EU4Environment in Eastern Partner Countries:
Water Resources and Environmental Data (ENI/2021/425-550)

INVESTIGATIVE MONITORING ARMENIA 2022

Contract-No: 20940-C1/AM-HMC-2022/1

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ABOUT THIS REPORT

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ABOUT EU4ENVIRONMENT – WATER RESOURCES AND ENVIRONMENTAL DATA

This Programme aims at improving people's wellbeing in EU's Eastern Partner Countries and enabling their green transformation in line with the European Green Deal and the Sustainable Development Goals (SDGs). The programme's activities are clustered around two specific objectives: 1) support a more sustainable use of water resources and 2) improve the use of sound environmental data and their availability for policy-makers and citizens. It ensures continuity of the Shared Environmental Information System Phase II and the EU Water Initiative Plus for Eastern Partnership programmes.

The programme is implemented by five Partner organisations: Environment Agency Austria (UBA), Austrian Development Agency (ADA), International Office for Water (OiEau) (France), Organisation for Economic Co-operation and Development (OECD), United Nations Economic Commission for Europe (UNECE). The programme is principally funded by the European Union and co-funded by the Austrian Development Cooperation and the French Artois-Picardie Water Agency based on a budget of EUR 12,75 million (EUR 12 million EU contribution). The implementation period is 2021-2024.

https://eu4waterdata.eu

CONTENTS

List of abbreviations

ADA....................... Austrian Development Agency
BQE....................... Biological Quality Elements
DoA....................... Description of Action
DG NEAR.............. Directorate-General for Neighbourhood and Enlargement Negotiations of the European Commission
EaP........................ Eastern Partners
EC.......................... European Commission
EECCA .... Eastern Europe, the Caucasus and Central Asia
EMBLAS .... Environmental Monitoring in the Black Sea
EPIRB .... Environmental Protection of International River Basins
ESCS...................... Ecological Status Classification Systems
EU .... European Union
EUWI+................... European Union Water Initiative Plus
GEF........................ Global Environmental Fund
ICPDR................... International Commission for the Protection of the Danube River
INBO .... International Network of Basin Organisations
IOW/OIEau .... International Office for Water, France
IWRM .... Integrated Water Resources Management
NESB .... National Executive Steering Board
NFP .... National Focal Point
NGOs.................... Non-Governmental Organisations
NPD....................... National Policy Dialogue
OECD.................... Organisation for Economic Cooperation and Development
RBD....................... River Basin District
RBMP.................... River Basin Management Plan
Reps...................... Representatives (the local project staff in each country)
ROM...................... Result Oriented Monitoring
ToR........................ Terms of References
UBA....................... Umweltbundesamt GmbH, Environment Agency Austria
UNDP .... United Nations Development Programme
UNECE.................. United Nations Economic Commission for Europe
WFD...................... Water Framework Directive

Country Specific Abbreviations Armenia

EMIC .... Environmental Monitoring and Information Centre (until January 2020)

HMC..................... Hydrogeological Monitoring Centre (since February 2020)

MNE..................... Ministry of Environment

SCWS .... State Committee on Water Systems

SWCIS .... State Water Cadastre Information System of Armenia

WRMA .... Water Resources Management Agency

Executive Summary

The scope of this document is to address the principles of the EU Water Framework Directive's concept of investigative monitoring.

Part I of the document describes the background and relevant technical details of this concept, which are of general relevance for all countries that intend to carry out this tool in line with the WFD. It describes the agreed concept and fundamentals to establish an investigative monitoring. This part, consequently, is the official basis for the national investigations and are integral part of the relevant contracts which lay down the execution of the practical investigation. It has been developed under EUWI+ and serves as template for the activity carried out under EU4WD.

Part II addresses specific national considerations, which were identified in the course of EU4Environment - Water Resources and Environmental Data program activities. They build the basis for national investigations which were carried out in summer of 2022. Thus, this document acts as a living document and shall summarize the investigative monitoring process for one EU4Environment country from the first considerations to the final conclusions. Part II is intended to be the template for reporting of national results, conclusions and lessons learned during the practical investigation. It is integral part of the contracts and describes the execution of the practical investigation.

Thus, Part II of this document presents a template for later reporting, once the fieldwork is accomplished. The activity concludes with reflections on lessons learned, which will be discussed after the final conclusions of the investigations.

1 General Issues

The European Union's Water Framework Directive (WFD, 2000/60/EC[1]) aims at the improvement and protection of all water bodies at river basin level, including inland surface waters, transitional waters, coastal waters and groundwater bodies. Harmonized monitoring programmes are required to describe uniformly the quality of the water bodies involved.

Monitoring is a key activity in integrated water management.

There are three different principal forms of monitoring foreseen in the implementation of the EU Water Framework Directive [2],[3] (see also Figure 1 below).

- **Surveillance monitoring:** This serves to supplement and validate impact assessment procedures for all water bodies; to enable the adequate preparation of future monitoring programmes; and to assess long-term changes in natural conditions or as a result of anthropogenic activity. Results of 12 months surveillance monitoring programmes enable the development of river basin management plans.
- **Operational monitoring:** This serves to describe the status of water bodies which are at risk of failing their environmental objectives, to evaluate the effectiveness of measure taken or to monitor according to international obligations. Chemical and physical parameters are analysed 12 times per year, biological quality elements are checked, depending on the quality element, once to six times a year. It is suggested to run two campaigns per RBM cycle[4].
- **Investigative monitoring** is undertaken in special cases at certain rivers or river sections when
    - More data are needed to understand the causes for failure of environmental quality objectives.
    - Results of the surveillance monitoring suggest a mismatch with objectives, but without having an operative site available.
    - The impact of accidental pollution needs to be assessed.
    - Some more checking is needed of the impact of not yet monitored substances.
    - Some practical testing of new methods is advised.

Investigative monitoring might also include alarming or early warning monitoring. In particular, this summarizes monitoring of water bodies close to an abstraction point for drinking water by continuous or semi-continuous monitoring, e.g. by measuring chemical parameters like conductivity, dissolved oxygen, turbidity or alike or biological parameters like fish [Fehler! Textmarke nicht definiert.]. In the last couple of years, a lot of knowledge has been gathered in terms of precautionary measurements to protect the supply of safe drinking water against contamination[5] or on biological assays.

[1] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy

[2] COMMON IMPLEMENTATION STRATEGY FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC), Guidance Document No 7, Monitoring under the Water Framework Directive

[3] COMMON IMPLEMENTATION STRATEGY FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC), Technical Report - 2009 – 025, Guidance Document No. 19, GUIDANCE ON SURFACE WATER CHEMICAL MONITORING UNDER THE WATER FRAMEWORK DIRECTIVE

[4] EUWI+ Thematic Summary Reports for each EUWI+ country

5 https://erncip-project.jrc.ec.europa.eu/networks/tgs/water

This document aims at describing the general rationale for the type of investigative monitoring (IM) and providing general considerations on the necessary steps for implementation of investigative monitoring. Ideally, the document can provide guidance to establish an investigative monitoring action along or back-to-back with the planned field surveys in each of the EU4Environment - Water Resource s and Environmental Data project countries.

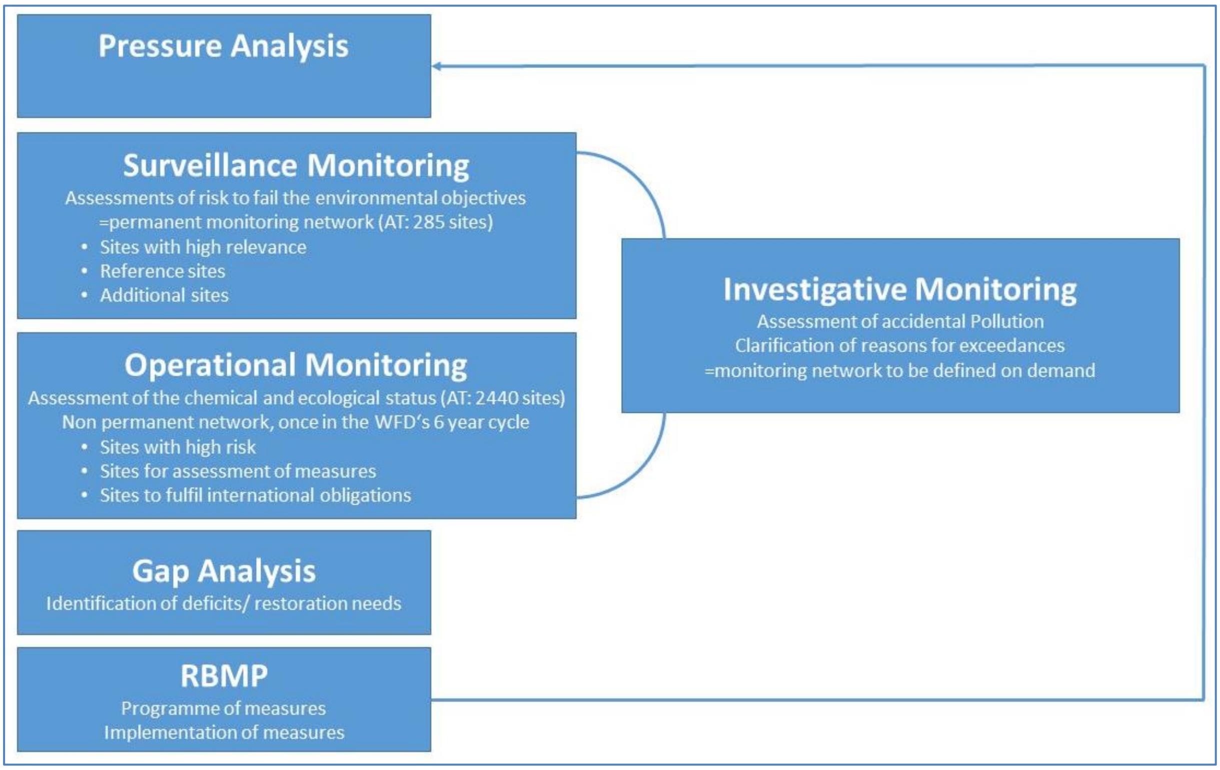

Figure 1: Surveillance, operational and investigative monitoring in the WFD's six years cycle

2 General Aspects of Investigative Monitoring

2.1 Planning and preparedness

While surveillance and operational monitoring, as part of an integrated water management, is carried out on a pre-determined basis with well-defined sampling sites in the water bodies, defined parameters and monitoring at a certain frequency, investigative monitoring has to be carried out upon special need. Potential reasons for investigative monitoring can be:

- The achievement of the good environmental status is at risk, but available data are not sufficient to determine the reason, and samples from more and different sites are needed to investigate the hypothesis why the environmental objective is likely to fail in certain river areas.
- (Non-)Deliberate water contaminations, like accidents or spills, or observed fish deaths suggest a severe contamination of a water body, and investigative steps have to be taken to better identify the nature and magnitude of the incident under time critical conditions.

For this reason, investigative monitoring needs a different approach to ultimately identify a problem by addressing it in the most appropriate monitoring design. This requires some flexibility in identifying the best determinants and individual approaches, to serve the needs of each unique situation. Provident organisational planning is therefore of utmost importance. This requires organisational and responsibility structures in place among the relevant authorities and a clear communication between all entities involved, especially when it comes to time-critical conditions along an accident or any other spontaneous contamination. Preparedness of all institutions along a clear and approved concept of investigative monitoring is key to be able to react promptly and properly to situations of uncertainty, which demand a high degree of flexibility and adaptation.

In a special case, continuous monitoring stations, which are used to monitor some water quality parameters for drinking water abstraction, can be built in. Involving early warning systems in investigative monitoring campaigns is mentioned here as a supportive instrument.

2.2 Suggested pool of institutions to be involved

This chapter narrows down the EU WFD concept of investigative monitoring to the framework and model application the EU4Environment - Water Resources and Environmental Data project and introduces which organization should potentially be involved in investigative monitoring. To clarify their roles and responsibilities, it is suggested to bring them together and to discusoles and responsibilities aloinrealistic scenario. In terms of water monitoring, it is recommended to appoint a Point of Contact (POC) at the relevant entity (e.g. Ministerial Department) being responsible for surface water monitoring to coordinate all activities and liaise with all other responsible authorities in case of emergencies (e.g. police, civil protection), particularly when it comes to accidental contaminations.

The necessary framework for investigative monitoring could be established among the following entities, which play an important role in national integrated water management. This is a suggested general scheme and needs to be adapted to the national structures and competencies in each of the six countries:

- **Ministerial Department responsible for the preparation of the RBMP (MDRBM)**; particularly the entity in charge of the status assessment of water bodies and for drafting the program of measures; they are the recipients of the monitoring results, take care of data management, the evaluation of results and deduction of measures; they need to work closely together with
- **Ministerial Department responsible for Surface Water Monitoring (MDSW).** Definition of the target of monitoring – which question has to be answered by which action; drafting of a monitoring concept which lays down individual actions and which is ideally agreed by all stakeholders. This entity could act as the Point of Contact the investigative monitoring and take the responsibility to coordinate with all other involved entities.
- **River Basin Management Authority (RBMA)**. For the IM, this institution has knowledge about all pressures identified in the river basin. It can help with the identification of pressures (e.g. industries emitting certain pollutants) which are not fully covered or their impact is not fully clear.
- **Ministerial Department for Emergency** (e.g. in Ministry for the Interior). Involvement in case of an industrial/transport accident with high impact, floods, or alike, depending on general national procedures. This entity has in place the procedures to assess and scope an emergency and to communicate restrictions to the affected people (Civil Protection) or affected users (e.g. drinking water utilities).
- **Blue light organizations**. This term summarizes the police, firefighters, and ambulance services as first responders in case of accidents. Their role is to mitigate the situation and record evidence. Normally, these organizations are the first on-site and thus play an essential role in communicating an unusual case to competent and responsible authorities.
- **Sampling unit.** This is the institution or group which carries out sampling according to well-established procedures, even in emergencies; the sampling unit has strong communication with the involved laboratory or laboratories into the requirements set for the sampling procedures.
- **Laboratory.** Provides the analytical service ordered by the leading organization. The laboratory is in close contact with other organizations in establish the procedures, which are required to achieve the information, needed (specific parameters, limits of detection, etc.). The laboratory produces a report about analysed samples which is essential for the lead organisation to take decisions (e.g. impact-mitigating measures).

2.3 Design of concept for investigative monitoring within EU4Environment - water resources and environmental data

Once all relevant entities have been identified, a concept can be derived that lays down the responsibilities of the organisations respectively. There are three conceivable scenarios with different implications on the extent of investigative monitoring:

1. Investigations to determine the reason why a water body is likely to fail the good environmental status;
2. Investigations to determine the magnitude of spontaneous contamination caused e.g. by a transport or industrial accident or deliberate contamination;
3. Monitoring carried out by an independent entity to assess the quality of water (e.g. drinking water utility).

These three different scenarios afford a different degree of involvement of the above-mentioned entities. Scenario 3 is somehow a specificity, as its data are gathered for an internal reason but could be supportive of other scenarios when it comes to early warning.

Above the different degrees of collaboration that are needed in these three scenarios, there is a pattern of interaction between the entities, which is of general importance, and validity.

2.3.1 Investigative monitoring triggered by water body at risk

This may be needed if data from surveillance and operative monitoring suggest that a water body is at risk of failing the good environmental status, or if the available set of data is not sufficient to explain why the good status cannot be reached. The assessment of pressures might indicate potential emissions, which have not yet been monitored, or the network of sampling sites might not be suitable to deduct confusions. In this case, a strong collaboration between the RBMA and the MDSW is needed to identify whether further parameters have to be measured or additional measuring sites have to be investigated. A clear exchange with the sampling unit and the laboratory is needed; the concept follows more or less the general decision and communication pathways, as laid down in Table 1.

Table 1: General decisions and pathways for communication to elaborate a concept for investigative monitoring

- Appointment of a **Point of Contact (POC)** for investigative monitoring taking the overall responsibility to coordinate the monitoring activity and establish the communication between all involved entities
    - ***By: national decision***
- The determination of chemical and/or biological parameters that have to be analysed.
    - ***By: MDRBM, RBMA and/or MDSW***
- The determination of sites to be sampled and monitored
    - ***By: MDRBM, RBMA and/or MDSW***
    - It can consist of existing sites for surveillance of operational monitoring, in case further information is needed
        - But it may need also additional sites for better determining the magnitude of contamination
            - Downstream of potential polluters, maybe with reference upstream of a suspected emission point
- The determination of pre-requisites for sampling
    - ***By: Communication between laboratory, sampling unit, and POC***
    - Choice of appropriate <u>sampling and transport containers</u> for each parameter
    - <u>Stabilization</u> of samples on-site and by which means for all parameters
    - Specification of sample filtration/treatment on-site, for all parameters
    - Specification of the transport conditions
- Determination of the sampling procedure (spot, mix by volume/time, etc.) to best respond to the problem
    - ***By: Communication between laboratory, sampling unit, and POC***
- Definition of necessary and feasible quality parameters as a requirement for the analysis
    - ***By: Communication between laboratory, sampling unit, and POC***
    - determination of LOD/LOQ for all parameters
    - definition of (a) standard method(s) for all parameters
- Determination of an adequate time for the delivery of results
    - ***By: laboratories and POC***
- Delivery of results to the responsible entity (POC)

- Assessment of results, deduction of needed measures
- ***MDRBM, MDE, RBMA, and/or MDSW with the support of laboratory***

2.3.2 Investigative monitoring triggered by accidental contamination/emergency

Contaminations as a result of emergencies (accidents) are mostly time-critical events and need thorough organizational preparedness to be tackled promptly and without delay. Apart from recording evidence of an event, samples and analyses are needed to assess the potential impact on the environment, to take appropriate measures to prevent subsequent damages (e.g. for the drinking water supply), and to mitigate the impact situation.

Police and firefighters are mostly the first to be on site as first responders. Depending on the magnitude of contamination, several additional steps have to be taken to investigate the situation and to clarify the impact on the water body and connected uses (e.g. irrigation, recreation). Therefore, the roles and responsibilities should be clear to all entities involved and, ideally, first responders can alert directly the POC at the responsible water authority to enable the chain of action and start with preparing investigations. Relevant information from the field should be delivered to the Point of Contact who then can decide to rapidly send a sampling unit to the site to take samples and initiate investigations and laboratory analyses.

2.3.3 Continuous water quality monitoring

Investigative monitoring might also include alarming or early warning monitoring. In particular, this summarizes the monitoring of water bodies close to an abstraction point for drinking water by continuous or semi-continuous monitoring, e.g. by measuring chemical parameters like conductivity, dissolved oxygen, turbidity or alike, or biological parameters like fish toxicity. Mostly, continuous water quality monitoring is applied by drinking water utilities to monitor the abnormalities in the composition of the water. Data can be used to feed early warning systems that support taking decisions. Data are normally not promptly available to authorities, as their use for reporting is limited. However, in case of emergencies, this kind of monitoring can assist drinking water suppliers in taking decisions to prevent contamination of the supply system. In case sensors are installed at the point of abstraction from the raw water source, data can help to monitor the status of the water. Involving early warning systems in investigative monitoring campaigns is mentioned here as a supportive instrument.

3 Investigative Monitoring in the northern river basin management area

The first investigative monitoring in the Debed River Basin was implemented within the EUWI+ project in 2020[6].

Within the programme EU4Environment - water resources and environmental data, an investigative monitoring (IM) survey was carried out under the service agreement number - 20940-C1/AM-HMC-2022/1. In particular, the service comprised the scoping of the issue to be investigated, the stakeholders to be involved in the monitoring, the identification of relevant water bodies, drafting of a rationale for the survey, planning of 15 sampling sites in the area and its practical implementation.

The fieldwork included completing of field protocols and water sampling. The HMC laboratory in Yerevan conducted the chemical analysis (heavy metals and on-site parameters), reported the results and elaborated of an overall IM report including a description of activities, results of the entire IM process, conclusions and lessons learnt. In line with the IM concept, substantial communication was expected with other stakeholders identified in the inception phase of the survey.

The overall objective of the investigative monitoring was to plan and carry out a survey in Armenia in coherence with the Water Framework Directive (WFD).

The objective of the survey, which was carried out in July 2022, was to form a sound methodological basis for future monitoring programs as an essential part of river basin management planning.

The scope was to

- Identify a problem by addressing it in the most appropriate monitoring design;
- Provide data for the evaluation of the water body;
- Provide data for the evaluation of the monitoring design in preparation for further surveys;
- Provide data for the pressure-impact assessment to evaluate existing assessment methods or develop new ones;
- Create a database for the upcoming risk, status and trend assessment;
- Practice inter-institutional collaboration.

3.1 Description of the problem and determination of sampling sites

The Northern River Basin Management Area of the Republic of Armenia is mainly influenced by:

- Metal mining activities (diffuse and non-point source pollution)
- Point source pollution from non-treated wastewater of settlements.
- Diffuse pollution sources: agriculture and transportation activity.

The impact of diffuse sources on surface water is difficult to assess and has not been studied well.

[6] Background and concept paper for investigative monitoring : Investigative Monitoring Report Armenia, 2021 EUWI+,

For investigative monitoring, the sampling points were selected in the areas of potential impact from metal mining activities. The sampling sites were also selected considering the results of a previous study, in which research monitoring was previously carried out. However, the results obtained were not sufficient and it was necessary to conduct additional monitoring in the same area with a different approach.

A considerable amount of research has been done in the past and the impact of a number of mining areas in the Debed River Basin was highlighted. This work continues the research to identify new potential impacts and explore the identified problem areas.

For the investigative monitoring, 15 sampling sites at 10 rivers were proposed. 12 sampling sites were located in the Debed RBD, and 3 sampling sites in the Aghstev RBD. Site names, numbers and geographical coordinates are provided in Table 2 and Figure 2.

Table 2. Characterization of the sampling sites with geographical coordinates

Site No.	Basin	River name	Site location	Latitude	Longitude
IM1	Debed	Tandzut	Village Antarashen	40º45'23.3''	44º37'24.2''
IM2	Debed	Zhangot jur	mouth	40º46'19.7''	44º34'33.4''
IM3	Debed	Tandzut	After mixing Zhangot jur stream	40º46'33.3''	44º33'28.7''
IM4	Debed	Pambak	0.5 km downstream Vanadzor city	40º48'49.9''	44º30'26.8''
IM5	Debed	Qaraberd	mouth	40º49'34.6''	44º33'06.7''
IM6	Debed	Pambak	After mixing Qaraberd river	40º49'41.7''	44º33'30.3''
IM7	Debed	Pambak	Up to Village Vahagnadzor	40º52'51.4''	44º35'15.0''
IM8	Debed	Sisiget	mouth	40º52'56.7''	44º35'22.7''
IM9	Debed	Pambak	After mixing Sisiget river	40º53'06.0''	44º35'25.1''
IM10	Debed	Dzoraget	0.5 km upstream Stepanavan city	41º00'48.3''	44º22'54.0''
IM11	Debed	Mghart	mouth	40º59'29.1''	44º33'28.5''
IM12	Debed	Dzoraget	After mixing Mghart floodgate	40º57'22.8''	44º35'05.9''
IM13	Aghstev	Aghstev	Village Lermontovo	40º46'13.0''	44º37'15.2''
IM14	Aghstev	Golovino	mouth	40º43'01.4''	44º47'55.3''
IM15	Aghstev	Aghstev	1.2 km upstream Dilijan city	40º44'21.1''	44º49'24.0''

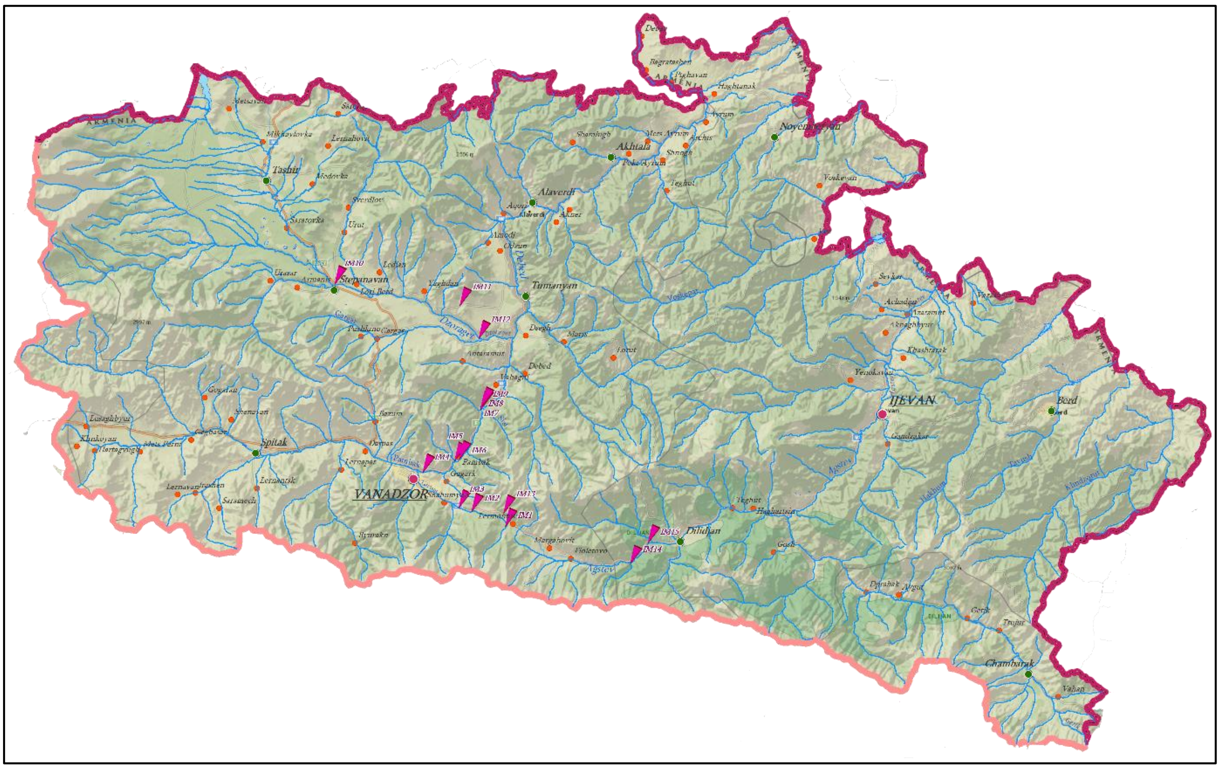

Figure 2. Map of Sampling Sites

3.2 Pressure sources selected for the investigative monitoring

Tandzut River near the Vanadzor city (IM1, IM2, IM3)

This site is possibly impacted by the Tandzut abandoned mining site.

Tandzut abandoned mining site: The Tandzut mine is (Figure 3) located 14 km out of the town of Vanadzor, on the northern slope of the Pambak mountain range, upstream of the Tandzut River. The mining overburden was generated as a result of a geological study and exploitation works of the Tandzut sulphur-pyrite (kolchedana) mine. There are three separate areas of overburdens in the Tandzut precinct (in sum 3 ha, 80,000 m^3).

The Tandzut sulphur-pyrite mine was discovered in the late 19^{th} century. During that period, the mine was exploited openly and a large number of sulphur-pyrite ore was extracted from the richest places. A small concentrator was built at the mine. The ruins of the concentrator and auxiliary structures are currently preserved and from 1933-1951, the Tandzut mine was conserved. Afterwards, several exploration works were done and more than 4,000 m^3 of surface mountain excavations were made.

At present, the Tandzut pyrite mine is not an object of right use. Mineral waste accumulated in the area is considered ownerless / abandoned and rain and snow waters penetrate the waste through cracks, mobilizing the compounds of sulphur and heavy metals and flowing into the Tandzut River through the Zhangot jur stream.

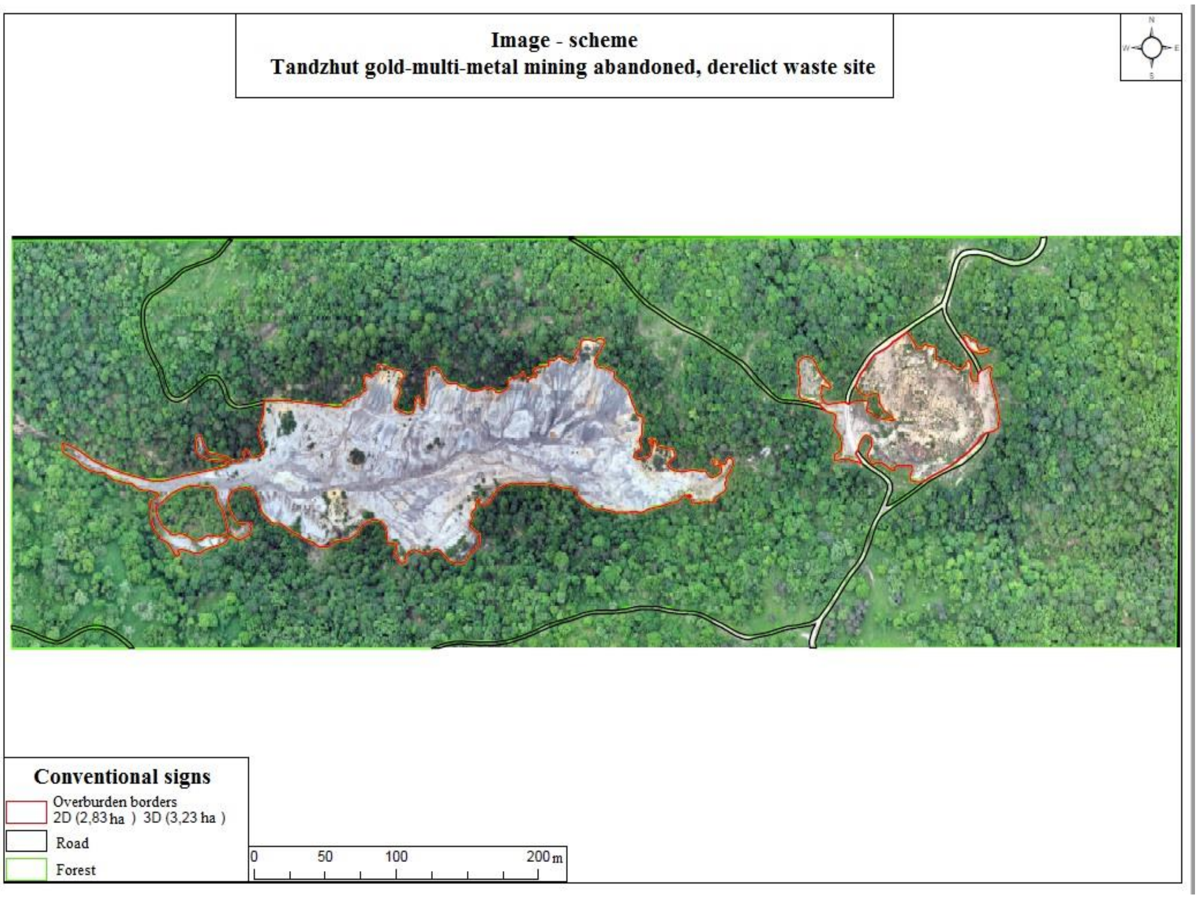

Figure 3. Orto map of Tandzut mining

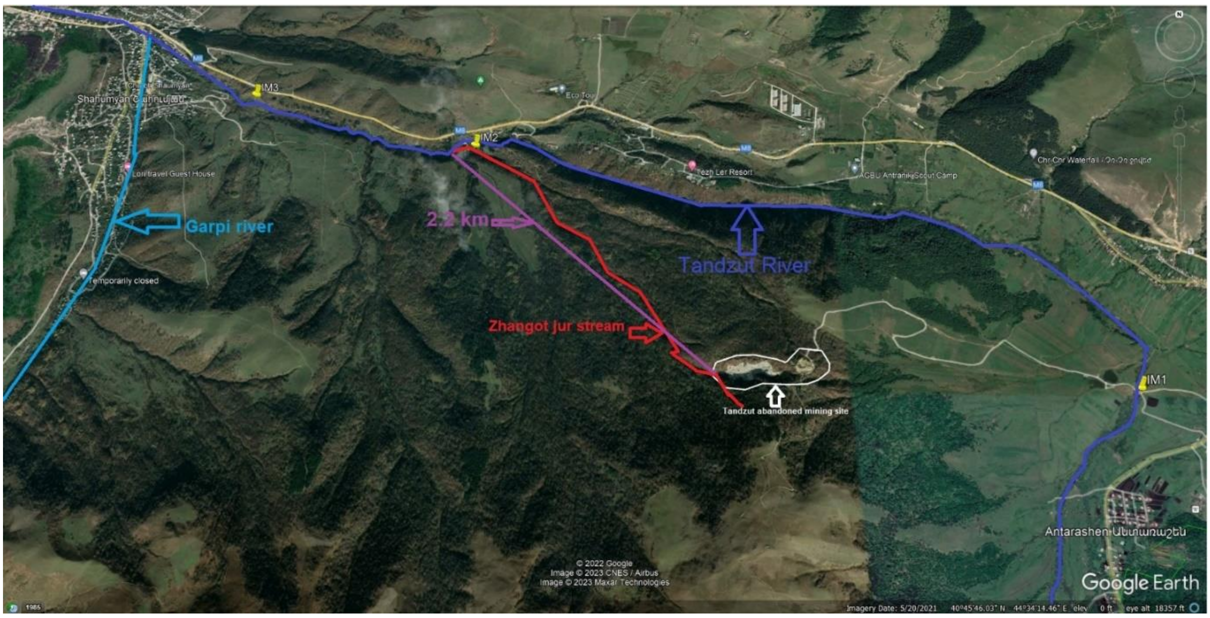

Figure 4. Map of the Tandzut site

The impact of this site on the water quality of the Tandzut River was also studied during the investigative monitoring of 2020 within the project EUWI+. However, the monitoring results showed that the location of the sampling site downstream of the Tandzut River was not chosen correctly. It was decided during this investigative monitoring to carry out the sampling before mixing with the Garpi tributary. In addition, the investigation was carried out from the Zhangot jur stream flowing through the Tandzut site.

Considering the results of the previous study, in this site the parameters such as Zn, Cu, Cr, Co, As, and sulphate ion, pH, and EC were included in the investigative monitoring program.

Figure 5. Overburden in Tandzut site

In June of 2022, HMC SNCO carried out investigative monitoring of soil pollution in the area of the Tandzut mining site. At that time it was observed an acid drainage flowing into the Zhangotjur stream, which flows into the Tandzut River.

Figure 6. Acidic drainage floating into the Zhangot jur stream

Pambak River- v. Pambak (IM4, IM5, IM6)

The Qaraberd gold mine is located in the Lori region, on the southern slope of the Bazum mountain range, on the left bank of the Pambak River, and 4.5 km from the city of Vanadzor to the northeast. The Qaraberd deposit was discovered back in the 60s of the previous centuries. Preliminary exploration of the mine began in 1993 and continued until the late 90s. In 2007-2008, the performed works covered an area of about 1,700 ha, which included not only the Qaraberd gold mine itself but also the Meghrut manganese and Zhdanov gold mines.

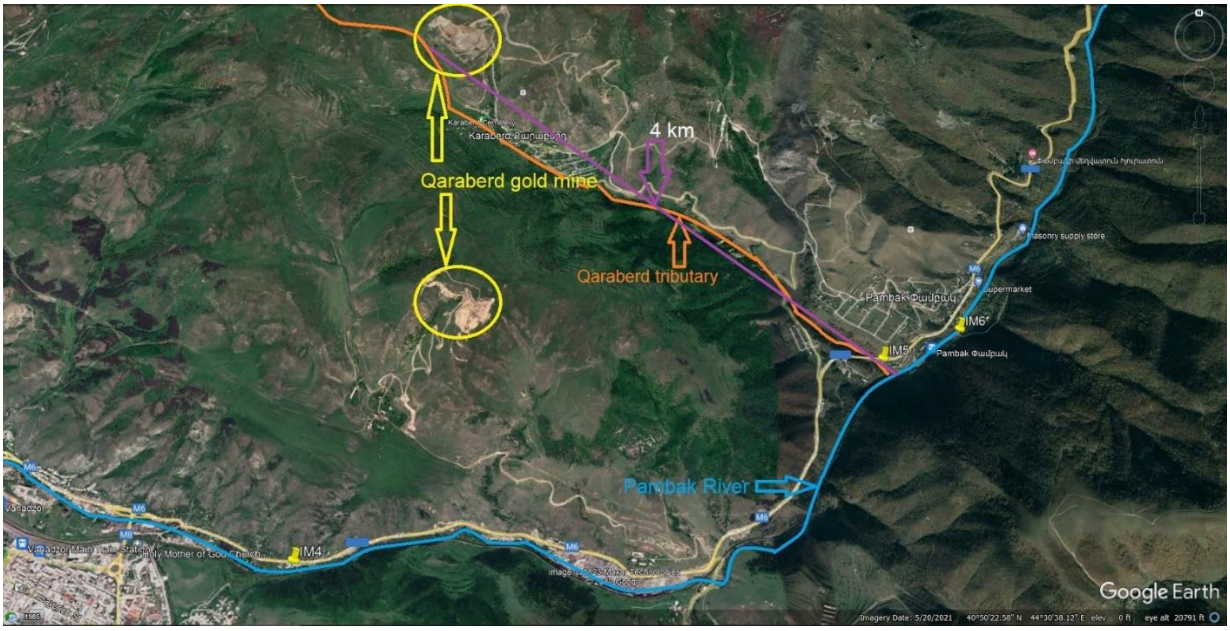

Figure 7. Map of the Qaraberd site

To study the impact of Qaraberd mining area on the Pambak River, the sites before and after mixing with the Qaraberd tributary, and in the tributary of Qaraberd need to be investigated. The flow length from the site of the Qaraberd mine to the confluence with the Pambak River the Qaraberd is approx. 4 km.

At this site, heavy metals such as Zn, Cu, Cr, Co, As, and sulphate ion, pH, and EC was be analysed.

Hanqadzor abandoned mining site (gold, polymetal site, IM7, IM8, IM9)

Hanqadzor is an abandoned mining area. The location of the subsoil waste of the mining site is about 8- 9 km south of Debed community, and about 5-6 km of Yeghegnut village southeast (**Figure 8**). The subsoil waste overburdens were formed as a result of the passage of underground and surface mountain excavations used during mineral extraction in the Hanqadzor, Sisimadan, Eliar study of the Hanqadzor-Sisimadan mineral field.

According to the summary reports of the geological works of Hanqadzor of 1956-1959 and the 1974 reports of exploration of the Hanqadzor mineral field and preliminary exploration works in the central area of the Hanqadzor copper mine at the beginning of the 19^{th} century, small mining enterprises operated here. At present, the Hanqadzor mining area is not an object of right use. Mineral waste accumulated in the area is considered ownerless / abandoned and ground, rain and snow waters penetrate the waste through cracks, mobilizing the compounds of heavy metals and flowing into the Pambak River (IM9) through the Sisiget river (IM8).

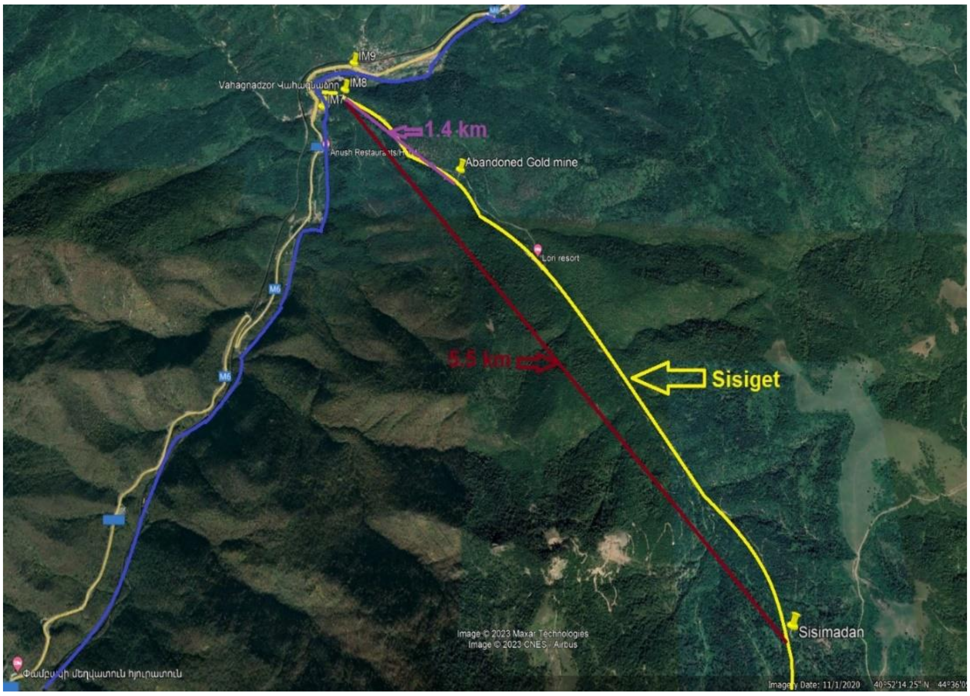

Figure 8. Map of the Hanqadzor mining site

In July 2022, the HMC SNCO carried out investigative monitoring of soil pollution at the area of the Hanqadzor mining site. At that time, it was recorded that there were acid drainage flows on to the Sisiget stream, which flows into the Pambak River.

The main acid drainage into the Sisiget river was observed from the Sisimadan deposit - 5.5 km upstream the river mouth. Some acid drainage was also observed from the gold abandoned deposit - 1.4 km upstream the river mouth. It is possible that after flowing such a long distance the river cleans itself.

At these sites, arsenic, copper, lead, chromium, cadmium, zinc, and other heavy metals as well as sulphate, EC, and pH were measured.

Figure 9. Acidic drainages from mine deposits floating into the Sisiget stream

Mghart gold mining site (IM10, IM11, IM12)

Dzoraget river – v. Arevatsag. This site is possibly impacted by the Mghart gold and silver mine.

Mghart gold and silver mine is located 1.5 km west of Mghart village in the Dzoraget Basin. The mine has been in operation since 2005, but mining operations have been stopped today. It should be noted that the Mghart mine tailings are located right on the Mghart floodplain.

Figure 10. Mghart mine tailings

Mineral waste accumulated in the area is considered ownerless / abandoned and rain and snow waters penetrate the waste through cracks, mobilizing the compounds of heavy metals and flowing into the Dzoraget River through the Mghart floodgate.

The flow length from the site of the Mghart mine tailings to the confluence with the Dzoraget River, the Mghart floodgate is approx 1.4 km.

Figure 11. Map of the Mghart gold mining site

Fioletovo mining site (IM13, IM14, IM15)

Aghstev river – t. Dilijan. This site is possibly impacted by the Fioletovo mining site and the Dilijan old municipal dumpsite.

The Fioletovo gold mine is located in the Margahovit minefield, which stretches along the Aghstev River between the cities of Vanadzor and Dilijan (see Figure 12). The location of subsoil use waste at the Fioletovo mining site is 0.5 km east of Fioletovo village and 3.5 km northeast of Margahovit railway station. The presence of subsoil use waste is caused by the geological study of the Fioletovo gold mine and the experimental mining of ore.

Geological studies in the Margahovit mineral field began even before our era. The conditions and reserves of the actual Fioletovo gold mine were confirmed in 2012. The mineral bodies of the Fioletovo gold mine have been studied in depth by underground drilling with shaft No. 13 and mine shafts.

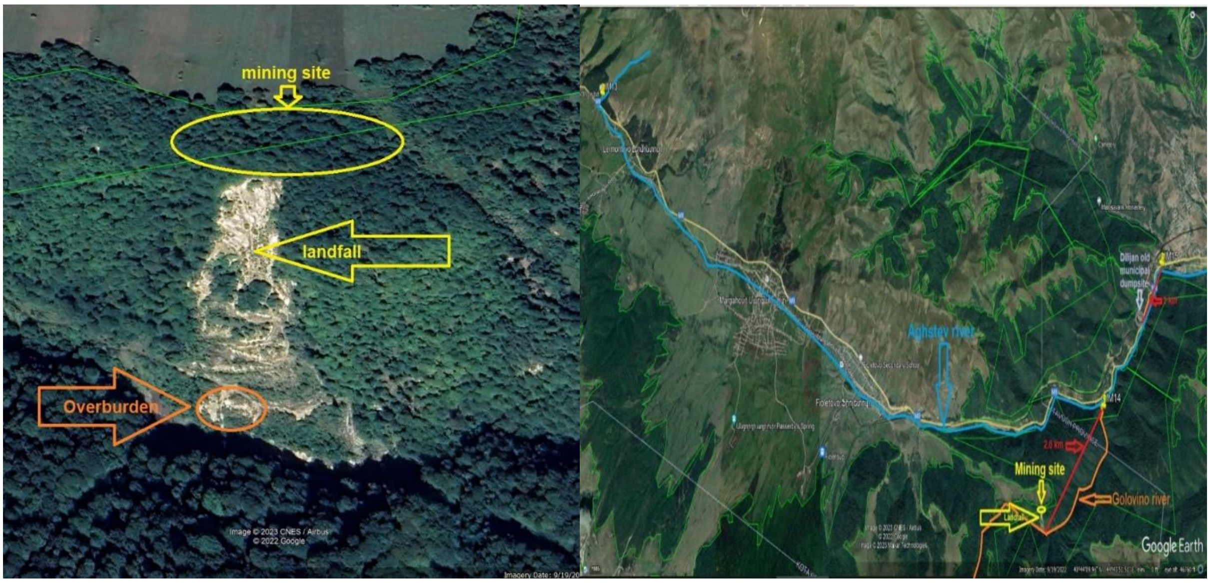

Figure 12. Map of the Fioletovo mining site

Currently, the Fioletovo gold mine is not an object of subsoil use rights. Land use waste accumulated in the area is treated as derelict/abandoned. According to the results of field studies, it was documented that the surfaces of the landfills underwent natural reclamation, and were covered with grass and shrubs.

Figure 13. Landfall in Fioletovo mining site

In June 2022, the employees of HMC SNCO carried out an investigative monitoring of soil pollution in the area of the Fioletovo site. At that time, it was observed that certain collapses occurred in the area and there were acid drainage flows to the Golovino River (see Figure 14), which flows into the Aghstev River after 2.6 km. A self-cleaning effect of the river is likely after flowing such a long distance.

Figure 14. Acidic drainages floating into the Golovino river

The old municipal dumpsite of Dilijan has been closed quite recently and has undergone some reclamation. It is located above the city of Dilijan, 100 m from the Aghstev river. Waste and its decomposition products accumulated piecemeal at the dumpsite through rain and snow waters and are flowing into the Aghstev River through the floodplain.

From the site of the Fioletovo mine to the confluence with the Aghstev River, the Golovino stream flows for 2.6 km.

Figure 15. Dilijan old municipal landfill

Table 3. Proposed sampling sites for the investigative monitoring in Armenia within the EU4Environment - water resources and environmental data project

No.	River	RBD	Site location	Pressure type	Target of investigation
IM1	Debed	Tandzut	Village Antarashen	Reference	To investigate abandoned Tandzut overburden pressure on the river
IM2	Debed	Zhangot jur	mouth	Mining - Abandoned dumpsite of Tandzut Sulphur-pyrite mine	To investigate Tandzut site overburden pressure on to the stream Zhangot jur
IM3	Debed	Tandzut	After mixing Zhangot jur stream	Mining - Abandoned dumpsite of Tandzut Sulphur-pyrite mine	The Tandzut River joins the Pambak River downstream the city of Vanadzor, where the pressure of the city on the river is very high. To correctly assess the impact of the Tandzut site overburden, it is expedient to carry out monitoring below the confluence point with the Zhangot jur stream of the Tandzut River.
IM4	Debed	Pambak	0.5 km downstream Vanadzor city	Before Qaraberd gold mining possible pressure	To investigate Qaraberd gold mining possible pressure on to the river Pambak from the side of Qaraberd tributary
IM5	Debed	Qaraberd	mouth	Qaraberd gold mining possible pressure	To investigate Qaraberd gold mining possible pressure on to the Qaraberd tributary
IM6	Debed	Pambak	After mixing Qaraberd river	Qaraberd gold mining possible pressure	To investigate Qaraberd gold mining possible pressure to the river Pambak below the confluence point with the Qaraberd tributary
IM7	Debed	Pambak	Up to Village Vahagnadzor	Before Hanqadzor polymetallic mining possible pressure	To investigate the abandoned Hanqadzor polymetallic mining site possible pressure on to the river Pambak from the side of Sisiget tributary
IM8	Debed	Sisiget	mouth	Hanqadzor polymetal mining possible pressure	To investigate the abandoned Hanqadzor polymetallic mining site's possible pressure on the Sisiget tributary
IM9	Debed	Pambak	After mixing Sisiget river	Hanqadzor polymetallic mining possible pressure	To investigate the abandoned Hanqadzor polymetallic mining site's possible pressure to the river Pambak below the confluence point with the Sisiget tributary
IM10	Debed	Dzoraget	0.5 km upstream Stepanavan city	Before Mghart gold mining possible pressure	To investigate Mghart gold mining possible pressure on the river Dzoraget from the side of Mghart floodgate

IM11	Debed	Mghart	mouth	Mghart gold mining possible pressure	To investigate Mghart gold mining possible pressure
IM12	Debed	Dzoraget	After mixing Mghart floodgate	Mghart gold mining possible pressure	To investigate Mghart gold mining possible pressure to the river Dzoraget below the confluence point with the Mghart floodgate
IM13	Aghstev	Aghstev	Village Lermontovo	Reference	To investigate pressure on the Aghstev river
IM14	Aghstev	Golovino	mouth	Fioletovo mining precinct possible pressure	To investigate the abandoned Fioletovo mining site’s possible pressure on the Golovino tributary
IM15	Aghstev	Aghstev	1.2 km upstream Dilijan city	Fioletovo mining precinct and Dilijan old municipal dumpsite	To investigate the abandoned Fioletovo mining site's and Dilijan old municipal dumpsite possible pressure to the river Aghstev below the confluence point with the Golovino tributary

3.3 Sampling period

The sampling was carried out from 18-21 July 2022.

Table 4. Sampling dates and information on meteorological and hydrological conditions

River	Date	Site No.	Sampling team	Meteorology	Hydrology
Tandzut	7/20/2022	IM1	T. Araqelyan, V. Karyan, H. Frunzikyan	*Sunny*	*enough water*
Zhangot jur	7/22/2022	IM2	T. Araqelyan, V. Karyan, H. Frunzikyan	*Covered*	*enough water*
Tandzut	7/22/2022	IM3	T. Araqelyan, V. Karyan, H. Frunzikyan	*Covered*	*enough water*
Pambak	7/18/2022	IM4	T. Araqelyan, V. Karyan, H. Frunzikyan	*Sunny*	*enough water*
Qaraberd	7/18/2022	IM5	T. Araqelyan, V. Karyan, H. Frunzikyan	*Sunny/ Covered*	*enough water*
Pambak	7/18/2022	IM6	T. Araqelyan, V. Karyan, H. Frunzikyan	*Sunny*	*enough water*
Pambak	7/19/2022	IM7	T. Araqelyan, V. Karyan, H. Frunzikyan	*Sunny*	*enough water*
Sisi	7/19/2022	IM8	T. Araqelyan, V. Karyan, H. Frunzikyan	*Sunny*	*enough water*
Pambak	7/19/2022	IM9	T. Araqelyan, V. Karyan, H. Frunzikyan	*Sunny*	*enough water*
Dzoraget	7/21/2022	IM10	T. Araqelyan, V. Karyan, H. Frunzikyan	*Covered*	*enough water*
Mghart	7/21/2022	IM11	T. Araqelyan, V. Karyan, H. Frunzikyan	*Covered*	*No water*
Dzoraget	7/21/2022	IM12	T. Araqelyan, V. Karyan, H. Frunzikyan	*Covered*	*enough water*
Aghstev	7/20/2022	IM13	T. Araqelyan, V. Karyan, H. Frunzikyan	*Sunny*	*enough water*
Golovino	7/20/2022	IM14	T. Araqelyan, V. Karyan, H. Frunzikyan	*Sunny*	*enough water*
Aghstev	7/20/2022	IM15	T. Araqelyan, V. Karyan, H. Frunzikyan	*Sunny*	*enough water*

3.4 Responsibilities

For the proper work each part of the survey has its responsible person. The assignments of the responsible persons are summarized in Table 5.

Table 5. Responsible institutions and persons in preparation and during the survey

Responsibilities	Institution, contact person, email address
General	
Responsible for the organization of surface water body sampling	Institute: "Hydrometeorology and Monitoring Center" SNCO, Ministry of Environment Contact person: Alina Zurnachyan (Head of Surface Water Quality Monitoring Service) E-Mail: alina.zurnachyan@gmail.com
Fieldwork	
Responsible for functional check of sampling equipment	Institute: "Hydrometeorology and Monitoring Center" SNCO, Ministry of Environment Contact person: Tigran Araqelyan (Head of the Field survey department) E-Mail: tigranaraqelyan91@mail.ru
Responsible for field work (biological and chemical sampling)	Institute: "Hydrometeorology and Monitoring Center" SNCO, Ministry of Environment Contact person: Vardan Karyan (Head of Soil, Sediment and Hydrobiological monitoring service) E-Mail: vhkaryan@gmail.com
Responsible for calibration of on-site measuring equipment	Institute: "Hydrometeorology and Monitoring Center" SNCO, Ministry of Environment Contact person: Tigran Araqelyan E-Mail: tigranaraqelyan91@mail.ru
Chemical analysis	
Overall responsible for the chemical analysis in the lab, including reporting and data delivery	Institute: "Hydrometeorology and Monitoring Center" SNCO Contact person: Gayane Shahnazaryan (Deputy Director) E-Mail: shahnazaryangayane@gmail.com Alina Zurnachyan (Head of Surface Water Quality Monitoring Service) E-Mail: alina.zurnachyan@gmail.com Anna Zatikyan (Head *of Information Analytical Service*) E-Mail: anna_zatikyan@hotmail.com Vardan Karyan (Head of Soil, sediment and hydrobiological monitoring service) E-Mail: vhkaryan@gmail.com
Responsible for sample transport from the field to the laboratory	Institute: "Hydrometeorology and Monitoring Center" SNCO, Ministry of Environment Contact person: Tigran Araqelyan E-Mail: tigranaraqelyan91@mail.ru
Analysing laboratory and contact person	Institute: "Hydrometeorology and Monitoring Center" SNCO, Ministry of Environment Contact person: Alina Zurnachyan (Head of Surface Water Quality Monitoring Service) E-Mail: alina.zurnachyan@gmail.com

4 Methods

4.1 Sampling and field methods

The sampling was done at 14 sampling sites of Debed and Aghstev RBDs. The sample at sampling site IM11 could not be taken due to an insufficient quantity of water in the Mghart floodgate.

The dates and times of the transport of the field survey were coordinated with the experts responsible for the sampling. The total field survey took about five days. The sampling was done by the field team (presented in Table 4).

The field protocols (Annex 1) were completed by the sampling team for each sampling site. The protocols include detailed information about the river basin, name and type, site number and geographical coordinates, sampling date and time, weather and the results of water quality field parameters, name of the surveyor with signature and additional comments.

A photo documentation (Annex 2) per site was elaborated which gives a general overview of the river at the sampling site and allows evaluation of the meteorological and hydrological conditions, details of a substrate, anthropogenic impacts, etc.

The surface water samples were transported to the HMC laboratory for further processing and analysis. The handover was documented by using “Protocol for the delivery and handover of samples” (see attached Annex 3).

Hydrobiological specimens were picked out of the sediment samples, which were stored in vials with formalin and kept for later analysis.

4.2 Laboratory analyses

The HMC laboratory analysed 40 physicochemical parameters (see Table 6**Fehler! Verweisquelle konnte nicht gefunden werden.**) from each of the 14 sampling sites. The field team handed over the data to the chemical laboratory staff which was included in the test report. The physicochemical parameters were measured according to the appropriate ISO standard methods.

Table 6. List of Parameters analyzed in the field and the laboratory

Parameter	Unit	LOD	LOQ	Standards
Field measurements				
Water temperature (WT)	°C			
Dissolved oxygen concentration (DO)	mg/L			ISO 5814:2012
Oxygen saturation (O_2-Sat)	%			ISO 10523:2008
pH	-			ISO 10523:2008
Electric conductivity (EC)	µS/cm			ISO 7888:1985
Laboratory analyses				

Parameter	Unit	LOD	LOQ	Standards
pH (lab control)	-			ISO 10523:2008
Electric conductivity (EC, lab control)	µS/cm			ISO 7888:1985
Total suspended solids (TSS)	mg/L			ISO 11923:1997
Biological oxygen demand (BOD_5)	mg/L			ISO 5815:2003
Chemical oxygen demand ($K_2Cr_2O_7$) (COD)	mg/L			ISO 6060:1989
Ammonia-N (NH_4-N)	mg/L	0.003	0.005	ISO 7150-1:1984
Nitrate-N (NO_3-N)	mg/L	0.001	0.01	ISO 10304-1:2007
Orthophosphate, as P (PO_4-P)	mg/L	0.001	0.002	ISO 6878:2004
Total phosphorus (TP)	mg/L	0.005	0.01	ISO 17294:2016
Chloride ion (Cl)	mg/L	0.025	0.05	ISO 10304-1:2007
Sulphate ion (SO_4)	mg/L	0.125	0.25	ISO 10304-1:2007
Calcium (Ca)	mg/L	0.005	0.01	ISO 17294:2016
Magnesium (Mg)	mg/L	0.005	0.01	ISO 17294:2016
Sodium (Na)	mg/L	0.005	0.01	ISO 17294:2016
Potassium (K)	mg/L	0.005	0.01	ISO 17294:2016
Lithium (Li)	mg/L	0.00005	0.0001	ISO 17294:2016
Beryllium (Be)	mg/L	0.00005	0.0001	ISO 17294:2016
Boron (B)	mg/L	0.0005	0.001	ISO 17294:2016
Aluminum (Al)	mg/L	0.005	0.01	ISO 17294:2016
Titanium (Ti)	mg/L	0.00005	0.0001	ISO 17294:2016
Vanadium (V)	mg/L	0.00005	0.0001	ISO 17294:2016
Chromium (Cr)	mg/L	0.00005	0.0001	ISO 17294:2016
Iron (Fe)	mg/L	0.005	0.01	ISO 17294:2016
Manganese (Mn)	mg/L	0.00005	0.0001	ISO 17294:2016
Cobalt (Co)	mg/L	0.00005	0.0001	ISO 17294:2016
Nickel (Ni)	mg/L	0.00005	0.0001	ISO 17294:2016
Copper (Cu)	mg/L	0.00005	0.0001	ISO 17294:2016
Zink (Zn)	mg/L	0.00005	0.0001	ISO 17294:2016
Arsenic (As)	mg/L	0.00005	0.0001	ISO 17294:2016
Selenium (Se)	mg/L	0.00005	0.0001	ISO 17294:2016

Parameter	Unit	LOD	LOQ	Standards
Strontium (Sr)	mg/L	0.00005	0.0001	ISO 17294:2016
Molybdenum (Mo)	mg/L	0.00005	0.0001	ISO 17294:2016
Cadmium (Cd)	mg/L	0.00005	0.0001	ISO 17294:2016
Tin (Sn)	mg/L	0.0005	0.001	ISO 17294:2016
Stibium (Sb)	mg/L	0.00005	0.0001	ISO 17294:2016
Barium (Ba)	mg/L	0.005	0.01	ISO 17294:2016
Lead (Pb)	mg/L	0.00005	0.0001	ISO 17294:2016

4.3 Quality assurance

All the analyses were done in a professional manner and accordance with the standard laboratory operating procedures. The transport storage, preservation, and chemical analyses were undertaken according to the accredited laboratory procedures together with the application of internal analytical quality controls.

5 Results

5.1 Field protocols and data

The field protocols are provided as a separate attachment in Annex 1 (PDF format).

The photos are provided as JPG as separate files in the folder Annex 2.

The surface water samples were transported to the HMC laboratory for further processing and analysis. Handover was documented by using the "Protocol for the delivery and handover of samples" and provided as a separate attachment in Annex 3 (PDF format).

5.2 Chemical analyses

The results of the physicochemical analyses are summarized in Table 7 and are additionally provided in excel format as Annex 4.

The reports of the laboratory are provided in Annex 5 in English.

The water quality was assessed based on the national water quality norms (see Table 8). The water quality norms were defined according to the provisions of RA Government Decree №75-N "On establishing the norms for assuring water quality of each Water Basin Management District, depending upon local peculiarities" (27 January, 2011) and considering the "one-out-all-out-principle". The national water quality norms for Debed and Aghstev Rivers are given in Annex 8. According to these norms, each water parameter can be classified into 5 classes based on their concentrations.

Table 7: Results of the chemical analyses from 14 sampling sites in summer 2022.

River	Sampling site	Site num.	WT field	DO field	O_2-Sat field	pH field	EC	TSS	COD	BOD_5	NH_4-N	NO_3-N	PO_4-P	TP	Cl	SO_4
			°C	mg/L	%		µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Tandzut	Village Antarashen	IM1	21.7	8.10	92.4	8.15	90	18.4	10	1.81	0.122	0.075	0.009	0.022	1.75	5.80
Zhangot jur	mouth	IM2	20.0	7.80	86.5	2.90	2674	126.9	40	2.13	9.439	0.512	0.119	0.144	12.78	1280.1
Tandzut	After mixing the Zhangot jur stream	IM3	19.5	7.90	86.1	7.56	136	22.4	10	1.93	0.247	0.183	0.005	0.025	2.020	26.55
Pambak	0.5 km downstream Vanadzor city	IM4	17.7	6.77	71.0	8.05	590	32.3	25	5.31	28.36	3.713	0.356	0.537	15.71	53.68
Qaraberd	mouth	IM5	15.6	8.76	88.2	8.64	505	23.1	15	1.73	0.521	2.870	0.037	0.057	7.37	53.06
Pambak	After mixing Qaraberd river	IM6	18.0	8.22	87.0	8.47	554	138.1	20	2.58	1.805	4.320	0.172	0.248	12.26	49.23
Pambak	Up to Village Vahagnadzor	IM7	18.5	8.54	91.4	8.59	404	22.6	15	1.31	0.325	1.803	0.083	0.122	6.52	52.69
Sisiget	mouth	IM8	18.2	8.59	91.3	8.34	267	20.2	15	1.27	0.079	0.270	0.006	0.010	1.80	59.05
Pambak	After mixing Sisiget river	IM9	20.4	7.54	83.7	8.54	472	95.1	20	2.30	0.471	3.689	0.160	0.231	9.99	45.09
Dzoraget	0.5 km upstream Stepanavan city	IM10	15.5	8.38	84.0	8.72	197	7.5	10	2.23	0.116	0.578	0.026	0.055	2.90	4.15
Dzoraget	mouth	IM12	24.7	7.26	87.4	9.06	310	10.5	5	2.22	0.225	1.013	0.083	0.140	5.65	16.87
Aghstev	After mixing Mghart floodgate	IM13	15.1	8.37	83.3	8.42	141	18.3	10	1.24	0.075	0.311	0.003	0.005	1.67	5.97
Golovino	Village Lermontovo	IM14	18.8	8.48	91.1	8.65	359	4.7	5	1.70	0.077	0.733	0.009	0.013	4.34	25.98
Aghstev	mouth	IM15	19.0	8.19	88.3	9.00	274	59.0	10	1.83	0.251	1.259	0.049	0.082	5.76	12.55

The results of the chemical analyses – continued.

River	Sampling site	Site num.	Na	Mg	K	Ca	Li	Be	B	Al	Ti	V	Cr	Fe	Mn
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Tandzut	Village Antarashen	IM1	8.29	1.57	0.93	10.89	0.0006	<0.0001	0.0190	0.093	0.00399	0.00148	0.00057	0.105	0.0134
Zhangot jur	mouth	IM2	7.36	11.79	0.80	32.49	0.0049	0.0002	0.0120	14.963	0.05657	0.04347	0.00331	321.5	0.536
Tandzut	After mixing Zhangot jur stream	IM3	5.70	2.40	1.41	16.67	0.0008	<0.0001	0.0131	0.132	0.00285	0.00106	0.00038	1.900	0.0102
Pambak	0.5 km downstream Vanadzor city	IM4	21.19	12.20	4.14	62.96	0.0021	<0.0001	0.1190	0.021	0.00420	0.00339	0.00152	0.0734	0.0276
Qaraberd	mouth	IM5	13.11	12.37	4.73	61.01	0.0011	<0.0001	0.1051	0.074	0.00594	0.00475	0.00108	0.0795	0.00320
Pambak	After mixing Qaraberd river	IM6	15.57	12.00	3.48	63.73	0.0019	<0.0001	0.1099	0.209	0.01023	0.00371	0.00127	0.260	0.0456
Pambak	Up to Village Vahagnadzor	IM7	11.89	9.07	2.02	47.09	0.0009	<0.0001	0.0515	0.025	0.00298	0.00183	0.00079	0.0460	0.0208
Sisiget	mouth	IM8	4.90	6.05	0.98	35.79	0.0002	<0.0001	0.0158	0.036	0.00283	0.00076	0.00052	0.0607	0.00375
Pambak	After mixing Sisiget river	IM9	13.18	10.26	3.09	55.41	0.0016	<0.0001	0.0886	0.345	0.01614	0.00381	0.00125	0.524	0.0397
Dzoraget	0.5 km upstream Stepanavan city	IM10	6.03	4.68	1.42	25.45	0.0022	<0.0001	0.0386	0.029	0.00366	0.00700	0.00098	0.0664	0.00816
Dzoraget	mouth	IM12	8.97	6.67	3.52	42.43	0.0006	<0.0001	0.0282	0.116	0.00451	0.00533	0.00079	0.139	0.0275
Aghstev	After mixing Mghart floodgate	IM13	2.47	2.92	0.88	14.98	0.0002	<0.0001	0.0097	0.044	0.00382	0.00261	0.00046	0.0562	0.00215
Golovino	Village Lermontovo	IM14	8.73	7.30	0.88	51.41	0.0031	<0.0001	0.0515	0.054	0.00150	0.00138	0.00069	0.0187	0.00168
Aghstev	mouth	IM15	9.00	5.62	2.07	36.27	0.0023	<0.0001	0.0392	0.161	0.00635	0.00356	0.00139	0.332	0.0148

Results of the chemical analyses – continued.

River	Sampling site	Site num.	Co	Ni	Cu	Zn	As	Se	Sr	Mo	Cd	Sn	Sb	Ba	Pb
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Tandzut	Village Antarashen	IM1	0.0001	0.0006	0.0009	0.0009	0.0004	0.0003	0.086	0.0021	<0.0001	<0.001	0.0002	<0.01	0.0013
Zhangot jur	mouth	IM2	0.0842	0.0192	4.0312	0.2584	0.2357	0.0675	0.180	0.0086	0.0012	<0.001	0.0037	<0.01	0.0099
Tandzut	After mixing Zhangot jur stream	IM3	0.0007	0.0010	0.0317	0.0139	0.0018	0.0007	0.100	0.0017	<0.0001	<0.001	0.0001	<0.01	0.0006
Pambak	0.5 km downstream Vanadzor city	IM4	0.0003	0.0023	0.0033	0.0062	0.0016	0.0005	0.348	0.0018	<0.0001	<0.001	0.0002	0.0285	0.0014
Qaraberd	mouth	IM5	0.0002	0.0017	0.0026	0.0021	0.0019	0.0005	0.336	0.0031	<0.0001	<0.001	0.0001	0.0257	0.0010
Pambak	After mixing Qaraberd river	IM6	0.0006	0.0020	0.0038	0.0020	0.0017	0.0002	0.363	0.0021	<0.0001	<0.001	0.0002	0.0260	0.0011
Pambak	Up to Village Vahagnadzor	IM7	0.0002	0.0013	0.0014	0.0008	0.0011	0.0001	0.259	0.0016	<0.0001	<0.001	0.0001	0.0340	0.0010
Sisiget	mouth	IM8	0.0001	0.0009	0.0032	0.0039	0.0012	0.0006	0.186	0.0016	<0.0001	<0.001	0.0001	0.0283	0.0011
Pambak	After mixing Sisiget river	IM9	0.0007	0.0018	0.0063	0.0023	0.0018	0.0005	0.310	0.0020	<0.0001	<0.001	0.0003	0.0257	0.0022
Dzoraget	0.5 km upstream Stepanavan city	IM10	0.0001	0.0010	0.0007	0.0020	0.0020	<0.0001	0.121	0.0006	<0.0001	<0.001	0.0001	0.0134	0.0012
Dzoraget	mouth	IM12	0.0004	0.0018	0.0020	0.0013	0.0022	0.0001	0.219	0.0011	<0.0001	<0.001	0.0002	0.0261	0.0015
Aghstev	After mixing Mghart floodgate	IM13	<0.0001	0.0006	0.0010	0.0003	0.0021	0.0004	0.057	0.0008	<0.0001	<0.001	<0.0001	<0.01	0.0007
Golovino	Village Lermontovo	IM14	0.0002	0.0014	0.0014	0.0008	0.0006	0.0003	0.288	0.0007	<0.0001	<0.001	0.0001	0.0210	0.0009
Aghstev	mouth	IM15	0.0002	0.0014	0.0023	0.0025	0.0017	0.0004	0.207	0.0041	<0.0001	<0.001	0.0002	0.0166	0.0015

Table 8: Water quality at the sampling sites of the Debed and Aghstev River Basins based on physicochemical parameters and the national water quality norms

River Basin	River	Sampling Site	Site number	Water quality parameter	Water quality class	Integrated class of water quality
Debed	Tandzut	Village Antarashen	IM1	Mo	Moderate	Moderate
	Zhangot jur	mouth	IM2	COD, PO_4, Ni	Moderate	Bad
				Zn, Be, Se, TDS	Poor	
				NH_4, NO_2, Cu, As, Mo, Mn, V, Co, Fe, Al, Sb, SO4, TIN, TSS	Bad	
	Tandzut	After mixing with Zhangot jur stream	IM3	Cu, Mo	Moderate	Poor
				Fe	Poor	
	Pambak	0.5 km downstream Vanadzor city	IM4	BOD, NO_3, Mo, TDS, TSS	Moderate	Bad
				NO_2, PO_4, P	Poor	
				NH4, TIN	Bad	
	Qaraberd	mouth	IM5	NH_4, NO_3, TDS	Moderate	Poor
				Mo	Poor	
	Pambak	After mixing with Qaraberd river	IM6	NO_3, PO_4, Mo, TIN, P	Moderate	Bad
				NH_4	Poor	
				NO_2, TSS	Bad	
		Up to Village Vahagnadzor	IM7	Mo	Moderate	Bad
				NO_2	Bad	
	Sisiget	mouth	IM8	Mo	Moderate	Moderate
	Pambak	After mixing with Sisiget river	IM9	NH_4, NO_3, PO_4, Mo, Fe, TDS, P	Moderate	Bad
				TSS	Poor	
				NO_2	Bad	
	Dzoraget	0.5 km upstream Stepenevan city	IM10	NO_2, V	Moderate	Moderate
		After mixing Mghart floodgate	IM12	-	Good	Good
Aghstev	Aghstev	Village Lermontovo	IM13	-	Good	Good
	Golovino	mouth	IM14	NO_2, Fe, TSS	Moderate	Moderate
	Aghstev	1.2 km upstream Dilijan city	IM15	-	Good	Good

The surface water quality is assessed by Government Decision No. 75-N (27.01.2011) which establishes the water quality standards for each river basin district (RBD), considering the background concentration that may be varied depending on local geology. The assessment system comprehends five classes for each water quality indicator: excellent (1st class), good (2nd class), moderate (3rd class), poor (4th class) and bad (5th class). The list contains 43 water quality parameters.

The final/general class is determined based on the same principle as Water Framework Directive (WFD), i.e., the "one out, all out" principle. Thus, the classification is given by the indicator of worst quality and when different water quality parameters fall into different classes, the final result considers the worst one.

5.3 Biological analyses

Biological sampling was conducted following the EUWI+ surface water sampling manual (EUWI+, 2019). The results of the biological survey are provided as an Excel table in Annex 6.

The benthic invertebrates were sampled using the multi-habitat sampling (MHS) method developed during EU AQEM and STAR projects.

According to the method, it is necessary to take a sample from 20 sites (20 times) from each sampling location. However, depending on the amount of water in the river, the speed of the flow, as well as the characteristics of the terrain, sometimes it is not possible to take a complete sample and a sample is taken in half. The whole sample from 10 to 20 (depending on the sampling site characteristics) single samples from every sampling site was taken to the laboratory for further analysis. Rare and endangered animals such as large mussels or crayfish were picked out, documented in the field, and released again.

Samples were fixed with a formaldehyde solution. The samples were stored in the cooling box and delivered to the laboratory for sorting and identification.

The evaluated results are summarized in **Table 9**. The ecological status was calculated following the Ecological Status Classification System (ESCS) developed by EUWI+. The ECSC system considers the composition and abundance of taxa, the ratio of disturbance-sensitive taxa to insensitive taxa, the level of diversity, and the occurrence of major taxonomic groups (EUWI+ RefCond reports).

Table 9: Ecological Status at the sampling sites

River	Site No.	Type of sampling site	Nr. of taxa	Nr. of individuals	nEQR	Ecological status	Water quality based on chemical parameters
Tandzut	IM1	R	19	388	1.00	High	Moderate
Zhangot jur	IM2	I	0	0	0.00	Bad	Bad
Tandzut	IM3	I	12	163	0.79	Good	Poor
Pambak	IM4	C	10	218	0.34	Poor	Bad
Qaraberd	IM5	I	21	2452	0.69	Good	Poor
Pambak	IM6	I	15	451	0.16	Bad	Bad
Pambak	IM7	C	13	478	0.45	Moderate	Bad
Sisiget	IM8	I	13	87	1.00	High	Moderate
Pambak	IM9	I	9	589	0.05	Bad	Bad
Dzoraget	IM10	C	20	1342	0.67	Good	Moderate
Mghart	IM11	I	0	0	0	-	-
Dzoraget	IM12	I	10	51	0.52	Moderate	Good
Aghstev	IM13	R	20	530	1.00	High	Good
Galavino	IM14	I	24	650	1.00	High	Moderate
Aghstev	IM15	I	18	366	0.75	Good	Good

(R=reference, I=influenced, C=comparative)

In the Zhangot jur stream (IM2) no animals were found. The Mghart floodgate (IM11) was dried out at the time of sampling.

The field protocols and photos (as JPG) are provided as a separate folder in Annex 7 (Word format).

5.4 Hydro-morphological assessment

The hydro-morphological assessment is provided in Table 10 (see Annex 7.1 and 7.2, Word format).

Table 10: Hydro-morphological assessment of the observation points

Basin	River name	Site location	Date	Site No.	Hydrological status	Morphological status	Hy-Mo Status
Debed	Tandzut	Village Antarashen	20.07.2022	IM1	1.0	1.5	1.25
Debed	Zhangot jur	mouth	22.07.2022	IM2	1.0	2.0	1.50
Debed	Tandzut	After mixing Zhangot jur stream	22.07.2022	IM3	3.5	2.2	2.85
Debed	Pambak	0.5 km downstream Vanadzor city	18.07.2022	IM4	4.0	2.4	3.20
Debed	Qaraberd	mouth	18.07.2022	IM5	1.0	1.3	1.15
Debed	Pambak	After mixing Qaraberd river	18.07.2022	IM6	2.5	1.7	2.1
Debed	Pambak	Up to Village Vahagnadzor	19.07.2022	IM7	2.5	1.6	2.0
Debed	Sisiget	mouth	19.07.2022	IM8	1.0	1.4	1.2
Debed	Pambak	After mixing Sisiget river	19.07.2022	IM9	3.5	2.3	2.9
Debed	Dzoraget	0.5 km upstream of Stepenevan city	21.07.2022	IM10	3.5	2.1	2.8
Debed	Mghart	mouth	21.07.2022	IM11	-	-	-
Debed	Dzoraget	After mixing Mghart stream	21.07.2022	IM12	3.5	1.3	2.4
Aghstev	Aghstev	Village Lermontovo	20.07.2022	IM13	2.0	1.7	1.85
Aghstev	Golovino	mouth	22.07.2022	IM14	1.0	1.4	1.2
Aghstev	Aghstev	1.2 km upstream of Dilijan city	20.07.2022	IM15	4.5	2.4	3.45

5.4.1 Hydrological assessment

Characterizations of the hydrological regime in respect of mean and low flow, flow range and flow fluctuation This chapter should provide an overview of the single hydrological parameters and the overall hydrological score status including the identification of the drivers for an observed hydrological change. The quantitative parameters of each hydrology assessment category are provided in Table 11 (see Annex 7.1).

Table 11. Hydrological assessment

Basin	River name	Site location	Date	Site No.	Mean flow	Low flow	Water level range	Flow fluctuation	Hydro Score
Debed	Tandzut	Village Antarashen	20.07.2022	IM1	1	1	1	1	1.0
Debed	Zhangot jur	mouth	22.07.2022	IM2	1	1	1	1	1.0
Debed	Tandzut	After mixing Zhangot jur stream	22.07.2022	IM3	3	5	3	3.5	3.5
Debed	Pambak	0.5 km downstream Vanadzor city	18.07.2022	IM4	5	5	1	4	4.0
Debed	Qaraberd	mouth	18.07.2022	IM5	1	1	1	1	1.0
Debed	Pambak	After mixing Qaraberd river	18.07.2022	IM6	3	3	1	2.5	2.5
Debed	Pambak	Up to Village Vahagnadzor	19.07.2022	IM7	3	3	1	2.5	2.5
Debed	Sisiget	mouth	19.07.2022	IM8	1	1	1	1	1.0
Debed	Pambak	After mixing Sisiget river	19.07.2022	IM9	3	5	3	3.5	3.5
Debed	Dzoraget	0.5 km sq. above Stepanavan	21.07.2022	IM10	3	5	3	3.5	3.5
Debed	Mghart	mouth	21.07.2022	IM11					
Debed	Dzoraget	After mixing Mghart stream	21.07.2022	IM12	3	5	5	3.5	3.5
Aghstev	Aghstev	Village Lermontovo	20.07.2022	IM13	3	1	1	2.0	2.0
Aghstev	Golovino	mouth	22.07.2022	IM14	1	1	1	1	1.0
Aghstev	Aghstev	1.2 km upstream of Dilijan city	20.07.2022	IM15	5	3	5	4.5	4.5

5.4.2 Morphological assessment

The morphological parameters cover four categories: channel form, instream features, bank/riparian zone and floodplain parameters. This chapter should provide an overview of the single morph parameters and the overall morphological status. The single parameters within each morphological assessment category are provided in Table 12 (see also in Annex 7.2).

Table 12. Single morphology parameters per sampling site

Basin	River name	Site location	Date	Site No.	Channel form	Instream features	Riparian zone	Flood-plain	Morph Score
Debed	Tandzut	Village Antarashen	20.07. 2022	IM1	1	2.8	1.2	1.0	1.5
Debed	Zhangot jur	mouth	22.07. 2022	IM2	1	3.2	1.3	2.5	2.0
Debed	Tandzut	After mixing Zhangot jur stream	22.07. 2022	IM3	1	2.4	2.7	2.7	2.2
Debed	Pambak	0.5 km downstream Vanadzor city	18.07. 2022	IM4	1	2.6	3.0	3.0	2.4
Debed	Qaraberd	mouth	18.07. 2022	IM5	1	2.3	1.0	1.0	1.3
Debed	Pambak	After mixing Qaraberd river	18.07. 2022	IM6	1	2.4	2.2	1.0	1.7
Debed	Pambak	Up to village Vahagnadzor	19.07. 2022	IM7	1	2.3	1.7	1.4	1.6
Debed	Sisiget	mouth	19.07. 2022	IM8	1	2.3	1.3	1.1	1.4
Debed	Pambak	After mixing Sisiget river	19.07. 2022	IM9	1	2.3	3.0	3.0	2.3
Debed	Dzoraget	0.5 km above Stepanavan	21.07. 2022	IM10	1	2.2	2.0	3.0	2.1
Debed	Mghart	mouth	21.07. 2022	IM11	1	-	1.3	1.0	1.1
Debed	Dzoraget	After mixing Mghart stream	21.07. 2022	IM12	1	2.03	1.0	1.1	1.3
Aghstev	Aghstev	Village Lermontovo	20.07. 2022	IM13	1	3.2	1.7	1.1	1.7
Aghstev	Golovino	mouth	22.07. 2022	IM14	1	2.1	1.3	1.0	1.4
Aghstev	Aghstev	1.2 km upstream of Dilijan	20.07. 2022	IM15	1	1.9	3.7	3.0	2.4

6 Discussion of results

Tandzut River near the Vanadzor city (Sampling sites IM1, IM2 and IM3)

At the sampling site IM1, the water quality based on the chemical parameters has been assessed as moderate due to the elevated concentrations of Mo (see Table 8).

According to the hydrobiological assessment, the water quality at the IM1 has been assessed as high (see Table 9) by nEQR-1.00 value.

This site is not impacted by any pollution source and the concentration of Mo could be considered typical for site geochemistry.

The Zhangot jur stream (IM2) is influenced by leachates of an open mine (see Figure 6). The influence of the Tandzut mining site on the Zhangot jur stream is obvious. The results of physicochemical analyses have shown that the water of Zhangot jur is acidic and has a rusty color (see Figure 16). Based on the chemical parameters, the water quality of the Zhangot jur stream at the site IM2 was assessed as bad, due to the high concentrations of ammonia, nitrate, sulphate, Cu, As, Mo, Mn, V, Co, Fe, Al, Sb, TIN, TSS.

The Zhangot jur stream is completely devoid of biodiversity. At the sampling site IM 2, in the mouth of the Zhangot jur stream no animals were found and the ecological quality has been assessed as bad.

In the Tandzut River, after mixing with Zhangot jur stream (Sampling site IM3, see Figure 16) in comparison with the non-influenced site (sampling site IM 1), the concentrations of some parameters have increased sharply such as arsenic, sulphate ion, cobalt, zinc, iron, and copper, were increased by 4.2, 4.6, 6.7, 14.7, 18.1, 34.1 times, respectively.

A slight increase (1.4 - 4.0 times) of concentrations of ammonia and nitrate ions, EC, Mg, K, Ca, Al, Ni, and Se also has been observed.

Based on the chemical parameters, the water quality at sampling site IM3 was assessed as poor due to the elevated concentration of Fe (see Table 8).

At sampling site IM3 in comparison to sampling site IM1, the density of benthic macroinvertebrates decreased by 5 times, and the species diversity decreased from 19 to 12. However, the ecological status has decreased only from high to good (by nEQR-0.79 value).

The investigative monitoring has revealed that Tandzut mining site has impact on to the Tandzut River through Zhangot jur stream.

Figure 16. Tandzut river upstream (IM1), Zhangot jur stream (IM2), Tandzut river after mixing of Zangotjur stream (IM3)

The comparison with soil monitoring data of investigated area also was done (Table 13). The background concentrations of some metals in soil of the Vanadzor area were compared with the riparian area of Zhangot jur and the area of mining overburden. The data confirmed that Zhangot jur and its riparian area are polluted with some heavy metals. The concentrations of V, Cu, Zn, As, Cd, Pb, Mo and Sr at the riparian area of Zhangot jur stream several times are higher than at the background sites of Vanadzor area.

Table 13: Some heavy metals of the soil monitoring data in Tandzut area

Site	Concentration, mg/kg							
	V	Cu	Zn	As	Cd	Pb	Mo	Sr
Background of Vanadzor area	70	41	68	1.5	0.6	16.3	1.4	202
Riparian area of Zhangot jur	422	161	36	67	7	40	11	426
Neighbourhood areas of mining overburden	438-859	176-200	78-370	77-134	8-11	82-286	13-39	333-662

Pambak and Qaraberd Rivers (Sampling sites IM4, IM5 and IM6)

At the sampling site IM4, according to the results of the water quality assessment based on the chemical parameters, the water quality was assessed as bad due to the elevated concentrations of ammonia and total inorganic nitrogen (see Table 8). According to the hydrobiological data, the water quality was assessed as poor (see Table 9) by nEQR-0.34 value.

The pressure of the city of Vanadzor, which is the 3rd biggest city of Armenia, on the Pambak river is quite large. The Pambak river is influenced by the untreated wastewater.

Based on the chemical parameters, the water quality of the Qaraberd River at the site IM5 was assessed as poor, due to the high concentrations of Mo. The ecological quality is assessed as good, by nEQR-0.69 value.

Figure 17. Pambak river, up to an influence of Qaraberd river (IM4), Qaraberd river (IM5), and Pambak river after mixing of Qaraberd river (IM6)

The results have shown that the Qaraberd mine does not have a significant impact on the biodiversity of the Qaraberd River (sampling site IM5). Almost all metals appear in concentrations comparable concentrations to most of the other sites. It is possible that after flowing such a long distance - 4 km, self-cleaning of the river takes place. This can be concluded, as IM6 shows significantly lower values for COD, BOD, NH4 and P. However, nitrate is increased and could indicate oxidation processes, as aslo the O2 saturation is higher at IM6 which shows an increased availability of dissolved oxygen. Unfortunately, there was no opportunity to visit the Qaraberd mine and see the situation on the spot.

After the confluence of the Qaraberd River with the Pambak River, at the sampling site IM6, the water quality based on the chemical parameters was assessed as bad due to the high concentration of nitrate ion and TSS. The ecological quality also was assessed as bad, by nEQR-0.16 value.

The impact of Qaraberd mine on the Pambak River is not observed. The decline in the ecological status of the Pambak River is related to domestic pressures rather than the impact of the Qaraberd mine.

It is suggested to continue the investigation at the mouth of Qaraberd River to have comprehensive data and information about the impact over a period of one year.

Hanqadzor abandoned mining site (Sampling sites IM7, IM8 and IM9)

At the sampling site IM7, the water quality based on the chemical parameters was assessed as bad due to the elevated concentration of nitrate ion (see Table 8). According to the hydrobiological data, the water quality has been assessed as moderate (see Table 9) by nEQR-0.45 value.

At the sampling site IM8 (Sisiget river mouth) the ecological quality was assessed as high, by nEQR-1.00 value. The water quality based on the chemical parameters was assessed as moderate due to the elevated concentration of molybdenum.

A large volume of acidic drainage discharges from the mine adit, which is comparable in volume to the volume of Sisiget in that location. However, the Hanqadzor abandoned mining area does not have a significant impact on the biodiversity of the river mouth of the Sisiget River.

Figure 18. Pambak River up to the Vahagnadzor village (IM7), Sisiget river (IM8), Pambak River, after mixing of Sisiget River (IM9)

At sampling site IM9, after the confluence of Sisiget river, the ecological quality is assessed as bad, by nEQR-0.05 value. The water quality based on the chemical parameters was assessed as bad due to the elevated concentration of nitrate ion (see Table 8).The Pambak river at the sampling site IM9 is again under utility-domestic pressure.

The Hanqadzor abandoned mining area does not have a significant impact on the Sisiget River and therefore on the Tandzut River.

Mghart gold mining site (Sampling sites IM10, and IM12)

At sampling site IM10, Dzoraget river up to Stepanavan city, the ecological quality was assessed as good, by nEQR-0.67 value. The water quality based on the chemical parameters was assessed as moderate due to the elevated concentration of nitrate ion and vanadium.

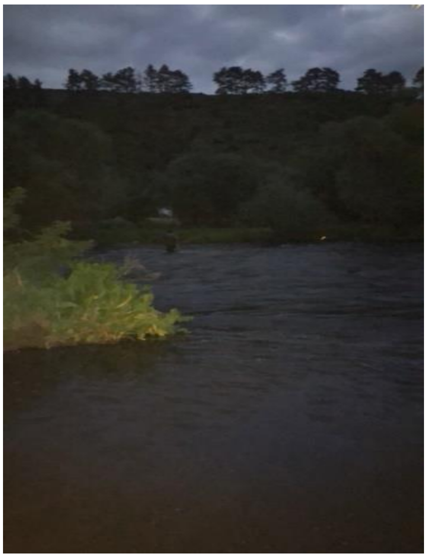

Figure 19. Dzoraget River up to the Stepanavan city (IM10), Dzoraget River after mixing Mghart stream (IM12)

Since there was no water in the Mghart floodplain (sampling site IM11), it was not possible to assess the impact of the Mghart gold mine on the Dzoraget River.

At the sampling site IM12, after the influence of the Mghart floodplain, the ecological quality of the Dzoraget river is assessed as moderate, by nEQR-0.52 value. The decline in the ecological status of the Dzoraget River may also be related to communal-domestic pressures.

The water quality based on the chemical parameters was assessed as good.

Fioletovo abounded mining site (Sampling sites IM13, IM14 and IM15)

At sampling site IM13, the ecological quality was assessed as high, by nEQR-1.00 value. According to the chemical parameters, the water quality was assessed as good. This site can serve as reference/background site for the Aghstev River. It will be proposed to include the sampling site in the state water quality monitoring network.

At sampling site IM14, Golovino river mouth, the ecological quality was assessed as high, by nEQR-1.00 value. The water quality based on the chemical parameters was assessed as moderate due to the elevated concentration of nitrate ion, iron and TSS.

The Golovino River is to a certain extent influenced by Fioletovo abandoned mining site, which is caused by acidic drainage waters.

At sampling site IM15, Aghstev river up to Dilijan city, the ecological quality (EQR) is assessed as good, by nEQR-0.75 value. The water quality based on the chemical parameters was assessed as good.

An impact by the old municipal landfill of Dilijan is rather likely, but is expected to be during snow melts and mudslides. However, our fieldwork was carried out during the summer months and under clear weather conditions and it was not possible to record this effect in the field.

The Fioletovo mining site does not affect the ecological condition of the Aghstev River.

Figure 20. Aghstev river upstream (IM13), Golovino river (IM14), Aghstev river up to Dilijan city (IM15)

7 Conclusions

The Tandzut site is significantly influenced by Zhangot-jur stream, which consequently affects the Tandzut River. Most of the parameters in the Tandzut River show increased values after the confluence with Zhangot-jur compared to the Tandzut at Antarashen village. Based on the physicochemical parameters, the assessment of the water quality of Tandzut River turns into poor after confluence with Zhangot jur. A similar decrease applies for the ecological status, which turns from high to good. Thus, the influence is not negligible and should be kept in focus in the future. It is suggested to include the Tandzut River in the State monitoring programme.

Results of heavy metals in the Qaraberd River suggest that the mining site does not influence the river as most of the heavy metals were detected in concentrations comparable to most of the other sites. However, results in the Pambak River suggest an influence mainly caused by untreated urban wastewaters from the city of Vanadzor. In the course of the river, a decrease of COD, BOD and NH_4 suggests oxidative degradation while nitrate increases at a high oxygen saturation. The ecological status along the Pambak River decreases and is related to domestic pressures from untreated wastewaters. It is suggested to continue the investigation at the mouth of Qaraberd River to have comprehensive data and information about the impact over a period of one year.

Due to the results of heavy metals, the abandoned mining site at Hangadzor does not influence the Sisiget River and thus the Tandzut River. However, the ecological status of Pambak River at IM 7 and IM9 are rated as bad due to the still high concentrations of nitrate. Domestic discharge influence the quality of the river and measures need to be taken to reduce this pressure. Also, the acidic drainage from the mine adit should be controlled in order to protect the river's quality.

The ecological and chemical status of the Dzoraget River was assessed as good and moderate, respectively. Domestic pressures seem to be responsible (nitrate). A potential influence from the Mghart gold mining site could not be assessed due to the lack of water at site IM11. This site should be kept under further control.

The quality at the sites around the Fioletovo mining site were assessed as good and moderate. A significant impact by the mining site could not be detected. However, acidic drainage water leaking from the mining site should be investigated. There is also an old municipal landfill, which potentially leaks during snow melt. This should be investigated further, preferably during snow melt, and remediation of the site should be considered. It is proposed to include the sampling site IM13 in the state water quality monitoring network.

The present field survey served as an example for HMC on how to effectively plan and carry out an investigate monitoring. Through this activity, a better understanding of the impact of mining sites on water quality of the rivers could be achieved and pollution sources could be identified. A better understanding of the impact of mining sites on water quality was gained, allowing for suggestions to include sites in regular operational monitoring activities.

Investigative monitoring is an essential component of the Northern River Basin Management Plan. It provides a comprehensive basis for assessing the water bodies, identifying potential pressures and impacts, assessing risks, determining the current status and developing effective management measures for the Northern River basin.

Gaps and steps to be considered

Generally, there is weak inter-institutional collaboration among all stakeholders. To improve inter-institutional collaboration, gaps being responsible for the weak collaboration need to be identified and involvement in the planning and implementation of other stages of the investigative monitoring has to be enforced and well coordinated by the monitoring department of the Ministry of Environment.

Remarks on the requirements of the Water Framework Directive

Generally, article 8 of the WFD establishes the requirements for the monitoring of the status of water bodies, as laid down in Annex V of the WFD to classify the ecological and chemical status, supplement and validate the risk assessment procedure, design future monitoring programmes efficiently or ascertaining the magnitude and impacts of accidental pollution. Basis of classification of surface water bodies are biological quality elements (BQE), while physico-chemistry and hydro-morphology act as supporting elements. “Supporting” means that the values of the physico-chemical and hydromorphological quality elements are such as to support a biological community of a certain ecological status, as this recognises the fact that biological communities are products of their physical and chemical environment. It is not intended that these supporting elements can be used as surrogates for the biological elements in surveillance and operational monitoring (EUWI+, 2021).

There are several guidance documents available, which help taking the right steps towards implementing the cycle of the WFD. In particular, guidance 13 describes the “overall approach to the classification of ecological status and potential” (EU 2005) and illustrates the approach for surface waters in

Figure 21.

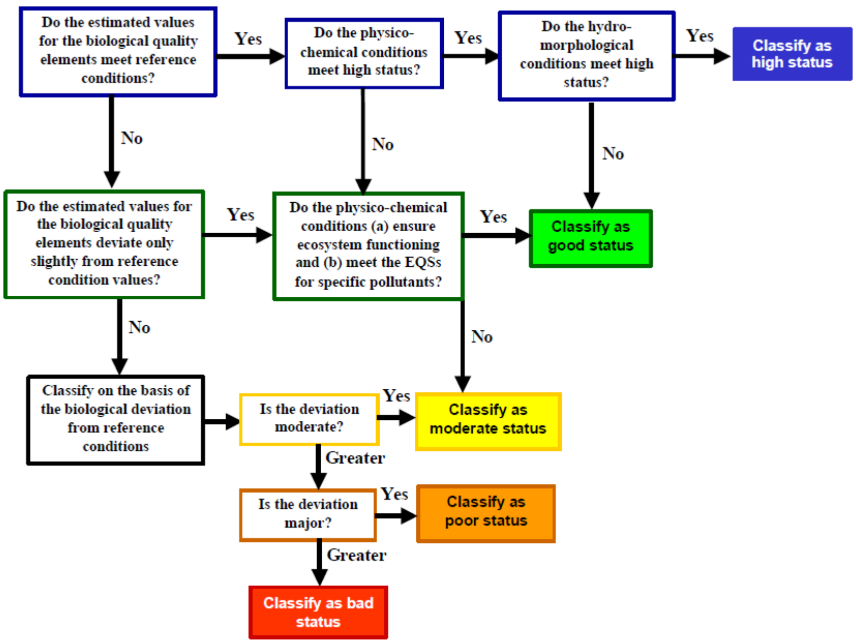

Figure 21: Indication of the relative roles of biological, hydromorphological and physico-chemical quality elements in ecological status classification according the normative definitions in WFD Annex V:1.2. (source: EU 2005)

For these reasons, it is important to clarify the role of specific pollutants in certain water bodies, as being done with this investigative monitoring. This shall help identify specific contamination or determine natural geogenic burden of contamination or help designing a concept for surveillance or operational monitoring.

8 References

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9 Annexes

Annex 1: Field protocols, separate files

Annex 2: Photo documentation, separate files

Annex 3: Protocol for sample delivery and handover, separate files

Annex 4: Chemical data summary

Annex 5: Report

Annex 6: Biological data summary

Annex 7: Hydromorphology

Annex 8: Water quality norms

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