Roads Department of the Ministry of Regional Development and Infrastructure of Georgia

Environmental and Social Impact Assessment of Works for the Improvement of Chumateleti-Khevi Section of E-60 Highway

Prepared by: "Eco-Spectri" Ltd

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Table of Contents

LIST OF ACRONIMS

EA	-	Environmental Assessment
EIA	-	Environmental Impact Assessment
EMP	-	Environmental Management Plan
ESIA	-	Environmental and Social Impact Assessment
ESMP	-	Environmental and Social Management Plan
HSE	-	Health, Safety, Environment
HS	-	Health and Safety
GIS	-	Geographic Information System
GoG	-	Government of Georgia
IPPC	-	Integrated Pollution Prevention and Control
KP	-	Kilometer Post
MED	-	Ministry of Economic Development of Georgia
MEPA	-	Ministry of Environmental Protection and Agriculture of Georgia
MLHSA	-	Ministry of Labour, Health and Social Affairs of Georgia
NGO	-	Non-Governmental Organization
RD	-	Roads Department of the Ministry of Regional Development and Infrastructure of Georgia
MRDI	-	Ministry of Regional Development and Infrastructure of Georgia
ToR	-	Terms of Reference
WB	-	The World Bank

EXECUTIVE SUMMARY

Introduction

The Government of Georgia is implementing a program to upgrade the major roads of the country, managed by the Roads Department (RD) of the Ministry of Regional Development and Infrastructure (MRDI). The program aims to improve transportation and transit of goods to surrounding countries, which is a significant and growing contributor to GDP.

Transport of goods into and through Georgia has increased over the past 10- 15 years as markets have expanded following the breakup of the Soviet Union, and Georgia is now a major transit country. Almost two-thirds of goods in Georgia are transported by road, and haulage by domestic and international truck companies is very evident on the country's highways. However many roads are poorly equipped to cope with the volume of traffic and the proportion of heavy vehicles, and factors such as insufficient dual carriageways, routing through inhabited areas and inadequate maintenance and repair, hinder throughputs and increase transit times. This creates difficulties for haulage companies and their clients, truck drivers, Georgian motorists and local residents.

The critical target of the program for upgrading major roads in Georgia is the E-60 or the East-West Highway (EWH) - the main route to neighboring Azerbaijan and Russia, also connecting to Turkey and Armenia. For planning purposes, the EWH has been divided into sections of various lengths. The World Bank is providing series of loans to the Government of Georgia for upgrading this highway through East West Highway Improvement Projects (EWHIPs). Three projects of these series are now completed covering the highway section between Agaiani and Agara. EWHIP-4 and East West Highway Corridor Improvement Project (WEHCIP) are currently under implementation covering the sections Agara to Zemo Osiauri and Zemo Osiauri to Chumateleti (shortly before Rikoti tunnel, which takes the EWH from East Georgia to the West).

The next section of EWH targeted for the improvement lies between Chumateleti and Khevi, and includes construction of an additional tunnel through Rikoti mountain pass. Preparatory work for this investment is being financed from EWHCIP and includes conduct of the Environmental and Social Impact Assessment (ESIA) of the proposed infrastructure. Civil works in this section may be supported with the Additional Financing to the EWHCIP as well as from the sources other than the World Bank.

Objective of the ESIA

Objective of the conducted ESIA was to identify expected positive and negative environmental and social impacts of the improvement and operation of EWH between Chumateleti and Khevi in the construction and operation phases;identify likelihood, magnitude and spread of these impacts; and work out measures for avoiding or mitigating these impacts. ESIA contributed to the analysis of routing and design alternatives and the selection of the solutions most suitable from economic, fiscal, technical, social and environmental perspectives. The ESIA report includes an Environmental and Social Management Plan (ESMP) which will become a part of the contract for the provision of upcoming civil works and serve as a field guide for good environmental performance mandatory for adherence by contractor.

Screening Outcome

Under the Article 4, Paragraph 1, Subparagraph "j" of the Law of Georgia on Environmental Impact Permit, construction of international and intrastate highways and railways, bridges and

underway crossings beneath them, as well as engineering structures for the protection of highways, railways and their territories is subject to the State ecological examination. Therefore, improvement of Chumateleti-Khevi section of the EWH is subjected to the ecological examination and issuance of an environmental permit. The permit is to be issued based on the expert conclusion of the State Ecological examination by the Ministry of Environmental Protection and Agriculture of Georgia (MEPA).

According to the requirements of the World Bank's safeguard policy OP / BP 4.01 Environmental Assessment, upgrading of EWH fall under environmental Category A requiring a full-scale ESIA and the development of an ESMP.

Public Participation

The Bank policies and the Georgian legislation require meaningful public participation and involvement in the process of ESIA and environmental management planning. The main principles of the public consultation include:

- Conduct of at least two public consultation meetings for environmental Category A activities: one at the early stage for agreeing on the Terms of Reference (ToR) of the ESIA and the approach to this study and the second – at the final stage of the process to discuss the draft ESIA report;
- Prior disclosure of the documents to be publicly discussed, and announcement of the time and venue of the consultation meeting through central and local means of public communication;
- Invitation of written comments/questions on the draft ESIA; and
- Incorporation of public feedback into the ESIA report and re-disclosure of the finalized document.

RD carried out the public consultation meeting on ToR for the ESIA on May 6, 2016. As part of the ESIA, consultations were held in September 2016 with the owners and employees of businesses located in the vicinity of the highway corridor, as well as with individual entrepreneurs. Information-sharing meetings were also held with the representatives of Khashuri municipality and population of Khevi village. The draft ESIA report will be posted on the web page of the MRDI. Hard copies of the document will be made available at the offices of Khashuri local self-governments located in the vicinity of the EWH, RD, and the office of Ltd "Eco- Spectri".

The first Public Consultation Meeting on the Draft Environmental and Social Impact Assessment Report for the Modernization of Chumateleti-Khevi Section of East-West (E-60) Highway was conducted in 10th of march in 2017 in Village Vertkvichala. According the requirements of Georgian legislation Public Consultation Meeting on the Draft Environmental and Social Impact Assessment Report for the Modernization of Chumateleti-Khevi Section of East-West (E-60) Highway were conducted in Khashuri Municipality and in Kharagauli Municipality buildings (see attachment 1) January 12, 2018. Also, the draft Resettlement Action Plan (RAP) was discussed on January 12, 2018 in village Khevi.

Sensitive Environmental Receptors and Potential Impacts

The EWH section covered by this ESIA is 11.2 km long, out of which 2.4 km is the length of three tunnels and 22 bridges to be constructed. In terms of environmental and social sensitivities, this section and the adjacent territory may be divided into four categories: (i) section from Chumateleti to the East portal of the Rikoti tunnel (1.5 km, including a smaller tunnel with the length of 0.7 km); (ii) coupled Rikoti tunnel (1.7 km); (iii) section from the West portal of the tunnel up to

village Khevi (5 km); and (iv) village Khevi (3 km).

The main environmental impacts are expected at the construction phase and come from clearing of the right- of-way (RoW), establishment/operation of work camps and temporary access roads, operation/servicing of construction machinery, massive excavation works required for the tunnel construction and works near waterway.

Clearing of the RoW will in certain areas will imply de-listing of land plots from the State Forest Fund. Drilling of the new tube of the Rikoti tunnel will generate vast volume of excess material and its disposal in the environmentally decent way will be a challenge both technically and financially. Establishment of construction camps and access roads will be associated with the generation of solid waste and wastewater, compression of soil, and noise related nuisance. Parking, operating and servicing of construction machinery will carry the risk of operational spills of oils and lubricants (i.e. the risk of soil pollution) and generation of noise, vibration, dust, and emissions. It is expected that the construction material will be purchased from suppliers licensed to operate quarries or borrow pits. License for use of natural resources - in case the contractor decides to use own quarries/borrow pits - will be obtained by the contractor from the National Environment Agency of the MEPA. Construction works will also have implications for the occupational health and safety of workers/personnel.

Impacts of the new road during its operation phase are less diverse. Environmental aspects of the highway operation will be air pollution from automobile emissions, and pollution of soil with litter and drainage from the highway as well as water pollution with liquid/powder cargo and/or fuel and lubricants from the cars as a result of traffic accidents on the road section and runoff from the road. Project design brings the risks of negative impacts on environment to the feasible minimum. Provision for road safety, control over the operation of the Rikoti tunnel, and traffic regulation will contribute to managing risks of accidents. Installation of noise barriers is not required. Traffic safety will be an important issue with health, social, and environmental implications.

Direct social impact of the construction in the first and third sections will affect catering facilities (9) located adjacent to the highway, fueling station (1) and individual road-side vendors whose work is seasonal and lasts for 3 or 4 months a year. As of October 2016, some 14 individual traders were found within the subject section of the EHW corridor. 13 of them were interviewed (1 of them refused). Based on the information obtained from the respondents, the number of vendors is much higher (by 2, 5 or 3 times). They are mainly residents of the adjacent villages and trade with their own harvest (fruit, corn, honey, etc.).

All physical and legal bodies affected by the project will receive adequate compensation, amount of which will be specified during preparation of the Resettlement Action Plan.

Village Khevi is located on the both sides of the highway, stretching over the distance of about 3 km. in fact, the highway divides the village into two parts. At present, there are 12 access roads connecting village to the highway. In addition, present configuration of the highway allows pedestrians to cross the highway at any point. This facilitates the movement of the village residents from one part of the village to another. Also, there is a 3 km local motor road branching out from the highway that leads to village Tsakvi. This road provides the only motor access the village with 80 homesteads.

Reconstruction of the EWH will result in displacement of road-side small businesses, and alter motor and pedestrian communication within and around Khevi village. Compensation and alternative connectivity will be provided.

Project Alternatives

No-project scenario

No “showstoppers” have been identified during ESIA and the anticipated impacts can be managed by application of adequate construction standards and good environmental practices. Nonetheless, a “no-project” option was considered as one of the project alternatives. While it has no environmental and social impacts resulting from the construction works, continuing operation of the highway in its current poor condition would have negative environmental and social impacts from traffic jams, noise, low speed, and high emissions. In the future, with consideration of the anticipated increase of the traffic flow, the situation will worsen. On the global scale, under the "no-project" scenario, local communities would lose opportunity of benefiting from all positive effects associated with the highway improvement, including profits resulting from increased cargo turnover and tourism. Therefore, as the potential positive impacts of the project surpass its possible negative impacts, the “no-project” option was discarded.

Alternatives for placement of Rikoti tunnel tube

Two alternative routes for drilling the additional tube of the Rikoti tunnel were considered. As per the first alternative, the length of the tunnel would be 2,100 m commencing from the starting point of the bypass road of the existing tunnel and following the existing tunnel from the south, with its west portal to be placed on the right bank of river Rikotula. As for the second alternative, the new tube would run south the existing one and in parallel to it, and will have the length of 1,800 m. Comparing these two alternatives showed that the potential environmental impacts of both of them are equal; however under alternative 1, the amount of the excess material to be generated is higher than with alternative 2. This is a disadvantage of alternative 1, as disposal of the excess material will be pretty problematic. In addition, the longer the section of the tunnel, the more vulnerable it will be in a hydro-geological respect. With consideration of these factors, alternative 2 is preferable.

Alternatives of the road corridor

For approximately 7.5 km of the highway westwards from the West portal of the tunnel, feasibility of two alternative routes had been studied for placement of the two additional lanes of the highway. Under alternative 1, the new lanes would be separated from the existing ones passing on the right bank of river Rikotula and follow a new alignment on the left bank of the river. This would require clearing and cutting of the forested mountain slope, and building of additional bridges and overpasses. Alternative 2 implied widening the existing corridor on the right bank of the river Rikotula to place additional two lanes adjacent to the present ones.

In order to select the most optimal alternative of these two, the landscape, flora, fauna, geology and other environmental and economic indicators were considered as criteria. The comparison between the two alternatives identified the principal advantages and disadvantages:

- Under Alternative 1, two lanes of the highway cross a potential rockfall area between km 6+000 and km 7+000. This threat does not exist under Alternative 2, with all four lanes passing on the right bank of the river.

- Under Alternative 1, from November through February, the two lanes of the highway will mainly remain in the shade during the day. Under Alternative 2, all lanes are exposed to the sunlight permanently during the day, even in winter months. Hence, Alternative 1 carries higher risks for safe driving in winter condisions as compared to Alternative 2.

- Under Alternative 1, extraction of a larger number of trees, including those of the Red-Listed species, would be required as compared to Alternative 2.

- Under Alternative 1, wild animals would loose free access to the left bank of the river in the stretch of 5-6 km, while under Alternative 2, left bank of the river retains its current natural status and no additional impact is expected.

- Finally, estimated volume of excavated material that is left after backfilling is larger under Alternative 1 than under Alternative 2.

Careful assessment of these two alternatives showed overall advantage of Alternative 2, as the magnitude of its negative impacts is smaller, and mitigation of these impacts is technically more feasible and financially more affordable than coping with the persistent geohazards related to alternative one.

Project Description

The EWH section to be upgraded between Chumateleti and Khevi is classified as a road of the "international importance", with the design speed fixed at 80 km/h.

Construction of three tunnels is planned within the 11.2 km zone of the project area, the length of which are 0.7 km. 0.3 km and 1.7 km. Eight existing and new bridges have been proposed within the framework of feasibility study. Locations and length of these bridges may be changed at the detailed design stage.

Construction of three tunnels is planned within the 11.2 km zone of the project area, the length of which are 0.7 km and 1.7 km. 22 existing and new bridges have been proposed within the framework of feasibility study. Locations and length of these bridges may be changed at the detailed design stage.

The cross section of the road will be 26 m, with 13 m each side. The center mall will be 5 m wide. The shoulders will be 3 m and 0.5 m wide, the edges will have the gradient of 2.5% and the width of the roadway on both sides will be 7 m each. As for the sections of bridges, the one-side bridge will be 13.5 m wide, including the emergency side tracks and zone for repairs.

The minimal parameters of the cross section of the tunnel are as follows:

- Min. vertical size: 5.0 m;
- Lane width: 3.75 ∂ (100 km), 3.50 m (80 km);
- Min. shoulder width:0.25 ∂ (edge line);
- Min. pathway width: 0.75 m;
- Pathway height: 0.15 m.

Approximately 200 people will be employed during the construction stage, with 60-70% of them as local people. Hence no tangible influx of work force is expected.

ESIA Methodology

The ESIA process consisted of the six main activities that are common for similar studies conducted according to the international standards:

1. Collection of baseline data describing biophysical and social environment within the study area; desk studies and field surveys to address identified gaps in the existing data;

update of information on topics and areas where significant negative impacts are expected.

2. Identification of the expected positive and negative impacts of the proposed works on the highway and of its operation thereafter; assessment of the likelihood and significance of the potential negative impacts; and development of mitigation measures.
3. Analysis of alternatives in terms of location, technology, design and operation, including the "no-project" alternative.
4. Development of the Environmental Management Plan.
5. Drafting of the ESIA report.
6. Information disclosure and stakeholder consultation.

Background Environment

The area of the design section between Chumateleti and village Khevi is located in the high-mountainous zone of Central Georgia and is a part of the Trans-Caucasian geomorphological intermontane region, in the eastern part of so called Dzirula Massif called Zemo Imereti Elevation (Plateau).

In a hydro-geological respect, the ground waters formed in the thick elluvial cover of crystal rocks are important. According to the Seismic Hazard Map of Building Norms and Rules effective in Georgia "Earthquake-resisting construction (SSM III, 21.10.2009 N 128, article 1477)", the project area is located in the 8-point earthquake zone (MSK 64 scale) (See Figure 4.3) with the dimensionless coefficient of seismicity (A) equaling 0.16 (village Khevi) under the same document.

In respect of orography, the design corridor is presented by a mid-mountainous, erosive-denudation relief. In a geological respect, the territory is located within the limits of Paleozoic and Bathonian crystal sub-stratum. The existing road is located at the bottom of the forested slope of the river Rikotula gorge. It is characterized by a complex dissected relief.

The main artery of the hydrological network of the project corridor is the river Rikotula. A major part of the project area (in respect of sensitivity) is located on the territory of Kharagauli municipality and broad-leaved forest zone over Rikoti Pass. The forest here represents the impoverished variant of Colchic vegetation. The total number of relict Colchic species on the territory of the municipality is not very few, but the number of phytocenosis positions of species is not great. However, such Colchic relicts, as rhododendron (*Rhododendron ponticum*), flame azalea (*Rhododendron flavum*), cherry laurel (Laurocerasus officinalis), willow (*Buxus colchica*), ilex (*Ilex colchica*), Colchic ivy (*Hedera colchica*) and Israeli ruscus (*Ruscus ponticus*) are quite many in number. With their appearance, the forests here more look like the forests in east Georgia than other forests in west Georgia, even more so that the plant marking xerophytization, as oriental hornbeam (*Carpinus orientalis*), is not a rarity here.

The protected area located closest to the study corridor is Borjomi-Kharagauli National Park. The direct distance of the Park from the study corridor is 6 km.

The begging point of the project area to Khevi is less inhabited, and as for the section running near village Khevi, the road runs across several privately owned plots and residential houses. In addition, a public school in village Khevi is also under the impact.

From village Chumateleti to village Khevi, the project will affect both, the legal and private businesses. Mostly, these include the catering objects operating adjacent to the existing highway. As per preliminary design, 7 operating restaurants, 4 abandoned objects with different designations

(three restaurants and 1 repairs shop) and one fueling station come under the impact. The private entities trading with their own harvest or products gathered in the woods adjacent to the existing highway also lose their temporal incomes. The number of these entities is 35-40. As for the section running near village Khevi, the road runs across several privately owned plots and residential houses. In addition, a library and kindergarten of village Khevi come under the impact. The public school in village Khevi may also be subject to the project impact.

No famous cultural and/or historical monuments are fixed along the section from village Chumateleti to village Khevi. However, in the past, an archeological finding took place on the territory of Khvei community.

Expected Environmental Impacts and Mitigation

Within the scope of the project road, after describing the background state of the environment, by using the preliminary developed methodology and evaluation criteria, the scales of the expected negative impacts were identified. This was followed by the development of the measures to mitigate the expected negative impact on each receptor.

Emissions of harmful substances into the atmospheric air and noise: In the construction phase, there will be different sources of these impacts. The stationery sources of emission and noise may be a crushing-and-sorting shop, or concrete or bituminous concrete production unit. The mobile sources of emission of harmful substances into the atmospheric air and noise will be construction techniques and vehicles. In addition, emissions and noise are expected during the intense earthworks and management of the excess materials/waste rocks.

These impacts will have higher importance in terms of nuisance to local communities in the final section of the EHW, which runs across village Khevi.

In order to reduce the combustion emissions, the sources of pollution must be equipped with filters; vehicles and machinery must be maintained in good technical condition and idling should be disallowed; driving speeds should be limited near the residential zones. Stationery sources of emission such as, crushers and concrete production units, should be located in as much distance from the settled areas as possible (recommended distance of 500 m or more); earth roads should be sprinkled periodically (in hot and windy weather) once in 4 hours and speed of vehicle movement along the earth roads must be controlled at all times; loading and unloading of trucks should be undertaken with respect to impacts of dust generation and be limited in windy weather.

Negative impacts of air pollution, noise and vibration during the exploitation phase are expected as the traffic intensity increases. However, there will be less traffic jams along the improved and widened road and the engines of the driving vehicles will be less loaded. Consequently, the exhaust fumes and engine noise will not rise significantly.

Triggering of geological activity: Hazardous geological processes are expected to activate during the construction phase. The risks of slope destabilization, erosion and landslides will be associated with creation of the new corridor for EWH that implies clearing of vegetation, especially – removal of trees. Such risks are generally high and must be addressed through application of adequate engineering solutions and good construction practice, including: removal of the active layer from the slopes and reducing the slope inclination angle, building protecting walls and arranging effective drainage systems.

The major cause of activation of the hazardous geological processes in the operation phase will be the diminished vegetative cover. In the first years of the Highway exploitation, it will be necessary to monitor the adjacent slopes and apply additional stabilizing measures as necessary.

Impact on topsoil: The highest risks of the damage and erosion of the topsoil are observed during the earthworks and during the movement of heavy techniques in the project corridor. These may lead to the soil compaction and erosion and reduction of the soil fertility. The risks of deterioration of the soil quality are associated with unforeseen events (e.g. spills/leakage of oil products from the techniques operating in the project area, supply reservoirs or other equipment and machinery).

The most important measure to reduce the impact is to remove the topsoil in advance and duly store it until its further use in the process of reinstatement. Also, adequate waste management on site willl be critical for the protection of topsoil from pollution. No impacts on topsoil are expected in the operation phase. At the stage of the road exploitation, no topsoil is expected to destroy.

Impact of vegetation cover: Clearing of the RoW for the new alignment will imply removal of vegetation, including cutting of trees. Removal of trees for the road construction needs will not cause functional damage to the ecosystem, and will not affect any critical habitats, however compensatory tree planting will be required within the EWH corridor (except for the trees cleared from the private land plots). The compensation measures imply transferring the funds to the budget or compensation planting. This issue shall be regulated by the body issuing the permit to de-list trees and plants from the environment.

Impact on fauna: The impact on fauna is highest where the new road is planned to build under the project, from the western portal of design Rikoti Tunnel to village Khevi. This 5-km-long section is covered both, with primary and secondary forest massifs, seen in forming barriers form the animals near the water resources and will also have an impact on the animals' reproduction ability. However, it should be noted that the local fauna is adapted to the local environment, as the new alignment will run parallel to the presently existing E-60.

One of the principal mitigation measures is considering animal passes above and under the new highway by observing the relevant rules (Bekker et al. 2003), meaning building the passes distanced by 200-300 m to 3-4 km (1-3 km for large animals, up to 1 km for average-size mammals and 200-300 m for small animals). After the construction works are complete, the returned animals migrated earlier will have the drinking water available on the site.

Impact on the protected areas: Construction and operation of the EWH within Chumateleti-Khevi section will not have impact on the protected areas as the closest national park of Borjomi-Kharagauli is distanced from the road corridor for 6 km and more.

Disturbance of river ecosystem: the project zone passes along Rikotula River and crosses it at 6 places. Impacts on water resources are possible during the construction as well as maintenance period. Potential contamination of surface and ground waters, which can be caused by: accidental leakages of fuel/oil/ lubricants from cars end machinery (in emergency situations as well); (i) pollution caused by improper management of construction and waste materials; (ii) penetration of the contaminated sewage water into surface waters; (iii) contamination of ground waters with infiltrated surface water.

Pollution with solid waste may occur in case of improper management of construction materials or waste. The earthworks may cause silting the riverbed, while the construction engineering structures (bridges, bank protecting facilities, etc.) are expected to cause certain changes in the riverbed profile. The river Rikotula is not distinguished for rich ichthyofauna. Besides, the construction works are planned along small sections what will enable most of the species to move far from the construction site and return to their original habitats after the construction is over, even more so as most of the species present here, except Caucasian goby (*gobius cephalarges constructor*), have the migration ability. Increased water turbidity will have a negative impact on the spawning phase, particularly for the species spawning in low water where there is a stony bed

and oxygen-abundant current. Such species are: (i) Chub (*Leuciscus borysthenicus*) – spawning once a season, in April or May; (ii) Khramulya (*Varicorhinus capoeta)* – spawning in May or August, several times a season; (iii) Barbel (*Barbusbarbus*) - spawning in May or June, once a season. Growing river turbidity or spills of hazardous substance into the river water during the spawning season may lead to the total destruction of the spawn of the listed species.

For avoiding the pollution of water sites: (i) Penetration of contaminated waters into the water sites must be avoided; (ii) Fuel, oil, lubricants, construction materials and waste should be placed not less than 100 metre distance from water sites. Consequently, these territories should be protected by relevant berms or fills; (iii) Emergency response plans for spills must be developed; The Staff should receive appropriate training; (iv) The repairing and maintenance services of equipments must be avoided on the site. In extreme cases, a special area must be arranged for this purpose within the site, which should be properly protected.

Impacts of the operation of construction camps and access roads: in the construction phase, temporary construction camp(s) will be arranged within the project implementation area and will have temporary impacts on the surroundings. A construction camp may be used for lodging a limited number of workforce, for parking the construction vehicles and machinery, and for on-site storage of some types of construction waste. To mitigate impacts from the operation of the construction camp, its location shall be properly selected. It is advisable to place the construction camp on a degraded site with no or little vegetation. Access to safe drinking water and decent sanitary facilities shall be provided. If the construction camp is used for living for a number of workers, residential blocks must be separate from storage facilities, be property ventilated and illuminated. If the dormitory does not provide a separate space for cupboards/locker rooms, the minimum room space shall be 4 square metres per person (assuming a height of 2.4m); If the dormitory provides a separate space for cupboards/locker rooms, the minimum room space shall be 4 square metres per person (assuming the ceiling height of 2.4 m). Adequate number of toilets and sanitary fittings shall be provided (1 toilet, 1 hand wash basin, 1 urinal and 1 bathroom with bench per 15 male workers), catering and the first medical aid facilities will also be provided.

The major part of the project area passes on the existing highway and settlements. The already existing access roads will be used.

Visual-landscape change: The visual impacts during the construction process will be caused by the presence of people, cars as well as temporary facilities (means of transportation, camps, storages for the construction materials and residues, etc) in the construction corridor. Additional impacts on the landscape are expected from quarrying for the construction materials and disposal of the large amounts of excess material generated from slope cutting and drilling of the tunnel(s).

The cut slopes will be reinstated through landscaping, compacting, provision of drainage and creation of enabling environment for the natural regeneration of vegetation. Tree planting may be performed on the terraces as required.

Works provider will be encouraged to purchase natural construction material from the external providers operating on the existing quarries. Alternatively, a works provider may opt to operate his own quarries, in which case license for natural resource extraction must be provided from the National Environment Agency. Disrespected of the terms of the license, the works provider will be required to reinstate used-up sections of quarries by terracing, backfilling, compacting, provision of adequate drainage facilities, and stimulating natural regeneration of vegetation. Extraction of sand and gravel from the riverbed must be prohibited.

At the stage of construction of Chumateleti-Khevi EWH, approximately 2,400,00 m^3 excess material is expected to originate. Exact amount of excavated material to be used for backfilling

and building of the roadbed is not known at this stage. However, it is evident that a large amount of spoil will remain for permanent disposal. Based on the rough estimation of the volume and quality of excavated material, some 1,200,000m^3 to 1,400,000m^3 will have to be disposed. Minimal area for stockpiling of excess material is around 10-12 ha, provided that the height of piles does not exceed 5 m and impact on landscape as well as a threat of erosion is not excessive.

Due to the complex relief of the construction site area and the existing infrastructure in it, very few options exist for safe and sound disposal of large volume of excess material. Present ESIA considered five alternatives. Renting or purchasing the agricultural lands was turned down due to significant social impact and highly undesired laternation of land use type. Environmentally attractive alternative of using excess material for reinstatement of used quarries had to be dropped due to excessively long distance of waste transporation, whin, in addition to associated costs, would carry additional inconveniences and risks. Third alternative had been dropped once strong pushback from local communities became known from stakeholder consutlations. Fourth alternative was not selected because the land plot is crossed by a power line and an abandoned oil pipeline. The selected fifth alernative is State-owned, has convenient location, carries no existing infrastructure, has sparce vegetation and supports no important species, is away from human settlements, and local communities do not resist to its use for this purpose.

Construction Contractor will develop detailed plant for the disposal of excess material and have it agreed by the employer, relevant State agencies and the World Bank.

Impact on social-economic environment: While significant positive social and economic impacts are expected from the improvement of the EWH Chumateleti-Khevi section, the mentioned works are also associated with the physical and economic displacement of the local residents. In addition, one of the income sources of the local population, the street trade, will be lost. Movement will be limited in the construction phase causing certain discomfort for the local population, etc.

The overall objective of the Project in relation to land and asset acquisition is to assist the project affected populations (PAPs) in restoring their livelihoods at least to the level equal to the pre-project level. Specific principles that apply include:

- Construct the road to avoid residential areas wherever possible to minimize physical relocation of people, and select alignments that minimize acquisition of privately or publicly held productive land;
- Adopt design standards that minimize the need to impose land use restrictions in the adjoining areas;
- Develop fair and transparent procedures, as defined in the Entitlement Matrix in this Resettlement Framework, to determine compensation for: i) temporal loss of land/assets during the construction;(ii) permanent acquisition of land and assets; and (iii) restrictions on use of land that may be applied to areas adjoining the corridor;
- Acquire land (or right to use land) through negotiated agreements and with the use of the power of eminent domain only as a last resort.

Despite the fact that as a result of the construction works, the labor flow to the worksite is expected from external sources, it is expected that the impact will be minor, as the works are short-term and need a limited number of qualified labor. Furthermore, the experience gained within the scope of the complete and ongoing EWHI projects, makes it clear that instead of the standard workers' camps, the buildings and premises distanced from the residential areas were used for lodging the workers. The workers must be lodged adequately. In order to monitor this aspect, the Contractor will establish adequate supervision over it to check the degree of compliance with acceptable lodging rules.

The project will have a positive impact on the local population's employment. As the good practice of Georgia suggests, 70% of local labor is planned to employ in the construction phase what was the case with Agara-Osiauri section of the EWH financed by the WB. This requirement was incorporated in the Construction Contractor's Contract.

Impact on cultural heritage: The impact of the planned works on the visible monuments of the historical-cultural heritage will be insignificant. However, the likelihood of chance finds in the project area is higher than average. Various finds were excavated in village Khevi in the past. The blueprint of action in case of chance finds is provided and must be followed by all parties involved.

Cumulative impact: A large section of the EHW corridor within Chumateleti-Khevi section runs across the unsettled area and there are no industrial facilities in its vicinity. As per the existing information, the development of no large-scale infrastructure is planned to construct in highway corridor in future. Consequently, no cumulative effect is expected.

Residual impact: The project implementation will have significant residual impact due to landscape transformation through slope cutting and tunnel drilling that will lead to the generation and disposal of large amounts of the excess material needing disposal. Another residual impact possible to observe early in the operation phase will gradually reduce. This includes impacts on vegetation. The restoration of the vegetation on the cut slopes at the expense of establishing the favorable conditions for natural regeneration and compensatory tree planting will take long; however impacts may decrease to the minimum in the long term. To achieve such an outcome, the application of mitigation measures (maintenance of artificial plantations, replacement of destroyed greenery, maintenance of drainage systems, etc.) should be carried on even after the project is complete.

Environmental and Social Management Plan

The goal of the ESMP is to develop the mitigation measures and monitoring indicators for the impacts identified through the ESIA. It also describes institutional arrangements for applying mitigation measures and exercising control over their implementation. In the construction phase, the works provider to be contracted by RD will be responsible for applying prescribed mitigation measures. This obligation will be contractually binding, as the ESMP will be attached to the works contract to be its integral part. RD will have overall responsibility for environmental monitoring of works and for ensuring full adherence to the ESMP. It is expected that RD will hire a consultant company for the technical supervision of works and will include day-to-day environmental oversight into the tasks of such a consultant. However, the RD will use its own capacity to organize environmental monitoring and reporting and will bear overall responsibility for it.

The Supervision Department of the MEPA will exercise State control over the compliance with the terms of environmental permit to be issued for the works in Chumateleti-Khevi section of the EWH and with the requirements of the national environmental legislation of Georgia.

As the EWH is an international road, the RD owns and operates it. Once the construction works for upgrading the highway section between Chumateleti and Khevi are completed, RD will be responsible for its operation and maintenance. Ensuring road safety and good environmental performance will be a high priority at the operation stage and will comply with the requirements of the national legislation and the best international practices.

The RD, by means of outsourcing, will permanently maintain greenery planted upon completion of the road works for the landscape reinstatement and compensation for trees removed during the construction. Regular collection of solid waste will be organized along the highway. The State Technical Control of the Highway through regular oversight and inspection will be provided

1. INTRODUCTION

The Government of Georgia has embarked on a programme to upgrade the major roads of the country, managed by the Roads Department (RD) of the Ministry of Regional Development and Infrastructure (MRDI). The program aims to improve transportation and transit of goods to surrounding countries, which isa significant and growing contributor to GDP. The program aims to improvetransportation and transit ofgoods to surrounding countries, which is a significantand growing contributor to GDP. Transport of goods into and through Georgia hasincreased over the past 10-15 years as markets have expanded following the breakup of the Soviet Union, and Georgia is now a major transit country. Almosttwo-thirds of goods in Georgia are transported by road, and haulage by domesticand international truck companies is very evident on the country's highways.However many roads are poorly equipped to cope with the volume of traffic and the proportion of heavy vehicles, and factors such as insufficient dual carriageways,routing through inhabited areas and inadequate maintenance and repair, hinderthroughputs and increase transit times. This creates difficulties for haulage companies and their clients, truck drivers, Georgian motorists and local residents.

The main target of the program for upgrading major roads in Georgia is the E-60, or the East-West Highway (EWH) - the main route from neighboring Azerbaijan and Russia, also connecting to Turkey and Armenia. For planning purposes, the EWH has been divided into sections of various lengths. The World Bank is providing series of loans to the Government of Georgia for upgrading this highway through East West Highway Improvement Projects (EWHIPs). Two projects of these series are now completed covering the highway section between Agaiani and Ruisi. EWHIP-4 is under implementation covering the section between Ruisi and Agara. East-West Highway Corridor Improvement Project (EWHCIP) is under preparation. The project will finance upgrading of the highway from Zemo Osiauri through Chumateleti (shortly before Rikoti tunnel, which takes the East-West Highway from East Georgia to the West.

Transport sector development in Georgia is essential for the achievement of sustainable economic growth, alleviation of poverty, achievement of the government's regional development strategy objectives and promotion of tourism. This is also reflected in four-point Governmental reform plan. Major objective of spatial arrangement considered by this plan is to complete the modernization of EWH, which is esential for Georgia to become a regional transport-logistics hub.

The Government of Georgia has given the highest priority to the completion of the EWH from Tbilisi to Poti and has already obtained various funding for several parts of the EWH. **Table 1.1** below outlines the completed, ongoing and planned improvement in upgrading of the East –West Highway.

Table 1.1 Status of EWH Corridor Improvement

Road Section	Length	Planned Upgrading	Financier	Status
Natakhtari-Agaiani	16.7 km	4 lane dual carriageway	State Budget	Completed
Agaiani-Igoeti	11.7 km	4 lane dual carriageway	World Bank	Completed
Igoeti-Sveneti	25.5 km	4 lane dual carriageway	World Bank	Completed
Sveneti-Ruisi	14.3 km	4 lane dual carriageway	World Bank	Completed

Ruisi - Agara	19.5 km	4 lane dual carriageway	World Bank	Completed
Agara-Zemo Osiauri	12km	4 lane dual carriageway	World Bank	Implementation
Zemo Osiauri - Chumateleti	14 km	4 lane dual carriageway	World Bank	Implementation
Chumateleti - Khevi	11 km	4 lane dual carriageway	World Bank	Preparation
Khevi - Argveta	50 km	4 lane dual carriageway	ADB	Preparation
Zestafoni-Samtredia	56.5 km	2 lane due carriageway - 41.3 4 lane dual carriageway - 15.2	JICA	Preparation
Samtredia-Choloki	70 km	4 lane dual carriageway	EIB	Preparation
Choloki - Kobuleti bypass	32 km	2 lane dual carriageway	ADB	Completed

Present ESIA report is prepared for Chumateleti-Khevi road section modernization to be supported by the Additional Financing to East West Highway Corridor Improvement Project (Chumateleti-Argveta), and by the European Investment Bank (Samtredia-Choloki) namely from the East portal of Rikoti tunnel (the end of Zemo Osiauri- Chumateleti road section) to Khevi village.

This is one of the most difficult section due to climatic, topographic and geological conditions of the corridor. In addition, its corridor crosses river Rikotula at several places and ravines. It should be noted that this section of the East-West Highway is characterized by the frequent traffic jams and high risk of road traffic accidents, emergency high risks, especially in adverse weather conditions.Therefore its modernization will significantly improve traffic conditions, reduce travel time and risks of accidents.

Objective of the conducted ESIA was to identify expected positive and negative impacts of the improvement and operation of East West Highway between Chumateleti and Khevi on the natural and social environment; identify likelihood, magnitude and spread of these impacts; and work out measures for avoiding or mitigating these impacts. ESIA contributed to the analysis of routing and design alternatives and the selection of the solutions most suitable from economic, fiscal, technical, social and environmental perspetives. Environmental and Social Management Plan worked out in the process of ESIA will become part of the contract for the provision of upcoming works and serve as a field guide for good environmental performance mandatory for adherence.

The present ESIA was carried out by “Eco-Spectri” Ltd for the RD of the MRDI.

Contact information about Road Department of Georgia and consulting company “Eco-Spectri” Ltd is given in the **Table 1.2** below.

Table 1.2: Contact Information

Executive Agency	**Road department od Georgia**
Address	12 Al. Kazbegi str, Tbilisi 0160, Georgia
Spare of Activities	Rehabilitation/Improvement of Chumateleti-Khevi Section of E-60 Highway
Head od the Department:	Irakli Karseladze
Contact person	Gia Sopadze
Phone:	+995 322 370508

E-Mail	info@georoad.ge; maya_vashakidze@yahoo.co.uk
Consulting Company	**“Eco-Spectri” Ltd**
Direcrtor	Irakli kaviladze
E-mail	info@eco-spectri.ge
Phone:	+995 599 979748; +995 322 904422

2. LEGAL AND INSTUTUTIONAL FRAMEWORK

This chapter reviews the provisions for environmental protection in the laws of Georgia that are relevant to the proposed Project. It also discusses the potential implications of the international treaties to which the Republic of Georgia is a party. Finally, the administrative framework for environmental management is also described.

2.1 Environmental Policies and Laws of Georgia

Georgian legislation comprises the Constitution, environmental laws, international agreements, subordinate legislation, normative acts, presidential orders and governmental decrees, ministerial orders, instructions and regulations. Along with the national regulations, Georgia is signatory to a number of international conventions, including those related to environmental protection.

The following Georgian laws and regulations are applicable to the EWHCIP AF:

The Constitution of Georgia 1995 (last amended in 2013)
The Constitution of Georgia is the supreme legal document establishing general principles concerning environmental protection. Article 37 states: "Everyone shall have the right to live in a healthy environment and enjoy natural and cultural surroundings. Everyone shall be obliged to care for the natural and cultural environment." In Constitution are formed the basic requirements about the need of environmental protection and information accessibility for people about environmental conditions.

Also, the Constitution of Georgia states that „the legislation of Georgia shall correspond to universally recognized principles and rules of international law. An international treaty or agreement of Georgia unless it contradicts the Constitution of Georgia, the Constitutional Agreement, shall take precedence over domestic normative acts (change is added by the Constitutional Law of Georgia of 30 March 2001).

This means that conditions of the legal agreement between Georgia and the International Bank for Reconstruction and Development for the provision of Additional Financing for East West Highway Corridor Improvement Project prevail over the national legislation in case of contradiction. It also means that in case requirements of the national environmental and social legislation differ from any statement made in the present ESIA report and ESMP included in it, the latter shall prevail, because legal agreement between Georgia and the IBRD makes implementation of ESMP is mandatory.

Law of Georgia on Environmental Impact Permit 2007 (Last amended in 2016)
The Law gives a complete list of activities subject to ecological examination (Article 4, Chapter II) and defines environmental examination through the EIA process as an obligatory step for obtaining
authorization for implementation of the planned development. The legislation sets out the legal basis for issuance of environmental permits, including implementation of an ecological examination, public consultations and community involvement in the processes. According to the established procedure the granting permission for, or refusal to issue, a permit is based on the findings of the EIA report and associated environmental documentation presented to the MEPA by the project proponent. Paragraph 6 of the law requires the applicant to organize and undertake public consultation of the EIA report prior submission of the final version of the document to the MEPA.

After January 1, 2018 the new Environmental Assessment Code entry into force. Since the draft of the EIA report for the planned development was disclosed before the entry into force of the new Environmental Assessment Code, permit application/issuance procedure follows the steps defined in the law on Environmental Impact Permit described below.

Specific provisions of the law that may affect the proposed Project are discussed later in this chapter.
In line with the requirements of the presented Law, Roads Department shall apply for and obtain the environmental impact permit from the Ministry of Environment protection and agriculture of Georgia, which will be an integral procedure for the issuance of Construction Permit by the Ministry of Economy and Sustainable Development for works planned towards upgrading of East West Highway Corridor between Chumateleti and Khevi.

Law of Georgia on Licenses and Permits 2005 (Last amended in 2016)
The Law regulates activities which may result in increased hazard to human life or health, involves interests of importance to the State or public, or connected to consumption of State resources. The Law defines the full list of activities which require licenses and permits, and sets out the rules for granting, amending and abolishing licenses and permits.

By using this law, the Road Department identified the Project category for Chumateleti-Khevi section, and the list of all documents and stages which are necessary to receive the ecological expertise. which will be an integral procedure for the issuance of Construction Permit by the Ministry of Economy and Sustainable Development

Law of Georgia on Ecological Expertise 2007 (Last amended in 2013)
The Law makes an ecological examination obligatory for issuance of development permits. According to the Low the independent expert opinion is mandatory to adopt a decision on the issuance of an Environmental Impact Permit. The ecological expertise is the responsibility of the MEPA, which undertakes expert examination in accordance with the provisions on the Procedure of Conducting State Ecological Expertise, and the normative-technical and methodological guidance documents and the procedure established under law, through a commission of experts.

The Ministry of Environment Protection and Agriculture, in line with the requirements of the given Law, will identify and invite all independent experts, whose conclusions will be used to fix the compliance of the EIA document developed for the rehabilitation of Chumateleti-Khevi road section with the requirements of the Georgian legislation, normative acts and standards.

After January 1, 2018 the new Environmental Assessment Code entry into force. Since the draft of the EIA report for the planned development was disclosed before the entry into force of the new Environmental Assessment Code, permit application/issuance procedure follows the steps defined in the law on Environmental Impact Permit described above.

Law of Georgia on Water 1997 (Last amended in 2015)
The Law regulates the use of water resources, determines the rights and responsibilities of water users, and regulates water abstraction and discharges. Consistent with the legislation, water within the territory of Georgia owned by the State can be abstracted only for consumption. Any actions directly or indirectly violating the State ownership rights for water are prohibited.

Within the scope of Chumateleti-Khevi road section rehabilitation and operation project, the law regulates the water intake and water discharge processes. In order to meet the requirements of

the said law, the actions, which will help avoid, reduce or manage the pollution or strong negative impact on the river Rikotula and other rivers in the project zone must be identified.

Law of Georgia on Soil Protection 1994 (Last amended in 2015)
The Law aims at ensuring preservation of integrity and improvement of soil fertility. It defines the obligations and responsibility of land users and the State regarding the provision of soil protection conditions and ecologically safe production. The Law sets the maximum permissible concentrations of hazardous matter in soil and restricts the use of fertile soil for non-agricultural purposes, the execution of any activity without prior striping and preservation of top soil, open quarry processing without subsequent re-cultivation of the site, terracing without preliminary survey of the area and approved design, agricultural activities that could lead to overgrazing, wood cutting, damage of soil protection facilities, and any activity that could potential deteriorate soil quality (e.g. unauthorized chemicals/fertilizers, etc.).

The law sets general basis for the protection of soil from erosion, contamination, sedimentation, sanitization, secondary swamping, etc., regulation of the open extraction of natural resources and construction materials, impact from human economic activity. The Law sets up norms and standards for allowable concentration limits of pollutants in the soil to ensure human health and better environment.

Within the scope of the presented project, the requirements of the said law regulate the rules of topsoil removal, storage and further management in the process of widening the existing road. It is similarly important to meet the requirements of the law at the stages of planning the widening of the existing road in the landslide zone or during the construction works.

Law of Georgia on Protection of Atmospheric Air 1999(Last amended in 2016)
The Law regulates protection of the atmospheric air from adverse anthropogenic impact within the whole Georgian territory (Part I, Chapter I, Article 1.1). Adverse anthropogenic impacts are any human induced effect on atmospheric air causing or capable of causing a negative impact on human
health and environment (Part II, Chapter IV, and Article II.I).

At the stage of construction of Chumateleti-Khevi section, the requirements of the said law will regulate the level of noise, vibration and emissions on the territory of village Khevi. In addition, the right kind of the noise walls to install on the territory adjacent to the public school in Khevi during the operation phase will be identified. If the requirements of the said law cannot be met, it will be necessary to construct a new building for the school at the safe distance from the autobahn.

Waste Management Code 2015 (Last amended in 2016)
The purpose of this Code is to establish a legal framework in the field of waste management to implement measures that will facilitate waste prevention and its increased re-use as well as environmentally safe treatment of waste.

The objective of this Code is to protect the environment and human health through:

a) The prevention or reduction of waste and its adverse impact;b) the establishment of effective mechanisms for waste management;
c) The reduction of damage caused by the consumption and the more efficient use of resources.

In line with the requirements of the said law, the Construction Contractor for Chumateleti-Khevi section must hire a duly qualified environmental manager who will be obliged to develop Waste Management Plan and submit it to MEPA for approval. In line with the requirements of the Waste

Code, the Construction Company is obliged to control the process of managing the originated waste through the final disposal of the waste.

Law on Compensation for Damage Arisen from the Use of Hazardous Materials 1999 (Last amended in 2010)
The Law specifies how charges for the use of and/or harmful impact on the environment are to be calculated and levied by the MEPA.

Law on Hazardous Chemical Substances1998
This Law regulates handling of dangerous chemical substances, but it has been stopped by the law of Georgia "on the control technical danger" which regulates processes when activity contains possibility of issue of explosion and intoxication which appears (represents) the increased risk for health of people and environment.

Within the scope of the project, no great amounts of hazardous substances are expected to be stored in the construction sites; however, following the fact that the construction sites follow the riverbed, full observance of the requirements of the Law is necessary, both in the phases of storage and exploitation of the hazardous substances.

The Law on Minerals 1996(Last amended in 2015)
The Law establishes the requirement to obtain a license according to the procedures established under this law and the Law on Licensing and Permits (June 25, 2005). According to the current system all quarries and borrow pits require to obtain a license.

If the Construction Contractor opens his own quarries of excess materials, a relevant license will be necessary to obtain. Within the scope of the project, a particular attention must be paid to the restoration of the quarries. The Supervising Consultant must also pay due attention if the requirements of the quarry management are met used within the scope of the present project.

In case extraction of inert material from the riverbed, the supervisor consultant should pay attention to the fact that the constractior does not worsen the visual side of the site.

The Wildlife Law 1996 (Last amended in 2015)
The law mandates the MEPA to regulate wildlife use and protection overall territory of the country, including existing protected areas. For now, the Ministry of Energy is responsible for this function also. This law also determines activities on protected areas by the corresponding structural units.

Meeting the requirement of the Law is particularly important along CH 0.00 - 7.00 section of the project when a new road is laid through the forest massif. Before the commencement of the construction activities, additional detailed studies will be necessary.

The Law on Red List and Red Book of Georgia 2003 (Last amended in 2016)
The Law establishes the legal basis for the preparation and approval of the Red List and Red Data Book to provide these instruments for the protection and restoration of threatened species of flora and fauna. The new **Red List of Georgia** was approved in May 2006 and is as such legally enforceable. The Red List is organized in accordance with the guidelines and principles of the International Union for the Conservation of Nature (IUCN). According to article 4 of the law: „any type of activity is forbidden, including, hunt, cutting and others, besides special occasions (events) fixed by law".

Within the scope of the project, meeting the requirements of the Law is particularly important along the first 7-km-long project zone. Both, endemic and other Red–Listed flora and fauna

species are common along this section.

Forest Code of Georgia 1999 (Last amended in 2013)
The Law establishes legal grounds for protection, restoration, and forth use of the Georgian Forest Fund and its resources. The Law defines property rights to the forests of Georgia, the principles for the protection and use of forest resources and establishes the procedures for their use and the requirement to obtain a license.

Large areas of the forest massif are to cut down within the scope of the project. This process must be accomplished by full observance of the requirements of the Law. The territory needed by the project will be necessary to remove from the forest fund. In addition, the full inventory and other actions will be needed.

2.2 Laws and Regulations Related to Social Aspects and Land Ownership

Law of Georgia on Privatization of State-owned Agricultural Land 2005 (Last amended in 2010)
This Law regulates the privatization of state-owned agricultural land. On the basis of this law, either
leased or unleased state-owned agricultural land can be subject to privatization. However, the categories of agricultural lands listed as follows are not subject to privatization: a. Grazing lands except grazing lands leased before enacting the law; b. Cattle-driving routes; c. First sub-zone (strict regime zone) for the sanitary protection zone of water supply bodies; d. Forest fund land used for agricultural purposes; e. Recreation lands; f. Lands allocated to historical, nature and religious monuments; g. Protected areas; h. Agricultural lands being used by budgetary institutions and legal entities of public law in the form of usufruct.

Within the scope of the project, all private and legal entities using or illegally owning the property must be identified, and the said property or action must be legalized and compensated.

The Law of Georgia on Recognition of the Property Ownership Rights Regarding the Land Plots Owned (Used) by Physical Persons or Legal entities; 2007 (Last amended in 2016)
The Law defines general terms and procedures for entitlement of the right to land ownership. Although ownership rights cannot be bestowed onto the following lands: cattle-driving routes; cemetery and pantheon; water field (stock); sanitary and protection zones; protected areas; historical, nature and religious monuments; recreation parks, forest-parks, squares and others; land containing water reservoir, hydraulic works and sanitary-protection zones of these objects; lands of special purpose (allocated for defense and mobilization); lands accommodating community infrastructure units (transport and underground utilities, water-supply, sewage, communication and power-supply systems); land parcel of public use (playground, street, passage, road, pavement, shore) and recreation sites (park, forest-parks, squares, alley, protected area); lands accommodating state-owned objects, including parcels which contain state property not subjected to privatization according to Georgian Law on Privatization of State Property; lands allocated for construction and operation of oil and gas mains, as well as any associated over- and under-ground structures and facilities.

This Law defines the set of criteria, based on which the affected non-registered land plots used by private owners within the EWH corridor could be attributed to the category of localizable land (there is legal basis for registering land and paying compensation) or category of non-localizable land not eligible for compensation.

The Law of Georgia on Public Registry (2008)
The Law provides an organizational and legal basis for the registration of ownerships rights, encumbrance and mortgage on real estate, as well as the liabilities of the registration authority. Pursuant to this Law, ownership rights related to real property, mortgage, usufruct, servitude, lease, sub-lease, rent, sub-rent, lending are subject to registration in the Public Register.

All land plots within the EWH corridor which are not registered but evidence is present that their legislation may be undertaken, will be registered following the requirements of this Law.

The Law of Georgia on Rules for Expropriation of Ownership for Necessary Public Needs 1999 (Last amended in 2013)
The Law defines terms, rules and procedures for the expropriation of assets necessary in the public interest. Expropriation requires the Presidential decree and a court decision. The decision of the court gives a detailed description of the appropriable property and due compensation to the owner. The Law states the public interests which allow expropriation of assets. These are the construction/installation of: a) Roads and highways; b) Railways; c) oil, gas and oil product pipelines; d) Power transmission and distribution lines; e) Water supply, sewage and storm water drainage systems; f)Telephone lines; g) Premises and objects of public needs; h) Works required for national defense; i) Mining and reserve development. After issuance of the Presidential decree a person seeking for expropriator's right announces in the central and local printed media about the project, its scope, area coverage and brief description of the potentially appropriable property. All affected landowners also shall be informed about the dates of application to the court and action proceeding.

An expropriator should endeavor to obtain property in agreement with the owner. Prior to negotiation the expropriator evaluates the property and determines an estimated compensation sum or other property compensation according to fair market price. Agricultural lands are to be evaluated together with price of crops that could be yielded by the owner throughout the current agricultural year.

Because of the significance of EWHICP AF, this Law will be applicable as the final instance in case all attempts to purchase the land by means of negotiations are exhausted. After the land plot expropriation, the owner will receive full compensation.

Labor Legislation
Applicable Labor Laws are as follows:

- Labor Code of Georgia (2006) governs the rights of the employees in all enterprises, institutions and organizations. This law establishes the requirements regarding human rights
  and creation of safe and healthy working environment including health and safety conditions, social security and insurance. However, there are no established norms and standards related to the workers accommodation.
- Law of Georgia on Employment (2001) regulates the employment policy of Georgia, including protection of the unemployed in terms of economic, social and legal issues. For the protection of the unemployed, this law promotes employment programs.

The rights of all employees engaged in the construction of EWH will be protected in line with the requirements of these laws.

2.3 Requirements for Environmental Assessment in Georgia

The Environmental Impact Assessment (EIA) is defined under the Georgian Law as: "studying and examination procedure of the planned activities is designed to protect separate components of the

environment, human, as well as landscape and cultural heritage. EIA study, identifies and describes the direct and indirect impacts on human health and safety, herbage and animals, soil, air, water, climate, landscape, ecosystems and historical monuments, or all the above factors unity, among the factors that influence the cultural values (cultural heritage) and the social - economic factors".

The law requires that the EIA or its accompanying information shall include:

- A layout (indicating a distance) of the place where the project shall be implemented;
- Volume and classes of emissions expected of stationary pollution sources and hazardous substances discharged and emission and a project of hazardous substances discharged and emission standards allowed to limit);
- A short summary on the activities (as a technical summary)
- A full schedule of the technological cycle to the administrative body issuing a permit even the activity includes commercial and/or state secret.

The law also requires that wherever relevant, the EIA process shall take into account the environmental principles as listed in Section 3.1.2. This is particularly important for those aspects of the environment for which specific laws, regulations and standards have not been enacted.

The EIA Process

After January 1, 2018 the new Environmental Assessment Code entry into force.

Since the draft of the EIA report for the planned development was disclosed before the entry into force of the new Environmental Assessment Code, permit application/issuance procedure follows the steps defined in the law on Environmental Impact Permit described below.

The Law of Georgia on Environmental Impact Permit sets the legal basis for issuance of an environmental permit, including implementation of an ecological examination, public consultations and community involvement in the processes. Granting of permission or refusal to issue a permit is based on ecological examination of environmental documents submitted to the MEPA by the project proponent.

Article 6 of the Environmental Impact Permit Law requires the project proponent to organize a public hearing of the EIA prior to submission of the final version documentation to the MEPA. The permit application/issuance procedure for the Project, including EIA coordination, establishment of the timeframes for information disclosure and public review and discussion in accordance with Georgian Law will include the following steps:

- **Step 1:** The project proponent publishes information on the Project in central and regional newspapers. The advertisement has to include the project title, location, place and the date, time and venue of public disclosure meeting(s). It will also identify locations where the ESIA can be reviewed and where comments may be submitted.

- **Step 2:** Within one week after publishing the information in the newspapers, the project proponent will submit the EIA report (hard copy and electronic version) to the MEPA. A period of 45 days is allowed for public comments on the EIA. Between 50 and 60 days after publication, the project proponent will hold a series of meetings to receive comments from stakeholders (which may include government agencies, local authorities, NGOs, community members). Within five days of the meetings, the project proponent will submit minutes of the meetings (summary of comments and discussions) to the MEPA.

- **Step 3:** All comments received from the stakeholders at the meeting or in writing will be reviewed and addressed in the final version of the ESIA. A copy of all written comments, the minutes together with a comment-response section will be included in the final ESIA as an Appendix. The final ESIA will be submitted to the MEPA and made available to the public, along with a project location map, an executive summary, and the any necessary reports on emissions and allowable limits. The permit is to be issued or denied within 20 days from registration of the submission.

According to the Law on Construction Permit, 2004 and Law on Licenses and Permits 2005, construction and modernization of highways requires the Construction Permit. Procedures for obtaining the permit are described in the Law of Georgia on the Construction Permit. The administrative body responsible to issue the permit is the Ministry of Economy and Sustainable Development. Under the law, the Ministry is required to ensure involvement of other ministries including the MEPA in the permitting process. For the projects subjected to the construction permit, the construction permit incorporates elements of environmental impact permit.

Environmental impact permit is also required for running asphalt and concrete batching plant. License for use of natural resources, if own quarries are to be used, is also required. The authority responsible for issuing the license is MEPA. All other issues such as temporary disposal of inert construction waste and unusable asphalt are regulated with the local municipal authorities and require a formal agreement with them.

2.4 World Bank Policy Requirements

EWHCIP AF will be financed by the World Bank and hence the World Bank's safeguard policies are applicable. The project triggers several safeguard policies: OP 4.01, OP 4.04, OP 4.11 and OP 4.12.

Operational Policy 4.01 – Environmental Assessment provides the framework for World Bank environmental safeguard policies and defines the project screening and categorization in order to determine the level of environmental assessment required. EWHCIP AF will support the upgrading of large scale transport infrastructure, most part of which will be built along the new alignment. It may therefore have significant and irreversible impacts. According to the OP/BP 4.01, EWHCIP AF is classified as a category A. It requires a full-scape ESIA, and public consultation on at least two stages of the environmental review process. Development of an environmental and social mitigation and monitoring plans for the construction and operation phases is also required by this safeguard policy.

Operational Policy 4.04 – Natural Habitats outlines the World Bank policy on biodiversity conservation taking into account ecosystem services and natural resource management and use by project-affected people. Construction of the re-aligned highway will require creation of a new right-of-way, which will pass through some forested areas. Construction works will include a number of river crossings too. Potential impacts of the project at its construction and operation phases on the natural and critical habitats were explored as part of ESIA according to the requirements of OP/BP 4.04.

Operational Policy 4.11 – Physical Cultural Resources*:* sets out the World Bank requirement to avoid or mitigate adverse impacts resulting from project developments on cultural resources. Project implementation is not expected to negatively affect any known physical cultural resources. However, the portion of the highway to be constructed along a new alignment carries the potential of encountering chance finds in the course of earth works, which have happened in several past projects in neighboring locations. Hence likelihood of encountering chance finds in Chumateleti to Khevi section of the Highway is higher than the country-wide average. The policy is triggered to have adequate arrangements in place for handling such situations.

Operational Policy 4.12 – Involuntary Resettlement states that involuntary resettlement shall be avoided to the extent possible. Where the acquisition of land or other assets is necessary, the policy sets out requirements for participation in resettlement planning, mandates compensation for assets at replacement cost, and expects the borrower to see that incomes and standards of living of affected persons are improved or at least restored to what they were prior to displacement. OP 4.12 is triggered as the planned construction works for upgrading the existing road into a two-lane dual carriageway road will require land acquisition.

2.5 Comparative Analysis of Applicable National Legislation and Requirements of the Involved International Financing Institutions

Present ESIA was carried out on the proceeds of the World Bank loan. Works for upgrading Chumateleti-Khevi section of EWH will be financed by the European Investment Bank (EIB) and the World Bank. Therefore, environmental and social requirements of these international financial institutions (IFIs) are applicable to the preparation and construction phases of this project. National legislation of Georgia also fully applies. In case of differences between the two, more stringent requirements have to be applied.

Although Georgia has adopted Environmental Assessment Code (January 2018), which introduces screening and scoping procedures to the environmental assessment, present ESIA was initiated prior to enactment of the Code and was not subject to its regulations. However, following requirements of the World Bank, the TOR of the ESIA describing the scope of environmental and social studies was disclosed and discussed with stakeholders.

IFIs expect that social aspects of the proposed investment are covered to full in the ESIA process, and that measures for mitigation of social impacts are integral part of Environmental and Social Management Plans (ESMPs). National legislation requires coverage of public health implications of the proposed activities, while aspects of social equity, inclusion, vulnerability, etc. are not expected to be fully explored and addressed through the ESIA.

Resolution No. 242 of the Government of Georgia dated August 20, 2010 on the Rules of Forest Use dated August 20, 2010 states that in case clearance of forest vegetation is required to construct new infrastructure in the area designated for special use within the boundaries of the State Forest Fund, the developer/project proponent is obligated to pay a single compensation fee in the amount set forth in Table 1, Annex 7 of the above-referenced Resolution. The fee is paid to the State budget and accumulated funds are intended for afforestation / reforestation purposes. However, the paid amount is not earmarked for forest restoration in the specific area of impact and its timing is not defined either. After having paid the fee, project proponent has no further obligation to undertake compensatory tree planting. In difference from the above approach, IFIs expect that ecological loss incurred by clearing of vegetation for the purposes of a given investment project is thoroughly assessed and in case compensation is deemed necessary and feasible, it is undertaken to make up for the specific impacts caused by the given project.

2.6 International and National Environmental Standards and Norms

EWHCIP AF will be implemented in compliance with the national regulations and also in line with the Environment, Health, and Safety (EHS) Guidelines of the World Bank Group. Therefore more stringent requirements of the two are applicable.

In accordance with the Law of Georgia on Public Health, the environmental qualitative norms are approved by Decrees of the Minister of Labor, Health and Social Affairs of Georgia (Decree 297/N of 16.08.2001, including the changes made to it by further decrees of the Ministry 38/N of 02.24.2003, 251/N of 09.15.1006, 351/N of 12.17.2007). The quality of atmospheric air (pollution with hazardous matter) is also defined by the order of the Minister of Environment Protection and Natural Resources (#89, 23 October 2001) on approval of the rule for calculation of index of pollution of atmospheric air with hazardous pollution.

2.6.1 Ambient Air Quality Standards

National and IFC guidelines for ambient air quality are presented in tables 2.6.1.1 and 2.6.1.2.

Table 2.6.1.1. Georgian Standards for Ambient Air Quality

Sustance	Maximum Permissible Concentration (MAC) mg/m^3 average time
Nitrogen Dioxide	0.085/30 minetes
	0.04/24 hours
Sulphur Dioxide	0.5/30 minutes
	0.05/24 hours
Carbon oxide	5.0/30 minutes
	3.0/24 hours
Inorganic Dust	0.3

Table 2.6.1.2. IFC Ambient Air Quality Guidelines

	Averaging Period	Guideline value in μmg/m^3
Sulfur dioxide (SO_2)	24-hour 10 minute	125 (Interim target-1) 50 (Interim target-2) 20 (guideline) 500 (guideline)
Nitrogen dioxide (NO_2)	1-year 1-hour	40 (guideline) 200 (guideline)
Particulate Matter PM_{10}	1-year 24-hour	70 (Interim target-1) 50 (Interim target-2) 30 (Interim target-3) 20 (guideline) 150 (Interim target-1) 100 (Interim target-2) 75 (Interim target-3) 50 (guideline)
Particulate Matter $PM_{2.5}$	1-year 24-hour	35 (Interim target-1) 25 (Interim target-2) 15 (Interim target-3) 10 (guideline) 75 (Interim target-1 50 (Interim target-2) 37.5 (Interim target-3) 25 (guideline)
Ozone	8-hour daily maximum	160 (Interim target-1) 100 (guideline)

World Health Organization (WHO)Air Quality Guidelines Global Update, 2005. PM 24-hour value is the 99th percentile. Interim targets are provided in recognition of the need for a staged approach to achieving the recommended guidelines.

In general, Georgian standards for ambient air correspond to international IFC/WB standards, however in relation with particular substances there can be minor differences and in that case more stringent standards are applicable.

2.6.2 Water Quality Standards

The values of Maximum Admissible Concentrations of the harmful substances in surface and groundwater are provided in the Environmental Quality Norms approved by the Order#297N (16.08.2001) of the Ministry of Labor, Health and Social Protection (as amended by the Order No 38/n of the same Ministry of 24.02.2003). The admissible level of pollutants in surface and groundwater is given in Table 2.6.2.1. below.

Table 2.6.2.1. Georgian Standards for Water Quality

No	Description	Maximum Permissible Concentration
Surface Water		
1.	pH	6.5-8.5
2.	Diluted oxygen, mg/l	4 – 6
3.	Chlorides, mg/l	350
4.	Oil products, mg/l	0.3
5.	Zinc (Zn^{2+})	1g/kg
6.	Lead (Pb total)	23,0
7.	Chrome (Cr^{6+})	32,0
8.	Cadmium (Cd, total)	6,0
Ground Water		
	TDS, mg/l	
	Sulphates, mg/l	250
	Chlorides, mg/l	250
	Sodium, mg/l	200
	Calcium, mg/l	140
	Magnesium, mg/l	85
	Total coliforms, in 250 ml	Inadmissible

2.6.3.Noise Level Standards

Admissible noise standards of IFC and Georgian national standards for the residential area are similar. The standards about the noise are allowed according to the Decree # 297/N of the Ministry of Health, Labor and Social Affairs of Georgia on Affirmation the Qualitative Norms of the Environment, issued on August 16, 2001. There are defined as the admissible norms of noise as the maximum of the admissible norms for several zones of the territories. For the residential areas the standard requirements for noise are given in the Table 2.6.3.1.

For IFC noise impacts should not exceed the levels presented in Table 2.6.3.2. or result in a maximum increase in background levels of 3 dB at the nearest receptor location off site.

Table 2.6.3.1.Georgian Standards for Noise Levels

Time	The everage allowed size of noise (dbA)	The maximum allowed norms of noise (dbA)
7am-11pm	**55**	**70**
11pm- 7am	**45**	**60**

Table 2.6.3.2. **. IFC Noise Level Guidelines**

	One hour L_{aeq} (dbA)	
Receptor	Daytime 07:00 – 22:00	Nighttime 22:00 – 07:00
Residential; institutional; educational	55	45
Industrial; commercial	70	70

As it shown in the tables 2.6.3.1 and 2.6.3.2 the both (IFC and GEO) standards envisage the same level of admissible threshold of equivalent noise: 45 dbA for nighttime and 55 dbA for daytime.

2.7. Institutional Framework

Ministry of Environment Protection and Agriculture

MEPA is responsible for all environmental protection issues and natural resources. The responsibilities of the Ministry as the competent authority are to: a) intermit, limit, or stop any activity having or likely to have adverse impact on the environment, b)issue a series of licenses and permits (including for environmental impact), c) control the execution of mitigation measures by the developer, and d) receive free and unrestricted information from the developer about the utilization of natural resources, monitoring systems, waste management and explanations from authorities concerning the project.

RD will apply for the environmental permit for works to be undertaken under EWHCIP AF to the MEPA. Department of Ecological Examination of this Ministry will undertake expert review of the ESIA report and take decision on the issuance of an environmental permit as well as on the conditions under which the permit is to be granted.

The MEPA consists of several functional departments, which are responsible for different aspects of environmental protection and administration. Department of Permits is responsible for carrying out State Ecological Expertise and issuing environmental permits. Department of Environmental Supervision is responsible for execution of control over the environmental protection.

Ministry of Economy and Sustainable Development

Ministry of Economy and Sustainable Development is responsible for carrying out the review of technical documentation (including conclusion of independent experts) and issuing Construction Permits for infrastructural projects, as well as for supervision over constructing activities and for arranging Acceptance Commission after completion of construction.

State supervision of construction and compliance monitoring is provided by the Main Architecture and Construction Inspection under the Ministry of Economy and Sustainable Development of

Georgia.

The National Environmental Agency under the Ministry of Economy and Sustainable Development issues licenses for the natural resource use (except gas and oil). This includes also licenses for quarries and borrow pits supplying the road projects with the inert construction materials.

Ministry of Regional Development and Infrastructure

The MRDI oversees regional and infrastructure development throughout the country which includes modification and modernization of the State road network of international and domestic importance. MRDI works out suggestions and recommendations pertaining important investments into the national infrastructure and submits them for review and decision-making to the Cabinet. The RD is an agency subordinated to MRDI.

Roads Department of the Ministry of Regional Development and Infrastructure

The RD of the MRDI is responsible for elaboration of policy and strategic plans related to developing motor roads, management of road and traffic related issues and construction, rehabilitation, reconstruction and maintenance of the roads of public use of international and national significance, utilizing funds from the state budget, lawns, grants and other financial sources.

RD is an implementing entity of the World Bank-financed EWHCIP AF and will carry responsibility for all aspects of the project implementation. Because the EWH is an international motor road, RD will be responsible for its operation and maintenance beyond the Project life. Present ESIA was commissioned by RD and RD will exercise control over the adherence of construction works with the ESMP included in the present ESIA report.

The RD is responsible for general oversight of environmental compliance of works through ensuring quality performance of the technical supervisor and the contractor. RD will perform these functions through its Service of Environmental Protection and Service of resettlement comprising of twelve staff members with relevant education and professional skills. Service of Environmental Protection is supposed to review the EIAs and EMPs related to the Roads Department projects and perform monitoring of compliance of the contractor's performance with the approved EMPs, EIAs, environmental standards and other environmental commitments of the contractor.

A Supervision consultant will be hired by the RD to provide technical control and quality assurance of civil works. Environmental monitoring will be an integral part of the consultant's assignment and information on the compliance with the EMP will be included into the supervisor's regular reporting to the RD. The RD will have an overall responsibility for applying due environmental diligence. This will include ensuring quality of the supervision consultant's performance, site inspections, timely response to any issues identified by the consultant or by the RD inspectors, and record keeping on all environmental aspects of the project implementation.

Works supervisor will be responsible for reporting to the RD on the environmental and social performance under the EWHCIP AF on monthly basis through including safeguard compliance section into the general reporting. RD will make monthly reports from the works supervisor available to the World Bank upon demand. This reporting will be based on the information received from the works supervisor, but should also reflect results of RD's own due diligence (quality control over the supervisor's work) and RD's assessment of supervisor's performance.

Ministry of Culture and Monument Protection

The Ministry of Culture and Monument Protection is responsible on supervision of the

construction activities in order to protect archaeological heritage. In case if construction is to be carried out in a historic sites or zones of cultural heritage, consent of the Ministry of Culture, Monument Protection and Sport is also required for issuing construction permit.

In case of chance finds of the potential archaeological value, project proponent shall contact the Ministry of Culture and seek guidance on the course of action. All action has to be taken on hold till the guidance from the Ministry is received formally. Project proponent is obligated to allow sufficient time and provide favorable conditions for undertaking works necessary for excavation, removal of artifacts from the site and its conservation. Works may resume only upon formal consent of the Ministry of Culture. In rare cases, changes may be required in the project design to bypass the site of exceptional importance and historic value.

Municipalities

The Constitution of Georgia gives the principles to identify the rights of a self-governing unit and not the rights of a self-governing unit. A detailed list of the rights of a self-governing unit based on the principles given by the Constitution is given in Article 16 of the Code of the Local Self-Governing Body of the Organic Law. Municipalities participate in spatial and territorial planning of the municipality and approving urban planning documents, including the general plan of land use. They issue construction permits for small scale infrastructure. Municipalities are also authorized to exercise control of the construction works. Municipalities are mandated to manage public property and natural resources (e.g. land and forest) owned by them. They are in charge of the collection and disposal of household waste, management of local roads, controlling street trade, protecting and regulating cemeteries, and a few other functions that may have relevance for decision-making and construction under EWHCIP AF. In addition, local municipalities will play an important role is designated and allocating sites for the arrangement of construction camps and will have crucial function in the grievance redress mechanism, functioning as interlocutors between local communities, construction contractor, technical supervisor and the RD.

3. ANALYSSIS OF ALTERNATIVE OPTIONS

3.1 Introduction

E-60 Highway is a very important component of South Caucasus road system. On the territory of Georgia, the Highway runs from Red Bridge (at Azerbaijani border) to the city of Poti (on the Black Sea coast). Its length on the territory of the country is approximately 388 km. In the central part of the country, the Highway runs across a mountainous area, through a quite complex relief (approximately 600-900 m above sea level).

The present EIA document considers the modernization project of approximately 12-km-long section of E-60 Highway, which will run from the eastern portal of Rikoti Tunnel (the end of Zemo Osiauri-Chumateleti section) to village Khevi. The section under consideration will be located in Khashuri and Kharagauli municipalities.

The present condition of the Highway is as follows: Rikoti Tunnel is directed from south-east to north-west. It is a two-lane dual carriageway Tunnel. The length Rikoti Tunnel is approximately 1782 m and it was built in 1982 in quite complex geological conditions. The section of the Tunnel has a shape of a horse-shoe; its width varies from 9.84 to 10.40 m. Owing to the rehabilitation works of recent years, the technical condition of the Tunnel has improved a lot and now, it meets the European standards. From east, the Tunnel has a bypass, which runs across the ridge crest and connects the eastern and western portals of the Tunnel. The said bypass was mostly used before the Tunnel was built.

After the Tunnel, the Highway runs north-west with approximately 6-km-long section of it being a 3-lane road. 2 lanes of 3 are directed from west to east. Then, the Highway alignment continues from east to west, to village Khevi. There are two emergency side tracks arranged on the right side of the road. The major portion of the considered section of the Highway runs across the non-inhabited area, only with its final 2,5-km-long section running close the residential houses in villages Tsakva, Grigalati and Khevi of Kharagauli municipality.

The corridor of the given section of E-60 Highway crosses a number of rivers and gullies. The road improvement means increasing the traffic intensity by building a four-lane dual carriageway highway with artificial buildings placed along it, such as bridges, tunnels, bearing walls, etc.

The EIA report considers various alternative options, including: no-project (no-action) alternative, alternative road corridor alignments and alternactive options of Rikoti Tunnel.

3.2 No-Project (No-Action) Alternative

As mentioned above, at present Zemo Osiauri-Chumateleti section of E-60 Highway is being constructed. The design section is the continuation of the section under construction. In case of a zero alternative, four-lane dual carriageway of EWH will hit a bottleneck of Rikoti Tunnel with two-lane road surface causing congestion and undermining positive impacts of the highway improvement undertaken all way from Tbilisi to Chumateleti (last section under construction). It may be said that a zero alternative of Chumateleti-Khevi section would be environmentally and socially neutral in terms of additional impacts, however it would carry a significant cost of lost opportunities.

When analyzing the No-Action alternative, accent must be made on free movement opportunity along the existing Highway. As mentioned in the introductory part, the alignment of the considered

section of the Highway is located in severe climatic conditions. In winter, in terms of abundant precipitations, the traffic is often constrained, as following the sizes of the road, it is difficult to rapidly clean the roadway off snow. In spring and autumn, the reason for the Highway failure and traffic constraints is the periodic landslide processes developed adjacent to the road. In case of long-term traffic constraints, the alternative traffic routes of EWH are as follows:

- Dzirula-Kharagauli-Moliti-Pona-Chumateleti local highway, with the length of 52 km, or
- Gomi-Sachkhere-Chiatura-Zestaponi local highway, with the length of 103 km.

These alternative alignments lengthen the travel time a lot and contribute to the risks of traffic safety (this is particularly true with large vehicles). Furthermore, the alternative alignments run across some settled areas of Imereti region and consequently, the growing traffic flows has a negative impact on the living conditions of the local population.

In the future, in parallel to the growing traffic flows (what is highly probable if considering such announced tourism development projects, as Anaklia Deep Sea Port Project and the like), it is expected that the situation described above will be further aggravated, and even the cases of traffic collapse are possible what may become a reason for serious constraints in the social-economic development of the country. At this point, it should also be noted that No-Action Alternative will drastically reduce the social-economic effect gained from the already modernized sections of E-60 Highway and will have an extremely negative impact on the expectations of the country population and businesses.

The implementation of the project will much contribute to the free East-West traffic flow what, on its turn, will reduce the probability of the realization of the risks listed above. Besides, the local population will be engaged in the construction works what will have a positive impact on their incomes.

Following the above-mentioned, it may be said that the modernization project of Chumateleti-Argveta section of E-60 Highway (including the Highway portion under consideration) will contribute much to the sustainable economic development of the country and there is no alternative to its implementation. As for the negative environmental impacts of the project implementation, their scales and areas of spreading can be reduced at the expense of due compensation and mitigation measures.

3. 3 Alternatives of Rikoti Tunnel Design

3.3.1 No additional tube at Rikoti Tunnel

If there is no additional tube (tunnel) drilled through the mountain pass, then two lanes will take one direction through the existing tube and other lanes of the opposite direction will use the existing bypass road of 4.5 km. Advantage of this alternative is that it does not expand environmental footprint of the highway, however disadvantages are far more significant.

The existing bypass of Rikoti Tunnel is a IV-category road with approximately 7-m-wide asphalt roadway. The road alignment has highly inclined sections and deep-lunged torques, and it fails to duly ensure traffic safety, particularly for large vehicles. Furthermore, in winter, in terms of abundant precipitations, the traffic is often hampered, as following the sizes of the road, it is difficult to rapidly clean the roadways off snow. Because of these characteristics of the bypass road, it may not be considered as part of the main road infrastructure for international traffic on the EWH and having no additional tube of Rikoti Tunnel is not a feasible option.

The section Chumateleti - West portal of Rikoti Tunnel covers essentially only the dualing of Rikoti Tunnel. The rehabilitation of the existing Rikoti Tunnel was recently completed, including structural improvements and installation of new lighting, ventilation and other safety equipment. Therefore, the existing Rikoti Tunnel should be utilized as one directional tube for the upgraded East-West Highway.

3.3.2 Alternative alignments of additional tube

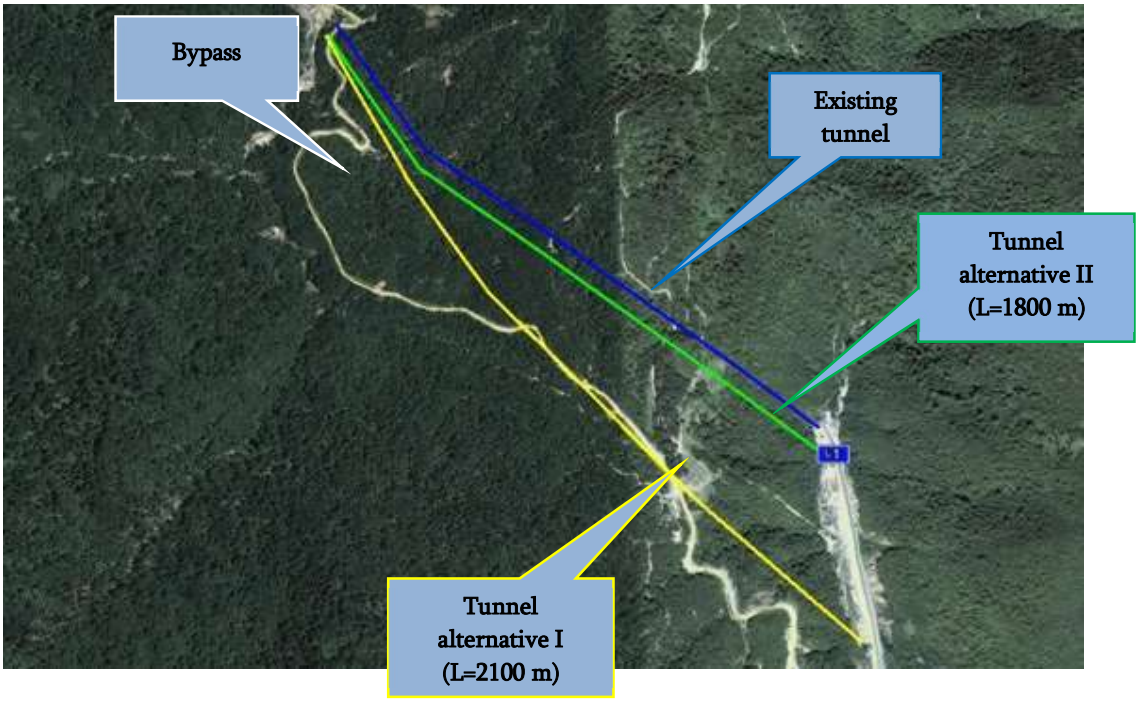
The alternative options for placement of an additional tube of Rikoti Tunnel are shown in Figure 3.3.2.1

Alternative I with the length of 2100 m starts near the starting point of the bypass road. Its alignment lies far from the existing Tunnel. The western portal will be arranged on the right bank of the river Rikotula, adjacent to the bore of the existing Tunnel. Alternative II will run in parallel to the existing Tunnel and its length will be approximately 1800 m.

While comparing these two alternatives, preferance was given to Alternative 2. In fact, this alternative has been confirmed after the approval of eastern portal section of Chumateleti Tunnel, without additional consideration and comparison of the optimalal alternative.

From environmental point of view, in case of Alternative 2, the length of the Tunnel is much less and therefore, the volume of generated waste will be also reduced. This alternative is also economically profitable.

Figure 3.3.3.1 Alternative Tunnel Alignments



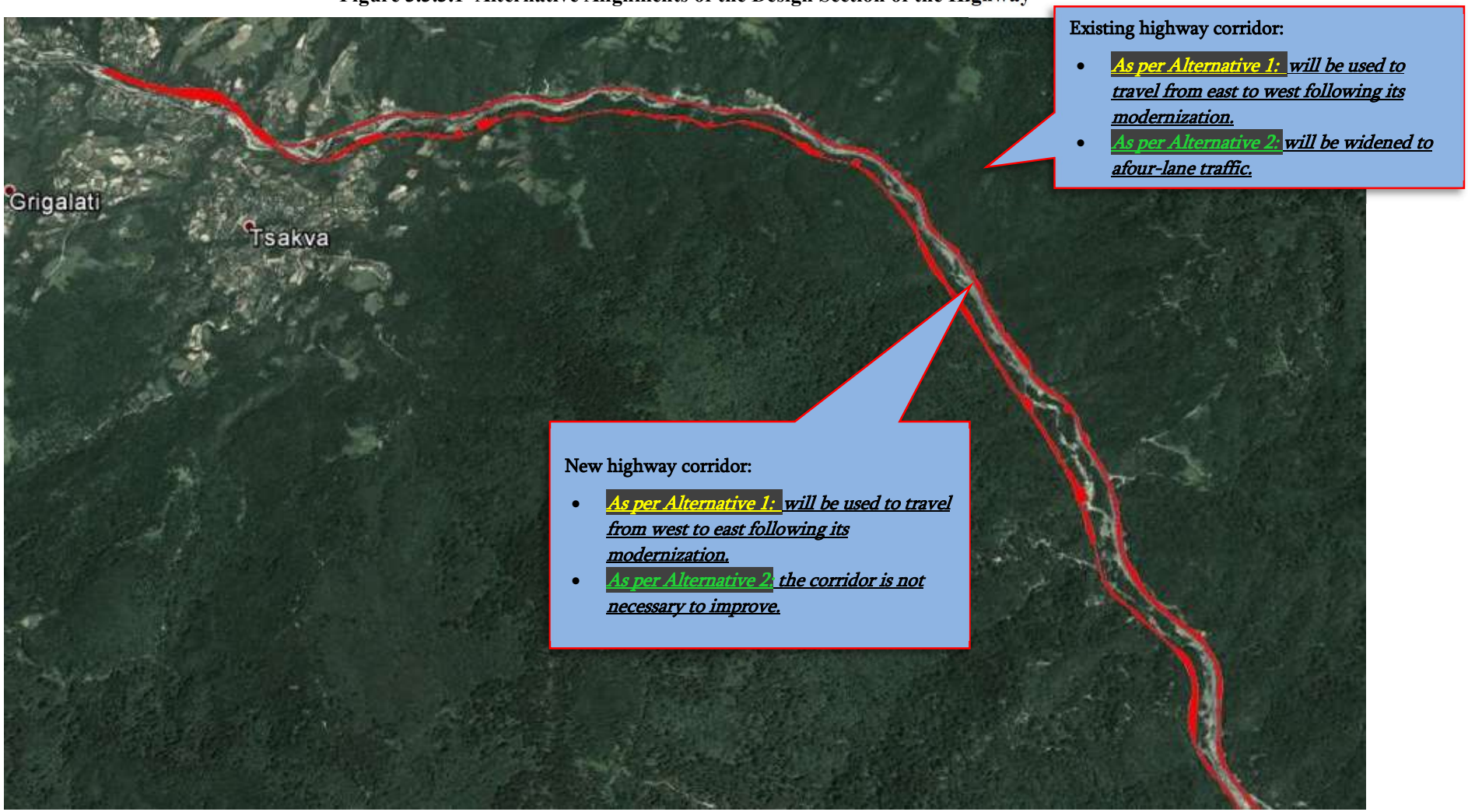
3.3.3 Alternative alignments from the western portal of the Tunnel to CH7+50

If considering the relief along the section under consideration, identifying several real alternative options seems difficult. The feasibility study considered 2 main alternative alignments from the western portal of the Tunnel to CH7+50 within the scope of the project:

- Alternative 1: means modernizing the existing highway running along the right bank of the river Rikotula and upgrading it to the international standards without any significant widening. This side will serve the vehicles moving from east to west. Two additional lanes will be built on the other side of the river (on its left bank), through the virtually non-exploited corridor covered with dense forest for the vehicles driving from west to east. New bridges and overpasses will be planned along the new Highway (an alternative option in the process of designing is referred to as "the separated ways").
- Alternative 2: excludes the improvement of a new corridor on the left bank of the river Rikotula. Two dual carriageway lanes will be constructed at the expense of widening the existing Highway, by cutting the slopes and constructing new bridges and other engineering facilities (in the process of designing, the alternative option is referred to as "2+2 alignment").

Both alternatives are plotted in Figure 3.3.3.1 A brief description of the corridors of the alternative options is given below.

Figure 3.3.3.1 Alternative Alignments of the Design Section of the Highway



Alternative 1: "separated ways"

The given alignment was developed by considering the recommendations of the Feasibility Study held in 2015 and aimed at optimizing the left and Right Branches of the new road alignment. The route of the separated ways means the development of individual routes for the Left Branch and Right Branch of a two-lane road between the western portal of Rikoti Tunnel and km 7+500. Thereafter, the two lanes merge and form a conventional two-lane dual carriageway road of the Highway.

Right branch

The alignment of the Right Branch is directed from the existing western portal of Rikoti Tunnel and closely follows the existing E60 route, which is a winding road up to km 7+500. Thereafter, the Right Branch carriageway merges with the Left Branch carriageway to form a conventional two-lane dual carriageway up to the end of the project.

In terms of geometrical elements, the horizontal alignment of the proposed Right Branch alignment is compliant with the 80 km/h design speed, but the length of the transition curve elements (clotoids) do not always fully comply with the Georgian Standard. The horizontal radii have values between 250 m (the minimum value permitted by the Georgian Standard) and 1500 m.

The longitudinal profile on the Right Branch has a vertical gradient of less than 6.0% over the majority of the alignment, which accords with TEM Standard and the Georgian National Standard. However, between km 2+520 and km 5+690, a length of approximately 3.1 km, the gradient is 6.8%. Such a gradient, which exceeds the maximum permitted gradient of 6.0%, approximates to the gradient on the existing road and is similar to the vertical profile that was developed in the Feasibility Study. However, it should be noted that the Right Branch relates to the downhill direction of the highway, and consequently the steep gradient has implications for the safety of road users.

Brief description of the corridor: There are two emergency side tracks at CH 4+5 and CH 6+50. The emergency side tracks are isolated from the main highway and are designed for the non-controllable vehicles to slow down or stop. The emergency side tracks use a gravitation effect to reduce the vehicle moving speed up to stop. However, the existing emergency lanes need improvement. As per the information of the local people, sometimes the side tracks failed and there were lethal outcomes.

Some sections on the right side of the existing road contain landslide sites. Several years ago, landslide occurred along these sites and damaged the road. Consequently, some sections of the roadway, following the certain reconstruction works (making the fills on the riverbed side) shifted towards the riverbed. There are relevant engineering structures built at some places, but the slope stability is not yet satisfactory and there is probability of similar events to occur in the future. There are several springs with small output flowing on this side of the road. From the side of the river Rikotula, the road is more or less protected. There are coast-protecting structures built at some sites.

The sketch map of the Right Branch alignment of Alternative 1 with relevant figures is given below.

Figure 3.3.3.2. Alternative 1. Right branch alignment from CH 0+00 to CH 4+00

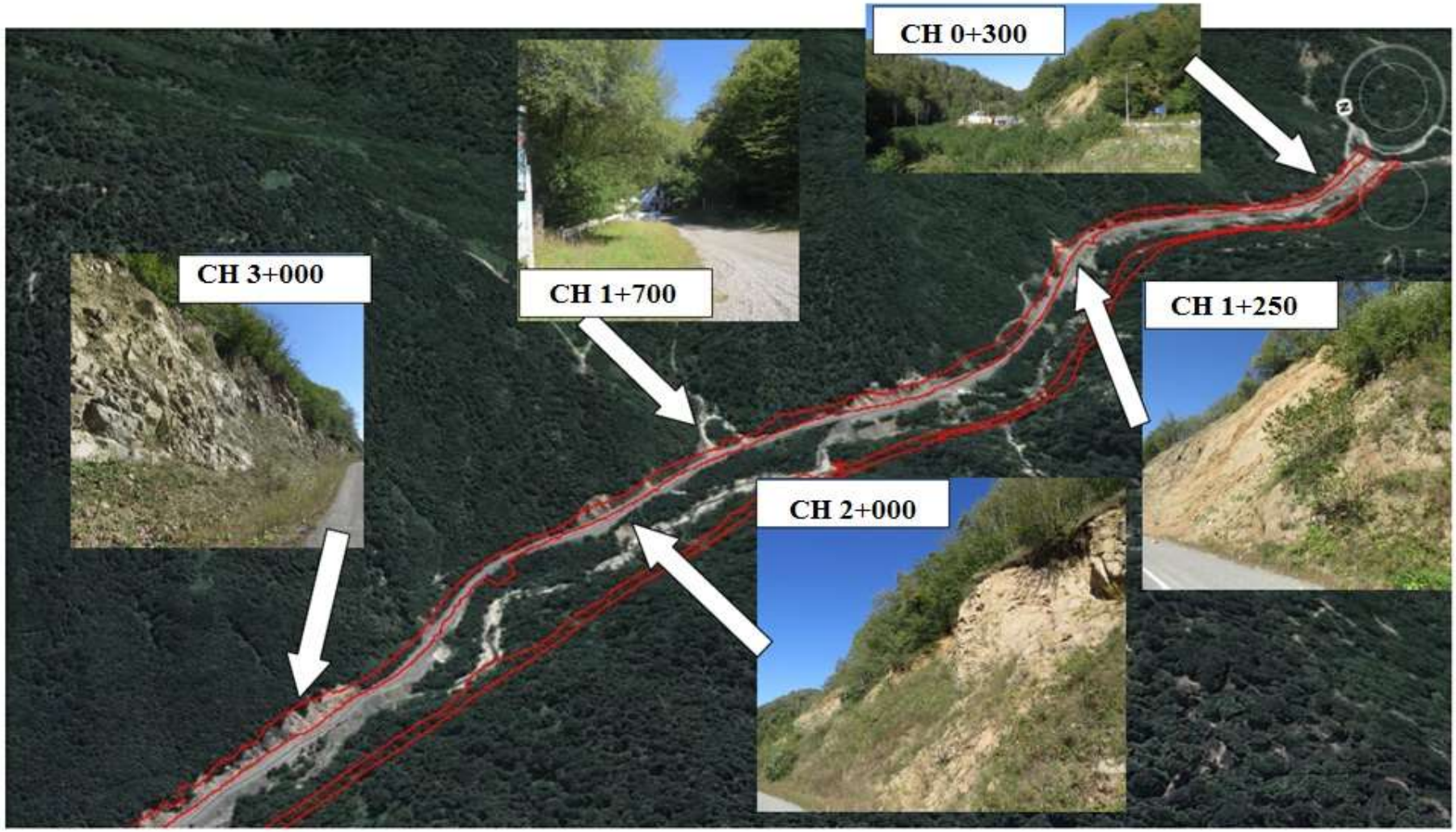
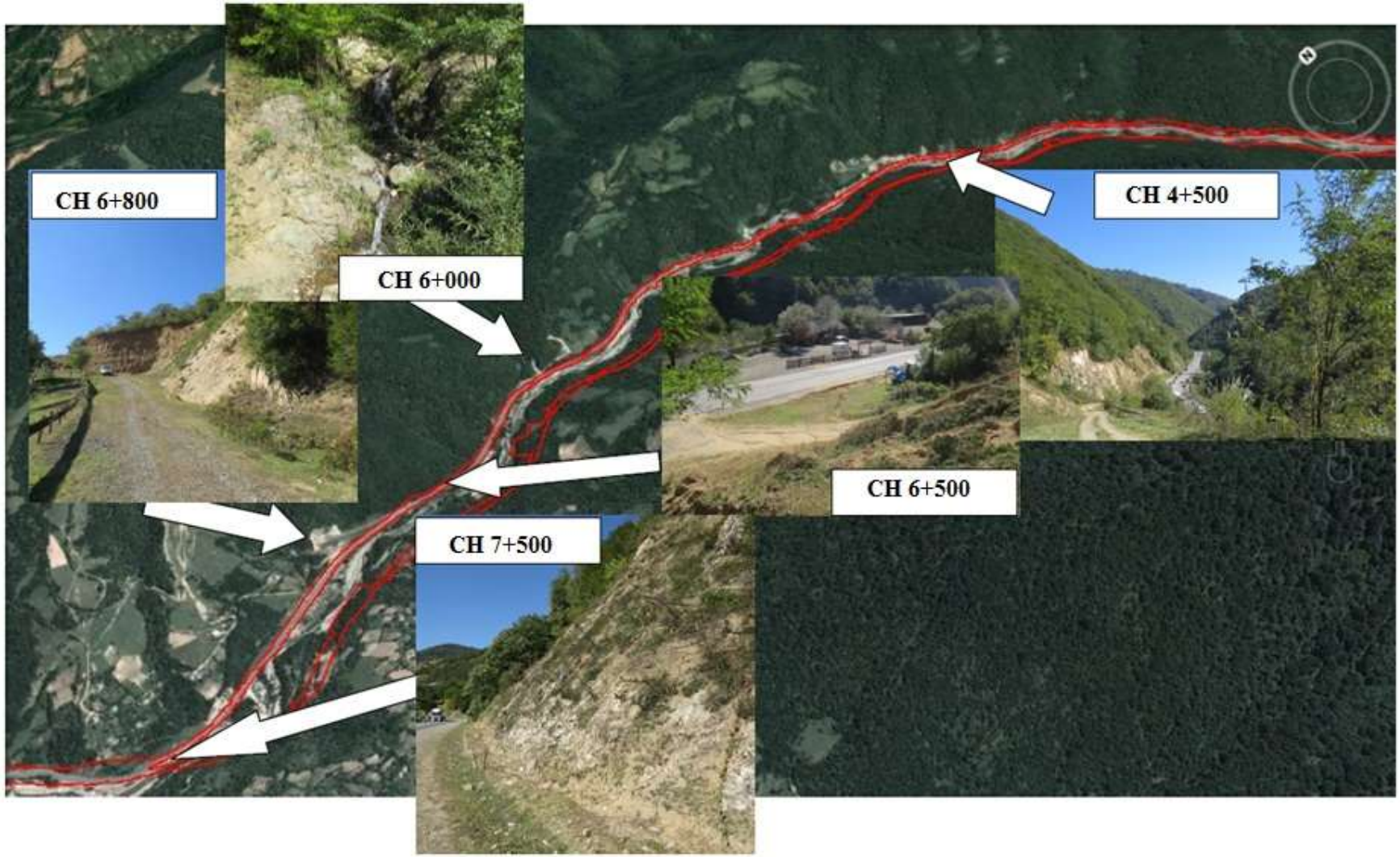


Figure 3.3.3.2. (Continued) Right branch alignment from CH CH 4+00 to CH 7+50



Left branch

From the western portal of the second bore of Rikoti Tunnel, the Left Branch enters the steeply sloping mountain area where it runs parallel with Rikotula river (in this area, the cross-section is mixed, i.e. not the same), up to km 7+000. From here, the alignment turns to the right, crosses the river Rikotula and joins the Right Branch, forming a conventional 2-lane dual carriageway up to the end of the project.

The horizontal alignment of the Left Branch carriageway is generally compliant with the 80 km/h design speed. The radii have values between 250 m (the minimum value permitted by the Georgian Standard) and 1500 m. However, in terms of the different geometrical elements, the lengths of the curve transition elements (clotoids) are not fully compliant with the Georgian Standard.

The longitudinal profile on Left Branch was determined taking into account TEM standards and the Georgian National Standard, and has a maximum (uphill) gradient of 6.0%. Given that the alignment runs uphill, and has a gradient in excess of 3.0% over a total length of approximately 7 km, climbing lanes are required to be included in the design of the carriageway of the Left Branch.

Brief description of the corridor: The corridor starts at the West end of design Rikoti Tunnel (CH0+00), at 880 m asl and crosses the river Rikotula with a design bridge right at the beginning. Up to CH4+00 (680 masl), the corridor is directed from south-east to north-west; it crosses the relief with a steep inclination covered with dense forest without any engineering communications or agricultural plots. It should be noted that according to the local people, there was a narrow ground road running along this section of the river bank in the past intended for the maintenance of an oil pipeline intended to construct in the Soviet era. There is no pipeline here at present, but some sections of the earth road have survived. The corridor crosses the left tributaries of the river Rikotula and erosive areas. On this side, in order to ensure the stability of the slopes, terracing and arranging a bearing wall is necessary, while on the right side, fills/coast-protecting facilities are needed to mitigate the erosive action of the river Rikotula.

A new corridor of the section from CH4+00 to CH7+50, with its natural and social conditions, does not much differ from the section described above. The corridor is directed from east to west. It also runs across complex relief. The last portion of the section will presumably impact a small area of the agricultural plots, which are used as pastures or hey meadows. The implementation of the project along this section will have a direct impact on the catering objects (9) and fueling station (1) located adjacent to the main and individual traders, whose business is seasonal lasting for 3-4 months a year. In October, 14 individual traders were registered adjacent to the design section. 13 of them participated in the interview (1 of them refused). However, as the interview evidenced, their real number is 2,5 or 3 times more. They are mainly the residents of the nearby villages and trade with their own harvested products (fruit, corn, honey, etc.). Furthermore, a drinking water spring in the corridor will probably come under the impact.

The sketch map of the Left Branch alignment of Alternative 1 is given below.

Figure 3.3.3.3. Alternative 1. Left branch alignment from CH 0+00 to CH 4+00

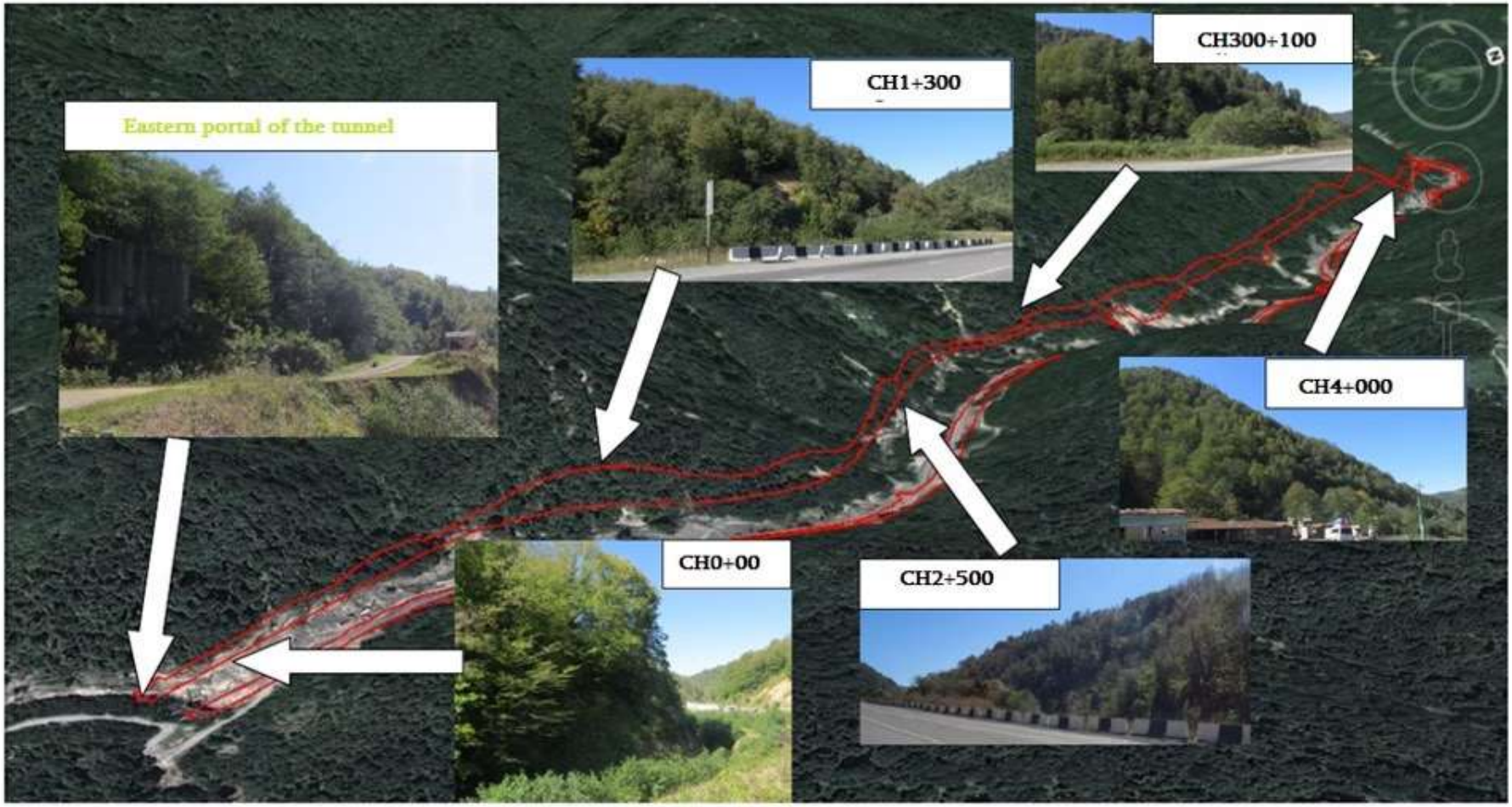
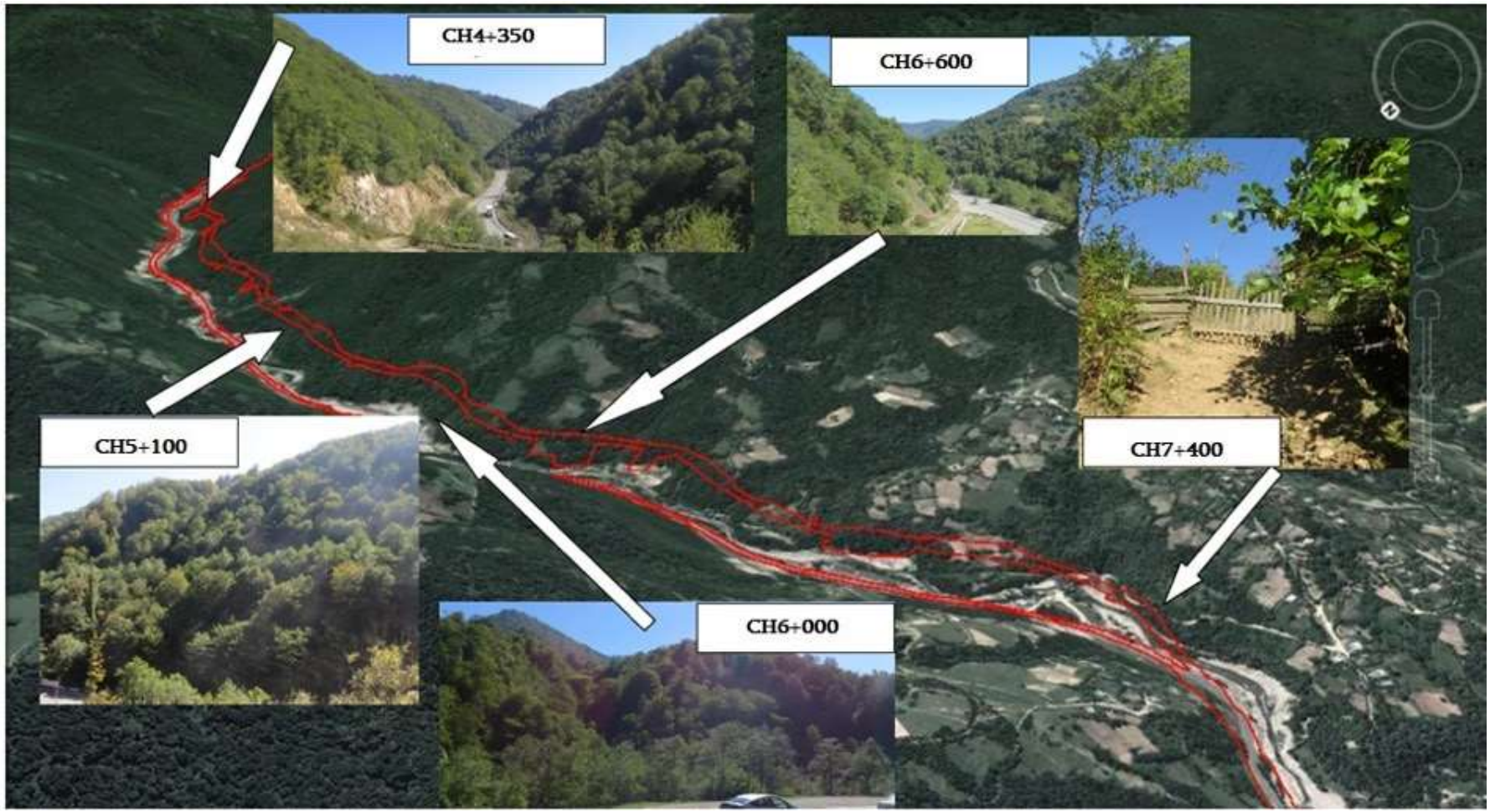


Figure 3.3.3.3. (Continued) Alternative 1. Left branch alignment from CH 4+00 to CH7+50



Alternative 2: «2+2» alignment – No new corridor

A "2+2" alignment was studied as an option for alignment optimization by creating a "2 lane dual carriageway" alignment, with the two carriageways adjacent to each other and approximately following the axis of the existing road alignment. This alignment, which is not compliant with the conclusions of the Feasibility Study, was prepared in order to prove that such an alignment could be viable because there is a significant doubt regarding the viability of the Left Branch as proposed by the Feasibility Study.

The "2+2" alignment will involve designing pairs of new bridges to replace the bridges on the existing road, increasing the length of existing retaining walls to support the edge of the road platform, as well as requiring river regulating facilities over significant lengths of the Rikotula river.

The advantage of the "2+2" alignment is that the geotechnical conditions of the existing cuttings are well known, based on the exposed cut faces, and are on the whole favorable to developing a "2+2" alignment. In addition, the potential height of cut slopes are expected to be less than those that will be formed in the alignment based on the Feasibility Study. There will also be reduced environmental impacts, as the forest on the left bank of the Rikotula river would not be disturbed.

On the other hand, with "2+2" alignment, the traffic management measures will be required to ensure that traffic can move along the road during the ongoing construction works, while considerable temporary measures will be required to safeguard traffic during the excavation of the new cuttings, and the downhill section of the road alignment.

The corridor of «2+2» alignment almost coincides with the corridor of the Right Branch of Alternative 1 with its description given above.

3.4 Comparative analysis of the alternative alignments

The comparative analysis of the alternative alignments evidences that Alternative 2, i.e. «2+2» alignment, is more acceptable. The advantage of this alternative is particularly evident in an environmental point of view.

The following circumstances are worth mentioning:

- In case of positioning the Left Branch alignment on the left bank of the river Rikotula, approximately 1 430 000 m^3 material will be needed to dig out. The value of these ground works yields a significant financial economy in case of moving the alignment to the right side of the river Rikotula.
- Positioning the Left Branch alignment on the left bank of the river Rikotula means constructing 17 new bridges, while «2+2» alignment, which follows the existing road, needs the construction of the following bridge structures:
  - Two new bridges for the alignment to cross the river Rikotula.
  - Changing the bridge established near Rikoti Tunnel with the alignment of the existing road.
- The left bank of the river Rikotula remains largely in shadow from November through February, whereas the ground surface on the right bank of the Rikotula river receives the full benefit of any winter sunshine. Consequently, the winter weather conditions on the left bank of the Rikotula river are prolonged into March and this will have a negative impact on road

users during the winter months. This negative impact will be largely mitigated if the road alignment is moved to the right bank of the Rikotula river.

- The Left Branch corridor to be positioned on the left bank of the river Rikotula crosses an instable location (a possible fossil landslide area) between Km 6+000 to Km 7+000. This area can be avoided if the alignment is changed to the right side of the river Rikotula. Besides, there is a high probability of extra engineering-geodynamic problems in the corridor covered with dense forest on the left side to occur during the ground works. The problems in the given respect on the right bank are much more evident today.
- By separating the Left and Right Branch alignments, if they are arranged on the different banks of the river, significant difficulties are expected in respect of constructing turning spots and emergency passovers and secondary roads at the main.

Furthermore, the following conditions are worthwhile in respect of environmental protection:

- Emissions and noise: at the construction and operation stages, in respect of emissions and noise propagation in the atmospheric air, Alternative 2 option should be preferred. With Alternative 1, the impact area is wider due to the use of two corridors distanced from one another. With Alternative 2, the works will be accomplished only on the right bank of the river where the background environment is already transformed – the vehicle movement influences the environment. Consequently, the area and scales of impact will be much less.
- Geological threats: in the corridor of the existing road, on the right side, there are several landslide sites fixed much complicating the chance of widening the road in his direction. At a glance, it would be better to cut a new corridor on the left bank of the river Rikotula leaving the right side of the existing road intact. However, it should be considered that the relief on the left bank of Rikotula river is no less complex, with the slopes built with the same types of rock. It is true, there are only few active landslide sites fixed in the corridor at present, but clearing the cover of trees and vegetation during the process of cutting the corridor and terracing will disturb the rock stability and there is a high probability of new landslide-prone hearths to originate what will have negative outcomes not only in the construction phase, but also in the long-term perspective. By considering the above-mentioned, the option of Alternative 2 must be preferred in an environmental respect.
- Water environment: in case of improving both banks of the river Rikotula, the risks of water pollution will be higher. Furthermore, the cultivated areas will increase and this will increase the surface flow and risks of pollution with suspended particles. In addition, with Alternative 1, a drinking water spring at the end of the corridor will come under the impact.
- Soil: as per Alternative 1, the corridor with the forest ecosystem with the soil as its important component, will be exploited. As per option 2, less valuable areas will come under the impact. So, in this respect, a minor advantage can be given to Alternative 2.
- Biological environment: under Alternative 1, a certain section of the road will pass through a virtually intact forest zone. It should be noted that as the botanical studies suggest, the Georgian Red-Listed plant species on this slope of the gorge are more in number. In addition to the impact in the construction phase, the forest degradation will continue in the future. Cutting down the forests will disturb the environmental balance and will have a significant impact on the local ecosystem/habitats. It is true that even with alternative option 2, clearing the forested areas adjacent to the existing road is inevitable, but in this case, the impact area will be much less. In addition, the vegetation cover in this zone clearly shows the trace of anthropogenic impact. Due to different diseases, the plants are drying at some locations. Due to the development of the roads on the left bank of the river Rikotula, the local population

will have an easier access to the forest resources. Due to this fact, there is a risk of more active illegal cuttings. In this respect too, Alternative 2 must be preferred.

- Visual-landscape environment: the landscape in the corridor envisaged by Alternative 1 on the left slope of Rikotula river is not rare or of a particularly high value. However, its components (vegetation cover, relief, etc.) are in fact intact and are highly natural. Consequently, the landscape can be considered as of an average value. As for the zone adjacent to the existing road corridor (Alternative 2), the anthropogenic impact of a human is clearly seen with it. Due to a poor tree and vegetation cover, ongoing erosive and landslide processes and presence of various engineering facilities here, its value can be considered as low. Following this, Alternative 2 suggesting that a less valuable landscape will come under the impact must be preferred.
- Limitation of free movement, risks of accident: in the construction process, in respect of free movement, Alternative 1 of the road corridor is more feasible. In case of implementing the project with this plan, the traffic regulation will be much easier. In particular, at the construction stage, when the corridor is prepared on the left slope of Rikotula river, the traffic flows will be relocated to the existing road (the vehicles will drive as they are driving at present). After the eastern-western traffic lane is complete, the traffic will be relocated to the newly built highway and the construction works will continue to modernize the existing road. With Alternative 2, the construction works must be accomplished in the existing road zone. Following the small width of the gorge, the traffic flow control will be quite difficult. Therefore, the greatest disadvantage of Alternative 2 can be considered to be the limitation of free movement at the construction stage needing special organization of the construction works.

By considering the above-mentioned important circumstances, in the environmental respect, Alternative 2, i.e. “2+2” alignment is much more feasible. No additional branch on the left bank of Rikotula river is recommended to construct.

3.5 Summarizing the alternatives

Based on the analysis of the environmental background and expected impacts of the project realization, Table 3.5.1 below gives the comparison of the considered alternatives both, in the road modernization and operation phases.

Table 3.5.1. Comparison of the expected impacts of alternative options

Legend:

Construction phase-	C
Operation phase -	O
Positive impact -	
Negative impact -	
No impact is expected/ insignificant change -	
The scales and probability of expected impact are evaluated as follows -	L – the impact scale is less than with other alternative options; H - the impact scale is higher than with other alternative options.

Impact / Alternative option	Emissions, noise, vibration		Disturbance of geological stability		Deterioration of soil quality		Disturbance of ground stability		Impact on water environment		Impact on the vegetation cover		Impact on fauna		Visual-landscape changes		Waste origination and expected impact		Impact on private property		Changes in the conditions of traffic		Employment and improved economic conditions	
	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O
No-action alternative																								
• The Project will be implemented		L																						
• No-project alternative		H																						
Road corridor alternatives:																								
• Alternative 1	H	H	H		H		H		H		H		H	H	H		H				L	L		
• Alternative 2	L	L	L		L		L		L		L		L	L	L		L				H	H		
Tunnel alternatives:																								
• Alternative 1									H								H							
• Alternative 2									L								L							

Due considerations have been given during the design of the new road alignment to minimize the adverse impacts of land acquisition and involuntary resettlement. Efforts have been put to incorporate best engineering solution in avoiding large scale land acquisition and resettlement. The allignment has been optimized in tight collaboration with RD and WB.

4. PROJECT DESCRIPTION

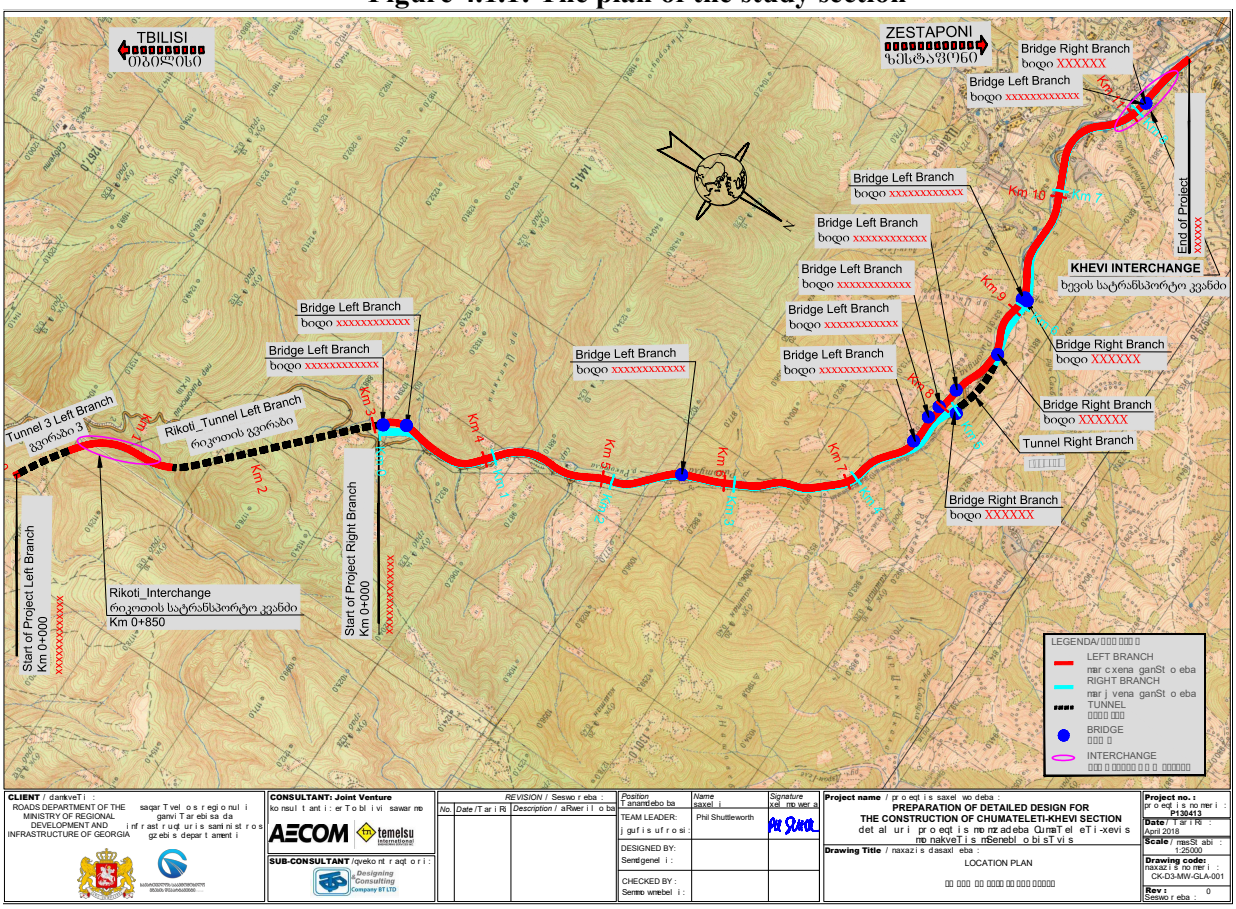
4.1 Introduction

The program to upgrade the major roads of the country initiated by the Government of Georgia aims to improve transportation and transit of goods to the neighboring countries. The program is managed by the RD and focuses initially on the EWH which runs from Russia and Azerbaijan, with connections to Turkey and Armenia. Upgrading of the EWH from single lane dual to double lane dual carriageway has already been completed between, Natakhtari-Agaiani, Agaiani-Igoeti, Igoeti-Sveneti, Sveneti-Ruisi, Ruisi-Agara Choloki-Kobuleti Bypass. Works are underway between Agara-Zemo Osiauri, Zemo Osiauri-Chumateleti, Khevi-Argveta, Zestafoni-Samtredia, Samtredia-Choloki, and the EWHCIP AF will cover the section between Chumateleti-Khevi. EIB committed financing of EWH upgrade between Samtredia and Choloki.

The 12 km long section of EWH covered by the present ESIA will pass through Khashuri and Kharagauli Municipalities, namely, from Chumateleti to Khevi village. The East portal of Rikoti Tunnel is located in Khashuri Municipality (Shida Kartli Region), while the West portal and the section of the highway Westwards from that portal belongs to Kharagauli Municipality (Imereti Region).

The plan of the study section is given in **Figure 4.1.1**.

Figure 4.1.1: The plan of the study section



The modernization of the section needs the construction of new tunnels and other structures to improve the road capacity. In addition, the project envisages the construction of the road section through a complex topography and geology without hampering the traffic.

Along Chumateleti-Khevi section, winter in the environs of Rikoti Tunnel (at 900 masl) is severe and is less severe in the environs of Khevi (approximately 470 masl). The relief also differs along different sections of the alignment: there are both, steep forest slopes in the gorges of the rivers Chumateleti and Rikotula and less inclined relief near Khevi.

The alignment runs across the complex engineering-geological conditions, including periodic geological processes meaning the presence of the possible instable areas under the influence of the landslides of the past.

Reconstruction of the road corridor into a dual carriageway means the construction of bridges, tunnels and bearing walls in complex topographic and geological conditions to improve the road capacity. The project must envisage that the construction woks must be accomplished without hampering the traffic flow. The Project Implementer is the Road Department of the Ministry of regional Development and Infrastructure of Georgia.

4.2 Design Standards

The project was developed by considering the relief of the area of the traffic flow and relevant standards and characteristics. In particular, the project envisages ensuring the required minimum safety and comfort of the drivers by providing the space for the visibility distance, friction coefficients and vehicle maneuvering and protection of the environmental standards and traffic properties.

In order to obtain the best alignment optimization for Right Branch and Left Branch, where it is possible, we used the optimal solution according to TEM norms, Georgian National Standard norm, DIN (German norm) or other European norm. These are summarised in **Table 4.2.1** below, which also indicates the selected minimum design parameters.

The horizontal and vertical alignment elements are the main criteria used in developing highway design. It is important that these two elements are coordinated with other elements that are related to the design speed to ensure a co-ordinated design is prepared for road drainage, intersection design etc.

The horizontal and vertical design parameters for the 80kph design speed are presented in the table below.

Table 4.2.1 – Summary of Minimum Design Standards Adopted

Main Carriageway Design Element (80 kph Design Speed)	TEM	Georgian National Standard	DIN (EKA3 urban motorway, 80km/h Design Sp	Other (PD 162/2002 Romanian standard similar to TEM)	Selected Standard
Lane width:	3.75/3.50m	3.50m	3.50m	3.50m	3.75m
Minimum SSD:	100m	140m	125m	100m	100m
Min Radius without super-elevation	1	600m	1050m	1100m	600m

Min Radius without widening	-	450m	-	-	450m
Minimum Radius	240m	250m	280m	240m	250m
Maximum Gradient	6.0%	6.0%	6.0%	6.0%	6.0%
Minimum Crest Curve Radius	-	5000m	3000m	3000m	5000m
Minimum Sag Curve Radius	3000m	3200m	3600m	2000m	3000m
Interchange Slip Roads Design Element at (40 kph Design Speed)					
Lane width:	4.4m (without widening)	-	4.5m	4.4m (without widening)	4.4m (without widening)
Minimum SSD	-	-	40m	-	-
Min Radius without super-elevation:	-	-	-	-	-
Min Radius without widening	-	-	-	-	50m
Minimum Radius:	50m	-	50m	60m	50m
Maximum Downhill Gradient (Diverge Slip)	8.0%	-	7.0%	8.0%	8.0%
Maximum Uphill Gradient (Merge Slip)	7.0%	-	6.0%	7.0%	7.0%
Minimum Parallel Diverge Length	150m +90m		150m+30m	75m+754m	150m+60m
Minimum Parallel Merge Length	200m+90m	-	150m+30m	150m+75m	200m+60m
Minimum Crest Curve Radius	800m	-	1500m	1500m	800m
Minimum Sag Curve Radius	400m	-	750m	400m	400m

4.2.1 Stopping Sight Distance

Stopping Sight Distance can be defined as the distance needed for a driver to see an object on the road ahead and bring the vehicle to a stop to avoid collisions with other vehicles or objects on the road. According to TEM, for a design speed of 80 kph, the minimum stopping sight distance is 100m (TEM Table 3e), while the equivalent minimum stopping sight distance included in the Georgian National Standard is 140m. The Stopping Sight Distance of the Georgian Standard has been included in the development of the design as it has a higher embedded safety factor.

The equation below is used to calculate the road widening that is required to satisfy the stopping sight distance requirements:

The offset (y) from an obstruction that is required to calculate the widening (w) is given by (y) =C2/8R

where, C: visible distance criteria (m);
R: horizontal radius (m).

The value of widening to be applied depends on the position of the eye relative to the obstruction. Typically the eye is taken to be in the centre of the lane adjacent to the obstruction. Based on TEM Standard, the widening that is required on curves with radius less than 500m is included in **Table 4.2.1.1**:

Table 4.2.1.1: Required Widening to maintain Stopping Sight Distance (based on TEM)

C2 =	R	8R=	Y=C2/8R	Widening
100000	250	2000.0	5.0-0	2.00
100000	300	2400.0	4.17	1.17
100000	350	2800.0	3.57	0.57
100000	400	3200.0	3.13	0.13
100000	450	3600.0	2.78	-

Along the E60 highway between Rikoti and Khevi, there are many locations where the radius of the new road alignment is reduced to below 400m, while there are several curves with a radius of 250m. In these instances, where the alignment has a horizontal radius of less than 450m and the carriageway is on the outside of the central median the stopping sight distance would be less than the prescribed 100m for an 80 km/hour Design Speed. In such cases, it has been necessary to increase the width of the road platform by widening the edge clearance adjacent to the central median in order to ensure that the minimum required stopping sight distance can be maintained, in accordance with **Table 4.2.2.**

4.2.2 Horizontal Layout

The minimum permissible radius for 80 kph design speed is 250 metres, it is preferable to adopt curves with higher radii wherever possible. However, due to the nature of the terrain, which is a

steep hillside incised by deep valleys, the designs based on curves with radii of 300 metre and above will not be economic as, with such designs, the road will either have to be pushed deeper into the hillside, thereby increasing the volume of excavations, or moved out of the hillside and thereby increase the lengths of bridges and retaining walls, or possibly a combination of both.

In terms of geometrical elements, the horizontal alignment of both the Left Branch and the Right Branch are compliant with an 80km/h design speed. The main elements of the alignment design are discussed below.

4.2.3 Start and End of the Project

As indicated in Section 3 of this Report, the start of the project is defined as being at Km 127+50 of the Left Branch of the road alignment that has been prepared for the Detailed Design for E60 Highway Section from Zemo Osiauri to Chumateleti. The alignment of the new Left Branch for the Chumateleti to Khevi project has been designed to be consistent with the road alignment of the existing design and due account will be taken of the differences in the topographic datum used for the two designs.

Similarly, where the Chumateleti-Kevi road design interfaces with the design project after Khevi, the alignment of the two designs ensures that the two designs are consistent and the new road alignment will be continuous.

4.2.4 Transition Curves

The transition curve elements (clothoids) were originally based on the TEM norm, as described for Alignment A, and according to the following two criteria:

1. The first criteria relates to the rate of change of centrifugal acceleration experienced by vehicles. This criteria follows the formula:

L≥v3/RC (1-Rgǭ/v2)
where:
v = design speed (m/sec);
G= acceleration of gravity (m/sec2);
R = radius of the curve to be connected (m);
Ǭ = super-elevation (% x 100);
C= maximum rate of change of the centrifugal acceleration, which is typically no greater than 0.5 m/sec3;
Based on the above formula, the length of clothoid required for a radius of 250 metres will be 57.04 metres. The lengths of the clothoid curves will be shorter for curves with larger radii.

2. The second criteria relates to the difference in gradient of the edge of the road relative to the design line.

For a 2 lane carriageway the width of road pavement will be 9.5m, while for a 2 lane carriageway plus climbing lane the width of road pavement will be 11.5m.

The maximum difference in gradient that is permitted between the edge of the road pavement relative to the design line, in accordance with TEM is 0.5% (TEM 3.1.5.2)

The formula for calculating the length of clothoid required for the run out of super-elevation is:
$L \geq (\delta h / 0.005)$

Where: where δh = the difference in elevation of edges compared to axis (m)

The length of the clothoid curves that are generated in accordance with TEM are not practical for inclusion in a design that is attempting to fit the road alignment into the difficult terrain. Therefore, in order to reduce the calculated length of clothoid, a higher value of the permitted relative gradient has been adopted. In this respect the DIN standard permits a value of 0.9% in these circumstances (DIN Table 18), and it is considered that it should be permissible to use this as a relaxation of the TEM standard. The formula for calculating the length of clothoid required for the run out of super-elevation using the DIN standard becomes:

$L \geq (\delta h / 0.01)$

Considering a curve with radius 250m, following another curve of opposite hand, the value of δh will be 7% x 10,0m = 0.70 for a 2 lane road (W = 10,0m) and 0.77 for a 2 lane road with climbing lane (W = 11.0m). Hence, using the formula above, the lengths of clothoid that will be required for a curve with 250m radius and super-elevation of 7.0% will be 70m for a 2 lane carriageway and 77m for a two lane carriageway plus climbing lane.

4.2.5. Longitudinal Section

Right Branch

The geometrical elements of the longitudinal profile on the Right Branch in the designs in B., & C., above, were determined taking into account TEM standards and the Georgian National Standard, with the exception of a length of approximately 3.10 Km where the gradient is 6.8%. This gradient, which exceeds the maximum permitted gradient of 6.0%, approximates to the gradient on the existing road.

Following the development of an alternative alignment with a maximum vertical downhill grade of 6.0% for the Right Branch, the level of the new alignment would be approximately 21m higher than the level of the existing road at km 5+900. This new alignment would be raised above and offset to the right of the existing road alignment, as discussed for the design in Section D., above.

Given that the alignment runs downhill, the provision of an additional climbing lane is not required.

The tables below summarise the gradients that are derived for the design along the whole of the Right Branch in the different scenarios:

Table 4.2.5.1: Vertical Alignment Elements in Designs B & C (Right Branch)

Right Branch	Gradient (%)				
	0-1	**1-3**	**3-4**	**4-6**	**>6**

Length (km)	**0.25**	**2.35**	**1.10**	**0.75**	**4.10**
Percentage (%)	**2.20%**	**27.80%**	**12.90%**	**8.80%**	**48.30%**

Table 4.2.5.2: Vertical Alignment Elements in Designs D & E (Right Branch)

Right Branch	Gradient (%)				
	0-1	**1-3**	**3-4**	**4-6**	**=6**
Length (km)	**0.25**	**2.35**	**1.10**	**4.85**	**0**
Percentage (%)	**2.20%**	**27.80%**	**12.90%**	**57.10%**	**0%**

Left Branch
The geometrical elements of the longitudinal profile on Left Branch were determined taking into account TEM Standard and the Georgian National Standard.

The table below summarises the gradients that have been adopted along the whole of the Left Branch in the designs in scenarios B., & C., above:

Table 4.2.5.3: Vertical Alignment Elements in Designs B & C (Right Branch)

Left Branch	Gradient (%)				
	0-1	**1-3**	**3-4**	**4-6**	**>6**
Length (km)	**0.45**	**1.14**	**0.17**	**2.10**	**4.70**
Percentage (%)	**4.60%**	**13.40%**	**2.00%**	**24.7%**	**55.30%**

Table 4.2.5.4: Vertical Alignment Elements in Designs D & E (Right Branch)

Left Branch	Gradient (%)				
	0-1	**1-3**	**3-4**	**4-6**	**=6**
Length (km)	**0.25**	**2.35**	**1.10**	**0.75**	**4.10**
Percentage (%)	**2.20%**	**27.80%**	**12.90%**	**8.80%**	**48.30%**

In order to maintain the Level of Service for light vehicles (cars) on climbing sections so that it is equivalent to that on the flat, an additional (climbing) lane has been included in the design to segregate the slow moving heavy vehicles from the faster road traffic. This is a mandatory

requirement. Given that the alignment of the Left Branch runs uphill, and has a gradient in excess of 3.0% over a total length of approximately 7 km, a climbing lane is required to be included in the design of the carriageway of the Left Branch.

4.2.6 Typical Cross-sections

The Typical Cross-section parameters of roads are related to the forecast traffic flows and will vary depending on the predicted traffic volumes that are identified in the Traffic Study and the required Level of Service of the road under operation.

The Typical Cross-sections of the road incorporate all the elements between the road boundaries including carriageway, shoulders, and verges, cutting side slopes or embankment slopes, retaining walls, roadside drains and interceptor drains. These elements serve several purposes and can have a significant impact on construction costs and on road operation and safety.

The Typical Cross-section for highway branches, interchange slip roads and local road re-establishments that are included in the Georgian National Standard are listed below for each section of the road alignment:

Typical cross-section of Left Branch (one-way carriageway with two lanes, from start of the project to the western portal of Rikoti Tunnel)

Platform width: 14,4m;

- Lighting space : 0,8m.
- Guardrail space (outside the Edge Clearance on RHS): 0,8m.
- Edge clearance/shoulder: 1,0m;
- carriageway (2 traffic lanes): 2 x 3,75m = 7,5m;
- Emergency Lane: 2,5m;
- Verge: 0,5m;
- Guardrail space (outside edge of verge LHS): 0,8m.

Typical cross-section for one-way carriageway with two lanes (Right Branch from Km 3+000 to Km 6+750)
Platform width: 13.4m;

- Lighting space : 0,8m.
- Guardrail space (outside the Edge Clearance on RHS): 0,8m.
- Edge clearance/shoulder: 1,0m;
- Carriageway (2 traffic lanes): 2 x 3,75m = 7,5m;
- Emergency Lane: 2,5m;
- Verge: 0,5m;

Guardrail space (outside edge of verge RHS): 0,8m.

- Widening for stopping sight distance (where required): max 2,0m;

Typical cross-section for one-way carriageway with two lanes plus climbing lane (Left Branch from Km 3+000 to Km 7+100)
Platform width: 15,1m;

- Guardrail space (outside the Edge Clearance on RHS): 0,8m,
- Edge clearance/shoulder: 1,0m;
- Carriageway (2 traffic lanes): 2 x 3,75m = 7,5m;
- Climbing Lane: 3,5m;
- Edge clearance: 1,0m;
- Verge: 0,5m;
- Guardrail space (outside edge of verge LHS): 0,8m.
- Widening for stopping sight distance (where required): max 2,0m;

Typical cross-section for "2 lane dual carriageway" (from Km 7+500 to the end of the Project)

- Platform width: 26,6m ;
- Carriageway (2 x 2 traffic lanes): 4 x 3,75m = 15,0m;
- Reduced Central Reserve: minimum 4,0m (in case there is widening due to stopping sight distance, the central reserve is widened to a maximum of 6,0m);
- Emergency Lane: 2 x 2,5m = 5,0m;
- verge: 2 x 0,5m = 1,0m;
- guardrail space (outside edge of verge): 2 x 0,8m.
- Widening for stopping sight distance (where required): max 2,0m;

Typical cross-section for "2 lane dual carriageway with climbing lane included on Left Branch" (from Km 3+450 to Km 6+000 and from Km 9+300 to Km 7+100)

- Platform width: 28,6m ;
- Carriageway (2 x 2 traffic lanes): 4 x 3,75m = 15,0m;
- Climbing Lane on Left Branch: 1 x 3,5m = 3,5m;
- Reduced Central Reserve: minimum 4,0m (in case there is widening due to stopping sight distance, the central reserve is widened to a maximum of 5,0m);
- Emergency Lane on Right branch: 1 x 2,5m = 2,5m;
- Edge clearance on Left Branch: 1 x 1,0 m = 1,0m;
- verge: 2 x 0,5m = 1,0m;
- guardrail space (outside edge of verge): 2 x 0,8m.

Typical cross-section for slip roads at interchanges (according to TEM, not specified in the Georgian National Standard)

Two-way cross section:

- Platform width: minimum 10,6m;
- Carriageway (traffic lanes): 2 x 3,5 m = 7,0m;
- Edge clearance: 2 x 1,0 m = 2,0m;
- Guardrail space (outside from platform edge): 2 x 0,8m.

One-way cross section:

- Platform width: minimum 7,6m;
- Guardrail space (outside from platform edge): 0,80m,
- Edge clearance: 0,5m;

Carriageway (traffic lane): 4,0 m;

- Edge clearance: 1,50 m;

- Guardrail space (outside edge of verge): 0,80m.

Typical cross-section for local roads re-establishments (two-way)

- Platform width: 7,0m;
- Carriageway (traffic lanes): 2 x 3,0 m = 6,0m;
- Shoulders: 2 x 0,5 m = 1,0m.

Typical cross-section for local roads re-establishments (one-way)

- Platform width: 5,5m
- Carriageway (traffic lane): 4,5 m
- Shoulders: 2 x 0,5 m = 1,0m

4.3 Interchanges

The Feasibility Study ("Update of Feasibility Studies for E-60 Highway Section from Zemo Osiauri to Argveta, PEC 2014–2015") recommended locations for the provision of interchanges along the route of the e60 corridor between Zemo Osiauri and Argveta.

Within the limits of the Chumateleti to Khevi section of the road corridor, the Feasibility Study recommended that interchanges should be provided in the area of Chumateleti, before the entrance of the existing Rikoti Tunnel, and at Khevi.

This section of the report summarises the work that has been done to identify suitable layouts for interchanges at these two locations.

4.3.1 Interchange at Rikoti

The Feasibility Study reviewed alternative junction layouts in the area between Chumateleti and the Rikoti Tunnel, based on the different options for the road corridor, and concluded that for Alternative A1-A, the road corridor finally adopted in this section of the road corridor, a simple interchange would be formed in the proximity of Rikoti Tunnel with connections between the two branches of Rikoti Tunnel and the existing E60 only.

The layout for the interchange that was proposed in the Feasibility Study has been reviewed and it was noted that the proposed layout did not provide for a U-Turn facility, which is essential to maintain a reasonable level of access to properties that connect with the existing road between Rikoti Tunnel and Khevi once it becomes part of the Right Branch of the highway. It was also noted that the proposed layout did not provide for all turning movements at the interchange.

In view of our observations on the proposed layout of the interchange, AECOM-TEMELSU JV has undertaken a study to identify the form of interchange that would provide for all turning movements. The details of the study and the conclusions reached were included in a Technical Paper (Technical Paper No. 1) that was submitted to Roads Department on 11 May, 2017.

The main elements of the layout of the proposed interchange are described below:

- The alignment of the highway runs at a distance of approximately 750m north of the village of Chumateleti. It then enters Tunnel #3 and emerges from this tunnel approximately 780 metres before the eastern portal of the existing Rikoti Tunnel.

- After exiting from Tunnel #3, the Right Branch crosses the alignment of the existing E60 road and then curves to the north where it merges with the existing E60 just before the entrance of the existing Rikoti Tunnel. The Right Branch is elevated above ground level after exiting from Tunnel #3 and this section of the road alignment includes a viaduct structure for a length of approximately 420 metres to carry the new Right Branch across the E60 road.
- The proposed new Left Branch emerges from Tunnel #3 adjacent to the Right Branch and crosses the alignment of the existing E60 road and the Chumateleti river and then heads north west to the southern portal of the proposed second tube of Rikoti Tunnel.

- The length of road alignment between the two tunnel portals is only 780 metres, which has a significant impact on the options for developing the layout of the proposed interchange. As a result, the lengths of the acceleration / deceleration lanes of the slip roads are the critical factors in the design. The lengths of the acceleration / deceleration lanes are presented in the table below.

Table 4.3.1.1.: Rikoti Interchange - Merge Diverge Sections

Slip Road	**Length of Parallel Merge/ Diverge**	Taper	**Departure from Standard required**
Slip Road No. 1 Diverge, Right Branch	150m	60m	
Slip Road No. 2 Merge, Right Branch	180m	60m	yes
Slip Road No. 3 Merge, Left Branch	145m	60m	yes
Slip Road No. 4 Diverge, Left Branch	150m	60m	

- With the exception of the lengths of the parallel merge sections, the design of the slip roads is in each case compliant with the requirements of TEM standards for 40km/h design speed.

- Minimum Radius 50 m
- Maximum Gradient 8.0 %
- Minimum Vertical radius 800 m

4.3.2 Interchange at Khevi

The Feasibility Study recommended that an interchange should be included in the project at Khevi. A preliminary review of the layout of the buildings adjacent to the existing road and the terrain indicated that the opportunity to develop alternative locations and layouts for an interchange at Khevi would be limited due to the proximity of buildings fronting onto the existing road as well as the proximity of the Rikotula River which flows close to the left side of the road alignment through Khevi. Our studies have concluded that the only suitable location for the interchange is at km 11+000 (approx.).

The main issue relating to the design of an interchange at Khevi is that the available width of the corridor between the houses and shops that front onto the right side of the existing road and the school and the police station on the left side of the road is only just sufficient to develop a 2 lane

dual carriageway road alignment without an interchange, but is not sufficient to also include parallel slip roads.

Taking into account the limited available width, AECOM-TEMELSU JV prepared two alternative layouts for the road passing through Khevi together with the interchange. Both of the interchange layouts were based on a typical "Diamond" interchange layout, with slip roads connecting to a roundabout that is located below the main line alignment. All geometrical elements of the slip road alignments are in accordance with TEM standards, based on a minimum design speed of 40km/h.

In both options, a roundabout was provided to connect with the slip roads to form the interchange. This roundabout has been established approximately 4 – 5 metres below the level of the existing road and the main road is raised to pass over the roundabout.

A local service road has been included in the design of the intersection, adjacent to the Right Branch of the main road, to maintain access to properties on the north side of the road. This service road passes over the highway at Km 11+700 and after that it will cross the Rikotula river and connect with the local road network on the south side of the river. In addition, new bridges for local roads will also be provided across the Rikotula river at km 11+130 as part of the Khevi Interchange layout as well as at Km 10+340.

Other arrangements for local traffic include a right in / right out access on the Right Branch at Km 6+850 to provide access to the community on the hillside to the North and Northeast of Khevi.

Certain lengths of river training works are required between Km 10+650 and Km 11+350 to facilitate the alternative interchange layouts.

Option 1

Option 1 assumes that the properties fronting onto the right side of the existing road will be demolished to make more space for the new road layout and the interchange. The proposed layout, which includes a service road with footpath running parallel to the road alignment to provide continuity of access for the remaining properties on the right side of the road.
Design Report.

In this layout the school building and the police station will not be directly affected by the new road layout, and the left side of the main road will be approximately 26 metres from the nearest wall of the school building. Although the main road will be carried on a raised embankment in front of the school building, any noise intrusion can be mitigated by including noise absorption panels along the edge of the Left Branch.

Option 2

Option 2 assumes that the school and the police station on the left side of the existing road will be demolished to make more space for the new road layout and the interchange. A service road with footpath would be included in the design running adjacent to the Right Branch of the road alignment to provide continuity of access for the properties that front onto the right side of the existing road.

It should be noted that, with the layout in Option 2, the shops that are adjacent to the existing road would lose trade from passing traffic because they would be isolated from the main road. In addition, the road levels of the main road alignment will have to be raised to carry the main road over the

interchange, which will result in a 4m – 5m high embankment in front of these properties, and there is a perception that they will effectively be isolated from the main community in Khevi.

In view of the negative residual impacts that are inherent in Option 2, the consultant recommended that Option 1 be taken forwards for development of the detailed design.

4.4.Road Pavement Design

4.4.1 Standards to be adopted in the Design

As requested in the Terms of References, for Chumateleti – Khevi project, the design pavement takes into consideration two alternative pavement types:

- Asphalt pavement
- Concrete pavement

For tunnels, a concrete pavement will adopted for fire safety reasons.

The pavement design has been carried using internationally practiced standards for the design of road pavement structures in similar environment, meaning:

PD 177-2001 - Normative for rigid and flexible pavement design (analytical method)

NP081-2002 - Norm regarding the Design of Rigid Pavements

These norms are widely used across Romania, which is a country located in a similar environment comparing as Georgia and they were developed for use in Romania in early 2000 considering European design norms.

4.4.2 The Design Life

The design life for flexible pavements (asphalt pavement) is 20 years. For rigid pavement (concrete pavement) alternative design lives of 20 years and 40 years have been assessed. The results from the analysis of alternative pavement designs were then compared and the most appropriate pavement design has been selected for the project, taking into account whole life costs and a design that best suits the climatic condition etc. of this particular project road in Georgia, including the obvious requirement that sections of road pavement will be constructed in relatively short lengths.

Demand Calculation for Pavement Design

In order to determine the pavement design, the following traffic forecast, extracted from "*Update of Feasibility Studies for E-60 Highway Section from Zemo Osiauri to Argveta and undertaking Detailed Design for E-60 Highway Section from Zemo Osiauri to Chumateleti*" – Appendix 1 - Traffic forecast by section and Year and Scenario, has been used. Figures are given for each individual section of the E60 corridor and for each forecast year.

To estimate the total axle loading over the forecast period, demand volumes were expressed as number of standard 11.5 tonnes axles. The equivalent factors that are applied, based on the function of the type of pavement (e.g. flexible pavement and rigid pavement) are given in Table 4.4.2.1 below.

Table 4.4.2.1 – Traffic Forecast, 2019-2059

Type of pavement	2 axles	3-4 axles	Articulated	Bus
Flexible pavement	0.1	0.7	0.9	0.6
Rigid pavement	0.2	2.6	1.5	2.0

Notes:

1. *Three forecast growth scenarios were elaborated (low, best and high). For the current analysis, figures included in the 'best' scenario were used.*
2. *The Feasibility Study includes traffic figures corresponding to the 2019-2049 (30 years). The figures for 2049-2059 have been extrapolated based on growth rates corresponding to the previous interval*

The total number of 11.5 tonnes axles over the forecast period 2019-2059 are given in **Table 4.4.2.2** below, for each pavement type.

Table 4.4.2.2 – Traffic forecast, 2019-2059 – Number of Standard 11.5 t axles

Number of equivalent 11.5 tonnes axles - Flexible pavements					
	2019	**2029**	**2039**	**2049**	**2059**
Section 2B	*1,808*	*2,771*	*3,778*	*4,837*	*6,188*
Number of equivalent 11.5 tonnes axles - Rigid pavements					
	2019	**2029**	**2039**	**2049**	**2059**
Section 2B	*4,238*	*6,495*	*8,856*	*11,338*	*14,504*

Source: Consultant's analysis

The traffic figures intended for the pavement design represent the total number of axle crossings over the forecast period and are determined using the following formula:

$T_d = Nc = 365 \times 10^{-6} \times Years \times C_s \times 0.5 \times (D_b + D_f)$ where:

- 365 number of days in a year;
- Years number of forecast years (20 years are considered for flexible pavements and 20 years for the rigid pavements)
- C_s cross section factor corresponding to the heaviest loaded lane (for a 2x2 motorway, Cs equals to 0.45)
- D_b demand figures corresponding to the first year of forecast
- D_f demand figures corresponding to the last year of forecast

Note. The total number of axle crossing is determined across the whole forecast interval as sum of each individual yearly figures.

Table 4.4.2.3 – Traffic Forecast intended for use in the Pavement Designs

Road Section	20 years, 2019-2039, flexible pavements	20 years, 2019-2039, rigid pavements	40 years, 2019-2059, rigid pavements
Section 2B	8.93	20.94	58.10

Source: Consultant's analysis

For a flexible pavement, the demand over a forecast period of 20 years (2019-2039) varies from 7.42 to 11.58 million standard 11.5t axles, whereas for the rigid pavement traffic varies from 17.26 to 27.15 million standard 11.5t axles. Demand over a forecast period of 40 years (2019-2039) varies from 41.78 to 75.33 million standard 11.5t axles for the rigid.

4.4.3 Flexible Road Pavement

The design has been undertaken in conformity with the Romania Norms for flexible and semi-rigid pavement design, PD 177 – 2001 (the analytical method).

The analytical design method is based on establishing a pavement structure and on checking its strain, under the action of calculated traffic, so as to simultaneously fulfil the following criteria:

- Admissible specific strain at the basis of bitumen layer;
- Admissible strain tension at the basis of natural aggregate layer, stabilized with hydraulic or pozzolanic binders, in case of semi-rigid pavement structure;
- Admissible specific compression strain at subgrade (road bed) level.

The pavement design entails the following stages:

1. establishing the calculated traffic;
2. establishing the bearing capacity at subgrade level;
3. selecting a structure of the road pavement;
4. analysing the pavement under the strain of standard axle load (using ALIZE or CALDEROM calculation software);
5. establishing the road pavement behaviour under traffic conditions
6. verification the road pavement under the action of the frost-defrost phenomenon

4.4.4 Rigid Road Pavement

The design verification for the rigid pavement alternative has been undertaken using the Norm regarding the Design of Rigid Pavements – NP 081 - 2002.

The calculation process within the design method uses finite element model executed through the multi-layer procedure, composed of: cement concrete slab and the layer equivalent to the real layers sub-adjacent to the slab (foundation layer, capping layer and foundation ground) conditioned by the following hypotheses:

- The traffic load features (standard axel of 115 kN) are as follows:
  - Load on dual tires: 57,5 kN;
  - Tire print pressure: 0,625.MPa;
  - Impact coefficient: 1,2;
  - Designed tire print pressure: 0,625 MPa × 1,2 = 0,750 MPa.
- The design traffic load is the load on the dual tires of the standard axel of 115 kN increased by the impact coefficient and conveyed through a rectangular print tangent to the edge of the slab, equivalent to the real elliptical print, with the following dimensions: L x I = 37 x 25 (cm);
- The load from daily temperature variations is resulted from the constant daily temperature gradient, equal to 0,67 of the thickness of the slab;
- The slab rests uniformly on the foundation layer;
- The movements at the contact between the slab and the layer equivalent to the real

layers sub-adjacent to it are defined by the reaction modulus at the surface of the foundation layer.

The design operations will follow the sequence presented below:

1. Establishing the calculated traffic
2. Establishing the bearing capacity of the foundation ground
3. Establishing the composure of the layers sub-adjacent to the concrete slab
4. Establishing the bearing capacity at the level of the foundation layer
5. Adopting the class of road cement concrete (symbolized as BcR)
6. Establishing the concrete's ultimate bending tensile stress
7. Adopting the dimensioning hypothesis
8. Establishing the thickness of the cement concrete slab
9. Verification of the road pavement at freeze-thaw (frost-defrost phenomenon).

Comparison of Pavement Construction Costs

Taking into consideration the available information, at the date of the preparation of this report, in order to be able to compare the estimated execution costs for each road pavement alternative, the costs per square meter of pavement are summarised in Table 4.4.4.1 below.

Table 4.4.4.1 – Preliminary Costs of Alternative Pavement Designs

Type of Pavement Construction	Thicknes s [cm]	Price / sq.m
Preliminary Flexible Pavement Structure (from Feasibility Study):	**65 cm**	**11.88**
Preliminary Flexible Pavement Structure (Alternative 1):	**52 cm**	**9.13**
Preliminary Semi-rigid Pavement Structure (Alternative 2):	**62 cm**	**13.59**
Preliminary Rigid Pavement Structure (from Feasibility Study):	**75 cm**	**28.35**
Preliminary Rigid Pavement Structure (Alternative 1):	**71 cm**	**28.64**
Preliminary Rigid Pavement Structure (Alternative 2) - 40 years life time:	**72 cm**	**29.26**

As it may be observed, the "Preliminary Flexible Pavement Structure (Alternative 1)" is the most favourable road pavement solution in terms of execution costs – 9.13 Euro/sq.m.

4.4.5 Selection of the Pavement Construction

When taking into consideration the constraints on the construction programme, it is evident that the road pavement is likely to be constructed in short sections, as and when each part of the road alignment, including the culverts, retaining wall structures, earthworks and road foundation have been completed.

At this stage, the processes required for constructing the road pavement need to be addressed. Given that working in short sections does not lend itself to concrete pavement construction, and a flexible form of construction is more adaptable to this type of working, the proposed pavement design for the project is:

Sections of road within tunnels:	Rigid Pavement
All other sections of road construction:	Flexible Pavement

Polymer Modified Bitumen in Surface Course.

Subsequent to preparing the pavement design analysis, it was agreed during a design review meeting to incorporate polymer modified bitumen in the surface course in view of the enhanced resistance such materials provide against cracking, particularly during the cold winter months.

In view of this, the surface course of the main artery and the slip roads and roundabouts at intersections will adopt a polymer modified bitumen in the asphalt mix. To optimise costs, the thickness of the polymer modified bitumen surface course will be reduced by 2cm and the underlying layers increased in thickness so that the overall thickness of pavement construction remains unchanged.

4.5 Geotechnical Design

This chapter summarises the geotechnical design for earthworks and retaining structures based on the visual inspections performed during the site visits and the subsequent development of the geotechnical designs.

4.5.1 Introduction

The proposed alignment goes through an orogenic zone identified with steep topographic features and formed by crystalline rock lithologies of extensive metamorphism and weathering (that has resulted in an over layer of residual and colluvium soils of variable thickness), which is often identified with steep slopes and instability risks. The observed geomorphological features and the cuttings along the existing E60 route display the familiar features of these processes and have been investigated by intrusive means in order to form a representative ground model for the design of the proposed alignment including retaining and reinforcing measures for the concerned sections of the existing E60 route. The added effects of regional seismicity result in this region being presented as a high risk area in the landslide hazard assessments of previously published reports and studies, such as "Landslide Hazard in Georgia", [Gaprindashvili G., Tsetereli E., Gaprindashvili M., European Geosciences Union General Assembly 2014, Vienna, Austria]. However, it should also be noted that sudden and heavy rains on saturated ground play a much more important role in creating instability in the steep sided terrain.

The engineering geological and geotechnical evaluations carried out for this section of E60 corridor have identified various aspects of the earthworks, which have been addressed over the development of the geotechnical earthworks design, which includes retaining structures and reinforcing measures.

As far as the bridges, tunnels and other over ground structures are concerned, location specific evaluations have been addressed at each structure as part of the relevant designs.

4.5.2 Geotechnical Design Philosophy

The ground model (i.e. geotechnical parameters and engineering geology) are developed and formed based on engineering geological field studies and ground investigations (GI; both intrusive and non-intrusive) along with evaluation of the foreseeable geological anomalies.

The design analyses of the earthworks (cuttings and fill embankments) have been carried out in accordance the specifications and standards listed among the contract documents, which are mainly Georgian and Eurocode design requirements with the relevant references including BS and other international recognised design norms.

4.5.3 Determinations of Geotechnical Design Parameters

The geotechnical design parameters are determined by use of the physical properties of soil lithologies and rock mass reported by the Factual GI Reports (GIR). The following process is followed:

A) Index (i.e. density, grading and other physical properties), strength and deformation parameters of soil lithologies were determined from the GIR information,

B) Index (i.e. density, fabric, lithology and macro petrography) and material strength parameters were determined from the GIR descriptions and uniaxial strength tests,

C) The rock mass strength and deformation parameters were determined by using the RMR and Jcond (joint condition 89) approach presented by Bieniawski (1989), which was further developed and by GIS approach by Romana (1993).

D) The rock mass parameter determinations referred above takes into consideration the following:

a) Rock Mass Rating and Geological Strength Index (GSI) were determined and used in a formula of RMR=GSI +5,

b) The GSI was further refined with the boreholes reported RQD values by using Bienawski's GSI and RQD correlation,

Correlation A:

GSI=0.5 RQD + 1.5 Jcond (see Figure 4.5.3.1 below)

Figure 4.5.3.1 – Assessment of GSI Values

Condition of discontinuities	Very rough surfaces Not continuous No separation Unweathered wall rock	Slightly rough surfaces Separation < 1 mm Slightly weathered walls	Slightly rough surfaces Separation < 1 mm Highly weathered walls	Slickensided surfaces or Gouge < 5 mm thick or Separation 1 – 5 mm Continuous	Soft gouge > 5 mm thick or Separation > 5 mm Continuous
Rating	30	25	20	10	0

Guidelines for classification of discontinuity conditions

Discontinuity length (persistence) Rating	< 1 m 6	1 to 3 m 4	3 to10 m 2	10 to 20 m 1	More than 20 m 0
Separation (aperture) Rating	None 6	< 0.1 mm 5	0.1 – 1.0 mm 4	1 – 5 mm 1	More than 5 mm 0
Roughness Rating	Very rough 6	Rough 5	Slightly rough 3	Smooth 1	Slickensided 0
Infilling (gouge) Rating	None 6	Hard infilling < 5 mm 4	Hard filling > 5 mm 2	Soft infilling < 5 mm 2	Soft infilling > 5 mm 0
Weathering Rating	Unweathered 6	Slightly weathered 5	Moderate weathering 3	Highly weathered 1	Decomposed 0

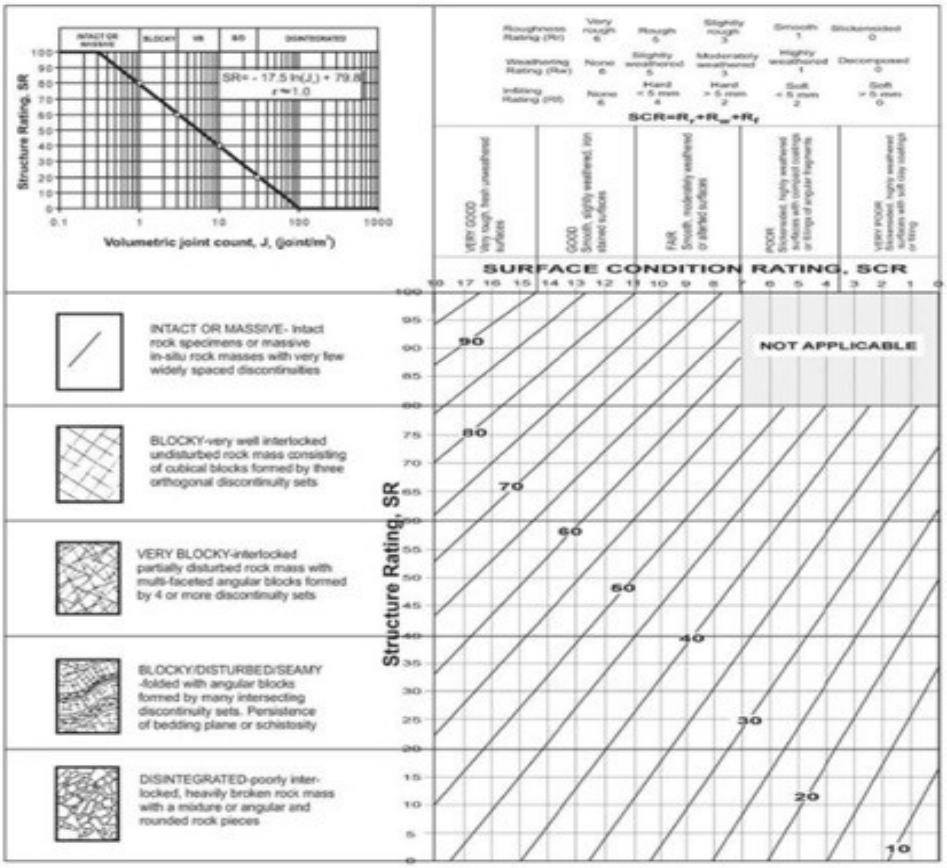
c) The above equations were then combined to develop GSI functions by using Romana's correlations with Structure Rating (SR) and Surface Conditions Rating (SCR) (graphs below),

Correlation B:

GSI= f(SR, SCR) from the Chart below (Ref. 5 & 6) Where SR= Structure Rating =-17.5Ln(J_v)+79.8
With J_v (Joint/m)= (111-RQD)/3.3

And SCR = R_f+R_w+R_f (Refer to the chart in Figure 4.5.3.2 below).

Figure 4.5.3.2 – Assessment of GSI Values



4.5.4 Earthworks Design Analyses:

E) **Cutting Slope Design Analyses:**

The design of cutting slopes has been developed through the following stages:

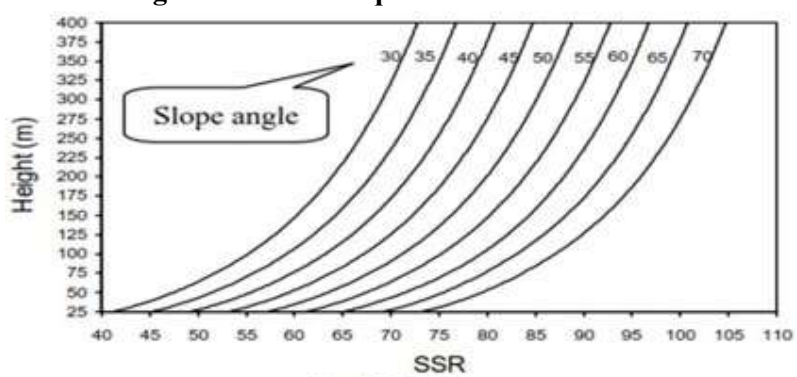
a) Slope Stability Rating (SSR): This stage allowed assessments of the cut slope geometry that could be reinforced where necessary to obtain a stable cutting overall with determined and expected geotechnical parameters variations within the rock mass. This approach facilitates a preliminary starting point for the cut slope design to be detailed. The table in Figure 4 below summaries the contributing characteristics of the rock mass to the SSR rating calculation.

Figure 4.5.4.1 – Rock Mass Rating for SSR calculation

	Parameter		Range of values					
1	Modified GSI		(Refer to Fig 1)					
	Rating		0 - 100					
2	Uniaxial compressive strength (MPa)		0 -10	10 -25	25 - 50	50 - 100	100 - 150	150 - 200
	Rating		0	7	18	28	37	43
3	Rock type (Refer to Table 2)		Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
	Rating		0	4	9	17	20	25
4	Slope excavation method		Waste damp	Poor blasting	Normal blasting	Smooth blasting	Presplitting	Natural slope
	Rating		-11	-4	0	6	10	24
5	Ground-water	Groundwater level from Bottom of the slope / Slope height *100	Dry	0 – 20 %	20 – 40 %	40 – 60 %	60 - 80 %	80 – 100 %
	Rating		0	-1	-3	-6	-14	-18
6	Earthquake force	Horizontal acceleration	0	0.15 g	0.20 g	0.25 g	0.30 g	0.35 g
	Rating		0	-11	-15	-19	-22	-26

The graphics below summarizes the required SSR values corresponding to a FOS of 1.3.

Figure 4.5.4.2 – Required SSR values for FOS 1.3



(3) (F.S=1.3)

This approach facilitated a starting point for a suitable overall cut slope inclination applicable to the rock mass characteristic identified from the GIR and as a result 2V:1H slope geometry was selected to be developed with regular berms reinforcing measures in order to optimize the cut slope heights and widths.

b) Kinematic Analyses: The potential planar, wedge and toppling failures of the jointed rock mass exposed in the cutting slopes were evaluated by kinematic analyses for cutting slopes and required localized rock bolts were designed to prevent these failures within the rock mass. The RMR rating were used together with adjustment factors along in the kinematic analyses carried out by stereonets. The Tables below summarize the RMR and F1, F2, F3 and F4 factors.

Table 4.5.4.1 – Assessment of RMR

A. CLASSIFICATION PARAMETERS AND THEIR RATINGS									
Parameter			Range of values						
1	Strength of intact rock material	Point-load strength index	>10 MPa	4 - 10 MPa	2 - 4 MPa	1 - 2 MPa	For this low range - uniaxial compressive test is preferred		
		Uniaxial comp. strength	>250 MPa	100 - 250 MPa	50 - 100 MPa	25 - 50 MPa	5 - 25 MPa	1 - 5 MPa	< 1 MPa
	Rating		15	12	7	4	2	1	0
2	Drill core Quality RQD		90% - 100%	75% - 90%	50% - 75%	25% - 50%	< 25%		
	Rating		20	17	13	8	3		
3	Spacing of		> 2 m	0.6 - 2 . m	200 - 600 mm	60 - 200 mm	< 60 mm		
	Rating		20	15	10	8	5		
4	Condition of discontinuities (See E)		Very rough surfaces Not continuous No separation Unweathered wall rock	Slightly rough surfaces Separation < 1 mm Slightly weathered walls	Slightly rough surfaces Separation < 1 mm Highly weathered walls	Slickensided surfaces or Gouge < 5 mm thick or Separation 1-5 mm Continuous	Soft gouge >5 mm thick or Separation > 5 mm Continuous		
	Rating		30	25	20	10	0		
5	Groundwater	Inflow per 10 m tunnel length (l/m)	None	< 10	10 - 25	25 - 125	> 125		
		(Joint water press)/ (Major principal σ)	0	< 0.1	0.1, - 0.2	0.2 - 0.5	> 0.5		
		General conditions	Completely dry	Damp	Wet	Dripping	Flowing		
	Rating		15	10	7	4	0		

B. RATING ADJUSTMENT FOR DISCONTINUITY ORIENTATIONS (See F)						
Strike and dip orientations		Very favourable	Favourable	Fair	Unfavourable	Very Unfavourable
Ratings	Tunnels & mines	0	-2	-5	-10	-12
	Foundations	0	-2	-7	-15	-25
	Slopes	0	-5	-25	-50	

F. EFFECT OF DISCONTINUITY STRIKE AND DIP ORIENTATION IN TUNNELLING**			
Strike perpendicular to tunnel axis		Strike parallel to tunnel axis	
Drive with dip - Dip 45 - 90°	Drive with dip - Dip 20 - 45°	Dip 45 - 90°	Dip 20 - 45°
Very favourable	Favourable	Very unfavourable	Fair
Drive against dip - Dip 45-90°	Drive against dip - Dip 20-45°	Dip 0-20 - Irrespective of strike*	
Fair	Unfavourable	Fair	

Case	*Very favorable*	*Favorable*	*Fair*	*Unfavorable*	*Very unfavorable*
P $\lvert\alpha_j - \alpha_s\rvert$	> 30°	30–20°	20–10°	10–5°	< 5°
T $\lvert(\alpha_j - \alpha_s) - 180°\rvert$					
P/T F_1	0.15	0.40	0.70	0.85	1.00
P $\lvert\beta_j\rvert$	< 20°	20–30°	30–35°	35–45°	> 45°
P F_2	0.15	0.40	0.70	0.85	1.00
T F_2	1	1	1	1	1
P $\beta_j - \beta_s$	> 10°	10–0°	0°	0° to − 10°	< − 10°
T $\beta_j + \beta_s$	< 110°	110–120°	> 120°	—	—
P/T F_3	0	− 6	− 25	− 50	− 60

P, plane failure; T, toppling failure; α_j, joint dip direction; α_s, slope dip direction; β_j, joint dip; β_s, slope dip.

Method	*Natural slope*	*Presplitting*	*Smooth blasting*	*Blasting or mechanical*	*Deficient blasting*
F_4	+ 15	+ 10	+ 8	0	− 8

c) Slope Stability Analyses (using RMR and GIS): The optimized cut slope inclinations (i.e. 2V:1H with regular berms at certain height intervals) were analyzed with limit equilibrium slope stability (Slope-W) programs in a location specific manner based on the relevant intrusive and non-intrusive GI information and field studies in order to determine types and extents of support and reinforcing measures necessary to achieve the cut slope designs with the specification requirements listed in the contract documents. These analyses facilitate the determination of support and reinforcing measures relevant to the material classes identified and refined along the project route (Table 4.5.4.1 below summarize these findings).

Table 4.5.4.1 – Support and Reinforcing Measures for Various Material Classes

CLASS	SMR	SUPPORT & REINFORCING MEASURES (See Notes 1 to 3)
I	81-100	☐ SCALING AS REQUIRED; ☐ PASSIVE MEASURES, REMOVAL OF LOOSE BLOCKS, OVERHANGS AND EXCAVATION REMNANTS FROM THE CUT FACE; ☐ SURFACE WATER DRAINAGE AS NECESSARY (isolated weep holes at points of water discharge from the rock mass).
II	61-80	☐ LOCALISED BOLTING & MESHING AS REQUIRED - Required rock bolt length = 4m; Grid pattern on the cut slope 2.5m (h) & 1.5m (v); ☐ DENTITION MEASURES WHERE NECESSARY (as per details DWG CK-D3-GD-EW-SS-006); ☐ SURFACE WATER DRAINAGE AS NECESSARY (isolated weep holes at points of water discharge from the rock mass); ☐ ANCHORS TO BE INSTALLED TO PREVENT LOCAL WEDGE AND PLANAR FAILURES WHERE DAYLIGHTING DISCONTINUITIES FORM THESE TYPES OF LOCAL INSTABILITIES. [1]
III & IV [2]	21-60	☐ SYSTEMATIC BOLTING - Required rock bolt length = 8m; Grid pattern on cut slope 1.5m (h) & 1.5m (v); • SYSTEMATIC SHOTCRETE - Single mesh reinforced, ≥150mm thick; ☐ WEEP HOLES: – ALONG CONTACT BETWEEN ROCKHEAD & COLLUVIUM/RESIDUAL SOILS; – BETWEEN ROCK BOLTS 3m (h) & 3m (v) spacing, 6m length. ☐ DENTITION MEASURES WHERE NECESSARY AND ALONG THE BERMS (as per details DWG CK-D3-GD-EW-SS-006); ☐ ANCHORS TO BE INSTALLED TO PREVENT LOCAL WEDGE AND PLANAR FAILURES WHERE DAYLIGHTING DISCONTINUITIES FORM THESE TYPES OF LOCAL INSTABILITIES. [1]
V	COLLUVIUM (φ = 30°, Cu = 0kPa) RESIDUAL SOIL (φ = 35°, Cu = 75kPa) *These parameters include initial interlock*	• SYSTEMATIC BOLTING - Maximum total length = 16m, minimum length into rock = 3m (which ever requirement is met first); Grid pattern on the cut slope = 1m (h) & 1.5m (v); • SYSTEMATIC SHOTCRETE - Double mesh reinforced, ≥200mm thick (Residual soil)/ ≥250mm thick (Colluvium); • WEEP HOLES: – ALONG CONTACT BETWEEN ROCKHEAD & COLLUVIUM/RESIDUAL SOILS; – BETWEEN ROCK BOLTS 3m (h) & 3m (v) spacing, 6m length. • ANCHORS TO BE INSTALLED TO PREVENT LOCAL WEDGE AND PLANAR FAILURES WHERE DAYLIGHTING DISCONTINUITIES FORM THESE TYPES OF LOCAL INSTABILITIES. [1]

[1]: Rock anchors will be required if mapping during construction shows potential planar or wedge failure.

[2]: III and IV rock classes jointly occur within the same folding, faulting patterns and in practice it is not possible and practical to vary the reinforcing measures within a few metres. Reinforcing measures have been defined to stabilize both classes.

F.Embankment Design Analyses:

d) Embankment Stability Analyses: Embankments stability analyses were carried out by using Slope-W program and where necessary replacement and reinforcing measures are being recommended. The specified horizontal seismic acceleration coefficient was considered in stability analyses along with the relevant partial and overall factors specified in the relevant Eurocode Annexes.

e) Embankment Settlement Analyses: Embankments stability analyses were carried out where necessary replacement measures are being recommended. If identified during the construction potential areas of long term settlements are to be monitored in line with the relevant relevant specification requirements. Settlement calculations were conducted in accordance with relevant the relevant Eurocode Annexes.

4.5.5 Ground Engineering Concerns

The proposed alignment is located mostly over the side long ground that forms the Rikotula river valley, where existing slopes have either reached a state of natural equilibrium or are in the process of reaching a state of natural equilibrium. These cases represent the existing slopes of the side long ground as being either stable or unstable, respectively. The following cases have been identified as ground engineering concerns in relation to the earthworks components such as cuttings (with and without stability and reinforcing measures) and fill embankments (with and without retaining structures).

A: Stability of earthworks over stable side long grounds,
B: Stability of earthworks over unstable side long grounds,
C: The effects of regional seismicity.

Geotechnical Solutions based on a review of the cutting side slopes of the existing road

In the few areas where debris flows are observed from the degradation of the surface slopes exposed to the weather conditions along the existing alignment, retaining walls (mass concrete gravity walls and reinforced concrete cantilever walls) have been adopted in the design to isolate the debris from the carriageway and road drainage.

To prevent rock falls as shown in the photograph below, protection measures such as anchored mesh have been included in the design to support the material on the cut slope. The design will need to be verified during the construction stage based on the nature of the exposed rock characteristics.

4.5.5.1 Photograph showing rockfall at the base of the cutting

Several of the existing cuttings will be re-profiled in order to develop the alignment of the Right Branch whilst elsewhere new cut slopes will be formed. Shallow cutting side slopes will be formed with a profile between 2V:1H & 1.3V:1H, which closely approximates to the existing cut slopes.

For deeper cutting side slopes formed in good quality rock material, a slope of 3V:1H with berm at each 10m height has been considered.

In other weaker material, side slopes of 2V:1H have been adopted. Although a slacker slope would have been preferred in several locations, the restricted width of the available road platform between the hillside and the Rikotula River has precluded the option of moving the road alignment to the left, while the steepness of the rising ground above the Right Branch means that the heights of the cut slopes based on slopes of 1.5V: 1H would exceed 60 metres. The adoption of cutting side slopes with a profile of 2V:1H is therefore a compromise solution, and significant cut slope stabilisation measures will be required in these cut slopes. Depending on the site conditions encountered at each cut section and to ensure the stability of cutting side slopes, a mix of different slope profiles combined with protection measure has been adopted.

4.5.6 Stability of Earthworks over Stable Side Long Ground

In this case, as explained above, the natural slopes have reached their state of natural equilibrium and the existing sloping ground satisfies the Ultimate Limit State (ULS) design requirements that no slide and bearing capacity failures are expected. Therefore, the changes in the state of stresses induced by the earthworks need to be considered in the design along with Serviceability Limit State (SLS) analysis considering settlement and displacement processes. This ground engineering concern is addressed by adopting the following approach.

a) Engineering geological mapping has been prepared to identify any foreseeable instability features. The absence of such features allowed the concerned section of side long ground to be regarded as stable,

b) Location specific ground information in the form geological cross sections and profiles with the geotechnical properties (both strength and deformation characteristics from the ground investigations) of the soils and rock formations are used the analyses,

c) The ULS and SLS analyses for cuttings and fill embankments is carried out to establish if the proposed earthworks would alter the state of natural equilibrium beyond the limits of the proposed earthworks (i.e. above & beyond the cuttings and below & beyond the fill embankments),

d) Active measures for cuttings (anchoring, nailing and netting with hard and soft facing) and for fill embankments (reinforcing measures, gravity, cantilever, reinforced earth and embedded walls) have been included in the design together with support measures that include measures for dealing with cutting slopes containing mixed soil and rock,

e) Passive measures for cuttings (drainage, scour protection and catchment ditches and walls) and fill embankments (erosion protection, ground water control and replacement of existing ground) have also been included in the design,

f) A geotechnical risk register, referring to foreseen and foreseeable geo-hazards, has been prepared. This Risk Register is based on the findings of the engineering geological mapping and the ground investigation (intrusive and non-intrusive) program along with the ULS and SLS analyses of the earthworks elements,

   This risk register also identifies the potential for unforeseeable and unforeseen geo-hazards being present outside the proposed alignment corridor as residual risks.

4.5.6.1 Example of passive earthworks stabilisation measures in stable side long ground

4.5.6.2 Examples of active stability and reinforcing measures in stable side long ground

4.5.6.3 Examples of Stabilisation Measures in side long ground of mixed rock and soil formations

Typically, the nature of the ground requires a road cross-section that has high cut slopes on the right side of the alignment and retaining walls to support the road platform on the opposite side of the carriageway. In general, it is noted that the Right Branch alignment is formed predominantly in cuttings reaching heights greater than 25-30 metres and, depending on the ground conditions, as the side slope of the terrain increases to an inclination >50°, the cuttings side slopes in places exceeds 40m.

In order to avoid the weathering and superficial erosion of the shallow cut slopes, protection measures will be taken, mainly through installation of anti-erosion systems (anchored mesh) as described above.

The new shallow cut slopes will be formed with a profile between 1.3V:1H & 2V:1H, which is close to the natural slope. For cutting side slopes formed in good quality rock material, slopes of 2V:1H with berms at each 10m height have been considered. Depending by site conditions and to assure the stability of cuttings, a mix of both slope profiles combining with protection measure have been adopted.

Mass concrete gravity walls have been designed up to a height of 5.0m at the edge of road platform, while reinforced concrete or reinforced earth walls are more suitable for support heights typically up to 10m. Where the height exceeds 9m – 10m, reinforced earth and reinforced earth walls can be used. For the Chumateleti-Khevi section, two types of reinforced earth walls will be adopted to support the road as follows:

- Reinforced precast concrete facing panels with geosynthetic strip reinforcements
- Gabions facing with coated steel wire double twist mesh reinforcements.

4.5.7 Stability of Earthworks over Unstable Side Long Ground

In comparison to the case explained above, it is apparent that some stretches of the side long ground might not have reached their state of natural equilibrium and the existing sloping ground may not satisfy the ULS design requirements. Features of instability could be evident in terms of slides, creep failures and continuous settlement of the ground where earthworks elements would have to be designed and constructed with ground reinforcement and stabilisation measures. Therefore, the imbalance in state of pre- existing stresses and ULS and SLS designs have had to take this into consideration along with stresses induced by the earthworks elements. The following approach has been adopted to deal with this ground engineering concern:

a) The engineering geological mapping has been used to identify anomalies that could indicate unstable ground and inform the ground investigation programme,
b) The ground model that includes data from the field works and the geotechnical investigation findings has been back analysed without the proposed earthworks elements. This analysis included seismic load effects in order to establish any deficiency in the current safety factor,
c) The calculated strength and deformation parameters from the back analysis are compared with the ground investigation findings in order to model the ground to establish the required preconstruction stability measures for the permanent earthworks elements within and the proposed road corridor,
d) The required stability and treatment measures for the construction of the earthworks elements (cuttings, fill embankments, retaining and reinforcing systems, scour and erosion protection) are then determined and re-analysed with the proposed permanent works elements,
e) The required reinforcing and treatment measures within the proposed alignment corridor have been identified and included in the permanent works designs,
f) Based on the works described above a geotechnical risk register has been prepared for foreseen and foreseeable geo-hazards,
g) This risk register also emphasizes potential unforeseeable and unforeseen geo- hazards within and outside the proposed alignment corridor as residual risks

4.5.7.1 Mass replacement stability measures in unstable side long ground

4.5.7.2 Toe weight RE Walls and Embedded Pile Walls used in unstable side long ground

Piled walls can be designed for the support of cut slopes or for the stabilisation of landslides. The effectiveness of this type of wall is increased significantly when they are tied back to the ground behind with an additional anchor system.

4.5.7.3 Example of shallow landslip around km 1+120

4.5.7.4 Photograph of instability area showing failure steps

soil erosion and creating circumstances that could generate a landslide. Any areas of forest land that are affected by the execution of the highway but are not within the final footprint of the road will be reforested by planting native species. When establishing the species, the local flora and vegetation which root easily shall be taken into account.

4.5.7.5. Photograph of instability area showing failure steps and superficial topsoil flow

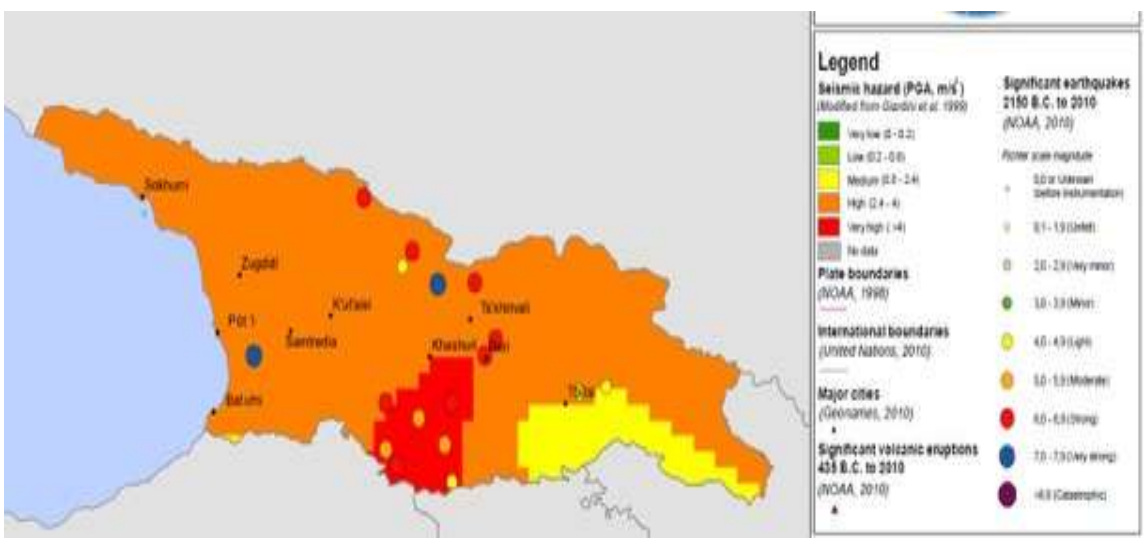
Where the road platform is supported on embankment and the slope of the natural ground is greater than 1:5 (20%), benches are required to be formed in the ground under the embankment, with total removal of topsoil, in order to ensure stability of the embankments. For inclination of the terrain steeper than 1:3 (33%) benches will not be enough and additional measures to prevent slippage such as reinforced earth walls have been required. Such measures have the added advantage of reducing the area occupied by the embankments.

4.5.8.The Effects of Regional Seismicity

The earthquake risks of the region have been identified and well documented by the Central Government Departments and Research Establishments (both nationally and internationally) with published data, such as that in Figure 4.5.8.1. The rationale for the seismic design of earthworks elements will include the following stages:

a) The potential activation of the existing slides within the corridor has been modelled and analysed with 100 years return period horizontal seismic acceleration coefficient. For Chumateleti-Khevi area, the PGA is below 0.2 g.
b) Any required stability measures required to resist instability caused by seismic events have been identified and included in the design of the permanent works,
c) Where possible the alignment optimisation (avoidance of area at risk) has been adopted where feasible to minimise risks,
d) The effects of seismically induced additional loads have been accounted for in the soil structure interface analysis at the locations of concrete structures.
e) Foreseeable and unforeseeable activation of geo-hazards within and outside the corridor have been included in the geotechnical risk register as residual risks.

Figure 4.5.8.1: Seismic Zone Map



Hydraulic Design

4.6.1 Secondary Hydraulic Structures

The locations of culverts, both box culverts and pipe culverts, have been selected so that the expected flow will pass through the culverts with as little interruption as practical. The main criteria for the hydraulic design of the box culverts are:

- All culverts that are sited in existing water courses have been sized for the 100-year flood flow, and the corresponding flood elevation has been checked to ensure there will not be damage to adjacent properties.
- Due to the mountainous area, the sizing of box culverts has taken into account the possibility that the watercourses might transport large volumes of rocks and fallen trees, to minimise the risk that the culverts will become blocked.
- Although the design flows may not require it, the minimum dimensions of box

culverts is 2.0m x 2.0m section, to assist in future maintenance.

- Culverts have been designed to ensure that the maximum water velocity will be less than 6 m / s in reinforced concrete box culverts to avoid excessive erosion and damage to the structure. Where this could not be achieved due to the steepness of the terrain, a layer of sacrificial concrete has been included in the design of the culverts.
- The freeboard inside the body of the culvert (between the maximum water depth and the roof of the drainage structure) is at least 1.0m for a 100-year flood.
- Gabions and / or riprap protection has been included in the design at the ends of the culverts to avoid the effects of possible scour erosion.

4.6.2 Sizing of Box Culverts

The sizing of the box culverts uses the data obtained from the Hydrology Study. Although the majority of the culverts are designed at locations where streams with a relatively low flow intercept the road, other water courses have been found to have design flows of up to 54 cubic metres/second. Consequently a range of box culvert cross-sections has been adopted for the project, as listed below:

- Chumateleti River at Rikoti Interchange : 6.0m wide x 5.0m high box culvert;
- Side channnel in Khevi : 2 No. x 5.0m wide x 2.8m high box culvert;
- Side channnel at 1+700 and at Khevi : 5.0m wide x 2.8m high box culvert;
- Intermediate catchments : 3.5m wide x 2.5m high box culverts

Overall, 52 box culverts are required for the project, with the following cross sections:

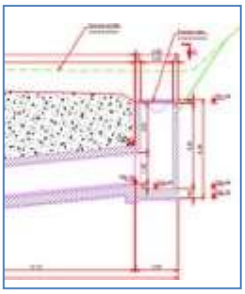
- 2.0m x 2.0m
- 3.5m x 2.5m
- 5.0m x 2.8m
- 6.0m x 5.0m

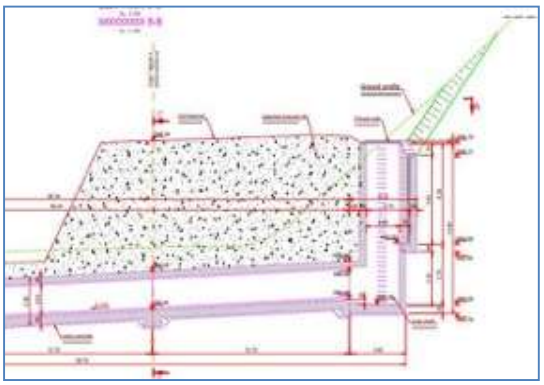
4.6.3 Design of Box Culverts

The project includes the replacement of the existing 5.0m wide x 3.0m high box culvert that passes the flow of the Chumateleti river under the existing E60 highway in front of the entrance portal of Tunnel #3. Major traffic management and temporary works will be required for the construction of this culvert. Replacement of the similarly sized box culvert that passes under the existing road directly in front of the entrance portal of Rikoti Tunnel will also be included in the project. Construction of this culvert will be undertaken during the period when the existing Rikoti Tunnel is closed for the construction of cross- passages in the tunnel.

A major feature of the culverts in the Rikotula Valley, after Rikoti Tunnel, is that the culvert inlets on a significant number are located at the base of the cut slopes on the Right Branch. The design of the inlets for these culvert has incorporated a drop shaft to transfer the water into the culvert section as indicated in **Figure 4.6.3.1** below.

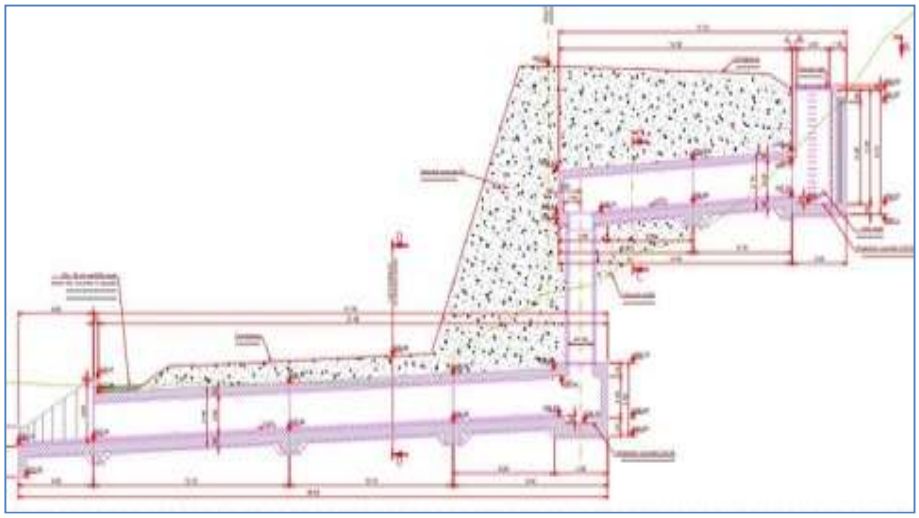
Figure 4.6.3.1 – Examples of Culverts with Deep Entrance Shafts





Furthermore, the geometry of the road where the Right Branch climbs above the Left Branch has resulted in a situation where the depth of inlet shaft became excessive. In these locations, namely culvert C-28 at 3+882, C-29 at 4+164, C-30 at 4+386 and C-38 at 6+494, an innovative solution incorporating a drop shaft between two levels of the culvert has been adopted. This is depicted in **Figure 4.6.3.2**.

Figure 4.6.3.2 – Culvert C-30 with Drop Shaft



4.6.4 Road Drainage

The road drainage design has been developed following the finalisation of the road alignment design. Longitudinal drains have been provided in the central median where one of the carriageways is super-elevated and at the edges of the road to ensure the removal of water from the paved carriageway of the road and thereby provide adequate service under adverse weather conditions. The road-side drainage system, the subgrade drainage and the cross-drainage systems are integrated to maximise efficiency.

Typically, all water flowing off the carriageways, shoulders and footpaths is intercepted and channelled to appropriate discharge points, except where the edge of the road is on a shallow embankment where discharge over the fill slope is permissible.

In view of the mountainous areas, the location and design of such discharge points has been carefully selected in order to avoid erosion of the earthworks embankments at the transitions between cuttings and embankment fill. Where necessary, carrier drains have been included in the design to take the

The sizing of the various elements of the road drainage has been undertaken using Autodesk Civi3D software. The road drainage is designed to cater for a 10 year design storm and the calculations assume that there is 100% run-off from the road pavement.

4.6.5 Subgrade Drainage

Subgrade drainage is provided along the road in cuttings and in areas of shallow embankments to prevent the harmful effects caused by saturation of the subgrade, which can reduce the life of the road pavement and thereby result in high maintenance costs.

The aim of these longitudinal drains is to intercept any flows of underground water, which can be encountered at a small distance below the level of the natural ground surface, and which may infiltrate in the body of the road or at the formation level causing degradation of the pavement bearing layers.

To facilitate maintenance, access manholes are fitted at regular intervals.

4.6.5 Interceptor Drains

In areas of side long ground, where flows of water can descend the hillside over large distances before being collected, both in the natural drainage channels and as sheet flow, it is good practice to intercept such surface water to prevent it from flowing over cut faces. If the surface water is not intercepted and diverted away from the cut slopes, it can cause major problems for the maintenance of stable cutting side due to erosion of the surface materials and degradation of the cut faces. These eroded materials will also be deposited in the side drains of the motorway, thereby impeding the flow in the side drains.

Conventionally, trapezoidal drains are used to intercept surface water flows, but on steeper ground more innovative solutions are required. For the Chumateleti-Khevi Project, the trapezoidal drains have been replaced with rectangular concrete channels due to the steep hillside.

4.6.6 Scour Protection

During periods of high flow, rivers can erode their banks. This process, while destructive can be seen to be a natural process. However, when such processes occur in the proximity of a new road construction, the impacts can be catastrophic if the design does not anticipate the likely scenarios and take measures to prevent damage to the road.

The areas where erosion processes can be expected in the project are in the two main river courses – the Chumateleti river in the area of Rikoti Interchange and the Rikotula river that flows parallel to the road alignment between the western portal of Rikoti tunnel and Khevi. These rivers have relatively steep water courses, with grades of 2.5% and 6.5% respectively, which generate fast run-off and significant flood flows. Consequently, there is significant risk to the constructed works that lie close to the river courses unless protection measures are implemented.

While the hydraulic design of structures is based on the estimated 100 year flood (or Q1%), the design storm that is used to develop the design of erosion protection is typically based on an assessment of the likely damage that could occur if a certain design flow is exceeded. Consequently, the design of erosion protection of bridge foundations should be based on a more severe criteria than the erosion protection of road earthworks. Accordingly, gabion mattresses have been used for the protection of foundations of bridges and retaining walls, while rip rap or gabion protection can be adopted for the protection of earthworks, depending on the flow characteristics.

The design of the rip rap protection is based on both the velocity and the level of the river at the relevant section, which are calculated from the volume flow in the river, which in turn is a product of the design storm. To generate the design data a 50 year design flow has been adopted, which is typically approximately 80% of the 100 year flow. The results of this analysis indicate that the D50 stone size (the size where 50% by weight will be of a smaller size) will vary from 500mm for the Chumateleti River catchment to 1750mm in parts of the Rikotula river valley. As it is unlikely that stones of such dimensions will be produced during the excavations for tunnels or from the rock cut excavations, the initial proposal to use stone rip rap protection has been abandoned. Instead, gabions will be used for the protection of the earthworks slopes in the main river valleys. Elsewhere, stone rip rap will be adopted for erosion control at culvert outlets and the like.

Three types of protection have been developed, depending on the specific requirements at each location:

a) Protection of Bridge Foundations
   Gabion mattress 500mm thick, has been designed in order to prevent scouring of the foundations of bridges in the Rikotula river.

b) Protection of the Foundations of Retaining Walls
   Similar details have been prepared in order to prevent scouring of the foundations of retaining the walls that will be constructed close to the watercourses of the Chumateleti river and the Rikotula river.

c) Protection of Earthworks
   Gabion mattresses 300mm thick, have been designed in order to protect embankments from erosion where they are close to the flood zones of the Chumateleti river and the Rikotula river.

The assessment of the required scour protection measures has been undertaken using HEC- RAS software and Excel spreadsheet tables.

Indicative characteristics of the main river channels are given below:
<u>Chumateleti River</u>:

Calculated 100 year flood flow at North Roundabout is 46.9 cu.m/sec

Derived 50 year flood flow = 37.5 cu.m/sec

- Grade of river channel : 3.5%
- Width of river channel : varies 4m – 12m
- Predicted height of flood : 1.5m
- Flow Velocity : 3.7m/sec

Rikotula River:

Ch. 3+060 : The calculated 100 year flood flow is 27.6 cu.m/sec
Derived 50 year flood flow = 22.1 cu.m/sec

- Grade of river channel = 6.5%
- Width of river channel : varies 3m – 6m
- Predicted height of flood : 1.0m
- Flow Velocity : 4.4m/sec

Ch. 7+645 : The calculated 100 year flood flow is 117 cu.m/sec
Derived 50 year flood flow = 93.6 cu.m/sec

- Grade of river channel = 6.5%
- Width of river channel : varies 6m – 8m
- Predicted height of flood : 1.75m
- Flow Velocity : 6.7m/sec

Ch. 10+300 : The calculated 100 year flood flow is 189 cu.m/sec
Derived 50 year flood flow = 151 cu.m/sec

- Grade of river channel = 3.5%
- Width of river channel : varies 8m – 12m
- Predicted height of flood : 2.0m
- Flow Velocity : 5.3m/sec

4.6 Other Roadworks Designs

4.7.1 Road Signs / Markings / Safety Barriers

The designs for traffic safety includes designs of road signs and road markings as well as the designs of safety barriers. The designs of these measures have been prepared following the completion of the highway alignment.

The designs of road signs and road markings have been developed in accordance with Georgian Standards, while the designs of safety barriers comply with EN 1317 Standard for Road restraint Systems.

4.7.2 Road Lighting

In accordance with the requirements of the Terms of Reference, road lighting shall be included in the design. The road lighting has been provided for the main carriageways and the interchange branches and roundabouts.

Where the carriageways of the Left Branch and the Right Branch are separated, the lighting infrastructure (Columns, cables, supply pillars etc) is located adjacent to the right lane of each carriageway, viewed in the direction of travel. Where the carriageways are adjacent, forming a "2+2" dual carriageway, the lighting columns are located in the central reserve of the road.

The level of road lighting illumination has been selected according to the classification and design speed of the road, and equipment with low consumption has been specified in order to minimise the operation costs of the road lighting.

4.7.3 Access Roads

Due to the construction of the E60 highway improvement project, certain local roads and access roads leading to and from the localities and properties within the project area will be affected. Consequently, alternative access arrangements have been developed for any parts of the local road network that will be interrupted by the construction and included in the detailed design layout.

During the development of the final layout of the project, works related to relocation of the roads intersected by the highway have been designed and detailed. It is also a requirement that traffic flows on these roads will be ensured throughout the construction works, by means of a temporary traffic management plan.

Where existing access to properties is from the existing E60 and needs to be maintained, dedicated access junctions connecting to the motorway have been included in the design to provide right in/right out junctions. These minor accesses all incorporate acceleration / deceleration lengths (include tapers) to separate the local traffic from the through traffic.

These accesses are located as follows: Km
1+700 Right branch;

Km 5+880 Right Branch Km 6+850 Right Branch

As described in the section on Khevi Interchange, In addition, the existing Rikoti Tunnel Bypass road has a connection to the Right Branch at Km 0+060.

4.7.4 Emergency Escape Lanes

On the west side of the Rikoti Tunnel, the vertical alignment of the existing E-60 highway encounters a long, steep downgrade of approximately 6.8%, which exceeds normal standards for a modern highway. This down gradient has been reduced to 6.0% in the modified alignment of the Right Branch. Even so, there remains a risk that heavy goods vehicles could go out of control at a high speed due to brake failure, though this risk is slightly reduced with a 6% down gradient.

To mitigate negative impacts, if a brake failure should occur, two emergency escape lanes were constructed on the existing E60at chainage 4+500 and 6+500. The emergency escape lanes leaving the main highway are designed for the purpose of taking out-of-control vehicles away from the main traffic stream and then slowing and stopping the vehicles safely. As part of the upgrade of the E-60, these existing emergency escape lanes will be utilised and enhanced.

The existing emergency lanes use only gravity to gradually reduce the speed of a vehicle until it stops. As part of the detailed design, the upgrade of these escape lanes has included a section of arrestor bed of loose gravel. The arrestor bed works by increasing the rolling resistance to the movement of vehicles and stops vehicles within a much shorter distance than an escape lane that relies on the length of the access and gravity.

4.7 Bridge Design

4.8.1 Overview of Bridge Design

This section of the Draft Design Report summarises the design activities performed for the preparation of the designs of the bridge structures. Based on the Terms of Reference and Feasibility Study, the scope of the detailed engineering design for the construction of Chumateleti-Khevi road

section anticipated the design studies for 17 new bridges and the evaluation for 5 existing bridges, with a total of 22 bridges.

With the major change in the alignment of the Left Branch (it has been relocated from the left bank of Rikotula River to the right bank adjacent to the existing road), there has been a significant change in the locations and lengths of the bridges. Based on the final road layout, a total number of 17 bridges and a box underpass have been designed. The list of the bridges is given in **Table 4.8.1.1** below:

Table 4.8.1.1 - List of Bridges in the Project

No.	BRIDGE NAME	LOCATION		LENGTH (m)
1	LEFT BRANCH VIADUCT	Rikoti Interchange		374
2	BRIDGE TA-1	Right Branch after Rikoti Tunnel.	4+980	186
3	BRIDGE TA-2	Right Branch after Rikoti Tunnel.	5+620	187
4	BRIDGE TA-3	Right Branch after Rikoti Tunnel.	6+040	178
5	BRIDGE TA-4	Khevi Interchange - Main Road		72
6	BRIDGE AT-3	Replacement Bridge - Left Branch	9+065	26
7	BRIDGE AT-4	Replacement Bridge - Left Branch	8+185	71
8	BRIDGE AT-5	Replacement Bridge - Left Branch	7+990	51
9	BRIDGE AT-6	Replacement Bridge - Left Branch	7+860	25
10	BRIDGE AT-7	Replacement Bridge - Left Branch	7+645	25
11	BRIDGE AT-8	Left Branch after Rikoti Tunnel	3+290	80
12	BRIDGE AT-9	Left Branch after Rikoti Tunnel	3+060	27
13	BRIDGE AT-10	Left Branch after Rikoti Tunnel	5+605	107
14	BRIDGE LR-1	Khevi Interchange - Service Road		20
15	BRIDGE LR-2	Khevi Interchange - Service Road		82
16	BRIDGE LR-3	Khevi Interchange - Link Road		20
17	Underpass UP-1 ON SR3	Rikoti Interchange		110
18	VIADUCT ON SR4	Rikoti Interchange		100
		Total Length		1741

4.8.2 Bridge Type Selection

In parallel to the latest developments in bridge construction and materials, an extensive range of bridge types exists which can provide solutions to each projectt's specific needs.

Functionality, safety, constructability, economic feasibility, durability and architectural and environmental conformity with the surrounding are the basic parameters to be considered in the determination of the appropriate bridge type.

The two basic geometric parameters that largely determine the bridge type selection are the number and lengths of spans; and the width of the bridge platform.

Based on the alignment layout, the bridge decks accommodate either two lanes, or three lanes depending on whether a climbing or acceleration/deceleration lane is required. Also in a few areas, the width of the edge strips are increased to secure the required forward sight distance on horizontal curve locations.

Most common bridge types can accommodate a wide range of platform widths, in this regard the span length has been considered to be the main geometrical criterion in the selection of the bridge type for the project.

According to the layout of the road platforms, the span of the bridges varies between 20 metres and 42 metres. 6 bridges have a single span, varying in length between 20 and 26 metres. The Left Branch Viaduct at Rikoti Interchange has the longest span of 42 metres. Considering the range of spans, of 20 to 42 metres, it has been found reasonable to select reinforced concrete bridges incorporating precast prestressed beams as the standard type of construction for the whole project. In order to decrease the total number of different types of beams, a total number of 4 different beam sections have been developed and used in the whole design. The beams have I section, with heights of 1000mm, 1200mm, 1500mm and 1800mm.

Construction of the precast concrete beams at a remote casting yard will ease beam production and ensure quality assurance requirements are achieved. High strength pre- stress strands are placed within each beam to greatly increase their structural capacity. Furthermore, since these precast beams are erected in their actual position using a mobile crane, the required space for the superstructure construction can be significantly reduced.

4.8.3 Design of New Bridges

Although the types of bridge structures within the scope of the project can be classified under various alternative sub-headings, by considering the overall design of the project, the most practical classification is to itemise the bridges in accordance with their positions along the project alignment.

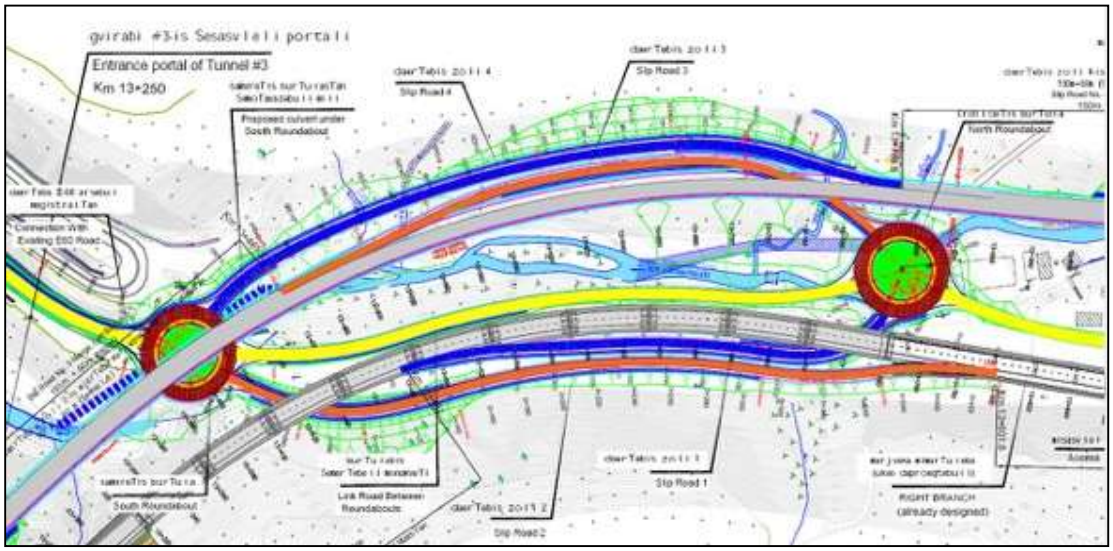
Rikoti Interchange

Among the new designed bridges, the viaduct on the Left Branch of the highway at the Rikoti Interchange, which is located between Tunnel #3 and Rikoti Tunnel is the most important bridge among all bridges in the project, due to its length, location and layout.

The Feasibility Study included a recommendation that an interchange should be provided in the area before the existing Rikoti Tunnel. The intention of providing an interchange at this location was to provide a facility that would enable traffic on the existing road network to join the new highway as well as providing a facility for traffic to change from the eastbound to the west bound carriageway in the area immediately before Rikoti Tunnel. To serve this purpose, the Consultant has made comprehensive studies at this region to come up with the most feasible solution by considering interchange design.

Among various studies, the Consultant recommended the layout which should be adopted for the interchange by considering that it provides the best solution in terms of providing an interchange that provides for all turning movements as well as compliance with design standards. A general plan view for the recommended layout is given below.

Figure 4.8.3.1 - Layout of Rikoti Interchange



There are three major elements of bridge design required to conform with the layout of this interchange :

a. the proposed new viaduct on the Left Branch,
b. the impact of the interchange layout on the design of the bridge designed for the Right Branch, and
c. the underpass structure that is needed to take Slip Road 3 under the Left Branch.

<u>New Viaduct on the Left Branch:</u>

The proposed new Left Branch of the highway starts before the eastern portal of Tunnel #3 and, after emerging from the western portal of Tunnel #3, crosses the alignment of the existing E60 road and then heads north west towards the southern portal of the second tube of Rikoti Tunnel. The designed viaduct starts approximately 15 metres after the west portal of Tunnel #3, due to the steep topography. The overall length of the viaduct with 9 spans is 374 metres, which is approximately twice the length of the longest bridge among the remaining. The width of the deck varies due to the need to incorporate the merge and acceleration lane of Slip Road 3 with the main alignment. For the slip road merge, at two pier locations the piers and capping beam have been extended in order to accommodate the increased width and the merge section properly; and one separate pier and one separate abutment have been designed for the slip road bridge.

Regarding the locations of the intermediate piers on the viaduct, the pier locations have been determined by considering the optimum span length, best fit with the interchange roundabouts, any interaction with the merge and diverge slip roads, the adjacent river and culvert passages etc. The longest span length for the whole project has been used for this viaduct as 42 m.

Moreover, a separate bridge with 3 spans and a total length of 100 metres has also been designed for Slip Road 4, located adjacent to and to the west of the main viaduct.

Bridges between Rikoti Tunnel and End of Project

Apart from the viaduct on the Left Branch at the Rikoti Interchange, all the remaining bridges that are either replacement bridges (for the existing old bridge locations) or new planned structures are located between the Rikoti Tunnel western portal and the end point of the project.

The general layout and the geometrical configuration of these bridge structures have been designed based on the extensive information provided by other engineering disciplines, mainly from the road alignment design, topographic mapping, geological and geotechnical data and further considerations.

After the finalisation of the alignment in plan and profile, the locations of the abutments and piers have been determined considering the topographical conditions and the requirements of the road layout.

Right Branch Bridges after Rikoti Tunnel

At the Right Branch after Rikoti Tunnel, three bridges have been designed all of which have five spans and are the longest bridges excluding the Left Branch Viaduct at Rikoti Interchange. The span length of the bridges are typically 37 metres, and the total length of these structures varies between 178 and 187 metres. Based on the span length, the precast beam type with a height of H = 1500mm has been used in the design for the superstructure of these bridges.

All three bridges are located where the Left and Right Branches are completely separated. The first bridge is located just before the east portal of Tunnel #4, and the second one is designed just after the west portal of the same tunnel. The third bridge follows shortly after and is located approximately 700 metres before the merge of the two branches.

Left Branch Bridges after Rikoti Tunnel

In general, the alignment of the Left Branch after Rikoti Tunnel typically follows the existing road. A total number of 8 bridges have been designed for this section, 5 of which are the replacement bridges at the existing bridge locations. A review on the existing bridges is given below.

4.8.4 Review on Existing Bridges

Based on the adopted road alignment design strategy of using the existing road platform as the road platform of the new alignment for Left Branch, the evaluation regarding the condition of the existing bridges played an important role when making the decision about whether these bridges will be rehabilitated and preserved to remain in service or whether to replace them with new bridges that are guaranteed to satisfy the project design expectations.

The names and the approximate locations for these 5 existing bridges are as follows:

Table 4.8.3.2 - List of Existing Bridges on Rikoti - Khevi Section

No.	Bridge Reference	Rikoti-Khevi Section		
		From	To	Length
1	BR-AT-3	7+605	7+620	15
2	BR-AT-4	7+810	7+825	15
3	BR-AT-5	7+935	7+975	40
4	BR-AT-6	8+125	8+160	35
5	BR-AT-7	9+060	9+075	15

With respect to the condition assessment studies of these existing bridges, the condition evaluation engineering studies have been completed and presented in Technical Paper No. 2 "Condition Assessment Report for the Existing Bridges" dated 13 June, 2017.

Within the coverage of Technical Paper No. 2, the initial objectives and the scopes of the condition assessment studies were defined and the detailed geometrical and structural form of the bridges was given. The report also identified the survey methods that would be used, such as visual inspection and inspection with non-destructive methods. Condition survey site trips have been made by the engineering team at different stages of design. Based on these surveys, it has been observed that, nearly all of the bridge structures show an excessive range of deficiencies and damages which have taken place during their service life. In all bridges, defects such as aging, lack of concrete cover, plaster spalling, cavities, dents on concrete members and spalling due to reinforcement corrosion are among the main type of deficiencies observed on the structural components. It was concluded that little or no effective maintenance work appeared to have been carried out on the bridge components which makes the level of current damages more critical.

In the Condition Assessment Report, these observed damages are classified under sub heading such as:

- Drainage Damages
- Construction Defects
- Expansion Join Damages
- Damages on Bridge Bearings etc.

The causes and potential results of each damage type on the bridge sub-structure and superstructure elements are described in detail.

In addition to these considerations (on the existing physical condition of the bridges) the various issues that have prevented the Consultant from performing fully accurate and precise structural design calculations that would reflect the demand/capacity ratio of the bridge components are also covered within the assessment report. These problems are briefly summarised below:

- Non-availability of the original design documents and assumptions.
- Even if it is assumed that the original design is in full compliance with SNIP/GOST codes, the level of negative effects of the damages and resulting section losses are indeterminable.
- Due to the age of the bridges, traffic load class of A11 or N30, which were probably assumed during the original design phase, have been superseded by current.

SNIP/GOST live load class of HK-14 and AK-14. The AASHTO traffic load classes which are also adopted for the current design are also higher than the classes referred during original design phase.

Finally, after all explanations about the performed survey studies, their outcomes and detailed evaluations for the general bridge components, which have been summarised here in this Design Report, are covered in the referenced Technical Paper No. 2 "Condition Assessment Report for the Existing Bridges".

At this point, it is convenient to repeat the conclusion of the Condition Assessment report. Following the detailed evaluations, it was concluded that the structural members of the existing bridges would not satisfy the required performance levels and therefore they will not have an adequate level of safety under the service conditions of the project by considering service period loading cases. It should also be reminded that there are also significant damages and deficiencies on the major bridge structural elements that would definitely inhibit each bridge from being able to comply with the performance level dictated by the project requirements for the future service periods. Therefore, the designer has recommended to demolish the existing 5 bridges and replace them with new bridges that have been designed and will be constructed using the latest design

methodologies and construction quality control and assurance approach that is adopted for the project.

Furthermore, the decision to the replace the existing bridges has permitted an improved horizontal alignment to be developed for the Left Branch which removes several tight curves that were part of the existing road alignment.

New Bridges on Left Branch After Rikoti Tunnel

The first three bridges after Rikoti Tunnel are completely new bridges and are required based on the new alignment layout; two of these bridges have three spans and one has a single span. The next 5 bridges in this section are the replacement bridges, at the locations of the existing bridge structures. 3 of the replacement bridges are designed with a single span; one has been designed with two spans, and the longest one with three spans.

4.8.5 Bridges in Khevi Area

At the Khevi Interchange, where the left and right platforms are merged; the main interchange viaduct has been designed as two spans with a span length of 35 m. The abutment and pier locations have been designed as single sub-structures supporting both the left and right platforms.

Three additional bridges for the service roads have been designed at Khevi Area. Among those, the longest one is the bridge connecting the service road adjacent to the Right Branch to the service road that has been designed along the south bank of the Rikotula river, referred to as LR-2 bridge. This bridge passes over the main road; and based on the layout, has been designed to have four spans, each 20 metres. The other river bridges located on the Link road between the Khevi Interchange and the village and on the service road along the south side of the Rikotula river are the shortest and smallest bridges designed in the whole project, with a single span of 25 metres.

Bridge Cross-Section

The below figures, showing the cross-section and layout of a river bridge as an example, indicate the typical cross-section and layout of the designed main road bridges.

Figure 4.8.5.1- Typical Layout Plan and Longitudinal Section of a Main Road Bridge

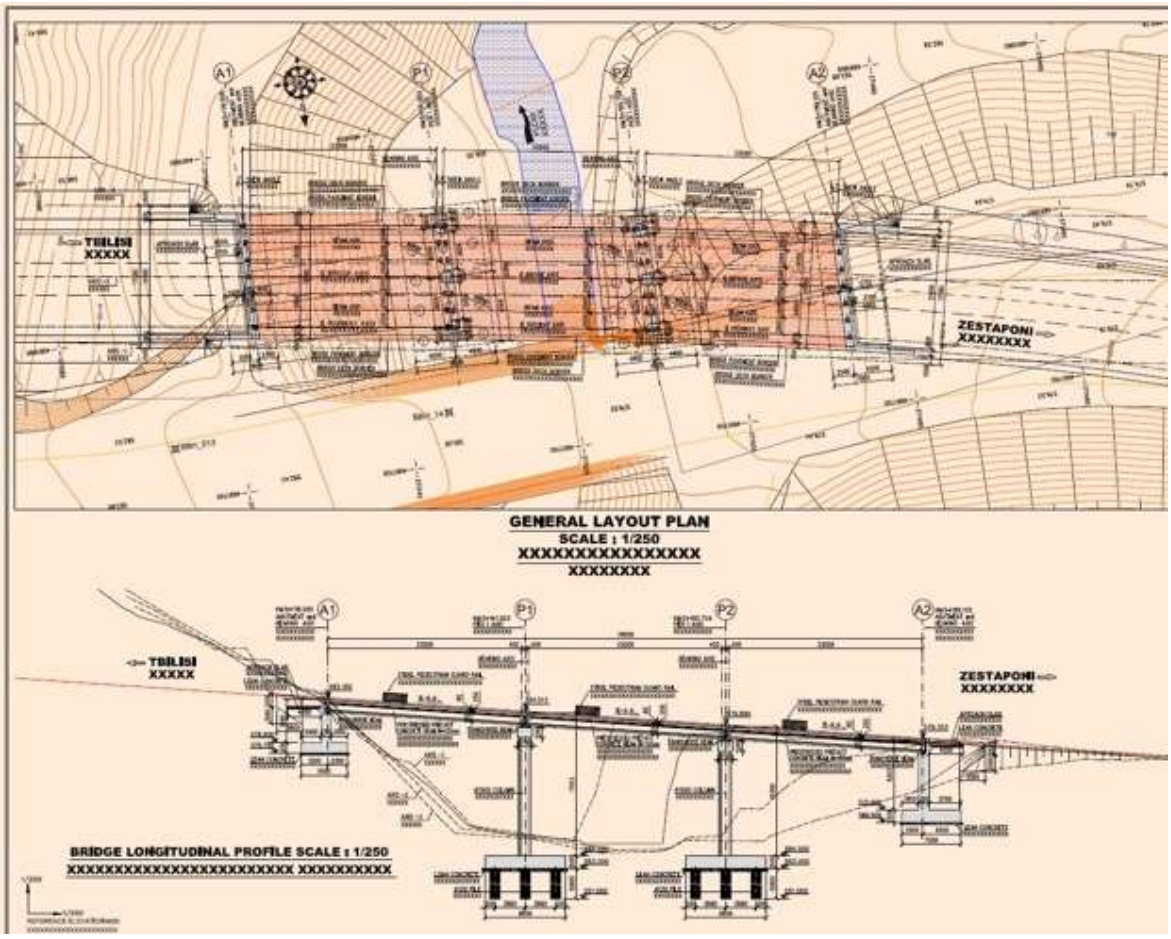
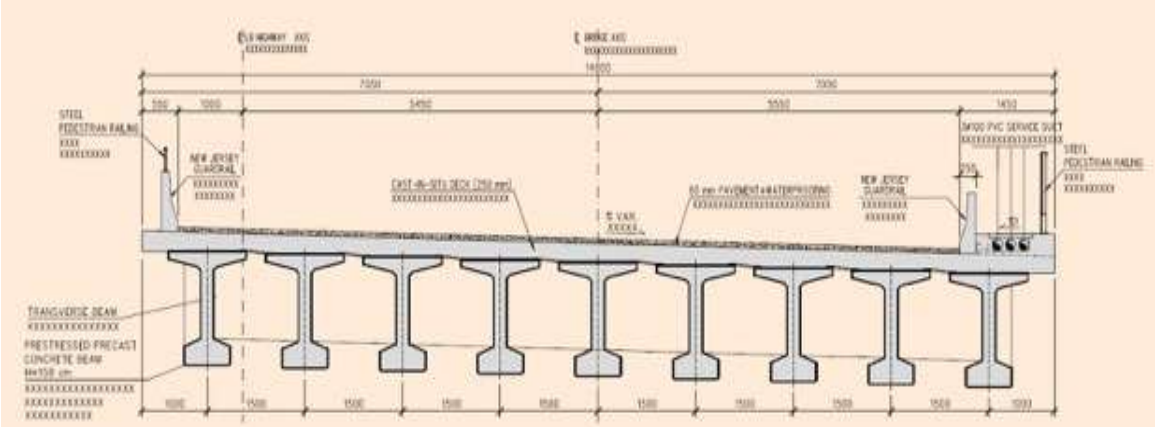


Figure 4.8.5.2 - Typical Cross Section of Main Road Bridges



For all main road bridges, New Jersey type concrete barriers are considered at the sides of the paved road platform. A single pedestrian walkway has been included in the design.

Adjacent to the right side of the roadway (according to traffic flow direction). The distance after the barrier at the left edge of the structure has been optimised to reduce the overall width of the structure.

For the service road bridges, the typical layout and cross sections are shown below. Raised walkways have been included in the design along both sides of the bridge considering two-way traffic. These walkways include a light vehicle/pedestrian barrier at the outer edges of the bridge.

Figure 4.8.5.3 - Typical Layout Plan and Longitudinal Section of a Service Road Bridge

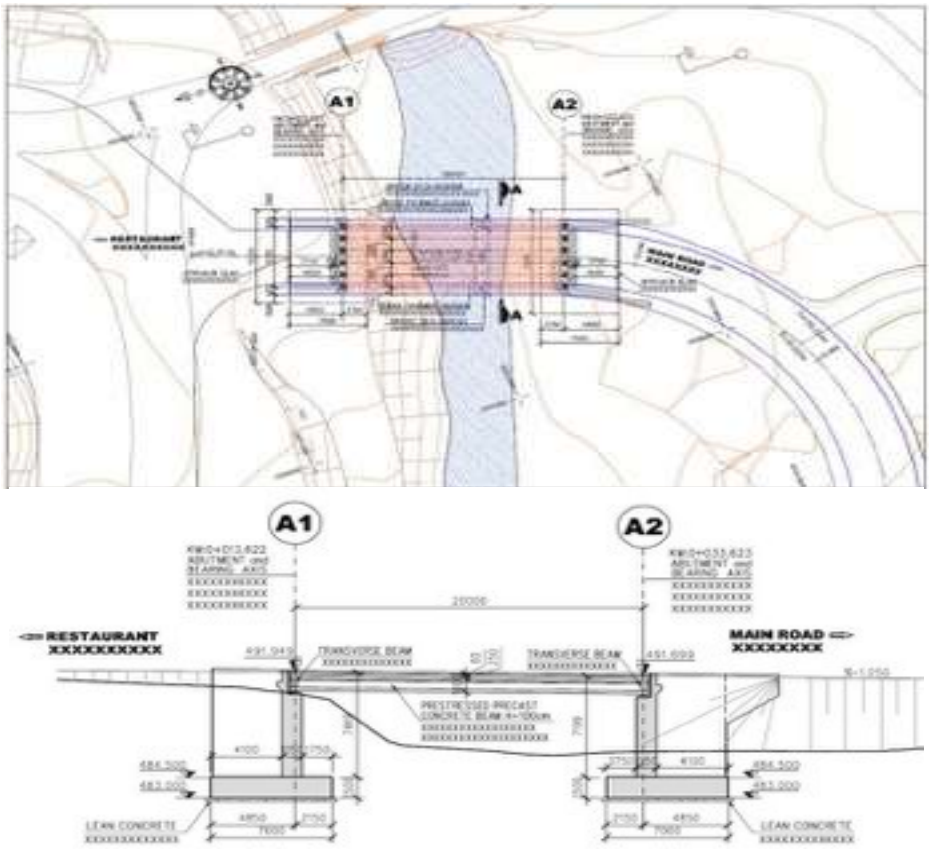
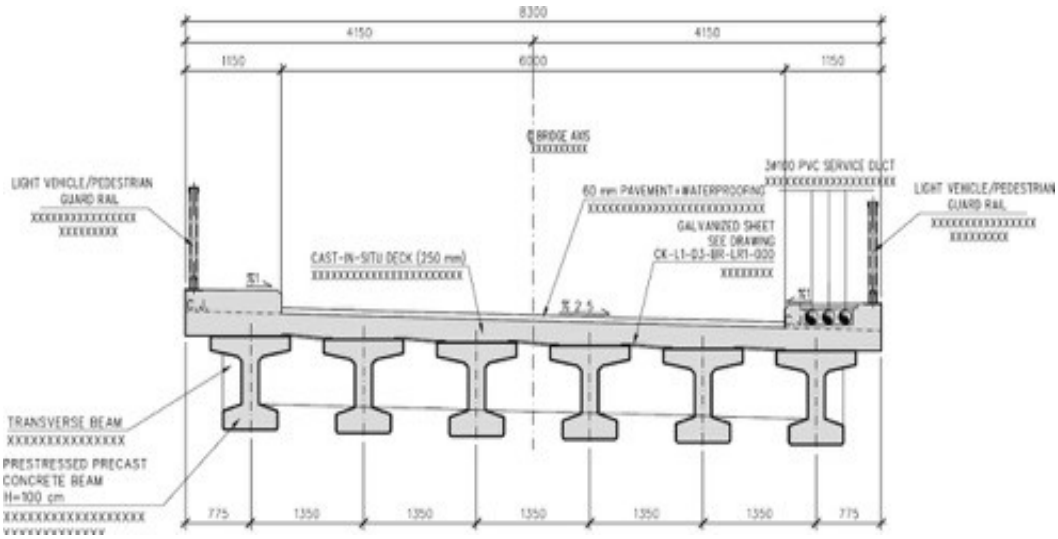


Figure 4.8.5.4 - Typical Cross Section of Service Road Bridges



Foundations of the Bridges

Site investigations have been performed for each bridge, in order to identify and evaluate the soil conditions at the abutment and pier locations. Geophysical survey results have been used for only two bridges (which are at the Right Branch after Rikoti Tunnel, located just before and after Tunnel #4), for all remaining bridges, boreholes have been performed. Boreholes have been carried out at almost every abutment or pier location.

In the determination of the foundation depth and type of the structure, the results of the abovementioned investigations have been considered. As a general principle, all foundations have been designed as either shallow foundation bearing on rock or piled foundation with the end of the piles socketed into rock. In this regard, based on the depth of the weak layers (which may be alluvial-colluvial soil; residual soil formed by highly weathering of the rock), the foundation elevation and type has been evaluated. For large depths of weak layers, pile foundations have been used to transfer the bridge loads to the stronger layers at greater depth. Any foundation on soil, residual soil or highly weathered

- very weak rock has been avoided.

Based on the geotechnical site investigations and the layout of the bridges; 6 of the bridges have been designed with shallow foundations, 6 have been designed with pile foundations, while a combination of shallow and piled foundations have been considered for different abutments/piers on the rest of the bridges.

Design Fundamentals

For each bridge, a design and calculation report has been prepared and submitted in **Volume 2 – Section 09**. of this Draft Design Report. In this section, the fundamentals of the adopted bridge design are briefly discussed.

Adopted Specifications and Loads

For the design of all bridges;

- AASHTO–Standard Specifications for Highway Bridges (SSHB), 2002
- AASHTO–Standard Specifications for Seismic Design of Highway Bridges, 2002

and their Interim Issues are used. For indefinite cases in these specifications, necessary sections of the CALTRANS – Bridge Design Specifications Manual and Design Memos, State of California, Department of Transportation, 2000-2004, ACI – Concrete Manual, vol. 1-5, 2002 are referred.

External forces that are referred in design during the construction, erection and operation of structures are explained below. Detailed load analysis for the related load cases for each structural members are given separately in the relevant sections of the calculations.

During design, factors and loading combinations for the referred load scenarios are taken according to AASHTO-SSHB and AASHTO-SDHB. The self-weight of the bridge elements are calculated using the following unit volume weights:

- Prestressed Concrete 25.0 kN/m3
- Reinforced Concrete 25.0 kN/m3
- Asphalt Pavement 23.0 kN/m3
- Compacted Earth Fill 19.0 kN/m3

Bridge design is detailed in accordance with traffic load scenarios and truck load of HS20- 44 as per AASHTO requirements. The load combination coefficients, impact factors and the dynamic effect coefficients are taken from the related sections of AASHTO-SSHB. As the pedestrian walkway width is wider than is 0.6, 3kN/m2 uniformly distributed pedestrian moving load is taken into account with reference to the relevant section of the specification.

As the interested bridge falls within the definition of "Conventional Bridge" as per AASHTO classifications with concrete girder construction with spans not exceeding 150 meters, seismic design methodology of "Response Spectrum Design" defined in "AASHTO SSHB-Division 1-A Seismic Design" and all the related structural and geometrical requirements given in the related sections are followed. Necessary Importance Classifications, Seismic Performance Categories, Site Specific Soil Effects and Elastic Seismic Response Coefficients are taken into consideration in accordance with guidelines and instructions defined in the AASHTO SSHB Division1-A. For the Peak Ground Acceleration A = 0.20 g value is referred by considering the Georgian seismic map for the local project region.

Materials

The following building materials are used in bridge structural designs. The physical and strength properties of these members are taken from the relevant specifications (SSHB and ASTM A416-80).

Prestressed Girder Concrete : C45 fc'=450
kg/cm² Reinforced Concrete : C30 fc'=300kg/cm²

Lean Concrete : C16 fc'=160 kg/cm²

Prestressed Equipments: 0.6" low relaxation strand fs'=18617 kg/cm²
Reinforced Equipment: S420 fy'=4200 kg/cm²

Modulus of Elasticity of Concret. C45 Ec=360566 kg/cm²

C30 Ec=294401 kg/cm²

Modulus of Elasticity of Prestressed Equipment: Es=1947530 kg/cm²
Modulus of Elasticity of Reinforced Equipment: Es=2038936 kg/cm²

Superstructure Design

Viaduct superstructure consists of several precast, prestressed, "I" girders aligned adjacently to each other along bridge platform width. After the girders are placed, the superstructure will be transformed into an integrated composite section by pouring the deck concrete that will provide the required super-elevation required by the road alignment horizontal curves.

The cross-sectional properties of the super-structure elements used in the calculations are calculated by considering the construction and service conditions and calculated on the basis of the super-structure's behaviour as a composite structure. Properties of the composite sections composed of "I" Beam + Slab + Pavement elements are determined by using the ratio of modulus of elasticity of different building materials.

Substructure Seismic Design

As mentioned previously, seismic design of the bridge sub-structure main components such as abutments, piers and their foundations, design methodology defined in "AASHTO SSHB-Division 1-A Seismic Design" are referred.

During seismic analyses of the sub-structure bridge elements, finite element structural analyses software "SAP2000 Structural Analysis Program" is introduced. Program input values and analysis result outcomes are given in detail in each design report.

All details of the analyses and calculations are submitted in each bridge design report.

4.9 Tunnel Design

The design scope of the tunnels in the Chumateleti-Khevi section of the E-60 Highway includes the second tube (south) of Tunnel #3, the second tube (for the west-east direction) of existing Rikoti Tunnel, which were considered in the Feasibility Study. Moreover, a new tunnel at the elevated right branch after Rikoti Tunnel, named as Tunnel #4 with a length of 350 metres has also been included in the design based on the alignment and topographical requirements. A list of the tunnels in the project is given below:

Table 4.9.1 - List of Tunnels in the Project

Name	Location*	Length* (m)	Type
Tunnel #3	Left Branch Km : 0+020 - 0+520	500	Single Tube (Left)
New Rikoti Tunnel	Left Branch Km : 1+230 - 3+030	1800	Single Tube (Left)
Tunnel #4	Right Branch Km : 5+115 - 5+465	350	Single Tube

** The tunnel chainages and lengths include the portal structures*

A summary of the design works performed for the tunnels is given below under different headings. Design reports have been prepared and submitted as Appendices to this report for each tunnel.

Therefore, the following sections regarding the tunnel design are included to provide a brief summary of the design works and do not cover all design information. Detailed information about the civil and electromechanical design can be found in each design report.

4.9.1 Geological Evaluation

Overview of the Project Area

The project area is located on Dzirula Massif which has been formed as an inter- continental rift developed in response to structural inversion caused by still ongoing regional compressive regime. The core of the massif is made up of mainly granitic rocks which typically offer very favourable geotechnical conditions for tunnelling works in their initial mode of formation due to their huge masses and compact structures. However, under tectonic forces leading to local to regional faulting these rock masses become susceptible to both surface weathering and "bottom to top" hydrothermal alteration processes in the presence of rain and juvenile water respectively. These processes eventually result in mineralogical and chemical changes in K-Feldspars and Na-Ca Plagioclase Feldspars and the formation of clay mineral and quartz. Among these chemical processes the hydrothermal alteration is the most hazardous for tunnel projects because of its direct association with deep seated faulting. Consequently, such granitic rocks could play a major role on the technical constructability of the tunnel project. This adverse aspect of granitic rock masses demands great care during tunnel driving particularly with respect to undetectable weathering and alteration zones in the close vicinity of the tunnel periphery both for short and long term stability concerns.

Tectonic Setting of Project Area

The structure and geological history of the Caucasus, where the project area is located, are largely determined by its position and still converging Eurasian and African-Arabian lithospheric plates, within a wide zone of continental collision. Therefore it is essential to comprehend the tectonic processes the Caucasus have gone through during their geologic history, which are briefly outlined below:

- To start with, the project area is situated on Dzirula Massif which is interpreted as the *"uplift block"* developed in response to *"structural inversion"* of major faults caused by the regional compression tectonics.
- During the Late Proterozoic Early Cenozoic, the region belonged to the Tethys Ocean and its Eurasian and African-Arabian margins there existed a system of island-arc, intra- arc rifts, back-arc basins characteristics of pre-collisional stage of its evolution of the region.
- Pre-Jurassic basement rocks of Paleotethys Ocean are mainly represented by:
  - Rift related (divergent boundary) volcano-sedimentary rocks, extruded and deposited in the back-arc basin, then metamorphosed at convergent boundaries. These rocks involve crystalline slates and phyllites;
  - Subduction-related granitic rocks which in turn metamorphosed to granite gneisses in places.
- Pre-Cretaceous rocks are related to Neotethys Ocean and mainly represented by shallow marine, terrigenic and carbonated deposits of passive margin as well as continental-volcanogenic flysch-like rocks island-arc volcanism. These rocks are reported to have tectonic contacts with the underlying Pre-Jurassic rocks.
- Post Cretaceous rocks of Oligocene and Miocene are continental rocks deposited after the closure of Neotethys Ocean and mainly consist of clayey sandy sediments.

- The geometry of tectonic deformations in the Transcaucasus is largely determined by the wedge-shaped rigid Arabian block intensively indenting into the Asia Minor Caucasian region. All structural-morphological lines have clearly-expressed arcuate northward - convex configuration reflecting the contours of the Arabian block.
- All these rocks of Dzirula Massif are overlain by weathered products of the older rocks exposed at the surface and dilivium deposits of recent ice ages.

4.9.2 General Geology

In the near vicinity, granitic rock, flysch formations cover deposits, such as diluvium and slope wash crop out: The engineering properties of these geological formations will be described briefly below in order to establish a base for the geotechnical conditions of the tunnel project.

Granitic Rocks

Tectonically the study area is located in the Dzirula Massif, included in the central uplift zone of Lesser Caucasus Intermountain System. Due to their mineralogical content, granitic rocks are very susceptible to both weathering and alteration which have deep impact on geotechnical properties of the rock as well as of the rock mass. Excluding the below mentioned altered and weathered likelihood zones in granites, the rock material and mass normally offers favourable engineering properties for tunnelling works.

Therefore some important aspects of the weathering and alteration processes that develop in granites need to be mentioned, as follows:

a) Chemical Weathering in Granitic Rocks

Chemical weathering involves complex processes that alter the internal structures of minerals by removing or adding elements. Water is by far the most important agent of chemical weathering. Although pure water is non-reactive, a small amount of dissolved material is generally all that is needed to activate it, such as carbonic acid, which is formed when carbon dioxide is dissolved in water. The most abundant products of the chemical breakdown of the feldspar are clay minerals. Quartz, the other main component, is very resistant to chemical weathering and hence it remains substantially unaltered when attacked by weakly acidic solutions. Eventually, this chemical reaction leads to the change in mineral content and the increase of pore volume promotes the action of mechanical disintegration and chemical decomposition. Apart from mineralogical changes, porosity increases considerably and the dry density of the rock material is decreasing simultaneously.

b) Hydrothermal Alteration in Granitic Rocks

In general, it is very difficult to distinguish between the effects of hydrothermal alteration and weathering on mineralogy as well as on geotechnical rock properties of granites cropping out at the project area. However, one important aspect of hydrothermal activity is that juvenile water, circulating through faults, is involved in this process and therefore it is more of *"bottom to top"* phenomenon in the continental crust, as is the case in our tunnel project. The chemical process and adverse effects of hydrothermal alteration is, therefore almost always associated with faults.

Cretaceous Volcano-Sedimentary Rocks

These rock masses are represented as flysch-like formations revealing alternation of conglomerate, sandstone, siltstone and claystone bedding planes due to their mode of deposition. Although these rocks were not observed along the tunnel route, at the higher elevations, the remnants of such rocks

are likely to occur in some parts of the eastern portal. The intense vegetation cover, however, does not allow to make more than a superficial investigation at the site.

Diluvial Deposits

These cover deposits that are the remnants of the deluges that occurred during a temperate climate that followed the ice age. This soil formation is mainly made up of gravel to sand, occasionally cobble to boulder size material within clay matrix. It is mostly seen on the slopes of the existing cuts at the by-pass covering the highly weathered granite.

4.9.3 Geotechnical Evaluation

Geotechnical Conditions at Tunnel #3 Entry Portal

During the site visits several attempts were made to reach to the area of the entry portal, and it has been possible to reach as close as possible to the exact portal location, in spite of the very heavy forestation on the steep ground. These visits were fruitful in many respects in that geological evidence was identified with which to estimate the depth of diluvial deposits and rock types, which are as follows:

The diluvial deposits are very superficial and immediately underlain by massive granite migmatite. The morphology suggests that this geological environment is very likely to continue up to the portal area with some variations due to the nature of the migmatite formation. This observational data also suggests that there are no serious stability issues, such as landslip, that are likely to affect the portal area.

Exit Portal

The rough terrain conditions combined with the heavy forestry totally hindered access to the entry portal and along the tunnel route. Therefore only at the exit portal, where TBH-1 borehole was drilled, were subsurface investigations possible.

Superficially, the site conditions in the area of TBH-1 borehole appeared to be covered by deep diluvial and colluvial material. This situation was clearly observed along the access road that was constructed to the borehole site where the thickness of the said recent deposition reached to 6-7m at some localities. The close-up examination of these exposures provided the following characteristics of the diluvial material which are reported to be the product of the last ice age:

- A very distinguishing feature of diluvial deposits is that they contain plenty of flat granitic rock fragments ranging in size from cobble to boulder and even to massive block on some occasions. It is very evident that these rock fragments were derived from the mechanical disintegration of granitic rocks due to frost wedging, alternating freezing and thawing of water. When broken in-situ they give the impression of slightly to moderately weathered granitic rocks.
- Though the thickness of the diluvial deposits was determined to be around 9m, this depth is likely to be variable, both plus and minus, depending on the old morphology of the site.

It is very evident that borehole data alone could not be sufficient to classify the rock mass for the empirical tunnel support design. Moreover, no representative laboratory sample was available from the core samples. Thus the evaluations of rock conditions for the exit portal have also involved the data collected from the existing rock cuts located nearby.

Empirical Rock Classification Along The Tunnel Route

In the design of tunnel support, several empirical rock classifications are used in practice internationally. Two of these rock classifications, namely; Engineering Classification of Rock Masses for the Design of Tunnel Support (RMQ - N. Barton, R. Lien, and J. Lunde).

Geomechanical Classification of Jointed Rock Mass (RMR - Bieniawski, 1989), are quantitative classifications. In addition to these classification systems, GSI (Geological Strength Index, Hoek, and Marinos, 2000) is also widely utilized as a qualitative empirical classification system. GSI is based on two seemingly simple but effective parameters- structure and surface conditions-to estimate rock mass shear strength parameters (m, s, c, □, E) of rock masses. Since it is visual and practical to use and also is interchangeably inter-related with RMR (GSI= RMR-5), GSI is a very popular classification system.

The field observations made along the existing Tbilisi-Kutaisi road and in the Chumateleti River valley that runs parallel to the road, to the east of the tunnel alignment, indicate that the following rock types are likely to be encountered:

- Granite Migmatites (Diatexite)
- Q-Diorite Gneiss and Meta Ophiolite (Metatexite)
- Red Granite

The chemical alteration products of granitoids - called gruss - on the other hand, are only anticipated to occur locally around the portal areas but not along the tunnel route due to the high overburden.

The localities of these rock types are plotted on the GSI CHART given below as a basis for the Empirical Rock Support Classification. As the TBH-1 borehole data did not provide any appropriate core sample for laboratory testing; the uniaxial compressive strength of intact rocks has been determined at the site through empirical experience.

Empirical Approaches to Tunnel Support Design

For convenience, the above-given rock names will be used in the empirical classification of rock masses for empirical tunnel support design. Although the geotectonic working model suggests that there is a very low probability of encountering TYPE-I and TYPE-II rock qualities those rock masses are nevertheless considered in the following geotechnical evaluations.

TYPE-I: $Q>40$

Rock Type: Fresh microcline Red Granite
$GSI>73 \rightarrow RMR>78 \rightarrow Q=43.72$

TYPE-II: $10<Q\leq40$

Rock Type: Fresh to slightly weathered Q-Diorite Gneiss and Meta Ophiolite partly affected by the intrusion of microcline Red Granite $60<GSI\leq73 \rightarrow 60<RMR\leq78 \rightarrow 10.32<Q\leq43.72$

TYPE-III: $4<Q\leq10$

Rock Type: (a) Slightly to moderately weathered Q-Diorite Gneiss and Meta Ophiolite partly affected by the intrusion of microcline Red Granite; (b) Slightly to moderately weathered Granite Migmatite.

$50<GSI\leq60 \rightarrow 55<RMR\leq65 \rightarrow 3.40<Q\leq10.30$

TYPE-IV: $1.0<Q\leq4.0$

Rock Type: Moderately weathered Granite Migmatite.
$40<GSI\leq50 \rightarrow 45<RMR\leq55 \rightarrow 1.46<Q\leq3.40$

TYPE-V: 0.4<Q≤1.0 (ENTRY PORTAL)

Rock Type: Moderately to highly weathered Granite Migmatite (Diatexite prevalent)
30<GSI≤40→35<RMR≤45→0.37<Q≤0.89

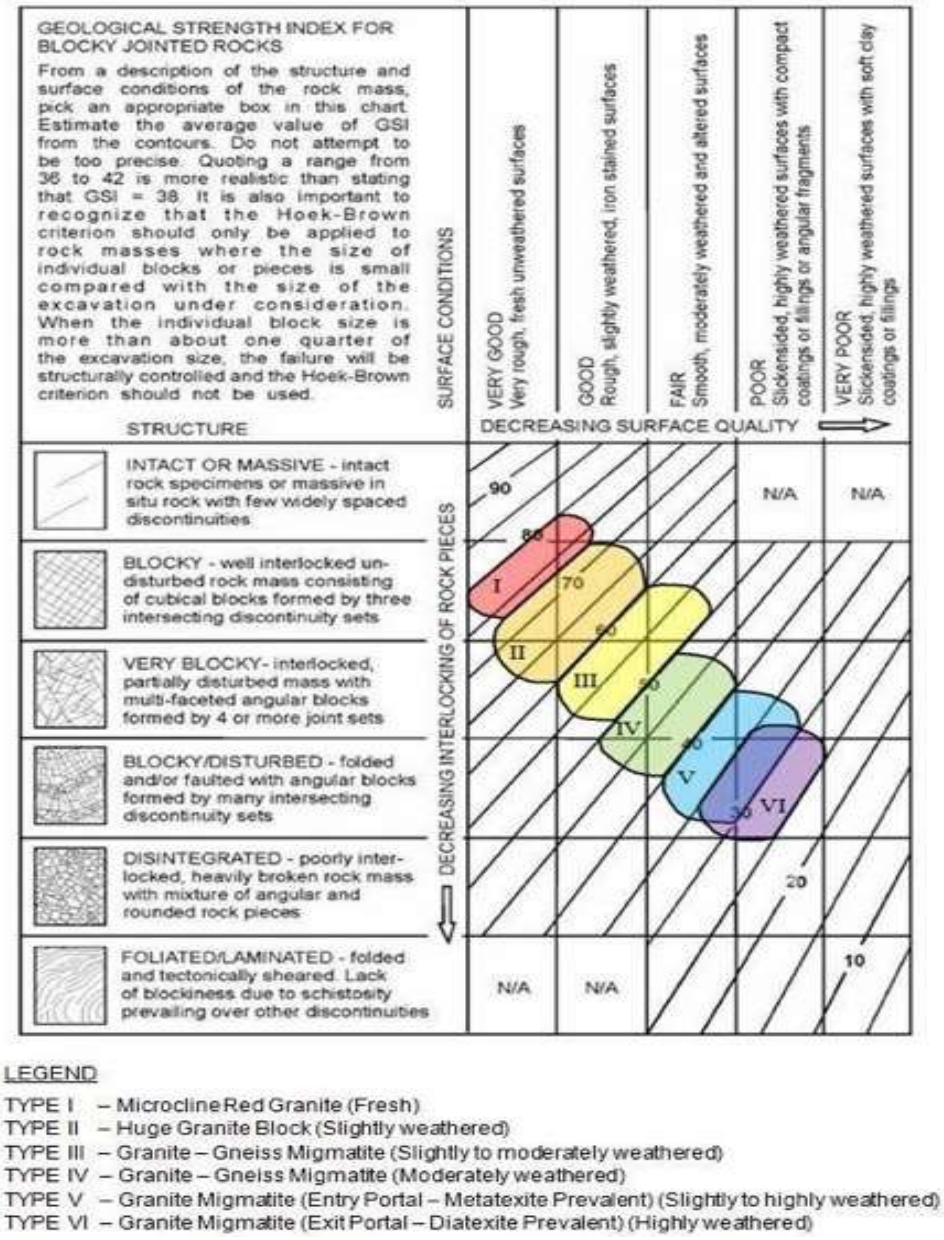
TYPE-VI: 0.1<Q≤0.4 (EXIT PORTAL)

Rock Type: Highly weathered Granit Migmatite (Diatexite prevalent)

20<GSI≤30→25<RMR≤35→0.12<Q≤0.37

Empirically Designed Tunnel Support Elements

Figure 4.9.3.1 - Localities of various rock types estimated along the Tunnel



LEGEND

TYPE I – Microcline Red Granite (Fresh)
TYPE II – Huge Granite Block (Slightly weathered)
TYPE III – Granite – Gneiss Migmatite (Slightly to moderately weathered)
TYPE IV – Granite – Gneiss Migmatite (Moderately weathered)
TYPE V – Granite Migmatite (Entry Portal – Metatexite Prevalent) (Slightly to highly weathered)
TYPE VI – Granite Migmatite (Exit Portal – Diatexite Prevalent) (Highly weathered)

The following important geotechnical considerations for SUPPORT TYPES of Tunnel #3 Project are made:

- Due to the heterogeneity of migmatite rocks, the probability of encountering TYPE-I support is only attributed to the existence of dyke-type red granites. This low probability could only materialize in red granitic rocks provided that they possess reasonably huge dimension where RMR≥78 (GSI=73).

- The Q=15 value calculated for TYPE-II is at the lower end of the range, but higher Q values can be encountered along the tunnel route.
- In cases where granitoid rock masses are encountered and are qualified to be TYPE-I and TYPE-II during the excavation stage, the dimensions of such rock masses that embrace the full tunnel section need to be investigated by fore-boring prior to making the final decision.

Tunnel Support Measures in Different Rock Classes

TYPE-I: Q≥40.0

ROOF:

No support required; for sake of work safety: 5cm of shotcrete (one layer)

L=4.0m, Ø=28, grouted, un-tensioned spot bolting.

WALL:

No support required

TYPE-II: 10.0≤Q<40.0

ROOF:

5cm of shotcrete (one layer)

s=2.0x2.0m, L=4.0m, Ø=28, grouted, untensioned systematic bolting.

WALL:

5cm of shotcrete (one layer)

L=4.0m, Ø=28, grouted, untensioned spot bolting.

TYPE-III: 4.0.≤Q<10.0

ROOF:

Two layers of shotcrete (5+5cm) with steel-mesh

s=1.5x1.5m, L=4.0m, Ø=28, grouted, untensioned systematic bolting.

WALL:

5 cm of shot-crete (one layer)

s=2.0x2.0m, L=4.0m, Ø=28, grouted, untensioned systematic bolting.

TYPE-IV: 1.0≤Q<4.0

ROOF:

Three layers of shotcrete (5+5+5cm) with 2 layers of steel-mesh s=1.0x1.0m, L=4.0m, Ø=28, grouted, untensioned systematic bolting.

WALL:

Two layers of shotcrete (5+5cm) with steel-mesh

s=1.0x1.0m, L=4.0m, Ø=28, grouted, untensioned systematic bolting

TYPE-V: 0.4≤Q<1.0

ROOF+WALL:

Three layers of shotcrete (7.5+7.5+5.0cm) with 2 layers of steel-mesh s=1.0x1.0m, L=4.0m, Ø=28, grouted, untensioned systematic bolting. s=1.5m, INP=100 steel arch

TYPE-VI: 0.1≤Q<0.4

ROOF+WALL:

Three layers of shotcrete (7.5+7.5+5.0cm) with 2 layers of steel-mesh s=1.0x1.0m, L=4.0m, Ø=28, grouted, untensioned systematic bolting. s=1.5m, INP=100 steel arch

Invert concrete

Material Parameters for Rock Masses

Table 18 below summarises the rock mass parameters determined based on the above rock mass classifications.

It is often a matter of debate among the geotechnical engineers as to which shear strength parameters should be used in the numerical analysis. In this context, our empirical experience suggests that the combination of RMR (Bieniawski, 1989) and Q System (Barton, 2002), provide more reliable shear strength values for rock masses as compared to the Hoek RocLab values which are based on Hoek and Brown failure criteria. In this respect, we have chosen the following mass shear strength parameters by utilizing the following formulas:

A: RMR (Bieniawski, 1989)→ c= 5 RMR (kPa); Ø=0.5 RMR+5

B: Q System (Barton, 2002→ c= (RQD/Jn)x(1/SRF)x(σ_i) [MPa]

The shear strength parameters of rock masses along with the other relevant parameters are presented in the Table 4.9.3.1.

Table 4.9.3.1: parameters of rock masses

SECTION	Entry Portal	Tunnel														Exit Portal
Lithology	GRANITE MIGMATITE (DIATEXITE)			Q-DIORITE GNEISS + META OPHIOLITE (METATEXITE)		RED GRANITE	Q-DIORITE GNEIESS + META OPHIOLITE (METATEXITE)		GRANITE MIGMATITE (DIATEXITE)		RED GRANITE	GRANITE MIGMATITE (DIATEXITE)				
KM	0+035 - 0+050	0+050 - 0+120	0+120 - 0+170	0+170 - 0+220		0+220 - 0+240	0+240 - 0+280		0+280 - 0+330		0+330 - 0+350	0+350 - 0+390	0+390 - 0+430	0+430 - 0+460	0+460 - 0+505	
RMR	35	45	50	60	70	78	70	60	55	60	78	55	50	45	30	
GSI	30	40	45	55	65	73	65	55	50	55	73	50	45	40	25	
Q	0.70	1.12	1.95	5.92	17.97	43.72	17.97	5.92	3.39	5.92	43.72	4.74	1.95	1.12	0.21	
Q Range	$0.4 < Q \leq 1.0$	$0.4 < Q \leq 1.0$	$1.0 < Q \leq 4.0$	$4.0 < Q \leq 10$	$10 < Q \leq 40$	$40 \leq Q$	$10 < Q \leq 40$	$4.0 < Q \leq 10$	$1.0 < Q \leq 4.0$	$4.0 < Q \leq 10$	$40 \leq Q$	$4.0 < Q \leq 10$	$1.0 < Q \leq 4.0$	$1.0 < Q \leq 4.0$	$Q \leq 0.4$	
Uniaxial Compressive Strength, s_c (MPa)	25	30	35	50	60	75	60	60	40	55	75	40	30	25	20	
Elastic Modulus, E (MPa)	813.83	2394.78	2509.90	4761.63	10229.79	24811.63	10229.79	5713.96	3590.15	7856.69	24811.63	3989.06	2151.34	1796.09	478.85	
Unit Weight (g) (MN/m^3)	0.024	0.024	0.025	0.026	0.026	0.027	0.027	0.027	0.026	0.026	0.027	0.025	0.025	0.024	0.023	
Cohesion, c (MPa)	0.200	0.250	0.250	0.300	0.350	0.380	0.350	0.300	0.275	0.300	0.380	0.300	0.250	0.225	0.200	
Internal Friction Angle, Φ (°)	25.00	30.00	30.00	35.00	40.00	44.00	40.00	35.00	32.00	35.00	44.00	35.00	30.00	28.00	25.00	
MR / (Ei)	400/16000	500/22500	500/25000	350/21000	375/26250	550/42900	375/26250	350/21000	450/24750	525/31500	550/42900	500/29000	500/29000	450/20250	400/16000	
mi	24	24	24	27	27	32	27	27	24	24	32	24	24	24	24	
mb	1.970	2.816	2.380	4.076	6.204	10.291	6.204	4.076	2.936	3.623	10.291	2.936	2.380	2.816	1.648	
s	0.0004	0.0013	0.0011	0.0039	0.0133	0.0357	0.0133	0.0039	0.0021	0.0039	0.0357	0.0021	0.0011	0.0013	0.0002	
a	0.522	0.511	0.508	0.504	0.502	0.501	0.502	0.504	0.506	0.504	0.501	0.506	0.508	0.511	0.531	
Overburden Height, h (m)	10	30	75	90		100	105		95	90	85	80	75	40	15	
SUPPORT TYPE	V		IV	III	II	I	II	III	IV	III	I	III	IV	V	VI	

Tunnel Support Elements for Design

Empirically designed support element recommendations, based entirely on Q- Classification System along with and rock material and mass parameters are already presented in previous sections. Under this heading, the design support systems, determined after the detailed evaluations with numerical analyses have been given.

TYPE-I: Q>40

Top Heading:

5 cm thick shotcrete

Spot rock bolts - L=4.0m, □=28 mm.

Bench:

5 cm thick shotcrete.

TYPE-II: 10≤Q<40

Top Heading:

10 cm thick shotcrete, incorporating one layer of wire mesh,

Systematic rock bolts – L = 4.0m, ϕ = 28 mm on 2.0m x 2.0m - 2.5m grid

Bench:

10 cm thick shotcrete, incorporating one layer of wire mesh.

TYPE-III: 4≤Q<10

Top Heading:

15 cm thick shotcrete with 2 layers of wire mesh,

Fore-poling L= 6m, ϕ = 28 mm (or 1.5") steel pipe, if required, INP 100 steel arch with 1.5m - 2.0m spacing, if required,

Systematic rock bolts – L = 4.0m, ϕ = 28 mm on 1.5m x 1.5m-2.0m grid.

Bench:

15 cm thick shotcrete with 2 layers of wire mesh,

INP 100 steel arch with 1.5m - 2.0 m spacing, if required,

Systematic rock bolts – L = 4.0m, ϕ = 28 mm on 1.5m x 1.5m-2.0m grid.

TYPE-IV: 1≤Q<4

Top Heading:

20 cm thick shotcrete with 2 layers of wire mesh,

Fore-poling L= 8.0m, ϕ = 28 mm (or 1.5" steel) steel pipe, INP 160 steel arch with 1.25m - 1.5m spacing,

Systematic rock bolts – L = 4.0m-6.0m, ϕ = 28 mm on 1.25m x 1.25m-1.5m grid.

Bench:

20 cm thick shotcrete with 2 layers of wire mesh, INP 160 steel arch with 1.25m - 1.5m spacing,

Systematic rock bolts – L = 4.0m, ϕ = 28 mm on 1.25m x 1.25m-1.5m grid.

TYPE-V: 0.4≤Q<1

Top Heading:

20 cm thick shotcrete with 2 layers of wire mesh, Fore-poling L= 8.0m, ϕ = 28 mm (or 1.5") steel pipe, INP 160 steel arch with 1.25m - 1.5m spacing,

Systematic rock bolts – L = 4.0m - 6.0m, ϕ = 28 mm 1.25 m x 1.25m-1.5m grid.

Bench:

20 cm thick shotcrete with 2 layers of wire mesh, INP 160 steel arch with 1.25m - 1.5m spacing,

Systematic rock bolts – L = 4.0m, ϕ = 28 mm on 1.25m x 1.25m-1.5m grid.

Invert:

20 cm thick shotcrete with 2 layers of wire mesh, INP 160 steel arch with 1.25m - 1.50m spacing.

TYPE-VI: 0.1≤Q<0.4

Top Heading:

25 cm thick shotcrete with 2 layers of wire mesh

Fore-poling L=6.0m – 8.0m, ϕ = 28 mm (or 1.5") steel pipe INP 160 steel arch with 0.75m - 1.15m spacing

Systematic rock bolts L = 6.0m - 9.0m, □=28 mm on 1.00 m x 0.75m-1.25m grid.

Bench:

25 cm thick shotcrete with 2 layers of wire mesh, INP 160 steel arch with 0.75m - 1.25 m spacing,

Systematic rock bolts – L = 6.0- 9.0 m, ϕ =28 mm on 1.0m x 0.75m-1.25m grid.

Invert:

25 cm thick shotcrete with 2 layers of wire mesh, INP 160 steel arch with 0.75m - 1.25 m spacing.

4.9.4 Geotechnical Conditions at Rikoti Tunnel Entry Portal

East Portal of new Rikoti Tunnel has a lateral distance of app. 100 m from the existing road and tunnel. Existing Rikoti Tunnel starts approximately 70 m after the new tunnel excavation.

Two boreholes were drilled to examine the geological condition at portal area; BH-RIK 10 at km:1+240 and left side of project axis, TBH-02 at km: 1+285 on project axis. Data from boreholes are summarized below.

BH-RIK-10

0.0 - 4.1m	Colluvium slightly sandy-silty highly clayey cont some small rock fragments, gravel in size very stiff to hard, SPT=50/5
4.1 - 7.6m	Colluvium highly sandy,slightly clayey containing high amount of rock fragments
7.6 - 23.0m	Diorite, moderately weak, moderately weathered, intense fractured to crushed CR= 39-65% RQD=0
23.0 - 36.0m	Diorite,very weak highly altered, completely weathered, intense fractured to crushed CR= 44-66% RQD=0

TBH-02

0.0 - 5.50m	Colluvium highly sandy, moderately clayey cont., high amount of rock fragments

5.5 - 8.2m Diorite, very weak, completely weathered, completely crushed CR= 40% RQD=0

8.2 - 12.3m Diorite, weak highly weathered, moderately altered, intense fractured crushed CR= 63-90% RQD=0

12.3 - 19.5m Diorite, weak to very weak, highly to completely weathered, highly altered, highly fractured to crushed CR= 55-98 % RQD=53,0,0,11,7

19.5 - 31.5m Diorite, very weak, highly to completely weathered crushed CR= 43-54 % RQD=0

Soil profile at east portal can be generalized as colluvium with an app. thickness of 8.00 m and weak-very weak, highly to completely weathered diorite. Colluvium consists of sand, clay, silt and rock fragments. Content of clay, sand and rock fragment content varies. For left slope due to the higher clay content □' (internal angle of friction) is taken as 28°. For the face slope due to the higher sand content □' (internal angle of friction) is taken as 32°. Cohesion and unit weight for the colluvium are 10 kPa and 19-20 kN/m^3 respectively.

For highly weathered rock the following values are estimated by Geological Evaluation;

□c (uniaxial compressive strength)=15
MPa GSI (Geological Strength Index)=25

mi=29

Considering those parameters and disturbance factor(D)=0.7 strength parameters for highly weathered rock are determined based on generalized Hoek Brown failure criterion and summarized in the below table.

Table 4.9.4.1 - Material Parameters Used in Slope Stability Analysis

Collluvium	Highly Weathered Rock	Fill of Cut & Cover
c = 10 kPa	c = 85 kPa	c = 5 kPa
□ = 28 - 32 degrees	□ = 37 degrees	□ = 35 degrees
□ = 19-20 kN/m^3	□ = 24 kN/m^3	□ = 21 kN/m^3

A high cut slope at the left cannot be avoided due to the topographical condition of the portal area. Considering the topographical properties of the portal area and geological condition, km: 1+260 is evaluated suitable for the start of the tunnel excavation. A cut and cover section is planned to be constructed at east portal between km: 1+230-1+260 for the long term stability of slopes. The upper slope at the left cut has an inclination of 1H/1V in colluviums and lower slopes mostly in weathered diorite have an inclination of 1H/3V. Inclination of the face cut slope and right cut are taken as 1H/3V and 2H/3V respectively.

It was found reasonable to apply support the slopes with self-drilling bolts (□32) based on the geotechnical evaluation and results of the limit-equilibrium analyses performed. For the face cut and upper 2 level of left cut, the support system has been designed as:

1.0m*1.0m rock bolt L=12 m self-drilling
bolt 20 cm shotcrete, wiremesh Q295/295

The lower level of left cut and right cut has been designed to be supported with;
1.5m*1.5m rock bolt L=6 m self-drilling bolt

20 cm shotcrete, wiremesh Q295/295

Slope stability analyses, using limit-equilibrium method, for cut slopes have been performed for 3 cases;

i) supported with self-drilling bolts-short term ($FS_{required} = 1.3$)

ii) supported with self-drilling bolts and cut and cover structure-long term ($FS_{required} = 1.5$)

iii) supported with self-drilling bolts and cut and cover structure-long term seismic ($FS_{required} = 1.1$)

Weep holes will be established with a pattern of 3x3 m and 12 m length at permanent slopes where drainage pipes will also be placed in order to ensure drainage of any groundwater or seeping water at the back of the shotcrete cover.

Exit Portal

West Portal of new Rikoti Tunnel is located has a lateral distance of app. 65 m from the existing road and tunnel. Existing Rikoti Tunnel ends app. 25 m after the new tunnel excavation.

One borehole was drilled to examine the geological condition at portal area; TBH-05 at km: 3+010 on project axis. Data from borehole are summarized below.

TBH-RIK-05

0.0 - 5.0m Artificial fill (highly sandy, highly gravelly-mostly alluvium origin);

5.0 - 11.8m Colluvium highly sandy, slightly clayey containing small amount of rock fragments;

11.8 - 17.0m Diorite,very weak, completely weathered, crushed CR= 52-55 % RQD=0;

17.0 - 24.0m Diorite, weak to very weak, highly to completely weathered, highly fractured to crushed CR= 41-45 % RQD=0

Soil profile at west portal can be generalized as soil layer (artificial fill+colluvium) with an app. thickness of 12.00 m and weak-very weak, highly to completely weathered diorite.

Artificial fill and colluvium has similar material content, so they have been evaluated as a single layer. While soil layer is highly sandy, highly gravelly, slightly clayey □' (internal angle of friction) is taken as 32°. Cohesion and unit weight for the colluvium are 10 kPa and 20 kN/m^3 respectively. Strength parameters for highly weathered rock determined for the east portal can be used also for the weathered rock at west portal.

A piled cut and cover tunnel has been designed to decrease slope height at portal area with the following construction sequence:

- Excavate to a level to use as a drilling platform
- Form piles along both side
- Construct roof and complete the portal structure
- Backfill over roof
- Excavate inside the portal and construct all finishing works

To obtain a platform for piles and roof deck a face and side cuts will be done temporary slopes with inclination of 2H/3V.

Slopes will be supported with self-drilling bolts (□32) with pattern of sh=1.5*sv=1.5 m, length of 8 m, tensile capacity of 280 kN, bond strength of 15 kN/m. Slope stability analyses have been performed with for the same cases defined in the previus section for entry portal.

Empirical Rock Classification Along The Tunnel Route

The geotechnical and geological evaluation regarding the rock mass classification and determination of tunnel excavation and support systems have been performed based on the same principles adopted for Tunnel #3, which have been explained in the previous section.

The geotectonic model of the project area suggests that granitic rocks are expected to be encountered along the whole length of the tunnel route; other rock types such as crystalline slate or volcanogenic sedimentary rocks are rarely likely to occur as xenolith (foreign inclusion). Owing to the several tectonic episodes, the granitic rocks have gone through their geologic history, and there is consequently a high possibility of encountering hydrothermally altered rock layers or pockets along the tunnel alignment. This implies that the issues that will influence the technical constructability of the tunnel will be determined by the chemical weathering and hydrothermal alteration of the granitic rocks which could have developed in the local fault zones.

Although not confirmed by official documents, there is anecdotal information (verbally expressed geotechnical views) that during and after the construction of the existing tunnel several collapses occurred in the tunnel. At this time, it is not possible to definitely identify the reason of these collapses, which may be due to either poor rock conditions or bad excavation and support implementations with old technology. Therefore, it is essential that the possibility of any alteration zones, that are theoretically assumed to be developed in local fault zones, need to be investigated by means of fore-drilling during tunnel driving.

The excavation and support systems have been evaluated based on Q-Classification System and also numerical analyses results. The same support systems, defined for Tunnel #3 will also be used for Rikoti Tunnel. Moreover, an additional support system for possible locations of faults along the tunnel route has been suggested as:

TYPE-VII: Fault Zone/Soil Type Material

Top Heading:

- 25 cm thick shotcrete with 2 layers of wire mesh
- Steel pipe reinforced grouting L=9.0m ϕ114 mm steel pipe
- INP 160 steel arch with 0.75m spacing
- systematic rock bolts L = 6.0m, □=28 mm on 1.00 m x 0.75m-1.25m grid.

Bench:

- 25 cm thick shotcrete with 2 layers of wire mesh,
- INP 160 steel arch with 0.75m m spacing,
- Systematic rock bolts – L = 6.0 m, ϕ =28 mm on 1.0m x 0.75m-1.25m grid.

Invert:

- 25 cm thick shotcrete with 2 layers of wire mesh,
- INP 160 steel arch with 0.75m spacing.

4.9.5 Geotechnical Conditions at Tunnel #4

It was not possible to access the Tunnel #4 route in order to perform boreholes, due to the topographical conditions and forest cover. Therefore, in order to provide data for the rock mass evaluations, geophysical tests have been performed for the tunnel portal locations by seismic refraction method, which has provided the shear wave and primary wave velocity variation along the investigation lines to a depth of about 40m. In this regard, the geological and geotechnical evaluations have been made based on the site inspections and geophysical investigation results.

Field observations made on the rock cuts based on the conceptual Geotectonic Working Model in the light of evaluations such as (i) visual imagery in the sense of creating thinking; (b) scientific and technical intuition and (c) empirical experience. These evaluations were essential to project the data collected from the rock-cut exposures to the tunnel alignment for geotechnical evaluations. In this context, our empirical experience directed us to the drainage gulleys where the best exposures are day lighted by running water. The fruits of such observation method are manifested by the rock exposures representing the typical sample of migmatite. Eventually with these data in hand, with due consideration of structurally variable rock mass characteristics of migmatites, the geological plan and profile are prepared. Another important aspect of the field observations was the rough estimation of "colluvium" depth. This issue was particularly important in the last part of the tunnel alignment due to the very limited overburden conditions. Here again, the best data is provided by the rock cuts along the existing terrain. Accordingly, our rough field estimation of colluvium depth in the lowland area observed to be between 6m to 3m.

Geophysical Investigations

At the study area, seismic profiling using refracted wave method up to 40m depth was done. Based on seismic profiling direct and shear wave velocities of elastic waves were observed, corresponding seismic-geological profiles were built. Based on geophysical observations as a result of all profiles three main layers was detected:

- Layer 1 – Surface layer which corresponds to the colluvium, highly sandy, slightly clay (with elastic wave velocity range: Vp=235-593 m/s, Vs=160-353 m/s);
- Layer 2- Intermediate layer which corresponds to diorite, completely weathered, very weak, containing a low amount of rock (with elastic wave velocity range: Vp=702-1814 m/s, Vs=380-894 m/s);
- Layer 3 – This layer follows to the Layer 2 and is observed up to a 40m depth which corresponds to diorite, moderately fractured, moderately weathered, weak, containing a high amount of rock (with elastic wave velocity range: Vp=1034-4101 m/s, Vs=582-2450 m/s).

Entry Portal

In the project area and near vicinity the stability problems of both open cuts and tunnel portals are mainly imposed by the thick accumulation of diluvial deposits, remnants of the last ice ages. It is fortunate that in this specific tunnel project, diluvial deposits are observed to be very scarce and the stability of portal areas is predominantly governed by the thickness of colluvium and depth of highly weathered granite migmatite.

Despite the fact that the geological section gives the impression of unstable ground, the close up examination leads to the following conclusions:

- The top soil is made up of completely weathered rock, which hardly sustains the trees, while moderately to highly weathered rock exposures are clearly seen on the surface.
- The weathering state of rock will upgrade to at least moderately weathered level so that open excavations with 1H:2V could maintain their temporary stability until the application of the required support elements.

Our empirical experience suggests that the following method of application support elements such as shotcrete with steel mesh, works successfully in relatively weak rock conditions:

- Two layers of shotcrete reinforced by steel mesh in the following sequence:
  * Steel mesh reinforced shotcrete will be applied all the rock surfaces including the berms and will be extended beyond the top of excavation passing through the head channel.
  * The systematic bolting pattern will be applied according to the geological conditions

prevailing, to be determined during the excavation.

Another important point worth mentioning about the entry portal is the method excavation. The rock conditions indicate that machinery excavation should be suitable. But there is a possibility of encountering competent rock layers such as q-diorite gneiss and red granite which will require blasting or excavation using rock breakers. In case such conditions prevail, *"cautious blasting techniques"* in terms of "pre-splitting" shall be applied. *"Vibration velocity"* and *"rock throw"* will be kept under control for both stability and environmental reasons.

Exit Portal

At the exit portal area the bedrock is obscured by the covering colluvium. Therefore the rock cuts on the existing road have been used to interpret the geological conditions at the portal open cuts. Accordingly, the following conclusions are drawn:

- In the subsidiary creek competent rock exposures observed on the road level, extends up to the portal area with no sign of rock on the surface. Thus, it is a probability that such rock masses might be encountered in the portal area. But the predominant rock type is expected to be moderately to highly weathered granite migmatite.
- Superficial observations give the impression that the colluvium depth is around 4-5m at exit portal area, but could be deeper in some localities.
- The application of support elements and blasting technique recommended for entry portal is also valid for this portal.

Empirical Rock Classification Along The Tunnel Route

The geotechnical and geological evaluation regarding the rock mass classification and determination of tunnel excavation and support systems have been performed based on the same principles adopted for Tunnel #3, which have been explained in the previous section. The similar support types with a total number of six (Type I to Type VI) have been suggested for the tunnel construction.

4.9.6 Cautious Blasting Technique and Ground Vibrations

The expression "cautious blasting" primarily refers to blasting carried out in built-up areas and sensitive construction sites with regard to surrounding buildings, installations and facilities in terms of "vibration velocity" and "rock throw". As there are indispensable needs to blast in built-up areas and sensitive construction sites, blasting techniques and damage criterion have been developed to carry out the works accordingly. The "cautious blasting technique" by use of delay-time detonators and with due consideration of "allowable vibration velocity" is the appropriate solution to this problem. In this specific project "cautious blasting" in terms of "vibration velocity" for environmental concerns and "smooth blasting" in order not to disturb the rock in the tunnel periphery.

When planning the blasting, where ground vibration problems are likely to occur, it is important to make full use of the empirical relationship between distance/charging given as;

$V=k\,(Q/R^{3/2})^{1/2}$ (1) (Langefors relationship)
Where;

V= Vibration velocity in mm/sec

Q= Instantaneously detonating charge in kg,
R= Distance to the structure in question in m,

k= Constant (approximately 400 for Swedish hard rock)

Therefore, it is recommended that limiting vibration velocity of 50mm/sec is applied where the need for the application of cautious blasting is required.

4.9.7 Tunnel Geometry and Cross-Sections

Tunnel Alignment

The criteria that are considered in determining the alignment of the tunnels are:

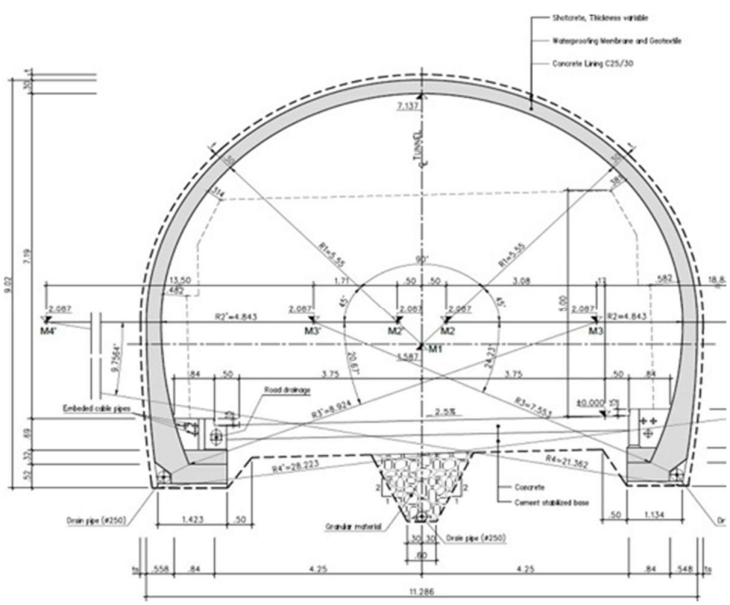
- The design speed for the road section is 80 km/hr. Based on this, the minimum radius of the horizontal alignment will be 450m in order to provide the minimum required stopping sight distance;
- The gradient (s%) of the tunnel will conform to the condition of s ≤ 5% given in the EU Directive (2004/54/EC of the European Parliament and of the Council on the minimum safety requirements for tunnels in the Trans-European Road Network)
- The minimum vertical sag curve radius is 3,200m while the minimum vertical crest curve radius is 5,000m, again to provide the minimum required stopping sight distance.

The original scope of the project covers the design of the left tubes of Tunnel #3 and the new Rikoti tunnel which are both on the left platform of the road. They will be constructed parallel to the right tubes. The separation distance between the tube axis of Tunnel #3 with the right tube varies between 18m-37.5m from the start to the end of tunnels. The minimum distance between the new (left) tube and the existing Rikoti tunnel will be 35m, in order to minimize the possible impact of the blasting and excavations for the new tunnel on the existing tubes. This distance is defined from the outside of the tunnel walls and correspond to approximately 3 x Tunnel Width. Tunnel #4 will be constructed as a single tube at the Right Branch, where the left and right branches are separated.

Tunnel Cross-Section

All tunnels will have two lanes serving unidirectional traffic. Other cross-section parameters are: the minimum vertical clearance of 5.0m, lane widths of 3.75m, edge clearance of 0.50m, walkway width of 0.75-0.85m and a walkway height of 0.15m. The cross-section of the tunnel will provide sufficient space to enable the installation of equipment such as lighting, ventilation, and traffic management systems and safety facilities in the area that falls outside of the clearance envelope for road traffic. Cross sections for tunnel with and without invert are given in the design drawings. The figure below shows the typical cross-section of Rikoti Tunnel.

Figure 4.9.6.1 - Typical Tunnel Cross-Section



Lay-Bys and Cross-Passages

According to the EU Directive, emergency exits for tunnel users to leave tunnels on foot, without their vehicles, (direct exit from the tunnel to the outside, cross-connections between tunnel tubes, exits to an emergency gallery, and shelters with an escape route from the tunnel tube) should be established with a maximum distance of 500m. Cross- passages for emergency services should be provided at least every 1500m. Lay-bys are mandatory for bidirectional tunnels longer than 1,500m, but not mandatory for unidirectional tunnels.

In this regard, one cross passage for pedestrians (interval < 500m) is planned in Tunnel 3 at km: 0+270. The cross sections of the emergency exit passage for pedestrians, with and without invert, are given in the design drawings. One cross passage for vehicles (interval < 1,000m) plus two cross-passages for pedestrians (interval < 500m) are planned in the Rikoti tunnel. A lay-by will be established in new Rikoti Tunnel and these will coincide with the axis of an emergency passage. The cross sections of the emergency exit passages for pedestrians and vehicles, with and without invert, are given in the design drawings. The cross-passages for Rikoti tunnel are summarized in the following table.

Table 4.9.6.1 - Cross-Passages & Lay-bys

Chainage	
1+230	Tunnel start
1+680	Emergency passage for pedestrian
2+130	Emergency passage for vehicle and Lay by
2+580	Emergency passage for pedestrian
3+030.80	Tunnel end

For Tunnel #4, which is single tube with a short tunnel with a length of 350 m, no lay-bys or cross passages are required.

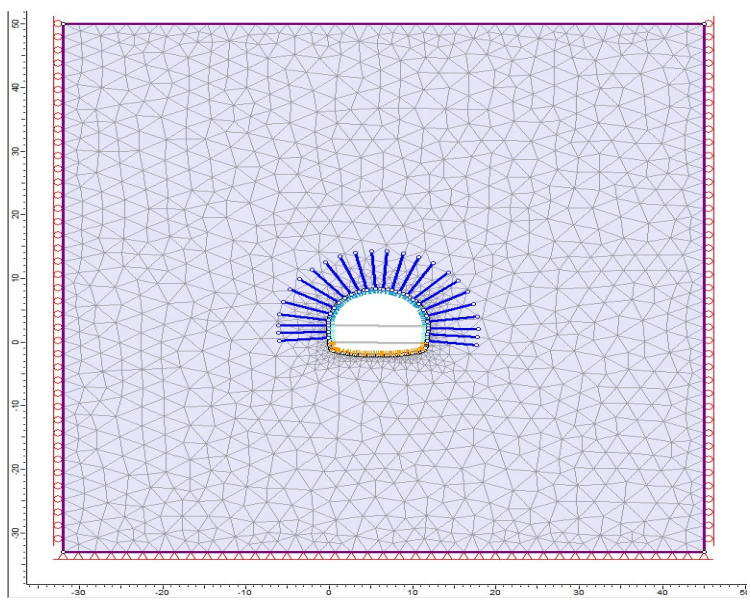
Numerical Analysis and Design of Excavation and Support Systems

In the stress analyses and support system design of tunnels, the computer program PHASE^{II} is used, which is one of the most common finite element program in underground excavations and tunnels. The program enables analysis of successive stress distributions, varying in accordance with the staged excavation + support method, in tunnel-soil systems modelled by the "Finite Element Method". Finite element method is particularly preferred for underground excavation. In this method, the rock mass surrounding the excavation is modelled by finite element method, whereas, the zone far from excavation is modelled by boundary conditions. Thus, non-linear (elasto-plastic) rock mass which exhibits heterogeneous behaviour, can be treated with discontinuity planes when required. Each element used in the model can have different geometries defined by the coordinates of nodes and isotropic or orthotropic material characteristics. The material data include: unit weight, elasticity modulus, Poisson's ratio, sand the strength parameters. The program can give the general (global) stresses, effective principle stresses, and deformations in elements, plasticization zones with respect to the required failure theory, separately for each type of loading and excavation stage as computer output or graphical drawings. As the numerical model of the tunnel to be designed, the topographical surface or effective load height, final excavation boundary of the tunnel section, internal boundaries showing excavation stages and material boundaries are defined in the PHASE^{II} program. If the shotcrete or internal lining included in the support system is bolts specified by a different material boundary, they can be defined in bilateral implementation spacings, i.e. surrounding the excavation and along the tunnel axis, as fully bonded, with end anchorages or as

prestressed. The stresses in staged excavation can be calculated from initial stresses prior to excavation and as cumulative when required or as the stress difference for any two excavation stages. The support system is also included in the system in any required stage as for the excavation stages. The shotcrete, bolts, anchorages and backfill can be defined for any stage. The material parameters for the excavation section are changed as required. Thus, part of the total rock mass is enabled to act on the support system. Finally, the soil is enabled to carry itself within allowable limits and the remaining load is enabled to be transferred to the support system.

The numerical models for tunnels are prepared so as to reflect the tunnel – soil interaction realistically as per the criteria specified in previous sections, and to increase the accuracy of the results as far as possible. In the models, the soil elements are intensified around the excavation particularly where stress accumulations are significant. As the models are prepared, the conditions that may cause the most unfavorable stresses during the excavation stage and support system implementation. The soil elevations over the tunnel are defined as the maximum soil elevation which may cause the most unfavorable stress in the zone where all types are valid. As the groundwater, support systems and design parameters are defined, rock classification is also considered. In portal zones actual ground surface is used in the model while top boundary of the model reflects the effective overburden in other analyze models due to the minor overburden change in section. The below figure shows a typical finite element model used for the computations:

Figure 4.9.6.2 - Example of Finite Element Model



The excavation and support systems, which have been evaluated based on the rock- mass classifications have been taken into account in the numerical analyses; and the displacements during excavation stages, the failure zones around the excavation, the forces acting on the support elements like shotcrete and rock bolts are analysed in detail in these numerical analyses. Detailed information about the numerical analyses, inputs and results can be found in the Design Report of each tunnel.

Monitoring Plan

Measurement stations will be established in the tunnel and 3 dimensional deformation measurements will be performed to check the adequacy of supports and control the stability of the

gallery. Spacing of measurement stations will be arranged according to ground condition and support class. The proposed spacings are 40m for Type I, II, III, 20m for Type IV, V and 10m for Type VI and VII.

Measurement points are reflectors mounted with convergence bolts to the rock. Three measurement points will be established after top heading excavation and additional two after bench excavation. They will be established at the nearest possible position to the face and will be protected from any damage. Measurements will be performed with an accuracy of +/- 1mm.

Measurement periods are foreseen as below however it will be arranged according to the site conditions;

Week 1: daily

Week 2: twice in a week

Week 3 and 4: once in a week
After Week 4: once in month

Measurements will be presented as graphs (absolute deformation in x, y and z direction versus time) with gallery advance data. They will be evaluated periodically.

Tunnel Electro-Mechanical Design

The design of the tunnel electro-mechanical Systems have been prepared in accordance with International design standards and norms. The following sub-systems have been designed as summarized:

- Fire Protection Systems Design has been performed including the tunnel ventilation systems, fire alarm and detection systems and fire-fighting systems. Based on the calculations, a total number of 26 (13 pairs) and 12 (6 pairs) of jet fans have been determined for Rikoti and Tunnel #3 ventilation systems respectively. A detailed fire alarm and detection system including heat and smoke detectors has been designed for Rikoti Tunnel and Tunnel #3. For Rikoti Tunnel and Tunnel #3, the detailed fire-fighting system design involved water supply system with fire water reservoir and pumps, a standpipe system with fire hose stations and Clean Agent (EM 200) suppression system. For Tunnel #4 (with a total length of 330 m except the portal structures), a ventilation or detailed fire-fighting system is not required due to its short length based on the current international standards.
- Mechnical Systems Design has been performed in detail for Rikoti Tunnel and Tunnel-3, including the pump room and transformer buildings.
- Electrical Systems Design has been performed for all Tunnels. For all tunnels, lighting calculations have been performed and detailed lighting design has been performed. The electrical supply and distribution systems have been designed for all tunnels. Communication systems, including tunnel monitoring and control, telephone, alarm, CCTV etc. have been designed for Rikoti Tunnel and Tunnel #3.

4.10 Retaining Walls

A considerable length of retaining walls has previously been constructed on the left side of the existing road where it runs adjacent to the Rikotula river, to retain the existing road platform. Some of these existing walls exhibit cracks in the surface elevation which indicates local failures of the concrete structure, while others are still in relatively good condition.

Irrespective of the condition of these walls, the layout of these walls is not compatible with the geometry of the new road alignment, and therefore all of the walls will have to be replaced with new reinforced concrete walls that have been designed to support the edge of the new road platform.

In all, 29 sections of retaining wall, with a total length of approximately 2,800 metres, are required to support the edge of the road platform of the Left Branch where it runs close to the edge of the Rikotula river. These walls, which have heights varying from 3 metres to 20 metres, are designed as reinforced concrete cantilever walls.

Elsewhere, significant lengths of retaining walls are required to support the edge of the road platform of the Right Branch a) where the Right Branch is raised relative to the adjacent Left Branch between Km 2+800 – 4+500 and between Km 6+600 – 6+500 and

b) in the steeply sloping ground between Km 4+500 – 6+500. The total length of walls that have been included in the design to support the road platform of the Right Branch is approximately 2,770 metres.

Retaining walls are also required at Rikoti Interchange (940 metres) and at Khevi Interchange (1,950 metres).

Overall, approximately 9,500 metres of retaining wall have been designed and will be constructed. The designs of the proposed walls have adopted 4 construction types:

- Mass concrete walls have largely been adopted where the height of the retained road platform requires a wall less than 4 metres high.
- Reinforced concrete cantilever walls have been adopted where the height ranges between 3 metres and 10 metres.
- On steeply sloping ground, or in areas where the foundation soils are weak, reinforced concrete cantilever walls with piled foundations have been adopted.
- Elsewhere, mechanically stabilised earth walls have been adopted as this form of construction becomes economical when the wall height exceeds 8m. However, as it demands a greater plan area for its construction, it is not suitable for use in all terrains.

As indicated in the Inception Report (March 2017), these design of these walls has been developed by adopting the following design codes:

Retaining Walls:	EuroCode EN 1990, 1991, 1992 (Structural Design)
	EN 1997, BS 8002, 8004 (Geotechnical Design)
Mechanically Stabilized	
Earth Walls:	BS EN 8006-1:2010

The lengths of each section of retaining walls can vary from as little as 10 metres (wall LB18) and extend to 235 metres (Wall LB15).

<u>Concrete Walls</u>

Both the Mass Concrete walls and the Reinforced Concrete walls will be constructed in panel lengths not exceeding 5 metres.

The retaining walls follow both the elevation and the axis of the highway. In cross- section, the thickness of the tops of the walls is typically 0.5m and increases up to 2.4m thick at the base for the highest walls. The visible face of the retaining walls will have a 25V: 1H slope, which is adopted mainly for aesthetics. A drainage layer is incorporated at the back of these walls, which is collected and dispersed by weepholes constructed through the base of the walls. Also, the base slabs of the reinforced cantilever walls will vary in thickness from 0.70m to 2.75m.

The reinforced concrete and mass concrete retaining walls will typically be founded directly on a layer of selected granular fill, with a minimum thickness of 0.6m depending on ground conditions. However, where conditions require, ground improvement using mass concrete will be adopted.

Mechanically Stabilised Earth Walls

Typically mechanically stabilised earth walls comprise a vertical facing panel supported by straps that are incorporated into the backfill behind the wall. The design relies on the friction grip that the compacted gravel has on the buried straps.

Examples of Mechanically Stabilised Earth Walls are:

a) *Reinforced precast concrete facing panels with geosynthetic strip reinforcements*

Figure 4.10.1Typical Reinforced Earth wall with precast concrete panels

b) *Gabions facing with coated steel wire double twist mesh reinforcements.*

In some cases, a combination of the wire mesh together with polymer geogrid reinforcements can be adopted in order to ensure the internal stability limit.

Figure 4.10.2 Example of Reinforced Earth wall with gabions facing

In some locations, box culverts are also located where retaining walls are included in the design to support the Left Branch of the road, and special measures have had to be adopted for the design of the retaining walls at these locations.

4.11 RELOCATION OF AFFECTED UTILITIES

4.11.1 Utilities that will be Impacted by the Construction Works

As indicated in Section 4.6 of this report, there are three utility types that will be affected by the road construction:

- Water services at Rikoti Interchange and at Khevi;
- 35KV and 10KV power lines at Rikoti Interchange plus 10KV power lines at Khevi. In addition, the existing and a 35KV substation at Rikoti Interchange will be relocated away from its current location adjacent to the Chumateleti river.
- Diversion of telecommunications cables – these cables run along the full length of the project and there protection and diversion will be a significant element among the many work activities.

The main issues associated with the diversion of these utilities are discussed below.

Diversion of Water Services

The water services that are to be diverted are:

a) At Rikoti Interchange, where an existing 200mm diameter steel pipeline is present on the north side of the existing road.

   This pipeline, which is owned by Khashuri Municipality, will be disturbed by the works needed for the new slip roads adjacent to the Right Branch.

   The existing pipeline, which is in poor condition and is leaking, starts in the Chumatelti river valley, upstream of the entrance to Rikoti Tunnel, and is then aligned along the back of the rock trap wall that was constructed at the base of the cuttings on the north side of the existing road over a length of 280 metres.

b) At Khevi, where the existing water supply to the school and the water supply to the police station will be interrupted by the road works.

<u>Water Pipeline Replacement at Rikoti Interchange</u>

A replacement 200mm diameter steel pipe will be installed adjacent to Slip Road 2 and the Right Branch of the motorway:

The replacement pipeline starts in the Chumateleti Valley, approximately 100 metres north of the entrance portal of Rikoti Tunnel, and then follows along the right side of the Right Branch between Km 13+540 – 14+000, and continues for a further 400 metres adjacent to Slip Road 2 to Ch. 0+030, with two crossings under the slip road (at Ch. 0+030 and at Ch. 0+180). The overall length of the replacement pipeline is approximately 800 metres.

A replacement truss bridge has also been included in the design to support the new pipeline where it crosses the Chumateleti river, as the existing structure is in a very poor condition.

A short length of 63mm diameter HDPE pipe will branch from the steel pipe and cross under the Right Branch at Km 13+947 to maintain the service to the buildings on the south side of the existing road.

Water Pipeline Replacement In Khevi

Two private water services are affected by the road scheme in Khevi. These pipelines supply water to the school (DIN 32 pipe) and the police station (DIN 50 pipe) in Khevi, and are fed from springs on the hillside to the north of the village.

The 32mm diameter water supply for the school is impacted on by the works for the interchange between Km 10+980 – 11+050. A replacement pipeline is provided, starting at Ch. 0+380 of the Service Road which it crosses at Ch. 0+400, and then connects to the right side of Slip Road 1, which it follows between Ch. 0+200 to along the south side to Ch. 0+300. The pipeline then crosses under Slip Road 2, passes just in front of Abutment A1 of the bridge at Khevi and then under Slip Road 3, which it follows for 40 metres to connect with the existing pipeline. The length of the replacement pipeline is 240 metres and significantly exceeds the length of the existing pipeline (133 metres within the affected section). Therefore, in order to reduce the loss of water pressure an enlarged 40mm pipeline is used for the replacement. This pipeline will be located in ducts at each road crossing.

The second pipeline crosses the existing road at Km 9+240 (Left Branch Chainage) and then runs in the shoulder on the south side of the existing road between Km 9+240 and Km 11+350. The replacement 50mm diameter pipeline will initially be located in the shoulder of the Right Branch for a length of 270 metres, and then crosses to the south side of the motorway in a steel duct. The route of this pipeline is then modified, to run along the left shoulder of the Service Road that is provided on the south side of the river up to the junction at Ch. 0+920. The pipeline then crosses the service road and runs along the west shoulder of the link Road for 40 metres and then follows the access road to the Police Station.

The overall length of the replacement pipe is approximately 1690 metres, which increases the length by 160 metres. Due to the low flow, there is no need to increase the size of this pipe. The pipeline will be located in ducts at each road crossing.

4.11.2 Electricity Utilities

Rikoti Interchange

The 800 metres long section of existing road alignment before the entrance to Rikoti Tunnel is characterised by the high intensity of electricity power lines connecting to and from the 35KV transformer that is located adjacent to the Chumateleti river. Theexisting infrastructure includes 3 high rise masts for the high voltage line supplying the sub-station as well as poles for 10KV lines.

As the layout of the interchange at Rikoti occupies most of the level ground adjacent to the Chumateleti river, it is necessary to undertake a major overhaul and renewal of the electricity infrastructure at this location. At the same time, new power lines are required to service the sub-stations that will be constructed for Tunnel #3 (1 No.) and for Rikoti Tunnel (2 No.).

The development of the designs for the replacement infrastructure and the new services has only been possible once the Technical Terms have been concluded between the service provider (Energo-Pro) and the Roads Department of the Ministry of Regional Development and Infrastructure.

Based on the final agreed layout, the 35 KV sub-station will be located approximately 90 metres before the tunnel entrance between the Left Branch and the Right Branch in the area currently occupied by buildings that were used as a camp during the rehabilitation of the existing Rikoti Tunnel.

The 35KV power line will be relocated onto xx replacement high pylons to carry the power line over the elevated Left Branch to the new sub-station.

10 KV power lines for the transformer sub-stations for Tunnel #3 and the new Rikoti Tunnel left tube will be supplied by the relocated sub-station.

In addition, a 10KV power line will be taken from the sub-station, through the left tube of Rikoti Tunnel and along the full length of the alignment to provide power for road lighting and for the small transformer sub-station for the tunnel #4 at Km 5+240 on the Right Branch.

4.11.3 Diversions of Telecommunications Cables

The telecommunications network services that need to be diverted relate to the fibre optic cables that are owned by Foptnet and PCmax. These cables are located in both shoulders of the existing road and run through the whole length of the project. Consequently, the planning of the replacement services has been a significant aspect of the project planning.

The services will be taken into ducts that will be installed in the left shoulder of the Left Branch of the new highway. Temporary relocation and protection of the existing utilities will be a contract requirement to ensure that the service is not interrupted except when making connections between the old and the new.

4.11.4 Access Roads

Due to the construction of the E60 highway improvement project, certain local roads and access roads leading to and from the localities and properties within the project area will be affected. Therefore, the local road network which will be interrupted by the construction must be redesigned.

During the development of the final layout of the project, works related to relocation of the roads intersected by the highway will be designed and detailed. It is also a requirement that traffic flows on these roads will be ensured throughout the construction works, by means of a temporary traffic management plan, which will be prepared as part of the development of the design

Due to the fact that the position of the two branches has not been finally established, it is not possible to finalise the designs of the access roads along the motorway.

Where existing access to properties is from the existing E60, access roads junctions towards/from the motorway will be designed to be right in/right out junctions and will incorporate acceleration / deceleration lengths (include tapers) for local traffic.

4.11.5 Emergency Escape Lanes

On the west side of the Rikoti Tunnel, the vertical alignment of the existing E-60 highway encounters a long, steep downgrade of approximately 6.8%, which exceeds normal standards for a modern highway. This down gradient will be reduced to 6.0% if the modified alignment of the Right Branch is accepted (refer to the discussion in Section 8.2 above. Even so, there is a risk that heavy goods vehicles could lose their brakes and go out of control at a high speed whichever alignment is adopted, though the risk will be reduced with a 6% gradient.

To mitigate negative impacts, if a brake failure should occur, two emergency escape lanes were constructed at chainage 4+500 and 6+500 on the existing E60. The emergency escape lanes leaving the main highway are designed for the purpose of taking out-of-control vehicles away from the main traffic stream and then slowing and stopping the vehicles. As part of the upgrade of the E-60, these existing emergency escape lanes will utilised and enhanced.

The existing emergency lanes use only gravity to gradually reduce the speed of a vehicle until it stops. As part of the detailed design, the design of these escape lanes will be enhanced by increasing the

rolling resistance by incorporating an arrester bed in the emergency escape lanes.

4.11.6 Stage Construction of the Works

A priority in the programming of the works will be to construct areas of new road pavement wherever possible adjacent to the existing road, either the permanent pavement for the new road carriageway or temporary road pavement, in order to maximise the opportunity to transfer traffic onto new road pavement at an early stage of the construction and thereby free up space to construct the adjacent works.

In cases where the new road carriageway overlaps the existing road and is to be constructed at a significantly different level from the existing road pavement, it might not always be possible for the new pavement to be constructed to the full width of the carriageway. In such circumstances, the earthworks and pavement will initially be constructed to a reduced width, following which traffic, either one direction or both directions, will be transferred to use the new road pavement. Construction will then continue in one or two more stages in the space released by the transfer of traffic onto the newly constructed road pavement.

In other instances where the construction is more complicated, such as the Rikoti Interchange and the Khevi Interchange, critical lengths of roads within the interchange area, such as the slip roads, will be constructed first so that traffic can be diverted onto the completed pavement to provide space for construction of earthworks embankments, retaining walls, road pavement and structures. In successive steps, traffic will be diverted onto completed works so that the remaining works of the interchange can be constructed.

4.11.7 Construction camps

There are locations of two construction camps (nos. 1 and 2) selected for the construction works at the pre-design stage (See the General location plan).

The area selected for construction camp #1 is a private non-agricultural plot of 4740 m^2. The selected plot is located adjacent to the existing E-60. There are old buildings and premises on the plot, which were a repairs area for vehicles in the past. As per the preliminary assessment, the existing structures can be used during the construction process and presumably, they will not be dismantled (See Fig. 1). The area selected for construction camp is located on the right bank of the river Rikotula and is under a strong anthropogenic impact. There is no topsoil in this area and the distance between it and the area with topsoil is 30-70 m. There are some trees and plants in this area and the nearest residential house (in village Tsakva) is approximately 780 m from the territory selected from construction camp #1.

Figure 4.11.7.1 Location of construction camp #1

In addition to the buildings and premises on the territory selected for the construction camp, various communications are necessary to provide, such as plants and equipment, offices, waste storage area, etc.

The territory selected for the construction camp #2 is a land plot of approximately 3000m^2 located in Khashuri Municipality, approximately 100 m from the eastern portal of Rikoti Tunnel, adjacent to E-60 Highway (it should be noted that this territory was used as a construction camp in the past in Rikoti Tunnel rehabilitation process). There are various communication lines on this territory, which can be used for the construction purposes in the future. The territory is fenced and the improved yard is finished and is with a concrete pavement. This area is distanced from the populated areas by a great distance. It should be noted that this territory was used as a construction camp in the past in Rikoti Tunnel rehabilitation process.

There is a forest massif adjacent to the area, where the trees and plants are planned to delist from the environment in order to build the project road. There is no topsoil spread immediately in the area selected for the construction camp.

Figure 4.11.7.2 . Construction camp #2

4.11.8 Construction Materials

During the road construction preference will be given to extracting material from existing quarries instead of opening the new quarry by the Contractor.Material purchase will only be permitted from licensed suppliers. It should be noted that major part of waste rock generated during earth works and tunneling may be used in the construction works.

The nearest existing sand and gravel quarries are:

- Ltd "New Space" - sand and gravel quarry of Chkherimela River (Kharagauli Municipality, village Sighandzile);
- Ltd "New Space" - sand and gravel quarry of Chkherimela River (I and II District)(Kharagauli Municipality, village Sighandzile);
- Sole Proprietor "George Kazarashvili" - "Vertkvichala" sand and gravel quarry on Dzirula River (Kharagauli Municipality, village Vertkvichala);

However, it should be noted that reserves of these quarries are not sufficient.Therefore, it is possible that sand and gravel will be transported from a considerable distance, including from existing quarries

in Zestafoni, Khashuri and Kharagauli Municipality.Most of them are located on the banks of Mtkvari and Kvirila rivers.

Bitumen and bituminous products are not produced locally in Georgia. Nowadays, bitumen is mainly imported from Iran, Azerbaijan and Romania. Bituminous products, which is necessary for the project (production and construction) must be imported and comply with European standards.

Cement is produced locally by shareholding companies SAQCEMENTI and KARTULI CEMENTI in Kaspi (60 km away from Tbilisi, to the north-west direction) and in Rustavi (30 km away from Tbilisi, to the South-East direction). Cement is produced in sufficient quantity and appropriate quality.

4.11.9 Generalised Support Types for Tunnels and Relevant Support Elements

For the formations along the tunnels, various Q values will be encountered within different intervals. Thus, the calculated Q values for the tunnels are defined in intervals with regard to rock quality and support categories.

The support classes and the relevant support elements are presented below within this context:

TYPE-I: 10≤Q<40 (ÖNORM class A2) Top Heading:

- 5.0 cm thick shotcrete,

- spot rock bolts - L=4.0m, =28 mm. Bench:

- 5.0 cm thick shotcrete.

TYPE-II: 4≤Q<10 (ÖNORM class B1) Top Heading:

- 10.0 cm thick shotcrete, incorporating one layer of wire mesh,

- systematic rock bolts – L = 4.0m, φ = 28 mm on 2.0m x 2.0m - 2.5m grid Bench:

- 10.0 cm thick shotcrete, incorporating one layer of wire mesh.

TYPE-III: 1≤Q<4(ÖNORM class B2) Top Heading:

- 15.0 cm thick shotcrete with 2 layers of wire mesh,
- forepoling L= 6m, φ = 28 mm (or 1.5”) steel pipe, if required,
- INP 100 steel arch with 1.5m - 2.0m spacing, if required,
- systematic rock bolts – L = 4.0m, φ = 28 mm on 1.5m x 1.5m-2.0m grid. Bench:
    - 15.0 cm thick shotcrete with 2 layers of wire mesh,
    - INP 100 steel arch with 1.5m - 2.0 m spacing, if required,
    - systematic rock bolts – L = 4.0m, φ = 28 mm on 1.5m x 1.5m-2.0m grid.

TYPE-IV:0.4≤Q<1(ÖNORM class B3-a)

Top Heading:

. - 20.0 cm thick shotcrete with 2 layers of wire mesh,

. - forepoling L= 8.0m, φ = 28 mm (or 1.5" steel) steel pipe,

. - INP 160 steel arch with 1.25m - 1.5m spacing,

. - systematic rock bolts – L = 4.0m-6.0m, φ = 28 mm on 1.25m x 1.25m-1.5m grid.

Bench:

- 20.0 cm thick shotcrete with 2 layers of wire mesh,
- INP 160 steel arch with 1.25m - 1.5m spacing,
- systematic rock bolts – L = 4.0m, φ = 28 mm on 1.25m x 1.25m-1.5m grid.

TYPE-V:0.1≤Q<0.4 (ÖNORM class B3-b)

Top Heading:

- 20.0 cm thick shotcrete with 2 layers of wire mesh,
- forepoling L= 8.0m, φ = 28 mm (or 1.5") steel pipe,
- INP 160 steel arch with 1.25m - 1.5m spacing,
- systematic rock bolts – L = 4.0m - 6.0m, φ = 28 mm 1.25 m x 1.25m-1.5m grid.

Bench:

- 20.0 cm thick shotcrete with 2 layers of wire mesh,
- INP 160 steel arch with 1.25m - 1.5m spacing,
- systematic rock bolts – L = 4.0m, φ = 28 mm on 1.25m x 1.25m-1.5m grid.

Invert:

- 20.0 cm thick shotcrete with 2 layers of wire mesh,
- INP 160 steel arch with 1.25m - 1.50m spacing.

TYPE-VI:0.01≤Q<0.1(ÖNORM class C2)

Top Heading:

- 25 cm thick shotcrete with 2 layers of wire mesh
- forepoling L=6.0m – 8.0m, φ = 28 mm (or 1.5") steel pipe
- INP 160 steel arch with 0.75m - 1.15m spacing

- systematic rock bolts L = 6.0m - 9.0m, =28 mm on 1.00 m x 0.75m-1.25m grid.

Bench:

- 25.00 cm thick shotcrete with 2 layers of wire mesh,
- INP 160 steel arch with 0.75m - 1.25 m spacing,
- systematic rock bolts – L = 4.0m, φ =28 mm on 1.0m x 0.75m-1.25m grid.

Invert:

- 25.0 cm thick shotcrete with 2 layers of wire mesh,

As stated above, Q classification recommends the supporting elements of a tunnel with a given span width and Q intervals and in this sense it is a sound reference plane for a rock mass classification for tunnels. However, at the determination stage of rock mass strength parameters and stand-up time of excavation, the parameters generated by the help of Q classification are not so reliable. RMR classification and Hoek & Brown failure criterion will be considered for the determination of design parameters by understanding their limitations.

It is known that RMR classification can be utilized to predict the unsupported stand-up time for analytical purposes. Moreover, RMR classification gives the opportunity for the evaluation of physical parameters such as deformation modulus, cohesion and angle of internal friction, for the analytical solutions of tunnel support design. It should however be noted that among these parameters, shear strength parameters obtained from RMR are too conservative and should be considered as parameters reflecting the features of discontinuities. On the other hand, the deformation modulus of rock mass generated from RMR can be considered to be optimistic values. Therefore, they may be required to be modified by using engineering judgment.

According to the NATM principles, a self-carrying arch is formed around the tunnel excavation by the primary support system and the final concrete lining is a constructive element for the lighting and ventilation equipment. The concrete lining will be designed to carry the self-weight of the lining, rock load due to reduction in the bearing load capacity of the primary support, temperature and shrinkage loads and seismic effects.

The proposed excavation and support systems will be analysed using the software (PHASE – 2) which is capable of modelling in situ stress conditions, excavation and the support sequence by finite element methods. The tunnel excavation and support will be analysed with 2 dimensional software using techniques to reflect the 3 dimensional sequence of tunnel excavation.

4.11.10 Trafic Management During Construction

Temporary Works

A major activity of the new road construction involves the excavation of large volumes of material to form the cuttings that will be the platform for the new road.

Where excavations are undertaken above the alignment of the existing road, it will be necessary to construct containment measures to prevent material from the excavations, and from the construction of embankments, from falling down the hillside onto the eisting road. The contract documents will therefore include a requirement for the selected contractor to construct temporary containment walls along the edge of the existing road at all times when earthworks are being undertaken at a higher elevation. Such walls can consist of pre-cast 'L-shaped' walls, 4m to 5m high. The panels will be linked using cables or steel bars to ensure that the load is distributed to adjacent panels.

Blasting in rock cuttings is another activity that can potentially affect the operation of the road. While it is recognised that traffic will have to be stopped for a period of 5 to 10 minutes while each blast takes place, it will be essential that modern blasting techniques are adopted to avoid fly rock blocking the road, which could involve extensive clean-up operations. Such measures will involve the use of multiple delays in the blasting sequence, to minimise the weight of explosive that is fired in each delay, as well as use of blast mats to prevent the surface rock from flying into the air. The contract documents will again prescribe that blasting trials must be undertaken and appropriate blasting techniques adopted at all times.

A crew with the mechanical shovels and road cleaners will be required to be available on site during each blast in case of any unforeseen rock movement. Such crews will be required to clear any rock falls with minimal delay to traffic.

Stage Construction of the Works

A priority in the programming of the works will be to construct areas of new road pavement wherever possible adjacent to the existing road, either the permanent pavement for the new road carriageway or temporary road pavement, in order to maximise the opportunity to transfer traffic onto new road pavement at an early stage of the construction and thereby free up space to construct the adjacent works.

In cases where the new road carriageway overlaps the existing road and is to be constructed at a significantly different level from the existing road pavement, it might not always be possible for the new pavement to be constructed to the full width of the carriageway. In such circumstances, the earthworks and pavement will initially be constructed to a reduced width, following which traffic, either one direction or both directions, will be transferred to use the new road pavement. Construction will then continue in one or two more stages in the space released by the transfer of traffic onto the newly constructed road pavement.

In other instances where the construction is more complicated, such as the Rikoti Interchange and the Khevi Interchange, critical lengths of roads within the interchange area, such as the slip roads, will be constructed first so that traffic can be diverted onto the completed pavement to provide space for construction of earthworks embankments,

Preparation of Detailed Design for the Construction of E60 Chumateleti-Khevi Section retaining walls, road pavement and structures. In successive steps, traffic will be diverted onto completed works so that the remaining works of the interchange can be constructed.

Temporary Traffic Diversions

Traffic management during construction will be particularly important in order to keep the traffic flowing on the road. The most critical sections where the new works could potentially disrupt the flow of traffic are in the section before Rikoti tunnel and the section of road alignment in the proximity of Khevi. In general, to the extent feasible, the traffic management will make use of the existing road pavement while construction of the new road pavement is carried out.

Although the specific details of traffic management have still to be prepared, it is relatively easy to predict the traffic management measures that will be required in the section in and around Khevi during construction of the interchange. In order to minimize the impact on traffic movement during construction of the interchange and the full dual carriageway cross-section, the slip roads for the Khevi Interchange that are adjacent to the Right Branch will be constructed first, together with the support measures for the new Right Branch and the underpass structure on the Right Branch. The west bound traffic will then be diverted onto the completed slip roads to provide space for construction of the embankment and road pavement for the Right Branch. Once these works have been completed, all traffic will be diverted onto the Right Branch carriageway, following which the

remaining works of the interchange will be constructed.

Sequential traffic management plans will be prepared for each section of road construction wherever the existing road will be occupied by the new road alignment.

Maximizing road safety and local amenity during the construction phase will be a priority in the establishment of the necessary traffic management procedures. Wherever construction operations are scheduled to take place adjacent to passing traffic, a clear zone will be included in the traffic management design and physical barriers installed between the work and the passing traffic.

5. ESIA METHODOLOGY

The ESIA process consisted of the six main activities that are common for similar studies conducted according to the international standards:

1 Collection of baseline data describing biophysical and social environment within the study area; desk studies and field surveys to address identified gaps in the existing data; update of information on topics and areas where significant negative impacts are expected.
2 Identification of the expected positive and negative impacts of the proposed works on the highway and of its operation thereafter; assessment of the likelihood and significance of the potential negative impacts; and development of mitigation measures.
3 Analysis of alternatives in terms of location, technology, design and operation, including the "no-project" alternative.
4 Development of the Environmental Management Plan.
5 Drafting of the ESIA report.
6 Information disclosure and stakeholder consultation

Background state of the atmospheric air:

As there has never been an atmospheric air observation station near Rikoti Tunnel, the methodical guidance (Resolution no. 38/N of the Minister of Labor, Health and Social Affairs of Georgia of February 24, 2003 "On Approving the Standards of Qualitative State of the Environment") can be used to evaluate the pollution of the atmospheric air with harmful substances, in particular, "Background concentrations for towns and settled areas without the observations over the atmospheric air quality" is determined depending on the number of people.

Emission calculation:

The relevant construction infrastructure will be used for construction works to be arranged in the mobilization phase of the construction. The construction infrastructure consists of: a concrete production unit, fueling station with relevant reservoirs, welding equipment, crushing and sorting shop, truck parking area, diesel reservoirs and conveyor belt, etc.

In line with the above-mentioned, the sources of pollution of the atmospheric air can be classified as organized and non-organized sources. The organized sources are: cement silos and fuel reservoirs. The non-organized sources are: truck parking areas, crushing and sorting shop and conveyor belt. The present chapter describes the emissions for the camp located near the settled area (the worst scenario).

Concrete production shop

A concrete production shop is destined to produce hard and transportable concrete mass. It is a stationary facility incorporating the following units:

- Concrete mixer, inert material supply system, pneumatic system, automated control system and operator's cabin.
- The concrete mixer has an internal lifting equipment, conveyor and belt conveyors ensuring the automated supply of inert materials.
- Inert material dosing system is made up of a gathering bin and automated dosing equipment. The dosing equipment is equipped with a precise dosing and supply system ensuring automated correction of the concrete mass.

- Water and additive (which is in a liquid phase) supply system is made up of a balancing chamber ensuring precise dilution. The system is equipped with an anti-corrosion pumping device.

The control system is automated and has a modern computer controller ensuring the automated control in the concrete production process and automated correction of the water amount.

Loading cement in the silos (equipped with a fabric filter), transporting and producing the cement mass will be accomplished in a hermetic state thus reducing the atmospheric pollution.

The concrete producing shops (concrete producing unit) are distinguished for minor atmospheric pollution, because as the concrete production process suggests, the technological process following the mixing of the naturally wet inert materials and cement is done with a wet method.

The sources of pollution of the atmospheric air are the following technological processes and equipment: processing of inert materials, truck parking area, diesel reservoir, belt conveyors and cement silos.

The actual humidity of gravel varies within the range of 9-10%, while that of sand is >10%.

2 cement silos with the total volume of 100 t (equipped with the relevant filter) will be installed at the plant. Open storages for sand and gravel (with 300 m^2 area each);

The total length of the belt conveyors is 20 m and the width of 1,0 m.

The emission is calculated for the peak values of the expendable materials. The concrete production receipt (for 1 m^3) is as follows: sand – 650 kg; gravel – 1100 kg; cement – 420 kg.

The maximum rated output of the concrete mixer is 50 m^3/h. The maximum presumable annual yield with two-shift labor (16 hrs.) is evaluated as 4000 t/year. Consequently, the annual output will be 50 m^3/h * 4000 t/year = 200,0 thousand m^3/year.

Sand- 0,65t x 50 m3/h x 4000h/year = 130 thousand t/year.

(the sand humidity does not exceed 3% and consequently, the emissions is not calculated)

Gravel-1,10 t x 50 m3/h x 4000h/year = 220 thousand t/year. [55 t/h]

Cement-0,420t x 50 m3/h x 4000h/year = 84 thousand t/year. [21 t/h]

In order to produce the given goods, the plant will be equipped with relevant equipment and devices and the relevant engineering infrastructure will be provided.

In line with the basic flow chart, an autoloader, through the ramp, will transfer sand and gravel to the measuring hopper (4 hoppers sized 3 m x 3m), following which, through the dosing systemoand belt conveyors, it will be supplied to the concrete production unit. At the same time, depending on the concrete grade to obtain, the computer system will regulate the relevant proportion of the ingredients (sand, gravel and cement) and sends them to the mixing aggregate. An hourly output of a concrete production unit is 80 m3/h. The ready concrete is directed to the end users by means of concrete trucks.

Emission calculation from a diesel reservoir (G-1)

The reservoir inspiratory valve is the source of atmospheric air pollution during the storage of oil products (small inspiration) and loading them (big inspiration).

The emissions of polluting substances are calculated in line with [10]. The quantitative and qualitative properties of polluting substances are given in **Table 5.1.**

Table 5.1. Quantitative and qualitative properties of polluting substances

Polluting substance		Max. single emission, g/sec	Annual emission, t/year
Code	Description		
333	Dihydrosulfide (Hydrogen sulfide)	0,0000091	0,0000005
2754	Alkanes C12-C19 (Saturated hydrocarbons C12-C19)	0,0032575	0,0001714

The source data to calculate the emission are given in **Table 5.2.**

Table 5.2. Source data to calculate the emission

Product	Qty a year, t/year		Reservoir design	Pump output, m^3/h	Reservoir capacity, m^3	Number of reservoirs	Simultaneity
	Bðð	Bðð					
Diesel fuel, group A.The liquid temperature is close to the air temperature	312	312	Above-ground vertical exploitation mode “dosing”. Emission limiting system – No.	30	25	2	+

The accepted legend, calculation formulae and calculation parameters and their substantiation are given below. Maximum single emission of the oil products vapor (g/sec) is calculated by formula:

$$M = (C1 \cdot K^{max}p \cdot V^{max}ч) / 3600, \text{ g/sec};$$

Annual emission of the oil products vapor is calculated by formula:

$$G = (У2 \cdot B_{оз} + У3 \cdot B_{вл}) \cdot K^{max}p \cdot 10^{-6} + Gxp \cdot K_{нп} \cdot N, \text{ t/year}.$$

У2,У3 – is the evarage specific emission from a reservoir during the year, in autumn-winter and spring-summer periods respectively, g/t. Its value is obtained from Annex 12.

Воз, ***Ввл***– is the amount of liquid to be loaded in the reservoir in autumn-winter and spring-summer periods, respectively, t.

$K_{max p}$- is the multiplier gained from the experiment. Its value is obtained from Annex 8.

Gxp-is the emission of oil products stored in one reservoir, t/year. Its value is obtained from Annex 13.

Кнп- is the multiplier gained from the experiment. Its value is obtained from Annex 12.

N - is the number of reservoirs.

Maximum single and annual emissions of the polluting substances in the atmospheric air are calculated below.

Diesel fuel:

M =3,92 · 0,1 · 30 / 3600 = 0,0032667 g/sec;

G =(2,36 · 312 + 3,15 · 312) · 0,1 · 10-6+ 0 · 0,0029 · 2 = 0,0001719 t/year;

Dihydrosulfide (Hydrogen sulfide):

M =0,0032667 · 0,0028 = 0,0000091 g/sec;

G =0,0001719 · 0,0028 = 0,0000005 t/year;

2754 Alkanes C12-C19 (Saturated hydrocarbons C12-C19):

M = 0,0032667 · 0,9972 = 0,0032575 g/sec;

G =0,0001719 · 0,9972 = 0,0001714 t/year;

Emission calculation from the cement silo (G-2)

The technological process of concrete production implies loading the cement into a silo from the cement truck by using a pneumatic method and its dosed supply by using a worm-and-peg method through the scales and directly into the mixer, where sand, grit, water and chemical additive (plasticizer) components are added in advance in line with the receipt.

As per the plant data, 84,0 thousand tons of cement must be supplied to a silo a year. The silo is equipped with a standard fabric filter, with a stated efficiency of 99,8% (a small sleeved fabric filter, grade КФЕ-С, so called “silo filter” is destined for the aspiration of excess pressure of the silos. Regeneration with compressed air. The filtered dust returns to the silo. The filter length is 200 m. The air consumption range is 300-1000m3/h. The filtration area is 5m2.

As per [7], the annual emission of cement dust will be 84000 t x 0,8kg/t x 10^{-3} = 67,2 t/year The emission, by considering the stated efficiency of the fabric filter will be:

67,2 t/year x (1-0,998)= 0,1344 t/year.

Calculation of a per-second emission of maximum single emission (g/sec):

Average load-carrying capacity of one cement truck is 30 t, the time of unloading is 1 hr (3600 sec); per-second emission of cement dust will be: 30t x 0,8kg/t x 103 / 3600sec = 6,667 g/sec;

By considering the efficiency of the fabric filter, we obtain: 6,667 g/sec x(1-0,998)= 0,014 g/sec.

The concrete mixer itself is a system closed from all sides and having no contact with the atmospheric air. Consequently, no dust is emitted into the atmospheric air.

(The elastic pipe installed on the concrete mixer is connected to the upper bunker and the dust originated during the materials loading, is directed backwards).

Calculated emission:

Code	Description of a substance	%	Mass (g/sec)	Mass (t/year)
2908	Inorganic (cement) dust	100	0,014	0,1344

Emission calculation from a belt conveyor (G-3)

The calculation is accomplished in line with the following methodical guidance [11].

The transportation is done by means of open conveyor belts with the width of 1 m. Its total length is 20 m. The design wind velocities (m/sec) are: 0,5(**K3= 1**); 4,5 (**K3= 1,2**). An average wind velocity: 4,5 (**K3= 1,2**).

The quantitative and qualitative properties of emisison of polluting substances are given in **Table 5.3**.

Table 5.3. Quantitative and qualitative properties of emission of polluting substances

Polluting substance		Max. single emission, g/sec	Annual emission, t/year
Code	Description		
2908	Grit	0,0054178	0,0780163

The accepted legend, calculation formulae and calculation parameters and their substantiation are given below.

The emission of the total mass of weighted particles occurring during the material transportation with an open belt conveyor, is determined by formula:

$$MK = 3,6 \cdot K3 \cdot K5 \cdot WK \cdot L \cdot l \cdot \gamma \cdot T, \text{ t/year};$$

Where,

K3 – is the multiplier, considering local weather conditions;

K5 – is the multiplier, considering the material humidity;

WK – is the specific dust-formation from the belt conveyor, kg/m2*sec;

L - is the width of the belt conveyor, m.

l- is the length of the belt conveyor, m.

γ - multiplier, considering the forming of fine particles of the material;

T- is the annual operating time, h/year;

Maximum single emission originated during the material transportation from an open belt conveyor, is determined by formula:

$$M'K = K3 \bullet K5 \bullet WK \bullet L \bullet l \bullet \gamma \bullet 10^3, \text{ g/sec};$$

Maximum single and annual emissions of the polluting substances in the atmospheric air are calculated below.

M'2908$^{0.5м/с}$= 1 · 0,1 · 0,0000045 · 20 · 1 · 0,5 · 10^3= 0,0045148*g/sec*;

M'2908$^{4.5м/с}$= 1,2 · 0,1 · 0,0000045 · 20 · 1 · 0,5 · 10^3= 0,0054178*g/sec*

M2908= 3,6 · 1,2 · 0,1 · 0,0000045 · 20 · 1 · 0,5 · 4000 = 0,0780163*t/year*.

Under Recommendation [8], during the technological process, followed by the emission of the weighted particles in the building not equipped by general exchange ventilation (emission takes place from the windows or door exits), or in the absence of the exhaust system, during the calculation of the emission of solid components into the atmospheric air, it is purposeful to correct the calculated value of the emission of harmful substances with 0,4 multiplier.

Emisison correction implies multiplying the calculated value by 0,4 multiplier:

Inorganic dust:

0,0054178 × 0,4 = 0,002167 g/sec;

0,0780163 × 0,4 = 0,0312 t/year.

Emission calculation from the inert material crusher (G-4)

The calculation is accomplished based on the following methodological guidance. The multipliers of specific dust emission in the raw material production are:

during the primary and secondary crushing: a) for dry material - 0,14 kg/t, and b) for wet material - 0,009 kg/t, respectively.

350 000 t/year × 0,009 kg/t ÷ 1000 = 3,15 t/year

3,15t/year ÷ 16h/day ÷ 250day/year÷ 3600 × 1000000 = 0,21875 g/sec.

Under Recommendation [8], p. (13), during the technological process, followed by the emission of the weighted particles in the building not equipped by general exchange ventilation (emission takes place from the windows or door exits), or in the absence of the exhaust system, during the calculation of the emission of solid components into the atmospheric air, it is purposeful to correct the calculated value of the emission of harmful substances with 0,4 multiplier.

Emisison correction implies multiplying the calculated value by 0,4 multiplier:

Inorganic dust:

0.21875 × 0,4 = 0,0875 g/sec;

2,52 × 0,4 = 1,26 t/year.

Emission calculation from a construction machine (excavator) (G-5)

A source of emission of polluting substances is the drives of the road-building machines operating under load or idling. The calculation is accomplished as per the following methodological guidance [9]. The quantitative and qualitative properties of emisison of polluting substances from road-building machines are given in **Table 5.5**.

Table 5.5. Quantitative and qualitative properties of emission of polluting substances from road-building machines

Polluting substance		Max. single emission, g/sec	Annual emission, t/year
Code	**Description**		
301	Sodium dioxide	0,0327924	0,472211
304	Sodium (II) oxide	0,0053272	0,0767112
328	Soot	0,0045017	0,064824
330	Sulphur dioxide	0,00332	0,047808
337	Carbon monoxide	0,0273783	0,394248
2732	Hydrocarbons oil fraction	0,0077372	0,111416

The calculation is accomplished in terms of ambient temperature of the working ground of the road-building machines.Number of working days: 250.

The source data to calculate the emission of polluting substances are given in Table 5.6

Table 5.6. Source calculation data

Description of road-building machines	Idling, min;	Qty	Operation time of one machine							No. of working days
			A day, h				in 30 min., min			
			Total	without load	Loaded	Idling	without load	Loaded	Idling	
	Caterpillar excavating machine, capacity: 61-100-60 KW (83-136 hp)	1 (1)	16	6,4	6,93333	2,66667	12	13	5	250

The accepted legend, calculation formulae and calculation parameters and their substantiation are given below:

Maximum single emission of an ***i***-the substance is calculated by formula:

$$\boldsymbol{G}_i = \sum^{k}_{k=1}(\boldsymbol{m}_{ДВ\ ik} \cdot \boldsymbol{t}_{ДВ} + 1{,}3 \cdot \boldsymbol{m}_{ДВ\ ik} \cdot \boldsymbol{t}_{НАГР.} + \boldsymbol{m}_{XX\ ik} \cdot \boldsymbol{t}_{XX}) \cdot \boldsymbol{N}_k / 1800, \text{ g/sec};$$

Where,

$m_{ДВ\ ik}$ – is the specific emisison of the *i*-th substance during a vehicle movement without a load, for the *k*-th group, g/min;

$1{,}3 \cdot m_{ДВ\ ik}$ – is the specific emisison of the *i*-th substance during a vehicle movement with load, for the *k*-th group, g/min

$m_{ДВ\ ik}$ –is the specific emisison of the *i*-th substance during a vehicle idling, for the *k*-th group, g/min;

$\boldsymbol{t}_{ДВ}$ -is the vehicle movement time in a 30-minute interval without a load, min;

$\boldsymbol{t}_{НАГР.}$ - is the vehicle movement time in a 30-minute interval with load, min;

t_{XX} -is the vehicle idling time in a 30-minute interval, min;

N_k – is the number of machines of the ***k-th*** group operating simultaneously in a 30-minute interval.

The total emission of the *i*-th substance from the road machines is calculated by formula:

$$M_i = \sum^{k}_{k=1}(m_{ДВ\,ik} \cdot t'_{ДВ} + 1{,}3 \cdot m_{ДВ\,ik} \cdot t'_{НАГР.} + m_{XX\,ik} \cdot t'_{XX}) \cdot 10^{-6}, \text{ t/year};$$

Where,

$t'_{ДВ}$ – is the total time of driving the machines of the ***k-th*** group without a load, min;

$t'_{НАГР.}$ – is the total time of driving the machines of the ***k-th*** group with load, min;

t'_{XX} – is the total time of idling of the machines of the ***k-th*** group, min;

The values of specific emission of polluting substances during the operation of the road-building machines are given in **Table 5.7.**

Table 5.7. Emission of polluting substancesspecific during the operation of the road-building machines, g/min

Type of a road-building machine	Polluting substance	Movement	Idling
Caterpillar excavating machine, capacity: 61-100 KW(83-136 hp)	Sodium dioxide (Nitrogen (IV) oxide)	1,976	0,384
	Nitrogen (II) oxide	0,321	0,0624
	Soot	0,27	0,06
	Sulphur dioxide	0,19	0,097
	Carbon monoxide	1,29	2,4
	Hydrocarbons oil fraction	0,43	0,3

The calculation of the annual and maximum single emissions of polluting substances (g/sec) is given below:

G_{301} = (1,976·12+1,3·1,976·13+0,384·5)·1/1800 = 0,0327924 g/sec;

M_{301} = (1,976·1·250·6,4·60+1,3·1,976·1·250·6,93333·60+0,384·1·250·2,666667·60)·10^{-6} = 0,472211 t/year;

G_{304} = (0,321·12+1,3·0,321·13+0,0624·5)·1/1800 = 0,0053272 g/sec;

M_{304} = (0,321·1·250·6,4·60+1,3·0,321·1·250·6,93333·60+0,0624·1·250·2,666667·60)·10^{-6} = 0,0767112 t/year;

G_{328} = (0,27·12+1,3·0,27·13+0,06·5)·1/1800 = 0,0045017 g/sec;

M_{328} = (0,27·1·250·6,4·60+1,3·0,27·1·250·6,93333·60+0,06·1·250·2,666667·60)·10^{-6} = 0,064824 t/year;

G_{330} = (0,19·12+1,3·0,19·13+0,097·5)·1/1800 = 0,00332 g/sec;

M_{330} = (0,19·1·250·6,4·60+1,3·0,19·1·250·6,93333·60+0,097·1·250·2,666667·60)·10^{-6} = 0,047808 t/year;

G_{337} = (1,29·12+1,3·1,29·13+2,4·5)·1/1800 = 0,0273783 g/sec;

M_{337} = (1,29·1·250·6,4·60+1,3·1,29·1·250·6,93333·60+2,4·1·250·2,666667·60)·10^{-6} = 0,394248 t/year;

G_{2732} = (0,43·12+1,3·0,43·13+0,3·5)·1/1800 = 0,0077372 g/sec;

M_{2732} = (0,43·1·250·6,4·60+1,3·0,43·1·250·6,93333·60+0,3·1·250·2,666667·60)·10^{-6} = 0,111416 t/year;

The value of maximum single emission of dust during the operation of a single-buckle excavator is determined by formula:

M = QExcxExKExcxK1xK2xN/TExc, g/sec,

Where,

QExc = is the specific emission of dust from 1m3 overloaded material, g/m3 [4,8]

E- is the buckle capacity, m3 [0,7-1]

M = QExc x E x $K_{\text{Ǝ}}$ x K1 x K2 x N/TExc = 4,8*1*0,91*1,2*0,2*1/30=0,035g/sec. The total dust emission during the operation of a single-buckle excavator is determined by formula:

G = M x 3600 x T x 10-6 = 0,035 x 3600 sec x 16 h x 250 day x 10-6 = 0,504t/year.

Emission calculation from a construction machine (bulldozer) (G-6)

The emission of air substances is identical to that of an excavator, while the maximum emission of the weighted particles is calculated as follows:

G = (Q_{Bul} x Q_{Dens} x V x K1 x K2 x N)/(TBC x $K_{\text{ƀƷ}}$), g/sec; Where,

Q_{Bul} -is the dust specific emission from 1 t of the material to be transported G/T-0,74

Q_{Dens} - is the rock density (t/m3-1,6).

K_1 – is the wind velocity coefficient (K1=1,2);

K_2 – is the humidity coefficient (K2=0,2);

N- is the number of techniques operating simultaneously (unit);

V – is the volume of a prism movement (m3) 3,5

TBC – is the bulldozer cycle time, sec. 80.

$K_{\text{ƀƷ}}$ - is the rock loosening coefficient ($K_{\text{ƀƷ}}$ -1,15)

G = (Q_{Bul} x Q_{Dens} x V xK1 x K2 x N)/(TBC x $K_{\text{ƀƷ}}$) = 0,74*1,6*3,5*1,2*0,2*1/(80*1,15) = 0,011 g/sec

The total dust emission during the bulldozer operation is determined by formula:

G = M x 3600 x T x 10-6 = 0,011 x 3600 sec x 16 h x 250 day x 10-6 = 0,1584t/year.

Emission calculation from keeping and storage of inert materials (G-7)

The calculation is accomplished as per the following methodological guidance [11].

Warehousing

Unloading of the bulk materials is done without a loading sleeve. As for the local conditions, the warehouse is open from all sides (*K4* = 1); the height of the material unloading is 1,0 m (*B* = 0,5);

volley unloading from the dump truck is done of over 10 t of the material (*K9* =0,1); design wind velocities (m/sec): 0,5 (*K3* = 1); 4,5 (*K3* = 1,2); average annual wind velocity: 4,5 m/sec: (*K3* = 1).

The quantitative and qualitative properties of emissions of polluting substances are given in **Table 5.8.**

Table 5.8. Quantitative and qualitative properties of emission of polluting substancesas per the methodology

	Polluting substance	Max. single emission, g/sec	Annual emission,
Code	Description		t/year
2908	Inorganic dust containing silicium dioxide of 70-20%	0,0586667	0,00084

The source data to calculate the emission of polluting substances are given in **Table 5.9**.

Table 5.9. Source calculation data

Material	Parameter
Inert material	Quantity of the unloaded material: G_h = 88 t/h; G_{annual} = 350000 t/year. The mass share of a dust fraction in the material: K_1=0,04. The share of dust converting into aerosol: K_2=0,02. Humidity >10% (K_5=0,1). The material sizes: 50-10 mm (K_7=0,5).

The accepted legend, calculation formulae and calculation parameters and their substantiation are given below. A maximum single dust emission is calculated by formula:

$$МГР = K1 \cdot K2 \cdot K3 \cdot K4 \cdot K5 \cdot K7 \cdot K8 \cdot K9 \cdot B \cdot Gч \cdot 10^6 / 3600, \text{ g/sec}$$

Where,

K1- is the weight part of dust fraction in the material (0-200 mkm);

K2- is the dust part (of the total dust weight part) transforming into an aerosol (0-10 mkm);

K3-is the multiplier, considering the local weather conditions;

K4-is the multiplier, considering the local conditions, degree of protection of the unit against the external impact, conditions of dust-formation;

K5-is the multiplier, considering the material humidity;

K7-is the multiplier, considering the material sizes;

K8- is the correction multiplier for various materials by considering the dipper types when using a different type of a transfer; *K8* = 1;

K9- is the correction multiplier for volley unload from the dump truck;

B –is the multiplier, considering the dropping height;

Gч–c is the amount of the material to transfer in one hour (t/h).

The total annual dust emission is calculated by formula:

$$ПГР = K1 \cdot K2 \cdot K3 \cdot K4 \cdot K5 \cdot K7 \cdot K8 \cdot K9 \cdot B \cdot Gгод, \text{ t/year}$$

Where,

Gгод- is the annual amount of the material to transfer, t/year;

Maximum single and annual emissions of the polluting substances in the atmospheric air are calculated below.

$$M2908^{0.5д/sec} = 0{,}04 \cdot 0{,}02 \cdot 1 \cdot 1 \cdot 0{,}1 \cdot 0{,}5 \cdot 1 \cdot 0{,}1 \cdot 0{,}5 \cdot 88 \cdot 10^6 / 3600 = 0{,}0488889 \text{g/sec};$$

$$M2908^{4,5д/sec} = 0{,}04 \cdot 0{,}02 \cdot 1{,}2 \cdot 1 \cdot 0{,}1 \cdot 0{,}5 \cdot 1 \cdot 0{,}1 \cdot 0{,}5 \cdot 88 \cdot 10^6 / 3600 = 0{,}0586667 \text{ g/sec};$$

$$П2908 = 0{,}04 \cdot 0{,}02 \cdot 1{,}2 \cdot 1 \cdot 0{,}1 \cdot 0{,}5 \cdot 1 \cdot 0{,}1 \cdot 0{,}5 \cdot 350 = 0{,}00084 \text{ t/year}.$$

Warehousing

The calculation is accomplished as per the following methodological guidance [11]. The quantitative and qualitative properties of emisison of polluting substances are given in Table 10.

Table 5.10. Quantitative and qualitative properties of emisison of polluting substances

Polluting substance		Max. single emission, g/sec	Annual emission, t/year
Code	Description		
2908	Inorganic dust with 70-20% content of silicium dioxide	0,0055915	0,0911493

The maximum single emission of dust during the warehousing the bulk material is calculated by formula:

$$MXP = K4 \cdot K5 \cdot K6 \cdot K7 \cdot q \cdot Fраб + K4 \cdot K5 \cdot K6 \cdot K7 \cdot 0{,}11 \cdot q \cdot (Fпл - Fраб) \cdot (1 - \eta), \text{ g/sec}$$

Where,

K4-is the multiplier, considering the local conditions, degree of protection of the unit against the external impact and conditions of dust-formation;

K5-is the multiplier, considering the material humidity;

K6-is the multiplier, considering the profile of the stored material;

K7-is the multiplier, considering the sizes of the material;

Fраб- is the area in the plan with regular warehousing operations (m^2);

Fпл- is the area of dust-formation in the plan (m^2);

q – is the maximum single emission (g/sec) of specific dust formation, g/(m^2*sec);

η – is the emission reduction degree by using a dust-reducer system.

The value of multiplier ***K6*** is determined by formula:

$$K6 = F_{макс} / F_{пл}$$

Where,

Fмакс- is the factual area of the stored material in terms of a full warehouse, m^2;

The maximum value of the dust specific dust-formation is determined by formula: g/(m2*sec);

$$q = 10^{-3} \cdot a \cdot U^b, \text{ g/(m}^2\text{*sec)};$$

Where,

a and ***b*** – are empirical coefficients depending on the type of the material to transfer;

Ub –is the wind velocity, m/sec;

Total annual dust emission in case of warehousing the bulk material is calculated by formula:

$$П_{ХР} = 0{,}11 \cdot 8{,}64 \cdot 10^{-2} \cdot K4 \cdot K5 \cdot K6 \cdot K7 \cdot q \cdot F_{пл} \cdot (1 - \eta) \cdot (T - T_д - T_c) \text{ t/year};$$

Where,

T –is the full time of storage of the material in the time under consideration (day);

Tд- is the number of rainy days;

Tc- is the number of days with stable snow cover.

The design parameters and their values in are given in **Table 5.11**.

Table 5.11. Design parameters and their values

Design parameters	**Values**
Material to transfer: inert material empirical coefficients, which depend on the type of the material to transfer	***a*** = 0,0135 ***b*** = 2,987
Local conditions: the warehouse is open from all four sides	***K4***= 1
Material humidity: up to 10%	***K5***= 0,1
Surface profile of the stored material	***K6***= 600 / 400 = 1,5
Material sizes: 500-100 mm	***K7***= 0,5
Design wind velocities, m/sec	***U'*** = 0,5; 4,5
Average annual wind velocity, m/sec	***U*** = 4,5
Working surface of the unloading works, m^2	***Fраб***= 20
Area of dust-formation in the plan, m^2	***Fпл***= 400
Actual area of dust-formation in the plan, m^2	***Fмакс***= 600
Full time of storage of the material in the time under consideration (day)	***T*** 366
Number of rainy days	***Tд***= 70
Number of days with stable snow cover	***Tс***= 31

Maximum single and annual emissions of the polluting substances in the atmospheric air are calculated below.

<u>Inert material</u>

$q2908^{0.5\ m/sec} = 10^{-3} \cdot 0{,}0135 \cdot 0{,}5^{2.987} = 0{,}0000017$ g/(m^2*sec); $M2908^{0.5\ m/sec} = 1 \cdot 0{,}1 \cdot 1{,}5 \cdot 0{,}5 \cdot 0{,}0000017 \cdot 20 + 1 \cdot 0{,}1 \cdot 1{,}5 \cdot 0{,}5 \cdot 0{,}11 \cdot 0{,}0000017 \cdot (400 - 20) = 0{,}0000079$ g/sec;

$q2908^{4,5\ m/sec} = 10^{-3} \cdot 0{,}0135 \cdot 4{,}5^{2.987} = 0{,}0012064$ g/(m^2*sec); $M2908^{4,5\ m/sec} = 1 \bullet 0{,}1 \bullet 1{,}5 \bullet 0{,}5 \bullet 0{,}0012064 \bullet 20 + 1 \bullet 0{,}1 \bullet 1{,}5 \bullet 0{,}5 \bullet 0{,}11 \bullet 0{,}0012064 \bullet (400 - 20) = 0{,}0055915$ g/sec;

$q2908 = 10^{-3} \cdot 0{,}0135 \cdot 4{,}5^{2.987} = 0{,}0012064$ g/(m^2*sec);

$П2908 = 0{,}11 \cdot 8{,}64 \cdot 10^{-2} \cdot 1 \cdot 0{,}1 \cdot 1{,}5 \cdot 0{,}5 \cdot 0{,}0012064 \cdot 400 \cdot (366-70-31) = 0{,}0911493$ t/year

Total of disposal + storage (2908) will be:

g/sec: Warehousing + Storage	0,0586667	0,0055915	∑ 0,06425
t/year: Warehousing + Storage	0,00084	0,0911493	∑ 0,091989

Emission calculation from a diesel generator set (50 KW) (G-8)

The calculation is accomplished as per the following methodological guidance [7]. During the exploitation of a stationery diesel-generator, harmful (polluting) substances are emitted in the discharge gases in the atmospheric air. The values of single emissions of maximum single emission (g/sec) of gases are calculated by using the data of a diesel-generator unit taken from the technical documents (exploitation capacity), while the annual emission is calculated by using the annual fuel consumption.

The quantitative and qualitative properties of emission of polluting substances are given in **Table 5.12.**

Table 5.12. Quantitative and qualitative properties of emission of polluting substances

Polluting substance		Max. single emission, g/sec	Annual emission, t/year
Code	Description		
301	Nitrogen dioxide (nitrogen (IV) oxide)	0,0457778	0,688
304	Nitrogen oxide (II)	0,0074389	0,1118
328	Soot	0,0027778	0,04285
330	Sulphur dioxide	0,0152778	0,225
337	Carbon monoxide	0,05	0,75
703	Benzpyrene	0,0000001	0,0000008
1325	Formaldehyde	0,0005972	0,00855
2732	Hydrocarbons oil fraction	0,0142917	0,2143

The source data to calculate the emission are given in **Table 5.13**.

Table 5.13. Source calculation data

Data	Capacity KW	Fuel consumption t/y	Specific Consumption g/KW*h	Simultaniety
Manufacturer Group A EU countries, USA, Japan Average capacity: (Ne < 73,6 KW; n = 1000-3000 rpm) before repairs.	50	50	250	+

Maximum emission of an ith polluting substance from a stationery diesel-generator is determined by formula: ***Mi***= (1 / 3600) · ***eMi*** · ***PЭ***, g/sec;

Where,

eMi – is the emission of an ith polluting substance from a diesel-generator in terms of rated mode, g/KW*h;

PЭ- is the exploitation capacity of the diesel-generator, KW;

(1 / 3600) – is the recalculation of the multiplier from hours to seconds.

The total annual emission of the ith polluting substance from a diesel-generator is determined by formula: ***WЭi***= (1 / 1000) · ***qЭi*** · ***GT***, t/year

Where,

qЭi - is the emission of an ith polluting substance from a diesel-generator per 1 kg of fuel, g/kg;

GT- is the annual fuel consumption of the diesel-generator, t/year;

(1 / 1000) – is the recalculation of the multiplier from kilograms to tons.

The consumption of the discharge gases from the diesel-generator is determined by formula:

$$GОГ = 8{,}72 \cdot 10^{-6} \cdot bЭ \cdot PЭ, \text{ g/sec};$$

Where,

bЭ – is the specific fuel consumption in the exploitation mode, g/KW*h;

The volumetric consumption of the discharge gases from the diesel-generator is determined by formula:

$$QОГ = GОГ / \gamma ОГ, \text{ m3/sec}$$

Where,

γОГ - is the specific weight of the discharge gases, which is determined by formula:

$$\gamma ОГ = \gamma ОГ(t=0°C) / (1 + TОГ / 273), \text{ kg/m}^3$$

Where,

γОГ(t=0°C) – is the specific weight of the discharge gases at 0°C,

γОГ(t=0°C) = 1,31kg/m³;

TОГ- is the temperature of the discharge gases, *K*.

In case of organized specific emission of formed gases from a stationery diesel units (height: up to 5 m) into the atmospheric air, the value of temperature may be taken at 450°C, while it may be taken as 400 °C in case of specific emission from 5 to 10 m.

The maximum single and annual emissions of polluting substances into the atmospheric air are calculated below:

Nitrogen dioxide (Nitrogen (IV) oxide):

M=(1 / 3600) · 3,296 · 50= 0,0457778g/sec;

WЭ=(1 / 1000) · 13,76 · 50 = 0,688 t/year;

Nitrogen oxide (Nitrogen (II) oxide):

M=(1 / 3600) · 0,5356 · 50 = 0,0074389 g/sec;

WЭ=(1 / 1000) · 2,236 · 50 = 0,1118t/year;

Soot:

M=(1 / 3600) · 0,2 · 50 = 0,0027778 g/sec;

WЭ=(1 / 1000) · 0,857 · 50 = 0,04285t/year;

Sulphur dioxide:

M=(1 / 3600) · 1,1 · 50 = 0,0152778 g/sec;

WЭ=(1 / 1000) · 4,5 · 50 = 0,225 t/year;

Carbon oxide:

M=(1 / 3600) · 3,6 · 50 = 0,05 g/sec;

WЭ=(1 / 1000) · 15 · 50 = 0,75t/year;

Benzpyrene:

M=(1 / 3600) · 0,0000037 · 50 = 0,0000001 g/sec;

WЭ=(1 / 1000) · 0,000016 · 50 = 0,0000008t/year;

Formaldehyde:

M=(1 / 3600) · 0,043 · 50 = 0,0005972g/sec;

WЭ=(1 / 1000) · 0,171 · 50 = 0,00855t/year;

Hydrogens oil fraction:

M=(1 / 3600) · 1,029 · 50 = 0,0142917g/sec;

WЭ=(1 / 1000) · 4,286 · 50 = 0,2143t/year;

The volumetric consumption of the discharge gases is given below:

G*ОГ*=8,72 · 10^{-6}· 250 · 50 = 0,109 kg/sec.

At the height of up to 5 m: **T**ОГ = 723 K (450 °C):

γОГ= 1,31 / (1 + 723 / 273) = 0,359066 kg/m3

Q*ОГ*= 0,109 / 0,359066 = 0,3036m3/sec

At the height of 5-10 m: **T**ОГ = 673 K (400 °C):

γОГ= 1,31 / (1 + 673 / 273) = 0,3780444 kg/m3

Q*ОГ*= 0,109 / 0,3780444 = 0,2883 m3/sec

Emission calculation from the construction machines (dump truck) (G-9)

During the initial heating and driving around the territory, as well as during idling. The calculation is accomplished as per the following methodological guidance. The quantitative and qualitative properties of emisison of polluting substances from the autoloader are given in **Table 5.14**.

Table 5.14. The quantitative and qualitative properties of emisison of polluting substances from the vehicles

Polluting substance		Max. single emission, g/sec	Annual emission, t/year
Code	Description		
301	Nitrogen dioxide (nitrogen (IV) oxide)	0,0032889	0,0086669
304	Sodium (II) oxide	0,0005344	0,0014084
328	Soot	0,0001583	0,0004172
330	Sulphur dioxide	0,0008333	0,002196
337	Carbon monoxide	0,0097778	0,0257664
2732	Hydrocarbons oil fraction	0,0044444	0,011712

The calculation is accomplished for the emissions from the road-building machines parking area at the environmental temperature. The driving distance of the road-building machines when leaving the parking area is 0,1 km and it is 0,1 km when entering the parking area. The duration of the engine operation when idling in case of leaving the parking area is 2 minutes and it is 0 minutes in case of returning to the parking area. Number of working days: 250, including 250 transient days.

The source data to calculate the emission of polluting substances are given in **Table 5.15.**

Table 5.15. Source calculation data

Machine type	Max. single emission of vehicles, g/sec Number of vehicles				Ecological control	Simultaneity
	Total	A day: Leaving/entering	Leaving 1h	Returning 1h		
Truck, before 1994 Carrying capacity: 8-16t		10	10	5	5	-

The accepted legend, calculation formulae and calculation parameters and their substantiation are given below:

The emission of the ith substance from the machine of a kth type when leaving the territory ***M1ik*** and at returning ***M2ik*** is calculated by formulae:

$$M1ik = mПРik \cdot tПР + mL\,ik \cdot L1 + mXXik \cdot tXX1, ȣ$$

$$M2ik = mL\,ik \cdot L2 + mXXik \cdot tXX2, ȣ$$

Where,

mПРik– is the specific emisison of the ith substance during the heating of the vehicle engine of a kth type, g/min.

mL ik– is the specific emisison of the ith substance during the driving of the vehicle of a kth type with the speed of 10-12 km/h, g/km.

mXXik– is the specific emisison of the ith substance during the idling of the vehicle of a kth type, g/min.

tПР- is the time of engine heating, min.

L1, ***L2***- is the distance driven by the vehicle on the territory of the parking area, km;

tXX1, ***tXX2***- is the engine idling at leaving or returning to the territory of the parking area, min;

When accomplishing the ecological control, the specific emission of vehicles reduces. Therefore, the emission values must be calculated by formula:

$$m'ПРik = mПРik \cdot Ki, \text{ g/min};$$

$$m''XXik = mXXik \cdot Ki, \text{ g/min};$$

Where,

Ki – is the multiplier, considering the reduction of the ith polluting substance during the ecological control.

The total emission of the ith polluting substance is calculated for each individual year by formula:

$$M^{i}j = \sum^{k}_{k=1} \alpha в (M1ik + M2ik) Nk \cdot DP \cdot 10^{-6}, \text{ t/year};$$

Where,

αв - is the multiplier of leaving the parking area;

Nk – is the number of vehicles of a kth type operating simultaneously in the design period.

DP- is the number of working days in the design period (warm, transient, cold).

j– is the period of a year (T- Warm, П- Transient, X-Cold).

In the cold and transient periods of the year, the impact of emission properties will be considered only for the vehicles leaving the parking area parked in open parking areas.

The value of general total annual emission ***Mi*** is calculated by summing up the emission of one kind of substance in different periods of the year: $Mi = M^{T}i + M^{П}i + M^{X}i$, t/year;

The maximum single emission ***Gi*** of the ith polluting substance is calculated by formula:

$$Gi = \sum^{k}_{k=1} (M1ik \cdot N'k + M2ik \cdot N''k) / 3600, \text{ g/sec};$$

Where,

N'k, ***N''k*** – is the number of vehicles of a kth type leaving and entering the parking area in 1 hour;

Out of the obtained values of ***Gi*** , the maximum single emission (g/sec) by considering the simultaneity of movement of vehicles of different groups will be selected.

Specific emission of polluting substances specific in case of reducing emission during the heating the engine, idling or ecological control, as well as in case of emission reduction when the vehicle is driving on the ramp, ***Ki***, are given in Table 5.16.

The specific emission of polluting substances from trucks with their base similar to that of autoloader is given in **Table 5.16**.

Table 5.16. Specific emission of polluting substances

Type	Polluting	Heating, g/min			Driving distance, g/km			Idling, g/km	Ecological control
		T	П	X	T	П	X		
A truck, carrying capacity: 8-16 t; with diesel engine									
	Nitrogen dioxide (nitrogen (IV) oxide)	0,408	0,616	0,616	2,72	2,72	2,72	0,368	1
	Sodium (II) oxide	0,0663	0,1	0,1	0,442	0,442	0,442	0,0598	1
	Soot	0,019	0,0342	0,038	0,2	0,27	0,3	0,019	0,8
	Sulphur dioxide	0,1	0,108	0,12	0,475	0,531	0,59	0,1	0,95
	Carbon monoxide	1,34	1,8	2	4,9	5,31	5,9	0,84	0,9
	Hydrogens oil fraction	0,59	0,639	0,71	0,7	0,72	0,8	0,42	0,9

The calculation of maximum single and annual emissions is given below:

M1=0,408 · 4 + 2,72 · 0 + 0,368 · 1 = 2 g;

M2=2,72 · 0 + 0,368 · 1 = 0,368 g;

M301= (2 + 0,368)· 366 · 10 · 10^{-6}= 0,0086669t/year;

G301=(2 · 5 + 0,368 · 5) / 3600 = 0,0032889 g/sec.

M1=0,0663 · 4 + 0,442 · 0 + 0,0598 · 1 = 0,325 g;

M2=0,442 · 0 + 0,0598 · 1 = 0,0598 g;

M304=(0,325 + 0,0598) · 366 · 10 · 10^{-6}= 0,0014084t/year;

G304=(0,325 · 5 + 0,0598 · 5) / 3600 = 0,0005344 g/sec.

M1=0,019 · 4 + 0,2 · 0 + 0,019 · 1 = 0,095 g;

M2=0,2 · 0 + 0,019 · 1 = 0,019g;

M328=(0,095 + 0,019) · 366 · 10 · 10^{-6}= 0,0004172t/year; ***G328***=(0,095 · 5 + 0,019 · 5) / 3600 = 0,0001583 g/sec. ***M1***=0,1 · 4 + 0,475 · 0 + 0,1 · 1 = 0,5 g;

M2=0,475 · 0 + 0,1 · 1 = 0,1 g;

M330=(0,5 + 0,1) · 366 · 10 · 10^{-6}= 0,002196t/year;

G330=(0,5 · 5 + 0,1 · 5) / 3600 = 0,0008333 g/sec.

M1=1,34 · 4 + 4,9 · 0 + 0,84 · 1 = 6,2 g;

M2=4,9 · 0 + 0,84 · 1 = 0,84 g;

M337=(6,2 + 0,84) · 366 · 10 · 10^{-6}= 0,0257664t/year;

G337=(6,2 · 5 + 0,84 · 5) / 3600 = 0,0097778 g/sec.

M1=0,59 · 4 + 0,7 · 0 + 0,42 · 1 = 2,78 g;

M2=0,7 · 0 + 0,42 · 1 = 0,42 g;

M2732=(2,78 + 0,42) · 366 · 10 · 10^{-6}= 0,011712t/year; ***G2732***=(2,78 · 5 + 0,42 · 5) / 3600 = 0,0044444 g/sec.

Maximum admissible concentrations of harmful substances in the atmospheric air

During the plant exploitation, the emission of harmful substances is expected. The maximum single and average daily maximum admissible concentrations of such an emission [5] are given in **Table 5.18.**

Table 5.18. Maximum admissible concentrations of harmful substances in the atmospheric air

№	Description of a harmful substance	Code	Maximum admissible concentration (MAC), mg/m^3	
			Max. single emission, g/sec	Average daily
1	Sodium dioxide	301	0,2	0,04
2	Nitrogen oxide	304	0,4	0,06
3	Soot	328	0,15	0,05
4	Sulphur dioxide	330	0,5	0,05
5	Hydrogen sulfide	0333	0,008	-
6	Carbon monoxide	337	5,0	3,0

7	Benzpyrene	0703	-	0,000001
8	Hydrogens oil fraction	2732	1,2	-
9	Saturated hydrogens (Alkanes C12-C19)	2754	1,0	-
10	Weighted particles	2902	0,5	0,15
11	Inorganic dust: 70-20% SiO2	2908	0,3	0,1

Calculation of harmful substances in the atmospheric air

Camp 1

The dispersion analysis was accomplished by using the data given above as per [12]. The dispersion analysis incorporated 12 individual substances, 4 aggregate impact groups and 1 incomplete aggregate impact group. MAC criteria were obtained [5].

Estimate grounds

№	Type	Full description of the ground				Width (m)	Step (m)		Height (m)	Comment
		Middle point coordinates, I side (m)		Middle point coordinates, II side (m)						
		X	Y	X	Y		X	Y		
1	Given	-1000	-100	1000	-100	1400	100	100	2	

Estimate points

№	Point coordinates (m)		Height (m)	Type of point	Comment
	X	Y			
2	-83,00	500,00	2	At the border of a 500-m zone	North
3	627,00	169,00	2	At the border of a 500-m zone	East
4	126,00	-503,00	2	At the border of a 500-m zone	South
5	-495,00	-37,00	2	At the border of a 500-m zone	West
1	-375,00	-610,00	2	Point on the border of the settled area	The nearest settlement

Camp 2

The dispersion analysis was accomplished by using the data given above as per [12]. The dispersion analysis incorporated 12 individual substances, 4 aggregate impact groups and 1 incomplete aggregate impact group. MAC criteria were obtained [5].

Estimate grounds

№	Type	Full ground description				Width (m)	Step (m)		Height (m)	Comment
		Middle point coordinates, I side(m)		Middle point coordinates, II side (m)						
		X	Y	X	Y		X	Y		
1	Given	-800	0	800	0	1500	100	100	2	

Estimate points

№	Point coordinates (m)		Height (m)	Type of point	Comment
	X	Y			
1	9,00	660,00	2	At the border of a 500-m zone	North
2	546,00	40,00	2	At the border of a 500-m zone	East
3	81,00	-513,00	2	At the border of a 500 m zone	South
4	-500,00	54,00	2	At the border of a 500 m zone	West

Literary sources used in calculations

1. Law of Georgia "On Environmental Permit"
2. Georgian Law "On Atmospheric Air Protection"
3. Resolution #42 of the Government of Georgia of January 6, 2014 "On Approving the Technical Regulation of the Inventory of the Stationary Sources of Pollution of Atmospheric Air"
4. Resolution #408 of the Government of Georgia of December 31, 2013 "On Approving the Technical Regulation of Calculation of Maximally Admissible Emission Standards of Harmful Substances into the Atmospheric Air"
5. Resolution no. 38/N of the Minister of Labor, Health and Social Affairs of Georgia of February 24, 2003 "On Approving the Standards of Qualitative State of the Environment"
6. Resolution #1-1/1743 of the Minister of Economic Development of Georgia of August 25, 2008 "Design Standards – Building Climatology"
7. Resolution #435 of the Government of Georgia of December 31, 2013 "On Approving the Technical Regulation of the Instrumental Method to Identify the Factual Amount of Emissions from the Stationary Sources of Pollution into the Atmospheric Air, Standard List of the Special Measuring Instruments to Identify the Factual Amount of Emissions from the Stationary Sources of Pollution into the Atmospheric Air and Methods to Calculate the Factual Amount of Emissions from the Stationary Sources of Pollution into the Atmospheric Air in Case of Different Technological Processes"

8. Methodical Text-Book to Calculate, Standardize and Control of the Emissions of Polluting Substances into the Atmospheric Air, СПб., 2002

9. Methods for Inventory of the Emissions of Polluting Substances from the Motor Transport Plants into the Atmospheric Air (by using a calculation method), Moscow, 1998.

10. Calculation of the Emissions of Polluting Substances is done in line with "The Methodological Guidance to Calculate the Emissions of Polluting Substances from the Reservoirs into the Atmospheric Air", Novopolotsk, 1997 (by considering the additions of the Research Institute "Atmosphere" 1999, 2005, 2010).

11. The Methodological Guidance to Calculate the Emissions of Polluting Substances from Non-Organized Sources in the Industry of the Construction Materials", Novorossiysk, 2001; Methodical Text-Book to Calculate, Standardize and Control of the Emissions of Polluting Substances into the Atmospheric Air, СПб., 200512. УПРЗА ЭКОЛОГ, version 3.00, Firm :Integral", Saint-Petersburg, 2001-2005.

Noise measurements

The background noise was measured by a Korean device "Wenca". The measurements were done at several points along the design road and on the territory of village Khevi at larger scales. At all design points, the measurements were done by using the following methods: the data of each point were taken (total 10 points) with 5-minute intervals, for half an hour (total 6 data) and the average noise level was calculated at all points (**Fig.5.1 and 5.2**).

The noise was measured along the existing road. The distance of different points of the design road to the existing road is different. Measurement was done at the turning point in village Tsakvi, at so called "Tsakvi spring", which is distanced by 126 m from the existing road and is located at the point distanced by 132 m from the road, on the edge of the road running to Tsakvi (this location is forest at present).

Figure 5.1. Noise measuring at the East portal of Rikoti tunnel	**Figure 5.2. Noise measuring on the existing road, near a public school in Khevi village**
	

At the border of the residential zone, sound level La (dbA) is identified under SNiP II-12-77M (Building Norms and Rules), which in the open space is calculated according to the following formula:

$$L = L_p - 15 \lg r + 10 \lg \Phi - \frac{\beta_a r}{1000} - 10 \lg \Omega$$

where
Lp– represents the octave-band of the sound wave at the design point, dbA;
L_W - is the octave-band pressure level of noise source, dbA;
r – is the distance between a source and a target point, m;
Φ– is a measureless factor of sound source direction, and its value varies according to acoustic radiation solid angle;
Ω – is solid angle of acoustic radiation (in radians) and for location in open space (on column, pipe, etc.) Ω = 4π, on a half-space (surface, such as floor, ground) Ω = 2π, for location in a dihedral angle Ω = π;
βa– is the octave-band of sound attenuation in the atmosphere (open space) (dbA/km) dependant on the sound frequency. Its values are given in the table below.

Average geometric frequencies of the octave lines, H Hz.	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
βa, dbA/km	0	0.3	1.1	2.8	5.2	9.6	25	83

By considering the table above, the total value noise impact of the equipment and machinery on the construction camp will be 100-105 dbA. The noise levels calculated by using the formula above (50, 100, 200, 500, 100 and 2000 m away) will be as follows:

$$L_{50} = L_p - 15\lg r + 10\lg \Phi - \frac{\beta_a r}{1000} - 10\lg \Omega, = 105 - 15*\lg 50 + 10*\lg 2 - 10.5*50/1000 - 10x\lg 2\ \pi = 74.02\text{dB}$$

$$L_{100} = L_p - 15\lg r + 10\lg \Phi - \frac{\beta_a r}{1000} - 10\lg \Omega, = 105 - 15*\lg 100 + 10*\lg 2 - 10.5*100/1000 - 10x\lg 2\ \pi = 68.98\text{dB}$$

$$L_{200} = L_p - 15\lg r + 10\lg \Phi - \frac{\beta_a r}{1000} - 10\lg \Omega, = 105 - 15*\lg 200 + 10*\lg 2 - 10.5*200/1000 - 10x\lg 2\ \pi = 63.41\text{dB}$$

$$L_{500} = L_p - 15\lg r + 10\lg \Phi - \frac{\beta_a r}{1000} - 10\lg \Omega, = 105 - 15*\lg 500 + 10*\lg 2 - 10.5*500/1000 - 10x\lg 2\ \pi = 54.29\text{dB}$$

$$L_{1000} = L_p - 15\lg r + 10\lg \Phi - \frac{\beta_a r}{1000} - 10\lg \Omega, = 105 - 15*\lg 1000 + 10*\lg 2 - 10.5*1000/1000 - 10x\lg 2\ \pi = 44.53\text{dB}$$

$$L_{2000} = L_p - 15\lg r + 10\lg \Phi - \frac{\beta_a r}{1000} - 10\lg \Omega, = 105 - 15*\lg 2000 + 10*\lg 2 - 10.5*2000/1000 - 10x\lg 2\ \pi = 29.51\ \text{dbA}$$

Background radiation measurements

Measurements of the background radiation were taken on October 15-16, 2016, by using a standard certified Russian appliance RADEX. Continuous measurements were done along the whole route (Figures 5.3 and 5.4) within the limits of the construction corridor and on the territory of village Khevi at larger scales.

Figure 5.3. Measurement taking at East portal secondary school in of Rikoti tunnel

Figure 5.4. Measurement taking at village Khevi

Radiation background was also measured at several points of the territory of the planned route, on the left bank of the river Rikotula. As per the measurements, the radiation background varied between 6 and 12 mR/h on the said territory.

Botanical survey

The assignment consisted of the desk top review of the primary and secondary data followed by the field works for reconnaissance of proposed road alignment. Survey was conducted in the period of September - October 2016.

The objective of the botanical study was to identify plant communities within the section of interest, reveal sensitive populations and, if found, provide quantitative characteristics thereof. With consideration of expected direct and indirect impact, the corridor of 100 m on each side of the centerline was surveyed. The field works included initial walkover through the corridor by experienced botanist, who was identifying specific habitats within the corridor and describing the extent. During the analysis of collected information, the sensitivity zones were identified for each section. After the information from initial walk over was analyzed, specific zones were identified to carry out more detailed (in depth) study of vegetation cover. This detailed information was used to fill the existing gaps (white spots) and provide full picture of baseline to be used as basis for proper ESIA. The needs for such detailed study were indicated during the screening and scoping process.

After the completion of the botanical survey of the road corridor, the detailed characteristics of sensitive areas have been analyzed. Based on the information gained from literature review and field surveys the moderate and high sensitive areas as well as presence of endemic, rare and other protected species in the project impact zone were identified.

Survey of fauna

Survey methods used for establishment of fauna baseline included a desk study of publicly available reference materials and field surveys along the road alignment, these two having different objectives.

The objectives of the desk study were: description of main wildlife habitats and animal species in the project region, revealing of sensitive habitats and species requiring particular attention or protection, identification of major wildlife data gaps and provision of basic information for proper planning and implementation of field surveys. The desk study was undertaken bearing in mind these objectives, prior to implementation of field surveys.

Fauna field survey has been undertaken in October 2016. It comprised entire project corridor, with the objectives to describe wildlife habitats along the road alignment, identify which sensitive fauna habitats reported/unreported in the literature could fall within the project RoW and determine territories disturbance of which should be avoided not to cause significant impact on wildlife. The "walkthrough" method was used to achieve these objectives. Animal species and signs of their vital activity (traces, droppings, dens, feather, etc.) encountered during the survey within or near the corridor were recorded.

The general faunistic overview of the study area was prepared, as well as the comprehensive description of the wildlife for the highway corridor. The information provided is a combination of the desk review and field survey findings. The results of the field surveys are organized in a way to create clear picture of the project-specific details. Wildlife sensitivity maps are prepared for the project corridor to highlight sensitive wildlife areas.

Cultural heritage and archaeology survey

Information on archaeological and cultural heritage sites was collected from scientific publications and the site reconnaissance field surveys conducted within the framework of the current ESIA, legislative acts of the Georgian Ministry of Culture and Monument Protection, various Internet resources and interviews with local population. Based on this information, the sites were listed and mapped indicating names, categories, location and dates of the sites. Monuments representing immovable monuments of the national importance were identified according to the decree (#3/133) of the Minister of Culture and Monument Protection of 30/3/2006.

Socio-economic study

The socio-economic baseline study along the EWH section was carried out through review of existing information from the Geostat, the survey conducted by "Eco-Spectri" Ltd in November 2016. It provides information regarding average conditions of local population in two Khashuri and Kharagauli municipalities crossed by the road. The field survey using especially designed questionnaires (see sample questionnaire in Annex 8) was carried out by socio-economic expert - Keti Dgebuadze in the village Khevi and along the highway corridor. The collected data were analyzed, collated, and summary findings were verified against the available statistical data.

Chemical analyses of water

Laboratory analysis of surface water and soil were undertaken for compiling baseline information on the quality of environment within the study area. Analyses were performed by the Center for Ecological Expertise and Analysis of the R. Agladze Institute of Inorganic Chemistry and Electrical Chemistry. The laboratory is equipped with the following appliances to do the above-listed analyses: muffle burners, diffraction roentgenograph ДРОН-3М; photocolorimeter КФК-2МП; polarograph OH-105; derivatograph Q1500D; atomic absorption spectrophotometer C-115; potentiometer, spectrophotometer-16; differential scanning microcalorimeter ДСМ-2М.

Studies of the surface water quality in the river Rikotula were undertaken through collecting samples near the Rikoti tunnel. Water quality analyses included measurement of the following parameters: content of total nitrogen (TN), total phosphorus (TP), and total petroleum hydrocarbons (TPH). In addition, the physical and chemical parameters, such as temperature, pH and conductivity were measured.

The soil samples were taken in about 10 m radius from the road pavement. Total 4 samples were taken. Two samples were taken from the territories of the restaurants located along the road and other two samples were taken on the territory of village Khevi, 8-10 m from the main road. They were analyzed for the content of heavy metals.

Soil Pollution

Evaluation of adverse impacts on soil and soil pollution was performed according to the Georgian laws and regulations (the law applicable to the largest extent is the Law on the Soil Protection, 1994 (amended in 1997 and 2002).

The soil samples were taken in about 10 m radius from the road pavement. Total 4 samples were taken. Two samples were taken from the territories of the restaurants located along the road and other two samples were taken on the territory of village Khevi, 8-10 m from the main road. They were analyzed for the content of heavy metals. Samples were collected in plastic bags, labeled and delivered to the lab for testing. The samples are dried, averaged and sieved.

Table 5.1. Methods of soil analysis

Cu, Zn, Pb, Ni, Co, Co, Cd	ISO 11047, ISO 11466 - Aqua Regia extract Determination of Cu, Mn, Fe, Mn, Co, Pb, Cd, Ni, Zn, Cr, Ni. Al
As	SO 2590 - General method for the determination of arsenic – Silver diethildithiocarbamate photometric method

The sample analysis revealed that concentration of all metals is below relevant maximum allowable concentrations adopted in the EU.

Criteria for Assessing Expected Impacts

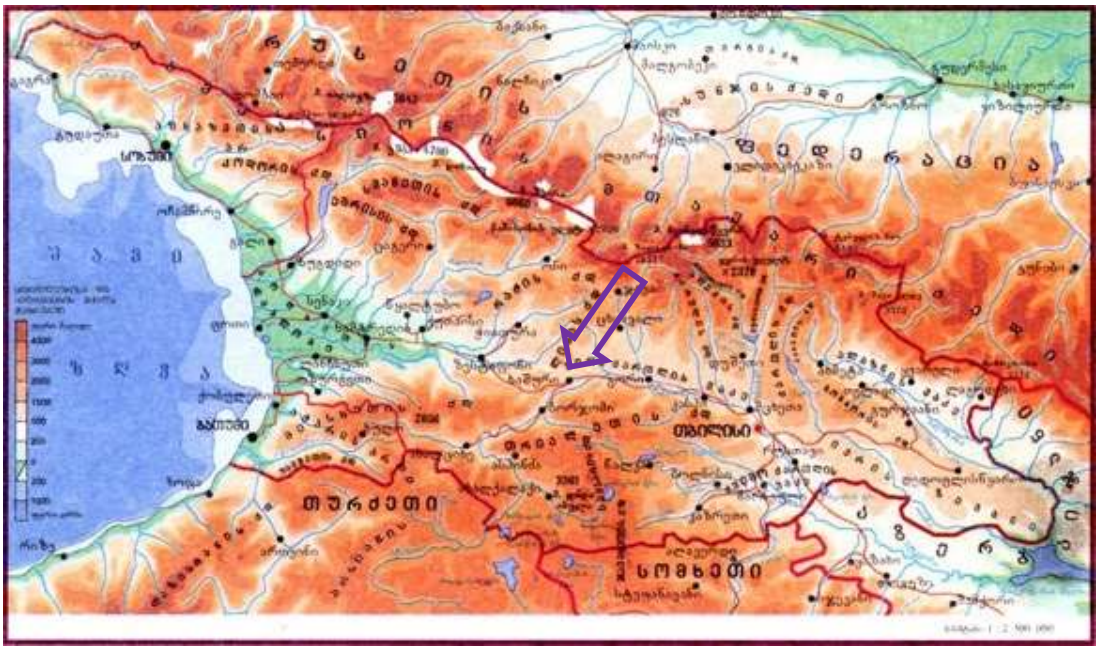
Qualitative and quantitative criteria were used for the assessment of expected impacts on air and water quality, soil and landscape, flora and fauna, ecosystems, social environment and historical-cultural monuments. Impacts were classified as significant, modest and minor, as seen in a table provided in Annex 4.

6. BASELINE INFORMATION

6.1 Biophysical Environment

From physical and geographical point of view, the EWH corridor is located on the hill of Imereti within submeridional range - Likhi Range (Surami Range), which divides Georgia into the eastern and western parts. The length of the range from Ertso mountain pass to Lomi Mountain is 102 km. Rikoti Tunnel runs through under the southern section of this mountain range. Likhi Range is a watershed of Caspian and Black Seas. The middle section tectonically belongs to Dzirula crystalline array, north – to the Caucasus, South – to Lesser Caucasus. It performs the role of climate separator.

Map 6.1. Location of the study area marked on the physical map of Georgia



According to the administrative-territorial division of Georgia, the eastern part of the road corridor (namely, Rikoti Tunnel) belongs to Khashuri Municipality (Shida Kartli region). Most part of the corridor passes within the boundaries of Kharagauli Municipality (Imereti region). Neighboring administrative-territorial units are Baghdadi, Zestaponi, Chiatura, Sachkhere, Kareli and Borjomi Municipalities.

Microclimatic Characteristics

As it was noted, the study corridor is located on the border of climatic districts of east-west Georgia. More specifically, the corridor runs through the eastern periphery of the humid subtropical climate district of Georgia, where the signs typical for a subtropical climate are weakened, climate is relatively continental, precipitation is reduced, annual and daily amplitudes of temperature are increased.

These places are normally characterized by cold winters and warm summers. Average annual air temperature reaches a maximum in August - +26.5 ^{0}C, while the minimum in February - 2.4 ^{0}C. The annual average rate of precipitation is 565 mm. Number of snowy days during the year is 55-60 days, the thickness of snow cover near the tunnel is frequently within the range of 0.5—0.7. Like air temperature, soil temperature is the lowest in December-January. Relative humidity is 75%.

Below we give the climatic characteristics of the study corridor based on the data of Khashuri and Kharagauli weather stations (source: “Building Climatology”).

Table 1.2.1. Average air monthly and annual temperatures, t°C

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Khashuri												
-1,9	-0,8	3,5	9,0	14,3	17,6	20,5	20,7	16,7	13,3	5,2	0,3	9,7
Kharagauli												
3,2	3,9	7,1	12,0	17,1	20,2	22,6	23,0	19,6	15,1	9,9	5,3	13,2

Table 1.2.1. Extreme air temperatures, t°C

Average maximum of the hottest the month	Average of the coldest five-day-long periods	Average of the coldest day	Average of the coldest period	Period with average temperature of <8°C		Average temperature at 1:00 pm	
				Duration, days	Average temperature	In the coldest month	In the hottest month
Khashuri							
27,5	-11	-15	-2,1	117	4,6	5,6	27,6
Kharagauli							
29,0	-5	-8	3,0	160	1,5	0,9	25,7

Table 1.2.3. Air humidity, %

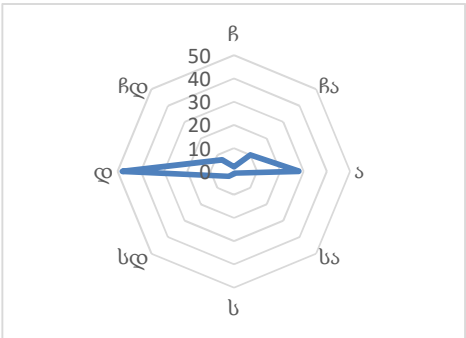
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average
Khashuri												
4,8	5,0	5,8	7,9	11,6	14,5	16,9	16,3	13,4	10,0	7,4	5,8	9,9
Kharagauli												
5,7	6,0	6,8	9,3	13,5	17,2	20,5	20,2	16,4	12,0	8,7	6,4	11,9

- The annual amount of atmospheric precipitations is:
  - Khashuri – 644 mm;
  - Kharagauli - 1366 mm;
- Daily precipitation maxumum:
  - Khashuri – 80 mm;
  - Kharagauli - 105 mm;
- Weight of the snow cover:
  - Kharagauli – 0.68 KPa;
  - Khashuri - 0,64 KPa;
- Number of days with a snow cover:
  - Kharagauli – 38
  - Khashuri - 56
- Water-content of the snow cover:
  - Kharagauli - 46 mm;
  - Khashuri - 48 mm.

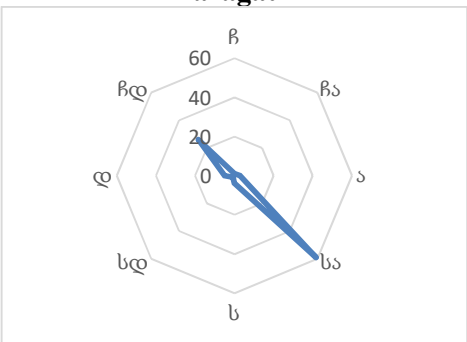
- As the data of Kharagauli weather station suggest, the wind properties are as follows:
  - Rated wind pressure value w0 5 once a year: 0.17 KPa;
  - Rated wind pressure value w0 15 once a year: 0.23 KPa;
  - Wind with the following velocity possible once a year: 21 m/sec;
  - Wind with the following velocity possible once in 5 years: 24 m/sec;
  - Wind with the following velocity possible once in 10 years: 25 m/sec;
  - Wind with the following velocity possible once in 15 years: 28 m/sec;
  - Wind with the following velocity possible once in 20 years: 21 m/sec;
- As the data of Khashuri weather station suggest, the wind properties are as follows:
  - Rated wind pressure value w0 5 once a year: 0.38 KPa;
  - Rated wind pressure value w0 15 once a year: 0.48 KPa;
  - Wind with the following velocity possible once a year: 18 m/sec;
  - Wind with the following velocity possible once in 5 years: 24 m/sec;
  - Wind with the following velocity possible once in 10 years: 25 m/sec;
  - Wind with the following velocity possible once in 15 years: 28 m/sec;
  - Wind with the following velocity possible once in 20 years: 21 m/sec;

Wind rose %:

Khashuri



Kharagauli



- As the data of Kharagauli weather station suggest, the rated seasonal freezing depth of grounds is:
  - Argillaceous and loamy - 0 cm;
  - Fine and dust-like sand clay-sand – 0;
  - Large- and average-coarse gravelry sand – 0;
  - Large-clastic – 0.
- As the data of Khashuri weather station suggest, the rated seasonal freezing depth of grounds is:
  - Argillaceous and loamy - 48 cm;
  - Fine and dust-like sand clay-sand – 46;
  - Large- and average-coarse gravelry sand – 49;
  - Large-clastic – 57.

6.2 Geology

6.2.1 Geomorphology

The area of the design section is located in the high-mountainous zone of Central Georgia and is a part of the Trans-Caucasian geomorphological intermountain region, in the eastern part of so called Dzirula Massif called Zemo Imereti Elevation (Plateau). This territory represents an elevated part of the intermountain lowland of Georgia and geologically, it coincides with Dzirula crystal massif – an intermediary massif located between the Greater Caucasioni and the Lesser Caucasioni folded zones and built with solid Precambrian rocks.

Within the limits of the massif, there are three major types of relief developed over Precambrian, Middle-Jurassic and Upper Cretaceous-Middle-Middle Sarmatic structural stages:

- Allochthone-denudation,
- Allochthone-structural, and
- Autochthonous-erosive

The third out of the three structural types of relief is common in the study area, which, as mentioned above, is built with Paleozoic and Proterozoic crystal rocks: mostly granites, gabbros and their derivatives. These rocks have clear outcrops in the river gorges and along the roads. The relief developed in this area is commonly characterized by low- and middle-mountainous erosive breakdown. The said part of the Plateau of Dzirula massif is complicated by relict and modern gorges with terraces and both, modern and old stable and quasi-stable landslide forms developed in them.

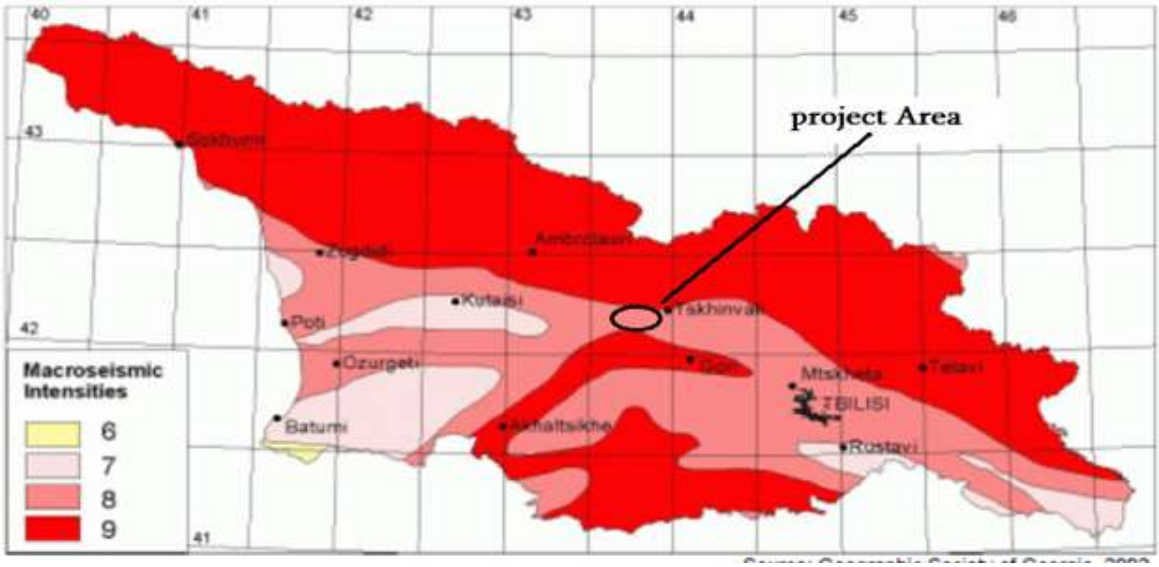
6.2.2 Tectonics and seismicity

As per the tectonic zoning plan of Georgia (by E. Gamkrelidze, 2000), the study area belongs to Dzirula sub-zone of the Central elevation zone of Trans-Caucasian intermountain region (outcrop of the Paleozoic crystal massif). The long history of the geological development of this area and complex tectonic structure greatly contribute to the geo-morphology of the area and define the nature and intensity of the modern geological processes occurring there.

The study area is characterized with quite intense tectonics seen in the presence of faults of different scales and ages (generations) and tectonic zones, along which the rocks are intensely crashed and fractured. Despite the small dimensions of the study area, it is characterized with contrasting geological structures, which is caused by the location between two geological structures: from the east – sedimentary cover of Dzirula massif and from the west – exposure zone of Dzirula crystal massif.

According to the Seismic Hazard Map of Building Norms and Rules effective in Georgia "Earthquake-resisting construction (SSM III, 21.10.2009 N 128, article 1477) PN 01.01-09)", the study area is located in the 8-point earthquake zone (MSK 64 scale) (Map 7.4) with the dimensionless coefficient of seismicity (A) equaling 0.16 (village Khevi) under the same document.

Map 6.3.1. Seismicity Map of Georgia

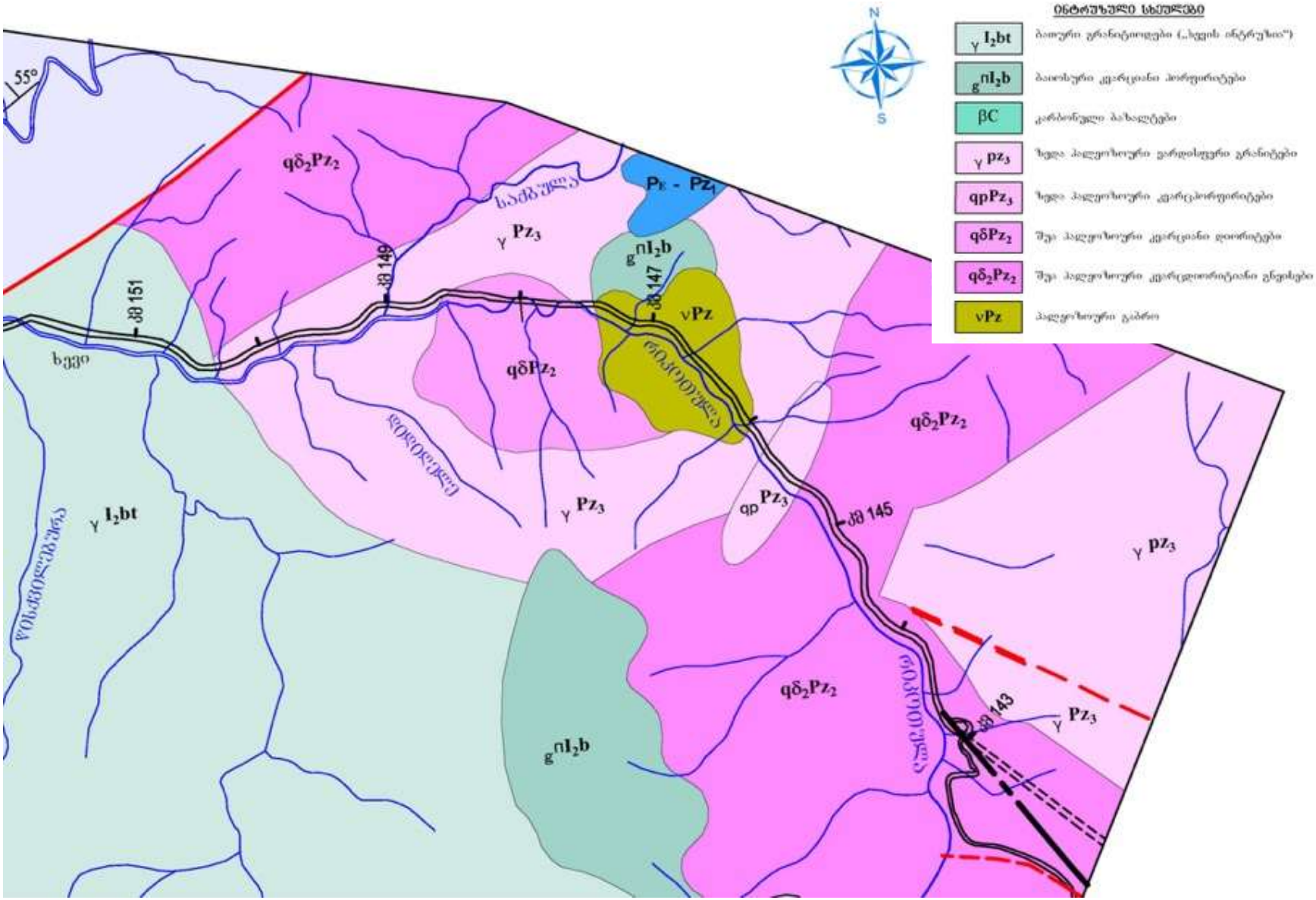


6.2.3 Geology and Geotechnical Overview

he expected ground conditions in the Chumateleti-Khevi section of the E60 road corridor are rock mostly covered by diluvium deposits with various thicknesses. The rock which can be described as Granitoid and Diorite has mainly a locally weathered and decomposed surface. The existing slopes of the terrain are generally steep.

Within the road alignment survey, on the Chumateleti-Argveta segment, basic rocks of different ages, genesis and lithological composition are representative. Within a considerable part of the survey area, intrusive rocks are found: granites, granitoids, gabbro, and quartz diorites, as well as volcanic-sedimented, marine-sedimented and intrusive Jurassic rocks of different suites and stages, such as: augite and labradorite- porhyrites, tuff breccia, lava breccia, tuff sandstones, sandstones, carbonaceous sandstones, conglomerates, limestones, granitoids and quartz porphyrites.

Map 6.3.2.1. Geological map of the project area



According to the orography, the study area is presented with Middle Mountain, erosive-denudation relief. Geologically the territory is located within the Paleozoic and crystal substrate. Existing road is located is located at the forested bottom of Dzirula river slope and is characterized with complicated dismembered relief.

At the western portal of the Rikoti tunnel – up to the road km 8+500, the existing road is located at the base of the right forested slope of the river Rikotula. It has a rugged, dissected relief.

The main structuring rocks of the area are Palaeozoic quartz diorites, quartz-porphyrites, pink granites, gabbro and Bathonian granitoids. Basic rock material is mostly covered by thick eluvia and overlying diluvia silty clays containing angular cobbles and gravel. The thickness of the diluvium varies within 1.0m - 6.0 m, while the thickness of the underlying structuring eluvium is much greater and may exceed 10-12 m.

The left slope of the river Rikotula is morphologically dissected in a complex way and is represented by an uneven surface. However, in general, its geological structure and geotechnical conditions are identical to that of the Rikotula River's right slope.

In geodynamics terms, rock falls may occur in the parts of the Rikotula valley where the slopes are steep, and in some places it is anticipated that slumping might develop. Where the river sharply changes direction, its erosion action in the form of stream-bank erosion should be taken into account. During winter, when snow cover is high, small snow slides can develop and solifluction phenomena may occur.

Geodynamical significant events are landslides which have been observed quite frequently in the survey area. Some of these are thought to be stable, though construction works in the area could trigger activation of suspended processes. Some of them are fossil landslides around Km 6+700 – Km 7+300 on the Left and Right branches.

Along the alignment of the existing road on the right slope of the Rikotula River, certain cut slopes have eroded and slumped significantly, forming minor landslides which have significantly disrupted the normal road operation.

The road construction will involve a considerable volume of excavation in the sidelong ground. Also, new cuttings will be required for widening and improvements of the existing road. In general, the cuttings will be constructed with 3:1 (vertical: horizontal) slope, 3m width berm at 10m height. Where good quality rock is encountered, it is likely that the cuttings may be constructed with side slopes of 4:1 or 5:1 (vertical: horizontal) depending on the geotechnical conditions. In contrast, the cut slopes formed in the surface diluvium deposits will probably be formed with side slopes of between 40 degrees and 50 degrees to the horizontal (84% - 120%).

It is anticipated that the excavated rock from cuts will be used as general fill. In addition, it should be suitable for use in certain granular pavement layers if it is processed.

6.2.4 Geotechnical Conditions in area of Tunnel #3

The terrain along the alignment of Tunnel #3 is mostly covered with colluvial soils and dense vegetation. The small visible outcrops and the geophysical survey given in the design of the tunnel in the previous section of the E60 (the Detailed Design for E60 Highway Section from Zemo Osiauri to Chumateleti, prepared by Pyunghwa Engineering Consultants under a separate design commission) indicate the geological layers along the tunnel alignment as being mainly sandstone and granite: sandstone at the at the north eastern end (the exit end of Tunnel #3), granite from the middle to the

south-western end of the tunnel, and weathered and heavily fissured granite at the south-western portal area of the tunnel. The more detailed geological overview of Tunnel #3 alignment (thickness of soil cover, properties of geological formations etc.) will be ascertained after a detailed surface geology survey with the contribution of a geotechnical investigation drilling, if access is possible.

6.2.5 South-East Portal

An irregular morphology, starting from the upper elevations at the existing bypass road extending down to the existing E60 road under service, is considered to be an old landslide area. Although the rock type constituting the area is not clearly observed due to intense vegetation and soil cover, it is very likely that the old landslide has been developed in flysch formation. From a geotechnical point of view the adverse impact of this old landslide area can superficially be interpreted as follows:

- On the basis of empirical experience, the construction of a stable tunnel portal and stable cuttings on the related approach to the tunnel may be difficult and require extensive stabilizing measures.
- Depending on the final location of the tunnel portal, it is possible that this critical area in terms of stability could influence part of the tunnel route. These superficially determined adverse geotechnical conditions will be verified in the geotechnical investigation programme.

6.2.6 Western Portal

This portal is located to the left of the existing Rikoti tunnel (Photograph 2). The observations made during the site visits reveal that the area is covered by deep overburden soils. The area, however, appears to be stable and, although no rock outcrop is visible, it is thought to be situated in granitic rocks as per the general rock conditions in the near vicinity. Of course, this area also needs to be investigated by means of core drilling prior to the detailed portal design.

Fig 6.3.3.1.1. The current morphology of the old landslide area reaching to the upper elevations above the level of the tunnel entry portal and related approach road cuttings

Fig 6.3.3.1.2. iew of the western portal of the existing tunnel; the tunnel portal of the new Left Branch will be situated to the right of the existing tunnel portal.

6.2.6 Tunnel Route

The geotectonic model of the project area suggests that granitic rocks are expected to be encountered along the whole length of the tunnel route; other rock types such as crystalline slate or volcanogenic

sedimentary rocks are rarely likely to occur as xenolith (foreign inclusion). Owing to the several tectonic episodes, the granitic rocks have gone through their geologic history, and there is consequently a high possibility of encountering hydrothermally altered rock layers or pockets along the tunnel alignment. This implies that the issues that will influence the technical constructability of the tunnel will be determined by the chemical weathering and hydrothermal alteration of the granitic rocks which could have developed in the local fault zones.

Although not confirmed by official documents, there is anecdotal information (verbally expressed geotechnical views) that during and after the construction of the existing tunnel several collapses occurred in the tunnel. At this time, it is not possible to definitely identify the reason of these collapses, which may be due to either poor rock conditions or bad excavation and support implementations with old technology. Therefore, it is essential that the possibility of any alteration zones, that are theoretically assumed to be developed in local fault zones, need to be investigated by means of fore-drilling during tunnel driving.

Conclusions and Recommendations:

Based on the geotectonic model of the project area established in previous studies, our superficially made preliminary studies at the tunnel site have given the following conclusions:

- The project area is situated on Dzirula Massif which has been formed as a result of tectonic inversion structure developed in response to still ongoing regional compressive regime.

- The core of Dzirula Massif is mainly made up of granitic rocks which are susceptible to both chemical weathering and hydrothermal alteration mainly due reaction of feldspar minerals with surface and juvenile water. The end product on both processes is mostly clay and sand pockets with unknown geometry.

- The superficially developing (exogene) weathering is "top to bottom" chemical process that can be visualized on the surface whereas deep-seated fault-related hydrothermal alteration (endogene) is "bottom to top" chemical process and difficult to detect by field studies. Among these alteration processes the latter one is the most hazardous for tunnelling works mainly due its indefinable location and geometry developed in association with faulting.

- Field studies proved that the south-eastern portal (facing Tbilisi) and its approach road cuttings of the tunnel under design appear to be located in an old landslide area extending both laterally and vertically over a relatively substantial area. At the western portal area and immediate vicinity, no distinct instability problem has been observed.

6.2.7 Geotechnical Investigation Programme

Geotechnical Investigations are being performed throughout the road corridor in order to collect information about the soil and rock characteristics in the project area. Both field investigations and laboratory testing will be undertaken to identify the different geological units and their extent, and to assess the strength and deformation characteristics of the soil and rock material for the respective geotechnical evaluations.

The field investigations include drilling boreholes, in-situ tests and sampling in these boreholes, trial pits as well as sampling, measurement of ground water level and geophysical tests where considered

to be necessary and appropriate. Laboratory testing will involve the tests for representative soil and rock samples collected from the boreholes or trial pits.

The number, locations and depths of the boreholes and trial pits are determined considering the particular geological conditions of the road corridor and critical locations which may pose specific problems (such as high cuts, embankments, weak soil or landslide zones, retaining structures, tunnels and bridges). The following guidelines have been taken into account for the geotechnical investigation program:

- Boreholes or trial pits will be performed in a sufficient number and depth in order to reveal the soil and rock characteristics in horizontal and vertical, at the areas of cuts, embankments, tunnels, bridges, retaining structures and culverts. Additional boreholes or trial pits will also be considered for borrow pit areas if considered as necessary.

- For the critical areas where potential landslides or weak soil zones have been identified, relevant investigations (visual inspection, boreholes, trial pits, geophysical tests) will be carried out. A minimum number of three boreholes (top, middle and bottom) for the landslide areas is foreseen.

- At least one borehole will be drilled at the location of each abutment or pier of the bridges.

- At least one borehole or trial pit will be performed at the location of each culvert.

- At least one borehole or trial pit will be performed for each cut or fill section with significant height (e.g. H > 5m).

- Geophysical tests will also be performed to augment the data recorded from the boreholes and trial pits if considered as necessary.

- The Standard Penetration Test (SPT) will be carried out at appropriate intervals in soil. Rock samples and disturbed (D) and undisturbed (UD) soil samples will be obtained during drilling.

- Water samples will also be obtained during drilling works.

- The depth of the borehole will vary according to the encountered soil conditions. In general, it is foreseen to finish the drilling after some advancement into the bedrock.

- Dynamic probing tests will be performed to identify soil strength if considered as necessary at some areas.

All borehole drilling works, sampling, in-situ and laboratory tests will be performed according to BS 5930:2015, "The Code of Practice for Site Investigations" and ASTM (American Society for Testing and Materials) guidelines and specifications.

Basically, the following laboratory tests will be performed on the disturbed and undisturbed soil and rock samples taken for the geotechnical design. Some additional tests will be performed if considered as necessary.

Tests on the rock samples: Bulk unit weight, Uniaxial Compressive Strength (including the modulus of elasticity and Poisson's ratio), Point Load Index Test.

Tests on the Undisturbed Soil Samples (UD) Natural water content and bulk unit weight, Grain size distribution (Sieve and hydrometer analysis included), Atterberg Limits, Triaxial Shear Test for UU (if required CU or CD type triaxial shear test), Consolidation (Odometer).

Tests on the Disturbed Soil Samples (D) Natural water content, Grain size distribution (Sieve and hydrometer analysis included), Atterberg Limits, CBR, Proctor, Organic matter content, Soil and Water aggressiveness against concrete.

The locations of the proposed boreholes and trial pits for the section between Rikoti Tunnel and Khevi, Left and Right Branch (km 0+000 – km 8+500) based on the Feasibility Study corridors, are included in **Volume 2 – Section D** of this Interim Report.

6.3 Soils

Within the eastern part of the Dzirula Gorge, three types of soils are observed: grey soils, yellow-greysoils, and humus-grey soils.

Pozdolic grey soils mainly appear on the intensively exhausted clay soils and clays. Their profiles are characterized with thin underlying formation followed by 3-5-cm humus horizon and 15-20-cm obviously fadedpodzolic horizon. The profiles end with alluvial-metamorphic hardened straw-colored and yellow or reddish-yellow horizon turning into the main rock. The humus content is low and the reaction is the acid one.

Yellow soils are mainly spread on terrace formations and piedmont plains. The humus soil is represented by a granular soil layer (19-15 cm). Deeper there is anilluvial-metamorhic horizon that gradually turns into the main soil-forming rock. The content of the humus horizon in this type of soil makes 6-10%, and the level of acids prevails higher than the level of base materials.

Humus-calcareous soils are limestones, dolomites and their fission products. Their upper part has dark grey color that fades lower. In the upper part of the profile the reaction is neutral, in the lower part - alkaline. The lower part of the profile is enriched with carbonate. Concentration of humus in the upper part of the horizon is 6-10%. This soil type is met in the limestone rock zones characteristic for Cretaceous rocks along the Caucasus.

6.4 Hydrology

Hydrology of the Main River Catchments

The rivers in the area largely originate on the south-east slope of the west branch of Surami Range. The geology of the area is represented by crystalline strata of the Dzirula Massif, mainly composed by granites. The main rivers in this area are the Chumateleti river, which crosses the alignment of the existing E60 in two places immediately before

he entrance to the existing Rikoti Tunnel, and the Rikotula river, which emerges at the western portal of the Rikoti Tunnel. At Km 6, the Sakbula joins the Rikotula river, emerging from a steep valley on the right bank of the latter. With the addition of the Sakbula river, the flow in the Rikotula river approximately doubles.

The Chumateleti river (Catchment B36) originates on the south-east slope of the west branch of Surami Range, at an elevation of 1285m above sea level. The river descends ~ 385 metres in a southerly direction over a distance of approximately 5.0 kilometres to where it crosses under the existing E60 road immediately in front of the south-eastern portal of the existing Rikoti Tunnel. The catchment area is ~ 9.8 km^2, with a basin width of 3 km and the gradient of the catchment is ~ 8%. The catchment is forested and the river is understood to carry a heavy load during times of flood. The

design flow that was included in the Feasibility Study for the Chumateleti river was 36 m^3/s. The catchment has been re-analysed and the new calculated flow is 41.2 m^3/s.

Evidence of this is the build-up of boulders within the box culvert that carries the river back under the E60 road approximately 780 metres south of Rikoti Tunnel. Although there is approximately 2.5 metres of headroom at the entrance to this structure, the headroom is reduced to less than 1.5 metres at the exit, indicating that there has been a loss of free height of approximately 1 metre due to deposition of boulders. This aspect of the river valley will be taken into account during the design of the replacement structure at the proposed new southern roundabout of Rikoti Interchange. The catchment properties at this second crossing are: Area = 9.8 km^2 (B36) + 1.14 km^2 (B58) = 10.94 km^2, Length = 5.85 km, height = ~ 405 metres. The calculated flow at this structure is 44.2 m^3/s

The Feasibility Study identifies that the Rikotula river also originates in the west branch of Surami Range, at 1100m above sea level and flows into Dzirula river. However, mapping shows that the highest part of the catchment is 1350m above sea level. The overall length of the river is ~ 10.1 km, with a total elevation drop of ~ 643m, average gradient 6.4% and catchment area ~ 70.4 km^2. The total length of the first category tributaries is ~ 45 km. The topsoil within the catchment area is of highland forest type, with dense large leafed forest occupying 65% of the catchment area. The river valley is V-shaped along the whole length, with steep slopes that merge with the mountainsides of the adjoining ranges. The riverbed is moderately winding and branchless.

The river is fed with snow, rain and ground waters and is characterized by spring snow- melt floods, flash floods in autumn and winter and unstable low flows in summer. It should be noted that flash flood water levels caused by rainfall typically exceed the flood water levels due to snowmelt and there has been severe flooding in the Khevi area in the past.

The Rikotula river first influences the road design at the western portal of Rikoti Tunnel (Catchment B37). At this location, the catchment area upstream of the road alignment is ~ 4.64 km^2 the total elevation drop is ~ 372m, the catchment width is 2.8 km, while the overall length of the river is ~ 3.3 km. The calculated river flow for design of the bridge crossing at this location is 21.5 m^3/s. The river then crosses under the road at Km 4+570, with three additional crossings in the next 1.5 km. At Km 4+570, the length of the Rikotula river catchment has increased to nearly 8km, and the river has dropped a further 270 metres at an average gradient of approximately 6%. At this point, the catchment has been augmented by side flows from both the right and left bank, increasing the catchment

area to ~ 20.1 km^2. The calculated river flow for design of the bridge crossing at this location is 121 m^3/s.

At Km 6+030, the Sakbula river (Catchment B10) joins the Rikotula river. The Sakbula river rises just to the north of the headwaters of the Chumateleti River, and has a catchment area of ~ 24.8 km^2 a length of 11km and falls from a headwater elevation of 1300m to 525m. The catchment width varies up to a maximum of 4km. The design flow that was included in the Feasibility Study for the Sakbula river was 118 m^3/s. The catchment has been re-analysed and the new calculated flow is 135 m^3/s.

With the addition of the Sakbula river, the overall catchment area increases to ~ 45 km^2. And the combined river flow is 187 m^3/s. The Rikotula river then continues a further 2 kilometres to Khevi, by which time the overall catchment area has increased to ~ 60 km^2. The catchment flow at Khevi is

calculated to be 219 m^3/s.

The flow rates in the rivers that are given above will be reviewed after receiving results of laboratory testing that will be undertaken in the ground investigation programme. These tests will indicate the amount of silts and clays in the soils which can influence the rate of infiltration of water into the soils.

Table 6.5.2.1. Water peak discharges of the rivers and gorges crossing the modernization road from Rikoti Pass to village Khevi

Section No. and name of the river	F km^2	L km	i Bed	K	δ	λ	K^{I}	Peak discharges			
								τ= 100 years	τ= 50 years	τ= 20 years	τ= 10 years
Rikotula #1^{II}	5.85	3.75	0.164	5.00	1.07	0.84	-	48.6	37.4	26.4	20.3
Gorge #2^{II}	0.16	0.60	0.308	5.00	1.12	0.83	0.70	3.83	2.94	2.08	1.60
Gorge #3^{II}	0.25	0.80	0.319	5.00	1.05	0.83	0.70	4.82	3.71	2.62	2.01
Gorge #4^{II}	2.26	2.50	0.240	5.00	1.09	0.83	0.84	23.7	18.2	12.9	9.89
Gorge #5^{II}	0.39	1.05	0.371	5.00	1.08	0.83	0.70	6.74	5.18	3.66	2.81
Gorge #6^{II}	1.36	1.90	0.303	5.00	1.08	0.84	0.81	17.2	13.2	9.33	7.18
Gorge #7^{II}	0.23	0.73	0.432	5.00	1.05	0.84	0.70	4.81	3.70	2.61	2.00
Gorge #8^{II}	0.68	1.62	0.346	5.00	1.10	0.85	0.70	9.89	7.60	5.37	4.13
Gorge #9^{II}	0.41	1.30	0.346	5.00	1.14	0.85	0.70	7.39	5.68	4.01	3.08
Gorge #10^{II}	0.15	0.62	0.484	5.00	1.01	0.90	0.70	3.80	2.92	2.06	1.59
Gorge #11^{II}	0.13	0.48	0.406	5.00	1.05	0.85	0.70	3.33	2.56	1.81	1.39
didi Rele #12^{II}	0.84	2.10	0.317	5.00	1.06	0.84	0.70	10.6	8.15	5.75	4.42
Gorge #13^{II}	0.37	1.22	0.316	5.00	1.07	0.90	0.70	6.81	5.23	3.70	2.84
Gorge #14^{II}	0.10	0.45	0.333	5.00	1.03	0.92	0.70	2.90	2.23	1.57	1.21
Rikotula #15^{II}	51.3	11.0	0.083	5.00	1.12	0.88	-	174	134	94.4	72.6
nikraula #19^{I}	0.46	1.18	0.305	5.00	1.05	0.90	0.70	7.70	5.92	4.18	3.21
Gorge #20^{I}	0.14	0.60	0.242	5.00	1.02	0.88	0.70	3.28	2.52	1.78	1.37

6.5 Biological Environment

Flora

The following hardwood species are dominant in the forest massifs in the corridor of the study area: common chestnut (*Castaneasativa*), oriental beech (*Fagusorientalis*), Caucasian hornbeam (*Carpinus caucasicus*), Caucasian lime (*Tilia caucasica*), maple (*Acercampestre*), elm (*Ulmuselliptica*), common nut (*Corylusavellana*), bladder(nut (*Staphylea* pinnata),wild pear (*Pyruscaucasica*), shamrock (*Malusorientalis*), medlar (*Mespilusgermanica*), cherry plum

(*Prunusdivaricata*), Caucasian pine (*Pinussosnowskyi*) and eastern spruce (*Piceaorientalis*) are mixed in the forest stand.

The plants typical to dry ecotopes are mostly common over the mountain slopes: Georgian oak (*Quercusiberica*), Imeretian oak (*Quercusimeretina*) (VU), elm Zelkova (*Zelkovacarpinifolia*) (VU) grow mostly over the limestoens; oriental hornbeam (*Carpinusorientalis*),Black Locust (*Robiniafseudoacacia*), elm (*Ulmusfoliacea*), Gleditschia (*Gleditschiatriacanthos*), ash (*Fraxinusexcelsior*), wild pear (*Pyruscaucasica*), shamrock (*Malusorientalis*), medlar (*Mespilusgermanica*), cherry plum (*Prunusdivaricata*), pomegranate (*Punicagranatum*), aspen (*Populus* sp.), Yellow Azalea (*Rhododendron flavum*), etc (see Fig. 6.4.1 and 6.4.2.).

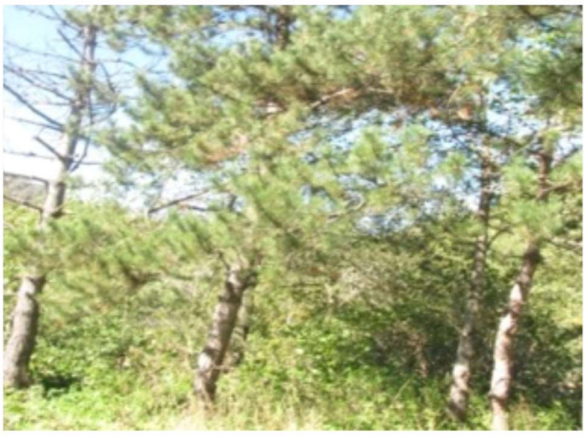
Fig. 6.4.1. Forest massifs in the corridor of the study area

Fig 6.4.2. Slope on the left bank of the Rikotula

The following plants are found along the roads: pine (*Pinus* sp.) and cedar (*Cadrus deodara*). Damaged and withered pine-trees were also found (Fig. 6.4.3. and Fig. 6.4.4.).

Fig. 6.4.3. Damaged pine trees

Fig. 6.4.4.. Slope on the left bank of the river Rikotula



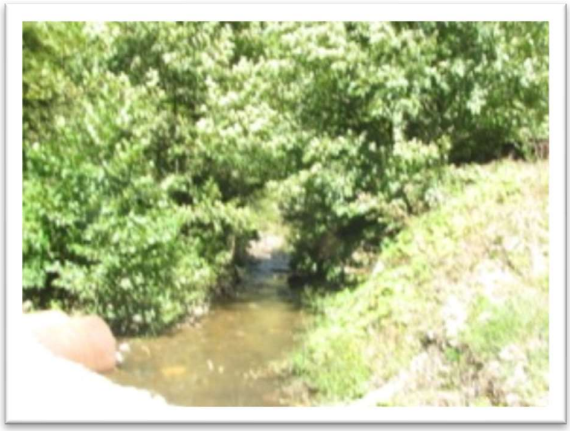
The study corridor and the fragments of its adjacent forest are represented by beech forest with evergreen sub-forest; beech forest with ferns (on the limestone ecotopes) andbeech forest with evergreen sub-forest with gramineous species (on the humid ecotopes).

The following bushes and liana plants are common: blackberry (*Rubus caesius*), hawthorn (*Crataegus* sp.), dog-rose (*Rosacanina*), traveller's joy (*Clematisvitalba*), cat briar (*Smilaxexcelsa*), Italian woodbine (*Loniceracaprifolium*), and Pontic daphne (Daphne *pontica*).

The following species grow in bulk in the forest: male fern (*Dryopteris filix-mas*), Caucasian peony (*Paeoniacaucasica*), waterwort (*Aspleniumtrichomanis*), Pachyphragma (*Pachyphragmamacrophyllum*), sweet fern (*Polypodiumvulgare*), Georgian cyclamen (*Cyclamenvernum*), and violet (*Viola* sp.) mountain fescue (*Festucamontana*), watercress (*Nasturtiumofficinale*), nettle (*Urticadioica*), many associations of series of mixtoherbosa, mountain fescues (*FestucaMontana*) and ferns (*Dryopteris filixmas*).

The dominant species growing in great numbers in the floodplains over the river banks areash tree (*Alnusbarbata*) and different kinds of willow (*Salix* sp.) (Fig. 6.4.5.)

Fig: 6.4.5. Floodplains on the river bank



A pure oak forest grows on the slopes with southern exposition, while over the slopes with more shadow and thin soil, mixed forests of oak-and-hornbeam and oak-and-chestnut occur. Some sections of windbreaks composed of broadleaf and coniferous species are present along the existing carriageway.

Fig. 6.4.6. Windbreak

The major subforest-forming and bush-forming species on the ecotopes are: nut (*Corylusavellana*), hawthorn (*Crataegus* sp), Yellow Azalea (*Rhododendronflavum*), bladder-nut (*Staphyleapinnata*), etc. The sub-forest over the humid ecotopes is formed by: cherry laurel (*Laurocerasus* officin*a*lis), rhododendron (*Rhododendron ponticum*), ilex (*Ilexcolchica*), Imeretian buckthorn (*Rhamnusimeretina*), etc.

The most common mushroom species within the limits of the study corridor and in its adjacent area are: *Amanitacaesarea*, *A.citrina*, *A.rubescens*, *Lactariusacris*, and other high mushrooms in the beech and hornbeam forests are: Amanita caesarea (*Amanitaceae*), orange birch bolete (*Leccinumversipelle*), lurid bolete (*Boletusluridus*), Chanterelle (*Cantharellus cibarius*), wood blewit (*Lepista nuda*), etc. All of them are edible and have nutrition values.

Hardwood forests are characterized with a typical set of pests and diseases. Particularly important is chestnut blight (*Cryphonectria parasitica*) commonly called Endothia parasitica in Georgia. This pathogenic fungus is particularly aggressive to the chestnut trees weakened for various reasons and causes their withering. As a result of such an impact, there are many damaged or faded trees in the forest.

Plant species included in the Red List of Georgia

Plant species with different conservation values are found in great numbers in the impact zone (species included in the Red List of Georgia, Red Book of Georgia, Rare) and plants with economic value. The list of Red Book species are given in **Table 6.1** below.

Table 6.1. Red Book species found in the impact zone

Georgian	Latin	Protection Status	Basis for including in the Red List of Georgia
Imeretian oak	*Quercus imeretina*	VU	Endemic, small fragmented area

Common nut	*Castanea sativa*	VU	Tendency of the area reduction and fragmentation
Elm Zelkova	Zelkova carpinifolia	VU	Small fragmented area
Walnut tree	*Juglans regia*	VU	Small fragmented area
Colchic willow	*Buxus colchica*	VU	Tendency of the area reduction and fragmentation
Common bladder-nut	*Staphylea pinnata*	-	Red Book of Georgia, 1982, small area
Common persimmon	*Diospyruslotus*	-	Red Book of Georgia, 1982, small area
Common chestnut	*Castanea sativa*	VU	Tendency of the area reduction and fragmentation
Persian walnut	*Juglans regia*	VU	Small fragmented area

Fauna

Survey results conducted by zoologists in Zemo Imereti region, namely within Rikoti Pass, mountainous massifs of Kharagauli and Zestafoni municipalities are used for description of species composition of animals in the project corridor. Existing information is also filled with the field works carried out in the EWH corridor (Rikotula River gorge).Local fauna comprises representatives of systematic categories of the wildlife, starting from Protozoa and completed with mammals. Over time, fauna of the region was significantly changed by the agricultural activity of human.

Specialists assessed condition of fauna in the adjoining forests of the study area. The fact that complete assessment of the local wildlife is rather difficult should be also considered. During the field works, special attention used to pay animal feces, traces and holes. As for the ornithofauna, it was assessed by visual observation and according to their nests. Together with these methods, information from the literary sources was also used. The conducted surveys, together the literary sources gave us the opportunity to make some certain conclusions.

In terms of biodiversity of animals, initial part of the corridor is noteworthy (from the outlet of the tunnel to the section of Khevi village), where human impact is less noticeable. Study corridor that runs through Khevi village is anthropogenic and natural habitats are less preserved there.

Difference between the right and left slopes of Rikotula River is also noteworthy. Functioning of the highway on the right bank is the main source of disturbance of animals and therefore, this area is not a significant habitat for them. Natural landscape of the left bank is quite undamaged. Due to the dense vegetation cover, impact caused by noise of transport movement and emission of combustion products is relatively low. It is important to note that there is no artificial barrier between Rikotula River and the forested area on its left bank, and animals depending on water can move toward Rikotula River without any obstacle. Hence the left bank of the river sustains more wildlife and is important for their habitation.

Mammals

24 species (even more) of mammals are spread in the region. This group includes the species which are on the verge of extinction. Among the predators we can point out bear – *Ursusarctos,* Caucasian wolf - *Canis lupus,*otter - *Lutra lutra (*CR, IUCN)lynx - *Lynx lunx,* forest cat -*Felis silvestris.* From

the hooves are famous roe - *Capreolus capreolus*and from rodents *squirrel (Sciurus anomalius)* (Table 6.2).Red Book species found in the impact zone are Black bear (*Ursus arctos*) and Lynx (*Lynx lunx*) (Table 6.3).

Out of the Red-Listed species, a brown bear (*Ursus arctos*) and lynx (*Lynx lynx)* are seen in the project area (Table 6.6.2.2). However, the habitats of these species are found on the left bank of the river Rikotula, at high elevations. Adjacent to the existing road corridor, where the modernized road will run, there is no probability of the habitats of the above-said species to be found as a result of a high anthropogenic impact within the limits of the corridor.

Given the fact that Rikotula river is within the construction zone and after the completion of the construction about 5 km long section of the river will pass between two highways (western portal of tunnel - village Khevi), additional problem will be created on the left bank of the river, namely, animals will have some barriers to water resources.

One of the main mitigation measure is to arrange exits for animals on new highway in accordance with the relevant rules *(Bekker at.al. 2003),* which involves arrangement of crossings with intervals from 200-300 m up to 3-4 km. The distance between these crossings depends on species of local fauna (for large animals - 1-3 km, for medium size animals – 1 km, and for small animals - 200-300 m). After completion of construction works, if migrated animals will be back they will have access to drinking water.

Table 6.2. Mammals of the study area

Species	In Latin	Biotype
Roe Deer	*Capreolus capreolus*	Forest
Sow (wild)	*Sus scrofa*	Forests - shrubs
Black bear	*Ursus arctos*	Forest
Wolf	*Canis lupus*	Forest
Jackal	*Canis aureus*	Forests - shrubs
Fox	*Vulpes vulpes*	Forests - shrubs
Lynx	*Lynx lynx*	Forest
Jungle-cat	*Felis chaus*	Forests
Marten	*Martes spp*	Forests - shrubs
Caucasian squirrel	*Sciurus anomalus*	Forest
White-toothed shrew	*Crocidura russula*	Forest
Badger	*Meles meles*	Shrubs
Common shrew	*Sorex araneus*	Forest

Table 6.3. Red Book species found in the impact zone

Species	Latin	Protection Status
Black Bear	***Ursus arctos***	EN
Lynx	***Lynx lunx***	CR

Avifauna

Avifauna is represented by the species typical for forests, such as sparrows, woodpeckers, owls, does, etc. The variety of birds visits these territories during the spring and summer periods. There is a great doubt that the constructions might damage these species in future. Rocky places should be investigated as the rare birds of prey may inhabit here and the activities outlined in the project might negatively impacts on them.

During the field survey, the following species were observed (**Table 6.4**):

Table 6.4. Avifauna species recorded in the project area

Species in Georgian	Species in English	Biotype
Hawk	Accipiter gentilis	Forests
Pigeon	Columba palumbus	Forests
Forest owl	Strix aluco	Forests
Cuckoo	Cuculus canorus	Forests
Green woodpecker	Picus viridis	Forests
Dunnock	Prunela modularis	Forest edges
Blackbird	Turdus merula	Forests and steppes
Titmouse	Parus caeruleus	Forests and steppes
Jay	Garrulus glandarius	Forests
Finch	Fringilla coelebs	Forests
Goldfinch	Carduelis carduelis	Forest edges

Reptiles

The herpetological fauna of the region is not diverse. According to the data eight species of lizards and six species of snakes inhabit on these territories. Adjarian lizard –*Lacertarudis,* Caucasian lizard - *L.caucasica* (VU) Dagestan lizard - *L.dagestanica* (VU) are Caucasian endemic species. Snakes: Caucasian nedder - *Vipera kaznakovi* (VU)*, Vipera transcaucasiana, Elaphe longissima eskulapes, Natrix tessellata*, *Natrix natrix*, *Coronella austriaca*.

Amphibians

From the amphibians the following species are spread: various species of efts-*Triturus sp.*, *Hyla arborea*, *Rana macrocnemis*, *Rana ridibunda*. Caucasian endemic species: *Pelodytes caucasicus* and Bufo verrucosissimum.

Invertebrate

The following families are spread in the study area: *Nematoda, Oligocheta, Hirudinea, Mollusca, Crustacea, Arachnida, and Insecta.* From the univalves is famous *Helis buchi,* which is of therelict form and represends the endem of the South Caucasia. It is a vulnerable VU taxon and should be included in the red list. Invertebrate fauna is mostly of mesophilic species which are spread in forests. Some of them inhabit in high zones of the Caucasian mountain. Butterflies are most interesting species inhabited in high mountains. Local butterflies are diverse. Among them there are many endemic, relic and rare species: *Parnassius apollo* VU and *Allancastria caucasica* VU..

Aquatic life

Fish fauna and hydrofauna (plankton, benthos, peryphiton and macrophytes) of 10.2 km long Rikotula River is not studied. Study of fish fauna and hydrofauna has been conducted in lower, middle

and upper reaches of Kasleti River, including the project influence zone. The study included the history of local, experienced fishermen (interview method).

The small rivers and springs existing in the corridor of the road construction site are water aboundand during melting the snow they cause flood sna landlines, therefore the rivers are less rich in fish fauna.

84 species of freshwater fish are spread on the territory of Georgia. Fish fauna of the study area is represented by following species: Loach (Cobitis aurata); Mtkvari nase (chondrostoma curi); Dnieper chub (Leuciscus borysthenicus); Caucasian goby (gobius cephalarges constructor); common barbel(Barbus barbus) and Khramulya (Varicorhinus Capoeta).Fish species in the study area have a certain value for population in terms of fishery and additional food.

6.5 Protected Areas

Protected areas are not presented in the target area. The closest protected area is Borjomi-Kharagauli national park. The distance from the project area is 6 km and more.

Borjomi-Kharagauli Protected area is located in the central part of Georgia and comprises the eastern part of Lesser Caucasus. Its total area is 85,083 hectares, i.e. more than 1 % of the total territory of Georgia. Borjomi-Kharagauli protected areas comprisessix regions: Borjomi, Kharagauli, Akhaltsikhe, Adigheni, Khashuri and Baghdati. Administrative and visitor centersof the national parks are located in Borjomi and Kharagauli. Administration of the National park monitors four separate protected areas – Borjomi reserve, Borjomi-Kharagauli national park, Nedzvi Managed Reserve and Goderdzi Petrified Forest Natural Monument.

Borjomi-Kharagauli National Park is located in the center of Caucasian eco-region. Due to its vulnerability and rich biodiversity the Ecoregion is included in World Wide Fund for Nature's priority list of 35 most outstanding natural places and Conservation International's list of 34 biodiversity hot spots.

6.6 Quality of Environment

As per the measurement data, the background radiation in the study corridor is lower than the existing radiation background in Georgia and varies between 6 and 12 mR/h. The nearest point, where the background radiation indicator was measured in September of 2016 by the National Environmental Agency, was in the city of Zestaponi. As per the Agency's information, the radiation background was 11 mR/h.[1]

Background noise along the study corridor is provided in Table 6.5 below. As described in chapter 2.6.3, the maximum permissible level of noise during daytime is 70 dB. However, based on National Legislation „10 dB A- higher levelsare permitted on highways of urban and regional importance". thus, basic level of noise in the project area is within the norm.

Table 6.5.1 Results of the measurements of background noise in the project zone

Point of measurement	I datum	II datum	III datum	IV datum	V datum	VI datum	Mean value

[1] Information Bulletin #9 - http://nea.gov.ge/ge/service/garemos-dabindzureba/7/biuleteni/

East end of Rikoti tunnel $42^{0}03^{II}11.33^{II}$ N: $43^{0}25^{II}50.88^{II}$ E;	81.8	76.0	82.8	79.2	75.4	77.8	**78.8**
West end of Rikoti tunnel $42^{0}03^{II}50.48^{II}$ N: $43^{0}28^{II}54.61^{II}$ E	80.4	77.8	81.2	77.5	78.0	80.2	**79.1**
Restaurant "Jargveti" $42^{0}05^{II}36.57^{II}$ N; $43^{0}25^{II}21.62^{II}$ E	79.2	79.6	81.2	78.8	81.4	80.7	**80.1**
Restaurant "Khevi" $42^{0}05^{II}41.50^{II}$ N; $43^{0}25^{II}34.71^{II}$ E	78.8	79.0	80.2	75.8	78.9	79.3	**78.6**
"Tsakvi spring" at 126 m from the existing road $42^{0}05^{II}32.18^{II}$ N; $43^{0}25^{II}20.42^{II}$ E	55.2	55.6	56.4	55.6	55.4	56.1	**55.7**
Adjacent to the new road (132 m) $42^{0}05^{II}34.51^{II}$ N; $43^{0}25^{II}26.92^{II}$ E	52.4	53.2	53.4	52.7	52.4	52.5	**52.8**
Village Khevi; on the existing road $42^{0}05^{II}44.55^{II}$ N; $43^{0}25^{II}51.74^{II}$ E	77.5	76.9	76.8	77.3	77.4	76.9	**77.1**
Village Khevi;adjacent to school $42^{0}05^{II}44.55^{II}$ N; $43^{0}25^{II}51.74^{II}$ E	55.7	56.9	55.6	57.2	56.8	57.1	**56.5**
Village Khevi; on the existing road $42^{0}05^{II}50.22^{II}$ N $43^{0}24^{II}19.46^{II}$ E	78.2	79.1	78.8	80.2	79.4	78.6	**79.0**
Village Khevi; on the existing road $42^{0}05^{II}49.35^{II}$ N; $43^{0}24^{II}08.72^{II}$ E	79.4	78.7	78.2	78,4	80.2	78.6	**79.0**

Results of chemical analyses of the surface water quality in the river Rikotula are provided in Tables 6.5.2. and 6.5.3. below. Generally, the water quality is good and the river water can be used both, for drinking (after relevant treatment) and for the technical purposes during construction works.

Table 6.5.2. Physical parameters of the river water

River	Temperature	PH	Turbidity	Electrical conductivity

Rikotula	**18.4**	**7.8**	**0.29**	**0.084**

Table 6.5.3. Chemical parameters of the river water

River	Cl	CO_3	SO_4	Ca	Mg	Na	K	DO	TDS
Rikotula	5.1	37.7	7.4	9.0	4.1	6,0	0.4	9.6	79

Soil quality along the existing section of the highway was determined by measuring content of heavy metals. Results are provided in Table 6.5.4 below. The chemical study of the soil evidenced that the content of heavy metals in the soil other than lead (PB) meets the effective Dutch and world standards for soil. An increased content of lead was found not only along the project section of the main road, but also along the entire highway as a result of using leaded petrol for the vehicles for decades. Due to a very long impact period, legacy pollution from the 20th century is still present in the highway corridor.

Table 6.5.4. Metal content in soil along the EWH corridor

#	Sampling point	**Cu**	**Pb**	**Zn**	**Co**	**Ni**
1	$42^0 05^{II} 36.57^{II}$ N; $43^0 25^{II} 21.62^{II}$ E	50	80	170	40	35
2	$42^0 05^{II} 41.50^{II}$ N; $43^0 25^{II} 34.71^{II}$ E	50	80	180	40	35
3	$42^0 05^{II} 44.55^{II}$ N; $43^0 25^{II} 51.74^{II}$ E	50	70	180	40	30
4	$42^0 05^{II} 49.35^{II}$ N; $43^0 24^{II} 08.72^{II}$ E	50	80	150	40	35

Atmospheric air quality

Before 1991, the atmospheric air quality was permanently monitored in large cities was Georgia. As for the project area, due to great distances from it to the settled areas, the degree of pollution of the atmospheric air with harmful substances was never measured.

The present data of the air are needed to totally evaluate all possibilities of the atmospheric air impact associated with the atmospheric air pollution in the road area adjacent to Rikoti tunnel.

As there has never been a station near Rikoti tunnel to observe the atmospheric air, the degree of pollution of the atmospheric air in the study area can be measured by using the methodology guidelines, in particular, "Background concentrations for cities and settled areas with no observations over the atmospheric air". The values of concentration of harmful substances depending on the number of population are given in **Table 6.5.6**.

Table 6.5.6.. Background pollution of atmospheric air near settlements

Number of population, thousand men	Background concentration, mg/m3			
	Nitrogen dioxide	Sulfur dioxide	Carbon monoxide	Dust
250-125	0,03	0,05	1,5	0,2
125-50	0,015	0,05	0,8	0,15
50-10	0,008	0,02	0,4	0,1
<10	0	0	0	0

There are no settled areas with more than 10,000 inhabitants adjacent to the study section of the highway. Hence the background data may be considered as equaling to 0.

6.7 Social-Economic Situation

General

Kharagauli municipality (with the area of 913,9 km^2) is located in the geographical center of Georgia, in the south-eastern part of Imereti. From the east, the municipality is bordered by Khashuri and Sachkhere municipalities, by Zestaphoni and Baghdati municipalities from the west, by Chiatura and Sachkhere municipalities from the north and by Borjomi and Baghdati municipalities from the south. The center of Kharagauli municipality is settlement Kharagauli. The distance from Tbilisi to Kharagauli is 180 km. Kharagauli municipality includes 20 territorial units. The number of villages in Kharagauli municipality is 78.

The area of Khashuri municipality is 585,2 km^2. Form the east and north it is bordered by Kareli municipality, from the north it is bordered by Sachkhere municipality, by Borjomi municipality from the south and west and by Kharagauli municipality from the west. The total length of the municipalities is 118 km. The distance from the country capital to the Khashuri is 120 km and it is 47 km to the regional center. The municipality includes one city (Khashuri), one settlement (Surami) and 11 rural administrative units including 84 villages.

The following villages are located in the community of Khevi of Kharagauli municipality, near the highway: Khevi, Grigalati, Tsitskiuri and Tsakva. The area of the administrative units of Khevi is 858,66 ha. The population of Khevi is 395 homesteads with 1349 residents. The distance from Kharagauli to the administrative center is 47 km and 37 km to the nearest railway station Dzirula.

Village Khevi is located on the western slope of Likhi Ridge, on the bank of river Rikotula, at 520 masl. The old name of the village is Khevijvari.

Village Tsakva is located on the western slope of Likhi Ridge, on the left bank of river Rikotula, at 650 m (sea level), 48 km from Kharagauli.

Village Grigalati is located on the northern slope of the dividing ridge of the rivers Dzirula and Rikotula, at 600 masl, 48 km from Kharagauli.

Village Tsitskiuri is located on the western slope of Likhi Ridge, on the left bank of river Dzirula, at 540 masl, 50 km from Kharagauli

Local Population

As per the data of 2016, the population of Kharagauli municipality is 19,4 thousand people making 0,52% of the total population of Georgia and 3,64% of Imereti region. The number of residents in Khashuri municipality makes 1,41% of the total population of Georgia and almost 20% of Kartli region. As compared to the previous year, the number of population in Kharagauli municipality has decreased and it has increased in Khashuri municipality. The absolute majority of the population in both municipalities is the Georgians.

As per the official statistics (source: National Statistics Office of Georgia), the number of the population in Kharagauli and Khashuri municipalities is shown in **Table 6.6.1**.

Table 6.6.1. Population index, thousand people

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015**	2016

Georgia	4 401,3	4 394,7	4 382,1	4 385,4	4 436,4	4 469,2	4 497,6	4 483,8	4 490,5	3 713,7	3 720,4
Imereti	700.1	697.6	694.2	693.5	700.4	704.5	707.5	703.9	703.3	533.6	532.9
Kharagauli municipality	27.6	27.5	27.4	27.4	27.5	27.5	27.4	27.2	27.1	19.5	19.4
Shida Kartli	314.0	313.6	312.8	313.0	310.6	313.0	314.6	313.5	313.8	263.4	263.8
Khashuri municipality	61.8	61.6	61.4	61.4	62.3	62.5	62.6	62.4	62.5	52.6	52.7

Note. The data with ** are based on the general population census of November 5, 2014 and sum of the total population growth for the last two months of 2014 (natural increase + migration balance).

As per the census data of 2002, there were 1362 residents in the community of the Khevi, with their absolute majority being the Georgians. The number of population of the community, by villages and sex is given in **Table 6.6.2**.

Table 6.6.2. Number of population of the villages under the project impact

Village	Number of population		
	Total	**Men**	**Women**
Khevi community	**1362**	**665**	**697**
Khevi	269	137	132
Stakva	369	186	183
Grigalati	469	226	243
Tsitskiuri	255	116	139

Employment

The specific weight of the self-employed in the total number of the employed in Imereti region is high constituting mainly the rural population with 1 ha or more land plot area. As per the official statistics (source: National Statistics Office of Georgia), by 2015, the number of the active population (labor force) in Imereti region was 376,5 thousand people, including 343,5thousand employed. The number of self-employed is 229,8 thousand men. The unemployment level is 8.8.%.

The economically active population of Kharagauli municipality is mainly employed at public bodies, in education, timber industry, production, sales and processing of agricultural products and tourism.

The number of active population in Shida Kartli is 148,9 thousand people, with 93,1 thousand people being self-employed. The unemployment level is 9.0%.

As for the residents of the villages near the project highways, their absolute majority is self-employed and the unemployment level is high. The main source of income is agriculture (mostly, cattle-breeding, corn-growing and bee-raising). The population sells the agricultural products at the municipal centers. It should also be noted that a certain proportion of the rural residents takes the agricultural products (maize, honey, etc.) at the roadsides to sell them. In addition, there are some public outlets located along the road.

Industry

During the Soviet times, industry was well-developed in Kharagauli municipality, with food enterprises, mining industry and timber plants, wine, milk and furniture complexes of enterprises. At present, the industrial scales have declined a lot. They produce stone blocks, process the timber and

bottle mineral water "Zvare". Out of the industrial enterprises of the municipality, a bentwood furniture factory in Marelisi (working under full load at present) and exploitation sites of mineral resources, such as marble (in Khoriti), granite (in Vakhani, Moliti), curb and building stone (in Khandebi, Kozmani), JSC "Imeri" operating with the resources of a former wine factory "Samtresti" and several small timber processing enterprises are worth mentioning.

Folk trade is highly developed in the municipality: the residents of Sakasria, Vertkvichala, Tsikhisdziri Makatubani and Khevi weave baskets, vintage baskets, flower bowls and breadbaskets with lime-tree and cherry-tree bark and nut wicker with high techniques and make pots, jugs, wine bowls and pitchers with clay. They decorate the clay ware by glazing, painting, scratching and with relief figures.

No entrepreneurial objects are found near the project corridor.

Agriculture

The major branch of economic activity in the study area is agriculture. 1.5% of the total area of Kharagauli municipality is used for agricultural purposes. 70.9% of this territory is occupied by pastures and 29.1% is used for ploughing and sowing, annual crops grow over 22.5% of the area, permanent plantings grow over 11,5% and perennial plants grow over 6,6% of the area. Out of agricultural branches, cattle-breeding and bee-raising are developed the best. Kharagauli municipality is the leading municipality of bee-raising in Georgia. The branches of specialization are: vine-growing, fruit-growing, maize-growing and cattle-breeding.

The qualitative properties of agricultural production are quite high in the municipality. Despite the fact that the processing industry is less developed in the municipality, virtually with no medium or large farms there, the region has very high basic indicators in the qualitative and ecological respects of the agricultural production.

As mentioned above, the main source of income of the population on the villages adjacent to the study area is the sales of agricultural products.

Tourism

Tourism plays an important role in the economics of the municipality, with Borjomi-Kharagauli National Park and Nunisi resort on the territory of the municipality being major destinations promoting the development of tourism there. The project area, in tourism respect, is less valuable. There are no tourist routes or internationally important historical-cultural monuments or tourist facilities (hotels) in the municipality.

6.8 Historical and Cultural Heritage

No historical or cultural heritage has been observed adjacent to the project zone. Nearest historical monuments are located in 1 km from the project area and the project will not have impact on them.

The ancient archeological remainders found on the territory of Kharagauli municipality prove that the people here lived a seeing life for the whole history. There is a cave named "Devis Khvreli" in the municipality, where the primate man lived in the Early and Upper Paleolithic Ages.

A treasure of bronze items in Bezhatubani dated by the XI-X cc. B.C., a famous necropolis in Sargveshi where the archeologists found golden things dated by the Antique epoch, a miniature monument of a ram found on the territory of village Lashe dated by the VII-V c. B.C. and the treasure of Bori dated by approximately the I c. B.C.-III c. A.D. are worth mentioning. A rich antique tomb was found in village Sargveshi where the archeologists found a silver cup, rings, bracelets and beads. These items belong to the I c. A.D. A great number of monuments of the feudal age are found in the

municipality: a three-nave Basilica in Ubisa, a Church of Godmother of Nunisi, a church of St. George in Vani and the Kozman church in Boriti. Important monuments of the XI-XIII centuries are the Gedsamania, Tbeti, Lashe and Nebodziri churches and many others. There are many ancient spiritual, secular and fortification buildings and castles and towers in the area.

As of the historical-cultural monuments in the villages near the project corridor, they are as follows: "Okoni" Church of St. George in village Khevi built in the XIX century where the people celebrate the "Day of Okoni".

There is St. George Church in village Tsakva. In Tsakva, during the earthworks, they accidentally found a clay pot with silver Arab coins of the VII-VIII century evidencing the link of this region to the old world.

There is St. Nicholas Church in village Grigalati and there is a Church of Godmother in Nebiereti district built in the middle centuries. There is St. George Church on Rikoti Pass. The recent excavations in village Grigalati revealed clay and metal items. The oldest piece of this collection is the clay makes with Asomtavruli (old Georgian script) inscriptions dated by the XI-XIII cc.

7. IMPACT ASSESSMENT AND MITIGATOIN

Present ESIA included identification and weighting of positive and negative environmental, social, and cultural impacts at the construction and operation phases. It was based on the background information, design documents, and pre-defined quantitative and qualitative criteria of assessment.

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7.1 Impact on the atmospheric air quality

7.1.1. Impact on the atmospheric air quality in the construction phase

In the construction phase, there will be various kinds of sources of the harmful substances emission into the atmospheric air in the project area.

The stationery sources of emission may be: crushing and sorting shop and concrete production unit. With them, the major air pollutant will be inorganic dust. The mobile sources of emission may be: the construction technique and construction vehicles (bulldozers, excavators, trucks, etc.). Emissions of inorganic dust will also take place during the intense earthworks and excess materials/waste rocks management process.

The emissions were calculated for the selected construction camps (See Clause 5). The summary tables below give the maximum admissible concentrations (in MAC proportions) of the polluting substances at the control points, and the further drawings show the results of dissipation models.

Camp 1. Maximum admissible concentrations of polluting substances in the atmospheric (MAC proportions) at the control points

Description of a harmful substance	Maximum admissible concentration (MAC) proportion of harmful substances from an object	
	At the border of the nearest settled area	At the border of a 500 m radius
Nitrogen dioxide	0.06	0,1
Nitrogen oxide	5.2e-3	7.9e-3
Soot	9.4e-3	0.01
Sulphur dioxide	4.5e-3	7.8e-3
Hydrogen sulfide	2.8e-4	5.6e-4
Carbon monoxide	2.5e-3	3.8e-3
Benzpyrene	1.0e-3	1.9e-3
Formaldehyde	1.7e-3	3.3e-3
Hydrogens oil fraction	3.1e-3	4.8e-3
Saturated hydrogens (AlkanesC12-C19)	8.0e-4	1.6e-3

Weighted particles	0.01	0.02
Inorganic dust: 70-20% SiO2	0.07	0.14
Incomplete total impact group 6009(301+330	0.04	0.07
Total impact group 6035 (333+330)	2.0e-3	3.4e-3
Total impact group 6046 (337+2908)	0.07	0.15

Camp 2. Maximum admissible concentrations of polluting substances in the atmospheric (MAC proportions) at the control points

Description of a harmful substance	Maximum admissible concentration (MAC) proportion of harmful substances from an object	
	At the border of the nearest settled area	At the border of a 500 m radius
Nitrogen dioxide	<0,1	0,1
Nitrogen oxide	<8.3e-3	8.3e-3
Soot	<0.01	0.01
Sulphur dioxide	<8.1e-3	8.1e-3
Hydrogen sulfide	<5.3e-4	5.3e-4
Carbon monoxide	<4.0e-3	4.0e-3
Benzpyrene	<1.9e-3	1.9e-3
Formaldehyde	<3.2e-3	3.2e-3
Hydrogens oil fraction	<5.0e-3	5.0e-3
Saturated hydrogens (AlkanesC12-C19)	<1.5e-3	1.5e-3
Weighted particles	<0.02	0.02
Inorganic dust: 70-20% SiO2	0.14	0.14

Incomplete total impact group 6009(301+330		<0.07	0.07
Total impact group (333+330)	6035	<3.4e-3	3.4e-3
Total impact group (337+2908)	6046	<0.14	0.14

The analysis of the calculation results evidences that the quality of the atmospheric air in the adjacent areas during the operation of the camps, both for a 500-m rated zone and settled area does not exceed the standards given by the legislation (See the additional information as a table in **Annex 9**).

Immediately during the construction works, in respect of impact, a last, 2-km-long section of the design corridor is particularly notable. This section runs across the settled area of village Khevi. Without additional mitigation measures, the MAC values may be exceeded what is assessed as of an average value. Intense mitigation measures will be necessary along this section.

Graphical interpretation of modeling the emissions of harmful substances

Camp 1

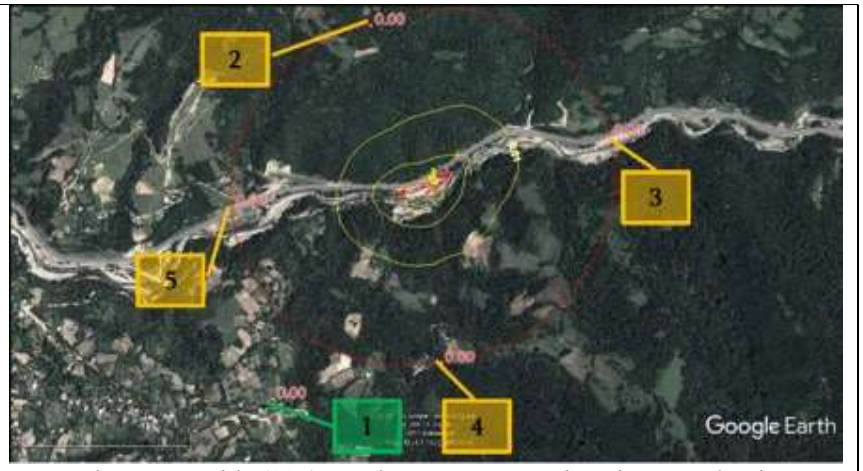
Nitrogen dioxide (code 301) Maximum concentrations in control points

Nitrogen oxide (304) Maximum concentrations in control points

Soot (328) Maximum concentrations in control points

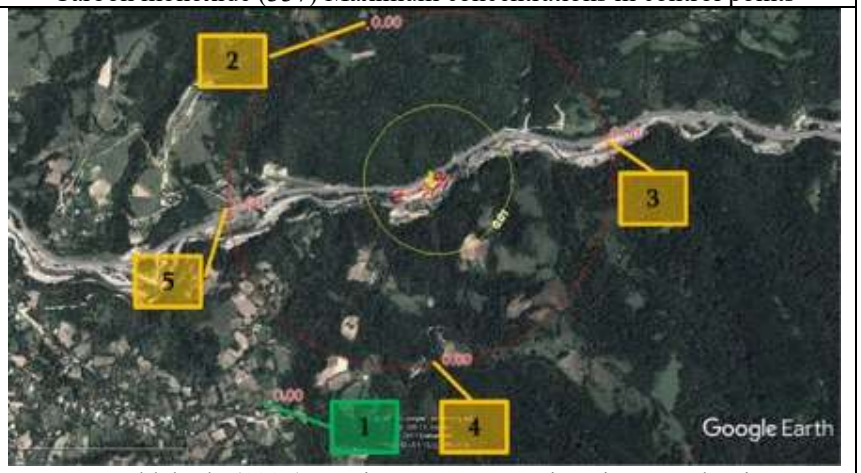
Sulphur dioxide (330) Maximum concentrations in control points

Hydrogen sulfide (333) Maximum concentrations in control points



Carbon monoxide (337) Maximum concentrations in control points

Benzpyrene (703) Maximum concentrations in control points



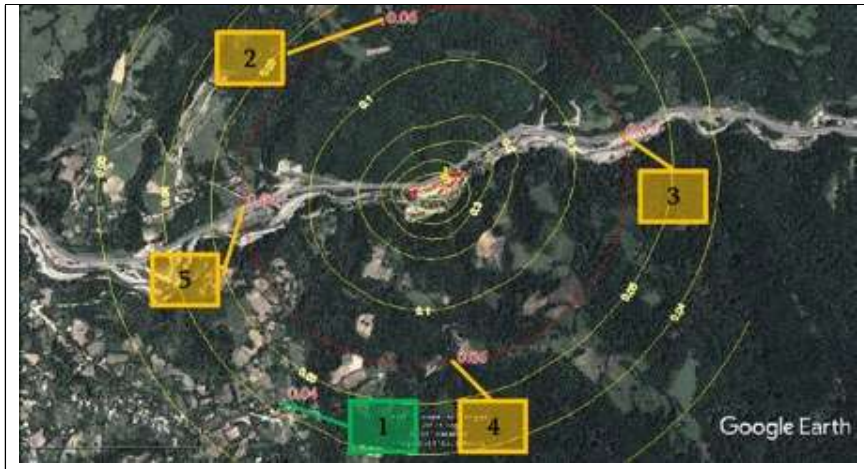
Formaldehyde (1325) Maximum concentrations in control points

Hydrogens oil fraction (2732) Maximum concentrations in control points

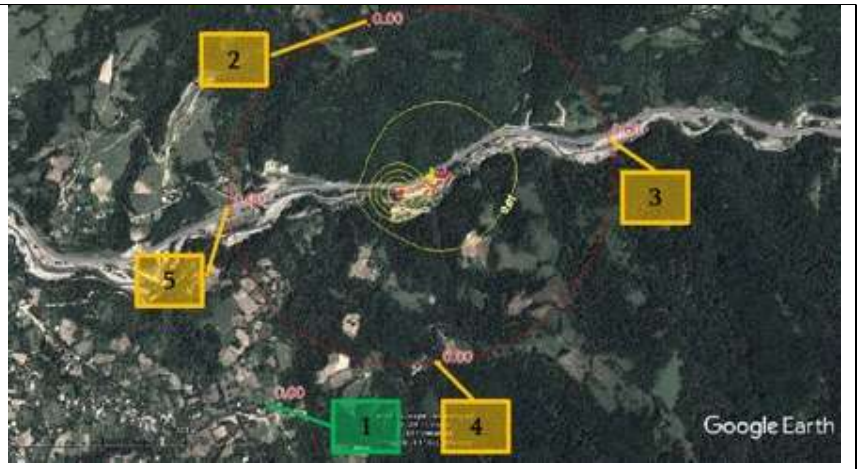
Saturated hydrogens (2754) Maximum concentrations in control points

Weighted particles (2902) Maximum concentrations in control points

(SiO2 20÷70%) Maximum concentrations in control points



Incomplete total impact group 6009 (301+330) Maximum concentrations in control points

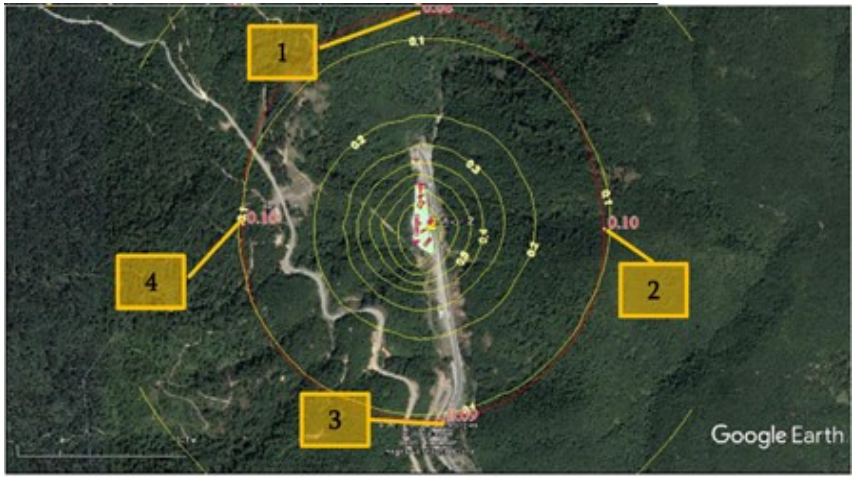


Total impact group 6035 (333+1325) Maximum concentrations in control points

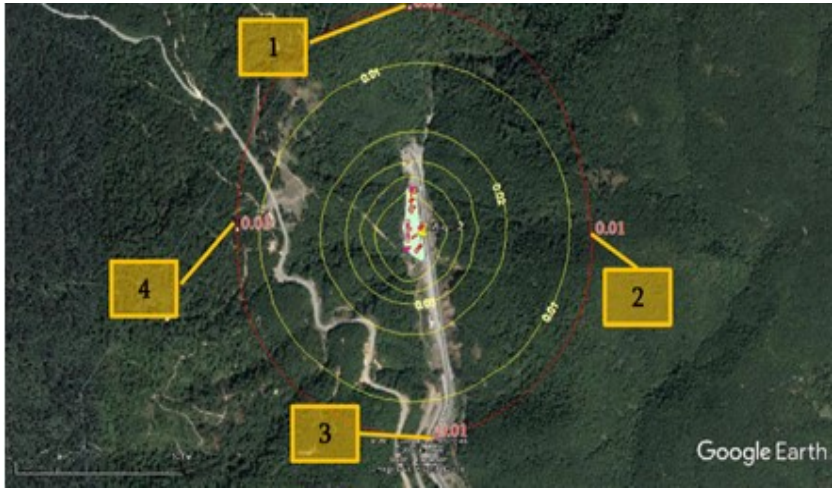
Total impact group 6043 (330+333) Maximum concentrations in control points

Total impact group 6046 (337+2908) Maximum concentrations in control points

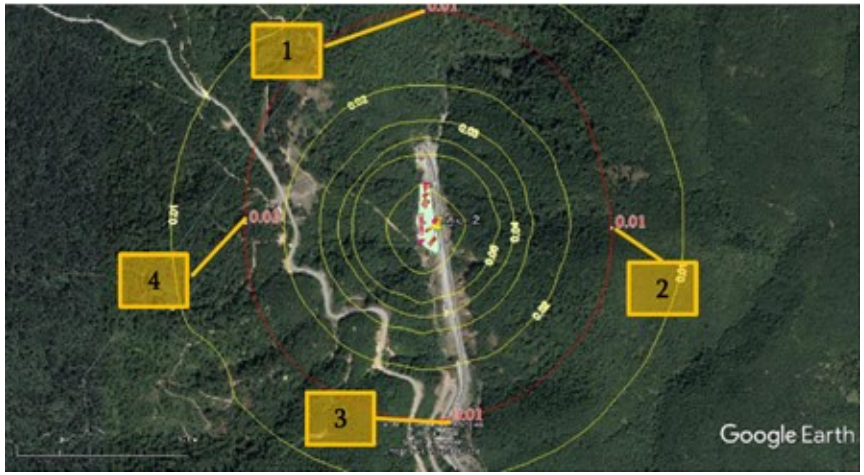
Camp 2.



Nitrogen dioxide (code 301) Maximum concentrations in control points



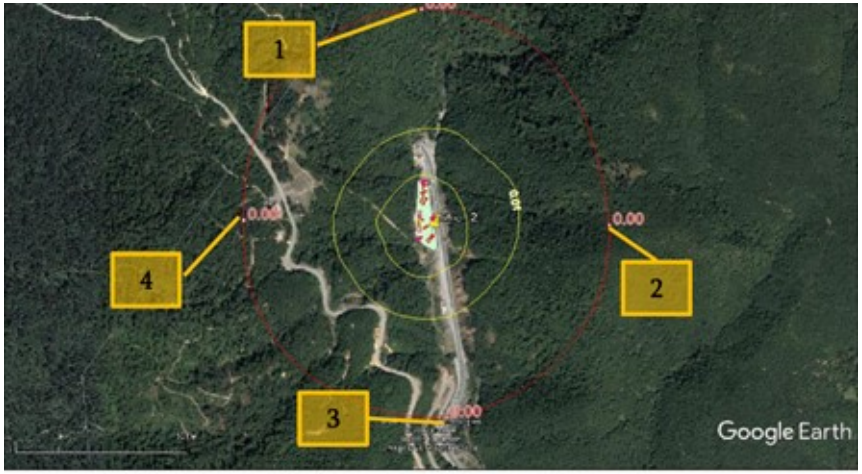
Nitrogen oxide (304) Maximum concentrations in control points



Soot (328) Maximum concentrations in control points

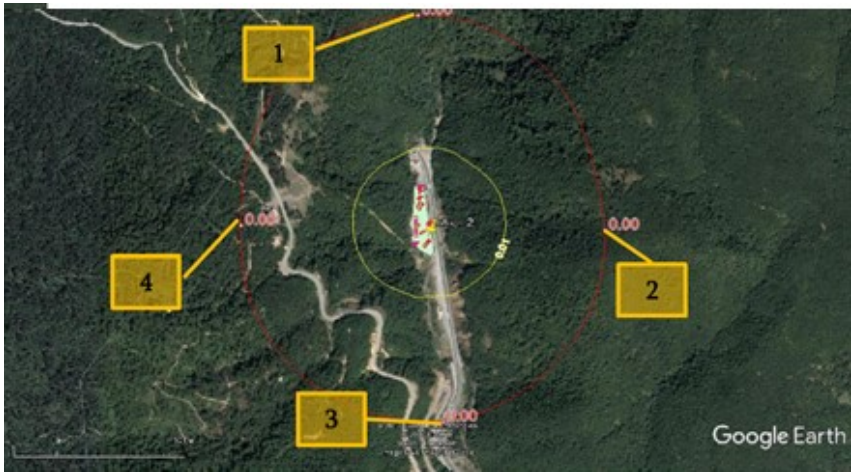
Sulphur dioxide (330) Maximum concentrations in control points

Hydrogen sulfide (333) Maximum concentrations in control points



Carbon monoxide (337) Maximum concentrations in control points

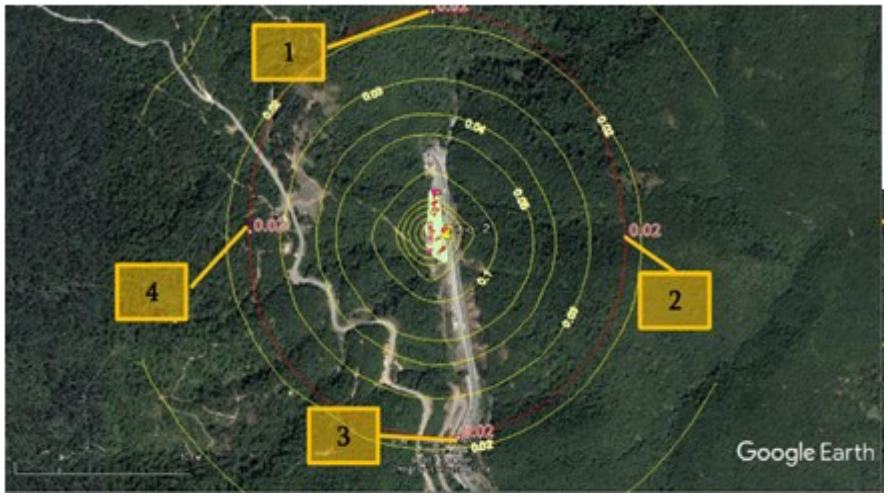
Benzpyrene (703) Maximum concentrations in control points



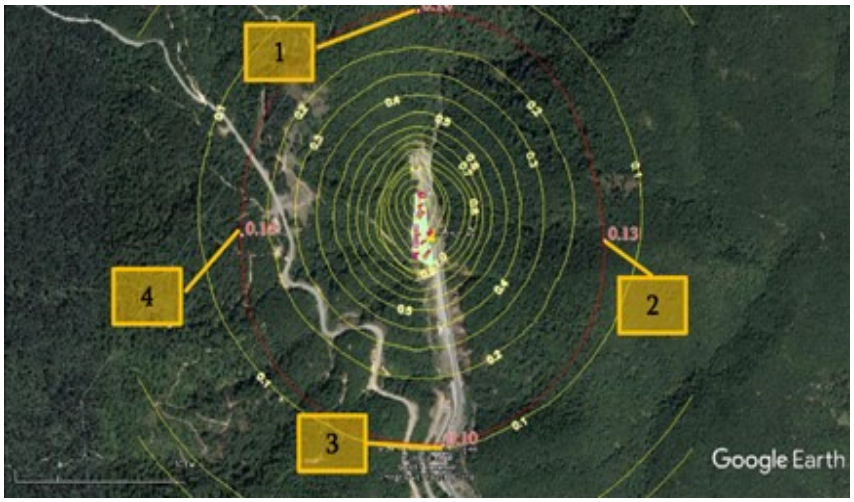
Formaldehyde (1325) Maximum concentrations in control points

Hydrogens oil fraction (2732) Maximum concentrations in control points

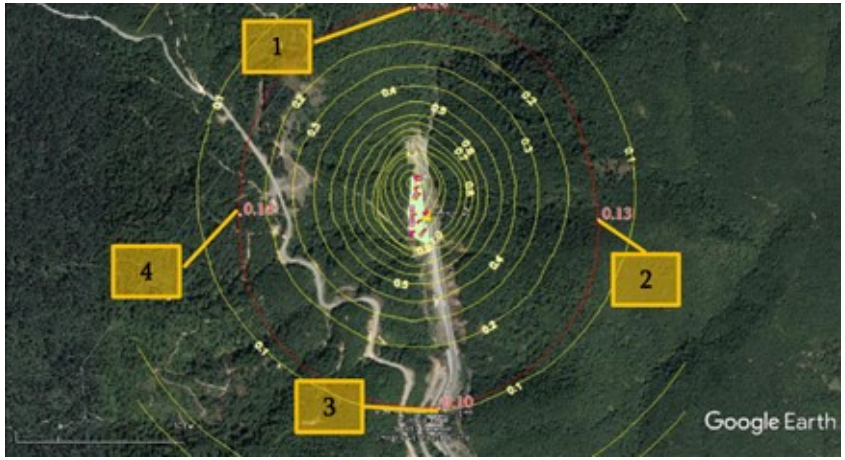
Saturated hydrogens (2754) Maximum concentrations in control points



Weighted particles (2902) Maximum concentrations in control points



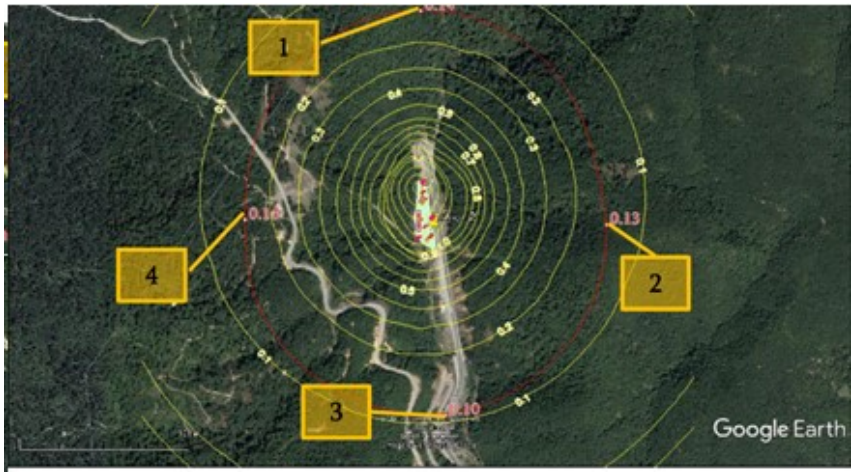
(SiO2 20÷70%) Maximum concentrations in control points



Incomplete total impact group 6009 (301+330) Maximum concentrations in control points

Total impact group 6035 (333+1325) Maximum concentrations in control points

Total impact group 6043 (330+333) Maximum concentrations in control points



Total impact group 6046 (337+2908) Maximum concentrations in control points

Impacts in the operation phase

The modernization of EWH will increase its capacity and with a greater volumes of traffic, exhaust fume will also grow. However, at the same time, the occurrence of traffic jams will reduce significantly and the loads of the vehicle motors will not be so great in case of overtake at the expense of the extended roadbed and reduced slopes and steering angles. Depending on the considered policy reforms towards controlling vehicle fleet and technical condition of individual cars, as well as enhancing quality control of fuel, emissions in future may even decrease or, at least, do not climb tangibly as a result of forecasted increase of traffic.

Mitigation measures in the construction phase

Stationary sources of emissions (e.g. concrete plant, aggregate crushing-sorting machine) shall be located away from the human settlements and equipped with appropriate filters. Plants must be registered and fall under control of the MEPA as required by the national legislation.

In addition, the technical condition of vehicles and machinery shall be regularly controlled. Idling of engines should be restricted. In order to reduce dust propagation, it is required to protect the limited speed of the vehicles and to properly manage the dusty materials. An effective way of reducing dust emission is regular watering of the road in dry weather. Overall, emission preventive measures will not be associated with significant costs.

Mitigation measures in the operation phase

Based on the best possible estimates, operation of the upgraded section of EWH will not tangible increase nuisance from dust and emissions. However these parameters should be periodically measured and in case of unacceptable increase, mitigation measures be worked out. Overall, maintaining vegetation in the road corridor will serve as an effective tool for dust control.

7.1 Noise and vibration

Impacts in the construction phase

Two main sources of noise and vibration in the construction phase will be crushing equipment to be used for processing of natural construction materials and operation of construction vehicles and machinery.

Expected needs for deploying various types of construction machinery and the related levels of noise per unit are provided in **Table 7.2.1**.

Table 7.2.1. Noise levels of the construction machines and machinery

Machines and machinery	Noise level (dbA) 10-15 m from the source
Equipment and machines to produce road construction materials (crusher, grating, mixer, etc.)	100 and more
Pile fixing	100 and more
Bulldozer	90
Excavator	88
Dump truck	85

Truck mixer	85
Pneumatic hammer	88
Pneumatic equipment	85
Crane	88
Compressor	81

Output and duration of operation of the units to produce the construction materials needed for the road construction are to be decided by the works provider. The present state and conditions of the highway corridor allow locating the major stationery sources of noise quite far from the settled areas.

As the calculations show, if the stationery sources of noise are located 500 m or more from the sensitive receptors, no noise in excess of the maximum admissible levels established by national legislation[2] will occur. These calculations do not consider the natural barriers (relief and vegetative cover), which further reduce the noise propagation.

As for the noise caused by vehicle movement and construction works, the last 1-km-long section of the EWH section between Chumateleti and Khevi is of higher sensitivity. During the intense works along this section, the noise in excess of the maximum admissible levels is expected to occur near some residential houses and the school. The impact will be significant, but short-term. It will discontinue immediately upon completion of works. Operation of machinery beyond conventional working hours shall not be allowed. Because of the configuration of the landscape, earth works near the residential area will be of considerably lesser magnitude than those away from settlements. Hence minimal levels of vibration will be experience by local residents, which is unlikely to compromise structural integrity of their houses.

Noise and vibration propagation in the operation phase

The sources of noise during operation phase will be running engines, friction between tires and the road, and sonic signals.

When evaluating the impact, the existing state is to consider, in particular: following the sizes of the roadway, angles of inclination and turning radii, the traffic is hampered at some time moments leading to the increased load of the vehicle motors, more intense use of sonic signals, etc. Following the reconstruction and modernization of the road, the sources of noise will be limited, and the impact on the animals in the forest zone will diminish as a result of the facilitated traffic. The exploitation of the modernized road will change the noise and vibration background for better.

On the other hand, due to the increased traffic capacity of the highway, the traffic intensity will increase. The noise caused by the vehicles driving with the speed of 80 km/h along the last, 2-km-long section of the EWH between Chumateleti and Khevi is likely to have a negative impact on the residents of adjasent houses and the school located close to the road. According to the SNiP 2.05.02-85 the distance from the edge of the mainline roads (highways) till the border of the residential area should be taken not less than 50m, and in case of application of the noise protective facilities, not less than 25m. At the stage of developing the detailed design, the list of buildings and premises to be relocated at the project implementation stage will be specified accurately.

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Mitigation measures in the construction phase

[2] Environmental Quality Norms approved by the Order#297N (16.08.2001) of the Ministry of Labor

Stationary installations causing noise and vibration shall be placed away from the settlement as much as possible. All construction equipment and vehicles must be in a good technical condition. Intensive construction works shall be implemented during the daytime. Arrangement of temporary noise barriers may be required prior to the intensive construction works in the vicinity of settlement of Khevi village. Condition of nearby buildings should be periodically checked and the impact of vibration on cracks and damages should be determined through observation. If it is established that the existing level of vibration damages the nearby buildings and premises, a number of mitigation measures will be necessary:

- Explosions near the sensitive sites must be prohibited.
- Heavy technique is to be replaced by the light one.
- Hand labor is to be used in particularly sensitive areas.
- Maximum one unit of techniques, which is a source of vibration, must operate on the construction site.

In case of accidental damage of buildings and premises Construction contractor will conduct assessment of damages, compare with existing baseline information and corresponding remedial actions (e.g. reparations, etc.) proposed to the affected party. If damages can't be mitigated or fixed the affected houses and other buildings will managed in accordance to the principles of the RPF[3] and it will be compensated in full for the whole building irrespective of the specific degree of impact. Compensation will be provided in cash at replacement cost free of deductions for depreciation, transaction costs or salvaged materials. All relevant PAPs are entitled to this provision by default irrespective of the registration status of the affected item. Salvaged materials after demolition of the building are deemed to be owned by the AH.

Mitigation measures in the operation phase

Once the highway section enters into operaiton, RD should conduct monitoring of noise levels and depending on the outcome, consider placement of noise barriers within the Khevi village, while local municipal authorities should give priority to greening of the school area.

7.2 Geohazards

Impact in the construction phase

As it was already mentioned in the geological baseline description, the project corridor passes through a quite complex terrain. Some sections are damaged by landslide and other gravitational processes, as well as by water erosion. Landslide processes are endangering the stability of the road. A few years ago, a large mass has been collapsed due to which the movement towards east-west direction has been paralyzed.

Activation of dangerous geological processes is expected at the construction phase. Risks of destabilization of the rocks will be primarily related to the removal of vegetation cover and felling, grounding works (in order to expand road embankment). Besides, activation of dangerous geodynamic processes may be caused by the preparation of a new corridor roadbed, by the arrangement of road-engineering structures and improper management of waste rocks.

[3] RESSETTLEMENT POLICY FRAMEWORK (RPF) = Update of Feasibility Studies for E-60 Highway Section from Zemo Osiauri to Argveta and Undertaking Detailed Design for E-60 Highway Section from Zemo Osiauri to Chumateleti

Dangerous geodynamic processes are likely to rise, especially in rainy days and during the snow melt. Disorganized management of surface runoff will be an additional factor for intensification of the erosion processes, therefore significant attention must be paid to the arrangement of draining channels and their proper operation.

In general, at the construction phase, the risk of dangerous geological processes can be assessed as high, for which appropriate engineering solutions are required, including: removal of active layer from the slopes and reduction of slope tilt angle, arrangement of protective walls, mine drainage channels, etc.

Impact in the Operation Phase

The major reason of activation of geodynamic processes during the operation of the road is lack or malfunctioning of draiage system on the cut slopes and failure in bringing back the vegetative cover.

Mitigation measures in the construction phase

In order to maintain geological stability, special attention should be paid to the earth works. In order to ensure stability of the slope, it is required to remove active landslide bodies as far as possible and to terrace the slope, as well as to drain rain and spring waters through bypassing the steep slopes and other sensitive areas. Site reinstatement, including landscaping, compacting of slopes, and providing adequate drainage must be an integral part of construction works and a contractual obligation of works provider.

Mitigation measures in the operation phase

Erosion of cut slopes is the main threat at the operation phase. This impact may be mitigated by proper design, arrangement and maintenance of drainage on the cut slopes, proper planning and executing of compensatory planting/greening, and providing enabling environment for the natural regeneration of vegetation. In case of unexpected activation of deep geological activity, additional measures for slope stabilization may be required.

7.2.1 Geotechnical Solutions based on a review of the cutting side slopes of the existing road.

In the areas where debris flows are observed from the degradation of the surface slopes exposed to the weather conditions along the existing alignment, retaining walls (mass concrete gravity walls and reinforced concrete cantilever walls) will be adopted to isolate the debris from the carriageway and road drainage.

To prevent rock falls as shown in the picture below, protection measures such as anchored mesh will be included in the design to support the material on the cut slope. The design will be verified during the construction stage based on the nature of the exposed rock characteristics.

Some of the existing cuttings will be re-profiled as part of the proposed alignment of the Right Branch and it is anticipated that new cut slopes will also be formed. The shallow cutting side slopes will be formed with a profile between 2V:1H & 1.3V:1H, which closely approximates to the existing cut slopes.

For deeper cutting side slopes formed in good quality rock material, a slope of 3V:1H with berm at each 10m height would be considered. Depending by site conditions encountered and to ensure the stability of cutting side slopes, a mix of both slope profiles combined with protection measure will be adopted.

Where the existing road runs adjacent to the Rikotula river, a considerable length of retaining walls has been constructed on the left side of the road, in order to retain the road platform. Some of these existing walls have cracks in the upper surface (elevation) with local failures of the concrete structure,

while others are still in relatively good condition. Where degradation has occurred, reinforced concrete coating works will be necessary and new retaining walls will replace the ones that have failed.

7.2.2 Stability of Earthworks over Stable Side Long Ground

The new shallow cut slopes will be formed with a profile between 1.3V:1H & 2V:1H, which is close to the natural slope. For cutting side slopes formed in good quality rock material, a slope of 3V:1H with berm at each 10m height would be considered.

Mass concrete gravity walls will be designed up to a height of 5.0m at the edge of road platform. Reinforced concrete or reinforced earth walls are more suitable for support heights typically up to 10m, while reinforced earth and reinforced earth walls can be used at greater heights. Three types of reinforced walls will be taken into consideration to support the road as follows:

- *Reinforced precast concrete facing panels with geosynthetic strip reinforcements*
- *Gabions facing with coated steel wire double twist mesh reinforcements.* In some cases, a combination of the wire mesh together with polymer geogrid reinforcements can be adopted in order to ensure the internal stability limit state.
- *Reinforced earth wall.*

Fig 7.4.1. Example of passive earthworks stabilisation measures over stable side long grounds

fig 7.4.2. Examples of active stability and reinforcing measures over stable side long ground

Fig. 7.4.3. Examples of Stabilisation Measures over stable side long ground of mixed rock and

soil formations

Fig. 7.4.4. Typical Reinforced Earth wall with precast concrete panels

Fig. 7.4.5 Typical Reinforced Earth wall with precast concrete panels

Fig.7.4.6 Example of Reinforced Earth wall with gabions facing

7.2.3 Stability of Earthwork Over Unstable Side Long Ground

In comparison to the case explained above, it is apparent that some stretches of the side long ground

might not have reached their state of natural equilibrium and the existing sloping ground may not satisfy the ULS design requirements. Features of instability could be evident in terms of slides, creep failures and continuous settlement of the ground where earthworks elements would have to be designed and constructed with ground reinforcement and stabilisation measures.

Signs of unstable ground were observed between km 5+800 – km 7+000 of the Left Branch. This area can be described as a possible old shallow slide, not deeper than 2m and stable in the short term, considering especially the position of old trees. Even if the slide area can look much deeper, one of the reasons could be that a series of shallow landslides has occurred in the same place over different periods. It is thought that excavations in this area could destabilise the ground further upslope by undercutting, which weakens the overall stability of the slope. More information relating to the area of instability is expected to be available once the geotechnical investigations are carried out in order to choose the most appropriate technical solutions.

Piled walls can be designed for the support of cut slopes or the stabilisation of landslides. The effectiveness of this type of wall is increased significantly when they are tied back to the ground behind with an additional anchor system.

De-forestation above the road alignment should be avoided in order to minimize the risk of soil erosion and creating circumstances that could generate a landslide. Any areas of forest land that are affected by the execution of the highway but are not within the final footprint of the road will be reforested by planting native species. When establishing the species, the local flora and vegetation which root easily shall be taken into account.

Where the road platform is supported on embankment and the slope of the natural ground is greater than 1:5 (20%), benches are required to be formed in the ground under the embankment, with total removal of topsoil, in order to ensure stability of the embankments. For inclination of the terrain steeper than 1:3 (33%) benches will not be enough and additional measures will be taken to prevent slippage, such as reinforced earth wall (refer to typical cross section No. 02). Such measures have the added advantage of reducing the area occupied by the embankments.

Figure 7.4.5: Example of Stability of earthworks over unstable Side

Figure 7.4.6 Mass replacement stability measures over unstable side long ground

7.2.4 Hydraulic Structures

a minimum freeboard (the vertical distance between the level of the water surface corresponding to the design flow and the underside of the structure) of 1.5m should be included in the design of structures crossing main channels, or 1.0m for minor watercourses

the support piers of structures should ideally be placed outside the main water channel. Where piers need to be included within the flood channel, such piers should be aligned with the flow direction in order to minimize afflux (the increase in water level upstream of a structure caused by constriction of the flow).

7.2.5 Scour Protection

Special measures will be taken to avoid damage to the road during periods of high flood, both in the short and long term. These measures will include the design of culverts in lower points of the terrain, distribution ditches between culverts, designed levees as well as scour protection along the base of embankments and at the foundations of piers and abutments.

7.2.6 Road Drainage

Longitudinal drains will be provided to ensure the removal of water from the paved carriageway of the road so that it can provide adequate service under adverse weather conditions. The road-side drainage system, the subgrade drainage and the cross- drainage systems will be integrated to maximise efficiency. All water flowing off the carriageways, shoulders and footpaths will be intercepted and channelled to appropriate discharge points. In mountainous areas, the location and design of such discharge points must be carefully selected in order to avoid erosion of the earthworks embankments.

Subgrade Drainage will be provided in cuttings and in areas of shallow embankments to prevent the harmful effects caused by saturation of the subgrade, which can reduce the life of the roadpavement and thereby result in high maintenance costs.

7.2.7 Interceptor Drains

In areas of side long ground, where flows of water can descend the hillside over large distances before being collected in the natural drainage channels, it is good practice to intercept such surface water that would otherwise flow over cut faces. If the flows of water are not intercepted and diverted away from the cut slopes, they will cause major problems for the maintenance of stable cutting side. Conventionally, trapezoidal drains are used to intercept flows of surface water, but on

steeper ground more innovative techniques might be required. These techniques can include the construction of stone walls or concrete walls to create a drainage ditch profile above the ground surface.

7.3 Hydrology and Aquatic Environment

Impacts in the construction phase

Tunnel construction may influence ground water system. During tunneling, there is the probability of crossing water-bearing horizons, which may result in drying of individual springs. In addition to the tunnel construction, intensive earth works may also have an impact on groundwater debit. It is difficult to forecast such impact. The impact may be considered significant, taking into account the length of the tunnel, amount of earth works to be carried out, and hydrogeological conditions of the area. However, the area of impact is rich in springs usable for drinking purposes and significant reduction of water resources is not expected.

Pollution of surface and groundwater is expected as from the generated solid and liquid construction waste, operation and accidental spills of fuel and lubricants, and from household sources of liquid waste generated at the construction camps. Operation of concrete plants and drilling of the tunnel will generate large amounts of wastewater, which may become a major source of pollution of release untreated. Under the preliminary design, installation of piles in the river during the construction of bridges is not planned. Construction of bridges will imply works in the waterway and carry risks of intentional or accidental dumping of construction and household waste as well as construction vehicles and machinery being washed in or driven through the waterway.

Impacts in the operation phase

Building up a strip of land on the left bank of the river will limit to some extent feeding of groundwater with precipitation (rain/snow). However, the impact will be insignificant. Other expected impacts are also low and typical for the operation of any road. These include pollution of the highway corridor with the trash thrown from the passing vehicles, pollution with construction waste generated during maintenance works, and pollution with oil products and other contaminants carried by the storm water runoff. Accidents involving cargo vehicles may result in dumping or spillage of the carried matter, due to proximity of this section of the highway to the river, pollution may easily enter the watercourse. However reconstruction of the EWH is expected to sharply decrease traffic accidents and minimize needs for road repair. Hence the risks of operation phase are considered low.

Mitigation measures in the construction phase

In order to maintain the groundwater flow and its quality, it is required to use technically sound construction equipment and vehicles; efficient use of spring waters through arrangement of reservoirs.

All measures for the protection of the quality of Rikotula River water and its tributary valleys should be also taken. In this regard, adequate management of wastewater is instrumental, implying collection of industrial- fecal waters. For sanitation purposes, preference should be given to sewage pits / biological toilets, while for other types of wastewater - relevant treatment facility should be arranged, for insatnce, arrangement of sedimentation ponds in order to clean leakage from suspended particles and / or in case of arrangement of car wash facility, it should be equiped with the oil reservoir. In case of making decision on discharging the wastewater into the surface water bodies, based on the national legislation, a forecast and plan of maximum permissible discharge must be prepared and submitted to the MEPA.

In order to prevent unforeseen contamination of surface waters, following appropriate environmental

measures shall be taken: Arrangement of fuel tanks and other potential sources of contamination away from surface water bodies as much as possible; arrangement of water drain channels throughout the polluting sites perimeter; arrangement of road cover in dry weather.

Mitigation measures in the operation phase

In order to avoid water contamination, it is necessary to equip the drainage channels with stone filters considering the amount of precipitation and the treeain of the given area.

7.4 Impact on Soil Fertility and Quality

Impacts in the construction phase

The highest risks of topsoil damage and erosion are expected during earth works and movement of heavy machinery in the project corridors. It may result in soil compaction, erosion and deterioration of its fertility. The most significant measure to reduce such impact is preliminary removal of surface topsoil layer and proper storage for further usage.

The areas for arrangement of construction camps can be selected so that there will be no topsoil layer or the topsoil layer will be very poor. Topsoil removal-storage works will be mainly provided in the project corridors and spoil ground areas. However, considering the high degree of relief defragmentation of the study area and slope gradient, these works are unprofitable and technically difficult to be implemented. Topsoil layer can be removed only in separate sections of the corridor. The average thickness of the topsoil layer is 20 cm. According to the preliminary assessment, in both cases, the amount of topsoil layer to be removed will not exceed 500 m^3 (the amount of topsoil layer to be removed will be clarified during detailed design). Removed soil cover will be stored on pre-selected areas and after completion of works it will be used for cultivation of marginal zones.

Earth works, as well as soil removal-storage will increase the risk of erosion and soil wash-out. Impact risk will be relatively higher during high precipitation period.

Soil quality deterioration may be caused by unconsidered events (for instance: spill /leakage of fuel/lubricants from construction machinery and vehicles, storage reservoirs, operating on the project areas, improper handling and spillage of hazardous substances; improper management of topsoil, removed during construction phase; improper management of wastewater, etc.).

In total, impact degree on soil fertility and quality can be assessed as medium. Significance of the residual impact is depended on performance of the ESMP.

Impacts in the operation phase

Destruction and destabilization of topsoil layer is not expected on operation phase. Road operation is usually connected with pollution of soil, located at the road line. The second reason of the pollution can be considered the waste at the road.

Impact degree on soil during road operation phase can be assessed as low. Impact management at this stage is difficult, as impact is caused by movement of passengers on the road. There is no significant difference between the discussed alternatives.

Mitigation measures in the construction phase

One of the environmental commitments of the building contractor during the implementation of earth

works will be minimal impact on the fertile soil layer. In addition, erosion and damage of soil should be prevented and measures should be taken to maintain the quality of soil fertility, namely: Routes determined for transport and equipment must be protected; Topsoil should be removed and disposed separately from other materials, on pre-selected areas protected from surface runoff. Temporary water drain channels should be arranged on the perimeter of bulk soil. In case of long-term storage of topsoil, its maintenance shall be considered. After completion of the construction works, pre-excavated topsoil shall be used for restoration of the damaged areas and improve productivity.

In order to avoid soil contamination, sound construction equipment shall be used. The fuel tank should be placed in areas protected by berms and embankments in order to prevent spills in case of necessity. Spill should be immediately contained and cleaned up from absorbent material. Accidentally contaminated ground / soil shall be removed and disposed as soon as possible. After the completion of the construction works, recultivation of the area and restoration of sanitary conditions will reduce the probability of impact on soil quality and stability. In case of emergency spills detailed guidelines are provided in Annex 6.

Mitigation measures in the operatin phase

Good maintenance of drainage system is instrumental in avoiding erosion and degradation of soil. Fitoremedation can be considered as one of the most effective mitigation measures of soil pollution.

7.5 Vegetative Cover

Impacts in the construction phase

A significant impact on the vegetation cover and forest ecosystem is expected during the modernization of the road Highway. In particular, both, direct and indirect impacts are notable during the works.

A direct impact is expected during the clearing the RoW off the vegetation cover. In this respect, woody areas including the artificial forest massifs are notable, which are spread in the project area as well. Forests are considered as particular environmental sites and unique and most important ecosystems in ecological, esthetic, cultural, historical and geological respects. As per the Forest Code of Georgia (2000), Ch. 41: “Special protection regime is applied to the resort and green zones of the state economic forest fund, as well as floodplain forests and subalpine forest zone”. It should be noted that several plant species included in the Red List of Georgia will come under the impact.

The results of inventory of the timber resources on the territory under the impact are summarized in **Table 7.7.1**.

Table 7.7.1. The results of inventory of the timber resources in the design corridor

#	Species	Number	Volume	Note
1	Alder	2268	335.281	
2	Hornbeam	2250	332.537	
3	Chestnut	233	64.42	Red List
4	Lime	162	45.129	
5	Bird cherry	15	4.64	
6	Persimmon	10	2.67	

7	Cherry plum	3	0.167	
8	Oriental hornbeam	314	16.617	
9	Oak	35	9.382	
10	Walnut	16	4.594	Red List
11	Cypress	27	13.545	
12	Pine	270	76.499	
13	Cedar	20	18.34	
14	Willow	109	12.364	
15	Acacia	800	88.602	
16	Asp	12	3.422	
17	Wild pear	26	3.64	
18	Shamrock	2	0.422	
19	Beech	538	121.388	
20	Maple	148	15.76	
21	Nut	72	2.564	
22	Elm	12	0.733	
23	Fig tree	13	0.826	
24	Spruce	3	2.347	

An indirect impact is also expected on the vegetation cover. For instance, in case of pollution of the adjoining areas with construction waste, soil damage/compaction in the construction process, spills of oil products; emissions of harmful substances into the atmospheric air. As a result of such impacts, the restoration of the natural functions of the vegetation cover may take several years what will have a negative impact on the ecosystems.

In order to avoid negative impact on the vegetation cover, remedy and compensate the damage during the construction, a standing group of environmental monitoring must be formed. The group will undertake the monitoring of the target area together with other components of the environment.

In the construction phase, the impact on the vegetation cover and forest ecosystem may be considered as high.

During the modernization of the Highway significant impact is expected on vegetation cover and forest ecosystem, namely both direct and indirect impacts are expected during construction works.

Direct impact is vegetation removal from the right of way of the road. In this regard, forested areas including artificial forest plantations should be noted, which is also observed within the project corridor. Forests are considered as special environmental protection areas, from ecological, aesthetic, cultural, historical and geological point of view as the unique and most important ecosystems. According to the Forest Code of Georgia (2000), Chapter 41, " resort and green areas of the state-owned forests, as well as riparian forests and subalpine stripes of forests are protecteda areas."It should be noted that several species included in the Red List of Georgia may be also impacted. Species and quantities of palnts to be cutted will be specified as a result of detailed botanical study.

Indirect impact is also expected on vegetation cover. For example: pollution of the surrounding areas

with construction material waste; Soil damage / compaction, oil spills during construction; Air emissions of harmful substances. As a result of such impacts recovery of the natural functioning of the vegetation can take several years, which will have negative impact on the ecosystem.

Impact on vegetation cover and forest ecosystem during construction phase can be considered as high.

Impacts in the operation phase

Risk of damage and destruction of vegetation cover during the operation phase is minimal. Possible indirect impacts may be related to the dust and exhaust emissions from transport movements, or to the pollution with surface runoff.Contaminants from the road surface may affect the development of the green cover.

Mitigation measures in the construction phase

Prior to cutting the trees, it is required to obtain permit (Decree of the Government of Georgia on the "exclusion of certain areas from the State Forest Fund"; tree-cutting works shall be implemented under the supervision of specialists of the National Forestry Agency.

The forest use procedure under the legislation of Georgia is envisaged by Decree of Government of Georgia No 242 of 20 August 2010 on Forestry Regulations, under which the project area must be de-listed from the State Forest Fund of Georgia.

A permit to de-list trees and plants from the State Forest Fund of Georgia is issued by the National Forest Agency excepting the vegetation species protected by the Red List of Georgia. A decision to de-list trees and plants from the Red List of Georgia is made by the Ministry of Environment Protection and Agriculture.

A body issuing a permit to use the timber resources of the state forest fund sets the compensation measures the user has to accomplish after withdrawing the trees and plants from the environment.

As a compensation measure, a user shall undertake to restore (reproduce) the resources of Red-Listed species with 1:10 ratio and with 1:3 ratio in other cases at his own expenses.

The State Forest Fund registration is the function of the authorized bodies of the National Forest Fund.

Based on the agreement with them, the registration of the State Forest Fund can be done at the expense of a physical or legal entity.

In case of withdrawal of the Red-Listed trees and plants from the environment, the concerned party shall apply to the Ministry of Environment Protection and Agriculture of Georgia in writing regarding the presence of the Red-Listed species in the project area.

The Ministry of Environment Protection and Agriculture of Georgia (Forest Agency or Agency of Protected Areas) shall examine the information about the presence of the Red-Listed species in the project area and shall apply to the Government of Georgia in the manner envisaged in case of realizing state and public projects (sub-clause "f", clause 1, Article 24 of Georgian Law On the Red List and Red Book of Georgia). In the above-mentioned case, a decision on obtaining (withdrawing from the natural environment) the threatened wild plants or their parts is made by the Government of Georgia (clause 23, article 24).

Within the scope of the project in question, the forest inventory will be carried out and the forest management plan or forest use plan will be developed by the Consultant after the detailed design of

the project is developed.

For conservation and restoration of the vegetation cover, instead of damaged forest the same species of plants should be cultivated and maintained on the free areas adjacent to the project corridor, which will reduce the residual impact up to theaverage value.

Arrangement of artificial vegetation cover on pre-selected areas within the EWH corridor can be considered a significant mitigation measure.

In order to compensate for the damage to vegetation, compensatory planting shall be carried out within the proposed highway corridor in agreement with the Ministry of Environment Protection and Agriculture of Georgia (in particular with the "National Forestry Agency") and local self-government bodies. Plant maintenance to be carried out for at least 2 years. Recommended compensatory measures are - planting 3 roots of the same species for each damaged (removed from the environment) specie. Compensatory measures for red list species (Imeretian oak, Common nut, Elm Zelkova, Walnut tree and Colchic willow) shall be carried out at a ratio of 1/10. The Red-Listed seedlings are available at the following nursery-gardens: (a) Gori nursery- garden, (b) LEPL Sartichala nursery-garden, and (c) nursery-garden Green Service Ltd.

7.6 Wildlife

Impacts in the construction phase

Works on the EWH will be implemented in a fairly dense forested area and near the forest, which is a significant habitat of numerous animal species (including the Red List species).

Impacts during the construction phase are:

- As a result of vegetation cover removal and earthworks habitats (nests, holes) may be lost. Tree- vegetation cuts will also affect the food base;
- Construction of additional two lanes of the EWH on the left bank of the river along approximately 5 km will cause fragmentation of terrestrial habitat of animals (including small mammals, reptiles and amphibian). Movement of some species of animals from forested area to the riverbed will be limited. This will affect their reproduction, food extraction;
- Small-sezed animals may fall in trenches and pits and may be injured;
- During the movement of vehicles and construction equipment, collision with animals may be expected;
- Emission of noise, dust and combustion products, as well as human intensive activities will cause animal disturbance and migration to other places;
- Unsystematic spread of waste, unproper management of waste (change in environmental quality indicators) will cause a further deterioration of the living conditions of terrestrial and aquatic animals;
- Night lighting systems at construction camps may cause disturbance of animals and disorientation of birds;

There may be the cases of poaching by staff. Considering the above, impact on animal species should be assessed as high. Construction work carried out under the conditions of appropriate mitigation measures, as well as the completion of the construction works for recultivation, somewhat will mitigate the impact. After completion of construction works there will be no more sources of a certain kind of impacts (construction camps, equipment, construction workers), which will contribute to some species to return to their old habitats. Impacts in the operation phase During the operation of the highway, some sources of direct and indirect impact on wild life (for instance: earthworks and

construction works, camps and son on) will be suspended and will no longer exist. However, the intensity of traffic movement will be increased. Therefore, the risk of collision with animals and impacts related to noise propagation will be increased as well. Due to habitat fragmentation is expected in the first section of the EWH corridor between Chumateleti and Khevi. This is where the newly constructed carriageway on the left bank of the river will separate from each other the forested zone and Rikotula riverbed. Natural ravines crossing the highway corridor are charachterised with low waters and fish fauna is scarcely presented there. Also important is the fact that there will be no discharge of wastewater into surface water bodies and therefore the risk of the impact on aquatic biological environment is minimal. Impact on fish fauna is expected during the maintenance works of the road in case of pollution of Rikotula River. Overall, during the operation of the Highway, impact on animals may be assessed as medium. Mitigation measures in the construction phase

Following mitigation measures should be carried out in order to minimize impact on wildlife during the construction phase:

- Protection of working borders to prevent excess damage of vegetation cover;
- Inspection of project corridors (specified) on the preparation stage and reveal animals inhabiting zones (nests, holes) within the corridors;
- Restriction of speeds of machinery and transport;
- Fencing of holes and trenches with sharp color things in order to avoid falling of animals in them;
- Filling of holes and trenches in limited terms. Before launching filling works holes should be checked probability of being animals in them should be excluded;
- Arrangement of small boards on trenches to provide artificial crossings for small animals;
- Minimum usage of light on the construction camps. Light shouldn't be directed toward the forest zone;
- Proper management of wastes;
- Implementation mitigation measures of noise propagation, emission of harmful substances and water contamination;
- Providing instruction for the personnel and establish fines against poaching;

After construction the construction works, providing the reinstatement works. Mitigation measures in the operation phase Following issues should be considered during the operation phase:

- In order to reduce impact caused by habitat fragmentation, arrangement of artificial crossings under the road should be installed;
- Recurrent collection of wastes accumulated along the road line;
- Planting and caring of plants and trees in the corresponding zones in order to compensate damage on the vegetation cover;

During maintenance works of the highway, all mitigation measures should be considered (developed for the construction phase), which will reduce emission of harmful substances and water pollution.

7.7 Fisheries and Aquatic Habitats

Impacts in the construction phase

Temporary impacts on fisheries may include direct contact by construction equipment with, sedimentation and water turbidity in the immediate vicinity of the construction work area, and the

potential for minor introduction of pollutants from construction operations. As already mentioned, the river Rikotula is not distinguished for rich in Ichthyofauna. Besides, the construction works are planned along small sections what will enable most of the species to move far from the construction site and return to their original habitats after the construction is over. Moreover, as most of the species present here, except Caucasian goby (gobius cephalarges constructor), have the migration ability. Increased water turbidity will have a negative impact on the spawning. This is particularly true with the species spawning in low water with a stony bed and oxygen-rich current. Such species are: (i) chub (Leuciscus borysthenicus), which spawns once a season, in April or May, (ii) khramulya (Varicorhinus Capoeta), spawning several times a season, from May through August, and (iii) barbell (Barbus barbus), which spawns in May or June, once a season. Increased river water turbidity or spills of hazardous substances during the spawning season of these fish species may lead to the total destruction of hard-roe on the site.

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Mitigation measures in the construction phase

Mitigation measures will be implemented to reduce impacts to fisheries and aquatic habitat during construction. Placement of machinery in at least 50 m from the water bodies (wherever possible. If this seems impossible, permanent control over and safety measures are necessary to avoid water pollution):

- Avoiding blocking the river bed during the works on the riverbed or near it.
- Prohibiting washing and fueling the vehicles near the riverbed.
- Ensuring a trouble-free operation of all vehicles to avoid the risk of fuel/oil spills in the water.
- Ensuring the right management of materials and waste.
- Ensuring proper management of the originated wastewaters. The wastewaters can be discharged into the surface water bodies only after their preliminary treatment.
- The waste originated during the works will be collected and temporarily stored in the specially designated area on the site, distanced from the water bodies.

7.8 Landscape

Impacts in the construction phase

Within the assessment of landscape impact and visual changes of the sight, the value of the selected territory, its natural quality and human impact on the mentioned territory are the most important issues. Consideration should be given to how noticeable is the EWH corridor be for the receptors, such as population and passers. Visual-landscape changes are also related to preparatory and construction works; movement of construction machinery and transport is expected during the works. In addition, temporary units will be located on the construction camps, vegetation cover will be cut, and significant amount of removed soil will be produced. Its temporary and permanent disposal will cause deterioration of the aesthetic view. Potential receptors of visual-landscape changes may be local population and passengers, as well as wildlife. The initial part of the corridor runs along the unpopulated areas. These sites are not under the visual sight of the population and the construction work will just impact on the animals and passengers. Situation is quite different in the corridor of the last road section. Main impact receptors will be population of Khevi village community (existing highway is well observed from the local villages). After the completion of the construction works,

machinery and vehicles, construction materials and wastes will be removed from the territory. In addition, temporary structures will be demolished, labor force will leave the project zone, reinstatement of the temporary developed territories will be carried out that will reduce the impact.

Drilling of tunnels and construction of road bed on the right bank of the river will result in the generation of a large amount of excess material. Its exact mount will be calculated at the stage of detailed design. Current estimate makes around 2,400,000 m^3. However, part of this material will be used during highway construction. Depending on the quality of excavated material, some 1,000,000m^3 to 1,200,000m^3 will be used for backfilling. This leaves the amount of approximately 1,200,000m^3 to 1,400,000m^3 for disposal.

Impacts in the operation phase

Main source of the visual impact is the traffic movement on the operation phase. Considering the current baseline condition (frequent traffic jams, emergency situations and so forth), operation of the road will have positive impacts. Planting of trees and plants along the road corridor will support restoration of the landscape components. Over time, the new infrastructure is adaptable and visual discomfort caused by visual changes will be less disturbing for the population. The impact can be assessed as low.

Mitigation measures in the construction phase

In order to maintain the visual and landscape conditions as much as possible, construction camps and temporary infrastructure should be arranged in the initial part of the project corridor. Arrangement of such infrastructure in the vicinity of Khevi community is not recommended. Colors of temporary structures shall be in harmony with the environment (green, brown). Temporary structures, materials and waste (including spoil) should not be placed in visible places as far as possible. It is necessary to constantly pay attention to sanitary and environmental conditions. After completion of the construction works, restoration of damaged areas and removal of temporary structures will significantly improve the visual landscape of the environment.

Excess material generated from cutting of slopes and drilling the tunnels will be placed in the temporary storage locations and then – the mount which may not be used as a construction material or backfilling – will be moved out to the permanent disposal sites. Both types of storage locations: temporary and permanent, will be agreed with MEPA and local authorities prior to generation of waste. Selection of the disposal sites will be based on multiple criteria, including environmental, aesthetic, economic, and financial. Areas adjacent to the section of EHW between Chumateleti and Khevi offers a lot of locations for the temporary storage, but none for the permanent disposal of excess material.

While selecting sites for the final disposal of the amounts of excess material not utilized during construction, the guiding principle must be minimizing of:

- distance from the point of waste generation;
- transformation of the landscape;
- risks of causing floods, waterlogging, ground subsidence, landslides and avalanches;
- destruction of vegetative cover;
- need for taking productive agricultural land and pastures.

Additional challenge related to the management of excess material is that part of it will be generated during construction of the new road bed on the left bank of Rikotula River, while the existing bridges

over this river are not of capacity sufficient for carrying heavy vehicles loaded with cut-to-spoil material. Hence at the stage of the detailed design, a strong bridge of relevant parameters should be included. The preliminary design does not envisage construction of such bridge (see annex 6).

Detailed guidance on the waste management planning is provided in **Annex 6**.

7.8 Construction Camps

The establishment of contractor's work camp may cause adverse impacts if various aspects such as liquid and solid waste management, equipment maintenance, materials' storage, and provision of safe drinking water are not addressed properly. The site for the work yard will be selected by the contractor in agreement with the Municipality, RD and the supervisor.

Workers' living facilities have various ongoing impacts on adjacent communities. In order to manage these, it is good practice to design a thorough community relations management plan. This plan will contain the processes to implement the fidings of the preliminary community impact assessment and to identify, manage, mitigate or enhance ongoing impacts of the workers' accommodation on the surrounding communities. It should be noted that, no instances of discontent of local population with influx of workers in the area has been reported in other projects financed by the WB.

To ensure that potentially resulting impacts are kept at a minimum the contractor will be required to prepare the following plans or method statements:

- The Georgian legislation does not give the standards or normative acts for making and operating workers' camps. IFC Performance Standard 2 (PS2) on Labour and Working Conditions minimum meet the basic needs of workers.
- Layout plan of the work camp including a description of all precautionary measures proposed to avoid potential adverse impacts on the receiving environment (surface and ground water, soils, ambient air, human settlement);
- Waste management plan covering the provision of garbage bins, regular collection and disposal in a hygienic manner, as well as proposed disposal sites for various types of wastes (e.g., domestic waste, used tires, etc.) consistent with applicable national regulations; and
- Description and layout of equipment maintenance areas and lubricant and fuel storage facilities including distance from the nearest surface water body. Storage facilities for fuels and chemicals will be located at a save distance to the water body. Such facilities will be bounded and provided with impermeable lining to contain spillage and prevent soil and water contamination;
- community development – impact of workers' camp on local employment, possibility of enhancing local employment and income generation through local sourcing of goods and services;
- community needs – ways to identify and address community needs related to the arrival of specifi infrastructures such as telecommunications, water sanitation, roads, health care, education, housing community health and safety – addressing and reducing the risk in the increase in communicable diseases, corruption, trade in illegal substances such as drugs, alcohol (in the Muslim context), petty crimes and other sorts of violence, road accidents;
- Awareness and health education program for workers and local communities will be carried out. This should combine information on sanitation, health risks, HIV/AIDS prevention and work safety measures. The implementation of these by the construction company shall be closely monitored by the supervisor and the RD.
- community social and cultural cohesion – ways to mitigate the impact of the presence of large numbers of foreign workers, often males, with different cultural and religious background,

ways to mitigate the possible shift in social, economic and political structures due to changes in access to income generation opportunities;

- These plans will be approved by the Engineer prior to beginning of construction activities

7.9 Social Environment

Introduction

Chumateleti-Khevi section of E-60 highway is territorially located on Rikoti Pass. The section starts 2 km before the east portal of Rikoti tunnel. Then, it passes the coupled Rikoti tunnel and ends at the end of village Khevi. As per the preliminary design, the project, following the technical parameters of the highway, will have a direct impact on a number of objects found in the project zone, as well as on the infrastructure buildings and premises.

Section 11,2 km of the project zone, in respect of social impact, can be divided into several sections with varying scales and types of social impact:

1. Section from Chumateleti to the east tunnel portal (1,5 km).
2. Coupled Rikoti tunnel (1,7 km).
3. Section from the west tunnel portal to the starting point of village Khevi (5 km).
4. Village Khevi (3 km).

The first and third sections are similar. Along these sections, there are mostly catering objects and individual traders who are local residents trading with their own harvest seasonally found in the area adjacent to the highway. The second section is a design tunnel and no social impact is expected on it. As for the fourth section, where village Khevi is located on both sides of the highway, the project will affect some infrastructure and privately owned buildings and premises. As a result of the project implementation, the number of acccess roads to the private houses will be drastically reduced. The major social issues to consider at the stage of project detailed design are: (a) small and private businesses, (b) access roads, and (c) public establishments.

Small and private businesses

A direct impact of the project implementation on the first and third sections will be seen as an impact on the catering objects (9) located adjacent to the highway, fueling station (1) and individual traders, whose work is seasonal and lasts for 3 or 4 months a year. In October, 14 individual traders were fixed adjacent to the project section. 13 of them were interviewed (1 of them refused). However, as the interview evidenced, their real number is much more (by 2, 5 or 3 times more) (Fig. 7.1 and 7.2). They are mainly the residents of the adjacent villages and trade with their own harvest (fruit, corn, honey, etc.).

The owners of the trading objects and their employees were also interviewed (Questionnaire for socio-economic study is given in Annex 8). During the interview, all interested persons were informed about the planned project and their questions about the topics interesting to them were answered (Fig.7. 3 and 7.4).

Fig. 7.1 and 7.2. Meeting with the street vendors

Fig. 7.2 and 7.3. Meeting with the representatives of small businesses

The information about the small business objects and prepmisess adjacent to sections 1 and 3 is given in **Annex 5.**

Due to the construction of the road junction planned in village Khevi, which, as per the project proposals, must be located in the center of the village, both, public establishments and private businesses and plots will be under the impact.

The detailed information about the land plots, business structures and premises in village Khevi, which will be under the impact, is given in **Figure 7.4**.

In addition, there is a turning point to village Tsakvi along the project road, at: $42^{0}05^{II}36.57^{II}$ N; $43^{0}25^{II}21.62^{II}$ E, 3 km from the highway. At present, this turning point is the only motor road to access the village with 80 homesteads.

<u>Brief analysis of social survey</u>

22 private and legal entities having businesses in the project zone were interviewed during the accomplished preliminary social research. 8 out of the 22, or 36% are legal entities, while other 14 (64%) are private entities. The number of the interviewed is presumably approximately 25-30% of the businessmen in the project area. Most of the legal entities (87,5%) own restaurants and catering objects, while one of them owns a gas-filling station. As for the individual traders, 4 (28.5%) of them sells honey, while others 8 (67.5%) sell the agricultural products grown by them (corn, pumpkin, nut, etc.) or products gathered in the forest (mushrooms, chestnut, etc.). A detailed social research will be carried out at the stage of developing the project resettlement action plan.

100% of the inquired people are ethnic Georgians. 86% of them live in adjacent villages and only 14% (two owners of the restaurant and gas-filing station) live in other regions of Georgia.

For 3 street traders out of the 14 interviewed people (31.5%), this business is the only source of income. 6 of them also receive a pension, while other 5 traders (27,5%) have alternative income sources.

As for 8 legal entities, for 5 of them (62,5%) business is the only source of income, while 3 (37,5%) have alternative income sources.

The overarching objective of the Project in relation to land and asset acquisition is to assist the project affected populations (PAPs) in restoring their livelihoods at least to the level equal to the pre-project level.

The measure accomplished along the EWH Ruisi-Agara section, when with the help of the local municipalities, the area for individual traders was selected and trading objects were built for the individual traders, who formerly ran their business in an unorganized manner and now were given the possibility to run the same business in the area specially designed for them can be considered the best practice. It is desirable to accomplish a similar action in the project zone with the help of Kharagauli and Khashuri Municipalities so that the private entities should not lose their existing sources of income.

Resettlement Action Plan

For the project prepared RAP which covers the 8.6 km length Section of the road from East Portal of Rikoti Tunnel to village Khevi (Kharagauli Municipality) and 0,26km lenth of road before the Easter part of Rikoti tunnel (Khashuri Municipality), including the interchanges in the section between the western portal of Tunnel #3 and the eastern portal of Rikoti Tunnel, and in Khevi to provide access onto the highway and to facilitate U-turn manoeuvres.

In terms of tenure the affected land plots are distributed in accordance with the following legal categories:

- **Category 1**. Titled private agricultural land plots with valid registration. 57 of the affected land plots (with agregated area of 59,393 sq.m.) have valid registration.

- **Category 2.** 26 land plots of 24,476 sq.m non titled, but legalizable according to current legislation through 1 stage registration in NAPR. Related right establishing documents are available in Archives.

All of these mentioned 2 categories of land plots owned by 57 AHs are subject for compensation.

- **Category 3.** State Owned land plots illegally occupied by private users (squatters). In this sub-section of the road we have 2 land plots (2,257 sq.m.) occupied by squatters.

- **Category 4.** 30 State owned land plots of 17,305 sqm not used by private users. Most of these land plots belong to the existing road infrastructure and the rest part constitutes adjacent wind belt zone. Category 3 and 4 land parcels are not subject for compensation. The squaters use illegally occupied land plots adjacent to their registered plots for locating their some of the commercial facilities. Main part of the

commercial facilities are located on registered land plots. The squaters will receive compensation for crops and assets located on the land, but not compensation for the land. There are no public land plots in the affected area used by leaseholders. Below in table summary of impact LARP.

Summary Impact on Land Acquisition and Resettlement

No	**Impacts**	**Unit**	
Land Tenure Patterns			
	Total Land parcels affected	No.	115
	Total land Area to be acquired	Sqm	**103,431**
	Category 1. Category 1. Titled private agricultural land plots with valid registration	No.	57
	Category 2 . Private Legalizable	No.	26
	Category 3. State Owned Used by Private Users (Squatters	No	2
	Category 4. State Owned	No.	30
Land Use and Compensation Categories			
	Type 1; Arable land. The land plots of agricultural status, located close to villages but remotely from the existing mainline road. These land plots are used for agricultural needs; (10 Gel/sqm)	No	29
	Type 2; The land plots of agricultural official status, used as residential land (17 Gel/sqm).	No	7
	Type 3. The land plots of residential official status, (17 Gel/sqm)	No	19
	Type 4. The land plots of non-agricultural status, used as commercial land (33 Gel/sqm)	No	28
	Type 5; State Owned , Used by Private Users – Non Legalizable	No	
	Type 6 State Owned Not Used by Private Users	No	
Affected Structures			
	1-storey brick residential house	No	1
	2-storey residential house with the first floor made of block/brick, the second floor made of wood	No	4
	2-storey house, made of stone, brick, and blocks	No	3

	-storey house, made of brick and blocks Unfinished building (without roof) 3-storey residential 1house, made of stone, brick, wood, and blocks	No	1
	Post office (nonoperational	No	2
	Ki1ndergarten	No	1
	Mi1ni-HPP and pipeline (D=530 * 5 , 1.5 km)	No	1
	Block -built Office	No	1
	Shop	No	3
	Georgian Tandoor bakery Building	No	3
	Concrete Pillar Workshop	No	3
	Vulcanizing Service Station (Workshop)	No	1
	Gas Filling Station	No	1
	Wooden Eatery	No	1
	Eatery made of block, reinforced concrete and stone	No	8
	Auxillary Structures	No	48
	Small Structures (Fences etc.)	No	
Affected Households			
	Severely affected Households	No	111
	Vulnerable Households	No	6
	Resettled households	No	9
	AH losing registered plots (needs correction of cadastral drawings and re-registration)	No	41
	AH losing legalizable plots (rightful owners, 1 stage registration through NAPR)	No	21
	AHs losing non-legalizable land plots (squatters)	No	2
	AH losing agricultural land plots	No	23
	AH losing agricultural land plots used as residential	No	6
	AH kosing residential plots	No	16
	AH with non-agricultural (commercial) land plots	No	21
	AHs losing businesses (in total)	No	15

	AHs losing businesses with their own land plots and facilities	No	11
	AH losing Jobs	No	28
	AHs losing outdoors trading incomes	No	31
	AH losing crops	No	21
	AH losing trees	No	40
	Total AH	No	116
	Total Affected Persons	No	511

Given the magnitude of impacts (there are 119 AHs (533PAPs), 114 severely affected and 6 vulnerable AHs, 9 AHs physically relocated), the project under this RAP is classified as "A" for resettlement and preparation of full scale RAP is necessary for project implementation.

In overall 116 AHs (511 PAPs) are affected by the project: 58 directly, losing their land plots and associated assets and businesses, 5 AHs are losing businesses where they rent the facilities (out of these 1 AH is renting his own facilities and is doublecounted), 28 employees of businesses are losing their permanent jobs and 31 outdoors traders are losing their seasonal income (out of these 31 traders, 2 are members of the same AH, three AH are already accounted as losing land). Nine AHs are losing their residential houses and are subject for physical relocation. They will be compensated for lost buildings and structures at replacement cost and in addition will receive relocation allowances.

In total 111 AHs have been attributed to severely affected category. A total of 54AHs out of 58 losing land are severely affected due to loss of more than 10% of their productive land or commercial land and facilities used for their business. Three AHs operating leased facilities are also deamed as being severely affected, as they have no guarantteed opportunity to lease other facilities. (Company of one AH is renting facilities leased by his household and he is already accounted as land owner losing more than 10% of land). 28 employees losing their permanent jobs and 26 outdoors traders (out of 31) are also deemed as being severely affected. Five roadside vendors/outdoors traders are already accounted as severely affected as they lose also land or legal businesses.

The project impact extends to directly affected APs comprising 47% male and 53 % females: 102 male and 115 females. Further, 1 of the 49 directly affected AHs is headed by woman. Special attention will be given to the impact of resettlement on women and other vulnerable groups during monitoring and evaluation of the RAP. The project will have a positive impact on gender, and civil works contracts will include provisions to encourage employment of women during implementation. Additionally, women headed households have been considered as vulnerable and special assistance was provided in the RAP entitlements.

7.10 Positive Socio-Economic Effect

Benefit gained as a result of project implementation covers the entire population of the country. Increase of traffic flows (including transit) and simplification of movement, as well as sharp reduction of accidents are expected.

The project will also have positive impact on imployment of local population. According to the best practice shown in Georgia it is envisaged to hire 70% of workforce from local population as it took place in Agara-Osiauri section under the EWH Project financed by the WB. This requirement was included in the agreement of the construction contractor.

Considering the all above mentioned issues, impact on socio-economic impacts can be considered as positive and high value.

7.11 Chance Finds

Impacts in the construction phase

Archeological material (clay pots, silver coins, etc.) was discovered in the adjoining territories of the villages under the impact zone. Based on this, we can suppose that there is probability of late discovering archetypes during the planned earth works. Due to this, corresponding conclusion on late discovering of archeological monuments should be prepared within the granting procedures of the construction permit. Construction works should be planned implemented in compliance with the mentioned conclusion.

Mitigation measures in the operation phase

In case chance find is encountered in the course of earth works, the contractor must immediately stop any physical activity on site and inform the Road Department (RD). The RD promptly notifies the Ministry of Culture and Monument Protection, which takes over responsibility for the following course of action. Works may resume only upon receipt of written permission from the Ministry of Culture and Monument Protection.

7.12 Cumulative Impact

Large part of the project corridor runs through the unpopulated area. There are no significant sources of industrial or municipal pollution in Khevi community. According to the current information, construction of no other large-scale infrastructure than the EWH is planned in future. Based on the above, cumulative impact is not expected.

7.13 Residual Impact

Visual impacts will originate from the disposal of large amounts of excess material generated through drilling of tunnels. Residual impacts therefore may not be avoided, however their mitigation to the acceptable level is possible through good landscaping, restoration of vegetation.

8. ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

8.1 Introduction

Following the requirements of the Georgian environmental legislation and environmental policies of the international finance organizations, an important component of an ESIA report is the environmental and social management plan (ESMP). The goal of the ESMP is to develop the mitigation and monitoring measures for the impacts identified within the scope of the ESIA procedures to be used in practice by the project implementing agency - the RD, and thus, bring its activities into compliance with the environmental and social requirements envisaged by the national legislation as well as with the environmental and social policies of the international finance organizations.

The given ESMP is based on the information given in the previous chapters, in particular, activity specifics, and background properties of the natural and social environment of the working area, expected negative impacts during the activity and their propagation area. The SEMP is drafted for different stages of activity, including designing and preparatory works planning phases (SEMP for designing and preparatory works planning phases see tables 8.2, 8.3 and 8.4). The ESMP is a live document and it can be detailed immediately during the accomplishment of the activities following the monitoring outcomes or other practical terms. Any changes or corrections to this ESMP will be done based on the formal agreement between RD and the World Bank.

The ESMR document will be incorporated in the work tender documents and the tender participants will have the possibility to specify their environmental protection duties in their proposals. After the onset of the construction works, the ESMP will be the part of the agreement between the client and the construction contractor and it will be necessary to accomplish in the course of the construction works.

Responsibility for the implementation of ESMP in construction and operation phases will be carried by RD because this Department is an implementing entity for EWHCIP AF as well as operator of the EWH. Service of Environmental Protection under RD consists of 4 environmental specialist (staff) and 2 consultants. Service of resettlement consists of 7 staff members and 1 consultant. In addition, State control over the implementation of various aspects of ESMP will be undertaken by the Environmental Supervision Department of the MEPA.

8.2 Environmental documents and records

It may be said that an important and perhaps, absolutely necessary mechanism of EMP realization is putting the relevant environmental documents to order and ensuring their permanent update. After identifying the Construction Contractor and issues of building organization, the Roads Department of Georgia, in line with the national legislation, is obliged to develop the following environmental documents and submit them to the MEPA to reach an agreement:

- Developing the project for the maximum allowable discharge (MAD) standards of polluting substances discharged into the surface waters together with the waste water (if necessary);
- Technical report of the stationary sources of harmful substances emitted into the atmospheric air (if necessary);
- Detailed plan of waste management;
- Results of taxation of the vegetation cover in the project corridor;
- Documents envisaged by the terms of the Permit issued under the conclusion of the ecological expertise(quarterly reports of the environmental monitoring and the like may be implied).

The Construction Contractor must be engaged in the development of all above-listed documents.

On its turn, the contract concluded with the Builder must envisage his obligation to submit and agree the following documents and records to the Client:

- Traffic management plan;
- Health and safety management plan;
- Emergency response plan.

In addition, the Implementer (and the Construction Contractor on his errand) shall keep and use the following records in practice during the construction:

- Plan and schedule of the works to accomplish;
- List of the machines and equipment needed for construction;
- Records related to the occurring environmental problems;
- Records about the waste management issues;
- Written marking of the areas of waste disposal and waste transportation instructions issued by the local authority;
- Records about the supplies of necessary materials and their consumption;
- Complaints log books;
- Incident registration logs;
- Reports about the correction actions;
- Logs of equipment control and technical maintenance;
- Reports about the personnel training.

8.3 Costs of ESMP Implementation

EMP value can be calculated after drafting the detailed design. At this stage, the unit prices of necessary infrastructure are presented.

At the construction stage, 1000,000 m^3 excess materials are expected to originate. A certain portion of it will be used for backfilling at the construction stage, while the remained amount will be placed on the preliminary selected site agreed with the local authority. A presumable cost of disposal of 1 m^3 excess material is 8 USD (transportation, disposal and area restoration).

The compensation value of the trees will be calculated after the inventory of the plantings. Price of one seedling is 2 USD on average, and the cost of their planting and growing is 2 USD as well. Consequently, the cost of planting 1 tree is 4 USD.

At the stage of developing the detailed design, the length of the mitigation barrier (linear meters) needed in the project zone will be determined. Unit price of the protecting barriers including their installation cost is as follows:

1. The cost of anchoring or paneling one square meter is 500 USD.
2. The cost of installing one square meter of a bearing wall is 350 USD.
3. The price of one square meter of the protecting wall is 2000 USD.
4. The cost of prevention measures against mudflow, following the scale of the territory, varies between 500.000 and 1.000.000 USD.

8.4 Planning stage of construction organization

Negative impact	Mitigation measure	Supervising body	Approximate value
Emissions of harmful substances into the atmospheric air, propagation of dust, noise and vibration	– Selecting the sites for construction camps and concrete unit far from the settled area of Khevi community. The stationary sources of pollution are recommended to place in the initial part of the project corridor. – The sources of emission and noise must be placed as far as possible from the surface water zones; – Treatment (crushing and sorting) of inert materials must be done on the mining site as far as possible.	Roads Department	Extra costs may be associated with the greater distances of transportation; however, these costs will not be too great.
Disturbance of the stability of the geological environment	– Selecting geologically stable areas with least possible inclination for ground disposal.	Roads Department	
Impact on aquatic environment	– The priority for the collection of industrial and fecal waters must be given to cesspools and UD toilets. Discharge of the wastewater into the surface waters must be brought to minimum. – Sites for the sedimentation pools must be planned at the tunnel ends. – Water supply reservoirs must be considered on the construction camps in order to ensure the rational use of water resources. – A drainage system must be arranged on the construction camp.	Roads Department	To be considered in the total contract value
Waste	– Maximum use of waste rocks in the construction process (shall be decided based on the relevant laboratory studies).	Roads Department	The costs are expected to decline
Visual-landscape change	– Selecting the sites for temporal construction infrastructure and waste storage at maximally invisible locations, far from the settled area of Khevi community. – Selecting the color and design of the temporal construction infrastructure suitable for the natural environment.	Roads Department	Extra costs may be associated with the greater distances of transportation and price differences
Impact on private property/ business	– Developing the Resettlement Action Plan and giving out compensations/compensating the damage.	Roads Department	Costs may be associated with hiring the consultant
Impact on traffic flows	– Developing the traffic management plan to consider the interests of the local people.	Roads Department	To be considered in the total contract value

8.5 Construction stage

Type of work	Location	Expected negative impact	Mitigation measure	Responsible entity	Controlled by
Preparatory works: mobilization of the temporal infrastructure, transport and construction appliances and equipment and mechanisms needed for construction.	The area of the construction camps	Emissions of harmful substances into the atmospheric air, propagation and noise propagation	– Equipping the concrete unit with relevant air-cleaning systems. – Making noise-protection barriers if necessary between the noise sources and the receptors (population).	Construction Contractor	Roads Department, Ministry of Environmental Protection and Agriculture
		Risks of pollution of surface and ground waters and soils	– Use of non-faulty construction techniques and vehicles. – The machines/equipment and potentially polluting materials will be placed far from the surface water objects, in the areas protected against the atmospheric precipitations. – Equipping the territory with sewage, storm-water and treatment systems at the initial construction stages. – Limiting the perimeter of the oil products supply reservoirs to prevent the propagation of the pollutants in case of emergency spills. – Discharge of any kind of untreated wastewater into the rivers is to be prohibited. – Making the water-proof layers over the surfaces of the storing areas.		
		Negative visual-landscape change	– Temporal structures, materials and waste will be placed at locations far and not visible from the visual receptors. – The color and design of the temporal structures will be chosen to suit the environment. – Demobilization of the temporal infrastructure and recultivation works following the completion of the works.		
		Risks of safety of local people and personnel	– Use of non-faulty construction techniques and vehicles; – Fencing the camp territories right at the initial stage of the construction; – Installing the safety signs along the perimeter of the territory. – Protecting the perimeter of territory and controlling the movement of foreign people in the area. – Equipping the personnel with PPE. – Equipping the camps with first aid kits; – Ensuring electrical safety. – Keeping an incident registration log. – Personnel training at the initial stages.	Construction Contractor	Roads Department

Cleaning the corridor off the vegetation cover and accomplishing the earth works. The removal of the topsoil is meant. Putting the area topography to order (terracing, making sections and fills) making foundations	Project road corridor	Cutting down the vegetation cover, habitat loss/fragmentation.	– Obtaining the permit from LEPL National Forest Agency before the onset of the works; – Cutting down the trees and plants under the supervision of the specialists an authorized agency (LEPL National Forest Agency); – The expected impact is partly compensated at the expense of recultivation and landscaping works. – Protecting the project perimeter to prevent excess harm to the plants.	Construction Contractor	Roads Department, LEPL National Forest Agency
		Noise propagation, emissions of dust and combustion products	– Use of non-faulty construction techniques and vehicles; – Accomplishing the noisy works during the day as far as possible; – Running the vehicle drives at minimal speed.	Construction Contractor	Roads Department
		Loss of topsoil and degradation of sites	– Cutting the topsoil and piling it in isolation from the lower soil layer and other materials; – In order to avoid the topsoil erosion, the height of fill must not exceed 2 m and the inclination of the fill slope must not exceed 45°; – Water-diversion channels will be made along the perimeter of the topsoil fill and will be protected against the scattering by the wind blow; – In case of storing the topsoil for long, measures must be taken to maintain its qualitative properties. Periodic loosening or grass sowing is meant.	Construction Contractor	Roads Department, Ministry of Environmental Protection and Agriculture
		Development of hazardous geo-dynamic processes	– Control over the clearing off the trees and vegetation cover; – Diverting the rain- and spring waters by bypassing highly sloped and other sensitive sites by using relevant water diversion techniques (channels, pipelines, temporal berms, settling basins); – Removing the active bodies in the landslide-prone areas to the extent possible and terracing the slopes to ensure their stability; – Compacting the ground fill properly to avodi slope collapse. – Limiting or stopping the works over the slope in the periods with precipitations. – Recultivating the damaged areas after the completion of the works, sowing grass and planting the trees over the slopes.	Construction Contractor	Roads Department, Ministry of Environmental Protection and Agriculture
		Erosion and deterioration of esthetic view.	– The topsoil and subsoil must be placed far from the surface water objects; – The sites will be immediately filled and compacted and the surfaces and slopes will be graded. If needed, the slope stabilization techniques will be used;	Construction Contractor	Roads Department

			– Site restoration by scattering the topsoil from above and creating the conditions favorable to restore the vegetation cover.		
		Risks of pollution of surface and ground waters.	– Use of non-faulty construction techniques and vehicles; – In case of spills of oil/lubricants, the spilled product will be localized/cleaned in the shortest possible time. – The appliances creating the risk of ground water pollution when in operation will be equipped with drip pans; – The vehicles must be preferably washed at private car washing areas; – Using temporal water diversion channels; – Filling the holes in a timely manner.	Construction Contractor	Roads Department, Ministry of Environmental Protection and Agriculture
		Damage or harm to animals.	– Observing the borders of the working area; – Bordering the ditches to prevent the animals from falling into them and getting harmed; – Efficient use of the mitigation measures for the pollution of the environment (air, water, soil); – Accomplishing the ground works within limited terms.	Construction Contractor	Roads Department, Ministry of Environmental Protection and Agriculture
		Accidental damage to the archeological monuments	– In case of finding any strange item, stopping the works immediately and informing the technical supervisor or the Client; – Renewing the works only after the formal instruction is received from the technical supervisor or the Client.	Construction Contractor	Roads Department, National Agency to protect cultural environment
Laying tunnels	Tunnel, tunnel portal and exit	Noise and vibration propagation	– Doing explosions with little changes.	Construction Contractor	Roads Department, Ministry of Environmental Protection and Agriculture
		Pollution of surface waters with the waters flowing out of the tunnel	– Making cesspools at the tunnel portals and ensuring their proper exploitation.		
		Personnel safety risks	– Using relevant ventilation system during tunneling; – Observing labor safety rules during the drilling and explosion works; – Equipping the personnel with PPE; – Reducing the working time of the personnel in the tunnel.		
Building bridge piers and accomplishing other works in the / near the riverbed	Construction grounds near the riverbeds	Pollution of surface waters	– Use of non-faulty construction techniques and vehicles; – Equipping the oil equipment with dripping systems; – The works to be accomplished in active riverbeds must be done within the limited time; – Prohibiting car wash in the riverbeds.	Construction Contractor	Roads Department, Ministry of Environmental Protection and Agriculture

Transportation	Corridors of the roads used to transport necessary materials, temporal structures, labor and waste. The routes running near the settled areas are also significant. The transport operations will continue for the whole construction period.	Noise propagation, emissions of dust and combustion products	– Use of non-faulty construction techniques and vehicles; – Limiting the driving speeds; – Maximally limiting the use of public roads and searching for and using alternative routes; – Watering the working surfaces in dry weather; – Covering vehicle body during transportation of dusty materials; – Informing population on the expected intense vehicle movement.	Construction Contractor	Roads Department
		Damage to the local road surfaces	– Limiting the movement of heavy techniques along the public road as much as possible; – Restoring all damaged road sections as much as possible to make the roads available to the people.	Construction Contractor	Roads Department, local authority
		Overloaded transport flows, limited movement	– Selecting an optimal bypass to the working area; – Installing road signs and barriers at necessary locations; limiting the movement of heavy techniques along the public road as much as possible; – Using flagmen in case of intense traffic; – Making temporal bypasses; – Informing the population about the time and periods of intense transport operations.	Construction Contractor	Roads Department, local authority
		Risks of safety of local people and personnel	– Use of non-faulty construction techniques and vehicles; – Driving the vehicles with admissible speeds; – Minimizing the use of the roads crossing the settled areas; – Limiting the traffic on holidays	Construction Contractor	Roads Department
Paving the road surface and facing works	Design corridor	Pollution of soil and surface waters	– Laying the road surface only in dry weather; – The road surface must be laid only by taking the relevant safety measures: the materials or waste must not dissipate over the site, etc.	Construction Contractor	Roads Department, Ministry of Environmental Protection and Agriculture
Waste management	Temporal waste storage areas, transport corridors and final storage areas	Irregular propagation of waste, environmental pollution	– Delivering the construction and other necessary materials only in needed quantities; – Re-using the waste as much as possible, including the use of excess material for backfilling; – Arranging the temporary waste storage areas and equipping them with relevant signs; – Temporary and final disposal of excess material in agreement with the emplyer's Plan for Managing Excavated Marterial; – Assigning the duly qualified personnel for waste management. – Instructing personnel on waste management.	Construction Contractor	Roads Department, Ministry of Environmental Protection and Agriculture

8.6 Operation phase

Type of work	Location	Expected negative impact	Mitigation measure	Responsible entity	Controlled by
Exploiting the road in a common mode	Along the road	Noise propagation	– Aranging noise barriers in the impact areas identified through noise level monitoring and/or upon request of affected communities.	Road maintenance contractor	Roads Department
		Littering and pollution of road corridor	– Regular cleaning of the roadside zone; – Regular cleaning and repairing of water channels and pipes	Road maintenance contractor	
		Development of hazardous geo-dynamic processes	– Monitoring the trouble-free performance of the protective engineering facilities for slopes and riverside zone and regular repairs.	Road maintenance contractor	
		Accidents and emertgencies	– Equipping the road with relevant signage and signaling systems; – Equipping the road with the nighttime illumination system; – Permanent control of the technical state of the road cover and other road infrastructure (road signs, crossings, etc.), and accomplishing the relevant rehabilitation measures immediately after any damage.	Road maintenance contractor	
		Loss of roadside vegetation	– Replacing the damaged/weathered plants along the road with new ones.	Road maintenance contractor	
Planned repairs and preventive works	Along the road	Propagation of polluting substances (water, soil pollution) during the repairs and replacement	– The road surface must be repaired in dry weather to avoid the pollution of the surface flow; – In order to avoid the dissipation of the materials used to repair the damaged road sections, the relevant works must be planned in an expedient manner.	Road maintenance contractor	

9. ENVIRONMENTAL AND SOCIAL MONITORING PLAN

9.1 Introduction

As the previous chapters of the ESIA report note, there are risks of certain impacts on some environmental receptors during the activity. One of the preconditions for reducing the negative nature and value is the correct management of the strict and well-planned activity under strict supervision (environmental monitoring).

The monitoring methods incorporate visual observation and measurements (if needed). The monitoring program describes the monitoring parameters, time and frequency of monitoring, and collection and analysis of monitoring data. The size of monitoring depends on the value of the expected impact/risk.

The environmental monitoring plan in the project base must cover the issues, such as:

- Assessment of the state of environment.
- Identification of the reasons for changes in the environment and evaluation of the outcomes.
- Identification of the correction measures when the target values cannot be reached.
- Regular supervision over the degree and dynamics of the impact of the activity on the environment.
- Compliance with the legal requirements for impact intensity.
- Control over the set parameters associated with significant ecological aspects.
- Prevention and timely identification of the possible violations related to ecological aspects or emergencies during the activity.

The following are subject to the regular observation and evaluation in the course of environmental monitoring:

- Atmospheric air and noise;
- Water;
- Soil;
- Biological environment;
- Labor conditions and meeting the safety standards, etc.

9.2 Environmental and Social monitoring plan in the construction phase

What? (Is the parameter to monitor)?	**Where?** (Is the parameter to monitor)?	**How?** (Must the parameter be monitored)?	**When?** (frequency or duration of monitoring)	**Who** (Is responsible for monitoring)?
1	**2**	**3**	**5**	**6**
Dust propagation, exhaust fumes	• Construction camps; • Construction corridors; • Transportation routes; • The nearest residential houses	– Instrumental measurement (How)	– Checking dust propagation – during the intense operations and vehicle movement, particularly in dry and windy weather. – Checking the technical state - at the start of the working day; – Instrumental measurement - in case there are complaints	Roads Department
Noise propagation	• Construction camps; • Construction corridors; • Transportation routes; • The nearest residential houses	• Control over the tehcnical performance of machines and equipment; • Instrumental measurement.	– Checking the technical state - at the start of the working day; • Instrumental measurement – in case of filed complaints	Roads Department
Engineering-geological stability	• Sensitive instable sections identified in the project corridor.	• Visual observation; • Controlling the efficiency of the protective buildings; • Periodic examinations by the engineering geologist.	• Every day before the onset of the groudn works; • Particularly after the periods with precipitations;	Roads Department
Soil and ground quality	• Areas adjacent to the construction camps; • Design corridor; • Materials and waste storage areas; • Corridor of the access road	Visual observation: • No significant oil spills are observed; • Laboratory control	• Visual observation - at the end of the working day; • Laboratory examination - in case of large oil spills	• Visual observation - By anenvironmental manager • Laboratory control - with the help of the Contractor
Temporal storage of the removed ground and topsoil	• Construction corridor; • Ground storage areas.	Visual observation: – The lower soil layer and topsoil are piled separately. – The height of the topsoil pile does not exceed 2 m. – The inclination of piles does not exceed 45°. – The soil is placed far from the surface water objects.	Every day following the completion of ground works.	Roads Department, by an environmental manager

		• There are water diversion channels along the perimeter of the storage area; • The soil is stored temporarily at places preliminary agreed with the technical supervisor.		
	• Construction Contractor's office	Examining the documented agreement about the temporal use of soil.	Shortly after the ground works are complete	
Vegetation cover and fauna	• Construction corridor	Visual observation: • The works within the limits of the marked zone and no additional harm or plants or illegal cuttings take place. • No harm or death of animals is fixed.	• Visual observation - at the end of the working day;	By an environmental manager
Management of industrial and fecal waters	• Construction camps	• Discarging the industrial and fecal waters into the assenization pools; • The assenization pools are cleaned and their technical state is satisfactory; • No untreated wastewater is discharged into the rivers;	• Visual observation - on every working day;	By an environmental manager
Waste management	• Construction camps; • Construction corridor; • Temporal waste storage areas;	Visual observation: – The sites of temporal waste disposal are assigned in the construction area and are duly marked. • The storage areas for hazardous waste are protected against the penetration of strangers and against the weather impact; – On the territory, at due locations, there are marked containers to collect domestic waste. – The sanitary condition of the territory is satisfactory – no dissipated waste is observed. • The waste is not stored on the territory for long;	• Visual observation - at the end of each working day;	By an environmental manager
	• Construction Contractor's office	– Checking the waste registration log, – Checking the documented agreement about waste disposal	– Document check - once a month –	By an environmental manager

Oils and oil products management	• Construction camps; – Warehousing facilities	Visual observation: • The protected areas for oils, oil products and other liquid products marked in a due manner;	• Visual observation - at the end of each working day;	By an environmental manager
Technical state of the access roads, possibility of free movement	• Corridors of the transportation routes	Visual observation: – The vehicles move along the routes specified in advance, bypassing the settled areas as far as possible. – The state of the driving routes is satisfactory. – Free movement is not limited. – Driving speeds are observed.	– During the intense transport operations	By an environmental manager
Labor safety	– Working area	Visual observation: – The territory is fenced and protected against the illegal penetration of strangers, – The personnel are equipped with PPE. – The technical state of the exploited equipment and mechanisms is satisfactory. – Electrical and fire safety is ensured. – The safety, prohibiting and information signs are installed on the territory and along its perimeter. – There is a banner on the territory with the basic safety rules. – Smoking areas are specially assigned.	– Visual observation- before the onset of each working;	By an environmental manager
		Unscheduled control (Inspection): • The personnel observe the safety rules and use the PPE.	• Inspection - regularly.	By an environmental manager

9.3 Environmental and Social Monitoring Plan for Operation Phase

What? (Is the parameter to monitor)?	**Where?** (Is the parameter to monitor)?	**How?** (Must the parameter be monitored)?	**When?** (Frequency or duration of monitoring)	**Who?** (Is responsible for monitoring)?
Hazardous geological processes	• Sensitive sections in the main road corridor; • Sites of the protective buildings.	• Visual observation; • Controlling the efficiency of the protective buildings.	• Twice a year, at the end of winter and in autumn	Roads Department
Vegetation cover	• Vegetation in the RoW.	• Visual observation	• Several times a year;	Roads Department
Traffic safety	• In the road corridor	Visual observation: • Checking the presence of the relevant road signs; • Examining the technical state of the road cover.	• Several times a year;	Roads Department
Operation of drainage system	• In the road corridor	• Examining the technical state of the drainage system.	• Several times a year;	Roads Department
Littering and waste pollution	• In the road corridor	Visual observation	• On a periodic basis	Roads Department

10. PUBLIC CONSULTATION AND GRIEVANCE REDRESS MECHANISM

10.1 Public Consultations

Public consultation process on the works to be undertaken under EWHCIP commenced at the early stage of conceptual design. Once the environmental and social screening and scoping of the proposed works had been undertaken, a ToR for the ESIA was drafted and disclosed. RD discussed the ToR with stakeholders and finalized thereafter (Minutes of meeting and List of participants are given in Annexe 1).

Minutes of public consultation meeting on Terms of Reference for Environmental and Social Impact Assessment for construction of the E-60 highway bypass between Chumateleti-Khevi was conducted on May 6, 2016. Upon delivery of the final draft of the present ESIA report, it was disclosed in Georgian and English languages through the web page of RD and discussed with stakeholders on February 15, 2017 and March 3, 2017 (Village Vertkvichala); January 12, 2018 (Khashuri Municipality building); March 10, 2018 (Kharagauli Municipality). ESIA report will be finalized through incorporation of the public feedback and the full account on the consultation process will be attached (minutes of the consultation on ToR for ESIA are already available in the attachment to the present ESIA report). During the ESIA disclosure period, hard copies as well as the electronic version of non-technical summary of ESIA will be available at the following addresses:

- Local government of Kharagauli Municipality – address: settlement Kharagauli, #15 9 April str;
- Local government of Khashuri Municipality – address: c. Khashuri, #2 Tabidze str;
- Information center of Khevi community
- Roads Department of Georgia – Address: Tbilisi, #12 Al. Kazbegi str.

Also, the draft ESIA report is aviable and later – its finalized version will be available for downloading from the following web sites:

- Roads Department of Georgia: www.georoad.ge
- Website of the MEPA: www.moe.gov.ge

During ESIA disclosure period, stakeholders will have an opportunity to send comments at the following e-mail addresses:maya_vashakidze@yahoo.co.uk

10.2 Grievance Redress Mechanism

During implementation of the Project, there might be several issues related to environmental and social hazards and disputes on entitlement processes occurred due to the Project activities. A Grievance Redress Mechanism will be set up for the Project to deal with both the environmental and social issues of the Project.
The present chapter specifies the procedures of establishing Grievance Reddress Mechanism (GRM) and its structure and composition. The Safeguard Units of the IA has important role for establishing the GRM.

The GRM consists of temporary, project-specific units established at the municipal level in project affected municipalities and regular system established at IA. ***Grievance Reddress Committee (GRCE)*** established at municipal level as a project-specific instrument, which is functional only for the period of the project implementation.***Grievance Redress Commission (GRCN)***is formed as permanently functional informal structure within the IA to ensure grievance review, resolution and record.

Grievance Redress Commission

Grievance Redress Commission (GRCN) is formed by the order of the Head of RDMRDI as a permanently functional informal structure, engaging personnel of RDMRDI from all departments having regard to the environmental and resettlement issues and complaint resolution. This includes top management, Environmental and Social Safeguards Units, Legal Departments, PR department and other relevant departments (depending on specific structure of the IA). The GRCN is involved at the Stage 2 of grievance resolution process. The Order shall also state that if necessary representative of local authorities, NGOs, auditors, representatives of APs and any other persons or entities can be engaged in a work of GRCN.

Grievance Redress Committee

Grievance Redress Committee (GRCE) is an informal, project-specific grievance redress mechanism, established to administer the grievances at Stage 1. This informal body will be established at community level in affected Municipality (village/community authority). The GRCE shall include representatives of Municipal LAR Teams and local communities. The RD representative in the Municipal LAR Team shall coordinate the GRCE formation. He/she will then be responsible for the coordination of GRC activities and organizing meetings (Convener). In addition, GRCE shall comprise village Rtsmunebuli or his/her representative, representatives of APs, women APs (if any), and appropriate local NGOs to allow voices of the affected communities to be heard and ensure a participatory decision-making process.

Representative of the Resettlement and Environment Division of RD is coordinating the work of the Committee and at the same time he/she is nominated as a contact person for collecting the grievances and handling grievance log. The local authorities at the municipal level, civil works Contractor, Supervising Company (Engineer), as well as APs (through informal meetings) will be informed about the contact person and his contact details are available in offices of all mentioned stakeholders.

The Contact Person collects and records the grievances, informs all members of the Committee and the management of RD regarding the essence of the problem, engages the relevant stakeholders in discussions with the applicant of grievance, handles the process of negotiation with AP at the stage 1 of the grievance resolution. The Contact Person prepares the minutes of meetings and ensures signatures. In case if the grievance is resolved at the stage 1, the Contact Person records the fact of closing the grievance in his log and informs RDMRDI management about this in written. If the complainants are not satisfied with the GRC decisions, they can always use the procedures of Stage 2 of grievance resolution process. In that case the Contact Person helps the AP in lodging an official complaint (the plaintiff should be informed of his/her rights and obligations, rules and procedures of making a complaint, format of complaint, terms of complaint submission, etc.).

The APs should be informed about the available GRM. This could be achieved through implementing information campaigns, distributing brochures (e.g. Communication Plan), keeping all focal points up-to-date & maintaining regular communication with them, allowing multiple entry points for complaints, introducing forms for ease of reporting complaints.

10.3 Grievance Redress Procedures

Brief description of all stages of Grievance Resolution Process are given in the **Table 10.1** below.

Table 10.1. Grievance Resolution Process

Steps	Action level	Process
Stage 1 (GRCE Level)	**Step 1:** Informal negotiations with APs	The complaint is informally reviewed by the GRCE Contact Person – Representative of Environmental and Resettlement Unit of IA/PIU, which takes all necessary measures to resolve the dispute amicably. At this stage, Contact Person engages in discussions with AP only those members of the GRCE, who have direct relation to the issue.
	Step 2: Formal negotiations with APs GRCE levelresolution of grievance	If the oral grievance is not solved during the negotiations, the GRCE will assist the aggrieved APs to formally lodge the grievances to the GRCE. The aggrieved APs shall submit their complaints to the GRCE within 1 week after completion of the negotiations at the village level or later, as he wishes. The aggrieved AP shall produce documents supporting his/her claim. The GRCE Contact Person will review the complaint and prepare a Case File for GRCE hearing and resolution. A formal hearing will be held with the GRCE at a date fixed by the GRCE Contact Person. On the date of hearing, the aggrieved AP will appear before the GRCE at the Municipality office for consideration of grievance. The member secretary will note down the statements of the complainant and document all details of the claim. The decisions from majority of the members will be considered final from the GRCEat Stage 1 and will be issued by the Contact Person/Convenor and signed by other members of the GRCE. The case record will be updated and the decision will be communicated to the complainant AP. After implementation of the agreed action the Protocol of Grievance Closure is prepared by the Contact Person. The protocol will be signed by the Chairman of GRCE and by the claimant.
Stage 2	**Step 3** Decision from central IA/PIU GRCN	If any aggrieved AP is unsatisfied with the GRCE decision, the next option will be to lodge grievances to the IA/PIU at the national level. GRCE should assist the plaintiff in lodging an official compalint to GRCN (the plaintiff should be informed of his/her rights and obligations, rules and procedures of making a complaint, format of complaint, terms of complaint submission, etc). The aggrieved AP shall produce documents supporting his/her claim, in accordance with the legal requirements (Administrative Code of Georgia). The GRCN of the IA shall review the complaint in compliance with the procedures specified in the Administrative Code of Georgia. If needed, a formal hearing will be held with the GRCN at a date fixed by the GRCN member secretary. On the date of hearing, the aggrieved AP will appear before the GRCN at the IA office for consideration of grievance. The Contact pperson will note down the statements of the complainant and document all details of the claim. The plaintiff shall be informed of the decision.
Stage 3	**Step 4** Court decision	If the IA/PIU decision fails to satisfy the aggrieved APs, they can pursue further action by submitting their case to the appropriate court of law (Rayon Court). The aggrieved AP can take a legal action not only about the amount of compensation but also any other issues, e.g. occupation of their land by the contractor without their consent, damage or loss of their property, restrictions on the use of land/assets, etc.

10.4 Grievance Log

The Grievance Logs will be developed at both – GRCE and GRCN levels.

The Grievance Logs will be developed and managed by the RD representative at site (Convenor of the GRCE/Contact Person) and will be kept at site (in the IA/PIU office or Engineer's office).

The records in Grievance logs include the following information:

- Name and contact details of the claimant
- Date of receiving claim
- Form of claim – (oral or written)
- To whom the claim has been addressed initially (entry point)
- The brief description of the essence of claim
- the stages, dates and participants of negotiations with the AP with GRCE (stage 1)
- Minnutes of meetings
- Final decision of the GRCE (in case of the dispute is resolved, the decision is about closure of the issue. In case if the dispute remains unresolved, the decision is about passing to the stage 2 of the grievance redress process)
- Date of decision of GRCE
- Documents prepared by AP with the help of GRCE for passing to GRCN

The copies of the records/documents may be also kept in the municipal office.

10.5 Conclusions and Recommendations

The following major conclusions were developed in the EIA process:

1. The activity considered by the EIA Report envisages the modernization of Chumateleti-Khevi section of East-West Highway (E-60). The Implementer is the Road Department of the Ministry of regional Development and Infrastructure of Georgia.

2. The EIA Report was developed by considering the requirements of the national legislation and environmental policies of the international finance organizations.

3. The EIA Report considers several alternative options to realize the project, including the analysis of two alternatives of the road alignment proposed at the stage of the feasibility study of the project. The best option in an environmental respect was selected.

4. The considered corridor of the Highway is distinguished for morphological and geological diversity. There are some sensitive sites hazardous in respect of geodynamic processes. However, the project envisages taking relevant preventive measures at the construction and exploitation stages. A program of geotechnical studies or accomplish in the detailed design process has been developed with the support of international experts.

5. During the construction works, the stationary and mobile sources of emission of harmful substances into the atmospheric air and noise propagation will present in the design corridor. By considering the relevant mitigation measures, the impact on the environment or population will not be significant. In the exploitation phase, noise barriers may become necessary along some sections.

6. The biological environment in the design corridor is not sensitive. The degree of naturalness of the vegetation cover and habitats is low. Consequently, an expected impact on the natural environment must be assessed as low or average. Despite this, the mitigation and compensation measures will be considered.

7. The design corridor crosses several rivers and gullies. Therefore, there are some risks of impact on the surface water quality in the construction phase. In order to prevent the risks, relevant control of the waste and effluents is necessary.

8. The impact on visible historical-cultural monuments will be insignificant. However, the probability of chance finds in the project area is higher than average. During the past excavations on the territory of village Khevi, they found different items. The instructions to follow in case of archeological findings in the area have been developed and they are obligatory to follow by all parties.

9. The implementation of the project will be associated with the need for physical and economic resettlement. In this connection, a Resettlement Action Plan will be developed.

10. The construction works of the Highway must be accomplished within the zone of the existing road. Following the narrowness of the gorge, the traffic control will be complicated. Consequently, the relevant organization of the construction works will be necessary. Prior to the onset of the construction works of each site, traffic flow management plan must be developed and agreed with the parties concerned.

11. The modernization of Chumateleti-Khevi section is expected to have high positive social and economic impact. The project will be an important force promoting the sustainable economic development of the country and the risks of car accidents and limited movement will be reduced drastically.

12. The EIA Report gives the Environmental Management Plan and Environmental Monitoring Plan. Provided the measures given by these plans are realized, the expected impacts will reduce sharply.

Simultaneously with the activity, the environments measures envisaged by the EIA Report and Georgian environmental legislation will be realized, including:

- The obligation envisaged by the terms of the Permit and mitigation measures given in the EIA Report will be discharged.
- The measures under the Waste Management Plan will be taken. The question of organizing the dumpsites will be agreed with the local authority.
- The works of the forest cutting down in the design corridor will be agreed with LEPL "National Forest Agency". Particular attention will be paid to the protection of the Red-Listed species, and their delisting from the environment will be done in terms of special supervision.
- The measures to compensate the damage inflicted to the trees and vegetation cover will be determined by the rule to calculate compensation fee to use the forest fund with a special purpose approved by Decree no. 242 of August 20, 2010 of the Government of Georgia "On Approving the Rule of the Forest Use". The measures to compensate the delisting the trees and vegetation cover from the forest fund will be determined under Decree no. 242 of August 20, 2010 of the Government of Georgia "On Approving the Rule of the Forest Use".
- Particular attention will be paid to ensuring the engineering-geological stability. If necessary, additional protective structures will be used; proper monitoring will be accomplished.
- In case of claims of the population, all possible measures to resolve them will be undertaken.
- The safety of movement of people along the Highway will be ensured.
- After the completion of the construction works, the exploited areas will be cleaned, the waste will be disposed and the damaged areas will be restored and recultivated.
- All serious unforeseen environmental problems, if any, will be communicated to the Ministry of Environmental Protection and Agriculture of Georgia.

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4. საქართველოს მთავრობის 2013 წლის 31 დეკემბრის №408 დადგენილება „ატმოსფერულ ჰაერში მავნე ნივთიერებათა ზღვრულად დასაშვები გაფრქვევის ნორმების გაანგარიშების ტექნიკური რეგლამენტის დამტკიცების თაობაზე“.
5. საქართველოს შრომის, ჯანმრთელობისა და სოციალური დაცვის მინისტრის 2003 წლის 24 თებერვლის ბრძანება №38/ნ «გარემოს ხარისხობრივი მდგომარეობის ნორმების დამტკიცების შესახებ».
6. საქართველოს ეკონომიკური განვითარების მინისტრის 2008 წლის 25 აგვისტოს ბრძანება № 1-1/1743 „დაპროექტების ნორმების-„სამშენებლო კლიმატოლოგია“.
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11. ANNEXES

Annex 1. Minutes of Meeting

MINUTES

of public consultation meeting on

Terms of Reference

for Environmental and Social Impact Assessment for construction of the E-60 highway bypass between Chumateleti-Khevi

06.05.2016 Tbilisi

Chairman of meeting: Gia Sopadze, Head of Environment Protection Unit, Ressettlement and Environment Protection Division

Secretary of meeting: Maya Vashakidze, Environmental Consultant Roads Department of Georgia

Speakers: Gia Sopadze, Maya Vashakidze

Attendees of the Meeting: See attachment 1

Agenda of the Meeting:

- Introduction and context
- Presentation of TOR
- Questions & answers

Topic presented: Introduction made by Gia Sopadze about construction of the E-60 highway. The speaker mentioned that Georgia, located along the transit corridor and connecting Europe and Asia, has a potential to connect some countries in the region with global economy. The Government of Georgia is conducting a program to upgrade the major roads of the country, managed by the Roads Department (RD) of the Ministry of Regional Development and Infrastructure (MRDI). The World Bank is providing series of loans to the Government of Georgia for upgrading this highway through East West Highway Improvement Projects (EWHIPs). Two projects of these series are now completed covering the highway section between Agaiani and Ruisi. EWHIP-3 and EWHIP-4 are under implementation covering the section between Ruisi and Zemo Osiauri. A new project will finance upgrading of the highway from Chumateleti through Khevi, which takes the East-West Highway from East Georgia to the West. TOR currently under consideration is for consulting services sought by the RD to carry out Environmental and Social Impact Assessment (ESIA) of works for upgrading East-West highway from Chumateleti to Khevi. The RD is hiring consultant for detailed design separately, but these two teams (the Consultant for ESIA and the Consultant for Detailed Design) will cooperate and share information with each other to find best solution, the consultants will take into account the World Bank's Safeguards Policies and Georgian Legislation and final decision will be made for environmental and social friendly alignment.

ESIA report will be developed based on the World Bank's safeguard policies: OP/BP 4.01 Environmental Impact Assessment, OP/BP 4.04 Natural Habitats, OP/BP 4.11 Cultural Heritage, OP/BP 4.12 Involuntary Resettlement and OP/BP 4.20 Gender and Development. The project is classified as environmental category "A", since it covers new construction which may have significant and irreversible impacts on the natural and social environment. Pursuant to the national legislation environmental permit need to be obtained.

The content of ToR was presented by Maya Vashakidze. She explained how the consultant will approach the upcoming assignment, what would be the scope of various thematic studies under ESIA, and how the ESIA process will be informed by engagement of various stakeholders. It was mentioned that ESIA will incorporate a range of desktop studies and field surveys. Sensitive receptors will be identified. Direct and indirect; short term, medium and long term; negative and positive; reversible and irreversible (if any)impacts on biodiversity, physical and social environments in the project impact zone during construction and on operation stage, will be evaluated. It has been stressed that the ESIA team will cooperate with design team and resettlement specialist to ensure avoidance, minimization and/or mitigation of potential impacts on recipients. Mitigation

measures for medium and high impacts will be recommended; residual and cumulative impacts - ranked. The ESIA will be carried out with consideration of the national environmental legislation/regulations and the Works Bank requirements. Transparency of information will be ensured throughout the ESIA process. Information will be posted to the RD website and remain in public domain for familiarization and review. Feedback mechanisms will be explained to community to make stakeholder engagement process efficient.

Ms. Maya Vashakidze also provided information concerning the World Bank OP/BP 4.01 Environmental Assessment, OP/BP 4.04 Natural Habitats, OP/BP 4.11 Physical Cultural Resources, OP/BP 4.12 Involuntary Resettlement and OP/BP 4.20 Gender and Development. She explained World Bank Guidelines for environmental and social management.

Below is a summary of Q&A session which followed presentations by RD:

Question	Answer
Does the ToR cover studies regarding the landslides or other geodynamic processes?	The ToR is covering geological, hydrological and hydrogeological research to provide detail information about potential impact during construction or operation phases
Does the ToR cover studies about Eco-corridors for animal migration? Red list data?	After final alignment the consultant will make detail research of the territory, which will give us clear understanding of whether the Red List species and/or routs of animal migration are likely to be affected.
Will the ESIA look at the expected impacts of the project on the traditional lifestyle and economic activity of the affected communities (e.g. animal husbandry)?	As part of the social impact assessment, the ESIA will explore all potential impacts that the project may have on the local communities. The overall goal of the project is to facilitate economic activity and growth. As for the local communities in particular, the Roads Department is obligated to ensure that no one is left worse of as a result of the project implementation. Therefore, if ESIA reveals potential issues that highway construction may cause to movement of cattle within the highway corridor, then adequate cattle passes will be arranged.
Will the local population be protected from the noise?	According to the previous ESIA reports, the consultant will prepare noise and vibration modelling for the operation phase, which will show impacts to the local population and develop mitigation measures to prevent negative impacts (if any).
Does the ToR include planning compensation for the cut trees?	According to the presented ToR, the consultant will prepare compensatory tree planting plan and a special annex to the ESIA report will be the forest inventory in those parts of the State Forest Fund that are found in the Right of Way and need to be de-listed. If the inventory shows presence of the species entered into the Red List of Georgia, then this annex should include documentation needed to apply for a tree cutting permit applicable to such species according to the national legislation. The annex should include full package of documentation required for de-listing required areas from the State Forest Fund, as well as a compensatory tree planting plan that suggests and characterizes the planting area, species and age composition of seedlings, plating and plantation tending techniques, etc. The plan should be designed for the theoretical scenario of all trees falling in the de-listing plots being extracted with an understanding that actual felling needs may be lesser.

Chairman of meeting: Gia Sopadze (signed)

Secretary of meeting: Maya Vashakidze (signed)

Attendees of the Meeting

მონაწილეთა სია

სახელი, გვარი	საკონტაქტო ინფორმაცია	შენიშვნა
[illegible]	551 70 11 15	
[illegible]	599 09 28 68	
[illegible]	599 47 67 17	
[illegible]	568 27 47 74	
[illegible]	595 88 00 37	
[illegible]	591 180 790	
[illegible]	599 27 88 39	
[illegible]	595 11 92 11	
[illegible]	591 29 28 17	

მონაწილეთა სია

სახელი, გვარი	საკონტაქტო ინფორმაცია	შენიშვნა
[illegible]	593 630 840	
[illegible]	592 16 43 43	
[illegible]	595 88 88 880	
[illegible]	599 366-703.	
[illegible]	595 049-738	
[illegible]	555-84-54-30	
[illegible]	595 21 91 41	[illegible]
[illegible]	574 486748	
[illegible]	577 46 64 46	

მონაწილეთა სია

სახელი, გვარი	საკონტაქტო ინფორმაცია	შენიშვნა
მაია ვაშაყიძე	593 32 30 77 maya_vashakidze@yahoo.co.uk	
მარიამ მეგრიშვილი	555 400 205 mbegrishvili2@gmail.com	

Photos:

MINUTES

of public consultation meeting on

Environmental and Social Impact Assessment Report for construction of the E-60 highway bypass between Chumateleti-Khevi

10.03.2017 Village Vertkvichala

Chairman of meeting: Maya Vashakidze, Environmental Consultant, Roads Department of Georgia, Ressettlement and Environment Protection Division

Secretary of meeting: Mariam Begashvili, Social Consultant, Roads Department of Georgia

Speakers: Maya Vashakidze, Mariam Begashvili

Attendees of the Meeting: See attachment 1

Agenda of the Meeting:

- Introduction and context
- Presentation of ESIA Document
- Questions & answers

Topic presented: Mariam Gogishvili delivered an introductory note regarding the construction of E-60 highway. She noted that Georgia, the country located along the transit corridor and connecting Europe and Asia, has a potential to link several countries of the region with the regional economy. For years, the World Bank financed a series of East-West highway corridor improvement projects. At present, the preparatory works for East-West highway corridor improvement project is under way. The outcome of these works will be the rehabilitation of the highway between Zemo Osiauri and Chumateleti. In the process of designing the works, "Eco-Spectri" Ltd, the consultant company hired by the Roads Department, commented about the natural and social environment impact assessment. The ESIA was carried out based on the World Bank's safeguard policies: OP/BP 4.01 Environmental Impact Assessment, OP/BP 4.04 Natural Habitats, OP/BP 4.11 Physical Cultural Resources, and OP/BP 4.12 Involuntary Resettlement. The project is classified as environmental category "A", since it covers new construction, what may have significant and irreversible impacts on the natural and social environment. Pursuant to the national legislation, an environmental permit needs to be obtained.

Mr. Irakli Kaviladze explained how "Eco-Spectri" Ltd. approached the assignment, what was the scope of various thematic studies under ESIA, and how the ESIA process was informed to the various stakeholders. It was mentioned that ESIA incorporated a range of desktop studies and field surveys. The background study covered a series of components, such as: climate and meteorology; geology, geomorphology; hydrology, hydrogeology; soils, landscape and land use; air quality and noise; seismic conditions and hazardous processes; habitats, flora and fauna; historical and archeological sites and social environment. The sensitive receptors were identified; direct and indirect; short-term, medium- and long-term; negative and positive; reversible and irreversible (if any) impacts on biodiversity, physical and social environments in the project impact zone during the construction and on operation stage were evaluated. It was stressed that in the process of developing the ESIA report, the ESIA team must closely cooperate with design team to ensure avoidance, minimization and/or mitigation of potential impacts on recipients. Mitigation measures for medium and high impacts will be recommended; and residual and cumulative impacts should be ranked. The ESIA was carried out considering the national environmental legislation/regulations and the Works Bank requirements.

The transparency of information was ensured throughout the ESIA process. The said document was posted to the RD website and remains in public domain for familiarization and review. The feedback mechanisms were explained to the community to make the stakeholder engagement process more efficient.

Ms. Maya Vashakidze also informed the meeting attendees about the World Bank OP/BP 4.01 Environmental Assessment, OP/BP 4.04 Natural Habitats, and OP/BP 4.11 Physical Cultural Resources.

Ms. Mariam Begashvili informed the interested participants about the World Bank's social safeguard policy OP/BP 4.12 Involuntary Resettlement.

The speakers explained the meeting attendees the World Bank Guidelines for environmental and social management.

Note: The interested parties and local population were informed about the date and venue of the consultation meeting on the draft ESIA report in advance. In particular, the relevant information was distributed via the e-bases of NGO "Caucasus Environment NGO Network" (CENN) on March 2, 2017 and via Roads Department of Georgia web-site on March 1 2017.

Below is a summary of Q&A session. During the meeting, the questions and comments of various participants were answered by the representatives of the Roads Department and representatives of "Eco- Spectri" Ltd.

#	Question/Comment	Answer
1.	When will the construction start?	Presently, a detailed design is being developed and will be presumably finalized by September of the current year. This will be followed by announcing tender for construction works..
2.	Can you give an exact list of project-affected families and plots so that we should plan our activities accordingly, e.g. I wonder if it is meaningful to do any agricultural works for me.	As already mentioned, a detailed design is being developed at present. Only after this process is over, it will be possible to exactly identify the project-affected land plots and businesses. After the registration and inventory process is over, the affected persons' property and plantings will be inventoried by the given moment, and their loss will be compensated within the scope of the resettlement action plan.
3.	If project-financed works require take of a part of someone's land plot and the remaining piece of the plan is useless for the owner, how will compensation work?	n case the project affects part of the land plot and the remaining part turns out to be useless for the owner - in particular, it is impossible to continue using the remaining portion of land following previous land use pattern because of the small size of the remaining plot or because of limited access to the plot, the project will purchase the plot in full, and the perennial plants on such plots will be compensated in full.

4.	There is no natural gas supply system in the village. Isn't such a system planned to lay for the village residents under your project?	Construction of the gas supply system falls within the competence of the local municipalities and should apply to your local municipality to clarify this question.
5.	The construction companies usually have their own labor. We would like to know if the local people will be employed within the scope of the project.	Under the World Bank safeguard policy, the best practice is maximum employment of local labor within the scope of the project. Based on the experience gained from similar projects for the construction of highway (other sections of E-60), we can assume that 60-70% of the local labor will be employed. Both, average-skilled and unskilled local labor will be hired during the construction process. It should be noted, though, that local workforce does not mean the population of your village, but may be presented by the people of nearby villages or municipalities.
6.	How much will you pay for 1 sq.m. of land?	While developing of the Resettlement Action Plan, a professional evaluator will be deployed for setting the value of land plots to be taken.
7.	To whom we should apply if the construction company damages our property?	Based on the Resettlement Action Plan and ESIA report developed in line with the World Bank policy, a Grievance Redress Committee will be organized which, in addition to the participant organizations, will include the representatives of local self-governing bodies and various groups of population. It is this committee obliged to consider all claims and proposals regarding the project impact at the first stage.
8.	At present, there is a direct car access road from the existing highway to my house. Will this access road remain in place after the project is implemented?	At present, there are 12 access roads linking the existing highway to the territory of village Khevi. Following the technical requirements of a high-speed highway, 12 car passages along a 3-km-long section is inadmissible. Under the preliminary design, one car passage is planned to construct leading to the center of village Khevi. As for the pedestrian passages, their number and locations will be determined during the development of the detailed design.

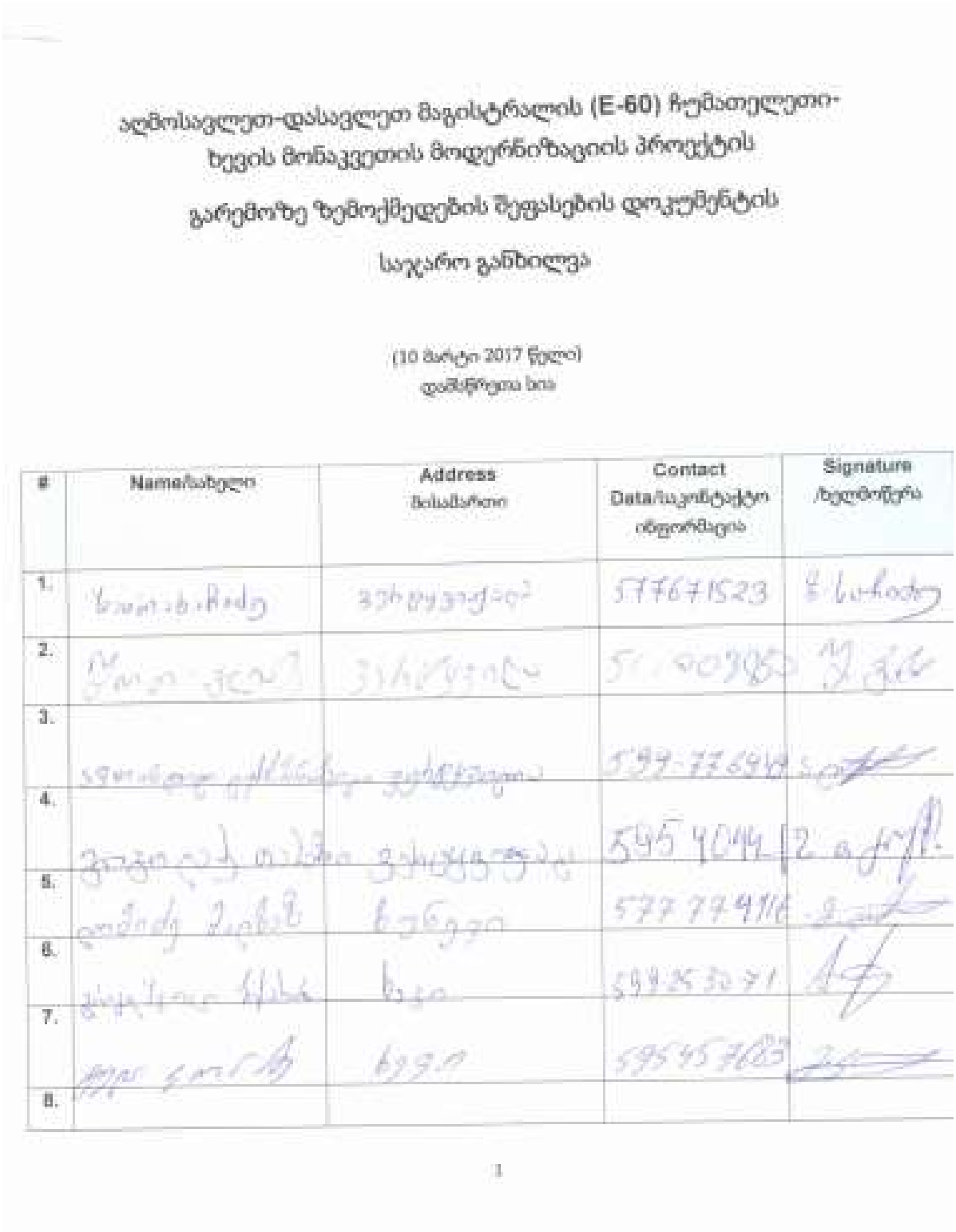
9.	In total, how many houses will be relocated?	At this stage, we can provide only rough information regarding his issue. This information may change during the development of the detailed design. In particular, mostly commercial and public buildings are subject to physical relocation. Under the existing design, only one residential house is under the direct impact. It should also be noted that after the development and approval of the detailed design, an independent consulting company will develop a resettlement action plan. Thereafter, the scale of resettlement and exact information about the affected economies will become clear.
10.	How can we be able to see the detailed design once it is developed?	Our today's meeting is one of the meetings planned to conduct with all interested parties within the scope of the project. Once the detailed design is available, the Resettlement Action Plan will be prepared. A meeting with the local population will be organized to discuss it with the affected people. Besides, the Resettlement Action Plan will be made available at local municipalities and the web site of the Roads Department of Georgia, where all of you will be able to see it.
11.	Will the river be polluted during the construction?	The presented document describes all mitigation measures to be applied by the Construction Contractor to avoid the river pollution. For example, the Construction Contractor will be prohibited to dispose hazardous substances or waste nearer than 50 m distance from the riverbed.
12.	Will the cattle passages be constructed with the project support?	Once the detailed design is available, the Resettlement Action Plan will be developed. The consultant company working on the Resettlement Action Plan will work out measures needed to restore the living conditions of the local population to at least the same level as they had before the implementation of the project. Consequently, if the construction of the highway blocks access rout for the cattle, the remedial action will be proposed in the form of arranging cattle passages.
13.	Will the trees cut down during the construction?	As mentioned, according to the preliminary design, the highway will be constructed from the western tunnel portal to village Khevi on the left bank of the river Rikotula. This will require cutting of trees. Within the scope of the project, a compensation planting plan will be developed as an individual document, under which instead of every cut-down tree, 3 trees will be planted, and if the cut-down tree is red-listed or is endemic, 10 new trees will be planted instead..

14.	How the noise, vibration and dust generated during the construction affect the settlements?	his problem is quite severe on the territory of village Khevi, particularly where a vehicle interchange is to be built. After the detailed design is developed, relevant measurements of possible impacts of noise, vibration and dust will be conducted and relevant mitigation measures will be elaborated, such as tree planting, installing additional noise-reflecting barriers, etc. If this action is not sufficient, temporal or permanent rese ttlement may apply.

Chairman of meeting: Mariam Gogishvili (signed)

Secretary of meeting: Maya Vashakidze (signed)

List of attendees:



აღმოსავლეთ-დასავლეთ მაგისტრალის (E-60) ჩუმათელეთი-ხევის მონაკვეთის მოდერნიზაციის პროექტის

გარემოზე ზემოქმედების შეფასების დოკუმენტის

საჯარო განხილვა

(10 მარტი 2017 წელი)

დამსწრეთა ხის

#	Name/სახელი	Address /მისამართი	Contact Data/საკონტაქტო ინფორმაცია	Signature /ხელმოწერა
1.	[illegible]	[illegible]	577671523	[illegible]
2.	[illegible]	[illegible]	[illegible]	[illegible]
3.	[illegible]	[illegible]	[illegible]	[illegible]
4.	[illegible]	[illegible]	595 40 44	[illegible]
5.	[illegible]	[illegible]	577 77 41 16	[illegible]
6.	[illegible]	[illegible]	598 25 30 71	[illegible]
7.	[illegible]	[illegible]	595 45 76 03	[illegible]
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9.	[illegible]	[illegible]	593767424	[illegible]
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15.	[illegible]	[illegible]	577 671521	[illegible]
16.	[illegible]	[illegible]	598112495	[illegible]
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Photos of Public Consultations:






MINUTES

of public consultation meeting on

Environmental and Social Impact Assessment Report for construction of the E-60 highway bypass between Chumateleti-Khevi

12.01.2018 **Khashuri Municipality**

Chairman of meeting: Maya Vashakidze, Environmental Consultant, Roads Department of Georgia, Ressettlement and Environment Protection Division

Secretary of meeting: Irakli Kaviladze - Director of "Eco-Spectri" Ltd., Environmental Expert

Speakers: Maya Vashakidze,

Attendees of the Meeting: See attachment 1

Agenda of the Meeting:

- Introduction and context
- Presentation of ESIA Document
- Questions & answers

Attenders:

1. Zurab Nozadze, head of Khashuri municipality sakrebulo;
2. Davit Gelashvili, representative of local authorities;
3. Zviad Tefnadze, representative of local authorities;
4. Elguja Gogoladze, chairman of fraction "Georgian dream";
5. Gela Kopadze, Local resident;
6. Natela tsitsishvili, Local resident;
7. Nunu bliadze, Local resident;
8. Levani Vefkhvadze, Local resident;
9. Maia Vakhtangashvili, Local resident;
10. Vakhtang Tavartqiladze, Local resident;
11. Davit getsadze, Local resident;

Topic presented: Topic presented: Maya vashakidze delivered an introductory note regarding the construction of E-60 highway. He noted that Georgia, the country located along the transit corridor and connecting Europe and Asia, has a potential to link several countries of the region with the regional economy. For years, the World Bank financed a series of East-West highway corridor improvement projects. At present, the preparatory works for East-West highway corridor improvement project is under way. In the process of designing the works, "Eco-Spectri" Ltd, the consultant company hired by the Roads Department, commented about the natural and social environment impact assessment. The ESIA was carried out based on the World Bank's safeguard policies: OP/BP 4.01 Environmental Impact Assessment, OP/BP 4.04 Natural Habitats, OP/BP 4.11 Physical Cultural Resources, and OP/BP 4.12 Involuntary Resettlement. The project is classified as environmental category "A", since it covers new construction, what may have significant and irreversible impacts on the natural and social environment. Pursuant to the national legislation, an environmental permit needs to be obtained.

Mr. Irakli Kaviladze explained how "Eco-Spectri" Ltd. approached the assignment, what was the scope of various thematic studies under ESIA, and how the ESIA process was informed to the various stakeholders. It was mentioned that ESIA incorporated a range of desktop studies and field surveys. The background study covered a series of components, such as: climate and meteorology; geology, geomorphology; hydrology, hydrogeology; soils, landscape and land use; air quality and noise; seismic conditions and hazardous processes; habitats, flora and fauna; historical and archeological sites and social environment. The sensitive receptors were identified; direct and indirect; short-term, medium- and long-term; negative and positive; reversible and irreversible (if any) impacts on biodiversity, physical and social environments in the project impact zone during the construction and on operation stage were evaluated. It was stressed that in the process of developing the ESIA report, the ESIA team must closely cooperate with design team to ensure avoidance, minimization and/or mitigation of potential impacts on recipients. Mitigation measures for medium and high impacts will be recommended; and residual and cumulative impacts should be ranked. The ESIA was carried out considering the national environmental legislation/regulations and the Works Bank requirements.

The transparency of information was ensured throughout the ESIA process. The said document was posted to the RD website and remains in public domain for familiarization and review. The feedback mechanisms were explained to the community to make the stakeholder engagement process more efficient. Ms. Maya Vashakidze also informed the meeting attendees about the World Bank EE/EE 4.01 Environmental Assessment, EE/EE 4.04 Natural Habitats, and EE/EE 4.11 Physical Cultural Resources. The presentators explained to the attenders about the World Bank directives on natural and social management.

Note: The interested parties and local population were informed about the date and venue of the consultation meeting on the draft ESIA report in advance. Below is a summary of Q&A session. During the meeting, the questions and comments of various participants were answered by the representatives of the Roads Department and representatives of "Eco- Spectri" Ltd.

#	Question/Comment	Answer
1	How will be the tree cutting implemented in the project zone and is it necessary to issue a certificate of ownership?	During the construction work trees will be cut, though, Within the scope of the project, a compensation planting plan will be developed as an individual document, under which instead of every cut- down tree, 3 trees will be planted, and if the cut-down tree is red-listed or is endemic, 10 new trees will be planted instead.
2	In what form can be used the land being in ownership - quarry's purpose	The land can be used as a quarry only after the procedure prescribed by law. It is necessary to apply to the Environmental Agency with relevant application and after completing all the procedures, register your land plot as a career.
3	Where the detailed design can be seen?	Other meetings are planned to conduct with all interested parties within the scope of the project. Once the detailed design is available, the Resettlement Action Plan will be prepared. A meeting with the local population will be

		organized to discuss it with the affected people. Besides, the Resettlement Action Plan will be made available at local municipalities and the web site of the Roads Department of Georgia, where all of you will be able to see it.
4	Can you tell us how many houses are to be resettled?	At this stage, the Resettlement Action Plan is being developed and public discussions will be held after completion of it. At this meeting the population will be provided with full information on all the parcels and the buildings that are built on them, which are under the influence of the project.
5	If a certain part of the land was demolished due to the project's requirement and the rest of the land was useless to me, how would you behave?	In case the project partially effects your land plot, the remaining part turns out to be useless for the owner, and it would be impossible to use the land with its old purpose, the project will purchase the plot in full, and the perennial plants on such plots will be compensated in full.
6	How much will the capacity of the local population to be employed during the construction period?	The construction contractor will sign an agreement under which a contractor is obliged to pay 70% of the local population. At the same time, the local population does not mean only those who live in the proximity of the project zone. The local population is a physical person living in Georgia.
7	In case of damages from the builders in the stage of construction works, who will react to this fact?	Based on the Resettlement Action Plan and ESIA report developed in line with the World Bank policy, a Grievance Redress Committee will be organized which, in addition to the participant organizations, will include the representatives of local self-governing bodies and various groups of population. It is this committee obliged to consider all claims and proposals regarding the project impact at the first stage.

Chairman of meeting: Maia Vashakidze (signed)

Secretary of meeting: Irakli kaviladze (signed)

Attachement 1: List of attendees of the public hearing

N	Name/სახელი	Representative/წარმომადგენლობა	Contact Data/საკონტაქტო ინფორმაცია	Signature/ხელმოწერა
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2	[illegible]	[illegible]	555 427977	
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4	[illegible]	[illegible]	593767424	
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14	[illegible]	[illegible]	562274774	
15	[illegible]	[illegible]	595 047-738	

Attachement 2: photos of public hearing

Photos:

MINUTES

of public consultation meeting on

Environmental and Social Impact Assessment Report for construction of the E-60 highway bypass between Chumateleti-Khevi

12.01.2018 **Kharagauli Municipality**

Chairman of meeting: Maya Vashakidze, Environmental Consultant, Roads Department of Georgia, Ressettlement and Environment Protection Division

Secretary of meeting: Irakli Kaviladze - Director of "Eco-Spectri" Ltd., Environmental Expert

Speakers: Maya Vashakidze,

Attendees of the Meeting: See attachment 1

Agenda of the Meeting:

- Introduction and context
- Presentation of ESIA Document
- Questions & answers

Attenders:

1. Nikoloz Tophuridze – Mayor
2. Archil Maghradze – I deputy;
3. Cotne Gorozia, local resident;
4. Teo Kervalishvili, local resident;
5. Tamaz Khmaladze, local resident
6. Marina Qadagishvili, local resident;
7. Mikheil Baqnidze, local resident;
8. Levani Dularidze, local resident;
9. Levani Vephkhvadze, local resident.

Topic presented: Maya Vashakidze delivered an introductory note regarding the construction of E-60 highway. He noted that Georgia, the country located along the transit corridor and connecting Europe and Asia, has a potential to link several countries of the region with the regional economy. For years, the World Bank financed a series of East-West highway corridor improvement projects. At present, the preparatory works for East-West highway corridor improvement project is under way. In the process of designing the works, "Eco-Spectri" Ltd, the consultant company hired by the Roads Department, commented about the natural and social environment impact assessment. The ESIA was carried out based on the World Bank's safeguard policies: OP/BP 4.01 Environmental Impact Assessment, OP/BP 4.04 Natural Habitats, OP/BP 4.11 Physical Cultural Resources, and OP/BP 4.12 Involuntary Resettlement.

The project is classified as environmental category "A", since it covers new construction, what may have significant and irreversible impacts on the natural and social environment. Pursuant to the national legislation, an environmental permit needs to be obtained.

Mr. Irakli Kaviladze explained how "Eco-Spectri" Ltd. approached the assignment, what was the scope of various thematic studies under ESIA, and how the ESIA process was informed to the various stakeholders. It was mentioned that ESIA incorporated a range of desktop studies and field surveys. The background study covered a series of components, such as: climate and meteorology; geology, geomorphology; hydrology, hydrogeology; soils, landscape and land use; air quality and noise; seismic conditions and hazardous processes; habitats, flora and fauna; historical and archeological sites and social environment. The sensitive receptors were identified; direct and indirect; short-term, medium- and long-term; negative and positive; reversible and irreversible (if any) impacts on biodiversity, physical and social environments in the project impact zone during the construction and on operation stage were evaluated. It was stressed that in the process of developing the ESIA report, the ESIA team must closely cooperate with design team to ensure avoidance, minimization and/or mitigation of potential impacts on recipients. Mitigation measures for medium and high impacts will be recommended; and residual and cumulative impacts should be ranked. The ESIA was carried out considering the national environmental legislation/regulations and the Works Bank requirements.

The transparency of information was ensured throughout the ESIA process. The said document was posted to the RD website and remains in public domain for familiarization and review. The feedback mechanisms were explained to the community to make the stakeholder engagement process more efficient.

Ms. Maya Vashakidze also informed the meeting attendees about the World Bank OP/BP 4.01 Environmental Assessment, OP/BP 4.04 Natural Habitats, and OP/BP 4.11 Physical Cultural Resources.

Ms. Maya Vashakidze informed the interested participants about the World Bank's social safeguard policy OP/BP 4.12 Involuntary Resettlement.

The speakers explained the meeting attendees the World Bank Guidelines for environmental and social management.

Note: The interested parties and local population were informed about the date and venue of the consultation meeting on the draft ESIA report in advance.

Below is a summary of Q&A session. During the meeting, the questions and comments of various participants were answered by the representatives of the Roads Department and representatives of "Eco- Spectri" Ltd.

#	Question/Comment	Answer
1	Why was it necessary to use the left side of the river instead of the initial variant, where would it be expected to process the right side of the river?	After detailed researches, the existing road expansion was resolved. The alternatives to which the new roadway on the left bank of the river was neglected. A number of reasons, including environmental considerations.
2	Should trees be cut during construction?	Tree cutting will be done at the construction stage, However, within the project, preparation of a compensation planting plan as a separate document is considered, according to which 3 trees will be planted instead of each cutting tree, and if the tree is included in the red book

		or the endemic species - will be planted 10 trees.
3	After detailed design preparation, where will it be available?	In addition to this meeting are planned to conduct other meetings with all interested stakeholders within the scope of the project. Once the detailed design is available, the Resettlement Action Plan will be prepared. A meeting with the local population will be organized to discuss it with the affected people. Besides, the Resettlement Action Plan will be made available at local municipalities and the web site of the Roads Department of Georgia, where all of you will be able to see it.
4	How much will the capacity of the local population to be employed during the construction period?	The construction contractor will sign an agreement under which a contractor is obliged to pay 70% of the local population. At the same time, the local population does not mean only those who live in the proximity of the project zone. The local population is a physical person living in Georgia.
5	In the case of damages from workers, whom should we approach?	Based on the Resettlement Action Plan and ESIA report developed in line with the World Bank policy, a Grievance Redress Committee will be organized which, in addition to the participant organizations, will include the representatives of local self-governing bodies and various groups of population. It is this committee obliged to consider all claims and proposals regarding the project impact at the first stage.
6	Will be the river polluted during the construction works?	The proposed EIA document describes all mitigating measures that will be required for the contractor to avoid pollution of the river.
7	Can you specifically say project affected families and plots, so that we plan our activities accordingly, for example, if agricultural activities are worthwhile?	As already mentioned, a detailed design is being developed at present. Only after this process is over, it will be possible to exactly identify the project-affected land plots and businesses. After the registration and inventory process is over, the affected persons' property and plantings will be inventoried by the given moment, and their loss will be compensated within the scope of the resettlement action plan.

8	Will there be an impact of noise, vibration and dust generated during the construction on the settlements?	After the detailed design is developed, relevant measurements of possible impacts of noise, vibration and dust will be conducted and relevant mitigation measures will be elaborated, such as tree planting, installing additional noise- reflecting barriers, etc. If this action is not sufficient, temporal or permanent rese ttlement may apply.

Chairman of meeting: Maya Vashakidze(signed)

Head of Eco-Spectri Ltd. Environmental Expert: Irakli Kaviladze (signed)

List of attendees:

N	Name/სახელი	Representative/წარმომადგენლობა	Contact Data/საკონტაქტო ინფორმაცია	Signature/ხელმოწერა
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15	[illegible]	[illegible]	599 366 - 703	

Photos:

ANNEX 2: WATER PEAK DISCHARGES

Table 1. Water peak discharges of the rivers and gorges crossing the modernization road from Rikoti Pass to village Argveti

(the option marked with the right blue line is marked as #1″ in the map)

Section No. and name of the river	F km^2	L km	i Bed	K	δ	λ	K^{I}	Peak discharges			
								τ=100 years	τ=50 years	τ=20 years	τ= 10 years
Rikotula #1^{I}	5.85	3.75	0.164	5.00	1.07	0.84	-	48.6	37.4	26.4	20.3
Rikotula #2^{I}	6.36	4.00	0.160	5.00	1.07	0.84	-	50.8	39.0	27.6	21.2
Gorge #3^{I}	0.59	1.42	0.246	5.00	1.11	0.84	0.70	8.66	6.66	4.70	3.61
Gorge #4^{I}	0.16	0.55	0.273	5.00	1.01	0.84	0.70	3.45	2.65	1.87	1.44
Gorge #5^{I}	2.92	2.70	0.176	5.00	1.10	0.84	0.87	28.5	21.9	15.5	11.9
Gorge #6^{I}	0.17	0.85	0.394	5.00	1.15	0.98	0.70	4.93	3.79	2.68	2.06
Gorge #7^{I}	0.36	1.20	0.354	5.00	1.14	0.83	0.70	6.66	5.12	3.61	2.78
Gorge #8^{I}	0.70	1.80	0.300	5.00	1.10	0.85	0.70	9.84	7.56	5.34	4.11
Gorge #9^{I}	1.16	2.00	0.285	5.00	1.12	0.85	0.81	16.0	12.3	8.68	6.68
Gorge #10^{I}	0.21	0.65	0.454	5.00	1.00	0.93	0.70	4.81	3.70	2.61	2.01
Gorge #11^{I}	0.16	0.80	0.406	5.00	1.09	0.90	0.70	4.15	3.19	2.25	1.73
Gorge #12^{I}	0.25	0.77	0.416	5.00	1.06	0.90	0.70	5.46	4.20	2.96	2.28
Rikotula #13^{I}	21.1	8.80	0.091	5.00	1.15	0.86	-	102	78.4	55.3	42.6
Gorge #14^{I}	0.08	0.40	0.462	5.00	1.09	0.94	0.70	2.81	2.16	1.52	1.17
sakbeula #15^{I}	26.7	12.5	0.060	5.00	1.20	0.85	-	108	83.0	58.6	45.1
Gorge #16^{I}	0.08	0.41	0.524	5.00	1.01	0.84	0.70	2.37	1.82	1.29	0.99
Gorge #17^{I}	0.22	0.80	0.400	5.00	1.02	0.88	0.70	4.68	3.60	2.54	1.95
Gorge #18^{I}	0.16	0.98	0.326	5.00	1.15	0.91	0.70	4.28	3.29	2.32	1.79
Nikraula #19^{I}	0.46	1.18	0.305	5.00	1.05	0.90	0.70	7.70	5.92	4.18	3.21
Gorge #20^{I}	0.14	0.60	0.242	5.00	1.02	0.88	0.70	3.28	2.52	1.78	1.37
Satevze #21^{I}	1.44	1.78	0.177	5.00	1.03	0.88	0.81	16.8	12.9	9.12	7.01
Rikotula #22^{I}-16^{II}	69.5	12.3	0.076	5.00	1.00	0.90	-	187	144	101	78.0
Tsiskvileburi #19-23^{I}-17^{II}	3.15	4.80	0.166	5.00	1.13	0.85	0.88	29.3	22.5	15.9	12.2
Gorge #20-24^{I}-17^{II}	0.22	0.70	0.250	5.00	1.11	0.86	0.70	4.71	3.62	2.56	1.97
Rikotula #21-25^{I}-18^{II}	73.8	13.6	0.070	5.00	1.00	0.90	-	189	145	103	79.0

Table 2. Water peak discharges of the rivers and gorges crossing the modernization road from Rikoti Pass to village Khevi

(the option marked with the left blue line is marked as #1″ in the map)

Section No. and name of the river	F km^2	L km	i Bed	K	δ	λ	K^{I}	Peak discharges			
								τ=100 years	τ=50 years	τ=20 years	τ= 10 years
Rikotula #1^{II}	5.85	3.75	0.164	5.00	1.07	0.84	-	48.6	37.4	26.4	20.3
Gorge #2^{II}	0.16	0.60	0.308	5.00	1.12	0.83	0.70	3.83	2.94	2.08	1.60
Gorge #3^{II}	0.25	0.80	0.319	5.00	1.05	0.83	0.70	4.82	3.71	2.62	2.01
Gorge #4^{II}	2.26	2.50	0.240	5.00	1.09	0.83	0.84	23.7	18.2	12.9	9.89
Gorge #5^{II}	0.39	1.05	0.371	5.00	1.08	0.83	0.70	6.74	5.18	3.66	2.81
Gorge #6^{II}	1.36	1.90	0.303	5.00	1.08	0.84	0.81	17.2	13.2	9.33	7.18
Gorge #7^{II}	0.23	0.73	0.432	5.00	1.05	0.84	0.70	4.81	3.70	2.61	2.00
Gorge #8^{II}	0.68	1.62	0.346	5.00	1.10	0.85	0.70	9.89	7.60	5.37	4.13
Gorge #9^{II}	0.41	1.30	0.346	5.00	1.14	0.85	0.70	7.39	5.68	4.01	3.08
Gorge #10^{II}	0.15	0.62	0.484	5.00	1.01	0.90	0.70	3.80	2.92	2.06	1.59
Gorge #11^{II}	0.13	0.48	0.406	5.00	1.05	0.85	0.70	3.33	2.56	1.81	1.39
didi Rele #12^{II}	0.84	2.10	0.317	5.00	1.06	0.84	0.70	10.6	8.15	5.75	4.42
Gorge #13^{II}	0.37	1.22	0.316	5.00	1.07	0.90	0.70	6.81	5.23	3.70	2.84
Gorge #14^{II}	0.10	0.45	0.333	5.00	1.03	0.92	0.70	2.90	2.23	1.57	1.21
Rikotula #15^{II}	51.3	11.0	0.083	5.00	1.12	0.88	-	174	134	94.4	72.6
nikraula #19^{I}	0.46	1.18	0.305	5.00	1.05	0.90	0.70	7.70	5.92	4.18	3.21
Gorge #20^{I}	0.14	0.60	0.242	5.00	1.02	0.88	0.70	3.28	2.52	1.78	1.37
Satevze #21^{I}	1.44	1.78	0.177	5.00	1.03	0.88	0.81	16.8	12.9	9.12	7.01
Rikotula #22^{I}-16^{II}	69.5	12.3	0.076	5.00	1.10	0.90	-	206	158	112	86.0

Table 3. Water peak discharges of the rivers and gorges crossing the modernization road from Rikoti Pass to village Khevi

(the option marked with the yellow line is marked as #1 in the map)

Section No. and name of the river	F km2	L km	i Bed	K	δ	λ	K_{I}	Peak discharges			
								τ= 100 years	τ= 50 years	τ= 20 years	τ= 10 years
Rikotula #1	5.85	3.75	0.164	5.00	1.07	0.84	-	48.6	37.4	26.4	20.3
Gorge #2	0.16	0.60	0.308	5.00	1.12	0.83	0.70	3.83	2.94	2.08	1.60
Gorge #3	0.25	0.80	0.319	5.00	1.05	0.83	0.70	4.82	3.71	2.62	2.01
Gorge #4	2.26	2.50	0.240	5.00	1.09	0.83	0.84	23.7	18.2	12.9	9.89
Gorge #5	0.39	1.05	0.371	5.00	1.08	0.83	0.70	6.74	5.18	3.66	2.81
Gorge #6	1.36	1.90	0.303	5.00	1.08	0.84	0.81	17.2	13.2	9.33	7.18
Gorge #7	0.23	0.73	0.432	5.00	1.05	0.84	0.70	4.81	3.70	2.61	2.00

Gorge #8	0.68	1.62	0.346	5.00	1.10	0.85	0.70	9.89	7.60	5.37	4.13
Gorge #9	0.41	1.30	0.346	5.00	1.14	0.85	0.70	7.39	5.68	4.01	3.08
Gorge #10	0.15	0.62	0.484	5.00	1.01	0.90	0.70	3.80	2.92	2.06	1.59
Gorge #11	0.13	0.48	0.406	5.00	1.05	0.85	0.70	3.33	2.56	1.81	1.39
Big Ghele #12	0.84	2.10	0.317	5.00	1.06	0.84	0.70	10.6	8.15	5.75	4.42
Gorge #13	0.37	1.22	0.316	5.00	1.07	0.90	0.70	6.81	5.23	3.70	2.84
Gorge #14	0.10	0.45	0.333	5.00	1.03	0.92	0.70	2.90	2.23	1.57	1.21
Tsakura #15	15.6	6.50	0.103	5.00	1.13	0.85	-	87.2	67.0	47.3	36.4
Gorge #16	0.05	0.27	0.370	5.00	1.02	0.90	0.70	1.80	1.38	0.98	0.75
Gorge #17	0.05	0.20	0.475	5.00	1.00	0.92	0.70	1.86	1.43	1.01	0.78
Gorge #18	0.06	0.33	0.364	5.00	1.05	0.95	0.70	2.20	1.69	1.19	0.92
Tsiskvileburi #19-23I -16II	3.15	4.80	0.166	5.00	1.13	0.85	0.88	29.3	22.5	15.9	12.2
Gorge #20-24I-17II	0.22	0.70	0.250	5.00	1.11	0.86	0.70	4.71	3.62	2.56	1.97
Rikotula #21-25I-18II	73.8	13.6	0.070	5.00	1.10	0.90	-	208	160	113	86.8

Annex 3: Impact Assessment Criteria

Table 5.2: Noise and vibration propagation – Impact Assessment Criteria

Kind of impact	Assessment criteria		
	Significant (high) impact	*Average impact*	*Insignificant (low) impact*
Noise propagation	Noise levels at the border of the settled area exceed 55 DbA during the day and 45 dBA at night, or exceeds50 dBA during the day and 40dBA at night at sensitive receptors. Excess noise levels are intense. Population's dissatisfaction is inevitable.	Noise levels at the border of the settled area little exceed 55 DbA during the day and 45 dBA at night; however, the impact is expected only in some cases or is temporal. The noise levels at the sensitive receptors are admissible; however, additional preventive measures are recommended.	The noise background levels have deteriorated a bit near the settled areas or sensitive receptors. In any case, no levels in excess of the admissible levels are expected. It is sufficient to take standard mitigation measures.
Vibration	Due to the use of heavy technique and other methods, vibration spreads to great distances. There is a probability of damage or destruction of buildings and premises, monuments of cultural heritage or disturbance of geological stability.	Vibration does not spread to far places, or the impact is short-term. The probability of damage of buildings and premises, monuments of cultural heritage or disturbance of geological stabilityis very little. Minor and periodic discomfort is expected.	Vibration propagates only in the working zone. No damage of buildings and premises, monuments of cultural heritage or disturbance of geological stability is expected. No addiitonal mitigation measures are needed.
Condition of the working area (noise and vibration)	It is impossible to work. Using ear-plugs or other protective equipment is less inefficient. It is necessary to change the service staff frequently.	Noise and vibration is a nuisance in the working area; but working is possible provided the relevant protective equipment are used or other measures are taken (e.g. cutting the working hours and the like).	The noise and vibration levels in the working zone are not high. No PPE is needed, or if needed only for short periods. An 8-hour-long working day is permitted.

Table 5.3:Assessment criteria of the expected impact on water

Kind of impact	Assessment criteria		
	Significant (high) impact	*Average impact*	*Insignificant (low) impact*
Changed flow rate of the surface waters	Under the project impact, the natural river flow rate is strongly changed (either for the year, or temporarily); it is difficult to maintain the present state of the water eco-system. Other water-consuming unit has a limited access to water, or due to the increased water flow, the risk of developing hazardous hydrological events has increased.	Under the project impact, the natural river flow rate reduced to 70%(either for the year, or temporarily); however, the water eco-system is mostly maintained. The access of another water-consuming unit to water has not changed, or Under the project impact, the natural river flow rate increased to 110%. The risks of developing the hazardous - hydrological events are possible to eliminate by using relevant protective measures.	Under the project impact, the natural river flow rate reduced to 70% (either for the year, or temporarily). The access of another water-consuming unit to water has not changed, or the unit is not used for other purposes. The river flow rate will not increase under the impact of the project.
Deterioration of the surface water quality, origination of the sewage	Fishing or drinking-and-industrial water object is under the impact, or Significant amount of sewage is expected. Despite building the treatment plant, there is a probability of discharging the excessively polluted waters, or the probability of emergencies is high. Due to the near location of the water body, there is a possibility for the solid remains and liquid mass to enter the water body.	An industrial-household water unit is under the impact. Sewage is originated; however, at the expense of relevant preventive measures (arranging the duly efficient treatment plant, etc.) it is possible to maintain the qualitative state of the surface water. The existing quality may be changed a bit what will have a minor impact on the water biodiversity, or the probability of emergencies to occur is not high. In such a case, the distances are so great that the risks of the polluting substances flowing into the water are minimal.	There are no surface waters near the water object. Therefore, there is only the possibility of indirect impact, which is not major. No sewage is expected to originate, or the small amounts of liquid remains can be managed by using the methods safe for the water environment (e.g. by an evaporating pond, recycling the liquid remains, etc.).
Ground water pollution	The activity implies using the methods creating the risks of excess pollution of the ground waters (e.g. burying the materials containing polluted substances, etc.); mitigation measures are less efficient, or the probability of emergencies to occur is quite likely with the infiltration of the large amounts of oil products or other polluting substances into the ground layers.	The activity implies using the methods creating certain risks of pollution of the ground waters; however, using the mitigation measures is efficient and significantly reduce the risks, or there is probability of emergencies to occur; however, relevant preventive measures are taken.	The risks of the ground water pollution are associated with the unforeseen cases only (minor oil product leakages from technique or equipment and the like.). No large amounts of liquid polluting substances are stored or used in the area threatening the ground waters in case of accidents.

Impact on the flow rate of the ground waters, changed infiltration properties of the grounds	The activity envisages arranging deep engineering facilities, with which it is possible to cross the underground water-bearing infrastructure. As a result, the outflows of the underground waters may decrease, or The activity envisages using large land areas/cutting down the forests what will deteriorate the ground infiltration properties. This may reduce the intensity of the underground water alimentation with the atmospheric precipitations.	The activity does not envisage arranging deep engineering facilities, and in addition, there are no particularly significant water-bearing horizons spreading on the territory. Despite this, cultivation of land areas or the used building and exploitation methods may have a certain impact on the outflows of less valuable springs.	By considering the small project area, used building and exploitation methods and existing hydro-geological conditions, the impact on the flow rate of the underground waters will be minor. No impact on either drinking, or industrial water is expected.

Table 5.4: Assessment criteria of the expected impact on the soil

Kind of impact	Assessment criteria		
	Significant (high) impact	*Average impact*	*Insignificant (low) impact*
Damage and erosion of the fertile soil layer	The project envisages using over 12,5 ha of agricultural plots or other land areas highly valuable in respect of fertility, or the methods used during the building and exploitation promote the activation of the soil erosion processes over significant areas.	The project envisages using less than 12,5 ha of agricultural plots or other land areas valuable in respect of fertility, or the area to manage is more than 12,5 ha, but this is not an agricultural land or is not otherwise valuable, or The methods used during the building and exploitation promote the activation of the soil erosion processes in some areas, but they can be prevented by using the relevant mitigation measures.	The project envisages using less than 12,5 ha of non-agricultural plots or other land areas less valuable in respect of fertility. Provided the fertile soils layer is duly managed, the impact will be minimal. No erosion beyond the used perimeter is expected.
Soil/ground pollution	Due to the methods used during the building and exploitation, the risks of polluting the fertile layer of the agricultural land of any area (exceeding MAC) are quite high or virtually inevitable or the probability of developing such emergencies leading to the pollution of over 100 m^2 area or over the depth of 0,3 m of soil and ground is quite high.	Due to the methods used during the building and exploitation, there are risks of polluting the less valuable surface layer of lands (exceeding MAC) or there is a probability of developing such emergencies leading to the pollution of less than 100 m^2 area or less than the depth of 0,3 m of soil and ground.	Only minor local pollution of soil/ground is expected, mostly in unforeseen cases. The technology of local cleaning the polluted soil can be used.

Table 5.5: Assessment criteria of the expected impact on the geological environment

Kind of impact	Assessment criteria		
	Significant (high) impact	*Average impact*	*Insignificant (low) impact*
Violation of the stability of the geological environment under the project impact, activation of hazardous processes	The project is planned to implement in the relief with the III degree of complexity in engineering-geological respect. During the earthworks, the probability of activation of such hazardous geodynamic processes, as landslide, rock fall, mudflow, etc. exists, or the risks of activation of the same processes exist in the operation phase of the object (hydrotehcnical facilities, tunnels, etc. can be considered as such object). It is necessary to build the protective facilities of complex structures or to make corrections to the project.	The project is planned to implement in the relief with the II degree of complexity in engineering-geological respect. During the earthworks or in the operating phase, the probability of activation of hazardous geodynamic processes. However, provided the protective measures in terms of simple-structure facilities these can be prevented.	The project is planned to implement in the favorable relief. No significant resources to build protective structures are needed. Only local, minor erosive processes may develop.
Impact of the existing engineering-geological conditions on the project facilities	The engineering-geological properties of the grounds are not favorable needing building deep foundations to establish the facilities on the cliffy rocks, or hazardous geodynamic processes threaten the stability of the object. It is necessary to build the protective facilities of complex structures or to make certain corrections to the project.	The engineering-geological properties of the grounds allow founding the object, but under certain conditions. The degree of the environment (ground and ground waters) aggressiveness to the reinforced concrete is satisfactory, or hazardous geo-dynamic processes pose a certain threat to the object's stability; however, the risk may be eliminated by taking protective measures of a simple structure.	The object is not a facility of a complex structure. The engineering-geological properties of the territory-constituent grounds are satisfactory. Consequently, there is no need for either deep foundations, or significant measures to protect the engineering facilities.

Table 5.6: Assessment criteria of the expected impact on the biological environment

Kind of impact	Assessment criteria		
	Significant (high) impact	*Average impact*	*Insignificant (low) impact*
Generic and quantitative changes in the vegetation cover	The project implementation will lead to the destroy of the endemic or Red-Listed species or the project implementation will lead to the use of the forested area over 1 ha or there is a risk for invasive kinds to spread	Following the project implementation, the risks of direct or indirect impacts on the endemic or Red-Listed species are minimal or the project implementation will lead to the use of the forested area less than 1 ha	Following the project implementation, there is no risk of impact on the endemic or Red-Listed species. Only the destruction of the homogenous low-value vegetation cover is expected. There is no risk for invasive species to spread.
Deterioration of the animal habitats, habitat loss or fragmentation	The project implementation will lead to the destroy, reduction or fragmentation of the area of the endemic and Red-Listed animal species or certain species may be reduced or certain population may disappear in the project implementation area or the object is a linear object creating a kind of barrier for migrating animals or there is a risk for invasive kinds to spread.	Following the project implementation, the impact on the endemic or Red-Listed species is less likely. The area of such living organisms with no ability to migrate to long distances may decrease, or quantitative changes of certain species are expected in the project implementation area, but their destroy is not likely.	The project area is under the anthropogenic impact and is not a shelter for animal species. Only the animals adapted to the human activity live in the area with high ecological valency. The object is not a barrier hampering the migrating animals.
Immediate impact on fauna specie s	Due to the project implementation, there are some cases of animal perish (including endemic or Red-Listed species) during the year, or increased probability of poaching.	Due to the project implementation, there are few cases of animal perish (less valuable species) during the year	Perish of the animal species is less likely. The impact is short-term. The probability of increased poaching is minimal.
Direct or indirect impacts on the protected areas	Due to small distance and following the methods used at the building and exploitation stages, there are risks of long-term direct or indirect impacts on the territory.	Following the methods used at the building and exploitation stages, there is a risk of indirect impact on the protected area, but the impact is not long.	Due to a great distance, an impact on the protected area is less likely.

Table 5.7: Assessment criteria of the expected impact on the visual-landscape environment

Kind of impact	Assessment criteria		
	Significant (high) impact	*Average impact*	*Insignificant (low) impact*
Landscape impact	The project implementation is planned within the limits of the rare and high-value landscapes, or the landscape and its components are in fact intact and have high degree of naturalness.	The project implementation is planned within the limits of a regional or local landscape or the landscape and its components are partially transformed due to the human actions. They have an average degree of naturalness.	The project implementation is planned within the limits of a low-value landscape, which can be substituted, or the landscape and its components are quite devastated due to the man's economic activity.
Visual changes	The project area is easily seen from many locations. Implementation of the activity will have a significant impact on the visual effect for the local people or tourists.	The project area is seen from some observation points having no touristic value.	The project area is almost invisible. The building and exploitation will have a minimal impact on the visual effect for the local people or tourists.

Table 5.8: Assessment criteria of the expected impact on the social environment

Kind of impact	Assessment criteria		
	Significant (high) impact	Average impact	*Insignificant (low) impact*
Positive impact			
Increased budgetary flows	Increased central budgetary flows	*Increased budgetary flows*	Increased central budgetary flows
Employment and growing income of the population	The possibility to hire 70% of workforce from local population or The possibility to hire 40% of workforce from local rural residents or the possibility to hire 20% of workforce from local population in the high-mountain villages.	A total of 30 to 100 people employment opportunities. or Local villagers from 10 to 30 people employment opportunities. or Highland status of rural residents few employment opportunities.	10 persons employment opportunity.
Improvement of transport infrastructure	Improvement of the technical state of the international, state and regional roads, high probability of distress of transport intensity.	Improvement of the technical state of the roads in some or high-mountainous village and easy transportation.	Simplified rehabilitation of rural roads and transportation

Other social-economic benefit	At a country, regional or municipal level, or for several high-mountainous villages: • Improved waste management conditions. • Improved water-supply and water-drainage conditions. • Improved power supply and gas supply conditions. • Improved accessibility to other kinds of resources.	For several or high-mountainous villages: • Improved waste management conditions. • Improved water-supply and water-drainage conditions. • Improved power supply and gas supply conditions. • Improved accessibility to other kinds of resources.	Only some families (homesteads) receive various social-economic benefits.
Negative impact			
Resettlement, need to use private property	One of several cases of physical resettlement, or over 10 cases of economic resettlement, or one or several cases of economic resettlement in a high-mountainous village	Up to 10 cases of economic resettlement. Provided the compensation measures are taken, no population's dissatisfaction is expected	No physical or economic resettlement is expected. Temporal use of the privately owned land plots and units may be needed, with the relevant compensation measures planned.
Deterioration of transport infrastructure	Deterioration of the technical condition of the international, state and regional roads, significant increase of transport intensity.	Deterioration of the technical condition of the roads in some or high-mountainous villages or significant increase in vehicle movement; however, the impact is temporal.	No deterioration of local roads or significant increase of transport intensity is not expected.
Other negative social-economic effects	At a country, regional or municipal level, or for several high-mountainous villages: • Deteriorated waste management conditions and landfill overload. • Deteriorated water-supply and water-drainage conditions or overloaded relevant systems • Limited accessibility to other resources.	For several or high-mountainous villages: • Deteriorated waste management conditions and landfill overload. • Deteriorated water-supply and water-drainage conditions or overloaded relevant systems • Limited accessibility to other resources.	For several families • Deteriorated waste management conditions and landfill overload. • Deteriorated water-supply and water-drainage conditions or overloaded relevant systems

			• Limited accessibility to other resources. However, the problem can be solved by searching alternative routes.

Table 5.9: Assessment criteria of the expected impact on the historical-cultural monuments

Kind of impact	Assessment criteria		
	Significant (high) impact	*Average impact*	*Insignificant (low) impact*
Damage to the historical-cultural monuments	Due to the small distance and following the methods used in the building and exploitation phases, there is a probability of damaging the monuments of the international or local historical-cultural heritage.	Due to the small distance and following the methods used in the building and exploitation phases, there is a probability of damaging the monuments of the local historical-cultural heritage.	Due to the great distance, the probability of damaging the monuments of historical-cultural heritage is less likely.
Unforeseen damage to the archeological monuments	Following the historical designation of the project area, there is a probability of the late identification of the archeological monuments.		The area is quite anthropogenic. Therefore, identification of the recent archeological monuments is less likely.

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ANNEX 4: Business Structures and Premises Adjacent to the EWH Section between Chumateleti and Khevi

	Company, Contact Information	Type of Business	Employers			Coordinates
			Female	male	sum	
	"Shubitidze and Company"Ltd. 599 18 22 44 – Malkhaz Shubitidze	1. Restaurant "Nazuqebi"; 2. Rest Room; 3. Market	12	4	16	$42^{0}03^{II}57.85^{II}$ N; $43^{0}28^{II}47.61^{II}$ E;
	Individual Enterprise "Kukuri Kurtanidze" 558 39 93 39 – Kukuri Kurtanidze	Restaurant "Kheoba"	3	9	12	$42^{0}04^{II}02.54^{II}$ N; $43^{0}28^{II}47.96^{II}$ E;
	Abandoned restaurant. Owner is not known					$42^{0}05^{II}14.16^{II}$ N; $43^{0}27^{II}56.88^{II}$ E;
	Individual Enterprise „Tengiz Mumladze" 557 36 78 98 Tengiz Mumladze	Restaurant "Gedebi"	5	5	10	$42^{0}05^{II}14.74^{II}$ N; $43^{0}27^{II}56.55^{II}$ E;
	"Edemi"Ltd. 514 01 11 10 - Murman	Restaurant "Edemi"	7	23	30	$42^{0}04^{II}39.96^{II}$ N; $43^{0}28^{II}31.37^{II}$ E;

	"Evrazia"Ltd. 593 36 34 24 Zviadi	Gas station	1	4	5	$42^{0}03^{II}39.46^{II}$ N; $43^{0}27^{II}25.60^{II}$ E;
	Abandoned service centre. Owner is not known					$42^{0}05^{II}42.81^{II}$ N; $43^{0}25^{II}54.42^{II}$ E;
	Abandoned restaurant. Owner is not known					$42^{0}05^{II}42.51^{II}$ N; $43^{0}25^{II}52.91^{II}$ E;
	"Sameba"Ltd. Avtandil Kurtanidze – 593 888883	Restorat "Jargvali"	13	27	40	$42^{0}05^{II}36.57^{II}$ N; $43^{0}25^{II}21.62^{II}$ E;
	Individual Enterprise "Ucha Kakiashvili" Ucha Kakiashvili – 598 132858	Resoranr "Khevi"	20	2	22	$42^{0}05^{II}41.50^{II}$ N; $43^{0}25^{II}34.71^{II}$ E;
	"Khepinura" Ltd. Owner: Adri Tabatadze Rented by Mariam Jananashvili – 551 130605	Fast food	16	2	18	$42^{0}05^{II}43.23^{II}$ N; $43^{0}24^{II}54.95^{II}$ E;

ANNEX 5: Guidelines for Waste Management

General Provisions

The below plan comprises all kinds of activities, which result in waste production, among these:

- Activities in normal exploitation conditions;
- Activities in abnormal exploitation conditions (i.e. during repair-construction works);
- Activities in case of emergency.

Goals and Objectives of Guidelines

Waste Management Guidelines set the rules of collection, transporting, allocation, treatment and disposal of different waste in accordance with the provisions of the environmental norms and rules.

Systemic method is used in the process of waste management, namely, it comprises the following key principles:

- Timely measures to avoid waste;
- If possible, facilitation of waste treatment;
- The destruction of waste is the last option.
- The waste management is conducted according to the below principles:
- Hierarchy principle in waste management;
- Proximity principle;
- Care commitment;
- Use of BATNEEC principles (the best known technique so far, which is not connected with excessive expenses);
- "The polluter pays" principle.

All of the above principles are discussed below.

Hierarchy Principle in Waste Management

Hierarchy principle in waste management illustrated in the below scheme implies the prioritization of various activities during waste management in terms of optimization.

Generally the best option is the prevention of waste, followed by the minimization of the amount and threat. In addition, it is accepted that re-use, restoration and recycling of waste is better and destruction is the last option.

Each waste flow should be processed according to the hierarchy. The selected technique should be the best in terms of threat and practicality.

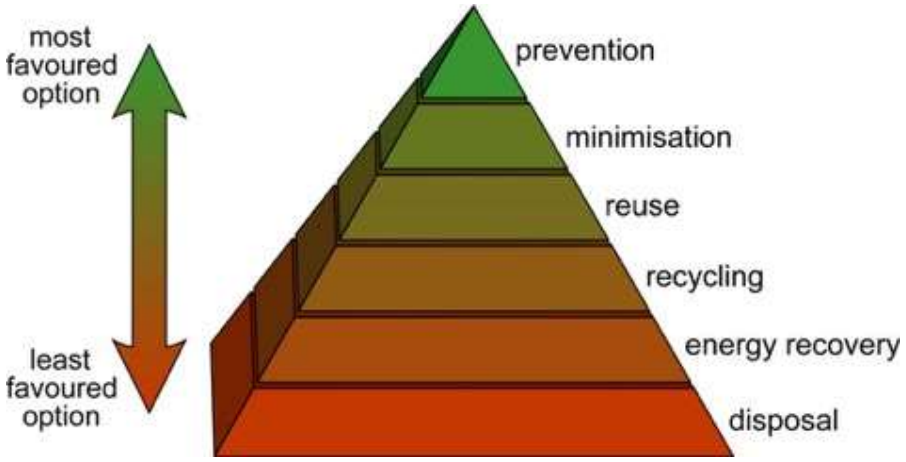


Fig.1. Hierarchy in Waste Management

Proximity Principle:

Proximity principle implies waste management be undertaken as near to the source of production as possible.

Care Commitment

The implementation of the "care commitment" program is facilitated for all types of waste.

The principle of "care commitment" implies that the person who produced or owns the waste is obliged to facilitate due management of the waste even after the waste is passed to the third party.

Care commitment system categorizes and sets the amount and character of the waste from "cradle to the grave" (i.e. from the production till the processing and final destruction including transportation).

The focus of the principle is on the fact that waste producer should select third party to whom the waste shall be passed with due diligence, evaluate the party's capacity and control the party's activities in terms of waste management.

Care commitment requirements are as follows:

- Waste, which is passed to the contractor or carrier for destruction, should have detailed written information on how the waste should be safely transported, processed and destroyed;
- The waste should be passed only to the permitted persons, i.e. registered waste carriers, licensed contractors, waste collectors of the local authorities or persons freed from the licensing obligation;
- Waste should be packaged as necessary, so that it will not spill or leak in the environment;
- All appropriate measures should be introduced, so that all persons who transport or destroy waste follow the requirements of law.
- BATNEEC (the best known technique so far, which is not connected with excessive expenses) principle implies waste management be implemented using the best known technique, which is not connected with excessive expenses.

"The Polluter Pays" Principle

The principle implies that the person who causes the contamination of the environment should indemnify the expenses necessary to eliminate the results of the pollution.

Waste management infrastructure in the project zone and licensed companies

The project zone is located on the territory of Khashuri and Zestaponi municipalities. The landfills of Zestaponi, Kharagauli and Khashuri municipalities are found closest to the project area. As they failed to meet the legal requirements, "Solid Waste Management Company of Georgia" Ltd. closed Kharagauli and Zestaponi landfills in 2016. Consequently, the nearest landfill to serve the project is Khashuri landfill. This landfill will be located on the territory of village Tagveta in Khashuri municipality. This landfill has been owned by "Solid Waste Management Company of Georgia" Ltd. since 2013. In recent years, the company accomplished construction and assembly works on the polygon. Within the scope of the project, the landfill was totally improved. The territory of the landfill was insulated and the waste was covered with an insulation layer. At present, the object is thoroughly electrified. The distance of the landfill to the project zone is 20-30 km.

At present, the above-said landfill is the most acceptable alternative for the disposal of the municipal and non-hazardous waste originated in the construction phase of Chumateleti-Khevi highway.

As for the hazardous waste, which is not expected to originate in great amounts in the construction phase, the licensed companies may be charged with managing it. Below, we give a list of companies (though incomplete) managing hazardous waste on the territory of Georgia:

1. "Mersi" Ltd. (Environmental Impact Permit No. 00054, date of issue: 7.11.2006). The company receives hydrocarbons by pyrolyzing the used tires and other rubber waste.
2. "Frontera East Georgia" Ltd. (Environmental Impact Permit No. 00040, date of issue: 5.9.2006). The company cleans the soils polluted with oil or oil slug and disposes the inert material waste and various chemicals in safe conditions.
3. "Nasadgomari" Ltd. (Environmental Impact Permit No. 00059, date of issue: 1.24.2007). The company owns the bio-remediation grounds, where the soils polluted with oil hydrocarbons are delivered and processed with special technology. The process envisages processing the polluted ground with mineral fertilizers and (artificial) introduction of microorganisms in the soils.
4. "Sanitary" Ltd. (Environmental Impact Permit No. 00136, date of issue: 11.17.2008). The company has a permit for temporal storage of hazardous waste. The types of waste for temporal storage are: used technical oils, oil paraffin, solid waste polluted with oil (plastic, uniforms, rugs), used adsorbents, used batteries, used luminescence/fluorescent bulbs, used antifreeze and paint waste/boxes. It is planned to export hazardous waste to the European countries (Germany, Holland) for final disposal or destruction with certain intervals (once a year presumably). If it is possible (provided there are proper technologies) the waste can be handed down to the contractor with the relevant permit to treat or make it harmless.
5. "Big Been" Ltd. (Environmental Impact Permit No. 00134, date of issue: 2.13.2015). The company makes packaging materials by secondary processing of polyethylene and polypropylene waste. The plant receives the waste from different industrial objects under the relevant agreement.
6. "Sarini" Ltd. (Environmental Impact Permit No. 00102, date of issue: 08.1.2014). The company undertakes management/incineration of toxic and hazardous waste.
7. "Georgian International Energy Company" Ltd. (Environmental Impact Permit Number – Conclusion, date of issue: 9.13.2010). The company has a landfill cell for asbestos and glass-fiber construction materials.

<u>The Main Goals of Waste management Process:</u>

- Facilitation of the waste identification according to its categories and threats;
- Facilitation of the segregated collection of waste, compliance with the conditions of the temporary disposal to exclude the impact of the waste on the environment and human health;
- Facilitation of the transportation conditions of waste, which should exclude the emission or loss of waste as well as probability of accidents, damage to the environment and human health;

- The use of methods safe to the environment and human health during the treatment, processing or disposal of waste;
- Minimization of the amount of waste;
- Re-use of waste;
- Identification of personal responsibility for waste management;
- Facilitation of the records on industrial and household waste.
- The implementation of the instructions given in the plan is compulsory to all employees.

General Requirements of Safe Waste Handling:

- The staff involved in waste management (collection, storage, transportation, delivery/receipt) should be trained in occupational health care and safety issues;
- The staff should be facilitated with special clothes, shoes and individual protection equipment. If required the staff clothes should be specially processed – especially after operations related to the hazardous waste;
- The staff should be able to provide first aid in case of poisoning or trauma during waste related activities;
- The people who have not undergone appropriate training, have no special clothes or have signs of sickness should not be allowed to work;
- Allocation of waste exceeding the set norm in the area of waste collection is not allowed. Allocation of waste near spark or warmth sources is not allowed;
- In case of allocation of different types of waste their compatibility should be considered;
- Storage of external items, personal clothes, special clothes, individual protection equipment is not allowed in the areas of industrial waste collection. Eating in such areas is strictly prohibited;
- Rules of personal hygiene should be strictly followed when working with industrial waste. Before eating and after completion of work hands should be washed with soap and warm water;
- In case of poisoning signs the work should be terminated and the affected person should address the nearest medical point and inform the management of the structural unit;
- The areas of collection of flammable waste should be facilitated with firefighting equipment. Smoking and use of open fire is strictly banned in the areas of allocation of such waste;
- The staff should know the waste characteristics and firefighting rules. The fire extinguishing of burning flammable or fuel liquids is possible with fire extinguishers, sand or asbestos clothes;
- Fire extinguishing of burning solvents with water is not allowed.

Responsibility for the Implementation of Measures Determined by the Plan

Management is responsible for the following:

- Approval of waste inventory charter;
- Facilitation with the equipment, resources and inventory required for waste management;
- Protection of the environmental legislation of Georgia in the process of the management of waste produced as a result of the plant activities.

Staff, who is involved in the waste management field, is responsible for the following:

- Non-fulfillment of waste collection, storage, transportation and other conditions as stipulated by the waste management plan;
- Allocation of waste in non-sanctioned places;
- Violation of norms, rules and records on waste production, processing, use and disposal;
- Delivery of incomplete incorrect documentation (information) on waste management or refusal to deliver such information;

- Delivery of waste without duly formalized documentation;
- Non-fulfillment of the requirements of the waste management plan by the subordinate staff.

Procedures and Rules of Waste Management

This section describes the measures and rules, which should be met (prior to processing and/or destruction) for waste management purposes. Management measures are reviewed according to the below priorities.

Waste Classification

Further management of waste significantly depends on the classification of waste at the place of production. Segregation of waste by waste types, meeting the storage requirements and processing/destruction – all of the above requires appropriate classification of waste.

Waste categories should be identified, samples taken, checked, tested or analyzed in laboratory with the aim to facilitate the classification of waste according to EU standards and determine the below issues:

- Which category the waste belongs to – hazardous, non- hazardous or inert;
- How waste management should be implemented.
- Person responsible for waste management should facilitate the below for waste classification:
- Use temporary inventory of waste, which should describe wide array of expected types of waste;
- If the specific type of waste is not included in the inventory, use other additional methodology to classify waste;

If the general methodology of waste classification is not complete, waste samples should be taken and checked in laboratory to facilitate the classification of waste by the below table.

Provisions for Waste Classification

Waste Classification	Provisions
Inert	According to provisions of article 2 of EU directive 1999/31/EEC, inert waste is the waste which is not subject to significant physical, chemical or biological changes. Inert waste is not resolved, burn or show any other physical or chemical reaction; it does not decompose and negatively impact other matter, with which it interacts; it does not cause the pollution of the environment and damage human health. The contamination effect and eco-toxicity of such waste should be insignificant and will not pose threat to the surface and/or ground water quality.
Hazardous	Hazardous waste is the waste determined by article 1(4) of 91/689 directive and has the following potential characteristics: explosiveness, acidity, high degree of flammability or flammability, irritation causing, toxicity, carcinogenicity, corrosiveness, infectiousness, teratogenesis, mutagenicity; emits very toxic or toxic gases as a result of contact with air, water or acid; substances which could create other substances and eco-toxic substances as a result of destruction.
Non-hazardous	Waste which does not meet the above described provisions.
Waste water	Fresh water which was polluted as a result of project activities.

Inventory

After the classification of waste, which should determine the potential threat of the waste, the person responsible for waste management shall develop the inventory list comprising the below information:

- Waste flows and sources;
- Description and classification of waste flows, i.e. if the specific waste is hazardous or not;
- Storage rules, if applicable;
- Destruction methods and contractors;
- Quantitative characteristics of waste – annual, quarterly or monthly, whichever necessary.

Inventory records during annual or other changes are handled by the persons responsible for waste management. The copies of the waste inventory lists are delivered to the plant management. The records are updated only but those persons who have undergone special training in the issue of the use of waste inventory list.

Correct inventory of waste is necessary for the identification of the below issues:

- How the waste should be processed (if applicable);
- How the waste should be handled (i.e. need for personal protection equipment and like);
- How the waste should be stored (if applicable);
- Rule of final processing/destruction.

The aim of the inventory and further measures, among them – labeling, is to provide for the sufficient information and consequently safe final destruction of waste.

Waste Segregation and Collection

Special containers should be placed in the proximity of the waste producing unit.

Waste should be segregated and allocated in the appropriate container at the waste producing unit.

As a result of the activities at different units waste, which is the subject to registration, collection, temporary storage, carriage, treatment, processing or disposal, is produced and collected.

The method of separated collection of industrial and household waste according to waste categories and threat should be organized and introduced at the object.

The below is the subject to segregated collection and storage:

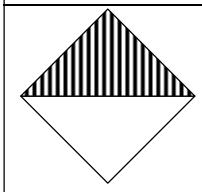
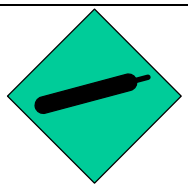
- Household waste;
- Industrial waste, the carriage of which is not banned on the household grounds (i.e. rubberized asbestos, rubber, plastic household items, wooden and paper waste, wood and sawdust waste, polyethylene pipes, sandpaper waste, etc.);
- Quicksilver containing substances and material;
- Lead containing waste;
- Chemical waste;
- Oily clothes, used respirator filters;
- Oil waste, among these – precipitator waste;
- Used industrial oils, lubricants;
- Material used during the liquidation of oil spills;
- Contaminated soil and sand;
- Metal scraps, welding electrode waste;
- Used rubber hoses, used tires;
- Used lead accumulator waste;
- Paint and paint barrel waste;
- Medical waste.

Labeling

Persons responsible for waste management are obliged to provide for marking of the waste containers in a way that the contents should be identified and described in detail. The above is necessary for the external staff to follow the safety rules of waste handling. Waste the type of which is not indicated shall be deemed hazardous and become the subject to the above described classification.

Appropriate labels should be applied to all containers (mugs, wheel boxes, barrels, etc.) so that it is clear which type of waste could be placed in the container. To avoid misunderstanding old labels should be removed.

Fig.2. Information and Warning Signs

 Explosive substances or material	 Toxic gas or substance	 Easily flammable gas and liquid	 Easily flammable solid substance
 Other hazardous substances and material	 Spontaneously igniting substance	 Non-toxic gas	 Hazardous if affected by water
 Infection threat	 Oxidant	 Corrosive substance	 Radioactive substance

 Smoking is banned	 Subject to processing	 For household waste	 Flammable

Waste Storage

The waste should remain on place for minimal period of time and removed as soon as possible for further treatment and destruction.

Waste storage places should be put on the corresponding plan of the object. The waste should be stored in such conditions to avoid the below:

Accidental leak or spill, surface or ground water contamination, breaking of container due to accidental crash, contact with the air due to utilization of secondary packaging and/or covers;

Corrosion or depreciation of containers both due to the environment (through provision of shelter) and the waste itself; to provide the above mentioned containers should be proof to the specific waste which should be placed in it, i.e. automobile accumulators should be placed on plastic plates which are corrosion proof;

Theft due to un-protected allocation of waste within the protected perimeter of the object.

Waste containers should correspond to the waste to be stored, its form, structure and threat. Only containers in good state of repair should be used. Covers should close or other type of covers used. Containers which react to the contents or could result in the leak of the dangerous substance should not be used. All hazardous waste should be strictly segregated from the other types of waste. Only one type of hazardous waste could be placed in a container. Solid and liquid waste should not mix.

The long term collection and storage of waste within the plant is allowed as temporary measure only if:

- Waste is used in the further technological cycle with their full utilization purpose;
- The user does not exist; etc.
- Proceeding from the toxic and physical-chemical characteristics of waste and its components temporary storage is allowed in:
- Industrial or auxiliary storages (storage, store-room);
- Temporary non-stationary warehouse;
- Open areas.
- The areas of temporary waste storage within the object are identified during the waste inventory process and should comply with the below requirements:
- The ground cover should be solid (concrete, asphalt-concrete or concrete tiles);
- The ground should be fenced and facilitated with ricks to avoid the spill of the harmful substances in rain sewerage or soil;
- The ground should be facilitated with comfortable access for auto-transport;
- The waste should be effectively protected against the impact of precipitations and wind (stalls, packaging, allocation of waste in containers, etc.).

During the temporary storage of waste in non-stationary warehouses and grounds the following conditions should be met: the possibility of waste disposal into the waste water or soil should be eliminated.

Hazardous waste could be stored in stationary warehouse. For this purpose a special warehouse area should be facilitated within the object. The area should be arranged according to the environmental requirements, namely:

- The floor and walls should be covered with ceramic tiles;
- The ceiling should be painted with moisture proof paint;
- The area should be equipped with the below:
- Exhaust ventilation system;
- Sink and tap for watering-washing of the area;
- Water intake drain;
- Iron lattices should be installed on the doors and windows;
- Racks and shelves should be installed for waste allocation;
- Waste could be allocated only in hermetic packaging, which should have appropriate labels.

Removal of hazardous waste from the plant and further management should be undertaken by organization with appropriate permit on this type of activity.

Waste Passing Rule

Passing of waste should be formalized through filling in the waste pass form. In each case the below information should be entered:

- Date and time of delivery;
- Description of waste with reference to amount;
- Information on waste producer;
- Information on waste carrier;
- Information on waste recipient;
- Signatures of the representatives of the producer, carrier and recipient.

The filled in form of waste pass should be present along with the carriage overheads from the waste production area or object to the designated place of destruction, that is treatment device of waste waters, landfill, etc.

Each form of waste pass should comprise the full description of waste, structure, production process, packaging, total amount of the passed waste and other relevant information.

Waste pass form should be filled in three copies. The formal procedure of waste pass is as follows:

- Waste pass form is signed by incumbent persons and sub-contractor, who conducts waste removal and carriage;
- The upper copy (first copy) stays at the object and is stored in the archive;
- The below two copies follow the waste till the place of processing, treatment or disposal;
- The carrier is obliged to make the responsible person sign the form at the waste recipient object. It should be indicated that the waste was received in the place of designation;
- After the above procedure the second copy is left at the recipient object;
- The carrier keeps the third copy in the office. Upon the next removal date the carrier should deliver the mentioned third copy to the area of waste production;
- The third copy stays at the waste production area and is stored along with the first copy;

The photo copy of the third copy is made at the area of waste production. The photo copy is sent to the environmental division within the fulfillment of reporting obligations.

The filled forms of waste pass are stored throughout the entire validity term of the contract.

The responsible person is obliged not to issue and sign the waste pass form, if he/she has sound suspicion that the waste has not reached the designated area in accordance with the applicable rules.

Waste Pass Form

Table 2

#	Information on waste producer	Information on waste carrier	Information on waste recipient	Waste composition	Rule/place of production	Packaging

#	Type of waste	Amount of waste	The period of waste collection	The number and name of automobile used for waste transportation	Driver's signature	Time of waste removal from the area of production	The time of waste reception at the place of waste reception	The waste producer's signature	Waste recipient's signature

Waste Producer Organization

Waste Recipient Organization

(It is filled in three copies, one stays with the waste producer, the second belongs to the driver and the third – to the waste recipient. After transportation the driver returns his/her copy to the waste producer).

Waste Transportation

Waste transportation should be conducted in full compliance with the sanitary, environmental and hazardous cargo carriage safety norms. All operations connected with waste loading/unloading and transportation should be maximally mechanized and hermetic.

The loss and dissipation of waste should be avoided during waste transportation. During the transportation of hazardous waste to the temporary storage the accompanying person should have the appropriate document – the request of removal of hazardous waste, which should be verified by plant management. The waste carrier facilitates the transport, loading and transportation of the hazardous waste to the designated area in accordance with sanitary, environmental and safety rules. Upon the completion of the operation the vehicle should be cleaned, washed and treated. The vehicle used for waste transportation should have appropriate warning sign.

Waste which is the subject to secondary processing should be removed from the plant territory by appropriate contractor company on the basis of a contract signed in advance.

Household waste is collected within the plant in special containers, while removal is conducted by the municipal cleaning service on the basis of a contract and according to the determined schedule.

The workers employed in the transportation (drivers and workers) should undergo appropriate training.

The below main risks are connected with cargo transportation:

- Automobile accidents;
- Dissipation or spill of cargo;
- Inappropriate loading of a vehicle.
- To avoid the above mentioned the below should be facilitated:
- The vehicle should be systematically checked in terms of technical state of repair and the traffic speed rules should be met;
- The hermiticity of containers should be checked;
- The cargo capacity of the vehicle should be considered during the loading in order to avoid over-loading of the vehicle;

Liquid impermeable capacious geo-membrane should be placed on the body of the vehicle. It should facilitate the detention of waste on the body of the vehicle in case of emergency spill.

If an accident still occurs despite the consideration of the above safety measures and the environment is contaminated, then the driver urgently contacts with the object administration, who implements the measures as stipulated by the emergency response plan and with the help of the rescue team.

Monitoring of Waste Management

During industrial waste collection, storage, transportation, use, treatment and disposal applicable ecological, sanitary-epidemiologic and safety norms and rules should be complied.

The registration of waste production, allocation, treatment and removal is conducted in special journal. The volume of the removed or utilized waste should be confirmed documentarily.

The person responsible for waste management should systematically control the below:

- The adequacy of the waste packaging;
- Presence of labeling on the packaging;
- The state of temporary waste allocation grounds;
- The amount of the collected waste and compliance with the applicable norms (visual control);
- Compliance with the procedure of the waste removal from the territory;
- Fulfillment of the requirements of ecological safety and safety technique.

Indicators of Effective Waste Management

As it has been already mentioned, different types of waste could be produced at the object. The applicable waste management rules should be complied to provide for appropriate waste management. The waste removal/disposal should be conducted according to the determined rule and following the applicable norms/rules of Georgia.

Potential Impact	Pollution of the territory due to inappropriate waste management
Sources	Packaging; Other construction waste; Waste collected during land works; Fuel use and storage; Repair of the equipment; Household waste
Goal	Facilitation of timely removal of waste according to the applicable rule; Prevention of damage to the environment caused by waste
Activity/Control	Facilitation of compliance with appropriate legislative and regulative requirements; Arrangement of special place for temporary waste storage; Throw of waste according to the applicable legislative requirements; Separation of hazardous and non-hazardous waste; Transportation of the household waste to the landfill; Re-use of waste (if applicable); The blocking of access and movement roads should be prevented

Effectiveness Indicator	Absence of grievances; Absence of waste collected during waste and technical servicing; Absence of hazardous waste and spill traces (i.e. oil, fuel, etc.)
Monitoring	Supervision over the allocation-removal procedures of waste; Regular monitoring of waste collection-removal; Due registration of records; Grievance records, if needed – response
Corrective Activities/Reporting	Corrective measures should be implemented as soon as a problem arises or a grievance is received; The work managers account for every incompliance/violation of applicable norms; If needed, the responsible person on the working place informs the management of the cases
Responsible Person	Executor of works
Responsibility for Monitoring/Execution	Plant management

Information on the Waste Produced during Object Exploitation

The following categories of waste are expected during object exploitation:

- Household waste;
- Office waste (paper, cartridges, bulbs, etc.);
- Packaging (wood, paper, etc.);
- Oil contaminated clothes, filters, absorption pillows;
- Oil contaminated soil;
- Polymer waste;
- Medical waste.

The amount of household waste produced during plant functioning is connected with the staff number. According to the preliminary data, up to 200 people shall be employed. Following the accepted norm, 0.70 m^3 of household waste is produced per employee annually. Proceeding from the above, the amount of household waste per year will be: 0.70 X 200 = 140 m^3. The installation of closed containers is planned for household waste at the object. The removal of this waste and disposal at the grounds will be conducted on the basis of the contract with the municipal cleaning service.

Oil contaminated mass as well as other hazardous waste shall be temporarily allocated within the plant in accordance with environmental and hygienic requirements and proceeding from the collection passed to the organization with appropriate environmental impact permit for further processing/disposal/treatment.

Wooden packaging material shall be passed to the local population for further re-use.

The management of waste produced at the object (classification, inventory, segregation, collection, storage, passing and transportation) and monitoring shall be conducted in accordance with the above principles, procedures and rule.

Annex 6: Plan for Managing Excavated Material

Construction of Chumateleti-Khevi Section of East-West Highway (E-60)

The present document is the Plan for managing material to be excavated during the construction of Chumateleti-Khevi Section of East-West Highway (E-60). The Plan is based on the calculations of the estimated volumes of material provided by the design company. Actual amounts may differ from estimated numbers to some extent.

Road section will be constructed in a difficult terrain, will require cutting of slopes and drilling of large tunnels. Hence, the amount of excavated material will be large. Part of this material will be used for backfilling. Nonetheless, significant volume of excess material will be generated and will have to be disposed.

1. Origin of Excavated Material

Works in the road section will involve excavation to form the tubes of the 3 tunnels, the permanent cuttings for the road platform as well as excavation of benches under embankments that are to be formed on steeply sloping ground. In addition, temporary trenches will be excavated for the construction of the foundations of bridges, retaining walls and culverts. Other construction activities will require filling to form embankments to support the road platform, filling behind the sub-structures of bridges, filling behind retaining walls and filling the trenches excavated for culverts. Materials will also be required to form the various layers of the road pavement construction.

Geologic characteristics of the road corridor show that a variety of material will be encountered during excavation. Consequently, it is necessary to form a plan for the reuse of the excavated material with the intention that the higher quality material is used in construction and the low quality and unsuitable materials, as determined by standard site testing, are taken to the disposal sites.

The volumes of materials that are likely to be excavated are listed in Table 1 below:

Table 1 – Sources of Excavated Material

Source	Total Volume (m^3)	Share of Re-useable (%)	Volume of Re-Usable (m^3)
Tunnels	254,500	100	254,500
Tunnel Portals	58,600	80	46,900
Earthworks: Ground Improvement	1,242,400	79	981,500
Earthworks: Benches	9,000	33	3,000
Additional Excavation for Capping	20,000	0	0
Bridges	181,000	77	139,400
Retaining walls	470,000	62	291,400

Culverts & Drainage	126,000	70	88,200
River Training Works	20,000	50	10,000
Total:	2,381,500		1,814,900

Excavated material will vary from high quality Category VI Gabbro, Granites and Diorite, to partly weathered and completely weathered Granites and Diorite, some of which will not be suitable for reuse due to plasticity and low bearing strength. It is anticipated that approximately 200,000 m^3 will be rock requiring either blasting or use of rock breakers to assist in the excavation, while approximately 300,000 m^3 will be non-rock material, which is expected to include a significant amount of granular material. The estimated amount of 300,000 m^3, while suitable for re-use in embankments, is likely to exhibit low bearing strength.

It is expected that the materials excavated for the construction of culverts and retaining walls will represent a similar mix.

The excavations for bridges will yield more of a higher quality material, while virtually all of the material excavated during the construction of tunnels will be rock.

The above analysis shows that approximately 2.25 million m^3 material will be excavated in total, of which approximately 70 - 75% will be suitable for re-use. Approximately 620,000 m^3 of unacceptable excavated material will be taken off site for disposal. Cut-to-spoil includes completely weathered material from cuttings as well as material that was deposited on the slopes of the rivers Rikotula and Chumateleti during construction of the existing Rikoti Tunnel and the existing road.

Overall, of the remaining 1.6 million m^3 suitable excavated material, it is expected that approximately 20% will have relatively low bearing capacity, leaving approximately 1.3 million m^3 of excavated material available for re-use.

2. **Re-use of Materials**

Table 2 below lists the approximate volumes of materials that are required for road construction.

Table 2 – Re-use of Excavated Materials

Construction Activities	Volume (m^3)	Comment
Tunnel Portals	31,000	Selection of higher quality materials
Tunnels: Road Foundation	20,000	Selection of higher quality materials
Earthworks: Fill	33,000	
Capping Layer	107,000	Selection of higher quality materials
Earthworks: Ground Improvement	10,000	Selection of higher quality materials
Earthworks: Benches	10,000	
Bridges	31,500	Selection of higher quality excavated materials
Concrete Retaining Walls	564,000	
Culverts & Drainage	57,000	

Stabilized Earth Retaining Walls	142,000	Possibly requires imported materials
Miscellaneous Drainage materials	50,000	
River Training Works	6,000	
Subbase	111,500	Selection and processing of higher quality excavated materials
Shoulder & median	32,000	
Total	1,205,000	

Table 2 shows that most of the material to be re-used will require some form of selection, whilst any materials that will be used in the construction of the subbase pavement layer and the filling of shoulders will require some form of processing to comply with the technical requirements.

Furthermore, it is possible that higher quality material will need to be imported if the material excavated from the tunnels and rock cuttings, after processing, do not yield a higher standard required for the granular fill of the mechanically stabilized walls and for the drainage material to be used with structures. Potentially, 200,000 m^3 of material may need to be imported for these works.

From the above, the following conclusions are drawn:

Total Volume of Excavated materials:	2,381,500 m^3
Excess material for disposal (weak and unsuitable for use)	566,600 m^3
Available for re-use	1,814,900 m^3
Excavated material required (fill and filling behind structures)	1,013,000 m^3
Excess material for disposal (surplus)	801,900 m^3
Total excess material for disposal	1,368,500 m^3
Stabilized Earth Retaining Walls – possibly imported	142,000 m^3
Miscellaneous drainage materials – possibly imported	50,000 m^3

Consequently, depending on the mechanical properties of the higher quality excavated material after processing, one of the following 2 scenarios play out:

a) there will be a surplus of 801,900 m^3 of material not required and to be disposed of in addition to 566,600 m^3 of unsuitable. In this scenario, approximately 192,000 m^3 of granular material will need to be imported for use in the fill of mechanically stabilized earth retaining walls and as miscellaneous drainage materials. **Total amount of excess material to be disposed will make 1,368,500 m^3.**

b) if part of unsuitable materials after processing prove to be acceptable for use as fill for stabilized earth retaining walls and for miscellaneous drainage materials, **the volume of excess material to be disposed will reduce to 1,176,500 m^3.**

The above analysis does not take into consideration the materials required for the granular base and the asphalt and concrete pavement works, which are all expected to be imported from suitable quarries.

Excavated material originated in the process of cutting the slopes and tunneling will be stored at the temporary storage locations and later, unsuitable part will be taken to the final disposal site. Disposal sites, both temporary and final, will be agreed with the Ministry of Environment Protection and Agriculture as well as with the local authorities upfront, before excavation starts. Sites of piling excavated material will be selected by considering a number of criteria, including environmental,

esthetical, economic and financial. There are several locations within the highway corridor suitable for temporary storage of material.

Figures 1-4 show the locations proposed for temporary storage of excavated material.

Figure 1: $42^{0}05^{II}42.51^{II}$ N; $43^{0}25^{II}52.91^{II}$ E

Figure 2: $42^{0}03^{II}39.46^{II}$ N; $43^{0}27^{II}25.60^{II}$ E

Figure 3: $42^{0}05^{II}14.74^{II}$ N; $43^{0}27^{II}56.55^{II}$ E

Figure 4: $42^{0}03^{II}57.85^{II}$ N;$43^{0}28^{II}47.61^{II}$

The locations shown in these figures cover approximately 2,5-3 ha, which is fully sufficient for the temporary storage of excavated material. It is expected that bulk of the originated excess material will be transported immediately to the final disposal sites without temporary storage.

3. Final Disposal of Excess Material

3.1. General requirements

When selecting the final disposal site for excess material, the following guiding principles were considered:

1. Distance from the waste origination site.
2. Landscape impacts.
3. Risk of origination of floods, freshets, ground subsidence, landslides or avalanches.

4. Destruction of the vegetation cover.

5. Use of fertile agricultural lands and pastures.

3.2. Analysis of Alternatives for Final Disposal of Excess Material

Chumateleti-Khevi section of the highway will pass mostly across mountainous terrain, where no access roads exist for the use by heavy construction machinery and vehicles. The area does not provide ample space for placing large amounts of excess material either. At the earlier stage of ESIA, only two alternatives were considered for the final disposal of excess material: Alternative #1 and Alternative #2.

At present, construction of Zemo Osiauri-Chumateleti section of the highway is underway. This section bypasses the city of Khashuri from the south and crosses the areas which, due to the absence of road network, were not viewed as the alternatives for the disposal of excess material earlier. As the right-of-way is cleared for Osiauri-Chumateleti section and access roads are arranged, additional sites for the disposal of material to be excavated from Chumateleti-Khevi section have been identified at the later stage of ESIA of this section.

Finally, six alternatives were identified and assessed for the final disposal of excess material.

3.2.1. Alternative 1. Renting or purchasing agricultural land with the total area of up to 20 ha on the left bank of the river Mtkvari, along Khashuri-Bakuriani road.

Figures 5 and 6: Potential areas to dispose inert materials

This territory comprises of agricultural land parcels most of which are privately owned and used for growing cereals. If excess material was to be disposed on this territory, the site would have to be reinstated in the manner allowing its agriculture use in future. For retaining land use pattern, the following actions will be necessary: (i) in line with the requirements of the Georgian legislation, the topsoil is to be stripped and stored in the adjacent area, (ii) excess material will be placed in piles of maximum 5m height, (iii) at the following stage, the topsoil will be spread over the stockpiles. Bringing the area back to agricultural use may be considered after site reinstatement.

As Figure 7 illustrates, predominant area of the selected territory is the private property of the local population. Unless all owners of land parcels agree to the disposal of material based on the conditions offered by construction contractor and a single large area is made available for this purpose, implementation of Alternative 1 may not be possible. Furthermore, negotiating and formalizing deals with the owners of 200 land parcels is likely to last for a long period of time, within which contracted construction company will not be able to commence physical activity creating major issues for contract management and disrupting work schedule. Furthermore, complains from land owners and disputes over the terms of deals concluded with them are likely to emerge and disrupt works. Because there is no assurance that Alternative 1 is workable, and because timeline of its implementation is unpredictable, **Alternative 1 has been discarded at the early stage of consideration**.

Figure 7: Cadaster map of the territory for the selected alternative

Figure 7 also shows that each resident owns 500 to 1,000 m^2 land plot on average. Consequently, approximately 200 individual land parcels will come under the impact. Estimated cost of land purchase from private owners, in case of their willingness to give them up, is 4,500, 000 GEL.

3.2.2. Alternative 2. Backfilling of quarries used for the extraction of natural construction material required for the construction of previous sections of the East-West highway.

These quarries are located in the vicinity of village Akhalsopeli (Figure8).

Figure 8: Locations quarries near village Akhalsopeli

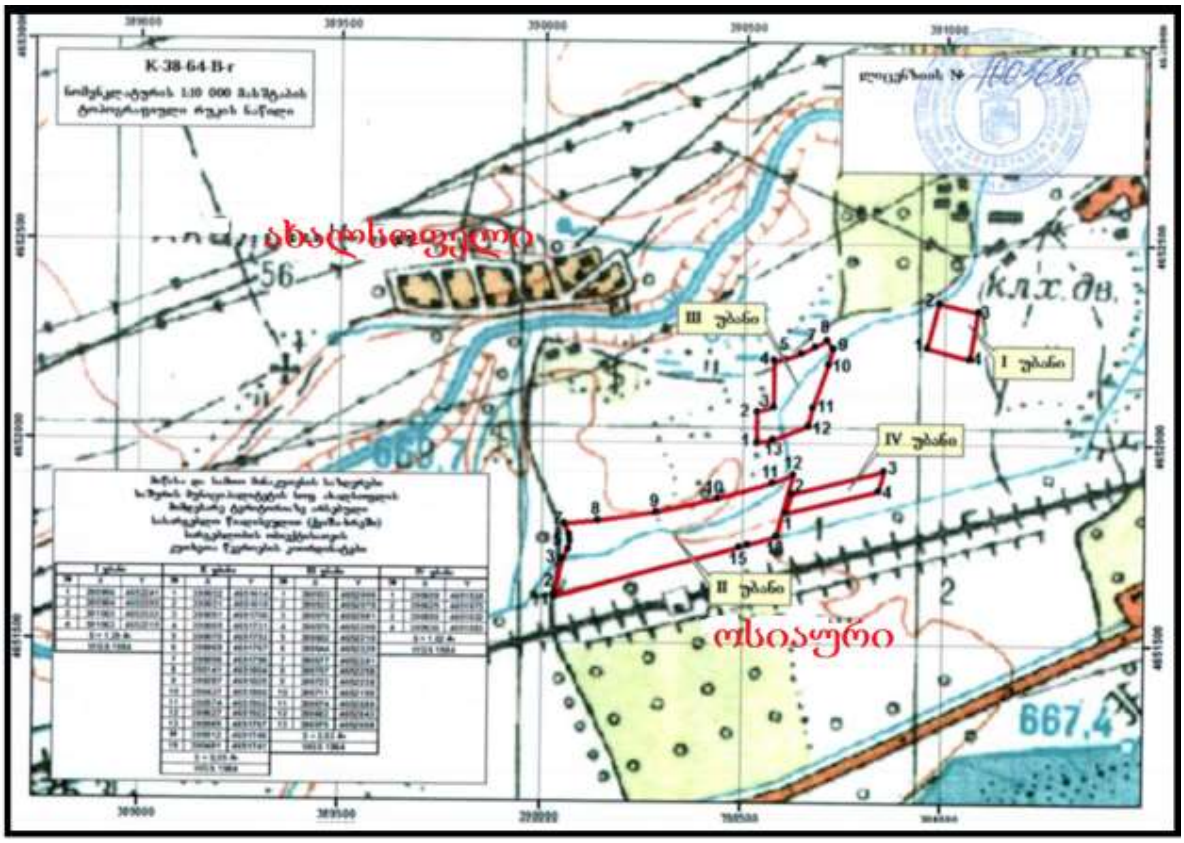


Table 1 shows X and Y coordinates of the locations of quarries needing re-cultivation in the area adjacent to village Akhalsopeli of Khashuri municipality.

Table 1. X and Y coordinates of the locations of quarries needing recultivation

Site N 1			Site N 2			Site N 3			Site N 4		
N	X	Y	N	X	Y	N	X	Y	N	X	Y
1	390956	4652241	1	390032	4651614	1	390533	46522000	1	390609	46511824
2	390984	4652355	2	390031	4651619	2	390533	46522078	2	390625	46511873
3	391083	4652333	3	390051	4651706	3	390576	46522091	3	390850	46511932
4	391063	4652215	4	390065	4651731	4	390576	46522208	4	390836	46511883
S = 1. 25 ha			5	390070	4651753	5	390602	46522210	S = 1. 02 ha		
			6	390069	4651767	6	390644	46522225			
			7	390056	4651796	7	390677	46522241			
			8	390141	4651804	8	390707	46522258			

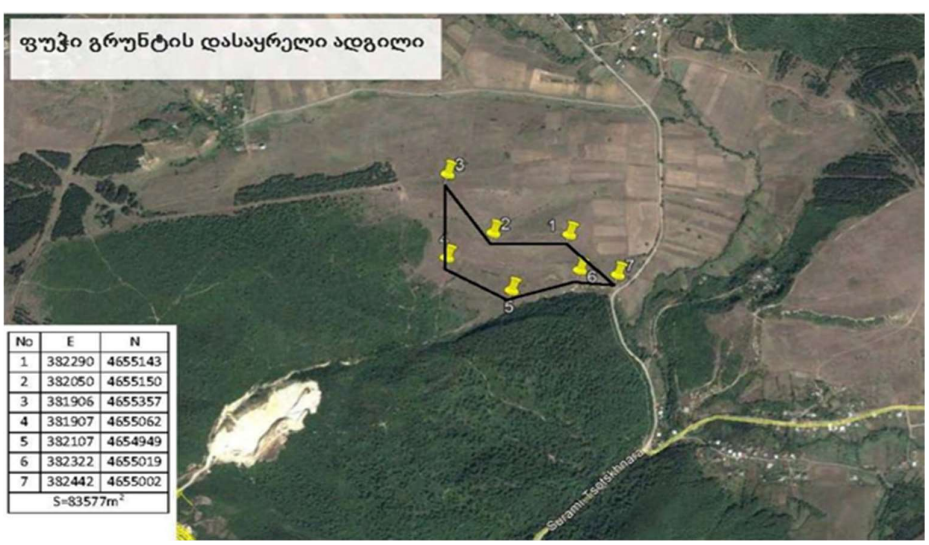
9	390287	4651825	9	390723	46522238
10	390437	4651860	10	390711	46522198
11	390574	4651902	11	390674	46522089
12	390627	4651922	12	390663	46522043
13	390585	4651767	13	390575	46522008
14	390512	4651746	S =2. 63 ha		
15	390491	4651741			
S = 8. 05 ha					

Black Sea Group Ltd., who holds license for the operation of subject quarries, confirmed a need for approximately 1,000,000 m^3 material for the purpose of quarry re-cultivation. So, the restoration of the quarries requires more material than the amount to be generated from earth works for the construction of Chumateleti-Khevi section of the highway.

3.2.3 Alternative 3. Using area of about 8 ha (83,577 m^3) located at the edge of Zemo Osiauri-Chumateleti section of the highway

This territory is distanced from Chumateleti-Kevi section construction site by 15 km on average. Land is State-owned and there are no trees growing in it (Figure 9). However, if was found that ASTALDI, a company providing works for the construction of Zemo Osiauri-Chumateleti section of the highway, has applied for the permission to dispose excess material being generated from the construction of Kvemo Osiauri-Chumateleti section of the highway in this plot and the application was turned down by the Ministry of Economy and Sustainable Development due to strong push-back from local communities. Hence, **Alternative 3 was not explored to greater detail and was discarded.**

Figure 9: Location of land plot considered as Alternative 3



3.2.4 Alternative 4. Using area located on a slightly inclined slope south-east of Khashuri city.

This area is approximately 12 ha. The territory is State-owned and sparsely vegetated. Local communities do not object to the use of this area for the disposal of excess material. However, the area is crossed by Urbnisi and Surami 220 kV power transmission lines. Also, according to the Municipality of Khashuri, there is an underground pipe formerly used for oil transportation and later abandoned without proper decommissioning. There is high likelihood of residual oil remaining inside the pipe. Relocation / decommissioning of these communication lines is not justifiable due to associated costs as well as possible environmental and social impacts. **Hence, the Alternative 4 was discarded without further examination**. The coordinates of this territory are as follows:

E	N
384996	4653174
385041	4653511
385494	4653454
385450	4653104

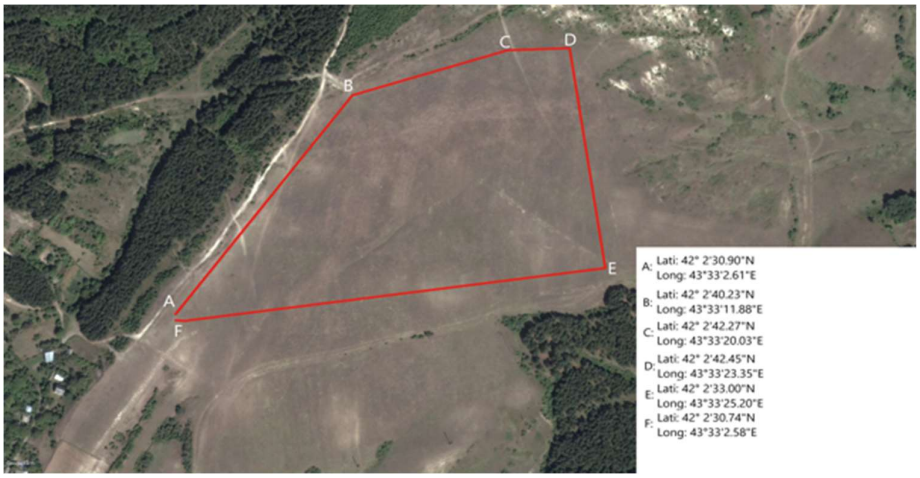
The location of Alternative 4 is given on the map in Figure 10.

Figure 10: Location of land plot considered as Alternative 4

3.2.5 Alternative 5. Use of area in approximately 15 km from the Chumateleti-Khevi section of the highway.

This area is approximately 12 ha. The territory is State-owned and sparsely vegetated. Local communities do not object to the use of this area for the disposal of excess material. Its location is illustrated in Figure 12.

Figure 11: Location of land plot considered as Alternative 5



ASTALDI company has applied for the permission to dispose excess material originating from the ongoing construction in Zemo Osiauri-Chumateleti section of the highway on the land plot adjacent to the one considered as Alternative 5. Location of that site is visible on Figure 12 below and the coordinates are as follows:

E	N
380562	4655808
380918	4655858
380906	4655500
380548	4655648
S=99713 m^2	

Figure 12: Location of land plot considered for disposal of excess material generated from construction of Zemo Osiauri-Chumateleti section of East-West highway

Coordinates of the site considered for the disposal of excess material generated from the construction of Zemo Osiauri-Chumateleti section of East-West highway and the site considered for the disposal of excess material that will come from the construction of Cumateleti-Khevi section were carefully compared to exclude an overlap.

Visual appearance of the site proposed under Alternative 5 can be viewed in Figures 13a and 13b below.

Figures 13a and 13b: Views of land plot considered as Alternative 5

3.3 Comparison of Alternatives

Out of 5 considered Alternatives, numbers 1, 3, and 4 were discarded at the early stage of assessment. Alternatives 2 and 5 were compared by using the criteria of assessment listed above.

1. Distance from the point of origin. There are two major locations where excess material will originate during works in Chumateleti-Khevi section of the highway: (i) territory adjacent to Rikoti tunnel, and (ii) the territory of village Khevi. These two locations are distanced by 10 km from one another. Distance from the closer point of origin of the excess material (Rikoti tunnel portal) to village Akhalsopeli is 31.6 km travel along the existing carriageway of East-West highway. Distance between Akhalsopeli and another source of material origin – Khevi village – is about 10km longer (Figure 14). However, transporting excess material along the busy highway and through densely populated Surami and Khashuri towns would be unacceptable. Transportation through alternative secondary roads would increase the distance up to approximately 50km. Such a long distance, associated safety risks, and costs of transportation make Alternative 2 unattractive while measures by this criterion. Alternative 5 implies transportation of excess material to a much closer destination – 9.1km along a secondary road. The distance may be further shortened as additional access roads are being laid for the purposes of Zemo Osiauri-Chumateleti section of the highway. Difference in costs of transportation of material to these two locations is substantial.

Figure 14. Positioning of Rikoti site and material disposal site under Alternative 2

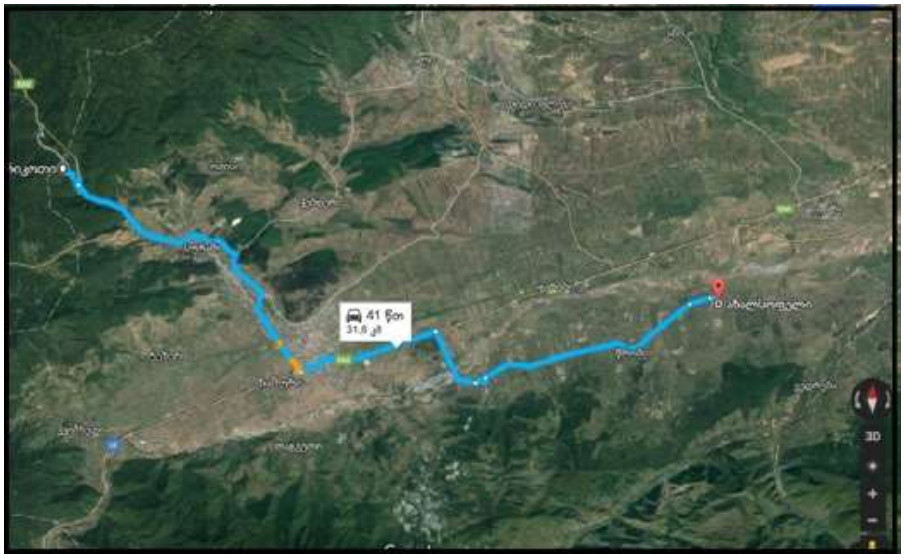
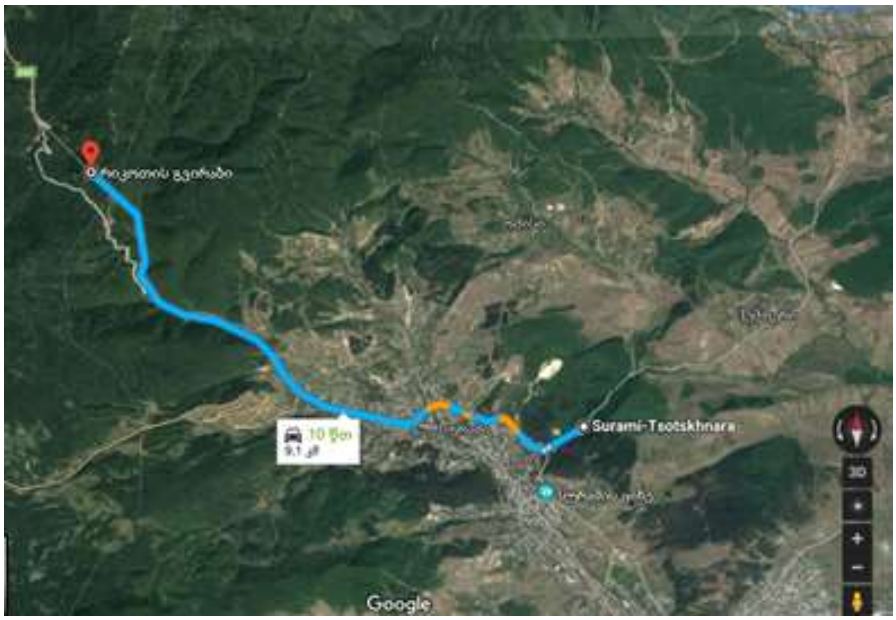


Figure 15: Positioning of Rikoti site and material disposal site under Alternative 5



2. Landscape transformation. In respect of the landscape change, Alternative 2 would allow restoration of the affected landscape in the territory of the quarries near Akhalsopeli, thus leading to positive environmental outcome. Landscape transformation under Alternative 5 will not have significant negative impacts. Well-designed and implemented reinstatement would be sufficient to bring residual impacts to the acceptable minimum.

3. Risk of origination of floods, freshets, ground subsidence, landslides or avalanches. Alternative 2 is neutral in terms of potential risks of triggering geological activity, because it implies restoration of the natural landscape formations. Alternative 5 does not carry such risks either if compacting and stabilization of excess material piles is done in accordance with conventional good practice, because

the area if flat, with minor inclination; no ravines or other water passages are present that might be blocked with stockpiling of material; and there are no settlements in proximity to this site.

4. Destruction of vegetation cover. Impacts on the vegetative cover will be minimal under both Alternatives 2 and 5, because the area under impact carries sparse vegetation. However, proper management of topsoil would be important for site reinstatement under Alternative 5.

5. Use of fertile agricultural lands and pastures by the project. The discarded Alternative 1 would have significant impact on agricultural lands. None of Alternatives 2 and 5 will affect cultivated land.

4. Conclusion

Comparison of alternatives using all relevant criteria of analysis revealed that Alternative 5 is preferable over others. It requires transportation of excess material over short distance, without entering settlements; has tolerable visual impact; no social impact; and low negative impact on the environment. Alternative 2 has positive impacts on landscape and environment, however distance to be traveled by heavily loaded trucks for the delivery of material to the disposal site adds considerable risk of traffic congestion, roadside accidents, and cost to Alternative 2. Therefore, **Alternative 5 is selected as the most preferred option**.

Construction companies bidding for the delivery of works in Chumateleti-Khevi section of the highway will be required to develop Waste Management Plan, including a plan for the disposal of excess material. Contractor will have to apply for and obtain permission for material disposal to the Agency of State Property Management under the Ministry of Economy and Sustainable Development, and to the Ministry of Environment Protection and Agriculture.

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ANNEX 7: Emergency Resonse Plan

Goals and Objectives of the Plan

Goal of the emergency response plan is to determine and establish guidelines for workers employed for the road construction works in order to ensure rational and coordinated actions of personal during techno genic accidents or incidents, as well as protection of personnel, population and environment.

Objectives of this plan are:

- Determination of possible emergency situations during the road construction;
- Determination of groups responsible for response to each type of emergency situation, their equipment, emergency action plans and responsibilities;
- Determination of internal and external alarm systems;
- Immediate activation of internal resources and, if necessary, mobilization of additional resources and relevant procedures;
- Provision of emergency management system;
- Ensure compliance with legislative, regulatory and safety requirements during emergency situations.

Expected emergency response plan envisages the requirements of Georgian laws and legislative acts.

Types of Emergency Situations

Considering specificities of planned activities, following types of emergency situations are expected:

- Traffic accidents;
- Accidental spills of pollutants;
- Fire;
- Personnel traumatism and incidents related to their health safety.

It is noteworthy, that emergency situations, listed above, may be subsequent and development of one emergency situation may initialize another one.

Traffic Accidents

Trucks and heavy machinery will be used during construction works. During their movement on public and access roads, following are expected:

- Collision with transport means, real estate or livestock of local population;
- Collision with local population;
- Collision with project personnel;
- Collision with other project machinery;
- Collision with local infrastructure facilities;

High risk of traffic accidents will be related to relatively intensified traffic. A number of preventive measures should be taken in order to minimize the risks of traffic accidents, including: limitation of traffic speed, arrangement of warning signs, selection of optimal routes for vehicles, regulation of traffic by standard-bearer, etc.

Accidental Spills of Pollutants

Oil spill risk may be related to a violation of the conditions of their storage, fuel or oil leakage from vehicles and equipment and so forth.

Fire

The main factor of accident may be anthropogenic, namely: indifference of personnel and violation of safety norms, violation of storage rules for fuels, oils and other explosive substances and etc. in order to prevent fire eruption, strict supervision over fuel and lubricants storage rules, provision of fire fighting means on the construction site, periodic training of personnel on fire prevention and elimination of its consequences will be required.

Personnel Traumatism and Incidents Related to their Health Safety

Except incidents related to other emergency situations, personnel traumatism may also be related to:

- Incidents related to heavy machinery/equipment used for project implementation;
- Fall from large heights;
- Poisoning with used chemical substances;
- Electric shock, during working near aggregates under high voltage.

General Preventive Measures

Preventive measures for traffic accidents:

- Selection of optimal transport movement routes and speed restrictions;
- Installation of warning, prohibiting and pointing road signs at access roads and construction camps;
- During movement of special and oversized machinery they should be escorted by specially equipped machinery and trained experienced personnel.

Preventive measures for hazardous substance spill:

- Strict supervision over implementation of fuel and chemicals' storage and use terms. Fitness of storage vessel must be checked before storing;
- The technical functionality of oil containing equipment should be periodically monitored;
- Termination of works / suspension of equipment and machinery operation and implementation of maintenance work after detection of minor spill, so that incident would not become large-scale.

Preventive measures for fire/explosion:

- Periodical training and testing of personnel on fire prevention issues;
- Storage of easily flammable and explosive substances at safe places. Installation of corresponding warning signs at their warehouses;
- Implementation of fire safety rules and arrangement of functional fire fighting equipment at the territory;

Preventive measures for personnel traumatism/injury:

- Periodical training and testing of personnel on labour safety issues;
- Provision of personnel with individual protection means;

- Warning signs should be arranged within the dangerous zones;
- Preparation of special staff, which will control implementation of safety norms at construction sites and will register facts of violation

Approximate Scale of Accidents

According to expected emergencies, liquidation resources and legislative requirements, accidents and emergency situations are sorted in 3 groups. Table 1 gives description of emergency situations according to their level, indicating corresponding reaction.

Accidents	Level		
	I level	II level	III level
General	The internal resources are sufficient for emergency liquidation	External resources and workforce are needed for emergency liquidation	Involvement of regional and country resources for emergency liquidation
Damage of other structures	Minor damage of road structures that is temporary, but will not interrupt significantly road operation. The provocation of other emergencies is less expected. Road service personnel will manage to liquidate emergency.	Hydraulic structures damage, which significantly impede the functioning of the traffic and the other risks provoking an emergency situation.	Significant damage to road structures (bank protection structures injury, significant damage to the roads, bridges, tunnels, etc.). There is a high risk of flooding and damage to infrastructure facilities. It is needed to mobilize external resources for rapid elimination of the accident.
Hazardous substance spillage	Local spillage, which does not need external interference and can be eliminated with internal resources. The risks of spreading of the substance on large areas and river contamination do not exist.	Large spills (spills of hazardous substances 0.3 tons to 200 tons). There are risk of substance spreading in the area and the risk of the river pollution.	Large spills (more than 200 tons)
Fire /Explosion	Local fire, which does not need any external interference and is easily controlled. The meteorological conditions are not conductive to the rapid spread of the fire. There are no inflammable and explosive sections/ warehouses and materials.	Large fires, which spread quickly due to the weather conditions. There are inflammable/explosive areas/ warehouses and materials. It is necessary to call the local fire squad.	A large fire, which spread rapidly. The ignition risk of surrounding neighbourhoods and provocation of other emergencies is high. The approach to the territory is complicated. The inclusion of the regional fire service for the liquidation of the incident is necessary.
Road accidents	The damage of equipment, vehicles, infrastructure and non-valuable items takes place. Human health is not in danger.	The damage of the equipment, vehicles, infrastructure and valuable objects takes place. There is the threat to human health or II level traumatism is registered.	The damage of the equipment, vehicles, infrastructure and valuable objects takes place. There is the high risk of development of other emergencies. There is the threat to human health or III level traumatism is registered.
Personnel injury / Traumatism	• One incident of traumatism; • Light fracture, bruises; • I degree burns (skin surface layer damage); • Assistance to injured personnel and the liquidation of the incident is possible by local medical service.	• Individual cases of accidents; • Severe fracture - a fracture of the joints of the middle; • II degree burns (deep layer of the skin lesions);	• Several traumatic accidents; • Severe fracture - Articular fracture etc.; • III and IV degree burns (skin, hypodermic tissues and muscle lesions); • There is the need to move injured personnel to the regional or Tbilisi medical service centres with relevant profile.

		• There is the need to move injured personnel to the local medical facility.	

Note: Considering the scale of the project, its duration and specificity of location, the anticipated emergency situations will be mainly of I levels and less likely of II level, except hydraulic structures damage.

Emergency Response

Response During Traffic Accidents

During the accident of road transport, it is necessary to implement the following strategic actions:

- To stop vehicles/equipment;
- Transmission of information in accordance with the emergency report scheme;
- In case if there is no danger for human health and there are no risks of provoking other emergency situations (for example: collision of other vehicles, explosion, fire, oil spill, hydrodynamic accident or others), then:
  - Get out of the vehicle/equipment or get away from the accident place and stand on a safe distance;
  - Wait for the police/rescue team to come.
- In case of further threats, act as follows:
  - Get out of the vehicle/equipment or get away from the accident place and stand on a safe distance;
  - If the vehicle accident has occurred on the dangerous section of the road of public use (for example: in the turning, there visual field on the road is limited), then ask to the accident witness to stop the cars moving in direction of an accident location;
  - If you are alone on the accident place, place the warning signs or sharp colour safe signs on the road away from the place of an accident, so that those signs will be visible for the drivers moving in direction of an accident place and will ensure the car stop;
  - In case of explosion, fire, oil spill, hydraulic accident and others, ac in accordance with the strategy given in the relevant paragraphs;
  - In case if there is a threat on the health of a person, do not try to move the body;
  - If the injured person is lying in the middle of the street, cover him with something and confine the accident location, so that it will be seen from a distance;
  - Remove everything from him, which might be making asphyxia (belt, scarf);
  - First aid to the injured in accordance with the first aid strategy given in the relevant paragraphs (but remember, by extra movement of the injured person, you might create additional risks to his health).

Response to Hazardous Material Spill

This section discusses only I scale emergency response strategy. The types of hazardous substances spill response are significantly determined by ground surface, also, the initial condition.
In case of hazardous substances spill on the pervious surface, it is necessary to implement the following strategic actions:

- Information transfer according to the other personnel and emergency service;
- Stopping every device-equipment working on the site;
- Ask personnel to mobilize equipment and personal protection means for emergency response;
- Block the entrances of household-fecal sewage systems (lids of wells);
- Absorbents should be placed together in such way to create continuous barrier (fence) in front of the edge of moving oil products. Ends of the barrier must be folded in front, so that it will have a shape of a horseshoe;
- Spilled oil products containment place must be covered with polyethylene membrane sheets, in order to prevent the oil occurrence in the lower layers of soil;
- It should be noted, that if it is not available to lay down the polyethylene sheets, then the barrier arrangement will cause the oil accumulation on one place, which in turn will cause soil saturation with oil and oil products occurrence in the lower layers;

- For drying in the spilled substances, absorbent pads usage is necessary;
- Gather the oil products in such way, that it will be possible to collect them in container and then remove;
- After absorption of the oil, these pads should be placed in polyethylene bags (if needed, these pads might be reused);
- The site should be completely cleaned from residual oil products, in order to exclude the wash-off of the pollutants by the rain water;
- After completion of cleaning operations, every cleaning material must be collected, wrapped and warehoused in relevantly safe areas.
- Processing of vegetation and upper layer of the soil on existing on the ground surface must begin right after removal of the pollution source or after stopping the leakage;
- When the whole spilled oil products will be cleaned, removal and remediation works implementation must start under supervision of construction works manager/head of the facility and invited specialists with a relevant competence.

Response During Fire

The strategic actions of the person and the personnel working in the vicinity, who detected fire or smoke, are as follows:

- Termination of works on every site, except for safety measures;
- Assessment of the situation, reconnaissance of fire hearth and adjacent territories;
- Withdrawal of the equipment-devices from the areas, where the fire spreading is possible;
- Electrical equipment should be turned out from the circuit;
- In case if fire is strong and it is hard to approach the fire hearth, some kind of fire or explosive hazardous sites/substances are located adjacently, then:
  - Get away from the danger zone:
  - Inform senior manager/operator about the accident;
  - Wait for rescue team and when they appear, inform them about the fire reasons and the situation in the vicinity of fire hearth;
- In case if the fire is not strong, the fire hearth is easily approachable and getting near to it is not dangerous for your health. At the same time, there are certain risks of fire distribution on adjacent territories, then, act as follows:
  - Inform senior manager/operator about the accident;
  - Search for the nearest fire stand and supply yourself with necessary fire inventory (fire extinguisher, axe, crowbar, bucket and etc.);
  - Try to liquidate fire hearth with fire extinguisher, in accordance with the instruction shown on the fire extinguisher;
  - In case if there is no fire stand on the site, use sand or water for fire hearth liquidation or cover it with less flammable thick cloth;
  - In case if the electrical equipment turned into the circuit are near the fire hearth, it is prohibited to use water;
  - In case of fire in the closed space, do not window the room (except for special needs), because the fresh air supports fire and fire scale growth.

Strategic actions of site manager/chief operator in case of fire:

- Gathering detailed information on fire hearth location, existing/stored devices-equipment in the vicinity and substances;
- Information transfer in accordance with the notification scheme;
- Visiting the accident place and reconnaissance of the situation, risks analysis and assessment of expected fire scales (I, II or III scale);

- Ask whole personnel to use vehicles and fire extinguishing equipment;
- Controlling and managing the personnel actions.

Response during Accidents Related to Human Injuries and Incidents Related to Their Health and Safety

The person, who is taking care of injured person, must notify ambulance about an accident as a first action. Before the rescue will appear, injured person must receive first aid service in accordance with the tactics given below in following chapters. Before carrying out medical service, it is necessary to assess the situation and determine if approaching and helping an injured person might create some threat.

First Aid during the bone fracture

Open and closed bone fractures are being distinguished:

- For the open fracture is characterized the violence of skin cover integrity. In this case, there is wound and bleeding in the damaged area. There is a high risk of infection in case of open fracture. In case of open fracture:
  - Promptly call helper, so that helper will immobilize the damaged area of the injured person, while you will process the wound;
  - Cover the wound with clean cloth and directly press on it to stop the bleeding. Do not press directly on broken bone fragments;
  - Without touching the wound with fingers, surround the damaged area with a clean cloth and fit ix;
  - If the broken bone fragment is seen in the wound, place the soft cloth around the bone fragment in such way, that the cloth will not be removed and the bandage would not impact on bone fragments. Fix the bandage I such way, that it will not disrupt the blood circulation below the wrapped place;
  - Carry out a broken bone immobilization, in the same way as during covered fracture;
  - Check pulse, capillary filling and sensitivity below the wrapped place once in every 10 minutes.
- We are dealing with a closed fracture, if the ski integrity is not damaged in the injured area. In this case, haemorrhage and edema are observed in the injured area. In case of closed fracture:
  - Ask injured person to stay still and fix the damaged part of the fracture above and below it by hand, before it will be immobilized (fixed);
  - For a good fixation, fix the injured part of the body on uninjured part. If the fracture is on the hand, fix it on the body with triangle bandage. If the fracture is on the leg, fix the damaged leg on another leg;

Check pulse, sensitivity and capillary filling below the wrapped place once in every 10 minutes. If the blood circulation or sensitivity is reduced, make a less tight bandage.

First Aid During Wounds and Bleeding

There are three types of bleeding:

- There is a little blood. In this case is risk of infection:
  - Clean the wound of injured person with any colourless liquid suitable for drinking;
  - Wrap the wound with clean cloth.
- There is a lot of blood. In this case there is a risk of blood loss:
  - Cover the wound with several layers of cloth and make press bandage;

- If the blood is still leaking, tight the cloth to the wound again (do not take of the blood-drenched cloth) and strongly press on blood source area.

- The blood is pouring like a fountain from the wound. In this case the blood loss is very fast. In this case you must push finger (or fingers) on the artery projection area to avoid this and then put a bandage.

The areas of load on the artery are: the lower third of an arm and upper third of the thigh. The bandage should be fixed like this:

- The bandage is fixed only in extreme case, because often it leads to irreversible damage;
- The bandage is fixed above wound;
- The location where the bandage will be fixed must be covered with cloths. If the wound area is bare, we should place clean cloth under the bandage;
- First bandage must be tight (fixed as possible), then the bandage is getting tight and in addition placed 3-4 times (rope, belt and etc. can be used instead of bandage);
- The bandage should be fixed for 1 hour in the winter and for 2 hours in summer. Then we should release and after 5-10 minutes fix it slightly above from the original location;
- Check if the bandage is properly fixed – if it is properly fixed, there should be no pulse on limb;
- What we should not do;
- Do not put a hand in the wound;
- Do not take anything from the wound. If some foreign body is seen in the wound, we should try to maximally fix it (put a bandage around this body).

- Internal bleeding is hardly determinable damage. Suspect internal bleeding, when the shock signs are observed after getting injured, but there is no significant blood loss. In case of internal bleeding:
  - Lay injured person on his back and rise his legs up;
  - Remind tight clothes on neck, chest, waist;
  - Do not give food, medicine or drinks to injured person. If injured person is conscious and is very thirsty, just wet his lips;
  - Warm injured person – cover with blanket or cloth;
  - Check the pulse in every 10 minutes, as well as breathing and consciousness. If the person is losing mind, place him in safe location.

First Aid in Case of Burn

The burn might be developed by hot objects and steam impact (thermal burn), by chemical substances impact on the skin (chemical burn), electricity impact (electrical burn). In order to properly carry out first aid, you must determine the degree of burn, which depends on damage depth and damage area (on what part is the burn distributed).

- The first aid measures during the burn are:

  - It is dangerous to breath in the smoke, so if there is a smoke in the room and it is not available to window fast, remove the injured person on a safe place, on a fresh air;

  - If the clothes are burning on the person, do not start to roll his body, pour the water on the body (in case of electrical burning, usage of water next to the equipment in the circuit, is prohibited);

  - If there is no possibility to use water, cover the body with non-synthetic cloth;

  - It is necessary to start cooling the burnt area in time with cold water (in case of I and II scale burn, water it for 10-15 minutes, in case of III and IV scale burn wrap it with clean wet cloth and then cool it in the water in such wrapped conditions);

- Remove the cloth and other objects, from the damaged area, which may interrupt blood flow. Do not remove cloth pieces, which are stick to the damaged area;
- Cover the damaged area with sterile wrapping. This would reduce the likelihood of infection;
- Breathing in a hot air is possible when burnt, which leads to the burning of respiratory tracts. If the victim has hard noisy breathing, facial or neck burn, singed hair cover of face and nose, swelled mouth and lips, swallowing difficulty, cough, hoarseness voice – suspect the respiratory tracts burn and wait for the medical service;
- Constantly check breathing and pulse before the medical service will come, be ready to carry out reanimation measures;
- It is not allowed to take off the clothes particles from the burnt skin, cause this may lead to the deepening of the damage;
- It is not allowed to destroy the integrity of blebs, because the skin cover is damaged and it makes a favourable conditions for the invasion of infection in the body;
- Do not use ointments, lotions or oils for processing the damaged parts;
- It is prohibited to process the chemical burn areas with neutralizing solutions/ For example, alkaline caused burn treatment with acid.

First Aid in Case of Electrical Trauma

There are three types of electrical trauma:

- The trauma caused by high-voltage electricity. The damage developed as a result of high voltage traumas, are fatal in most cases. Severe burns are being developed at this time. Due to the strong muscle compression the injured person is often threw away on a significant distance, which leads to serious injuries. In case of high-voltage power trauma:
  - It is prohibited to get close to the injured person, before the electricity will be turned off and if necessary, the isolation will be made. Remain 18 m radius safe distance. Do not let other witnesses to approach the injured person;
  - After receiving electric trauma, as soon as approaching the injured person, open the breathing ways without moving head back, by moving the lower jaw in front;
  - Check breathing and circulation signs. Be prepared to make reanimation measures;
  - If the injured person is unconscious but is breathing, place him in a safe location;
  - Carry out first aid in case of burns and other injuries.
- The electrical trauma caused by low-voltage electricity. Low-voltage electricity trauma may turn into serious damages and even death reason. Often, this kind of electrical trauma is caused by damaged plugs, wiring and equipment. When standing on a wet floor or touching undamaged electrical wiring with wet hands, the risks of getting the electrical trauma are sharply increasing. In case of low-voltage power caused trauma:
  - Do not touch the injured person, if he is touching the power source;
  - Do not use metal object for removing the power source;
  - If you are able, stop power supply (turn off the power switch). If it is not available, turn off the electrical equipment from the power source;
  - If you are not able to switch off the electricity, then stand on dry insulation thing (for example: a plank of wood, on rubber or plastic pad, on book or pile of newspapers);

- Remove the victim's body from the power source by broom, stick, and chair. You can move the victim's body away from the power source, or vice versa, the power source away from the body, if it is more convenient;
- Without touching the body of injured person, tie a rope around his foot and shoulders and move away from the power source;
- At least, grab the injured person in dry not-tight cloth and move him away from the power source;
- If the victim is unconscious, open the airways, check the breathing and pulse;
- If the victim is unconscious, is breathing and has a pulse, place in a safe location. Cool the burned areas and wrap it;
- If the visible injuries are not seen on the victim and feels good, advice to take a rest.

- The electrical trauma caused by lightning/thunder:
  - Various traumas, burns, face and eyes damage is often by the electrical trauma. Sometimes the lightning may cause a sudden death.

Quickly move damaged person form the place of the accident and serve with first aid as in case of different type of the electrical trauma.

Equipment Necessary for Emergency Response

Personal protection means are:

- Helmets;
- Safety glasses;
- Uniforms with reflective stripes;
- Waterproof boots;
- Gloves.

Fire extinguishing equipment:

- Standard fire extinguisher: on every site, as well as on every special machines and equipment;
- Buckets, sand, shovels and etc.;
- Properly equipped fire stands;
- Fire truck – the nearest fire fighters team truck will be used.

Emergency medical service equipment:

- Standard medical boxes: Standard medical boxes for vehicles: on every project vehicle and equipment;
- Ambulance car

Spill response equipment:

- Heavy duty plastic bags;
- Absorbent pads;
- Gloves;
- Drip trays;
- Buckets;
- Polyethylene film.

Necessary Qualification and Personnel Training

Testing of each system of emergency response must be periodically implemented, obtained experience must be documented and weak spots should be improved (the same should take place in case of accident realization).

The whole staff, employed on treatment facility construction and operation, must undergo introductory training, which includes emergency response course. Personnel additional training registration system should exist and be kept at offices of customer or contractors.

Annex 8: Questionnaire for socio-economic study

Family member interviewed
Date --
Checklist #
Name of the respondent
Date - - -
Signature
Name of the Head of Household

1. Household Characteristics

Name, Surname	Gender	Age	Ethnic Group	Religion	Education				
					Incomplete Secondary)	Completed Secondary	Professional /Technical	High School	Illiterate
Head of Household (HoH)									
Other Members of Family (with notes on relationship with the HoH)									

2. Residence area

Residence area	
Urban	Rural

3. Social Status (Vulnerability)

Any Social Allowances from the Government	Lower than poverty line 57000 scores	Medical Policy Lower than 70000 scores	Other social allowances

4. Women headed household (without breadwinner male)

Yes	No

5. Income Sources

Major Income	Agriculture	Permanent salary in the public service	Permanent salary in the private company	income from Own business	Periodic wages (workings)	Pension
Additional Income						

6. Credit and its structure (Yes/No and bank or individual credit)

Bank	Private Person	No

7. Real estate of the affected households[4]

Property	Category	Characteristics
Land	Agricultural/residential/commercial	area
Land plot 1		
Land plot 2		

8. Movable Property (number)

Radio	TV	Refrigerator	Washing Machine	Car	Motorbike	Bicycle	Gas stove	Heating devices	Conditioner

9. Livestock (How many)

Cattle	Pig	Sheep	Horse/donkey	Poultry

10. Current and basic expenses of the family (GEL per a year)

[4]This table is related to all assets of AHs but not only affected assets

For food	Not food	Totally

11. Availability of infrastructure and communal services (Yes/No)

Centralized water supply	Well	Spring	Centralized sewage	Septic tank in the yard	Electric power supply	Natural gas	Gas balloons	Liquefied fuel	fire wood

12. Medical Services and Education (Yes/No)

Local Policlinics	Local Hospitals	Municipal Hospitals	Kindergarten	Secondary School	High School	Local Road	Central roads

Annex 9. Engineering geological mapping of the project area

Engineering geological mapping of the Left Branch. The mapping on this area is based on theinformation recorded during the alignment walk over survey carried out in May 2017.

LEFT BRANCH

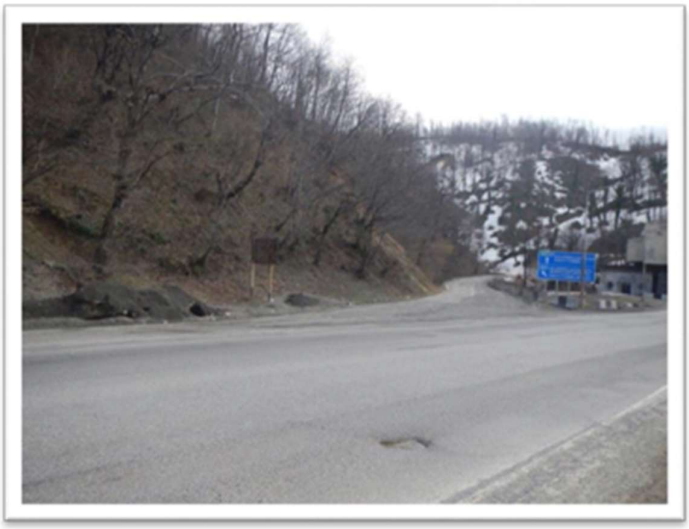
No. Point/ GPS	Location	Strata position / Age.	Description of the investigation point
	Km 7+400 - Km 8+500		From Km 7+400 the Left Branch is parallel and near the right branch till the end of the project Km 8+500 (from feasibility study). From here till the end are no more outcrops.
	Km 7+140 - Km 7+280		The motorway is in a cutting on the left part. Above the cutting are seen features of a fossil (old) landslide which will might be activated (triggered) by the execution the cutting. Also some houses are above the motorway.  The motorway is crossed by several gullies at Km 6+900, Km , with non-permanent flow. Wooded slope, from place to place rock appears. (DSCN0334)

01	Km 7+080 - Km 6+600		

RIGHT BRANCH

Engineering geological mapping of the Right Branch. The mapping on this area is based on the information recorded during the alignment walk over survey carried out in May 2017.

No. Point/ GPS	Location	Strata position / Age.	Description of the investigation point
01	Km 0+000 - Km 0+120	Middle Paleozoic	**Exiting Rikoti Tunnel. Beginning of the project Right Branch** During the geological engineering mapping we encounter areas with snow, more on the left side and less on the right side of the Rikotula river.  The Rikotula River flows adjacent to the left side of the

			existing E60. The river flows downhill from Rikoti tunnel towards Khevi. The flow of the river was very high due to the melting of snow from the slopes during this period. Also on the left between km 0+020 - 0+060 is the platform of the E60 road maintenance unit. The platform is located on the former disposal area that was created from the excavations of the Rikoti tunnel. On the right side of the existing road E60 at Km 0+080 is the junction with the Rikoti Tunnel bypass road. Km 0+080 - 0+120 on the right side of the E60 road is located on the forested side. Although some trees are inclined, there are no signs of creep or slippage. 
02/239	Km 0+120 - Km 0+160	Middle Paleozoic Outcrop 006	On the right side of the E60 road there is a succession of debris (erosion - gruss) and highly altered rocks made of Quartz-dioritic gneisses on the outcrops

			
03	Km 0+160 - Km 0+220	Middle Paleozoic	On the right side of the E60 road is the wooded slope. There are no signs of creep or slippage. On the left side of the E60 there is the Rikotula river that has the same flowing direction as the existing road. The flow of the river is very high due to the melting of snow from the slopes during this period.
04/240	Km 0+220	Valley 001	On the right side of the road E60 a gulley with steep banks with heights of 4.0 – 6.0m and width of 0.5m at the bottom and 4m at the upper part is observed and the water is discharged into the existing ditch. Above the thalweg on both banks there is a succession of sands resulting from the erosion of the rock (gruss) 

05	Km 0+220 - Km 0+360	Middle Paleozoic Outcrop 008	On the right side of the E60 road, Quartz-dioritic gneisses are at the surface on the outcrops. Rocks are moderately weathered with strength from strong to weak. At the base of the slope are deposits of erosion debris in the form of cone debris. 
06	Km 0+380	Valley 002	On the right side of the Rikoti River confluent with brook with permanent stream which crosses the E60 road through a culvert. The brook crosses a large valley with forest. On the right bank of the valley above thalwag erosion debris is observed. From place to place fresh rock appears.
07			The right-hand side of the E60 roadside is forest. From place to place on the upper side of the slope, there are outcrops made from diluvium material. At km 0+420 and km 0+440 - 0+460, superficial slip surface of top soil and shallow diluvium at the upper part of the slope. The distance is 7.00 - 8.0m to the road shoulder, which will not be affected by these slip surface.

			 On the left side of the E60 there is the Rikotula river that has the same direction of flow as the existing road. The flow is very high in this period. 
08/241	Km 0+500 - Km 0+560	Middle Paleozoic Outcrop 009	On the right side of the road E60 outcrops appear consist in Quartz-dioritic gneisses with Quart injections, weathered and brittle. At the base of the slope are observed rock fragments.

			
09	Km 0+560	Torrent(Gully) 001	Dry gully. During the rainy periods or during the snow melting season some small natural dams can be formed with (branches, roots, rock fragments, etc.) which may lead to high water flood.
10	Km 0+560 - Km 0+620	Middle Paleozoic	Slope with trees with areas from place to place where the Quartz-dioritic gneisses rock appears at the surface; in some areas Pink granites injections are observed. This rock is highly weathered to weathered. The strata are perpendicular to the direction of the road, which will not affect the road, except with the accumulation of rock fragments (scree) at the base of the slope. 
11	Km 0+620	Torrent 002	Moist gully. During the rainy periods or during the snow melting season some small natural dams can be formed with (branches, roots, rock fragments, etc.) which may

			lead to high water flood. 
12/242-243	Km 0+620 - Km 0+660	Middle Paleozoic Outcrop 010	On this area on the right side you can see rocks made of Quartz-dioritic gneisses and inclusions of Pink granites. This is due to the fact that the road is a few hundred meters from the geological boundary and a major fault that can be seen on geological maps. At the base of the outcrop there are accumulations of fragments of rocks separated from the slope. 
13/253	Km 0+660 - km 0+710	Middle Paleozoic Outcrop 011	Rocks Quartz-dioritic gneisses massive compact moderately weathered to highly weathered are observed. Also fragments and rock blocks at the base of the slope are observed. In the rainy days, material is drawn on the slope and it produces debris which is lain down on the base of the slope, like an alluvial cone. The phenomenon may also be due to the presence of a major fault in the

			vicinity of the area. 
14	Km 0+710	Valley 003	On the right side of the river Rikoti is a confluence with a non-permanent small stream which is crossing the E60 road through a tubular bridge Ø = 2.0m. The stream crosses a narrow wooded valley. Over time, it is possible to create floods that can affect the safety of the future highway (Right Branch). 
15	Km 0+710 - Km 0+880	Middle Paleozoic Outcrop 012	Similar with point 13/253 - Rocks Quartz-dioritic gneisses massive compact moderately weathered to highly weathered are observed. Also fragments and rock blocks at the base of the slope are observed. In the rainy days, material is drawn on the slope and it produces debris which is lain down on the base of the slope, like an alluvial cone. The phenomenon may also be due to the

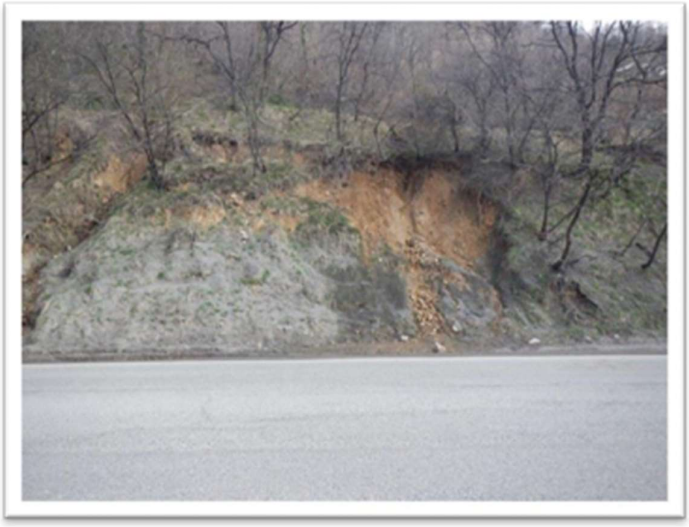
			presence of a major fault in the vicinity of the area. 
16/255	Km 0+880	Torrent 003	Gully with running water. In rainy or winter weather the materials (branches, roots trees, blocks of rock, etc.) can create temporary dams that lead to the production of large floods. 
17/256	Km 0+880 - Km 0+960	Middle Paleozoic Outcrop 013	Quartz-dioritic gneisses rocks, massive, compact, completely weathered. Diluvium is sliding at base of the slope. The rocks are very tectonized, friable due to a major fault in that area.

			
18	Km 0+960	Valley 004	On the right side of the Rikoti River confluence with a non-permanent flow of water crossing the E60 road through a tubular ridge Ø = 1.0m. The stream crosses a narrow valley with forests on both sides. The culvert can clog easily and in time water can cross over the Right Branch and can affect the safety of the future highway. 
18	Km 0+960	Valley 004	On the left side of the Right Branch (on the right bank of the Rikoti River) there is an existing support wall of concrete embedded in the slope of the rocky riverbed.

			
19	Km 0+960 - Km 1+200	Middle Paleozoic Outcrop 014	Quartz-dioritic gneisses rocks, massive, compact, moderately weathered to highly weathered. Diluvium is slipping to the base of the slope. 
19	Km 0+960 - Km 1+200	Middle Paleozoic Outcrop 014	At km 1 + 050 a sequence of Quartz-diorite gneisses rocks and Pink granites (geological limit?) with deposition of diluvium at the base of the slope

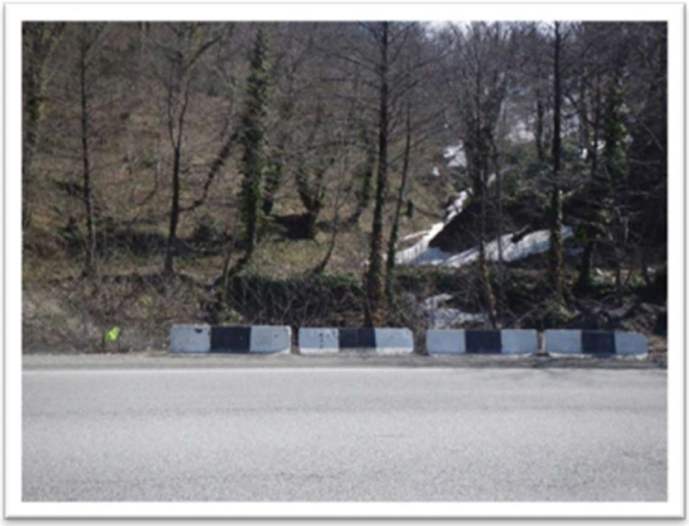
			 At km 1 + 070 on the existing E60 road, a forest road descends. Where initial there was a small area affected by a sliding but after the rain on the night of 07.04.2017 to 08.04.2017 there was larger slope failure at the upper part; the landslide blocked the local road. Before rain 

			 After rain/snow At km 1 + 100 on the left side of the Right Branch, a concrete support wall, with a length of over 20m and a height of 3.0m, embedded in the rock 

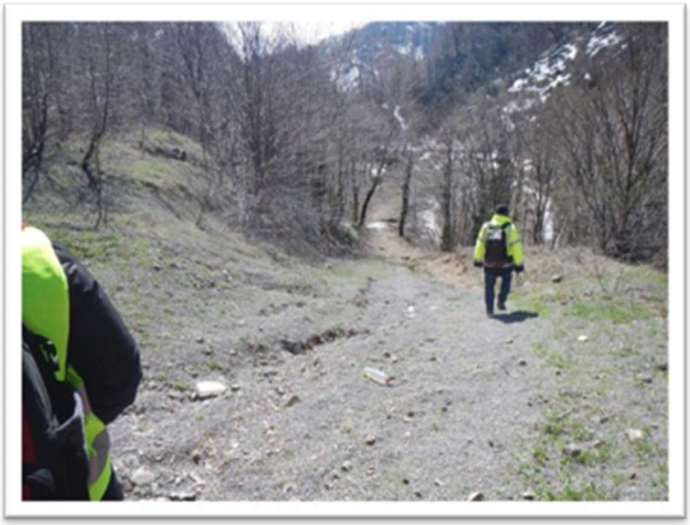
19	Km 0+960 - Km 1+200		 At km 1 + 150 there is a slope failure, which can affect the trees and slip with trees altogeth
20/258	Km 1+200 - Km 1+290	Middle Paleozoic Outcrop 015	t km 1 + 210 on the left side of the existing road E60 is a relatively good gabion wall. In this area the rocks are fresh, partially altered. There are no signs of slope instability. 

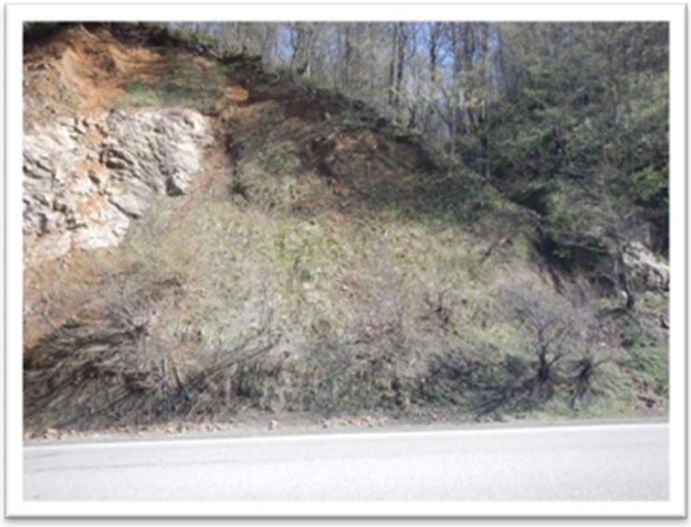
			
21	Km 1+290	Torrent 004	Dry gully. During the rainy periods or during the snow melting season some small natural dams can be formed with (branches, roots, rock fragments, etc.) which may lead to high water flood. 
22	Km 1+290 - Km 1+340	Middle Paleozoic	In this area the rocks are fresh, partially altered. There are no signs of slope instability.
23/259	Km 1+340 - Km 1+410	Middle Paleozoic Outcrop 016	Quartz-dioritic gneisses in alternance with pink granites. Healthy massive rocks, with large blocks from decimeter to metric which fails in a form of wedge. At the base of the slope there are fragments of rock.

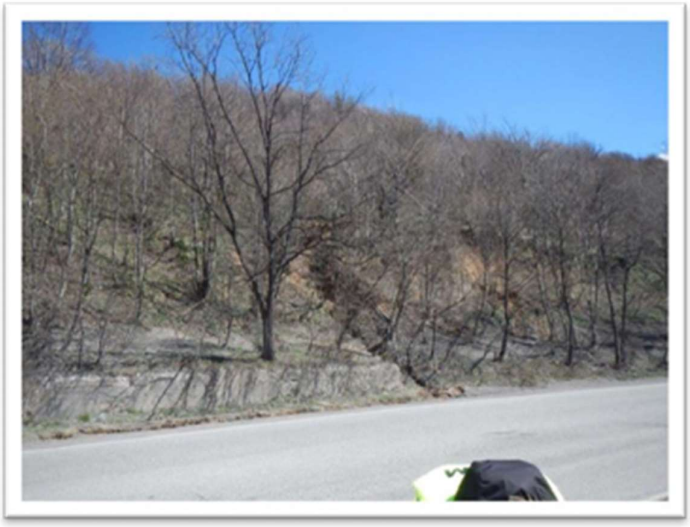
24	Km 1+410	Torrent 005	Dry gully. During the rainy periods or during the snow melting season some small natural dams can be formed with (branches, roots, rock fragments, etc.) which may lead to high water flood. 
25	Km 1+410 - Km 1+510	Middle Paleozoic	Quartz-dioritic gneisses in alternance with pink granites. Healthy massive rocks, with large blocks from decimeter to metric which fails in a form of wedge.  On the left side of the road there is a concrete retaining wall with a height of about xx.0m???.

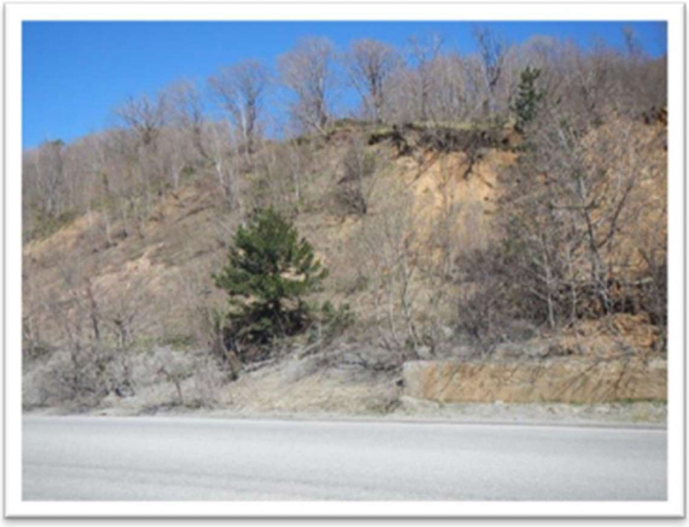
			
26	Km 1+510	Valley 005	On the right side of the Rikoti River confluence with a non-permanent flow of water crossing the E60 road through a tubular ridge Ø = 1.0m. The stream crosses a narrow valley with forests on both sides. In time floodings may appear which may affect the safety of the motorway (Right Branch). 
27	Km 1+510 - Km 1+920	Middle Paleozoic	Quartz-dioritic gneisses are observed. On the right slope wooded area. No signs of instability. At km 1 + 660 access the road to the restaurant and on the right side of the restaurant starts a forest road.

			 
27	Km 1+510 - Km 1+920	Middle Paleozoic	On the right side of the existing road E60 is a forest road which continues over the Rikoti river to the left side. Here is no bridge so the crossing is going through the river.

			
28	Km 1+840	Torrent 007	Gully with running water. In rainy or winter weather the materleftials (branches, roots trees, blocks of rock, etc.) can create temporary dams that lead to the production of large floods. 
29	Km 1+910	Torrent 008	Gully with running water. In rainy or winter weather the materials (branches, roots trees, blocks of rock, etc.) can create temporary dams that lead to the production of large floods.

			
30	Km 1+920	Middle Paleozoic Outcrop 017	Geological limit between Quartz-dioritic gneisses and Quartz-porphyrites. 
31	Km 1+920 - Km 2+120	Quartz-porphyries. Wooded slope.	
32	Km 2+010	Valley 006	On the right side of the Rikoti River is a confluence with a non-permanent flow of water crossing the E60 road through a tubular culvert Ø = 1.0m. At the time when the geological mapping was done running water was present

33	Km 2+120	Torrent 009	Gully with running water. In rainy or winter weather the materials (branches, roots trees, blocks of rock, etc.) can create temporary dams that lead to the production of large floods 
34	Km 2+120 - Km 2+200	Middle Paleozoic	Geological limit between Quartz-porphyries and pink granites. On the right side of the road concrete retaining wall, degraded and clogged, with a height of 1.0m. 
34	Km 2+120 - Km 2+200	Middle Paleozoic	Sliding of the diluvium material at Km 2+200.

			
35	Km 2+200 Km 2+260	Middle Paleozoic	Pink granites. Versant covered with diluvium material, with outcrop where the rock appears from place to place. 
36	Km 2+260	Valley 007	On the right side of the Rikoti River is a confluence with a stream with water crossing the E60 road through a tubular culvert D = 2.0m. Wooded valley with steep slopes. In rainy season flooding may occurs.

			
37/262	Km 2+260 - Km 2+520	Middle Paleozoic Paleozoic Outcrop 018	Geological Limit Until Km 2+500 pink granites are observed. Between Km 2+420 – 2+520 at the base of the slope new retaining wall is. After the geological limit gabbro rocks appear. The rocks are very fractured and tectonized, with rock block detachments on the versant of the slope. From km 2 + 480 rocks become massive, compact and fresh. 

37/262	Km 2+260 - Km 2+520	Middle Paleozoic Paleozoic Outcrop 018	 
38/263	Km 2+520 - Km 2+700	Paleozoic Outcrop 019	Gabbro, massive, compact, with a gap between discontinuities > 0.80m. At the contact of two wedge failures the rock blocks can detach.

			
39	Km 2+700 - Km 2+810	Middle Paleozoic Paleozoic Outcrop 020	Gabbro with pink granite inclusions. Outcrop with fresh rock and also areas with slipping diluvium at the base of the crop. 
40	Km 2+820	Torrent 010	Gully with running water. In rainy or winter weather the materials (branches, roots trees, blocks of rock, etc.) can create temporary dams that lead to the production of large floods.

			
41	Km 2+820 - Km 2+980	Paleozoic Outcrops 021 – 22	Gabbro, fissured and fresh rocks, fractured at the upper part. No signs of instability. There are some fragments of rocks at the base of the outcrop. 
42	Km 2+980	Valley 008	On the right side of the Rikoti River is a confluence with a stream with water crossing the E60 road through a tubular culvert D = 2.0m. Wooded valley with steep slopes. In rainy season flooding may occurs.

			
43	Km 2+980 - Km 4+380	Paleozoic	Gabbro rocks are observed. On the right side the area is covered with vegetation and shrubs. On the left, the river Rikoti flows in the same direction as the road. At km 3 + 680 on the left side of existing road E60 existing retaining wall with a length of 50.0m. At km 3 + 3 + 820 on the left side of the existing road E60 existing retaining wall with a length of 50.0m.
44	Km 4+380	Valley 009	On the right side of the Rikoti River is a confluence with a stream with water crossing the E60 road through a tubular culvert D = 2.0m. Wooded valley with steep slopes. In rainy season flooding may occurs. 

45/266	Km 4+380 - Km 4+520	Middle Paleozoic Paleozoic Outcrop 023	Geological Limit. Gabbro with pink granites inclusions at the top. At km 4+480 on the right side the old road E60 descended. At km 4 + 500 at the upper part of the outcrop is probably a gully. It is also noted that pink granites are overlaying the gabbro rocks.  
46/267	Km 4+520 - Km 4+640	Middle Paleozoic Outcrop 024	Pink granites rocks. In the riverbed there is gabbro over which there are pink granites. At km 4 + 500 on the left side of the E60 road there is an existing wall where the foundation is under water and scouring phenomena occurs. At km 4 + 570, the existing E60 road crosses the Rikoti

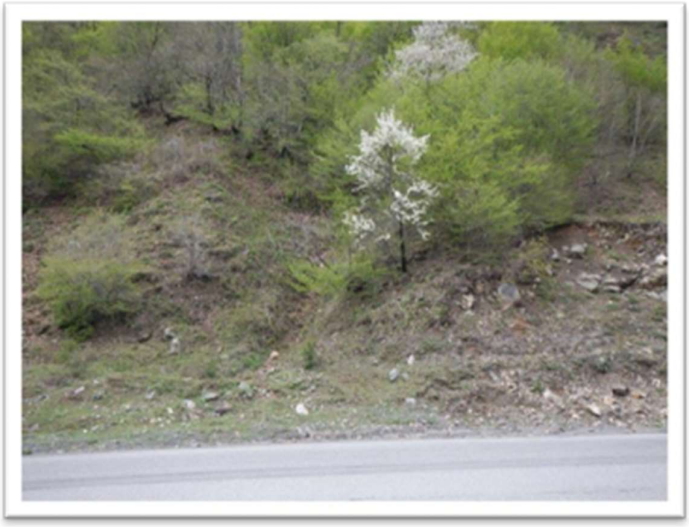
			River with a bridge. At km 4 + 580 on the left side of the existing road E60 existing retaining wall.  
47/269-270	Km 4+640 - Km 4+800	Middle Paleozoic Outcrop 025	Geological limit between pink granites and Quartz-dioritic gneisses Km 4 + 640 to km 4 + 760 to the left side of the existing road E60 the retaining wall continues. Existing E60 road crosses the Rikoti River with a bridge at km 4 + 780.

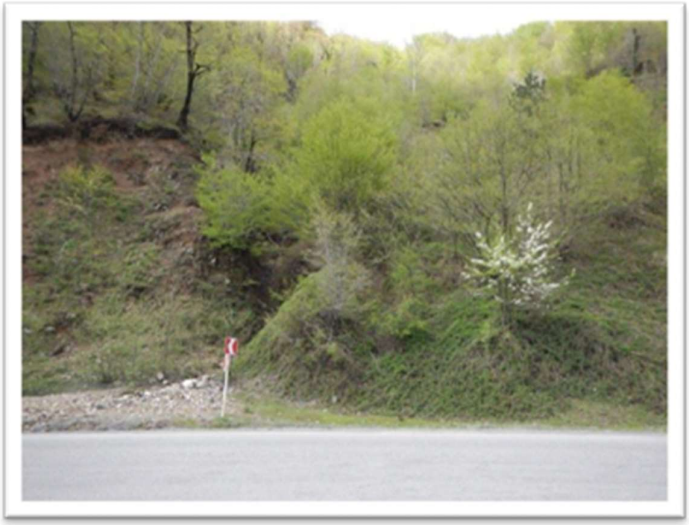
			
49/271	Km 4+800 - Km 5+160	Middle Paleozoic Outcrop 026	Quartz-dioritic gneisses rock is massive, compact and fresh (healthy) Km 4+800 – km 4+860  

			At km 4 + 780, km 4+940 and km 5+100 the existing E60 road crosses the Rikoti River with a bridge.  From km 4 + 880 erosions occur on the slopes. At the base of the outcrop, are rock blocks detached from the slopes. 
50	5+160	Torrent 011	At the upper part of the versant is a torrent, dry. In rainy or winter weather the materials (branches, roots trees, blocks of rock, etc.) can create temporary dams that lead to the production of large floods.
51/274	Km 5+160 -	Middle	Quartz-dioritic gneisses rocks

	Km 5+320	Paleozoic Outcrop 027	The right slope is covered with vegetation and shrubs at the top. No areas of instability have been observed, but detachment from the slope is possible. At the base of the slope there is a slight detachment of rock fragments. On the left side of the existing E60 wall there is a retaining wall with the scoured foundation underneath the Rikoti River.  
52	Km 5+320	Torrent 011	Gully with running water. In rainy or winter weather the materials (branches, roots trees, blocks of rock, etc.) can create temporary dams that lead to the production of large floods.

			
53	Km 5+320 - Km 5+460	Middle Paleozoic	Quartz-dioritic gneisses The right versant is covered with vegetation and shrubs at the top. There were no areas of instability, but are possible detachments from the slope. 
54	Km 5+460	Torrent 011	Gully with running water. In rainy or winter weather the materials (branches, roots trees, blocks of rock, etc.) can create temporary dams that lead to the production of large floods.

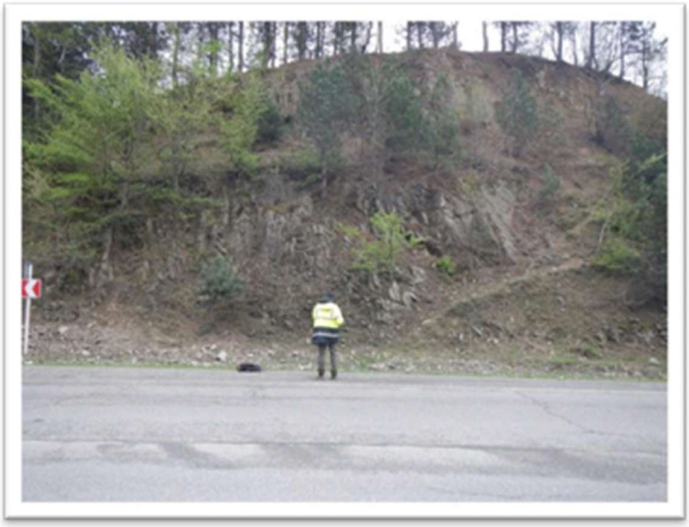
			
55	Km 5+460 - Km 5+580	Middle Paleozoic	Quartz-dioritic gneisses. The right versant is covered with vegetation and shrubs at the top. There were no areas of instability, but are possible detachments from the slope. At km 5 + 480 on the left side of the existing road E60 is an existing retaining wall. 
56	Km 5+580	Valley 010	Narrow valley with steep wooded banks. During rainy periods, floods can occur.

			
57	Km 5+580 - Km 5+680	Middle Paleozoic	Quartz-diorite gneisses. Right slope covered with vegetation and shrubs. No areas of instability were observed
58	Km 5+680 - Km 5+820	Middle Paleozoic Outcrop 028	Geological limit between Quartz-dioritic gneisses and pink granites. Versant covered with vegetation and shrubs at the top, with some slips of the diluvium at the slopes. At the base of the outcrop there are centimeter fragments of the rock detached from the slope. 

			
59	Km 5+820	Torrent 012	Gully with running water. In rainy or winter weather the materials (branches, roots trees, blocks of rock, etc.) can create temporary dams that lead to the production of large floods. 
60	Km 5+820 - Km 5+950	Middle Paleozoic	Pink granites rocks Versant covered with vegetation and shrubs at the top, with some slips of the diluvium at the slopes. At the base of the outcrop there are centimeter fragments of the rock detached from the slope.

61	Km 5+950	Torrent 013	Torrent; the water coming from the torrent is going through a culvert. In rainy or winter weather the materials (branches, roots trees, blocks of rock, etc.) can create temporary dams that lead to the production of large floods. 
62/275-276	Km 5+950 - Km 7+350	Middle Paleozoic Outcrop 029 Outcrop 030	Pink granites rocks At km 6 + 060 access to the restaurant. Outcrop is seen at the entrance, with altered and slightly altered rocks. At km 6 + 660 may be a possible fault. There is a clear boundary between fresh (healthy) rock and heavily altered and tectonized rock (gruss) At km 6 + 780 possible a former local borrow pit from sand. 

			  At km 7 + 220, there are outcrop on both sides of the road. On the right side, the rocks are altered with diluvium deposits at the base of the slope, and on the left side the rock is slightly weathered Right side of the existing road E60, debris con on slope of base.

			 
	Km 7+720		Start village Khevi 

	Km 8+500		End of the project.

Annex 10: Compensate plan for Timber Resources to Cut Down for the Modernization of Chumateleti-Khevi Section of the East-West Highway

1. Introduction

The Government of Georgia has decided to accomplish the Modernization Project of Chumateleti-Khevi Section of the East-West Highway (E-60), with a certain number of trees and plantations to remove from the environments in the construction phase.

A 12-km-long section of the EWH will run across Khashuri and Kharagauli Municipalities, in particular, from Chumateleti to village Khevi. The site from the final point of Zemo Osiauri-Chumateleti to Rikoti Tunnel east portal is located on the territory of Khashrui Municipality (Shida Kartli Region), while the west portal and the section west of the Tunnel belong to Kharagauli Municipality (Imereti Region).

Field visits were organized with the aim to accomplish the activities under the Requirements Specification and obtain the data about the natural-historical conditions of the compensation sites and plan, measure, etc. The territories and areas were identified based on the aerial survey results. All these measures are necessary to plan the forest and necessary economic actions. During the planning of a temporal forest nursery-garden, the following source was used as a normative document: Decree No. 241 "On the rule to tend and restore forests" of August 13, 2010 of the Government of Georgia.

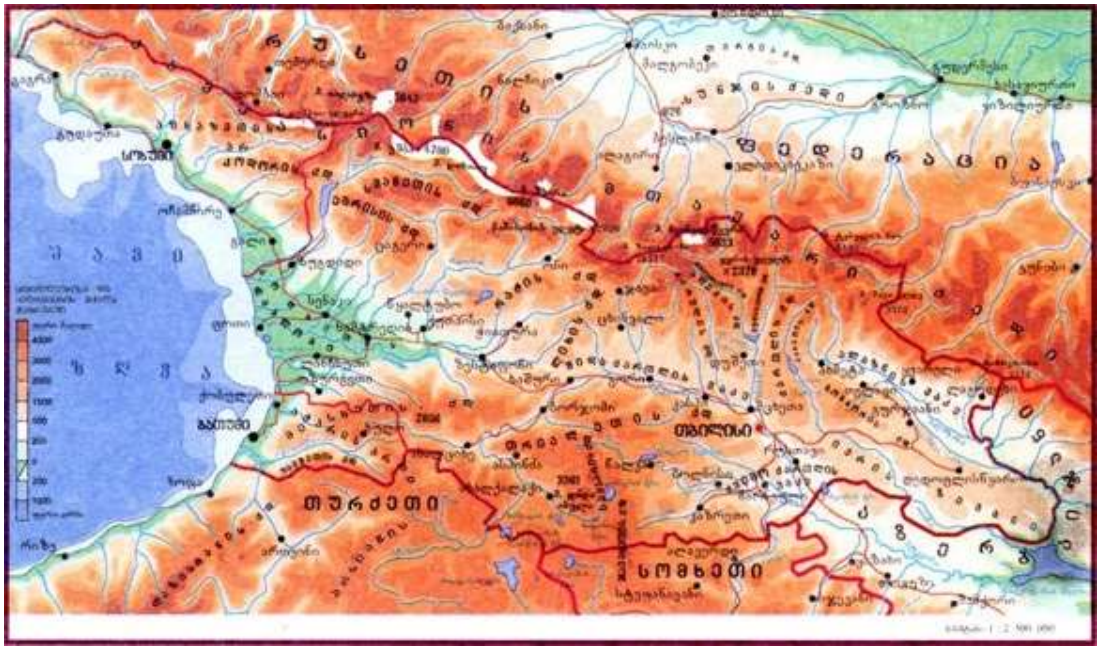
Various timber species were fixed on the compensation site and in the adjoining area, with their majority being of a natural origin. The fixed timber species were considered in the selection of the design timber species.

The territories for compensation plantings were selected by the Construction Contractor. The compensation area to grow the forest species must be selected in agreement with LEPL National Forest Agency. The selected area is desirable to be located near the road with an irrigation system available for its operation.

1.1. Physical-geographical location

In a physical-geographical respect, the corridor of the design highway is located on Imereti Plateau, within the limits of Likhi Ridge (Surami Ridge) – the sub-meridian ridge connecting the Caucasioni and the Lesser Caucasioni Mountain Systems dividing Georgian into east and west parts. The length of the Ridge from Ertso Pass to Lomismta is 102 km. Rikoti Tunnel runs under the southern section of the said Ridge, Rikoti Pass in particular. Likhi Ridge is the watershed of the Caspian and Black Seas. Tectonically, its middle section belongs to Dzirula crystal massif, with its northern part belonging to the Caucasioni and its southern section belonging to the Lesser Caucasioni. It has a function of a climatic delimiter. However, the border of the climatic-botanical zones of Kolkheti and the east Georgia follows not the watershed, but the eastern slopes of the Ridge.

Map 6.1.1. Location of the study area in the physical map of Georgia



According to the administrative-territorial division of the territory of Georgia, the eastern part of the design corridor (Rikoti Tunnel in particular) belongs to Khashrui Municipality (Shida Kartli Region), while the major portion of the corridor is located within the limits of Kharagauli Municipality (Imereti Region). The adjoining administrative-territorial units are Bagdati, Zestaponi, Chiatura, Sachkhere, Kareli and Borjomi Municipalities.

1.2. Microclimatic description

By considering the fact that the project area is located on the border of the climate zones of East and West Georgia, we give the consideration of the background conditions in both, Khashuri and Kharagauli Municipalities in the present document, as the trees and plantations will be removed from the territories of the said Municipalities and the forest restoration project must be realized on the territory of these Municipalities following their environmental conditions.

These areas are characterized by cold winter and moderately warm summer. Maximum value of the average annual air temperature reaches its maximum of +26.5ºC in August and its minimum value (-2.4 ºC) is fixed in February. The average annual precipitation value is 565 mm. The number of snowy days a year is 55-60. The thickness of the snow cover near the Tunnel often reaches 0.5-0.7 m. Like the air temperature, the soil temperature is the lowest in December and January. Relative humidity corresponds to the precipitation value and its average annual value is within the range of 75%.

Below we give the climatic characteristics of the study corridor based on the data of Khashuri and Kharagauli weather stations (source: “Building Climatology”).

Table 1.2.1. Average air monthly and annual temperatures, tºC

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year

Khashuri												
-1,9	-0,8	3,5	9,0	14,3	17,6	20,5	20,7	16,7	13,3	5,2	0,3	9,7
Kharagauli												
3,2	3,9	7,1	12,0	17,1	20,2	22,6	23,0	19,6	15,1	9,9	5,3	13,2

Table 1.2.1. Extreme air temperatures, tºC

Average maximum of the hottest month	Average of the coldest five-day-long periods	Average of the coldest day	Average of the coldest period	Period with average temperature of <8ºC		Average temperature at 1:00 pm	
				Duration, days	Average temperature	In the coldest month	In the hottest month
Khashuri							
27,5	-11	-15	-2,1	117	4,6	5,6	27,6
Kharagauli							
29,0	-5	-8	3,0	160	1,5	0,9	25,7

Table 1.2.3. Air humidity, %

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average
Khashuri												
4,8	5,0	5,8	7,9	11,6	14,5	16,9	16,3	13,4	10,0	7,4	5,8	9,9
Kharagauli												
5,7	6,0	6,8	9,3	13,5	17,2	20,5	20,2	16,4	12,0	8,7	6,4	11,9

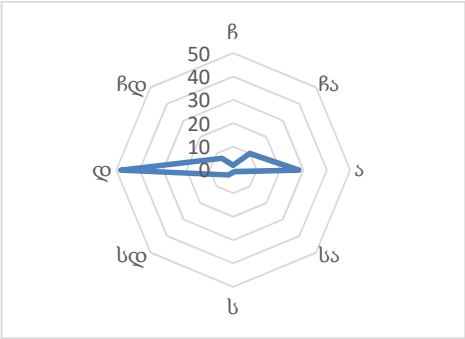
- The annual amount of atmospheric precipitations is:
  - Khashuri – 644 mm;
  - Kharagauli - 1366 mm;
- Daily precipitation maxumum:
  - Khashuri – 80 mm;
  - Kharagauli - 105 mm;
- Weight of the snow cover:
  - Kharagauli – 0.68 KPa;
  - Khashuri - 0,64 KPa;
- Number of days with a snow cover:
  - Kharagauli – 38
  - Khashuri - 56
- Water-content of the snow cover:
  - Kharagauli - - 45mm;
  - Khashuri - 48 mm.
- As the data of Kharagauli weather station suggest, the wind properties are as follows:
  - Rated wind pressure value w0 5 once a year: 0.17 KPa;
  - Rated wind pressure value w0 15 once a year: 0.23 KPa;
  - Wind with the following velocity possible once a year: 21 m/sec;

- Wind with the following velocity possible once in 5 years: 24 m/sec;
- Wind with the following velocity possible once in 10 years: 25 m/sec;
- Wind with the following velocity possible once in 15 years: 28 m/sec;
- Wind with the following velocity possible once in 20 years: 21 m/sec;

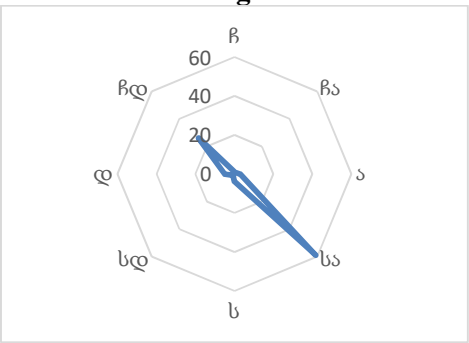
➢ As the data of Khashuri weather station suggest, the wind properties are as follows:
- Rated wind pressure value w0 5 once a year: 0.38 KPa;
- Rated wind pressure value w0 15 once a year: 0.48 KPa;
- Wind with the following velocity possible once a year: 18 m/sec;
- Wind with the following velocity possible once in 5 years: 24 m/sec;
- Wind with the following velocity possible once in 10 years: 25 m/sec;
- Wind with the following velocity possible once in 15 years: 28 m/sec;
- Wind with the following velocity possible once in 20 years: 21 m/sec;

Wind rose %:

Khashuri



Kharagauli



➢ As the data of Kharagauli weather station suggest, the rated seasonal freezing depth of grounds is:
- Argillaceous and loamy - 0 cm;
- Fine and dust-like sand clay-sand – 0;
- Large- and average-coarse gravelry sand – 0;
- Large-clastic – 0.

➢ As the data of Khashuri weather station suggest, the rated seasonal freezing depth of grounds is:
- Argillaceous and loamy - 48 cm;
- Fine and dust-like sand clay-sand – 46;
- Large- and average-coarse gravelry sand – 49;
- Large-clastic – 57.

1.3 Soils

Within the limits of East Dzirula, where the project corridor is located, there are three types of soil formations spread:

- Brown soils;
- Yellow brown soils, and
- Humus brown soils.

Brown soils are the most common type of soils in the Caucasus. Their formation is associated with the climatic conditions when the amount of precipitations exceeds evaporation thus forming a special soil-landscape belt. Within the limits of Dzirula massif, whicg covers the areas adjoining to the project Highway, the type of brown soil is changed, in particular, by brown podzolized, turf-calcareous and

other types of soil. Brown podzolized soils are mostly formed on the intensely weathered loams and clays. Their profile is characterized by a thin bed soil, followed by a humus horizon (3-5 cm) and then, by an intensely saline podzolized horizon (15-20 cm). The most upper layer of these profiles is a compacted alluvial-metamorphous beige-yellow or reddish-yellow horizon, which is then changed by the bedrock. The humus content is low and the reaction is acid.

The brown-yellow soils belong to Zheltozems. Within the limits of Dzirula massif, these soils, together with the brown soils, are spread in the zones of the massif, where a weathering crust presents. The major area of their spread is the terrace formations and piedmont plains. The humus horizon is presented by a granular soil layer (19-15 cm) and by dense cloddy alluvial-metamorphous horizon at deeper locations, which is gradually changed by the soil-forming rock. The content of a humus horizon in this soil layer is 6-10%. It is more acidic and less saturated with bases.

The humus-calcareous soils are formed under the vegetation, mostly on calcareous rocks. These soils are: limestones, dolomites and products of their decomposition, with their areas characterized by humid climatic conditions. High-carbonate nature of the soil-forming rocks leads to the development of the turf-calcareous and humus-calcareous soil profiles. Their upper part is of a grey color, is lighter below and is changed by the bedrock. The reaction in the upper part of the profile is neutral and is alkaline in its lower part, which is rich in carbonate. The humus content in the upper part of the horizon is 6-10%. The zone of spreading of this type of soil mostly coincides with the zones of limestone rocks, which are typical to the rocks of the Cretaceous Age found along the Caucasioni.

1.4. Biological Environment

The results of inventory of the timber resources on the territory coming under the impact during the process of the Highway modernization are summarized in Table 1.4.1.

Table 1.4.1. The results of inventory of the timber resources in the design corridor

#	Species	Number	Volume	Note
1	Alder	2268	335.281	
2	Hornbeam	2250	332.537	
3	Chestnut	233	64.42	Red List
4	Lime	162	45.129	
5	Bird cherry	15	4.64	
6	Persimmon	10	2.67	
7	Cherry plum	3	0.167	
8	Oriental hornbeam	314	16.617	
9	Oak	35	9.382	
10	Walnut	16	4.594	Red List
11	Cypress	27	13.545	
12	Pine	270	76.499	
13	Cedar	20	18.34	
14	Willow	109	12.364	

15	Acacia	800	88.602	
16	Asp	12	3.422	
17	Wild pear	26	3.64	
18	Shamrock	2	0.422	
19	Beech	538	121.388	
20	Maple	148	15.76	
21	Nut	72	2.564	
22	Elm	12	0.733	
23	Fig tree	13	0.826	
24	Spruce	3	2.347	

2. Recultivation Works

In developing the present document, we were guided by Decree No. 241 "On the rule to tend and restore forests" of August 13, 2010 of the Government of Georgia, which aims at regulating the legal relations arising during the implementation of the maintenance and restoration measures for the forests on the state forest territory to avoid the negative factors caused by the climate change by maintaining the ecological balance of forests and age structure, generic composition and qualitative state of the forests, forming stable and high-productive plantations, increasing the possibilities of forest use and maintaining the climatic conditions.

By considering the fact that during the construction of the project road, approximately 70 ha to use is located on the territory of the forest fund, the following forest restoration measures are absolutely necessary to take to compensate the said section:

- Forest restoration:
  - Supporting the natural forest restoration.
  - Planting and sowing.

The types of the forest restoration will be selected based on the ecological and economic feasibility, on the territories of the state forest where it is feasible. The natural forest restoration must be a priority.

1. Designing is necessary prior to the onset of the forest restoration measures subject to the following:

- ✓ a) Growing the forest cultures.
- ✓ b) Building nursery-gardens.
- ✓ c) Growing forest plantations.
- ✓ d) Growing protective plantings.
- ✓ e) Reconstruction of degraded forest plantations, eco-systems and forest landscapes.
- ✓ f) Measures to promote the natural forest restoration.

2. The forest restoration project must include the

- ✓ a) The basis for drafting the project (decree, agreement, etc.) and purpose.
- ✓ b) Detailed description of the area to restore: location (forest area, forest, quarter, litter), borders, adjoining areas and natural conditions (climate, soils, etc.).
- ✓ c) Description of botanical and bio-ecological peculiarities of the selected species.

- ✓ d) Description of the selected species of ento- and phyto-pests and recommendations to control them.
- ✓ e) Project measures and scope and parameters of the activities envisaged by such measures.
- ✓ f) Measure to take care after the forest, and
- ✓ g) Cartographic materials.

3. The forest restoration project is approved by the body with the right to manage the state forest fund.

4. The project of the measures to support the natural forest restoration must cover clauses a), b), e) and f) of article 2.

2.1.1. Stages to restore the forest

The stages of to restore and grow the forest are as follows:

- ✓ a) Producing seeds;
- ✓ b) Building a nursery-garden.
- ✓ c) Other measures envisaged by the forest restoration plan, including necessary many-year-long care.

The following can be used as planting materials for the forest restoration purposes:

- ✓ a) Seedlings.
- ✓ b) Young plants.
- ✓ c) Cutting, and
- ✓ d) root shoots.

2.1.2. Special requirements to restore the forest

The activities to select and use the plant species must be accomplished by meeting the requirements for maintaining the biodiversity.

The right to obtain a young plant, root shoots or cuttings for the forest restoration purposes is granted in the state forest fund to the body with the right to manage the state forest fund in Georgia.

The timber plant species to restore and grow the state forest fund are selected mainly among the local species typical to the given environmental conditions.

The timber plant species for introduction must be selected by studying their natural-climatic and other properties to avoid their negative impact on the local species and other factors.

The introduced species must be used mainly to form the forest plantations.

The duration of the works to care about the restored and/or grown forest and other features are envisaged by the forest restoration project.

If the forest restoration needs fencing the area to restore, the body with the right to manage the state forest fund has the right to use the dug-out or broken timber resources of the state forest fund or those lying on the ground.

The fence of the area to restore must be made of at least 2 m high timber resources, elevated 1.5 m above the ground.