fig. 25. Bypass channel of the Sapohiv stream, November 2018

The results of the “Methodology for Comprehensive Evaluation of Tailings Management Facilities Safety” application, based on the analysis of the visual observation data, staff interviews, and documentation analysis, showed a partially unsatisfactory level of ensuring proper operation of the facility (Table 4).

Table 4. Results of categorial evaluation of Kalush CHPP-Nova TSF operation (below 50% are highlighted)

No.	Category	Safety criteria compliance level, %	Category significance (critical – extremely important)[38]
I	Geological, climatic and local conditions	75.4	non-critical
II	TSF location plan	71.1	non-critical
III	Substances (waste volume and toxicity)	94.4	critical
IV	Dam and screens	83.3	critical
V	Transport and infrastructure	92.6	critical
VI	Water flow management	61.7	critical
VII	Environmental impact assessment	61.7	critical
VIII	Emergency Response Plan	**34.6**	critical
IX	Monitoring	**35.4**	critical
X	Training and personnel	**48.1**	non-critical
XI	Verification and reporting	**49.4**	non-critical
XII	Closure and rehabilitation	66.7	critical
	Overall result	**64.6**	–

The list of TSF operation non-compliances identified during the research and the measures to maintain the facilities safety are provided in the Report in the tabular form according to the pattern: “identified non-compliance” – “legislative criteria” – “corresponding recommendation”. Below are provided the recommendations, the implementation of which is critical safe operation of the TSF.

[38] Critical categories are extremely important TSF safety categories, which relate mainly to technical aspects of facility operation and safety maintenance. Detected non-compliances with the safety requirements in these categories require mandatory urgent action. Non-critical categories relate to issues mostly concerned with documentation management and reporting, and the facility personnel qualification level

Measures recommended for implementation by SE Kalush CHPP-Nova

1. **Ensure proper operation of the TSF**
   - 1.1 Conduct the Environmental Impact Assessment of the "TSF reconstruction" activity, for which the Project Technical Documentation was developed in 2018, pursuant to the Law of Ukraine "On Environmental Impact Assessment" (Art. 3, Part 3, Clause 2).
   - 1.2 Ensure the proper operational condition of the existing facilities in accordance with the developed Project Technical Documentation on TSF reconstruction
   - 1.3 Prevent the ash-and-slag mixture spreading and dust carryover beyond the TSF during the dry season: take the necessary dust suppression measures and, as needed, perform additional checks for dust concentration and air pollution in the facility-affected area
   - 1.4 Arrange the operational road to ash section 2 of the TSF
   - 1.5 Clear up the open channel of clarified water and the bypass channel
   - 1.6 Install appropriate warning and prohibiting signs in the area of the TSF: roads to the facility, along the TSF contour and the clarified water pond, along the drainage (filtration) and clarified water channels
2. **Ensure proper operational control over the condition of the TSF hydraulic structures**
   - 2.1 Install the test equipment at the TSF and perform instrumental monitoring
   - 2.2 Regularly monitor the open channel of clarified water and the bypass channel to prevent overgrowth and siltation
3. **Ensure the company's emergency preparedness at the TSF**
   - 3.1 Review and complement the Accident Localization and Elimination Plan of SE Kalush CHPP-Nova with consideration of all the probable accident scenarios at the TSF
   - 3.2 Perform identification and passportization of the TSF as a Potentially Hazardous Facility in accordance with the current legislation requirements
4. **Ensure the maintenance of the operational documentation for the TSF**
   - 4.1 Processing of the operational control materials
     - log records and data analysis
     - compile an annual report with a conclusion on the condition of the hydraulic structures based on the operational control

Measures recommended for implementation by SE Kalush CHPP-Nova

4.2 Develop documentation on facility operation

- annual Action Plans to Ensure Reliable Operation of the Ash and Slag Removal and Storage System
- operational monitoring procedures, and
- supplement the Operating Instruction for the hydraulic ash removal system with information on the procedures for safe operation and emergency response plan of the TSF

4.3 Develop Waste Management Plans

5. In expert opinion, the best way to prevent the anthropogenic pressure posed by the TSF of SE Kalush CHPP-Nova on the SWB in the Dniester River Basin is to ensure proper operation of the facility, reduce the level of waste production, and maximum recycling of accumulated waste

4. PJSC Naftokhimik Prykarpattia

PJSC Naftokhimik Prykarpattia is a former Nadvirna Oil Refinery, one of the oldest oil refineries in Ukraine, located near the Nadvirna town, Ivano-Frankivsk Region. The company owns **two TSFs** – **oil sludge storage facility 1 and oil sludge storage facility 2** (in this Summary the terms are “TSF 1” and “TSF 2”).

The main industrial production of TSF operator was suspended in 2010. According to the staff interviews, the TSFs have not been filled with production waste since that time.

Over more than 50 years of TSF operation (since 1967), the facilities have accumulated **7,468.712 tons of industrial waste:** oil sludge from wastewater mechanical treatment and waste from cleaning of oil and fuel oil tanks. The chemical composition of oil sludge is a mixture of hydrocarbons, mechanical impurities and water, with gas emissions – hydrocarbon vapors. The oil refining waste substances are characterized by strong toxic effects: pronounced mutagenicity and carcinogenicity of aromatic hydrocarbons, narcotic effect – the cardiovascular system and blood parameters effect (decrease in hemoglobin and erythrocytes); liver damage, endocrine disorders, skin irritation and pigmentation are also possible.

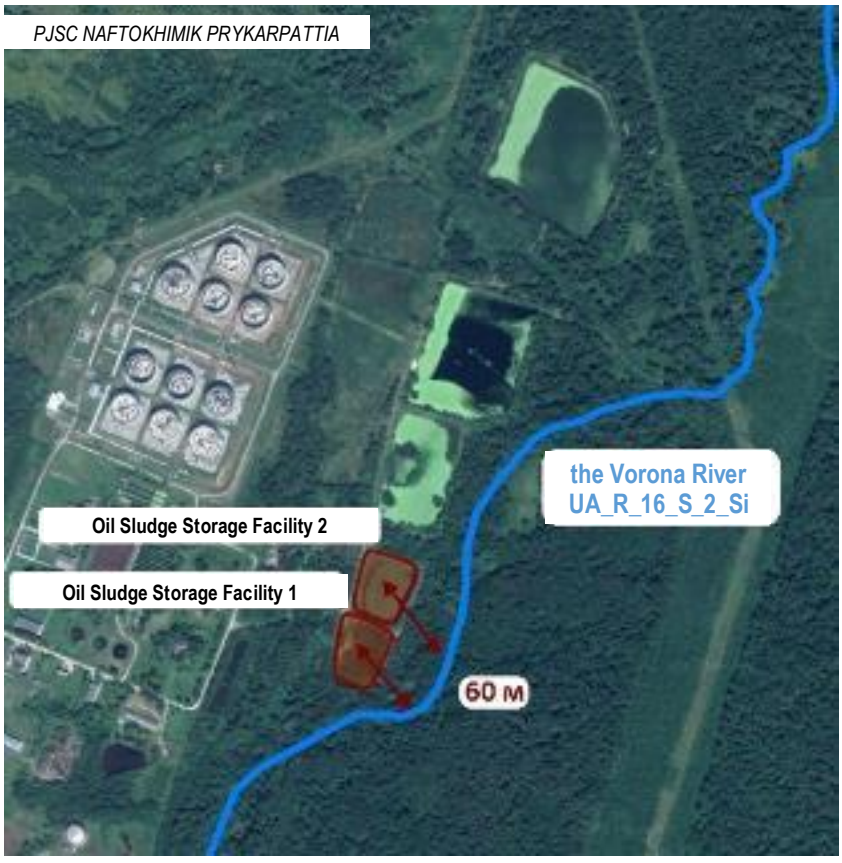

Fig. 26. Location of the Naftokhimik Prykarpattia TSFs relative to the hydrographic network

The TSFs are located in 60 m from the Vorona River (UA_M5.2_0432, UA_R_16_S_2_Si; Fig. 26). Linear hydrographic network: the Vorona River – the Bystrytsia-Nadvirnianska River – the Bystrytsia River – the Dniester River. In case of accidents at the TSFs, pollutants can reach the transboundary Dniester River.

The climatic, hydrological, geological conditions, and seismicity of the site of Naftokhimik Prykarpattia TSFs are considered as the main external natural hazard drivers of TSFs operation, namely:

- climatic hazard driver: the area of the TSFs is characterized by significant amount of precipitation, which may cause overfilling of the TSFs, with waste overflowing the embankment
- hydrological hazard drivers:
  - the groundwater in the TSFs area occurs at a depth of 0.4-0.8 m and is categorized as unprotected (vulnerable to pollution), which causes a risk of toxic waste getting to the aquifer
  - there is no the flooding hazard driver – the TSFs are located beyond the boundaries of any rivers with a potential flooding ability (based on the preliminary assessment of the flooding risks of the Dniester River Basin area)
- seismicity of the area: the TSFs are located in a seismically hazardous area (the background seismic intensity is 7 points[39]). The existing seismic activity can adversely affect stability of the embankment and other TSF structures, which in turn increases the risk of accidents

Research on the current state of two TSFs of Naftokhimik Prykarpattia in 2018 showed that the facilities operation level does not meet the requirements of the environmental and technogenic safety standards. In particular, the following significant non-compliances have been identified:

- **the documentation does not reflect the waste disposal to TSF 2: there are signs of recent waste disposal to the TSF (traces of petroleum products on the facility flanks). While the WDF Passport indicates that TSF 1 and 2 have not been filled with waste since 2010**
- **hazardous waste, waste petroleum products are stored on the unprotected ground beyond TSF 2 reservoir**

Fig. 27. TSF 1, general view

[39] The DSTU B.V.1.1-28 scale for average soil conditions and 5% probability of exceeding the regulatory seismic intensity over 50 years (Map ZSR-2004-B). According to DBN B.1.1-12: 2014. Construction in seismic areas of Ukraine. State Construction Codes of Ukraine

- **there are signs of petroleum products escaping beyond the boundaries of the facilities' structures, minor flooding of the areas adjacent to the TSFs: formation of a water body beyond the facilities with signs of petroleum products content. This may indicate on the failure of the enclosing structures' stability and of the anti-seepage properties of the clay insulation screen**

Fig. 28. Storage of waste (petroleum products) on the ground beyond the TSF 2 reservoir

- **the technical state of the TSFs structures has not been inspected**
- **no environmental impact monitoring of the TSFs**
- **there is no hazardous waste management license (it was revoked in October 2018)**
  - **TSF emergency preparedness of the company is not ensured:**
    - **there is no information on identification and passportization of the TSFs as Potentially Hazardous Facilities**
    - **the company Accident Localization and Elimination Plan does not consider probable accident scenarios at the TSFs**
    - **The Environmental Emergency Response Plan at the TSFs of 2004[40] fails to take into account all the existing potential hazards and as of 2018 has not been updated for 14 years**

[40] Full title "Environmental Emegency Response Plan for the ponds of Shop 10: Sludge Storage Facilities, Oil Sludge Ponds 1 and 2, Silt Storage Facilities (Silt Pond 3) to Prevent Pollution of Soils, Water Resources and Atmosphere", PJSC Naftokhimik Prykarpattia, approved on 29.03.2004

- **there are system-level non-compliances in maintenance of the operational documentation, there is no key safety documents – design documentation and Hydraulic Structure Passports, while the company's Operating Instruction and Accident Localization and Elimination Plan need updating.**

Fig. 29. Water body with traces of petroleum products content, located beyond the TSFs (behind the external dam, towards the river)

The above key non-compliances in the operation of such potentially hazardous facilities need to be addressed to minimize their impact on the environment and to prevent accidents. Relevant recommendations are provided in the section below.

The results of the “Methodology for Comprehensive Evaluation of Tailings Management Facilities Safety” application, based on the analysis of the visual observation data, staff interviews, and documentation analysis, showed an unsatisfactory level of ensuring proper operation of the TSFs (Table 5).

Table 5. Results of categorial evaluation of Naftokhimik Prykarpattia TSFs operation (below 50% are highlighted)

No.	Category	Safety criteria compliance level, %	Category significance (critical – extremely important)[41]
I	Geological, climatic and local conditions	53.7	non-critical
II	SF location plan	**43.8**	non-critical
III	Substances (waste volume and toxicity)	66.7	critical
IV	Dam and screens	**27.4**	critical
V	Transport and infrastructure	70.4	critical
VI	Water flow management	**23.1**	critical
VII	Environmental impact assessment	**23.8**	critical
VIII	Emergency Response Plan	**28.0**	critical
IX	Monitoring	**24.4**	critical
X	Training and personnel	63.0	non-critical
XI	Verification and reporting	**24.1**	non-critical
XII	Closure and rehabilitation	50.0	critical
Overall result		**41.5**	–

The list of TSF operation non-compliances identified during the research and the measures to maintain the facilities safety are provided in the Report in the tabular form according to the pattern: “identified non-compliance” – “legislative criteria” – “corresponding recommendation”. Below are provided the recommendations, the implementation of which is critical safe operation of the TSFs.

[41] Critical categories are extremely important TSF safety categories, which relate mainly to technical aspects of facility operation and safety maintenance. Detected non-compliances with the safety requirements in these categories require mandatory urgent action. Non-critical categories relate to issues mostly concerned with documentation management and reporting, and the facility personnel qualification level

Measures recommended for implementation by PJSC Naftokhimik Prykarpattia

1. **Obtain a license for hazardous waste management**
2. **Ensure proper operation of the TSFs**
   - 2.1. Take necessary actions related to hazardous waste management – namely the waste petroleum products stored on unprotected ground beyond the reservoir of TSF 2:
     - clean the area of disturbed lands near TSF 2 from hazardous waste, conduct soil surveys on the pollution level, and rehabilitate the disturbed lands
     - ensure the waste disposal into a specially designated facility during operation of the TSF
   - 2.2. Inspect the technical state of the TSFs structures to identify the causes of seepage towards the Vorona River and the environmental impact. Prevent the escape of waste to the environment and further migration of pollutants into water bodies
3. **Perform regular control and monitoring of the TSFs current state**
   - 3.1. Regular visual and instrumental observations
   - 3.2. Regularly monitor the environmental impact of the TSFs, in particular install a network of monitoring wells for groundwater level and pollution monitoring, and perform the surface water, soils, and air quality monitoring
   - 3.3. Perform scheduled survey and passportization of the hydraulic structures at least once every three or five years (depending on the facilities construction class)
   - 3.4. Perform the regular survey of the TSFs at least once a year
4. **Ensure the company's emergency preparedness at the TSFs**
   - 4.1. Revise and complement the "Accident Localization and Elimination Plan for the Mechanical Treatment Facility Installation of Shop 10", including consideration of probable accident scenarios at the TSFs
   - 4.2. Perform identification and passportization of the TSFs as potentially hazardous facilities in accordance with the current legislation requirements
5. **Ensure the maintenance of the operational documentation for the TSFs**
   - 5.1. Develop documentation on the facilities operation
     - Hydraulic Structure Passports for the TSFs
     - ensure availability of technical documentation with the design parameters of the TSF structures

Measures recommended for implementation by PJSC Naftokhimik Prykarpattia

- update the Operating Instruction based on the current state of the facilities

5.2. Develop documentation on waste management

- WDF Passports for each TSF with the information on the current state of the facilities
- procedure for environmental monitoring of the TSFs
- Waste Management Plans, and
- record and reflect the amount of waste disposed to the TSFs in the reporting documentation

6. The temporary conservation or closure of the TSFs and rehabilitation of disturbed lands is recommended, given that the storage facilities have not been filled with production waste since 2010 (according to the documentation)

7. In expert opinion, the best way to prevent the anthropogenic pressure posed by inactive TSFs of PJSC Naftokhimik Prykarpattia on the SWB in the Dniester River Basin is the maximum recycling of accumulated waste, further closure of the facilities and rehabilitation of disturbed lands

5. Dolynanaftogaz Oil and Gas Production Department of PJSC Ukrnafta

Dolynanaftogaz Oil and Gas Production Department of Public Joint Stock Company “Ukrnafta” (hereinafter the “Dolynanaftogaz”) is a part of PJSC Ukrnafta and performs the development of oil and gas deposits and oil and gas production. The production facilities are located in the Dolyna and Rozhniativ Districts of the Ivano-Frankivsk Region. The company has an oil sludge and oil emulsion processing installation. As of 2019, the company owns **10 active Sludge Storage Facilities** (in this Summary the term is “TSFs”) located in the company’s 4 structural units: Oil Preparation and Pumping Shop “Main Facilities” (OPPS), Cluster Pump Station 2 North Dolyna (CPS-2 ND), Cluster Pump Station 7 (CPS-7), Group Technological Installation “Strutyn” (GTI-3).

Fig. 30. Location *of the company structural units with the active Sludge Storage Facilities*

According to the company data, the total amount of waste accumulated in the TSFs was 10,178.035 tons as of April 1, 2019. When analyzing the company documentation and the data of the Ivano-Frankivsk Regional State Administration[42], it was determined that one facility – “ecological pond” TSF of the OPPS unit is not registered by the Regional State Administration, and the amount of the waste accumulated in the TSFs do not match. Inconsistencies in the company’s documentation and the Regional State Administration data demonstrate the non-compliances of the accumulated industrial waste accounting by the company and, as a consequence, reporting of incorrect data.

The chemical composition of oil sludge is a mixture of hydrocarbons, mechanical impurities and water, with gas emissions – hydrocarbon vapors. The oil refining waste substances are characterized by strong toxic effects: pronounced mutagenicity and carcinogenicity of aromatic hydrocarbons, narcotic effect – effects on the cardiovascular system and blood parameters (decrease in hemoglobin and erythrocytes); liver damage, endocrine disorders, skin irritation and pigmentation are also possible.

[42] List of liquid industrial waste storage facilities in the Ivano-Frankivsk Region. Ivano-Frankivsk Regional State Administration Letter 323/1/119/01-050 dated 05.02.2019

8 TSFs pose the pressure on the Lushchava River SWB (UA_R_16_S_2_Si, UA_M5.2_0281; Fig. 31), and 2 TSFs of GTI-3 unit – on the Duba River SWB (UA_R_16_M_2_Si, UA_M5.2_0359; Fig. 32). Linear hydrographic networks: “Untitled Stream – the Yar stream – the Lushchava River – the Svicha river – the Dniester River”; and “the Smereka stream – the Dub River – the Chechva River – the Lomnytsia River (Limnytsia) – the Dniester River”. In case of accidents at the TSFs, pollutants can reach the transboundary Dniester River.

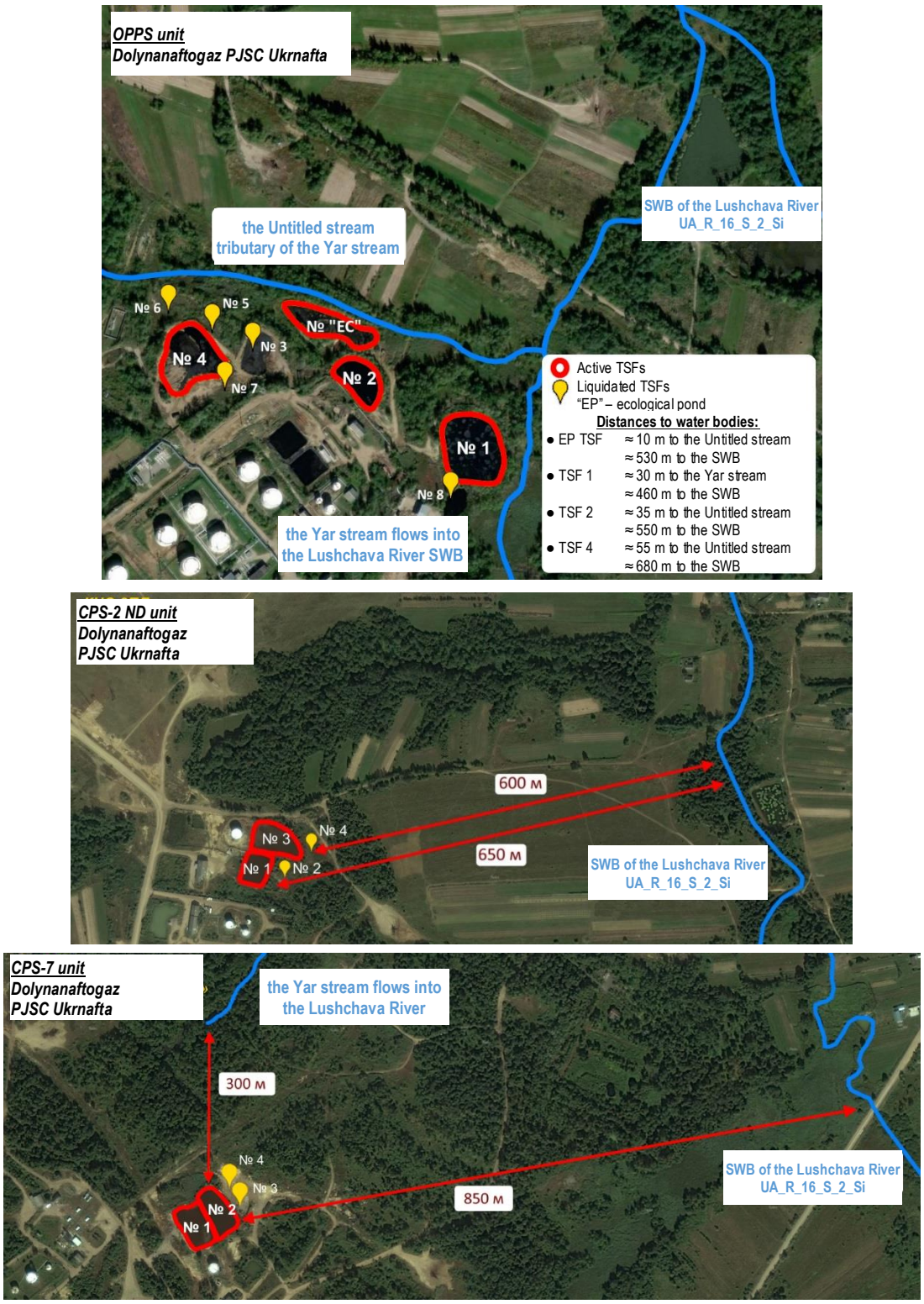

Fig. 31. TSFs location of OPPS, CPS-2 ND, and CPS-7 units relative to the hydrographic network

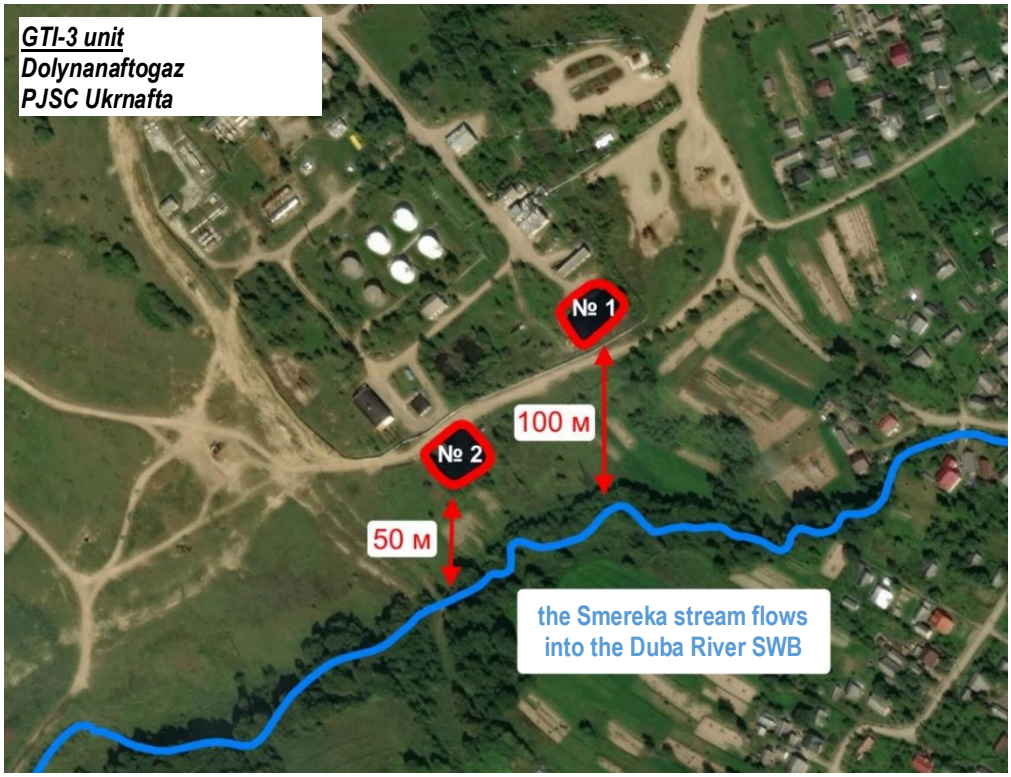

Fig. 32. TSFs location of GTI-3 unit relative to the hydrographic network

The climatic, hydrological, geological conditions, and seismicity of the site of Dolynanaftogaz TSFs are considered as the main external natural hazard drivers of TSF operation, namely:

- climatic hazard driver: the TSFs are located in a humid zone with significant amount of precipitation, which may cause overfilling of the facilities, with waste overflowing the embankment, and intensify the processes of pollutants hypergenesis and migration
- hydrological hazard driver: there is no the flooding hazard driver – the TSFs are located beyond the boundaries of any rivers with a potential flooding ability (based on the preliminary assessment of the flooding risks of the Dniester River Basin area)
- seismicity of the area: the facilities are located in a seismically hazardous area (the background seismic intensity is 7 points[43]). This can adversely affect stability of the embankment and other TSFs structures, which in turn increases the risk of accidents

[43] The DSTU B.V.1.1-28 scale for average soil conditions and 5% probability of exceeding the regulatory seismic intensity over 50 years (Map ZSR-2004-B). According to DBN B.1.1-12: 2014. Construction in seismic areas of Ukraine. State Construction Codes of Ukraine

The research on the current state of the ten Dolynanaftogaz TSFs in 2019 showed that the facilities operation level does not meet the requirements of the environmental and technogenic safety standards. In particular, the following significant non-compliances have been identified:

- **critical filling level of all the TSFs – reaches the edge of the embankment; signs of overflow**
- **signs of integrity failure of waterproofing layer, decreasing of anti-filtration screens properties and embankment reliability of all the TSFs: the water bodies in lowland area of the TSFs are with pronounced brown color in some places; there is a significant number of minor floodings with traces and a smell of petroleum products in the surrounding area. The formed range of contaminated area is observed around the TSFs**

Fig. 33. TSF 1 of OPPS unit, the filling level reaches the edge of the embankment, April 2019

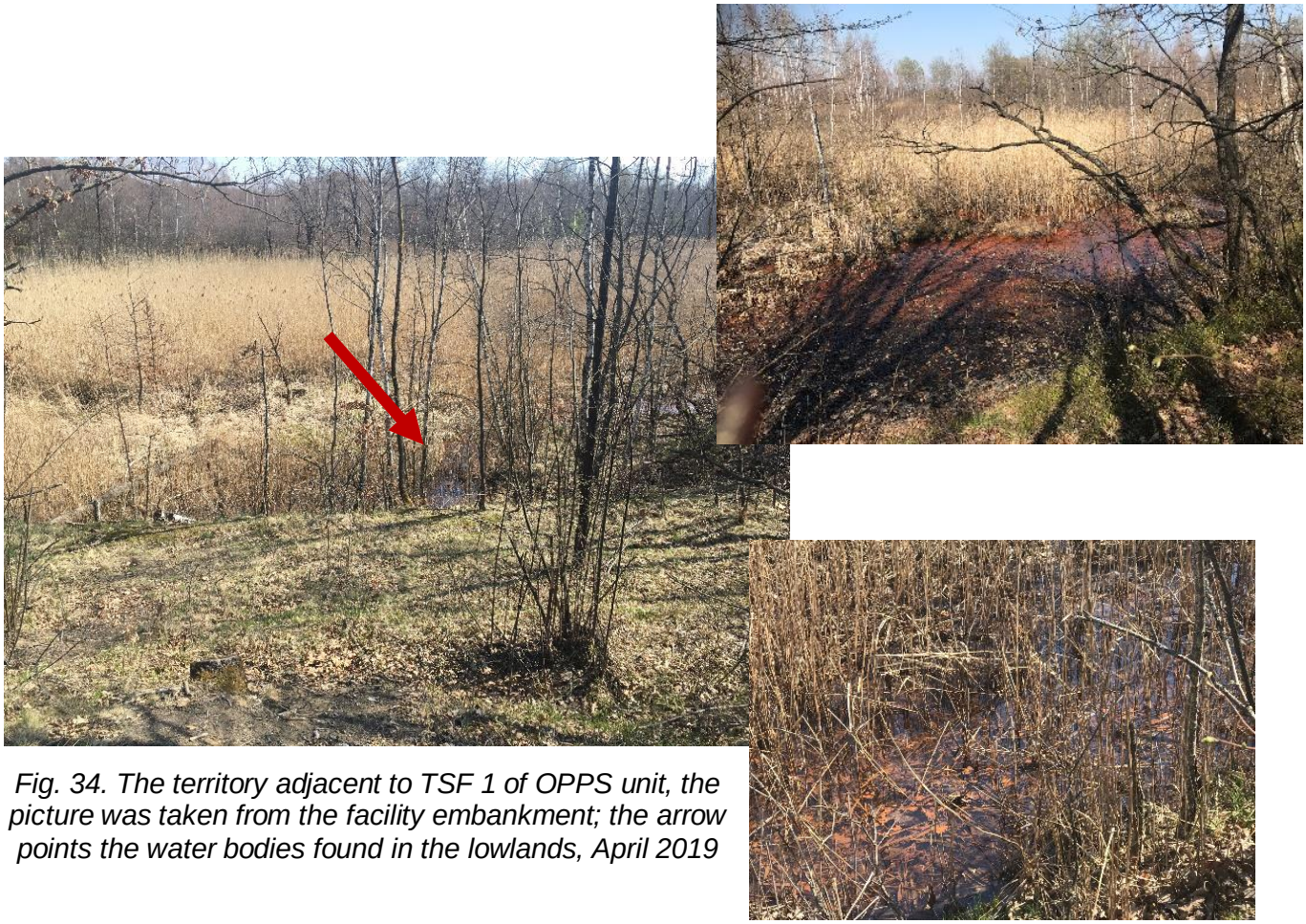

Fig. 34. The territory adjacent to TSF 1 of OPPS unit, the picture was taken from the facility embankment; the arrow points the water bodies found in the lowlands, April 2019

- **the soil excavation is observed in the lower part of TSF 1 of OPPS unit and the embankments of TSF 1 of CPS-2 ND unit. This creates a risk of integrity failure risk for the facility embankments and, as a consequence, waste leakage into the environment**
- **waste is stored on the unprotected ground beyond TSF 4 of OPPS unit and TSF 1 of GTI-3 unit (there are traces of petroleum products mixed with soil)**
- **violation of procedures for technical state control of the TSFs:**
  - **the visual observation results of the facilities condition and filling levels measurements of the TSFs of CPS-2 ND, CPS-7, and GTI-3 units are not recorded in the logs**
  - **"ecological pond" TSF of OPPS unit is not equipped with a measuring ruler to control the facility filling level**
  - **the measuring ruler height on the TSFs of CPS-7 unit and TSF 2 of GTI-3 unit visually does not match the maximum filling level, considering different height of embankment around the perimeter**

Fig. 35. TSF 1 of OPPS unit, the signs of embankment integrity failure, April 2019

Fig. 36. The petroleum products stored on the ground beyond the TSF 1 of OPPS unit

Fig. 37. TSF 4 of OPPS unit, signs of waste overflow over the embankment edge, July 2019

- **the environmental impact monitoring of the TSFs is carried out not in full:**
  - **there is no monitoring of the soils quality in the area of TSF 4 and "ecological pond" TSF of OPPS unit**
  - **the pathway to the monitoring well near the TSFs of CPS-2 ND unit has not been cleared up, which may indicate that measurements at this sampling point are not taken**

Fig. 38. Ditch between TSFs 1 and 3 of CPS-2 ND unit, July 3, 2019

- **improper arrangement of the TSFs structures:**
  - **there are dug ditches without indications of special arrangement elements between the TSFs of CPS-2 ND unit and at the "ecological pond" TSF of OPPS unit**
  - **there is no fencing around TSF 4 of OPPS unit**
  - **fencing and embankment contour failure of the GTI-3 unit TSF**
  - **inconsistencies of TSFs' areas and volumes indicated on the signs near the facilities and in the documentation, CPS-2 ND and CPS-7 units**

Fig. 39. Ditch from the adjacent area to the "ecological pond" TSF of OPPS unit, July 2019

Fig. 40. The "ecological pond" TSF of OPPS unit, July 2019

- **waste disposal to the "ecological pond" TSF is not reflected in the documentation: there are traces of recent production waste disposal to the TSF (traces of petroleum products on the structure flanks), given that according to the WFS Passport, the TSF has not been filled with waste since 2007**

- **TSF emergency preparedness of the company is not fully ensured:**
  - **there is no information on identification and passportization of the TSFs as Potentially Hazardous Facilities**
  - **The Accident Localization and Elimination Plan of OPPS unit does not consider accidents at the TSFs**
  - **there is no documentation on the personnel actions in case of emergency at the TSFs of CPS-2 ND, CPS-7, and GTI-3 units**
- **there are non-compliances in maintenance of the operational documentation: the Operating Instructions and WDF Passports of the TSFs need to be updated; the amount of disposed waste do not match in the WDF Passports, statistical reporting forms, and other documentation; there are no waste management plans**

Fig. 41. GTI-3 unit TSF 2, critical filling level, July 2019

Fig. 42. Fencing and embankment contour failure of GTI-3 unit TSF 2

The company has no plans for closure of the existing TSFs, which have not been filled with production waste (TSF 2 of GTI-3 unit since 2014, TSF 1 of OPPS unit since 2017), while the company spends resources (electricity, employees) to maintain their safety.

The above key non-compliances in the operation of such potentially hazardous facilities need to be addressed to minimize their impact on the environment and to prevent accidents. Relevant recommendations are provided in the section below.

Apart from active TSFs, there are also TSFs at the Dolynanaftogaz site that were liquidated (closed). There is no documentary evidence on the actual number of such facilities. The 11 liquidated TSFs were identified based on the company design documentation[44] and Google Earth Pro images. No relevant documentary evidence was provided on the liquidation stages of each TSF, e.g., the results of the company laboratory tests, conclusions of the sanitary-epidemiological service, acts drawn by relevant commissions, including environmental authorities. Moreover, a visual inspection of two liquidated TSFs areas showed that the relevant activities have not been fully completed. Based on the observations from a distance, the land has not been aligned, the surface is not stable, vegetation is absent.

The lack of documentary evidence on the stages of TSF liquidation demonstrates that the company pays insufficient attention to both organizational issues of hazardous industrial waste management and waste-polluted land protection measures.

Fig. 43. Territory of the liquidated TSF of CPS-7 unit, July 2019

Fig. 44. Territory of the liquidated TSF 8 of OPPS unit, April 2019

[44] Waste Recycling and TSF Reclamation Project Design Documentation for the Dolyna, the North-Dolyna, and the Strutyn Oil Deposits, SPE Geotest, 2001

The results of “Methodology for Comprehensive Evaluation of Tailings Management Facilities Safety” application, based on the analysis of the visual observation data, staff interviews, and documentation analysis, showed an unsatisfactory level of ensuring proper operation of the TSFs (Table 6).

Table 6. Summary results of categorial evaluation of 10 Dolynanaftogaz TSFs operation (below 50% are highlighted)

No.	Category	Operational safety criteria compliance level for 10 TSFs, %		**Category significance** (critical – extremely important)[45]
		Lowest value	Highest value	
I	Geological, climatic and local conditions	**24.6**	**35.1**	non-critical
II	TSF location plan	**38.1**	**47.6**	non-critical
III	Substances (waste volume and toxicity)	61.1	75.0	critical
IV	Dam and screens	**12.3**	**23.5**	critical
V	Transport and infrastructure	**11.1**	**14.8**	critical
VI	Water flow management	**14.6**	**18.8**	critical
VII	Environmental impact assessment	**15.9**	**20.6**	critical
VIII	Emergency Response Plan	**11.3**	**13.5**	critical
IX	Monitoring	**43.2**	58.0	critical
X	Training and personnel	**33.3**	**33.3**	non-critical
XI	Verification and reporting	**48.8**	**48.8**	non-critical
XII	Closure and rehabilitation	**11.5**	**11.5**	critical
	Overall result	**29.8**	**33.0**	–

The list of TSF operation non-compliances identified during the research and the measures to maintain the facilities safety are provided in the Report in the tabular form according to the pattern: “identified non-compliance” – “legislative criteria” – “corresponding recommendation”. Below are provided the recommendations, the implementation of which is critical for safe operation of the TSFs.

[45] Critical categories are extremely important TSF safety categories, which relate mainly to technical aspects of facility operation and safety maintenance. Detected non-compliances with the safety requirements in these categories require mandatory urgent action. Non-critical categories relate to issues mostly concerned with documentation management and reporting, and the facility personnel qualification level

Measures recommended for implementation by Dolynanaftogaz Oil and Gas Production Department of PJSC Ukrnafta

1. Ensure proper operation of the TSFs

1.1 Perform the waste inventory stored in all the TSFs, which will eliminate inconsistencies in data reporting and determine the actual amount of recyclable waste

1.2 Prevent critical filling levels of the TSFs:
- pump out the liquid from the TSFs timely to reduce the filling level
- carry out the additional observations of the filling level during heavy precipitation
- ensure the compliance of measuring rulers with the maximum TSF filling level and TSF embankment height along the entire perimeter of the facility taking into account the relief features

1.3 Perform the survey on the technical state of the TSFs structures to identify the causes of seepage, the environmental impact and determine the pollution area. Based on the survey results, develop and implement measures to prevent the pollution and eliminate its consequences

1.4 Prevent the soil excavation of TSF embankments to avoid the structures integrity failure and waste leakage into the environment

1.5 Take necessary actions related to hazardous waste management – namely the oil sludges stored on unprotected ground beyond TSF 4 of OPPS unit and TSF 1 of GTI-3 unit:
- clean the area of disturbed lands near the TSFs from hazardous waste, conduct soil surveys on the pollution level, and rehabilitate disturbed lands
- ensure the waste disposal into a specially designated facility during operation of the TSFs

1.6 Arrange a ditch to divert rainwater from the OPPS unit territory to the “ecological pond” TSF in a proper way (ensure the clear contours of the structure, the slope towards the TSF) to prevent soil contamination of the surrounding area. The TSF scheme shall reflect the appropriate structure arrangement

1.7 Set up a wire fencing around TSF 4 of OPPS unit

1.8 Repair the fencing and embankment contour failure of GTI-3 TSF 2

2. Perform regular monitoring of the TSFs current state

2.1 Install the measuring ruler at “ecological pond” TSF of OPPS unit in order to monitor TSF filling level

Measures recommended for implementation by Dolynanaftogaz Oil and Gas Production Department of PJSC Ukrnafta

2.2 Perform visual observations of the structures' condition and measure the filling levels of the CPS-2 ND, CPS-7, and GTI-3 "Strutyn" units TSFs, with results recording in the company facilities' operation logs

2.3 Perform the soils quality monitoring in the area of OPPS unit TSF 4

2.4 Ensure the access to the observation well in the CPS-2 ND TSFs area

2.5 Perform scheduled survey and passportization of the hydraulic structures at least once every three or five years (depending on the facilities construction class)

2.6 Perform the regular survey of the TSFs at least once a year

3. Ensure the company's emergency preparedness at the TSFs

3.1 Revise and complement the "Accident Localization and Elimination Plan, OPPS unit, Main Facilities", including consideration of probable accident scenarios at the TSFs

3.2 Develop an Emergency Response Plan for TSFs of the CPS-2 ND, CPS-7, and GTI-3 units

3.3 Perform identification and passportization of the TSFs as potentially hazardous facilities

4. Ensure proper closure of inactive TSFs and rehabilitation of disturbed lands

4.1 Fully perform the closure of OPPS unit TSF 8 and of the TSFs located at CPS-7 unit area and rehabilitation of disturbed lands

4.2 Carry out the control of TSF physical stability, soils, surface and groundwater condition during and after completing the activities

4.3 The closure of GTI-3 TSF 2, which has not been filled with production waste since 2014, and rehabilitation of disturbed lands is recommended

4.4 Ensure the maintenance of the reporting documentation related to the activities on closure of the TSFs and rehabilitation of disturbed lands

5. Ensure the maintenance of the operational documentation for the TSFs

5.1 Address non-compliances in the documentation on operation of the TSFs:

- record the actual arrangement of CPS-2 ND unit TSFs 1 & 3 on the corresponding TSF schemes
- indicate the relevant TSF areas and volumes on the signs near the CPS-2 ND and CPS-7 TSFs according to their characteristics
- update the Operating Instructions based on the current state of the facilities

Measures recommended for implementation by Dolynanaftogaz Oil and Gas Production Department of PJSC Ukrnafta
- it is recommended to revise the name of the “ecological pond” TSF according to the facility technological purpose (sludge storage facility) 5.2 Address non-compliances in the waste management documentation: - develop Waste Management Plans - record and reflect in the reporting documentation the amount of the waste disposed in the “ecological pond” TSF - update the WDF passports, provide up-to-date information according to the facilities’ current state and annual data on environmental monitoring - reflect in the statistical reporting forms the total amount of the waste accumulated in the TSFs
6. In expert opinion, the best way to prevent the anthropogenic pressure posed by the TSFs of Dolynanaftogaz Oil and Gas Production Department of PJSC Ukrnafta on the SWB in the Dniester River Basin is to ensure proper operation of the facilities, reduce the level of waste production, maximum recycling of accumulated waste, closure of inactive TSFs, and rehabilitation of disturbed lands

6. Burshtyn TPP Separate Division of JSC DTEK Zakhidenergo

The Separate Division Burshtyn Thermal Power Plant of JSC DTEK Zahidenergo (hereinafter in the Summary "Burshtyn TPP") is the largest power plant in western Ukraine, located near the Burshtyn town, Halych District, Ivano-Frankivsk Region. The Burshtyn TPP is separated from the integrated power system of Ukraine and operates as part of the so-called "Burshtyn Island" in parallel with the Union for the Co-ordination of Transmission of Electricity (UCTE): electricity is supplied to consumers in the Western region of Ukraine and to Eastern European countries. Thermal energy is supplied to the household and utilities sectors of Burshtyn town and Demianiv village. Burshtyn TPP owns **four TSFs**: **the Ash Storage Facility 1, 2, the Slag Storage Facility , the Ash Storage Facility 3, and the Hydraulic Waste Storage Facility. The total volume of waste stored in the four facilities is 40.393 mln tons** according to the Ivano-Frankivsk Regional State Administration data[46] of 15.02.2019. The total area under the TSFs is **291.28 ha.** The facilities have been in operation for over 50 years (commissioned in 1965-1971).

Fig. 45. View of the TPP buidlings from the Ash Storage Facility 1, 2

The issue of accounting for the "Ash Storage Facility 1, 2" needs to be clarified in the company documentation and the WDF register as a single or two separate WDFs, taking into account the waste disposal technological process and operating conditions. The Hydraulic Waste Storage Facility owned by Burshtyn TPP was found during analysis of the Ivano-Frankivsk Regional State Administration data. Information about this facility was not provided during the visit to the company.

Burshtyn TPP had not ensured the sufficient openness in cooperation with the GEF Project during the research, despite the importance of the research purpose and interest at the state level in the TSF operation issues in the transboundary Dniester River Basin. In particular, **the company agreed site visit to the TSFs, but did not provide relevant documentation.** The GEF Project sent an official request letter for documentation copies on operation of the TSFs[47]. No relevant documents were provided in response to the request, which complicated the research.

[46] List of liquid industrial waste storage facilities in the Ivano-Frankivsk Region. Ivano-Frankivsk Regional State Administration Letter 323/1/119/01-050 dated 05.02.2019

[47] Letter to the Head of the Environmental Safety Department, Electricity Generation Administration, DTEK Energo, "On the research of Burshtyn TPP Tailings Storage Facilities" dated 14.11.2018

Insufficient data on TSF technical parameters and specific features made it impossible to assess the TSF operational safety using the Methodology[48] and to review the anthropogenic pressure on water bodies using the DPSIR analytical framework provided in the Guidelines[49]. **The TSFs of Burshtyn TPP inventory results are based on the analysis of the visual inspection of the TSFs and information from open data sources.**

The TSFs of Burshtyn TPP are located in the area of the Hnyla Lypa River SWB (UA_M5.2_0377, UA_R_16_M_2_Si), the Dniester River SWB (UA_M5.2_0007, UA_R_16_XL_2_Si), the Burshtyn Impoundment SWB (UA_M5.2_0376, preliminary heavily modified water body – pHMWB), and the Hnyla Lypa River SWB (UA_M5.2_0375, UA_R_16_M_2_Si; Fig. 46-47).

Linear hydrographic network of the Hydraulic Waste Storage Facility site: the Hnyla Lypa River – Burshtyn Reservoir – the Hnyla Lypa River – the Dniester River", in other facilities' site: "Untitled Stream – the Hnyla Lypa River – the Dniester River". In case of accidents at the TSFs, pollutants can reach the transboundary Dniester River.

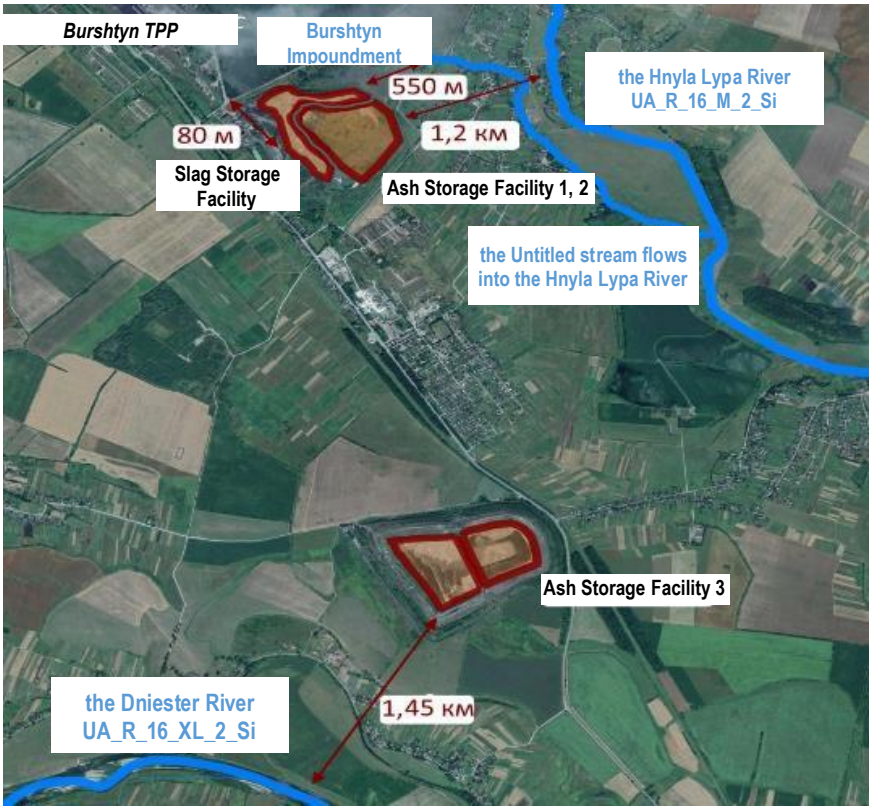

Fig. 46. Location of the Ash Storage Facilities and Slag Storage Facility in relation to the hydrographic network

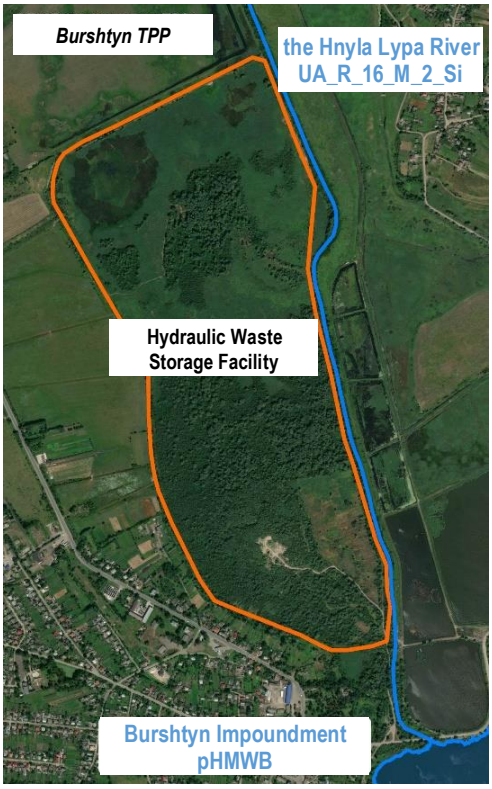

Fig. 47. Location of the Hydraulic Waste Storage Facility in relation to the hydrographic network

[48] Methodology for Comprehensive Evaluation of Tailings Management Facilities Safety
[49] "Guidelines for determining the main anthropogenic pressures and their impacts on the status of surface waters", approved by Protocol No. 2 at the Scientific and Technical Council meeting of the State Water Agency of Ukraine on 27 November 2018

The climatic, hydrological, geological conditions, and seismicity of the site of Burshtyn TPP TSFs are considered as the main external natural hazard drivers of TSF operation, namely:

- climatic hazard driver: a humid zone with a large amount of precipitation can cause dam erosion and overfill of the TSFs in case their sections are filled to a critical level; strong winds can facilitate the spread of the ash-and-slag mixture and dust carryover beyond the facilities
- hydrological hazard driver: the Hydraulic Waste Storage Facility of Burshtyn TPP is located within the Hnyla Lypa River with a potential flooding ability in the area the Lypivka village - estuary (based on the preliminary assessment of the flooding risks of the Dniester River Basin area)
- seismicity of the area: the TSFs are located in a seismically hazardous area (the background seismic intensity is 6 points[50]). This can adversely affect stability of the facility dams and other structures, which in turn increases the risk of accidents.

The Ash Storage Facility and the Slag Storage Facility contain waste of IV Hazard Class: ash dust and fuel slag. The predominant minerals in the ash-and-slag waste are silicon, aluminum, and iron oxides, and in small quantities – calcium, magnesium, potassium, sodium, and sulfur oxides. The ash slags contain, but in much smaller quantities, heavy metals in the form of low-solubility and insoluble compounds. Such waste can cause degradation of hydrobionts, flora and fauna, and adversely affect human health. Toxic effects of substances contained in waste are manifested mainly in irritation of mucous membranes, chronic damage of the respiratory tract, and deposition of highly dispersed particles in the lungs, causing delayed pathological changes.

Fig. 48. Burshtyn TPP Ash Storage Facility 3, July 2018

[50] The DSTU B.V.1.1-28 scale for average soil conditions and 5% probability of exceeding the regulatory seismic intensity over 50 years (Map ZSR-2004-B). According to DBN B.1.1-12: 2014. Construction in seismic areas of Ukraine. State Construction Codes of Ukraine

Special hazard to the environment is posed by **aluminosilicate fly-ash microspheres** carried over from the surface of the ash-and-slag storage facilities. This ash-and-slag material is formed through high-temperature combustion of coal at power plants. The size of such microspheres ranges from several dozen to several hundred micrometers. The scope of the material application is quite extensive: from manufacturing of refractory materials to oil and gas wells plugging. Dried microspheres are lifted by wind gusts above the ash storage facility surface and can be carried over long distances. Microspheres, due to their small size, penetrate the organism of humans and animals through the respiratory organs, and can damage it.

Substances contained in ash during continuous irrigation of ash storage facilities pose a threat of groundwater and surface water pollution with heavy metals over a large area. Also, the pollution processes are facilitated by acid precipitation related to the composition of the Burshtyn TPP air emissions and by dusting of the dam crests, slopes and dry areas of the TSF beaches. Continuous watering (moistening) of the TSF surface on the one hand is a measure of dust suppression, and on the other hand can contribute to intense rinse of the TSFs and carryover of pollutants and microelements into groundwater and surface water.

The peculiarity of the location area of Burshtyn TPP TSFs are the settlements in close proximity. Distances from the facilities to the residential buildings range from approximately 50 m to 340 m.

The environmental impact assessment (EIA) for the planned activities of Burshtyn TPP to enlarge Ash Storage Facility 1, 2 (reconstruction)[51] was carried out in 2019. A review of the comments presented at the public discussions stage showed the local population's concern about TPP operation and the increasing environmental impact following the Ash Storage Facility reconstruction. However, according to the EIA Report, most of the comments were rejected by the company on the grounds that the maximum allowable concentration of the pollutants at the boundaries of sanitary protection zone and residential buildings are within the norm according to the company's monitoring studies and pollution dispersion calculations. The Ministry of Ecology and Natural Resources of Ukraine issued the EIA conclusion, which determined the admissibility of pursuing the planned activity[52].

[51] Environmental Impact Assessment Report "Enlargement of Ash Storage Facilities 1 and 2 (Reconstruction) of SD Burshtyn TPP of JSC DTEK Zakhidenergo, Kyiv, 2019

[52] Conclusion on the Environmental Impact Assessment of the Planned Activities on "Enlargement of Ash Storage Facilities 1 and 2 (Reconstruction) of SD Burshtyn TPP of JSC DTEK Zakhidenergo", Ministry of Ecology and Natural Resources of Ukraine, No. 7-03/12-2019262788/1 dated 01.07.2019

Despite the data provided in the EIA Report, the visual inspection of the company's Ash Storage Facilities 1, 2 in 2018 showed intense dusting of the ash-and-slag waste, as described below. In addition, information portals refer to dust storms in the area of Burshtyn TPP facilities caused by strong winds[53].

A visual inspection of the Burshtyn TPP TSFs in 2018 showed the following non-compliances in operation of the facilities:

- **there is an intense dusting of the Ash Storage Facilities and Slag Storage Facility sites, including the possible spread of dried aluminosilicate microspheres of fly ash, which pose a threat to the environment and public health. The eyes, nasopharynx, and respiratory tract irritations were clearly felt when walking at the sites of TSFs**

Fig. 49. Burshtyn TPP Ash Storage Facility 3, dry beach areas, July 2018

[53] Online media "KURS". Publication "Firefighters tamed a "dust storm" at the Burshtyn TPP ash storage facility", dated 30.06.2019

Fig. 50. Ash Storage Facility 1, 2, areas of dry beaches

- **Intense dusting demonstrate the ineffectiveness of the dust suppression measures taken by the company, especially in the dry season**
- **Abandoned condition of drainage channels: undeveloped flanks, some places are not cleared.**

Additionally, the Questionnaire for local population in the Burshtyn TPP TSF-affected area was developed during the research. The Questionnaire was submitted to the Dniester BWA for further research on TPP impact on the quality of water supply sources in the region.

Fig. 51. Ash Storage Facility 1, 2. Intense dusting and dust suppression

Fig. 52. Drainage channel, section of Ash Storage Facility 1, 2

Insufficient openness of such a large-scale enterprise as Burshtyn TPP for cooperation with international organizations demonstrates one of the socio-political factors of TSF management in Ukraine – limited access to the information about such potentially hazardous facilities of the country. The TSFs with a large amount of accumulated waste (40.393 mln tons) require constant attention to the technical state of their structures and the facilities' environmental impact. Environmental and technogenic safety of such TSFs should be ensured through an established dialogue between the state and business.

Measures recommended for implementation by Burshtyn TPP Separate Division of JSC DTEK Zakhidenergo

1. Perform the research on the threats of intense dusting in the area of the TSFs, namely study the issue of dried aluminosilicate microspheres spreading as a threat of SWB pollution and their impact on public health
2. Prevent ash-and-slag mixture spreading and dust carryover beyond the ash-and-slag storage facilities during the dry season: take the necessary dust suppression measures and, if necessary, perform additional checks for dust concentration and air pollution in the facility-affected area
3. Perform the arrangement and clearing up the drainage channels and regularly monitor their condition to prevent overgrowth and siltation
4. Specify the accounting issue of the "Ash Storage Facility 1, 2" in the company documentation and the WDF Register as a single or two separate WDFs, taking into account the waste disposal technological process and operating conditions. Correct the inconsistencies of the facility name in the documentation
5. **In expert opinion, the best way to prevent the anthropogenic pressure posed by the TSFs of Burshtyn TPP Separate Division of JSC DTEK Zakhidenergo on the SWB in the Dniester River Basin is to ensure proper operation of the facilities, reduce the level of waste production, and maximum recycling of ash-and-slag waste stored in the TSFs occupying huge land areas**

TSF operators

7. **State Enterprise Sirka**
8. **PJSC Stebnyk Mining and Chemical Enterprise Polimineral**
9. **PJSC NPK-Galychyna**
10. **Boryslavnaftogaz Oil and Gas Production Department of PJSC Ukrnafta**

7. State Enterprise Sirka

State Enterprise Rozdil Mining and Chemical Enterprise "Sirka" (hereinafter "Sirka") is an extractive industry company pursuing sulfur ores extraction and enrichment and is located near the Novyi Rozdil town, Mykolaiv District, Lviv Region. The company owns **three TSFs**: **No. 1, No. 2 and the TSF at the hydraulic waste facility, which are facilities of the research. In addition, a large number of other types of waste is accumulated at the site of the TSFs – phosphogypsum, lump sulfur residues, solid municipal waste (SMW) and tar residues imported from Hungary (Hungarian tars).**

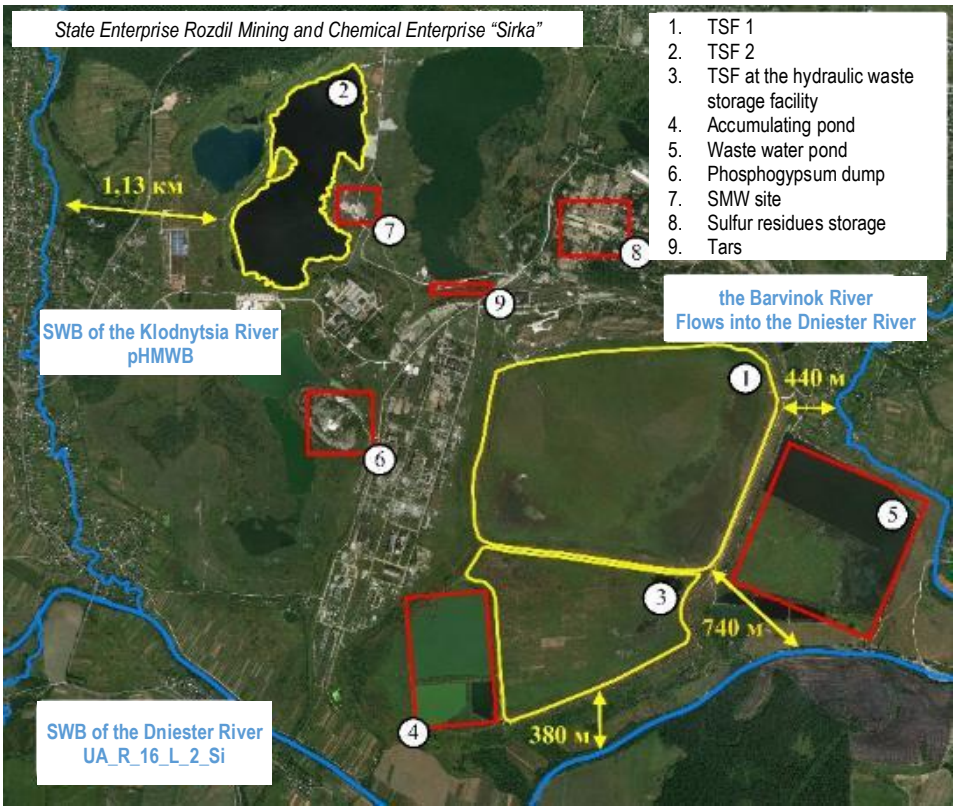

Fig. 53. Location of the Sirka TSFs and other waste facilities in relation to the hydrographic network

The company also owns a hydraulic waste dump of loams No. 3, located near the Rozdil village and Berezyna village, Lviv Region, and Podorozhnie lake, located in the Zhydachiv District, Lviv Region, near Podorozhnie, Marynka and Krekhiv villages. The hydrogen sulfide Podorozhnie lake was formed at the site of the Podorozhnie Quarry, where sulfur was extracted by the open-pit method in the past. It has an area of about 400 ha and a depth of 40 m to 90 m. There is an intensified landslides and sagging on the quarry flanks. One research publication notes presence of strontium in the flotation tailings: the strontium balance reserves approved for the Podorozhnie Ore Mine amounted to 4.96 million tons[54].

[54] R.M. Panas, M.S. Malanchuk "Monitoring of Geological and Hydrological Conditions and Methods of Sulfur Deposit Development in the Precarpathian Basin". Lviv Polytechnic National University. Geodesy, cartography and aerial photography. Issue 74. 2011

Sulfur ore has not been extracted at the location of TSF operator since 1997. The TSFs have been inactive since 2001, their proper closure and rehabilitation of disturbed lands was not implemented. The implementation of projects on sulfur quarries liquidation, environmental balance and landscape restoration in company's activity area are the purpose of establishing " and main activity of State Enterprise "Sirka. Environmental response to the former open-pit mining of sulfur deposits has been partially addressed through individual projects for a long time. However, the important activities are not fully funded during implementation of such projects, and therefore, the issues of environmental and technogenic safety of industrial waste are not fully addressed.

For more than 60 years of operation (since 1957), the TSFs have accumulated over **100 mln tons of sulfur ore enrichment waste and flotation tailings – the total amount of waste in three TSFs ranges from 85 to 108.9 mln tons according to various data sources[55].** The waste hazard class has not been identified and there is no waste passportization and accounting. In addition, a large number of other types of waste is accumulated at the site of the TSFs. The waste is stored in violation of current legislation and poses additional pressure on water bodies, in particular: **700 m^3 of lump sulfur residues, 1.29 mln m^3 of circulating water sediments, 3 mln tons of phosphogypsum, 17 thous tons of Hungarian tars, and 560 thousand m^3 of SMW**.

The environmental impact of waste is caused by the toxic effects of the substances contained in them – mainly sulfur and sulfuric acid, as well as phenols and heavy hydrocarbons contained in tars. In particular, the effects may include acidification of soil and water bodies and, accordingly, harmful impact on microorganisms – reduced soil fertility, slowing down of plant growth, disruption of the ichthyocenosis structure.

The shortest distance from the TSFs to water bodies is 380 m to the Dniester River (UA_M5.2_0006, UA_R_16_L_2_Si), 440 m to the Barvinok River flowing into the Dniester River, and 1 km to the Klodnytsia River (UA_M5.2_0151, pHMWB; Fig. 53 above). In case of accidents at the TSFs, pollutants can reach the transboundary Dniester River.

[55] Data sources:

- Letter of the Department of Ecology and Natural Resources of the Lviv Regional State Administration No. 31-351/0/2-18 dated 06.07.2018 "Regarding the consideration of the letter" – provision of information on the TSFs in the Lviv Region
- Inventory of accumulated industrial waste at the site of State Enterprise Rozdil Mining and Chemical Enterprise "Sirka", Girkhimprom Institute LLC, Lviv, 2017
- "New Rozdil is Born of Sulfur", Girkhimprom Institute LLC

The climatic, hydrological, geological conditions, and seismicity of the site of Sirka TSFs are considered as the main external natural hazard drivers of TSF operation, namely:

- climatic hazard driver: heavy rains that occur in the area of the TSFs can intensify dam erosion and cause overfilling of the facilities, with waste overflowing the dam crest
- hydrological hazard driver: the TSFs are located within the boundaries of the Dniester and Klodnytsia Rivers with a potential flooding ability (based on the preliminary assessment of the flooding risks of the Dniester River Basin area)
- geological hazard driver: the Lviv Region is characterized by a significant spatial occurrence of rocks favorable for the development of karst processes, which determines development of karst phenomena in large areas. According to the monitoring study, there is a slight intensification of landslides and erosion processes on the northern flank of the Rozdil Sulfur Quarry near the village of Malekhiv, Mykolaiv District, Lviv Region. Activation of karst processes poses a threat of waste entering the voids during land subsidence under the facilities
- seismicity of the area: the TSFs are located in a seismically hazardous area (the background seismic intensity is 6 points[56]). This can adversely affect stability of TSF dams and other structures, which in turn increases the risk of accidents.

Fig. 54. Aerial photo of Sirka TSF 2, July 2018

[56] The DSTU B.V.1.1-28 scale for average soil conditions and 5% probability of exceeding the regulatory seismic intensity over 50 years (Map ZSR-2004-B). According to DBN B.1.1-12: 2014. Construction in seismic areas of Ukraine. State Construction Codes of Ukraine

The research on the current state of three Sirka TSFs in 2018 showed that the facilities operation level does not meet the requirements of the environmental and technogenic safety standards. In particular, the following significant non-compliances have been identified:

- **there is a failure of TSF 1 dam integrity, which poses a threat of dam failure and waste spillage. The company has developed the project design documentation for restoring the structure integrity[57], however as of 2018, the work has not been performed**

Fig. 55. Landslide on the eastern side of TSF 1, February 2018 [company photo]

- **there is no treatment of rainwater which flows into the Dniester River from the enterprise territory: no water treatment plant and no arranged flanks of the channel "Lake Hlyboke – the Dniester River" for the drainage of water from the flooded eastern part of the Northern quarry (former sulfur quarry), that is polluted due to improper development of the waste disposal sites (landfills, sulfur and tars warehouses)**
- **abandoned condition of drainage channels – not cleared up, covered with vegetation**
- **there are signs of minor flooding in the areas adjacent to the TSFs. This indicates improper operation of the drainage channels**
- **there are no warning signs to prevent unauthorized access to the company facilities. According to the interviews, the local population dismantles the company's inactive structures for scrap metal**

Fig. 56. Aerial photo. Signs of minor flooding near TSF 2

[57] Design Project Documentation for restoration of the eastern dam cross profile in Section PK11+50-PK15+00 (TSF 1), developed under Contract 34/18, 6/1 dated May 21, 2018. Drawings and cost estimates

- **the technical state of all the three TSF structures has not been monitored**
- **no environmental impact monitoring**
- **TSF emergency preparedness of the company is not ensured:**
  - **there is no information on identification and passportization of the TSFs as Potentially Hazardous Facilities**
  - **the Emergnecy Response Plans for the TSFs have not been developed**
- **there are no key safety documents – design documentation, passports of hydraulic structures, passports of waste disposal facilities, monitoring procedures and others.**

Fig. 57. Aerial photo. Abandoned condition of drainage channels, TSF 2

Fig. 58. Condition of drainage channels, July 2018

Additionally, during the visual inspection of the company's TSFs, the other waste facilities were observed. Visual inspection of the lump sulfur residues storage, tar storage site and SMW storage site showed improper development of the waste facilities, in particular:

- **hydrogen sulfide water drains from the storage of lump sulfur residues that is open-air stored on a concrete base of a destroyed warehouse**
- **the improper developed SMW storage site poses a pressure on water bodies: washing of easily soluble compounds by atmospheric precipitation produces a filtrate which flows into TSF 2**
- **there are signs of contaminated infiltrates getting into nearby water bodies from the tar storage site**

Fig. 59. SMW storage site, signs of filtrate formation

Fig. 60. Tar storage site in the northern part of TSF 1, July 2018

Fig. 61. Aerial photo. Lump sulfur residues storage site, July 2018

The other waste facilities located in the area of the TSFs create preconditions for the domino effect – successive occurrence of accidents at facilities located in close proximity to each other.

The above key non-compliances in the operation of such potentially hazardous facilities need to be addressed to minimize their impact on the environment and to prevent accidents. Relevant recommendations are provided in the section below.

As of 2018, SE Sirka has not been pursuing its main business activity, resulting in lack of financial, technical and human resources to properly manage such potentially hazardous facilities as TSFs and other sites of industrial waste storage. The company has a growing debt to reimburse preferential pensions for the previous periods and the rent for the land under the waste storage facilities from past production.

The results of the “Methodology for Comprehensive Evaluation of Tailings Management Facilities Safety” application, based on the analysis of the visual observation data, staff interviews, and documentation analysis, showed a most unsatisfactory level of ensuring proper operation of the TSFs (Table 7) – the compliance with the safety criteria is below 50% almost in all categories.

Table 7. Results of categorial evaluation of Sirka TSFs operation (above 50% are highlighted)

No.	Category	Safety criteria compliance level, %			Category significance (critical – extremely important)[58]
		TSF 1	TSF 2	TSF 3[59]	
I	Geological, climatic and local conditions	15.8	29.8	29.8	non-critical
II	TSF location plan	10.4	33.3	10.4	non-critical
III	Substances (waste volume and toxicity)	13.6	13.6	13.6	critical
IV	Dam and screens	25.8	**64.2**	32.1	critical
V	Transport and infrastructure	12.5	20.8	12.5	critical
VI	Water flow management	17.9	19.8	17.9	critical
VII	Environmental impact assessment	0.0	0.0	0.0	critical
VIII	Emergency Response Plan	0.0	0.0	0.0	critical
IX	Monitoring	0.0	0.0	0.0	critical
X	Training and personnel	0.0	0.0	0.0	non-critical
XI	Verification and reporting	11.5	26.4	11.5	non-critical
XII	Closure and rehabilitation	0.0	0.0	0.0	critical
	Overall result	**9.0**	**17.3**	**10.7**	–

The list of TSF operation non-compliances identified during the research and the measures to maintain the facilities safety are provided in the Report in the tabular form according to the pattern: “identified non-compliance” – “legislative criteria” – “corresponding recommendation”. Below are provided the recommendations, the implementation of which is critical for safe operation of the TSFs.

[58] Critical categories are extremely important TSF safety categories, which relate mainly to technical aspects of facility operation and safety maintenance. Detected non-compliances with the safety requirements in these categories require mandatory urgent action. Non-critical categories relate to issues mostly concerned with documentation management and reporting, and the facility personnel qualification level

[59] TSF at the hydraulic waste storage facility

Measures recommended for implementation by State Enterpise Sirka

1. **Perform works on restoring the dam integrity of TSF 1 according to the developed Project Design Documentation**
2. **Ensure the safety of all the TSFs:**
   - 2.1 Ensure the proper condition of TSF drainage channels – restore the destroyed areas, clear up the channels
   - 2.2 Install the appropriate warning signs in the area of the TSFs (“danger zone”, “unauthorized passage and entry prohibited”, “no swimming”)
3. **Take action to prevent escape of waste to the environment and further pollutants migration into water bodies from the TSFs and other industrial waste facilities**
   - 3.1 Ensure treatment of rainwater which flows into the Dniester River from the enterprise territory – build a water treatment plant and complete the construction of the channel “Lake Hlyboke – Dniester River” for the drainage of water from the flooded eastern part of the Northern quarry
   - 3.2 Take the necessary action related to hazardous waste management – tars:
     - ensure the temporary waste disposal at a specially designated facility, with an impermeable coating, autonomous drainage, and protection from precipitation and wind
     - perform the tars recycling
     - inspect the soils and the adjacent water bodies quality to determine the pollution level
     - develop and implement measures to eliminate the environmental pollution and on rehabilitation of the disturbed lands
   - 3.3 Take the necessary action related to waste management – lump sulfur residues:
     - perform the lump sulfur residues recycling and liquidation of the storage facility
     - inspect the soils and the adjacent water bodies quality for the pollution level
     - develop and implement measures to eliminate the environmental pollution and on rehabilitation of disturbed lands
4. **Perform regular control and monitoring of the TSFs current state**
   - 4.1 Regularly monitor the water drainage channels to prevent overgrowth and siltation
   - 4.2 Perform regular visual and instrumental observations

Measures recommended for implementation by State Enterpise Sirka

4.3 Regularly monitor the environmental impact of the TSFs, in particular install a network of monitoring wells for groundwater level and pollution monitoring, and perform the surface water and soils quality monitoring

4.4 Perform control checks of the hydraulic structures readiness for safe operation during floods and autumn/winter periods at least twice a year

4.5 Perform scheduled survey and passportization of the hydraulic structures at least once every three or five years (depending on the facilities construction class)

4.6 Perform the regular survey of the TSFs at least once a year

5. Ensure the company's emergency preparedness at the TSFs

5.1 Develop Emergency Response Plans for all the three TSFs in accordance with the regulatory requirements, including consideration of all the probable accident scenarios, flood risk assessment in case of an emergency (modelling of the dam failure or overfill scenario of the TSFs) and probability of the domino effect

5.2 Perform identification and passportization of the TSFs as potentially hazardous facilities in accordance with the current legislation requirements

6. Ensure the maintenance of the operational documentation for the TSFs

6.1 Develop documentation on operation of the facilities
- operating manual
- Hydraulic Structure Passports for the TSFs, and
- ensure availability of technical documentation with the design parameters of the TSF structures

6.2 Develop documentation on waste management
- Waste Passports with definition of the composition, properties, and hazard class of the waste stored in the TSFs
- Passports for the Waste Disposal Facilities
- Waste Management Plans
- procedure for environmental monitoring of the TSFs, and
- ensure statistical reporting on waste management.

7. In expert opinion, the best way to prevent the anthropogenic pressure posed by inactive TSFs of State Enterprise Sirka on the SWB in the Dniester River Basin is the maximum recycling of accumulated waste, further closure of the facilities, and rehabilitation of disturbed lands

8. PJSC Stebnyk Mining and Chemical Enterprise Polimineral

Public Joint Stock Company Stebnyk Mining and Chemical Enterprise "Polimineral" (hereinafter "Polimineral") is an extractive industry company pursuing the potassium ores extraction and enrichment. It is located in the Stebnyk town, Drohobych District, Lviv Region. The company owns **1 TSF**, which remained from the activities of previous years.

In 2013, PJSC Rise Company acquired shares in PJSC Stebnyk MCE Polimineral, which were later sold to Zorema West LLC. State property that was not subject to privatization – Ore Mine 2, the TSF, brine line and their structures were handed over to the buyer – Zorema West LLC for responsible uncompensated storage.

One of the company's key issues, which affects safe operation of the facility, is pumping of brine from the TSF according to the "Comprehensive Project on Ore Mine 2 Conservation and Rehabilitation of Disturbed Lands", developed by Girkhimprom Institute LLC. The impossibility to achieve the designed indicators in practice was turned out during the project implementation, namely the solution saturation to the required parameters in industrial conditions. Injection of insufficiently saturated brines can lead to destruction of pillars in the ore mine, and therefore failure to achieve the main goal of the project – Ore Mine 2 conservation, and as a consequence – emergence of karst failures.

Fig. 62. Aerial photo. TSF and adjacent territory.
Legend: 1 – Section 1; 2 – Section 2; 3 – village of Bolekhivtsi; 4 – highway; 5 – pump station

The company stopped extracting potassium salts in 1988. According to the interviews, the TSF has not been filled with production waste since that time. The total amount of waste in the TSF as of 2018 was **12.74 mln m^3,** of which 2.85 mln m^3 was the liquid phase in TSF Section 2 and 8.29 mln m^3 and 1.6 mln m^3 of the solid phase stored in Sections 1 and 2, respectively. Waste stored in the TSF in the form of brines by its chemical composition is chloride, sulfate and a small amount of carbonate salts with a salinity of 140-150 g/l. The substances contained in waste are characterized by toxic effects, mainly due to their irritating properties, and can be manifested in reduced population and species composition of hydrobionts, increased respiratory and digestive diseases, and disruptions of mineral metabolism in the human body.

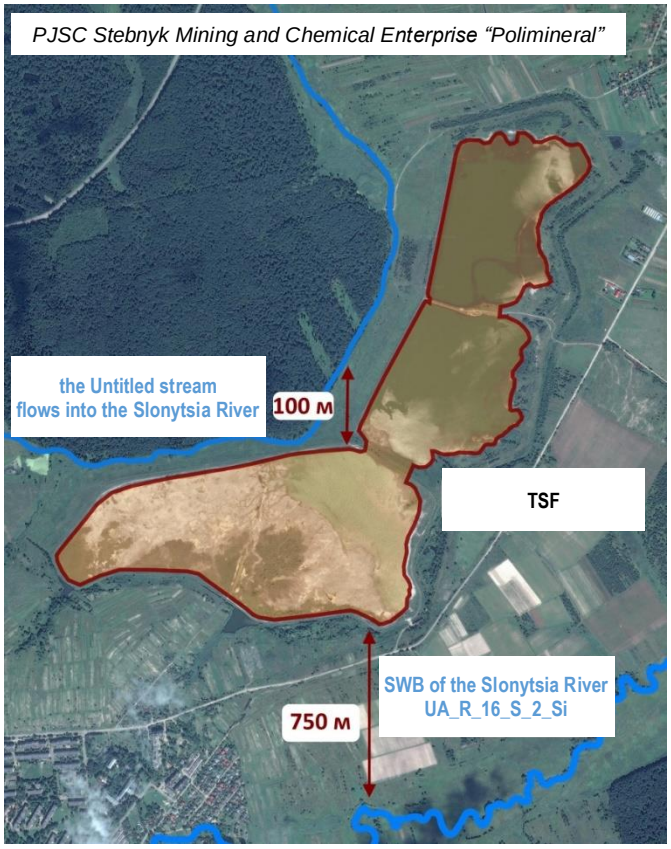

Fig. 63. Location of the TSF in relation to the hydrographic network

The TSF is 100 m away from the Untitled stream flowing into the Slonytsia River, and 750 m from the Slonytsia River SWB (UA_M5.2_0099, UA_R_16_S_2_SI; Fig. 63). Linear hydrographic network in the TSF location area: the Untitled stream – the Slonytsia River – the Tysmenytsia River – the Bystrytsia Tysmenytska – the Dniester River. In case of accidents at the TSF, pollutants can reach the transboundary Dniester River.

The climatic, hydrological, geological conditions and seismicity of the site of Polimineral TSF are considered as the main external natural hazard drivers of TSF operation, namely:

- climatic hazard driver: heavy rains that occur in the TSF site can cause overfilling of the facility, with waste overflowing the dam crest
- hydrological hazard driver: there is no the flooding hazard driver – the TSF is located beyond the boundaries of any rivers with a potential flooding ability (based on the preliminary assessment of the flooding risks of the Dniester River Basin area)

- geological hazard driver: **formation and intensification of karst-suffusion processes within the Stebnyk potassium ore mine affected area** – existing karst failures that pose a threat of infrastructure destruction (roads, power lines, water pipelines, industrial and construction structures) and further development of produced water breakthroughs into mining workings. This indicates the existing threat of groundwater and surface water bodies pollution of the nearby small rivers of the Dniester River Basin (the Vyshnytsia and the Slonytsia), including the Dniester River itself

Fig. 64. Karst failure in the mining branch area of Ore Mine 2, date of shooting – July 2018.
Fig. a – general view, Fig. b – top view, aerial photo,
Fig. c – area near the karst failure (1): highway (2), Truskavets town (3)

- seismicity of the area: the TSF is located in a seismically hazardous area (the background seismic intensity is 7 points[60]). This can adversely affect stability of TSF dams and other structures, which in turn increases the risk of accidents

As of 2018, the company monitors seismic activity using one seismic station[61]. Also, the Lviv Polytechnic National University conducts a monitoring study of the earth's surface and prediction of spatial displacements, initiated and funded by the Lviv Regional State Administration. The territory sensing technology applying automation equipment and geoinformation systems within the Stebnyk deposit of potassium salts is used.

The research on the current state of Polimineral TSF in 2018 showed that the facility operation level does not meet the requirements of the environmental and technogenic safety standards. In particular, the following significant non-compliances have been identified:

Fig. 65. TSF, diverting water channel

- **a critical filling level of Section 2 of the TSF was observed from May to August 2018. Intense precipitation pose a threat of dam failure and brine leakage with further escape of pollutants into the Dniester River Basin water bodies**
- **there are signs of minor flooding the areas adjacent to the TSF**
- **the diverting water channels are partially uncleared**

[60] The DSTU B.V.1.1-28 scale for average soil conditions and 5% probability of exceeding the regulatory seismic intensity over 50 years (Map ZSR-2004-B). According to DBN B.1.1-12: 2014. Construction in seismic areas of Ukraine. State Construction Codes of Ukraine

[61] S.I. Subotin Institute of Geophysics on “Seismic Monitoring in the Area of Stebnyk Potash Plant”

- **abandoned condition of the onshore pump station at Section 2 of the TSF and scrap metal storage in the adjacent territory**
- **the environmental monitoring of the TSF is not fully performed: there is no soil quality monitoring**
- **there are no warning signs to prevent unauthorized access to the TSF**
- **there is no documentation on TSF waste passportization and accounting: no Waste Passport and WDF Passport, the forms of state statistical reporting on waste management are not filled in**

Fig. 66. Adjacent territory and onshore pump station

Fig. 67. Aerial Photo. Signs of minor flooding near TSF Section 1

The above key non-compliances in the operation of such a potentially hazardous facility need to be addressed to minimize its impact on the environment and to prevent accidents. Relevant recommendations are provided in the section below.

The review of **internal emergency planning** showed that PJSC Stebnyk MCE Polimineral **developed an Emergency Response Plan for the TSF** with a list of probable accident scenarios and measures to be taken in case of an emergency. However, a flood risk assessment in case of an emergency (modelling of the dam failure or overfill scenario of the TSF) was not performed. Passportization of the TSF as a Potentially Hazardous Facility was not fully done: the Passport form of Potentially Hazardous Facility does not correspond to the approved 1NS (enterprise) form and the Certificate of Facility Registration in the State Register of Potentially Hazardous Facilities has not been received.

A large-scale accident already happened at the TSF in the past **– in 1983, a shift of the bottom slope caused a Section 2 dam failure with brine leakage**, resulting in about 4.5 mln m^3 of waste escaped into the hydrological network. The critical filling level of Section 2 of the TSF (from May to August 2018) and natural conditions in the facility area, listed at the beginning of this section, significantly increase the risk of various scale accidents. Thus, flood risk assessment in case of an emergency at the TSF (modelling of the dam failure or overfill scenario of the TSF) is extremely important for this facility, as well as proper emergency preparedness of the company and public authorities.

Fig. 68. TSF, Section 2

The results of the “Methodology for Comprehensive Evaluation of Tailings Management Facilities Safety” application, based on the analysis of the visual observation data, staff interviews, and documentation analysis, showed an unsatisfactory level of ensuring proper operation of the TSF (Table 8).

Table 8. Results of categorial evaluation of Polimineral TSF operation (below 50% are highlighted)

No.	Category	Safety criteria compliance level, %	Category significance (critical – extremely important)[62]
I	Geological, climatic and local conditions	**37.0**	non-critical
II	TSF location plan	90.5	non-critical
III	Substances (waste volume and toxicity)	61.1	critical
IV	Dam and screens	55.6	critical
V	Transport and infrastructure	62.5	critical
VI	Water flow management	**33.3**	critical
VII	Environmental impact assessment	**23.8**	critical
VIII	Emergency Response Plan	60.1	critical
IX	Monitoring	75.6	critical
X	Training and personnel	70.6	non-critical
XI	Verification and reporting	80.5	non-critical
XII	Closure and rehabilitation	**43.8**	critical
Overall result		**57.9**	–

As of 2018, PJSC Stebnyk Mining and Chemical Enterprise Polimineral has not been pursuing its main business activity – extraction of mineral raw materials for the chemical industry and production of mineral fertilizers, as it is impossible to implement the Ore Mine 2 conservation project, which is a condition of the company sale contract. Further, the company has a growing debt to reimburse preferential pensions for the previous periods. The company issues are considered at the meetings of the Interagency Working Group, which includes representatives of the company, central and territorial executive bodies. Even so it is necessary to find ways of expediting the solution of Ore Mine 2 conservation issue given the high risk of catastrophic karst failures, which occurred twice over the past 3 years.

The list of TSF operation non-compliances identified during the research and the measures to maintain the facilities safety are provided in the Report in the tabular form according to the pattern: “identified non-compliance” – “legislative criteria” – “corresponding recommendation”. Below are provided the recommendations, the implementation of which is critical for safe operation of the TSF.

[62] Critical categories are extremely important TSF safety categories, which relate mainly to technical aspects of facility operation and safety maintenance. Detected non-compliances with the safety requirements in these categories require mandatory urgent action. Non-critical categories relate to issues mostly concerned with documentation management and reporting, and the facility personnel qualification level

Measures recommended for implementation by PJSC Stebnyk Mining and Chemical Enterprise Polimineral

1. Ensure TSF safety

1.1 Maintain an acceptable level of the waste (brine) liquid phase in the TSF. For gradually reducing the brines level in the TSF by their pumping into the voids of Ore Mine 2, adjust the existing design project documentation developed by Girkhimprom Institute LLC or develop new design project documentation for Ore Mine 2 conservation and rehabilitation of disturbed lands taking into account the current industrial conditions

1.2 Inspect the technical state of the TSF structures to identify the causes of minor flooding the adjacent areas and the environmental impact, develop and implement relevant response measures

1.3 Regularly clear up the TSF water drainage system

1.4 Ensure proper condition of the onshore pump station and the adjacent territory at Section 2 of the TSF

1.5 Install the appropriate warning signs in the area of the TSF (“danger zone”, “unauthorized passage and entry prohibited”, “no swimming”)

2. Perform regular control and monitoring of the TSF current state

2.1 Regularly perform full-scope environmental monitoring of the TSF. In particular, carry out the soils quality monitoring

2.2 Perform scheduled survey and passportization of the hydraulic structures at least once every three or five years (depending on the facilities construction class)

2.3 Perform the regular survey of the TSF at least once a year

3. Ensure the company’s emergency preparedness at the TSF

3.1 Supplement the Emergency Response Plan of the TSF with a flood risk assessment in case of an emergency (modelling of the dam failure or overfill scenario of the TSF)

3.2 Perform the passportization of Potentially Hazardous Facilities in full:

- develop a Potentially Hazardous Facility Passport using the approved 1NS (enterprise) form
- maintain a Potentially Hazardous Facility Passport using specialized software posted on the website of the State Register of Potentially Hazardous Facilities (Research Institute of Micrography)
- obtain a Certificate of Facility Registration in the State Register of Potentially Hazardous Facilities

Measures recommended for implementation by PJSC Stebnyk Mining and Chemical Enterprise Polimineral

- identify Facilities of High Hazard among the identified Potentially Hazardous Facilities

4. Ensure the maintenance of the operational documentation for the TSF

4.1 Develop a Hydraulic Structure Passport for the TSF

4.2 Develop documentation on waste management

- Waste Passport with definition of composition, properties and hazard class of the waste stored in the TSF
- Passport for the Waste Disposal Facility
- Waste Management Plans, and
- ensure statistical reporting on waste management

5. In expert opinion, the best way to prevent the anthropogenic pressure posed by inactive TSF of PJSC Stebnyk Mining and Chemical Enterprise Polimineral on the SWB in the Dniester River Basin is the maximum recycling of accumulated waste, further closure of the facility and rehabilitation of disturbed lands

9. PJSC NPK-Galychyna

Public Joint Stock Company Oil Refinery Galychyna (hereinafter “NPK-Galychyna”) is a former Drohobych Oil Refinery and is one of the oldest oil refineries in Ukraine. The plant is located near Drohobych town, Lviv Region. The company owns **Sludge Storage Facilities** (in this Summary the term is “TSFs”) located at the site of the former Oil Refinery 1 and at the site of the former Oil Refinery 2.

The main business activity of PJSC NPK-Galychyna is oil refining and production of petroleum products, however **the company has been idle since 2011:** does not refine oil, instead provides services for transportation of goods, storage, rental of rail tank cars, etc.[63]

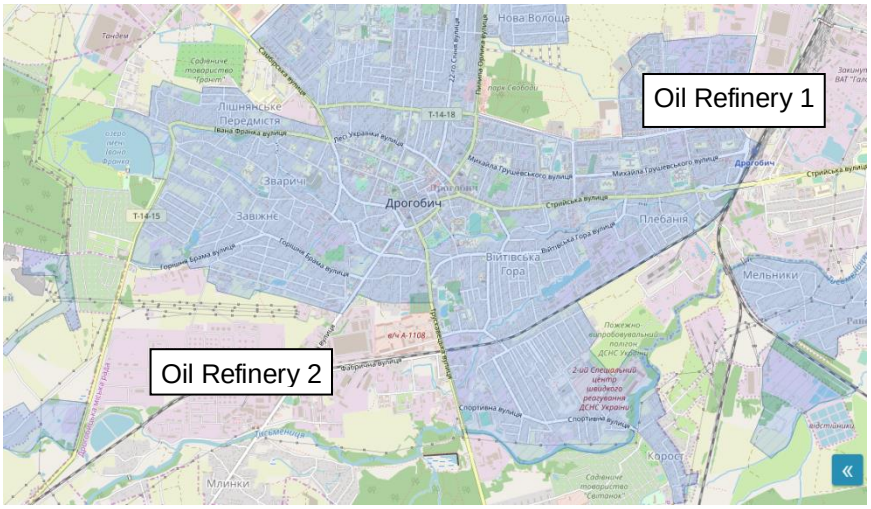

Fig. 69. Location of PJSC “NPK-Galychyna” sites

The TSFs of Oil Refinery 1 are registered by the state as closed waste disposal facilities (WDF). The company’s documentation does not properly account these facilities: according to the UkrNDINP “MASMA” 2005 report[64], there are 7 separate TSFs at Oil Refinery 1 site (Fig. 70). The company documentation designates these facilities as two groups of TSFs: Group 1 and 2, and, accordingly, two WDF Passports have been developed. According to the interviews, Group 1 TSFs include TSFs 5-7, and Group 2 – TSFs 1-4, but the company’s documentation does not schematically reflect such grouping, **the enterprise reports to the Regional State Administration on two TSFs (Group 1 and Group 2), while in fact it is 7 separate TSFs (1-7).**

[63] According to the PJSC NPK-Galychyna 2019 Annual Report
[64] Report on the research “Perform a Comprehensive Analysis of OJSC NPK-GALYCHINA Oil Waste” dated 30.12.2005, Ukrainian Research Institute of Oil Refining Industry “MASMA”

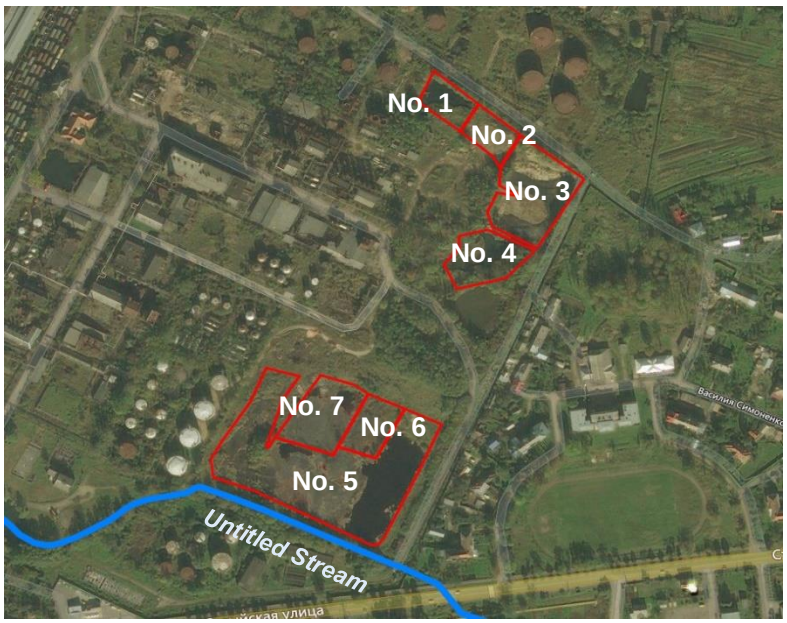

Fig. 70. TSFs 1-7 of Oil Refinery 1

According to the interviews, four out of seven TSFs of Oil Refinery 1 have been liquidated. However, no information was provided on the implementation of the liquidation stages, including data on the IDs of liquidated TSFs, the year of their liquidation, the amount of waste stored in the TSFs and the scope of work on technical and biological rehabilitation of disturbed lands.

The TSF of Oil Refinery 2 is an active facility according to the WDF Register. Information about this facility was not provided during the visit to the company. Its existence on the balance of PJSC NPK-Galychyna was revealed during documentation analysis. The data on technical parameters of the structures, amount and type of the accumulated waste was not provided. The request on a second visit for a visual inspection of the TSF of Oil Refinery 2 was rejected by the company.

Fig. 71. TSF of Oil Refinery 2

The total amount of waste in NPK-Galychyna TSFs (Oil Refinery 1 and Oil Refinery 2) is **39,827.08 tons**, according to the data from the WDF Register of the Lviv Region provided in 2019. The chemical composition of oil sludge is a mixture of hydrocarbons, mechanical impurities and water, with gas emissions – hydrocarbon vapors. The substances contained in oil refining waste are characterized by strong toxic effects: pronounced mutagenicity and carcinogenicity of aromatic hydrocarbons, narcotic effect – the cardiovascular system and blood parameters effects (decrease in hemoglobin and erythrocytes); liver damage, endocrine disorders, skin irritation and pigmentation are also possible.

The shortest distance from the TSFs of Oil Refinery 1 to water bodies: 10 m to the Untitled stream flowing into the Tysmenytsia River, and 580 m to the SWB of the Tysmenytsia River (UA_M5.2_0090, UA_R_16_M_2_Si; Fig. 72). The TSF of Oil Refinery 2 is located 25 m from the SWB of the Ratochyna River (UA_M5.2_0097, UA_R_16_S_2_Si; Fig. 73). Linear hydrographic network: the Untitled stream – the Tysmenytsia River – the Bystrytsia Tysmenytska River – the Dniester River; and the Ratochyna River – the Tysmenytsia River – the Bystrytsia Tysmenytska River – the Dniester River. In case of accidents at the TSFs, pollutants can reach the transboundary Dniester River.

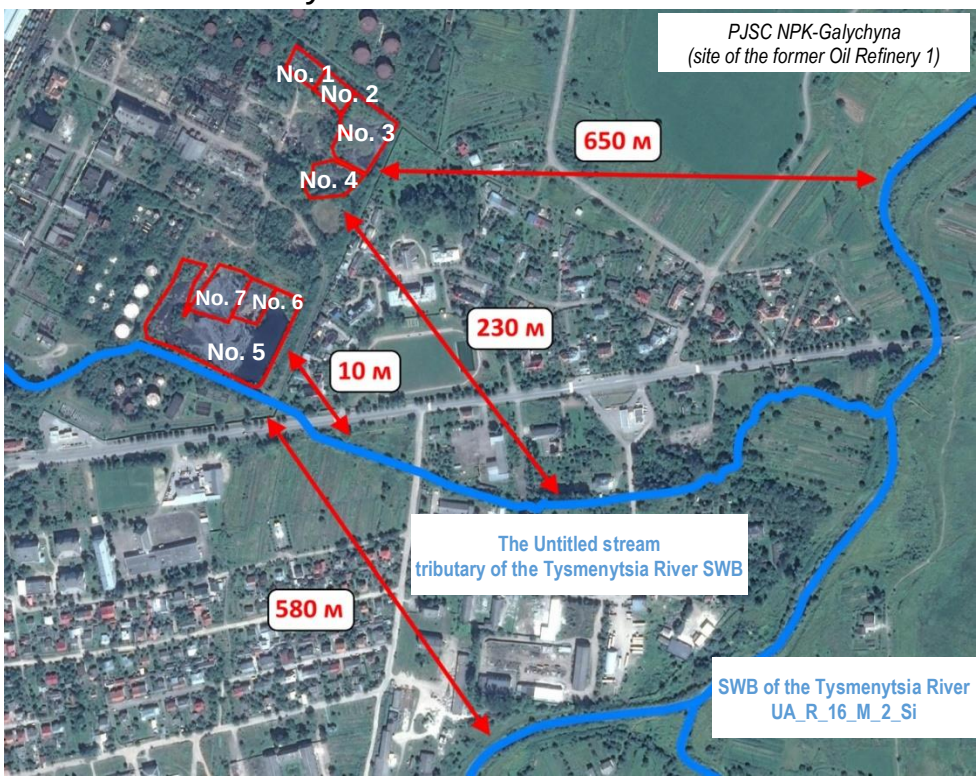

Fig. 72. Location of the NPK-Galychyna's Oil Refinery 1 TSFs relative to the hydrographic network

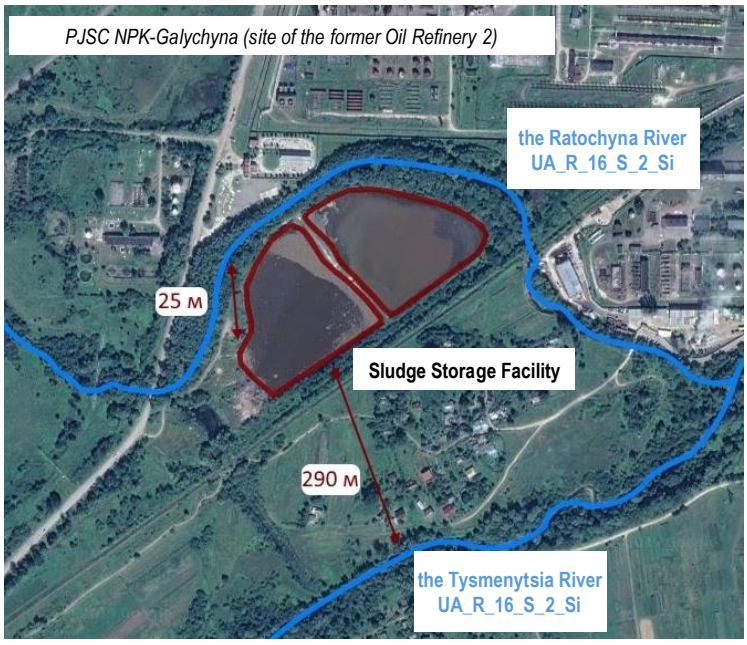

Fig. 73. Location of the NPK-Galychyna's Oil Refinery 2 TSF relative to the hydrographic network

The climatic, hydrological, geological conditions and seismicity of the site of NPK-Galychyna TSFs are considered as the main external natural hazard drivers of TSF operation, namely:

- climatic hazard driver: heavy rains that occur in the area of the TSFs can cause overfilling of the facilities, with waste overflowing the embankment
- hydrological hazard driver: there is no the flooding hazard driver – the TSFs are located beyond the boundaries of any rivers with a potential flooding ability (based on the preliminary assessment of the flooding risks of the Dniester River Basin area)
- seismicity of the area: the TSFs are located in a seismically hazardous area (the background seismic intensity is 7 points[65]). The existing seismic activity can adversely affect stability of the embankment and other TSF structures, which in turn increases the risk of accidents.

A peculiarity of the Oil Refinery 1 TSFs territory is proximity to a residential buildings: private houses, a school, a stadium (20 m – 80 m). The established sanitary protection zone of the TSFs, which according to the documentation should be 50 m, is not maintained. Additionally, there is a risk of minor flooding the buildings basements and water pollution in the household wells. Residential buildings and other oil refinery company's industrial facilities located near the TSFs create preconditions for the domino effect – the probability of occurrence or successive occurrence of accidents at facilities located in close proximity to each other.

In 2018, the TSFs of NPK-Galychyna located at the site of the former Oil Refinery 1 were visited, and the provided documentation, staff interviews, and information from open data sources was analysed. The research on the current state of the TSFs in 2018 showed that the facility operation level does not meet the requirements of the environmental and technogenic safety standards. In particular, the following significant non-compliances have been identified[66]:

- **signs of integrity failure of waterproofing layer, decreasing of anti-filtration screens properties and embankment reliability of all the TSFs: minor flooding is observed with traces and odors of petroleum products in the surrounding area; in addition, the results of the company 2016-2018 monitoring indicate increased content of petroleum products in water samples from the monitoring wells in the autumn months of 2018. The formed range of contaminated area is observed around the TSFs**
- **TSFs 3 and 5 have a critical filling level reaching the edge of the embankment**
- **unidentified waste, similar in color and odor to oil refining waste, is placed on unprotected ground beyond TSFs 5-7**

[65] The DSTU B.V.1.1-28 scale for average soil conditions and 5% probability of exceeding the regulatory seismic intensity over 50 years (Map ZSR-2004-B). According to DBN B.1.1-12: 2014. Construction in seismic areas of Ukraine. State Construction Codes of Ukraine

[66] During the TSFs visual inspection, the company security did not allow making photos and videos

- **TSF emergency preparedness of the company is not ensured:**
  - **there is no information on identification and passportization of the TSFs as Potentially Hazardous Facilities**
  - **the company Accident Localization and Elimination Plan does not consider probable accident scenarios at the TSFs**
  - **there is no documentation on the personnel actions in case of accidents at the TSFs**
- **environmental impact monitoring of the TSFs is carried out not in full. In particular, there is no soil quality control, no groundwater samples are taken from Well 4 located within the residential buildings area**
- **the visual observations of the structures' condition and measurements of the TSF filling levels are not recorded in the logs**
- **there is no hazardous waste management license**
- **there are system-level non-compliances in the maintenance of operational documentation, there is no key safety documents – design documentation, Hydraulic Structure Passports, Waste Management Plans, WDF Passports for each TSF have not been developed, and the Operating Instruction needs updating.**

The TSFs of Oil Refinery 1 were decommissioned in 1995. The company has developed project technical documentation for oil sludge recycling, liquidation (closure) of the TSFs and rehabilitation of disturbed lands (2003). A visual inspection of the liquidated TSF showed that the land is not aligned; the surface is unstable; precipitation collects on the surface of uneven terrain, which can lead to water erosion and erosion of TSF embankments; there is no access road. The facility has been actually decommissioned – oil sludge was removed, the facility was filled with a layer of inert soil, which demonstrates the improper implementation of all the TSF liquidation stages, including rehabilitation of disturbed lands.

NPK-Galychyna TSFs of Oil Refinery 1 are inactive for about 25 years, and no closure of the TSFs and rehabilitation of the disturbed lands were performed, while the company spends resources (electricity, man-hours) to maintain their safety.

The above key non-compliances in the operation of such potentially hazardous facilities need to be addressed to minimize their impact on the environment and to prevent accidents. Relevant recommendations are provided in the section below.

The results of the "Methodology for Comprehensive Evaluation of Tailings Management Facilities Safety" application, based on the analysis of the visual observation data, staff interviews, and documentation analysis, showed an unsatisfactory level of ensuring proper operation of the TSFs (Table 9) – the compliance with the safety criteria is below 50% in all categories.

Table 9. Results of categorial evaluation of the TSFs operation located at the site of the former Oil Refinery 1

No.	Category	Safety criteria compliance level, %		Category significance (critical – extremely important)[67]
		TSFs 1-4	TSFs 5-7	
I	Geological, climatic and local conditions	17.5	17.5	non-critical
II	TSF location plan	24.4	24.4	non-critical
III	Substances (waste volume and toxicity)	47.9	37.9	critical
IV	Dam and screens	29.6	20.2	critical
V	Transport and infrastructure	33.3	33.3	critical
VI	Water flow management	24.4	19.0	critical
VII	Environmental impact assessment	28.6	9.5	critical
VIII	Emergency Response Plan	13.3	13.3	critical
IX	Monitoring	26.0	30.1	critical
X	Training and personnel	27.5	27.5	non-critical
XI	Verification and reporting	9.5	9.5	non-critical
XII	Closure and rehabilitation	43.6	21.1	critical
	Overall result	**27.1**	**22**	–

The list of TSF operation non-compliances identified during the research and the measures to maintain the facilities safety are provided in the Report in the tabular form according to the pattern: “identified non-compliance” – “legislative criteria” – “corresponding recommendation”. Below are provided the recommendations, the implementation of which is critical for safe operation of the TSFs.

[67] Critical categories are extremely important TSF safety categories, which relate mainly to technical aspects of facility operation and safety maintenance. Detected non-compliances with the safety requirements in these categories require mandatory urgent action. Non-critical categories relate to issues mostly concerned with documentation management and reporting, and the facility personnel qualification level

Measures recommended for implementation by PJSC NPK-Galychyna

1. **Obtain a license for hazardous waste management**
2. **Ensure proper operation of the TSFs**
   - 2.1 Inspect the technical state of the TSFs structures to identify the causes of seepage and the environmental impact, while also determining the pollution area. Based on the results, develop and implement measures to prevent the pollution and eliminate its consequences
   - 2.2 Prevent filling of TSFs 3 and 5 to the critical level:
     - pump out the liquid from the TSFs timely to reduce the filling level
     - carry out the additional observations of the filling level during heavy precipitation
   - 2.3 Identify the waste stored near TSFs 5-7 and ensure the waste disposal into a specially designated facility. Clean the area of disturbed lands near the TSFs from waste, conduct soil surveys on the pollution level and rehabilitate disturbed lands
   - 2.4 Recalculate the size of sanitary protection zone for the TSFs in accordance with the actual location of the residential buildings
3. **Perform regular control and monitoring of the TSFs current state**
   - 3.1 Regularly perform visual observations of the structures' condition and measure filling level of the TSFs , with recording of the obtained results in the company structures' operation logs
   - 3.2 Ensure full-scope environmental monitoring of the TSFs. In particular, perform soil quality control and resume groundwater monitoring in Well 4 to control the impact of the TSFs within the residential buildings
   - 3.3 Perform scheduled survey and passportization of the hydraulic structures at least once every three or five years (depending on the facilities construction class)
   - 3.4 Perform the regular survey of the TSFs at least once a year
4. **Ensure the company's emergency preparedness at the TSFs**
   - 4.1 Revise and complement the "PJSC NPK-Galychyna Accident Localization and Elimination Plan", including consideration of probable accident scenarios at the TSFs
   - 4.2 Perform identification and passportization of the TSFs as Potentially Hazardous Facilities in accordance with the current legislation requirements

Measures recommended for implementation by PJSC NPK-Galychyna

5. Ensure proper closure of the TSFs located at Oil Refinery 1 site and rehabilitation of disturbed lands

5.1 Fully perform the closure of Oil Refinery 1 TSFs (numbers 1-7) and rehabilitation of disturbed lands in accordance with the project technical documentation

5.2 Perform the monitoring of TSF physical stability, condition of the soils, surface and groundwater during and after completing the activities

6. Ensure the maintenance of the operational documentation for the TSFs

6.1 Develop documentation on facility operation

- Hydraulic Structure Passports for the TSFs
- ensure availability of technical documentation with the design parameters of the TSF structures
- update the Operating Instruction based on the current state of the facilities
- update the mapping of the TSFs , displaying the actual contours of structures and IDs of the TSFs

6.2 Develop documentation on waste management

- WDF Passports for each TSF 1-7, indicate information based on the current state of the facilities, and indicate the actual amount of waste stored for each TSF
- procedure for environmental monitoring of the TSFs
- Waste Management Plans

7. In expert opinion, the best way to prevent the anthropogenic pressure posed by inactive TSFs of PJSC NPK-Galychyna on the SWB in the Dniester River Basin is the maximum recycling of accumulated waste, further closure of the facilities, and rehabilitation of disturbed lands

10. Boryslavnaftogaz Oil and Gas Production Department of PJSC Ukrnafta

Boryslavnaftogaz Oil and Gas Production Department of Public Joint Stock Company “Ukrnafta” (hereinafter the “Boryslavnaftogaz”) is a lead structure unit of PJSC Ukrnafta for comprehensive development of oil and gas deposits, oil with condensate and natural and oil gas extraction. The main department is located in Boryslav town, Drohobych District, Lviv Region. The company owns **one TSF –** sludge storage facility (in this Summary the term is “TSF”).

The TSF is intended for storage and settling of solid petroleum products waste from the Boryslavnaftogaz oil collection points. The facility was commissioned in 2001. As of 1 January 2019, it stores **1,551.102 tons** of oil sludge solid fraction. The chemical composition of oil sludge is a mixture of hydrocarbons, mechanical impurities and water, with gas emissions – hydrocarbon vapors. The oil refining waste substances are characterized by strong toxic effects: pronounced mutagenicity and carcinogenicity of aromatic hydrocarbons, narcotic effect – effects on the cardiovascular system and blood parameters (decrease in hemoglobin and erythrocytes); liver damage, endocrine disorders, skin irritation and pigmentation are also possible.

The TSF of Boryslavnaftogaz is located 500 m from the Tysmenytsia River SWB (UA_R_16_S_2_SI, UA_M5.2_0089; Fig. 74). Linear hydrographic network: the Tysmenytsia River – the Bystrytsia Tysmenytska River – the Dniester River. In case of accidents at the TSF, pollutants can reach the transboundary Dniester River.

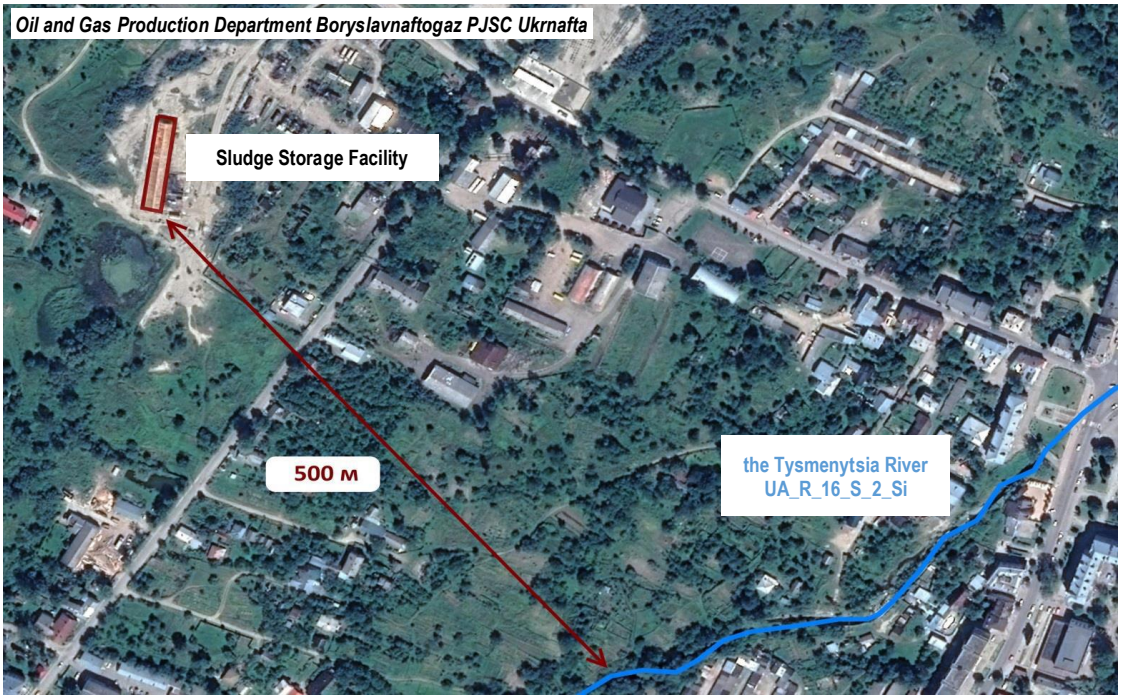

Fig. 74. Location of the Boryslavnaftogaz TSF relative to the hydrographic network

The climatic, hydrological, geological conditions and seismicity of the site of Boryslavnaftogaz TSF are considered as the main external natural hazard drivers of TSF operation, namely:

- climatic hazard driver: the TSF location is characterized by high humidity and significant amount of precipitation, which can cause overfilling of the facility, with waste overflowing the flanks, and intensify the processes of hypergenesis and migration of pollutants
- hydrological hazard drivers:
  - the groundwater in the TSF area occurs at a depth of 2.5 m with a seasonal fluctuation of 1.1 m, and is categorized as “nominally protected” (vulnerable to pollution), which causes a risk of toxic waste entering the aquifer
  - there is no flooding hazard driver – the TSF is located beyond the boundaries of any rivers with a potential flooding ability (based on the preliminary assessment of the flooding risks of the Dniester River Basin area)
- seismicity of the area: the TSF is located in a seismically hazardous area (the background seismic intensity is 7 points[68]). The existing seismic activity can adversely affect stability of the TSF structures, which in turn increases the risk of accidents.

A peculiarity of the TSF location is proximity to a residential buildings: private houses are located 80 m away. The requirements for sanitary protection zone of the TSF, which according to the company’s documentation should be 300 m, have been violated. Additionally, there is a risk of minor flooding the buildings basements and water pollution in the household wells.

The research on the current state of the Boryslavnaftogaz TSF in 2019 showed that the facility operation level does not meet the requirements of the environmental and technogenic safety standards. In particular, the following significant non-compliances have been identified:

- **the oil sludge overflow and spread beyond the TSF was observed, the liquid fraction of waste reaches the flank edges**
- **filling level of the TSF is not measured with recording the results in the monitoring log**

[68] The DSTU B.V.1.1-28 scale for average soil conditions and 5% probability of exceeding the regulatory seismic intensity over 50 years (Map ZSR-2004-B). According to DBN B.1.1-12: 2014. Construction in seismic areas of Ukraine. State Construction Codes of Ukraine

- **the amount of waste disposed in the TSF exceeds its design volume: as of January 1, 2019, the actual 1,551.1 tons of waste exceeds the design volume of 1,200 tons**
- **TSF emergency preparedness of the company is not fully ensured:**
  - **there is no information on identification and passportization of the TSF as a Potentially Hazardous Facility**
  - **the company Accident Localization and Elimination Plan was not provided; there is no information on consideration of probable accident scenarios at the TSF**
  - **there is no documentation on the personnel actions in case of accidents at the TSF**
- **there are non-compliances in maintaining the operational documentation: there is no Operating Instruction; the WDF Passport, the Waste Passport (oil sludge) and the statistical reporting forms need updating.**

Fig. 75. Overflow and spread of oil sludges beyond the SSF

The above key non-compliances in the operation of such a potentially hazardous facility need to be addressed to minimize its impact on the environment and to prevent accidents. Relevant recommendations are provided below.

The TSF of Boryslavnaftogaz is a specially constructed storage, the bottom and the sides of which have concrete insulation screens. This facility design feature is not covered by most of the safety criteria stated in the “Methodology for Comprehensive Evaluation of Tailings Management Facilities Safety”, which determined the impossibility of its full-scope application.

The current state of the TSF was determined using the national legislation criteria in the oil and gas industry and waste management.

Visiting the Boryslavnaftogaz company, an expert group inspected the sites of **oil natural leaks to the surface near the Tysmenytsia River, a tributary of the Dniester River.**

The following occurs on the territory of Boryslav town as a result of long-term oil and gas extraction (over 150 years):

- leaks of the oil-containing mixture in the area of about 20,000 pit wells (shaft wells left over from former oil extraction). The total number of the pit wells is unknown. Such facilities are essentially unsealed land cavities, some of which were found in the Tysmenytsia riverbed
- oil natural leaks to the surface near oil and gas producing wells. In total, there are about 2,000 wells in the town, operated by subsoil users PJSC Ukrnafta and Econaftogaz Research and Production Enterprise LLC
- destruction of the shore protecting infrastructure with subsequent escape of the oil-containing mixture into water bodies

Fig. 76. Leaks of the oil-containing mixture in the area of pit wells

Fig. 77. Oil natural leaks to the surface near oil and gas producing wells and near a residential building

Proposals on possible steps to reduce the pressure of petroleum products on the water bodies in the Dniester River Basin were considered during a working meeting on the environmental issues of Boryslav town (July 12, 2019). The Boryslav City Council executives, representatives of the Dniester BWA, Drohobych Water Management Administration, the Reform Support Team of the Ministry of Ecology and Natural Resources of Ukraine and GEF Project experts attended the meeting.

Fig. 78. Working meeting on environmental issues of Boryslav town

During the discussions, the Boryslav City Council and the Dniester BWA were proposed the following solutions to respond the environmental consequences of long-term oil extraction in Boryslav:

- inform the Ministry of Environmental Protection and Natural Resources of Ukraine on the current environmental situation related to long-term oil and gas extraction in the Boryslav town
- apply to local research institutions with a proposal of developing an oil pit wells database as sources of water body pollution through their identification in the framework of a research involving students and international experience-sharing grant projects
- arrange a meeting with subsoil users operating in Boryslav and discuss the leak-prevention ways at the oil mining facilities and setting up of engineering shore reinforcement structures in the areas of wells and oil collection points
- develop a list of measures to reinforce the shoreline in the shore destruction areas
- consider the issue of an oil pollution of the water bodies flowing into the Tysmenytsia River at a scheduled Dniester Basin Council meeting and discuss the proposals to be included in the Dniester River Basin Management Plan. Invite representatives of central and local authorities, as well as water users, specialists of research institutions and public organizations to participate in the discussion.

Following the discussions, the Boryslav City Council applied to the Ministry of Environmental Protection and Natural Resources of Ukraine with a proposal to establish a working group involving representatives of the Ministry of Environmental Protection and Natural Resources of Ukraine, Lviv Regional State Administration, Dniester BWA, and PJSC Ukrnafta to address the proper closure of abandoned oil pit wells, arrange engineering shore reinforcement structures in the areas of wells and oil collection points, as well as identify the funding sources for these measures.

The issue of oil pollution of water bodies in the Dniester River Basin near Boryslav town requires a trilateral dialogue to pool the efforts of the central and local authorities, territorial water administrations and local businesses to attract technical assistance from countries with similar experience.

The list of TSF operation non-compliances identified during the research and the measures to maintain the facility safety are provided in the Report in the tabular form according to the pattern: “identified non-compliance” – “legislative criteria” – “corresponding recommendation”. Below are provided the recommendations, the implementation of which is critical for safe operation of the TSF.

Measures recommended for implementation by Boryslavnaftogaz Oil and Gas Production Department of PJSC Ukrnafta

1. **Ensure proper operation of the TSF:**
   - 1.1 Take the necessary measures to prevent overflow and spread of oil sludge (liquid fraction) beyond the TSF
     - pump out the oil sludge from the TSF to reduce the filling level
     - clean the area of disturbed lands near the TSF from hazardous waste, conduct soil surveys on the pollution level, and rehabilitate disturbed lands
   - 1.2 Ensure the waste amount stored in the TSF not exceeding the facility's design volume
   - 1.3 Prevent critical filling levels: measure the filling level of the TSF, recording the results in the monitoring log, and pump out the liquid from the TSF to reduce the filling level
   - 1.4 Recalculate the size of sanitary protection zone for the TSF in accordance with the actual location of the residential buildings
2. **Ensure the company's emergency preparedness at the TSF**
   - 2.1 Perform identification and passportization of the TSF as a potentially hazardous facility in accordance with the current legislation requirements
   - 2.2 Revise and complement the company Accident Localization and Elimination Plan including consideration of probable accident scenarios at the TSF
3. **Ensure the maintenance of operational documentation for the TSFs**
   - 3.1 Develop documentation on facility operation and waste management
     - Operating Instruction for the TSF
     - procedure for environmental monitoring of the TSFs
     - Waste Management Plans
   - 3.2 Display current waste management data in the documentation
     - forms of statistical reporting: the total amount of waste accumulated in the TSF
     - WDF Passport: the results of environmental monitoring of the TSF
     - Waste Passport for oil sludge: amount of waste production, disposal, recycling.
4. **In expert opinion, the best way to prevent the anthropogenic pressure posed by the TSF of Boryslavnaftogaz Oil and Gas Production Department of PJSC Ukrnafta on the SWB in the Dniester River Basin is to ensure proper operation of the facility, reduce the level of waste production, and maximum recycling of accumulated waste**

IV. RESULTS OF TSF INVENTORY IN THE ODESA REGION

TSF operator

11. CJSC Moldovan Thermal Power Plant

11. CJSC Moldovan TPP

Closed Joint Stock Company Moldovan Thermal Power Plant (hereinafter Moldovan TPP) is one of the largest thermal power plants providing electricity to Moldova, built in 1964 on the western bank of the Kuchurhan estuary, in the southern part of the Transnistrian region of the Republic of Moldova.

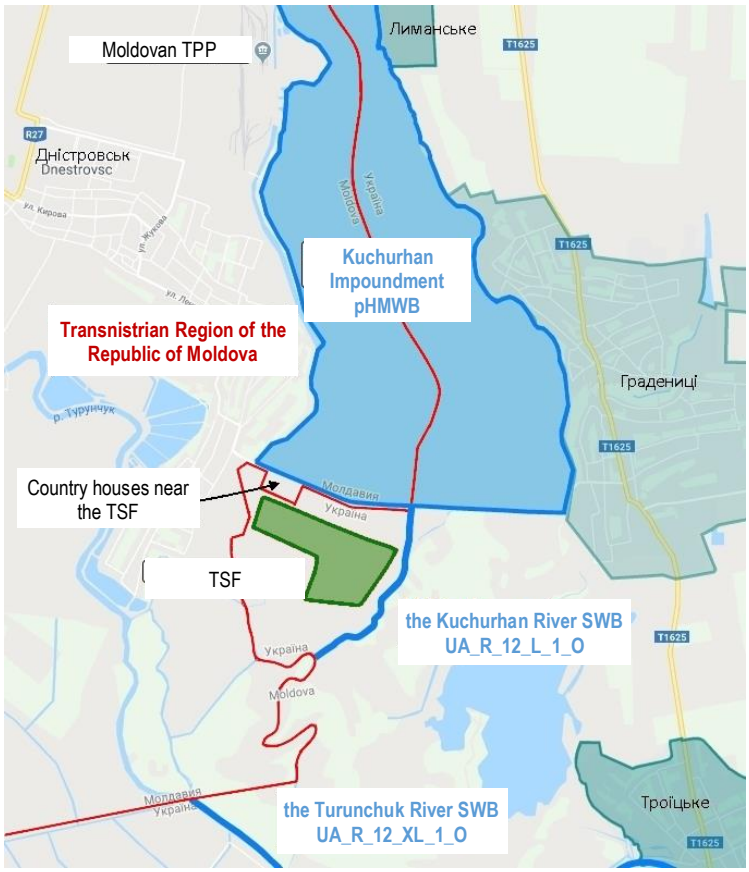

Fig. 79. Location of Moldovan TPP, the TSF is located in Ukraine

The peculiarity of the situation is that **the power plant's Ash-and-slag Storage Facility** (in this Summary the term is "TSF") **is located in Ukraine, whereas the owner and the entity responsible for its operation is a Transnistrian company – Moldovan TPP**. After dissolution of the USSR and establishment of the border of independent states, the plant's TSF turned out to be located on the lands of the Hradenytsia Village Council of the Biliaivka District, Odessa Region. According to the Moldovan TPP information, coal has not been used as fuel in the last decade and tailings have not been disposed to the TSF since 2005. Despite the fact that the facility is inactive, it affects the environment and human health, which has been repeatedly complained about by local residents.

There is no information on the total amount of ash and slag accumulated in the TSF. From the available documentation it is known that **711.750 thous tons of waste were disposed to the TSF from 2002 to 2004**. Also, according to preliminary calculations, **over 41.6 thous tons of dust per year** is emitted from the TSF surface, which is carried over by the wind and affects the inhabitants of Hradenytsi village, Biliaivka District, Odessa Region. The accumulated ash waste is not irrigated.

According to the conclusions made by the Department of Ecology and Natural Resources of the Odessa Regional State Administration, Moldovan TPP is one of the main enterprises polluting the environment in the Biliaivka District of the Odessa Region.

Key issues related to Moldovan TPP operation

1. Unresolved status of the TSF of Moldovan TPP.
2. The TSF is operated with violations of the environmental legislation: the rehabilitation of disturbed lands was not performed, the technological requirements for sections filling are not met, the accumulated ash-and-slag waste is not irrigated, which additionally pollutes the air and soils.
3. Moldovan TPP is a special water user of the Kuchurhan impoundment and discharges the diluted plant production waste from the impoundment into the Turunchuk River, which adversely affects the region's environment.
4. Moldovan TPP does not pay an environmental pollution fee. There are no permits on air emissions and waste disposal. The waste disposal fees have not been paid since 2000.
5. The Moldovan TPP land-use documentation is not developed in accordance with the current Land Code of Ukraine.
6. A radiation survey of the land under the Moldovan TPP's industrial waste, carried out by specialists of the Department of Radiation Hygiene of the State Sanitary and Epidemiological Service of the Odessa Region, found that the gamma background (14 μR/hour) was exceeded 2-3 times compared to the regional average.

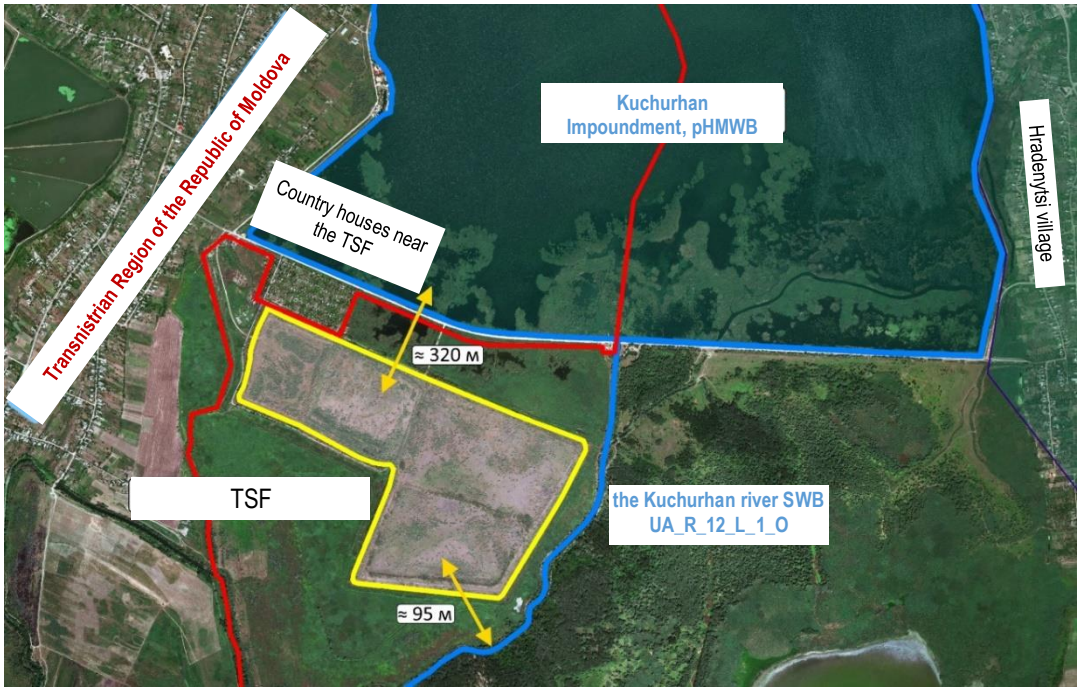

Fig. 80. Location of the TSF of Moldovan TPP in relation to the hydrographic network

On October 11, 2019, Ukrainian experts together with representatives of the Moldovan Party visited the TSF site to determine the facility's current state and technical features. The visual inspection found that:

Fig. 81. Overgrown TSF surface

- **the TSF surface is overgrown with reeds, which reduce carryover of dust large fractions. However, this does not solve the problem, because the disturbed lands have not been properly rehabilitated, and there is a dusting of fine ash-and-slag particles, which are carried over by the wind**
- **the dam, located on the opposite side of the Moldovan TPP, was repeatedly enlarged**
- **a destroyed pump station and a former settling pond (Fig. 82) – the former parts of the plant tailings facilities, were found. These facilities may indicate the boundaries of the first section of the TSF. Thus, there are signs of violated technogenic requirements related to filling of the TSF sections: waste is stored beyond the first section boundaries – the allotted plot of land intended for these purposes (around the pump station and the settling pond)**
- **in turn, the settling pond is in ruins, its boundaries are visible on several sides, and the other side of the pond is level now with the accumulated ash and slag waste that is determined based on the vegetation presence. Thus, the settling pond water, getting directly into the ash-and-slag mixture, maintained the moisture level and contributed to overgrowth of the TSF surface with vegetation**

Fig. 82. Photo of the ruined pump station. The arrow points to the Moldovan TPP buildings

- **behind the TSF dam there is a pipeline (apparently it was not used) for pumping ash and slag waste (Fig. 83). Probably, the land behind the dam was planned as a reserved section in case of filling the main storage facility. High-voltage electric transmission towers end at the level of the ruined pump station and the dam. Apparently, this was the border of the first section and there were transformer stations, which were missing at the time of the inspection.**

Fig. 83. Pipeline behind the TSF dam

The TSF of the Moldavian TPP is, in fact, an abandoned facility occupying large areas of Ukrainian lands (272.8 hectares). The waste storage conditions were violated during TSF operation. Contaminated drainage water from the facility is drained into the bypass channel, which flows into the Kuchurhan River, a left tributary of the Turunchuk River of the Dniester River Basin. The company did not properly perform the closure of the TSF and rehabilitation of disturbed lands.

Fig. 84. View of the Moldovan TPP buildings

Key issues that need to be addressed with the management of Moldovan TPP

1. Payment of the environmental tax for environmental pollution
2. Payment of the land tax
3. Reimbursement of the costs to maintain drainage pump stations, protective dams, drainage channels, and payment for electricity during their operation
4. Legal transfer of the drainage pump stations and channels from Ukraine to Moldavan TPP balance sheet
5. Maintenance of the optimal level in Kuchurhan Impoundment
6. Development and approval of the rules for the Kuchurhan Impoundment water resources use
7. Proper closure of the TSF, rehabilitation of the lands disturbed by ash and slag disposal for many years, with restoration of soil and vegetation.

V. RECOMMENDATIONS TO COMPETENT AUTHORITIES

These recommendations are intended for the government authorities responsible for legislative regulation of such facilities as liquid industrial waste storage facilities (tailings storage facilities).

Such main central government authorities in Ukraine are:

- Ministry of Environmental Protection and Natural Resources of Ukraine[69] which ensures formation and implementation of the state policy in the sphere of environmental safety, and
- State Emergency Service of Ukraine (SES of Ukraine)[70] which implements the state policy in the sphere of technogenic safety.

Regulation of TSF safety is also within the competence of such central and local government authorities as State Agency of Water Resources of Ukraine, Dniester Basin Water Administration, State Environmental Inspectorate of Ukraine, State Labor Service of Ukraine, Verkhovna Rada Committee on Environmental Policy and Nature Management, Regional State Administrations (Department of Ecology and Department of Civil Protection), and local governments (district, city, and village councils).

The peculiarity of TSF research in the Dniester River Basin in the framework of the GEF/ UNDP/ OSCE/ UNECE project “Enabling Transboundary Cooperation and Integrated Water Resources Management in the Dniester River Basin” was to consider TSFs as sources of impact on water bodies. And, first of all, implementation of the provided recommendations will help reduce the pressure from TSFs on the surface and groundwater bodies.

Implementation of measures can be coordinated by the Dniester BWA for environmental rehabilitation of the surface waters within the Dniester River Basin area, namely prevent pollution of water bodies with industrial waste by facilitating proper operation of TSFs. The research results can be useful in the work of the Dniester BWA to assist in addressing the following issues at the state and local levels:

- **consider the research results in the drafting of the Dniester River Basin Management Plan**
- **make proposals on development of state target and regional programs on the issues specified in this Summary**
- **initiate cooperation between public authorities and enterprises to search for resources and ways of implementing priority measures**
- **consider the issue of TSF safety at the meetings of the Dniester Basin Council involving the experience of national institutions, leading experts, innovative technologies, and search for international technical assistance from countries with similar experience.**

[69] Ministry of Environmental Protection and Natural Resources of Ukraine website
[70] State Emergency Service of Ukraine website

List recommendations to competent authorities

▪ Legislative and regulatory

1. Development of TSF management system focused on their comprehensive safety maintenance should be ensured through development of legislation on industrial waste management and improvement of legislation on prevention of major accidents according to the European law: Directive 2006/21/EU on the Management of Waste from Extractive Industries[71] and Directive 2012/18/EC on the Control of Major-Accident Hazards Involving Dangerous Substances (SEVESO III)[72], including development of appropriate methodologies.

   It is also necessary to improve methodological support for planning emergency response measures at TSFs in terms of consideration of all the probable accident scenarios, flood risk assessment, and prevention of accidental transboundary water pollution (Fig. 85).

   Special attention should be paid to interagency cooperation both at the national and international levels through coordination between institutions dealing with various aspects of TSF management. The UNECE Convention on the Transboundary Effects of Industrial Accidents (hereinafter "the Convention")[73] contributes to establishment of international cooperation between the participating states on the prevention of industrial accidents, ensuring preparedness for and responding to them.

Implementation of the Convention on Industrial Accidents is closely linked to implementation of the SEVESO III Directive. Adoption of the relevant Draft Law[74] will allow Ukraine to become a party to the Convention, which will help to improve the system of prevention, preparedness and response to transboundary industrial accidents, as well as exchange best practices in the sphere.

[71] Original title "Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries and amending Directive 2004/35/EC", the English version is available at the link
[72] Original title "Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC", the English version is available at the link
[73] Information about the Convention is posted on the UNECE website
[74] The Draft Law of Ukraine "On Ukraine's Accession to the Convention on the Transboundary Effects of Industrial Accidents" was published on 23 April 2004 on the SES of Ukraine website in the section "Electronic Consultations with the Public"

List recommendations to competent authorities

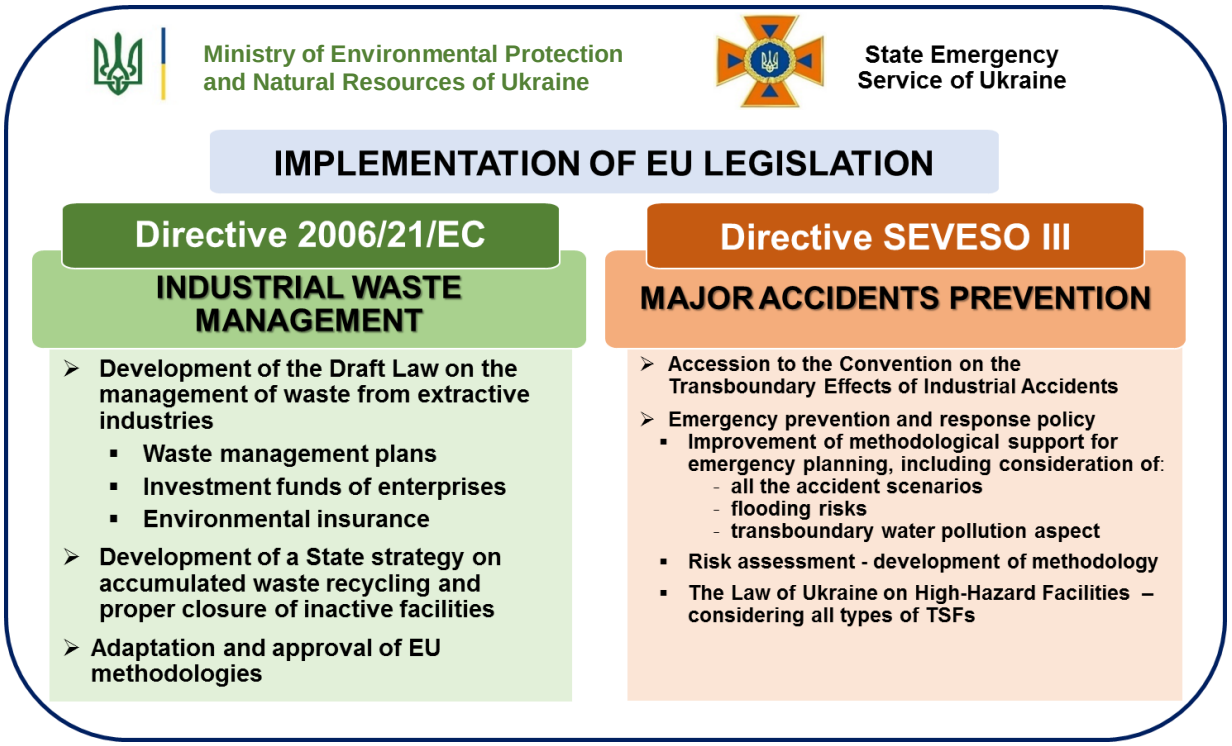

Fig. 85. Recommendations for improving the legislative regulation of TSF operation

▪ Organizational

2. Establishment of interaction and constructive dialog between the government authorities and TSF operators to implement the recommended measures addressing TSF operational non-compliances identified in the research. Also, it is recommended that the enterprises join in the work of the Dniester Basin Council and raise for discussion at the Basin Council meetings all issues related to maintaining TSF safety
3. Improving interaction between civil defense authorities and TSF operators as business entities, taking into account best practices available in this sphere[75]:
   3.1 Development, integration and practice drills (trainings) of Emergency Response Plans (Accident Localization and Elimination Plans) for the companies' TSFs (internal planning) and Emergency Response Plans of civil protection services (external planning) taking into account prevention of accidental transboundary water pollution – distribution of responsibilities, roles, resources, and actions in emergency response at TSFs

[75] For example, "Checklist for contingency planning for accidents affecting transboundary waters (for competent authorities)" is published on the UNECE website

List recommendations to competent authorities

4. Improving the policy on major accident prevention:
   - Introduction of dam stability satellite monitoring
   - Waste processing technologies (see Annex 3)
5. Carrying out regular state supervision (control) of the companies' compliance with the requirements of the current legislation concerning environmental protection and TSF safe operation
6. Analysis of the surface and groundwater quality monitoring results in TSF-affected area per company reports and state water monitoring data with additional laboratory tests where necessary.

Priority actions for TSF operators
Oriana-ECO LLC, State Enterprise Sirka, and PJSC Stebnyk Mining and Chemical Enterprise Polimineral

- Consideration at the interagency level the solutions to the socio-economic issues of TSF operators, which lack financial, technical, and human resources to perform proper closure of inactive facilities and rehabilitation of disturbed lands. In particular:
  - reduction of the financial burden on the companies due to the growing debt over obligations to reimburse preferential pensions for the previous periods and pay rent for the land under the storage facilities of the waste from former production
  - ensuring the lowering of TSF filling level of PJSC Stebnyk Mining and Chemical Enterprise Polimineral and reducing the risk of karst failures through adjustment of the existing project design documentation developed by Girkhimprom Institute LLC or development of new project design documentation for Ore Mine 2 conservation and rehabilitation of disturbed lands
  - implementation of the project on development of Novyi Rozdil Industrial Park, where the industrial waste storage facilities of State Enterprise Sirka are located, in line with the project design documentation package developed in 2013-2015 to attract investments, create new jobs, and ensure availability of funds for maintaining environmental safety of the SE Sirka territory. The planned industrial park is included in the Register of Industrial Parks of the Ministry of Economic Development
- **There is an urgent need to develop a state assistance program for Oriana-ECO LLC, State Enterprise Sirka, and PJSC Stebnyk Mining and Chemical Enterprise Polimineral aimed at implementation of the proposed measures to prevent emergencies of both national and transboundary scale**

ANNEX 1. TABLE OF TAILINGS STORAGE FACILITIES IN THE DNIESTER RIVER BASIN AND THE NEAREST SURFACE WATER BODIES

No.	Facility name	Facility location	Year of commissioning	Waste	Waste volume million tons	Distance to SWB/ water body	SWB characteristics
IVANO-FRANKIVSK REGION							
1.	TSF 1, Oriana-ECO LLC	Kalush, Ivano-Frankivsk Region	1967	Halite stones, Hazard Class IV	15.000	80 m	the Kropyvnyk River UA_M5.2_0310 UA_R_16_S_2_Si minor river on the uplands in silicate rock
						1150 m	the Syvka River UA_M5.2_0309 UA_R_16_M_2_Si medium river on the uplands in silicate rock
2.	TSF 2 Oriana-ECO LLC	Kalush, Ivano-Frankivsk Region	1984	Brines, Hazard Class IV	9.700	60 m	the Kropyvnyk River UA_M5.2_0310 UA_R_16_S_2_Si minor river on the uplands in silicate rock
						530 m	the Frunyluv River UA_M5.2_0311 UA_R_16_S_2_Si minor river on the uplands in silicate rock
3.	TSF 3 (Sludge Storage Facility), Oriana-ECO LLC	Kalush, Ivano-Frankivsk Region	1974	Brines, Hazard Class IV	1.300	115 m	the Kropyvnyk River UA_M5.2_0310 UA_R_16_S_2_Si minor river on the uplands in silicate rock
4.	Ash-and-slag Storage Facility, SE Kalush CHPP-Nova	Kalush, Ivano-Frankivsk Region	1967	Ash (coal ash dust); slag (fuel slag), Hazard Class IV	1.913	1180 m to SWB, 0 m to the Sapohiv stream flowing into the Kropyvnyk River	the Kropyvnyk River UA_M5.2_0310 UA_R_16_S_2_Si minor river on the uplands in silicate rock

No.	Facility name	Facility location	Year of commissioning	Waste	Waste volume million tons	Distance to SWB/ water body	SWB characteristics
5.	Industrial water treatment Sludge Storage Facility, Karpatnaftokhim LLC	Ivano-Frankivsk region, Kalush, 4 Promyslova str.	1993	Sludge formed from water clarification (industrial water treatment sludge), Hazard Class IV	0.009189635	80 m to SWB, 50 m to the bypass channel flowing into the Kropyvnyk River	the Kropyvnyk River UA_M5.2_0310 UA_R_16_S_2_Si minor river on the uplands in silicate rock
						200 m to SWB	the Frunyluv River UA_M5.2_0311 UA_R_16_S_2_Si minor river on the uplands in silicate rock
6.	Hypochlorite wastewater Sludge Storage Facility, Karpatnaftokhim LLC	Ivano-Frankivsk region, Kalush, 4 Promyslova str.	1968	Sludge formed in the process of wastewater treatment at the enterprise (sludge after treatment of hypochlorite wastewater), Hazard Class IV	0.000836658	1100 m to SWB, 750 m to the Sapohiv stream flowing into the Kropyvnyk River	the Kropyvnyk River UA_M5.2_0310 UA_R_16_S_2_Si minor river on the uplands in silicate rock
7.	Ash Storage Facility 1, 2 DTEK, Burshtyn TPP	Burshtyn, Halych District, Ivano-Frankivsk Region	1965	Fuel ash dust, Hazard Class IV	9.171	1200 m to SWB, 550 m to the Untitled stream flowing into the Hnyla Lypa River	the Hnyla Lypa River UA_M5.2_0377 UA_R_16_M_2_Si medium river on the uplands in silicate rock
8.	Ash Storage Facility 3, DTEK, Burshtyn TPP	Burshtyn, Halych District, Ivano-Frankivsk Region	1971	Fuel ash dust, Hazard Class IV	27.184	1450 m	the Dniester River UA_M5.2_0007 UA_R_16_XL_2_Si very large river on the uplands in silicate rock
9.	Sludge Storage Facility, DTEK, Burshtyn TPP	Burshtyn, Halych District, Ivano-Frankivsk Region	1965	Fuel slag dust, Hazard Class IV	2.678	80 m	Burshtyn Reservoir UA_M5.2_0376 pHMWB substantially modified SWB candidate

No.	Facility name	Facility location	Year of commissioning	Waste	Waste volume million tons	Distance to SWB/ water body	SWB characteristics
10.	Hydraulic waste Storage Facility, DTEK, Burshtyn TPP	Burshtyn, Ivano-Frankivsk Region	1969	Water clarification sludge, Hazard Class IV	1.360	0 m adjacent to the right bank of the Hnyla Lypa River	the Hnyla Lypa River UA_M5.2_0375 UA_R_16_M_2_Si medium river on the uplands in silicate rock
11.	TSF 1, PJSC Naftokhimik Prykarpattia	Nadvirna, Ivano-Frankivsk Region	1967	Wastewater mechanical treatment oil sludge, Hazard Class III	0.006623213	60 m	the Vorona River UA_M5.2_0432 UA_R_16_S_2_Si minor river on the uplands in silicate rock
12.	TSF 2, PJSC Naftokhimik Prykarpattia	Nadvirna, Ivano-Frankivsk Region	1967	Sediment at the reservoir bottom, Hazard Class II	0.000845499	60 m	the Vorona River UA_M5.2_0432 UA_R_16_S_2_Si minor river on the uplands in silicate rock
13.	Sludge Storage Facility Pos. 415-3, PJSC “Barva” Fine Organic Synthesis Plant	Yamnytsia, Tysmenytsia Distr., Ivano-Frankivsk Region	1976	Sludge formed in the process of wastewater treatment at the enterprise, class of danger IV	0.000420251	The company refused to cooperate with the GEF Project and provide data	
14.	Sludge Pit 1 (OPPS), Oil and Gas Production Department Dolynanaftogaz of PJSC Ukrnafta	Ivano-Frankivsk Region, Dolyna Distr., Yavoriv	1986	Oil sludges, Hazard Class III	0.00086	460 m to SWB, 30 m to the Yar stream flowing into the Lushchava River	the Lushchava River UA_M5.2_0281 UA_R_16_S_2_Si minor river on the uplands in silicate rock
15.	Sludge Storage Facility 2 (OPPS), Oil and Gas Production Department Dolynanaftogaz of PJSC Ukrnafta	Ivano-Frankivsk Region, Dolyna Distr., Yavoriv	1986	Oil sludges, Hazard Class III	0.0006289	550 m to SWB, 35 m to the Untitled stream flowing into the Yar stream	the Lushchava River UA_M5.2_0281 UA_R_16_S_2_Si minor river on the uplands in silicate rock

No.	Facility name	Facility location	Year of commissioning	Waste	Waste volume million tons	Distance to SWB/ water body	SWB characteristics
16.	Sludge Storage Facility 4 (OPPS), Oil and Gas Production Department Dolynanaftogaz of PJSC Ukrnafta	Ivano-Frankivsk Region, Dolyna Distr., Yavoriv	1970	Oil sludges, Hazard Class III	0.004925	680 m to SWB, 55 m to the Untitled stream flowing into the Yar stream	the Lushchava River UA_M5.2_0281 UA_R_16_S_2_Si minor river on the uplands in silicate rock
17.	“Ecological” sludge Storage Facility (OPPS), Oil and Gas Production Department Dolynanaftogaz of PJSC Ukrnafta	Ivano-Frankivsk Region, Dolyna Distr., Yavoriv	1990	Oil sludges, Hazard Class III	0.000160232	530 m to SWB, 10 m to the Untitled stream flowing into the Yar stream	the Lushchava River UA_M5.2_0281 UA_R_16_S_2_Si minor river on the uplands in silicate rock
18.	Sludge Storage Facility 1, CPS-2 ND, Oil and Gas Production Department Dolynanaftogaz of PJSC Ukrnafta	Ivano-Frankivsk Region, Dolyna Distr., Yavoriv	1986	Oil sludges, Hazard Class III	0.000551603	650 m	the Lushchava River UA_M5.2_0281 UA_R_16_S_2_Si minor river on the uplands in silicate rock
19.	Sludge Storage Facility 3, CPS-2 ND, Oil and Gas Production Department Dolynanaftogaz of PJSC Ukrnafta	Ivano-Frankivsk Region, Dolyna Distr., Yavoriv	1986	Oil sludges, Hazard Class III	0.000355688	600 m	the Lushchava River UA_M5.2_0281 UA_R_16_S_2_Si minor river on the uplands in silicate rock
20.	Sludge Storage Facility 1, CPS-7, Oil and Gas Production Department Dolynanaftogaz of PJSC Ukrnafta	Ivano-Frankivsk Region, Dolyna Distr., Dolyna	1986	Oil sludges, Hazard Class III	0.000924	850 m to the SWB, 300 m to the Yar stream flowing into the Lushchava River	the Lushchava River UA_M5.2_0281 UA_R_16_S_2_Si minor river on the uplands in silicate rock

No.	Facility name	Facility location	Year of commissioning	Waste	Waste volume million tons	Distance to SWB/ water body	SWB characteristics
21.	Sludge Storage Facility 2, CPS-7 (OPPS), Oil and Gas Production Department Dolynanaftogaz of PJSC Ukrnafta	Ivano-Frankivsk Region, Dolyna Distr., Dolyna	1986	Oil sludges, Hazard Class III	0.00111072	850 m to SWB, 300 m to the Yar stream flowing into the Lushchava River	the Lushchava River UA_M5.2_0281 UA_R_16_S_2_Si minor river on the uplands in silicate rock
22.	Sludge Storage Facility 1, GTI-3, Strutyn (OPPS), Oil and Gas Production Department Dolynanaftogaz of PJSC Ukrnafta	Ivano-Frankivsk Region, Rozhniativ Distr., Ivanivka	1970	Oil sludges, Hazard Class III	0.000614227	3940 m to SWB, 100 m to the Smereka stream flowing into the Duba River	the Duba River UA_M5.2_0359 UA_R_16_M_2_Si medium river on the uplands in silicate rock
23.	Sludge Storage Facility 2, GTI-3, Strutyn (OPPS), Oil and Gas Production Department Dolynanaftogaz of PJSC Ukrnafta	Ivano-Frankivsk Region, Rozhniativ Distr., Ivanivka	1971	Oil sludges, Hazard Class III	0.000046675	4050 m to SWB, 50 m to the Smereka stream flowing into the Duba River	the Duba River UA_M5.2_0359 UA_R_16_M_2_Si medium river on the uplands in silicate rock
LVIV REGION							
24.	TSF 1, State Enterprise “Rozdil Mining and Chemical Enterprise “Sirka”[76]	2 Hirnycha str. Novyi Rozdil, Lviv Region	1957	Wastes from sulfur ore enrichment and flotation tailings, Hazard Class IV	65.000	740 m to SWB, 440 m to the Barvinok River	the Dniester River UA_M5.2_0006 UA_R_16_L_2_Si large river on the uplands in silicate rock
25.	TSF 2, State Enterprise “Rozdil Mining and Chemical Enterprise “Sirka”[78]	2 Hirnycha str. Novyi Rozdil, Lviv Region	1987	Wastes from sulfur ore enrichment, Hazard Class IV	10.000	1130 m	the Klodnytsia River UA_M5.2_0151 pHMWB substantially modified SWB candidate

[76] According to various data sources, the total amount of waste in the three SE Sirka TSFs is approximately between 85 mln tons and 108.9 mln tons. The data is based on the document “Inventory of accumulated industrial waste on the territory of SE Rozdil Mining and Chemical Enterprise “Sirka”, Girkhimprom Institute LLC, Lviv, 2017

No.	Facility name	Facility location	Year of commissioning	Waste	Waste volume million tons	Distance to SWB/ water body	SWB characteristics
26.	TSF at the hydraulic waste storage facility, State Enterprise “Rozdil Mining and Chemical Enterprise “Sirka”[78]	2 Hirnycha str. Novyi Rozdil, Lviv Region	—	Wastes from sulfur ore enrichment, Hazard Class IV	10.000	380 m	the Dniester River UA_M5.2_0006 UA_R_16_L_2_Si large river on the uplands in silicate rock
27.	TSF, PJSC Stebnyk Mining and Chemical Enterprise “Polimineral”	127 Drohobytska str., Stebnyk, Lviv Region	1966	Brine, Hazard Class IV	12.74	750 m to SWB, 100 m to the Untitled stream	the Slonytsia River UA_M5.2_0099 UA_R_16_S_2_Si minor river on the uplands in silicate rock
28.	TSFs 5-7 (Group 1), Oil Refinery 1, PJSC NPK-Galychyna	82 Boryslavska str., Drohobych, Lviv Region	1948	Wastewater mechanical treatment oil sludge, Hazard Class III	0.01350	580 m to SWB, 10 m to the Untitled stream	the Tysmenytsia River UA_M5.2_0090 UA_R_16_M_2_Si medium river on the uplands in silicate rock
29.	TSFs 1-4 (Group 2), Oil Refinery 1, PJSC NPK-Galychyna	82 Boryslavska str., Drohobych, Lviv Region	1948	Wastewater mechanical treatment oil sludge, Hazard Class III	0.00820	650 m to the SWB, 230 m to the Untitled stream	the Tysmenytsia River UA_M5.2_0090 UA_R_16_M_2_Si medium river on the uplands in silicate rock
30.	TSF, Oil Refinery 2, PJSC NPK-Galychyna	Drohobych, Lviv Region	—	N/A	0.01812708	25 m	the Ratochyna River UA_M5.2_0097 UA_R_16_S_2_Si minor river on the uplands in silicate rock
31.	TSF, Oil and Gas Production Department Boryslavnaftogaz of PJSC Ukrnafta	26 Karpatska Brama str., Boryslav, Lviv Region	2001	Oil sludges, Hazard Class III	0.001551102	500 m	the Tysmenytsia River UA_M5.2_0089 UA_R_16_S_2_Si minor river on the uplands in silicate rock
ODESA REGION							
32.	Ash-and-slag Storage Facility, CJSC Moldovan TPP, an enterprise of the	lands of the Hradenytsia Village Council of the	—	Ash-and-slag waste	Data not available	95 m	the Kuchurhan River UA_M5.2_1115 UA_R_12_L_1_O large river in the lowlands in organic rock

No.	Facility name	Facility location	Year of commissioning	Waste	Waste volume million tons	Distance to SWB/ water body	SWB characteristics
	Transnistrian region of the Republic of Moldova	Biliaivka District of the Odessa Region in the border strip between Ukraine and the Republic of Moldova (Transnistrian segment of the Ukrainian-Moldovan border)				320 m	Kuchurhan Reservoir pHMWB substantially modified SWB candidate
LIQUIDATED FACILITIES – OGPA Dolynanaftogaz sludge Storage Facilitys (Documentary evidence on the actual number of facilities is not available. Determined according to the company's project technical documentation and Google Earth Pro images)							
33.	Liquidated Storage Facility 3, OPPS, Oil and Gas Production Department Dolynanaftogaz	7 Promyslova str., Dolyna, Ivano-Frankivsk Region SF – Yavoriv	—	N/A	N/A	600 m to SWB, 40 m to the Untitled stream flowing into the Yar stream	the Lushchava River UA_M5.2_0281 UA_R_16_S_2_Si minor river on the uplands in silicate rock
34.	Liquidated Storage Facility 8, OPPS, Oil and Gas Production Department Dolynanaftogaz	7 Promyslova str., Dolyna, Ivano-Frankivsk Region SF – Yavoriv	—	N/A	N/A	545 m to SWB, 60 m to the Yar stream flowing into the Lushchava River	the Lushchava River UA_M5.2_0281 UA_R_16_S_2_Si minor river on the uplands in silicate rock
35.	Liquidated Storage Facility 5, OPPS, Oil and Gas Production Department Dolynanaftogaz	7 Promyslova str., Dolyna, Ivano-Frankivsk Region SF – Yavoriv	—	N/A	N/A	620 m to SWB, 50 m to the Untitled stream flowing into the Yar stream	the Lushchava River UA_M5.2_0281 UA_R_16_S_2_Si minor river on the uplands in silicate rock

No.	Facility name	Facility location	Year of commissioning	Waste	Waste volume million tons	Distance to SWB/ water body	SWB characteristics
36.	Liquidated Storage Facility 6, OPPS, Oil and Gas Production Department Dolynanaftogaz	7 Promyslova str., Dolyna, Ivano-Frankivsk Region SF – Yavoriv	—	N/A	N/A	650 m to SWB, 30 m to the Untitled stream flowing into the Yar stream	the Lushchava River UA_M5.2_0281 UA_R_16_S_2_Si minor river on the uplands in silicate rock
37.	Liquidated Storage Facility 7, OPPS, Oil and Gas Production Department Dolynanaftogaz	7 Promyslova str., Dolyna, Ivano-Frankivsk Region SF – Yavoriv	—	N/A	N/A	630 m to SWB, 60 m to the Untitled stream flowing into the Yar stream	the Lushchava River UA_M5.2_0281 UA_R_16_S_2_Si minor river on the uplands in silicate rock
38.	Liquidated Storage Facility 2, CPS-2 ND, Oil and Gas Production Department Dolynanaftogaz	7 Promyslova str., Dolyna, Ivano-Frankivsk Region SF – Yavoriv	—	N/A	N/A	610 m	the Lushchava River UA_M5.2_0281 UA_R_16_S_2_Si minor river on the uplands in silicate rock
39.	Liquidated Storage Facility 4, CPS-2 ND, Oil and Gas Production Department Dolynanaftogaz	7 Promyslova str., Dolyna, Ivano-Frankivsk Region SF – Yavoriv	—	N/A	N/A	580 m	the Lushchava River UA_M5.2_0281 UA_R_16_S_2_Si minor river on the uplands in silicate rock
40.	Liquidated Storage Facility 3, CPS-7, Oil and Gas Production Department Dolynanaftogaz	7 Promyslova str., Dolyna, Ivano-Frankivsk Region SF – Dolyna	—	N/A	N/A	850 m to SWB, 300 m to the Yar stream flowing into the Lushchava River	the Lushchava River UA_M5.2_0281 UA_R_16_S_2_Si minor river on the uplands in silicate rock
41.	Liquidated Storage Facility 4, CPS-7, Oil and Gas Production Department Dolynanaftogaz	7 Promyslova str., Dolyna, Ivano-Frankivsk Region SF – Dolyna	—	N/A	N/A	850 m to SWB, 300 m to the Yar stream flowing into the Lushchava River	the Lushchava River UA_M5.2_0281 UA_R_16_S_2_Si minor river on the uplands in silicate rock

No.	Facility name	Facility location	Year of commissioning	Waste	Waste volume million tons	Distance to SWB/ water body	SWB characteristics
42.	Liquidated Storage Facility 1, CPS-12, Oil and Gas Production Department Dolynanaftogaz	7 Promyslova str., Dolyna, Ivano-Frankivsk Region SF – Tiapche	—	N/A	N/A	260 m	the Sadzava River UA_M5.2_0280 UA_R_16_S_2_Si minor river on the uplands in silicate rock
43.	Liquidated Storage Facility 2, CPS-12, Oil and Gas Production Department Dolynanaftogaz	7 Promyslova str., Dolyna, Ivano-Frankivsk Region SF – Tiapche	—	N/A	N/A	275 m	the Sadzava River UA_M5.2_0280 UA_R_16_S_2_Si minor river on the uplands in silicate rock

ANNEX 2. ANALYTICAL DPSIR[77] FRAMEWORKS FOR TAILINGS STORAGE FACILITIES IN THE DNIESTER RIVER BASIN

DPSIR analytical framework for Oriana-ECO LLC Tailings Storage Facilities

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for Oriana-ECO LLC Tailings Storage Facilities
Driver	**Driver** (human activities that may impact the environment)	Operation of three TSFs of a mining and chemical industry company for the extraction and enrichment of potassium-magnesium ores in the Kalush District of the Ivano-Frankivsk Region of Ukraine. The company has not been pursuing its main business activity – extraction of mineral raw materials for the chemical industry and production of mineral fertilizers. The production waste SFs are not in operation. Peculiarities of TSF operation: - **Natural conditions as the main external factors of natural hazards:** humid zone with significant amount of precipitation, which can aggravate dam erosion processes, seeping and washing of salts from the TSFs and the adjacent territories. Seismically hazardous area and the area of modern karst process activation. Flooding by river waters is a hazard - **Linear hydrographic network**: the Frunyluv River – the Kropyvnyk River – the Syvka River – the Dniester River. The Syvka River is located 1150 m from TSF 1; the Kropyvnyk River flows between TSFs 2 and 3, the distance to them being 60 m and 115 m, respectively, and the shortest distance to TSF 1 being about 80 m; the Frunyluv River is located north of TSF 2 at a distance of 530 m - **Waste volume:** 26 mln m^3 of potassium-magnesium ore mining and enrichment waste. The waste hazard class has not been identified and the waste has not been provided with a passport or accounted for - **Waste composition:** brines, represented by sodium, magnesium and potassium chlorides and sulfates - **Current state of the TSFs:** the level of TSF operation is unsatisfactory. Key non-compliances of operation: partial closure of TSF 1 and rehabilitation of disturbed lands, filtration of brines through the TSF dam, a critical filling level and seepage of brines through the dam are observed at TSF 2, the drainage and water discharge systems of TSF 1, 2, and 3 are destroyed

[77] DPSIR is an analytical framework for describing the interactions between society and the environment by 5 indicators: Driver – Pressure – State – Impact – Response.

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for Oriana-ECO LLC Tailings Storage Facilities
Pressure	**Pressure** (direct consequence of an activity)	There are visual indications of TSF impact on the environment: - Progressing filtration of brines through TSF 1 & 2 dams, which evidences disintegration of the complex of these hydraulic structures and causes salinization of soils and surface and groundwater bodies - critical level of TSF 2 filling, which can lead to waste overflow in case of intense precipitation
State	**State** (conditions that arise in the water bodies (SWB) due to activities)	The company does not monitor surface and groundwater in the TSF-affected area – current data is missing. According to 2010 research carried out by Joint UN Mission and EU Environmental Emergency Response Commission, mineralization of brines in streams which seep through the external slopes of TSF 1 depends on the amount of precipitation and varies between 14.8 g/l and 413.8 g/l. The Kropyvnyk River streamflow has developed a hydrochemical anomaly. The salt concentration in the river periodically exceeds 60 g/l. According to the monitoring carried out by government agencies, the concentration of chlorides and dry residue in the surface waters of the Syvka and Kropyvnyk Rivers was persistently exceeded compared to the MAC. The alluvial aquifer groundwater had a dry residue concentration of 1100-2300 mg/dm^3 due to an increased chloride concentration of 527.0-1857.0 mg/dm^3, the MAC value being 250 mg/dm^3. There are visual indications of soil contamination, flooding of the adjacent areas, and waste seeping beyond the TSFs. Comprehensive study of the TSFs – a review of natural conditions and peculiarities of the company's TSF locations, volume and toxicity of waste, examination of the current state of structures and analysis of the available monitoring results – suggests that the conditions that arose during operation of the Oriana-ECO LLC TSFs are different from the background ones
Impact	**Impact** (consequence of the pressure for the environment)	The environmental impact of the TSF waste is caused by toxic effects of the substances contained in them – mainly sodium, magnesium, and potassium chlorides and sulfates. Their concentrations in surface and groundwater exceed the MAC several times. Waste seeping through TSF dams increases concentrations in surface waters 2 or 3 times for some salts (NaCl, MgSO4), and even more for some others. The waste comprising substances are characterized by toxic effects, which are mainly due to their irritating properties, and can be manifested in a reduced population and species composition of hydrobionts, increased respiratory and digestive diseases, and disruptions of mineral metabolism in the human body. To determine the actual consequences for the environment from operation of the TSFs, the state of the environment (including surface and groundwater bodies) should be analyzed in comparison with certain biotic components in the reference rivers, where there are no anthropogenic pressures

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for Oriana-ECO LLC Tailings Storage Facilities
Response	**Response** (measures taken to improve the state of water bodies)	Measures to improve the state of water bodies should aim at: ▪ **pressure reduction:** - address all the non-compliances related to the technical state of the TSF structures and operation - perform regular technical surveillance of the structures' condition and monitoring of the TSF impact on the environment - improve the policy of emergency prevention and response at the TSFs - introduce technologies for disposal of the TSF waste ▪ **state determination**: - improve the system of continuous surface and groundwater monitoring in the TSF area ▪ **impact determination**: - conduct research on which biotic components, and to what extent, feel the effects of pressures from the TSFs. Measures recommended to the TSF operator and competent authorities provided in this Summary may be taken into account when developing the Dniester River Basin Management Plan for water body protection.

DPSIR analytical framework for Karpatnaftokhim LLC Tailings Storage Facilities

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for Karpatnaftochim LLC Tailings Storage Facilities
Driver	**Driver** (human activities that may impact the environment)	Operation of two TSFs (TSF 1[78] and TSF 2[79]) of an enterprise for production of petrochemical and chemical products in the Kalush District of the Ivano-Frankivsk Region of Ukraine. Peculiarities of TSF operation: - **Natural conditions as the main external factors of natural hazards:** humid zone with significant amount of precipitation, which can cause overfilling of the TSFs if the reservoirs get filled to a critical level. Seismically hazardous area and the area of modern karst process activation. Flooding by river waters is a hazard - **Linear hydrographic network**: the Frunyluv River – the Kropyvnyk River – the Syvka River – the Dniester River. The TSF 1 is located 1.1 km from the SWB of the Kropyvnyk River and 750 m from the Sapohiv stream. The TSF 2 is located 80 m from the SWB of the Kropyvnyk River and 200 m from the SWB of the Frunyluv River; distance to the bypass canal ≈ 50 m - **Peculiarities of the location**: TSF 1 is neighbored by the SE Kalush CHPP-Nova Ash-and-slag Storage Facility, which creates preconditions for the domino effect - **Waste volume:** accumulated volumes as of the end of 2017 – industrial water treatment sludge amounted to 9,189.635 tons – hypochlorite wastewater treatment sludge – 836.658 tons - **Waste composition:** TSF 1: water – 80%, solid phase (clay, copper and nickel hydroxides) – 20%. TSF 2: water hydroxides – 98%, dry residue – 0.3%, solid phase (CaO, Al(OH)3, $Fe(OH)_3$, SiO_2) – 1.7% - **Current state of the TSFs:** based on the visual inspection, the TSFs are in satisfactory condition, there are no signs of obvious problems and malfunctions, but there are signs of land subsidence near the reserve section of the TSF 1, which may indicate a threat of water logging of the nearby treatment facilities. The facilities operation level estimated using the Methodology partially fails to meet the requirements of the environmental and technogenic safety standards

[78] Neutralization and Treatment of Industrial Wastewater Shop
[79] Water Supply and Sewerage Shop

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for Karpatnaftochim LLC Tailings Storage Facilities
Pressure	**Pressure** (direct consequence of an activity)	Hazardous waste – sludges from hypochlorite wastewater and industrial water treatment – may leak, seep, and filtrate to unprotected aquifers through the TSF bottom and flanks, pollute soils and infiltrate to unprotected aquifers from the soil surface
State	**State** (conditions that arise in the water bodies (SWB) due to activities)	The state of pollution of the environmental components in the TSF area is not fully monitored – the results of surface water pollution assessment in the area of both TSFs are not available; groundwater pollution in the area of the TSF 1 is monitored only in one monitoring well; and no monitoring is done in the TSF 2 area. Therefore, there is no data to determine the parameters of the current state of SWB
Impact	**Impact** (consequence of the pressure for the environment)	In absence of the surface water monitoring results and any hydrobiological studies in the TSF area, the consequences of the pressure can be assessed only by analogies and assumptions. The environmental impact of waste is caused by the toxic effects of the substances contained in them: ▪ **copper** compounds, reacting with tissue proteins, produce an intense irritating effect on the mucous of the upper respiratory tract and gastrointestinal tract. Intoxication with copper compounds may cause autoimmune reactions and metabolic disorders of monoamines ▪ **nickel** primarily affects hematopoiesis and carbohydrate metabolism. Metallic Ni and its compounds cause tumors in animals, as well as occupational cancer. The carcinogenic effect of Ni is associated with impaired cell metabolism. Ni salts cause damage to human skin, with development of hypersensitivity to metal ▪ toxicity of **aluminum** is manifested in its influence on metabolism, especially mineral one, on the function of the nervous system, and in the ability to act directly on cells – their reproduction and growth; prolonged inhalation of aluminum dust and some of its compounds leads to fibrosis of lung tissue ▪ **hypochlorites**, neutralizing microorganisms, can disrupt trophic connections in aquatic ecosystems of biological structures and natural reservoirs. To determine the actual impact, it is necessary to study the state and compare some biotic components with their counterparts in the reference rivers.

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for Karpatnaftochim LLC Tailings Storage Facilities
Response	**Response** (measures taken to improve the state of water bodies)	Measures to improve the SWB state should aim at: ▪ **pressure reduction:** - address all the non-compliances in the TSF operation - perform regular technical surveillance of the structures' condition and monitoring of the facilities' impact on the environment - improve the policy of emergency prevention at the TSFs - search for ways of maximum disposal of the accumulated waste ▪ **state determination** – installation of a surface and groundwater monitoring system in the TSF area ▪ **impact determination** – conducting research on which biotic components, and to what extent, feel the effects of pressure from the facilities. Measures recommended to the TSF operator and competent authorities provided in this Summary may be taken into account when developing the Dniester River Basin Management Plan for water body protection.

DPSIR analytical framework for Tailings Storage Facility of State Enterprise Kalush Combined Heat and Power Plant-Nova

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for TSF of SE Kalush Combined Heat and Power Plant-Nova
Driver	**Driver** (human activities that may impact the environment)	Operation of an Ash-and-slag Storage Facility of an enterprise for production of thermal and electric energy in the climatic, hydrological and geological conditions of the Kalush District of the Ivano-Frankivsk Region of Ukraine. Peculiarities of TSF operation: - **Natural conditions as the main external factors of natural hazards:** humid zone with significant amount of precipitation, which can aggravate dam erosion processes, seeping and washing of salts from the TSF and the adjacent territories. Seismically hazardous area and the area of modern karst process activation. Flooding by river waters is a hazard. The hydrological hazard driver is not applicable – the TSF is located beyond the boundaries of any rivers with a potential flooding ability (based on the preliminary assessment of the flooding risks for the Dniester River Basin) - **Linear hydrographic network**: the Sapohiv stream – the Kropyvnyk River – the Syvka River – the Dniester River. The TSF is located in the floodplain of the Sapohiv stream, which flows into the Kropyvnyk River of the transboundary Dniester River Basin. - **Peculiarities of the location**: the ash-and-slag Storage Facility is closely neighbored by the industrial sites of the Karpatnaftokhim LLC enterprises with an TSF and treatment facilities, and Goodvalley Ukraine LLC - **Waste volume:** As of 2018, SE Kalush CHPP-Nova had accumulated 1.913 mln tons of hazard Class IV waste, of which 1.601 mln tons of ash and 0.312 mln tons of fuel slag. - **Waste composition:** The predominant minerals in the ash and slag are silicon, aluminum, and iron oxides, and in small quantities – calcium, magnesium, potassium, sodium, and sulfur oxides. The ash slags contain, but in much smaller quantities, heavy metals in the form of low-solubility and insoluble compounds - **Current state of the TSF:** neglected emergency section and ash Section 2, dehydrated areas of the ash-and-slag beach in ash Section 1, undeveloped maintenance road at ash Section 2 of the ash-and-slag Storage Facility, neglected drainage **channels**. The facility operation level estimated using the Methodology partially fails to meet the requirements of the environmental and technogenic safety standards The company developed Technical Project Documentation for reconstruction of the ash-and-slag Storage Facility in 2018 to extend its service life and upgrade the existing facilities to proper operational condition

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for TSF of SE Kalush Combined Heat and Power Plant-Nova
Pressure	**Pressure** (direct consequence of an activity)	The SE Kalush CHPP-Nova storage facility has been in operation since 1968. During this period, the waterproofing properties of structures may deteriorate, resulting in filtration of toxic substances from the SF and from the contaminated adjacent area to unprotected aquifers. Dehydrated areas of the ash-and-slag beach in ash Section 1 poses a threat of ash-and-slag mixture spreading and dust carryover beyond the ash-and-slag Storage Facility in the dry season, which may adversely affect the flora and fauna
State	**State** (conditions that arise in the water bodies (SWB) due to activities)	- Monitoring of surface water quality of the Sapohiv stream in the SF location area is carried out at two stations: 200 m before Discharge 1 and 500 m after Discharge 1 by 13 components. No exceedance of the maximum allowable concentrations for the household watercourses in 2015-2017 was recorded. But in 2018, an increased concentration of suspended substances was observed. - The company monitors the groundwater quality through two monitoring wells. The 2018 ash-and-slag Storage Facility reconstruction project provides for arrangement of a monitoring network of 38 monitoring wells. Based on sampling in the two available monitoring wells, almost all the salt composition components are within acceptable concentrations. Well 3G demonstrates increased chlorine concentration (1.1 MAC), which may be due to the mineralogical composition of rocks - Monitoring of the hydrochemical situation in the ash-and-slag Storage Facility area is not carried out in full. The laboratory does not determine the cationic composition and concentration of toxic pollutants, which prevents analyzing the processes and dynamics of the spread of pollution with these substances in the examined area. - The results of the state monitoring prevent assessment of the impact exerted by the SE Kalush CHPP-Nova TSF on the state of surface waters (the monitoring post on the Syvka River is located ≈ 14 km in a straight line from the ash-and-slag Storage Facility)
Impact	**Impact** (consequence of the pressure for the environment)	Ash-and-slag wastes can cause degradation of hydrobionts, flora and fauna, and adversely affect human health. Toxic effects of the waste are manifested mainly in irritation of mucous membranes, chronic damage of the respiratory tract, and deposition of highly dispersed particles in the lungs, causing delayed pathological changes. According to the EIA section on the ash-and-slag Storage Facility reconstruction activities, a major industrial complex formed in the region exerts significant anthropogenic pressure on soils. Dust particles settled on plants have a comprehensive effect on them, which can be divided by its nature of the action into physical and chemical.

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for TSF of SE Kalush Combined Heat and Power Plant-Nova
		The factors that adversely affect animals in the technogenic environment include: reduction of habitable areas, change in the nature of habitats, dust and gas air pollution, soil and vegetation pollution with toxic substances. Dust acts mainly as an irritant to the digestive system, namely stomach and intestine tissues. The comprehensive influence of the ash-and-slag Storage Facility operation factors leads to a reduction in the animal species diversity, a decrease in the number and productivity of the animal populations included in the hunting fauna, extinction of rare animal species, etc. To determine the impact on the aquatic environment, it is necessary to study the state and compare some biotic components with their counterparts in the reference rivers.
Response	**Response**(measures taken to improve the state of water bodies)	Measures to improve the SWB state should aim at: ▪ **pressure reduction:** - address all the non-compliances in the ash-and-slag Storage Facility operation - perform regular technical surveillance of the structures' condition and monitoring of the facility's impact on the environment - improve the policy of emergency prevention at the ash-and-slag Storage Facility - introduce technologies for processing of the accumulated waste ▪ **state determination** – expansion of the surface and groundwater monitoring system in the ash-and-slag Storage Facility location area ▪ **impact determination** – conducting research on which biotic components, and to what extent, feel the effects of pressure from the facility Measures recommended to the TSF operator and competent authorities provided in this Summary may be taken into account when developing the Dniester River Basin Management Plan for water body protection.

DPSIR analytical framework for PJSC Naftokhimik Prykarpattia Tailings Storage Facilities

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for PJSC Naftokhimik Prykarpattia Tailings Storage Facilities
Driver	**Driver** (human activities that may impact the environment)	Operation of an oil refining enterprise's two TSFs in the climatic, hydrological, and geological conditions of the Ivano-Frankivsk Region of Ukraine. The TSF operator's main industrial production was suspended in 2010. According to the staff interviews, the TSFs have not been filled with production waste since that time. Peculiarities of TSF operation: - **Natural conditions as the main external factors of natural hazards:** torrential and local nature of precipitation can cause overfilling of the TSFs, with waste overflowing the embankment, and intensify the processes of hypergenesis and migration of pollutants. The groundwater is categorized as unprotected, occurring at a depth of 0.4-0.8 m. Seismically hazardous area. The hydrological hazard driver is not applicable – the TSFs are located beyond the boundaries of any rivers with a potential flooding ability (based on the preliminary assessment of the flooding risks for the Dniester River Basin) - **Linear hydrographic network**: the Vorona River – the Bystrytsia-Nadvirnianska River – the Bystrytsia River – the Dniester River. The Vorona River flows lower than the TSFs 60 m away, and the embankments of the hydraulic structures have a noticeable slope towards the river. This can promote the penetration of toxic waste products into the surface water body - **Waste volume**: 7,468.712 tons of industrial waste, of which 6.6 thous tons of oil sludge from mechanical wastewater treatment and 0.85 thous tons of waste from cleaning of oil and fuel oil tanks - **Waste composition**: the TSFs contain oil sludges from mechanical wastewater treatment (petroleum products 25-35%, mechanical impurities 15-25%, water 50-60%) and sediment from tank bottoms (petroleum products 74.6%, mechanical impurities 16.4%, water 9%). - **Current state of the TSFs**: the visual inspection performed in July 2018 identified waste storage on unprotected ground beyond TSF 2, which leads to contamination of soils and poses a real threat of polluting the groundwater body near the TSFs. A reservoir with indications of oil content outside the SFs was found, which may indicate chronic seeping of waste through the TSF embankment

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for PJSC Naftokhimik Prykarpattia Tailings Storage Facilities
Pressure	**Pressure** (direct consequence of an activity)	Over 50 years of TSF operation (since 1967) have led to probable loss of the structures' waterproofing properties, and as a result – to filtration of toxic substances from SFs and from the contaminated adjacent area to unprotected aquifers. Visual assessment revealed indications of soil contamination and seeping or leakage of petroleum products beyond the TSFs
State	**State** (conditions that arise in the water bodies (SWB) due to activities)	Monitoring of the surface and groundwater quality in the TSF area is not performed, there is no data to determine the parameters of the current state of the SWB. Comprehensive study of the facilities – a review of natural conditions and peculiarities of the company's SF locations, volume and toxicity of waste, examination of the current state of structures – suggests that the conditions that arose during operation of the PJSC Naftokhimik Prykarpattia production waste SFs are different from the background ones
Impact	**Impact** (consequence of the pressure for the environment)	Environmental impact of the refinery waste SF caused by **toxic effects of waste substances** – primarily hydrocarbons that are part of the oil sludge. The oil refining waste substances are characterized by strong toxic effects: pronounced mutagenicity and carcinogenicity of aromatic hydrocarbons, narcotic effect – effects on the cardiovascular system and blood parameters (decrease in hemoglobin and erythrocytes); also, possible liver damage, endocrine disorders, skin irritation and pigmentation. Excessive concentration of heavy metals and petroleum products in various biosphere objects has an inhibiting and toxic effect on living organisms. To determine the actual consequences for the environment from operation of the SFs, the state of the environment (including surface and groundwater bodies) should be analyzed in comparison with certain biotic components in the reference rivers, where there are no anthropogenic pressures

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for PJSC Naftokhimik Prykarpattia Tailings Storage Facilities
Response	**Response**(measures taken to improve the state of water bodies)	Measures to improve the situation should aim at: ▪ **pressure reduction**: - address all the non-compliances in the TSF operation - perform regular technical surveillance of the structures' condition and monitoring of the facilities' impact on the environment - improve the policy of emergency prevention at the TSFs - introduce technologies for disposal of the accumulated waste ▪ **state determination:** - improve the system of continuous surface and groundwater monitoring in the TSF area ▪ **impact determination** - conduct research on which biotic components, and to what extent, feel the effects of pressures from the TSFs Measures recommended to the TSF operator and competent authorities provided in this Summary may be taken into account when developing the Dniester River Basin Management Plan for water body protection.

DPSIR analytical framework for Tailings Storage Facilities of Dolynanaftogaz Oil and Gas Production Department of PJSC Ukrnafta

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for Dolynanaftogaz Tailings Storage Facilities
Driver	**Driver** (human activities that may impact the environment)	Operation of ten sludge storage facilities of an oil and gas mining enterprise, which are located in the Dolyna and the Rozhniativ Districts of the Ivano-Frankivsk Region. The company also owns 11 liquidated facilities (filled with soil). The documentation on the liquidated sludge pits has not been provided. The operating sludge storage facilities are located at the company's 4 structural divisions: Oil Preparation and Pumping Shop (OPPS), Cluster Pump Station 2 North Dolyna (CPS-2 ND), Cluster Pump Station 7 (CPS-7), Group Technological Installation (GTI-3) "Strutyn". Due to a large number of the company's TSFs, the distance to the watercourses flowing into the SWBs and to the SWBs themselves is between 10 m to 650 m, depending on their location. Peculiarities of TSF operation: - **Natural conditions as the main external factors of natural hazards:** Prolonged torrential rains can cause overfilling of the sludge storage facilities, with waste overflowing the embankment. Seismically hazardous area. The hydrological hazard driver is not applicable – the sludge storage facilities are located beyond the boundaries of any rivers with a potential flooding ability (based on the preliminary assessment of the flooding risks for the Dniester River Basin) - **Linear hydrographic network**: in the location area of the OPPS, CPS-7 and CPS 2-ND is as follows: the Untitled stream – the Yar stream – the Lushchava River – the Svicha River – the Dniester River. In the area of GTI-3 "Strutyn" area: the Smereka stream – the Duba River – the Chechva river – the Lomnytsia (Limnytsia) River – the Dniester River. - **Peculiarities of the location:** The OPPS industrial site and the cluster pump stations (CPS-7, CPS-2PD) are located near the village of Yavoriv, Dolyna District. The industrial site of the oil collection point GTI-3 "Strutyn" is located in the village of Ivanivka, Rozhniativ District. The minimum distance from the residential development of Ivanivka is 300 m. - **Current state of the SFs:** examination of the **OPPS Sludge Pit 1** found that the structure had a critical filling level; a small pond with a prominent brown color was identified about 10 m away, which may evidence waste filtration through the sludge pit embankment. Inspection of the **OPPS Sludge Pit 4** showed a critical filling level the structure. Indications of waste overflow over the embankment edge were revealed – there are traces of petroleum products next to the structure, the pit contours are not clear. The pit does not have a wire fence. Some of the petroleum product waste is located outside the pit and there are traces of petroleum products mixed with soil. **OPPS "ecological pond"**

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for Dolynanaftogaz Tailings Storage Facilities
		sludge pit: there is no measuring ruler to control the level of waste and the critical level of reservoir filling. The distance to the Untitled stream is about 10 m. The visual inspection **sludge of the CPS-2 ND Sludge Storage facilities 1 and 3** have signs of water logging under the embankment and in the surrounding area. According to the interviews, visual observations of the structures' condition and measurements of the filling levels are not recorded in the logs. The **CPS-7** territory has a critical level of pit filling. The territory outside Sludge Pit 2 at the site of the liquidated storage facilities has traces of petroleum products in the water and indications of water logging. The site is not leveled. The facilities operation level estimated using the Methodology partially fails to meet the requirements of the environmental and technogenic safety standards - **Waste volume:** According to the company data, as of 01.04.2019, the 10 sludge storage facilities of OGPA Dolynanaftogaz have in total accumulated 10,178.035 tons of oil sludge, of which almost half – 4,925 tons were removed to OPPS TSF 4 "Main Structures" - **Waste composition:** detailed examination of the oil sludges showed that they include paraffins (20.4-32.3%), non-condensed cycloalkanes (11.9-19.4%), alkylbenzenes (8.9-10.2%), indanes and tetranins (5.7-7.9%), naphthalenes (7.6-11.9%), anthracenes and diphenyls (0.8-3.9%), acenaphthylenes (0.8-3.9%), and benzothiophenes (1.3-2.6%)
Pressure	**Pressure** (direct consequence of an activity)	Most sludge storage facilities have been in operation since 1986; OPPS Pit 4 CPPN and GTI "Strutyn" Storage facilities 1-2 were built in 1970-1971. Such long operation caused probable deterioration of the structures' waterproofing properties, resulting in filtration of hazardous substances from the sludge storage facilities and from the contaminated adjacent area to unprotected aquifers.
State	**State** (conditions that arise in the water bodies (SWB) due to activities)	Surface water monitoring is carried out at nine river stations: the Lushchava River, the Tuzhanka (Turianka) River, the Sadzava (Sadzhava) River and the Yar stream flowing into the Lushchava River. The impact of the sludge storage facilities on surface waters according to the company monitoring data can be identified only at the Yar stream station. It is located below the OPPS "Main Structures". All the other stations aim only at monitoring the company's wastewater quality and do not reflect the impact of the sludge storage facilities on the surface water quality. Groundwater quality control is carried out through a special network of monitoring wells. According to the company's monitoring data, as of 2001, the concentration of petroleum products in the groundwater near OPPS Pit 4 was exceeded 80 times. As of 2015-2018, the excess of surface water

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for Dolynanaftogaz Tailings Storage Facilities
		was recorded in terms of ammonium nitrogen, NO_2, chemical oxygen demand and biochemical oxygen demand. The company's groundwater quality monitoring data was provided for 2015-2018, but it was not supported with background values or MAC indicators. It can be noted that Wells 1/1 (OPPS territory) and 5 (CPS-2ND territory) showed significant concentrations of Cl. The hydrogen index in the groundwater samples in the OPPS area ranges from 4.26 to 6.91 pH units. Such low hydrogen indicator and iron concentration in the samples may testify to presence of iron bacteria in groundwater or migration of organic acids in groundwater.
Impact	**Impact** (consequence of the pressure for the environment)	The impact on the environment from the OGPA Dolynanaftogaz SFs is caused by toxic effects of the waste substances, first and foremost hydrocarbons. The oil refining waste substances are characterized by strong toxic effects: pronounced mutagenicity and carcinogenicity of aromatic hydrocarbons, narcotic effect – effects on the cardiovascular system and blood parameters (decrease in hemoglobin and erythrocytes); liver damage, endocrine disorders, skin irritation and pigmentation are also possible. Excessive concentration of heavy metals and petroleum products in various biosphere objects has an inhibiting and toxic effect on living organisms. To determine the actual impact, it is necessary to study the SWB state and compare some biotic components with their counterparts in the reference rivers, where there are no anthropogenic pressures.
Response	**Response** (measures taken to improve the state of water bodies)	Measures to improve the state of water bodies should aim at: ▪ **pressure reduction:** - address all the non-compliances related to the technical state of the sludge pit structures and operation - perform technical surveillance of the structures' condition and monitoring of the facilities' impact on the environment - improve the policy of emergency prevention at the sludge storage facilities - introduce technologies for disposal of the accumulated waste ▪ **state determination**: - improve the system of continuous surface and groundwater monitoring in the sludge pit area (expansion of the monitoring well network) ▪ **impact determination**:

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for Dolynanaftogaz Tailings Storage Facilities
		- conduct research on which biotic components and to what extent, feel the effects of pressures from the sludge storage facilities Measures recommended to the TSF operator and competent authorities provided in this Summary may be taken into account when developing the Dniester River Basin Management Plan for water body protection.

DPSIR analytical framework for State Enterprise Sirka Tailings Storage Facilities

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for SE Sirka Tailings Storage Facilities
Driver	**Driver** (human activities that may impact the environment)	Operation of three TSFs and other hazardous waste storage locations of an extractive and chemical industry state enterprise pursuing mining and enrichment of sulfur ores in the territory of the Mykolaiv District of the Lviv Region of Ukraine. The company has not been extracting mineral resources since 1997 and is currently not involved in maintaining the ecological balance in its operation area. Peculiarities of TSF operation: - **Natural conditions as the main external factors of natural hazards**: precipitation is in the form of torrential rains, which strongly affect the regime of rivers and can intensify the processes of dam erosion and overfilling of the TSFs, with waste overflowing the dam crest. Seismically hazardous area and karst phenomena development area. Flooding by river waters is a hazard - **Linear hydrographic network**: TSF 1 is located 740 m from the Dniester River SWB and 440 m from the Barvinok River; TSF 2 – 1130 m from the Klodnytsia River SWB; TSF at the hydraulic waste Storage Facility – 380 m from the Dniester River SWB - **Waste volume:** 85 mln tons[80] of waste from sulfur ore enrichment and mineral fertilizer production. Also the company has accumulated a large number of other types of waste: 700 m^3 of lump sulfur residues, 1.29 mln m^3 of circulating water sediments, 3 mln tons of phosphogypsum, 17 thous tons of tars, and 560 thous m^3 of SHW. - **Waste composition:** the TSF waste contain about 75% calcite, 5% sulfur, 6-7% gypsum, up to 1% celestine, 10-15% clay minerals; the concentration of manganese, strontium, barium, lithium, which is associated with the genesis of sulfur ores, is increased in comparison with sulfur ore. - **Current state of the TSFs:** the level of TSF operation is unsatisfactory. In particular, the integrity of the TSF 1 dam was lost, the drainage canals are neglected, the wastewater from the company's site, which gets into the Dniester River, is not treated, other company waste is stored in violation of current legislation and creates

[80] According to various data sources, the total amount of waste in the three SE Sirka TSFs is approximately between 85 mln tons and 108.9 mln tons

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for SE Sirka Tailings Storage Facilities
		additional pressure on water bodies, the key safety-related operational and reporting documentation is not maintained
Pressure	**Pressure** (direct consequence of an activity)	There are visual signs of the impact of the TSFs and other hazardous waste storage places on the environment: contamination of the surrounding area with hazardous substances, seeping. Hazardous substances may filter from the company's TSFs, other of waste storage places, and from the contaminated adjacent area to unprotected aquifers
State	**State** (conditions that arise in the water bodies (SWB) due to activities)	Monitoring of surface and groundwater in the TSF-affected area is not performed, therefore, there is no data to assess the SWB state parameters. There are visual indications of soil contamination, water logging of the adjacent areas, and seeping of flotation waste beyond the TSFs. In the tar storage area, the MAC of the soil samples were exceeded relative to the background for manganese, lead, zinc, and petroleum products. Comprehensive study of the TSFs – a review of natural conditions and peculiarities of the company's TSF locations, volume and toxicity of waste, examination of the current state of structures – suggests that the conditions that arose during operation of the SE Sirka TSFs are different from the background ones
Impact	**Impact** (consequence of the pressure for the environment)	In absence of monitoring of the surface and groundwater state by the company and any hydrobiological research, the consequences of the pressure can be assessed only by the method of analogies and assumptions. The environmental impact of waste is caused by the toxic effects of the substances contained in them - mainly sulfur and sulfuric acid, phenols, and heavy hydrocarbons contained in the tars. In particular, the effects may include acidification of soil and water bodies and, accordingly, detrimental impact on microorganisms – reduced soil fertility, slowing down of plant growth, disruption of the ichthyocenosis structure.

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for SE Sirka Tailings Storage Facilities
		To determine the actual consequences for the environment from operation of the TSFs, the state of the environment (including surface and groundwater bodies) should be analyzed in comparison with certain biotic components in the reference rivers, where there are no anthropogenic pressures
Response	**Response** (measures taken to improve the state of water bodies)	Measures to improve the SWB state should aim at: ▪ **pressure reduction:** - address all the non-compliances in the operation of the TSFs and other waste storage locations - perform regular technical surveillance of the structures' condition and monitoring of the SF impact on the environment - improve the policy of emergency prevention at the TSFs - introduce technologies for disposal of waste in the TSFs. ▪ **state determination:** - install the system of surface and groundwater monitoring in the TSF area ▪ **impact determination** - conduct research on which biotic components, and to what extent, feel the effects of pressures. Measures recommended to the TSF operator and competent authorities provided in this Summary may be taken into account when developing the Dniester River Basin Management Plan for water body protection.

DPSIR analytical framework for PJSC Stebnyk Mining and Chemical Enterprise Polimineral Tailings Storage Facility

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for PJSC Stebnyk Mining and Chemical Enterprise Polimineral Tailings Storage Facility
Driver	**Driver** (human activities that may impact the environment)	Operation of an extractive and chemical industry enterprise's TSF in the climatic, hydrological, and geological conditions of the Drohobych District of the Lviv Region of Ukraine. Peculiarities of TSF operation: - **Natural conditions as the main external factors of natural hazards:** formation and activation of karst-suffusion processes in the area affected by the Stebnyk potassium ore mine; seismically hazardous area; torrential and local nature of precipitation, which can cause TSF overfilling if the reservoir gets filled to a critical level. - **Linear hydrographic pattern**: the Untitled stream – the Slonytsia River – the Tysmenytsia River – the Bystrytsia Tysmenytska River – the Dniester River. The TSF is located 1.5 km northeast of the town of Stebnyk and consists of two sections. 100 m from the TSF there is the Untitled stream flowing into the Slonytsia River. The SWB itself flows around the TSF on three sides, the smallest distance between them being 750 m. - **Waste volume**: 12.74 mln m^3, of which 2.85 mln m^3 is the liquid phase in TSF Section 2 and 8.29 mln m^3 and 1.6 mln m^3 of the solid phase contained in Sections 1 and 2, respectively. Waste passportization and accounting at the TSF is not maintained - **Waste composition**: the brines by their chemical composition are chloride, sulfate and a small amount of carbonate salts with a salinity of 140-150 g/l. This type of waste is categorized as Hazard Class IV. - **Current state of the TSF**: July 2018 witnessed a critical level of TSF Section 2 filling, which, in case of a large amount of precipitation, poses a threat of dam break and brine leakage with subsequent entry of pollutants into the water bodies of the Dniester River Basin; neglected drainage system
Pressure	**Pressure** (direct consequence of an activity)	Critical level of TSF filling, which can lead to waste overflows in case of intense precipitation. Many years of operation caused probable deterioration of the structures' waterproofing properties, resulting in filtration of toxic substances from the TSF and from the contaminated adjacent area to unprotected aquifers.

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for PJSC Stebnyk Mining and Chemical Enterprise Polimineral Tailings Storage Facility
State	**State** (conditions that arise in the water bodies (SWB) due to activities)	According to the company monitoring, all the mineralization values in the water samples from the piezometers on the TSF dam exceeded 1 g/l, the maximum value being 2.8 g/l. In the Ore Mine 2 area the values of salt concentrations in the surface water samples often exceed the values of the background sample, which testifies to a direct impact on water resources. Comprehensive study of the TSF – a review of natural conditions and peculiarities of the location, volume and toxicity of waste, examination of the current state of structures and analysis of the available monitoring results – suggests that the conditions that arose during operation of the TSF are different from the background ones
Impact	**Impact** (consequence of the pressure for the environment)	The environmental impact of the TSF waste is caused by toxic effects of the substances contained in them – the waste includes chloride and sulfate salts – NaCl, KCl, $MgSO_4$. It is known that excessive salt concentration in water produces an inhibiting and toxic effect on living organisms; on saline soil, plants are delayed in growth and development, some of them die, the crop yield falls dramatically. To determine the actual consequences for the environment from operation of the TSFs, the state of the environment (including surface and groundwater bodies) should be analyzed in comparison with certain biotic components in the reference rivers, where there are no anthropogenic pressures
Response	**Action program** (measures taken to improve the state of water bodies)	Measures to improve the SWB state should aim at: ▪ **pressure reduction:** - address all the non-compliances in the TSF operation - perform regular technical surveillance of the structures' condition and monitoring of the SF impact on the environment - improve the policy of emergency prevention at the TSF - introduce technologies for processing/ neutralization of waste in the TSF ▪ **state determination** – development of a program for surface and groundwater monitoring in the TSF area ▪ **impact determination** – conducting research on which biotic components, and to what extent, feel the effects of pressure from the TSF. Measures recommended to the TSF operator and competent authorities provided in this Summary may be taken into account when developing the Dniester River Basin Management Plan for water body protection.

DPSIR analytical framework for PJSC NPK-Galychyna Tailings Storage Facilities

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for PJSC NPK-Galychyna Tailings Storage Facilities
Driver	**Driver** (human activities that may impact the environment)	Operation of an oil refining enterprise's TSF in the climatic, hydrological and geological conditions of the Drohobych District of the Lviv Region of Ukraine. The PJSC NPK-Galychyna TSFs are located near the town of Drohobych at two industrial sites: the territory of the former Oil Refinery 1 (OR-1) and Oil Refinery 2 (OR-2). Information on the characteristics of the OR-2 TSF is missing, the relevant documentation was not provided. Peculiarities of TSF operation: - **Natural conditions as the main external factors of natural hazards:** torrential and local nature of precipitation can cause overfilling of the TSFs, with waste overflowing the embankment edge. Seismically hazardous area. The hydrological hazard driver is not applicable – the TSFs are located beyond the boundaries of any rivers with a potential flooding ability (based on the preliminary assessment of the flooding risks for the Dniester River Basin) - **Linear hydrographic network**: the Untitled stream – the Tysmenytsia River – the Bystrytsia Tysmenytska River – the Dniester River. A water body, the Untitled stream flowing into the Tysmenytsia River, is approximately 10 m from the OR-1 storage facilities. The Ratochyna River is located 25 m from OR-2. The linear hydrographic network is as follows: the Ratochyna River – the Tysmenytsia River – the Bystrytsia Tysmenytska River – the Dniester River. - **Peculiarities of the location**: Proximity of the residential development, the shortest distance from private houses to the OR-1 TSFs is 20 m - **Waste volume**: as of 2018, the storage facilities contain oil refining waste – oil sludge from mechanical treatment of wastewater of Hazard Class III, the total volume of which is 39,827.08 tons - **Waste composition**: The chemical composition of oil sludge is a mixture of hydrocarbons, mechanical impurities and water, with gas emissions – hydrocarbon vapors. Water 5% -90%; petroleum products 4%-60%; mechanical impurities 10%-30%; the sulfur content in the petroleum product is 0.2%-0.31% - **Current state of the TSFs**: there are indications of water logging of the adjacent territory. Critical level of structure filling. Unidentified waste is stored beyond storage facility structures on undeveloped ground

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for PJSC NPK-Galychyna Tailings Storage Facilities
Pressure	**Pressure** (direct consequence of an activity)	Nearly 50 years of TSF operation caused probable deterioration of the structures' waterproofing properties, resulting in filtration of toxic substances from SFs and from the adjacent area to unprotected aquifers. Visual assessment revealed indications of soil contamination and seeping or leakage of petroleum products beyond the facilities
State	**State** (conditions that arise in the water bodies (SWB) due to activities)	The company monitors the surface water quality in the OR-1 TSF area at two points of the Untitled stream – before the plant and after the plant. The following indicators are determined: petroleum products, suspended substances, chlorides, and dry residue. Excessive values were recorded only for suspended substances and once for chlorides (at the station before the plant). The groundwater quality in the OR-1 TSF area is monitored once a month in six wells. The analysis of the monitoring results showed a dramatic increase in the concentration of petroleum products in the samples from Wells 1, 2, 3 (approximately 2 times) in 2018. Comprehensive study of the facilities – a review of natural conditions and peculiarities of the company's TSF locations, volume and toxicity of waste, examination of the current state of structures and analysis of the available monitoring results – suggests that the conditions that arose during operation of the Oriana-ECO LLC TSFs are different from the background ones.
Impact	**Impact** (consequence of the pressure for the environment)	Environmental impact of the refinery waste SF caused by **toxic effects of waste substances** – primarily hydrocarbons that are part of the oil sludge. The oil refining waste substances are characterized by strong toxic effects: pronounced mutagenicity and carcinogenicity of aromatic hydrocarbons, narcotic effect – effects on the cardiovascular system and blood parameters (decrease in hemoglobin and erythrocytes); liver damage, endocrine disorders, skin irritation and pigmentation are also possible. Excessive concentration of heavy metals and petroleum products in various biosphere objects has an inhibiting and toxic effect on living organisms. To determine the actual consequences for the environment from operation of the SFs, the state of the environment (including surface and groundwater bodies) should be analyzed in comparison with certain biotic components in the reference rivers, where there are no anthropogenic pressures

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for PJSC NPK-Galychyna Tailings Storage Facilities
Response	**Response**(measures taken to improve the state of water bodies)	Measures to improve the situation should aim at: ▪ **pressure reduction**: – address all the non-compliances in the TSF operation – perform regular technical surveillance of the structures' condition and monitoring of the facilities' impact on the environment – improve the policy of emergency prevention at the TSFs – introduce technologies for disposal of the accumulated waste ▪ **state determination:** – improve the system of continuous surface and groundwater monitoring ▪ **impact determination:** – conduct research on which biotic components, and to what extent, feel the effects of pressures Measures recommended to the TSF operator and competent authorities provided in this Summary may be taken into account when developing the Dniester River Basin Management Plan for water body protection.

DPSIR analytical framework for Tailings Storage Facility of Boryslavnaftogaz Oil and Gas Production Department of PJSC Ukrnafta

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for of the Boryslavnaftogaz Tailings Storage Facility
Driver	**Driver** (human activities that may impact the environment)	TSF operation, which is administratively located in the Drohobych District of the Lviv Region within the town boundaries of Boryslav, Dniester River Basin area. The distance to the Tysmenytsia River SWB is ≈ 500 m. Peculiarities of operation: - **Natural conditions as the main external factors of natural hazards:** Significant amount of precipitation and high humidity, which may cause SF overfilling, with waste overflowing the embankment, and intensify the processes of hypergenesis and migration of pollutants. The groundwater is categorized as “nominally protected” (vulnerable to pollution), occurring at a depth of 2.5 m with a seasonal fluctuation of 1.1 m. Seismically hazardous area. The hydrological hazard driver is not applicable – the TSF is located beyond the boundaries of any rivers with a potential flooding ability (based on the preliminary assessment of the flooding risks for the Dniester River Basin) - **Linear hydrographic network**: the Tysmenytsia River – the Bystrytsia Tysmenytska River – the Dniester River - **Peculiarities of the location:** A storage facility with a capacity of 1200 m^3 is located 800 m north of downtown Boryslav, at the address: 5 Potik str. - **Waste volume:** 1,551.1 tons of oil sludge solid fraction as of 01.04.2019 - **Waste composition**: The chemical composition of oil sludge is a mixture of hydrocarbons, mechanical impurities and water, with gas emissions – hydrocarbon vapors - **Current state of the SF:** critical level of TSF filling: liquid oil emulsion reaches the edge of the embankment, there are overflows and spreading of the oil sludge waste beyond the facility, the structure’s filling level is not measured and the results are not recorded in the monitoring log, waste is placed in the TSF in excess of its design volume: as of 01.04.2019, the actual waste volume of 1,551.1 tons exceeded the structure’s design volume of 1,200 tons

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for of the Boryslavnaftogaz Tailings Storage Facility
Pressure	**Pressure** (direct consequence of an activity)	The TSF has been in operation since 2001. It is a specially constructed storage, the bottom and the sides of which have concrete insulation screens. Contamination of groundwater and surface water is possible as a result of inadequate operation and/or emergencies, including waste overflows over the flank edges
State	**State** (conditions that arise in the water bodies (SWB) due to activities)	The company monitors the state of surface water at the stations of the Lochenyi, the Tysmenytsia, the Ratochyna Rivers, the Ropny stream and Lake Mrazhnytsia. The state of groundwater is monitored through a special network of monitoring wells. According to the company, in 2018, the water samples taken from the surface and groundwater monitoring points at the Boryslav deposit showed that the MAC values were not exceeded in the rivers used for fishery. No petroleum products were detected in the selected samples of natural waters. It should be noted that during the previous monitoring periods of 2015-2017, petroleum products were periodically identified in the Tysmenytsia River in the area of Boryslav 2000 well. This is due to the geological features of the deposit structure and location of the wells, from which oil was extracted in the past, immediately in the riverbed and on its banks. According to the company research of hydrochemical indicators of surface and ground water and soil samples in the TSF area carried out in 2018, the regulatory MAC values and the background concentrations were not exceeded.
Impact	**Impact** (consequence of the pressure for the environment)	The impact on the environment of the OGPA Boryslavnaftogaz SFs is caused by toxic effects of waste substances – first and foremost hydrocarbons. The oil refining waste substances are characterized by strong toxic effects: pronounced mutagenicity and carcinogenicity of aromatic hydrocarbons, narcotic effect – effects on the cardiovascular system and blood parameters (decrease in hemoglobin and erythrocytes); liver damage, endocrine disorders, skin irritation and pigmentation are also possible. Excessive concentration of heavy metals and petroleum products in various biosphere objects has an inhibiting and toxic effect on living organisms. To determine the actual impact, it is necessary to study the SWB state and compare some biotic components with their counterparts in the reference rivers, where there are no anthropogenic pressures.

Indicator of the DPSIR framework		Description of the DPSIR framework indicator for of the Boryslavnaftogaz Tailings Storage Facility
Response	**Response**(measures taken to improve the state of water bodies)	Measures to improve the state of water bodies should aim at: ▪ **pressure reduction:** - address the non-compliances related to the technical state of the TSF structures and operation - perform technical surveillance of the structures' condition and monitoring of the facility's impact on the environment - improve the policy of emergency prevention at the TSF - introduce technologies for disposal of the accumulated waste ▪ **state determination**: - improve the system of continuous surface and groundwater monitoring in the TSF area (expansion of the monitoring well network) ▪ **impact determination**: - conduct research on which biotic components, and to what extent, feel the effects of pressures from the SF Measures recommended to the TSF operator and competent authorities provided in this Summary may be taken into account when developing the Dniester River Basin Management Plan for water body protection.

ANNEX 3. INFORMATION ON WASTE RECYCLING AND MONITORING OF DAM STABILITY

One of the conditions for ensuring safe operation of TSFs is dams stability. Today, there are various ways of monitoring the dam stability in the world. The satellite method of dam stability monitoring allows carrying out remote measurements, without the need to install the equipment onsite and visit the facilities.

The advantage of the method is its remoteness, the possibility of reverse analysis, low specific cost compared to instrumental methods, large coverage area, non-sensitivity to weather and atmospheric phenomena, possibility of using free software and images after some training.

Another and most efficient way to decrease the level of threats from the storage facilities is to reduce the amount or hazard level of accumulated waste – its full or partial recycling or neutralization.

Within the framework of the project, preliminary negotiations were held with relevant foreign companies on similar experience, available technologies and capacities for industrial waste recycling and installation of dam stability monitoring systems with training of specialists for further independent use. Contact details for these companies are provided below.

1. **ROMALTYN MINING SRL**
   web: www.romaltyn.ro
   Weisenbacher Vasile
   vasile.weisenbacher@romaltyn.ro

2. **WISUTEC Umwelttechnik GmbH**
   web: www.wisutec.de
   Uwe Walter, Executive Director, Head of Mining Department
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3. **Company Tauw**
   web: www.tauw.com
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4. **CDM Smith**
   web: www.cdmsmith.com
   Christiane Jung, Business Development Manager
   Christiane.Jung@cdmsmith.com