

Western Balkans Environmental Program

**CASE STUDIES
ON REMEDIATION
OF ENVIRONMENTAL
HOT SPOTS
IN THE
WESTERN BALKANS**





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FOREWORD

The present compilation of Case Studies summarizes the most tangible outputs of the Western Balkans Environmental Programme. The variety of environmental ‘hot spot’ issues that have been addressed across the six different Western Balkan countries offers a wide range of useful learning experiences.

May the community of local or regional ‘environmental’ practitioners in particular, find guidance and inspiration in these brief, factual ‘write-ups’. The cases described represent just the ‘tip of the iceberg’ of the hot spot cleanup needs in the Western Balkans region. A tremendous challenge still lies ahead in this field of mostly environmental engineering work.

The results shown here could not have been obtained without the high quality of technical advice provided consistently over the three-year implementation period and the highly effective management provided by the UNDP Montenegro Regional Management Unit of the programme. It is less fortunate that – at least in the near future – environmental programmes of this nature are likely to remain dependent on donor co-financing. The Government of the Netherlands which co-financed the present WBEP with the ‘local authorities’ can be satisfied with its actual implementation, and thus hopes to attract interest among the much wider potential donor community.

WBEP Advisory Board member
Klaus BROERSMA



PREFACE

This publication on 9 “case studies” of environmental hot spots in the Western Balkans aims to capture and share the information collected over 36 months in cleaning up sites or improving infrastructure for the benefit of the community and environment.

It covers the costs, timelines, difficulties and progress made in conducting chemical cleanups, improving waste water and energy infrastructure, containment of hazardous waste and hazard reduction works at mine sites in the transitional countries that make up the Western Balkans. It also includes valuable information on the companies involved and the institutional players.

While such information has already been made available to the many practitioners, institutional members and the general public involved in improvement works, international study tours, environmental training modules and workshops, there are real limitations in how far such valuable information and lessons learnt can be shared to those physically present.

This collection of case studies aims to bridge that gap and to gather and provide this information as widely as possible to those best able to use it and/or with an interest in the betterment of our environment both in the Western Balkans and globally.

Stewart WILLIAMS
WBEP Chief Technical Advisor

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INTRODUCTION

The Regional Environmental Hot Spots Programme “*Strengthening Capacities in the Western Balkans Countries/Territories to Mitigate Environmental Problems Through Remediation of High Priority Hot Spots*” was implemented in eleven locations in six countries/territories of the Western Balkans region (Albania, Bosnia and Herzegovina, Montenegro, Serbia, The FYR of Macedonia and UN Administrative Territory under Security Council Resolution 1244 Kosovo) suffering from the legacy of polluting industries and requiring industrial renewal, environmental cleanup and new economic initiatives.

The goal of this three-year, USD 15 million programme, funded by the Government of the Netherlands, was to improve the environmental situation and quality of life for citizens living in and around the polluted areas through the best cost measures, improved local and national policy dialogue while strengthening regional cooperation. The programme had three main components: physical works, institutional strengthening and capacity building and public awareness raising, all in relation to remediation of environmental hot spots and improving environmental management.

This programme aimed to harmonise development of technical, institution and community skills in the Western Balkans to best deal with environmental hot spot problems both now and in the future. This was done through the experience gained and exchanged regionally in dealing with concrete problems in each of the countries/territories and benefiting from practices adapted from the international community.

The information provided in this publication is based on the physical works conducted to quickly address important environmental problems in the region and not for the purposes of scientific or research-based projects. Presentation of the information is therefore provided as a start-to-finish chronology of each of the case studies with the relevant costs, timings and steps required to conduct the works.

The publication covers 9 of the 11¹ locations treated, which are grouped into 6 separate sections:

- AIR POLLUTION AND ENERGY
- WATER POLLUTION AND WASTE
- CHEMICAL REMOVAL AND DESTRUCTION
- METAL RECOVERY FROM MINE WASTE AND WATER
- MINE DUST AND WATER MANAGEMENT
- MINE TAILINGS CONTAINMENT AND RAPID RISK REDUCTION.

.....
¹ Two locations were included late in the programme and therefore case studies on remediation works at those two locations will be prepared at some later stage.

These sections have been organised to allow easy reference to a specific topic area and allow the reader to compare and contrast different case studies that are present within the same topic area, although some overlap does exist in relation to those sections related to former mining and mineral processing sites.

The case studies differ in relation to format and information provided. This is a result of the different types of physical works conducted at each case-study site (i.e. construction, earthworks, chemical collections) as well as the different information available for them in previous reports, assessments and technical documentation underpinning the physical works undertaken within the actual case studies. Reference to such material is provided at the end of each individual case study.

Direct quantitative information on existing environmental and human health risks at these sites was often limited. In addition, determining the environmental improvements made in a quantitative way was difficult as in most cases the benefits are to be realized in the future when the baseline information collected in this programme can be used to determine the actual, rather than inferred improvements to the environment and human health. Timelines for the works conducted have been provided in the summary tables at the end of each case study. The budgets spent for remediation activities have been provided in different currencies, depending on the currencies of the contracts signed.

The abstracts provided at the beginning of each case study have also been collected into a single "Abstract Summary" as the last chapter in this publication to allow quick consideration of the general elements provided as an overall summary of all case studies conducted. The reader may then progress to a specific case study for a greater level of detail.

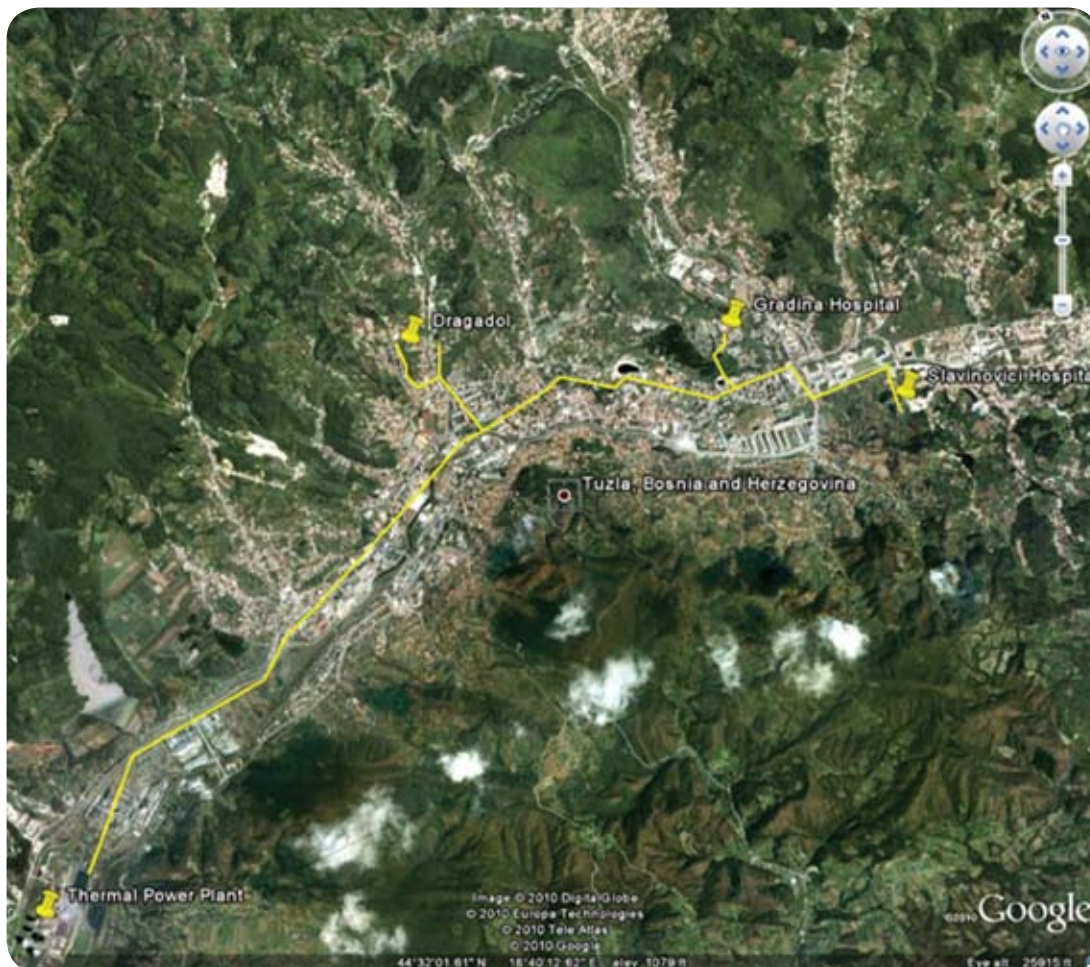
AIR POLLUTION AND ENERGY



Location
MUNICIPALITY OF TUZLA
Bosnia and Herzegovina

PROJECT WORKS

Closing down of the obsolete heat production facilities at two (2) clinics Gradina and Slavinovici (both important health centres) and one (1) community centre Dragadol (650 households) creating serious in-town air pollution by connecting the users to a significantly less polluting energy source (district heating system).



ABSTRACT

The works at Tuzla, conducted by the companies “Fuel Boss d.o.o” (works at Gradina) and “Tehnograd d.o.o.” (works in Slavinovici and Dragodol) to shut down obsolete coal-fired boilers at two health clinics and the 650-resident heating plant involved earthworks, demolition, and construction works, installation of 31 substations, 2.5 kilometres of pipe works, thermal insulation, solar heating and other ancillary works. It involved a total planning period of 9 months and a construction period of 13 months and it was conducted at a cost of USD 2,600,000 (including: development of technical design, clean up works and supervision) with contribution of USD 1,428,000 from the Government of the Netherlands and USD 1,172,000 from the Municipality of Tuzla (cash and in kind). The works will reduce harmful air emissions in the city core by an estimated 500 tonnes per heating season (SO_x, NO_x, and Particulate Matter (PM)), decrease CO₂ by 16,730 tonnes per year and reduce coal use by 7,500 tonnes/year. Approximate annual savings of USD 550,000 equals a payback period of 4 years.

Table 1 • **Summary of Clean-up Works Conducted in Tuzla**

LOCATION/TYPE	COST OF WORKS (rounded values) IN USD	ACHIEVED REDUCTIONS PER HEATING SEASON (rounded values)	
		Toxic Air Pollutants (tonnes/yr)	CO ₂ (tonnes/yr)
GRADINA HOSPITAL	1,042,000	320	13,000
SLAVINOVICI HOSPITAL	527,000	20	1,000
DRAGODOL AND TUSANJ RESIDENTIAL HEATING	1,031,000	160	3,000
TOTAL	2,600,000	500	17,000

LOCATION

The Municipality of Tuzla is one of the 13 municipalities of the Tuzla Canton and covers an area of 294 km² with a population of 132,000 inhabitants. The city of Tuzla is the administrative centre of the Tuzla Canton and is the largest economic centre of north-eastern Bosnia and Herzegovina. Around 75% of the population of the municipality live in the urban zone and the remaining population is located in rural local communities.

Traditionally, the basis of the cities' and region's economic growth was mineral goods, which are coal and non-metals (rock salt and quartz sand). Before the conflicts of the 1990's, large industrial complexes (chemical, mineral products and metal), production of electrical power and mining were the three main branches of the economy. Today, these industries are going through a very slow and difficult transition process. Before the war, most of the production came from huge industrial systems such as "SODASO" Tuzla, Coal Mines Tuzla, TPP Tuzla, "Umel" Tuzla, etc. In these industries around 60,000 people were employed and 75% of all investments were linked to these industries.

The richness and potential for development of this region are still the geological reserves of dark coal, estimated at around 316 million tonnes and lignite to the amount of around 2.66 billion tonnes, which is 24% of Bosnia and Herzegovina's total dark coal reserves and 66% of its lignite reserves. The mines are facing technical and economic problems that reflect the competitiveness of thermal power plant electricity production. On that point, power production is in the process of revival, since production has increased from 750 GWh in 1996 to 2,855 GWh in 2004, which is 77-80% of pre-conflict production levels.



ENVIRONMENT SITUATION

The area of the Municipality of Tuzla is considered one of the most polluted areas in Bosnia and Herzegovina with some of the worst air quality due to emissions from thermo-power plants, industrial heat production facilities and individual heating systems.

Air quality during the heating season in the urban areas of Tuzla is usually regarded in the national category II or III (polluted or very-polluted air) with periodic exceeding of permitted sulphur dioxide (SO₂) levels of 400 µg/m³ (3 to 4 times the maximum allowable concentration). The Air Quality Index (AQI) calculated during the period 2003-2006 exceeded the 100 µg/m³ level for up to 174 days per year and the 300 µg/m³ level for up to 32 days per year.

Outdated technology in Bosnia and Herzegovina as a whole still represents a significant source of SO₂ emissions. The SO₂ emissions from the territory of the canton and the large sources surrounding the canton amount to approximately 320,000 tonnes/year, or over 70% of the emissions of the whole of Bosnia and Herzegovina or 160,000 tonnes of sulphur per annum. These emissions are able to be transported over thousands of kilometres, making Bosnia and Herzegovina a net exporter of SO₂. According to a rough estimate, SO₂ deposition is highest in the northeast of Bosnia and Herzegovina, precisely on the territory of the Tuzla Canton, with over 2.5 g/m² per year.



Air pollution is further worsened through the widespread use of small boilers and domestic furnaces characterised by unsuitable combustion chamber construction, indoor household furnaces and small power boilers made based on West European licenses but constructed for different types of coals that do not allow for efficient, low polluting combustion of the Bosnia and Herzegovina coals. This is further impacted by the lack of guidance on using coal for residential and small scale heating, the lack of coal conditioning for the needs of small furnaces, poor maintenance of energy sector and industrial plants, particularly equipment on which emission of pollutants depends and an irrational use of energy.

According to existing data and estimations for the previous period, pollutions from industrial heat production facilities and individual heating systems, are the second largest pollutant in

the area. According to available data, there are around 50 active heat production plants with a total installed capacity of 42 MW. That data does not include individual house heating systems. Air quality in the urban part of Tuzla during heating season is mostly II and III category (polluted or very polluted air), and very often there are episodes of critical air pollution especially with SO₂ with a concentration of 400 µg/m³, which is 3-4 times the maximum allowed amount.

Based on a yearly consumption of 7,000 tonnes of coal, it is possible to estimate that the combustion of "dirty" dark coal and usage of outdated technologies leads to an emission of SO₂ in the order of around 300 tonnes per year. Beside the SO₂ emission, there is also significant emission of sedimentation particles, soot, nitrogen oxides (NO_x) (62 tonnes), carbon monoxide (CO) (1.73 tonnes) and carbon dioxide (CO₂) (13,000 tonnes).

This heavily influences air quality directly at the location of the clinical centres and communities, but also the whole city and through air circulation by prevailing winds, any air pollution created in Tuzla influences the air quality in the wider surrounding region. Plus, besides the direct air pollution effects, these emissions contribute to the problem of global warming by contributing to the "greenhouse" effect.

From studies it is also evident that the predominant direction of winds in the Tuzla area is southwest-northeast, with the result being that any air pollutants created in Tuzla are directly conveyed by winds towards the east of Croatia, the south of Hungary and the northern part of Serbia (Vojvodina), and thus contribute to a wider, regional impact on air quality.

HUMAN HEALTH

Although the high occurrence of respiratory diseases cannot be reliably attributed to a single major cause or quantified, it is certain that the significant air pollution in Tuzla area has been having a major role and impact on the population's health. As reported in the Information on the State of the Environment in the Territory of the Tuzla Canton in 1999 (Government of the Tuzla Canton, 2000), an investigation of air pollution concentrations and health effects in the population of Tuzla, conducted during the period 1985-1990, led to the conclusions that the high occurrence of certain diseases was in correlation with air pollution, and that the occurrence of some diseases was significantly higher during the winter months when air pollution is increased.

As previously elaborated, SO₂ and PM pollution, as measured by the monitoring stations, is significantly higher during the heating season. This indicates that, despite the relatively small contribution to effective overall air emission of these pollutants compared to that of the Thermo Power Plant (TPP) Tuzla, the scattered individual coal-fired heating systems contribute the most to low-altitude air pollution within the city of Tuzla during the winter. Based on available

information, the actual extent of the environmental impact of the clinic's and the community heating system's air emissions cannot be fully quantified. However, according to the distribution of these pollutants, they are likely to significantly contribute to the overall low-altitude SO₂, PM, and NO_x pollution in the urban area of the Tuzla municipality.

As a result of the impact that this has on human health, according to the Tuzla Canton, overall disease occurrence data for 2006 from acute infections of the upper respiratory system were the most frequent diseases with an occurrence rate of 2,547.2, followed by high blood pressure-related diseases at 801.0 and bronchitis at 435.4. A total of 4,084 respiratory disease-related cases of treatment at Tuzla-based medical institutions were registered in 2006, of which 1,259 related to admissions by people from the area of the Tuzla municipality, while the figure for 2007 is lower with a total of 3,293, of which 979 were related to Tuzla's city population. The total number of chronic respiratory diseases among the population of Tuzla in 2006 was 544, while the 2007 figure was 366 (Ref 2).

Based on the findings of the environmental assessment study, research of potential impact on human health due to air pollutant exposure in Tuzla during the period March 2003 - February 2006 has been conducted calculating an AQI of 42. Air concentrations of pollutants obtained by Tuzla air quality monitoring stations were used as inputs. Values calculated for Monitoring Station 1 (MS1 "Skver") and MS2 ("BKC" or "Tuzla1") exceeded an AQI of 100, representing the borderline level of poor air quality, on 136-173 and 70-164 days per year respectively. Most exceeding of AQI levels occurred during the winter months. During the research period the AQI exceeded a level of 300 (the high hazard borderline value during which the population should avoid outdoor activities) 16 and 32 times respectively. Particulate matter proved to be the most critical pollutant. Within the same research, the effect of daily variations in concentrations of air pollutants on mortality and hospitalisation was observed. It has been found that total cardiovascular and respiratory mortality figures significantly correlated with daily variations in SO₂ and particulate matter concentrations, whereas cardiovascular mortality also correlated with NO₂ concentration variations; and hospitalisation due to respiratory and cardiovascular diseases significantly correlated with daily variations in SO₂, particulate matter, NO₂ and Ozone (O₃) concentrations, specifically SO₂ with asthma, SO₂ and NO₂ with acute myocardium infarcts (heart attacks) and SO₂ and O₃ with chronic obstructive pulmonary disease (COPD).

INTERVENTIONS

Works involved a total reduction of combustion gases in Tuzla city centre by shutting down the two coal-fired hospital boilers and connecting two clinics, (1) the Tuzla University Clinical Centre, Gradina, and the (2) Hospital for Pulmonary Diseases and Tuberculosis, Slavinovici, along with (3) the Dragodol and Tusanj local communities to the district heating system.

Current coal-based systems have been removed completely with all requirements now being provided through the connections to the district heating system capacities – there is no increase of energy production because the district heating system uses the excess heat produced in the nearby thermo-power plant, which produces a huge surplus of heat previously being wasted, with the result being a direct and immediate reduction of emissions of “greenhouse gases” and many other significant pollutants. This represents a significant cost reduction in heating, process steam and sanitary hot water supply with an expected payback period of four years.

Plans to connect the Gradina Clinical Medical Centre to the district heating network have existed since 1986, but due to economic and later conflict-related problems they did not materialize until now.

It was foreseen through this project that a main branch pipeline would be constructed, connecting the clinical centre with the main district heating pipeline, which starts at the location of the post office building. Also, a new 10 MW substation would be constructed and in addition to this it was necessary to reconstruct the existing pipeline from the Gymnasium building to the post office building. The Gradina Clinical Medical Centre decided to keep, and convert one boiler into a natural gas boiler for preparation of steam and hot water during the period without heating. The connection for the “Slavinovici” Lung Disease Clinic started from the location at Sjenjak and a pipeline of a length of approximately 1.5 km was constructed.

Expectations were that after completion of the project, air pollution would be decreased significantly in the immediate locality, as well as in the city and further away, as it would enable closure of heat producing plants of a combined capacity of 21 MW, which is about 50% of the total industrial heat production capacity in the city right now. Besides these effects, there will be a decreased need for the transportation of ash from the clinic compound. This will be a secondary effect towards a decrease in air pollution further.



Total Emission Estimates

Assuming that exhaust gases from each boiler during the entire year on average contain 15 mg/m³ NO_x, 700 mg/m³ SO₂ and PM total 40 mg/m³, at an average exhaust gas flow rate of 23,000 m³/h, the average annual emissions from the heating system would be: 174 tonnes/yr SO₂, 2.5 tonnes/yr NO_x and 9.9 tonnes/yr PM total.

SO₂ emissions can also be calculated based on information on a reported average coal consumption of 6.35 tonnes/yr and combustible sulphur content of the given coal type (approximately 1.5% of the mass). Assuming combustion efficiency of 80-90%, average SO₂ emissions estimated in this way are 152.4-171.4 tonnes/yr. This represents up to approx. 10% of the total SO₂ emissions from all stationary sources in domestic and industrial use except for Tuzla Thermal Power Plant (TPP), as estimated for the whole of the city of Tuzla. This figure is in line with the previous one for SO₂ based on short-term air emission monitoring. The estimated emissions of NO_x represent up to approximately 2.6% of total NO_x emissions from all stationary sources in domestic and industrial use except for Tuzla TPP, whereas the total PM emissions represent up to approximately 0.4% of total PM emissions from all stationary sources in domestic and industrial use except for Tuzla TPP.



TUZLA UNIVERSITY CLINIC CENTRE GRADINA

The Gradina Medical Centre (Gradina Complex) is located in the eastern section of the city of Tuzla, on a slightly elevated hill between the Solina and Brcanska Malta neighbourhoods. There are numerous apartment blocks and individual residential houses in the area surrounding the Gradina Complex.

The previous coal-fired heating system provided the heating energy demands for the following:

- MC interior heating
- 6-bar sterilization steam production
- Provision of hot sanitary water.

The steam produced in the coal-fired boilers was distributed to steam/hot water heat exchange stations and from there hot water and 6-bar steam was further supplied to individual buildings within the complex.

Based on site observations, this system was in poor condition, lacking adequate pipe insulation, with limited temperature control due to the manual process controls.

Details on the clinic's decommissioned boilers are as follows:

- Three BKR 70 TPK Zagreb-type boilers with an installed capacity of 4.65 MW each
- One BKR 50 TPK Zagreb-type boiler with an installed capacity of 3.20 MW
(Total installed capacity: 17.15 MW).

Estimates during the heating season for the total emission of SO₂ from Gradina Hospital's boiler facilities amount to 202 tonnes: 36.85 tonnes of NO_x, 80 tonnes of PM and 12.78 tonnes of CO₂.

These boilers were commissioned in 1983 (1) and 1989/1990 (3). Average annual consumption of bituminous coal, sourced from the Djurdjevik mine, was reportedly 6,350 tonnes per year. This coal has the highest sulphur content of all coals sourced in Bosnia and Herzegovina (total sulphur approx. 2.3% mass, of which approx. 1.5% is combustible) and an average calorific value of 15,230 kJ/kg. The system was equipped with a stack cyclone for the removal of fly ash from smoke. However, details on cyclone efficiency were not available from the Medical Centre. No records of cyclone maintenance and removed fly ash quantities have been made.

During the winter season two BKR 70 TPK Zagreb boilers were in use 24 hours a day for heating purposes and the production of warm water and steam. During the summer season one BKR 70 TPK Zagreb boiler was used 12 hours a day for warm water and steam production purposes. According to information from the Medical Centre, the Gradina Complex was consuming approximately 5,330 kg/h of steam for the sterilisation of equipment, laundry and washing of dishes and air conditioning supply systems. However, according to the latest estimates, the actual demand is 3,651 kg/h. Fifteen (15) people were employed for the manual operation and daily maintenance of the system, including the extraction and temporary disposal of slag and ash at the southern rim of the complex.

There is no information on the effective annual heat needs for the whole complex in the previous period, though the MC management reported that the demand for heating was 9,098 kW and 3,558 kW for the 5,330 kg/h steam production. According to the latest estimates, the Gradina Complex energy demand for 11 individual units is 12,582 kW in total. The energy demand share per application is:

- MC interior heating and ventilation 8,382 kW (66.62%)
- 6-bar sterilization steam production 2,437 kW (19.37%)
- provision of hot sanitary water 1,763 kW (14.01%).

WORKS CONDUCTED IN GRADINA

Works involved the heating system being completely restructured and connected to the district heating system for winter-season heating and winter-season sanitary hot water supply; completely restructured boiler rooms with the coal-based boilers being converted into natural gas boilers for the supply of all-year-round steam, non-winter-season sanitary hot water and to serve as a secondary heating system in case of a malfunction of the district heating.

The connection pipeline has a length of 232 m in total. Insulated, corrosion-protected steel/Cr/Ni and hard polyethylene pipes are installed in ditches. The metal pipes were wrapped in protective polyethylene foil. Insulation materials included polyurethane foam, bitumen and fabricated stone wool. Prior to their placement on pipes, external pipe surfaces were covered with an additional protective high-temperature paint layer. Readymade heat transfer stations, as well as pumps, were also installed.

Works included connecting the pipeline installation with the heat transfer station, internal distribution network reconstruction and adaptation. Standard types of earthworks, demolition and construction works were also carried out, as required, to connect the existing buildings to the public hot water network. In addition to this, delivery and installation of a compact thermal substation (KTP 5000 or equivalent) has been done, as well as the supply of pumps, thermal insulation and painting. For exact specifications please see the Bill of Quantities at <http://ba.westernbalkansenvironment.net./content/view/84/1/lang,en/>

The preparatory and physical works at Gradina were conducted over a 9-month period (see Table 2) at a total cost of 1,042,574 USD (1,511,732 BAM)¹, and are expected to reduce toxic air pollutants by 318.85 tonnes and reduce CO₂ by almost 13,000 tonnes per heating season.

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¹ The exchange rate from February 2010 (1.45\$/BAM)

Table 2 • *Summary of Works in Gradina*

GRADINA HOSPITAL CLEAN UP WORKS		USD 1,042,574.46	MAY 2008– FEBRUARY 2010												
Environmental Assessment Study-EAS			MAY 2008–DECEMBER 2008												
			M	J	J	A	S	O	N	D	J	F	M	A	
Tendering procedure -Company to prepare the Environmental Assessment Study	\$ 11,886.21														
Evaluation and contracting															
Development of the Environmental Assessment Study															
Physical works			OCT-DEC 2008			JUNE 2009–FEBRUARY 2010									
			O	N	D	J	J	A	S	O	N	D	J	F	
Development and revision of the Final Design	\$ 35,466.67														
Tendering procedure - Company to conduct physical works	\$ 976,689.87														
Evaluation and contracting															
Physical works at Gradina hospital															
Ending of works															
Final commissioning of completed works															
Supervision			JUNE 2009–FEBRUARY 2010												
						J	J	A	S	O	N	D	J	F	
Tendering procedure - Company/ IIE to do the supervision of physical works	\$ 18,531.71														
Evaluation and contracting															
Supervision of physical works at Gradina hospital															
Final report prepared															

HOSPITAL FOR PULMONARY DISEASES AND TUBERCULOSIS SLAVINOVICI

The Slavinovici Hospital is also placed on a slightly elevated terrain, approximately 300 m southwards from the Jala River.

Details on the decommissioned coal-fired boilers that were in use by the hospital are as follows:

- Three (3) Neovulkan Zrenjanin boilers with an installed capacity of 243.3 kW each
 - One (1) HOK boiler with an installed capacity of 50 kW
 - One (1) Stadler boiler with an installed capacity of 35 kW
- (Total: 814.9 kW or approximately 0.815 MW).

During the winter season the abovementioned boilers were in use 24 hours a day for heating and warm water production purposes. During the summer season, only one Neovulkan Zrenjanin boiler was in use for 12 hours a day for warm water production. All the boilers were coal-fired with an annual consumption of lignite coal sourced from Kreka Mine of approximately 970 tonnes per year. This system was also not equipped with any particulate removal installations.

The dispersion model that has been developed within the project has shown that the impact of air emission from the combustion of coal in the Slavinovici Hospital boilers is relatively low. In addition to the reduced consumption of coal in comparison with Gradina Hospital and the Dragodol community, it should be noted that this boiler room uses coal from Kreka mines, for which the SO₂ emission factor is 50% less than for the coal from Đurđevik Mine.

The total emission of SO₂ from the Slavinovici Hospital boiler facilities during the heating season amounts to 9.6 tonnes, of which 3.5 tonnes are NO_x, 5.9 tonnes are particulates and 1,010 tonnes are CO₂.

WORKS CONDUCTED IN SLAVINOVICI

Works involved a complete restructuring of the heating system and connecting it to the district heating system for winter-season heating and winter-season sanitary hot water supply. Completely restructured boiler rooms with coal-based boilers were turned into natural gas boilers for the supply of all-year-round steam, non-winter-season sanitary hot water and to serve as secondary heating system in case of a malfunction of the district heating.

Works included connecting the pipeline installation with the heat transfer station, and reconstruction and adaptation of the internal distribution network. Standard types of earthworks, demolition and construction works were also carried out, as required to connect the existing hospital buildings to the public hot water network.

In addition to this, delivery and installation of a compact thermal substation (KTP 650 ELTEC or equivalent), delivery and installation of a solar heating system (Solar Collector SKN 3.0s, Buderus product or an equivalent) have been conducted, as well as supply of pumps, construction works for a gas tank, thermal insulation and painting. Exact specifications are given in the Bill of Quantities which can be found at <http://ba.westernbalkansenvironment.net./content/view/84/1/lang/en/>

The preparatory and physical works at Slavinovici conducted over a 13-month period (see table 3) at a total cost of 526,958 USD (843,133BAM)² are expected to reduce toxic air pollutants by 19 tonnes and reduce CO₂ by almost 1,000 tonnes per heating season.

Table 3 • *Summary of Works in Slavinovici*

SLAVINOVICI HOSPITAL CLEAN UP WORKS		USD 526,959	JULY 2009 – JULY 2010												
PHYSICAL WORKS			J	A	S	O	N	D	J	F	M	A	M	J	J
Development of the Final Design	27,812.85 In Kind														
Tendering procedure - Company to conduct physical works	\$ 492,271.73														
Evaluation and contracting															
Physical works at Slavinovici hospital															
Ending of works															
Final commissioning of completed works															
SUPERVISION			JANUARY 2010 – JULY 2010												
			J	F	M	A	M	J	J						
Tendering procedure – Company/IIIE to do the supervision of physical works	\$ 6,874.37														
Evaluation and contracting															
Supervision of physical works at Slavinovici hospital															
Final report prepared															

.....
2 The exchange rate from June 2010 (1.6\$/BAM)

DRAGODOL AND TUSANJ LOCAL COMMUNITIES

Communities of Dragodol and Tusanj were previously covered by individual and separated residential heating systems.

The local community of Dragodol has a total of 29 apartment buildings units with 650 individual apartments (households) that were previously using solid-fuel heating systems (almost 100% based on coal). By connecting them to the district heating system, reduction of air pollution from these 650 households will be almost 100%, as the district heating system provides heating from waste energy (cogeneration process).

The dispersion model has shown that the impact of air emissions from the combustion of coal in home furnaces and boiler rooms on the quality of air with lower chimneys present in the Dragodol community area is restricted to the narrower area and thereby contributes to a greater degree of air pollution in the ground-level section of the atmosphere in the localities.

Previously the total emission of SO₂ from household furnaces in Dragodol community, during the heating season, amounted to 46.8 tonnes, 36.85 tonnes of NO_x, 80 tonnes of particulates, and 2,940 tonnes of CO₂.

WORKS CONDUCTED AT THE DRAGODOL COMMUNITY

The works have now connected the local community of Dragodol/Tusanj to the district heating system, covered by a completely new hot-water pipeline network. In total, this connects 650 residential households to the district heating system (capacity exists to connect a further 100 residential units to the new network).

This initiative was implemented in two phases:

PHASE 1: building a new Main Heating Pipeline 1.6 km in length;

PHASE 2: purchasing and installing 31 heating sub-stations.

Works involved completely restructuring the heating system and connecting it to the district heating system for winter-season heating. For the main heating pipeline, this involved supply installation, and connection of the three (3) district heating branches for connection to the targeted housing buildings which included supply and fitting of pre-insulated pipes, seamless steel pipes and thermal insulation and paintings.

Works also included connecting pipeline installation with the 31 heat transfer stations installed by the municipality, and reconstruction and adaptation of the internal distribution network. Standard types of earthworks, demolition and construction works were also carried out, as required to connect pipelines, substations and housing to the public hot water network. Exact specification is given in the Bill of Quantities which can be found at <http://ba.westernbalkansenvironment.net./content/view/84/1/lang,en/>

The preparatory and physical works at Dragodol conducted over a 10-month period (see table 4) at a total cost of 1,031,337 USD (1,650,140 BAM)³ are expected to reduce toxic air pollutants by 163.65 tonnes and reduce CO₂ by almost 3,000 tonnes per heating season.

It has been calculated this would give a reduction in average concentrations of SO₂ of up to 30 µg/m³, PM₁₀ of up to 25 µg/m³, and NO_x of up to 4 µg/m³.

.....
3 The exchange rate from June 2010 (1.6\$/BAM)

Table 4 • Summary of Works in Dragodol

DRAGODOL COMMUNITY PHYSICAL WORKS		USD 1,031,339	OCTOBER 2009 – JULY 2010											
CLEAN-UP WORKS			A	S	O	N	D	J	F	M	A	M	J	J
Development of Final design	\$ 29,339.78													
Revision of the Final Design	\$ 5,466.67													
Actual physical works implementation Municipality Tuzla contribution in-kind	\$ 343,718.60													
Tendering procedure for physical works	\$ 644,477.11													
Evaluation and contracting														
Actual works implementation														
Ending of works														
Final commissioning of completed works														
SUPERVISION			JANUARY 2010 – JULY 2010											
			J	F	M	A	M	J	J					
Tendering procedure - Company/ IIE to do the supervision	\$ 8,334.77													
Evaluation and contracting														
Supervision of physical works at Dragodol community														
Final report prepared														

REFERENCES

1. *ANALYSIS OF EFFECTS OF EMISSION REDUCTION FROM GRADINA AND SLAVINOVICI HOSPITALS, AND DRAGODOL COMMUNITY, AFTER CONNECTION ON THE DISTRICT HEATING NETWORK IN TUZLA*, Martin Tais 2010, Bosnia and Herzegovina Contact for Air Quality and Emission Inventory to the European Environment Agency, for UNDP Bosnia and Herzegovina;
2. *REDUCTION OF AIR POLLUTION THROUGH CONNECTING THE TUZLA CLINICAL CENTRE TO THE DISTRICT HEATING SYSTEM, AN ENVIRONMENTAL ASSESSMENT*, Bosna S Oil Services Company 2009, for UNDP Bosnia and Herzegovina;
3. *STRENGTHENING CAPACITIES IN THE WESTERN BALKANS COUNTRIES TO MITIGATE ENVIRONMENTAL PROBLEMS THROUGH REMEDIATION OF HIGH PRIORITY HOT SPOTS*, UNDP September 2007.

WATER POLLUTION AND WASTE



Location
MUNICIPALITIES OF VRBAS AND KULA
Republic of Serbia

PROJECT WORKS

Construction of 6.6 kilometres of new sewerage network (main wastewater collector), for collecting industrial and communal waste waters from industry and the community of Vrbas and Kula and surrounding settlements for treatment and to prevent the ongoing pollution of the Grand Backa Canal.



ABSTRACT

The works at Vrbas and Kula Municipality, conducted by the company “Graditelj NS” involved construction of a new waste water network i.e. main wastewater collector to connect two (2) municipalities and over twenty (20) industries to a new wastewater treatment system (central waste water treatment plant and wastewater network). This would permit the second phase of stopping further pollution of the Grand Backa Canal by an estimated 30,000 m³ of wastewater per day, and finally the third phase, to allow works on remediating the 400,000 m³ of polluted sludge in the canal to commence. With a planning period of 19 months and a construction period of 11 months, 6.6 km of pipeline was constructed at a total cost of USD 3.7 million including a USD 1.7 million contribution from the Government of the Netherlands for phase IV-1 and a USD 2 million contribution from the Serbian Government for Phase IV-2 and V.

Table 5 • *Summary of Clean-up Works in Vrbas and Kula*

LOCATION/ TYPE	COST OF WORKS (rounded values) IN USD	LENGTH OF WASTEWATER PIPE INSTALLED (rounded values) LINEAR METRES	ESTIMATED CAPTURE OF WASTE WATERS (rounded values) m ³ /yr
PHASE IV-1	1,800,083	2,060	1,560,000
PHASE IV-2	649,900	1,960	
PHASE V	1,265,677	2,610	
TOTAL	3,715,660	6,630	

LOCATION

The above works are located in the northwest of Vojvodina, Republic of Serbia, in an area known as Backa. Municipality of Vrbas is in the southeast of the South Backa region and the Municipality of Kula is in the centre of the West Backa region. The surrounding area is rich agricultural land and houses associated food production facilities.

The Danube-Tisza-Danube Canal, known in short as the DTD Canal or Veliki Backi Kanal (the Grand Backa Canal), was built in the 18th century, partly for transport and water supply, but also with the purpose of draining the wet and fertile soils of the Backa district of Vojvodina. It connects the Danube River in the west with the Tisza River in the east. The Grand Canal of the territory of Backa between the cities of Bezdán and Becej has a total length of approximately 130 km running west to east.

In the 20th century, the eighteen (18) kilometre-long area between Crvenka, Kula and Vrbas on the banks of the canal became heavily industrialized. This in turn resulted in an increase in settlement of these small towns along the canal such as Crvenka, Vrbas and Kula with a current total population of 57,000 people for these three towns.



ENVIRONMENT SITUATION

Overtime the canal became increasingly polluted, and in the worst stretch around Vrbas the canal has become more or less filled with industrial sludge from food processing factories, pig farms, slaughterhouses, edible oil factories, metal processing and untreated sewerage from the towns. In addition to the highly contaminated water an estimated 400,000 m³ of highly contaminated sludge is contained within the 6 km of the canal running through the populated part of Vrbas town.

An estimated 30,000 litres of wastewater enters the canal each day while the three towns of Crvenka, Kula and Vrbas have an estimated hydraulic load of 11,400 m³/day. Due to the lack of treatment of these industrial and municipal waters, the section of the Grand Canal running through Vrbas for six kilometres, has become so degraded with accumulated and continued effluents and solid wastes that it is considered the most polluted water course in Europe.

The waste waters and limited water that flows in the Grand Backa Canal network result in the sedimentation of suspended matter, heavy metals, biodegradable organic matters, mineral oils and faecal microorganisms in extremely high concentrations.

In relation to water quality, the water quality monitoring conducted on the Grand Backa Canal in 2008 show that profiles 3 (downstream the lock and entrance of the lateral canals), 8 (upstream of Vrbas, between sugar factory and Kula) and 9 (before entrance into I-64) are extremely polluted with microbes, physical-chemical and chemical parameters that are equal to sewerage water values (Ref 2).

The environmental and human health situation caused by the existing and continuing pollution of the Grand Backa Canal is very serious. This relates both to the very close proximity of communities to the waters themselves and the general impact of the pollution on the canal.

In relation to human health, the quality of the water is very similar to sewerage water and presents both a microbiological risk from coliform bacteria, E. coli and Enterococcus bacteria and viruses that are present. There is also a major risk from eutrophication including very high levels of nitrates that are present in the waters which can be responsible for "blue baby" syndrome which is caused by nitrate toxicity.

Therefore, it can be concluded that the waters are quite toxic to people if they are exposed to them. In addition to this there is a major odour impact from the canal itself especially in the warmer months of the year which heavily impacts on the communities clustered along the banks of the canal.

From an environmental health view much of the canal within a 5 km radius of the factories is almost biologically dead. The high levels of nutrients from the food processing factories result in all of the oxygen being removed from the water, killing any fish or macroinvertebrates present through suffocation.

This situation will continue until the factories stop discharging their effluents into the canal and the existing pollution present in the canal is removed.

INTERVENTIONS

The clean-up project of the Grand Backa Canal had already been initiated by the Municipality of Vrbas and the Autonomous Province Vojvodina. The whole project consists of 3 subprojects:

1. Construction of a new sewerage network, for collection of pre-treated industrial waste waters, communal waste waters of Vrbas and the surrounding settlements.
2. Central Waste Water Treatment Plant (Vrbas, Kula) – development of design documentation in progress, financial resources provided by Autonomous Province and Republic of Serbia.
3. Clean up and remediation of the Grand Backa Canal (planning and preparation of ToRs in progress).

Sub-project 1 “Construction of a new sewerage network” was the focus of this programme.

Works involved the construction of a new sewerage network for collection of pre-treated industrial waste waters, communal waste waters of Vrbas, Kula and the surrounding settlements. This basically involved building the missing part of the main wastewater collector of the Vrbas-Kula sewerage network.

It was divided into 3 phases of pipe construction over quite different terrain. This included Phase IV.1 which involved constructing 2,062 m of wastewater pipeline, Phase IV.2 with 1,958 m of pipeline and Phase V which included 2,609 m of pipelines as shown in the figure below.





Figure 1 • **Wastewater collector phases IV.1, IV.2 and V (Ch. Km 5+999 – km 12+624 and Pumping stations “Kula1” and “Kula 2”)**

Phase IV.1 was covered with the contribution from the Netherlands of USD 1,685,000 and construction was completed in a period of 90 days. Phase IV.2 was completed in a period of 40 days as part of the government contribution at a cost of USD 584,000. Phase V, with construction to commence in September 2010, is planned for 40 days as the final government contribution costing USD 1,171,771.

These works completed an important missing part of the main wastewater collector and included the following construction elements:

- Completed sections Phase IV.1, Phase IV.2 to the municipal border line Vrbas-Kula and Phase V (works started in September 2010). The chainage km 5+999 to km 12+624.
- Construction of the Pumping station “Kula 1” (at Ch. km 12+624) to pump collected waste waters of the town Kula (works planned within Phase V in September/October 2010).

- Construction of the Pumping station “Kula 2” at Ch. Km 11+049 to pump waste waters through the main wastewater collector (works planned within Phase V in September/October 2010).
- Construction, installation of the required electrical supply facilities (works planned within Phase V in September /October2010).

The collector is PEHD pipe of diameters: Phase IV.1 – Ø800 and Ø1000 mm, Phase IV.2 - Ø800 mm, Phase V – Ø500 and Ø700 mm. The pipeline is dimensioned to allow maximum flow of 680 l/s. The ring stiffness of the installed pipe is $SN \geq 8.0$ KN/m², higher than requested by the Technical specifications, due to heavy and unfavourable foundation (high ground water level) and exploitation (sewage) conditions.

Interception With Existing Infrastructure

PHASE IV.1 – At several points the collector intercepted with the existing infrastructure, e.g. the Sombor – Becej railway line, M3 regional road and the canal network-KC III lateral canal. For example, at intersection with the KC III canal, the canal bottom and sides were covered with reinforced concrete slab of length $L=12$ m to provide pipeline stability. These works lead to an extended construction period (90 days) and cost (USD 1,685,000) for 2,062 m of pipeline.

PHASE IV.2 – For this phase there were no such intersections which therefore permitted a shorter construction period (40 days) and a lower cost of works (USD 584,000) for 1,958 m of pipeline which is less than the time and cost for Phase IV.1.

PHASE V – There will be intersections with the lateral I-64 canal (right delta) 30 m long, the local road near the “Kula 2” PS and with exiting sewage collector in the vicinity of “Kula 1” PS. Construction time is calculated at 40 days at a cost of USD 1,900,000 for 2,609 m of pipeline.

The pumping station Kula 1 to be constructed is a sewage pump with a capacity of 127 l/s, with two operational pump units, a lifting height (pump head) of 5 m and installed power of 9 kW.

The pumping station Kula 2, which is constructed, is a sewage pump of 155 l/s capacity, with two operational pump units, a lifting height (pump head) of 5.4m and installed power of 14 kW.

The electrical block (facility) includes: electrical supply cable, construction of transformer stations, installation of switch gears and SCADA (Supervisory Control and Data Acquisition) systems.

Both pumping stations and the electrical block will be built as part of Phase V. The costs of this are calculated in the total cost of Phase V and the works will be paid by the Government of Serbia through Ecofund, the national fund for environment protection.

Preparatory And Earth Works

The excavation of the pipeline trench was predominantly in loess and loessid clays, the average excavation depth was 4m.

Lowering of the ground water level was provided by the construction of a longitudinal drainage layer along the trench bottom made of coarse grained river gravel, "iberlauf", of a thickness of 40 cm, and pumping the water out. The drainage layer also serves as a strengthened foundation layer/base for the collector pipes.

Before pipe installation, geotextile "geofilc T-300" was placed on top of the drainage layer and trench sides at a minimum height of 1 m to prevent infiltration of sand into the foundation.

After installation of the pipe and manholes, the trench was backfilled, with material from the excavation, placed and compacted in 30 cm layers. The revision manholes were precast reinforced concrete manholes. The total number of manholes for Phase IV.1 was 20 pcs, for Phase IV.2 20 pcs and for Phase V will be 34. Typical cross-sections for the manhole and collector are given below.

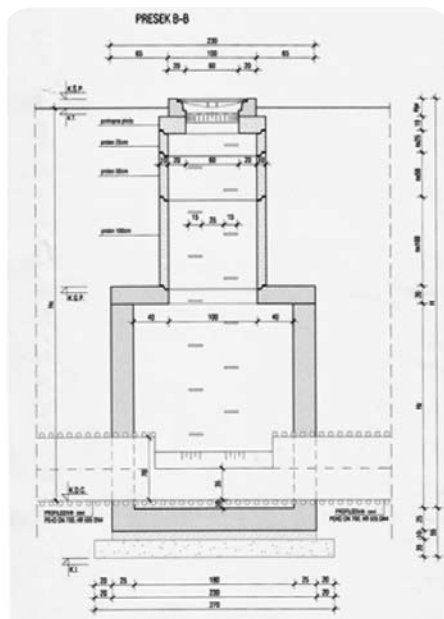


Figure 2 • *Manhole – typical cross section*

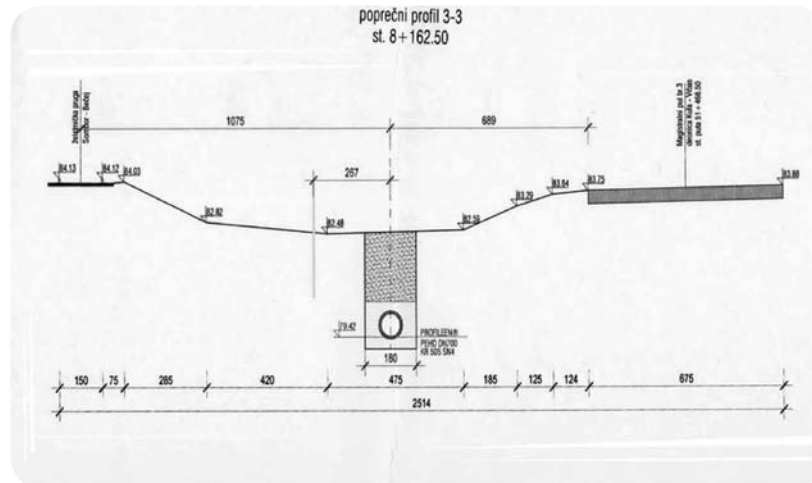


Figure 3 • *Typical cross section HDPE collector*

Commissioning

Phase IV.1 and IV.2 collectors were successfully hydraulically tested and the inside of the collectors inspected and recorded by video camera. Both sections were technically accepted following the formal procedure as per the Serbian Law on Planning and Construction and fully functional.

The total capacity will be 30,000 m³/day of wastewaters, which will be taken to CWWTP once it is constructed, and not discharged into the canal.

For the second phase of this cleanup, calls for tenders for the CWWTP were announced in June 2010 with an expected construction period of 2 years and start of operations by the end of 2012 or beginning 2013. This will be using EU Accession funding of an amount of approx. EUR 13 million (Ref 5). When this is completed and discharges into the canal stopped, the third phase will commence, which is the remediation of the canal itself, sludge removal, treatment of contaminated sludge sediment and its disposal. The third phase is expected to start in 2012 and finish in 2013 at a cost estimate of approximately EUR 20.8 million.



Table 6 • Summary of Works in Grand Backa Canal


GRAND BACKA CANAL - PHYSICAL WORKS		MARCH 2008–OCTOBER 2010										
PHASE IV.1 Ch km 5+999 - km 8+061	\$ 1,800,083	JANUARY 2008–OCTOBER 2008										
		J	F	M	A	M	J	J	A	S	O	
Final design for phase IV.1 developed	5,100											
Revision of final design	101,093											
Preparation of technical tender package												
Supervision of works												
Tendering procedure for a company to conduct physical works	9,000											
Evaluation and contracting												
Actual works implementation	1,684,890											
Final commissioning of completed works												
PHASE IV.2 Ch km 8+061 - km 10+019	\$ 649,904	JULY 2009–MAY 2010										
		J	A	S	O	N	D	J	F	M	A	M
Final design for phase IV.2 developed	6,500											
Revision of final design	34,986											
Preparation of technical tender package												
Supervision of works												
Tendering procedure for a company to conduct physical works	9,000											
Evaluation and contracting												
Actual works implementation	599,418											
Final commissioning of completed works												
PHASE V Ch. km 10 +019- km 12+628	\$ 1,265,677	SEP-OCT 09			MAY 2010–OCTOBER 2010							
		A	S	O	M	J	J	A	S	O	N	D
Final design for phase V developed	14,600											
Revision of final design	70,306											
Preparation of technical tender package												
Supervision of works												
Tendering procedure for a company to conduct physical works	9,000											
Evaluation and contracting												
Actual works implementation	1,171,771											
Final commissioning of completed works												

REFERENCES

1. *COUNTRY COMPONENT SERBIA – REMEDIATION OF THE GRAND BACKA CANAL – PROJECT DOCUMENT – WESTERN BALKANS ENVIRONMENTAL PROGRAMME*, UNDP Serbia 2009, Dobrila Simic, Vera Cvejic, Tomislav Djivuljskij;
2. *COUNTRY COMPONENT SERBIA – MONITORING OF THE GRAND BACKA CANAL – WESTERN BALKANS ENVIRONMENTAL PROGRAMME*, UNDP Serbia September 2008, Dobrila Simic, Vera Cvejic, Tomislav Djivuljskij ;
3. *STRENGTHENING CAPACITIES IN THE WESTERN BALKANS COUNTRIES TO MITIGATE ENVIRONMENTAL PROBLEMS THROUGH REMEDIATION OF HIGH PRIORITY HOT SPOTS*, UNDP September 2007;
4. *PILOT EVALUATION STUDY FOR THE TREATMENT OF CONTAMINATED SLUDGE SEDIMENT OF GRAND CANAL* , Final Report, Deconta, October 2006;
5. *PROJECT FACT SHEET VRBAS/KULA –VELIKI BAČKI CANAL – WASTEWATER TREATMENT AND SEWAGE COLLECTION PROJECT VRBAS/KULA* http://www.vrbas.net/dokumenti/razno/fs_vrbas_kula_en.pdf

CHEMICAL REMOVAL AND DESTRUCTION



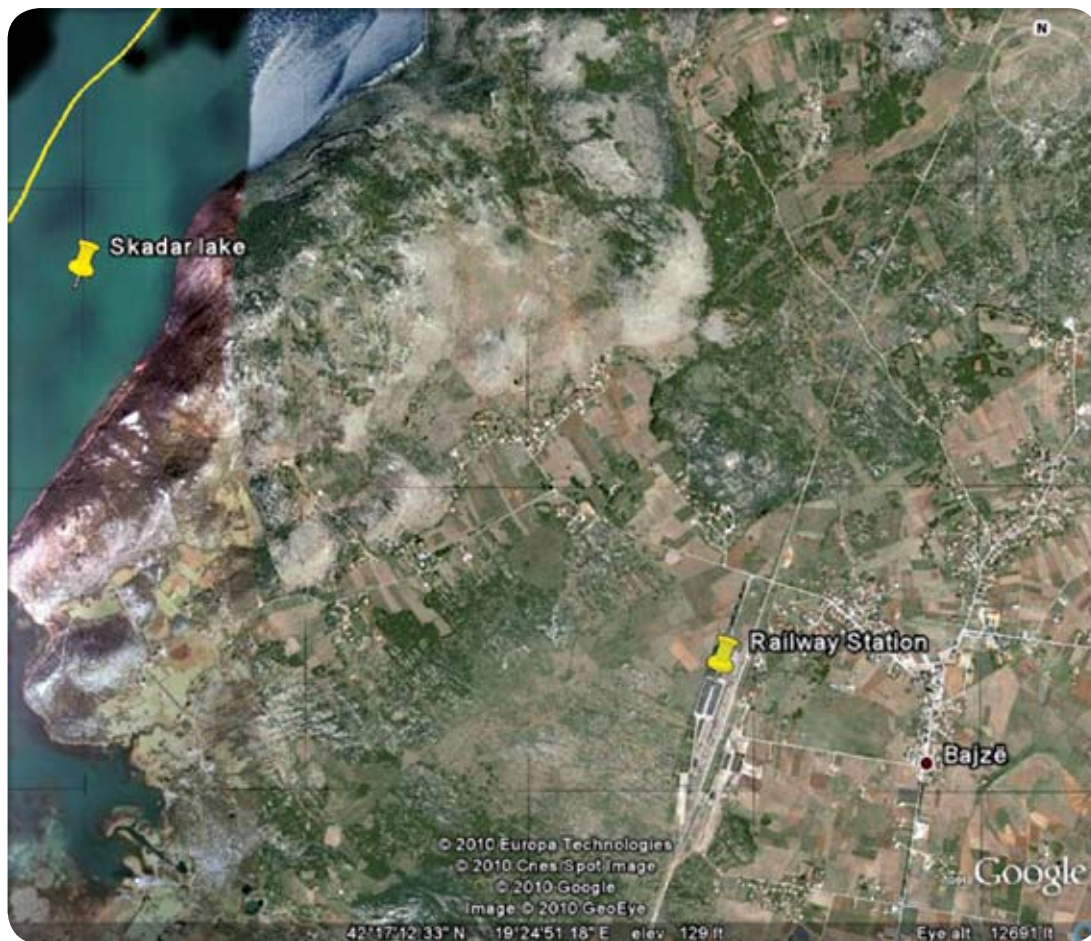


INDUSTRIAL
CHEMICALS
AND
LEATHER
WASTE

Location
BAJZA RAILWAY STATION, SHKODRA MUNICIPALITY
Albania

PROJECT WORKS

Investigating the impact on the site from the past storage of pesticides and hazardous waste and classifying, repackaging and removing toxic waste from the site through export to an international disposal facility.



ABSTRACT

The clean-up works at Bajza, conducted by the UK Company "Arundelle", resulted in the removal of 81.5 tonnes of waste from the site, with 65 tonnes to a landfill in Albania and 16.5 tonnes exported internationally, and verification that the site was clean. The original quantity of waste identified on the site was 280 tonnes, which leaves a surplus of 198.5 tonnes. Total clean-up costs were USD 346,000 with a contribution from the Government of the Netherlands of USD 222,000 and from the Albanian Government of USD 109,000 (USD 94,000 in cash and USD 15,000 in kind). Repackaging, temporary storage and disposal within Albania was completed in 4 months. However considerable delays (more than 1 year) and technical difficulties were encountered in exporting the 16.5 tonnes of waste for final disposal in the United Kingdom, related to the nature of the waste and apparent limited disposal options available there.

Table 7 • *Summary of Clean-up Works in Bajza*

WASTE TYPES	QUANTITY (rounded values) TONNES ACTUAL (*Original Estimate)	DISPOSAL LOCATION – COUNTRY	COST OF DISPOSAL (rounded values) IN USD
SODIUM FLUOROSILICATE (concentrate)	12 (*80)	United Kingdom (International Export)	6,250 (per tonne)
LEATHER WASTE (Contaminated)	4.5	United Kingdom (International Export)	1,560 (per tonne)
LEATHER WASTE	65 (*200)	Albania (National Disposal)	144 (per tonne)
TOTAL	81.5 (*280)		316,000

Note: The table shows total costs of disposal and per unit disposal costs (separately). Total costs also include repackaging, national/international transport, permit and storage costs.

LOCATION

Bajza is a small town (Kastrioti Commune) situated in the northern part of Albania, about 25 km from the city of Shkodra and about 2 km from the Montenegrin border. The railway station of Bajza is located on the shore of the border-straddling Lake Shkodra and all railroad transportation to and from Montenegro passes through Bajza railway station and its customs clearance (approximately 10,000 tonnes of freight are handled each month).

Before 1990 in Albania industry accounted for the largest share of GDP – about 58% using the country's rich chromites and copper deposits that are found in the north-central and northern parts of the country. Albania has also been subject to 25 years of oil and gas exploration in the south-western parts of the country. After the start of the transition period, however, industrial production decreased considerably owing to the closure of the main branches of heavy industry and by 1999 the share of industrial production in the GDP was only 11.9%.

UNEP-commissioned studies in 2000 and 2006 revealed that many of these closed industrial sites pose serious risks to human health and the surrounding environment.

In addition to these two main studies on environmental hotspots, a number of additional environmental hotspots have also been identified by the Ministry of Environment, Forestry and Water Management based on the information and request for interventions received from the local governments, as well as other donor programmes that focused on chemical management.

NEAP Albania (2002) reported that an estimated 3,100 tonnes of chemicals were sitting in the public economy sector and 1,000 tonnes of pesticides were sitting in the agricultural sector and many of them were obsolete stock and represent different levels of risks for health and the environment and should be effectively managed. However, there is still no accurate inventory of these substances at the national level and there is no plan to avoid or minimize their threat as hazardous waste.



ENVIRONMENT SITUATION

In the early 1990s an estimated 200-250 tonnes of hazardous chemicals (expired pesticides like Rrogor, vofatox, nogos, selinon, novakrom, spitsornit, 2-4 D, fugorat, sevin, lindane) and other materials were put together in one of the storage houses of the Bajza railway station. The origin of the chemicals was not quite clear, however during 1991-1992 the German company Schmidt-Cretan imported and temporarily stored in Bajza 480 tonnes of hazardous chemicals including toxaphene and phenyl mercury acetate, both of which have been banned in the EC since 1983. Although most of these pesticides were returned to Germany in 1993 for safe disposal, people from the surrounding area had raided the station and took many of the barrels emptying toxic chemicals directly in the railway station and storehouses. It was also reported that several sheep that had grazed around the storehouse and on the downhill side of the railway station had died after the incident took place. Moreover, in the following years fishermen on Lake Shkodra reported masses of dead fish in the lake.

Site visits conducted revealed that the bags of chemicals stored at the site were torn and the contents had been mixed with small pieces of leather (10-15 cm) stored in the same storehouses. The pieces of leather had been stored for many years to be exported to Hungary as a raw material for glue making. However, it was concluded that these pieces of leather were contaminated beyond re-use and should be safely disposed together with the rest of chemicals. The site visits also indicated that the whole storage area needed to be decontaminated under the strictest safety concern to avoid leakages of chemicals to the border-straddling lake.

While previous information indicated that the site was contaminated (i.e. the soils and the water) and had pesticides, originating from a train in 1992/1993 stored on the site, no actual assessment of either the waste or the site had actually been conducted. To address this gap in information, a German Company, Montec GmbH, was tasked with completing a preliminary site investigation and to classify the waste present on the site at a cost of USD 74,000 over a 3-month timeframe in 2008. The investigation using water and soil samples found no evidence that any contamination remained on the site. It also found from the samples taken from the waste that no pesticides were stored on the site, only the industrial chemical sodium fluorosilicate (Na_2SiF_6) (an estimated 80 tonnes) and the waste leather (an estimated 200 tonnes) in the railway storehouse.

Sodium fluorosilicate is both a dangerous good and a hazardous waste that can contaminate water and presents a toxicity risk to both human and the environment. It therefore does require special treatment, handling and repackaging before it is able to be disposed in a landfill or incinerated to remove its toxic properties (soluble fluoride). Removal from the site therefore remained a priority so that the site was then clean and able to be reused without an ongoing risk to the community.



INTERVENTIONS

Following the preliminary investigation a company from the United Kingdom, Arundelle, was contracted to repackage, transport and dispose of the waste and to reinstate the storehouse so it could be used, at a total cost of USD 316,000.

Investigations conducted by “Arundelle” found only 81.5 tonnes of waste in total present on the site, almost 200 tonnes less than the 280 tonnes predicted by the Montec and other previous reports. Of these 81.5 tonnes only 16.5 tonnes were classified as hazardous and required export internationally. The remaining 65 tonnes of waste (mostly leather) was classified as non-hazardous waste and could be disposed of within Albania.

Work on the site was conducted through a primarily manual process using appropriate personnel protection equipment including, butyl nitrile gloves, full facemasks with filters and disposable chemical suits. The site was also cordoned off into working areas, restricted areas and an emergency chemical shower and site shed organised to control access to the site and ensure all personnel were properly inducted and/or escorted in accordance with the site operational procedures.

As far as operations on the sites were concerned, “Arundelle” personnel separated the waste into three waste streams:

1. Uncontaminated leather waste (i.e. containing less than 1% Sodium Fluorosilicate);
2. Contaminated leather waste (i.e. containing more than 1% Sodium Fluorosilicate) and
3. Sodium Fluorosilicate concentrate (96% pure).

The uncontaminated leather waste was collected into sixty-five 1-tonne Bulk Bags and disposed at the Shkodra city landfill through the Albanian Company "Borshi shpk" in September 2009. The approximate disposal cost for the uncontaminated leather waste land-filled in Albania was EUR 110 per tonne (USD 158.30 per tonne, as per the exchange rate of September 2009).

The contaminated leather waste and sodium fluorosilicate concentrate were packed into one hundred and forty-three (143) separate 205-litre drums suitable for packing class 3 wastes in accordance with international dangerous goods codes and the Basel Convention.

These drums were initially removed from the site at Bajza to a temporary storage location in Tirana until international shipments were finalised. Initially this was expected to occur in late 2009 with disposal costs expected to be GBP 375 per tonne (USD 613.75 per tonne, as per the exchange rate of September 2009).

However complications in treating the sodium fluorosilicate to reduce the solubility of fluoride in the waste by stabilisations/solidification with cement and proprietary products caused delays into the first quarter of 2010 and eventually cancellation when the disposal company "Augean" raised the price to GBP 12,000 per tonne (USD 18,100 per tonne as per the exchange rate of July 2010, which is 32 times the original price when calculated in UK currency).

"Arundelle" then changed disposal companies in the UK to Grunden Waste Management using the "Tradebe" Incinerator in the UK to dispose of the waste. Due to complications with the sodium fluorosilicate (damaging fluxing properties at high temperature) disposal costs remained high at GBP 1,000 per tonne (USD 1,508 per tonne as per the exchange rate of July 2010) for the contaminated leather wastes and GBP 4,000 per tonne (USD 6,033 per tonne as per the exchange rate of July 2010) for the concentrated sodium fluorosilicate.

This resulted in increased disposal costs by a further USD 30,000 bringing the total to USD 346,000. New permits also needed to be obtained throughout the transit points as well from the UK and Albanian Environmental ministries. With all the required paperwork obtained the waste is to be shipped out till the end of 2010, finalising the removal of waste from the Bajza Railway Station and the cleanup of the surrounding areas of Lake Shkodra and the Bajza community.




Table 8 • *Summary of Works in Bajza*

BAJZA STOREHOUSE	USD 420,400	SEPTEMBER 2008 – SEPTEMBER 2009												
		S	O	N	D	J	F	M	A	M	J	J	A	S
PHYSICAL WORKS														
Preliminary Site Investigation prepared	\$ 74,400													
Tendering procedure for clean-up of Bajza	\$ 346,000													
Evaluation and contracting														
Implementation of actual works														

REFERENCES

1. *PRELIMINARY ENVIRONMENTAL ASSESSMENT, RISK ASSESSMENT AND PREPERATION OF BIDDING DOCUMENTS AND ACTION PLAN FOR REPACKAGING AND TEMPORARY STORAGE OF HAZARDOUS CHEMICALS*, Montec GmbH, Western Balkans Environmental Program UNDP Albania, November 2008;
2. *STRENGTHENING CAPACITIES IN THE WESTERN BALKANS COUNTRIES TO MITIGATE ENVIRONMENTAL PROBLEMS THROUGH REMEDIATION OF HIGH PRIORITY HOT SPOTS*, UNDP September 2007;
3. *LAKE SKADAR/SHKODRA INTEGRATED ECOSYSTEM MANAGEMENT PROJECT*, Ministry of Tourism and Environment of Montenegro (MoTE), Ministry of Environment, Forests and Water Administration of Albania (MEFWA), World Bank, GEF, April 2007;
4. *KASTRIOT COMMUNE LETTER TO MINISTER OF ENVIRONMENT*, June 2006;
5. *INDUSTRIAL WASTE IN ALBANIA, CASE #359, GREENPEACE 1996.*

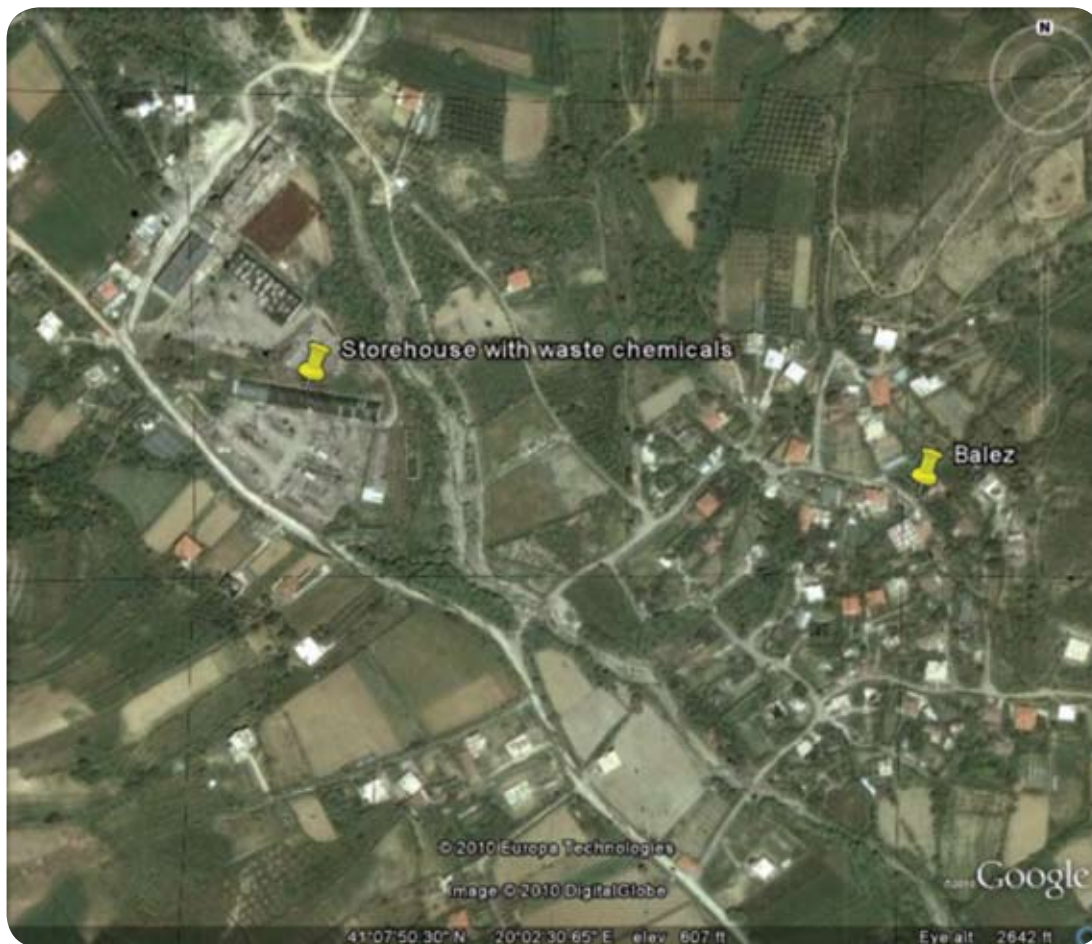


MIXED
INDUSTRIAL
AND
MILITARY
INDUSTRIAL
WASTE

Locations
BALEZ – GOVERNMENT CHEMICAL STOREHOUSE, ELBASAN MUNICIPALITY
KUKES, VERTOP, MENGAL, QAF MOLLE,
BRAR – MINISTRY OF DEFENCE CHEMICAL STOREHOUSES
Albania

PROJECT WORKS

Classifying, repackaging and removing approx. 216 tonnes of hazardous waste stored in government and military storage facilities at (6) different locations for export and destruction at international disposal facilities in Belgium, Germany and Greece.



ABSTRACT

The clean-up works at the Balez government chemical store and surrounding Ministry of Defence (MoD) storehouses resulted in the removal of approx. 216 tonnes of waste from those sites for export to Greece, Germany and Belgium for treatment, disposal to landfill or incineration by the Greek Company EPE. The total cost was approx USD 476,000 with a contribution of USD 359,000 from the Government of the Netherlands, a USD 117,000 cash contribution from the Albanian Government with a further USD 60,000 in kind including USD 18,600 for barrels, pallets and transport from the Organisation for Security and Cooperation in Europe (OSCE). The total time of the works included 4 months for planning and 7 months for all repackaging and export. Initial repackaging works progressed rapidly with 100 tonnes at Balez and at a later stage a further 110 tonnes of MoD waste. Pre-export testing revealed approx. 14 tonnes of the Balez waste was unable to be exported under this programme's lifetime, as it was found to be radioactive. A further 20 tonnes of MoD waste was substituted in place of this waste.

Table 9 • *Summary of Clean-up Works in Balez*

WASTE TYPES	QUANTITY (rounded values) TONNES	DISPOSAL LOCATION – COUNTRY	COST OF DISPOSAL (rounded values) IN EUR/TONNE
AMMONIUM NITRATE (NH ₄ NO ₃), AMMONIUM NITROGEN, ALOH ₃ , FE ₂ O ₃ , CONTAMINATED SOILS (LIGHT), CONTAMINATED PACKAGING MATERIALS	30	GREECE (International Export)	600–800
DICHLOROETHANE	130	BELGIUM (International Export)	1000–1300
LABORATORY WASTE, ADIPIC ACID	5	BELGIUM (International Export)	1000–1300
ARSENIC SALTS, CYANIDE SALTS, CONTAMINATED SOILS (HEAVY), BaCl ₂ , Na ₂ SO ₄ , NH ₄ Cl, STEARAT	51	GERMANY (International Export)	700–900
TOTAL	216		476,000

Note: The table only shows total costs and per unit disposal costs (separately). Total costs also include repackaging, national/international transport, permit and storage costs.

LOCATION

The primary cleanup location was the chemical depot located in a small village called Balez, 5 km north of Elbasan city. The store at Balez is owned by the Ministry of the Economy, Transport and Energy (METE), and managed on their behalf by NFI Meniera Company (NFIM). The storage started in the nineties when most industries were closing down. The first chemicals stored at this depot came from an uncontrolled stock of chemicals in a tunnel near Balez.

The site covers approximately 10,000 m². It is protected by a high wall, and is comprised of the following:

- A semi-cylindrical storehouse of 100 metres in length, in good condition with a concrete base. This depot is constructed/adapted for storage of chemicals.
- A large timber shed with surface area of 500 m² in very poor condition.
- A house for the site staff, together with an orchard and beehives.
- A significant open space suitable for temporary location of containers.

On the perimeter of the site are two large 2-storey buildings, one of which houses a wood processing business on the ground floor, and the local school on the first floor. The second building appears derelict, but may be in use. On the east side of the site there is a small stream (distance < 100 metres) that is connected to the River Shkumbin. Agricultural land and family houses surround the site and at a distance of 200 metres there is the village school.



In 2008 a national hotspots identification programme implemented by the UNDP and funded by the Government of the Netherlands identified the chemical storage site of Balez and a number of other related chemical storage sites of concern. The Ministry of Industry and Energetics (now the Ministry of the Economy, Transport and Energy), therefore arranged for the identification and removal of dangerous materials in premises under their jurisdiction, and their transport to a central storage site in the village of Balez, close to the city of Elbasan.

Materials from institutions under the control of other ministries (e.g. the Ministry of Health) have also been sent to the store. The store contains several buildings, one of which is in good condition but the others are not so. The site is permanently managed and guarded; however it is close to residential properties and a school, close to a tributary of the River Shkumbin and therefore represents a potential major hazard.

ENVIRONMENT AND HUMAN HEALTH SITUATION

There has been little environmental or human health monitoring conducted within the vicinity of this storehouse. The clean-up is therefore based on a precautionary move due to the presence of sometimes poorly packaged and/or unknown chemical waste and given the proximity to watercourses (River Shkumbin), residential properties, school and agricultural land.

As stated above, the storehouse was also filled to capacity with the chance that it might be overfilled and chemical stores would be stored in the open which could make the situation more problematic. This is why the site had also been identified as one of the priority sites within the National Hotspots identification programme as a priority for clean-up.

While new chemical stores will be located here, the expectations are that this will be conducted under more secure conditions than had existed previously due to on-the-job training of staff which occurred as part of this cleanup and better systems of classification and repackaging in the Albanian Regulatory and chemicals sector.

The materials contained in the Balez store were collected from a wide range of industrial sites around Albania. These sites included:

- A metallurgical complex at Elbasan;
- An industrial site at Lac;
- A fertiliser plant at Fier;
- A copper smelter at Rubik;
- A geological service laboratory in Tirana;
- Smaller industrial activities including textiles, ceramics, rubber, leather and shoes.

Initially these chemicals were collected in the late 1990's by the military, to ensure security during the difficult period following the disturbances of 1997-8. The chemicals were stored in a variety of packages, including drums, boxes, sacks, bottles and pressure vessels, and in a wide range of sizes, down to gram quantities in glass bottles.

In 2006 it was estimated that there were 68 different kind of chemical wastes stored in the depot with a total weight of 140 tonnes. This included chemicals as summarized in the table below:

Table 10 • *Types of Waste in Balez*

Adipic acid	3 tonnes
Arsenic waste	4 tonnes
Ferric oxide	5 tonnes
BaCl ₂	6 tonnes
Laboratory waste	7 tonnes
Cyanide salts	40 tonnes
Contaminated packaging	1 tonnes
Ca(C ₁₈ H ₃₅ CO ₂) ₂ calcium stearate	2 tonnes
ZnSO ₄	1 tonnes
Mixture of ammonium nitrate (33%)	2-3 tonnes
K ₂ O potassium oxide	200 kg
Mixtures of (BaCl ₂ ,KCl,Fe ₃ CN ₆ ,NaNO ₃ ,ZnCl ₂ ,SnCl ₂)	60-70 tonnes

In addition to the estimated 140 tonnes of chemical waste collected at Balez there were additional hazardous materials present at 'satellite' sites which were also to be repackaged and sent to Balez as part of this clean-up, up to an estimated quantity of 76 tonnes. These were expected to be similar types of waste and together the 140 tonnes from Balez and the 76 tonnes from the satellite sites would bring the total to 216 tonnes.

INTERVENTIONS

To carry out this chemical cleanup, a Greek company, Environmental Protection Engineering S.A (EPE), was contracted to repackage, transport and dispose of the waste, as well as to train the NFIM staff in practical chemicals management, at a total cost of USD 476,000.

Work on the site was conducted through a primarily manual process using appropriate personnel protection equipment. The site was also cordoned off into working areas and restricted areas and organised to control access to the site and ensure all personnel were properly inducted and/or escorted in accordance with the site operational procedures.

Initial repackaging of the chemical waste was combined with theoretical and practical chemicals management training for the nine (9) NFIM personnel responsible for the Balez chemical site. With repackaging completed on the site in February 2010 the company found that out of the original estimate of 140 tonnes of waste only 90 tonnes of waste were actually present. To counter this shortfall it was proposed that a total of 120 tonnes was brought to Balez from the 'satellite sites' managed by METE. However, the poor state of packaging at the satellite sites and minimal capabilities for METE resulted in only a further 12 tonnes of waste being transported from the satellite sites.



A further 110 tonnes of waste (dichloroethane) that could be included in the cleanup was identified through cooperation with the Albanian Ministry of Defence (MoD) and the Organisation for Cooperation and Security for Europe (OSCE). This waste is part of an estimated 400 tonnes of chemical waste under MoD jurisdiction at sites in Elbasan and Brar. The chemical waste was repackaged and transported to the port of Durres as part of the cost-sharing arrangement with the MoD and OSCE and initially included approx. 42.4 tonnes from Elbasan and a further 53 tonnes from Brar.

In July 2010 EPE conducted pre-export radiological screening of the Balez wastes and found that approx. 15 tonnes of the waste (13 tonnes of cyanide salts and approx. 2 tonnes of arsenic salts) contained unacceptable radioactive levels 2 to 6 times (200 cps to 500 cps) greater than background, which would make it illegal to transport under the existing permits. Given the time constraints a further 20 tonnes of MoD waste was substituted for the 14 tonnes of low-level radioactive waste which had already been safely repackaged and will remain under secure storage at Balez.

This increased the total amount of waste removed to 216 tonnes with 86 tonnes from Balez and the remaining 130 tonnes from MOD sites. As far as operations on the sites were concerned, EPE separated the waste into three waste streams based on disposal destination:

1. Disposal to Germany (Arsenic salts, cyanide salts, contaminated soils (heavy), mixture of salts (BaCl_2 , KCl , NaNO_3 etc.), Sodium sulphite (Na_2SO_3), NH_4Cl , stearat);
2. Disposal to Greece (Ammonium nitrate (NH_4NO_3), Ammonium Nitrogen, AlOH_3 , Fe_2O_3 , contaminated soils (light), contaminated packaging materials);
3. Disposal to Belgium (Dichloroethane, Laboratory waste, Adipic acid).

The wastes were packed into proper packaging: metal drums, canisters and big bags, all in accordance with the international dangerous goods codes and Basel Convention. The initial packaging of all the wastes and the proper packaging are summarized in the table below:

Table 11 • *Waste Packagings*

WASTE	INITIAL PACKAGING (NO UN APPROVED)	PROPER PACKAGING
DICHLORETHANE	METAL DRUMS 200 LT	METAL DRUMS 200 LT CLOSE TYPE UN APPROVED
ADIPIC	PLASTIC DRUMS 200 LT	METAL DRUMS 200 LT OPEN TYPE UN APPROVED
LABORATORY WASTE	NON	CANISTER OF 25 LT LIQUIDS/PLASTIC DRUMS OF 60 LT UN APPROVED
CYANIDES	METAL DRUMS 200 LT	METAL DRUMS 200 LT OPEN TYPE UN APPROVED
ARSENIC	METAL DRUMS 200 LT	METAL DRUMS 200 LT OPEN TYPE UN APPROVED
CONTAMINATED SOILS(HEAVY)	PLASTIC DRUMS 200 LT	METAL DRUMS 200 LT OPEN TYPE UN APPROVED
BaCl ₂	PLASTIC DRUMS 200 LT	METAL DRUMS 200 LT OPEN TYPE UN APPROVED
SODIUM SULFITE	PLASTIC DRUMS 200 LT	METAL DRUMS 200 LT OPEN TYPE UN APPROVED
Nh ₄ Cl	PLASTIC DRUMS 200 LT	METAL DRUMS 200 LT OPEN TYPE UN APPROVED
STEARAT	PLASTIC DRUMS 200 LT	METAL DRUMS 200 LT OPEN TYPE UN APPROVED
AMMONIUM NITRATE	PLASTIC DRUMS 200 LT	METAL DRUMS 200 LT OPEN TYPE UN APPROVED
AMMONIUM NITROGEN	PLASTIC DRUMS 200 LT	METAL DRUMS 200 LT OPEN TYPE UN APPROVED
CONTAMINATED SOILS (LIGHT)	PLASTIC DRUMS 200 LT	BIG BAGS UN APPROVED
Al ₀ H ₃	PLASTIC DRUMS 200 LT	BIG BAGS UN APPROVED
Fe ₂ O ₃	PLASTIC DRUMS 200 LT	METAL DRUMS 200 LT OPEN TYPE UN APPROVED
CONTAMINATED PACKAGING MATERIALS		BIG BAGS UN APPROVED

Final disposal prices were approx. 600-800 EUR/tonne for disposal of wastes in Greece, 700-900 EUR/tonne for disposal of wastes in Germany, and 1,000-1,300 EUR/tonne for disposal of wastes in Belgium.

Table 12 • *Summary of Works in Balez*

BALEZ STOREHOUSE CLEANUP WORKS	USD 476,173	SEPTEMBER 2009 – JULY 2010											
		S	O	N	D	J	F	M	A	M	J	J	
Tendering procedure for clean-up of Balez	\$ 476,173												
Evaluation and contracting													
Implementation of actual works													

REFERENCES

1. *TECHNICAL AGREEMENT BETWEEN THE MINISTRY OF DEFENCE OF THE REPUBLIC OF ALBANIA AND THE ORGANISATION FOR COOPERATION AND SECURITY IN EUROPE (OSCE) FOR THE ELIMINATION OF DICHLOROETHANE STOCKS FROM THE REPUBLIC OF ALBANIA*, July 2010;
2. *IDENTIFICATION AND PRIORITIZATION OF "ENVIRONMENTAL HOTSPOTS" IN ALBANIA, PROJECT DOCUMENT*, UNDP Albania 2008;
3. *STRENGTHENING CAPACITIES IN THE WESTERN BALKANS COUNTRIES TO MITIGATE ENVIRONMENTAL PROBLEMS THROUGH REMEDIATION OF HIGH PRIORITY HOT SPOTS*, UNDP September 2007;
4. "TREATMENT OF CHEMICALS THAT ARE IN THE ENTERPRISES AND COMPANIES OWNED BY THE MINISTRY OF ECONOMY, TRADE AND ENERGY", Working group report, December 2008.

METAL
RECOVERY
FROM
MINE
WASTE
AND
WATER



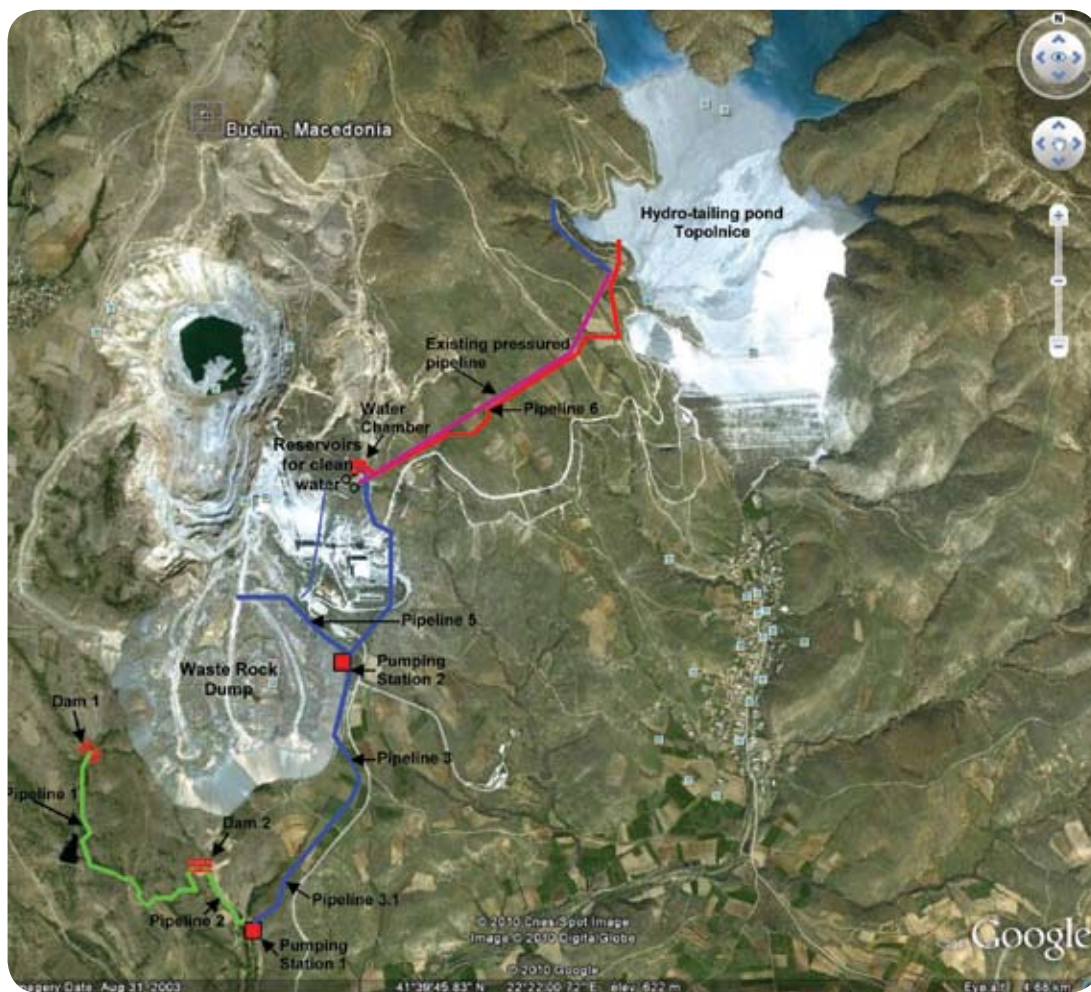


COPPER
RECOVERY
FROM
WASTE
ROCK
DRAINAGE

Location
BUCIM MINE, MUNICIPALITY OF RADOVIS
The FYR of Macedonia

PROJECT WORKS

Feasibility study and costed design for combining economic recovery of copper (Cu) with treatment of the contaminated waste rock drainage waters at Bucim Mine.



ABSTRACT

A fully costed feasibility study and general design to recover saleable copper (Cu) to subsidise costs in treating metal-rich (400mg/l) and toxic mine effluent was prepared by the Bulgarian company BT Engineering at a cost of USD 243,350. The concept was based on similar plants operating in Bulgaria. The preferred technology (Variant II.2) was identified for treating the 30 litres per second (946,000 m³/yr) of waste rock drainage discharged from the approx. 110 million tonnes of waste rock (containing 0.11% Cu) present at Bucim Mine. The study found this technology could recover 195 tonnes of copper per year, reducing the copper concentration by 90% from 230mg/l to 30mg/l and subsidise treatment costs of contaminated water from EUR 560,540 per year (USD 716,803)¹ by EUR 563,980 per year (USD 721,202) giving potential profits of EUR 3,440 (USD 4,399).

Table 13 • *Summary of the Variant II.2 treatment technology*

COPPER RECOVERY TECHNOLOGY – VARIANT II.2 (COST BALANCE)				
TREATMENT COSTS	EUR	COST RECOVERY	EUR	TOTAL (Yearly Profit)
<i>Water Management</i>	267,280	<i>Copper</i>	508,160	
<i>Water treatment costs</i>	293,260	<i>Technical Water</i>	55,820	
Sub-total	560,540	Sub-total	563,980	

.....
¹ The exchange rate used under this section is from March 2009 (0.782 €/€)

LOCATION

Bucim Mine is located in the Municipality of Radovis, in the south-eastern part of the FYR of Macedonia. The mine is located 14 km west of the city of Radovis, and 30 km east of the city of Stip, the largest city in the eastern part of the country. The capital, Skopje, is approximately 95 km from the mine, connected by the Radovis–Stip– Veles regional road.

A total number of 50,000 inhabitants live in the Municipality of Radovis and villages along the Rivers of Topolnica, Lakavica and Bregalnica (some of these settlements are in the Stip and Negotin Municipalities). Bucim, Topolnica and Damjan are the three villages in the vicinity of the mine. According to the 2002 census, the villages in the immediate vicinity of the mine site have a total of 1,192 inhabitants.

Bucim Mine itself has operated as copper mine since 1979 and until 2001 was state-owned and managed. In 2001 the mine was sold to a foreign company “Semcorp” but operations ceased in 2003 when the company became bankrupt. The mine was restarted again in May 2005 after being bought by the Russian company Romtrade Ltd, which later became Solway Industries Ltd, registered in the FYR of Macedonia as a domestic company with foreign capital and is still in operation.



The physical structures created by mining operations at Bucim Mine (waste rock dump and tailings impoundment) are the most prominent artificial structures in the eastern part of the FYR of Macedonia. The total area of the surface impacted by the mine is approximately 2,755 ha of which the open pit is 65.2 ha, the ore waste dump is 152.6 ha, the mining tailing impoundment is 38.7 ha, and the building, roads, and pipes occupy 1 ha.

In the period when the mine was opened in 1979, very little or no attention was paid to the protection of the environment or to health-related and other risks presented to the inhabitants from the surrounding settlements. The waste rock dump itself was designed without any concern for potential environmental effects; the same applies to the tailings impoundment. The result of this is that at the national level, Bucim Mine is ranked as the

second worst environmental hotspot out of 16 priority hot spots identified within the Second National Environmental Action Plan 2006 (NEAP) and the National Waste Management Plan 2006 -2012 (NWMP) 2005.

One of the primary negative impacts, which is the subject of the feasibility study (Ref 1), is the acid drainage that emanates from the 110 million tonnes of waste rock that has been produced over more than two decades of mining which is stored next to the mine pit. While one part of this drainage collects and drains through Bucimski Dol into Lake Bucim, an estimated 5 to 20 litres per second of acidic drainage with a pH of approx. 3.4 and a copper concentration of approx. 400mg/l evades this collection system and travels 890 metres along Jasenov Dol into the River Topolnicka.

ENVIRONMENT SITUATION

The acid mine drainage from the dump, with a pH of 3 and 400 mg/l copper content, has a clearly visible blue/green tint and due to its toxicity almost no flora and fauna survives in the acidic waters resulting in all rivers in the vicinity of the mine being effectively dead.

In addition to the pH value and Cu content, the drainage water from the waste rock dump is extremely polluted by other heavy metals including Zn, Ni, Cd and As. The measurements done within the Environmental Impact Assessment Study for Bucim Mine showed that the presence of heavy metals is over 50,000 times the Threshold Limited Volume which classifies these waters as V category waters according to the current national classification. This is the most polluted level with waters of V category being unusable for human consumption or for irrigation due to their negative impact on human health. These waters drain into the River Topolnica making the water from the river a very dangerous source of pollution for all water recipients along the river flow, as well as for the Rivers Lakavica and Bregalnica. The polluted waters are the main water sources for irrigation in the central eastern part of the country (i.e. the area between Stip, Radovis and Negotino). Crops irrigated with these waters, or livestock drinking from it will absorb heavy metals from the water and their consumption could cause various health effects such as stomach irritation, food poisoning and allergies, and even cancer in the case of prolonged consumption of agricultural products.

In addition to the local impacts, UNEP/ADA studies estimate pollution of the River Topolnicka from Bucim Mine could also contribute to cross-border pollution in Bulgaria and Greece via the River Nivcanska, a tributary of the River Strumica then the River Struma (Bulgaria) and of the Aegean Sea (Greece) via the River Bregalnica, an upper tributary of the River Vardar (Ref. 1 and 4).



INTERVENTIONS

The feasibility and detailed design sought to identify the best and most economically sustainable technology to treat the acid drainage from the waste rock dump that was to be captured and reused as technical water and for recovering saleable copper to reduce the treatment costs or, if possible, produce a profit.

Due to the mine having been state-owned for most of its operation this study and design was conducted in partnership with the current commercial owners who continue to use the same mine structures for their operation purposes.

Technologies Considered

In considering the potential technologies that could be used, these technologies were matched with the chemical characteristics and quantities collected through a field sampling programme. In essence, this involved the collection of 35 water samples of the acid drainage which in turn were analyzed for 40 different physical or chemical parameters.

The technologies that were considered included: filtration, sedimentation, coagulation, flotation, sorption, ion-exchange, extraction, distillation, para-circulation method (evaporation), chemical methods of water purification and biological methods of water purification.

From these technologies it was concluded that the most suitable technology would be copper cementation or sorption. The next step in considering these technologies involved processing and testing the treatment technology variants through treating a few hundred litres of polluted waters from different flows at Bucimski Dol and Jasenov Dol. This was done by laboratory

testing using different theoretical and practical treatment technologies for the production of marketable products containing copper. In all, the following four practically applicable variants for treatment of the polluted waters were:

- copper cementation from the polluted waters plus supply of copper-impooverished waters to the on-site copper processing plant as technical return water or to the waste rock dump for irrigation (dust control);
- sorption of copper from the polluted waters, generation of product – liquid regenerate with a copper content of 20-25 g/l and supply of the copper-impooverished waters to the on-site copper processing plant as technical return water or to the waste rock dump for irrigation;
- sorption of copper from the polluted waters, production of liquid regenerate with a copper content of 20-25 g/l, copper cementation from the regenerate with iron for the production of copper concentrate with a copper content of 65-70% and supply of copper-impooverished waters to the on-site copper processing plant as technical return water or to the waste rock dump for irrigation;
- sorption of copper from the polluted waters, generation of product – liquid regenerate with a copper content of 20-25 g/l, settlement as copper carbonate and supply of copper-impooverished waters to the on-site copper processing plant as technical return water or to the waste rock dump for irrigation.

The table below presents the different costs associated with each variant of the proposed treatment technology which range from EUR 1,990,554 for Variant II.2 to EUR 2,021,489 for Variant II.3 due to differing construction requirements for each of the technology variations.

Table 14 • *Investment Costs in Different Technology Variants (Ref1)*

ESTIMATED INVESTMENT COST	Variants – €			
	I	II.1	II.2	II.3
WATER MANAGEMENT	582,188	582,188	582,188	582,188
Waste water treatment plant				
Construction		373,991	359,290	373,088
Equipment		974,568	1,049,076	1,066,213
TOTAL FOR WWTP	699,474	1,348,559	1,408,366	1,439,301
TOTAL FOR INTEGRATED WATER MANAGEMENT SYSTEM	1,281,662	1,930,747	1,990,554	2,021,489

TECHNICAL COMPARISON OF THE DIFFERENT VARIANTS

The laboratory testing, modelling and calculations also calculated the expected technical and economical parameters for each of the 4 variants with the following results:

VARIANT I – Copper cementation of the released polluted solutions and supply of the produced copper-impooverished filtrate to the plant for technical return water or to the waste rock dump for irrigation:

- copper content in the polluted waters – 230 mg/l;
- copper content in the copper-impooverished waters – 80 mg/l;
- final product – copper concentrate – 65-70% Cu;
- annual production – 130 tonnes Cu;
- technological parameters of the process
- copper cementation of the released polluted waters at presence of metal iron and 3-5 g/l residual acid;
- supply of the produced copper-impooverished filtrate to the plant for technical return water or to the waste rock dump for irrigation. The mixture of the filtrate with the waters from the tailing pond is in the proportion 1:10.

VARIANT II-1 – Copper sorption of the released polluted solutions, supply of the produced copper-impooverished filtrate to the plant for technical return water or to the waste rock dump for irrigation and regeneration of the enriched sorbent for the generation of liquid regenerate:

- copper content in the polluted waters – 230 mg/l;
- copper content in the copper-impooverished waters – 30 mg/l;
- final product – liquid regenerate – 20-25 g/l Cu;
- annual production – 184 tonnes Cu;
- technological parameters of the process;

Copper sorption of the released polluted waters on ion-exchange resin for a reduction of the copper content from 230 to 30 mg/l, supply of the produced copper-impooverished filtrate to the plant for technical return water or to the waste rock dump for irrigation and regeneration of the enriched sorbent by a regeneration solution of 100 -120 g/l of sulphuric acid, for the production of a liquid regenerate with a copper content of 20-25 g/l and residual acid 40-50 g/l. The mixture of the filtrate with the waters from the tailing pond is in the proportion 1:10.

VARIANT II-2 – Copper sorption of the released polluted solutions, supply of the produced copper-impoverished filtrate to the plant for technical return water or to the waste rock dump for irrigation and regeneration of the enriched sorbent for the generation of liquid regenerate, copper cementation of the produced regenerate in the presence of metal iron and 3-5 g/l residual acid:

- copper content of the polluted waters – 230 mg/l;
- copper content of the copper-impoverished waters – 30 mg/l;
- final product – copper concentrate – 65-70% Cu;
- annual production – 180 tonnes Cu;
- technological parameters of the process;

Copper sorption of the released polluted waters on ion-exchange resin for a reduction of the copper content from 230 to 30 mg/l, supply of the produced copper-impoverished filtrate to the plant for technical return water or to the waste rock dump for irrigation and regeneration of the enriched sorbent by a regeneration solution of 100 – 120 g/l of sulphuric acid for the production of liquid regenerate with a copper content of 20-25 g/l and residual acid of 40-50 g/l. The mixture of the filtrate with the waters from the tailing pond is in the proportion 1:10 copper cementation of the produced regenerate in the presence of iron and 3-5 g/l of residual acid.

VARIANT II-3 – Copper sorption of the released polluted solutions, supply of the produced copper-impoverished filtrate to the plant for technical return water or to the waste rock dump for irrigation and regeneration of the enriched sorbent for production of liquid regenerate, settlement of copper in the regenerate as basic copper carbonate:

- copper content of the polluted waters – 230 mg/l;
- copper content of the copper-impoverished waters – 30 mg/l;
- final product – basic copper carbonate – 52-57% Cu;
- annual production – 176 tonnes Cu;
- technological parameters of the process;

Copper sorption of the released polluted waters on ion-exchange resin for a reduction of the copper content from 230 to 30 mg/l, supply of the produced copper-impoverished filtrate to the plant for technical return water or to the waste rock dump for irrigation and regeneration of the enriched sorbent by a regeneration solution of 100 – 120 g/l of sulphuric acid for the production of a liquid regenerate with a copper content of 20-25 g/l and residual acid of 40-50 g/l.

The mixture of the filtrate with the waters from the tailing pond is in the proportion 1:10. The produced regenerate is neutralized by a 20% solution of sodium carbonate, slowly with the involvement of heat and boiling, the produced solution is supplied for sedimentation and afterwards decantation and clarification – the sludge of copper carbonate is filtered and washed in parallel.

Table 15 • *Costs Comparison of the Four Different Variants (Ref 1)*

PRIME COST	UNIT	VARIANTS			
		I	II.1	II.2	II.3
TREATED WATER	m ³ /y (t/y)	946.08	946.08	946.08	946.08
COPPER IN THE WATERS	t/y	217.60	217.60	217.60	217.60
EXTRACTION THROUGH TREATMENT	%	65.00	92.00	90.00	88.00
PROCESSED COPPER	t/y	141.44	200.19	195.84	191.49
ANNUAL DEPRECIATION	€	128 166.19	193 074.68	199 055.44	202 148.91
SALARIES	€/g	90 000.00	90 000.00	90 000.00	90 000.00
CONSUMABLES	Om=p				
IRON	kg/kg	1.00		0.30	
ACID	kg/kg	0.07	0.66	0.66	0.66
ELECTRICITY	kW/kg (m ³)	0.03	0.04	0.04	0.05
ELECTRICITY	kW/kg (m ³)	0.40	0.28	0.29	0.29
RESIN	kg/kg		0.05	0.05	0.05
CARBONATE	kg/kg			0.05	0.88
TRANSPORT	€/kg		1.00		
SUBTOTAL		1.49	2.03	1.39	1.93
LABOUR	€/kg	0.64	0.45	0.46	0.47
AMORTIZATION		0.91	0.96	1.02	1.06
PRIME COST	€/kg	3.04	3.44	2.86	3.45
ANNUAL EXPENSES	thousand €	429.53	689.47	560.54	661.22
OPERATIONAL COSTS FOR MANAGEMENT OF THE WATERS	€/m ³	0.45	0.73	0.59	0.70
EXPECTED INCOMES					
FROM REALIZATION OF THE PRODUCTS	thousand €/y	367.01	519.46	508.16	496.87
FROM ECONOMIES IN THE PURCHASE OF TECHNICAL WATER	thousand €/y	55.82	55.82	55.82	55.82
TOTAL INCOMES	€	422.83	575.27	563.98	552.69
Annual profit	thousand €/y	-6.70	-114.20	3.440	-108.53
for 1 m ³ treated water	€/m ³	-0.01	-0.12	0.004	-0.11

ECONOMIC COMPARISON OF THE DIFFERENT VARIANTS

The table above presents the economic comparison of the different variants of the sorption/cementation technology comparing the operational costs with the profits earned from the sale of copper and technical water.

From the table it can be seen that in terms of expenses the lowest annual operational costs are entailed by Variant II.1 with EUR 429,530 (USD 578,881)² per year while the highest are in Variant II.3 - treatment and the production of copper carbonate – EUR 661,220 (USD 891,132) per year. In relation to incomes, the highest ones are earned from products generated in the management and treatment of the waters, by Variant II.1 with earnings of EUR 572,220 per year (USD 771,180), while the lowest are earned by Variant II.1 – EUR 422,830 per year (USD 596,800).

For the total annual result (costs minus profits) with a copper prices of USD 4,500/tonne at the time when the feasibility study was conducted (October 2008) and the expected copper quantity in the polluted waters (217 tonnes/year) only Variant II.2 through the production of cementation solution after the processing of the produced regenerate, has an annual profit of EUR 3,440 (USD 4,636) with the other variants all in deficits ranging from EUR 6,700 (USD 9,030) (Variant I) to EUR 114,000 (USD 153,639) (Variant II.1).

SELECTION FOR FUTURE IMPLEMENTATION

Based on the technical and economical parameters of the proposed variants presented above, as well as the construction costs, operational costs and saleable product, Variant II.2 was considered the most sustainable technology and selected for construction. It was the only positive financial result (taking into account the incomes from sales of copper) producing an annual profit of EUR 3,440 (USD 4,636) therefore fully covering the required treatment costs for the acid drainage waters.

This technology involves copper sorption of the released polluted solutions with the supply of the treated effluent-produced copper-impooverished filtrate to the plant for technical return water or to the waste rock dump for irrigation combined with regeneration of the enriched sorbent for production of liquid regenerate and copper cementation of the produced regenerate.

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2 The exchange rate used in this and in the next section is from October 2008 (0.742 €/€)

The design was not implemented in the framework of this programme as a sharp drop in copper prices to a low of USD 2,000 a tonne due to the Global Credit Crises in the second half of 2008 and in the first half of 2009 caused construction plans to be shelved by Bucim Mine. However, sharp rebounds and the sustained recovery in copper prices to USD 7,000 a tonne (August 2010) has again raised interest and plans by the company to recover copper from the acid drainage in the near future. In the interim, the acid drainage waters have been captured and are contained within the main mine tailings impoundment.

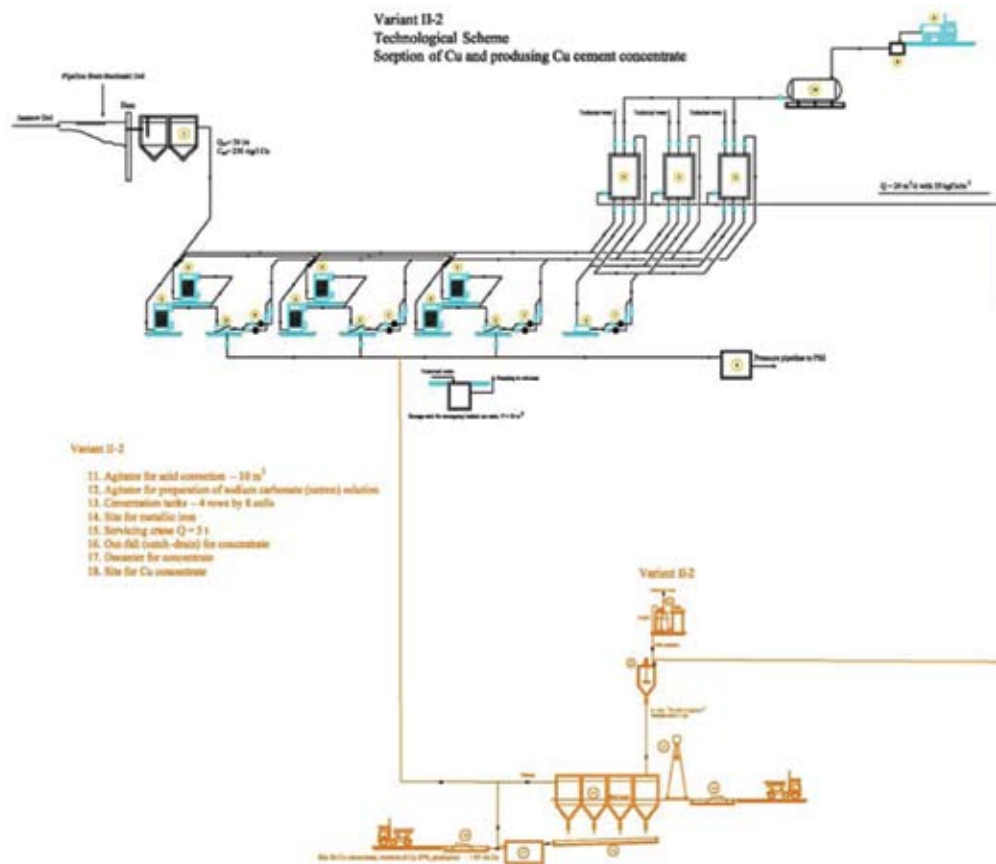


Figure 4 • **Variant II-2**

REFERENCES

1. *FEASIBILITY ASSESSMENT AND DEVELOPMENT OF A MAIN TECHNICAL DESIGN FOR WATER PROTECTION MEASURES*, BT Engineering on behalf of UNDP Macedonia, October 2008;
2. *STRENGTHENING CAPACITIES IN THE WESTERN BALKAN COUNTRIES TO MITIGATE ENVIRONMENTAL PROBLEMS THROUGH REMEDIATION OF HIGH PRIORITY HOT SPOTS*, UNDP September 2007;
3. *RAPID ASSESSMENT OF THE MAIN ENVIRONMENTAL, ECONOMIC AND SOCIAL IMPACTS ASSOCIATED WITH THE OPERATIONS OF BUCIM MINE*, UNDP, April 2007;
4. *ENVIRONMENTAL IMPACT ASSESSMENT STUDY (EIA) FOR BUCIM*, Faculty of Mining and Geology, Stip June 2006;
5. *MINING FOR CLOSURE, POLICIES AND GUIDELINES FOR SUSTAINABLE MINING PRACTICE AND CLOSURE OF MINES REPORT*, prepared on behalf of the Environmental Security Initiative, 2005;
6. *SOUTH-EASTERN EUROPEAN MINING-RELATED RISKS: IDENTIFICATION AND VERIFICATION OF ENVIRONMENTAL HOT SPOTS*, Philip Peck, UNEP Grid Arendal and Alexander Zinke, Zinke Environmental Consulting, August 2006;
7. *NATIONAL ENVIRONMENTAL ACTION PLAN*, Ministry of Environment and Physical Planning, October 2005;
8. *NATIONAL WASTE MANAGEMENT PLAN 2006-2012*, Ministry of Environment and Physical Planning, September 2005.



RECOVERY
OF LEAD
AND ZINC
FROM
MINE
TAILINGS
WASTES

Location
KISHNICA FLOTATION PLANT
UNATSCR 1244 Kosovo

PROJECT WORKS

Treatment trial of mineral processing waste from the Novo Brdo mine site at Artana through a reprocessing trial at Kishnica Mineral Processing (Flotation Plant) to identify economic cleanup mechanisms for these mine tailings wastes.



ABSTRACT

The planned treatment of Novo Brdo Mine tailings (containing up to 2.67% Pb, 2.70% Zn, and recoverable Ag and Au) through the reprocessing of 20,000 tonnes in the Kishnica Flotation Plant and transporting of 80,000 tonnes was halted with only 100 tonnes of tailings processed and 4,200 tonnes transported. Difficulties caused by the nature of the materials, a lack of material pre-treatment capability and the need for minor plant alterations (approx. EUR 15,000) resulted in the cancellation of the trial. Total costs were EUR 189,795 (USD 266,566.85)¹ with EUR 54,235 (USD 172,015) for actual processing chemicals used and EUR 135,560 (USD 137,385) for tailings transportation and related costs. Actual processing costs per tonne were calculated between EUR 8.55 and EUR 10.85 per tonne by independent assessments, while “Kishnica” calculated costs at EUR 23 per tonne.

Table 16 • *Summary of Kishnica Treatment Trial*

ACTION / ITEM	COST OF WORKS (rounded values) EUR	QUANTITY TRANSPORTED OR TREATED – TONNES
TRANSPORT (PLANNED)	349,947	80,000
CHEMICALS (PLANNED)	122,475	195.60
FINAL TRANSPORT (ACTUAL)	135,560	4,200
FINAL CHEMICALS (ACTUAL)	54,235	100
TOTAL	189,795	

.....
¹ The exchange rate used in this section is from August 2009 (0.712 €/€)

LOCATION

The Kishnica Flotation Plant is more correctly known as the mine of Novobërdë "Joint Flotation - Kishnica and Novobërdë", it is located in Badovic village, and is part of the industrial giant KXMK "Trepça". Formerly a large-scale mine complex and employer, the company today operates at a reduced capacity and with aging technologies and infrastructure. Located approx. 30 kilometres away from this Flotation Plant is the Trepca Mine at Artana/Novoberde where lead/zinc ore is still mined, but in the past had been the site of a long running mineral processing facility (now defunct). The legacy of this mineral processing at Artana is two large mine tailing waste stockpiles on the banks of the River Krivareka. The Kishnica plant is believed to have been constructed in the 1960s and is comprised of robust (but low-efficiency) Russian technology. The plant operated with a designed capacity (2 sections) of 400,000 tonnes per year before the conflict in the late '90s. Currently only one section of the plant is in operation with an average capacity of 35 to 40 tonnes of ore per hour. In general, all necessary sections (crushing, milling, classifications, flotation and concentrate drying sections) are in working condition.



ENVIRONMENT SITUATION

The 2 million tonnes of mine tailings, contained in two separate stockpiles known as T1 (approx. 400,000 tonnes) and T2 (approx. 1.6 million tonnes), present at Novo Brdo, were progressively deposited on the banks of the River Krivareka after mining and mineral processing commenced in the area from 1945 and 1963. The mine tailings are deposited in close proximity to the Marec Concentrator and are estimated to contain approx. 2.67% lead (Pb), 2.7% zinc (Zn) (testing by UNDP/Kishnica in June 2008), as well as recoverable silver (Ag), gold (Au) and rare earth elements. In addition to the economic metals there are also other harmful metals present such as arsenic (As), cadmium (Cd) and mercury (Hg). Both tailings were exposed to air and uncovered and were subject to strong erosion by surface runoff. At both dump locations, the material had slumped into the stream bed, and considerably added to the pollution. The mine tailings therefore represent a major hazard and ongoing

source of heavy-metal and acid pollution. While works have been conducted in this hot spot programme to remove the materials from within the river and cap and contain them to minimize pollution to the rivers, such structures are not permanent and require ongoing maintenance. The only permanent solution is to have the tailings completely removed from the current location next to the river and this has led to the proposal for treatment through the recovery of saleable metal. To move toward such a solution this treatment trial was developed to reprocess these tailing wastes at the Kishnica processing plant located 32 km from the Novo Brdo mine site at Artana.

INTERVENTIONS

Proposed Retreatment

Because of the inefficiency of the past mineral processing technologies considerable concentrations of economic metals such as zinc (Zn) and lead (Pb) remains in the mine tailing wastes. Due to the combination of improved processing technologies and higher prices for base metals such as Pb and Zn experienced in 2007 {Pb: EUR 2,300/tonne (USD 3,220/tonne), Zn: EUR 2,540/tonne (USD 3,530/tonne)} favourable circumstances were created for this proposal to reprocess the metal-rich tailings in the already existing reprocessing facility at Kishnica with a double benefit in both cleaning up an environmental problem and making an economic gain.

Given the circumstances of the Trepca mining consortium, there was however limited ability for the company to cover costs for such a trial. To provide a start-up to this activity it was agreed that this programme would provide sufficient chemicals to process 20,000 tonnes of tailings and would also transport 80,000 tonnes of tailings from the Novo Brdo/Artana site to the Kishnica Processing Plant 32 kilometres away. The rationale being that funds recovered from reprocessing the initial 20,000 tonnes could be used to reprocess the other 60,000 tonnes. It was then hoped that the process would be self-sustaining and the entire stockpile of 2 million tonnes of tailings would be reprocessed leaving the site free from all tailings.

To match this contribution, Trepca Corporation and its government partners agreed to provide an additional EUR 500,000 (USD 709,220, as per the exchange rate from October 2007) to transport more tailings from the T1 stockpile in Novo Brdo/Artana in addition to the processing and staff costs for the 20,000 tonnes for which chemicals were provided, and the other 80,000 tonnes to be transported. Given transport costs of approx. EUR 3.5/tonne this would have resulted in a further 142,000 tonnes of tailings being transported in addition to the original 80,000 tonnes.

Progress With Reprocessing Of Tailing

In 2008 the full quantity of chemicals required for processing 20,000 tonnes of tailings was purchased (195.6 tonnes) at a cost of EUR 122,475 (USD 164,617)² and contracts were signed to transport 80,000 tonnes of tailings at an agreed price of EUR 349,947 (USD 470,359). However, at this point two factors intervened that threatened the processing trial.

The first was the Global Credit Crises which saw base metal prices drop dramatically. Lead and zinc both fell to 35% of their previous value from previous highs in October 2007 to lows in October 2008 (Zn – EUR 2,540 to EUR 890; Pb – EUR 2,300 to EUR 818). The second was the company's advice that the plant was not up to the standards of a modern processing plant and concerns that the physical and chemical nature of the tailings (different to ore in wetness, particle size and oxidation state) would be damaging to the plant.

The drop in metal prices also saw the company's enthusiasm for the project drop and the negative economic impact from the plant "down-time" in processing non-profitable tailings (up to 2.67% Pb, 2.7% Zn) compared to the higher grade ore (4.40% Pb, 4.90% Zn, 137 g/t Ag and 1.1 g/t Au). A change in management first in Trepca and later in Kishinica Processing Plant led to a reduction of the trial to 20,000 tonnes from the initial 80,000 tonnes. However, when transportation commenced it was found there was no ability to store such quantities of the material at the Kishnica Plant Site, though 4,200 tonnes were able to be initially transported.



Independent Assessment

To continue with the trial, an independent expert was recruited to assess the plant and staff capability to reprocess the tailings that had already been transported, while arrangements were made to transport and store the remaining balance of 20,000 tonnes.

The independent assessment of the plant found that although it had been constructed in the 1960s it was generally in good working order and would be adequate for the trial. The

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² The exchange rate used in this section is from June 2008 (0.643 €/€)

assessment found that plant personnel were well-trained and experienced, so despite all the issues mentioned, they were quite capable of running the plant and processing ore within the aforementioned limitations.

It was found that plant performance indicators were rather low, with recovery rates of 67.90% for Pb and 75.6% for Zn, and concentrate qualities of 74% for Pb and 48% for Zn (reported by plant personnel). Estimated energy consumption was 33.51 kWh per tonne processed. No data for other consumables or labour was provided, but it is to be expected that these parameters are also above the industrial standard for similar plants.

The major reasons for the poor plant performances were considered to be due to:

- insufficient equipment maintenance,
- only manual control of the entire process,
- frequent interruptions in production due to power shortages and irregular ore supply.

All the above were detrimental to plant efficiency and resulted in increased processing costs approx. 30% - 40% above industrial standards.

New Approach For Reprocessing

To prepare the plant for reprocessing the tailings, a site visit, process analysis and discussion with Kishnica Plant's technical management was conducted to properly plan for the reprocessing trial, so that a satisfactory reprocessing result could be achieved, thus creating benefits instead of problems for the plant.

It was agreed with plant personnel that the only proper reprocessing approach would be to bypass the crushing and grinding sections of the plants and transfer the material directly to the flotation (either in classifier or conditioner injection points) as tailings have already been crushed once. To do so again would reduce the particle size even further which would result in them being too fine so that they would be lost from the system and metals would not be recovered from them. This is also a waste of time and energy.

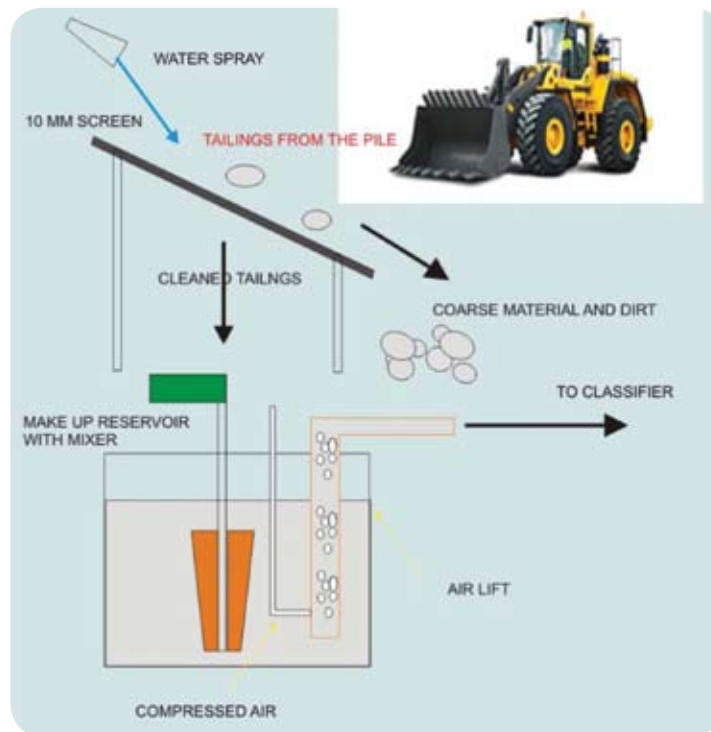


Figure 5 • **Proposal for Reprocessing of Tailing**

This processing scheme (given in the diagram above) is fully in line with site findings and plant personal recommendations, and comprised the following elements:

- water-spraying system,
- inclined screening surface (10 mm),
- collecting chute,
- reservoir with mixer,
- low-head airlift pump,
- pipeline,
- simple control systems (valves) and fittings.

During the discussion plant technicians came up with a preliminary cost estimate of approximately EUR 15,000 (USD 21,067)³. But, considering the purpose of the system (industrial trial processing of tailings), and relatively small amount of tailings to be processed, the already available and used equipment could be fitted to reduce costs for modification to a minimum.

If instead of new equipment, already available/used equipment were installed (simple water hose, used screen, available conditioner and air-lift pump from the non-operating section of the plant) the estimated costs could be significantly reduced.

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 3 The exchange rate in this and in the next section is from August 2009 (0.712 €/€)

The independent expert however had considered modification costs could be as low as EUR 2,000-3,000 (USD 2,809–4,214) using on-site equipment that was not presently in use or could be jury-rigged to perform the required function. It was recommended that plant personnel review all options and items availability, and come up with precise info and definite figures (timesheet for preparations and costs breakdown).

The independent expert also found plant staff to be experienced and skilful personnel able to lead and perform all necessary activities regarding reprocessing with the new scheme.

The independent analysis also calculated costs of EUR 8.55-10.85 per tonne to process tailings as there are savings in not requiring energy for crushing or transportation. The cost calculation however from Kishnica was EUR 23 per tonne though not all factors were available to determine why these calculations were higher.

Tailing Reprocessing Activities

While recommendations were given to Kishnica from the independent expert for the trial reprocessing, they were not incorporated. The result was an unsuccessful trial with the equipment jamming and very poor recovery of saleable metals as predicted by the independent assessment after reprocessing only 100 tonnes of tailings.

The independent expert found that the trial was performed by simply mixing tailings with ore and processing it, without any process modification or adaptation, as had been advised. This resulted in material flow problems due to old and inefficient equipment and a complete lack of systems for improvement of material flow like belt cleaners, trackers, sealing systems and chute liners, so processing of this material was impossible in the unmodified plant.

This trial resulted in very poor-quality products (the concentrate's metal content was below a marketable rate) and significant problems with material flow. The over-grinding of the tailings by running it through the crushers and ball mills resulting in dramatic changes in mass balance and material quality were the reasons for improper concentrate quality and total mineral losses, while the addition of the sticky and wet tailings resulted in material flow problems and equipment damages.

End Result

With the failure of the trial, the plant resumed processing of ore with the company being unable to make the necessary modification to reprocess the tailings. With the cancellation of the trial, chemicals with a value of EUR 122,475 (USD 172,015) were resold to Trepca and to chemical brokers for EUR 68,240 (USD 89,640), due to which a recovery of 52% the

original cost was achieved. The transportation contract was suspended, with 4,200 tonnes of tailings removed, at a total negotiated cost of EUR 135,560.60 (USD 176,052.96).

The failure of the trial demonstrated the actual complexity and limitations in this sort of reprocessing, both technically and commercially, in relation to the capabilities of private companies. While it was understood that the Kishnica processing plant had previously reprocessed large quantities of mine tailings in the past when approximately 700,000 tonnes were removed from the T2 stockpile at Artana, no actual details on such treatment were provided prior to their commitment to the treatment trial and no specific preparedness study was undertaken although it was requested.

The impact on metal prices was also a very significant and perhaps the most critical factor since prices were reduced to 35% of the value they had when this trial was first conceived. However, at the time of writing this case study (September 2010) there has been renewed interest in the value of reprocessing the T1 and T2 stockpiles by international companies with the T1 stockpile having been extensively analysed.

This has come about as zinc and lead have again increased in value from their lows of EUR 890 and EUR 818 when the trial was cancelled to current values of EUR 1,564 and EUR 1,554. In addition to this, it is believed there are valuable quantities of rare earth elements in the tailings which are currently at record highs. The prospects for an eventual complete removal and reprocessing therefore remain realistic though unrealized in this project.



REFERENCES

1. *FINAL DRAFT REPORT ON TAILING REPROCESSING AT KISNICA PLANT*, Dejan Mirakovski Dr.Sc.ME, Mirjana Golomeova Dr. Sc IPM, August 2009;
2. *LOCAL ECONOMIC DEVELOPMENT STRATEGY IN THE MUNICIPALITY OF NOVOBĚRDĚ 2008-2015*, Care International Kosovo, ICCED Prishtina, March 2008;
3. *STRENGTHENING CAPACITIES IN THE WESTERN BALKAN COUNTRIES TO MITIGATE ENVIRONMENTAL PROBLEMS THROUGH REMEDIATION OF HIGH PRIORITY HOT SPOTS*, UNDP September 2007;
4. *ENVIRONMENTAL ASSESSMENT AND REMEDIAL ACTION PLAN (EARAP) STAN TRG/STARI TRG AND ARTANA/NOVO BRDO MINES, KOSOVO*, Montec, May 2007;
5. *MINING FOR CLOSURE, POLICIES AND GUIDELINES FOR SUSTAINABLE MINING PRACTICE AND CLOSURE OF MINES REPORT*, prepared on behalf of the Environmental Security Initiative, 2005;
6. *SOUTH-EASTERN EUROPEAN MINING RELATED RISKS: IDENTIFICATION AND VERIFICATION OF ENVIRONMENTAL HOT SPOTS*, Philip Peck, UNEP Grid Arendal and Alexander Zinke, Zinke Environmental Consulting, August 2006.

MINE DUST AND WATER MANAGEMENT

Location
BUCIM MINE, MUNICIPALITY OF RADOVIS
The FYR of Macedonia



PROJECT WORKS

Capture and containment of contaminated mine waste drainage waters, construction of fugitive dust control systems and stabilization of tailings surface through expanded revegetation of tailings dam face.



ABSTRACT

The works at Bucim were twofold. The first part involved capturing the contaminated waters through diversion of clean waters, construction of 2.2 kilometres of pipe works, 2 pumping stations and dams to collect and pump the 946,000 cubic metres per year of contaminated drainage waters coming from the 110 million tonnes of waste rock into the 38.7 ha tailings dam. Total costs incurred were EUR 814,364 with a EUR 674,364 contribution from the Government of the Netherlands and contributions of EUR 140,000 from Bucim Mine. The second part involved controlling the mine dust particularly from the tailings dam through, in the short term, installing water reservoirs, pump systems and sprinklers to control un-vegetated parts of the tailings dam face, with long-term dust control occurring through re-vegetation of approx 30 ha of the stabilized tailings dam. Total costs for this were EUR 554,634 with EUR 318,630 from the donor and EUR 206,004 from Bucim Mine. The complete cost of all works (water protection and dust protection combined), including supervision amounting to EUR 19,154 was EUR 1,358,152.

Table 17 • *Summary of Mine Dust and Water Management, Bucim Mine*

TYPES OF WORK	COST OF WORKS IN EUR	ACHIEVED REDUCTIONS OF POLLUTANTS INTO THE ENVIRONMENT (rounded values)
WATER PROTECTION MEASURES	814,364	CONTAMINATED WATERS CONTAINED (m ³)
		946,000
		SURFACE AREA WHERE DUST IS CONTROLLED (Hectares)
Dust protection measures-water sprays	269,695	
Dust protection measures - afforestation	254,939	30
Supervision	19,154	
TOTAL	1,358,152	

LOCATION

Bucim Mine is located in the Municipality of Radovis, in the southeast part of the FYR of Macedonia. The mine is located 14 km west of the city of Radovis, and 30 km east of the city of Stip, the largest city in the eastern part of the country. The national capital of Skopje is approximately 95 km from the mine, connected via the Radovis – Stip – Veles regional road.

A total number of 50,000 inhabitants live in the Municipality of Radovis and villages along the Rivers Topolnica, Lakavica and Bregalnica (some of these settlements are administrative parts of Stip and Negotin Municipalities). Bucim, Topolnica and Damjan are the three villages in the vicinity of the mine. According to the 2002 census the villages in the immediate vicinity of the mine site have 1,192 inhabitants.

Bucim Mine itself has operated as a copper mine since 1979 and until 2001 was state-managed and owned. In 2001 the mine was sold to a foreign company “Semcorp” but operations ceased in 2003 when the company went bankrupt. The mine was restarted again in May 2005 after being bought by the Russian company “Romtrade Ltd.”, which was later transformed into “Solway Industries Ltd”, registered in the FYR of Macedonia as a local company with foreign capital and is still in operation.



As stated above, the copper mine has been operational since 1979, apart from a short period of closure following a first failed privatization bid in 2004. The mine was then closed for a short period, re-privatized and then re-opened under Russian ownership in April 2005.

Concentrate production contains metals equivalent to approximately 7,000 to 8,000 tonnes of copper concentrate and 300-400 kg of gold. About 110 million tonnes of waste rock (still containing 0.11% Cu) are stored alongside the pit, and some 80 million tonnes of flotation tailings are in a nearby valley. About 8 million m³/yr of water pass through the process loop and tailings dam and about 2 million m³/yr of additional process water are acquired from a nearby source. Pumped water volumes from the pit are generally in the range from 2.5 to 3 million m³/yr.

Copper tailings from the operation's concentrator plant are delivered by a tailrace and pumped system to an approximately 40 ha tailings dam in the nearby valley. The tailings dam contains over 80 million t of solid residues from the flotation process containing Cu, As, Ni and other minerals. Although the dam itself is in good condition there is always a risk of dam failure, which would result in serious consequences for the inhabitants in the villages along the Topolnica and Lakavica Valleys and lead to long-term contamination of the environment. Measures to relocate the village and its inhabitants at a less vulnerable site in an adjacent valley are currently under discussion.

The physical structures created by mining operations at Bucim Mine (waste rock dump and tailings dam) are the most prominent artificial structures in the eastern part of the FYR Macedonia and amongst the most polluting for air, water and soil. The total area of the surface impacted by the mine is approximately 2,755 ha of which 65.2 ha is the open pit, 152.6 ha is the ore waste dump, 38.7 ha is the mining tailing dam, and 1 ha is occupied by building, roads and pipes.

In the period when the mine was opened, in 1979, very little or no attention was paid to the protection of the environment or to the health and risks presented to the inhabitants from the surrounding settlements. The waste rock dump itself was designed without any concern for potential environmental effects; the same applies to the tailings dam. The result of this is that at a national level, Bucim Mine is ranked as the second worst environmental hotspot out of 16 priority hotspots identified within the Second National Environmental Action Plan 2006 (NEAP) and the National Waste Management Plan 2006 -2012 (NWMP) 2005.

ENVIRONMENT SITUATION

The primary negative impacts from copper ore mining and processing (the process of separation of an ore mineral from the waste mineral material) includes water and air pollution from the various ongoing activities, structures and especially the liquid and solid wastes produced in the more than two decades of modern mining activity.

The activities that form the subject of this case study are what has been done to capture and contain the contaminated water leaving the site, primarily from the waste rock stockpile and what has been done to control dust emissions, as both permanent and short-term measures, emanating from the dry beach that continues to develop on the face of the tailings mine impoundment.

The main hazards/risks and pollution produced from the waste rock drainage waters and dust sources include the following:

WASTE – Tailings dam (38.7 ha) with over 80,000,000 tonnes of solid residuals from the flotation process (containing remains of Cu, As, Ni and other heavy metal minerals) is the biggest sand dam (body volume over 60,000,000 m³) in the wider area.

Clouds of fugitive dust also emanate from the open dam crest (total surface of approx. 20 ha) and dry beaches, directly endangering inhabitants of the village of Topolnica, posing a high risk from respiratory illnesses and a nuisance. These fine dust particles also reach nearby agricultural fields.

The presence of large amounts of tailings also pose the risk of a dam failure, which could result in catastrophic consequences for people's lives (there are over 5,000 inhabitants in the villages along the Topolnica and Lakavica Valleys), properties and long term contamination of environment.

Also, the large waste rock dump with over 110,000,000 tonnes of waste rocks containing copper oxide ore, which in current process could not be treated, has been built along a much frequented regional road (Stip–Strumica). Almost no flora and fauna survive in the acid water generated from the waste rock dump resulting in the rivers in the vicinity of the mine effectively being dead.

SURFACE WATER – This site has issues with contaminated waters despite the relatively modest flow volumes. The major source of contaminated water (mostly containing Cd, Cu, Zn, Ni and As) is the waste rock dump outside the mine pit. Other sources include the flotation plant and the sedimentation pond though these are mostly contained. These industrial streams merge and flow into agricultural land at an average rate of roughly 20 litres per second.

The drainage from the waste rock dump is very acidic (pH<3) and contains approx. 400 ppm Cu (clearly visible blue/green tint) and other toxic metals, particularly Cadmium (Cd). Total flows have been calculated at 946,000 m³/yr. These waters drain through Jasenov dol for approx. 890 metres before entering the River Topolnica making the water from the river a very dangerous source of pollution for downstream surface waters.

Surface water and sediment samples clearly show environmental contamination by heavy metals such as Cu and Cd, with concentrations in the acidic water (pH 3) in the 400-800 ppm range and 189 ppm respectively. At these concentrations, Cu and Cd are up to 1,600 and 37,800 times higher than the EU standard for drinking water.

The measurements show that the presence of heavy metals also greatly exceeds the National Threshold Limited Volume which gives these waters a classification as V category waters (the most polluted in a ranking of I to V). Waters of the V category cannot be legally used for drinking or for irrigation because of the harmful effect on human health. These waters move from the

River Topolnica making the water from the river very dangerous source of pollution for all water recipients along the river flow, as well as for the Rivers Lakavica and Bregalnica. The polluted waters are the main water sources for irrigation in the Central Eastern part of the country (i.e. the area between Stip, Radovis and Negotin). Crops irrigated with these waters will absorb the heavy metal from the water and its consumption could cause various health effects, such as stomach irritation, food poisoning and allergies, and even cancer in the case of prolonged consumption of agricultural products.

The waters of the artificial lake (Bucimsko jezero) located near the mining pit are also very polluted, because the water from the pit (underground and atmospheric waters) is pumped into the lake. In dry periods (summer time) the flow of the water is in the range of 10 l/s and it rises up to 30 l/s during the rainy season. The waters of Bucimsko jezero also flow into the River Topolnica, thus contributing to further pollution of this river. In addition, the sediment at the bottom of the lake contains extremely high concentrations of Cu and other toxic elements such as As and Cd.

AIR – Air contamination by dust, gases (SO_x, NO_x, CO) and noise, which is also reported, directly endanger the personnel and inhabitants of settlement in immediate vicinity of mining operations. Due to the very fine structure of material disposed, erosion processes are extreme, especially wind erosion at the tailings dam. The airborne particulate pollution poses a direct risk to the health of the inhabitants of the nearby settlements, especially in the development of lung diseases. According to the 2003 REC report, as stated in the UNEP's booklet "Mining and the Environment in the Western Balkans" (Ref 1), many mineworkers have rheumatic ailments and silicosis from inhaling dust. In an effort to reduce the dust, trees have been planted and a barrier spray to temporarily bind the surface has been applied to a 4-hectare area.

SOIL – Contamination of the soil is much higher than the Threshold Limited Volume recommended in NOAA standards, going up to 50 times for Cu and 30 times for As. Soil salination processes are reported in wider surrounding of the mining area, as well as in the very fertile land along the Rivers Lakavica and Bregalnica, where water from these rivers is used for irrigation. As already explained above, consumption of agriculture products from agriculture land irrigated with waters that contain high concentrations of heavy metals, could negatively affect human health and cause various diseases.

INTERVENTIONS

The activities proposed within the hotspot project are aimed at addressing both the historical pollution and prevention of future pollution. While it is very difficult to estimate the exact percentage of pollution resulting from the new waste that is deposited at the old waste pile, the estimate presented in the EIA clearly demonstrates that the majority of the existing waste is of a historical nature.

The mine owner contributed in cash and in kind for implementation of the foreseen activities, and the breakdown of the project costs and the co-funding provided by the company is provided further below for each of the proposed activities.

The proposed intervention under this programme, based on the Environmental Impact Assessment Study for the Bucim Mine prepared in June 2006, aimed at addressing the historical pollution and prevention of future pollution in two main respects:

- 1) by designing a system for collection and treatment of the waters from the mining zone, the tailing pond and the waste-rock dump, thus eliminating the pollution of the River Topolnicka and further downstream Rivers Bregalnica and Vardar;
- 2) undertaking measures for suppression of dust, i.e. approximately 30 ha of the tailing dump to be re-cultivated with a method of direct re-vegetation of biologically inactive materials.

Capture And Containment Of Waste Rock Drainage

The capture and containment of waste rock drainage involve designing and building the following components for capturing, collecting and transporting the contaminated waters:

- a. Construction of pumping stations;
- b. Intake structure upstream of Jasenov dol;
- c. Drainage channels surrounding the dump;
- d. Collection Pond;
- e. Pipeline for transportation of the water to the tailing pond.

This system for water collection involved the following independent water collection systems:

- a water collection system for waters from open pit including pumping stations and pipelines to remove and pump, and to be recycled and used in the ore processing;
- a water collection system for drainage waters from the waste rock dump that includes:
 - drainage channels surrounding the dump;
 - drainage well for collection of shallow ground waters;
 - collection pond;
 - pumping stations and pipeline for transportation of the water to the tailing pond;
 - the technical design of systems and other project development document.

This newly constructed water recirculation structures now include facilities for collection and short-term storage of the polluted surface waters around the perimeter of the waste rock dump and their evacuation/pumping via buried pipelines to the tailings pond. Two small dams with associated structures are also now erected and the two pumping stations are now fully functional. Simultaneously, 2.2 kilometres of buried pressurized pipes connecting the new reservoirs through the pumping stations with the tailings pond have been installed and the pipeline is now fully operational and evacuating the polluted water.

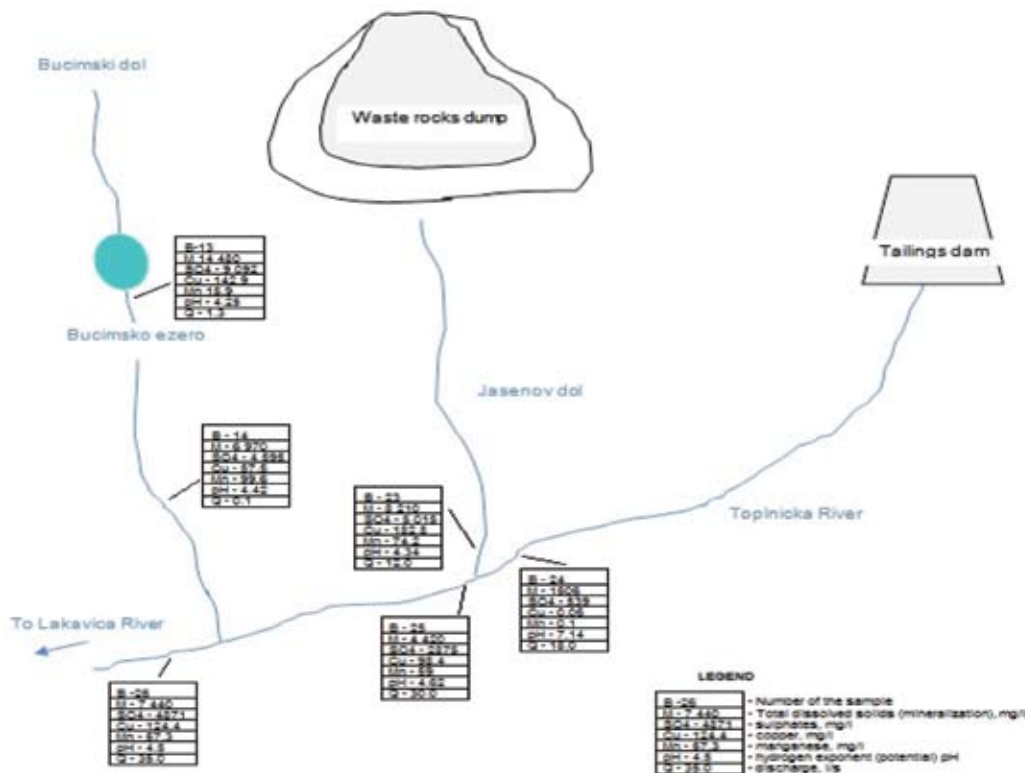


Figure 6 • **Surface Water Pollution**

Now that this system is being utilized, all of the polluted surface water discharges from the Bucim Mine have been eliminated, and the environmental conservation benefits for the regional and downstream water bodies are expected to be rather substantial. The evacuation and recycling of the polluted waters into the tailings pond will also substantially reduce the extraction of uncontaminated fresh water for refilling the tailings pond.

This investment eliminates the enormous past environmental burden of approx. 900,000 m³ of acidic water (pH>3) discharged per annum, including about 200 tonnes of Cu and other metals. Such quantities were taken up by the recipient surface waters each calendar year and their elimination enables natural restoration of these heavily polluted rivers. Predictive hydro-geological models prepared by consultants indicate that in a period of about 27 months it is very likely that natural removal of the pollutants from the Topolnica riverbed will occur. It is to be expected that the natural restoration and cleanup of the River Lakavica will take longer (at least 3 to 5 additional years), but significant water quality improvement will happen immediately after the pollutant load is terminated.

Bucim Mine contributed to the making of the polluted water evacuation system with the purchase and installation of pumps for the pumping stations built by the project and by extending the electrical power grid to the pumping stations. Bucim Mine also provided electric power transformers for powering the pumps and the other equipment installed in the pumping stations.

Dust Control And Reduction Measures

The dust control and reduction measures involved designing and building the following components for controlling the dust on the tailing mine impoundment dam:

- a. Dust control on the active part of the dam transportation roads;
- b. Construction of pumps, pipelines, reservoirs and boom-sprays;
- c. Re-vegetation of tailing dam.

This system for dust control collection involved the following independent water collection systems:

- Design and putting in place air pollution prevention systems by establishing vegetative cover on an additional 30 ha at the tailings dam and improvement of the irrigation system for vegetative cover and watering the uncultivated areas.
- Air protection measures – re-vegetation of approx. 30 ha of the tailing dump with a method of direct re-vegetation on biologically inactive materials
- Air protection measures – fugitive dust control system - a comprehensive system with fog cannons and the necessary accompanying equipment (water pipes and pumps) including automation equipment.

Revegetation

In order to prevent the airborne pollution as well as to contribute to the stabilization of the dam, an area of approx. 30 ha of the tailing dump was re-cultivated with a method of direct re-vegetation on biologically inactive materials. This method is much more efficient, less costly and provides better results in comparison to the classical methods that include covering the tailings with soil and manual planting of the vegetation. As part of the air pollution prevention measures the company had applied this method at the dam previously and the results have been very positive.

The cost for this intervention was EUR 254,939. Out of the total estimated costs, the project financed EUR 145,300 and the mine owner co-financed EUR 109,639 (in kind).

Fugitive Dust Control

In order to prevent fugitive dust emission from the tailing dam a comprehensive system with fog cannons was used. The system consisting of four fog cannons and the necessary accompanying equipment (water pipes and pumps) covered the dry tailings area, generating artificial fog thus preventing air erosion. This system was designed to work automatically which reduced the needs for manpower and maintenance.

The actual costs for this intervention were EUR 269,695. Out of the total estimated costs, the project financed EUR 173,330 and the mine owner co-financed EUR 96,365 (in kind).



All of the above activities were accomplished by the end of June 2010. Namely, an additional 11 ha at the tailings dam have been covered with topsoil, and vegetative cover was established where possible i.e. on about 5 ha. Over the life of the project more than 30 ha have been covered with top soil, which is another joint effort with the Bucim Mine and now all of the barren parts of the tailings dam are covered and therefore dust propagation is minimized.

Construction and equipment installation works for improvement of the irrigation system for the vegetative cover and the installation of a spraying system for wetting the dam crest were successfully completed by the end of April 2010. This investment included a complex seepage water recirculation system comprising intake, pumping station, pipeline and a new water reservoir (with a volume of 300 m³) as well as fixed and mobile irrigation equipment, water cannons for wetting the dry surfaces, and connection of the existing pipeline and equipment with the newly designed equipment/reservoir. The system was put into use by the end of May 2010.

The above air quality improvement investments have significantly reduced fugitive dust emissions from the dam surface. The spraying system installed combined with the establishment of vegetative cover have notably reduced wind erosion from the dam crest and dry beaches. In essence, implemented investments have already reduced the dust emissions in the affected areas and are ensuring healthier living conditions for the people who live in the vicinity of the dam. This investment also reduced contamination of public surfaces and nearby agriculture fields.

In addition to this, the owner of the Bucim Mine invested EUR 200,000 in the cleaning of Lake Bucim.

Table 18 • Summary of Mine Dust and Water Management Works in Bucim Mine


MINE DUST AND WATER MANAGEMENT BUCIM MINE EUR 1,358,152		OCTOBER 2008 – APRIL 2010														
WATER PROTECTION MEASURES		OCT – NOV 2008		MARCH - SEPT 2009					OCT 2009 – APRIL 2010							
		M	A	M	J	J	A	S	O	N	D	J	F	M	A	
Feasibility study and final design prepared	EUR 814,364															
Review of final design																
Tendering procedure for the physical works																
Evaluation and contracting																
Actual works implementation																
Final commissioning of completed works																
DUST PROTECTION MEASURES		OCT – DEC 2008			AUGUST 2009 – APRIL 2010											
		O	N	D	A	S	O	N	D	J	F	M	A			
Review of technical documentation	EUR 269,695															
Tendering procedure for the physical works																
Evaluation and contracting																
Actual works implementation																
Final commissioning of completed works																
DUST PROTECTION MEASURES – AFFORESTATION		AUG – NOV 2008				FEBRUARY – APRIL 2009						FEBRUARY - JUNE 2010				
		A	S	O	N											
Review of technical documentation	EUR 254,939															
Tendering procedure for the physical works																
Evaluation and contracting																
Actual works implementation																
SUPERVISION		AUGUST 2009 – JUNE 2010														
		J	A	S	O	N	D	J	F	M	A	M	J	J		
Tendering procedure - Company/ IIE to do the supervision of physical works	EUR 19,154															
Evaluation and contracting																
Supervision of physical works at Bucim Mine																
Final report prepared																

REFERENCES

1. *MINING AND ENVIRONMENT IN THE WESTERN BALKANS*, UNEP 2010;
2. *STRENGTHENING CAPACITIES IN WESTERN BALKAN COUNTRIES TO MITIGATE ENVIRONMENTAL PROBLEMS THROUGH REMEDIATION OF HIGH PRIORITY HOT SPOTS*, UNDP September 2007;
3. *RAPID ASSESSMENT OF THE MAIN ENVIRONMENTAL, ECONOMIC AND SOCIAL IMPACTS ASSOCIATED WITH THE OPERATIONS OF BUCIM MINE*, UNDP, April 2007;
4. *UNEP/GRID ARENDAL BALKAN VITAL GRAPHICS – ENVIRONMENT WITHOUT BORDERS*; ENVSEC 2007;
5. *SOUTHEAST EUROPEAN MINING-RELATED RISKS: IDENTIFICATION AND VERIFICATION OF ENVIRONMENTAL HOTSPOTS*, Philip Peck, UNEP Grid Arendal and Alexander Zinke, Zinke Environmental Consulting, August 2006;
6. *ENVIRONMENTAL IMPACT ASSESSMENT STUDY (EIA) FOR BUCIM*, Faculty of Mining and Geology, Stip June 2006;
7. *MINING FOR CLOSURE, POLICIES AND GUIDELINES FOR SUSTAINABLE MINING PRACTICE AND CLOSURE OF MINES REPORT*, prepared on behalf of the Environmental Security Initiative, 2005;
8. *NATIONAL ENVIRONMENTAL ACTION PLAN*, Ministry of Environment and Physical Planning, October 2005;
9. *NATIONAL WASTE MANAGEMENT PLAN 2006-2012*, Ministry of Environment and Physical Planning, September 2005.

MINE
TAILINGS
CONTAINMENT
AND
RAPID
RISK
REDUCTION



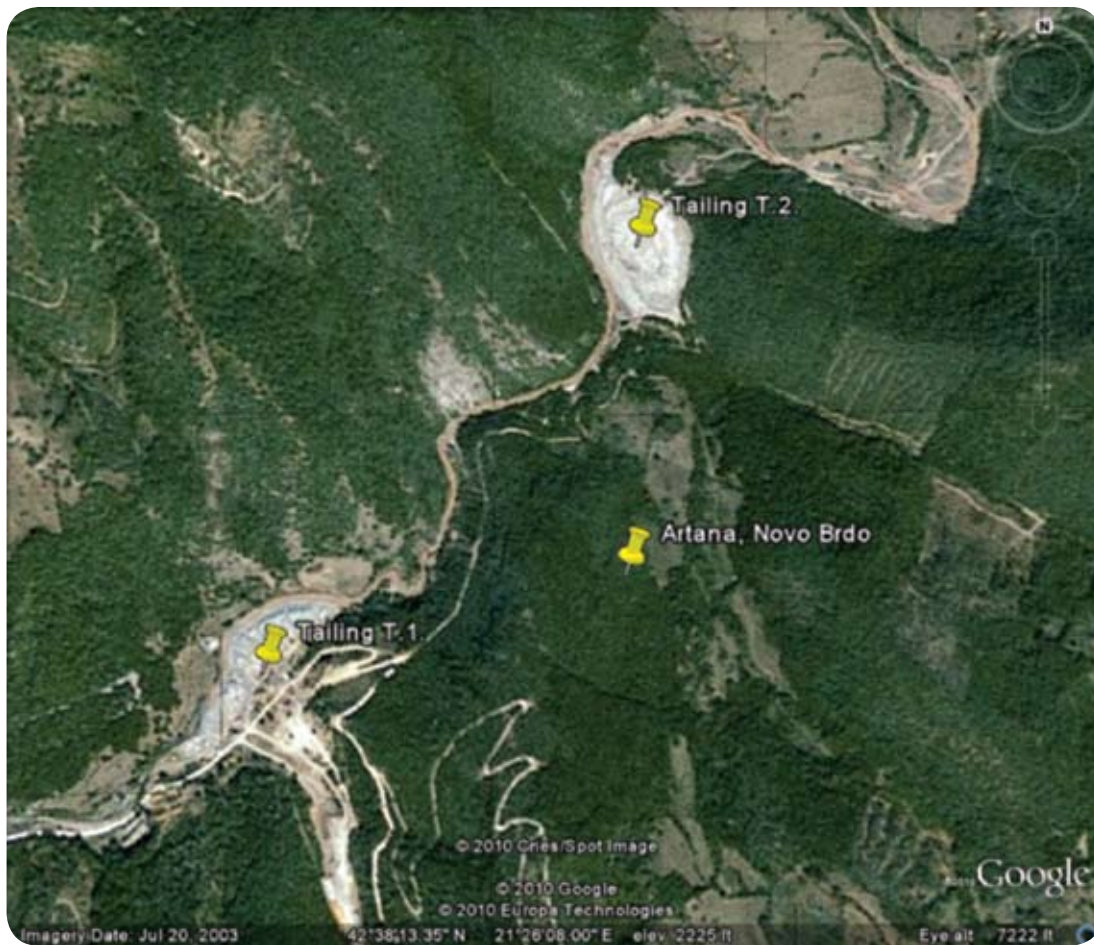


CAPPING
AND
CONTAINMENT
OF
LEAD
CONTAMINATED
MINE
TAILINGS

Location
**MINE TAILINGS STOCKPILES "T1" AND "T2", NOVO BRDO MINE, ARTANA,
UNATSCR 1244 Kosovo**

PROJECT WORKS

Emergency capping and containment of uncontrolled lead (Pb), cadmium (Cd), arsenic (As) and zinc (Zn) contaminated mine tailings dumped on the banks of the River Kriva and which have slumped into the waters.



ABSTRACT

Consolidation and containment works (river protection), including design and supervision, costing a total of approx. EUR 386,557 (USD 506,628)¹ with EUR 164,428 for T1 tailings dam and EUR 199,749 for T2 tailings dam, was conducted to contain approx. 2 million tonnes of lead-contaminated (Pb 26,700 mg/Kg) mineral processing wastes (tailings) and remove the portion which had slumped into the River Kriva. These uncontrolled tailing wastes were causing serious local and regional water pollution downstream (Pb 0.25 mg/L, Cd 0.212 mg/L, As 0.588 mg/L) and local air pollution from the heavy metal-contaminated dust being blown onto nearby villages and the school. The works conducted by UNATSCR 1244 Kosovo companies "Asfalti" (T1) and "Bejta Commerce" (T2) followed the general recommendations of the "Montec Report" conducted in 2007. Works were finalised in November 2008 (T2) and August 2010 (T1) involving removal of the tailings from the riverbed, construction of a protective earthen bund, capping (T1 and T2), revegetation and drainage works (T1 only). Further works remain to address the untreated acid mine drainage flowing from the Novo Brdo Mine adits into the River Kriva.

Table 19 • *Summary of Clean-up Works at T1/T2*

COST ITEMS	COST OF WORKS (rounded values) IN EUR	QUANTITY OF TAILINGS CONTAINED – TONNES
DESIGN AND SUPERVISION FOR T1 AND T2 WORKS	22,380	N/A
T1 PHYSICAL WORKS	164,428	400,000
T2 PHYSICAL WORKS	199,749	1,600,000
TOTAL	386,557	2,000,000

.....
¹ The exchange rate used – August 2010 – 0,763 \$/€

LOCATION

The lead (Pb) and zinc (Zn) mine at Artana/Novo Brdo is located 51 km south of Pristina. It is remote from any sizeable villages or towns, though some scattered villages such as Marec and a school are in close proximity to the site. The operating mine occupies the high ground near Mala Planina (Mala Mountain) in the drainage basin of the upper River Kriva. This stream flows northeast, passing the Artana/Novo Brdo Mine about 3 km to the west before making a broad loop to the east passing the mine to the north, and eventually flows south through the town of Kamenice approx. 13 km to the east-southeast of the mine.

There has been mining there since the Roman era, with intensive production of lead, zinc and silver (Ag) in medieval times. Modern mining started after 1945 at Artana and 1963 at Farbani Potok. The site now comprises the active mine itself and two tailings dumps adjacent to the former Artana concentrator along the Marec-Kriva riverbank. In the past two base metal mines, Artana (Novo Brdo Mine) and Farbani Potok reportedly had a manganese (Mn) mine operating around 1959. So far, about 1 million tonnes was reportedly mined from these deposits.

The lead and zinc mine remained operational until the 1999 conflict with the mine reported to contain an in-situ resource of 2,670,000 tonnes with a grade of 4.40% Pb, 4.90% Zn, 137 g/t Ag and 1.1 g/t Au (gold).

The Trepca Mine at Artana/Novo Brdo continues to mine Pb/Zn ore at a reduced capacity but no longer processes the ore at the site. This had occurred when the Marec concentrator was in operation at the bottom of the valley from 1959 to 1962. This activity is believed to have created the current tailings stockpiles known as T1, located next to the old concentrator, and T2, located a further 1.5 km downstream from the concentrator.

T1 contains an estimated 400,000 tonnes of tailings, while T2 contains an estimated 1.6 million tonnes. Tailings from both T1 and T2 stockpiles were disposed of on the banks of the River Kriva in a mostly uncontrolled manner. Here they have been uncovered by capping or vegetation and exposed to the air. In this location they have been subject to strong erosion by the river resulting in the tailings slumping into the stream bed and adding considerably to the pollution of the river.

There remains strong interest in the reprocessing potential of both stockpiles which have been extensively sampled for potential reprocessing and reportedly contain appreciable concentrations of Zn, Ag, and Au and possible rare earth elements. Though achieving such reprocessing is very much dependent on the fluctuating commodity prices, the processing of 700,000 tonnes of tailings from the T2 stockpile was reportedly undertaken in 1987 to 1988.

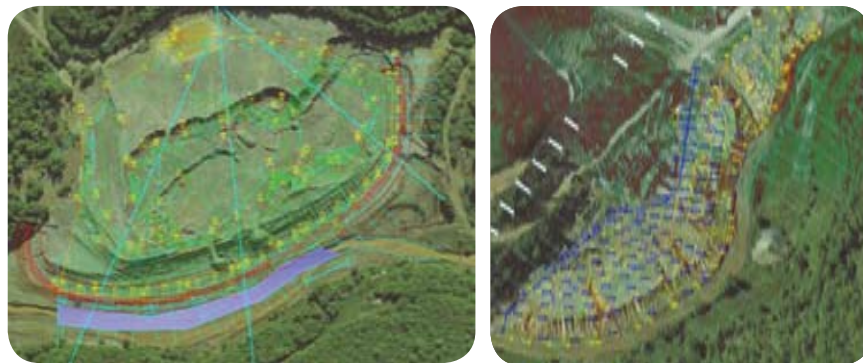
The Global Credit Crises saw base metal prices drop dramatically. Lead and zinc both fell to 35% of their value from previous highs in October 2007 to lows in October 2008 (Zn – EUR 2,540 to EUR 890; Pb – EUR 2,300 to EUR 818) impacting on the reprocessing trial covered within this publication.

In addition to pollution the tailings wastes contribute, acidic water from the Artana Mine itself drains out from the adit at level six in the mine with a pH of between 2 and 3. This merges with acidic waters from mine levels three and five at the front of the adit which then runs via a steep earthen channel approx. 500 metres before entering the Marec-Kriva River next to the T1 Stockpile.

The tailings stockpiles and acid mine drainage together represent significant sources of environmental pollution resulting in large amounts of contaminated, toxic waste being carried into the river.

ENVIRONMENT SITUATION

Acidic runoff, heavy metals including arsenic (As), cadmium (Cd), lead and zinc are carried into the river via surface runoff and leaching. Resulting water pollution presents an enormous threat to human and terrestrial species in the immediate vicinity and to aquatic species in the River Kriva. The area of the river above the T1 and T2 tailings and the mine drainage water is clear in colour and contains visible life. Chemical testing shows it to be free of heavy metals and neutral in pH. Below the tailings and mine drainage the water becomes a murky orange brown in colour and the river bed is heavily stained with iron oxide precipitates. This situation persists for many kilometres downstream, the pH drops to 4 and it is biologically dead.



Testing of the waters conducted in June 2010 in this programme near T1, T2 and the mine discharges show the water exceeds the EU drinking water standard by 58 times for arsenic (0.588 mg/L), 42 times for cadmium (0.212 mg/L) and 2.5 times for lead (0.253 mg/L). Similar concentration magnitudes were reported in the EARAP Report (Ref 6) with the following limit values: Pb - 0.8 mg/L; Zn - 20 mg/L; Cd - 0.24 mg/L. All of these heavy metals are serious contaminants causing a range of human health impacts including developmental, neurotoxic and carcinogenic health impacts and their exposure to humans and the environment must be minimised.

Data on air quality and dust deposition at the Artana/Novo Brdo mining site in the Kriva Valley is not available. Through discussions with the local community, dispersion of the tailings through wind erosion and problems with contaminated dust are less serious than the water contamination from the tailings and mine drainage waters. Even though the distance between the T1 tailings waste and the closest houses in Marec/Novo Marevce is less than 100 m, the T2 tailings waste are located about 1.6 km downstream of the Marec concentrator with single dwellings approximately 200 m to 400 m just north at the next bend of the river. Field visits to T1 and T2 did show limited development of dust partly due to there being wetter conditions during such visits, though consistent with the EARAP Report (Ref 6) it was seen that a thick crust had developed on the top of the tailings.



INTERVENTIONS

The measures recommended combating the environmental degradation caused by the mine tailings waste in T1 and T2 and the mine drainage waters from Novo Brdo Mine were as follows:

- Test the viability of reprocessing the tailings T1 and T2;
- Investigate any erosion protection measures for the tailings T1 and T2;
- Evaluate the requirements for a water treatment plant for the acidic and heavy metal-loaded waters flowing out of the Artana/Novo Brdo adits (merging at adit 6);
- Evaluate the possibilities of any passive water conditioning (e.g. engineered wetlands).

In response to these recommendations reprocessing was attempted within the programme and is discussed in a separate case study (Section Metal Recovery from Mine Waste and Water - Kishnica Reprocessing). In relation to water treatment, the lack of available time (need for detailed technical documentation, technical studies, pilot testing, etc.) and resources resulted in no treatment of acid mine drainage within this programme.

However, works to secure the tailings, reshape them and re-cultivate were possible within the resources and timeframe and were therefore conducted at each of the two sites, albeit in different ways. Given the limited funds available, priority was given to emergency measures that would mitigate the environmental impact now through river protection works to reduce the movement of contaminated tailings into the river. But, such work is envisaged as a temporary measure until the tailings can be removed for reprocessing in the future.

The measures to be taken included the following:

- Site clean-up (approximately 20 000 m² or 2 ha for each site);
- Excavation of contaminated soil from the vicinity of the nearest tailings dump;
- Backfilling of the excavations with inert material (waste rock, construction waste, fertile soil);
- Construction of diversion ditches – around the perimeter of the upper side to prevent upstream runoff water from entering the containment, thereby flushing and spreading contamination via water erosion;
- Construction of a protective embankment to divert river flow and prevent water flushing the tailings material;
- Temporary capping construction to minimize wind erosion and water penetration inside the tailings body (T1 only);
- Reshaping the tailings dump body to: i) optimize the total area to be covered; ii) optimize the slopes to achieve long-term stability (length, dip); iii) minimize wind and water erosion; iv) eliminate ponding and v) maximize runoff.



Works conducted at both the T1 and T2 sites involved geotechnical works over a similar area though with great differences in tailings volumes. This was due to the much greater volume (1.6 million tonnes) of tailings at the T2 site being quite compact and stacked at a much greater height than the tailings at the T1 site (400,000 tonnes) which was much lower in height but spread over a similar surface area.

The result of this is that works at both sites were conducted over a similar area (approx. 2 ha) with similar costs. For T1 the total cost of works alone were EUR 164,428 and for T2 EUR 199,749. However the great difference in the quantities of tailings contained at T1 and T2 has resulted in a greater level of protection and better design features being provided to the T1 stockpile (full cap and containment, better drainage structures, stone protection at the containment toe).

The T1 stockpile works also benefited from works being conducted later than for T2 when it was clear that reprocessing would not occur as quickly as hoped for, so better protection for the stockpiles should be provided. T2 works were completed in November 2008 over approx. 6 weeks, whereas works at T1 were completed in August 2010 over a 4-month period, which included severe delays from unseasonal and lengthy rainfall.

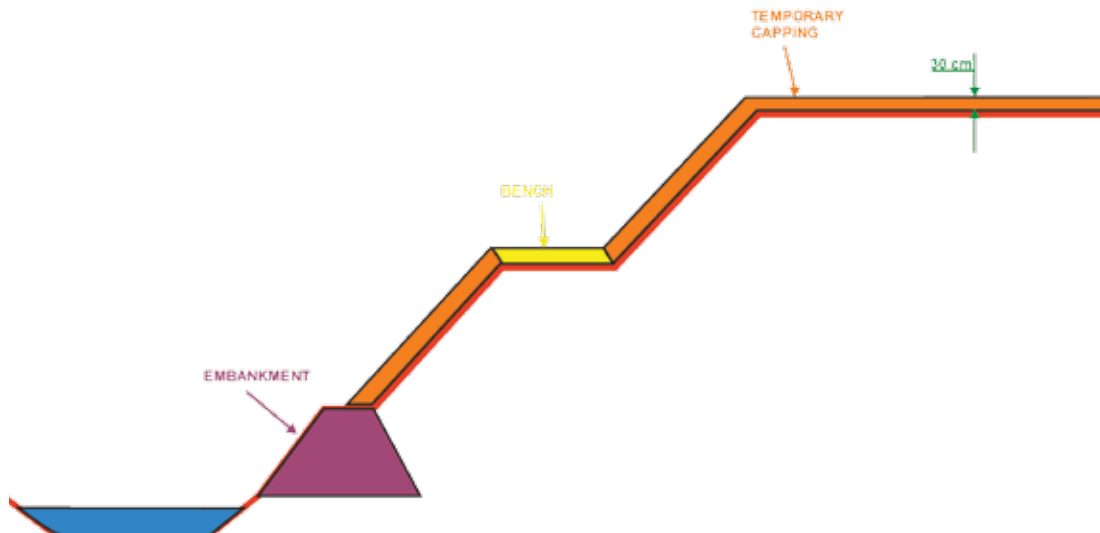


Figure 7 • *General Design Features for Reshaping and Capping of Tailings*

In general works at the two sites involved the following actions:

- Site cleanup of debris and other waste (approx. 20,000 m² or 2 ha), fencing and marking;
- Removal of tailings from the riverbed;
- Excavation of the humus layer;
- Construction of embankment (earth/gabions) along tailing perimeter in contact with river flow;
- Placed tailings in situ for reshaping in the containment area and construction of the clay barrier;
- Transport, spreading and compaction of all tailings materials into the stabilised and reformed containment area;
- Reshaping of the tailings dump body – the riverside slopes were adjusted to a slope of approx. 1:2 and the slopes were disrupted with a horizontal *berm* of minimum width 4 m (with transverse dip 2–3 % from the slope), the *berm* to run along the entire adjusted slope . The excess of material will be evenly spread on the upper part of the tailings body. Supply, transport, spreading and compaction of the clay-material embankment are to be in accordance with the final design;
- Final covering of tailing surfaces with clay, waste rock or crushed stone as per design with a thickness of 30 cm after slope compaction of 1% (T1 only); capping construction of waste rock or crushed stone. Due to possible reuse, only temporary capping with minimal compaction (loose on slopes) was conducted (T1 only);
- Tailing pit backfilling and planning with excavated earth material;
- Construction of diversion ditches – around the perimeter of the upper side to prevent runoff water from upstream entering, flushing and spreading the contamination via water erosion;
- Excavation of a 50 cm open trench constructed with clay (T1 only);
- Excavation, planning, and pitching, stone-wall encasement of the embankment toe (T1 only).

The works at T1 and T2 have now been completed and have both resulted in the tailings being removed from the riverbed and the mass flow of heavy metals from these sources being ostensibly halted for the time being. All works were achieved without hampering additional protection measures (possible mine water treatment/tailings reprocessing) for the T1 site through leaving necessary access required for a potential treatment plant and regulation of the flow of polluted mine waters.

Future access to tailings for reprocessing is also possible, since the capping provided for T1 is only temporary and easily removed, and has a dual benefit in protecting works from oxidation and erosion which may significantly reduce the effects of reprocessing. For the T2 site, works are more basic in having encased the tailings within an earthen bund, though the top of the tailings have been neither reshaped nor capped, meaning there is still some aerial exposure.

For both sites, however, ongoing maintenance of these containment structures will be required until the materials are reprocessed or the protection structures fail over time and the situation reverts to its previous state. Such maintenance needs to be coupled with addressing the acidic mine drainage through investigating and an in-mine solution (i.e. solutions in the mine for reducing the volume of water) and/or the end of pipe treatment of the acidic mine drainage itself.




Table 20 • *Clean-up Works in Artana (T1 and T2)*

WORKS AT T1 MINE TAILING SITE		January 2010 – July 2010											
		Jan	Feb	Mar	Apr	May	Jun	Jul					
TENDERING PROCEDURE – COMPANY TO CONDUCT PHYSICAL WORKS	EUR 164,428												
EVALUATION AND CONTRACTING													
PHYSICAL WORKS AT T1													
FINAL COMMISSIONING OF COMPLETED WORKS													
T1 MINE TAILING DESIGN AND SUPERVISION		January 20 – July 2010											
		Jan	Feb	Mar	Apr	May	Jun	Jul					
DEVELOPMENT OF THE FINAL DESIGN AND REVIEW	EUR 7,107												
EVALUATION AND CONTRACTING													
SUPERVISION OF PHYSICAL WORKS													
FINAL REPORT PREPARED													
WORKS AT T2 MINE TAILING SITE		January 2008 – December 2008											
		J	F	M	A	M	J	J	A	S	O	N	D
TENDERING PROCEDURE – COMPANY TO CONDUCT PHYSICAL WORKS	EUR 199,749												
EVALUATION AND CONTRACTING													
PHYSICAL WORKS AT T2													
FINAL COMMISSIONING OF COMPLETED WORKS													
T2 MINE TAILING – DESIGN AND SUPERVISION		June 2009 – February 2010											
		J	F	M	A	M	J	J	A	S	O	N	D
DEVELOPMENT OF THE FINAL DESIGN AND REVIEW	EUR 15,273												
EVALUATION AND CONTRACTING													
SUPERVISION OF PHYSICAL WORKS													
FINAL REPORT PREPARED													

REFERENCES

1. *REPORT CONCERNING ANALYSIS OF SAMPLES FROM WATER DRAINAGE IN ARTANA MINE, NOVO BRDO, SAMPLES OF WATER FROM THE RIVER KRIVA AND SAMPLES OF SOIL FROM THE MINE WASTE HEAP (TAILINGS) AT ZARKOV POTOK*, Tehnolab Ltd Skopje, for UNDP Kosovo, June 2010;
2. *MINING AND THE ENVIRONMENT IN THE WESTERN BALKANS*, UNEP 2010;
3. *DRAFT REPORT ARTANA – T1 PLANNED ACTIVITIES*, UNDP Kosovo, prepared by Dr. Sc. Dejan Mirakovski, December 2009;
4. *LOCAL ECONOMIC DEVELOPMENT STRATEGY IN THE MUNICIPALITY OF NOVOBĚRDĚ 2008-2010*, Care International Kosovo, ICCED Prishtina, March 2008;
5. *STRENGTHENING CAPACITIES IN THE COUNTRIES OF THE WESTERN BALKANS TO MITIGATE ENVIRONMENTAL PROBLEMS THROUGH REMEDIATION OF HIGH PRIORITY HOT SPOTS*, UNDP September 2007;
6. *ENVIRONMENTAL ASSESSMENT AND REMEDIAL ACTION PLAN (EARAP) STAN TRG/STARI TRG AND ARTANA/NOVO BRDO MINES, KOSOVO*, Montec, May 2007;
7. *UNEP/GRID ARENDAL; BALKAN VITAL GRAPHICS – ENVIRONMENT WITHOUT BORDERS*; ENVSEC 2007;
8. *SOUTHEAST EUROPEAN MINING-RELATED RISKS: IDENTIFICATION AND VERIFICATION OF ENVIRONMENTAL HOTSPOTS*, Philip Peck, UNEP Grid Arendal and Alexander Zinke, Zinke Environmental Consulting, August 2006;
9. *MINING FOR CLOSURE, POLICIES AND GUIDELINES FOR SUSTAINABLE MINING PRACTICE AND CLOSURE OF MINES REPORT*, prepared on behalf of the Environmental Security Initiative, 2005.

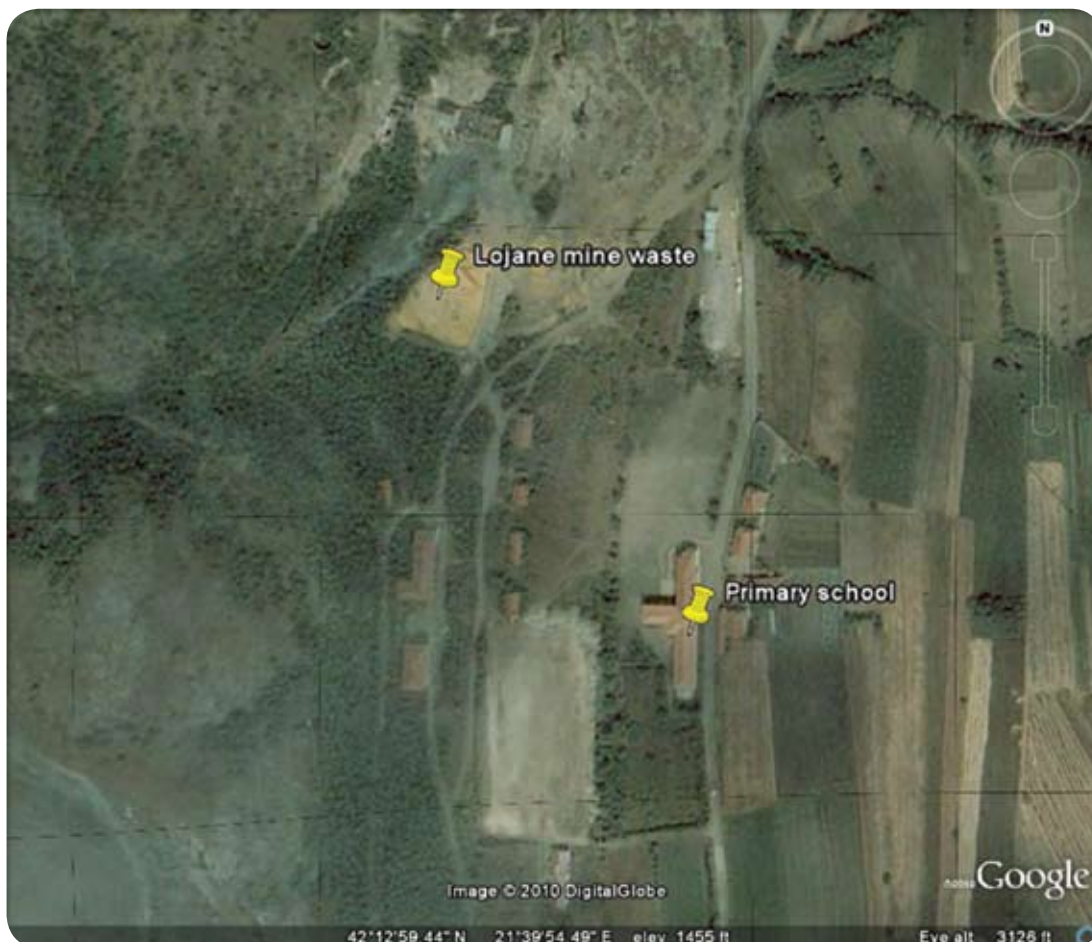


CAPPING
AND
CONTAINMENT
OF
ARSENIC
CONTAMINATED
PROCESS
WASTE

Location
LOJANE MINE, MUNICIPALITY OF LIPKOVO
The FYR of Macedonia

PROJECT WORKS

Emergency capping and containment of arsenic (As) contaminated mineral processing wastes close to a school and local villages.



ABSTRACT

Capping and containment works costing USD 217,110 were conducted to collect the main sources of arsenic-contaminated wastes (10,000 to 20,000 mg/kg) close to the school into one locality and cover it with a clay cap, to stop dust impacting on the students' and teachers' health where dust exceeds international limits (*Dutch Intervention Levels*) for Arsenic by 13 times (Ref 3). Works, conducted by the Macedonian Company, D.S Galab Dooel/Skopje, containing 20,000 m³ (2 ha) of arsenic contaminated waste cost a total of USD 205,125 and took 3 months to complete. Funding contributions included USD 103,536 from the Government of the Netherlands, USD 50,521 from the Government of the FYR Macedonia and USD 51,068 from UNDP Macedonia. Works were finalised in July 2010 with revegetation and maintenance to be conducted by local community institutions. An urgent need remains for the concessionaire to remove, contain or cover 15,000 tonnes of high-concentration arsenic waste (50% arsenic concentration) privately owned that remains uncovered less than 100 metres from the school.

Table 21 • *Summary of Site Works and Contamination at Lojane*

LOCATION/TYPE	COST OF WORKS IN USD	WASTES CONTAINED (M ³)	CONTAMINANT EXCEEDENCE IN THE SCHOOL
DESIGN AND REVIEW	6,785	N/A	As – 13 times (382 mg/kg)
SUPERVISION	5,200		Ni – 9 times (330 mg/kg)
PHYSICAL WORKS	205,125	20,000	Cd – 8 times (6.42 mg/kg)
TOTAL	217,110	20,000	

LOCATION

The Lojane Mine and its associated processing facilities are located in the Municipality of Lipkovo, in the north-east of the FYR of Macedonia. The municipality borders with Serbia to the north, the municipality of Kumanovo to the east, and the municipalities of Aracinovo and Gazi Baba to the south and west. A highway and international railway passes through the eastern part of the municipality connecting the community in a north-south direction following the flow of the Rivers South Morava and Vardar.

According to the 2002 Census, the Municipality of Lipkovo has 27,058 inhabitants and comprises 21 rural settlements. The village of Lipkovo is the administrative centre of the municipality and has 2,126 inhabitants. The village of Matejce is the biggest settlement with 3,126 inhabitants. Lojane Mine and its associated ore-processing facilities are located in the municipality of Lipkovo in the north-east of the country. Lojane Mine is identified as one of the 16 environmental hot spots within the Second National Environmental Action Plan (2005) and the National Waste Management Plan (2005). It is a chromium and antimony mine that was active in the period between 1923 and 1979.

The mine was operated by Italian Joint Venture Company until World War II. This was followed by a new state-owned company at the end of the war. For the mine's first 30 years of operations it had mostly targeted chromium production but in 1954 the mine began to extract antimony, and in 1965 an antimony smelter started operating at the site. In the mid-60s the company also became associated with the state-owned company, Zajaca, in 1964 after it was no longer able to export ore concentrate to the London Metal Exchange due to the high arsenic level in the concentrate. Ore concentrate was then sent to the Zajaca Metal Processing factory instead. The mine ceased all activities including mineral processing in 1979.

Until its closure in 1979, Lojane was an underground small-scale mining operation (room and pillar) and with primitive technology (in today's terms), probably engaging human power and the quantity of the materials excavated during the period when the mine was active (1923-1979) is estimated to amount to approx. 1,300,000 tonnes. The annual production capacity was between 25,000 to 30,000 tonnes, i.e. the operation was classified as relatively small (in today's terms, very small).

The total mine area is approx. 10 km². The area of consideration includes several locations where old production, storage and transportation facilities exist. Four mine adits and three ventilation shafts are located in the valley of Suva Reka. In the higher part of the valley the remnants of a small mining settlement and mine office/service building lie scattered over an area of approx. 3,000 m². In the same area are located three waste rock dumps and mined ore stockpiles. The remnants of the processing plant are located along the road connecting the villages of Vaksince and Lojane. The ore excavated was transported to the processing plant by a narrow railway line where the ore was reduced in size by the crushing and/or a

grinding circuit. Antimony (Sb) and arsenic (As) minerals were concentrated by flotation process. Concentrates were transported to the roasting plant and used to prepare ores for smelting. The old smelting facility and an open storage yard are located in the north-west of the village of Tabanovce, near Tabanovce international railway station, where customs and police control buildings were located.

With the cessation of works in 1979 in Lojane the Chromium (Cr) and Antimony (Sb) Beneficiation Plant and Mine were essentially abandoned, with the complete infrastructure i.e. production facilities (underground workings), beneficiation (flotation and smelting-ore roasting) facilities, waste dump and tailings ponds, storage yards, silos and workshops being left without any conservation measures to protect human and/or environmental health being undertaken.

In January 2007 after this long period of abandonment, the Government through the Ministry of Economy issued a concession for the exploitation of antimony from Lojane Mine to "Farmakom MB Zajaca", Serbia. In 2009 the granted concession agreement covered the abandoned mine and the area of the arsenic/antimony concentrate (15,000 tonnes) and the tailings dump (between the villages of Lojane and Vaksince).

The concessionaire had advised of plans to transport the concentrate away from the location for their further use but this had been subject to ongoing delays and complications within this programme and no conservation measures had been conducted by the company.

An open dumpsite for flotation and mining waste was essentially created by the mine and mineral processing conducted and is scattered in different locations across the operational site which covers an area of 10 km and contains toxic concentrations of arsenic, antimony and other hazardous substances.



Specifically, there are sources of contamination with heavy and toxic metals (As, Hg, Cr⁶⁺, Sb) along the old adits, roads and ruined buildings, polluting water and soil and entering the food chain, thus affecting a much wider area. Identified sources of pollution that include approx. 90,000 tonnes of waste rock that contains low-grade antimony and arsenic (1-2%) and 5,000 tonnes of stockpiled ore containing high-grade antimony and arsenic (5-10%) are located in the higher part of the valley. These dumps are prone to mechanical disintegration, wind and water erosion, thus presenting a significant source of contamination in the area between the villages of Lojane and Vaksince.

The tailings dump near the old flotation plant contains around 1,000,000 tonnes of fine material with an average concentration of As and Sb of up to 1-2%. The concentrate storage pond contains around 15,000 tonnes of high-grade concentrate of arsenic oxides (As_2O_3) (>50%). Just near to the tailings dump the local school and a few residential and commercial buildings are located, posing a significant threat to the health of children and adults working in these facilities.

Another source of contamination with toxic metals is located near the international railway station in Tabanovce where 4,000 tonnes of arsenic concentrate is stored in the open storage yard, left completely unprotected. In addition, there are around 2,500 barrels, almost disintegrated, filled with As_2O_3 located in the same place.

The most affected areas are between the villages of Lojane, Vaksince and Tabanovce and adjacent to the school.

Table 22 • *Summary of Wastes Present at Lojane Mine/Mineral Processing Complex (extract from Ref 3)*

LOCATION	OBJECTS	CHEMICAL COMPOSITION	QUANTITIES
Along the river Suva (Masugguri lill)	Office/Service Building	/	1.000m ²
Along the river Suva (Masugguri lill)	Shafts, Adits	/	3 shafts
			4 adits
Along the river Suva (Masugguri lill)	Waste rock dump 1	Low grade Sb ore and waste rocks (app.1-2% Sb&As)	20.000 tons
	Waste rock dump 2		20.000 tons
	Waste rock dump 3		50.000 tons
	Ore stockpile	High grade ore (app. 5-6% Sb, 4% As)	5.000 tons
Mining colony	Plant/Office Buildings	/	2.000m ²
Mining colony	Tailings Dump	/	1.000.000 tons tailings (1-2% As)
Mining colony	Arsenic concentrate	As_2O_3 (>50%)	15.000 tons
Roasting facility (Tabanovce railway station)	Open Stock Yard	As_2O_3 (>50%)	5.000 tons
Roasting facility (Tabanovce railway station)	Barrels	Sb concentrate	2500 pcs

ENVIRONMENT SITUATION

The results of the analyses conducted within the feasibility study for Lojane Mine have established the very high concentration of toxic wastes that are in close proximity to the villages and the school and the impacts these wastes have had in contaminating the water resources (underground and surface), soil and air.

Clear identification of sources of contamination; specification and quantification of contaminants involved; routes of exposure and zone-associated risk and security factors were identified.

What was shown is that the site is a dangerous source of contaminants with high concentrations of arsenic, heavy metals and other toxic compounds contaminating surface and underground water, soil and air. Arsenic in particular is found in high concentrations, up to 50% in some wastes, and is a very toxic element both to human health and to the environment. The 2007 CERCLA Priority List of hazardous substances ranks arsenic as the most serious contaminant, ahead of cadmium and lead (<http://www.atsdr.cdc.gov/cercla/07list.html>). Humans exposed to arsenic through food, water and air, as well as through skin contact experience severe health impacts with increasing concentrations. Exposure to the inorganic arsenic present in Lojane Mine can cause various health problems such as stomach irritation, decreased production of red and white blood cells, skin changes and lung irritation. It is suggested that uptake of a significant amount of inorganic arsenic can increase the likelihood of cancer developing, particularly skin, lung, liver and lymphatic cancer.

In addition to the high arsenic concentration in waste stockpiles that was previously mentioned, the analysis in the feasibility study found contamination in the following environmental areas:

SURFACE WATER – The River Suva collects drainage waters from the mine and the waste dumps which are washed with intense runoff from the steep slopes of the valley. This process is intensified during the high-water periods when the river floods the ore waste dumps. Therefore the content of arsenic in the River Suva is up to 40 times higher than the threshold limit value (TLV) for effluent waters in the country. Such high pollution could be explained by the high arsenic concentration in the ore waste and the extreme mobility of this metalloid. Extremely elevated arsenic concentrations in the River Suva's water certainly have a detrimental effect on aquatic life/biota in this water. Additionally this water is occasionally used for irrigation, thus polluting the plants/food produced, as long as the soil is irrigated.

Concentrations of contaminants in the Rivers Lojanska and Tabanovska, although higher than the threshold limit values prescribed in national regulations, are much lower in comparison to the River Suva due to favourable hydrological/hydrogeological conditions. Thus, the contaminated waters of the River Suva's flow are naturally contained. It should be noted however that the waters from these rivers are more widely used for irrigation and even as drinking water (the River Lojanska) which have a negative effect on human health, especially in prolonged use or contact.

GROUND WATERS – Based on the samples taken, the ground water quality is satisfactory and only slightly increased concentrations of arsenic are observed. This data confirms the thesis by the preliminary hydro-geological survey that there is no direct connection between contaminated surface waters and groundwater. It was also confirmed that the increased concentrations of arsenic in the groundwater found in two locations are the result of a high natural content of this element. These locations are the natural spring below the tailings as well as the well near the tailings pile (Bilnet Komerce Well). In both cases, the ground waters, due to their positive pressure, come to the surface and wash the tailings before they exit to the surface, thus collecting a huge amount of contaminants. The water from the spring creates a stream flow through the field and enters the River Suva. It is clear that the use of this water for any purpose could seriously affect exposed humans and animals.

SEDIMENTS – The extremely high levels of heavy metals in the sediment (As - up to 30 times the TLV; Cr - up to 10 times; Ni - up to 40 times; and Cd - up to 10 times the TLV) taken from the river bed of the River Suva are obviously the result of long-term deposition of leached metals due to the long period of uncontrolled pollution of the river flow.

SOIL – The soils in the immediate vicinity of the pollution sources are also highly contaminated with heavy metals. For example, the arsenic concentration is 50 times higher than the NOA (Netherlands Standard for Soil, since there are no national standards for soil). The most critical points are along the River Suva and the soils near the tailing dump.

AIR – Due to the very fine structure of the material disposed, erosion processes are present, especially wind erosion at the tailings dump sites. The airborne particulate pollution poses a direct risk for the health of the inhabitants of the villages especially those living or working in the immediate vicinity of the arsenic ponds (e.g. the school in Lojane).

INTERVENTIONS

With so many extremely highly concentrated arsenic sources on the surface at Lojane, uncovered, and in close proximity to the community, it is clear they are a primary source of arsenic contamination and a health risk to the community at this time and the priority for immediate action.

Disintegration of this material creates a self-induced cycle of pollution with permanently increasing potential, thus directly endangering the nearby villages, and through water and soil pollution enters the food chain, affecting a much wider area.

While there has been no direct study on the health status of the people living in the Municipality of Lipkovo, a study of the literature and consideration of the sources of site contamination revealed arsenic and other heavy metals blown as dust as the primary source of contamination to the villages and school.

Given that the resources were not available to address all of the site contamination problems an intervention was formulated to address the air pollution affecting the school with the hope that resources would be available at a later stage for a more comprehensive remediation programme for the site. This involves the mine concessionaire using barrier sprays on the concentrate storage ponds, or removing them altogether and a capping and containment system for other arsenic waste on a further 2 hectares. Although this only addresses part of the contamination problem, it should bring a significant and immediate reduction in airborne arsenic and its corresponding health hazards for the children in the nearby school.

The intervention to achieve the reduction in airborne arsenic and other heavy metals on the school from the mining and mineral processing wastes was based on an adaptation of the Technical Design (basic design level) for the completion of remediation activities for the flotation dump located between the villages of Vaksince and Lojane using the *Feasibility Study for Lojane Mine, Macedonia* prepared under the Czech-UNDP Trust Fund in 2007.



Works conducted by the Company D.S. Galab Doel/Skopje included the following elements:

- a. Site cleanup (approximately 20,000 m² or 2 ha):
 - I. Collection of dumped municipal waste from the roasting area, tailings dump and other close-by stockpiles;
 - II. Transport of collected waste to the tailings dump;
 - III. Excavation of contaminated soil from the vicinity of the tailings dump;
 - IV. Transport of contaminated soil from the surroundings to the tailings dump;
 - V. Backfilling of the excavations with inert material (waste rock, construction waste, fertile soil);
- b. Construction of diversion ditches – around the perimeter of the upper side to prevent entry of runoff water from upstream, flushing and spreading the contamination via water erosion;
- c. Blocking of the leaking abandoned well installed within the tailings dump, by injection of an impermeable solution and a concrete block plug;
- d. Reshaping of the tailings dump body – the eastern slope adjacent to the road from Vaksince to Lojane. Spreading of the excavated material on the upper part of the tailings body along with the crushed debris from demolished objects. Reshaping was necessary in order to: a) Optimize the total area to be covered, b) optimize the slopes (length, dip) prior cap construction, c) minimize wind and water erosion, d) eliminate ponding, and e) maximize runoff.
- e. Scraping the waste rock from the slope above the flotation plant to the tailings. The waste rock material, together with collected construction waste removed with the clean-up phase was used as filling in total thickness of $0.30 + 0.50 = 0.80$ m;
- f. Capping construction – layers (presented in Table 23). The final phase required covering the entire surface with a layer of cultivable soil, thickness of this topsoil layer was 30 cm, which allows seeding of indigenous vegetation.
- g. Revegetation – indigenous plants and trees in total approx. 2 ha.

Table 23 • *Layers of the capping*

Top soil (for revegation)	0,3m
Waste rock	0,3m
Bentonite clay	0,2m
Clay-Clay sands	0,3m
Waste rock	0,5m

Results

With the capping and containment of the 2 hectares of arsenic-contaminated waste completed in July 2010, remediation of one of the most toxic waste dumps from this mine has been achieved. The intervention, based on the findings of a feasibility study for remediation of Lojane Mine's historic pollution, used the recommended approach to prevent air pollution from the hazardous waste dump close to the primary school, which was for the area to be capped with an appropriate capping system (clay) and a layer of topsoil, and to be planted with suitable vegetation.

Works included construction of diversion ditches and channels for minimizing water flow through the contaminated materials, thus preventing mobilization of toxic elements spreading through the field below the containment area. The works also included removal of the contaminated topsoil within the school yard.

The primary beneficiary (Municipality of Lipkovo) has already assigned two municipal employees to maintain and irrigate the newly established vegetative cover. The programme donated small-scale irrigation equipment to the Municipality to enable this to be carried out and assure the survival and development of the newly-planted trees over the dry summer months.

The newly built cap literally eliminates emanation of fugitive dust from the previously exposed mine and surface of the mineral processing wastes, thus eliminating the main route of human exposure to toxic arsenic particles, especially exposure of school children as the most sensitive receptors. The newly built diversion ditches and channels minimize water flow through the dump body thereby significantly reducing surface and ground water contaminant loads, which used to be the main food-chain penetration pathway for those contaminants.

The capping system is sustainable for the foreseeable future for the following reasons: the dump site is relatively small; the bottom of the dump has low permeability (clay); and the position of the bedrock is flat so there will be minimal or zero contaminant migration into the nearby recipients.



For the other priority wastes present on the site a more comprehensive remediation programme for the site is required. Other remediation measures required to reduce the amount of dust from the major sources of arsenic contamination being carried into or around the school include the need for the mine concessionaire to use barrier sprays on the concentrate storage ponds, or removing them altogether, and a capping and containment system for other arsenic waste on a further 2 ha.

Although this site intervention addresses part of the contamination problem it should bring a significant and immediate reduction in airborne arsenic and its corresponding health hazards for the children in the nearby school.

Table 24 • *Clean-up Works in Lojane*

CLEAN-UP WORKS IN LOJANE – USD 217,110		August 2009 - June 2010											
WORKS AT LOJANE WASTE CONTAINMENT		A	S	O	N	D	J	F	M	A	M	J	J
Feasibility study developed	In kind contribution												
Developing final design	\$ 6,785												
Tendering procedure for remediation works	\$ 205,125												
Evaluation and contracting													
Actual works implementation													
Final commissioning of completed works													
LOJANE WASTE CONTAINMENT – SUPERVISION		December 2009 - July 2010											
		D	J	F	M	A	M	J	J				
Tendering procedure - Company/ IIE to do the supervision of physical works	\$ 5,200												
Evaluation and contracting													
Supervision of physical works at Lojane													
Final report prepared													

REFERENCES

1. *MINING AND ENVIRONMENT IN THE WESTERN BALKANS*, UNEP 2010;
2. *STRENGTHENING CAPACITIES IN THE WESTERN BALKANS COUNTRIES TO MITIGATE ENVIRONMENTAL PROBLEMS THROUGH REMEDIATION OF HIGH PRIORITY HOT SPOTS*, UNDP September 2009;
3. *FEASIBILITY STUDY FOR LOJANE MINE , MACEDONIA*, DEKONTA, CZECH-UNDP TRUST FUND; July 2007;
4. *UNEP/GRID ARENDAL, BALKAN VITAL GRAPHICS – ENVIRONMENT WITHOUT BORDERS*; ENVSEC 2007;
5. *BASELINE STUDY LOJANE MINE*, Faculty of Mining And Geology, Stip, November 2006;
6. *SOUTH-EASTERN EUROPEAN MINING-RELATED RISKS: IDENTIFICATION AND VERIFICATION OF ENVIRONMENTAL HOT SPOTS*, Philip Peck, UNEP Grid Arendal and Alexander Zinke, Zinke Environmental Consulting, August 2006;
7. *MINING FOR CLOSURE, POLICIES AND GUIDELINES FOR SUSTAINABLE MINING PRACTICE AND CLOSURE OF MINES REPORT*, prepared on behalf of the environmental security initiative, 2005;
8. *REDUCING ENVIRONMENT AND SECURITY RSK FROM MINING IN SOUTH-EASTERN EUROPE - DESK ASSESSMENT STUDY*, Philip Peck, EnvSec, 2004.;
9. *NATIONAL ENVIRONMENTAL ACTION PLAN*, Ministry of Environment and Physical Planning, October 2005;
10. *NATIONAL WASTE MANAGEMENT PLAN 2006-2012*, Ministry of Environment and Physical Planning, September 2005.



STABILIZATION
AND
RENEWAL
OF
TAILINGS
MINE
IMPOUNDMENT

Location
MOJKOVAC MUNICIPALITY
Montenegro

PROJECT WORKS

Construction of a wastewater treatment plant and stabilization and solidification of lead and zinc mine tailings in the tailing mine impoundment (TMI).



The works at the Mojkovac TMI were conducted by the Montenegrin Company “Yu Briv Kotor” (Wastewater Treatment Plant) and the Czech Company “Vodni Zdroje” (Mine Tailings Treatment). Work was conducted in two phases. The first phase involved construction of a 5,500-person equivalent wastewater treatment plant to receive and treat municipal sewerage. The second step involved emptying the water from the tailings impoundment and treating the 500,000 m³ of liquefied lead (Pb) and zinc (Zn) contaminated tailings inside the tailings impoundment. This has released 19 ha of land for the third phase involving a final capping layer and productive use of the now remediated site. With a planning and construction period of 3 years, works were finalized at a total cost of USD 10,800,508 (EUR 8.5 mil)¹ including the wastewater treatment plant constructed for USD 983,772 and the 500,000 m³ of tailings treated for USD 1,266,118. Total contribution included USD 1.63 million from the Government of the Netherlands, USD 1.14 million from the Czech Government and USD 8.1 million from the Government of Montenegro.

Table 25 • *Summary of Works Mojkovac Tailings Mine Impoundment*

WORKS CONDUCTED	COST OF WORKS (rounded values) IN USD	WASTE WATER CAPTURED AND TREATED (m³/yr)	TAILINGS TREATED (m³)
WASTEWATER TREATMENT PLANT	983,772	2920 (min) to 4380 (max)	
MINE TAILINGS TREATED	1,266,118		500,000
TOTAL	2,249,890		500,000

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 1 The exchange rate in this subsection is from September 2010 - 0.787 €/€

LOCATION

The Municipality of Mojkovac, with a territory of 367 km², numbers a population of 4,120 people in the city centre, with a total population of 10,066 in the Municipality of Mojkovac (according to the 2003 census). Located in the northern part of Montenegro, on the west bank of the River Tara, between the mountains of Bjelasica and Sinjajevina, upstream of the Tara Canyon and next to two national parks (Biogradska gora and Durmitor), at an altitude of 820 m, Mojkovac is surrounded by areas of high ecological value and tourist potential. In addition, the River Tara and its gorges are included on the UNESCO Heritage List. The town is situated at the crossroads of the main road connecting Montenegro's coast and the capital, to northern Montenegro and Serbia, and to the road leading towards Žabljak and Pljevlja.

Mojkovac was established during the rule of King Uros (1242-1276). In the past, the town was completely reliant on mining. As a mine, Brskovo was established when Saxons inhabited this area. Brskovo had a mint also, and money called "Grossi de Brescova" was minted there. In recent history, the lead and zinc mine "Brskovo", commenced operations in 1976 and with some breaks continued until 1991. At that point operations ceased and the mine, mineral processing facility and Tailings Mine Impoundment (TMI) were all essentially abandoned.



The land occupied by TMI is state-owned and was formed in the area between the right bank of the River Tara and the western side of the urban zones of Mojkovac. The TMI occupies an area of 19 ha and contains approximately 2 million m³ of disposed tailing impounded materials. In the past, the tailing impoundment walls have failed twice and could have caused severe damage to the River Tara and surrounding environment if repairs had not been made in time. One of these events occurred in the autumn of 1992, when the northern region of Montenegro was hit by very heavy rainfall.

The TMI was designed and constructed in three stages: the first one up to the peak elevation of 801 m above sea level (ASL), the second up to 805 m ASL, and the third and final stage, up to 807.5 m ASL. Its construction completely isolated the TMI from the River Tara. Along the side of the TMI facing the River Tara and adjacent to the Juskovica Brook on the northern side, an embankment dam was built using gravel from the riverbed. In size the dam is 1,130 m long, with an average height of 12.5 m. A concrete covering was also placed on the outer slope of the dam towards the River Tara, to prevent high river waters from entering the TMI. The dam slope and bottom of the TMI was constructed in a manner that should prevent the movement of tailings wastes from inside the TMI into the ground and the River Tara.

According to data on the total production of the Brskovo Mine, approximately 2,600,000 tonnes of tailings were produced and disposed of within the TMI. The available capacity of stage 3 (around 450,000 m³) is estimated to be 75% occupied by the flotation tailings. The unfilled volume of the TMI is approx. 475,000 m³ in area. The remainder was filled with the aforementioned tailings, municipal waste waters from the broken sewerage system (which was redirected to the TMI), and atmospheric rainfall. The concentration of the main heavy metals in the tailings wastes within the TMI are as follows: Pb = 0.20%; Zn = 0.30-0.40%; Cu = 0.10%; Fe = 4-5% and S = 10-12%. In addition to the main heavy metals present, there are also trace amounts of cadmium (Cd), antimony (Sb), mercury (Hg), arsenic (As), gold (Au), silver (Ag), germanium (Ge), molybdenum (Mo), etc. In addition to this, flotation reagents are present including cyanide (CN), copper sulphate (CuSO₄), xanthenes, and zinc sulphate (ZnSO₄).

Previous TMI Works

With the cessation of mining works and tailings waste production, a number of activities and events have occurred at the TMI. These include:

- a. Reclamation of the dam towards the River Tara, for 150 m of its length. The dam was damaged during great floods in 1992. To repair it, filling was done with crushed rocks and gravel, with works conducted at the end of 1992 and the beginning of 1993. Protection of the reclaimed dam was provided, in critical segments, by placing gabions along the dam base;
- b. Regulation of the River Tara bed, opposite the tailing mine impoundment. The works were conducted in 1993;
- c. Partial covering of the tailing mine impoundment area with gravel from the Tara and Rudnica riverbeds, in order to prevent the tailings being blown by wind in a dry spell. The works were carried out in 1993;
- d. Dislocation of the main sewer and a part of the precipitation collector in Mojkovac, partially leading through the area of the tailing mine impoundment. The works were however seriously damaged in the meantime by uncontrolled sewerage discharge into the TMI.

ENVIRONMENT SITUATION

The presence of the heavy metal contaminated tailings and uncontrolled municipal sewerage in the TMI has been a serious human and environmental risk. This is both due to the close proximity to the residential area of the city and the sensitive nature of the surroundings and their high environmental value. Given past dam failures, there have also been fears of a catastrophic failure of the dam wall with the potential loss of 500,000 m³ of tailings into the sensitive River Tara. As well as this risk, the dam was being used recreationally both for swimming and for catching fish for human consumption at great risk to human health.



The main environmental threats and impacts of the TMI, can be summarized as follows:

- Leaching of muddy and liquid components of the impounded material through the bottom and lateral sides of TMI and their migration to the River Tara, which is under national and international protection;
- Non-treated sewage waters from Mojkovac are being discharged into and remain in the TMI. Also, there is direct and indirect runoff into the River Tara;
- Precipitations, i.e. storm waters from the road (Kolasin-Mojkovac-Bijelo Polje) and neighbouring urban zones of Mojkovac are draining into the TMI, and consequently participate in the runoffs into the River Tara;
- Airborne pollution through windblown dust from the dry upper parts of the TMI. This is a threat to the human health of the local population living in the vicinity of the TMI due to the particle size and the presence of heavy metals;
- Ongoing disposal of communal solid waste into the TMI;
- Eventual breakdown of dam stability could cause overflow off toxic material from the TMI into the River Tara;
- Biodiversity (macrophyte vegetation, fish, birds) living in the water part of the TMI are exposed to contaminants present in the water and mud and bio-accumulate these toxic compounds or are otherwise harmfully impacted.

With due consideration to the negative impacts and risks that the TMI presented for the local population and environment (negative influence on health, economical development, environmental and dam stability, etc), in 2003/2004 the Ministry of Environmental Protection and Physical Planning of the Republic of Montenegro introduced requirements for a final solution to this problem and appointed the Faculty of Civil Engineering, Podgorica to develop a detailed design of the tailings impoundment for remediation and recultivation.

INTERVENTIONS

The planned works for the TMI in this programme involved two phases of work which are covered in more detail below. The first phase involved all works to construct and connect a new wastewater treatment system to stop the flow of sewerage into the tailings impoundment and ultimately into the River Tara. The second phase involved drainage of the impoundment so that no water remained. This would then be followed by stabilization of the muddy tailings sludge with lime, so that the contaminants within them would be less mobile and the material would have a strength similar to soil and be able to be used to build a solid surface. The remaining void in the impoundment would then be filled with clean fill to a final grade (i.e. a usable surface) and a temporary waterproof barrier.

This is to be followed by a third phase outside of this programme where a subsequent tender process is to be conducted to construct the final cap elements (i.e. drainage layer – gravel in pipework system, 1-metre earth layer and grass finish).

Construction of the wastewater treatment plant combined with the stabilizing, capping and containment approach aims to both prevent the TMI being an ongoing source of sewerage and metal contamination into the River Tara and to rehabilitate the tailings impoundment to permit productive public use of the area.



Preparedness Of Technical Documentation

In order to progress quickly with works, this project was based on the Government of Montenegro's Technical Design Project "*Remediation and Recultivation of the Mojkovac Lead and Zinc Tailings Mine Impoundment*" which had already been finalized and reviewed. Technical Design project was prepared by faculty of Civil Engineering, Podgorica and associated institutions in 2004, and as discussed above, with three planned phases and an approximate total budget of EUR 10,000,000. Only phase 1 and phase 2 are included within this programme, with further details on each provided below:

PHASE I

1. Additional research works in order to provide more precise data on mud volume and its suitability for stabilization;
2. Commissioning of the existing control manhole and drainpipes, construction of a new section of a drainage canal to divert atmospheric waters;
3. Facilities for tailings impoundment protection from external storm waters (a storm water collector and other facilities);
4. Reconstruction and completing of the sewerage system for wastewater in the area of the tailings impoundment;
5. Construction of a wastewater treatment plant for Mojkovac.

Construction of all of the above was completed in November 2008 and the wastewater treatment plant became operational at the beginning of November 2008, constructed on the northern side of the TMI dam, next to the mouth of the Juskovica Brook, works also included construction of an access road and regulation of Juskovica Brook. The WWTP constructed is a tertiary treatment plant capable of treatment to the national category 2 level, which is acceptable for protecting human and environmental health and is further diluted in the River Tara with a treatment capacity of 5,500 PE (people equivalent).

Total cost for all of these works was USD 983,772.

PHASE II

1. Removal of surface water from the tailings impoundment;
2. Stabilization of the tailings material, equipment procurement;
3. Tailings impoundment backfill;
4. Drainage layer construction (excavation, transport and filling of material);
5. Top-layer construction (excavation, transport and filling of material);
6. Diversion of storm water sewerage from the reclaimed TMI surface and waters from drainage layers away from the stabilised tailings.

Drainage of the tailings dam was completed through clear water being pumped into the River Tara in a quantity that dilution would ensure that contaminants remained at concentrations below the acceptable environmental threshold level. The remaining turbid waters, which would contain high levels of heavy metal contamination, were not pumped into the river but instead were used in the lime stabilization process.

The waters that were discharged were relatively low in contaminants, as had been indicated through water testing, and with dilution through the much greater flow of the River Tara would be well below human and environmental harm levels. Water testing had shown that the undisturbed waters within the TMI were mostly free of contamination as metals had been sorbed into the sediments.

The stabilization works awarded to the Czech Company "Vodni Zdroje" was progressively carried out between 2008 and 2010 and continued to completion of works in accordance with the plans. It was a relatively simple process which involved earth movers and bucket scoops and similar equipment being used to excavate the liquefied and muddy tailings from each area, transporting it to the onsite batch mixers where the tailings were mixed with 6% lime. Mixing was a relatively simple process with paddle mixers used to mix the reagents uniformly through the tailings within steel receptacles.

The stabilized and now solid products were progressively returned to the areas they were excavated once the material had cured. The process was repeated across the site until all 500,000 m³ of the material had been stabilized. To speed up the process and to work in areas where excavation might destabilize the adjacent main road between the TMI and the town of Mojkovac, the in situ mixer was used in place of batch mixing. This technology involves mixing and lime (calcium carbonate - CaCO₃) injection in the area where the tailings are situated rather than excavating the tailings, moving it, treating it and then returning it back to the original location. All stabilization works were completed in May/June 2010 at a total cost of USD 1,266,118.

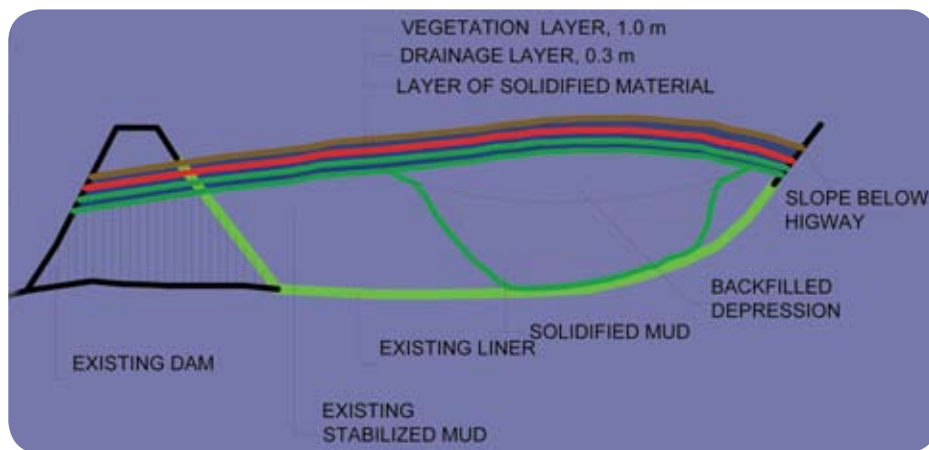


Figure 8 • *Vertical Section of the TMI Layers*

With the completion of phase 1 and 2 works in this programme phase 3 commenced with the launch of the tender and selection of a contractor. The end result of all 3 phases being completed will be the release of 19 ha of land for recreational and other uses by the Municipality of Mojkovac, and completion of the wastewater treatment plant ensures sewerage-contaminated waters are no longer released into the River Tara. A significant source of sewerage and heavy metals affecting the River Tara both within Montenegro as well as across the border in Bosnia and Herzegovina and Serbia has been eliminated along with the previous risk of a tailings impoundment failure.

Table 26 • *Summary of Work at Mojkovac Tailing Mine Impoundment*

CLEAN-UP WORKS IN MOJKOVAC	USD 2,249,890	APRIL 2007 – JANUARY 2010													
CONSTRUCTION OF THE WWTP	\$ 983,772	APRIL – DECEMBER 2007													
		N	D	J	F	M	A	M	J	J	A	S	O	N	D
Actual works implementation	\$ 368,772														
Actual works implementation – Govt. contribution	\$ 615,000														
Final commissioning of completed works															
TAILING MINE IMPOUNDMENT WORKS	\$ 1,266,118	AUG–SEPT 2008		APRIL 2009 – JANUARY 2010											
		A	S	A	M	J	J	A	S	O	N	D	J		
Tendering procedure for the physical works, phase II	\$ 1,266,118														
Evaluation and contracting															
Actual works implementation															
Final commissioning of completed works															




Figure 9 • *Architectural Solution of Former TMI – Methamorphosis*



REFERENCES

1. *MINING AND ENVIRONMENT IN THE WESTERN BALKANS*, UNEP 2010;
2. *PROJECT "REMEDATION AND RECULTIVATION OF THE MOJKOVAC LEAD AND ZINC TMI"* GOVERNMENT OF MONTENEGRO, 27 DECEMBER 2007;
3. *STRENGTHENING CAPACITIES IN THE WESTERN BALKAN COUNTRIES TO MITIGATE ENVIRONMENTAL PROBLEMS THROUGH REMEDIATION OF HIGH PRIORITY HOT SPOTS*, UNDP September 2007;
4. *UNEP/GRID ARENDAL; BALKAN VITAL GRAPHICS – ENVIRONMENT WITHOUT BORDERS*; ENVSEC 2007;
5. *SOUTH-EASTERN EUROPEAN MINING-RELATED RISKS: IDENTIFICATION AND VERIFICATION OF ENVIRONMENTAL HOT SPOTS*, Philip Peck, UNEP Grid Arendal and Alexander Zinke, Zinke Environmental Consulting, August 2006;
6. *MINING FOR CLOSURE, POLICIES AND GUIDELINES FOR SUSTAINABLE MINING PRACTICE AND CLOSURE OF MINES REPORT*, prepared on behalf of the Environmental Security Initiative, 2005.



CAPPING
AND
CONTAINMENT
OF ARSENIC,
LEAD AND
CADMIUM
CONTAMINATED
MINE
TAILINGS

Location
ZARKOV POTOK/KELMEND POND MINE TAILINGS DAM, STARI TRG/MITROVICA
UNATSCR1244 Kosovo

PROJECT WORKS

Emergency capping of arsenic (As), lead (Pb) and cadmium (Cd) contaminated tailings dam crest located above the city of Mitrovica and town of Stari Trg.



ABSTRACT

Works costing EUR 160,668 (USD 208,119)¹ (the Government of the Netherlands) were conducted by the Kosovo company "Kosova ERH & Kotori" to cover the arsenic (16,000 mg/kg), lead (7,163 mg/kg) and cadmium (616 mg/kg) contaminated dam crest of the 22.6 ha Zarkov Potok mine tailings dam by sealing it with a 50 cm earthen cap and stabilizing the uncontaminated surface with vegetation. These concentrations exceed international intervention levels (Netherlands Soil) by between 67 and 290 times for arsenic, 16-51 times for cadmium and between 5 and 13 times for lead. Works were conducted to minimize these dust-borne heavy metals impacting on the health of Mitrovica and surrounding communities. Contamination in this area is well documented, with this tailing dam one of many point sources in the area (which include Mitrovica Industrial Park, Zvecan Smelter, etc). The result is extreme levels of lead and other heavy metals reported in children, crops, soil and waterways. Works were finalized in December with a 6-week construction time capping 2.2 ha of the most exposed dam crest. Testing conducted in June 2010 shows the uncovered portions of the dam remain with very high concentrations of heavy metals and will require similar remediation in the future.

Table 27 • *Summary of Zarkov Potok Site and Works*

WORKS CONDUCTED	COST OF WORKS IN USD	CONTAMINATED AREAS COVERED (m²)	CONTAMINANTS PRESENT (mg/Kg)
DESIGN AND SUPERVISION	10,149	N/A	As – 3,700 to 16,000
PHYSICAL WORKS	197,970	80,000	Pb – 2,636 to 7,163
TOTAL	208,119	80,000	Cd – 194 to 616

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¹ Using the exchange rate for December 2008 – 0.772 \$/€

LOCATION

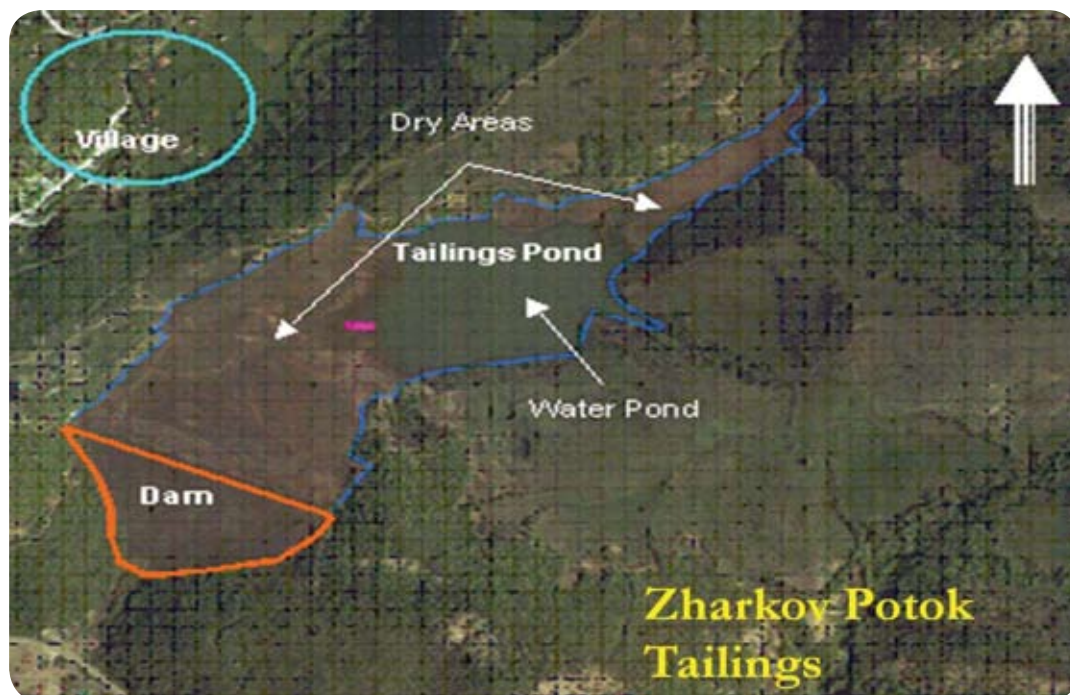
The Stan Trg - Stari Trg Mine is located roughly 8 km northeast of the city of Mitrovica which contains a population of 75,600 people in the urban core and 105,000 in the municipality area. While previously the site of intensive mining operations, it continues today at a greatly reduced capacity with much of the infrastructure in poor condition and employment a fraction of the original workforce. This is compounded by the shutdown of the downstream mining industries that were previously operating, such as the Zvečan metal smelter, the battery and fertilizer factories in Mitrovica Industrial Park, as well as others. The lead/zinc mine at Stari Trg is located on one side of the valley of the River Trepca (sometimes referred to as the River Barska), which is a tributary of the River Ibar. The concentrator at Prvi Tunel is located about 2 km downstream from the Stan Trg Mine, situated at the bottom of the narrow, steep-sided valley of the River Trepca. The Zarkov Potok tailings dam is located in a valley about 2.5 km southwest of the concentrator in the drainage basin of a small creek. Drainage from the impoundment flows a short distance from the dam southwest into the River Ibar some hundred metres below its confluence with the Sitnica. The distance between the toe of the tailings dam and the River Ibar is approximately 300 m.



The Zarkov Potok Tailings Pond project was designed in 1968. Tailings disposal lasted from 1984 until 1999. The tailings pond consists of a main dam, a western-side dam and the pond area which is filled with tailings from the processing of lead and zinc ores. The pond area of the Zarkov Potok tailings covers about 18.4 ha with the outer slope of the main dam enclosing about 4.2 ha.

The total mass of tailings wastes discharged into the dam is believed to be approx. 11 million tonnes. The current dam crest rises from approx. 586 m above sea level (asl) at the western end to approx. 591 m at the eastern end of the dam. The dam toe is located in the centre of the valley at approx. 512 m asl. The main dam is approx. 350 m wide and up to 79 m high at its highest point. The inclination of the outer slope of the main dam is $v : h = 1 : 2.5$. The main dam was designed to be constructed in four construction stages:

- a) **STAGE 1:** The first part of the dam consists of waste rock excavated from the rock slopes on both sides of the valley and from nearby slopes of the Ibar Valley. It is supposed to include a pioneer dam made of limestone and schists. Downstream of the pioneer dam a rock fill was constructed and a dam toe drainage layer made of crushed andesitic rock. The drainage layer is connected to the rock fill and located underneath construction stage 3 of the tailings dam.
- b) **STAGE 2:** construction of a tailings dam consisting of cycloned (coarse) tailings by increasing the dam crest of the pioneer dam constructed under stage 1.
- c) **STAGE 3:** construction of the tailings dam consisting of cycloned (coarse) tailings by increasing the dam crest of construction stage 2. Currently the final level of construction stage 3 has been constructed. According to the design documents construction stage 2 and 3 of the main dam include a vertical drainage filter for controlling the seepage line in the dam.
- d) A future construction **STAGE 4** was designed in the design project of 1968: according to the design documents the dam crest should be increased to 599 m asl. The dam body should then be elongated downstream. The western side dam was erected along the west perimeter of the tailings pond between two hills with an approx. height of 30 m. The outer dam slope inclination is v:h = approx. 1: 2.2. According to the design documents the western side dam consists of rock material (limestone, schists, andesite) excavated from the rock slopes nearby the tailings pond.



ENVIRONMENT SITUATION

Historic and ongoing mining activities from the Trepca group of mines have contributed to an environmental level of heavy metal and acid mine drainage pollution of the areas in close proximity to the Stari Trg with lead in particular having a well documented impact on human health, particularly in the vicinity of Mitrovica where the water, soil and food produced in the area have high levels of lead reported. The past and present mining activities are principally impacting on the residential areas through heavy metals being transported either through the air as dust from tailings or through the water through tailings heaps slumping into the rivers (or in close proximity to the rivers) and through direct drainage from the mines into the rivers.

There is considerable baseline data available, and this is summarized within the EARAP Report (Ref 4) showing that the mine complex at Stari Trg, including Zarkov Potok, contribute to the heavy metal contamination of Mitrovica and the surroundings through air and water pollution, though it forms only one part of such pollution caused by the poorly controlled activities of the whole industrial and mining complex in the area. These past practices have left a large-scale legacy of heavy metal contamination across the landscape, in the soil, air, water and agricultural crops. Nowhere is this impact as evident as in analysis of blood lead levels in children closest to the point sources of pollution which have been at extremely dangerous levels. The situation is so serious that the United States Center for Disease Control (CDC) was involved in emergency chelation therapy to reduce blood lead level in the most severely impacted children. The World Health Organisation (WHO) and national public health institutes have also been heavily involved in seeking to minimize the problem.

In general the information presented points to the lead dust sources (through food and transported surface dust) contributing to the worst aspects of lead, arsenic and cadmium load in the community and water pollution currently is secondary in importance. With the Zarkov Potok tailings dam perched above the town of Mitrovica with the dry tailings beaches forming an elevated mound on top of the tailings dam wall, it represented a clear point source of such airborne heavy metal contamination and was therefore selected for cleanup in this programme. Severe scouring and channel marks from the wind are apparent on the heaped tailings with a clear flight path for dust to be taken onto and around Mitrovica.

Prior information from the EARAP report (Ref 4) had also indicated the lead levels were approximately 10,000 mg/kg. Testing throughout this programme found excesses of Netherlands Soil investigation levels of 67 to 290 times for arsenic (3,700 to 16,000 mg/kg), 5 to 13 times for lead (2,636 to 7,163 mg/kg) and 16 to 51 times for cadmium (194 to 616 mg/kg). While accepted limits vary from country to country it indicates how high the concentrations are on the site and the very high health risk they continue to present while contamination can move through the air or water.

Prior to the works conducted in this programme, no cover had been placed on the surface of the tailings and dam, making them a significant source of dust. The Zarkov Potok Dam itself is located upstream of the town of Mitrovica and is thus a significant source of airborne heavy metals for nearby residents particularly during the hot, dry summer when strong winds blow across the dam and bare dry tailings beaches towards homes.

Complaints from the local community (especially the village of Kelmendi north of the tailings dam) in relation to dust blowing from the Zarkov Potok tailings area indicate it blows directly into the village area when a southerly wind is blowing, leading to contamination of arable land and water resources from airborne dust as well as to adverse health effects of the population. Dust emissions from the Zarkov Potok tailings impoundment would also result during high-wind events due to the high content of fine particulates, which on an uncovered and un-vegetated surface can be easily blown off the dam into the surroundings. As the tailings impoundment is only operated intermittently, large beach areas are exposed (in addition to the dam surface) and only precipitation events add moisture to the material, so that dry periods are likely to be associated with significant dust generation. Re-suspension of fine particulates during high wind events will occur whenever surface tailings are sufficiently dry and any surface crust is broken.

Analysis of the grain size of the Zarkov Potok tailings reveal a relatively high content of silt and clay sized material of about 35 % (Ref 4). Granulometric analyses of cyclone tailings provided by Trepca indicate that about 30 % of the currently produced tailings fall into the fraction associated with wind erosion (less than -200 mesh²). With the closest settlements situated only 250 m NW of the tailings pond, 300 to 400 m south of the dam toe and 800 m to the closest houses in the city of Mitrovica, there was an urgent need to take action on this site to cut off this source of airborne heavy metal pollution.

INTERVENTIONS

Given the scale of contamination from mine and mine-related industries in the Mitrovica and Stari Trg area, the planned intervention is quite limited. Remediation measures are focusing primarily on work to reduce the contaminant load entering the environment as much as possible. As indicated above, studies have shown airborne dust to be the largest contribution to the burden of lead in human bodies. Work is therefore focused on dust prevention and tailings stabilization at Zarkov Potok to stop this source of airborne heavy metal pollution.

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2 Mesh is very fine fibres criss-crossing, so any thing below that mesh size can get through it.

Works at Zarkov Potok at Stari Trg were conducted rapidly in good weather taking only 6 weeks to complete, at a total cost of USD 191,971 for reconstructing, reinforcing, reshaping 2.2 ha of the dam crest surface area as well as construction of a surface cap and revegetation of the dam crest as an emergency measure to improve air quality for residents living near the tailings pond.

The major activity involved excavating and transporting clean fill from the area of the tailing for creating the new crest and then protecting that material with a 50 cm layer of clay and a 10 cm layer of earth. This both capped the contaminated material beneath the clean fill and provided a substrate suitable for revegetation.

Levelling was done with machinery and compaction in layers every 30cm with specific compaction material in accordance with national standards and laboratory tests. After the crest body was created, a layer of clay was used to cover the new crest. The material was 30% clay mixed with sand and optimal humidity defined in laboratory. The same material was used for covering the slope area of the tailings dam body which was laid in two layers with a depth of 25 cm and compaction done with a compactor.

After applying layers of clay, the final surface layer of earth was applied and grass seeded across the site and is now well established. A conceptual plan of the cap is provided in the figures below.

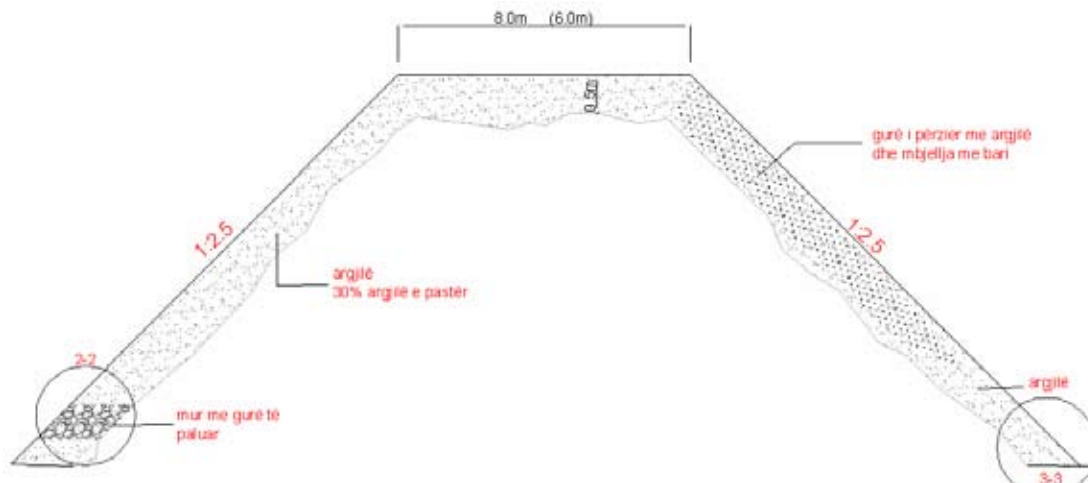


Figure 10 • *Vertical Section of the Dam Structure at Zarkov Potok Tailing*

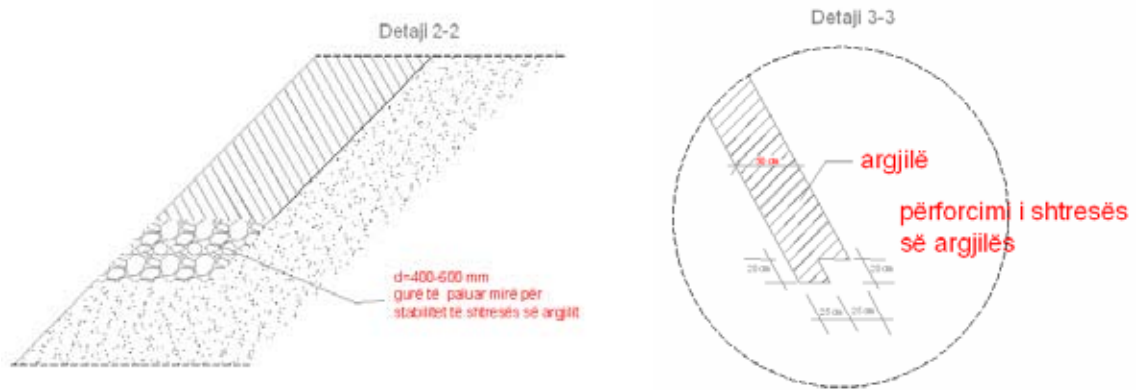


Figure 11 • **Vertical Section of the Dam Slopes**

With the works at Zarkov Potok having been completed and a significant portion of contaminated tailings and dam surface covered, an important first step in sealing heavy metal contamination within the major point sources has begun. However, ongoing maintenance of these containment structures will be required until more permanent solutions are possible or the protective covers will fail over time and the situation will revert to the previous position.

Such maintenance needs to be coupled with addressing the other point sources of airborne heavy metal pollution, both on the uncovered surfaces at this site which have now been shown as being heavily contaminated and for the other dust point sources in the area with the aim of reducing the body burden and subsequent health impacts that are presently impacting the community.



Table 28 • *Summary of Work at Zarkov Potok Tailings Dam Impoundment*

DAM CREST CAP AT ZARKOV POTOK TAILING	USD 208,119	JULY 2008– JANUARY 2009						
		Jul	Aug	Sept	Oct	Nov	Dec	Jan
Development of technical specifications and drawings and supervision	\$ 10,149							
Tendering procedure for physical works	\$ 197,970							
Evaluation and contracting								
Implementation and supervision of actual works								
Final commissioning of completed works								



REFERENCES

1. *REPORT – CONCERNING ANALYSIS OF SAMPLES FROM WATER DRAINAGE IN “ARTANA” NOVO BRDO MINE, SAMPLES OF WATER FROM THE RIVER KRIVA REKA AND SAMPLES OF SOIL FROM MINE WASTE HEAP (TAILINGS), ZARKOV POTOK*, Tehnolab Ltd Skopje, for UNDP Kosovo, June 2010;
2. *MINING AND ENVIRONMENT IN THE WESTERN BALKANS*, UNEP 2010;
3. *STRENGTHENING CAPACITIES IN THE WESTERN BALKANS COUNTRIES TO MITIGATE ENVIRONMENTAL PROBLEMS THROUGH REMEDIATION OF HIGH PRIORITY HOT SPOTS*, UNDP September 2007;
4. *ENVIRONMENTAL ASSESSMENT AND REMEDIAL ACTION PLAN (EARAP) STAN TRG/STARI TRG AND ARTANA/NOVO BRDO MINES, KOSOVO*, Montec, May 2007;
5. *UNEP/GRID ARENDAL; BALKAN VITAL GRAPHICS – ENVIRONMENT WITHOUT BORDERS; ENVSEC 2007*;
6. *SOUTHEAST EUROPEAN MINING-RELATED RISKS: IDENTIFICATION AND VERIFICATION OF ENVIRONMENTAL HOTSPOTS*, Philip Peck, UNEP Grid Arendal and Alexander Zinke, Zinke Environmental Consulting, August 2006;
7. *MINING FOR CLOSURE, POLICIES AND GUIDELINES FOR SUSTAINABLE MINING PRACTICE AND CLOSURE OF MINES REPORT*, prepared on behalf of the Environmental Security Initiative, 2005.

ABSTRACTS
SUMMARY

TUZLA

The works at Tuzla, conducted by the companies "Fuel Boss d.o.o" (works at Gradina) and "Tehnograd d.o.o." (works in Slavinovici and Dragodol) to shut down obsolete coal-fired boilers at two health clinics and the 650-resident heating plant involved earthworks, demolition, and construction works, installation of 31 substations, 2.5 kilometres of pipe works, thermal insulation, solar heating and other ancillary works. It involved a total planning period of 9 months and a construction period of 13 months and it was conducted at a cost of USD 2,600,000 (including: development of technical design, clean up works and supervision) with contribution of USD 1,428,000 from the Government of the Netherlands and USD 1,172,000 from the Municipality of Tuzla (cash and in kind). The works will reduce harmful air emissions in the city core by an estimated 500 tonnes per heating season (SO_x, NO_x, and Particulate Matter (PM)), decrease CO₂ by 16,730 tonnes per year and reduce coal use by 7,500 tonnes/year. Approximate annual savings of USD 550,000 equals a payback period of 4 years.

VRBAS

The works at Vrbas and Kula Municipality, conducted by the company "Graditelj NS" involved construction of a new waste water network i.e. main wastewater collector to connect two (2) municipalities and over twenty (20) industries to a new wastewater treatment system (central waste water treatment plant and wastewater network). This would permit the second phase of stopping further pollution of the Grand Backa Canal by an estimated 30,000 m³ of wastewater per day and finally the third phase to allow works on remediating the 400,000 m³ of polluted sludge in the canal to commence. With a planning period of 19 months and a construction period of 11 months, 6.6 km of pipeline was constructed at a total cost of USD 3.7 million including a USD 1.7 million contribution from the Government of the Netherlands for phase IV-1 and a USD 2 million contribution from the Serbian Government for Phase IV-2 and V.

BAJZA

The clean-up works at Bajza, conducted by the UK Company "Arundelle", resulted in the removal of 81.5 tonnes of waste from the site, with 65 tonnes to a landfill in Albania and 16.5 tonnes exported internationally, and verification that the site was clean. The original quantity of waste identified on the site was 280 tonnes, which leaves a surplus of 198.5 tonnes. Total clean-up costs were USD 346,000 with a contribution from the Government of the Netherlands of USD 222,000 and from the Albanian Government of USD 109,000 (USD 94,000 in cash and USD 15,000 in kind). Repackaging, temporary storage and disposal within Albania was completed in 4 months). However considerable delays (more than 1 year) and technical difficulties were encountered in exporting the 16.5 tonnes of waste for final disposal in the United Kingdom, related to the nature of the waste and apparent limited disposal options available there.

BALEZ

The clean-up works at the Balez government chemical store and surrounding Ministry of Defence (MoD) storehouses resulted in the removal of approx. 216 tonnes of waste from those sites for export to Greece, Germany and Belgium for treatment, disposal to landfill or incineration by the Greek Company EPE. The total cost was approx USD 476,000 with a contribution of USD 359,000 from the Government of the Netherlands, a USD 117,000 cash contribution from the Albanian Government with a further USD 60,000 in kind including USD 18,600 for barrels, pallets and transport from the OSCE (Organisation for Security and Cooperation in Europe). The total time of the works included 4 months for planning and 7 months for all repackaging and export. Initial repackaging works progressed rapidly with 100 tonnes at Balez and at a later stage a further 110 tonnes of MoD waste. Pre-export testing revealed approx. 14 tonnes of the Balez waste was unable to be exported under this programme's lifetime, as it was found to be radioactive. A further 20 tonnes of MoD waste was substituted in place of this waste.

BUCIM - Feasibility Study

A fully costed feasibility study and general design to recover saleable copper (Cu) to subsidise costs in treating metal-rich (400mg/l) and toxic mine effluent was prepared by the Bulgarian company BT Engineering at a cost of USD 243,350. The concept was based on similar plants operating in Bulgaria. The preferred technology (Variant II.2) was identified for treating the 30 litres per second (946,000 m³/yr) of waste rock drainage discharged from the approx. 110 million tonnes of waste rock (containing 0.11% Cu) present at Bucim Mine. The study found this technology could recover 195 tonnes of copper per year, reducing the copper concentration by 90% from 230mg/l to 30mg/l and subsidise treatment costs of contaminated water from EUR 560,540 per year (USD 716,803)¹ by EUR 563,980 per year (USD 721,202) giving potential profits of EUR 3,440 (USD 4,399).

KISHNICA - Flotation Plant

The planned treatment of Novo Brdo Mine tailings (containing up to 2.67% Pb, 2.70% Zn, and recoverable Ag and Au) through the reprocessing of 20,000 tonnes in the Kishnica Flotation Plant and transporting of 80,000 tonnes was halted with only 100 tonnes of tailings processed and 4,200 tonnes transported. Difficulties caused by the nature of the materials, a lack of material pre-treatment capability and the need for minor plant alterations (approx. EUR 15,000) resulted in the cancellation of the trial. Total costs were EUR 189,795 (USD 266,566.85)² with EUR 54,235 (USD 172,015) for actual processing chemicals used and EUR 135,560 (USD 137,385) for tailings transportation and related costs. Actual processing costs per tonne were calculated between EUR 8.55 and EUR 10.85 per tonne by independent assessments, while "Kishnica" calculated costs at EUR 23 per tonne.

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1 The exchange rate used under this section is from March 2009 (0.782 €/€)

2 Exchange rate used in this section is from August 2009 (0.712 €/€)

BUCIM – Physical Works

The works at Bucim are twofold. The first part involved capturing the contaminated waters through diversion of clean waters, construction of 2.2 kilometres of pipe works, 2 pumping stations and dams to collect and pump the 946,000 cubic metres per year of contaminated drainage waters coming from the 110 million tonnes of waste rock into the 38.7 ha tailings dam. Total costs incurred were EUR 814,364 with a EUR 674,364 contribution from the Government of the Netherlands and contributions of EUR 140,000 from Bucim Mine. The second part involved controlling the mine dust particularly from the tailings dam through, in the short term, installing water reservoirs, pump systems and sprinklers to control un-vegetated parts of the tailings dam face, with long-term dust control occurring through re-vegetation of approx 30 ha of the stabilized tailings dam. Total costs for this were EUR 554,634 with EUR 318,630 from the donor and EUR 206,004 from Bucim Mine. The complete cost of all works (water protection and dust protection combined), including supervision amounting to EUR 19,154 was EUR 1,358,152.

ARTANA

Consolidation and Containment works (River Protection), including design and supervision, costing a total of approx. EUR 386,557 (USD 506,628)³ with EUR 164,428 for T1 tailings dam and EUR 199,749 for T2 tailings dam, was conducted to contain approx. 2 million tonnes of lead-contaminated (Pb 26,700 mg/Kg) mineral processing wastes (tailings) and remove the portion which had slumped into the River Kriva. These uncontrolled tailing wastes were causing serious local and regional water pollution downstream (Pb 0.25 mg/L, Cd 0.212 mg/L, As 0.588 mg/L) and local air pollution from the heavy metal-contaminated dust being blown onto nearby villages and the school. The works conducted by UNATSCR 1244 Kosovo companies “Asfalti” (T1) and “Bejta Commerce” (T2) followed the general recommendations of the “Montec Report” conducted in 2007. Works were finalised in November 2008 (T2) and August 2010 (T1) involving removal of the tailings from the riverbed, construction of a protective earthen bund, capping (T1 and T2), revegetation and drainage works (T1 only). Further works remain to address the untreated acid mine drainage flowing from the Novo Brdo Mine adits into the River Kriva.

LOJANE

Capping and containment works costing USD 217,110 were conducted to collect the main sources of arsenic-contaminated wastes (10,000 to 20,000 mg/kg) close to the school into one locality and cover it with a clay cap, to stop dust impacting on the students’ and teachers’ health where dust exceeds international limits (*Dutch Intervention Levels*) for Arsenic by 13 times (ref 3). Works, conducted by the Macedonian Company, D.S Galab Dooel/Skopje, containing 20,000 m³

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3 The exchange rate used – August 2010 – 0,763 \$/€

(2 ha) of arsenic contaminated waste cost a total of USD 205,125 and took 3 months to complete. Funding contributions included USD 103,536 from the Government of the Netherlands, USD 50,521 from the Government of the FYR Macedonia and USD 51,068 from UNDP Macedonia. Works were finalised in July 2010 with revegetation and maintenance to be conducted by local community institutions. An urgent need remains for the concessionaire to remove, contain or cover 15,000 tonnes of high-concentration arsenic waste (50% arsenic concentration) privately owned that remains uncovered less than 100 metres from the school.

MOJKOVAC

The works at the Mojkovac TMI were conducted by the Montenegrin Company “Yu Briv Kotor” (Wastewater Treatment Plant) and the Czech Company “Vodni Zdroje” (Mine Tailings Treatment). Work was conducted in two phases. The first phase involved construction of a 5,500-person equivalent wastewater treatment plant to receive and treat municipal sewerage. The second step involved emptying the water from the tailings impoundment and treating the 500,000 m³ of liquefied lead (Pb) and zinc (Zn) contaminated tailings inside the tailings impoundment. This has released 19 ha of land for the third phase involving a final capping layer and productive use of the now remediated site. With a planning and construction period of 3 years, works were finalized at a total cost of USD 10,800,508 (EUR 8.5 mil)⁴ including the wastewater treatment plant constructed for USD 983,772 and the 500,000 m³ of tailings treated for USD 1,266,118. Total contribution included USD 1.63 million from the Government of the Netherlands, USD 1.14 million from the Czech Government and USD 8.1 million from the Government of Montenegro.

ZARKOV POTOK

Works costing EUR 160,668 (USD 208,119)⁵ (the Government of the Netherlands) were conducted by the Kosovo company “Kosova ERH & Kotori” to cover the arsenic (16,000 mg/kg), lead (7,163 mg/kg) and cadmium (616 mg/kg) contaminated dam crest of the 22.6 ha Zarkov Potok mine tailings dam by sealing it with a 50 cm earthen cap and stabilizing the uncontaminated surface with vegetation. These concentrations exceed international intervention levels by between 67 and 290 times for arsenic, 16-51 times for cadmium and between 5 and 13 times for lead. Works were conducted to minimize these dust-borne heavy metals impacting on the health of Mitrovica and surrounding communities. Contamination in this area is well documented, with this tailing dam one of many point sources in the area (which include Mitrovica Industrial Park, Zvecan Smelter, etc). The result is extreme levels of lead and other heavy metals reported in children, crops, soil and waterways. Works were finalized in December with a 6-week construction time capping 2.2 ha of the most exposed dam crest. Testing conducted in June 2010 shows the uncovered portions of the dam remain with very high concentrations of heavy metals and will require similar remediation in the future.

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4 The exchange rate in this subsection is from September 2010 - 0.787 €//\$

5 Using the exchange rate for December 2008 – 0.772 \$/€

LIST OF ABBREVIATIONS

ADA – Austrian Development Agency
ASL – Above Sea Level
AQI – Air Quality Index
CDC – Centre for Disease Control
CERCLA – the Comprehensive Environmental Response, Compensation and Liability Act (known as Superfund)
COPD – chronic obstructive pulmonary disease
CWWTP – Central Waste Water Treatment Plant
DTD Canal – Danube-Tisza-Danube Canal
EAS – Environmental Assessment Study
EARAP Report – Environmental Assessment and Remedial Action Plan Report
EC – European Commission
EPE – Environmental Protection Engineering
EU – European Union
FYR Macedonia – Former Yugoslav Republic of Macedonia
GDP – Gross Domestic Product
MC – Medical Centre
MESP – Ministry of Environment and Spatial Planning
METE – Ministry of Economy, Transport and Energy
MoD – Ministry of Defence
MS – Monitoring Station
NEAP – National Environment Action Plan
NFIM – Company NFI Maniera in charge of managing Balez storehouse
NOAA standards – National Oceanic and Atmospheric Administration standards
NWMP – National Waste Management Plan
OSCE – Organization for Security and Cooperation in Europe
PE – People Equivalent
PEHD pipes – Polyethylene High Density pipes
PS – Pumping Station
REC – Regional Environmental Centre
Ref – Reference
SCADA – Supervisory Control and Data Acquisition
T1 – Tailing 1
T2 – Tailing 2
TLV – threshold limit values
TMI – Tailing Mine Impoundment
TPP – Thermo Power Plant
UK – United Kingdom
UNATSCR 1244 Kosovo – UN Administrative Territory under Security Council Resolution 1244 Kosovo
UNEP – United Nations Environmental Programme
UNESCO – United Nations Educational, Scientific and Cultural Organization
UNDP – United Nations Development Programme
WBEP – Western Balkans Environment Programme
WWTP – Waste water treatment plant

CHEMICAL ELEMENTS

SO_x – Sulphur oxides
NO_x – Nitrogen oxides
CO₂ – Carbon dioxide
PM – Particulate matters
CO – Carbon monoxide
O₃ – Ozone
SO₂ – Sulphur dioxide
NO₂ – Nitrogen dioxide
Na₂SiF₆ – Sodium hexafluorosilicate
Cu – Copper
Pb – Lead
Zn – Zinc
Ag – Silver
Au – Gold
Cd – Cadmium
As – Arsenic
Hg – Mercury
Ni – Nickel

CURRENCIES

USD – United States Dollar
BAM – Bosnia and Herzegovina Convertible Mark
EUR – Euro
GBP – Great Britain Pound

MEASURES

GWh – gigawatt hour
Ha – hectare
kJ/kg – kilo joule per kilogram
km – kilometre
Km² – square kilometre
kg/h – kilogram per hour
kW – kilowatt
kWh – kilowatt hours
L – length
m – meter
m² – square meter
m³/h – cubic meter per hour
mg/m³ – milligram per cubic meter
mm – millimetre
Mt – mega tonne
MW – megawatt
Ppm – part per million
µg/m³ – microgram per cubic meter
Tonnes/yr – tonnes per year



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