# Nenskra Hydropower Project

# Supplementary Environmental & Social Studies

# Volume 2
# Project Definition

Supplementary E&S Studies for the Nenskra HPP:

| | | | | |
|---|---|---|---|---|
| Volume 1<br>Non-Technical Summary | **Volume 2**<br>**Project Definition** | Volume 3<br>Social Impact Assessment | Volume 4<br>Biodiversity Impact Assessment | Volume 5<br>Hydrology & Water quality Impact assessment |
| Volume 6<br>Natural Hazards and Dam Safety | Volume 7<br>Stakeholder Engagement Plan | Volume 8<br>Environmental & Social Management Plan | Volume 9<br>Land Acquisition & Livelihood Restoration plan | Volume 10<br>Cumulative Impact Assessment |

DISCLOSURE AUTHORIZED

November 2017

# Issue and revision record

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# Acronyms

| | |
|---|---|
| AA | Association Agreement between Georgia and the European Union. |
| AAF | Average Annual Flow |
| ADB | Asian Development Bank |
| AFRD | Asphalt Face Rockfill Dam |
| AIIB | Asian Infrastructure Investment Bank |
| APA | Agency of Protected Area |
| BHD | Birds and Habitat EU Directives |
| CSR | Corporate Social Responsibility |
| dbh | Diameter at Breast Height |
| EBRD | European Bank for Reconstruction and Development |
| ECAs | Export Credit Agencies |
| EF | Ecological flow |
| EHS | Environment, Health and Safety |
| EIA | Environmental Impact Assessment |
| EIB | European Investment Bank |
| EPC | Engineering-Procurement-Construction |
| E&S | Environmental & Social |
| ESAP | Environmental & Social Action Plan |
| ESIA | Environmental & Social Impact Assessment |
| ESMS | Environmental & Social Management System |
| EU | European Union |
| FS | Feasibility Study |
| FSL | Full Supply Level |
| GEL | Georgian Lari |
| GIIP | Good International Industry Practices |
| GSE | Georgian State Electrosystem |
| GHG | Greenhouse Gas |
| GIS | Gas Insulated Substation |
| HPP | Hydropower Project |
| HS | Health & Safety |
| IFC | International Finance Cooperation |
| KDB | Korean Development Bank |
| KfW | *Kreditanstalt für Wiederaufbau* (German Development Bank) |
| LALRP | Land Acquisition and Livelihood Restoration Plan |
| LESA | Lenders Environmental & Social Advisers |
| MoE | Ministry of Environment Protection and Natural Resources |
| $Mm^3$ | Million cubic meters |
| NACHP | National Agency for Cultural Heritage Preservation of Georgia |
| NGO | Non-Governmental Organisation |
| NTS | Non-Technical Summary |
| OECD | Organisation for Economic Co-operation and Development |
| OESA | Owners Environmental & Social Advisers |

| | |
|---|---|
| PA | Protected Area |
| PH | Powerhouse |
| PMF | Probable Maximum Flood |
| PRs | EBRD Performance Requirements |
| PS | IFC Performance Standards |
| RoW | Right of Way |
| SEP | Stakeholder Engagement Plan |
| SoW | Scope of Work |
| TBM | Tunnel Boring Machine |
| TL | Transmission Line |
| TT | Transfer Tunnel |
| UNESCO | United Nations Educational, Scientific and Cultural Organisation |

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# Preamble

In August 2015, the Nenskra Hydropower Project submitted the final Environmental & Social Impact Assessment Report (ESIA) to the Government of Georgia (GoG) as part of the national environmental permitting process. The 2015 ESIA report has been prepared by Gamma Consulting Limited (a Georgian consultant), based on field investigations undertaken in 2011 and 2014 and following the public consultations meetings held in May 2015. The Environmental Permit was awarded by the Environmental Authorities in October 2015.

In the present document, the ESIA submitted in 2015 is referred as the “2015 ESIA”.

Since then, several International Financial Institutions (the Lenders) have been approached to invest into the Project. To ensure compliance with their Environmental and Social (E&S) policies, the Lenders have recommended that a number of Supplementary E&S Studies be undertaken to supplement the existing 2015 ESIA. In particular, more details on the Project’s design, implementation and operation arrangements were identified as being necessary to better inform the general public as well as the other Supplementary E&S Studies. A first version of the Supplementary Environmental and Social Studies was publicly disclosed in February 2017.

This report n°901.8.5_ES Nenskra_Vol.2_Project Definition is the final Volume n°2 of the Supplementary E&S Studies prepared by SLR Consulting and issued in 2017 after the public disclosure period held from March 2017 to September 2017. It provides an updated description of the Nenskra HPP components and implementation schedule as known in September 2017. It is based on further details provided by the EPC Contractor after the 2015 ESIA report had been issued. It takes into account the comments received between March 2017 to September 2017 from the various stakeholders engaged by the Project. This document must be read in conjunction with the other volumes of the Supplementary E&S Studies organised as follows:

- Volume 1: Non-Technical Summary
- **Volume 2: Project Definition (this document)**.
- Volume 3: Social Impact Assessment
- Volume 4: Biodiversity Impact Assessment
- Volume 5: Hydrology & Water Quality Impact Assessment
- Volume 6: Natural Hazards and Dam Safety
- Volume 7: Stakeholder Engagement Plan
- Volume 8: Environmental & Social Management Plan
- Volume 9: Land Acquisition & Livelihood Restoration Plan
- Volume 10: Cumulative Impact Assessment.

# 1 Introduction

## 1.1 Overview

The proposed Nenskra Hydropower Project is a greenfield high head hydropower project with an installed capacity of 280 Megawatts (MW), located in the upper reaches of the Nenskra and Nakra valleys in the North Western part of Georgia in the Samegrelo-Zemo Svaneti Region (see Map 1.1). The Project uses the available discharges from the Nenskra River and the adjacent Nakra River, developing a maximum available head of 725 metres down to the powerhouse located approx. 17 kilometres downstream from the dam.

The main Project components comprise a 125 metre high[1], 870 metre long asphalt face rockfill dam on the upper Nenskra River creating a live storage of about 176 million cubic metres and a reservoir area at full supply level of 267 hectares. Part of the Nakra River will be diverted into the Nenskra reservoir through a 12.25 kilometre long transfer tunnel. The power waterway comprises a headrace tunnel of 15.1 kilometres, a pressure shaft and underground penstock of 1,790 metre long. The above-ground powerhouse is located on the left side of the Nenskra River and will house three vertical Pelton turbines of 93 MW capacity each, for a total installed capacity of 280 MW. A 220 kV transmission line that connects the powerhouse Gas Insulated Station yard to a new substation located in the Nenskra valley will have to be built.

All Project components will be located within the Mestia Municipality:

- The Nenskra dam and reservoir as well as the powerhouse and the penstock will be located within the Chuberi Community.
- The Nakra water intake will be located within the Naki Community. The access road to the Nakra water intake will cross the Naki Community and the Lakhamula Community.
- The Transmission Line, as well as the access road to the Nenskra dam will cross the Chuberi Community and the Khaishi Community.

## 1.2 Project history

### 1.2.1 Project development

The pre-feasibility of the Nenskra HPP was first studied in the 1980s at the same time as the Khudoni HPP, as part of the of the hydropower projects selected by the Government. From 2010 to 2012, new studies of the Nenskra HPP were undertaken for various developers:

- For Engurhesi Ltd in 2010. The Pre-Feasibility Study was prepared by the engineering company Stucky. At that time, the dam was located upstream of the 2017 dam location (approximately at 12 km from the source of the river, at 1600 m elevation, about 1 km downstream from the river Dalari outfall) and significantly higher (250m-high arch dam).
- For JSC Nenskra in 2011-12. The project general layout was conceived by Stucky during a Feasibility Study completed in May 2011, after comparison of several possible alternatives

[1] Dam height was previously disclosed as 130 m. Dam height is now referred to as 125 m as this relates to the height from the deepest point on the upstream face of the dam, whereas the 130 m previously quoted relates to the height from the deepest point on the downstream face of the dam. The reservoir full supply level and the design of the dam have not changed. This has been amended to provide consistency with other Project documents.

based on specific winter generation requirements. During the summer season 2011, Stucky performed geological and topographic campaign to define the main field data to support the design works, and the Initial Design was issued in 2012. At that time, the project location, layout and design were similar to the 2017 project definition.

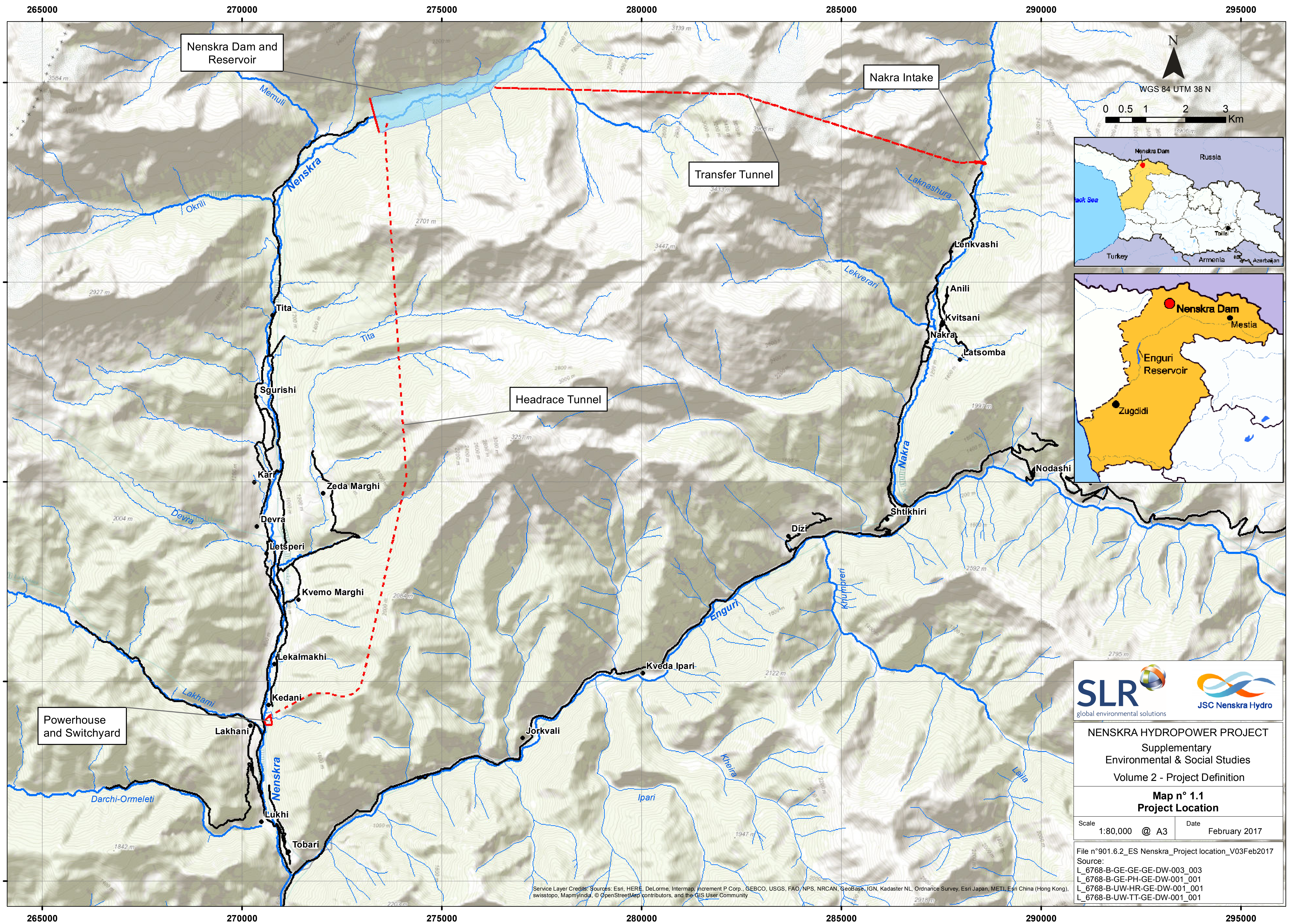
End of 2011, JSC Nenskra was 100% owned by Partnership Fund (see Section 1.4). In January 2012, JSC Nenskra issued a Request for Proposal seeking a strategic investor to develop the Project. Mid-2012, JSC Nenskra and Partnership Fund started negotiations with K-water on the terms and conditions for developing the Project. These negotiations took several months as in 2012 and 2013, the elections in Georgia delayed approvals. The parties formally agreed in December 2014 to develop jointly the Project.

What informed the decision by Partnership Fund to move forward with K-water to develop the Nenskra Project was not only the tariff proposal made by K-water, but also the changes accepted by K-water to the Project from the terms that were offered under the initial Request for Proposal conducted by JSC Nenskra. For example, at the time K-water submitted its tariff proposals the Project was envisioned to be a Build-Own-Operate with no transfer of the facility to the Government at the expiry of the Implementation Agreement. At present, the Project is a Build-Operate-Transfer and the scheme will be transferred to the Government after 36 years of operation (see Section 1.4).

The tender process for the EPC Contract was performed in the first semester of 2015. As described in Section 1.4, the Project Documents (Implementation Agreement, Power Purchase Agreement) were approved and executed in August 2015.

In 2015 the Engineering-Procurement-Construction (EPC) Contractor Salini Impregilo was contracted by the Project Company to carry out the detailed design of the Project's components, procure the required works, equipment and services and execute the works until the start of the power production. As part of the first engineering step, Salini Impregilo refined the initial design prepared by Stucky in 2012 and produced the 2016 Basic Design.

The Project definition presented in this report is based on the basic design proposed by the EPC Contractor up to December 2016. At the time of writing, no changes have been made by JSCNH to the project definition since December 2016.



Nenskra Dam and Reservoir
Nakra Intake
Transfer Tunnel
Headrace Tunnel
Powerhouse and Switchyard
WGS 84 UTM 38 N
0 0.5 1 2 3 Km
Nenskra Dam
Russia
Black Sea
Turkey
Armenia
Azerbaijan
Tbilisi
Nenskra Dam
Mestia
Enguri Reservoir
Zugdidi
Nenskra
Memuli
Okrili
Laknashura
Lekverari
Tila
Devra
Lakhami
Nakra
Enguri
Khumpreri
Kheira
Ipari
Laila
Darchi-Ormeleti
Lenkvashi
Anili
Kvitsani
Nakra
Latsomba
Nodashi
Shtikhiri
Dizi
Tita
Sgurishi
Kari
Zeda Marghi
Devra
Letsperi
Kvemo Marghi
Lekalmakhi
Kedani
Lakhani
Kveda Ipari
Jorkvali
Lukhi
Tobari
SLR global environmental solutions
JSC Nenskra Hydro
NENSKRA HYDROPOWER PROJECT
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Map n° 1.1
Project Location
Scale 1:80,000 @ A3
Date February 2017
File n°901.6.2_ES Nenskra_Project location_V03Feb2017
Source:
L_6768-B-GE-GE-GE-DW-003_003
L_6768-B-GE-PH-GE-DW-001_001
L_6768-B-UW-HR-GE-DW-001_001
L_6768-B-UW-TT-GE-DW-001_001
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### 1.2.2 ESIA process

The Project was subject to a first Environmental & Social Impact Assessment (ESIA) process in 2011 based on the information available in the Pre-feasibility Study.

In 2014-2015 a second ESIA process was conducted by the environmental consulting company Gamma Consulting Limited. The 2015 ESIA report was submitted by the Project to the GoG Environmental Authorities in April 2015 for evaluation. The public consultation meetings on the 2015 ESIA report were conducted in the project-affected area in June 2015. Following that public consultation process, the GoG required a number of changes to the ESIA report; in August 2015, the final ESIA report was submitted to the Ministry of Environment and Natural Resources Protection.

The Environmental Permit was awarded to the Nenskra Project in October 2015 (see Annex 2). The permit comes with a number of E&S conditions based on the 2015 ESIA commitments as well as additional measures required by the Ministry of Environment and Natural Resources Protection.

The Project Definition as described in the 2015 ESIA report was based on the Feasibility Study. The Project Definition proposed in this document is based on the design prepared by the EPC Contractor in December 2016 and approved by JSCNH and which goes into a greater degree of detail. At the time of writing, no changes have been made by JSCNH to the project definition since December 2016. It is the “design freeze” version for the 2017 Supplementary E&S Studies.

The main conceptual changes in the design since the completion of the feasibility study and issue of the 2015 ESIA - and which is reflected in this document – are as follows: (i) the dam axis has been slightly modified, (ii) the spillway and power intake locations have been slightly modified, (iii) the alignment of the transfer tunnel slightly modified, (iv) a reservoir by-pass cattle track will be constructed, and (iv) the powerhouse and the Nakra weir have been slightly displaced (70 metres) compared to the initial design.

## 1.3 Need and rationale

The development of the Nenskra HPP is part of Georgia larger plans to increase the country power generation capacity while reducing the dependency from (i) fossil fuel-fired power plants and from (ii) imported power form neighbouring countries (mostly from Russia, Turkey and Azerbaijan).

In 2014, the total available capacity of all generating facilities in Georgia[2] amounted to 3,480 MW, including 2,750 MW of hydro (80%) and 730 MW of thermal power (20%). The existing Georgian power system is characterized by a low demand and high generation in summer, and high demand and low generation in winter. During winter, when less water is available for the hydropower plants, thermal power’s share in total generation increases to 28% from less than 1% in summer. Georgia imports power from neighbouring countries to meet this higher winter demand.

The development of hydropower schemes with a regulation capacity is one of the governmental strategies to reduce this dependency on imported power during the winter period. Together with the proposed Khudoni HPP (702 MW), the proposed Namakhvani HPPs cascade (433 MW), and the proposed Oni HPPs Cascade (177 MW), the Nenskra HPP is one of the four hydropower projects with large regulating capacities, hence of country wide importance.

The Nenskra HPP will dispatch 100% of electricity to the Georgian grid under a 36 year Power Purchase Agreement (PPA) with ESCO (Electricity System Commercial Operator). The rationale

[2] GSE, Ten-Year Network Development Plan of Georgia for 2015-2025,

of the Project is to guarantee energy during the winter season to meet higher domestic demand and promote exports by ESCO during the summer season.

The economic cost-benefit analysis of the Nenskra HPP[3] publicly disclosed in 2017 shows that the Project is cost benefit justified. The main conclusions of this study are as follows: the negotiated tariff in the power purchase agreement in real terms in 2019 is US$5.48/MWh less than estimates of the long run marginal cost of power in Georgia in 2019 prices. The tariff is also lower than the price Georgia pays to import power in winter months from neighbours, including Russia. Georgia will also benefit because tax payments to the Government will be higher because the Project will pay corporate income tax, withholding tax, and land taxes to the Government. The Government does not receive income tax revenues from power generated by companies in neighbouring countries that export power into Georgia. The net effect of this is quantifiable net benefits of US$136 million in Present Value terms.

## 1.4 Project equity

The Project is being developed by JSC Nenskra Hydro, whose main shareholders are K-water and JSC Partnership Fund. K-water intends to develop the Project as the lead sponsor and shareholder (80%). K-water and Partnership Fund are referred to as the Owners in this report:

- K-water is an agency of the government of Korea responsible for water resource development and providing public and industrial water in South Korea. It is financially backed by the Government of Korea and is mandated as the Korean government's policy implementation arm for water related businesses. They develop and operate a number of hydropower generation facilities in Korea including the Soyanggang 200 MW rockfill dam and 412 MW Chungju multipurpose dam.
- JSC Partnership Fund is a state-owned investment fund established in 2011 to consolidate ownership of the largest Georgian state-owned enterprises such as GRC and Georgian Oil and Gas Corporation. It is charged with promoting private investment in energy, infrastructure and the transport sectors through co-financing in project's initial stage of development. Energy project experience includes the 230 MW Gardabani combined cycle thermal power plant.

An Implementation Agreement was signed between the Government, ESCO, GSE and JSC Nenskra Hydro in August 2015. This agreement is the key legal document that allows JSC Nenskra to design, finance, construct, operate and maintain the Nenskra HPP on a Build-Operate-Transfer basis. The scheme will be transferred to the GoG after 36 years of operation.

The Power Purchase Agreement (PPA) was signed in August 2015. It sets out the terms and conditions for the purchase by ESCO of capacity and energy generated at Nenskra Hydro power plant by JSC Nenskra Hydro for a period of 36 years. The PPA expects 120 MW power capacity during winter period i.e. December, January & February. The actual daily production will depend on instructions provided by the dispatch centre of Georgian State Electrosystem (GSE), as described in Section 4.5.2.

Both the Implementation Agreement and the PPA have been revised in June 2017. No changes relevant to the Supplementary E&S Studies have been made.

[3] Castalia Limited. Economic Cost-Benefit Analysis of Nenskra Hydropower Project: Summary Report. Report to IFC July 2017. Available on the Ministry of Energy website: http://www.energy.gov.ge/projects/pdf/pages/Nenskras%20Hidroelektrosadguris%20Proektis%20Ekonomikuri%20Sargeblianobis%20Analizi%201787%20geo.pdf

## 1.5 Involvement of international financing institutions

The Project Company approached a number of international financing institutions (IFIs) to finance the Project, which include European Bank for Reconstruction and Development (EBRD), the Asian Development Bank (ADB), the European Investment Bank (EIB), the Korean Development Bank, the Korea Trade Insurance Corporation (K-SURE) and the Asian Infrastructure Investment Bank (AIIB) - collectively called the potential 'Lenders'. This group of Lenders may change in 2018, prior to the financial close of the Project planned for the first quarter of 2018.

The Lender's involvement has had implications in terms of the E&S performance requirements to be complied with by the Project activities. The Project has not only to comply with the Environmental Permit obligations which are based on the 2015 ESIA. It also has to comply with the E&S policies of the Lenders, namely:

- The 2014 EBRD Environmental & Social Policy and the EBRD Environmental and Social Guidance Note for Hydropower Projects;
- The 2009 ADB Safeguard Policy Statement, 2001 ADB's Social Protection Strategy, 1998 ADB Gender and Development Policy, 2011 ADB Public Communications Policy;
- The 2012 IFC Performance Standards applied by KDB and K-Sure;
- The 2016 AIIB Environmental and Social Framework; and
- The 2013 EIB's E&S Standards.

## 1.6 Structure of the report

This document structured into the following main sections:

- Section 1 is the present introduction;
- Section 2 is the analysis of alternatives that were examined during the previous design stages of the Project;
- Section 3 is the detailed description of the main components of the Nenskra Hydropower Project, and
- Section 4 presents the construction and operation schedules as well as the main construction methods.

# 2 Analysis of alternatives

## 2.1 Purpose

Analysis of alternatives in environmental assessment is designed[4] to bring E&S considerations into the upstream stages of development planning as well as the later stages of site selection, design and implementation.

During the earlier stages of the Project preparation, the E&S aspects were taken into consideration by the Engineering Team while selecting the dam location, type and height. The alternatives analysis was documented into two technical documents:

- Preliminary Feasibility Study prepared in 2010 by Stucky for Engurhesi Ltd, and
- Feasibility Study - Phase 1, prepared in 2011 by Stucky for Georgian Railway Construction ("Project Alternatives"), using the findings of the Preliminary Environmental and Social Assessment prepared by Stucky and Gamma in 2010.

These two documents are confidential however the publicly released 2015 ESIA Study prepared by Gamma summarizes the alternatives analysis conducted during the earlier planning stage.

Project identification had largely been completed, and elements of the Project fixed, including the location, prior to JSCNH involvement. As the main sponsor, K-water has been responding in 2014 to a site (Nenskra and Nakra valley) and technology (hydropower) specific project application.

The Supplementary E&S studies were commissioned by JSCNH in 2015 when the proposed Project site (Nenskra and Nakra valleys), technology (hydropower with reservoir storage), and initial design (Rockfill dam, 125 metre high dam) which greatly influence the E&S impacts, had been already selected. From mid-2015 to end-2016, the Project environmental team worked with the Owners Engineer to examine the alternatives proposed by the EPC Contractor during the basic design preparation. When and where possible, this approach helped to select the most environmentally or socially friendly technical solution (see Section 2.5.1).

The objective of the present chapter is not to justify, a posteriori, why the proposed Nenskra HPP is the least-impact alternative to achieve the power production objectives required by the Government. There are other considerations such as politics preference (e.g. reducing dependence on import of electricity and fossil fuels necessary for operation of thermal power plants) which have - and will - prevail-(ed). The objectives of the present alternative analysis are to:

- Describe the basis for selection of the preferred alternatives (technology, location, design);
- Where alternatives have been selected that are sub-optimal from an environmental perspective, document justification for their selection, and
- Provides the information that reviewers of the analysis will need if they wish to check its conclusions or apply their own methods to compare alternatives.

[4] World Bank, 1996, Environment Department. Environmental Assessment Sourcebook Update, Chapter 17, Analysis of Alternatives in Environmental Assessment; ADB Safeguard Policy Statement, and EBRD Performance Requirement 1

It should be noted that the operational modes are dictated by electricity demand and are framed by the Implementation Agreement between JSC Nenskra Hydro, GoG, GSE and JSC Electricity System Commercial Operator. Consequently, alternative operational modes are not discussed in this section, as they would be for a power production regime that would not correspond with the Implementation Agreement requirements.

The selection of alternatives at strategic level by the Government of Georgia was not based on (i) a Sectoral Environmental Assessment to distinguish among alternative strategies and investment programs within the power sector, or (ii) a Regional Environmental Assessment to compare alternative development scenarios. The analysis of alternatives to the Nenskra HPP was therefore not build on a formal sectoral or a regional environmental assessment.

## 2.2 Project objectives

In line with the governmental strategy to reduce the country dependency on imported power and thermal power during the winter period[5], the Project objectives, as established with the Government of Georgia in the Implementation Agreement for the Nenskra HPP, are:

- The generation of a mandatory supply in the winter months (December, January and February) of 2.9 GWh per day, equivalent to a capacity of 120 MW during these three months, and
- The production of a total amount of energy over the year equal to or exceed 1,196 GWh which are the “Take Or Pay Quantity” of the Power Purchase Agreement established between JSCNH and ESCO.

To achieve these two objectives, the Government has granted JSCNH the right to:

- Design, engineer, develop, finance, construct, own, operate and maintain the hydropower facility and to transfer the facility to the government at the expiration of the Implementation Agreement term (i.e. after 36 years of operation);
- Impound the waters of the Nenskra River behind the dam, impound the waters of the Nakra River behind the Nakra Weir, transfer part of the water of the Nakra River to the Nenskra reservoir and use the waters impounded by the Nenskra Dam to generate the above mentioned electrical energy and sell it to ESCO, and
- Generate and sell the electricity which is not purchased by ESCO to any third party in accordance with the terms of the Power Purchase Agreement.

The Power Purchase Agreement has, among others, the two following essential terms:

- JSCNH will sell, and ESCO will purchase, all of the electricity made available by the Nenskra HPP up to the aforementioned “Take Or Pay Quantity” at the tariff agreed between ESCO and JSCNH, and
- ESCO may, at its option, purchase any or all of the excess energy made available by the Nenskra HPP at 10% of the tariff agreed between ESCO and JSCNH for the “Take Or Pay Quantity”.

## 2.3 Identification and evaluation of alternatives

The paragraphs below screen the potential alternatives to the Nenskra HPP as designed in 2017:

- Alternative technologies: renewables or fossil-fuel based power plants;

[5] See GSE, Ten Year Network Development Plan of Georgia for 2017-2027, approved in Dec. 2016 by the Ministry of Energy.

- Alternative hydropower operation mode: run-of-river, no Nakra diversion;
- Alternative dam location, type, height;
- Alternative powerhouse location;
- No project alternative, and
- Detailed design alternatives as recommended by the Supplementary E&S studies.

## 2.3.1 Alternative technologies

For energy projects, it is recommended[6] that alternative technologies be identified generically, without reference to project location. Energy production alternatives to hydropower would include renewable energy other than hydropower, and thermal power plants.

GSE prepared in 2015 a Ten-Year Network Development Plan of Georgia for 2015-2025. It has been approved by the Minister of Energy in April 2015. This document explains what the energy production alternatives are for Georgia and further provides the justification on selected technologies. The paragraphs below use the information provided in this strategic document.

### 2.3.1.1 Renewables: solar or wind power plant

Georgia has some fossil deposits (natural gas, oil, peat, coal) however they are available in insufficient quantities to allow economical use. The major power potential in Georgia using available resources is associated with water (hydro), wind, solar and geothermal energy resources.

Georgia has a potential of wind energy estimated to 4,000 GWh of average annual production. Nine zones were identified in Georgia where it would be possible to construct large wind farms, as shown in Table 1 below, with the estimated installed capacity and annual generation.

Producing the same annual energy quantity as Nenskra using wind resource would require the construction and operation of either the largest of the identified wind farms in Georgia or several of the other farms of lower capacity. Most of all, using wind farm would not guarantee a continuous and minimum production during the winter months as planned with the Nenskra HPP; forecast of production of wind farms is difficult due to complexity of wind forecast.

**Table 1 - Potential wind farms in Georgia**

| Location | Estimated Installed Capacity in MW | Estimated Annual Generation in GWh |
|---|---|---|
| Poti | 50 | 110 |
| Chorokhi | 50 | 120 |
| Kutaisi | 100 | 200 |
| Mountain-Sabueti I | 150 | 450 |
| Mountain-Sabueti II | 600 | 2,000 |
| Gori-Kaspi | 200 | 500 |
| Paravani | 200 | 500 |
| Samgori | 50 | 130 |
| Rustavi | 50 | 150 |
| Total | 1,450 | 4,160 |

*Source: GSE, Ten-Year Network Development Plan of Georgia for 2015-2025*

[6] World Bank, 1996, Environment Department. Environmental Assessment Sourcebook Update, Chapter 17

The geographic location of Georgia could also allow power production using solar energy. Annual duration of solar light and total annual solar radiation would depend on the region. With an average land-use requirement for solar power plants of 8 $m^2$/MWh[7], an annual production of 1,196 GWh (projected Nenskra HPP annual production) would require around 800-1,000 hectares. The Nenskra HPP would require an area of similar extent, i.e. 750 hectares for all infrastructures such as dam, reservoir, powerhouse, Nakra intake, service roads, and disposal areas.

However, solar power would face the same constraint of lack of reliable power production during the winter months as with wind power. Solar energy could not be an alternative to the Nenskra HPP without other forms of energy storage (e.g. hydro-cumulative power plants) to compensate the absence of power generation during the night or during cloudy days.

Bulk integration of wind and solar power facilities into Georgian network prior to 2025 would not respond to the strategic objective established by the Government, i.e. to reduce the dependency of power import during the winter period. In this respect, both forms of renewable energies do not represent an alternative to the Nenskra HPP which has an annual regulation capacity allowing power production during the winter period. For the next decade, construction of large hydropower plants with annual water storage capabilities such as Nenskra HPP is the preferred alternative technology using renewable source of energy.

The main alternative technology that could provide the same service and constitute an alternative to Nenskra HPP would be a thermal power plant of equivalent capacity (e.g. combined-cycle thermal power plant) i.e. using a non-renewable source of energy.

#### 2.3.1.2 Combined cycle thermal power plant

In line to the aforementioned reasons, as well as accounting for 3-5 % annual demand growth in Georgian power system, construction of two combined-cycle thermal power plants have been planned in Gardabani. The first plant of 230 MW capacity has been commissioned end of 2015. It has two gas-fired (75 MW each) and one steam (80 MW) turbines. This combined cycle thermal power plant is estimated to produce 1,800 GWh of energy annually and it will have the reserve capacity to supply the country's energy grid for 25 to 30 minutes in the case of a power failure. The gas-fired power plant will be located on 3 hectares of site about 40 kilometres away from Tbilisi. Electricity generated at the plant will be transmitted to the national grid through a 110 kV power transmission line.

The services provided by the newly constructed Gardabani combined cycle thermal power plant could be compared those planned with the Nenskra HPP, i.e. annual production of 1,800 GWh (1,196 GWh for Nenskra) and reliable/stable winter power production.

► A Combined Cycle Thermal Power Plant could be an alternative to the Nenskra HPP. See Section 2.4 for comparative assessment.

Volume 5 of the Supplementary E&S Studies (Hydrology and Water Quality Impact Assessment) provides an estimate of the greenhouse gas emissions (GHGs) produced by the Nenskra HPP, i.e. 68,500 $tCO_2$-eq/year over 30 years, including dam construction (0.059 tCO2-eq/MWh). GHG emissions for alternative technology (combined cycle gas thermal power plant) producing the same energy (1,200 GWh) would be around 546,000 $tCO_2$-eq/year using an electrical efficiency of 40% and a GHG emission rate[8] of 0.455 $tCO_2$-eq / MWh.

[7] Hertwich and others, PNAS, 2015, Integrated life-cycle assessment of electricity-supply scenarios confirms global environmental benefit of low-carbon technologies. See www.pnas.org/cgi/doi/10.1073/pnas.1312753111
[8] Inter-American Development Bank, 2012, Liquid and Gaseous Fossil Fuel Power Plant Guidelines. An Approach to Reconciling the Financing of Fossil Fuel Power Plants with Climate Change Objectives

### 2.3.1.3 Summary comparison of alternative technologies

A summary of a comparison of costs and GHG emissions from thermal power plant technologies compared to the hydropower technology is provided in Table 2 below.

**Table 2 – Summary comparison of alternative technologies to produce 280 MW of power**

| Power Generation Technology | CAPEX [a] (Million Euro) | OPEX [a] (Million Euro) | Maintenance costs [b] (Million Euro per annum) | Efficiency [c] (%) | GHG Emission intensity [c] (Tonnes $CO_2$/TJ) | GHG Emissions over 30 years [d] (Million Tonnes $CO_2$) |
|---|---|---|---|---|---|---|
| Hydropower | 873 [e] | 10 [e] | [f] | 85[c] | 3.24 | 2.4 |
| Coal power | 350 – 1,050 | 10 - 50 | 15 | 33 | 27.6 | 40 |
| Gas power | 150 – 350 | 1 – 20 | 10 | 40 | 15.3 | 18 |
| Oil power | 200 – 400 | 10 - 20 | 5 | 35 | 20 | 27 |

[a] Based on values report in "The UK 2050 Calculator" UK Government Department of Energy & Climate Change

[b] Based on values reported in Power Technology, 2014

[c] World Bank, 1998

[d] Volume 5 – Hydrology, Geomorphology and Water Quality Assessment (section 8)

[e] Source JCS Nenskra Hydro

[f] Included in OPEX – for hydropower OPEX is essentially maintenance cost

## 2.3.2 Alternative hydropower operation mode

The creation of the Nenskra reservoir is one of the main causes of the adverse impacts caused by the proposed Nenskra HPP in the Nenskra valley. The diversion of the Nakra River into the Nenskra reservoir is the main cause of the Project's adverse impacts in the Nakra Valley. Both components are related to the selected operation mode of the Nenskra HPP, i.e. regulation capacity through water storage upstream of the Nenskra dam. The paragraphs below examine possible alternatives to this water storage operation mode:

- Nenskra dam operated as a run-of-river (ROR) scheme;
- Nenskra dam operated without the Nakra River diversion, and
- Nenskra dam and Nakra dam operated independently.

### 2.3.2.1 Nenskra HPP operated as run-of-river

The two vital factors to consider for hydropower generation are the flow and the head of the river. The flow is the volume of water which can be captured and re-directed to turn the turbine generator, and the head is the distance the water will fall on its way to the generator. The larger the flow - i.e. the more water there is, and the higher the head - i.e. the higher the distance the water falls - the more energy is available for conversion to electricity.

The annual average flow and average monthly flow for the three months of winter are summarized in Table 3. These include both the natural Nenskra discharge and the derived Nakra flow. The combined average Nenskra and Nakra annual flows ate the dam site will be 25.7 m/s.

Should the Nenskra dam be operated as a ROR scheme, the power production during the three winter months would be much lower than the 120 MW required by the GoG; Only 40% of the required power generation could be achieved through a ROR operation during the winter months. This production would actually be lower because of the ecological flow that must be deducted from the available inflow. Without the inflow from the Nakra diversion (see Table 4), the winter production would even be lower than the targeted power generation.

**Table 3- Monthly inflow at proposed Nenskra dam site and power generation potential**

| Inflow | Monthly Average | | |
|---|---|---|---|
| | December | January | February |
| Nenskra + Nakra flow at dam site in $m^3/s$ | 8.3 | 6.7 | 6.3 |
| Available Power with ROR operation | 50 MW | 41 MW | 38 MW |
| Annual power generation with ROR operation | 36 GWh | 29 GWh | 28 GWh |
| Minimum power generation required to the Nenskra HPP | 89.3 GWh | 89.9 GWh | 82.9 GWh |

**Table 4- Monthly Inflow at proposed Nenskra dam site without Nakra diversion**

| Inflow | Monthly Average | | |
|---|---|---|---|
| | December | January | February |
| Nenskra River flow at dam site in $m^3/s$ | 5.4 | 4.3 | 4.1 |
| Available Power with ROR operation | 33 MW | 26 MW | 25 MW |
| Annual power generation with ROR operation | 24 GWh | 19 GWh | 18 GWh |
| Minimum power generation required to the Project | 89.3 GWh | 89.9 GWh | 82.9 GWh |

Operating the Nenskra Hydropower Project as a run-of-river scheme, with or without the Nakra River diversion, would not respond to the strategic objective established by the Government, i.e. to reduce the dependency of power import during the winter period. In this respect, this form of operation does not represent an alternative to the Nenskra HPP which has an annual regulation capacity allowing power production during the winter period.

#### 2.3.2.2 Nenskra reservoir without Nakra transfer

The scenario of the Nenskra HPP without the Nakra diversion has been examined during Phase 1 of the Feasibility Study of the Project in 2011. This scenario was further studied in 2014 as part of the Due Diligence on past studies conducted by K-water. The key conclusions of the power and energy simulations undertaken at that time are as follows:

- 120 MW Power in the months December, January and February can be provided in all cases, with or without the Nakra transfer;
- Without Nakra Transfer the annual energy production in average is 30% per year less than with the Nakra transfer, and
- Without Nakra Transfer, the firm annual production (i.e. the total energy that can be provided during at least 95% of the time) would be lower than the targeted 1,196 GWh of the Power Purchase Agreement established between JSCNH and ESCO.

Overall, without the contribution of the Nakra Tunnel, although the investment cost decreases, the electric output sensibly declines together with the overall profitability of the Project. The Power Purchase Agreement between JSCNH and ESCO was negotiated on the basis of an Internal Rate of Return which relies heavily on the Nakra transfer to achieve the annual power production target.

Alternatives with a higher Nenskra dam without the Nakra diversion are not considered as relevant for the present analysis. A higher Nenskra dam would mean a larger water storage capacity. This would increase the regulation capacity of the Nenskra HPP. The winter power production could then be higher however the annual power generation would remain unchanged. Without Nakra Transfer the annual energy production would remain in average 30% lower whether the dam is higher or not. The benefit of higher head would not significantly change that annual power generation.

#### 2.3.2.3 Nenskra HPP and Nakra HPP operated separately

This alternative was not studied during the previous stages of the Nenskra HPP preparation. For the same power generation objective, the construction and operation of two separated hydropower schemes would be less economically interesting than the planned Nakra transfer to the Nenskra reservoir. Assuming the Nenskra facilities are available (i.e. dam, headrace tunnel, powerhouse, transmission line) the additional cost for exploiting the Nakra hydropower potential is made of the cost of the transfer tunnel and the diversion weir only. If the Nakra hydropower potential had to be exploited independently, there would still be a need of a damming structure on the Nakra River and a headrace structure between the dam and the powerhouse. In addition, a new powerhouse and transmission line would have to be built.

Two alternatives could be considered for an alternative where Nenskra HPP and Nakra HPP would be operated separately:

- Option 1: Nakra HPP being operated with a water storage reservoir, and
- Option 2: Nakra HPP being operated as ROR scheme in addition of Nenskra.

At present there is no available public information on the technical or economic feasibility of a water storage reservoir HPP in the Nakra valley. The Ministry of Energy had identified the upper Nakra River has a potential hydropower site but operated as a Run-of-River (ROR) (see next paragraph). Assuming a water storage reservoir might be feasible, its E&S impacts would likely be of similar nature -if not worse because of the reservoir footprint- as the predicted impacts of the proposed Nakra diversion to the Nenskra reservoir. In this respect, this form of Nakra HPP operation does not represent an alternative to the Nakra diversion as planned by the Nenskra HPP.

A hydropower initiative on the Nakra River would likely be of RoR type. In 2011, the Ministry of Energy presented a potential HPP initiative[9] which is now outdated. It provided the following features for the Nakra 1 HPP which informs on what could have been a ROR HPP on the Nakra if the Nenskra HPP were not to divert the Nakra waters:

- Installed capacity of 14.8 MW, Average Annual Generation of 81 GWh, Turbines discharge capacity of 6.5 $m^3/s$ (2 turbines, 3.5 $m^3/s$ each);
- 5 metre high dam, gross head of 250 metre, 3.8 kilometre long headrace tunnel, 100 metre long penstock, transmission line of 3 kilometre, and
- Dam located upstream of the Naki village at an altitude of 1,350 metres above sea level, and immediately downstream of the confluence with the Laknashura River. Powerhouse located downstream of the Naki Village at 1,100 metres altitude.

A theoretical Nakra HPP that would produce the same annual energy as the Nakra transfer through the Nenskra reservoir would require a head of approx. 690 metres.

► Nenskra HPP and Nakra HPP operated separately could be an alternative to the Nenskra HPP. See Section 2.4 for comparative assessment.

Such a head would be achievable only if the Nakra HPP water intake was located upstream of the Lekverari River and the Nakra powerhouse downstream the Naki village. Any diversion of the Nakra River upstream of the Lekverari River for ROR hydropower generation would likely induce the same type of adverse effects as the proposed Nakra diversion to the Nenskra

[9] https://www.mzv.sk/documents/10182/13375/Nakra+1+HPP.pdf/ada18a8d-426d-407a-895a-51bf27fb1c65 - Web site of the Slovak Ministry of Foreign Affairs.

reservoir: it would reduce the capacity of the river to flush away accumulated sediments from debris flow and/or mudflow but to an extent depending on the diverted flow.

## 2.3.3 Alternative dam location, dam type and dam height

The alternatives analysis for various dam locations and dam heights was conducted during the prefeasibility stage (2011) and the feasibility stage (Phase 1 in 2011, Phase 2 in 2012).

### 2.3.3.1 Dam location

All Nenskra HPP facilities (dam and powerhouse) were selected in the Nenskra Valley upstream of the planned Khudoni HPP reservoir.

There are only a few narrow points in the upper reaches of the Nenskra valley which means that the number of possible dam sites is restricted. In total five dam sites have been identified in 2011 as suitable for dam construction. They are named Dam Site (DS) from 1 to 5 and are located on Map 2.1 next page and Figure 1 below[10]:

- Dam Site 1, 2 and 3 are located upstream of the dam site selected for the Project;
- Dam Site 4 is the dam site finally selected for the Project, and
- Dam Site 5 is located downstream of the dam site selected for the Project.


*Figure 1 - Location of Dam Site alternatives on the Nenskra River profile*

Based on the general cross-sections of the valleys, site inspections and geological assessments conducted during the Feasibility Studies:

- Dam sites 1 and 2 were suitable for arch dams only, and
- Dam sites 3, 4 and 5 were suitable for gravity dams.

The relation between the reservoir volume and the dam height is shown on Figure 2 below. It shows that the reservoir capacity-reservoir height relationship at Dam Site 2 and 3 are the least interesting. As an example, at Dam Site 2 a reservoir volume of 100 million cubic metres requires a dam height of 200 metres, whereas the required dam height at Dam Site 4 would only be 100 metres. For this reason, Dam site 2 and Dam Site 3 have not been considered as economically

[10] Stucky, 2012, Nenskra Hydropower Project, Phase II Initial Design, Selection of Dam Site, Dam Type and Dam Height

interesting and were not studied during the Feasibility Study stage. Besides, Dam Site 3 was assessed as not suitable due to geological problems in the foundations.

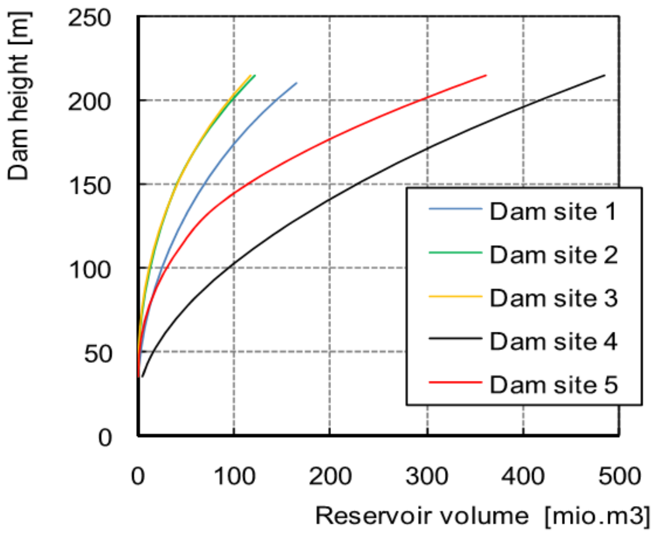



*Figure 2 - Relation between reservoir capacity and dam height for various dam locations*

Further geological and reservoir optimization studies made during the Feasibility Study demonstrated that the Dam Site 4 was a better technical and economical alternative than Dam Site 5. This is because the dam height (170 metres) needed to store the required volume of water and produce the minimum energy requirements at Dam Site 5 location would have required the construction of a much larger dam (~20 million cubic metres of material) than at Dam Site 4 location (~10 million cubic metres).

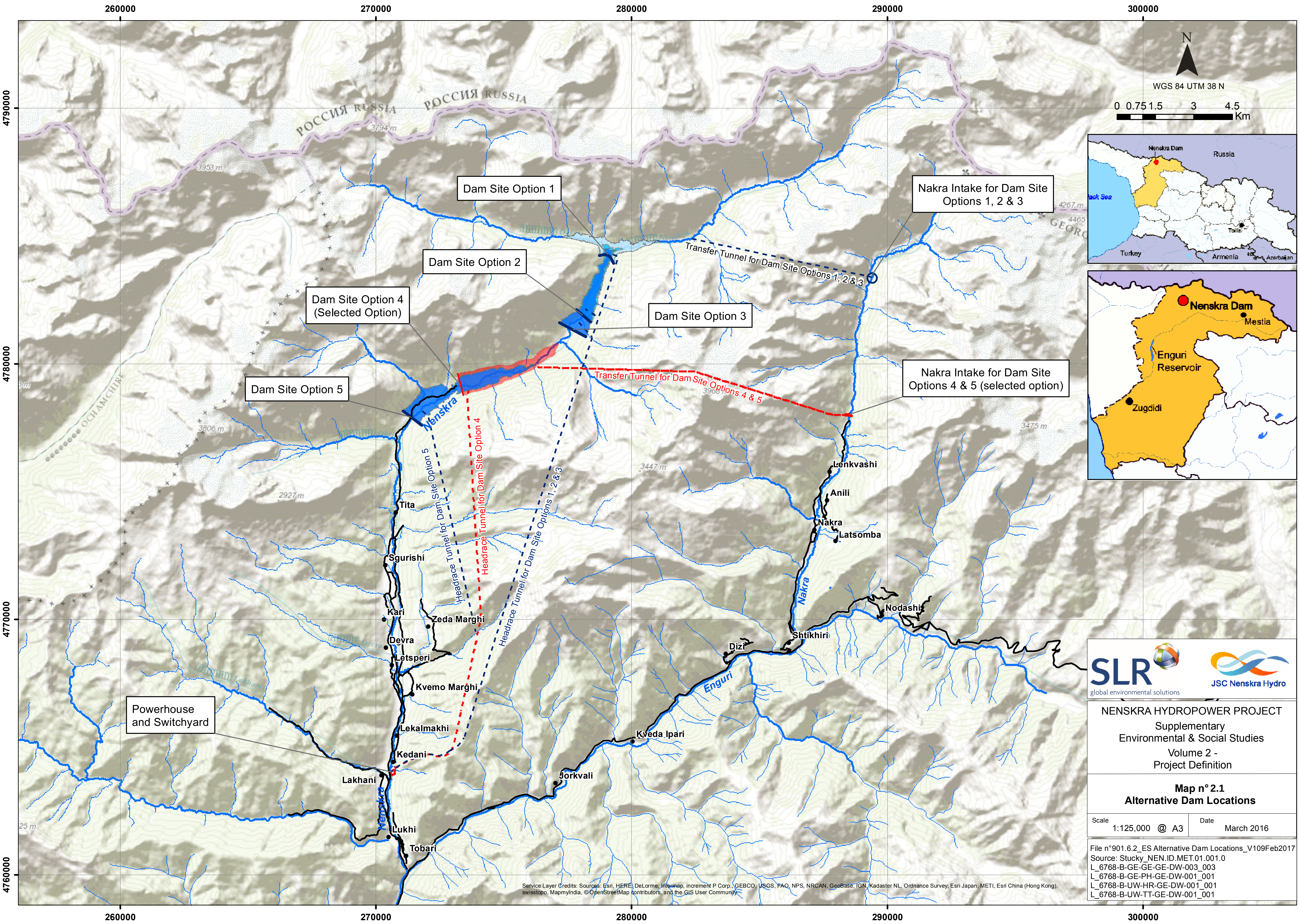
Dam Site 5 was therefore not further considered during the Feasibility Study. A dam site at location DS5 would also not be the preferred option in terms of environment and social issues. The footprint of both the dam and the associated reservoir would have been larger. The area of affected pasture would have been probably greater with more impaired accesses to subalpine areas. The benefit in terms of avoidance of sensitive habitats would have been negligible[11]. The requirements in terms of rockfill material would have been twice those needed for a dam at location DS4, hence the additional pressure on natural resources and landscape values.

An arch dam at Dam Site location DS1 with a height of 190 metres was therefore considered as the main technical alternative to a gravity dam located at DS4 during the feasibility stage.

► The Dam Site located at DS1 could be an alternative to the selected dam location DS4 of the Nenskra HPP. See Section 2.4 for comparative assessment.

That option would require a Nakra water intake located further upstream in the Nakra valley than the intake required for a dam built at Dam Site location DS4.

[11] See the map of habitat suitability in Volume 4 "Biodiversity Impact Assessment" of the Supplementary E&S Studies for the Nenskra HPP.



Dam Site Option 1
Dam Site Option 2
Dam Site Option 3
Dam Site Option 4 (Selected Option)
Dam Site Option 5
Nakra Intake for Dam Site Options 1, 2 & 3
Nakra Intake for Dam Site Options 4 & 5 (selected option)
Transfer Tunnel for Dam Site Options 1, 2 & 3
Transfer Tunnel for Dam Site Options 4 & 5
Headrace Tunnel for Dam Site Option 5
Headrace Tunnel for Dam Site Option 4
Headrace Tunnel for Dam Site Options 1, 2 & 3
Powerhouse and Switchyard
Nenskra
Nakra
Enguri
РОССИЯ RUSSIA
Tita
Sgurishi
Kari
Zeda Marghi
Devra
Letsperi
Kvemo Marghi
Lekalmakhi
Kedani
Lakhani
Lukhi
Tobari
Lenkvashi
Anili
Nakra
Latsomba
Nodashi
Shtikhiri
Dizi
Kveda Ipari
Jorkvali
WGS 84 UTM 38 N
0 0.75 1.5 3 4.5 Km
Nenskra Dam
Russia
Black Sea
Tbilisi
Turkey
Armenia
Azerbaijan
Nenskra Dam
Mestia
Enguri Reservoir
Zugdidi
SLR global environmental solutions
JSC Nenskra Hydro
NENSKRA HYDROPOWER PROJECT
Supplementary Environmental & Social Studies
Volume 2 - Project Definition
Map n° 2.1
Alternative Dam Locations
Scale 1:125,000 @ A3
Date March 2016
File n°901.6.2_ES Alternative Dam Locations_V109Feb2017
Source: Stucky_NEN.ID.MET.01.001.0
L_6768-B-GE-GE-GE-DW-003_003
L_6768-B-GE-PH-GE-DW-001_001
L_6768-B-UW-HR-GE-DW-001_001
L_6768-B-UW-TT-GE-DW-001_001

#### 2.3.3.2 Dam types

There are two main types of possible gravity dams:

- Concrete Gravity Dam: Conventional concrete dam constructed on good quality rock foundations. For faster construction of large volume dams, concrete mix is varied so as to allow placement by machines on a continuous basis – thus Roller Compacted Concrete. RCC mixes would contain significant amounts of fly-ash (to be imported from Turkey) to reduce the proportion of cement.
- Embankment dams: Water impermeability can be provided by a central clay core. Where clay is not available locally (which is the case in Nenskra valley), then asphalt can be used as an alternative. If suitable rock fill is available in quality and quantity close to the dam site, a rock fill dam with a central core or an upstream facing is possible.

Four types of gravity dams were examined during the Feasibility Stage and detailed design:

- Roller compacted concrete dam (RCCD), and
- Rockfill dam options:
  - Concrete Faced Rockfill Dam (CFRD);
  - Asphalt Core Rockfill Dam (ACRD), and
  - Asphalt Faced Rockfill Dam (AFRD).

In view of the site at DS4, based on geological assessments and the expected height of the dam the following were concluded:

- RCCD depends on the availability of strong rock close to the surface. Geological investigations conducted during the Feasibility Study showed that this was not the case. This alternative was ruled out in 2012, and
- Likewise, the CFRD alternative was assessed as not suitable in 2012 because of potential important deformation of the alluvial/colluvial deep foundation of the dam which may induce damages in the concrete facing and its joints.

The ACRD solution was therefore selected at the end of the Feasibility Stage in 2012. In 2015, the EPC Contractor proposed the AFRD alternative. As the two options do not have significant differences in terms of environmental or social gain/impacts, the AFRD alternative was ultimately chosen on cost grounds. In this respect, alternatives to the AFRD type are not considered as relevant for the present analysis.

#### 2.3.3.3 Dam Height

The Feasibility Study has examined several alternatives for the dam height at location Dam Site 4 (the preferred location). A dam of 140 metre height had been identified as the optimal height to achieve the production objectives (annual and winter).

A lower dam would have been less expensive to build but the reservoir volume would have been too small to achieve the annual power production target. Since no involuntary resettlement would result from the reservoir impoundment at dam height 140 metres, there were no critical environmental or social factors that would have imposed a lower dam alternative. The U-shape of the valley and the low gradient of the riverbed slope upstream of the proposed Dam Site 4 location allow a large water storage volume with a small reservoir footprint. Reducing the dam height would reduce the water volume stored in the reservoir but would have a limited benefit in terms of reduced reservoir footprint at full supply level (see Table 5). A reduction in 50% of the reservoir footprint would require a reduction in 80% of the reservoir volume. A dam height reduction of 30 metres (110 metres high) would reduce the reservoir footprint in 15% but the reservoir volume in 35%. The environmental or social benefit of a smaller dam would therefore be minor while the loss of reservoir volume, hence the electric output and overall profitability would be significantly affected. A smaller dam height was therefore not considered as a relevant project alternative.

The selected dam height (125 metres at crest level at Dam Site 4) was also assessed against higher dam alternatives (150, 160 and 170 metres). It was found that the optimum solution in terms of overall profitability corresponds to a dam structure 10 metres higher than the proposed one. The technical feasibility of increasing the dam height of 10 metres was however further studied after the completion of detailed site geological investigations. With an Asphalt Core Rockfill Dam type, a dam heightening was not advisable anymore for construction constraints.

**Table 5 - Relation dam height / reservoir footprint**

| Dam height at Location DS4 | Reservoir footprint at FSL | Volume stored in the reservoir (million $m^3$) |
|---|---|---|
| 140 m (1,440 m asl) | 2.8 $km^2$ | 207 $Mm^3$ |
| 110 m (1,410 m asl) | 2.4 $km^2$ | 133 $Mm^3$ |
| 90 m (1,390 m asl) | 2 $km^2$ | 89 $Mm^3$ |
| 70 m (1,370 m asl) | 1.6 $km^2$ | 53 $Mm^3$ |
| 60 m (1,360 m asl) | 1.4 $km^2$ | 38 $Mm^3$ |

*Source: Stucky, 2012, Phase II Initial Design, Reservoir Simulation and Power and Energy Studies*

In terms of E&S issues, higher dam alternatives would result in larger adverse impacts. No alternatives with higher dams at the selected location were therefore examined.

### 2.3.4 Alternative powerhouse location

One of the main factors that determine the power produced by a hydroelectric scheme is height difference between the powerhouse and the reservoir water level. The greater the difference in elevations the greater the power produced. Consequently, to maximise the Nenskra power production capacity, the powerhouse has been located as far downstream from the dam as possible in the Nenskra valley while respecting the following constraints:

- Powerhouse positioned upstream of the proposed Khudoni HPP reservoir level (altitude 702 metres asl).
- Powerhouse aligned with the selected route for the headrace tunnel and penstock respecting the actual topographic and geological conditions of the area.

The 3 potential powerhouse locations that have been evaluated in 2012 are illustrated below in Figure 3. It should be noted that it is not feasible to position the powerhouse farther downstream because of the inundated area of the future Khudoni reservoir and because of topographical constraints – as the downstream area is a deep and narrow gorge.

Option C is the location selected by JSCNH in 2015. In the figure the headrace tunnel is indicated by a black line, the penstock is indicated by a red line. Their locations are dictated by the topography of the series of ridges on the left bank of the valley. All sites have similar topographic conditions, i.e. stable slopes and areas of flat land close to the River to allow the development of an aboveground powerhouse.

All 3 powerhouse location alternatives cause physical displacement because of the land acquisition required for the permanent facilities (powerhouse and penstock) – and the temporary facilities (construction camps and technical installations). The land acquisition requirements and process are described in Vol. 9 - Land Acquisition and Livelihood Restoration Plan (LALRP). Option B and C would require the physical displacement of 3 households and

Option A would require physical displacement of at least 4 households. In this context, Options A and B would not bring any social benefit while Option C would be (i) lower, hence creating a higher head, and (ii) located at the south end of the village, hence more isolated. Option C was selected in 2015 without further alternatives analysis (see section 2.5.2.4 for input of the E&S team into the final design to avoid permanent physical displacement).

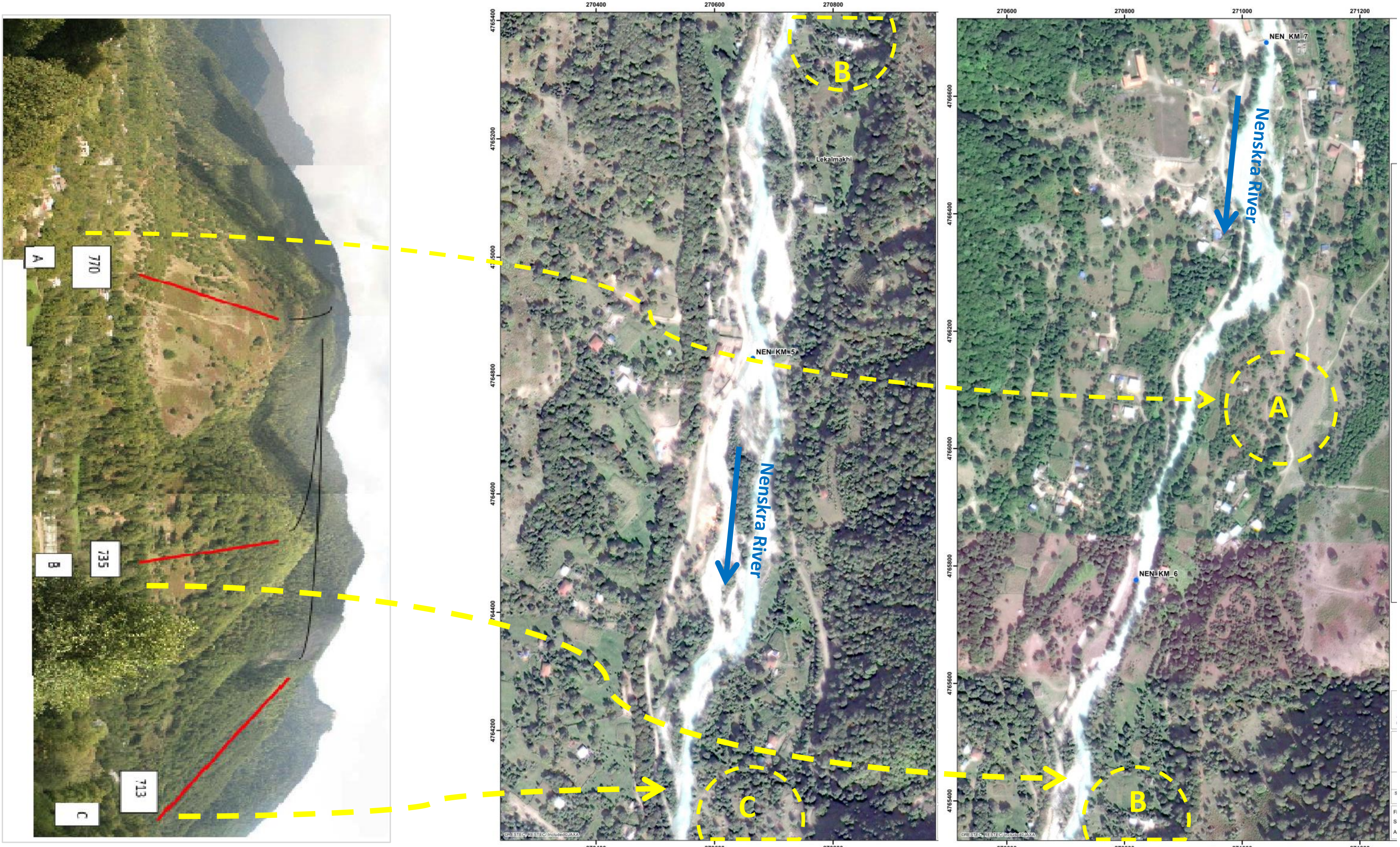



*Figure 3 - Options for the Powerhouse location*

### 2.3.5 No project alternative

The Project is justified by the need for additional power production capacity to meet the expected growth of power demand in Georgia. During the winter period the country is currently dependent on the importation of electricity from neighbouring countries and power produced by thermal power plants functioning with imported hydrocarbon fuels.

The present analysis assumes that the need for domestic power generation during the winter period is not questionable. In this context, if the proposed Nenskra HPP were not to be undertaken the Government would need to seek for an alternative investment that provides the same energy quantity during the winter period. It is assumed that establishing additional power connections with neighbouring countries through the construction of new transmission lines is not an alternative to the Nenskra HPP. Consequently, there are only 2 types of investment that can provide the same service as Nenskra HPP: (i) a thermal power plant of the same capacity or (ii) another large hydropower project with the same regulation capacity.

- Building a thermal power plant of similar capacity as the Nenskra HPP would represent the same alternative as presented in Section 2.3.1.2 above. It is further analysed against the other alternatives to the Nenskra HPP in Section 2.4, and
- As presented in Section 1.3, four hydropower projects have been identified by the Ministry of Energy as able to provide a large regulation capacity in Georgia: the Khudoni HPP (700 MW), the Oni HPP cascade (180 MW), the Namakhvani HPP Cascade Project (430 MW) and the Nenskra HPP (280 MW). When the present report was prepared, out of these four proposed HPP projects the Nenskra HPP was the most advanced (early works started in 2015, see Section 4.1.1). The commissioning dates for the Oni HPP cascade and the Namakhvani HPP Cascade are planned for two or three years after the commissioning date of the Nenskra HPP. The Khudoni HPP development experiences some delays due to strong local opposition.

The No Project Alternative would likely result in either the increase of power import from neighbouring countries or the development of new thermal plant to compensate the absence of winter power production.

A high level assessment of the GHG emissions produced by the three types of winter power supply (Nenskra HPP; Combined Cycle Gas Thermal Power Plant; Power import through transboundary grid) is presented in Table 6 below. The assumptions for the Nenskra HPP and a CCGT power plant greenhouse gas emissions are those described in Section 2.3.1.2. The grid electricity emission factors used to estimate the GHG emissions associated with electricity purchased from the grid are taken from the EBRD Greenhouse Gas Assessment Methodology (2010).

**Table 6 - Estimate of GHG emissions for the No Project alternative**

| | Nenskra HPP | CCGT Power Plant | Power import through Grid |
|---|---|---|---|
| Emission factor | 0.059 $tCO_2$-eq/MWh | 0.455 $tCO_2$-eq/MWh | From Russia: 0.538 $tCO_2$/MWh |
| | | | From Turkey: 0.703 $tCO_2$/MWh |
| GHG emissions during the winter period for 260 GWh | 14,842 $tCO_2$-eq | 118,300 $tCO_2$-eq | From Russia: 139,880 $tCO_2$-eq |
| | | | From Turkey: 182,780 $tCO_2$-eq |
| GHG emissions for Annual Generation of 1,196 GWh | 69,190 $tCO_2$-eq | 551,460 $tCO_2$-eq | - |

The No Project Alternative would avoid the predicted adverse environmental or social impacts met locally. But it would also rule out the expected positive impacts at national level which justify the Project. Those are the reduction of dependence on import of electricity and fossil fuels necessary for operation of thermal power plants in the winter period, flexibility of electric outputs in line with load changes, stable and reliable input to the Grid. They also include (i) the contribution to the attractiveness of the country to as Foreign Direct Investment destination, and (ii) the development of a strategic asset, which will be then returned to public ownership.

The main environmental benefit of the Nenskra HPP against the "No Project" alternative is linked to the reduction of GHG emissions. Table 6 shows that the Nenskra HPP would avoid the emission of about 100 Kt$CO_2$-eq per winter compared to a CCGT Power plant (125 Kt$CO_2$-eq / winter compared to the use of transboundary transmission line). The Project would further avoid the emission of 480 Kt$CO_2$-eq per year compared to a CCGT Power plant.

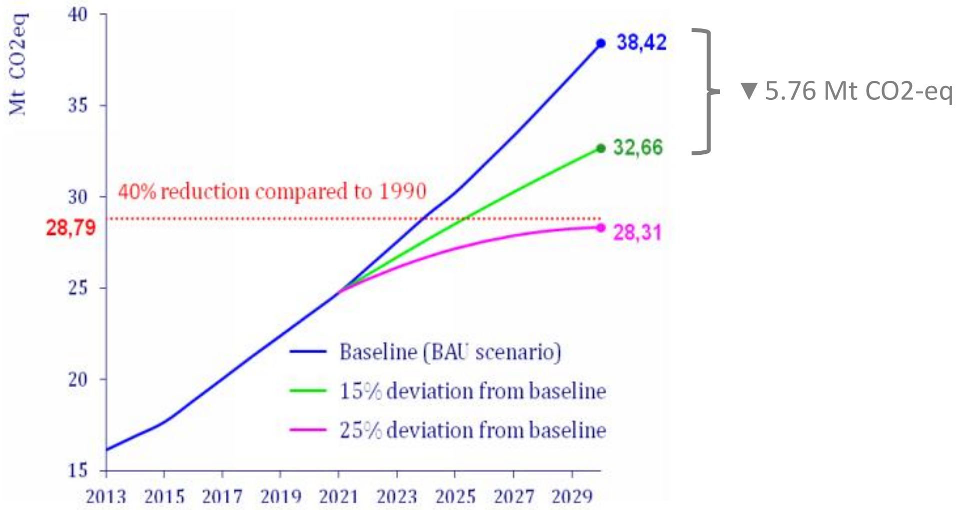



*Figure 4 - Intended nationally determined contribution (INDC) of Georgia to GHGs reduction*

According to the Third National Communication of Georgia to the UNFCCC, GHG emissions from Georgia in 2011 constituted 16,036 Kt$CO_2$eq. As part of its Intended Nationally Determined Contribution submitted to the UNFCCC[12], Georgia plans to unconditionally reduce its GHG emissions by 15% below the Business As Usual scenario for the year 2030 (see Figure 4). This objective of 15% reduction corresponds to 5,760 Kt$CO_2$-eq per year, all sectors together (e.g. electricity generation, transport, industry, residential, commercial agriculture). The contribution of the only Nenskra HPP to this national objective would therefore be of 8% if we consider an annual power production, which is significant. Should the Project be not undertaken, the country would have to find other solutions to reduce its GHG emission by as much.

## 2.3.6 Evaluation

The summary of the evaluation of the alternatives presented in Section 2.3 is presented in the following table.

**Table 7 - Summary of evaluation of alternatives**

| Alternative | Evaluation |
|---|---|
| Alternative technology | Alternative to hydropower using intermittent source of energy such as wind or solar will not achieve one of the purposes of the Project, i.e. power generation during winter period. They were rejected.<br>New and efficient thermal power plant such as Combined Cycle Gas Turbine Power Plant could be an alternative. Alternative 1. |

[12] See https://unfccc.int/files/adaptation/application/pdf/all__parties_indc.pdf

| Alternative | Evaluation |
|---|---|
| Alternative operation mode | Operating the Nenskra dam as a run-of-river scheme would not achieve one of the purposes of the Project, i.e. power generation during winter period. Operating the Nenskra HPP without the additional input from the Nakra hydropower potential would not achieve another purpose of the Project, i.e. annual power generation of 1,200 GWh. Both alternatives were rejected.<br>Operating the Nenskra HPP with a water storage reservoir and a Nakra HPP on a run-of-river mode could be an alternative. Alternative 2. |
| Alternative dam location and dam type | Dam location and dam type are closely related. At the selected Dam Site (DS4), the dam had to be a rockfill dam. At the alternative dam site DS1, the dam had to be an arch dam and could be an alternative to the selected dam site DS4. Alternative 3.<br>The other dam location alternatives have been rejected either for geological reasons or for technical, economic and environmental reasons. |
| Alternative dam height | There are no environmental or social gains to expect from a lowering for the Nenskra dam due to the topography of the valley upstream of the dam. There were geological and environmental reasons to not increase the height of the dam. Alternative dam heights were rejected. |
| Alternative powerhouse location | Out of the three possible powerhouse alternative locations, the Project selected the option that was the less impacting in terms of involuntary resettlement and location outside the Chuberi village. The two other options were rejected. |
| No Project Alternative | Leaves the Nenskra water resource undeveloped. Avoids the negative E&S impacts but economic and environmental benefits at national or global level would be forgone. Alternative rejected. |

## 2.4 Comparative assessment of alternatives

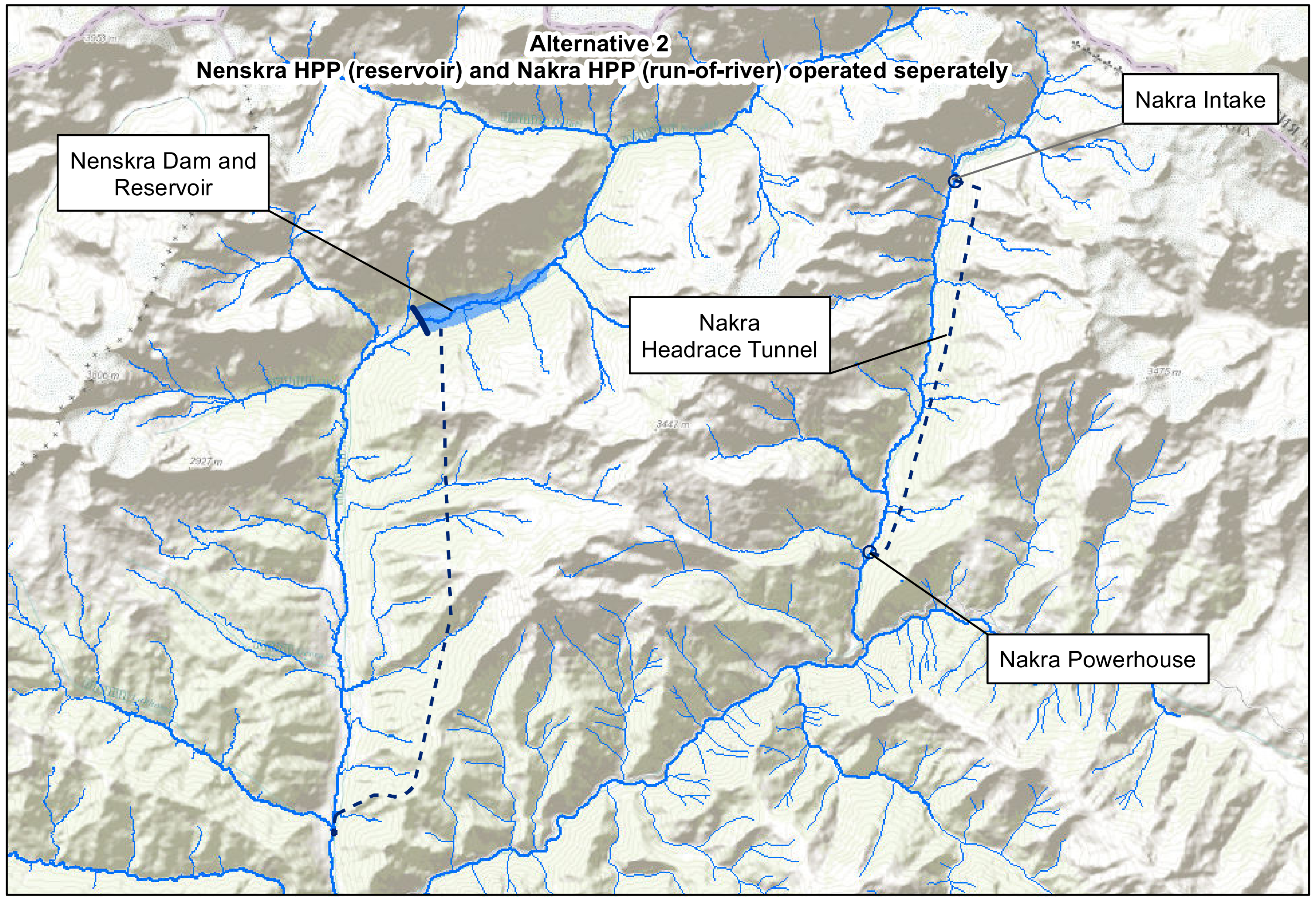
The alternatives selected for comparative assessment are the three alternatives listed in Table 7 and the alternative eventually selected by JSCNH:

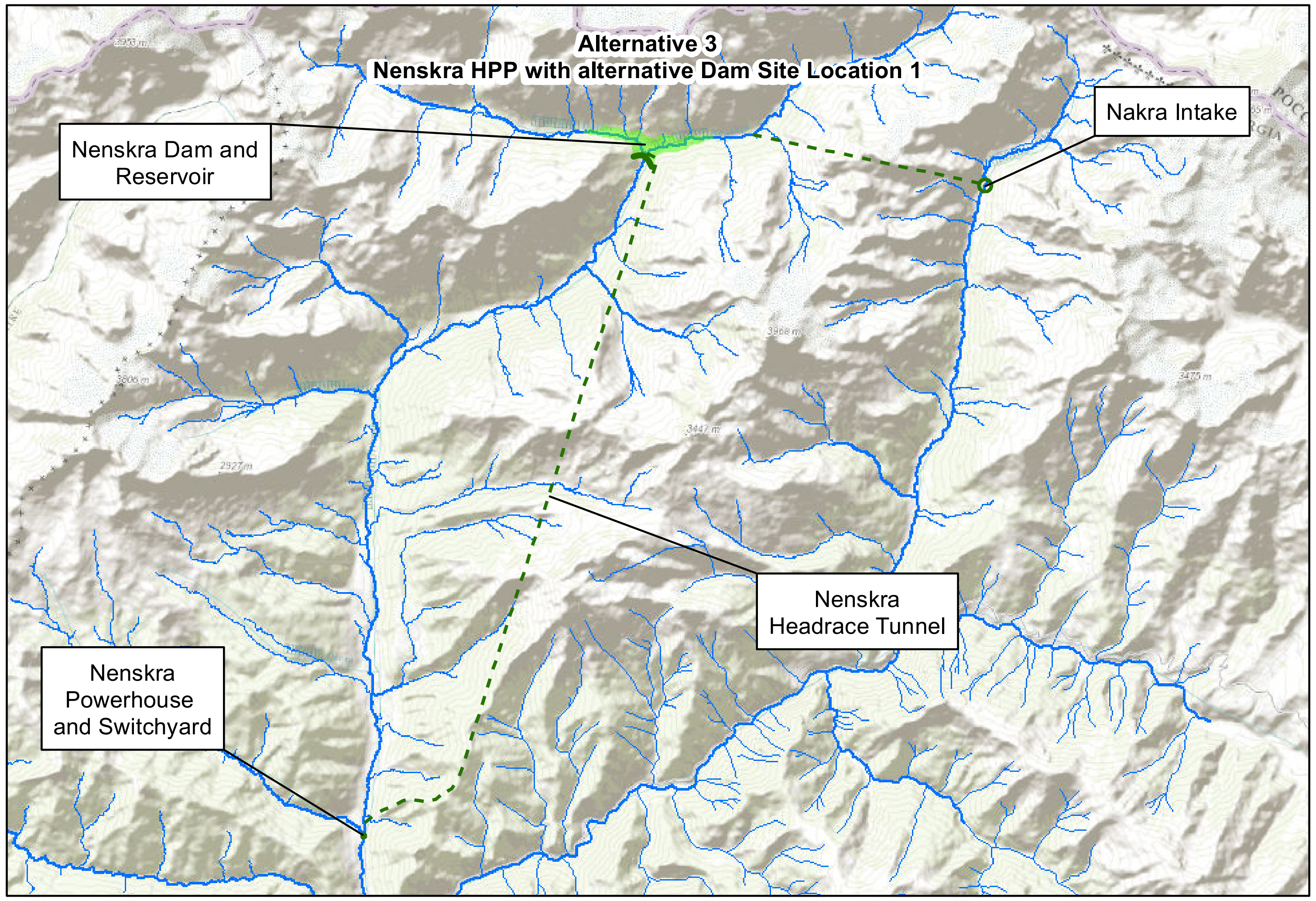
- Alternative 1 is a Combined Cycle Gas Turbine Power Plant of similar power production capacity;
- Alternative 2 is the Nenskra HPP (water storage reservoir) and a Nakra HPP (run-of-river) operated separately;
- Alternative 3 is the Nenskra HPP with a 190 m high arch dam located in the upstream reaches of the Nenskra valley, and
- Alternative 4 is the Nenskra HPP with a 125 m rockfill dam located in Dam Site Option 4 and the powerhouse located at site C (i.e. the selected alternative).

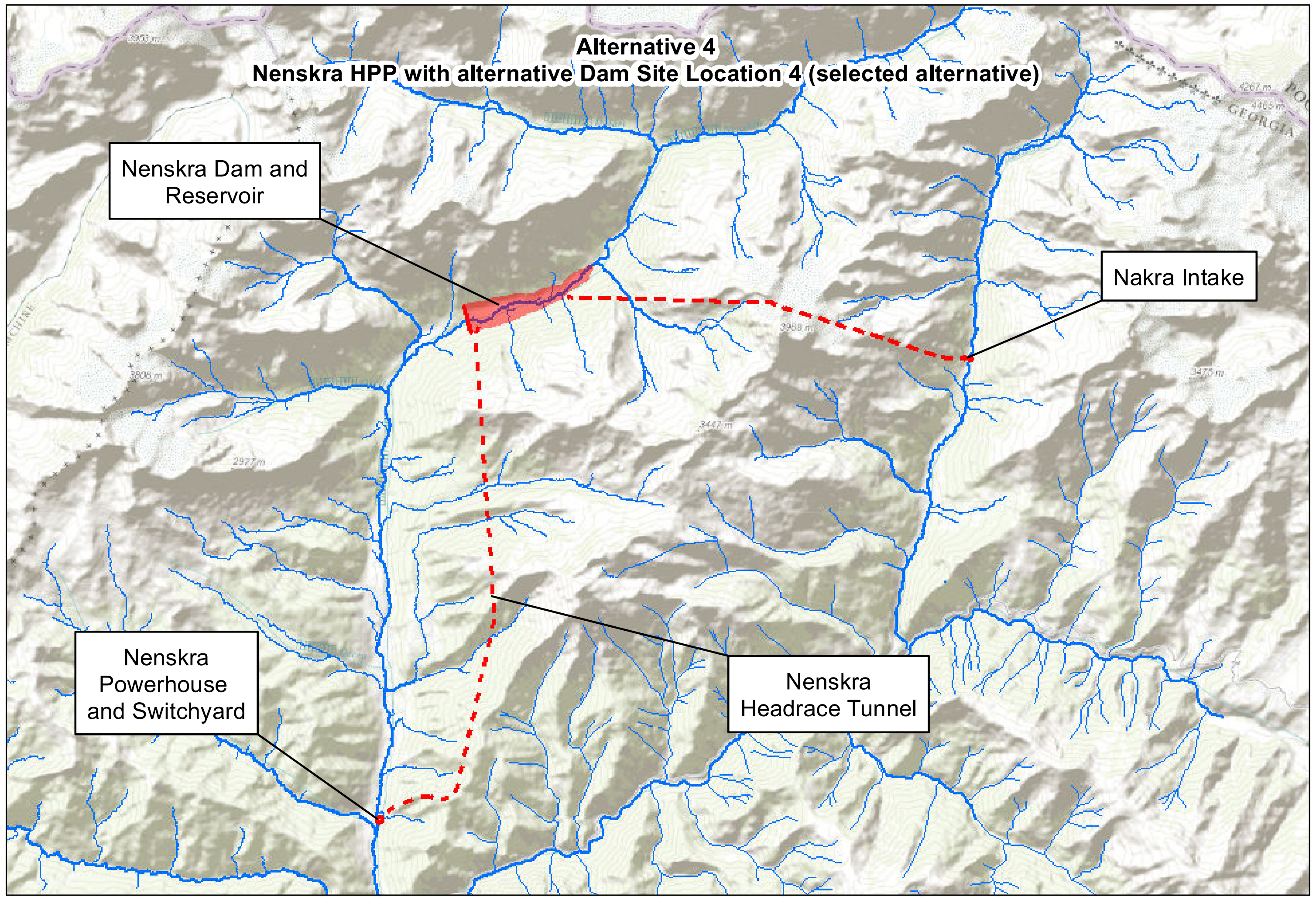
The detailed design alternatives listed in Section 2.5.1 are not compared in this chapter since by essence they are the preferred ones in terms of E&S aspects. Map 2.2 illustrates the layout of the three hydropower alternatives (Alternatives 2, 3, 4). Alternative 1 could be located anywhere in the country; it is not shown on the map.

The layout shown for Alternative 2 (Nenskra HPP and a Nakra HPP operated separately) is theoretical; it has never been studied. The Nakra water intake and the Nakra Powerhouse have been positioned in order to create the same gross head (~690 m) as the gross head created by Alternative 4.

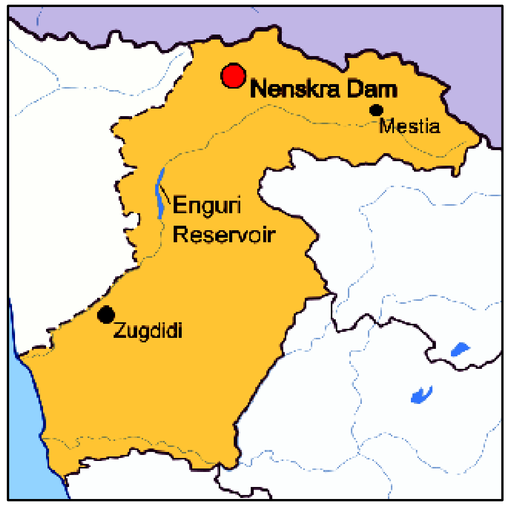
Table 8 compares the four alternatives using the social, environmental and strategic criteria. The quantitative information was obtained from the supplementary E&S investigations conducted in 2015, as documented in Volume 3 (Social Impact Assessment), Volume 4 (Biodiversity Impact Assessment), Volume 5 (Hydrology and Water quality impact assessment).





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SLR global environmental solutions

JSC Nenskra Hydro

NENSKRA HYDROPOWER PROJECT

Supplementary Environmental & Social Studies

Volume 2 - Project Definition

**Map n°2.3**

**Assessment of Hydropower Alternatives**

| Scale | Date |
|---|---|
| 1:200,000 @ A3 | February 2017 |

File n°
901.6.2_ES Assessment of Hydropower Alternatives_V09Feb2017
Source: Stucky_NEN.ID.MET.01.001.0
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## Table 8 - Comparative assessment of alternatives

| | Assessment Criteria<br>High Hi<br>Moderate M<br>Low Lo | Alternative 1<br>CCGT Power plant | | Alternative 2<br>Dam Site location DS4<br>Nenskra HPP + Nakra HPP operated independently | | Alternative 3<br>Arch dam located at DS1<br>Nenskra HPP with Nakra transfer | | Alternative 4<br>Dam Site location DS4<br>Nenskra HPP with Nakra transfer | |
|---|---|---|---|---|---|---|---|---|---|
| Social | Resettlement | > Land requirements <5ha<br>> Higher flexibility than hydropower alternatives.<br>> No resettlement achievable. | Lo | > Land requirements ~890ha: Alt 4. area + land requirements for Nakra powerhouse<br>> Two potentially affected households (same as Alt. 4) + possible risk at Nakra Powerhouse | Hi | > Land requirements ~600ha: Alt 4. area with 50% lower reservoir footprint<br>> Two potentially affected households (same as Alt. 4) | Hi | > Land requirements ~880ha: 70% Dam site, 20% powerhouse, 5% Nakra intake, 5% lines.<br>> Two potentially affected households at powerhouse area. | Hi |
| Social | Economic Displacement | > Higher flexibility than hydropower alternatives.<br>> Likely use of required land by third party but easier to identify and compensate. | Lo | > Pasture area, access to pasture areas, and logging areas affected by Nenskra reservoir and Nakra intake (same as Alt. 4)<br>> Possible additional activities affected by Nakra powerhouse.<br>> Agriculture and water supply not affected | Hi | > Reservoir located upstream existing pasture and logging areas<br>> Site installations at dam site and Nakra intake could still affect pasture areas.<br>> Agriculture and water supply not affected | M | > Small pasture areas and access to pasture areas affected at dam site (reservoir and site installations) and Nakra intake<br>> Logging areas affected at dam site although reservoir already heavily logged.<br>> Agriculture and water supply not affected | M |
| Social | Community Health & Safety | > Health: Air emissions from gas combustion<br>> Safety: Risks are traffic accidents during construction and jet fire from or Unconfined Vapour Cloud Explosion from gas leak during the operation.<br>> Mitigated through safety distance and design standards. | M | > No significant health impacts<br>> Safety: same as Alt. 4. Traffic accidents (construction); Sudden release of water downstream of Nenskra dam and reduced bedload capacity downstream of Nakra weir (operation).<br>> Mitigated through public awareness campaigns, emergency planning and structural measures | M | > No significant health impacts<br>> Safety: same as Alt. 4. Traffic accidents during construction and downstream hazards during operation. | M | > No significant health impacts<br>> Safety: Traffic accidents during construction. Sudden release of water downstream of Nenskra dam and reduced bedload capacity downstream of Nakra weir during operation.<br>> Mitigated through public awareness campaigns, emergency planning and structural measures. | M |
| Biodiversity | Loss of sensitive habitats | > Site specific but construction within forested areas, or wetland of conservation importance, is unlikely. Usually close to urban areas to reduce connection distance to consumer canters. | Lo | > Loss of ~3 km² of degraded mixed Broadleaf & Conifer Woodland (Nenskra reservoir) - Same as Alt. 4<br>> Loss of ~2 km ² of degraded Broadleaved Woodland in Nenskra powerhouse and Nakra intake - same as Alt. 4<br>> Possible additional forested area affected at Nakra powerhouse. | Lo | > Loss of ~1 km² of undisturbed mixed Broadleaf and Conifer Woodland (reservoir)<br>> Loss of ~1 km² of degraded Broadleaved Woodland in powerhouse and Nakra areas (same as Alt. 4) | Hi | > Loss of ~3 km² of degraded mixed Broadleaf and Conifer Woodland (reservoir)<br>> Loss of ~2 km ² of degraded Broadleaved Woodland in powerhouse and Nakra intake areas | Lo |
| Biodiversity | Pressure on threatened species | > Project-induced access to isolated areas resulting in additional pressure on hunting or illegal logging is unlikely. | Lo | > Non-significant loss of habitat for threatened species (e.g. bear and lynx) and Reduced access to upper part of Nenskra valley due to physical obstacle made of the Nenskra reservoir (Same as Alt. 4). | Lo | > Loss of habitat for threatened species (e.g. bear and lynx)<br>> Project-induced access to upper parts of Nenskra and Nakra valleys resulting in additional pressure on hunting and/or logging. | M | > Non-significant loss of habitat for threatened species (e.g. bear and lynx)<br>> Reduced access to upper part of Nenskra valley due to physical obstacle made of the Nenskra reservoir. | Lo |
| Biodiversity | River fish | > Unlikely effect on fish population or distribution. | Lo | > 17 km of Nenskra River and 8 km of Nakra River affected by flow diversion<br>> Spawning areas of *Salmo trutta* within and upstream of Nenskra reservoir. Migration discontinued in Nenskra valley. Same as Alt. 4 | M | > 25 km of Nenskra River and 16 km of Nakra River affected by flow diversion<br>> Spawning areas of *Salmo trutta* in area affected by dam and Nenskra reservoir affected area. Migration discontinued in Nenskra valley (no fish pass). | Hi | > 17 km of Nenskra River and 10 km of Nakra River affected by flow diversion<br>> Spawning areas of *Salmo trutta* upstream of Nenskra reservoir. Downstream migration discontinued in Nenskra valley (no fish pass). | M |
| National | Dependency on fossil fuel import | > Georgia is not an O&G producer. High dependency on gas or other fossil fuel import. | Hi | > Only during construction | Lo | > Only during construction | Lo | > Only during construction | Lo |
| National | Greenhouse Gas Emissions | > 546 KtCO2-eq/year - 6 times HPP alternatives<br>> Goes against COP 21 commitments | Hi | > Less than 80 KtCO2-eq/year<br>> Contributes to attaining COP 21 commitments | Lo | > 80 KtCO2-eq/year<br>> Contributes to attaining COP 21 commitments | Lo | > 80 KtCO2-eq/year<br>> Contributes to attaining COP 21 commitments | Lo |
| National | Risk on profitability | > Investment costs 50% of HPP alternatives<br>> Operation costs exposed to O&G price variations | M | > Investment and operation costs and higher than Alt. 4 (Nakra powerhouse)<br>> Technical feasibility of 700 m head HPP in Nakra not demonstrated. | Hi | > Higher head / lower storage volume option<br>> Dam types restricted, cost viability depends on best case geological conditions | M | > Lower head / higher storage volume option<br>> Best technical option with low implementation risks | Lo |

## 2.5 Selection of preferred alternative

### 2.5.1 Selected alternative

Hydropower technology (Alternatives 2 to 4) has been preferred to thermal power technology (Alternative 1) for strategic reasons, namely lower dependency to fossil fuel import and to oil and gas price variations. This choice was made by the Government of Georgia prior to the creation of JSCNH. In terms of environmental aspects, the main benefit of that decision is a greater contribution to the country's reduction in greenhouse gas emissions. Amongst the three hydropower alternatives, Alternative 4 assessed in Table 8 is the alternative selected by JSCNH for the development of the Nenskra HPP. This alternative is the preferred technical and economical hydropower solution in the Nenskra valley to meet the Project objectives in terms of winter and annual power production. The E&S impacts associated with this decision are considered to be equal or preferential as assessed in Table 8. Table 9 next page summarizes the main technical characteristics of the Nenskra HPP as described and assessed in the volumes of the Supplementary E&S studies, including the present report.

### 2.5.2 Environmental and social contributions to detailed design

In 2016, the EPC Contractor prepared the basic design of the Nenskra HPP components. JSCNH required a number of improvements to align on the latest findings of the Supplementary E&S studies. These changes are summarized below and further justified in the relevant Supplementary E&S study. The project components described in Section 3 take into account the changes required by JSCNH E&S team.

#### 2.5.2.1 Fish pass for the Nakra water intake

The construction of the diversion weir on the Nakra River has the potential to cause the loss of ecological continuity with respect to the fish population in the river. The Environmental Permit awarded in October 2015 by the GoG requires that a fish pass be installed on the Nakra River. The 2015 ESIA made no provisions with regard to the type of fish pass. The initial design proposed in 2015 by the EPC Contractor was a Larinier baffle type pass. As part of the Supplementary E&S Studies, and for reasons described in Vol. 4 "Biodiversity Impact Assessment", a different concept design of the fish pass was recommended and adopted by the Project. The fish pass will be of a type that is (in part) a "close to nature" natural channel type fish pass. The aim of the "close to nature" type pass is to resemble in form and function a side channel or natural tributary of the main river system. The conceptual design was prepared by the Supplementary E&S Studies Biodiversity Team in order to provide guidance so that the EPC contractor may design the fish pass once the location and elevations of the Nakra Weir and diversion tunnel have been subject to detailed design. No fish pass has been envisaged for the Nenskra dam as there is no efficient fish pass technology for very high dams such as the proposed Nenskra dam.

#### 2.5.2.2 Road alignment in the Nenskra Valley

In 2015, the initial design for dam access road planned to locate a new section of road on the left bank of the Nenskra River downstream from Chuberi. In order to avoid the resulting physical and economic displacement caused by this, JSCNH decided to upgrade the existing public road located on the right bank. This also provides the Chuberi community with an improved road which enables them to easily reach – and all year - the main road to Mestia road.

**Table 9 - Technical characteristics of the Nenskra HPP at a glance**

| Nenskra reservoir system | Characteristics |
|---|---|
| Dam height above riverbed | 125 m Asphalt Face Rockfill Dam |
| Dam crest length | 870 m at 1,436 m above sea level |
| Reservoir full supply level | 1,430 m above sea level |
| Reservoir minimum operating level | 1,340 m above sea level |
| Reservoir area and length at full supply level | 2.67 $km^2$ over 4.34 km |
| Live reservoir storage | 176.15 million $m^3$ |
| Nenskra watershed area at dam site | 222 $km^2$ |
| Nenskra Average Annual flow at dam site | 16.8 $m^3/s$ |
| Net annual evaporation in the reservoir | 50 mm |
| Sediment inflow at dam site from Nenskra River | 60,000 $m^3$ per year |
| Mandatory Ecological Flow | 0.9 $m^3/s$ |
| Peak flood discharge (1/10,000e) | 300 $m^3/s$ |
| Probable Maximum Flood | 1,145 $m^3/s$ |
| Headrace tunnel length and diameter | 15.1 km long by 4.5m |
| Nakra water intake system | Characteristics |
| Height of diversion weir above river bed | 8.70 m |
| Head pond area | Less than 1 hectare |
| Nakra watershed area at diversion weir site | 87 $km^2$ |
| Nakra Average Annual flow at diversion weir site | 9.3 $m^3/s$ |
| Diversion of Nakra flow to Nenskra reservoir | Up to a maximum of 45.5 $m^3/s$ |
| Mandatory Ecological Flow | 1.2 $m^3/s$ |
| Peak flood discharge (1/10,000e) | 263 $m^3/s$ |
| Probable Maximum Flood | 472 $m^3/s$ |
| Nakra transfer tunnel length and diameter | 12.25 km long by 3.5 m |
| Powerhouse system | |
| Type | Surface powerhouse |
| Installed power capacity - Installed discharge capacity | 280 MW - 47 $m^3/s$ |
| Turbines | 3 Pelton units of 93 MW each |
| Turbine level | Turbine level 705 m a above sea level |
| Monthly average net water head | 703m |
| Penstock length and diameter | 1,790 m long by 3 m diameter |
| Average annual generation | 1,196 GWh |
| 95% firm annual energy | 885 GWh |
| Minimum winter power generation (Dec. to Feb.) | 2.9 GWh per day |
| Transmission Line (Associated Facility) | |
| Type and voltage | 220 kV Power Line |
| Length | 1 to 5 km - Depends on location of new substation. |
| Access roads | |
| Nenskra valley | 20 km of public road to be upgraded |
| Nakra valley | 9 km of public road to be upgraded |
| Implementation costs | |
| Total Investment costs | 990 million USD |
| Operation costs | 11 million USD / year |

#### 2.5.2.3 Improvement of Nakra weir design for flood control and sediment management

In 2015, the initial design of the Nakra water intake was as an ungated structure, with no gate on the weir and no gate on the tunnel channel inlet (stop logs only). There were no possibilities to remotely suspend the water transfer from the Nakra valley to the Nenskra valley, in case of flood for instance. Likewise, the ungated weir did not allow for sediment flushing or occasional water flushing for sediment transport management. JSCNH decided in 2016 to improve the design and equip the two structures (tunnel and weir) with remotely controllable gates. Together with the natural-like fish pass (see § 2.5.2.1) that decision, taken in 2016 in coordination with the E&S team, has significantly improved the design and operability of the Nakra water intake, providing greater control over potential downstream impacts (see Vol. 5 - Hydrology and Water Quality). The gated intake will have a diesel generator and a permanent operator stationed.

#### 2.5.2.4 Displacement of powerhouse installations to avoid resettlement

The 2015 initial design of the powerhouse location and the penstock alignment would have required the permanent displacement of one household. Besides, the initial design of the construction camp and site installations at the powerhouse would have required the permanent displacement of a second household. In 2016, JSCNH required the Design Team to propose a solution that avoids permanent physical resettlement. Subsequently, the powerhouse was displaced further downstream, the building was downsized thanks to a reduced number of turbines (three instead of four units) and the penstock was realigned away from the house area (see Vol. 9 - Land Acquisition and Livelihood Restoration Plan).

#### 2.5.2.5 Disposal area for the tunnelling spoils at powerhouse

The tunnelling activity for the headrace tunnel construction will generate large volumes of spoil. Since the digging activity will be implemented from the surge shaft area towards the dam site, the tunnelling spoils will be evacuated at the powerhouse area (see Section 3.7.5). In 2015, the EPC Contractor proposed to dispose of the tunnelling spoils on the right bank of the Nenskra River which are inhabited. This would have resulted in involuntary resettlement operations. JSCNH rejected this solution and required alternative locations for the disposal areas. This work was still on-going when the present report has been completed. The site selection process is described in Section 3.7.5. The Project will first identify potential sites away from human settlement. The sites will be subject to governmental approval (location and construction method), technical approval (stability, capacity) and social license (consultation and compensation - See Vol. 9 LALRP). Management Plans will be prepared for each site as per the EPC Contract obligations showing the proposed design, measures to avoid adverse effects on the natural environment and communities, and proposed final landform and reinstatement plans.

#### 2.5.2.6 Improved by-pass capacities at dam site

##### A. Capacity of the Ecological flow by-pass pipeline in the Nenskra dam

As described in Section 3.2.2.3 (bottom outlet) and in Section 4.5.2.3 (Nenskra reservoir operation), the Nenskra dam will release a mandatory ecological flow of 0.9 $m^3/s$ as required by the Environmental Permit awarded in 2015. This Ecological flow will be released through a dedicated pipe which by-passes the bottom outlet gate. It was initially planned that this by-pass would have a maximum discharge capacity of 0.9 $m^3/s$. In 2016, JSCNH instructed the EPC Contractor to double the capacity of this by-pass pipe. Under normal operation, this will not change the mandatory ecological release, a valve would maintain the downstream release at 0.9 $m^3/s$. The decision to include a larger volume Ecological Flow pipe was not born out of residual uncertainty in the ecological (Vol. 4) or water quality (Vol. 5) assessments, it has been decided to offer some flexibility to temporarily increase the ecological flow if needs be.

**B. Downstream tributary diversion structure**

As described in Section 3.2.3.2, on the right bank of the Nenskra River, immediately downstream of the dam site, a small weir will be built to divert the discharge of a small seasonal tributary into the Nenskra reservoir. The initial design of that weir did not allow flexibility in terms of diverted flow: the diversion capacity was fixed and permanent. In 2016, JSCNH instructed the EPC Contractor to change the weir design and include a by-pass facility. Under normal operation, this will not change the flow diverted to the Nenskra reservoir. This measure will however offer some flexibility to temporarily reduce or suspend the small tributary diversion and let the water flow into the original riverbed. This flexibility could, for instance, be used to improve the water quality of the Nenskra River immediately downstream of the dam (see Vol. 5 “Hydrology and Water Quality).

**C. Adaptive management**

Timings and thresholds for implementing these two above mentioned measures will be defined through the Project operating procedures (see Vol. 8 - ESMP). The decision to take this action will be supported by an ecological / hydrological / water quality monitoring programme and clear thresholds (that can be monitored by that programme) for triggering adaptive management.

### 2.5.2.7 Examination of potential for a small hydropower installation at dam site

In 2015, JSCNH requested the Owners Engineer to examine the feasibility of using the mandatory ecological release to produce small-scale hydroelectricity at the dam site[13].

The examined technical solution was the installation of a small hydropower facility within the gate chamber at dam site. The available flow (0.9 $m^3/s$) and head (~100m) could have represented a potential power production of 3.5 GWh per year.

This initiative has eventually been ruled out for financial reasons as well as for safety reasons (i.e. access to/from the gate chamber in case of accident).

### 2.5.2.8 Communication with communities regarding hazards and public safety

Natural hazards and dam safety is one of the main concerns of local communities. To address these concerns, geological investigations and technical analysis have been undertaken in 2015 (see 2015 ESIA report in Annex 3) and 2016 by the Design Team (see Vol. 6 Natural Hazard and Dam Safety). An Independent Panel of Experts was further appointed in 2016 and 2017 to provide an independent opinion on dam safety and public safety aspects. A Natural Hazards and Dam Safety report has been prepared in the frame of the Supplementary E&S Studies (Vol. 6 “Natural Hazards and Dam Safety”), which is publicly disclosed. The report summarizes the findings of all investigations and solutions proposed to guarantee the public safety.

During the preparation of the report the E&S team contributed the following:

- Information on visual observations made in the dam and reservoir area with respect to potential natural hazards, including avalanche, debris flow, and landslide;

[13] Stucky, 2015, Nenskra HPP, Technical note on Small hydro installation in bottom outlet gate chamber.

- Evaluation of the situation in the Nakra valley. In the recent past during period of heavy rain there have been mudflow and debris flow events in lateral tributaries of the Nakra that have blocked the Nakra River causing flooding. With the Project, the risk of flooding when similar mudflow/debris flow events occur again may be higher. This is because the reduced river flow - caused by the diversion of part of the flow to the Nenskra - could cause the accumulation of solid materiel in the river, and the reduced river flow will have a lower capacity to flush away rock debris from mudflow/debris events that could flow blocking the river. A number of measures with regard to change in design, river bed maintenance and monitoring will therefore be implemented by the Project to avoid this potential adverse effect;
- Recommendations with respect to the engagement with communities regarding the sudden changes in flow rates of the Nenskra due to normal daily operation, case of spillage from the reservoir during wet years (2 years out of 10), and accidental events, and
- Recommendations regarding emergency planning and coordination with other hydropower operators.

These recommendations are captured in Vol. 6 – Natural Hazards and Dam Safety.

#### 2.5.2.9 Alternative construction methodologies

Throughout detailed design and construction, continuous choices and changes will be made with regards construction techniques. Consideration of E&S factors will be fully integrated within the selection process for construction methods. This will be made through review and approval of the Risk Assessment and Method Statements submitted by the EPC Contractor to JSCNH E&S managers. A Change Management Procedure will be in place to address the E&S risk assessment of any project components that were yet to be defined at the time of writing this report, or any material changes in design or in construction methods (see Vol. 8 - ESMP).

# 3 Description of project infrastructure

This Section 3 describes the various Project components. It is based on the Project definition as approved by JSCNH in 2017. There might be some adjustments proposed during the preparation of the detailed design in 2017-18. These changes should not question the relevance of the E&S supplementary studies because the impacting parameters were fixed by JSC Nenskra Hydro (e.g. height of the dam, construction schedule, power production strategy).

The Project will divert most of the Nenskra River flow and the Nakra River flow 20 km upstream of the confluence with the Enguri River to the lower part of the Nenskra valley, in doing so producing electricity for delivery to ESCO, utilising the difference in elevations between the upper Nenskra valley and the plain.

To accomplish this, several infrastructures will be constructed and will include:

- A dam on the Nenskra River to capture most of the Nenskra River waters and create the Nenskra Reservoir;
- A diversion weir on the Nakra River to capture most of the Nakra River waters and transfer them to the Nenskra Reservoir via a Transfer Tunnel, in order to increase the annual volume of water stored in the Nenskra Reservoir;
- Structures to divert the flow from the Nenskra Reservoir to the Powerhouse;
- A Powerhouse with the necessary facilities for converting the energy to electricity;
- Ancillary works to enable construction, operation and maintenance of the Project and to meet other obligations of JSC Nenskra Hydro, and
- A Transmission Line to interconnect the Powerhouse switchyards with the existing grid.

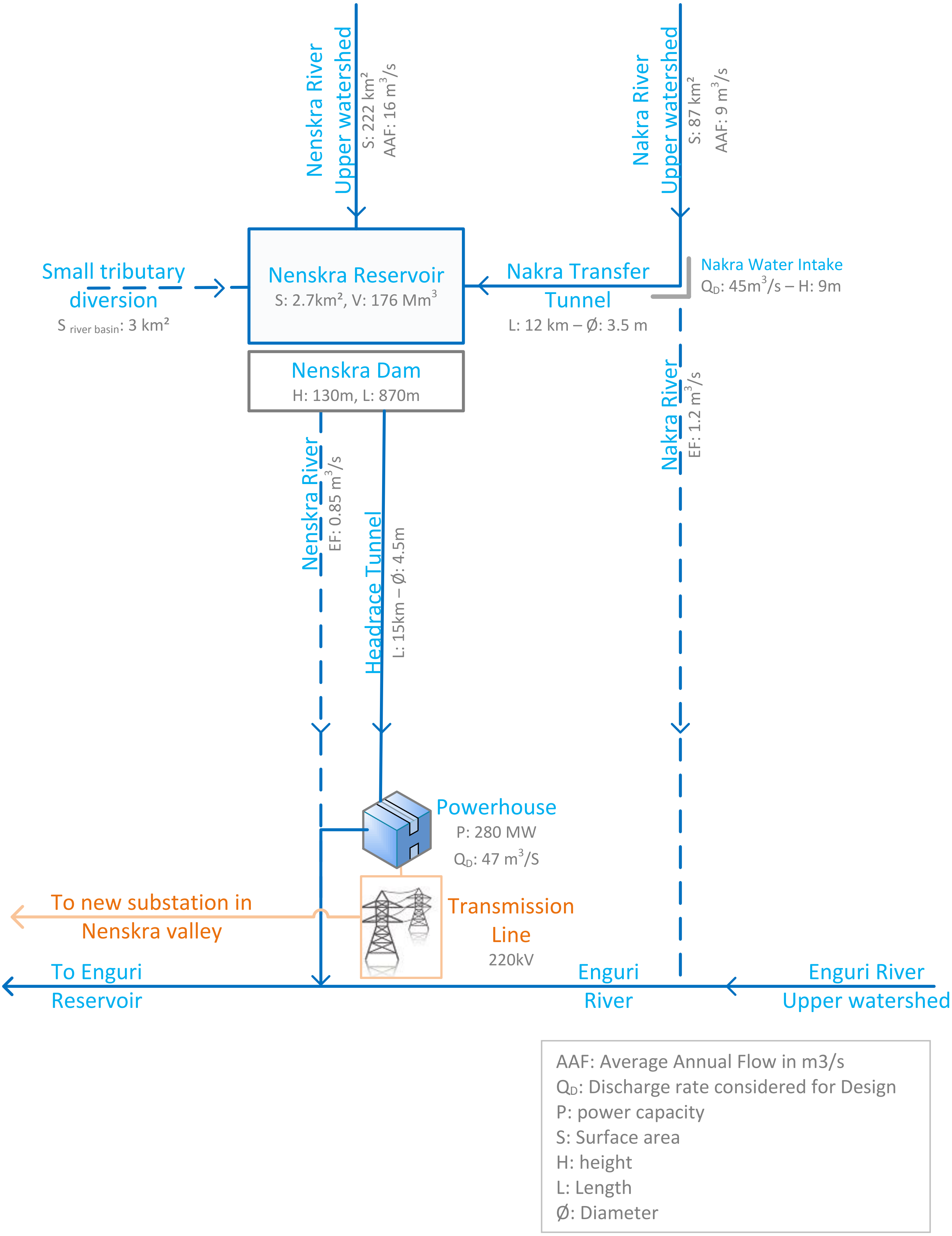
These infrastructures are described in more detail in the following sections. They are illustrated on Figure 5.

Most of the above-listed infrastructure will be financed by the Lenders. Infrastructures and activities which are financed by the Lenders are called Project Facilities. They are described in Section 3.1 to 3.8. Infrastructures and activities which are not funded by the Lenders as part of the Project and whose viability and existence depend exclusively on the Project and whose goods or services are essential for successful operation of the project are called Associated Facilities. They are presented in Section 3.9. Table 10 below summarizes what facilities are Project facilities or Associated facilities.

**Table 10 - Project facilities and Associated facilities**

| Project facilities | Associated facility |
|---|---|
| • Nenskra dam and reservoir<br>• Nenskra Headrace Tunnel and Nakra Transfer Tunnel<br>• Powerhouse, penstock, surge shaft, access road<br>• Nakra intake<br>• Nakra and Nenskra access roads<br>• Permanent operators’ village<br>• Temporary site installations, construction camp, spoil disposal areas, quarry area and borrow areas, Power supply lines required for construction | • 220 kV Transmission line from Powerhouse to Grid<br>• Access road for construction and maintenance<br>• Temporary site installations, construction camp, spoil disposal areas, quarry area and borrow areas, Power supply required for construction |

*Figure 5 - Nenskra HPP schematic diagram*



## 3.1 Design criteria, environmental constraints and climate resilience

The Project structures and facilities have been designed in alignment with design criteria that address environmental constraints including natural hazards such as extreme flood events and seismic activity. Climatic changes have been taken into account in the definition of extreme flood events and flood control structures (see Vol.5 - Hydrology and Water Quality Assessment).

The studies that have been undertaken and the resulting design criteria with respect to seismic activity and extreme floods are described in detail in Volume 6 – Natural Hazards and Dam Safety (section 2.2). It has been determined that the dam structure will resist the Peak Ground Acceleration of 0.65 g caused by the Maximum Credible Earthquake which has been determined to be 7.5 on the Moment Magnitude Scale.

## 3.2 Nenskra dam & Reservoir

### 3.2.1 Rockfill dam

The Nenskra Reservoir will be formed by the construction of a gravity rockfill dam with an upstream asphalt face.

The Nenskra Dam will have a crest length of approximately 870 m and an approximate height of 125 metres from the deepest foundation to its crest, which will not exceed 1,436 metres above sea level. The maximum width at foundation level will be 450 m and the total volume of the dam will be of 12.5 million cubic metres. The full supply level will be at 1,430 metres, the Maximum Operating Level will be at 1,435 metres (Probable Maximum Flood) and the Minimum Operating Level will be at 1,340 metres as illustrated in the Figure 6 below.

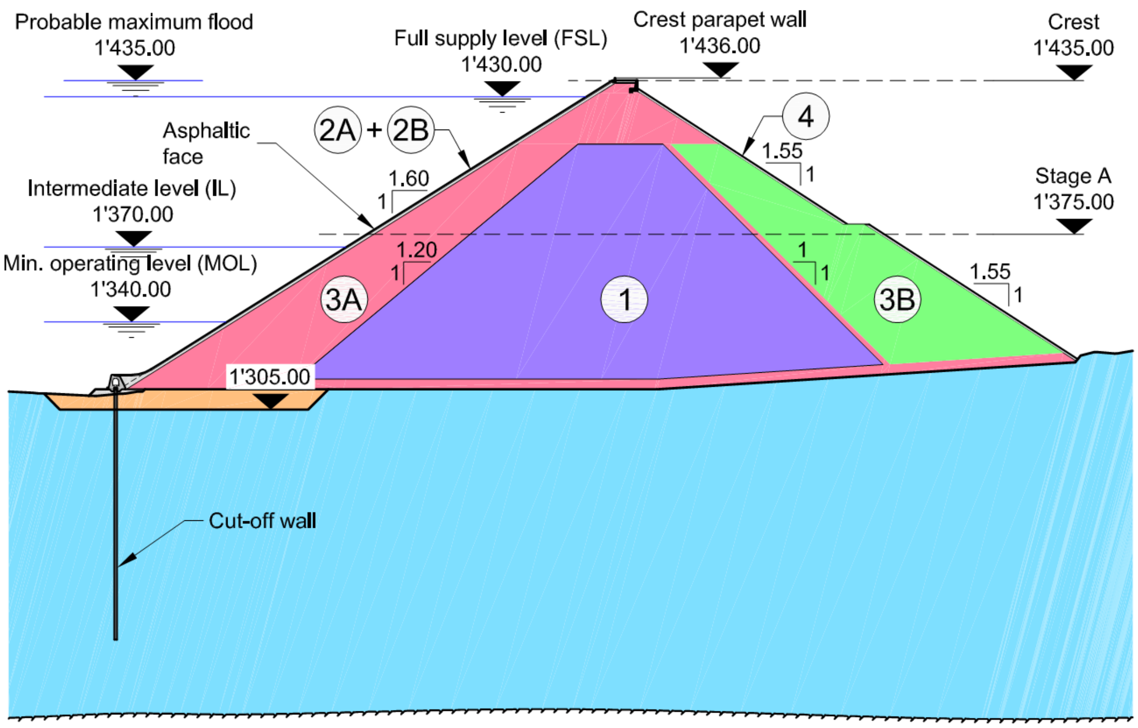



*Figure 6 - Typical cross section of the proposed Nenskra dam*

*Source: Lombardi - Civil Design - Nov. 2016*

The upstream slope will be 1.6/1. The downstream slope will be 1.55/1 with only one berm (5 m width) from the right to the left bank in order to provide access to monitoring devices and the bottom and spillway outlets. Codes and colours in Figure 6 reflect the different types of material used to construct the dam:

- The internal core of the dam 1 will be made of alluvial / talus cones material (~40 centimetres max. size). This material will come from the reservoir area;
- Quarried rockfill material will be placed on both sides of the core: rockfill 3A with material of 30 centimetres maximum size on the upstream slope and rockfill 3B with material of 70 centimetres maximum size on the downstream slope;
- Processed small rock 2B, consisting of a transition layer (~7 centimetres max. size) in order to prevent the direct contact between the asphaltic face and the rockfill;
- Protection layer 4 of the downstream slope with 40 centimetres medium size material, and
- Asphaltic face 2A, along the upstream slope, with a structure made of the following layers from inner to outer: 10 centimetres course binder layer, 5 centimetres lower dense bitumen layer, 8 centimetres drainage layer and 8 centimetres dense layer.

In addition to the fills, the dam cross section contains some concrete structures. These are the crest wall (see Figure 7) and the inspection gallery. The foundation will be grouted for seepage control; the cut-off wall will be located on the upstream slope's toe.

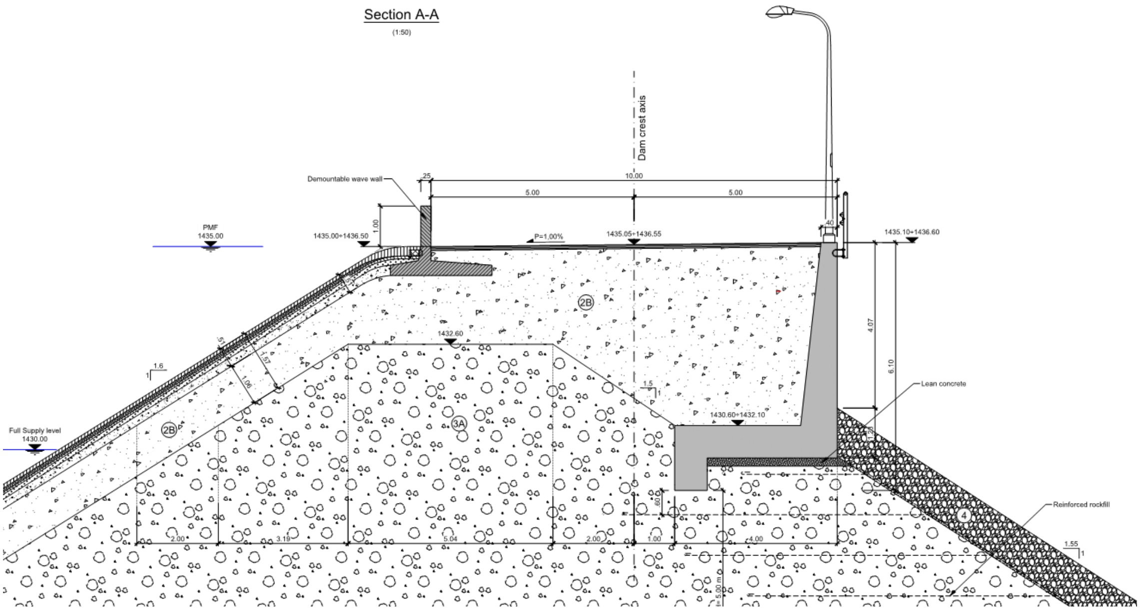



*Figure 7 - Cross section of Dam Crest*

*From Lombardi - L-6768-B-CW-DA-CS-DW-001_002_Dam crest Typical sections*

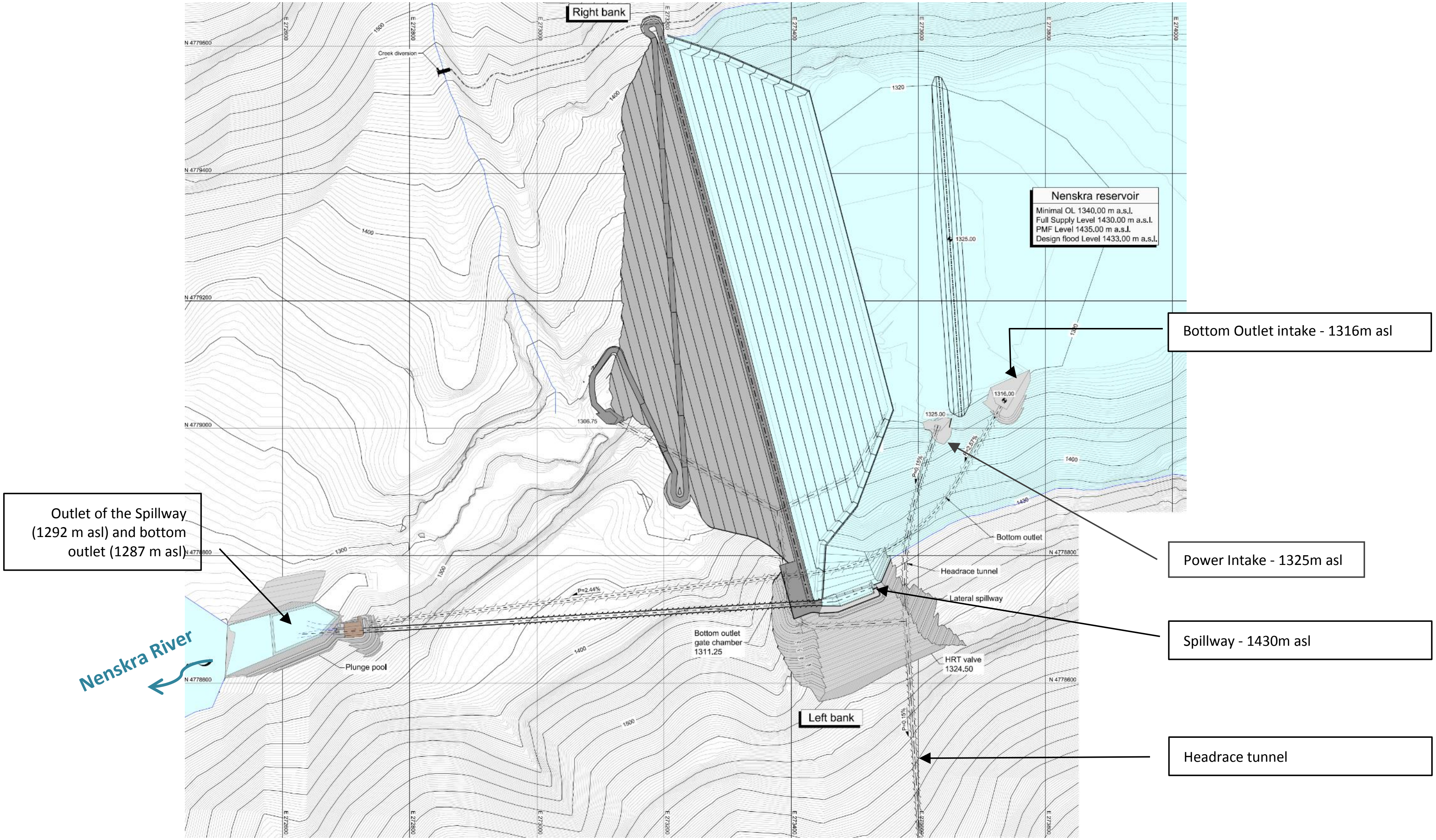
## 3.2.2 Power intake, spillway and bottom outlet

The water stored in the Nenskra Reservoir will flow downstream of the dam through three structures, all located on the left bank (see Figure 8) of the Nenskra River:

- In normal operation, most of the water stream will flow through the Power Intake (also called headrace tunnel intake) to supply the powerhouse 17 kilometres downstream of the dam through the headrace tunnel and to generate power.

- During high flows period, the water in excess will flow through the lateral spillway and be evacuated through a 850-metre long tunnel downstream of the dam.
- During the construction period, the river will be diverted through a 1,163-metre long bottom outlet. The bottom outlet will release water at the same location as the spillway tunnel outlet in the plunge pool situated 500 metres downstream of the dam foot. During the operation phase, the bottom outlet will remain closed, only the mandatory ecological flow will flow through.

*Figure 8 - General layout of the Nenskra Dam and associated structures*
*From L-6768-B-CW-SP-GE-DW-210_000*



### 3.2.2.1 Power intake

The power intake (elevation 1,325 metres asl) layout is illustrated on Figure 10. It is located on the left abutment in a rock outcrop. The intake will be of Bellmouth type, with two inlet areas of 10.5 square metres each (9.5 metres high), feeding the headrace tunnel (4.5 metres diameter).

### 3.2.2.2 Spillway

The ungated spillway (52 metre weir length, elevation 1,430 m asl) has been designed to (i) divert the Nenskra River and diverted Nakra River discharges during floods; (ii) control the reservoir level during flood events; and (iii) evacuate the large floods together with the bottom outlet. See Figure 9 for longitudinal view and Figure 11 for spillway inlet.

The overflow will be evacuated through a free-flow tunnel made of two parts:

- 90 metre long inclined shaft with a circular section of 7.5 metre diameter.
- 663 metre long gallery with a 7 x 7 metre internal section and exit in a plunge pool at the toe of the dam, through a ski jump.

The spillway capacity is 1,000 $m^3/s$. It was designed to divert the Probable Maximum Flood (i.e. 1,100 $m^3/s$ from Nenskra River and 45 $m^3/s$ from Nakra transfer) taking into account the reservoir routing effect, without contribution of the bottom outlet. The dam was designed with a minimal freeboard of 1 metre against the Probable Maximum Flood, in order not to overflow the dam in any cases.

### 3.2.2.3 Bottom outlet

The bottom outlet will be used to (i) divert the Nenskra River discharges during the dam construction; (ii) control the reservoir level during the first impounding and normal operation of the dam; (iii) evacuate the very large floods together with the spillway, (iv) flush the reservoir sediments downstream after 5 or 10 years if required and (v) allow the rapid reservoir drawdown in emergency situations.

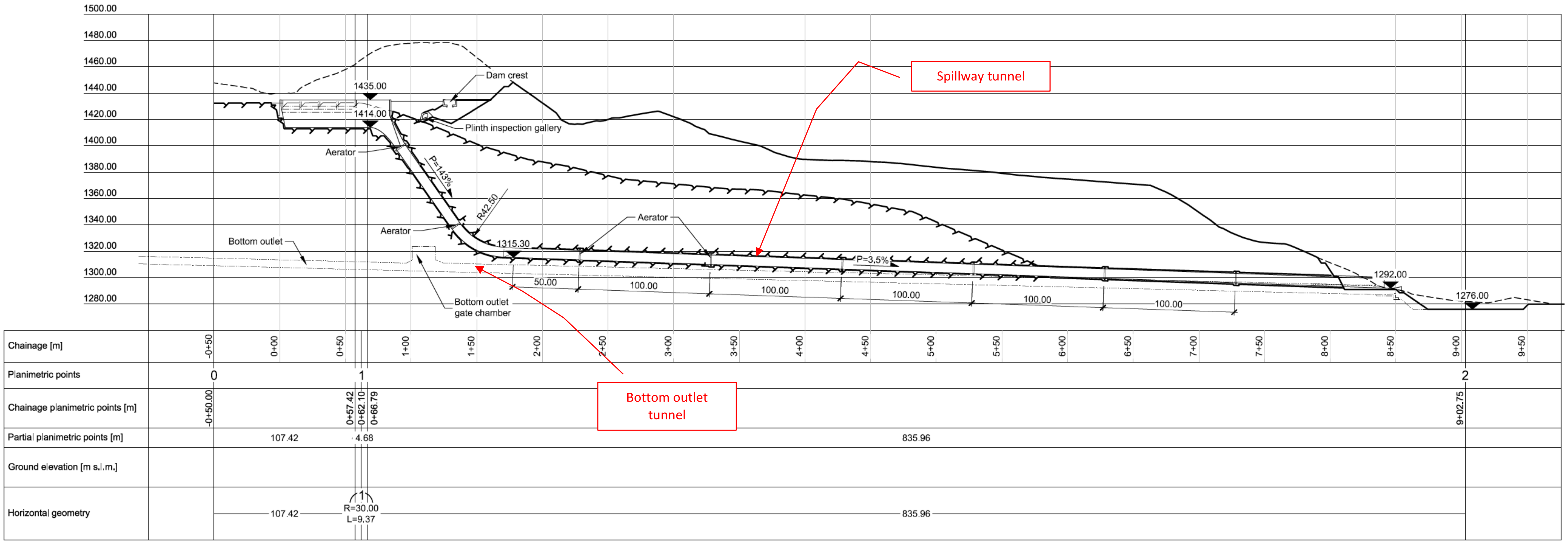
The piping which allows the ecological flow to pass through the dam structure is installed in in the valve chamber of the bottom outlet (see Figure 13).

The bottom outlet includes

- An inlet placed at elevation 1,316 m asl, 9 m below the power intake;
- A 1,163 m long tunnel divided in two sections by the gate chamber: (i) 457 metre long upstream stretch with a 4.8 x 4.8 metre section, and (ii) 706 metre long downstream stretch, designed for free surface flow, with a 6 x 6 metre section;
- A gate chamber made of 2 sliding gates (one for maintenance and the other for flow control) in an underground control building,
- An outlet structure ending with a flip bucket located at elevation 1,287 metres asl.

At normal operating level (1,430 metres asl) the discharge capacity of the fully opened bottom outlet would be 317 $m^3/s$. At full charge (retention level 1,435 metres asl), the discharge capacity could reach 323 $m^3/s$. The bottom outlet capacity during operation will be however limited to the 1 in 100 year flood volume (200 $m^3/s$). This will be ensured through specific redundant control system based on reservoir level and discharge measurement downstream of the bottom outlet gates.

*Figure 9 – Longitudinal view of the underground spillway and the underground bottom outlet*



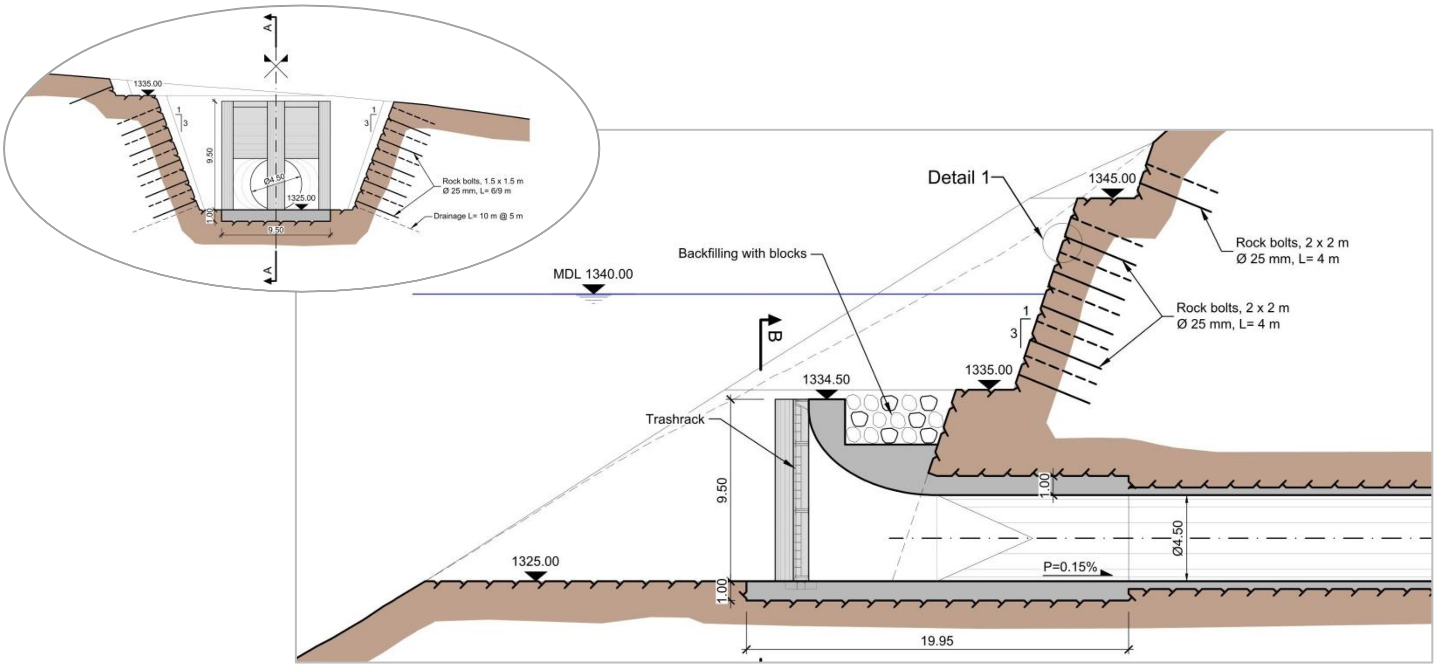



*Figure 10 - Power Intake in the Nenskra reservoir*
*From L-6768-B-CW-HR-IN-DW-001_000*

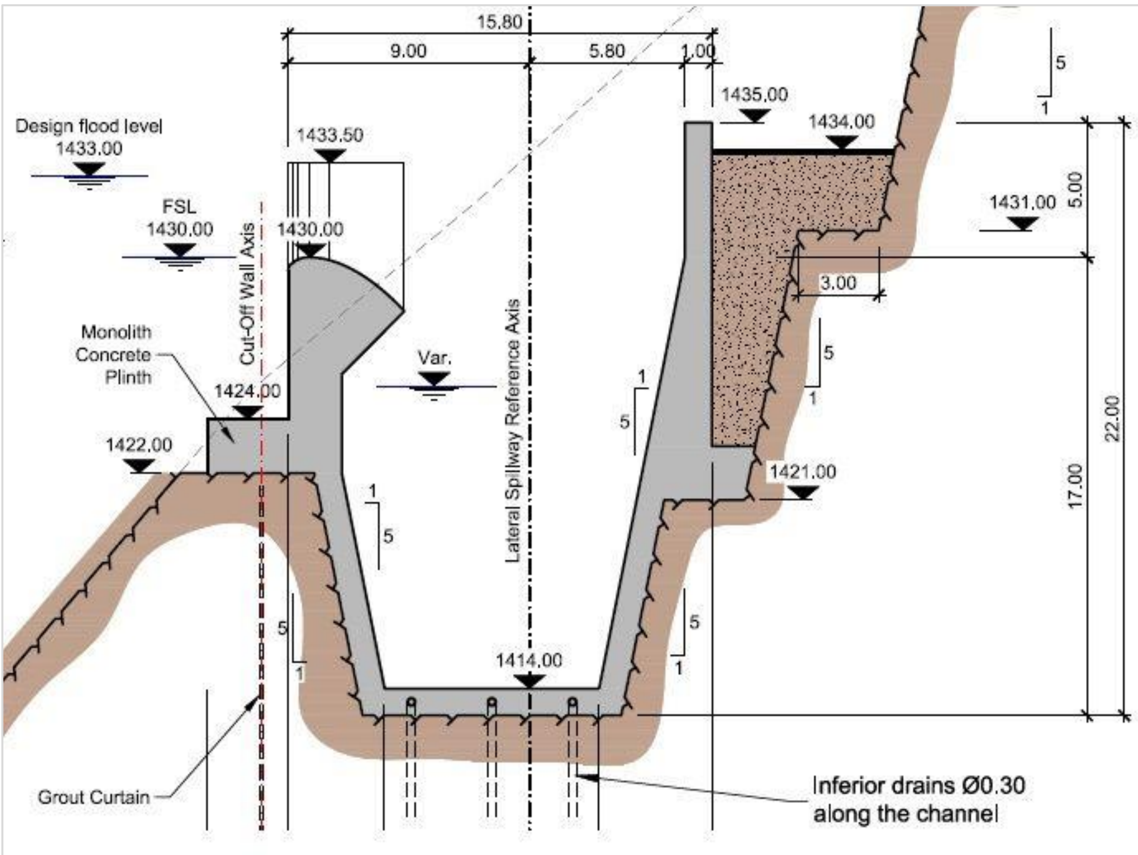



*Figure 11 - Lateral spillway in the Nenskra reservoir*
*From L-6768-B-CW-SP-WE-DW-102_001*

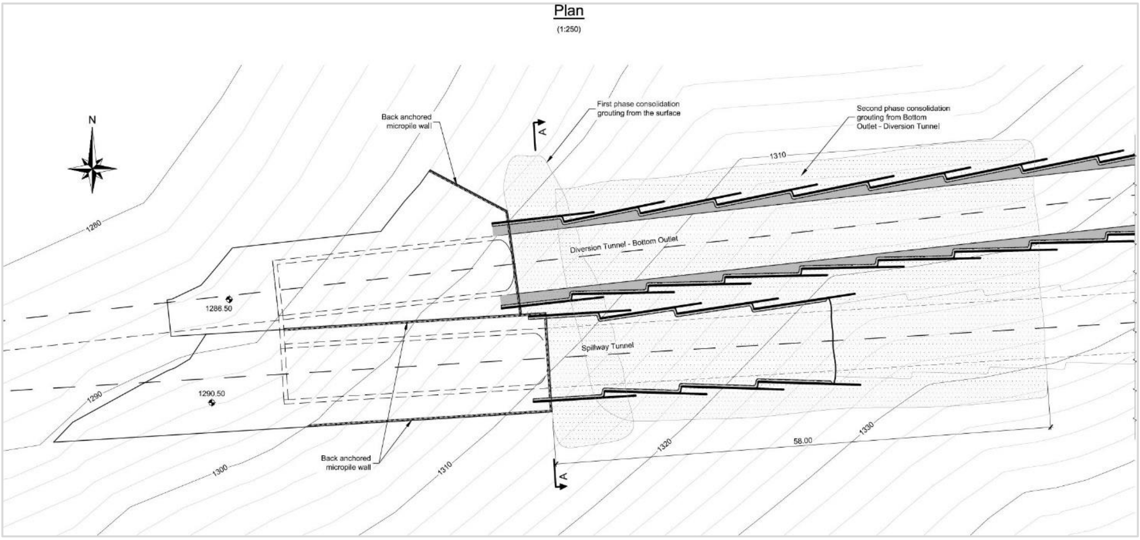



*Figure 12 - Outlets of the Spillway (above) and the Bottom Outlet (below) and plunge pool*

*Source: SALINI Drawing n° L-6768-B-CW-SP-OT-DW-102_001*

The bottom outlet tunnel will also be used to release the ecological flow during construction and operation. During normal operation, when the bottom outlet gates are closed, the ecological flow will be discharged downstream of the gates through a dedicated steel pipe with valves that bypasses the gates and could discharge up to 1.7 $m^3/s$ from the reservoir at minimum operation water level of 1,340 metres asl (see Figure 13).

## 3.2.3 Nenskra reservoir

### 3.2.3.1 Size of the reservoir

The reservoir created by the Nenskra dam will have the following characteristics:

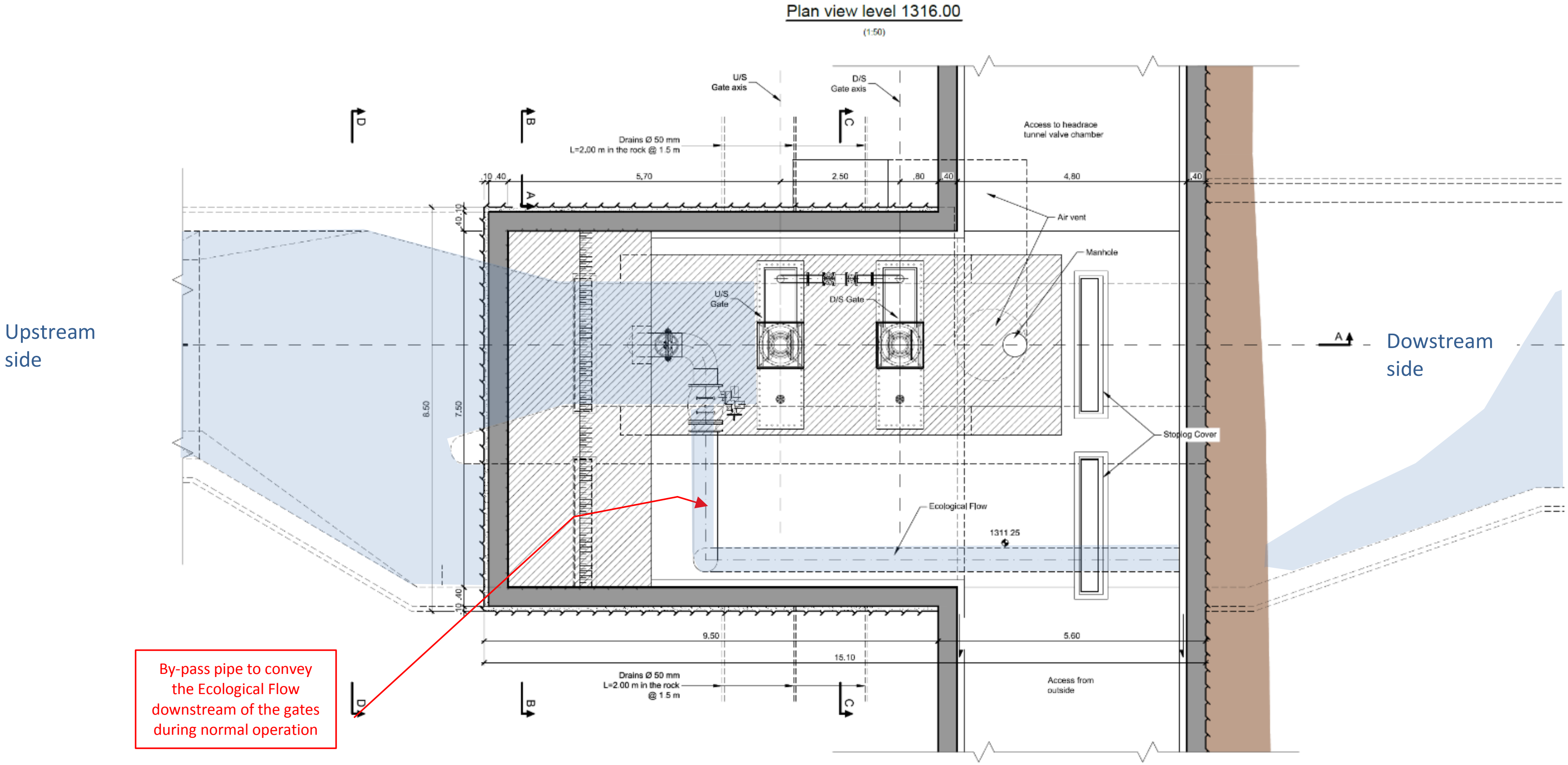
**Table 11 - Nenskra reservoir characteristics**

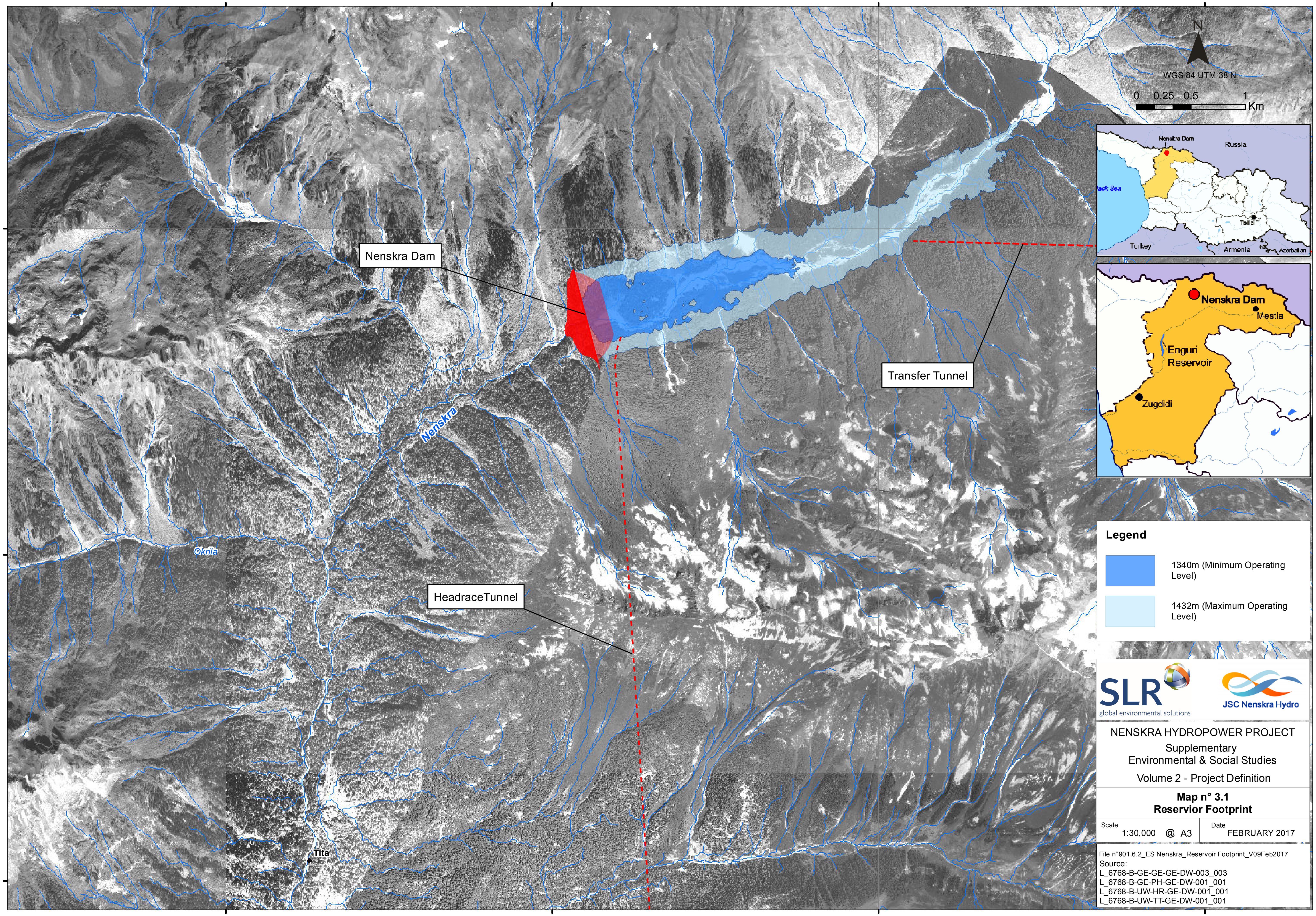
| Reservoir Operating mode | Water level | Reservoir area | Reservoir volume |
|---|---|---|---|
| Probable maximum Flood Level | 1,435 m asl | 2.77 $km^2$ | 191.63 million $m^3$ |
| Maximum Operating level | 1,430 m asl | 2.67 $km^2$ | 176.15 million $m^3$ |
| Lower Average Operating level | 1,370 m asl | 1.52 $km^2$ | 48.88 million $m^3$ |
| Minimum operating level | 1,340 m asl | 0.87 $km^2$ | 12.52 million $m^3$ |

The Map 3.1 shows the reservoir footprint for various operating levels. The variations of water level within the reservoir will depend on the power generation strategy which is explains in Section 4.4. The following pattern will be observed for the drawdown area (see Figure 14):

- During 5 months of the year from August to mid-December, the average water level in the reservoir will be higher than 1,420 metres, i.e. close to the higher average operating water level (1,430 metres).
- From December to end of March, the water level in the reservoir will decrease in 60 meters and reach 1,370 metres.
- From June to August, the water level in the reservoir would increase again in 60 meters up to the higher average operating level.

*Figure 13 - Underground gates chamber and restitution of ecological flow through the bottom outlet (from L-6768-B-UW-DT-GC-DW-002_000 and L-6768-B-UW-DT-GC-DW-003_000)*





270000
273000
276000
279000
4780000
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4774000
WGS 84 UTM 38 N
0 0.25 0.5 1 Km
Nenskra Dam
Russia
Black Sea
Tbilisi
Turkey
Armenia
Azerbaijan
Nenskra Dam
Mestia
Enguri Reservoir
Zugdidi
Transfer Tunnel
Nenskra
Okrila
HeadraceTunnel
Tita
Legend
1340m (Minimum Operating Level)
1432m (Maximum Operating Level)
SLR global environmental solutions
JSC Nenskra Hydro
NENSKRA HYDROPOWER PROJECT
Supplementary Environmental & Social Studies
Volume 2 - Project Definition
Map n° 3.1
Reservior Footprint
Scale 1:30,000 @ A3
Date FEBRUARY 2017
File n°901.6.2_ES Nenskra_Reservoir Footprint_V09Feb2017
Source:
L_6768-B-GE-GE-GE-DW-003_003
L_6768-B-GE-PH-GE-DW-001_001
L_6768-B-UW-HR-GE-DW-001_001
L_6768-B-UW-TT-GE-DW-001_001

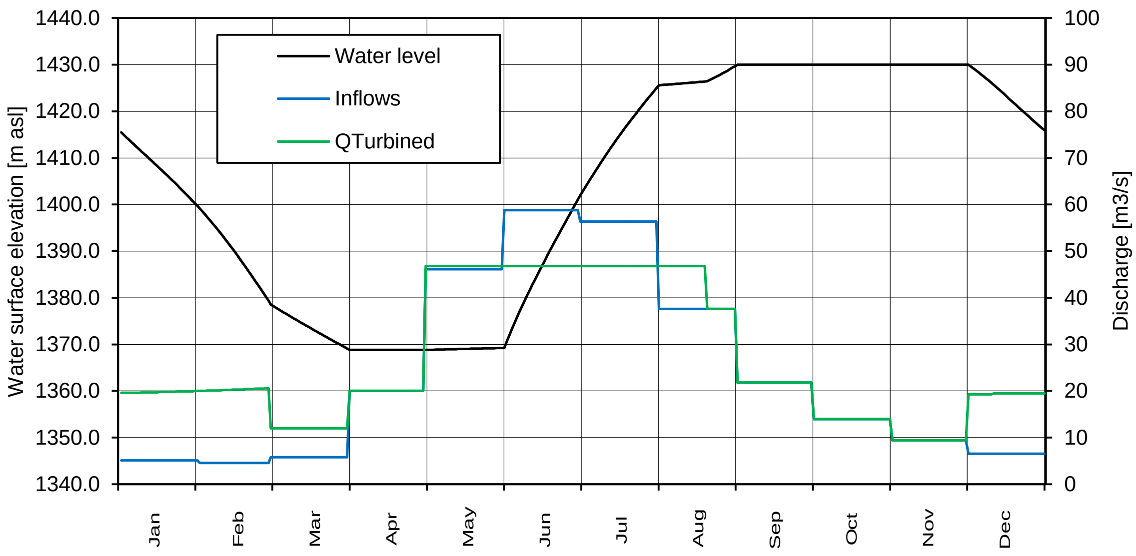



*Figure 14 - Average water levels in the reservoir*

*Source: Salini - From L-6768-B-HY-GE-GE-CR-002_001 - Power generation analysis - Dec 2016*
*Values from simulation and for indicative purposes only*

### 3.2.3.2 Small ephemeral tributary diversion

On the right bank of the Nenskra River, immediately downstream of the dam site, a small weir (8 metres long, 2 metres high) will be built to divert the discharges of a small ephemeral tributary (catchment area approx. 300 hectares) into the Nenskra reservoir. Its purposes are the improvement of Nenskra HPP performance through additional water inflows and the protection of the dam right abutment from erosion during flood events.

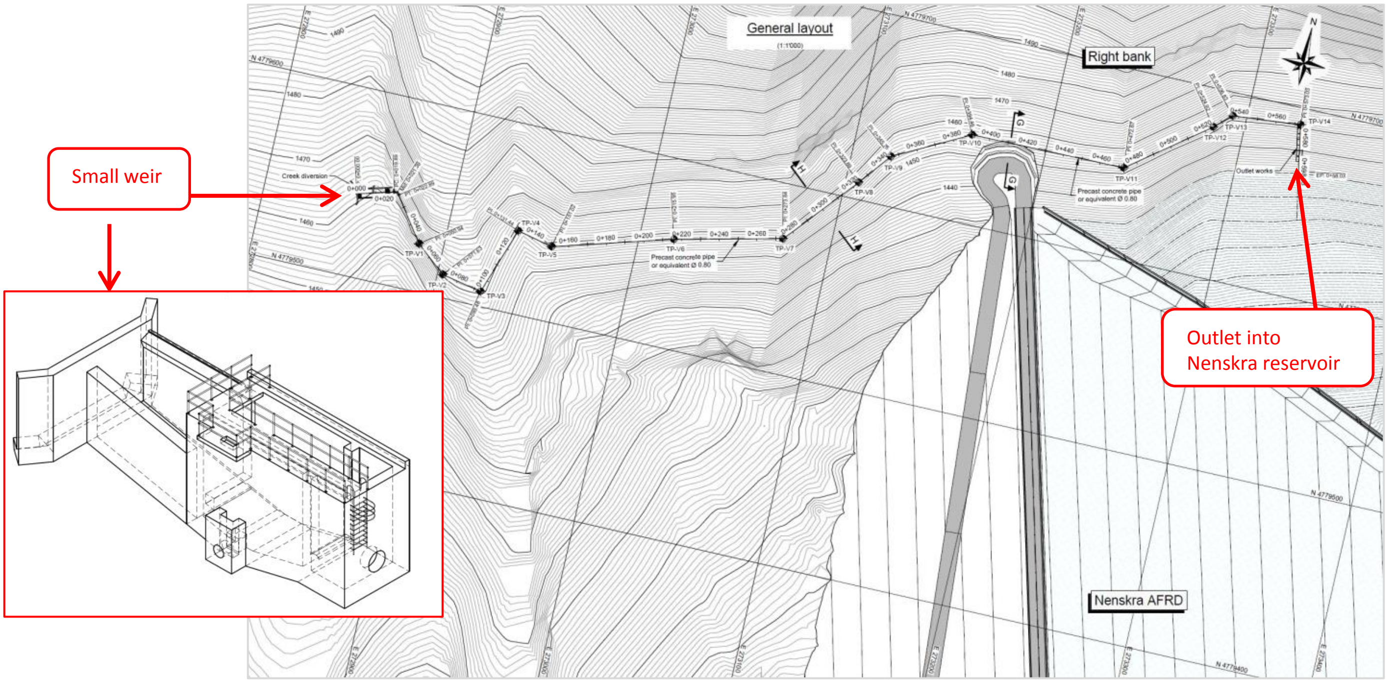



*Figure 15 - Small seasonal tributary diversion on the right bank downstream of the dam*
*From L-6768-B-CW-CD-GE-DW-001_000 and L-6768-B-CW-CD-GE-DW-003_000*

The small tributary is seasonal: the average annual flow is about 0.2 m³/s but water is flowing only part of the year, mainly between May and August (see Figure 16). For ecology, this steep boulders stones ephemeral stream is not suitable for sustaining aquatic life.



*Figure 16 - Small ephemeral tributary planned to be diverted on right bank downstream of the dam*
*Top photo: May 2015 - Bottom photo: September 2015*

# 3.3 Flow diversion

The Nenskra HPP requires the diversion of two main water flows:

- Diversion of the Nakra River flow from the Nakra River to the Nenskra Reservoir, and
- Diversion the Nenskra River flow and the diverted Nakra river flow stored in the Nenskra Reservoir into the headrace tunnel to supply the powerhouse: the power water way.

## 3.3.1 Nakra River water transfer

The Nakra River is a tributary of the Enguri River, joining it upstream of the confluence of Nenskra and Enguri rivers. The Nakra transfer works are designed to increase the production of the Nenskra Hydropower Project by transferring most of the river flow from the Nakra River into the Nenskra reservoir through a transfer tunnel (see Map 1.1). The intake structure on the Nakra River will consist of an ungated weir. The water will be conveyed through an open cut section from the river bed to the tunnel inlet.

The Nakra transfer tunnel will be 12.2 kilometres long, 3.5 metres diameter and 45.5 $m^3$/s design capacity. 11.7 kilometres of the tunnel will be excavated by TBM and the remaining 0.5 kilometres by drill and blast. It will operate evenly as free surface tunnel and as a pressure tunnel for large discharges.

The Nakra intake (see Figure 18) is designed as a concrete weir with a lateral intake followed by a concrete lined low-slope channel (0.2%), which transports the diverted water to the transfer tunnel inlet.

Both the weir and the intake are gated:

- The two gates of the weir are designed to be used for flushing the upstream basin and keep the water intake clean (see Figure 17), and
- The two gates of the intake are used to control discharge in the diversion tunnel and suspend transfer to Nenskra when required.

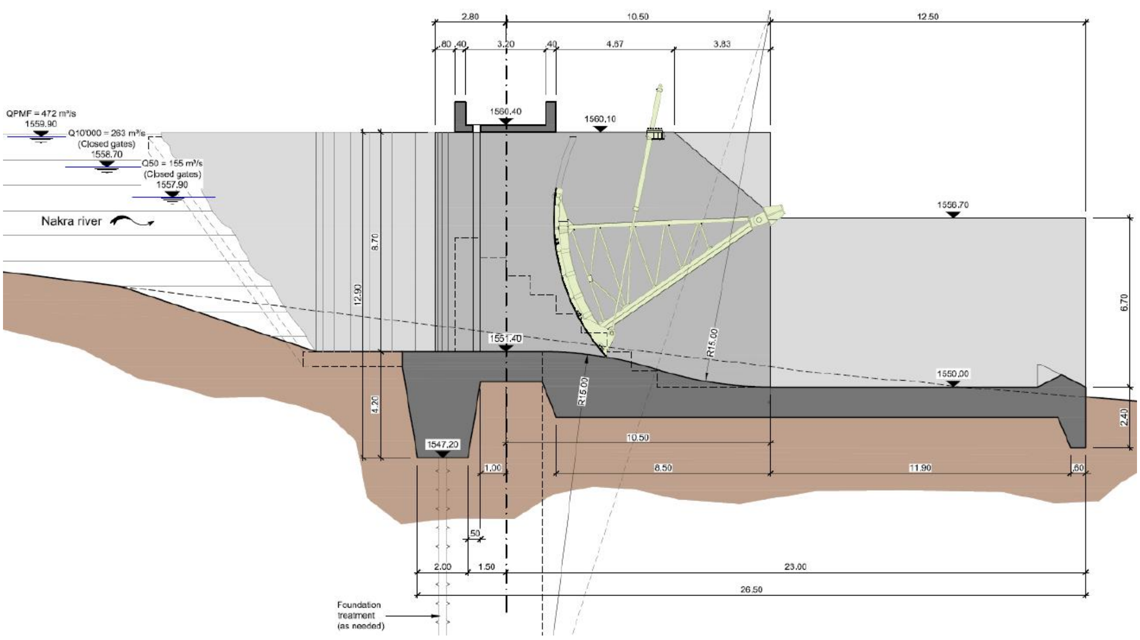



*Figure 17 – Radial gates on the Nakra weir*

*Figure 18 - General layout of the Nakra water intake*
*From L-6768-B-CW-NH-GE-DW-001_A00 and L-6768-B-GE-GE-GE-PT-006_000*

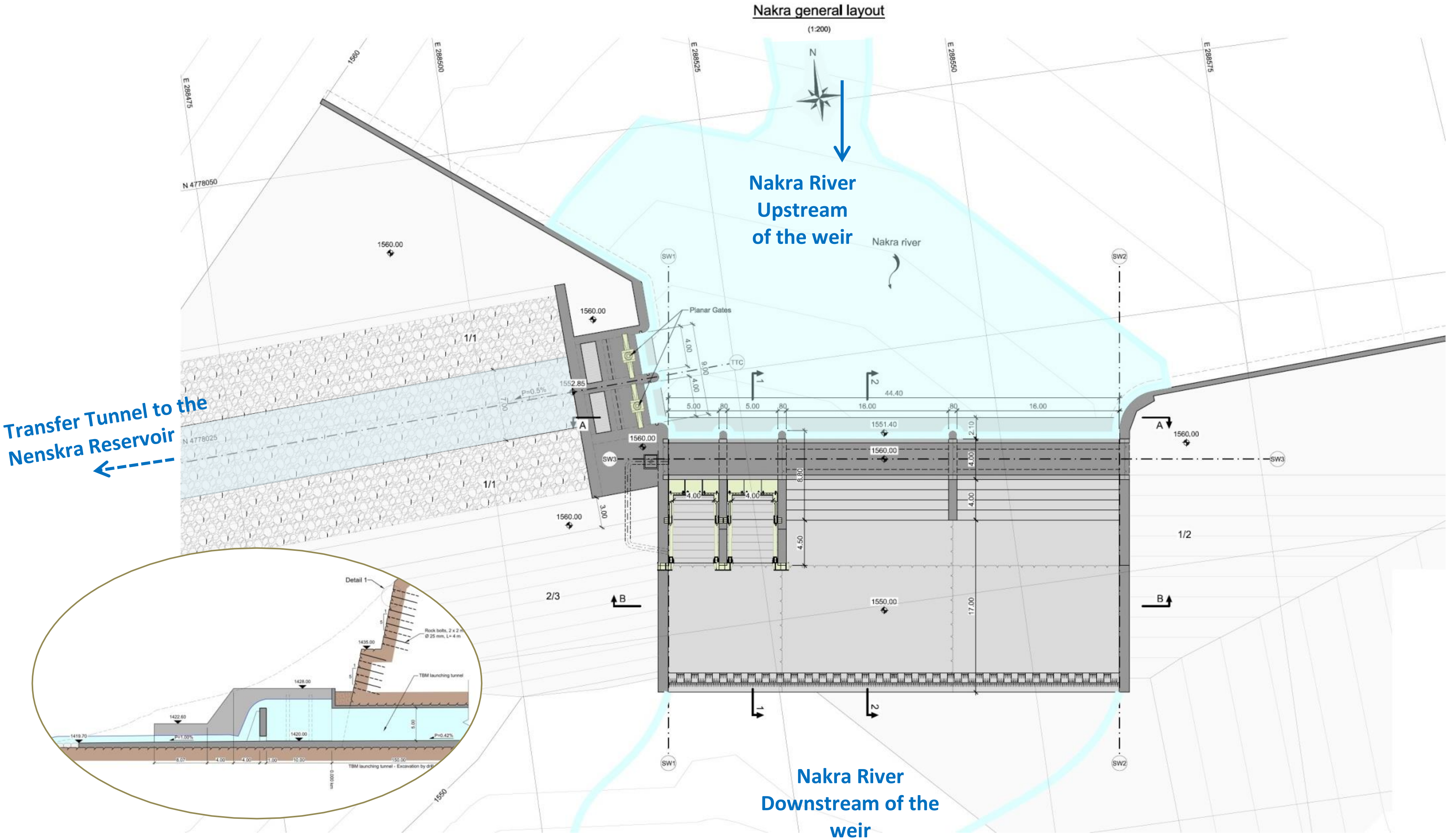
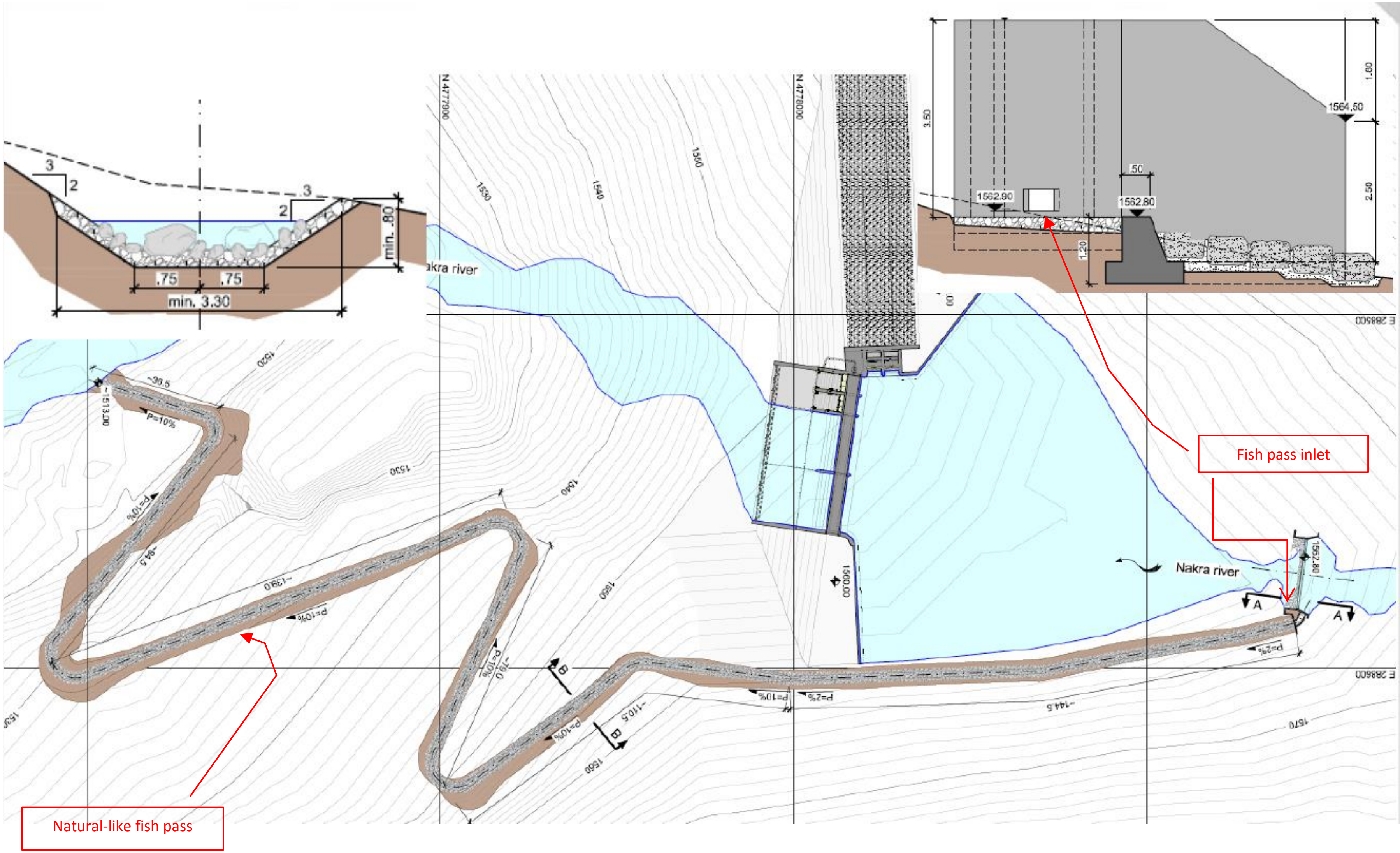


*Figure 19 – Conceptual layout of the Nakra fish pass*



The overall 46-metre wide and 8.7-metre high concrete weir is at elevation 1,557.620 metres asl. It has been designed so that the Probable Maximum Flood of the Nakra intake (472 $m^3/s$) can safely pass below the weir bridge intrados at el. 1,560 metres asl without any damage.

As appurtenant structures there is a fish pass on the left bank (see Figure 19). The Ecological Flow (1.2 $m^3/s$) will be made through the fish pass.

The Nakra Water intake will not generate a water storage reservoir. Only a small water head pond of less than one hectare will be created by the weir. The water volume in the head pond will depend on the sedimentation of the river section immediately upstream of the weir.

The water intake is designed to divert up to a maximum of 45.5 $m^3/s$, corresponding to the maximum monthly runoff of the Nakra River at intake location (46.7 $m^3/s$) subtracted the planned ecological flow release (1.2 $m^3/s$).

The Nakra transfer tunnel outlet is positioned on the left river bank of Nenskra River (see insert on Figure 18). The base slab will be at elev. 1,432 metres asl and the outlet crest is located at 1,437 metres asl. An orifice in the outlet wall assures the emptying of the transfer tunnel during low discharge periods.

The functioning of the hydraulic system is driven by the head difference between the water level at Nakra transfer tunnel inlet and in the steep part of the conduit and the water level in Nenskra reservoir.

Due to the small storage volume of the retention, the whole peak flood discharge will be evacuated over the weir crest.

## 3.3.2 Main water way from the Nenskra reservoir to the powerhouse

The main water way takes the water from the Nenskra reservoir to the powerhouse through the following structures:

- The headrace tunnel and gate chamber at the entrance of the tunnel;
- The surge shaft at the exit for the headrace tunnel, and
- The penstock, where most of the water head is obtained, between the headrace tunnel and the powerhouse.

These structures are illustrated on Figure 20 and further described in the next paragraphs.

### 3.3.2.1 Headrace tunnel

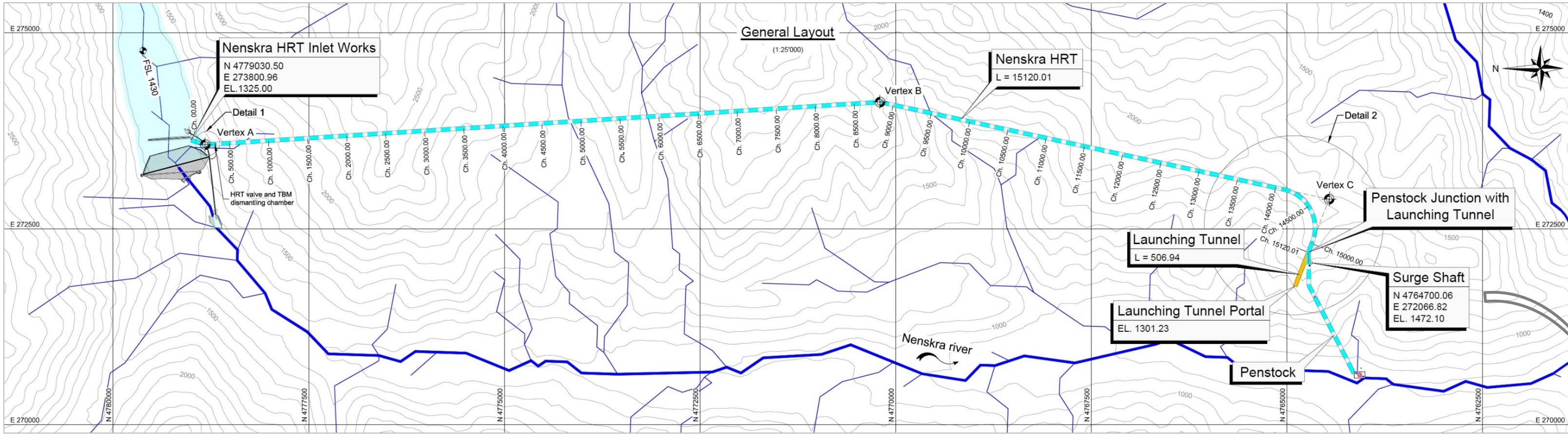
The water will be conveyed for power generation from the Nenskra reservoir to the powerhouse through a 4.5 metre diameter concrete lined headrace tunnel (HRT) with a length of 15.1 kilometres (see alignment on Figure 20). From the total tunnel length, 14.7 kilometres will be excavated with double shield TBM and installation of precast concrete segments, and 0.4 kilometres by drill and blast. The tunnel will have a gradient of 0.15% and a maximum water velocity of 3.15 metres per second corresponding to a discharge of 50 $m^3/s$.

In the upstream part of the headrace tunnel, approx. 300 metres from the power intake, a gate chamber will be constructed to control the water flow entering the headrace tunnel.

### 3.3.2.2 Surge shaft

Due to the considerable total length of the waterways (15.1 kilometre long headrace tunnel and 1.79 kilometre long penstock), a surge shaft (see Figure 21) is required to mitigate the short term (water hammer) and the long term (mass oscillation) transient phenomena induced by the discharge variations in the turbines.

*Figure 20 - General layout of the main water way*
*From L-6768-B-UW-HR-GE-DW-001_000*



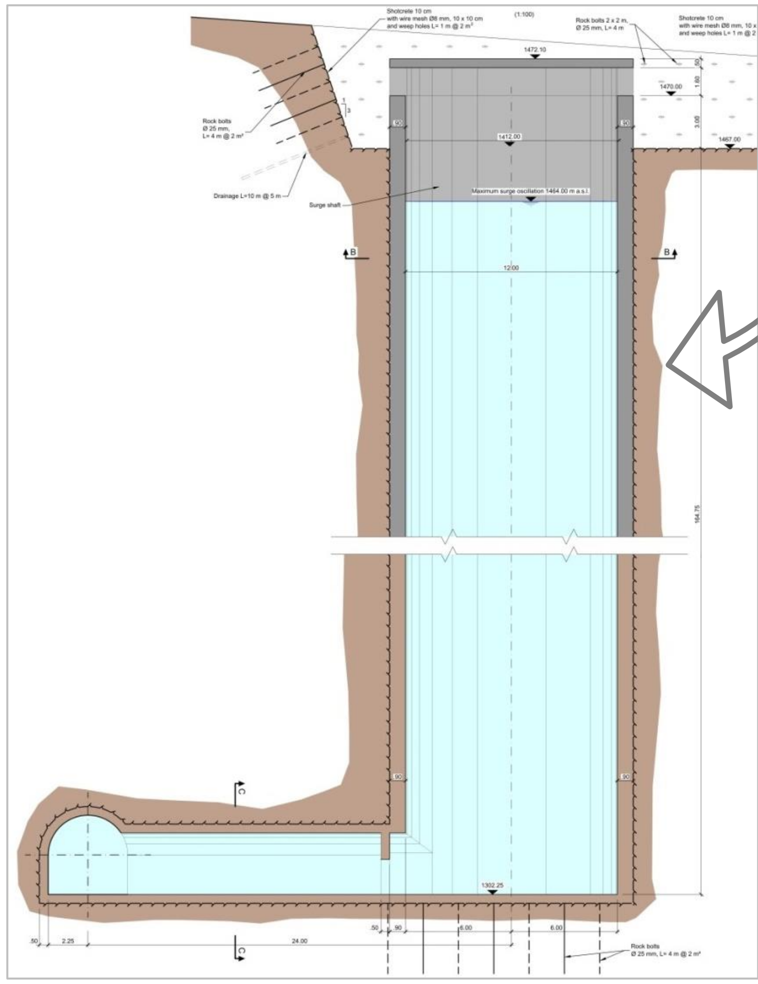



*Figure 21 – Surge shaft along the main waterway*
*From L-6768-B-HM-HR-HV-GE-DW-002_000*

The role of the surge shaft is therefore to mitigate pressure variations due to rapid changes in velocity of water. For that purpose, in the downstream part of the headrace tunnel, approx. 500 metres far from the penstock inlet, a 170 metre high surge shaft (90% being underground, visible part is 5 metre high) and an internal diameter of 12 metre will be built and operated. The surge shaft has been designed so that overflow is physically impossible.

### 3.3.2.3 Penstock

The steel lined penstock will be about 1,790 metre long with following reaches: (i) 445 metre upper horizontal penstock of 3.0 metre diameter (Figure 22), and (ii) 1,345 metre in trench steep inclined penstock of 3.0 metre diameter (Figure 23).

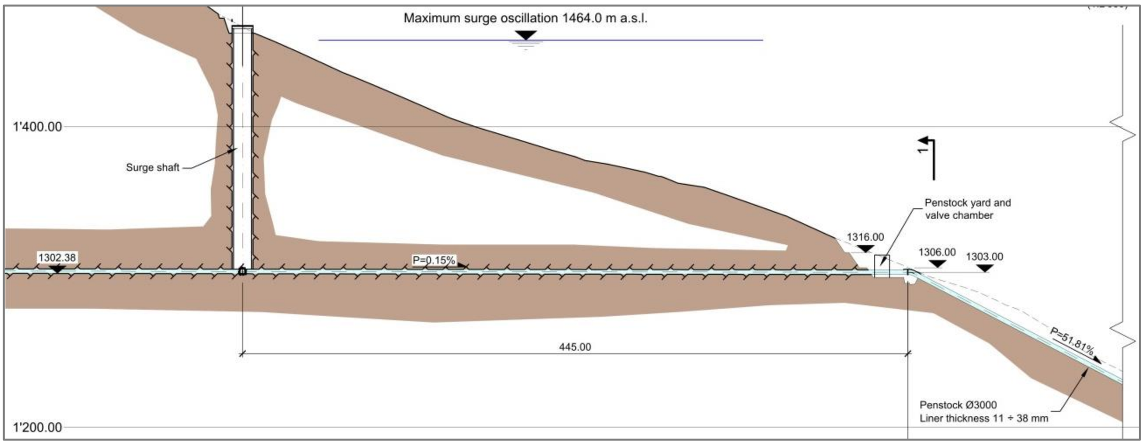



*Figure 22 - Penstock - underground horizontal section*

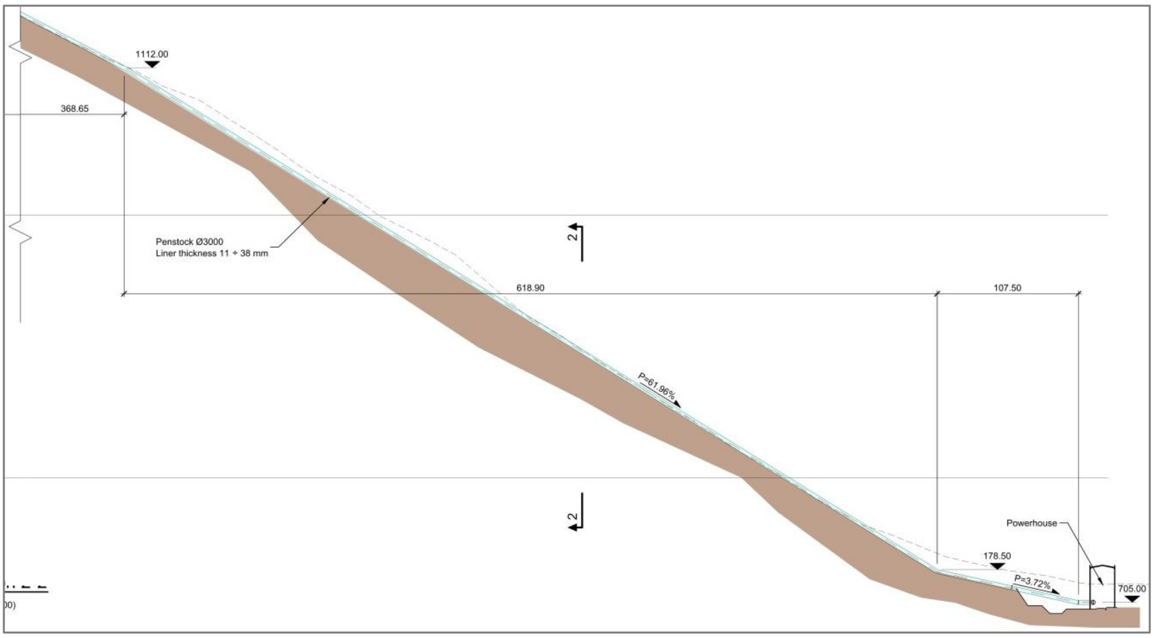



*Figure 23 - Penstock - trench inclined section*

The layout of the powerhouse headworks (surge shaft, valve chamber, penstock in trench, main inlet valve) is illustrated on Figure 24.

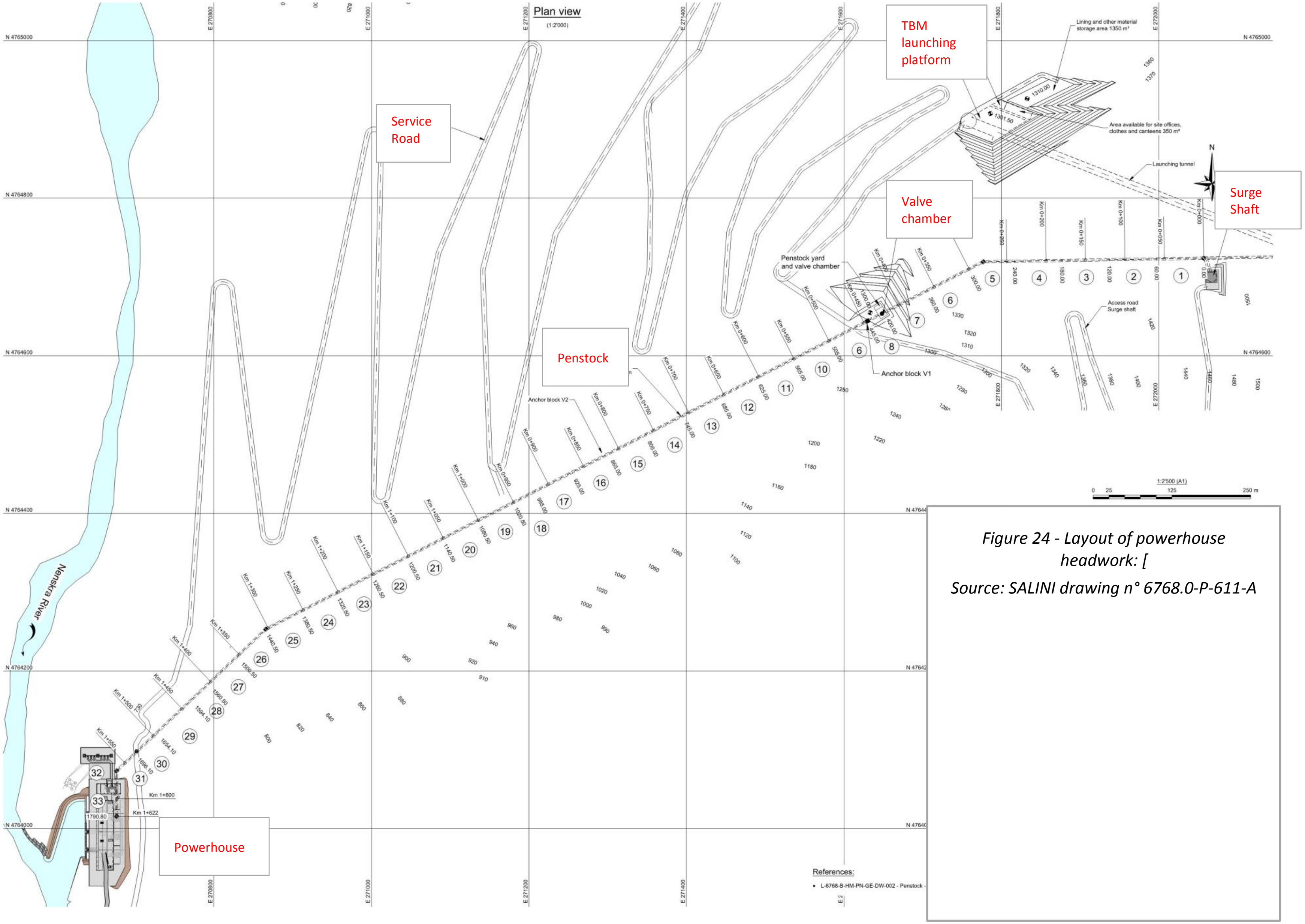



*Figure 24 - Layout of powerhouse headwork: [*

*Source: SALINI drawing n° 6768.0-P-611-A*

# 3.4 Powerhouse and power service lines

## 3.4.1 Powerhouse

The Nenskra HPP will have a surface-type powerhouse located on the left bank of the Nenskra River about 17 kilometres from the power intake (see Figure 25).

The elevation of the powerhouse is dictated by the maximum level of the reservoir of the proposed Khudoni Hydropower Project and the maximum flood level in the Nenskra River at the site.

The powerhouse will accommodate three vertical Pelton turbine units, transformers, control room and Gas Insulated Substation (GIS) switchyard (i.e. enclosed in a building - SF6 gas-insulated) next to the powerhouse.

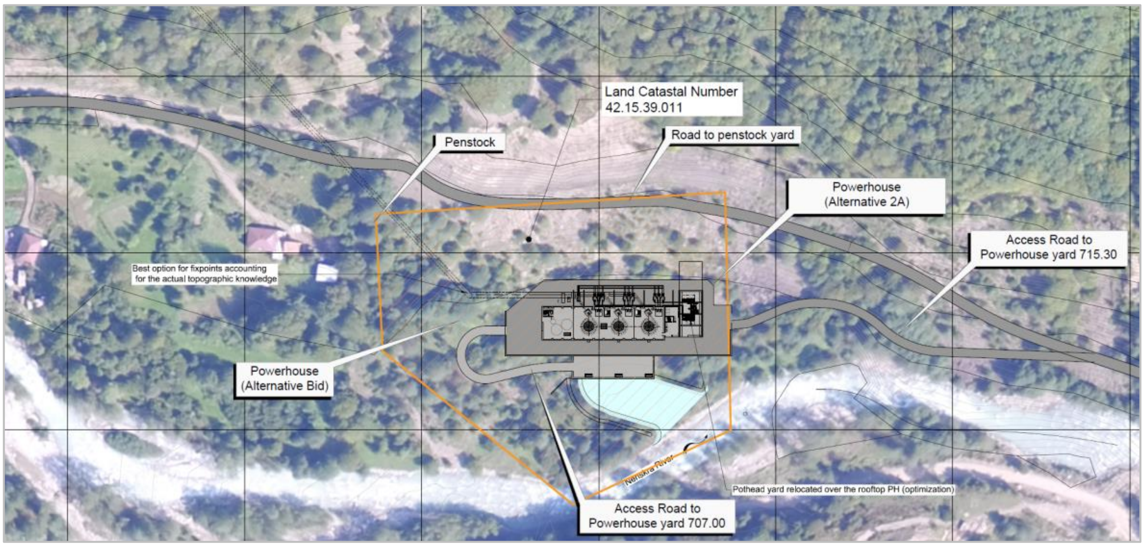



*Figure 25 - Powerhouse layout*

The powerhouse machine hall elevation will be at 715 metres asl, where auxiliary services cabinets and erection bays will be located. The turbine axis is located at 705 metres asl.

The main characteristics are as follows:

- Powerhouse building: 21 metres wide, 71 metres long and 17 metres high;
- GIS structure: 13 metres wide, 30 metres long and 14 metres high, and
- Tailrace channel: 30 metres wide, 100 metres long, 5 metres deep.

The Figure 26 and Figure 27 illustrate the front view and the plan view of the powerhouse.

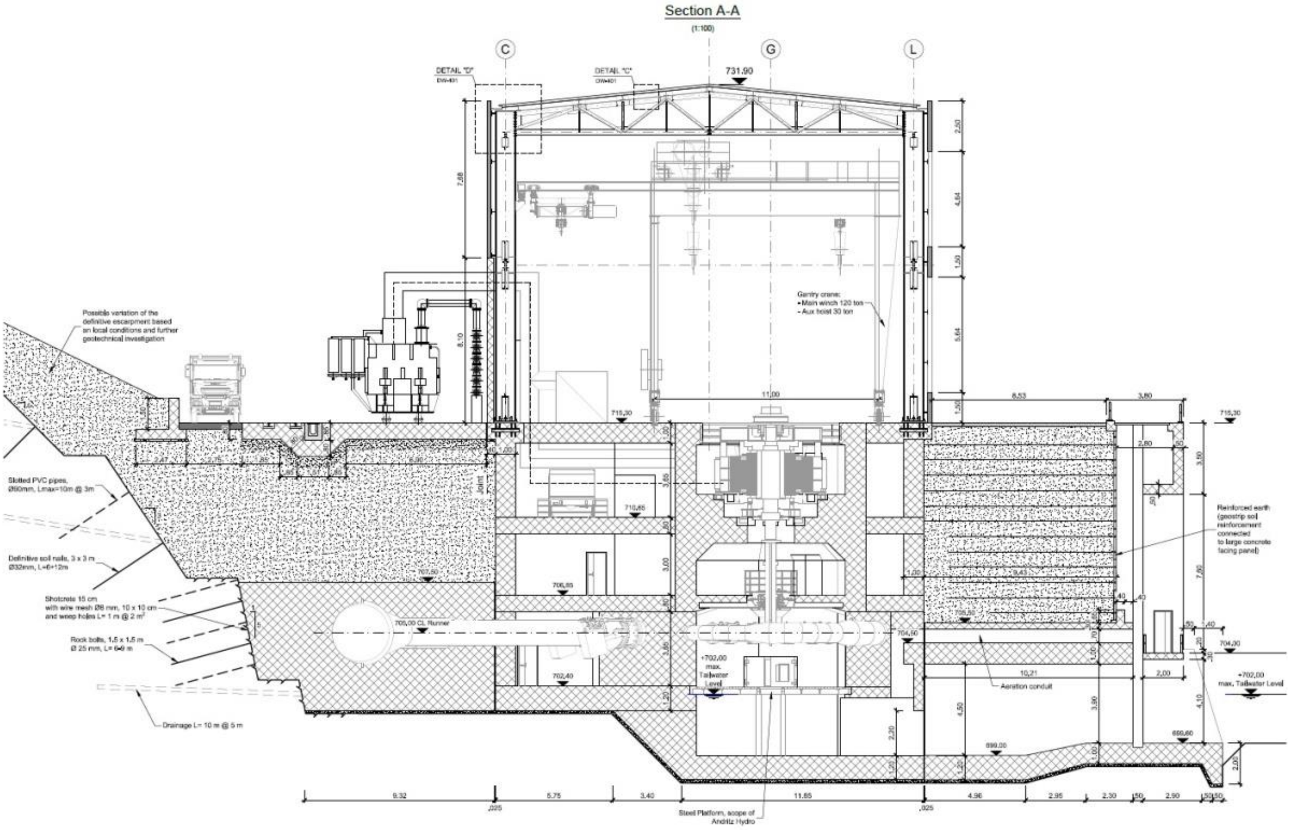



*Figure 26 - Powerhouse side view*
*from L-6768-B-CW-PH-GE-DW-208_001*

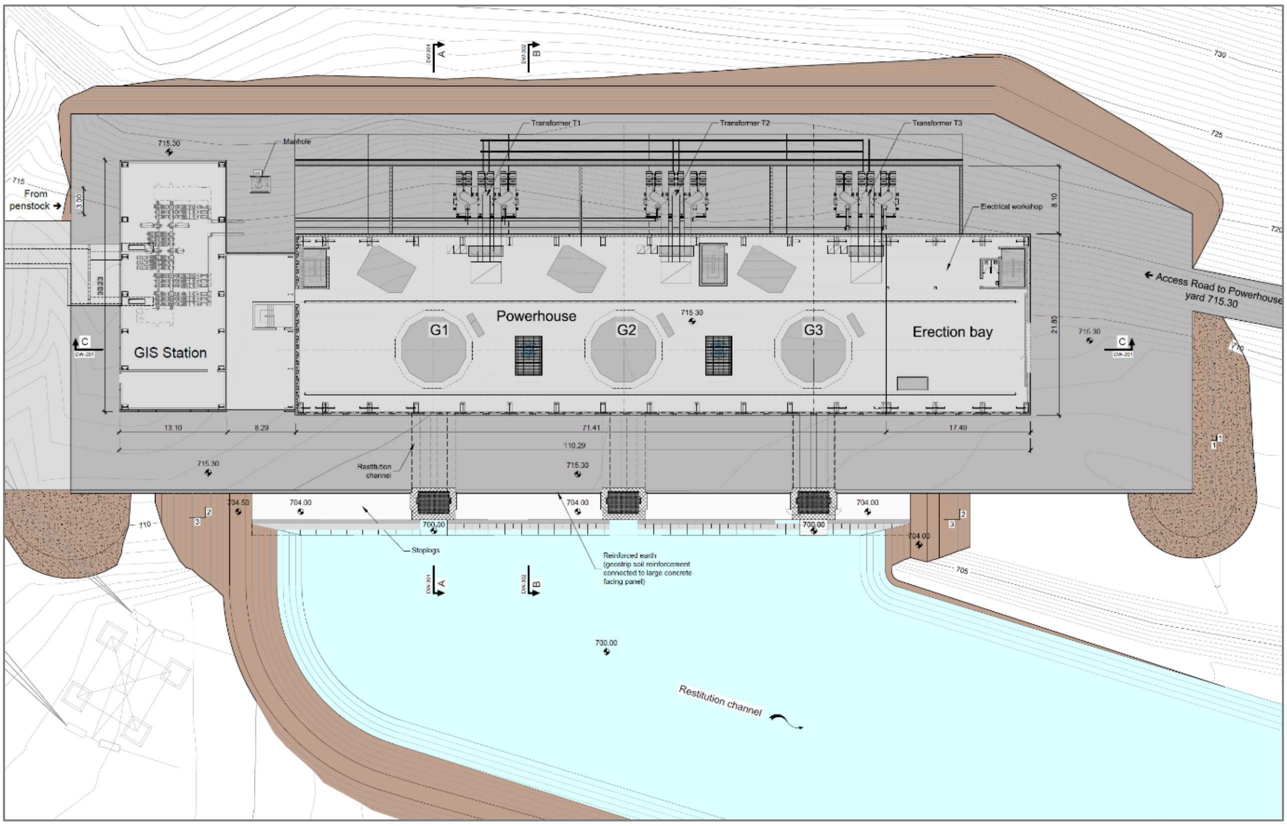



*Figure 27 - Powerhouse plan at ground level*
*From L-6768-B-CW-PH-GE-DW-201_001*

The proposed turbine arrangement is three vertical Pelton units, 93 MW capacity each (280 MW in total). The installed discharged capacity is 47 $m^3$/s.

The generating units will have lubricating oil in the bearings and transmission oil in the governor and actuators / servomotors. The same grade of oil is normally used for both. Oil will be periodically regenerated by centrifugal elimination of impurities and / or fine filtering. The hotter thrust bearing will be equipped with oil vapor separation. Abnormal events observed on similar generating units in other power plants were due to a combination of faulty bearing design and accidental spilling of lubricating oil from a bearing sump to the turbine or to the generator enclosure in case of sudden stopping of the unit (electrical braking). If such accident were to occur in the Nenskra powerhouse, oil spills would be retained in secondary containment inside the building. There is no pathway for oil to get into the water stream in normal operation.

### 3.4.2 Power service lines

During the operation phase, the Nakra Intake will be supplied in electricity by a diesel generator. The Nenskra facilities will be power-supplied with electrical service lines as follows:

- An 18 kilometre long 35 kV line between the powerhouse and the dam site, and
- A 7 kilometre long 11 kV line between the powerhouse and the surge shaft gate chamber.

The service line routes were yet to be defined when the present report was completed. The assumption is that the power service line alignment will be the same as the power supply line alignment required for the construction period (see section 3.7.7), and that it will follow the access road to the dam and the service road to the gate chamber while avoiding houses and other private assets.

## 3.5 Roads and bridges

The Project will upgrade two sections of existing roads: (i) section between the Kaishi Bridge (on the main Zugdidi to Mestia road) and the Nenskra dam site, and (ii) section between the Zugdidi to Mestia road and the Nakra water intake. Figure 28 below shows the typical cross section for the road to be constructed.

The carriageway will be of 6.5 metres width but the shoulders and drainage system will require additional space; the right-of-way required for the road will therefore vary from 8 to 10 meters. Figure 29 to Figure 31 next page show the road corridor that will be rehabilitated in the Nenskra valley.

The road corridor for the Nakra valley was yet to be defined when the present report was finalized. The upgrading works of the Nakra road will be designed in the end of 2017. Their execution is planned to start in April 2018. Consultations with local community will start in the first quarter of 2018 when a preliminary basic design for the Nakra road is available. The existing road will be upgraded taking into account the environmental & social design criteria presented in Section 3.7.8. In 2018 and 2019, the road will need to carry the traffic presented in Section 4.2.8, with mainly light vehicles but also heavy trucks (e.g. weir gates). In 2021, when the construction of the Nakra Transfer Tunnel is completed, the Tunnel Boring Machine will be disassembled and transported down to the Nakra road using several dozen of trucks. The size of these trucks (length, width) will influence the design of the Nakra road upgrading works.

Road upgrading works and any sections of new roads will be executed by the EPC Contractor in alignment with Good International Industry Practice (GIIP) as required in the Contract and the ESMP.

In the case that during the road construction/upgrading additional land acquisition is required, then this will be subject to the preparation and approval of a separate additional Land Acquisition and Livelihood Restoration Plan (LALRP) and described in Volume 9 - LALRP.

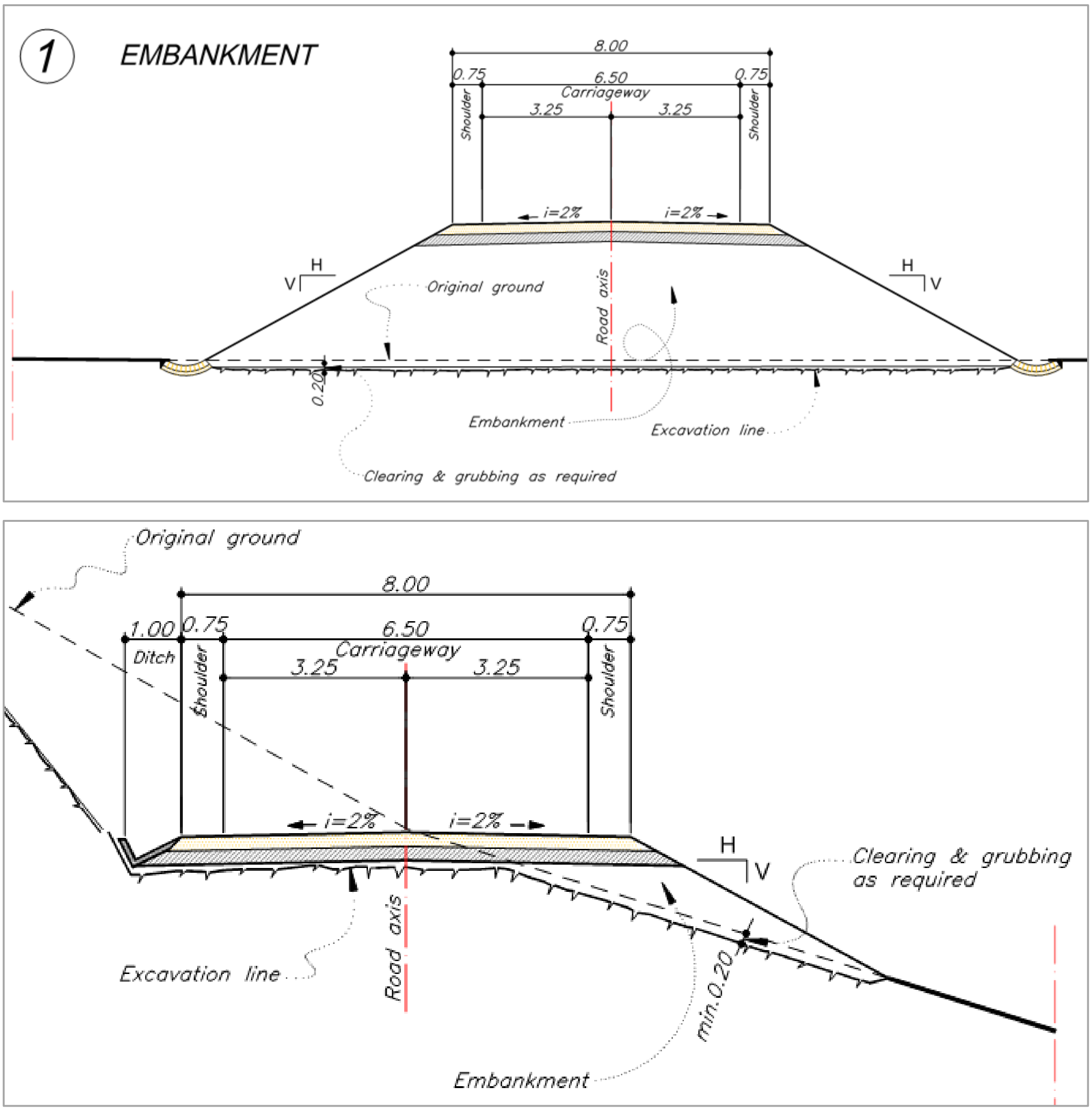
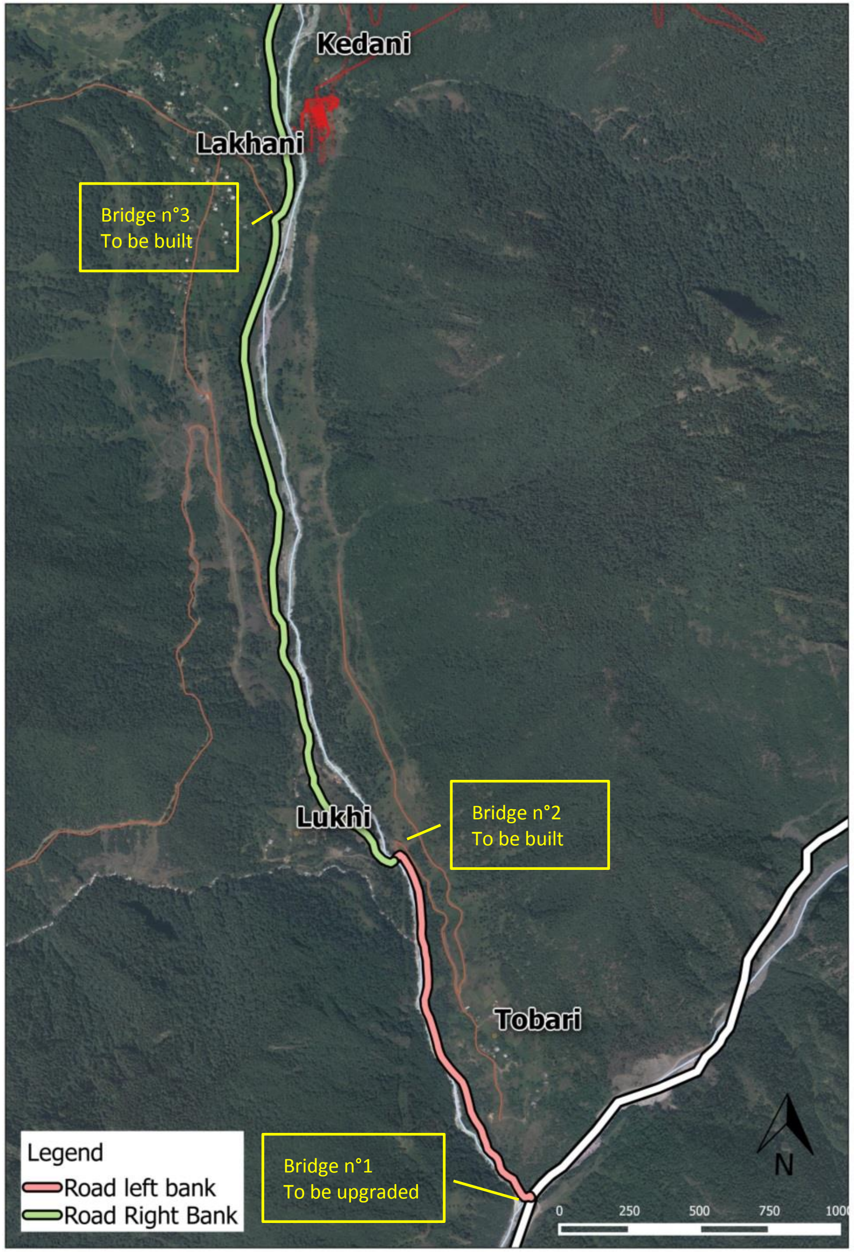



*Figure 28 - Road typical cross-sections*

Two new bridges will be constructed over the Nenskra River: in Lakhani 2 kilometres upstream of the powerhouse, and 3 kilometres downstream of the dam (see Bridge n° 4 in Figure 29 and Bridge n°11 in Figure 31).

Nine existing bridges will also be reinforced or completely re-built to support the weight of the special trucks used to carry the large construction (e.g. Tunnel Boring Machine) or operation (e.g. transformers, segments of penstock) equipment mobilized by the Project (see Figure 29 to Figure 31). It includes the Khaishi Bridge over the Enguri River on the main road to Mestia.

*Figure 29 - Proposed alignment of access road to the dam to be upgraded - Enguri to Letsperi*



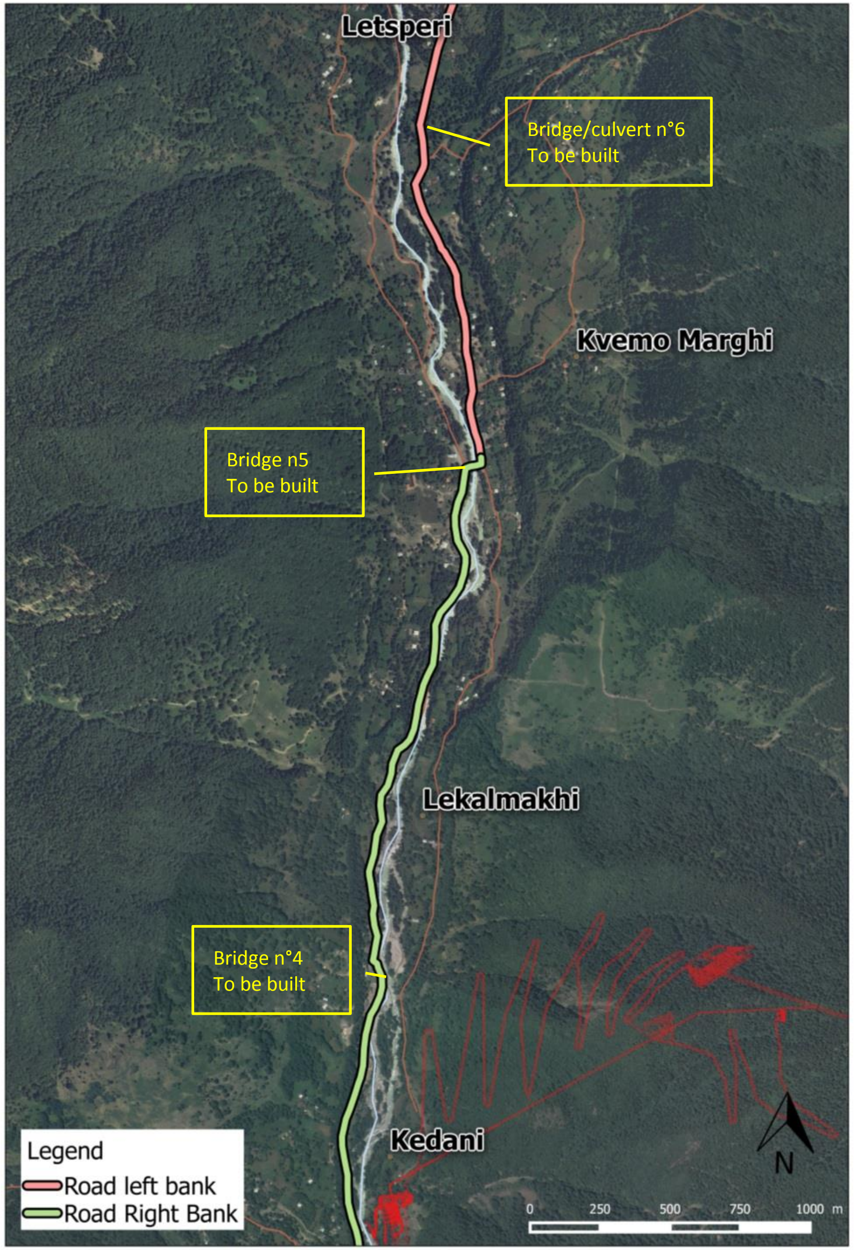
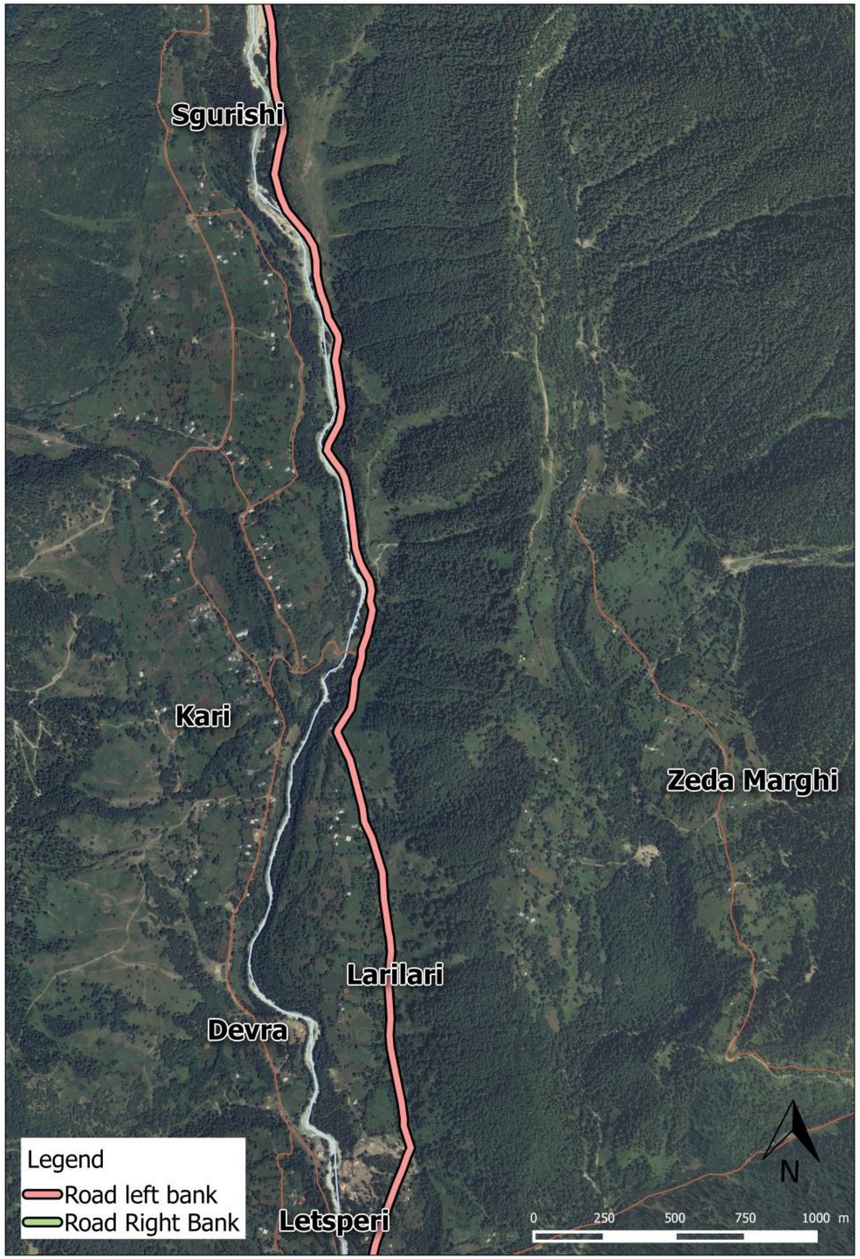
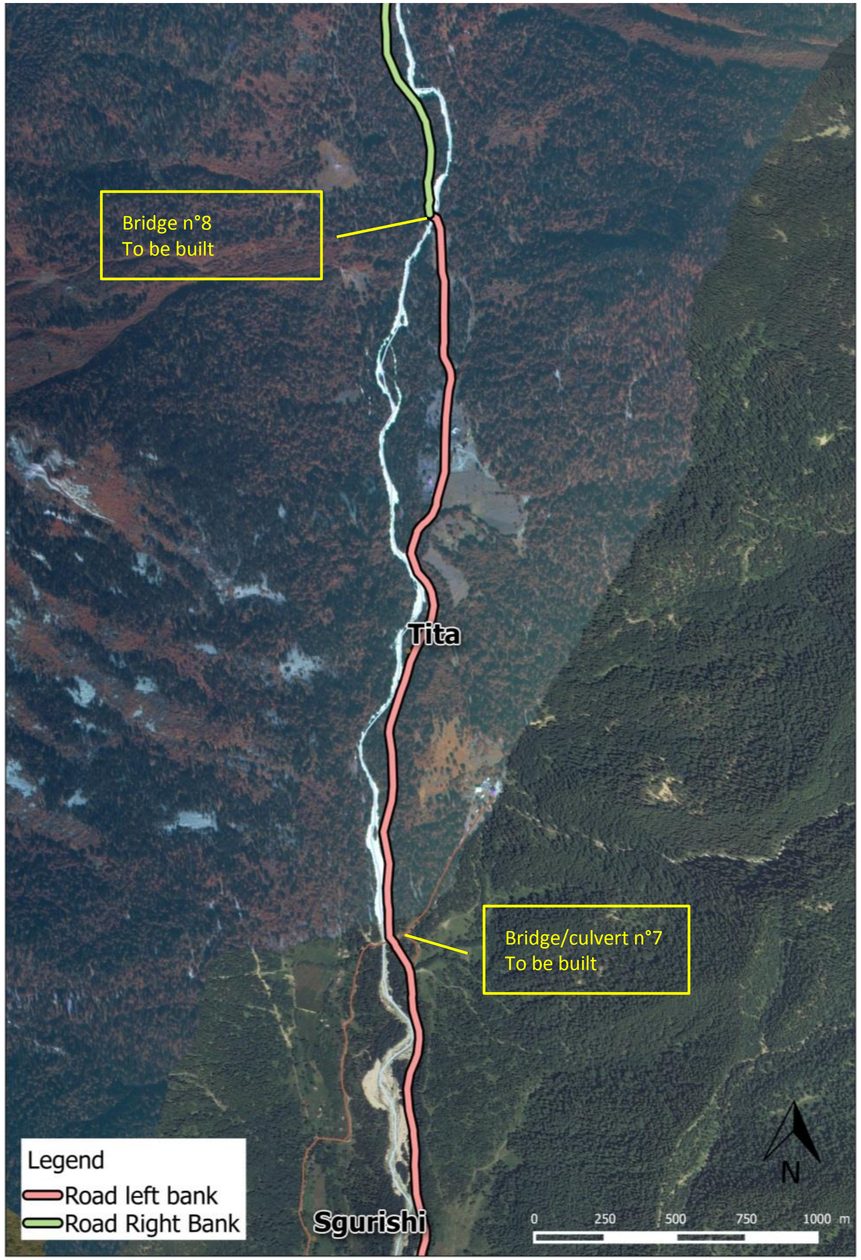



*Figure 30 - Proposed alignment of access road to the dam to be upgraded - Letsperi to Tita*



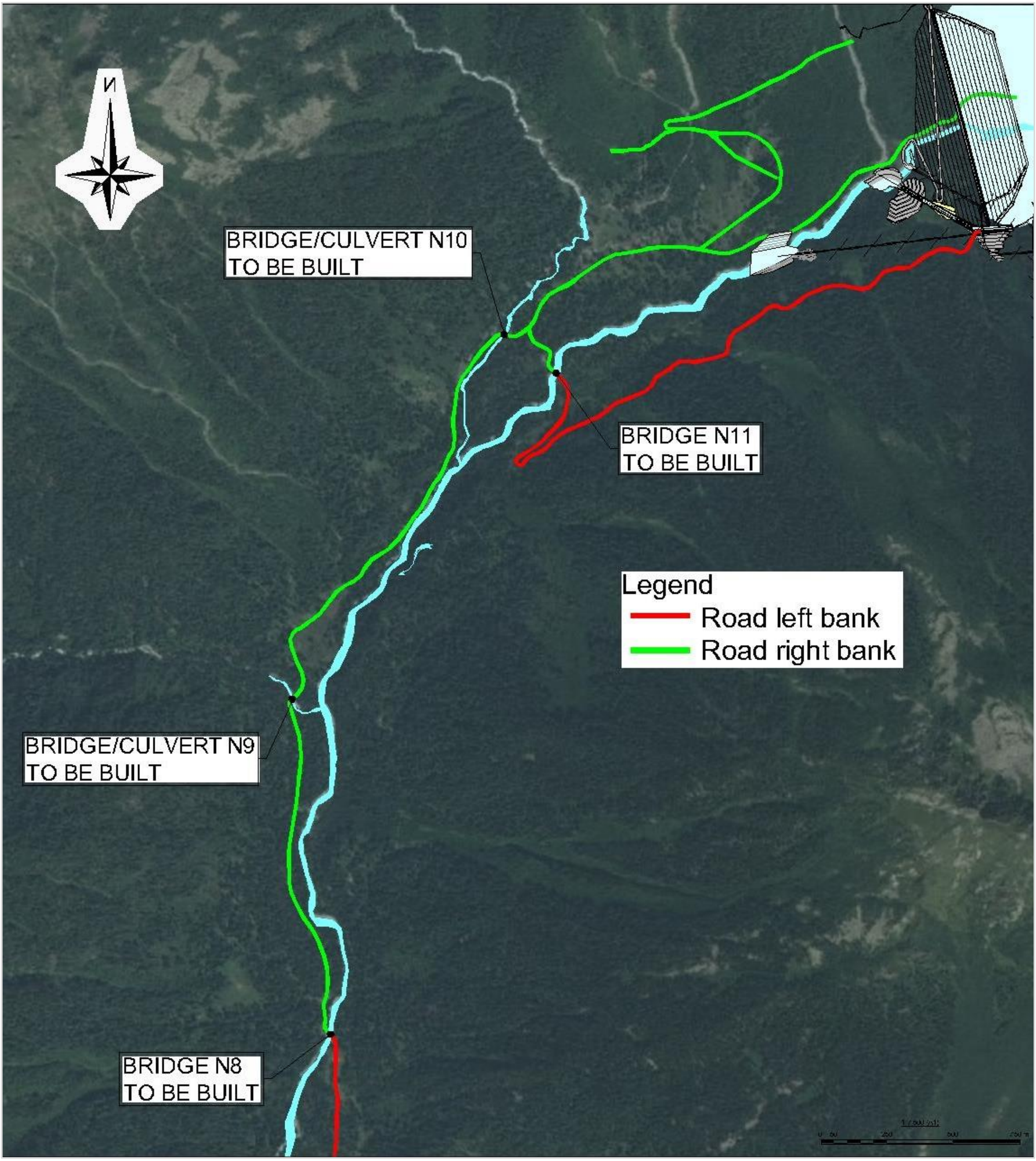



*Figure 31 - Proposed alignment of access road to the dam to be upgraded - Tita to Dam*

## 3.6 Operators' village

During the operation phase, JSCNH will accommodate the operation management team into permanent houses, named the "Operators' Village". The permanent Operators' village will also be used during the construction period to accommodate the JSCNH Supervision Team.

The Operators' Village will be located in the Nenskra valley, along the access road to the dam, 7 kilometres downstream of the dam site and 9 kilometres upstream of the powerhouse, close to Tita Village as illustrated in Figure 32 below.

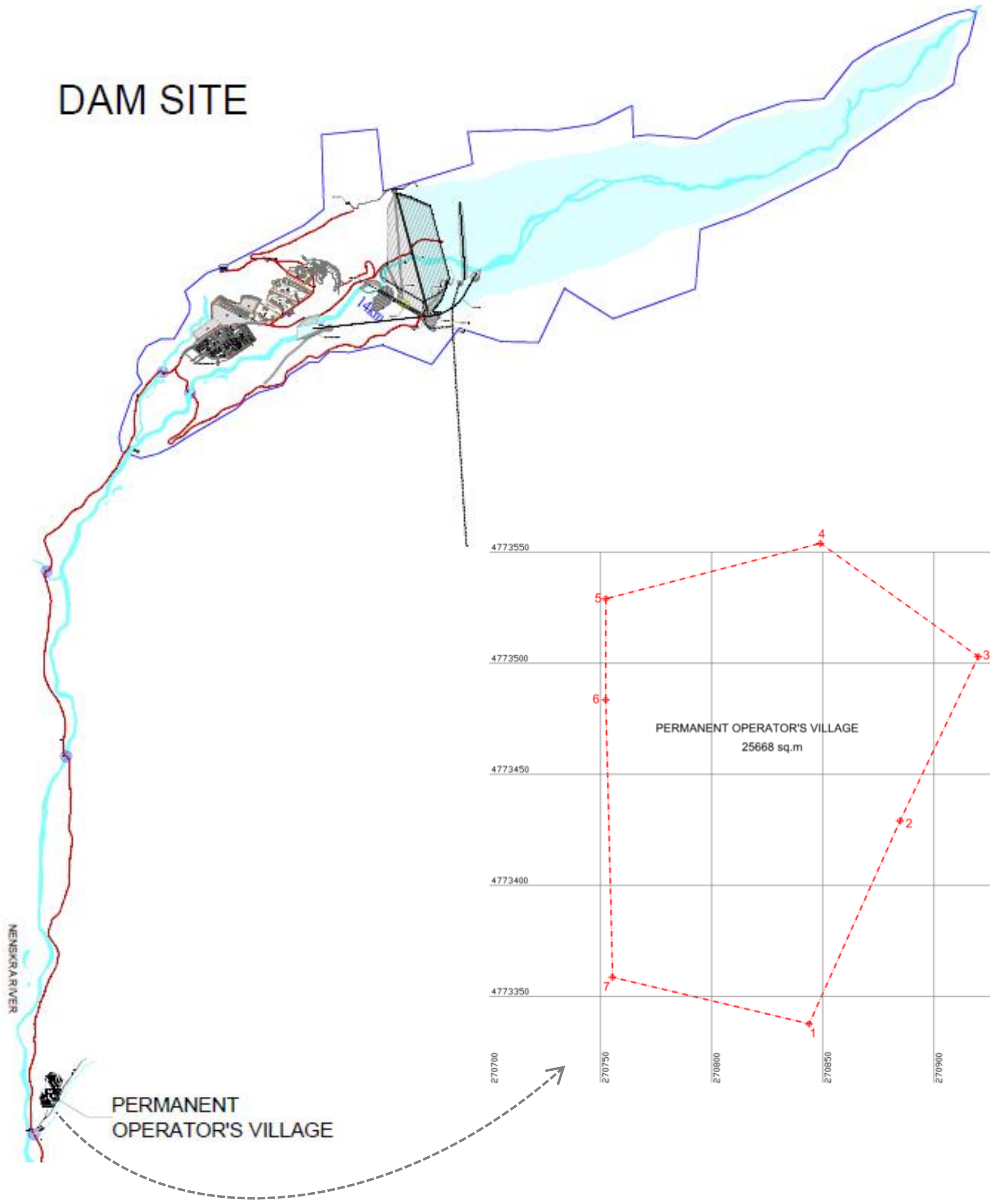



*Figure 32 - Location of permanent operators' village*

The Operators' Village will be made of 12 flats for families, 16 bachelor flats and 10 flats in guesthouse for singles; and collective building for canteen, single bedrooms as well as recreational areas. In addition, there will be workshops and storage facilities for spare parts.

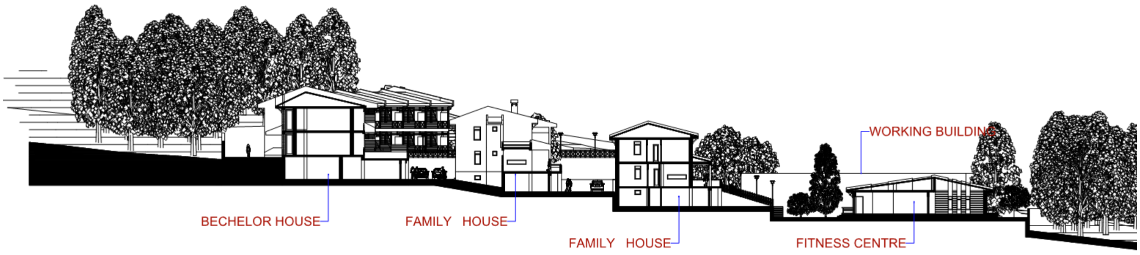



*Figure 33 - Cross section of the planned Operators' Village*

The number of persons to be accommodated in the Operators' Village will be about 100 people. Assuming a consumption of 300 litres per person for all needs (drinking, washing, cleaning, and maintenance), the daily consumption of raw water would be 30 $m^3$/day. It will be taken either through water well drilled for that purpose or from the small tributary flowing parallel to the Operators' village, which was used as source of raw water for the temporary Tita Construction Camp in 2017.

# 3.7 Temporary infrastructures required for construction purposes

Although only required for the construction period, the temporary infrastructures and facilities described in this section have the potential (volume and footprint) to permanently impact the local topography, landscape, soil and vegetation.

## 3.7.1 General work site organisation

### 3.7.1.1 Overview of worksites

The construction activities will be concentrated on 3 worksites (see Figure 34 for location):

- The dam site and reservoir area;
- The powerhouse and switchyard area, and
- The Nakra water intake area.

The tunnelling activities will be organized from the dam site and reservoir area (Nakra Transfer Tunnel) and from the powerhouse and switchyard area (Nenskra headrace tunnel).

The access road rehabilitation works will be organized using one of the three above listed areas as logistic base (i.e. no fly camps or road camps).

The transmission line works will be organized separately using logistics arrangements which were yet to be defined when the present document was issued (see Section 3.9).

In each of the 3 works sites, the EPC Contractor will execute the construction works as per the required design but will also operate:

- A construction camp where the workforce will be accommodated;

- Technical installations, including parking areas, workshops, laydown areas. At dam site, there will be a crushing/screening plant and a batching plant. There will only be a batching plant at the powerhouse worksite and at the Nakra intake worksite, and
- Disposal areas where the various spoils (from tunnelling and excavation) will be disposed of permanently.

The quarry areas will be located within the Nenskra reservoir area.

#### 3.7.1.2 Prevention of accidental pollution through layout and design

The detailed layout of the camps and technical installations described in the following paragraphs will be developed as the Project moves forward. The positioning of items will take into account the risk to the environment in case of accidental spillage or leaks and where possible will be located in areas away from water courses. Such items will include stockpiles, gravels, cement, oil storage, waste storage, septic tanks. The EPC Contractor is required to put in place pollution prevention and protection measures as described in the Volume 8 - ESMP.

### 3.7.2 Construction camps

Three construction camps will be installed:

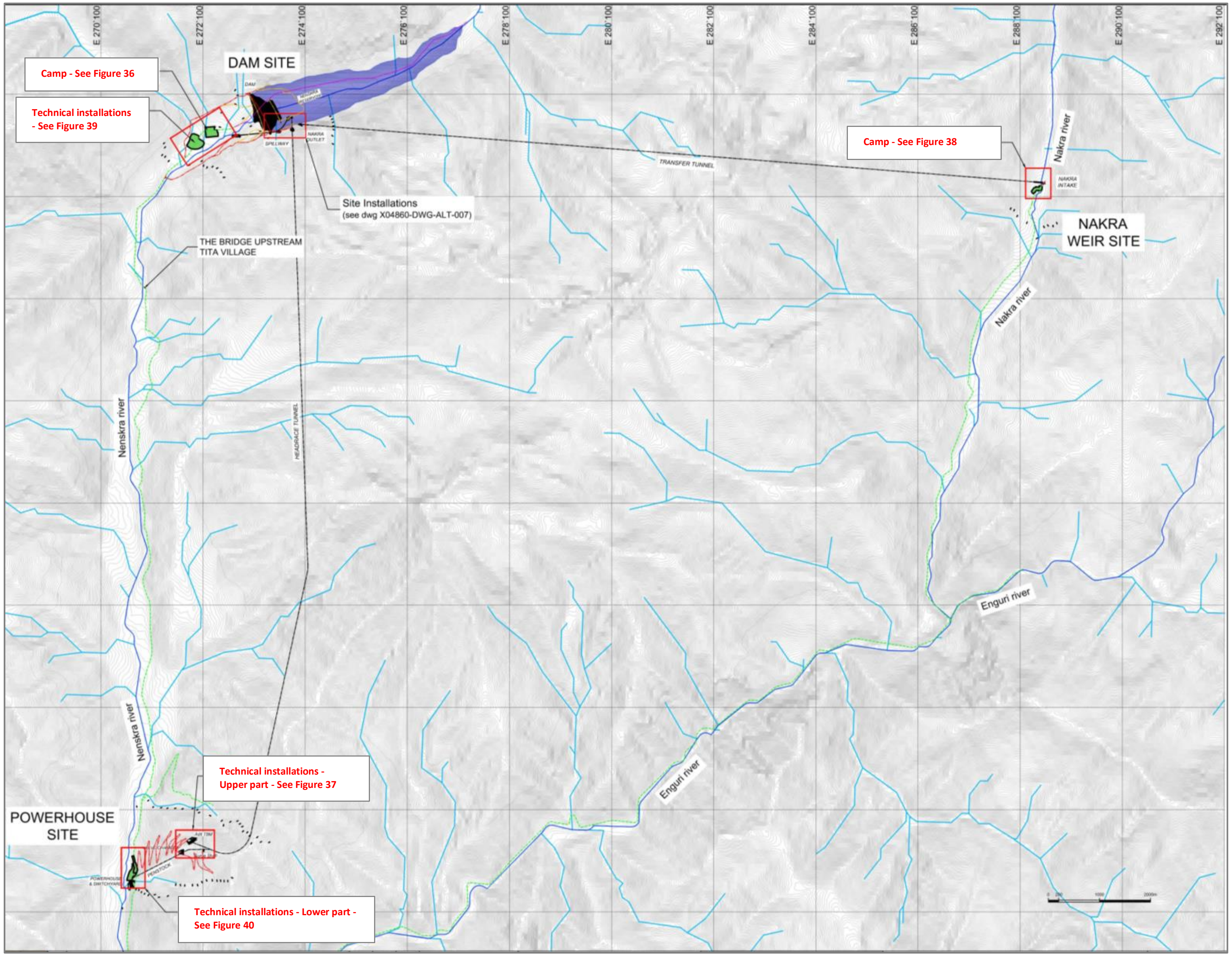
- The Powerhouse construction camp;
- The Dam Site construction camp, and
- The Nakra Water Intake Construction camp.

The Operator's Village (permanent houses and buildings for JSC Nenskra Hydro) to be used for construction and operation periods, will not be located in one of the three above listed construction camps. It will be built close to Tita hamlet (see Section 3.6).

A temporary construction camp will be built and operated during the Early works (until the main construction camps are operational) close to Tita hamlet, immediately adjacent to the future Operators' village. It will accommodate non-local workers and have a capacity of 30 persons.

*Figure 34 - Location of the 3 main construction sites*

*Source: SALINI - Drawing n° X04880-DWG-ALT-004-General layout*



These camps will provide the accommodation and relevant social buildings for all the staff employed by the EPC Contractor and its main subcontractors (Drilling and grouting works, cut-off wall construction; Dam Asphalt Face, Hydro mechanical installations, Electromechanical installations).

No accommodation has been considered for the local subcontractors to be mobilized during the early works phase (See Section 4.1.1).

### 3.7.2.1 Camp for the dam site

The camp at the dam site will have a capacity to accommodate 628 persons, made of:

- 24 senior staff employed by the EPC Contractor;
- 588 skilled and unskilled personal employed by the EPC Contractor: 100 junior supervisors, 280 skilled workers, 208 unskilled workers, and
- 16 persons from JSC Nenskra Hydro.

The camp will be located 2 kilometres downstream of the dam site on the right bank of the Nenskra River as shown on Figure 35. It will have the general layout as illustrated on Figure 36.

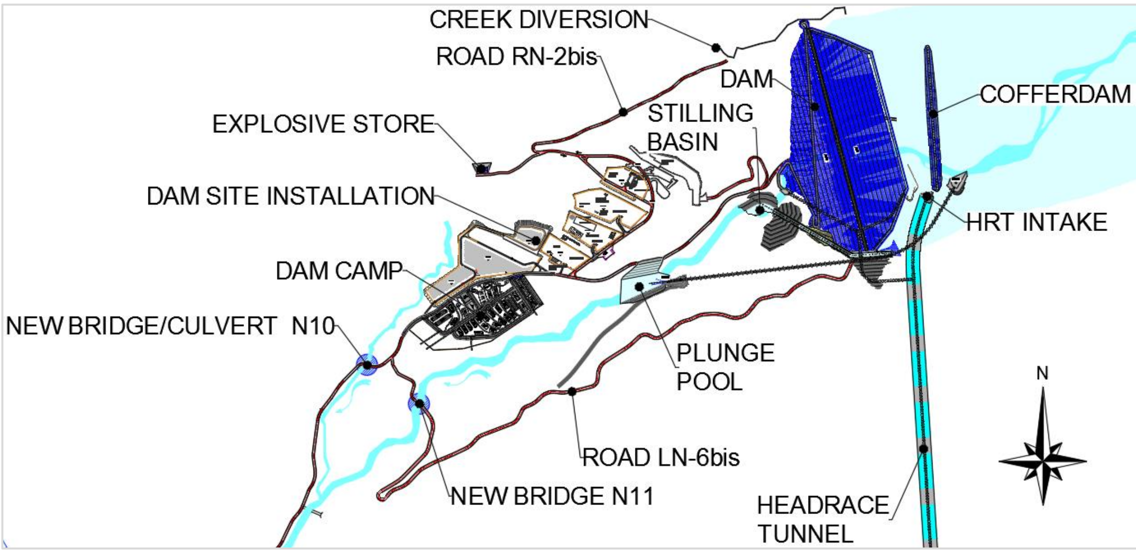



*Figure 35 - Location of camp and technical installations at dam site*

All buildings will be single storey constructed in prefabricated structure upon a 20 centimetres thick reinforced concrete slab casted on a 25 centimetres thick natural selected drainage material. Rooms will be provided with be provided with all necessary equipment for the living conditions in the Nenskra valley. There will be no family house in the camp.

In addition of rooms, the Dam camp will have the following social facilities:

- Canteen for senior/junior staff and for workers;
- Laundry;
- Club houses;
- Cooperative shop;
- Guard houses, and
- First aid station.

The camp will be provided with all the required distribution lines for:

- Domestic water;
- Power supply (all buried), and
- Sewage system to the treatment plant.

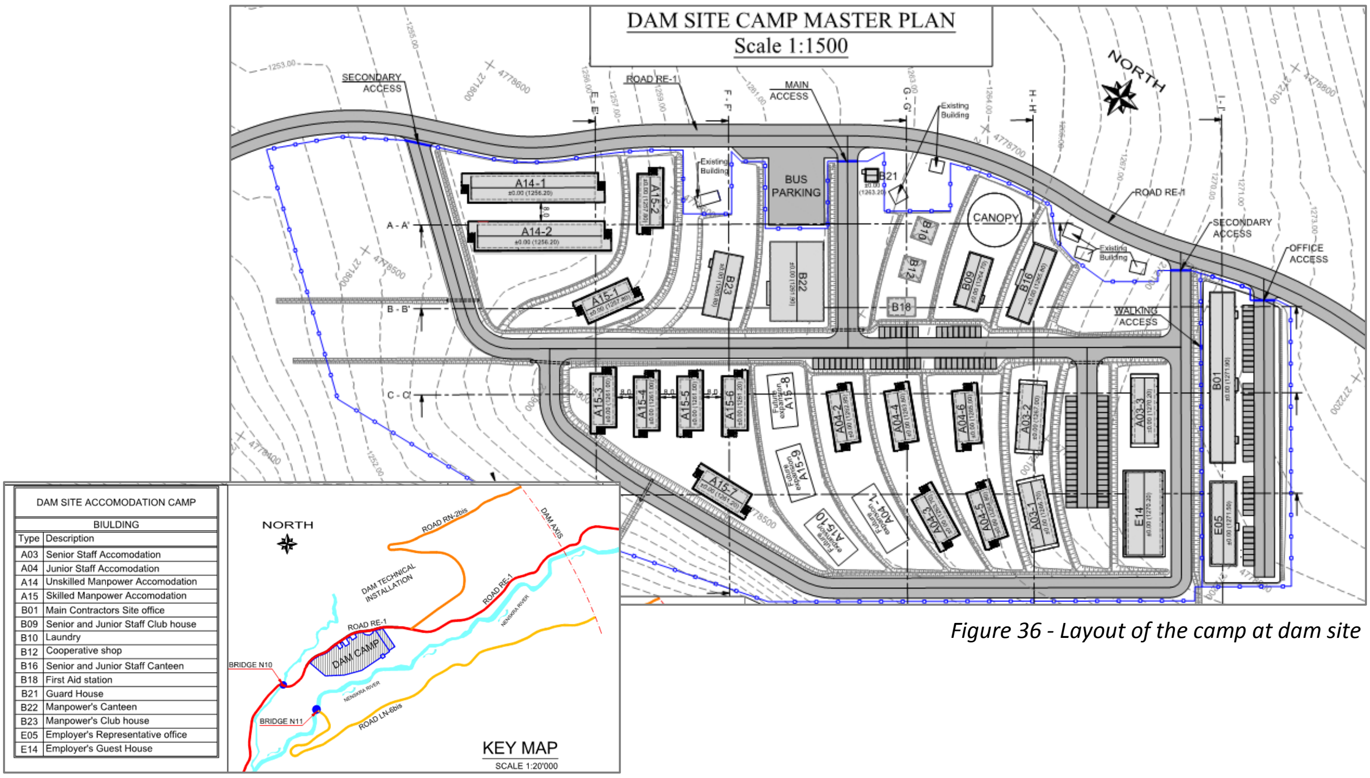



*Figure 36 - Layout of the camp at dam site*

In the camp, there will also be the potable water treatment plant to produce drinkable water from the Nenskra River water (170 $m^3$/day) and the waste water treatment plant, both designed for the camp's maximum capacity.

A pumping station will be installed on a pontoon floating on the Nenskra River. The raw water will be conveyed to a sediment tank and further processed in the treatment plant located in the camp area. The treated water will be then conveyed to an elevated water storage tank located in the camp and distributed by gravity to the final distribution points through buried pipelines.

The required power will be supplied by the main power stations located on the technical installation areas.

### 3.7.2.2 Camp for the powerhouse area

The camp at the powerhouse work site will have a capacity to accommodate 340 persons, made of:

- 16 senior staff employed by the EPC Contractor, and
- 324 skilled and unskilled personal employed by the EPC Contractor: 60 junior supervisory staff, 160 skilled workers, 104 unskilled workers.

The location of the Powerhouse camp was yet to be confirmed at the time of writing.

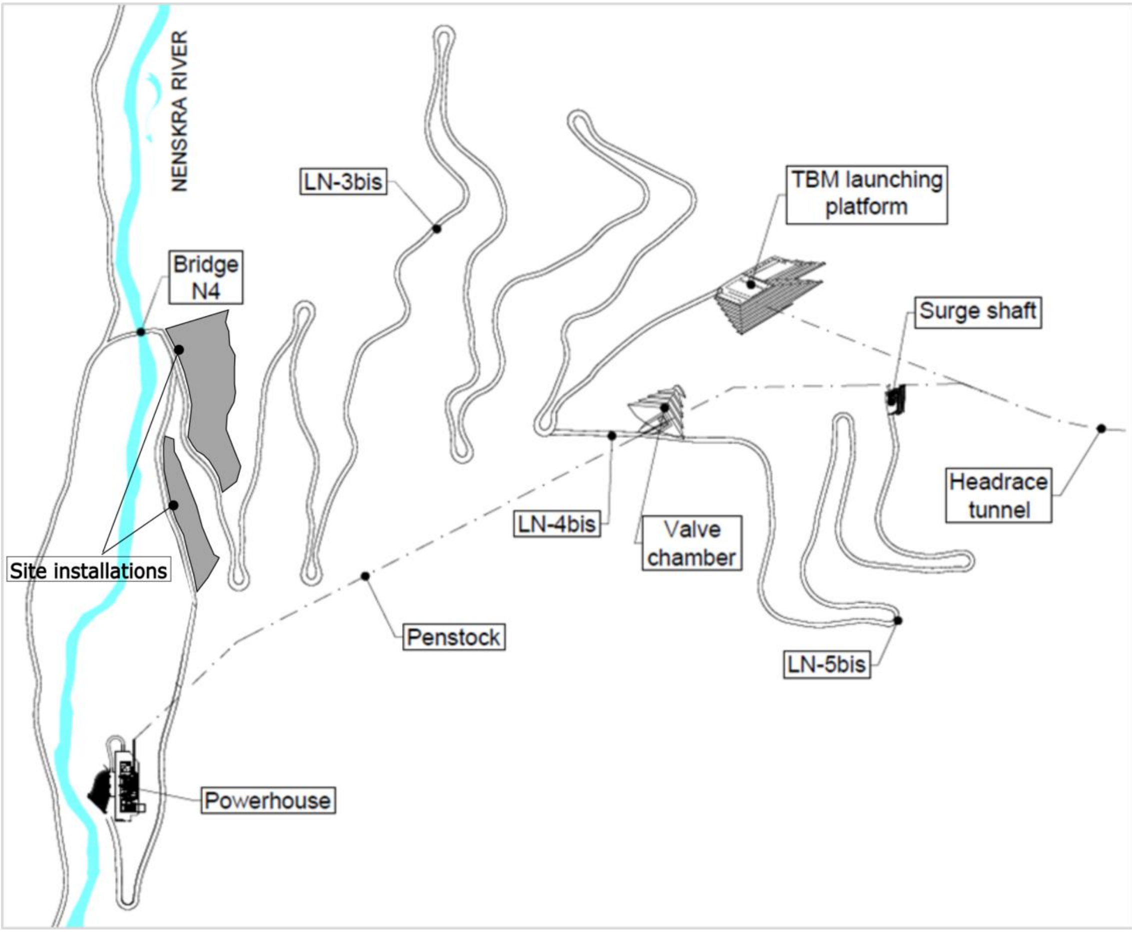



*Figure 37 - Location of technical installations at the powerhouse site*

As for the Dam camp, all buildings for the EPC Contractor staff will be constructed in pre-fabricated structure. There will also be collective buildings, such as canteen and laundry, club houses, and first aid station. The camp will be provided with a drinking water treatment plant using water pumped from the Nenskra River (92 $m^3$/day).

### 3.7.2.3 Camp for the Nakra headworks

The camp at the Nakra water intake site will have a capacity to accommodate 190 persons, made of:

- 8 senior staff, and
- 182 skilled and unskilled personal: 10 junior supervisory staff, 120 skilled workers and 52 unskilled workers.

The camp will be located 200 metres south of the Nakra headworks on the right bank of the Nakra River as shown on Figure 35. It will have the general layout as illustrated on Figure 38.

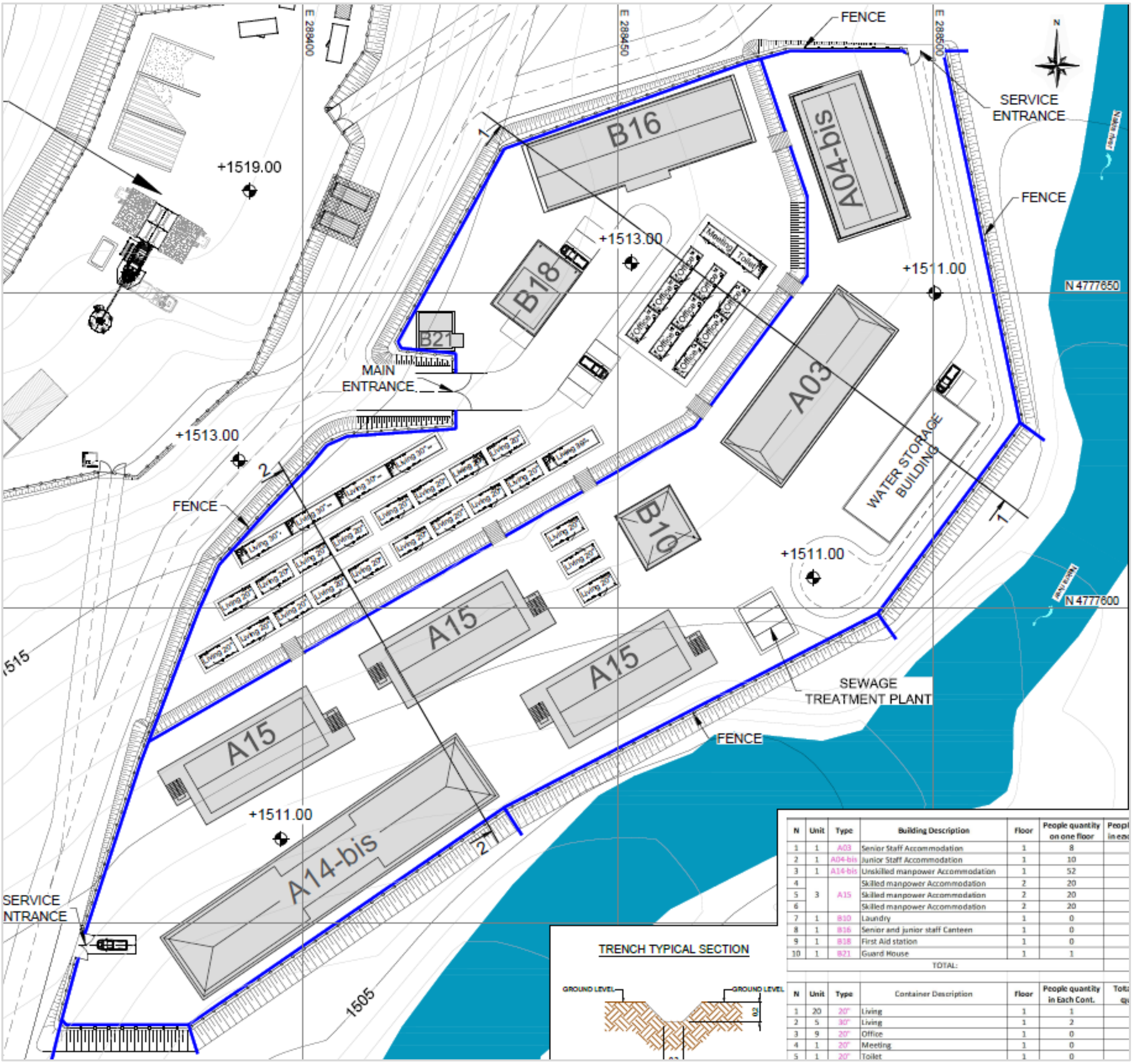



*Figure 38 - Layout of the camp at the Nakra intake site*

Buildings will be similar to the standard provided to the Dam camp and the Powerhouse camp, all in prefabricated structure. There will also be collective buildings, such as canteen and laundry and first aid station. The camp will be provided with a drinking water treatment plant using water pumped from the Nenskra River (36 $m^3$/day).

## 3.7.3 Technical installations

The technical installations include all facilities, laydown areas, parking areas and buildings required to execute the works other than the camps. They are located close to the camps for security and logistics reasons.

### 3.7.3.1 Dam area

#### A. Main technical installations

The main technical installations at the dam site will be located on the right bank of the Nenskra River, close to the Dam camp as shown on Figure 35. Their general layout is illustrated on Figure 39.

The main technical installations will include:

- The site offices for the EPC Contractor, the Engineer and the Employer;

- A first aid station;
- A laboratory , a warehouse, and the main workshop, all covered;
- A fuel deposit, plus one mobile fuel tank for distribution around the sites;
- A carpentry yard and a steel reinforcement yard;
- A concrete batching and mixing plant;
- A crushing and screening plant;
- An asphalt plant;
- A power generating plant, and
- The explosive storage building.

### B. Secondary technical installations

Other technical installations will be operated at the dam site during the construction period:

- TBM installations: the Tunnel Boring Machine operation will be require specific installations at the Nakra Transfer Tunnel outlet area: workshop, warehouse, small offices, dressing rooms, train parking and maintenance areas, ventilation, water and power supply facilities, and
- For each of the Spillway inlet portal, Power Intake portal, Bottom outlet inlet portal, and Access gallery portal :
  - Workshop (containers and sheltered areas for the maintenance and repair works of the equipment assigned to this part of the work);
  - Prefabricated buildings for dressing rooms supplied with the water/power/sewage lines;
  - Warehouse and first aid station, and
  - Facilities for ventilation, water and power supply.

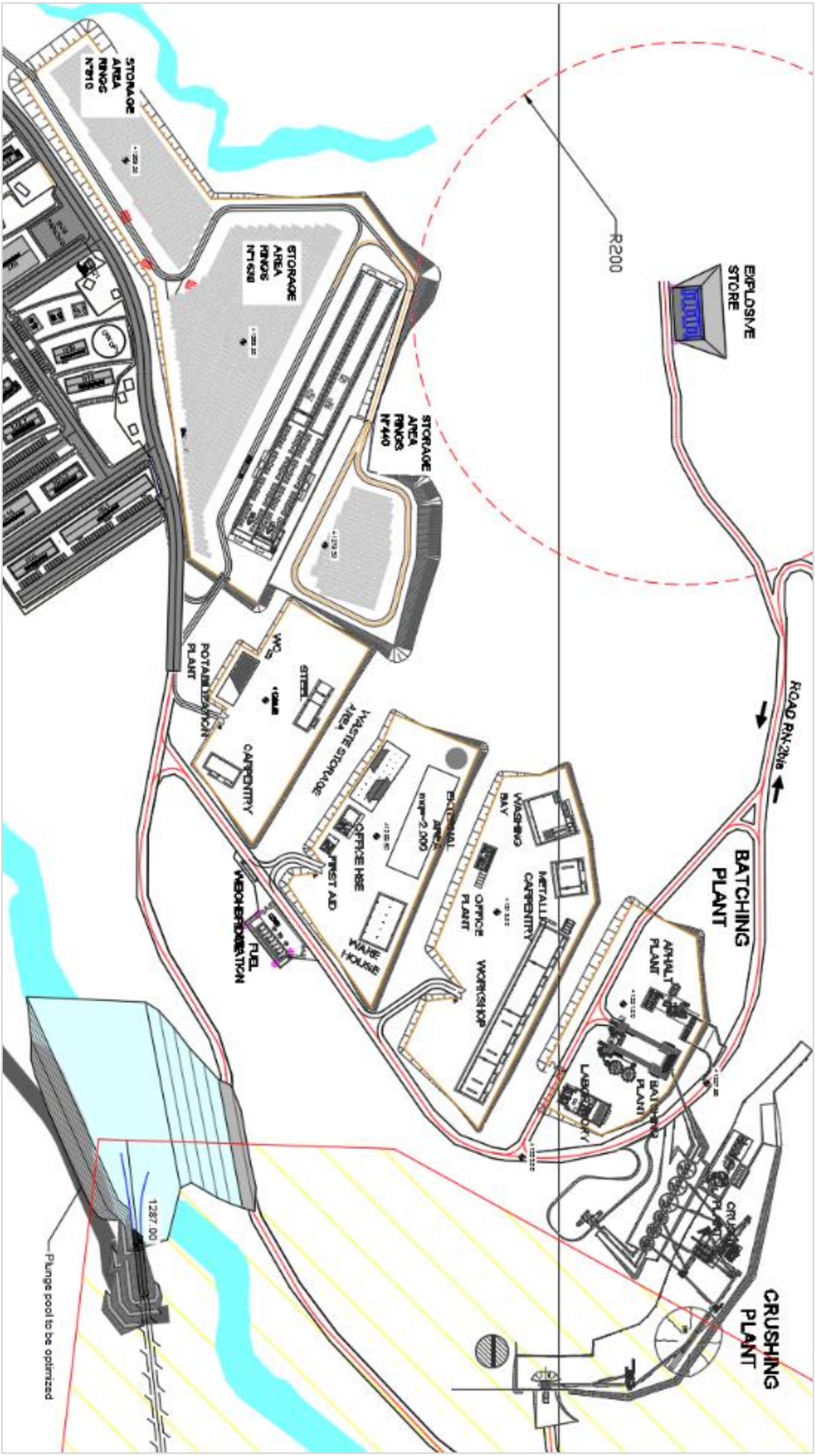



*Figure 39 - Layout of the technical installations at dam site*

#### 3.7.3.2 Powerhouse and switchyard area

The technical installations at the powerhouse are will be located in two main platforms:

- The powerhouse and switchyard installation area, located on the left bank of the Nenskra River between the powerhouse camp and the powerhouse construction site (see Figure 24 and Figure 40).
- The TBM platform installation located 600 metres above the powerhouse (at an altitude of 1,300 metres asl - See Figure 37) from which the TBM will be launched and driven for the headrace tunnelling activities.

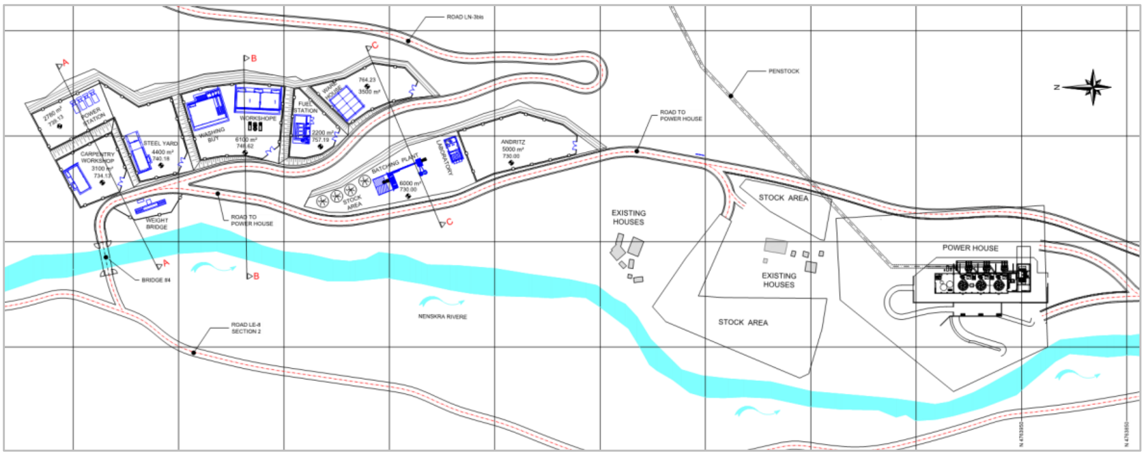



*Figure 40 - Layout of main technical installations at the Powerhouse area*

The main technical installations will include:

- A laboratory, a warehouse, and the secondary workshop, all covered;
- A first aid station;
- A fuel deposit made of 3 buried fuel tanks, plus one mobile fuel tank for distribution around the sites;
- A carpentry yard and a steel reinforcement yard;
- A concrete batching and mixing plant;
- A power generating plant;
- The explosive storage building, and
- On the powerhouse construction site, 2 stationary tower cranes will be operated.

The technical installations at the TBM launching platform will include:

- The workshop, warehouse, small offices, dressing rooms, train parking and maintenance areas, ventilation, water and power supply required to operate the TBM activities, and
- A first aid station.

In addition of the main technical installations and the TBM launching platform, there will be the following smaller technical installations: the surge shaft collar, the valve chamber collar, the adit tunnel for horizontal penstock. For each of these other technical installations, there will be a workshop (containers and sheltered areas for the maintenance and repair works of the equipment assigned to this part of the work); Prefabricated buildings for dressing rooms supplied with the water/power/sewage lines, Warehouse, Facilities for ventilation, water and power supply.

#### 3.7.3.3 Nakra intake area

The technical installations at the Nakra water intake site will be smaller than the installations operated at the dam site and the powerhouse site. The tunnelling activities will be driven from the Nenskra valley (e.g. TBM driving, evacuation of tunnelling spoil).

The site installations will be located on the right bank of the Nakra River, adjacent to the camp and will include:

- Site offices in 20 person portable cabins;
- Workshop and warehouse in 20 person portable cabins;
- First aid station in a 20 person portable cabins;
- Concrete batching and mixing plant;
- Power station and fuel tank, and
- Explosive storage area.

### 3.7.4 Quarry areas and borrow areas

The construction of the Nenskra Dam will require a vast amount of rockfill material. While the EPC Contractor will maximize the recycling of excavated material in order to save the costs relating to logistics and stockpiling, there is still a need to extract material from the natural environment.

For the three main construction sites (Dam site, Powerhouse site and Nakra Intake site), the main sources of sand, gravel, rockfill material and rocks for rip rap protection will be (i) the natural alluvium deposits and the quarry areas both located in the reservoir area and at dam site and (ii) the material recycled from the excavation works at the three sites after screening.

The need of material for the Nakra intake construction site will be covered as follows:

- Sand for shotcrete preparation will be transported by truck from the crushing plant installed at the dam site, and
- Aggregates required for the concrete production will be produced at the dam crushing plant or the powerhouse screening plant, and further transported by truck to the Nakra intake construct site.

Table 12 shows the estimated quantities (in tons) of material that would be extracted from the reservoir area and from the powerhouse area.

**Table 12 - Quantities of materials extracted at the dam area and the powerhouse area**

| Material | Use | Total (Tonnes) | Extracted from the Reservoir area (Tonnes) | Extracted from the Powerhouse area (Tonnes) |
|---|---|---|---|---|
| Sand | Concrete | 354,577 | 142,937 | 211,641 |
| | Filter and drain | 228,061 | 228,061 | |
| Gravel | Concrete | 447,947 | 179,289 | 268,658 |
| | Filter and drain | 298,138 | 298,138 | |
| Selected gravel | (Dmax=120 mm) | 185,859 | 185,859 | |
| Transition Material | (Dmax=200 mm) | 1,279,016 | 1,279,016 | |
| Rockfill material | (Dmax=600 mm) | 8,677,048 | 8,677,048 | |
| Rockfill material | (Dmax=1,000 mm) | 18,238,258 | 18,238,258 | |
| Rip Rap | | 1,037,000 | 1,037,000 | |

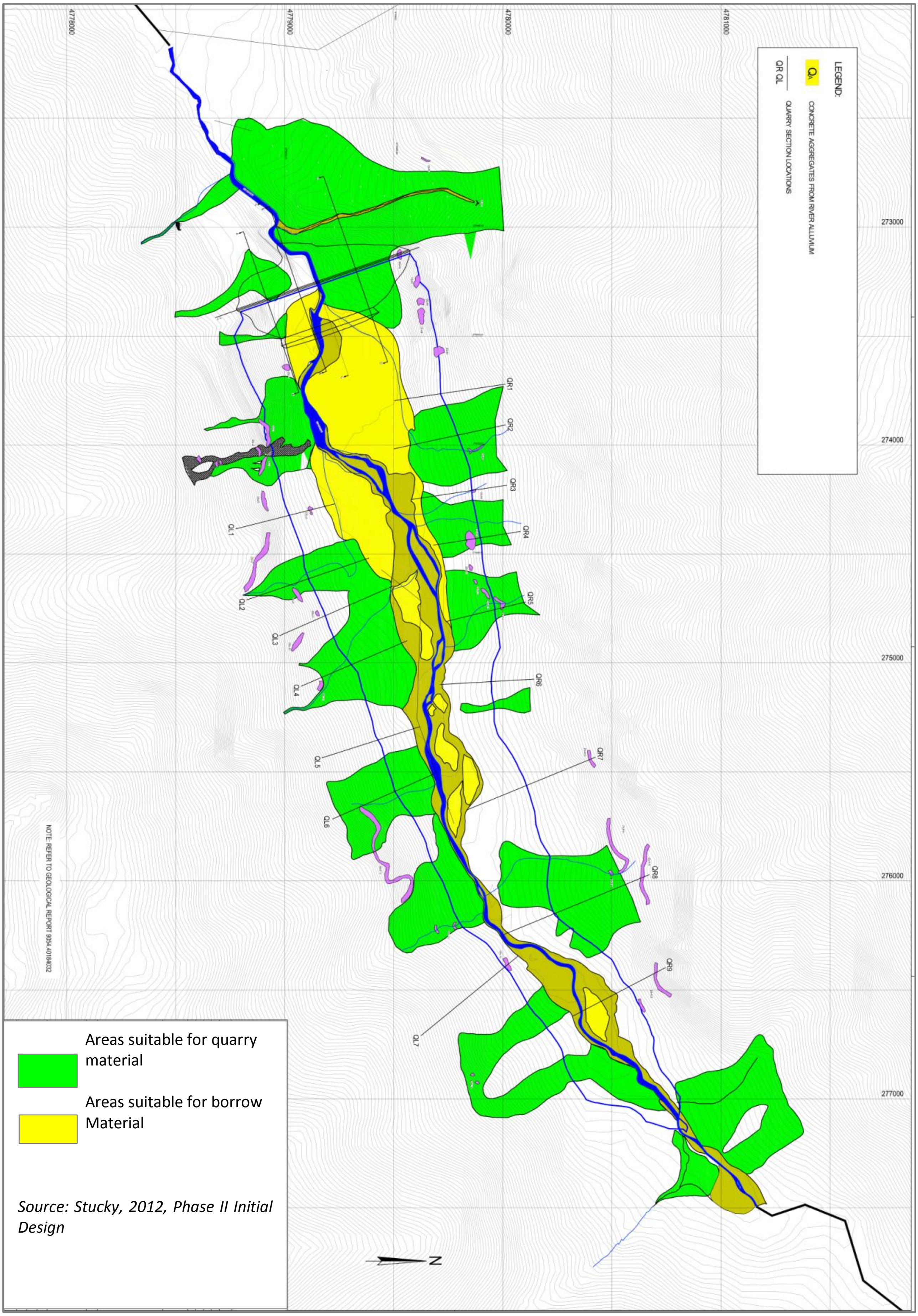
| Material | Use | Total (Tonnes) | Extracted from the Reservoir area (Tonnes) | Extracted from the Powerhouse area (Tonnes) |
|---|---|---|---|---|
| Sandy gravel from excavations | | 799,563 | 799,563 | |
| Sand and Gravel for Asphalt | | 181,250 | | |
| **Total** | | **31,726,717** | **31,065,169** | **480,299** |

*Source: SALINI - Construction Method Statement - Doc Vol. I_6 - Base Bid.*

The quarry and borrow areas in the reservoir area and at dam site will be located within the area areas located on Map 3.2. The areas in yellow represent the areas suitable for the borrow material (sand, gravel, rockfill). The green areas represent the areas suitable for the quarry material (riprap). These areas were identified during the Feasibility Study investigations in 2012 by Stucky.

The final map of planned borrow and quarry areas will be available prior to the start of the main construction period in the second half of 2017. To the extent possible, the quarry areas borrow areas will be exploited within the full supply level of the future reservoir. Should these limits extend above the Full Supply Level; the affected areas will be reinstated as per the Environmental and Social Management Plan provisions (See Volume 8 - ESMP).

*Map 3.2 -Potential quarry areas and borrow areas at dam site and in the Nenskra reservoir area*




*Source: Stucky, 2012, Phase II Initial Design*

### 3.7.5 Disposal areas

#### 3.7.5.1 Principles

The strategy to dispose of the material excavated during the construction of the Project infrastructures (e.g. tunnel, dam and powerhouse foundation) is based on the following principles:

- Permit to be obtained from the GoG and the design of the disposal area is to be in alignment with GIIP and Georgian regulatory requirements;
- Development of disposal areas not defined end of 2017 at the time of writing (see Section 3.7.8 for environmental & social screening of temporary facilities yet to be defined) will be subject to an additional LALRP prepared under the responsibility of the Project Company and which will be approved by GoG and Lenders. Pasture areas will be avoided to the possible extent;
- Reuse of suitable excavated material for construction purposes in order to minimize the volume of materials to be disposed of;
- As much as the operation constraints and the Environmental Permit allow, use the reservoir area for disposing excavated material and minimize stockpiling downstream of the dam;
- Use of the borrow areas and quarry areas which are no longer exploited as disposal areas, and
- Recycling of the tunnel excavation material for the road rehabilitation works or new access road construction as well as for road maintenance purposes.

The preliminary estimates carried out during the preparation phase by the EPC Contractor provide the following information:

- The total volume of excavated material that could not be reused for construction purposes and will have to be disposed of is 3.1 million cubic metres, broken-down as follows:
    - 1.94 million cubic metres generated during the excavation works for the foundation of the structures, 50% being produced at the dam site;
    - 525,000 cubic metres of spoil from tunnelling activities (Nakra Transfer tunnel), and
    - 625,000 cubic metres of overburden excavated from quarry areas and borrow areas.
- 40% of this material (1.2 million cubic metres) will be disposed of in borrow areas and quarry areas which are no longer exploited at the dam site (400,000 cubic metres of foundation excavation; All spoil from the excavation of Nakra Transfer Tunnel, Bottom outlet tunnel and Spillway tunnel; All spoil from the overburden of quarry areas and borrow areas)
- The remaining material (approx. 1.9 million cubic metres) will have to be disposed of in new disposal areas. Three disposal areas are planned to be constructed for this purpose:
    - **Disposal Area at the dam site**, where 1 million cubic metres could be stockpiled over 20 hectares (5 metres high). This volume would come mainly from structural excavations - See the location of Disposal Area in Figure 43 page 81.
    - **Disposal Area at the Nakra Water Intake site**, where 330,000 cubic metres could be stockpiled over 10 hectares (3.5 metres high). This volume would come mostly from structural excavation of the weir, the Transfer Tunnel intake structure and the

Transfer Tunnel excavation by drilling and blasting. See the location of Disposal Area in in Figure 43 page 81.

- **Disposal Area at the powerhouse**, where 570,000 cubic metres could be disposed of over several sites over about 16 hectares (3.5 metres high). This volume would be made of 300,000 cubic metres of tunnelling spoil (headrace tunnel) and 270,000 cubic metres of structural excavation (powerhouse and penstock trench). The location of the disposal areas at the powerhouse area were still under investigation when the present report was completed. It will be known in the second quarter of 2017 (see Section 3.7.5.2 below).

### 3.7.5.2 Future selection of the powerhouse disposal areas

Unlike the dam site and the Nakra intake site, the surroundings of the powerhouse area are inhabited. The use of land for the construction activities in this area requires careful planning and negotiations with land users.

Spoils at the powerhouse will be placed in designated disposal areas in a controlled manner to:

- Minimize the adverse effects on livelihoods;
- Minimize the adverse effects of leachate and surface water runoff from the fill on surface and ground waters;
- Ensure mass stability and prevent mass movement during and after construction, and
- Ensure that the final fill is suitable revegetation compatible with the natural surroundings and the intended land use (pasture, reforestation or tourism).

As the location of powerhouse disposal areas was yet to be defined at the time of writing, the ecology and social receptors potentially affected have not been assessed within the 2017 Supplementary E&S Studies. They will be studied as part of the future E&S risk assessments to be performed by the Project as ruled by the Changes Management Procedure (see Vol 8. ESMP), which include (i) the E&S analysis of technical alternatives (see Table 13 for options) and (ii) the E&S Risk Assessment of the selected solution. These assessments will be informed by site specific surveys where necessary; the need for surveys will be identified and recorded as part of the change management procedure.

**Table 13 - Environmental & social constraints relating to spoil disposal at powerhouse**

| Options | E&S constraints to be considered as part of the site selection process |
|---|---|
| Valley fills and head-of-hollow fills on the left bank along the serpentine road | > Impairment of natural surface or underground drainage<br>> Encroachment into forested areas or pasture<br>> Downstream sedimentation from leachate and surface run-off<br>> Spoil haulage routes during night time and nuisances to adjacent community |
| Former Nenskra riverbed and riverbanks downstream of Chuberi bridge. | > Long term stability and risk of downstream sedimentation in Enguri River and Reservoir<br>> Reduction of capacity to carry flood flows<br>> Spoil haulage routes during night time and nuisances to adjacent community<br>> Damage to aquatic habitat |

A Detailed Spoil Management Plan will also be prepared prior to the start of disposal activities as part of the Contractor Construction EMSP (See Vol. 8 ESMP). The objective of this plan is to (i) minimise spoil removal and associated impacts on community and the environment, (ii) maximise the beneficial reuse of spoil material from the Project; and (iii) address the Project wide objective to provide certainty of delivery by managing spoil in a manner that avoids impacts on construction activities and timing. This plan, which is also required by the Georgia regulation, will describe the construction methods and site rehabilitation planned for the disposal areas.

### 3.7.6 Construction roads and service roads

The access to the powerhouse area, the dam site and the Nakra water intake will be made using the existing public roads which will be upgraded (see Section 3.5).

Within each of the three worksites (Dam, Powerhouse, Nakra Intake), the EPC Contractor will built a number of accesses to connect the various sites installations. Figure 35 and Figure 37 show the service roads network that could be built at dam site and at the powerhouse. The final layout of these service roads will be defined in the second half of 2017, prior to the start of the main construction period. Access to service roads will be controlled.

Most of these roads will be used for construction purposes only. Some of them will be maintained during the operation phase to service the main installations. The layout of the final service roads will be known at the end of the main construction period.

In particular, the EPC Contractor will build an access road from the dam site to the Nakra Transfer tunnel outlet portal for construction purpose. The road will be used to bring the TBM equipment. During the tunnel construction period, it will be used to evacuate the tunnelling spoils. This road will be constructed above the reservoir full supply level. After construction, the Project may upgrade that access road to maintain a reservoir by-pass cattle track and provide access to the upper valley.

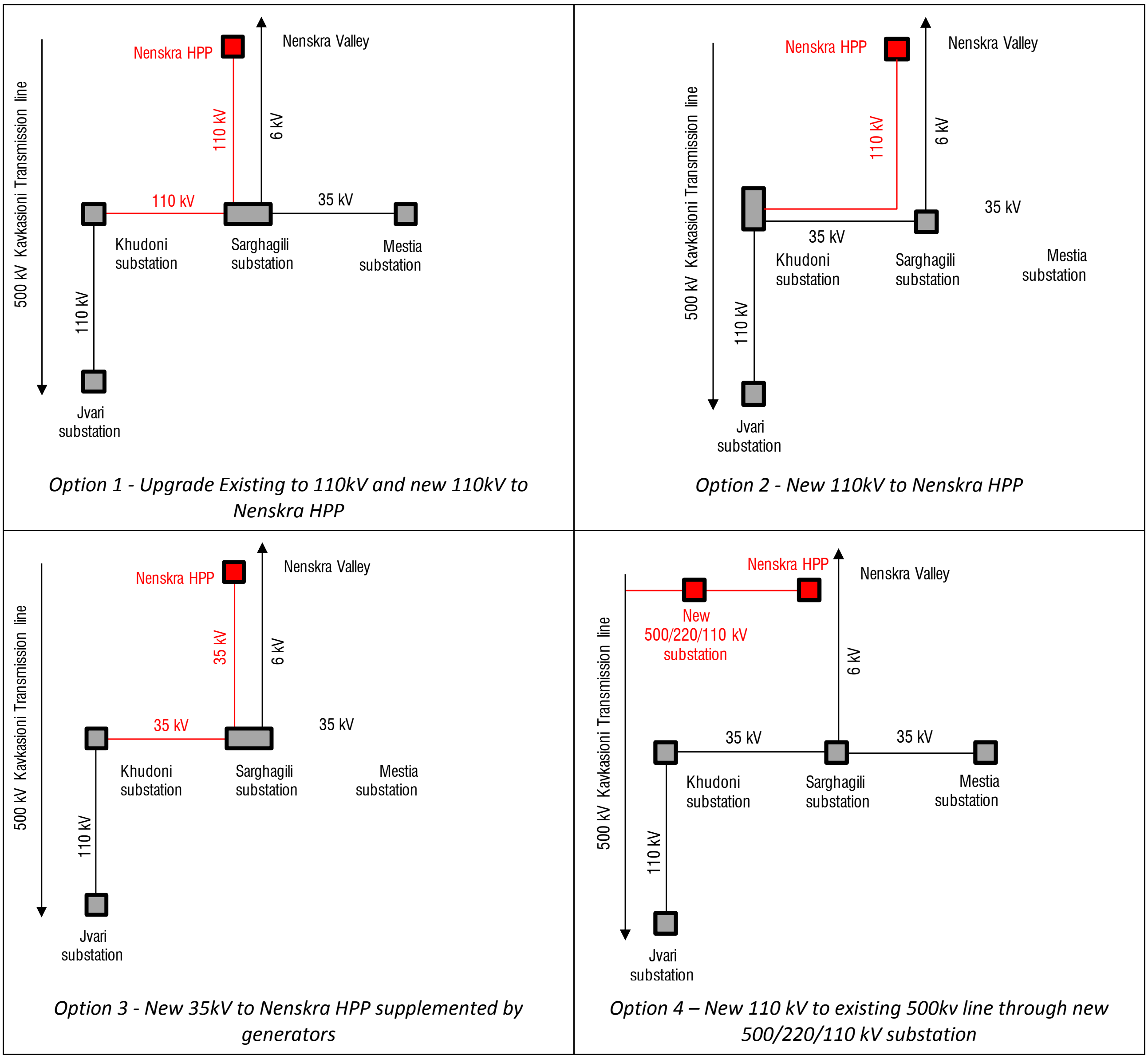
At the powerhouse, a “serpentine” road will connect the main access road to the TBM launching platform, the valve chamber and the surge shaft 700 m above the powerhouse. This road is likely to be become a service road during the operation phase. It will be used to transport the TBM sections up to the TBM platform, as well as the penstock sections. Because of the slope, the serpentine road will have several hairpin bends. It will be seen from far in the valley. The road and adjacent slopes will require careful reinstatement and landscaping at the end of the construction period to avoid erosion.

### 3.7.7 Electrical supply line

An electrical supply line will be implemented to supply up to 16 MW of the electricity required for the two Nenskra construction sites (Powerhouse and Dam site). One of the main drivers for power requirements during the construction period will be the two TBMs. As described in Section 4.2.3 one TBM will be operated from the powerhouse area (headrace tunnel construction). The second TBM will be operated from the dam area (Nakra transfer tunnel).

An existing 6 kV powerline from a substation in the Enguri Valley at Sarghagili is the only current power supply up the Nenskra Valley and this is insufficient for the power demands of the project. The nearest main transmission line to the Nenskra Valley is the existing 35 kV transmission line that follows the Enguri Valley to Mestia. In order to provide power supply to the construction sites the Project will require a new power supply line up the Nenskra Valley to connect to the Nenskra powerhouse.

At the time of writing, a number of options were being considered for this power supply. No one of these options is expected to trigger physical displacement of households. They are described in the following paragraphs and are also illustrated schematically in Figure 41.




*Option 1 - Upgrade Existing to 110kV and new 110kV to Nenskra HPP*

*Option 2 - New 110kV to Nenskra HPP*

*Option 3 - New 35kV to Nenskra HPP supplemented by generators*

*Option 4 – New 110 kV to existing 500kv line through new 500/220/110 kV substation*

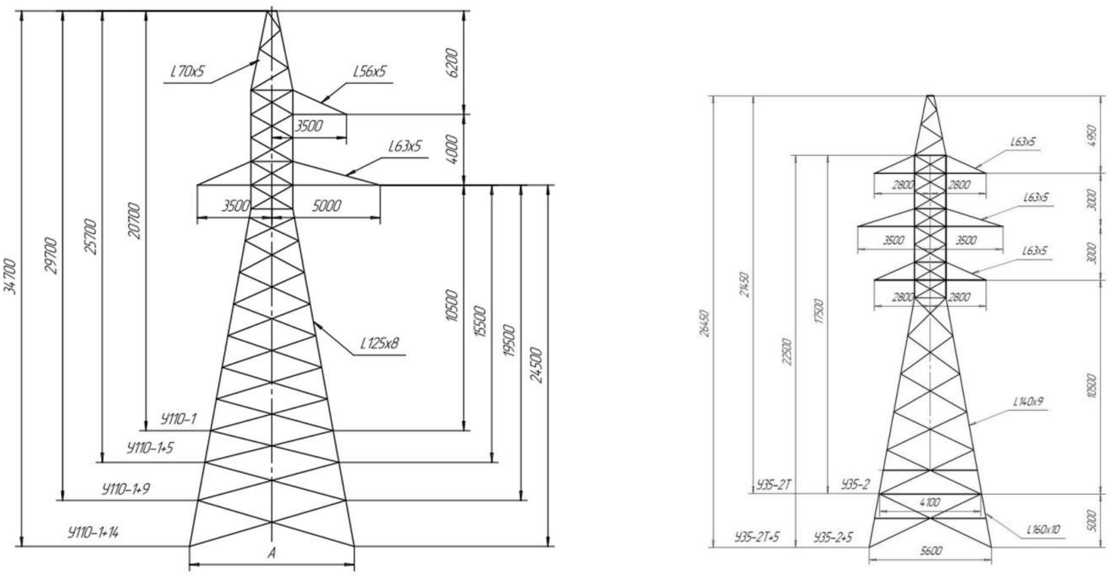
*Figure 41 – Construction power supply lines options*

*Black line = existing infrastructure; Red line = new infrastructure*

- Option 1: Rehabilitate the existing electrical system. This comprises rehabilitation of the line between the existing Jvari substation and the existing Khudoni substation (existing 35 kV transmission line and substations). At the time of writing, this rehabilitation of the transmission line was already underway with the upgrade increasing the voltage of the line to 110 kV. This involves re-using existing towers where possible and replacing others that are either damaged or not suitable for carrying heavier conductor wires. These works are being managed by GSE. Beyond Khudoni substation, studies are ongoing to investigate the feasibility of upgrading the existing 35 kV transmission line to 110 kV up to the Sarghagili substation. The transmission line would follow the same route as the existing line through the Enguri Valley where possible. From the Sarghagili substation, a new 110 kV transmission line would be constructed up the Nenskra Valley to the Nenskra Powerhouse. Routing of this option is still being examined; or

- Option 2: Construct a new 110 kV line between the Khudoni substation and the Nenskra powerhouse, where a 110/35/11 kV substation will be installed. Routing of this option is still being examined; or
- Option 3: Using the existing 35 kV transmission line between the Khudoni substation and Sarghagili substation the line would be upgraded to improve reliability of the transmission line, followed by the construction of a new 35 kV line up the Nenskra Valley. This option would not provide all the power demands of the construction of the project and would require the shortfall to be made up by the use of diesel generators. This option offers no real advantages over the construction of a new 110 kV line but remains an alternative until it can be proven that a 110 kV connection can be constructed through the Enguri Valley; or
- Option 4: One further option being considered is the supply of power from the existing Kavkasioni 500kV transmission line that passes close to the Nenskra powerhouse in the Nenskra Valley. This would require a connection from the Nenskra powerhouse to the new 500/220/110 kV substation planned to be built by GSE in the Nenskra Valley (see Section 3.9). But this new 500/220/110 kV substation is not planned to be ready before several years. This option can only be considered feasible to the Project if the construction of the new 500/220/110 kV substation and the tie-in with the existing 500kV Kavkasioni 500kV transmission line programme could be further fast tracked.

The transmission (conductor) lines for both a 35kV and 110 kV overhead transmission line would use steel lattice towers. A 110 kV tower would be approximately 34 m high, whereas a 35 kV would be smaller at 26 m in height as illustrated in Figure 42. Typical tower spacings would be approximately 200 m and would carry three conductor lines and one earth shielding wire. The transmission lines would also require clear ‘Right of Ways’ or safe protection zones which for a 110 kV line is 20 m and for a 35 kV line is 15 m from the outermost conductor line.




*110 kV tower* *35 kV tower*

*Figure 42 - 110 kV and 35 kV tower types used in Georgia*

As the final power supply solution is yet to be selected, the alignment of the planned power supply lines are yet to be finalised. However, it is currently anticipated that any new transmission line up the Nenskra Valley, be it 35 kV or 110 kV, would be constructed from the Sarghagili substation. From here it would cross the Enguri River and enter the entrance to the Nenskra

Valley. This is a very constrained steep valley gorge where the construction of towers is unlikely to be feasible. Alternative options using buried cables is being investigated.

Should the rehabilitation of the existing 35 kV line and the re-use of existing towers for a 110 kV line not be feasible, a new alignment for the 110 kV line would be required through the Enguri Valley from Khudoni substation to the Nenskra Valley. The route of such a line could follow adjacent to the existing 35 kV line. Routing around the village of Khaishi would also be investigated to ensure that the necessary clearances can be obtained from the conductor lines to buildings and houses.

In addition to the above-mentioned transmission lines, the following additional lines will be required:

- Construct a new 35 kV supply line between the powerhouse and the dam site;
- Install a new 11 kV supply line between the powerhouse and the TBM launching platform, and
- The Nakra construction site will be supplied power through an electrical generator.

As all facilities associated with the Nenskra Project, the power supply line will be planned, constructed, operated and dismantled by the EPC Contractor in compliance with the Lenders environmental & social policies and the Georgian environmental & social regulation. The Powerhouse and Dam sites could initially be powered by diesel-generators until the supply lines are operational.

### 3.7.8 Environmental & social assessment & permitting for temporary infrastructures yet to be defined

The present Supplementary E&S Studies were finalized end of 2017. End of 2017, some project components were yet to be defined by the Design Team, such as:

- The Construction Camp for the powerhouse worksite;
- The Spoil Disposal Area at the powerhouse and TBM adit areas;
- The Power Supply Lines, and
- The Nakra road upgrading works.

JSCNH has identified what are the typical E&S constraints which must be considered in the site selection, design and construction planning of these future components. They are summarized in Table 14.

## Table 14 - E&S Assessment & Permitting for temporary infrastructures yet to be defined

| Component | Brief description | Planned timing | Environmental or social constraints to be examined | E&S design criteria | Planned schedule for E&S Assessment and Permitting |
|---|---|---|---|---|---|
| 1. Construction camp for the Powerhouse worksite | Capacity of 340 persons - Footprint approx. 3ha - Walking distance from Powerhouse worksite. | > Basic Design in November 2017<br>> Start of construction planned in February 2018 | > Land take and potential impact on livelihoods<br>> Traffic between camp and worksite<br>> Noise and light nuisances during night for adjacent communities | > Avoid physical displacement<br>> Avoid encroachment into pasture or forestry area<br>> Compensation paid before start of works | > E&S Risk Assessment in November 2017.<br>> Addenda to LALRP available in January 2018.<br>> Site Environmental Protection Plan in January 2018. |
| 2. Disposal areas for the Powerhouse and Headrace tunnel worksites | 570,000m3 to be disposed in several sites within 3-5km from TBM adit | > Basic design in February 2018<br>> Detailed design in May 2018<br>> Start of disposal activities planned in December 2018 | > Land take and potential impact on livelihoods<br>> Encroachment into sensitive terrestrial or aquatic habitats<br>> Traffic between TBM adit and disposal areas<br>> Impairment of natural drainage<br>> Long-term stability and erosion control | > Long-term static safety.<br>> Avoid physical displacement.<br>> Avoid encroachment into pasture and into habitat of protected species<br>> Traffic restrictions during night time along inhabited areas<br>> No decrease of flood capacity in river/streams<br>> No downstream sedimentation of downstream water bodies or fields due to erosion and runoff.<br>> No significant long-term O&M requirements post construction<br>> Full rehabilitation as per EPC contract | > E&S Analysis of Alternatives (CC-ESMP) in Feb 2018.<br>> Ecological surveys to identify habitats and protected species (CC-ESMP) in May 2018.<br>> E&S Risk Assessment of Selected solution (CC-ESMP) in April 2018.<br>> Feasibility study to demonstrate (i) mass stability and prevent mass movement during and after construction, (ii) drainage control, (iii) maintaining of river flood capacity (CC-ESMP) in May 2018.<br>> Spoil Disposal Management Plan to be approved by GoG - Consistency with Traffic Management Plan (CC-ESMP) in Sept 2018.<br>> Addenda to LALRP available in May 2018 (Owner ESMS) |
| 3. Power Supply Lines (PSL) | 110 kV from Khudoni to Powerhouse<br>35 kV from Powerhouse to Dam<br>11 kV from Powerhouse to TBM adit | > Basic design in December 2017<br>> Start of construction in April 2018 | > Electrocution/collision of Migratory Birds<br>> Encroachment into sensitive terrestrial habitats (RoW and access roads) and erosion<br>> Restriction of land use within RoW and land acquisition for pylons and substations<br>> Cumulative impacts with 220kV TL | > Priority to existing corridors along roads and priority to upgrade of existing lines<br>> Avoid physical displacement<br>> Minimize encroachment into forestry area<br>> Environmentally-friendly design: line orientation/configuration, line marking and deflectors to mitigate birds collision<br>> Compensation for loss of assets or livelihoods paid before start of works | > E&S Analysis of Alternatives (CC-ESMP) and selection of preferred alignment in Sept 2017.<br>> Non-objection from JSCNH (CC-ESMP) and Lenders (Owner ESMS) in Dec 2017.<br>> Avian Risk Assessment and Ecological surveys to identify habitats and protected species (CC-ESMP) in Q1 2018 for the 110 kV and 35 kV PSLs.<br>> ESIA as required by GoG in Mar 2018 for the 110 kV and 35 kV PSLs (CC-ESMP)<br>> Addenda to LALRP available in Mar 2018 (Owners ESMS) for the for the 110 kV and 35 kV PSLs. |
| 4. Upgrading of Nakra access road | 10 km of upgrading of driving platforms from Mestia road to Nakra intake.<br>Enlargement where existing road is < 6.5m | > April 2018 for start of upgrading works<br>> Jul. 2018 for Nakra construction camp | > Loss of assets or property<br>> Damages to houses due to vibration<br>> Increased traffic and risk of accidents | > Use existing road as much as possible<br>> Avoid physical displacement<br>> Minimize encroachment into productive land<br>> Traffic management plan presented to local community<br>> Compensation for loss of assets paid before start of works | > Swept path analysis in Jan 2018 (CC-ESMP)<br>> Basic design in Feb 2018 (EPC Contract)<br>> Addenda to LALRP available in Mar 2018 (Owner ESMS)<br>> Preconstruction dilapidation survey in Mar 2018 (CC-ESMP) |

## 3.8 Land requirements

The land requirements for the Nenskra HPP comprise:

- The area needed for the permanent works. It includes the dam site, the reservoir footprint and the reservoir by-pass cattle track; the powerhouse, the penstock corridor, the service road and the surge shaft; the Nakra water intake; and the operator's village. It also includes the portion of the existing public roads that needs to be enlarged to allow the construction trucks to drive between worksites.
- The area needed for the temporary works. It includes the construction camps and the site installations in each of the three worksites (Dam, Powerhouse, Nakra diversion). It also includes the quarry area, the borrow areas and the disposal areas, as well as the service roads within each of the three worksites to the site installations. These structures are considered as temporary because they will be used during the construction period only. Upon completion of the construction period, the area affected by the temporary works will be rehabilitated as per the ESMP requirements (see Vol. 8 of the Supplementary E&S studies "Environmental and Social Management Plan").

The total land requirements for the Nenskra HPP are of 882.5 ha distributed as indicated in the table below and illustrated in Figure 43. Land will also be taken for road upgrading and widening in the two valleys.

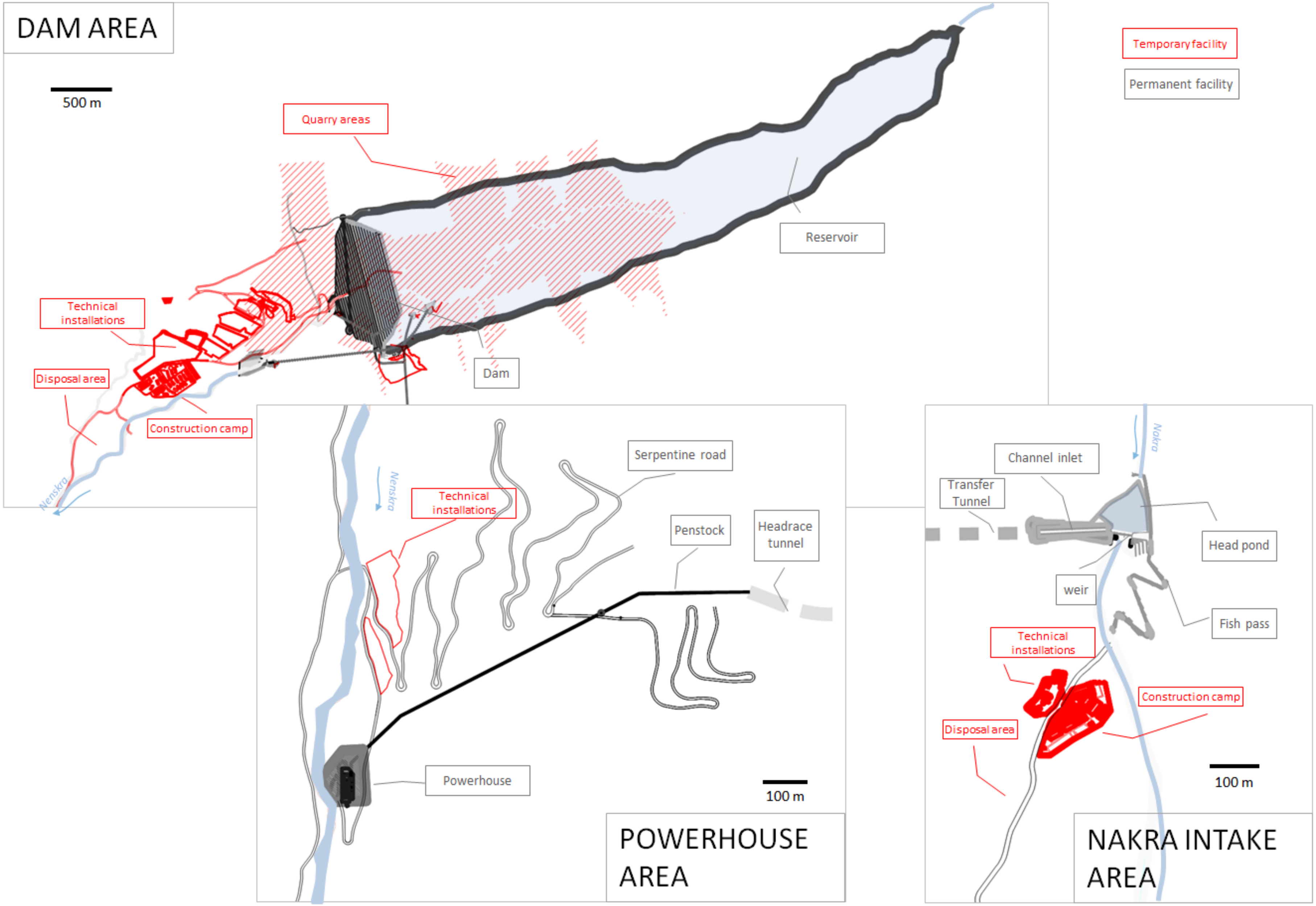
Vol. 3 "Social Impact Assessment" and Vol. 9 "Land Acquisition and Livelihood Restoration Plan" of the Supplementary E&S studies address the social implications of the Nenskra land requirement and the proposed approach to compensate the associated adverse effects.

**Table 15 - Land requirements for the Nenskra HPP**

| Components / sites | Total land take area (ha) | Permanent works area (ha) | Temporary facilities area (ha)[l] |
|---|---|---|---|
| Dam site | 560 | 355.1 [a] | 204.9 [b] |
| Operator's village | 2.5 | 2.5 [c] | --- |
| Powerhouse site | 188.8 | 29.1 [d] | 159.7 [e] |
| Nakra Water intake | 36.7 | 0.9 [f] | 35.8 [g] |
| Nenskra road widening [h] | 4.5 | 4.2 | 0.3 |
| Nakra road widening [i] | TBD | TBD | TBD |
| 35 kV power supply service line [j] | 36.0 | 36.0 | --- |
| 110 kV power supply service line [k] | 54.0 | 0.0 | 54.0 |
| Total | 882.5 | 427.8 | 454.7 |

[a] Includes dam (83 ha), reservoir (270 ha) and by-pass cattle track (~7km*3m=2.1ha)
[b] Includes construction camp, ancillary structures and disposal areas
[c] Includes, houses, recreational areas, workshops
[d] Includes powerhouse, GIS, structures, service road, valve chamber, penstock and surge shaft, 11 kV power supply service line between the powerhouse and the surge shaft)
[e] Includes construction camp and estimated spoil disposal areas (16ha - to be confirmed at a later stage)
[f] Weir and transfer tunnel intake channel
[g] Includes construction camp and disposal areas
[h] Road widening inside residential areas of Chuberi village
[i] To be confirmed at a later stage
[j] Estimate – to be defined later. Servitude between Nenskra powerhouse and dam, 18 km long, 20 m wide, includes 0.5 ha for pylons
[k] Estimate – to be defined later. Conservative approach taken here: Servitude between Khudoni substation and Nenskra powerhouse, 12 to 18 km long, 30 m wide, includes 25m² for each pylon (every 100 m) - 18 km conservatively considered in this estimate.
[l] Includes quarry areas, borrow areas, disposal areas and access roads required during construction

*Figure 43 - Land requirements - Temporary and permanent facilities*



## 3.9 Associated facilities: grid connection and power transmission

Nenskra HPP will be connected to the grid at the proposed Nenskra HPP 220 kV Gas Insulated Station yard (GIS) using 3 x 110 MVA, 10.5/200 kV generator transformers. The transformers will be installed at the upstream side of the powerhouse for the connection of the three generators to the grid.

From this Nenskra HPP GIS yard, the power generated by the Project will feed into the national grid network, and to this end it will be conveyed to a tie-in point at a new 500/220/110 kV substation in the Nenskra Valley by a 220 kV Transmission Line. At the start of public disclosure in February 2017, the reported location of this substation was at Khudoni, but it is now currently proposed to be located in the Nenskra Valley close to the existing 500 kV Kavkasioni overhead line in order to enable a connection into this transmission line.

The 220 kV Transmission Line and the required new 500/220/110 kV substation, as well as any access roads or borrow areas required for construction or operation, are Associated Facilities: Georgian State Electrosystem (GSE) will design, construct, install, commission, own, operate and maintain this Transmission Line and connection facilities. The grid connection point or boundary for the delivery of power will be the connection to the first tower at Nenskra HPP 220 kV Gas Insulated Station yard.

The location of the new 500/220/110 kV substation as well as the alignment of the proposed 220 kV Transmission Line were yet to be defined by GSE when the present report was completed. The expected completion dates for required substation and transmission lines are as follows:

- 2017: preparation of the feasibility study, and
- 2018 - 2020: detailed design, ESIA and construction.

GSE has confirmed that the ESIA and the land acquisition processes of the proposed transmission line will be undertaken by GSE taking due consideration of the Lenders E&S policies standards. The preparation of the ESIA for the 220 kV Transmission Line will be the responsibility of GSE, as part of the ESIA for the Open Program Extension Transmission Network Georgia II financed by the EBRD. Public disclosure of this ESIA is planned to start in September 2018.

A brief summary of anticipated impacts of the ESIA for the 220 kV Transmission Line has been included in Vol. 10 - Cumulative Impact Assessment in Section 2.5.

# 4 Project construction, operation and decommissioning

## 4.1 Construction schedule

The Project construction schedule is structured into two main periods:

- Early works and Detailed design from 2015 to 2018. This phase started by the issuance of the Limited Notice to Proceed (LNTP) by JSCNH.
- Main construction works and power generation from 2018 to 2022. This 4-year phase will start through the release of the Final Notice to Proceed (FNTP) by JSCNH.

The Project construction timeline is illustrated on Figure 44.

### 4.1.1 Early works and detailed design: 2015-2018

Some preliminary works will start before financial close. They include, among other activities, the upgrading of existing roads between the future powerhouse and the dam site, as well as the construction of new services roads within each of the three main worksites (i.e. the powerhouse site, the Nenskra dam site and the Nakra water intake area). They also include the construction of the workers camp and the technical installations at each of the three main work sites. These preliminary activities are summarized in Table 16.

### 4.1.2 Main construction works and power generation: 2018-2022

The main construction period will last 4 years. It will start with the issuance of the Final Notice To Proceed (FNTP) planned in March 2018 and will end up with the final Taking Over of the works by JSCNH in May 2022. Figure 45 shows the planned construction schedule at high level. The main construction milestones are planned as follows:

- The main construction works will start at the dam site and the powerhouse area in April 2018. The construction works at the Nakra water intake are planned to start in Q3 2018;
- The roads upgrading works to access the Nenskra dam site started in October 2015 and will be completed in Q1 2018. The road upgrading works to access the Nakra water intake area started in August 2017 and will be completed in Q3 2018. For both access roads, there will be additional rehabilitation works in 2020-21, but this will only be to improve what would have been damaged by the construction period (i.e. no additional land requirements);
- The Nenskra reservoir filling will start in Q3 2020 and will be done in 2 stages (1,370m and 1,430 m). First power generation is planned for 2021. The Nakra River flow is planned to be diverted through the Nakra Transfer Tunnel end of 2020;
- The Transmission Line construction works will be completed by 2020, and
- The EPC Contractor will start demobilizing its site installations in May 2021. The final taking over of the works by JSCNH is scheduled in May 2022.

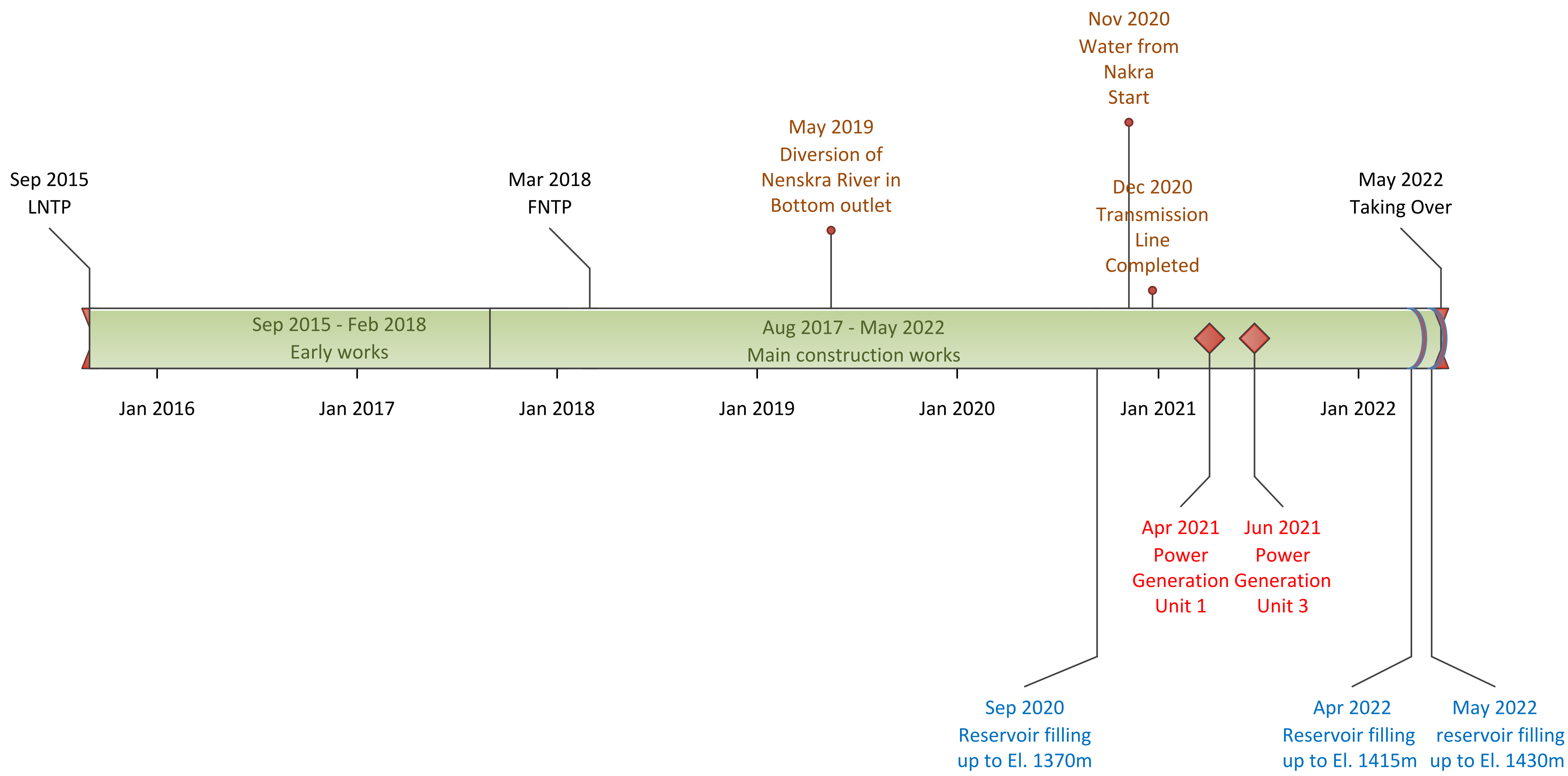
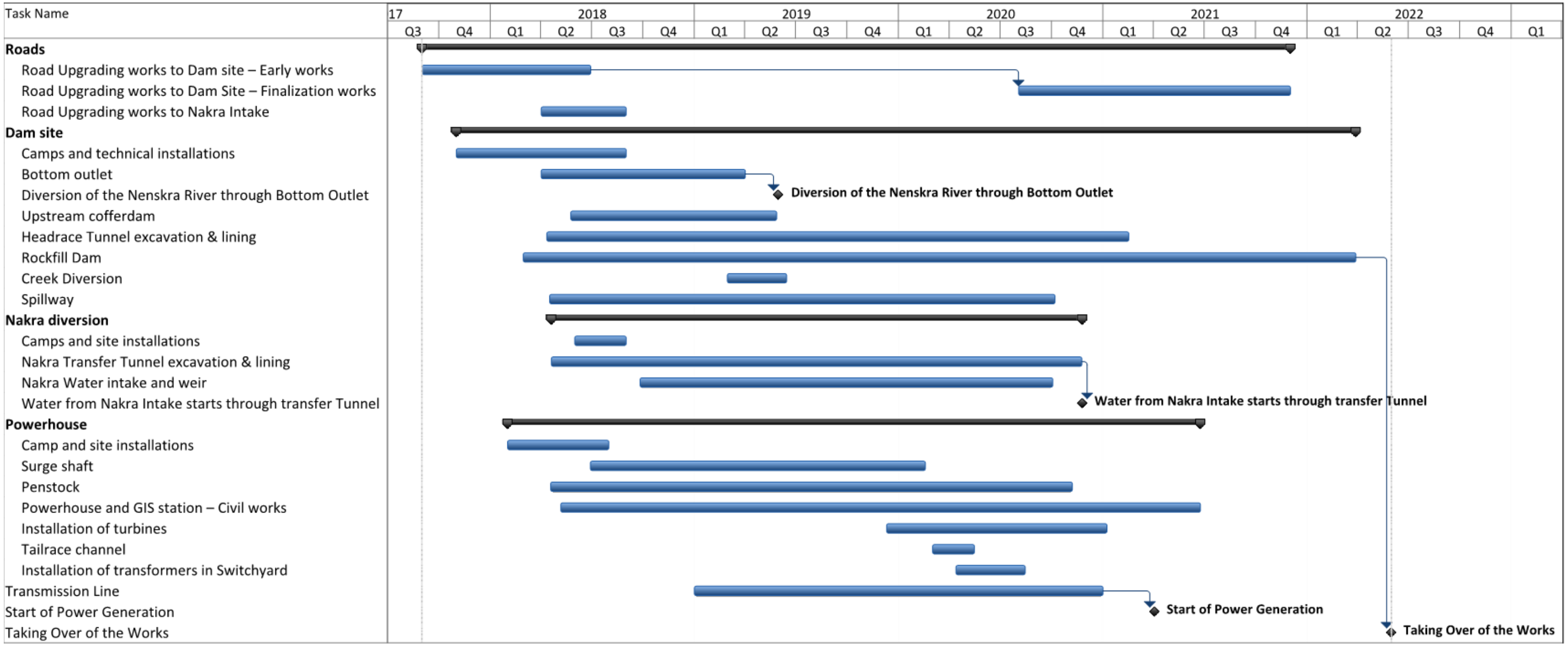



*Figure 44 - Project Timeline*

**Table 16 - Summary of planned Early Works activities from 2015 to 2018**

| Activity | | Description | Timeframe |
|---|---|---|---|
| Site investigations | Topographical survey | • All topographic survey field works required over the works site | Oct. 2015 to Dec. 2015 |
| | Additional Geotechnical field investigations | • Additional geological mapping of the rock outcrops; Drilling and testing of dam and cofferdam foundation and abutments; Geophysical survey of cut off area and of dam site to evaluate potential for Liquefaction; Drilling and testing for powerhouse foundation and shaft; Drilling and testing for aggregates, cohesive soil borrow areas; Trial trenches for dam and cofferdam foundation and abutments | Oct. 2015 to Jun 2018 |
| Construction activities | Access for geotechnical field investigations | • Opening of the paths for the transportation of the drilling rig around the investigation area | Oct. 2015 to Jun 2018 |
| | Existing road and bridges to the powerhouse and the Nenskra dam | • Upgrading of existing 20 km access road to the dam: from Kaishi Bridge to the Powerhouse to the Dam site. Road finishing work such as base layer and side drains to be done during the completion stage of the construction works<br>• Rehabilitation of the Kaishi bridge and construction of: (i) a new bridge in front of the future powerhouse, (ii) a new bridge at the dam site, (ii) two new bridge along the main access road to the dam site | Nov. 2015 to Jul 2018 |
| | New service roads | • Construction of all new accesses required to access the powerhouse area headworks (see Figure 37: access to the penstock excavation area, to the HRT Tunnel TBM launching platform, to the surge shaft and the valve chamber platforms); and to access all site installations at the dam site (see Figure 35: access to power intake platform, Nakra TT TBM launching platform, spillway and bottom outlet platforms) | Apr 2016 to Jul 2018 |
| | Powerhouse camp and technical installations | • Construction of all accommodation and social buildings as well as all associated infrastructures (service roads, water and power 24/07/2017networks, parking areas) for the powerhouse camp<br>• Foundation works for installation of the crushing plant and the batching plant at the powerhouse site<br>• Earthworks for platforms and construction of all technical installations facilities (e.g. offices, laboratories, yards, workshops and warehouses - See Section 3.7.3) within the powerhouse, switchyards and penstock area | Feb to July 2018 |
| | Dam camp and technical installations | • Construction of all accommodation and social buildings as well as all associated infrastructures (service roads, water and power networks, parking areas) for the dam camp<br>• Foundation works for installation of the crushing plant and the batching plant at the dam site<br>• Earthworks for platforms and construction of all technical installations facilities (e.g. offices, laboratories, yards, workshops and warehouses - See Section 3.7.3) with the dam area and all other site installations (e.g. power intake, bottom outlet) | Nov 2017 to Sept 2018 |
| Detailed design | General design and site installations | • Roadworks, bridges and culverts Design and relevant shop drawings<br>• Civil works preliminary basic design<br>• Numerical and physical model tests for AFRD in accordance to the requirements set out in Memo n°9)<br>• Hydro-electro-mechanical works general arrangement drawings<br>• Installations construction drawings preparation and relevant shop drawings | Nov. 2015 to Aug 2018 |
| | Finalization of plant and equipment requirement | • Finalization of plant and equipment requirement<br>• Orders for strategic equipment e.g. TBMs, crushing and batching plants, major earthworks plants | Nov. 2015 to Feb 2018 |

*Figure 45 - Tentative construction schedule - main construction period*



# 4.2 Construction methods

The following paragraphs describe the construction methods for selected Project components.

## 4.2.1 Diversion of the Nenskra and Nakra Rivers

### 4.2.1.1 Diversion of the Nenskra River

The Nenskra Rockfill dam will be built in stages:

- Stage 1 is the dam construction of the left and the right sections up to elevation 1,375 metres[14]. For this purpose, two temporary longitudinal cofferdams will be built along the river banks. They will allow the river to flow inside the original waterbed contained between the two cofferdams. Meanwhile, the bottom outlet tunnel will be built;
- Stage 2: At the completion of the bottom outlet tunnel an upstream cofferdam will be built. The Nenskra River flow will be diverted through the bottom outlet tunnel. The two temporary longitudinal cofferdams will be removed. The construction works will then focus on the central section of the dam up to elevation 1,375 metres upstream and up to 1,345 metres downstream, and
- Stage 3 is the dam construction of all sections up to elevation 1,436 metres.

During Stage 1 and Stage 2, the Nenskra rRiver flow will be maintained (i) through the existing river channel during stage 1 and (ii) through the bottom outlet channel during stage 2. From mid-2020, the reservoir filling will start. Immediately downstream of the dam, the Nenskra River flow could then be as low as the Ecological flow (0.9 $m^3$/s).

### 4.2.1.2 Diversion of the Nakra River

The Nakra diversion weir and the intake structures will also be constructed in stages:

- Stage 1: The Nakra River banks will be excavated to deepen the riverbed. Culverts will be put across the Nakra River to access the left bank. A longitudinal cofferdam will be constructed along the right bank to protect the construction works of the Nakra Transfer Tunnel inlet structure. During this stage, the river flow will pass through the deepened existing riverbed;
- Stage 2: A longitudinal cofferdam will be constructed along the left bank to protect the construction works of left section of the weir. During this stage, the river flow will still pass through the deepened existing riverbed;
- Stage 3: Removal of the longitudinal cofferdam along the left bank and construction of the right and central part of the weir field including piles protected by the right bank cofferdam. During this stage, the river flow will pass through the newly built left section of the weir, and
- Stage 4: Construction of the road bridge and removal of all cofferdams. The river flow would then pass over the weir.

During the four stages of construction, the Nakra River flow will be maintained through the existing river channel, either through the left side or the right side of the weir under construction. From end of 2020, the transfer of water from the Nakra Valley to the Nenskra

[14] All elevations in this report are indicated in meters above sea level.

reservoir will start. Immediately downstream of the weir, the Nakra River flow could then be as low as the Ecological flow (1.2 $m^3/s$).

### 4.2.2 Dam embankment construction and asphalt facing construction

The main dam embankment will be executed in the main stages described in Section 4.2.1.

The sequence for Stage 1 up to elevation 1,375 metres to be applied on both left and right sections of the dam embankment is as follows:

- Vegetation clearing and removal of stumps;
- Excavation of foundations using mechanical excavations, i.e. excavators with hydraulic jackhammer;
- Formation of a platform for cut-off wall construction;
- Inspection gallery construction, and
- Over the foundation level, placement of the selected rockfill material by layers and compaction up to elevation 1,375 metres.

The sequence for Stage 2 (central section of the dam up to 1,345 metres downstream and 1,375 metres upstream) is the same as for Stage 1. When the upstream dam embankment has reached elevation 1,375 metres the asphalt lining of the upstream face will start (Figure 46 below).

*Figure 46 - Illustration of upstream face asphalt lining (Terroba dam - Walo)*

The sequence of work is as follows:

- The surface of embankment will be compacted by vibrating slope roller secured by a winch on crest;
- A 20 centimetre layer of crushed stones will be placed over the whole upstream face. An emulsion may also be sprayed over the area (1.5 kilograms per square metres);
- The asphalt will be produced in the asphalt plant at dam site and transported by suitable trucks to the main winch. The main winch will support the asphalt paver and the feeding wagon on the slope. The paver will place the asphalt in vertical strips from dam toe up to the crest (see Figure 47). The main winch including the mounted paver and wagon will then be moved side wards and the placing of asphalt will continue on the adjacent strip. A "sandwich" system will be adopted: binder course (10 centimetre thick), lower dense

bitumen layer (5 centimetre thick), drainage layer (8 centimetre thick) and upper dense bitumen layer (8 centimetre thick);

- Sealing joints between dense asphalt and concrete at the slope base, and
- Application of mastic over the upstream dam face (up to 2 kilograms per square metre) using a paver controlled by a winch.


*Figure 47 - Illustration of asphalt paver on dam face*
*Asphalt Binder Layer (left) and Dense Asphalt Concrete (right) - Source: http://www.walo.co.uk/*

The sequence for Stage 3 of the dam embankment from 1,375 to 1,436 metres is similar to Stage 1 and Stage 2:

- Excavation in the area of the dam embankment section foundation;
- Grout curtain formation;
- Completion of the dam embankment in horizontal layers with all the required selected materials up to 1,431 metres;
- Asphalt lining of the upstream face, and
- Crest work execution up to 1,436 metres.

### 4.2.3 Tunnelling

The Nenskra HPP requires the construction of two main tunnels: the Nakra Transfer tunnel (see Section 3.3.1) and the Headrace Tunnel between the Nenskra reservoir and the powerhouse (see Section 3.3.2). Two tunnelling methods will be used:

- Conventional method of drilling and blasting for approx. 5% of tunnel length, and
- Tunnel Boring Machine (TBM) method for approx. 95% of tunnel length.

Drilling and blasting method will used to dig the first section of the tunnels. Once the first section has been opened, the TBM will start working. The TBM is used to excavate tunnels with a circular cross section and has the advantage to limit disturbance to the surrounding ground. TBM can bore through any type of matter, from hard rock to sand. The TBM is an all-in-one machine: it will execute the excavation of the tunnel, the erection of a precast lining and the grouting between the excavation and the precast lining. Both transfer and headrace tunnels will be progressively lined with concrete as construction moves forward. The thickness of the concrete lining will be 25-30 centimetres. In addition, the TBM system will ensure the transport of the excavated materials out of the tunnels.

The Nakra Transfer Tunnel will be dug from the Nenskra reservoir to the Nakra water intake. The excavated material will be managed in the Nenskra reservoir area. It is estimated that 27 months will be needed to complete the tunnel boring. After completion, the TBM will be removed and final works will be carried for a total period of two months. The TBM used for the Nakra Transfer Tunnel will be dismantled in the Nakra intake area. The EPC Contractor will then be transport the TBM away from the Project area using the access road in the Nakra valley, then the road to Zugdidi, before shipping to a new construction site.

The headrace tunnel will be dug from the powerhouse to Nenskra reservoir. The excavated material will be managed in the powerhouse area. It is estimated that 27 months will be needed to complete the tunnel boring. After completion, the TBM will be removed and final works will be carried for a total period of two months. The TBM used for the Headrace Tunnel will be dismantled in the Nenskra dam area. The EPC Contractor will then be transport the TBM away from the Project area using the access road in the Nenskra valley, then the road to Zugdidi, before shipping to a new construction site.

The bottom outlet tunnel will be built through drilling and blasting.

### 4.2.4 Open trench penstock construction

The penstock will be placed in an open trench excavation, where the penstock steel liners will be laid on an invert concrete slab with annular concrete saddles every about 36 metres and three concrete anchor blocks distributed along the penstock length, to be backfilled with suitable selected material and covered by topsoil with grassing and vegetation planting.

*Figure 48 - Illustration of penstock construction stages - Taken from another project.*
*Top right: concrete slab in bottom trench, Top left: installation of the penstock steel liners*
*Bottom: reinforced concrete box over the penstock steel liners*
*Source: Salini Impregilo*

The penstock axis (see design in Section 3.3.2.3) will be aligned with each of the six hairpin bends of the service road. A horizontal access road section will be then constructed form the six hairpins bends to the penstock alignment. This will simplify the removal of excavated material and the placing of all required materials. The trenching works for the penstock construction will be made by section. There will be 7 sections of approx. 200 metres length. Each section will be worked as follows:

- Vegetation clearing;
- Construction of a platform at the bottom of the section to receive and evacuate the excavated material, and
- Excavation of the material from the upper elevation towards downhill pushing the loose material into the platform; the average trench excavation area will be of 74 square metres with a minimum trench width at the bottom of 6 metres. A total of 95,000 cubic metres of material is planned to be excavated. If required, the hard material excavation will be blasted in benches of 8 metres.

When all sections are excavated, the sequence of works (Figure 48 above) will be as follows:

- Levelling and concrete slab construction in the bottom of the trench;
- Installation of the penstock steel liners from the bottom section proceeding uphill, including welding and water pressure tests, and
- Construction of the reinforced concrete box over the penstock steel liners.

Trench backfilling starting from the lower sections will progress uphill. The selected material will be pushed downhill from the nearest access road and further compacted. Topsoil will be spread over the area and revegetation activities will be undertaken.

### 4.2.5 Powerhouse construction

The powerhouse complex consists of:

- The retaining wall (300 metres long, 1 to 7 metres high, 1 metre thick) made all around the downstream part of the camp area to create a horizontal and flood resilient platform on which the camp will be built;
- The powerhouse building hosting the three turbines (71 metres long, 17 metres high, 21 metres wide);
- The substation in a building (GIS - Gas-insulated substation 30 metres long, 14 metres high, 13 metres wide);
- The three draft tubes between the turbines and the tailrace (31 metres long, 4.5 metres wide), and
- The tailrace canal between the powerhouse and the Nenskra River (100 metres long, up to 5 metres deep, and 30 to 65 metres wide).

The main sequence of work will be as follows:

- Step 1: Construction of a 10 metre wide working platform at an elevation of 727 metres asl, connected to the existing access road on the right bank. Installation of the plant required for the piling work and execution of the retaining wall over the entire perimeter with a piling rig;
- Step 2: Piling works for the powerhouse lateral side walls and construction of the foundations of the GIS and part of the powerhouse building. Excavation down to elevation 695 metres;
- Step 3: Installation of the two tower cranes to build the powerhouse;
- Step 4: Construction of the powerhouse superstructure;
- Step 5: Installation of the hydro-mechanical equipment;
- Step 6: Under the protection of a cofferdam in front of the tailrace, construction of the draft tubes and downstream protection wall;
- Step 7: Excavation of the tailrace canal;
- Step 8: Backfilling of activities behind the powerhouse and downstream of the powerhouse;
- Step 9: Placing of the transformers, and
- Step 10: completion of architectural works, landscaping, removal of tower cranes and removal of downstream coffer dam.

### 4.2.6 Water supply and wastewater

As indicated in Section 3.7.2, the source of water supply for all needs during the construction period (drinking water and industrial waters) will be the Nenskra River (dam site and powerhouse area) and the Nakra River (Nakra water intake).

The raw water will be pumped from the rivers and treated through sediment ponds. From there, the industrial waters will be distributed by gravity through buried pipelines. The drinking water will be further treated through the water treatment plant before distribution.

The water requirements for the construction period are summarized in Table 17.

**Table 17 - Industrial and drinking water requirements for construction purposes**

| Area | | Need | Daily water needs in $m^3$ | Duration in days | Pumping hours per day | Pumping rate in $m^3/s$ | Total in $m^3$ over the full construction period |
|---|---|---|---|---|---|---|---|
| Dam site | Industrial waters | TBM Nakra TT excavation | 228 | 520 | 20 hours | 0.003 $m^3/s$ | 118,560 |
| | | Concrete mixes | 120 | 400 | 9 hours | 0.013 $m^3/s$ | 48,000 |
| | | Washing the plants | 60 | 400 | | | 24,000 |
| | | Concrete curing | 20 | 400 | | | 8,000 |
| | | Sanitary uses | 10 | 400 | | | 4,000 |
| | | Miscellaneous | 25 | 400 | | | 10,000 |
| | Domestic water (628 pers.) | | 170 | 1,200 | | | 204,000 |
| | *Total at Dam site* | | *633* | - | - | *0.016* $m^3/s$ | *416,560* |
| Powerhouse area | Industrial waters | TBM HRT excavation | 260 | 590 | 12 hours | 0.02 $m^3/s$ | 153,400 |
| | | Concrete | 180 | 400 | | | 72,000 |
| | | Washing the plants | 120 | 400 | | | 48,000 |
| | | Concrete curing | 50 | 400 | | | 20,000 |
| | | Sanitary uses | 15 | 400 | | | 6,000 |
| | | Miscellaneous | 40 | 400 | | | 16,000 |
| | Domestic water (340 pers.) | | 92 | 1,200 | | | 110,400 |
| | *Total at Powerhouse area* | | *757* | | | *0.02* $m^3/s$ | *425,800* |

During construction, the Project will therefore extract 1,390 cubic metres per day from the Nenskra watershed downstream of the dam (0.036 cubic metres per second during pumping hours: 0.016 cubic metres per second at dam site + 0.02 cubic metres per second at Powerhouse). During operation, the water supply needs at the Operators' village will represent 30 cubic metres per day (0.0007 cubic metres per second during pumping hours). These figures are conservative: most of the water will return to the river system after treatment.

At the Nakra Intake work site, the bulk of the water needs will be made of the domestic water for the camp (drinking water, laundry, gardening) up to 36 cubic metres per day (i.e. 1 litre per second) and industrial waters required for concrete and shotcrete production as well as washing the plants.

In each of the three camps (Dam Site, Powerhouse, Nakra Intake), all wastewaters will be collected and drained to containerized treatment plants. The quality of treated effluents will be monitored on a regular basis and will comply with the World Health Organization guidelines before discharge into the Nenskra River. Wastewater from offices, warehouse and workshops will be directed to septic tanks. Special trucks will regularly maintain these septic tanks and transport the effluents to the wastewater treatment plants. Oily effluents collected in oil separators will be collected and transported to a specialized facility in Georgia for treatment and disposal.

## 4.2.7 Materials origin

As mentioned in Section 3.7.4, all material used as sand, aggregates, selected gravel, dam's rockfill or slope protection will be extracted within the future reservoir area.

The estimate and origin of the other main construction materials are described in Table 18 below.

**Table 18 - Main construction materials other than aggregates and rockfill**

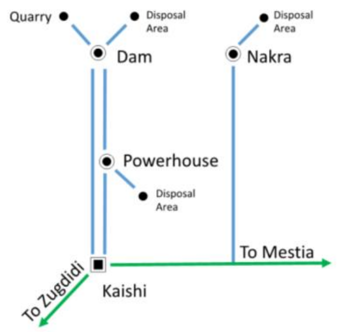
| Material | Quantities estimate | Origin |
|---|---|---|
| Cement | 120,000 tonnes | Local market |
| Fly ash | 18,500 tonnes | Turkey |
| Admixtures for concrete mix | 4,200 tonnes | Local market |
| Steel reinforcement | 11,000 tonnes | Local market |
| Steel rock bolts rods | 360,000 meters | Local market |
| Bitumen | 13,500 tonnes | Local market |
| Still plates for penstock | 4,200 tonnes | Local or international market |
| Explosives | 344,000 kilograms | Local market |

## 4.2.8 Traffic

The construction activities will generate vehicle traffic along the access roads from/to the three main worksites (dam site, powerhouse area, Nakra intake). The type of vehicles that will use the Nenskra access road and the Nakra access road are described in Table 19

**Table 19 - Type of vehicles used during construction period**

| | |
|---|---|
| Light vehicles such as cars, minibus and light trucks (<3.5 tonnes). |  |
| Heavy Vehicles for the transport of goods, referring to: conventional trucks (>3.5 tonnes) or mobile tanks used to transport liquids (e.g. diesel fuel) or powder material (e.g. cement, fly ashes). |  |
| Tippers used for transporting loose material such as sand and aggregates, as well as Mobile concrete mixers. |  |
| General mobile plants and equipment, such as mobile cranes, earthmoving equipment (excavator, dumpers, bulldozers, graders, or compactors). |  |
| Flatbed trucks for the transport of heavy loads such as construction equipment and abnormal loads that require more space than is available on a closed body (e.g. penstock sections, transformers, cement silos) |  |




The three main transport routes will be:

- Along the main road to Mestia, from Zugdidi to Kaishi.
- From Kaishi to Chuberi using the main road in the Nenskra valley to access the powerhouse and the dam
- From Kaishi to Nakra, using the main road to Mestia and then, the main road in the Nakra Valley.

The EPC Contractor estimated the number of trucks which will drive from one site to another every day during the construction period. The number of single transits per period and type of project vehicle is provided in Table 21. Although the construction activities will generate additional traffic on public roads over the 5 years of construction, the densest project traffic will be created from March 2018 to April 2020.

Most of the Project traffic will concentrate along the axis Zugdidi to Powerhouse to Dam. In terms of nuisances to local communities, the relevant indicator are (i) the number of vehicles that would pass in front of a given location per unit of time and (ii) the type of vehicle, i.e. light or heavy vehicles (see Table 20).

**Table 20 - Forecast of Project vehicles passages per location**

| Location | Indicator | Heavy vehicle | Light vehicle | Total |
|---|---|---|---|---|
| Kaishi | Single transits from Apr. 18 to May 20 | 6,069 | 37,961 | 44,030 |
| | Daily single transits | 8 | 49 | 56 |
| | Passage of Project vehicle per hour (12h per day) | 1 | 8 | 9 |
| | Time in minutes between passages | 46 | 7 | 6 |
| Chuberi upstream bridge | Single transits from Apr. 18 to May 20 | 27 723 | 21,930 | 49,653 |
| | Daily single transits | 36 | 28 | 64 |
| | Passage of Project vehicle per hour (12h per day) | 6 | 5 | 11 |
| | Time in minutes between passages | 10 | 13 | 6 |
| Chuberi downstream bridge | Single transits from Apr. 18 to May 20 | 5,871 | 33,092 | 38,963 |
| | Daily single transits | 8 | 42 | 50 |
| | Passage of Project vehicle per hour (12h per day) | 1 | 7 | 8 |
| | Time in minutes between passages | 48 | 8 | 7 |
| Naki | Single transits from Apr. 18 to May 20 | 198 | 4,869 | 5,067 |
| | Daily single transits | 0.25 | 6 | 6.5 |
| | Passage of Project vehicle per hour (12h per day) | 0.04 | 1 | 1 |
| | Time in minutes between passages | 1,418 | 58 | 55 |

During the peak construction activities (April 2018 to May 2020) people living in Kaishi could observe an increase of traffic on the road to Mestia of one truck every 46 minutes and one light vehicle (car, minibus or light truck) every 7 minutes. Likewise, people living along the Nenskra road downstream of the future bridge across the Nenskra River (bridge n°2, see § 3.5) could observe an increase of traffic of one truck every 48 minutes and one light vehicle every 8 minutes. People living between that future bridge and the dam could observe an increase of traffic of one truck every 10 minutes and one light vehicle every 13 minutes, which is due to transportation of aggregates from the quarry at the dam to the powerhouse or the Nakra intake.

People living in the Nakra village could observe an increase of traffic of one truck every day and one light vehicle every hour.

Although less relevant in terms of nuisance to local communities, movements of trucks within each work site using the service roads have also been estimated:

- Within the dam site area, the transportation of material from the quarry areas and borrow areas to the crushing/screening plants or directly the dam worksites will require 1,400 single transits per day. This would represent 2,800 passages of trucks per day. Over 24 working hours, this would represent 120 passages every hour, i.e. one passage of truck every 30 seconds at peak period;
- Within the dam site area also, the transportation of excavated material from the construction areas (dam foundation, tunnelling soil) and the disposal areas will require up to 400 single transits per day. This would represent 800 passages of trucks per day, i.e. one passage of truck every 2 minutes at peak period on a 24-hour working basis, and
- Within the powerhouse area, the transportation of tunnelling spoils and excavated materials from the tunnel adit or the powerhouse construction site would require up to 120 single transits per day at peak period. This would represent 240 truck trips (single) per day, i.e. the passing of one truck every 6 minutes if 24-hour traffic is permitted. Or one truck every 3 minutes if daily traffic only is permitted. The route used by these trucks will depend on where are located the disposal areas for the powerhouse area. If the access road to the disposal areas partly uses the Nenskra public road, the Project traffic along this public road would be increased accordingly.

The upgrading works for the main road will also generate project traffic. This will however be before and after the peak construction period, i.e. end 2017 - early 2018 and end 2020 - early 2021. It will represent 8 truck trips (single) per day along the Nenskra road.

**Table 21 - Estimate of Project's traffic on public roads from 2017 to 2021**

| Road | Indicator | Number of single transit trips per type of vehicle | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Dumper/ Tipper | Cement mixer | Lowbed | Truck tank | Heavy vehicle | Car | Light Truck | Minibus | T |
| Zugdidi to Dam site | Total vehicles 2017-2021 | --- | --- | 1,470 | 3,786 | 31 | 35,500 | 1,596 | 300 | 42,684 |
| | Peak 26 months (Apr. 18 to May 20) | --- | --- | 1,018 | 2,490 | 15 | 20,800 | 974 | 156 | 25,453 |
| | Daily transits | --- | --- | 1.3 | 3.2 | --- | 26.7 | 1.2 | 0.2 | 32.6 |
| | Passage per hour (12h per day) | --- | --- | --- | --- | --- | --- | --- | --- | 5 |
| | Time in minutes between passages | | | | | | | | | 11 |
| Zugdidi to Powerhouse | Total vehicles 2017-2021 | --- | --- | 1,087 | 1,672 | 14 | 12,200 | 1,104 | --- | 16,077 |
| | Peak 26 months (Apr. 18 to May 20) | --- | --- | 901 | 1,433 | 14 | 10,400 | 762 | --- | 13,510 |
| | Daily transits | --- | --- | 1.2 | 1.8 | --- | 13.3 | 1.0 | --- | 17.3 |
| | Passage per hour (12h per day) | --- | --- | --- | --- | --- | --- | --- | --- | 3 |
| | Time in minutes between passages | | | | | | | | | 21 |
| Zugdidi to Nakra | Total vehicles 2017-2021 | --- | --- | 87 | 145 | --- | 4,900 | 135 | 190 | 5,457 |
| | Peak 26 months (Apr. 18 to May 20) | --- | --- | 75 | 123 | --- | 4,600 | 115 | 154 | 5,067 |
| | Daily transits | --- | --- | 0.1 | 0.2 | --- | 5.9 | 0.1 | 0.2 | 6.5 |
| | Passage per hour (12h per day) | --- | --- | --- | --- | --- | --- | --- | --- | 1.1 |
| | Time in minutes between passages | | | | | | | | | 55 |
| Dam quarry to Powerhouse | Total vehicles 2017-2021 | 27,104 | --- | --- | --- | --- | --- | --- | --- | 27,104 |
| | Peak 26 months (Apr. 18 to May 20) | 24,200 | --- | --- | --- | --- | --- | --- | --- | 24,200 |
| | Daily transits | 31 | --- | --- | --- | --- | --- | --- | --- | 31 |
| | Passage per hour (12h per day) | --- | --- | --- | --- | --- | --- | --- | --- | 5 |
| | Time in minutes between passages | | | | | | | | | 12 |

# 4.3 Construction contracts

## 4.3.1 EPC Contract

The construction works will be executed by SALINI IMPREGILO as the EPC Contractor. EPC stands for Engineering Procurement Construction. EPC Contract is a prominent form of contracting agreement in the construction industry. The EPC Contractor carries out the detailed engineering design of the Project, procures all the equipment and materials necessary, and then constructs to deliver a functioning facility to JSC Nenskra Hydro.

Salini Impregilo was founded in 1959 and has developed into a major international construction and international contractor. They have been involved in the construction of buildings, public utilities, motorways, underground works, airports, water supply systems, waste disposals, hospitals and land development including hydropower projects. The EPC contractor is generally very experienced in the construction of similar engineering projects. They have around 35,000 employees worldwide and will therefore be well capable of providing the personnel and resources that the Project will require.

The major sub-contractors mobilized by the EPC Contractor are:

- Andritz Hydro, an Austrian company, for the electro-mechanical works (e.g. turbines, transformers, control & monitoring systems). It is considered to be one of the most respected suppliers of hydroequipment in the world;
- Lombardi SA, a Swiss consulting engineering firm, for the detailed design preparation. They have worked on a number of major infrastructure projects including designing and supervision of the Gotthard Tunnel in Switzerland (excavated using a TBM) and Cerro del Agua hydropower project in Peru, and
- Walo Bertischonger AG (the Walo Group) are a Swiss civil engineering contractor assisting Salini with engineering and execution of the asphaltic / bituminous lining works for the upstream asphalt face.

Salini's intention is to share no less than 30% of the works with Georgian contractors, including Georgian Construction Consortium Ltd or the Institute of Earth and Sciences of the Ilia University.

## 4.3.2 Construction costs

The total investment costs, including civil works, electromechanical works, advisory and management services are of the order of USD 990 million, including USD 16 million for the implementation of the ESMP measures by JSCNH during construction.

## 4.3.3 Manpower requirements

The manpower requirements below (Table 22) have been estimated upon workers camp capacity.

During the Early Works period, the number of workers will be between 50 (first year) to 100 people (second year).

The number of jobs that would be proposed to local people has been estimated on the assumption that the Project will aim at 100% of unskilled workers recruited from the local area (the Nenskra and Nakra valleys) if available. If not available, the recruitment will be extended to the nearest villages in the Mestia Municipality and the Svaneti region as secondary catchment areas. In the peak periods (April to November in 2018 and 2019) during the main construction phase, this could represent up to 364 positions. Other opportunities will be offered to skilled Georgian workers, some could be sourced from the Mestia Municipality.

**Table 22 – Estimate of the number of workers during the construction period**

| Construction site | Number of workers | | | **Total** |
|---|---|---|---|---|
| | **Management** | **Semi-skilled and Skilled** | **Unskilled** | |
| Dam Site | 24 | 380 | 208 | **612** |
| Powerhouse area | 16 | 320 | 104 | **340** |
| Nakra Intake | 8 | 130 | 52 | **190** |
| **Total** | **48** | **730** | **364** | **1,142** |

# 4.4 Nenskra reservoir filling

## 4.4.1 Reservoir vegetation clearing

The reservoir vegetation will be cleared prior to the impoundment. The detailed sequence of work will be prepared by the EPC Contractor prior to the start of the clearing activities as specified in the ESMP (see Volume 8 of the Supplementary E&S studies).

The need for reservoir vegetation clearing is justified for two reasons:

- Most of the valley floor and the slopes within the Nenskra reservoir area will be used as source of rockfill or rocks material (see Section 3.7.4). Vegetation will be cut to access to this resource, and
- The Water quality analysis made as part of the 2017 Supplementary E&S studies (see Vol. 5 Hydrology and Water quality) recommended vegetation clearing prior to impoundment for water quality improvement and GHG emissions reduction.

The trunks will be cut 30-50 centimetres above ground. Trees will be cut using chain saws. Bulldozers would only be permitted to pull and pile the cut vegetation. Branches and leaves will be removed from the trunk. Trunk, Branches and leaves will then be transported outside of the future reservoir area and stockpiled in an area to be defined with the Forest Authorities.

## 4.4.2 First impoundment and early energy generation

The first impoundment of the Nenskra reservoir is planned in two phases as illustrated in Figure 49 below:

- Phase 1. During the dam construction period, when the dam embankment has reached 1,375 metres asl, the reservoir will be gradually filled up, starting in 2020. By the end of September 2020, the water level will reach 1,370 metres asl. The turbines will be installed and commissioned in the power plant in spring 2021. The transfer tunnel between the Nakra and the Nenskra valleys will also be completed by end of 2020 and the Nakra River will begin to be diverted into the Nenskra reservoir at that period. Generation could start in 2021. It is the earliest period for the start of power generation by the Nenskra HPP. Depending on unpredicted construction events, the start of power generation might be delayed.

- Phase 2: End of 2021, beginning of 2022, the dam construction will be completed. The reservoir impoundment will proceed further during spring 2022. The objective will be to get fully operational production in 2022.

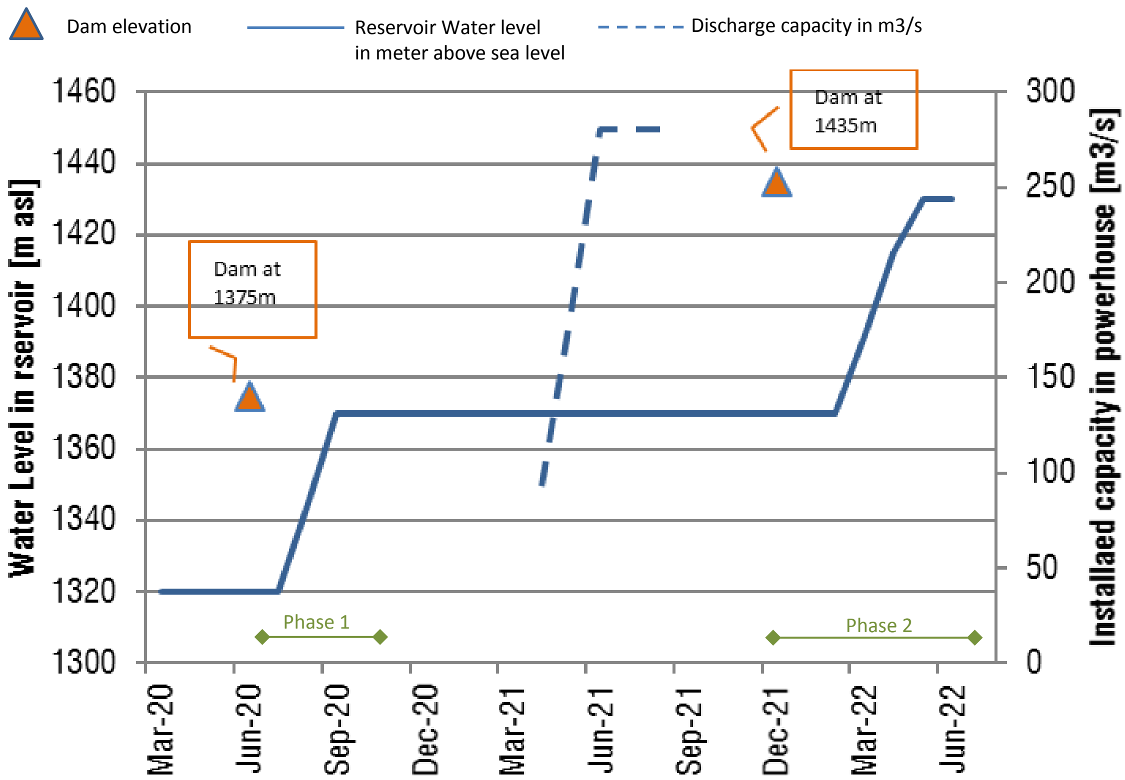



*Figure 49 - Reservoir filling phasing*

The procedure for reservoir filling will be developped by the EPC Contractor through a Reservoir Filling Plan (see Vol. 8 ESMP).

# 4.5 Operation

## 4.5.1 Operation & maintenance contracts

JSCNH will sub-contract the services required for the operation phase to two companies, both being incorporated by K-water:

- The Operation & Maintenance Operator, and
- The Technical Services Contractor.

The Operation & Maintenance Operator will provide the following services:

- In the last year of the construction period, the O&M Operator will (i) mobilise the O&M team, (ii) acquire fixed assets like cars or furniture, (ii) review pre-operation documents (design review, review of EPC documents), (iii) develop operating and maintenance procedures and plans together with the EPC Contractor, (iv) identify defects prior to start of power generation, (v) supply install, test and commission a computerised maintenance management system, and
- During operation phase, the O&M contractor will : (i) manage the office operation (power, water, telecommunication required), (ii) operate the project facility and optimise

availability, (iii) execute the scheduled maintenance (routine/major) and scheduled major overhaul, (iv) implement the environmental & social measures of the ESMP for the operation phase (See Vol. 8 - ESMP), (v) manage the security services, (vi) participate in meetings with lenders and other stakeholders, (vii) manage the administrative services for management of the project facilities and operators' village.

The Technical Services Contractor will assist JSCNH with (i) general financial and administrative functions, (ii) raising debt and equity financing before start of operation, (iii) technical functions to oversee operation and maintenance of all facilities, (iv) implementing and maintaining required insurance program, (v) obtaining and maintaining any consents, and (vi) resolving any disputes and negotiating any claims.

JSCNH Operation & Maintenance contractor and Technical Services Contractor will provide appropriate technical and personnel services for operating the Project. The operation will be highly automated, with an estimated 80 people employed to operate and maintain the Project The scheme will be transferred to the GoG after 36 years of operation.

### 4.5.2 Energy generation and operation of the powerhouse

The energy production will see large differences between summers and winters (see Table 23 - Values from simulation and for indicative purposes only).

**Table 23 - Average monthly production and average monthly flow released by the turbines**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monthly power production [GWh] | 89 | 83 | 84 | 84 | 137 | 156 | 153 | 137 | 87 | 60 | 36 | 90 |
| Monthly turbined discharge [m$^3$/s] | 21 | 24 | 23.5 | 24 | 36 | 41 | 33 | 27 | 19 | 14 | 10 | 20 |

*Source: JSCNH for monthly power production - Jan 2017*
*Stucky for monthly discharges in 5414/2036 - Hydrology, operation - March 2016*

The average annual production is planned to be 1,196 WGh. The estimated 95% firm annual energy is 885 GWh.

The average monthly power production will vary from one month to another as shown in Table 23. The actual daily production will depend on the operation mode of the powerhouse. The Project will be operated in accordance with the dispatch centre of Georgian State Electrosystem (GSE)[15]. Four hours before the beginning of each day, GSE will deliver dispatch instructions to JSCNH. These instructions will specify the electrical output required on an hourly basis for such day. JSCNH will start or stop individual turbine units accordingly. During the day, at any time, GSE may notify JSCNH of a revision of the dispatch instructions until 15 minutes prior to the time when more or less electrical output is required. The powerhouse operation will therefore be by quite dynamic, attempting to cover as much as possible the evening peak with a highest power output. A typical evolution of a realistic daily operation pattern has been estimated as follows:

- Low production during the night (10 pm to 6 am);
- Transition hour: 6 am to 7 am (night – day);
- High generation during the day (7 am to 5 pm), and
- Maximum power production the evening (5 pm to 10 pm).

[15] GSE is responsible for transmission of dispatched energy and technical control over the entire Georgian power system to ensure availability of the system for uninterrupted and reliable power supply.

Vol. 5 "hydrology and Water Quality" examines implications in terms of hydrological changes downstream of the powerhouse.

Risk of water freezing and potential implications ion operations was studied in 2016. The months of December, January and February are the coldest in the project area. January is the coldest month with observations collected at the Lakhami Meteorological Station (1980-1989)[16] presented in Table 24.

**Table 24 - Temperature observed in January at Lakhami Station (19_**

| Indicator | Air temperature at Lakhami station in January in °C | Nenskra River Temperature at Lakhami Station in January in °C |
|---|---|---|
| Monthly average | -3.6°C | 2.5°C |
| Monthly minimum | -7.8°C | 1.5°C |
| Observed Daily Minimum | -16.5°C | 0.5°C |

Freezing has been taken into account in the design. The main risk of interference with operations are with the penstock. Maximum time in which water inside the penstock could be left still, without ice forming, was calculated by the Design team. It is more than 100 days. Freezing will therefore not have implications on operations.

### 4.5.2.1 Routine

The Nenskra reservoir will be operated according to the following basic principles:

- Guarantee the dam safety and the public safety downstream of the dam and downstream of the powerhouse;
- Maintain a Mandatory Ecological flow of 0.9 $m^3/s$ downstream of the dam;
- Fill the reservoir at full supply level from September to November in order to secure the winter production from December to February. During these months of September to November, the reservoir will be operated in a pseudo run-of-river mode, and
- Manage the water volume stored in the reservoir the rest of the year in order to produce as much energy as possible.

The Figure 14 in page 43 shows the evolution of the average water level in the reservoir during a typical year. The reservoir water level will be kept full during the autumn and will start to decrease in December, for supplying the water necessary to satisfy the winter production requirement. March will finish emptying the reservoir while producing a significant portion. In April, the water inflow in the reservoir and the water consumption at the powerhouse will be balanced, leading to a reservoir operation close to a run-of-river pattern except if the operator prefers to restore as much head as possible before releasing water. During the spring and early summer, the reservoir will be filled in with the water released by the snowmelt. Overall the reservoir is expected to be drawn down to the minimum operating level less than 10% of the year. It is expected to be at the full supply level 25% of the year.

During a typical year, there will be only limited spillage due to the ability of the Project to discharge up to 47 $m^3/s$ through the turbines and the relatively large reservoir. The reservoir filling and discharge procedures will ensure that all regular inflows are managed with minimal spillage; in eight years out of ten it is expected that there will be no spillage resulting from normal reservoir inflows across the year.

In wet years, spillage to accommodate flood waters would be required when the reservoir is full and the volume of inflow waters exceeds the capacity of the turbines, or the turbines require to

[16] Stucky, Nenskra HPP - Phase II Feasibility Study - Meteorological and Hydrological Study - 2012

be shut down for any reason. The potential for spillage would be avoided as far as possible through suspension of water from the Nakra transfer tunnel under these conditions. Spillages of flood waters would be most probable through August due to the expected reservoir filling and operational regimes. The average annual spillage will be 2 million cubic meters; this is 0.25% of the total average inflow (811 million cubic metres). About 90% of the spillage will occur in July, some in June and August. The nine other months of the year should experience no spilling – floods excepted.

#### 4.5.2.2 Control under flood conditions

The main structure used to control the reservoir operation during flood conditions is the spillway. The purpose of the spillway is to release floods so that the water does not overtop and damage or even destroy the dam. As explained in the previous section, except during flood periods, water will not normally flow over the spillway. It will go through the main waterway (power intake, headrace tunnel, powerhouse). In the case of a flood event occurring when the Nenskra reservoir is at maximum operating level, the flood water will overflow via the ungated weir spillway, pass through the spillway tunnel and be discharged into the Nenskra downstream from the dam. The spillway has been designed to evacuate the probable maximum flood which is more than three times the 1 to 10,000 years flood return period.

During operation, the bottom outlet primary role is to lower the reservoir level below the spillway elevation if needs be. It might be used if the reservoir must be emptied in case of dam safety issues or maintenance requirements. In case of extreme large floods, the bottom outlet gate may also be opened to provide additional evacuation capacity once the reservoir is spilling, or it could be opened before the reservoir is full to slow the filling process. The bottom outlet capacity during operation will be limited to the 1 in 100 year flood volume (200 $m^3/s$)[17]. This will be ensured through specific redundant control system based on reservoir level and discharge measurement downstream of the bottom outlet gates. Except in case of major failure of the control systems[18], the opening of the bottom outlet will not, under any circumstances, generate a flow greater than the 1 in 100 year flood during operation. This will be included in the bottom outlet operating procedures.

Vol. 5 “hydrology and Water Quality” provide more details on implications in terms of hydrological changes downstream of the dam.

#### 4.5.2.3 Ecological flow

A mandatory ecological flow of minimum 0.9 $m^3/s$ will be released in the Nenskra River downstream of the dam all year. The ecological flow was determined as part of the 2015 ESIA (Gamma). The effectiveness of the ecological flow is assessed in the other volumes of the Supplementary E&S Studies: Volume 3 “Social Impact Assessment” for the downstream users, Volume 4 “Biodiversity Impact Assessment” for the river ecology, and in Volume 5 “Hydrology and Water Quality” for the water quality.

As described in Section 3.2.2.3, the ecological flow will be released through a dedicated pipe that by-passes the bottom outlet gate. It will therefore be provided from the deep reservoir water layers.

#### 4.5.2.4 Sediment management

The 2012 Feasibility Study assessed the sediment transport by the Nenskra River and found out that sedimentation is unlikely to be a significant issue for the Nenskra reservoir. It has been

[17] Additional capacity will be provided to the bottom outlet during construction for passing large floods.
[18] See Vol. 6 - Natural Hazards and Dam Safety

confirmed in 2016 by further analysis made by the EPC Design Team. The total sediment load at the dam site is estimated at 60,000 cubic metres per year. Even in case if total quantity of solid material fully accumulates in the reservoir, more than 1,000 years is required so that reservoir is full with sediments. With a sediment inflow rate of 60,000 cubic metres per year, the sediment accumulation could reach the level of the bottom outlet after approximately 20 years of operation. There could therefore - after a number of years – be a need to flush out the sediment that has accumulated in the reservoir in order to avoid blocking the bottom outlet gate. The bottom outlet must be maintained available as it has an important dam safety function and is a critical component for a sustainable scheme – as the ecological flow passes through the bottom outlet. The sediment will be flushed out by emptying completely the reservoir and by opening the bottom outlet gate at the start of a flood event in the order that the flood flushes the sediment out of the reservoir.

#### 4.5.2.5 Abnormal and emergency situations

The abnormal and emergency situations are discussed in Volume 6 – Natural Hazards and Dam Safety. It discusses high unexpected flows in the Nenskra that could result from accidental uncontrolled events, occasional and intermittent spillage of reservoir water via the spillway during wet years.

### 4.5.3 Operation of the Nakra diversion weir

The Nakra diversion weir is a gated structure. Under routine conditions, it will be operated passively. The gated intake will have a diesel generator and a permanent operator stationed.

The mandatory ecological flow of 1.2 $m^3/s$ will be released in the Nakra River downstream of the diversion weir all year. The ecological flow will be released through a fish pass (see Vol. 4 “Biodiversity Impact Assessment”).

Under routine operation, the flow of the Nakra River will be deviated into the transfer tunnel which conveys the river water to the Nenskra reservoir. The tunnel is designed for a maximum flow rate of 45.5 $m^3/s$ which is the mean monthly maximum flow. It means that all water but the ecological flow will be drained to the Nenskra reservoir during typical years, except when floods are greater than 45.5 $m^3/s$. River water will be discharged safely downstream when the upstream inflow is greater than 45.5 $m^3/s$ which would occur most probably in June.

Under flood conditions, when the Nenskra reservoir already spills, the transfer tunnel inlet could be closed with the two planar gates (see § 3.3.1) in order to avoid incremental flooding event downstream of the Nenskra dam. The closure of the transfer tunnel could also be required in case of tunnel maintenance works.

The Nakra weir will be equipped with radial gates to allow flushing of sediments trapped in the head pond and to contribute to maintaining support river bedload capacity downstream of weir.

## 4.6 Project decommissioning

JSCNH will operate the Nenskra HPP during 36 years; after these 36 years, a condition assessment and overhaul will be carried out by JSCNH. The scheme will then be transferred to the Government of Georgia and will be operated during several decades. The length of service is therefore difficult to estimate. The decommissioning of the Nenskra HPP might involve removal of the Nenskra Dam, Nakra water intake and Nenskra Powerhouse and returning the rivers to their original situation, but this is unlikely; Depending upon the length of service, the Nenskra reservoir may have established a new valuable ecosystem also beneficial to residents of the valley. In this instance, removal of the civil works would create a considerable negative effect. In general, decommissioning of a hydropower project requires as much planning as the construction of the Project in the first place. Considerable consultation would be required. It could be assumed that prior to decommissioning the Nenskra HPP, the Enguri HPP would also be decommissioned. This would result in the Enguri watershed being returned to a state that would be similar to its condition prior to the construction of both dams.

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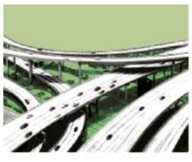
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