Hydropower Investment Promotion Project (HIPP)

MACHAKHELA 1 HPP PRE-FEASIBILITY STUDY REPORT

This publication was produced for review by the United States Agency for International Development. It was prepared by Deloitte Consulting in collaboration with Black & Veatch and Pierce Atwood Attorneys LLC.

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USAID HYDROPOWER INVESTMENT PROMOTION PROJECT (HIPP)

CONTRACT NUMBER: EEM-I-00-07-00005-0

DELOITTE CONSULTING LLP

IN COLLABORATION WITH BLACK & VEATCH AND PIERCE ATWOOD ATTORNEYS LLC.

USAID/CAUCASUS OFFICE OF ENERGY AND ENVIRONMENT

Definition of Technical Abbreviations

atm	Atmospheres
CAPEX	Capital Expenditure
EIA	Environmental Impact Assessment
FDC	Flow Duration Curve
GEL	Georgian Lari
GIS	Geographic Information System
GoG	Government of Georgia
GW	Gigawatt
GWh	Gigawatt-hours
HIPP	Hydropower Investment Promotion Project (USAID-funded)
ha	Hectare
HP	Hydropower
HPP	Hydropower Plant/Hydropower Project
IFI	International Financial Institutions
kg/s	Kilograms per Second
kV	Kilovolt
kW	Kilowatt (a measure of power)
kWh	Kilowatt-hour (a measure of energy)
m^3/s	Cubic meters per second
m^3/s-hrs	Cubic Meters per Second x Hours
masl	meters above sea level
MW	Megawatts
MWh	Megawatt-hours
SS	Substation
T	Metric Tonnes
TBM	Tunnel Boring Machine
US ¢	United States Cent (also USc)
US$	United States Dollar (also USD)
USAID	United States Agency for International Development

1 OFFERING PARTY

1.1GEORGIA

Georgia is situated at the juncture of Eastern Europe and Western Asia between the Black Sea, Russia, Armenia, Azerbaijan, and Turkey. The country covers a territory of approximately 69,700 km^2. Its population is more than 4.4 million.

The country is rapidly developing as a gateway from the Black Sea to the Caucasus and the larger Caspian region. Georgia's natural resources include forests, manganese deposits, iron ore, copper, gold, minor coal and oil deposits, and abundant hydro resources.

1.2 GOVERNMENT

Georgia's constitution reflects a representative democracy, organized as a unitary, semi-presidential republic. It is currently a member of the United Nations, the Council of Europe, the World Trade Organization, the Organization of the Black Sea Economic Cooperation, the Organization for Security and Cooperation in Europe, the Community of Democratic Choice, the GUAM Organization for Democracy and Economic Development, and the Asian Development Bank. The country aspires to join NATO and the European Union.

1.3.1 Investment in Project Development

GEDF will create special purpose vehicles (SPV) for each project. The preferred legal status of each SPV will be a joint stock company listed on the Georgian Stock Exchange. In case of interest from foreign portfolio investors, GEDF can issue GDRs during the IPO.

GEDF shall make initial equity investment in the range of 5-10% of total project cost with the objective of selling each renewable energy project at the initial stage of construction. GEDF may be required to inject more funds in a particular SPV if a project could not be sold or if its IPO is postponed for any other reason.

SPVs shall carry out all initial development work on a project, namely conceptual design, topographical and geological studies, hydrological calculations, environmental and social impact assessments, land acquisition for construction and impoundment areas for HPP projects, begin detailed project engineering and design, implement infrastructure development (access roads, grid connection, low voltage power supply lines, etc.), obtain all required licenses and permits, begin site construction, submit the Project Design Document ("PDD") for validation, place orders for hydro-mechanical and electrical equipment, enter into Power Purchase Agreement ("PPA") with local or foreign counterparty, and other project development activities.

An SPV should be able to obtain loans from IFIs and private financial institutions to leverage a project. The preferred approach is project financing. Completion of debt financing will occur once sufficient equity investment is acquired. The debt to asset ratio can be in the range of 50-70%.

Upon successful completion of the above, the government can announce an IPO of all or part of its shares in the SPV.

1 OFFERING

Part 2 of this Information Memorandum presents an approved offering by the Government of Georgia. The prefeasibility study contained herein is intended to present an overview of the offering and capture relevant data an investor may wish to explore further in conducting their own due diligence.

2 INVESTORS

Interested investors are encouraged to contact the Ministry of Energy and Natural Resources of Georgia to obtain additional information about the project and the MoU process, before undertaking their own due diligence and/or registering an expression of interest.

3 CONSIDERATIONS

While considering any investment, each recipient/interested party should make its own independent assessment and seek its own professional, financial, legal and tax advice.

Each recipient/interested party is encouraged to take into consideration a wide range of factors, among other things the Georgian transmission tariff methodology, the Georgian distribution wheeling tariff methodology, transmission transfer capability with Turkey in non-winter months, transmission capacity allocation, Georgian transmission capacity congestion management, harmonization of legislation and regulations relating to cross border power trading, Georgian market rules, Turkish transmission capacity allocation, Turkish transmission congestion management, and other considerations not referenced herein.

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Project Description

The site of the proposed Machakhela 1 HPP is located about 10.5 km upstream from the confluence of the Machakhelistskali with the Chorokhi River, near the village of Kokoleti, in the Khelvachauri District of western Georgia's Adjara Autonomous Region. The plant capacity will be 27 MW with annual generation production of approximately 130 GWh.

The Machakhela 1 HPP is envisioned to be the upper plant in a possible 2-HPP cascade (Machakhela 1 and Machakhela 2 HPPs) on the Machakhelistskali River. There would be significant construction and operations advantages to a single developer if the decision were made to undertake the study, design, construction and operation of both the Machakhela HPPs.

The Machakhela 1 HPP site offers relatively consistent, year-round mean annual generation of approximately 130 GWh. There will be an intake structure, power tunnel, tributary diversion dam with a small pool, a box culvert, forebay, steel penstock, surface powerhouse, tailrace, transformer substation, and transmission line connection. The main intake captures flow from the Machakhelistskali River just downstream from the Georgian border with Turkey. The arrangement of the two diversion structures and the water conductors efficiently exploits the usable head in the system, maximizing the energy output from the available water.

Access to the site is fair at this time. The locations of both the powerhouse and diversion weir site are adjacent to unpaved roads. About 8.5 km of road, south of the river, will be upgraded to reach the main diversion site. An additional 5 km of road, following the river, will be upgraded to reach the powerhouse and the tributary diversion.

A new 35 kV transmission line, about 8 km long, will be constructed along the public road to connect the Machakhela 1 HPP to the proposed Machakhela 2 HPP substation. From that point, the power will be connected to the transmission network through a new, double-circuit 35 kV transmission line to Batumi or a new 110 kV transmission line (connecting to the existing 110 kV line up the Adjaristskali River Valley).

The Machakhela 1 HPP development is expected to include two diversion intakes—one on the main river and one on a tributary. The main intake will include a moderate-size (23 m total height) concrete diversion structure with 30-m-long spillway crest, which ensures maximum water capture. The power tunnel will be 2.7 km long and 3.5 m in diameter, and will discharge directly into the pool formed by the tributary diversion structure. A box culvert, about 900 m long, will convey water from that pool to a forebay above the power plant. A 200-m-long penstock will carry flows down a steep slope to the powerhouse. A bifurcation will be located immediately above the powerhouse, channeling flow to the two units. The tailrace will be very short, with the unit draft tubes discharging less than 10 meters from the river bank.

Project cost and construction schedule

The currently estimated cost of the Machakhela 1 HPP is USD 52.4 million or about USD 1,939/kW of installed capacity. The project is expected to have a 1 year pre-construction period and 2 year construction period. The critical path of the project may be through the construction of the 2.7 km power tunnel plus 900 m of box culvert, or may be through the major equipment acquisition schedule.

Financial analysis

The project is expected to sell power during 3 months of the year within Georgia (for the first ten years of the plant's operating life) and the remaining time into the Turkish competitive power market. Based on preliminary assessment, the Machakhela 1 HPP Project provides a good opportunity for investment and should be further investigated by potential developers. The expected simple payback period is approximately 7.6 years based on parameters as shown in Section 8.0.

Conclusions/recommendations

According to preliminary assessments the plant offers a good potential opportunity to sell energy during three winter months inside Georgia, replacing (displacing) expensive thermal power, and export energy during the remainder of each year to take advantage of the seasonal differentials in power prices between Georgia and its neighboring countries.

Table 1: Project Significant Data

General	
Project name	Machakhela 1 Hydropower Project
Project location (political)	Khelvachauri District of Western Georgia's Adjara Region
Nearest town or city	Machakhlispiri
River name	Machakhelistskali
Total drainage area	255 km^2
Financial Estimates	
Estimated Construction Cost	$52.4 Million
Estimated Cost per kW capacity	$1,939 /kW
Simple Pay Back Period	7.6 years
Hydrological Data (Adjusted to Intake Location)	
Annual mean river flow at intake	15.6 m^3/s
Facility design discharge (m^3/s)	25 m^3/s
Annual average discharge through powerhouse	13.64 m^3/s
Preliminary design flood (100 yr return period)	230 m^3/s
Max. recorded flow	246.5 m^3/s
Intake Ponds	
Highest regulated water level (HRL)	375 masl (set to avoid backing water up into Turkey during floods
Minimum operating level (MOL)	371 masl
Sanitary or environmental flow (assumed)	1-10% of mean monthly flow for each month
Diversion Structures	
Machakhela 1 Diversion	
Crest elevation	371 masl
Abutment top elevation	375 masl
Maximum height	23 m from assumed bedrock to bridge deck
Sluice gate	3.0-m-wide x 5.0-m-tall
Trashrack	Bar rack upstream from intake gate to exclude large material from tunnel

Power tunnel intake gate	1 x 3.5 m wide x 3.5 m high wheel gate
Flood Discharge Capacity	
Crest elevation	371 masl
Crest Length	30 m
Capacity at design flood level (375 masl)	480 m^3/s
Tributary Diversion	
Crest elevation	368 masl
Crest length	5 m
Abutment elevation	370.5 masl
Flood capacity at 370 masl	28 m^3/s
Sluice gate	2.0 m x 2.0 m
Power water conductor/penstock	
De-silting basin	Not required, since diversion pools will provide for sediment settling.
Power tunnel	2.7 km
Diameter	3.5 m tunnel
Slope	0.20% minimum
Water velocity, at design flow	2.6 m/s
Box culvert	
Length	900 m
Invert	364 masl at intake and 361 at forebay
Size and Construction	3.5 m x 3.5 m reinforced concrete
Forebay	
Width	6 m
Length	30 m
Spillway crest elevation	368 masl
Spillway width	5 m
Maximum pool elevation	370 masl
Minimum operating elevation	366 masl
Bottom elevation/intake invert	361 masl
Penstock intake	
Trash racks	7 m high, 4 m wide
Maintenance gate, bulkhead type	3 m x 3 m
Operating gate, wheel type	3 m x 3 m
Penstock, length	200 m including bifurcation
Material	welded steel
Outside diameter	2.5 m
Powerhouse	
Type	Above-ground
Installed capacity at high-voltage transformer terminals	27.0 MW (at design flow)
Units and net capacity at high-voltage transformer terminals	Unit 1: 19.9 MW vertical Francis Unit 2: 9.9 MW vertical Francis
Rated speed	Unit 1: 300 rpm Unit 2: 375 rpm
Preliminary generator voltage	15 kV or manufacturer's recommendation
Rated generator capacity	Unit 1: 22.2 kVA at 0.90 Power Factor Unit 2: 11.0 kVA at 0.90 Power Factor
Size of powerhouse	16.5 m wide x 45 m long x 27 m high
Tailrace	
Length	10 m
Width	15 m
Type	Channel
Normal tailwater elevation	235 to 236 masl

Transmission line	
Interconnection location	New transmission line, constructed along the public road, to connect the Machakhela 1 HPP to the proposed Machakhela 2 HPP substation.
Distance to interconnection (km)	About 8 km
Voltage	35 kV
Power & Energy	
Gross head	135 m
Total head loss at rated discharge	7.6 m
Net head at rated discharge	127.4 m
Estimated average annual head loss	2.9 m
Estimated average annual net head	132.1 m
Estimated average annual generation	Approximately 130 GWh
Nominal installed capacity	27.0 MW
Preliminary annual plant factor (also called CF)	55%
Construction Period	
Conceptual design, feasibility studies & EIA	1 year
Engineering, procurement and construction	2 years
Ongoing environmental monitoring	Some studies and data collection will extend throughout construction.
Environmental	
Critical environmental receptors	Local communities throughout the development area

Figure 1: Georgian Project Location Map

1.0 GENERAL INTRODUCTION TO THE PROJECT

1.1 DESCRIPTION OF THE DEVELOPMENT AREA

The proposed Machakhela 1 Hydropower Project involves the construction of an approximately 27 MW run-of-river HPP on the Machakhela River, in the Khelvachauri District of western Georgia's Adjara Region. The approximate location is shown on the Georgian Project Location Map above. The Machakhela 1 powerhouse will be located 10.5 km upstream of the confluence of the Machakhela River with the Chorokhi River and approximately 9 km upstream from the Village of Sindieti, where the gauging station is located. The diversion weir is approximately 3 km further up the Machakhela River from the powerhouse. (see Figure 5 and Appendix 3).

The city of Khelvachauri is the administrative center of the Khelvachauri District. According to the statistical data of 2002, the district population is about 96,600 people, with a population density of 235 people/ km^2. The distance from Tbilisi to the administrative center of Khelvachauri is about 385 km by road and the Machakhela 1 project is a further 20 km southeast of Khelvachauri. Chikuneti is the closest village to the Machakhela 1 HPP.

The total area of Khelvachauri District is 413.3 km^2. Most of Khelvachauri District is mountainous dominated by Colchic type forests. See Section 2.6, Biodiversity and Appendix 7, Land Cover Map for further details.

The economy of the Khelvachauri District is dominated by agriculture, though some industry is also developed. The main agricultural activities of the Khelvachauri District are growing maize, beans, potatoes, tea, citrus, tobacco and vegetables. There are three tea factories and construction material processing industries (inert material processing and block processing factories) in Khelvachauri District. There is an existing 1.6 MW capacity hydropower plant operating on the Machakhela River. The 1.6 MW capacity Machakhela hydro power plant is located on the lower reach of the river Machakhela, and is currently operating at reduced capacity. The diversion for this plant is located a few hundred meters downstream from the proposed Machakhela 2 powerhouse, and the power plant is in the Kedkedi Village area.

There is no irrigation system in the watershed. Drinking water is supplied to the Khelvachauri District through a central water supply system. The government of the Adjara Region plans to completely rehabilitate the water supply system of the region. The local residents use the potable water supply for irrigating gardens and for crops that need large quantities of water.

The transportation infrastructure of Khelvachauri District is developed: The Acharistskali–Kirnati motorway, which goes through the region, is of national importance. Roads of local importance total about 187.85 km in length.

The development of the Machakhela HPP near a traditional resort zone (Batumi City) could facilitate tourism development in the area. The coastal zone of Adjara Region is a traditional tourist area. According to the Department of Tourism and Resorts of Adjara Region, tourist visits increased by 15% over the last five years with a good opportunity to attract more visitors. There are 3 sanatoriums, 3 holiday houses, 1 tourist base and about 20 hotels within the Khelvachauri District.

The region is culturally rich represented by many old churches, monasteries, towers and other cultural relics, although there are **no** cultural or historic sites within the Machakhela 1 HPP study area.

Table 2: Development Area Significant Data

Project Location (Political)	**Western Georgia's Adjara Autonomous Region**
Political Subdivisions	**Khelvachauri District**
Area Population	**96,600**
Nearest Town or City	**Chikuneti**
River Name	**Machakhelistskali**
Economic Activity in the Area	**Primarily agriculture and tourism**
Special Natural Resources	**Colchic type forests and trout fishery.**
Special Cultural Resources	**Churches, monasteries and historic locations**
Critical Environmental Receptors	**Mtirala National Park**

1.2 DESCRIPTION OF THE LOCAL ELECTRIC POWER SYSTEM

The transmission assets in the Machakhela River area, include a 35 kV line that ends at the existing 1.5 MW Machakhela powerhouse. This is owned and operated by Energo-Pro, the licensed distribution utility serving most of Georgia outside Tbilisi. There are lower-voltage distribution lines extending almost to the Turkish border. Energo-Pro also has a 110 kV transmission line that runs up the Adjaristskali River Valley, parallel to the Machakhelistskali, as far as their 16 MW Atshesi HPP.

2.0 BASELINE CONDITIONS

In order to establish a comparison for environmental evaluation of the Machakhela 1 HPP a set of baseline environmental conditions have to be identified. International practice today uses the baseline data to address changes that would occur during project construction and operations. Using this baseline and affected environment approach the project can be viewed and assessed in an acceptable manner. Section 2 provides general baseline conditions for a range of environmental and site criteria (receptors). Section 6.2 addresses the Affected Environment, and Appendix 10 presents a series of tables that address the expected range of impacts to these receptors and recommendations for mitigation procedures and plans that are considered standard practice today.

2.1 CLIMATE: GENERAL DESCRIPTION

The climate of Machakhela River watershed is humid subtropical which varies with the increase in altitude. The watershed area is characterized by moderate to mild winters and long hot summer seasons. Elevations range from 2,200 masl at the upper watershed boundary to approximately 40 masl near the junction with the Chorokhi River. The precipitation increases and air temperature decreases significantly with the increase in elevation. The annual precipitation on average is in the range of 1,550 mm in Keda (elevation around 300 m), 20 km northeast of the Machakhela 1 HPP. Precipitation is average to above-average during the fall and winter and average to below average during the spring and summer (April – August). Additional climatic information is presented in Section 6. Appendix 6 displays an Annual Precipitation Distribution Map for the Machakhela River watershed.

2.2 HYDROLOGY AND WATER RESOURCES:

Table 3: Hydrology Significant Data

Records available	**Daily flow measurements for 51 years (1941-1943, 1944-1993) at Sindieti, from the Department of Hydrometeorology.**
Method of analysis	**Monthly and annual flow-duration curves, flood frequency, 30 day minimum and maximum moving averages of daily discharge values**
Drainage area at gauge	**362.0 km^2**
Drainage area at the intake	**271 km^2 Including tributary collection area**
Adjustment factor	**0.7486**
Maximum plant discharge	**25 m^3/s**
Minimum plant discharge	**As low as 3.5 m^3/s**
Stream flow for power generation	**Based on combined flow duration analysis and average daily discharge energy analysis. Expected normal discharge range of 3.5– 25.0 m^3/s. Reasonable potential of approximately 130.0 GWh/year**
Flood flows (combined)	**Average Annual Flood (2.33 yr return period) = 70 m^3/s**
Highest recorded flow	**246.5 m^3/s**
Calculated 100 year flood	**230 m^3/s**
Recommended additional data collection and study recommendations for feasibility and design	**Stream flow gauging at various critical locations in the basin as well as at the Machakhela 1 HPP intake; meteorology stations for air temperature, precipitation, barometric pressure, relative humidity, wind speed and direction, solar insolation, and snow depth.** **These stream locations would also be used for other monitoring of suspended and bedload sediments, water quality parameters, water temperature, fish, etc.**

2.2.1 Catchment Description including Land Cover and Current Water Resource Use

Originating on the northern slopes of the Meskheti Mountain Range in Turkey at an elevation of 2,200 m the Machakhela River crosses the Georgian border and flows into the Chorokhi River. The Machakhela River is 37 km long and drains an area of 369 km^2. Its length in the territory of Georgia is 21 km. The main tributary within Georgia is the 11–km-long Skurdidi River. The length of other tributaries does not exceed 5-6 km. The river is fed by snow, rain and groundwater. The Machakhela River flow is characterized by spring floods, autumn high flows, unstable summer flow, and relatively stable winter low flows. Table 3 summarizes the hydrological information that was available from a gauging station in Sindieti just upstream from the Chorokhi River confluence.

The catchment area is heavily wooded with significant steep to very steep slopes that can create flash flood conditions. The Machakhela River is characterized by a narrow riverbed and steep descending slopes. Downstream from the HPP sites, the Machakhela River flows into the Chorokhi River, which in turn flows into the Black Sea.

Appendix 4 is the Watershed Map that outlines the watersheds that contribute to the various proposed HPPs diversion locations on the Machakhela River. Appendix 6 presents the annual precipitation map while Appendix 7 presents land cover in the watershed.

2.2.2 Surface Water Resource:

The rivers in Georgia drain into two main drainage basins: the western rivers drain into the Black Sea, and the eastern rivers drain into the Caspian Sea. Georgia is rich in water resources. About 78 per cent of water resources of the country are concentrated west of the Likhi Mountain Range and only 22 per cent east of the Likhi Range. The Machakhela HPPs are in the western Black Sea Drainage Basin, see Appendix 4, which is the Watershed Map.

2.2.3 Machakhela River:

The Machakhela River's upper course flows through a deep gorge with many rapids until it joins the Chorokhi River. The river is fed by mixed sources; rain, snowmelt, and springs. Table 4 displays the Machakhela 1 HPP intake area flow characteristics. The flow is characterized by high flows in autumn winter and spring. There are relatively stable lower flows during the summer.

The stream flow gauging station is the Sindieti Gauge approximately 15 km downstream from the Machakhela 1 HPP intake location. The gauge has a drainage area of 362.0 km^2. The gauge data used for this pre-feasibility analysis included the calendar periods: 1941-1943 and 1945-1993. A drainage basin adjustment of 0.7486 (271 km^2/362.0 km^2) was used to adjust flow records to the Machakhela 1 HPP intake location. Appendix 2 includes monthly and annual flow duration curves.

Table 4: River Flow in m3/sec at Machakhela 1 HPP Intake

Annual average flow (m^3/sec)	**16.15**
Maximum average daily flow of record (m^3/sec)	**256**
Minimum average daily flow of record (m^3/sec)	**1.12**
Average monthly discharge during seasonal runoff period (April, May, June, July August, September) (m^3/sec)	**17.87**
Average monthly discharge during winter Season (Oct – March) (m^3/sec)	**13.82**
Highest 30 day average discharge (m^3/sec)	**71.50**
Lowest 30 day average discharge (m^3/sec)	**2.24**
Average discharge during Georgian winter electric demand period (Dec-Feb) (m^3/sec)	**11.78**
Assumed river discharge reserved for environmental/sanitary/ and other beneficial natural channel functions and values *	**1-10% of average monthly discharge, for each month**

** This percentage range is a conservative average. Examination of the immediate tributary flows into the Machakhela River between the diversion dam and the powerhouse suggest that for several of the months of the year reserved flows for in-stream environmental and sanitary requirements may not be required. It is recommended that this issue be included as part of detailed feasibility studies in so far as the amount of energy potential to gained if reserves are not required could be significant (on the order of 5% of average annual generation).*

2.2.4 Sediments, Watershed Characteristics, and River Discharge

The Machakhela 1 HPP location carries much less suspended sediment than the Khula sediment monitoring station on the Adjara River, the nearest sampling station to the Machakhela 1 site. The sampling station at Khula is in the adjacent watershed at a higher elevation and much closer to the alpine region of the watershed. This region is steep and above tree line. The Upper Adjara River watershed is steep-sloped, generating a high-velocity surface runoff and high river velocities. During high flow periods large volumes of suspended sediment can turn the river a grayish brown color. The erosion of river banks and steep valley slopes also contributes to bed load movement of coarse sediment, large rocks and debris.

Table 5 presents projected sediment values for Machakhela 1 HPP based on the Khula Gauge for a range of return periods. The project team strongly recommends further suspended and bed load data sampling at the intake location to develop a clear understanding of sediment transport magnitudes and variations expected over a typical operations year. The table presents sediment loads that clearly support a significant and long term operation challenge for the Machakhela 1 HPP and the requirements to address sediment management during detailed feasibility design. Section 6.2 and Appendix 10 address possible mitigation measures for sediment management during construction and operations.

Table 5: Khula Gauge and Machakhela 1 Intake Sediment Load Estimates

Suspended Sediment Volume Projected for Machakhela 1 Development							
Khula Gage on Adjaristskali River -- Drainage Area in Sq Km **/5**							251
Percent or Frequency	0.50%	1.00%	5.00%	10.00%	25.00%	75.00%	
Return Period in Yrs.	200.00	100.00	20.00	10.00	4.00	1.33	Annual **/6**
Khula Sampling Station Estimated Suspended Sediment in Kg/Sec /1		16.00	11.00	9.60	7.10	4.00	2.00
Khula Sampling Station Estimated Bedload Sediment Estimate in Kg/sec **/1,/4**	0	0	0	0	0	0	0
Khula Sampling Station Estimated total Sediment Load in Kg/Sec **/1**	0.00	16.00	11.00	9.60	7.10	4.00	2.00
Machakhela 1 Adjusted total Suspended Sediment Load in Kg/Sec **/2**	0.00	16.28	11.19	9.77	7.22	4.07	2.03
Machakhela 1 Intake Sediment Estimate in T x1000 **/3**	0.00	430.51	295.98	258.31	191.04	107.63	53.81
Machakhela-1 Intake Sediment Estimate in Cubic Meters x 1000	0.00	287.01	197.32	172.20	127.36	71.75	35.88

Note 1/ Data Source: Surface water Resources Transcaucausia and Dagestan, Vol 9 West Caucausia Edition 1, Administration of hydrometerologic Service, Georgian SSR 1969

Note: /2 Adjusted total sediment load for Machakhela 1 is based on drainage basin ratio with Khulo Gage Sediment sampling Location drainage area. This is closest sediment sampling location to Machakhela 1 HPP.

Note: /3 to account for only the sediment flowing into the Machakhela 1 intake I took the ratio of the net usable area under the flow duration curve and divided that by the area under the full flow duration curve as part of this calculation.

Note: /4 No data available for Bedload estimates.

Note /5 Khulo Sampling Station is in the Adjaristskali Basin at an elevation significantly higher then Machakhela HPP intake. The watershed above the sampling location is mostly above tree line and most likely has much higher concentrations of suspended sediment load then the Machakhela River above HPP 1.

Note 6/ Value is estimated.

2.2.5 Meteorological Conditions

For the analysis of the climatology of the Machakhela 1 project area, information from the nearest Meteorological Station located in the town of Keda was used. Keda is located along the Adjara River, about 15 km north-northeast from the Machakhela River.

The project team recognizes that Keda is the best available data near the watershed but is at a significantly lower elevation than the Machakhela 1 HPP watershed. It is recommended that as soon as project approval is complete, a primary meteorology station should be installed near the Machakhela 1 diversion weir or at the powerhouse location.

The Adjara Region is characterized by a humid subtropical climate. Please see Table 6 for specific data from Keda Meteorological Station.

Annual average precipitation for Adjara Region is 1200-1500 mm. The Machakhela 1 HPP watershed is considerably higher than the Keda Meteorology Station and precipitation increases considerably with elevation.

The climate of Machakhela river watershed area is humid subtropical which varies with the increase in altitude. According the Keda meteorological station, the annual precipitation is about 1558 mm on average. Mtirala Mountain, about 15 km north of the Machakhela Basin, experiences the heaviest precipitation in the area. Average annual precipitation on the leeward side of the mountain is above 2000 mm, and on the seaward slope of Mtirala Mountain the mean annual precipitation exceeds 4000 mm. The occurrence of snow in the Machakhela River watershed varies from 16 to 30 days per year.

See Appendix 6 for the Annual Precipitation Map, which shows the variations in annual precipitation for the entire watershed, HPP locations, catchment and sub-catchment boundaries. Table 6 displays monthly values and annual mean values of climatology data at Kutaisi, which is the nearest large city, but is at a lower elevation than the project watershed and therefore warmer and drier.

Further data collection and analysis has identified a discrepancy in meteorological data provided from various sources. There is a significant difference in the magnitude of monthly average rainfall included in Table 6 that does not match well the distributed rainfall data that appears in Appendix 6. At the pre-feasibility level of analysis, the discrepancy has been identified so that the developer's engineering team can research this data further and decide which is more appropriate or how to adjust one set to match the other.

Table 6: Keda Climate Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Data Type	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**mean**
Average Monthly Air Temperature in °C	3.1	4.0	7.4	12.1	16.1	19.1	21.3	21.5	18.4	14.2	9.8.	5.3	12.7
Lowest Average monthly Air Temperature in °C	0.1	0.7	3.3	7.0	11.4	14.4	17.1	17.3	14	10	6.0	2.0	8.6
Lowest Air Temperature in °C	-15	-15	-11	-4	1	6	10	9	3	0	-11	-12	-15
Highest Average Monthly Air Temperature in °C	7.8	9.2	13.3	18.9	22.9	25.0	26.5	26.9	24.4	20.5	15.5	10.2	18.4
Highest Monthly Air Temperature in °C	22	26	31	36	38	42	42	41	40	33	27	23	42
Average Relative Humidity in %	78	76	73	70	73	76	80	82	83	81	79	77	77
Average Monthly Precipitation in mm	168	154	122	72	70	79	90	95	156	207	190	155	1558 (Mean annual Total)
Average Monthly Wind speed in meters/ second	1.0	1.0	1.4	1.6	1.6	1.6	1.4	1.3	1.2	1.0	0.9	0.8	1.2

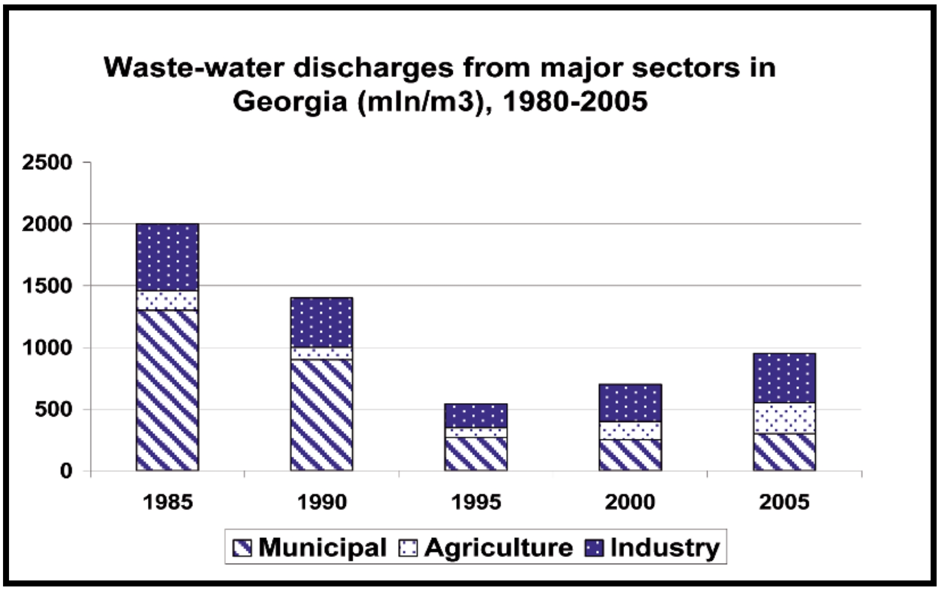
Source: Data on climate and meteorology for Keda was provided by the Department of Hydrometeorology of Georgia.

2.3 WATER QUALITY

Water Quality is a key environmental receptor and is a basic measure for assessing impacts from construction and operations. Water supply quality in the country is at a fair level, and a safe drinking water supply is the key component of the general objective to ensure the environmental safety and health of the people of Georgia. Poorly maintained and non-functional wastewater treatment facilities in urban areas and septic systems and non-treated municipal, agricultural and industrial discharges to rivers in most parts of the country present major challenges to overall water quality. (Ref: Betsiashvili M. and Ubilava, M. “Water Quality and Wastewater Treatment Systems in Georgia”, 2009).

Figure 2 presents wastewater discharges from major sectors in Georgia in millions of cubic meters.

Figure 2: Waste-water discharges



Ref: “Caucasus Environmental Outlook” Report of the Ministry of Environment and Natural Resources Protection of Georgia, 2005

After the break-up of the Soviet Union, contamination of surface waters in Georgia decreased, due to the major decrease of industrial production and subsequent wastewater discharges. This could have resulted in the temporary improvement of water quality. However, this is off-set by the fact that the majority of wastewater treatment facilities ceased to function or work at very low levels of efficiency. This lead to (and continues today) discharge of larger quantities of untreated wastewater directly into surface water bodies.

Field data for surface water quality in Georgia and the Machakhela River watershed is extremely limited. The water quality in Georgia is collected by the Environmental Baseline Monitoring Center of the State Department of Hydrometeorology (Hydromet). According to the Hydromet, 131 sampling points are chosen in Georgia for baseline water quality monitoring in the rivers and reservoirs. Due to the lack of funding, only 26 points are monitored at regular basis (i.e., samples are taken and analyzed each month), another 26 at irregular basis (i.e., samples are taken and analyzed 2 or 3 times per year), and the remaining 70 points are not monitored at this time. The infrequency of monitoring and questions about quality control during sample collection and analysis are of concern compared to international norms. Therefore, water quality sampling and resulting data should be included in any feasibility analysis to establish a **baseline** for water quality upstream of the HPP intake, in the bypass section of the river and in the river below where the tailrace merges with the river.

2.4 WATER WITHDRAWALS

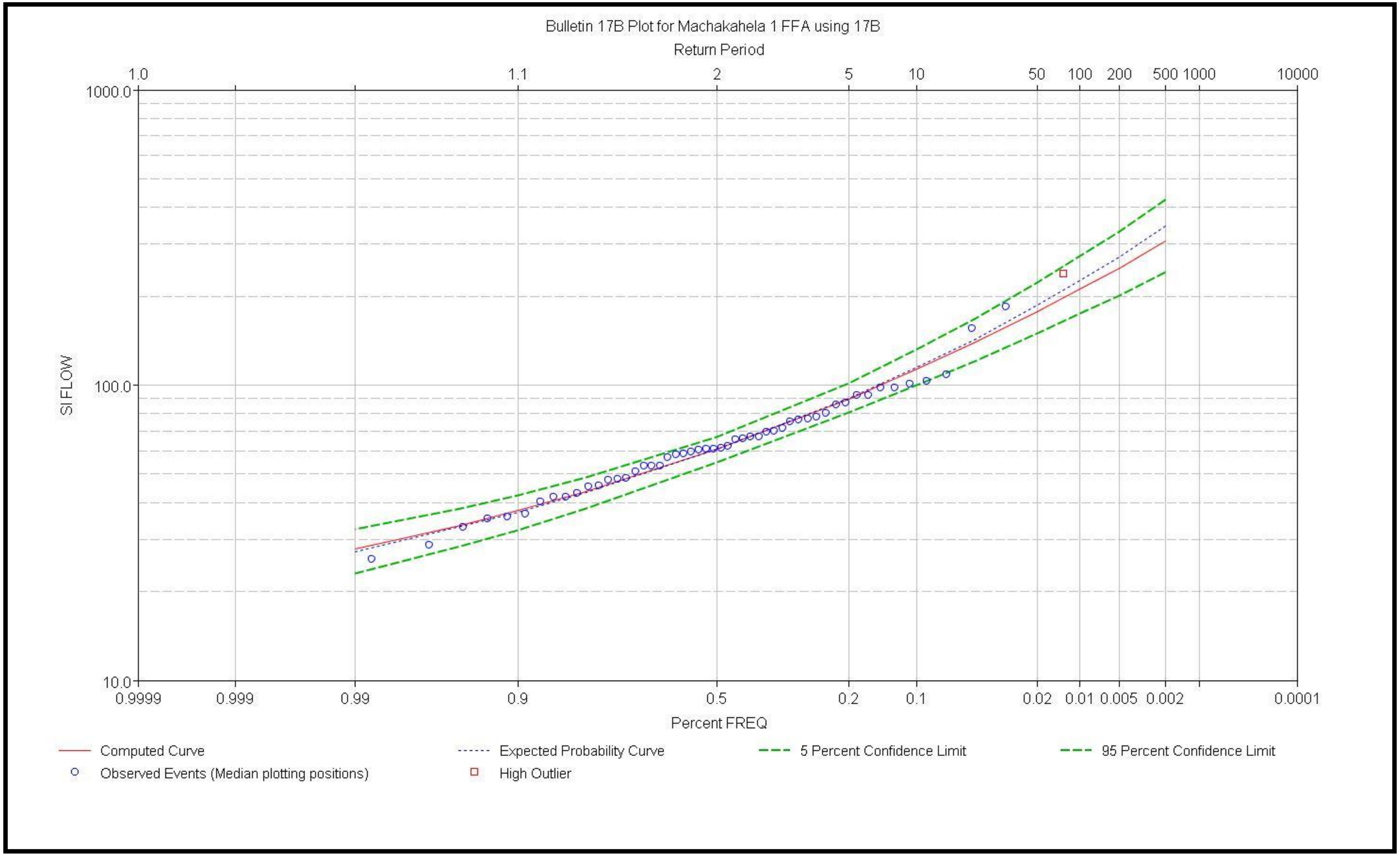
The proposed Machakhela 1 HPP run-of-river operations should have no impact on downstream water withdrawal users but during low flow periods coordination may be required to assure the local population that HPP operations are allowing adequate sanitary and environmental bypasses along with the other tributaries.

2.5 FLOODING AND FLOOD RISK

Flooding is characteristic in the Project watershed and in the project vicinity. Steep slopes, deep gorges, snowmelt runoff enhanced by warm temperatures and intense precipitation all contribute to major flooding risk for the project and the local environment.

With the availability of 51 years of record at the Sindieti Gauge, the U.S Army Corps of Engineers Hydrologic Engineering Center (USACE-HEC) Flood Frequency Analysis program (HEC-SSP) was used to check the earlier Soviet Report flood frequency values. The results are presented in the figure below. A drainage basin adjustment of 0.278779 was used to adjust these values to the proposed location of the Machakhela 1 intake location.

Figure 3: Machakhela 1 HPP Flood Frequency Analysis



2.6 BIODIVERSITY

2.6.1 Flora

The landscape of the potential HPP location area is dominated by forested lower elevation mountains that are separated by gorges. Forests occupy almost all of the watershed areas of the territory. Forests growing in the vicinity of proposed Machakhela 1 HPP watershed are State owned. The agricultural area is made up of gardens, orchards, vineyards and plots of maize. Appendix 7, Land Cover Map, displays general forest cover in the watershed.

The Machakhela River watershed area is rich in biological resources; the majority of the territory is occupied by forests. The proposed hydro power location site is surrounded with foothills covered by Colchic-type forests. Dominant trees are: chestnut (*Castanea sativa*), beech (*Fagus orientalis*), elm (*Ulmus foliacea*), and maple (*Acer campestre*). The sub-forest is dominated by evergreen species of rhododendron (*Rhododendron ponticum*). In the vicinity of the villages are higuera (*Ficus carica*) and Persian mulberry (*Morus nigra*).

Open meadows contain crown grass (*Paspalum thunbergii*), woundwort (*Prunella vulgaris*), lesser Caucasian stonecrop (*Sedum stoloniferum*), stonecrop (*Sedum hispidum*), strawberry (*Fragaria viridis*), yellow avens (*Geum urbanum*), medick (*Medicago falcate*), trefoil (*Trifolium subterranum*). (Source: Encyclopedia of Georgia, 1984).

2.6.2 Fauna

Golden Eagles have a year-round presence in mountainous regions of Georgia. Because of its high landscape diversity and low latitude Georgia is home to about 1000 species of vertebrates, (330 birds, 160 fish, 48 reptiles, and 11 amphibians). A number of large carnivores live in the forests, namely Brown bears, wolves, and lynxes. The number of invertebrate species is presumed to be very high but data is distributed across a large number of publications and is not easily summarized.

Large mammal species found in the region are badger *(Meles meles*), jackal (*Canis aureus*), fox (*Vulpes vulpes*) and mole (*Talpa caucasica*).

The Adjara Region is known for a diversity of birds including 40 nesting species, 30 wintering species, 50 migratory species and 30 species of non-regular migratory birds. Among them are: the black-throated diver (*Gavia arctica*), red-throated diver

(*Gavia stellata*), red-necked grebe (*Podiceps grisegena*), black-necked grebe (*Podiceps nigricollis*), mute swan (*Cygnus olor*), whooper swan (*Cygnus cygnus*), mallard (*Anas platyrhynchos*), shoveler (*Anas clypeata*), teal (*Anas crecca*), ducks (*Anas querquedula, Anser anser, Anser albifrons*), tufted duck (*Aythya fuligula*), pochard *(Aythya ferina*), herons (*Ardea cinerea and Ardea purpurea*), little egret (*Egretta garzetta*), little bitten and big bitten (*Ixobrichus minutus; Botaurus stellaris*), glossy ibis (*Plegadis falcinellus*), spoonbill (*Platalea leucorodia*), black-winged pratincole (*Glareola nordmanni*), black-winged stilt (*Himantopus himantopus*), great snipe (*Gallinago media*), curlew (*Numenius arquata*), marsh-harrier (*Circus aeruginosus*), and kingfisher (*Alcedo atthis*) (**Source:** Jordania R, Boeme B, Kuznetsov A, 1999).

The table below shows the list of some bird species identified in Machakhela watershed area.

Table 7 Nesting Bird Species of the Adjara Region

#	Species	Abundance
1	Heron (*Ardea cinerea*)	First ten days of April, nesting on the trees
2	Black vulture (*Aegypius mon*achus)	March, nesting on the trees
3	Grey Lag-Goose *(Ancer ancer*)	April, nesting on the ground
4	Eagle-owl (*Bubo bubo)*	March, nesting on the ground
5	Bittern (*Botaurus stellaris)*	April, nesting on the ground
6	Mallard (*Anas platyrhynchos*)	April, nesting on the ground
7	Gradwall (*Anas stepera*)	April, nesting on the ground
8	Wigeon (*Anas Penelope*)	May, nesting on the ground
9	Pochard (*Aythya ferina*)	May, nesting on the ground
10	White-eyed Pochard (*Aythya nyroca)*	May-June, nesting on the ground
11	Tufted Duck (*Aythya fuligula*)	June, nesting on the ground
12	Velvet Scoter (*Melanitta fusca*)	June, nesting on the ground
13	Coot (*Fulica atra*)	April-May, nesting on the ground
14	Black-headed Gull (*Larus ridibunus)*	April-May, nesting on the ground
15	Short-eared Owl (*Asio flammeus*)	April, nesting on the trees
16	Black Woodpecker (*Drycopus martius)*	April, nesting on the trees
17	Stock-dove (*Columba oeans*)	April-May, nesting on the trees
18	Wood-Pigeon (*Columba palumbus*)	May, nesting on the trees
19	Spotted Crake (*Porzana porzana*)	April-May and June-July, nesting on the ground
20	Rock-thrush (*Monticola saxatilis)*	May-June, nesting on the ground
21	Rose-colored starling (*Sturnus roseus)*	May, nesting on the ground
22	Lesser Spotted Woodpecker (*Dendrocopos minor*)	April-May, nesting on the trees
23	Shore-lark (*Eremophila alpestris*)	May-June, nesting on the ground
24	Nightingale (*Luscinia megarhynchos)*	May, nesting on the ground
25	Cetti's Warbler (*Cettia cetti*)	May-June, nesting on the ground
26	Bullfinch (*Pyrrhula pyrhulla*)	May, nesting on the trees

(Source: Jordania R., Boeme B., Kuznetsov A., 1999).

The Mtirala National Park is located 15 km north of the proposed hydro cascade. The park area is 15,804 hectares, and is 14 km from the Batumi–Tbilisi highway.

2.6.3 Fish Population

The local fishery is also considered a primary environmental receptor for baseline comparison. Literature on fish composition in the Chorokhi River is a few decades old. Since then no monitoring on fish species has been conducted. Therefore, it's hard to know what species still inhabit the study area. The sampling of fish species should be included as part of the feasibility study and environmental assessment.

3.0 GEOLOGY

3.1 GEOLOGICAL REPORT

The geologic data available at the time of the pre-feasibility study were geologic maps at the scale of 1:500,000, geologic maps of the Machakhela valley at 1:10,000, and a field reconnaissance report. A copy of this report and 1:100,000 geological maps covering the Machakhela River watersheds are included in Appendix 1.

3.2 SEISMOLOGY

The Machakhela River watershed is located on the southwestern part of the Foldsystem of the Lesser Caucasus mountain range, which is an ongoing uplift area created by the collision of tectonic plates. This inevitably creates an earthquake hazard zone along both sides of the mountain range. Within 150 km of the Machakhela HPPs there have been several “significant” earthquakes. The “significant” earthquakes in the area are listed in the table in Appendix 1, Geology. The source of this data is the National Geophysical Data Center / World Data Center (NGDC/WDC) Significant Earthquake Database, Bolder, CO, USA. (Available at http://www.ngdc.noaa.gov/nndc/struts/form?t=101650&s=1&d=1).

According to the current Georgian seismic zoning classification the project is in hazard zone 8. The design criteria for earthquake loads and resistance of structures must be defined in accordance with applicable standards and regulations. Through proper design and construction, the risk from earthquake damage can be mitigated.

3.3 CURRENT STATUS OF GEOLOGICAL INVESTIGATION

Because of the nature of a pre-feasibility study, surface mapping of outcrops has not been done and no borings have been conducted. Geological studies, including core borings, must be part of the feasibility study. It is critical that a site investigation program be done for the headworks area, tunnel alignment and the powerhouse area, using test pits and core boring in all areas during the feasibility study.

Table 8: Geology Significant Data

Available data	**1:500,000 Scale Geological Map of Georgia (2003); area geologic maps and sections at 1:50,000 (1973); scanned copies of hand-drawn geologic maps of the Machakhela valley at 1:10,000 (1980)**
Regional description	**Khelvachauri District of south western Georgia’s Adjara Region**
Seismicity, including earthquake loadings	**Richter Scale 5.7, Georgian Seismic Zone 8**
Field reconnaissance	**Done in 2011. Report available in Appendix 1.**
Subsurface borings	**To be done at Feasibility Study stage**
Investigation recommendations for Final Feasibility and Design	**Geotechnical borings at diversion dams, and powerhouse locations.**

4.0 HYDROPOWER PROJECT DESCRIPTION

4.1 PROJECT DESCRIPTION

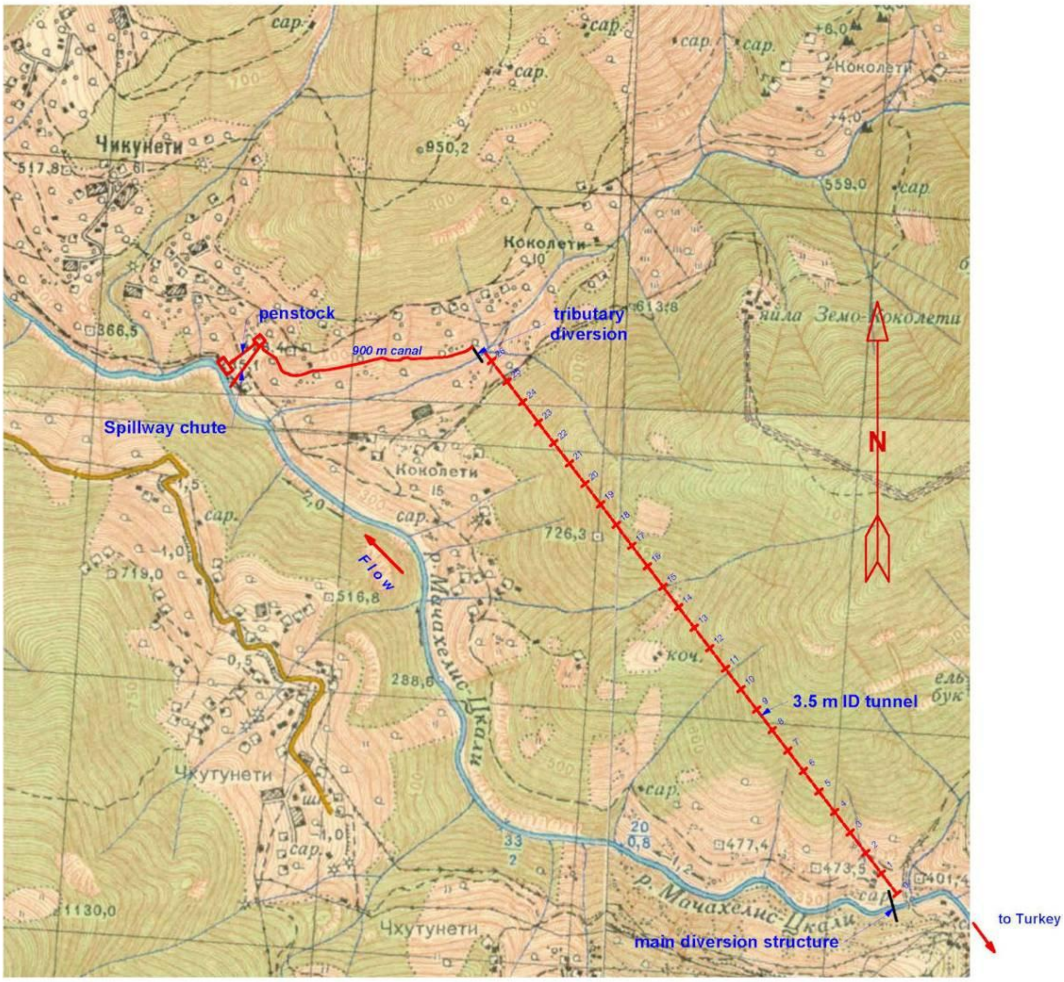
The Machakhela 1 HPP development is expected to include a diversion dam across the Machakhela River, 2,700-m-long power tunnel, secondary tributary diversion, 900-m-long box culvert, forebay, and 200-m-long steel penstock. These diversions collect runoff from an area of about 271 km^2. The power tunnel will have an inside diameter of 3.5 m. This diameter has been selected for both hydraulic and constructability reasons.

The power plant may work in island mode as well as in synchronization with the national power grid, allowing both direct and grid-connected supplies to consumers. To allow continuous operation of the Machakhela 1 plant, sufficient auxiliary backup power (probably a diesel generator) will be provided to allow black-starts when this plant is isolated from the national transmission network (island mode).

Access to the site is fair. The intake and powerhouse are adjacent to an unpaved public road that leads from Acharisaghmarti to Epeler. It may be necessary to relocate short sections at the diversion and power plant site. From the topographic maps available, it does not appear that it is practical to install a mid-tunnel adit. The excavation of the box culvert and forebay will require access to the downstream end of the power tunnel. This would also allow tunnel excavation at two faces.

An overall view of the project arrangement is shown in Figure 4.

Figure 4: Machakhela 1 Hydropower Project General Layout



In the figure above, the heavy red line represents the power tunnel and box culvert. The figure also indicates the proposed locations of the diversion dam at the upstream end of the tunnel and powerhouse on the downstream end of the penstock.

The 35 kV transmission line to connect the Machakhela 1 plant to the network follows the road and river. During the feasibility study and design, the developer must negotiate with Energo-Pro to connect the Machakhela 1 plant substation to their lines. For this study, it is assumed that 8 km of new 35 kV line will be constructed to the Machakhela 2 substation, which would have been constructed before this project. From that point, a double-circuit 35 kV line or a 110 kV line would tie into the existing Energo-Pro system.

4.1.1 Diversion Structures

The primary diversion dam will be on the Machakhela River, approximately 23 meters from the assumed bedrock elevation to the access bridge above the spillway. A 5-meter-high by 3-meter-wide low-level sluicing gate will be included at the base of the dam to flush sediment accumulations during high-flow periods. This sluice will be controlled by a hydraulically operated slide gate installed on the upstream side of the dam.

A tributary diversion structure will be built at the downstream end of the power tunnel to capture the runoff from a 16 km^2 side drainage. This tributary diversion will be approximately 23 meters from the assumed bedrock to the access bridge across the spillway. A 2.5-meter-high by 2.5-meter-wide low-level sluicing gate will be included at the base of the tributary diversion dam to flush sediment accumulations during high-flow periods. This sluice will be controlled by a hydraulically operated slide gates installed on the upstream side of the dam.

Layouts of the proposed primary and tributary diversion weirs and intakes are included in Appendix 5.

There will be no de-silting facility on the Machakhela 1 HPP because the upstream pools will allow sediment to settle. Please refer to Table 5 above for an estimate of annual sediment tonnage and volume for Machakhela 1 as a function of return period in the table. Also, Table 5 strongly suggests necessary field data collection for sediment from Machakhela 1 intake locations during the feasibility study.

4.1.2 Intake Facilities

At the main diversion dam, the power tunnel intake will be through a submerged reinforced concrete intake structure including a bar rack, bulkhead gate and wheel gate.

The power tunnel will discharge into the head pond at the tributary diversion and all water will flow into the reinforced concrete box culvert intake.

4.1.3 Power Tunnel

The Machakhela River power tunnel will have a total length of about 2,700 meters, with a finished inside diameter of 3.5 m. Rock quality is expected to be good, on average, but there are areas of weak rock along bedding planes, in contact areas, and in weak strata found in the area.

The power tunnel will probably be excavated using conventional drill and blast methods, due to the short length. The proposed alignment is shown on the Project Layout, Figure 4, above.

Most of the tunnel length will probably be supported using rock bolts and shotcrete. Sections through poor rock will require steel supports and reinforced concrete lining, and special measures may be needed to control groundwater inflow.

4.1.4 Box culvert

Downstream of the tributary diversion, the water will be carried to the forebay and penstock intake in a 3.5-meter-wide by 3.5-meter-deep reinforced concrete box culvert.

4.1.5 Surge Mitigation

There will be pressure surge considerations at the Machakhela 1 HPP, but they will be alleviated through the use of an open forebay at the penstock intake. The forebay will include a spillway and reinforced concrete chute, that will bypass flow to the river when pressure surges occur. his will provide attenuation of pressure waves at a location just 200 m upstream from the powerhouse.

4.1.6 Penstock

A 200-m-long 2.5-m-diameter steel penstock will lead to the powerhouse. A bifurcation just above the powerhouse will channel the flow to two turbine-generator units. There will be hydraulically operated butterfly valves on the inlet pipes to isolate the turbines.

4.1.7 Powerhouse

The surface powerhouse size and arrangement will be determined primarily by the size of the turbine-generator units selected for installation. The powerhouse will include the unit shutoff valves and most auxiliary systems, in addition to the units themselves.

The powerhouse dimensions for the assumed installation of two different size Francis units will be about 16.5 meters wide, 45 meters long, and 27 meters tall. It will include an overhead bridge crane with a capacity sufficient to lift the heaviest component in the turbine generator set (a 20 tonne crane capacity has been assumed for preliminary cost estimating purposes).

Draft tube gates and drainage pumps will be provided to dewater the units for inspection and maintenance. The draft tube gates will be downstream of the powerhouse and operators will be installed on a reinforced concrete deck.

4.1.8 Mechanical Equipment

There will be a butterfly-type turbine isolation valve for each unit, capable of closing against full flow. Operators will use high-pressure hydraulic power.

Turbine selection for the Machakhela 1 project must be evaluated in detail during feasibility studies. Preliminary turbine selections were made for Francis and Pelton options using the TURBNPRO evaluation software produced by Hydro Info Systems. Appendix 11 contains the program output for two options: two equal-sized Pelton units and two different-sized Francis units. The two turbine options produced about the same energy per year, but the Pelton units are ***much*** larger than the Francis units, and will require large generators as a result of the low speed and many poles required (See turbine specifications in Appendix 11). Table 9 displays the critical details from this turbine option evaluated for sizing tunnel, penstock, and powerhouse.

Vertical-shaft Francis units have been selected at this stage of study, and are probably the only suitable choice given the flow and head requirements. The proposed Francis units will have different capacities, to make the plant operating range as broad as possible. The two units selected will generate efficiently over a flow range from 3.5 m^3/s (slightly lower than the lowest expected flow) to 25 m^3/s. The characteristics of the two units, based on the TURBNPRO unit selection software calculations, are shown in the following table:

Table 9: Turbine Characteristics

Unit	Speed, rpm	Runner Discharge Diameter, mm	Design Flow, m^3/s	Minimum Flow, m^3/s	Maximum Turbine Power, MW	Minimum Turbine Power, MW
No. 1, Larger	300	1,690	16.7	7.0	19.9	7.3
No. 2, Smaller	375	1,247	8.3	3.5	9.9	3.7
Plant Total			**25.0**		**29.0***	

*The plant total output is lower than the sum of the two unit outputs, since head losses are greater with both units operating.

This installation will result in a maximum electric power output, at the high-voltage transformer terminals, of about 27.0 MW.

The Pelton turbine option includes two equal-size, six jet, vertical-shaft units, producing a mechanical output of up to about 14.4 MW each (with only one unit operating, maximizing net head). These units were found to be ***much*** larger than comparable Francis units at the Machakhela 1 rated head of 133 m.

Some of the advantages and disadvantages of each turbine type, which must be considered during feasibility studies, are listed in the following table:

Table 10: Advantages and Disadvantages of Turbine Types

Advantages	Disadvantages
Pelton Turbines	
Very wide operating flow range at high efficiency (typically 85 to 90 percent, over 10% to 100% of flow, for a six-jet machine) Jet deflectors allow very fast machine shutdown without stopping the water flow, greatly reducing surge control problems.	Slower rotational speed, which results in physically large turbines and generators. Lower peak efficiency, about 90% Runner must be set higher than maximum tailwater elevation, and the head between the runner centerline and tailwater is lost.
Francis Turbines	
High rotational speed, resulting in smaller turbine and generator dimensions Higher peak efficiencies (typically up to 93%) The full head on the unit is available for generation.	Narrow range of operation as compared to Pelton turbines. Special measures are needed to control pressure rise during unit shutdown.

Unit governors will be electronically controlled, with high-pressure hydraulic components.

Other powerhouse mechanical systems will include:

- Potable water supply
- Wastewater disposal
- Ventilation
- Fire suppression
- Compressed air
- Drainage and dewatering pump systems
- Draft tube gates and operators

4.1.9 Electrical Equipment

Generators will be vertical-shaft synchronous machines compatible with the selected turbines. Stator output voltage will probably be about 15 kV.

Static exciters will be used.

Medium-voltage breakers will probably be vacuum type.

Computerized relays, controls and monitoring will be used. Automatic generator control will be installed. The system will be in direct communication with the GSE dispatch center and Energo-Pro dispatchers in Tbilisi over fiber-optic, microwave, or satellite communication links.

Power transformers will be 15/35 kV and oil insulated.

Other electrical systems will include:

- A diesel generator to provide backup power and black-start capability
- Station service, including lighting, motor-control centers, etc.
- DC power supply including station batteries and chargers
- Lightning protection

4.2 ALTERNATIVES EVALUATED

Various powerhouse and diversion locations were investigated and evaluated. The current diversion location was selected to locate the dam:

- A short distance below the Turkish border.
- At a site where the dam length is relatively short and reasonable rock conditions appear to exist on both abutments.
- Avoiding conflict with the roadway.

The water conductors and intakes were located where there appears to be reasonable space, good overall alignment, and acceptable geologic conditions.

- Good tunnel portal conditions for the main power tunnel entrance.
- Sound foundations on competent rock.

Various combinations of water conductors were evaluated, including canals, tunnels, pipelines and penstocks. The combination of a power tunnel followed by a power channel and penstock was selected because of the large quantity of water, topography, and the generally acceptable geologic conditions along a potential tunnel alignment.

The surface powerhouse was selected for cost reasons.

4.3 PROPOSED PROJECT COMPONENTS

In summary, the project includes the following components:

- Two diversion structures
- Tunnel portal
- Water conductors (power tunnel, box culvert, forebay and penstock)
- Surface power plant
- A 10-m-long tailrace channel

- Electrical and mechanical plant equipment, including incoming valves, governors, turbines, generators, switch gear, etc.
- Auxiliary backup power to allow black-starts when isolated from network (island mode)
- Power plant substation, including two power transformers
- Upgrades to about 13.5 km of existing local roads
- 8 km of 35 kV transmission line to connect to the proposed Machakhela 2 substation

Table 11: Hydropower Development Significant Data

Maximum gross head	**133 meters**
Maximum generation flow	**25.0 m^3/s**
Number of units	**2 Francis units**
Potential installed capacity	**27.0 MW**
Mean annual power output	**Approximately 130 GWh**
Construction time	**3 years including final feasibility, EIA and design.**
Anticipated Life-span	**30 years**

5.0 POWER AND ENERGY STUDIES

Machakhela 1 HPP energy assessment was completed using available Machakhela River flow records (51 years of record) and operating scenarios that fit the proposed site and watershed conditions. River flow records are described in Section 2.2.2, Surface Water Resources. The energy assessment used three different approaches to estimate expected average annual and average monthly generation. Each approach will be summarized in the following paragraphs. There are differences between the three approaches that are due to differences in calculation approach. Results are considered acceptable when the energy output is within approximately 1% for each approach.

5.1 MONTHLY AND ANNUAL FLOW DURATION CURVE ANALYSIS

Flow duration curve analysis (FDC Analysis) is a standard practice used by hydrologists, scientists, and engineers to examine flow records and develop an understanding of discharge (in m^3/s) as a function of the percentage of time a flow value is equal to or exceeds a given value during a period of time. The time frame used in this analysis is both **monthly** and **annual** in hours. The area under a flow duration curve represents the available flow in a given time period (m^3/s-hrs). Available flow is defined as the flow or discharge magnitude available for hydropower generation in the time period selected. Both **monthly** and **annual** flow duration curves for the Machakhela 1 HPP are presented in Appendix 2.

The Flow Duration Curve Analysis approach uses an EXCEL workbook that provides a range of user selected input values required for calculating expected HPP generation. This includes a percentage of time a river discharge value is equal to or exceeds (**monthly** or **annual**), average HPP efficiency, estimates of gross head loss, and reserves for in-stream requirements. The FDC approach does not require the analyst/engineer to preselect an installed turbine capacity. Rather it provides a range of discharge values as a function of selected exceedance percentages to calculate generation (MWh) expectation(s) that becomes input in a turbine/generator selection.

Appendix 2 also contains a selected representative sample of an exceedance percentage and associated monthly discharge that would be expected to be available for HPP generation (in m^3/s-hr). This analysis subtracts reserve flows for in-stream requirements to identify net m^3/s-hr available for HPP generation. This value combined with average monthly HPP unit efficiency and average annual head loss is used to calculate average monthly generation in MWh.

Operations scenarios represent a conceptual understanding of how the Machakhela 1 HPP would be operated under a variety of flow conditions. Several factors are important in calculating the net available discharge for HPP generation. Plant operations decisions (oversee/check automatic operating system) must respond to environmental regulations, available river discharge for HPP generation, electricity demand, maintenance, etc. The FDC analysis can generally account for these operational variables by lumping them into overall HPP operations efficiency, changes to reserve percentages, and selection of appropriate equal to or exceeded percentage for river flow. The FDC analysis should be refined in significant detail during the feasibility study stage of project development. The FDC analysis approach provides an initial expectation of generation by **month** and **annually** and is expected to bring the analysis for energy to be within 1% of each other and the Daily Discharge Generation analysis. It is also used to help select the appropriate turbine discharge for the HPP installation. Monthly and annual curves and estimated generation are presented in Appendix 2.

5.2 DAILY DISCHARGE GENERATION ANALYSIS

When a proposed project design flow had been selected, a separate MS EXCEL workbook was used to calculate the power and energy production during each day within the period of stream flow records. The analysis accounts for:

- Adjustment of stream gauge flows to the project intake location, using a drainage basin area ratio.
- The month and season during which the flow occurs.
- The assumed bypass flow during the month in which the flow occurs.
- Water conductor diameter, calculated based on a target velocity at the full design flow.
- Friction losses using Manning’s equation, water conductor length and dimensions, and hydraulic roughness (“n”).

Hydraulic losses and controlling elevations are summarized in the following table.

Table 12: Summary of Machakhela 1 Hydraulic Conditions

Description	Design Flood	25 m3/s	20 m3/s	16.7 m3/s	15 m3/s	8.3 m3/s	Static Condition	Comments
	Flow Condition							
Main Reservoir Elevation	375.0	371.0	371.0	371.0	371.0	371.0	371.0	
Power Tunnel Loss (3.5-m-diameter)	4.9	4.9	3.1	2.2	1.8	0.5	0.0	
Energy Grade Entering Tributary Reservoir	370.1	366.1	367.9	368.8	369.2	370.5	371.0	
Tributary Reservoir, Controlled Elevations	370.0	366.1	367.9	368.0	368.0	368.0	368.0	Spillway Crest is 368
Power Box Culvert Flow Depth	3.5	3.1	3.5	3.5	3.5	3.5	3.5	Upstream end of box culvert invert is 364.0
Power Box Culvert Head Loss	1.0	1.0	0.2	0.1	0.1	0.0	0.0	
Forebay Inflow Elevation	369.0	365.1	367.7	367.9	367.9	368.0	368.0	Forebay Spillway Crest is 368
Forebay, Controlled Elevations	368.0	365.1	367.7	367.9	367.9	368.0	368.0	Elevation during flood will be slightly higher
Penstock Losses (2.5 m OD)	1.7	1.7	1.0	0.7	0.6	0.2	0.0	
Energy Grade at Powerhouse	366.3	363.4	366.7	367.2	367.3	367.8	368.0	
Tailwater	242.0	236.0	235.5	235.4	235.3	235.2	235.1	These are rough estimates
Net Head	**124.3**	**127.4**	**131.2**	**131.8**	**132.0**	**132.6**	**132.9**	

Power and energy production figures were calculated using a range of plant design flows to get a capacity factor of 50% to maximize the water capture during the high flow and potentially higher tariff season. Monthly results for a design flow of 25.0 m^3/s are summarized in the following tables. This flow is the maximum economical development for run-of-river operation. A somewhat smaller flow may be optimum, depending on the value of energy during the peak flow season.

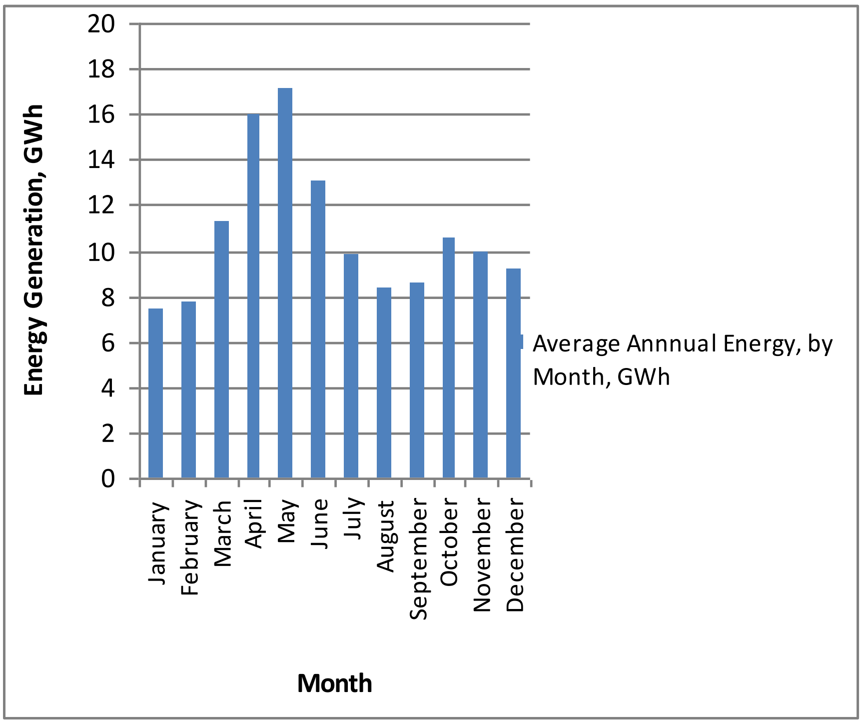
Table 13: Average Machakhela 1 HPP Power Production, 25.0 m^3/s Design Flow

Month	Mean Daily Power, MW	Minimum Daily Power, MW	Maximum Daily Power, MW
January	10.42	0.92	26.55
February	11.91	0.00	26.55
March	15.54	2.36	26.55
April	22.07	4.99	26.55
May	22.87	5.69	26.55
June	18.54	4.00	26.55
July	13.71	2.90	26.55
August	11.70	2.19	26.55
September	12.21	1.86	26.55
October	14.40	1.85	26.55
November	14.18	1.68	26.55
December	12.73	1.16	26.55
Annual	**15.02**	**0.00**	**26.55**

Table 14: Average Machakhela 1 HPP Energy Production, 25.0 m^3/s Design Flow

Month	Mean Daily Energy, GWh	Minimum Daily Energy, GWh	Maximum Daily Energy, GWh	Mean Annual by Month, GWh
January	0.25	0.02	0.64	7.75
February	0.29	0.00	0.64	8.08
March	0.37	0.06	0.64	11.56
April	0.53	0.12	0.64	15.89
May	0.55	0.14	0.64	17.01
June	0.44	0.10	0.64	13.35
July	0.33	0.07	0.64	10.20
August	0.28	0.05	0.64	8.70
September	0.29	0.04	0.64	8.79
October	0.35	0.04	0.64	10.71
November	0.34	0.04	0.64	10.21
December	0.31	0.03	0.64	9.47
Annual	**0.36**	**0.00**	**0.64**	**131.74**

Figure 5: Monthly Distribution of Average Annual Energy



6.0 ENVIRONMENTAL AND SOCIAL STUDIES

6.1 COMMUNITY AND SOCIO-ECONOMIC BASELINE DATA

The Khelvachauri District is located in Western Georgia's Adjara Region. encompassing an area of 413.3 km². According to the official statistical data from 2009, the District has a population of 96,600. The population density in the district is 235 people/km^2. The Khelvachauri District borders Kobuleti District to the north, Keda District to the east and the Black Sea to the west.

The city of Khelvachauri, located between Batumi and the Machakhela Basin, is the administrative center of the District. The Khelvachauri District consists of one town and 12 village communities.

The city of Khelvachauri is the administrative center of the Khelvachauri District. The distance from Tbilisi to Kelvachauri is about 385 km by road and the Machakhela 1 project is a further 20 km southeast of Khelvachauri. Chikuneti is the closest village to the Machakhela 1 HPP.

6.1.1 Infrastructure

Transport infrastructure of Khelvachauri District is developed: The Acharistskali–Kirnati motorway, which goes through the Region, is of national importance. Roads of local importance total about 187.85 km in length.

The location of the Machakhela watershed near a traditional resort zone (Batumi City) is one of the favorable factors for tourism development in this area. The coastal zone of Adjara region is a traditional touristic area, where the number of visitors increases from year to year. According to the information of Department of Tourism and Resorts of Adjara Region, the number of tourists increased in the Adjara Region by 15% over the last five years. According to the local residents of Khelvachauri District, they have good opportunities to attract more visitors. There are 3 sanatoriums, 3 holiday houses, 1 tourist base and about 20 hotels within the Khelvachauri District.

Rehabilitation of water supply, sewage systems and roads is ongoing. These projects are being implemented by Georgia's Ministry of Regional Development and Infrastructure and Municipal Development Fund.

6.1.2 Population and Settlements

The proposed Machakhela 1 HPP is located in Khelvachauri District of Adjara Region. The table below shows basic data of Khelvachauri District. Some socio-economic characteristics of this district are described below.

Table 15: Khelvachauri District Statistics

Location:	Khelvachauri District
Administrative District:	Khelvachauri
Area:	413.3 km^2
Population:	96,600
Population density:	235.9 people/km^2
Administrative center:	Khelvachauri

The economy of the Khelvachauri municipality is dominated by the agriculture, though industry is also developed. There are three tea factories and construction material processing industries (inert material processing and block processing factories) in Khelvachauri district. There is an existing 1.6 MW hydropower plant operating on the Machakhela River.just downstream of the Machakhela 2 HPP powerhouse and tailrace. The main agricultural activities of the Khelvachauri municipality are growing maize, beans, potatoes, tea, citrus, tobacco and vegetables

The closest settlement to the proposed HPP project is the village of Kokoleti.

The Planned Machakhela Protected Area: Machakhela Protected Area is planned to be established in the basin of the Machakhela River. It intends to conserve unique biodiversity of the area, support tourism development, promote alternative ways of income generation for local communities and facilitate trans-boundary cooperation by linking it with Jamili Biosphere Reserve in Turkey.

6.1.3 Cultural Heritage and Recreational Resources

The area is rich in old churches, monasteries and other cultural relics. Table below shows some of existing cultural resources of Khelvachauri municipality. There is one museum of ethnography in Kakhaberi village and one museum in the Machakhela village.

According to the literature review, no registered archeological and/or historical assets are located within the project development area.

Table 16 Historical, Cultural and Archeological Resources of the Khelvachauri District

#	Name	Location	Dated
1	Gonio Fortress	Village Gonio	I century AD
2	Arch Bridge	Village Makho	Medieval
3	Castle	Village Erge	Medieval
4	Chikuneti Bridge	Village Erge	Medieval
5	Church	Village Akhalsheni	Medieval

Source: Ministry of Culture of Georgia

The map in Appendix 9 shows some of existing cultural resources of the Khelvachauri District.

6.2 ENVIRONMENTAL RECEPTOR IMPACTS & MITIGATION PRACTICES

An important component of feasibility studies is addressing impacts to the receptors in the affected environment. Further, minimizing environmental and social impacts through accepted international practices are very important criteria for the evaluation, construction and operation of the Machakhela 1 HPP.

The proposed Machakhela 1 HPP site **baseline conditions** have been described in sections 2, 3 and 6.1 above. Appendix 10 presents tables of expected environmental receptor impacts and appropriate mitigation practices which should be included in feasibility studies. Effects on and mitigation approaches to protect Environmental Receptors are identified to provide a source of focus for environmental assessments studies that will help evaluate the overall impacts on the site and the local vicinity.

General Categories for Environmental Receptors:

- Surface Water Resources (Quantity, Water Quality, Flood Risk)
- Land Cover
- Air Quality
- Geology and Soils
- Cultural Heritage and Recreational Resources
- Biodiversity (flora, fauna, etc.)
- Community and Socio-Economic

Affected Environment Assessment: The Machakhela 1 HPP has two hydropower development activity periods that will impact environmental receptors, over different time horizons, and at different risk or impact levels. The following are the activity periods of interest:

- Construction: Compared to the lifecycle of the facility this is a short term impact period of approximately 2-3 years. It includes all phases of construction from initial land and water resource disturbance to startup of plant operations.
- Operations: Time horizon for full operational lifecycle before major component replacement is 30 to 40 years.

Risks to an environmental receptor from the activities are evaluated as Low, Medium, or High and should be refined further during the feasibility study. Risk evaluation also includes whether the impacts to receptors are (R) Reversible or (IR) Irreversible and (T) Temporary or (P) Permanent.

An important part of project feasibility design is to incorporate a set of mitigation practices that address impacts during the expected activities periods. These mitigation practices should be detailed, focused on environmental receptors, and be the standard and acceptable practices at the time of each activity period.

Tables for each environmental receptor listed above have been prepared in order to provide general assessment with respect to the proposed construction and operation of the Machakhela 1 HPP. These tables are presented in Appendix 10.

From an affected natural environmental perspective the Machakhela 1 HPP can be developed so that the project overall minimizes its construction and operations impacts on the local and watershed environment. Appropriate attention must be given to overall construction management planning and execution to assure inclusion of the necessary safety, health, and environmental mitigation practices to construct and operate Machakhela 1 HPP in an acceptable, legal, environmentally sensitive manner while complying with all regulations.

7.0 PROJECT COST ESTIMATE AND CONSTRUCTION SCHEDULE

7.1 CAPITAL EXPENDITURE

The capital expenditure is as important to the feasibility of a hydropower project as the energy that can be produced or the tariff that is expected for the energy generated. Based on this cost estimate, we have confidence that the completed project will cost about US$ 52.4 million or $1939 per kW of installed capacity, which is used in the financial analysis in Section 8.0.

As mentioned in other sections, this project could be implemented with either Francis or Pelton turbines. This will be determined by the developer during the feasibility stage, based on various characteristics of the two turbine types. For the purpose of this cost estimate, to maximize water utilization, efficiency and revenue, it was assumed that two different sized Francis turbines are housed in the above ground powerhouse.

Unit costs are based on a comparable hydropower project in Georgia started in 2009 and are increased or decreased depending on, volumes, flows, kW capacity, etc. All costs are in US dollars to avoid exchange rate issues and because a large part of the mechanical and electrical equipment will be imported.

7.2 ESTIMATE OF OPERATING COSTS

Operating costs generally can be estimated in two ways: as approximately 5-7% of revenues or 1% of capital expenditure. On the Machakhela 1 project both numbers were consistent, so we used the slightly higher 1% of initial capital cost in our financial analysis in Section 8.

Table 17: Machakhela 1 HPP Estimated Capital Expenditure

	Units	Amt	Unit Cost	Total US$	Year 1	Year 2	Year 3
Land purchase	ha	12	$10,000	$120,000	$120,000		
Preparatory & infrastructure works	LS			$1,500,000	$1,500,000		
Stream diversion and cofferdams	LS			$525,000		$262,500	$262,500
Machakhela 1 Main Dam	LS			$6,501,000		$4,550,700	$1,950,300
Tributary Dam	LS			$3,021,764		$1,510,882	$1,510,882
Upstream power tunnal portal	LS			$647,000		$323,500	$323,500
Headrace Tunnel including rockbolts & shotcrete	m	2,700	$832	$2,247,000		$1,123,500	$1,123,500
Power box culvert and forebay	LS			$4,809,000		$2,404,500	$2,404,500
Penstock	m	200	$921	$184,000			$184,000
Above ground power house	LS			$1,098,185		$658,911	$439,274
Tailrace Channel	m	10	$540	$5,000			$5,000
Transformer Switchyard	MW	27	$7,747	$209,000		$104,500	$104,500
Electric and mechanical parts (turn-key)	MW	27	$558,391	$15,077,000		$7,538,500	$7,538,500
Grid connection transmission line @ 35 KV	km	8	$150,000	$1,200,000			$1,200,000
Subtotal of Schedule Items				**$37,143,949**			
Geology (investigation field, lab and office) @ 1%	LS			$371,000	$371,000		
Feasibility study @ 1%	LS			$371,000	$371,000		
EIA @ 1%	LS			$371,000	$371,000		
EPCM @ 14%	LS			$5,200,000	$3,120,000	$1,040,000	$1,040,000
Contingencies (Assumptions Variable) @ 20%	LS			$8,691,390	$1,170,600	$3,903,499	$3,617,291
Total				$52,148,339	$7,023,600	$23,420,992	$21,703,747
MW Capacity	27.00		CAPEX/kW	**$1,931**			

7.3 CONSTRUCTION SCHEDULE

The construction schedule is envisioned to be one year for Geotechnical investigation, Feasibility Study and Environmental Assessment followed by two to three years of construction. Geotechnical investigation will include borings along the route of the tunnel, at the dam site and at the powerhouse site. Field observations and laboratory testing on the rock cores will contribute invaluable insight into the character of the rock in the tunneling zone. It may be advantageous to build the pioneer road to the downstream tunnel portal and upper penstock location. The Feasibility Study must include a much more detailed design and cost estimate based on the ultimate configuration determined by the developer.

The extent of the construction appears to be a 2 year schedule, with the critical path through the 2.7 km of tunneling. It appears that work on the diversion dam can be done throughout most of the year. During the spring runoff season (April through July) the water level and velocity in the narrow canyon may be too high for cofferdams to hold. All flow impediments, such as cofferdams, may need to be removed before the spring runoff period.

8.0 ECONOMIC AND FINANCIAL ANALYSIS

According to preliminary assessments the plant offers a good opportunity to sell energy during winter inside Georgia, replacing expensive thermal power, and export part of the energy during the remainder of the year to take advantage of the seasonal differentials in power prices between Georgia and its neighboring countries. It may be possible for the developer to offset some of his costs by trading “carbon credits” in an available market. This economic and financial analysis does not consider the complex issue of trading carbon credits but the potential developer should consider their applicability when reviewing the project’s overall financial returns.

Currently Georgia only needs new power capacity to meet its winter demand. The developer of the Machakhela 1 HPP may therefore need to find viable buyers of power in the region for the remainder of the year. One potential market for sale of the power from the HPPs is Turkey. The growth in electricity sales in Turkey is high and demand is quickly out-stripping supply. In addition, Turkey is joining the European transmission network in 2011 which provides the possibility to sell into the lucrative EU power market. The installation of the new 400 kV electricity transmission line between Georgia and Turkey is scheduled to be completed in 2012. Access to the Turkish and European market is dependent on the negotiation of the Georgia-Turkey Cross Border Energy Trading Agreement.

To sell Machakhela 1 HPP power to markets in other countries, there must be transmission access at affordable tariffs. Investigations by Georgian and Turkish utilities are ongoing concerning the capacity of the transmission network as well as the structure of tariffs to ensure that the sale of power is not impeded. To get current information on tariffs and cross-border sales the developer of the Machakhela 1 HPP should work closely with GSE, EnergoTrans and the Georgian National Energy and Water Supply Regulatory Commission.

Table 19 is a calculation of the monthly revenue and payback period for the investment. It starts with the m^3/s-hrs of water that can be captured at the Machakhela 1 HPP based on the monthly flow-duration curves (see Appendix 2) and an assumed bypass of 1-10% of the low monthly flows as flow reserved for in-steam habitat and environmental functions and values. This environmental bypass is not deducted during high flow periods when excess water is running over the spillway. This leads to the saleable kWh that can be generated per month. The net price per kWh at the plant is determined by applying the assumed tariffs for Georgia and Turkey and subtracting dispatch and transmission fees. These calculations are shown in Tables 17 and 18 for the Georgian and Turkish markets respectively. The net price for Georgia and Turkey are distributed according to the apparent demand pattern throughout the year. The monthly generation capacity of Machakhela 1 HPP is multiplied by net price per kWh for that month to get monthly net revenue at the plant. From this the amount of electricity used at the plant and therefore could not have been sold (we assumed 1% of generated capacity was used within the project) and operating costs at 1% of the initial capital cost are deducted to get net operating revenue. Based on this, the expected payback period (not including the cost of capital or time value of money) is calculated at approximately 7.6 years.

The price per kWh exported to the grid is based on the following current tariffs by starting with the gross tariff, deducting all dispatch and transmission costs to get the net tariff to the developer at the point the power is exported into the grid. It is presumed that the three month winter sales will be to ESCO with no dispatch or transmission tariff. Justification for Tables 17 and 18 appear in a memo included in Appendix 12.

Table 18: Machakhela 1 HPP Financial Analysis & Payback Period (27 MW and 25 m^3/s)

Month	Total CMS-HR Under Curve	Saleable CMS-HR per month	Saleable kWh	Price / kWh	Revenue		
January	7,815	6,995	7,702,206	0.0500	385,110		
February	7,888	6,950	7,652,850	0.0500	382,642		
March	12,469	10,433	11,487,844	0.0585	672,039		
April	19,175	14,533	16,001,562	0.0585	936,091		
May	19,846	15,670	17,253,886	0.0585	1,009,352		
June	13,298	12,248	13,486,371	0.0585	788,953		
July	9,752	9,248	10,182,753	0.0585	595,691		
August	8,412	7,876	8,672,360	0.0585	507,333		
September	9,049	7,958	8,762,350	0.0585	512,598		
October	12,069	9,725	10,708,306	0.0585	626,436	Weighted Average Tariff	
November	10,797	9,245	10,179,578	0.0585	595,505		
December	10,115	8,590	9,458,665	0.0500	472,933		
Totals	140,686	119,474	131,548,731	Total Revenue / Yr	7,484,684	$0.0569	
				(Site Electricity) @ 1%	($74,847)	7% of rev	1% of Cap
				(operating costs)	($521,483)	$518,689	$521,483
				Net Operating Revenue	$6,888,354		
				Estimated Capital Exp.	$52,148,339		
				Pay Back Period	7.57		

Design discharge = 25.0 m3/s

CF = 55%

Annual average m3/s through powerhouse = 13.64

This simple payback period represents only the engineering, construction and operating costs. It does not address considerations such as the time value of money, borrowing, interest, internal rate of return on assets or equity, etc.

Appendix 1

Geology Report & Associated Maps

CONTENTS

Introduction

In Adjara, as well as throughout Georgia, a top priority is to encourage development of existing, rich, hydropower resources.

Evaluation of the prospects for arrangement of small underground tunnels, derivation tunnels and catchment area in the mid-belt of the course of the river Machakhelistskali in Khelvachauri region is the main objective of this study, which is for use during the pre-design phase of project development.

The basic tasks, the study of which at this phase makes advisable to carry out further detailed researches on the study area are the following:

- Study area geological, hydro-geological and morphological description; determination and general description of those geological formations which are spread over the territory where the engineering constructions or hydro power plants are to be built; determination of geological-engineering genetic complexes in these formations and description of the main physical-tectonic properties of the complex host rocks; Moreover, description of those exogenic processes within the study area and nearby territories, which effectiveness can cause drawbacks during the building process and further exploitation of the constructions.

Searching and collection of the region geological, engineering-geological, hydro-geological and other existing archive and literature materials was done at the preliminary stage to resolve this problem; reconnaissance routes and general researches were conducted within the working area.

Based on the study of collected materials, reconnaissance routes data and air photo and satellite interpretation, a geological-engineering survey was prepared which is accompanied by graphical materials, including a geology and engineering-geology map showing the sections and locations of hydro-power structures.

The region physical-geographical description

The study area is situated in Shuakhevi administration region of Adjara Autonomous Republic, 30-45 km south-east from Batumi; the area covers the lower and middle reaches of the river Machakhelistskali between the villages Acharisaghmarti and Gorgadzeti.

The main orographic units in the mentioned region are Shavsheti and Karchkhali ridges.

Shavsheti ridge runs west to east, and separates the watersheds of the rivers Adjaristskali and Machakhelistskali. The ridge is lower to the west (altitudes of 700-800 m), and rises to the east, reaching altitudes of 2100 m. The study area covers the western part of the ridge where its highest point is the mount Milisi (990.2 m).

The north and the south slopes of Shavsheti ridge are symmetrical and characterized with rather steep inclination and are dissected with numerous tributaries of the rivers Adjaristskali and Machakhelistskali. The ridge and the crests of its branches have rather soft profile and plain surface.

Karchkhali ridge goes from the north-west to the south-east direction and represents the watershed divide between the basins of the rivers Chorokhi and Machakhelistskali. Study area covers only the north-west slope of the ridges and its branches.

Several branches run from the axial ridge to the north-west direction, particularly one of them – runs from the mount Khebadagi and cuts the basins of the Machakhelistskali left affluents Skurdidi and Saputkreti from the gorge of the river Kobindaristskali; second – flows at 4.0 km distance to the north from the mount Khebadagi which is watershed of the rivers Saputkreti and Skurdidi; and the third branch runs from the mount Gorgouli and separates the water catchment basins of the rivers of Skurdidi and Kedkeda which are the left bank tributaries of the river Machakhelistskali.

The study area hydrographic network is dense. Numbers of rivers and brooks flow down from the quite steep slopes of the ridges Shavsheti and Karchkhali and from their branches and they cross the base rocks perpendicularly and intersectional direction as well.

Machakhelistskali is the main river within the study area that drains between the south slopes of the western part of Shavsheti ridge and the slopes of the north branches of Karchkhali ridge and joins the river Chorokhi in the village Machakhelaspiri. Lower and mid belts of the gorge intrudes in the study area along 15 km distance (from the state boundary until the west periphery of the village Adjarisaghmarti). The river has V-shape on the whole length. The gorge is narrowing to 7-8 m from the state boundary along the stream until the village Gadzeti; then it again becomes V-shaped, the width of the bottom of the gorge varies within 40-60 m. Rapids are observed in the river-bed within the Gorgadzeti – Adjarisaghmarti interval. It is filled with big boulders/blocks and the velocity of water reaches 2.5 m/sec, but down decreases until 0.5 m/sec.

Below the village Adjarisaghmarti the river divides into several channels and creates low islands. The width of the riverbed reaches 50-70 m and the average depth of the river is 0.4-0.8 m, the average width – 18 m. The river water regime is characterized with flooding in spring, increasing of water level in autumn, unsteady minimal water level in summer and a steady minimal level in winter. The water depth increases until 0.8-1.5 m in spring and lasts for one day but in autumn it reaches 10-13m and lasts for 3 days; increase in water level often exceeds the flooding level in spring. The minimal winter level varies within

5.15 cm. The water annual inflow in spring reaches 35%, in summer – 18 %, in autumn – 28 % and in winter – 19 %. The riverbanks are mainly lean clay-cobble- sand contents and therefore are unstable during flooding.

Besides the river Machakhelistskali, numbers of its tributaries drain within the study area among which the left tributaries are abounding in waters, such as: Skuridi, Saputkreti, Kedkedi and the right bank tributary--the Kokoletistskali River.

According to the climatic conditions, the study area belongs to the marine humid subtropical climatic zone of west Georgia that is characterized by high air humidity, high atmospheric precipitation, with the low temperature variability and Musson [monsoon ?] winds.

The Black Sea proximity plays an important role in the climate formation; the region is famous for short, mild winters, and quite hot, long summers. Annual precipitation generally varies from 2500-3000 mm; it mainly comes in wintertime, partly in autumn, but the spring and summer periods are drier.

The annual mean temperature fluctuates within 13-15°C. January is the coldest month though the mean temperature in January is above zero (+5 to +7°C). It rarely snows there. The western (in spring) and the eastern (in winter) winds dominate in the boundaries of the region.

Plant cover spreading and compositions are subject to the vertical zoning principles. The territory is covered with oak, hornbeam, beech, and chestnuts forest up to the 500 m height. From 500 to 1200 m altitude, beeches are generally widespread and oaks are often observed.

Within the working region and in its nearby territory the populated areas are mainly on the terraces above the channels of the river Chorokhi and its tributaries Adjaristskali and Machakhelistskali, and on the flanks of the watershed ridges. The main villages are: Adjarisaghmarti, Chkhutuneti, Abzhanda, Kedkedi, Tabakhmela, Kokoleti and others.

Locals are Georgian people who follow agriculture and partly animal breeding. Asphalt highway joins the study region with the city Batumi; and other regional centers and villages are connected with each other with graded and unimproved roads, which are passable during the whole year. According to the seismic zoning, the territory of Georgia is located in 8 magnitude seismic zone.

Geology and Tectonics

Stratigraphy

The oldest formations in the study area which are exposed in day surface is Mid-Eocene (₽ $_2^2$) sediments that are represented with Naghvarevi Suite (₽ $_2^2$ ng)

The left flank of the Adjarastskali syncline, the left slope of the western part of Shavsheti ridge in the gorge of the riv. Adjaristskali and both slopes of the gorge of the river Machakhelistskali starting from the state boundary in the south including the left slope of Shavsheti ridge in the north are built with the sediments of the above-mentioned suite. According to the petrographic-lithological principles, Naghvarevi Suite is divided into 3 units, patches (I Meskhi invent.#13649).

To the east from the study area, the Naghvarevi Suite (₽ $_2^2$ ng) sediments in conformity overlap the Peranga -fragmented thick-layered tuff-breccias and basalt lavas; thickness is 1 000 – 1 500m. There are no Peranga Suite rock exposures in the working area and they are indicated only in the lower horizon of geological section.

Naghvarevi Suite lower, the first patch (₽ $_2^2$ ng_1) is represented with thin-layered, fine-grained pelitic tuffs, medium-grained, gray, brown tuffs and thin-layered tuff sandstones. The patch thickness reaches 600 m. Tuff-breccias thin layers are observed in the gorge of the river Machakhelistskali among the thin-layered tuff sandstones and tuff layers.

The rocks of this patch cover almost the half part of the study area, and are loacted in its south part.

Naghvarevi Suite second patch (₽ $_2^2$ ng_2) is generally represented with coarse-fragmented tuffs and fine-grained tuffs that in the upper horizons are changed with fragmented volcanic clastolites. The patch thickness is 500-600m. These sediments are spread in the central part of the working region.

In Naghvarevi Suite third, upper horizon (₽ $_2^2$ ng_3) the coarse-fragmented volcano-clastolites with heavy lava coverings are dominant which thicknesses are 300-450 m.

Chidila Suite (₽ $_2^2$ c^vd)

Naghvarevi Suite is in conformity followed by Chidila Suite, which represents Basalt complex massive and coarse-fragmented volcano-clastolites and lavas.

In the working region, Chidila Suite is represented with Sarpi facieses which thickness is 1000-1200 m. The suite first patch (₽ $_2^2$ c^vd_1) is in conformity arranged over the Naghvarevi Suite formations and is built with coarse-fragmented massive lava breccias, tuff-breccias and delenitic lavas (thickness 500-600m). In the patch we can often meet fine-grained thin-layered gray tuffs and tuff-sandstones.

The first patch is in conformity overlapped by the second patch ($₽_2^2\ c^vd$) which is represented with coarse-fragmented massive volcano-clastolites, numerous cover-layers of hornblende and olivine basalts; thickness of separate layer reaches 5-10 m. The patch common thickness is 450-500m.

Riverbed of the lower-belt of the river Machakhelistskali, both slopes from the village Adjarisaghmarti towards the river course direction till the village Kedkedi and the left slope of Shavsheti ridge existed on the working area are built with Chidila Suite sediments.

Makhuntseti Suite ($₽_2^3 c^vd$)

The suite covers the south as well as the north syncline of Adjaristskali and is represented with volcanic, volcanic sedimentary and terrigene (sandstones, argillites, marls) sediments. The working area doesn't include the suite sediments. Driving of derivation tunnels are considered the right bank of the mid-belt of the river Machakhelistskali (tunnel # 1) and on its left bank (tunnel # 2). The tunnels cross the Mid-Eocene volcanogenic formations of Naghvarevi and Chidila Suites (tuffs, tuff-sandstones, lava breccias, tuff-breccias; lava coverings of basalts, porphyrites, andesites).

Contemporary Quaternary Sediments – Q_4

The following quaternary sediments are generally spread over the study area, such as:

Eluvial sediments eQ_{IV} – these are the product obtained from the physical-chemical weathering of the base rocks, which are remained at the place and represented with the materials of different mechanical compositions – starting from boulders ending with clays. The crest parts of the ridges are covered with such kind of sediments which thickness varies from 1-2 m to 10-15 m.

Eluvial-deluvial sediments edQ_{IV} – the complex of the quaternary sediments is spread over a big part of the study area, on the old plain surface as well as on the inclined slopes. It is generally represented with brown and yellow clays, lean clay, their mixture and admixture of different size fragments of base rocks. Thickness varies from 2-3 m to 15-20 m.

Deluvial sediments dQ_{IV} – they are spread on the slopes of the mountains and in their bottoms in forms of plumes and are represented with different thicknesses (from ten centimeter to ten meter) clays and lean clays and admixtures of different size fragments of base rocks.

Coluvial sediments cQ_{IV} – these are the products obtained from the weathering of base rocks and are represented with the different sized fragments (from crushed stones to boulders) which are transferred and accumulated on the slopes of the mountain and in its bottom by means of gravity. These are coarse-fragmented ground with clayey-sandy fillings. Their thickness varies from several to 20 meter.

Alluvial-proluvial sediments apQ_{IV} - they are rarely spread and observed at the junction of the river Machakhelistskali and some of its affluents that work as mudflow conductive ones. The sediments are represented with poorly processed mixture of various sized crushed stones, sand - gravels and clay - lean clays.

Alluvial sediments aQ_{IV} - Riverbed, grove and above-grove I terrace sediments are determined in the river Machakhelistskali. The riverbed sediments (on the natural bars and islands) are represented with different-grained sands, lean clays and silts. The grove sediments are mainly represented with boulders and cobbles, sands and lean clay and clay fillings. The thickness varies from 2-3 m to 5-6 m. Riverbed and grove in the narrowed parts of the gorge of the river are filled with various rocks different sized boulders. The sediments on the I above-grove terrace are represented with well-processed different sized pebble-stones with boulders rare inclusions. All this mass is poorly cemented with clay, sand and clay-sandy mixture. Thickness of terrace is generally fluctuates within 2 – 5 m.

Tectonics

According to geotectonic zoning of Georgia, territory of study area enters Adjara-Trialeti tectonic zone of Adjara Trialeti Folded System and covers the southern peripheries of the south-west parts of Abastumani-Boshuri and Aspindza-Manglisi sub-zones.

From plicate dislocations only the Adjaristskali Syncline (1 – 1) is distinguished in the region that traces from the Black Sea coastal regions to the eastern direction. The fold axis has sub-parallel orientation; it is asymmetrical and is complicated with Adjaristskali $I-I^1$ and $II-II^1$ fault having thrusting character; and it is developed outside the boundaries of the study area.

Study area covers the west part of the south flank of syncline that is built with Middle and Upper Eocene volcanogenic sediments and is characterized with the 15 – 20° north-west inclination of the rocks. Syncline north flank inclination is the southeastern direction 160-170° and angle of inclination is 65 -70°.

From the structural standpoint, totally the left side of the gorge of the river Adjaristskali and also our working area create the steep-inclined left flank of syncline having slightly goffered surface. It is built with Middle Eocene tuffogenic rocks which inclination is ∠15 - 20°.

Geomorphology

Following characters of study area relief, such as: steep inclinations of slopes, their expositions, vertical and horizontal dissecting character, high-energy of relief of such a young highland as Adjara is, together with sharply variable climatic conditions play a core motive for development of modern geodynamic processes.

Study area is located in the south-west part of Adjara-Trialeti Folded System and five different tectonic units having specific morpho-structural characters are determined within its boundaries. Consequently, there are separated five morphological structures and in each of them smaller geo-morphological units – geo-morphological type (zone) and geo-morphological sub-type (sub-zone) are determined. Geo-morphological type (zone) is distinguished with morphological markings, genesis and hypsometric condition of relief and geo-morphological sub-type (sub-zone) – with relief character and its development cycle. Based on above-discussions, chart for geo-morphological zones of working region is drawn up.

morphological structures	Geo-morphological type (zone)	geo-morphological sub-type (sub-zone) Relief character and development cycle	Modern relief-transformation process. Location
III . Mountain-gorge relief developed on monoclinely inclined structures of Shavsheti ridge	III_1. Medium mountain-gorge erosive-denudative relief developed on substrata of Mid-Eocene tuffogenic rocks	III_1^3. Upper and middle parts of the slopes of Shavsheti and Karchkhali ridges, V-shaped steep-inclined deep sections of intensively dissected affluents of the river Machakhelistskali	Erosion, denudation; Shavsheti ridge west part, Karchkhali ridge north-west part
		III_1^4. Crest part of Shavsheti ridge with accomplished development cycle; wide oval shaped; plain surfaces old relicts in lateral sections.	Denudation Crest part of Shavsheti ridge west part
		III_1^5. Middle and Lower part of the gorge of the river Machakhelistskali with low terraces and alluvial cones developed at the heads of affluents.	Accumulation, rarely mudflows. Gorge of the river Machakhelistskali, between the villages Gorgadzei and Adjarisaghmarti

Mountain-gorge relief of Shavsheti ridge and its branches covers the whole length of the ridge from the east to the west until the banks of the river Chorokhi. Its substrata is generally built with Mid-Eocene monocline-inclined massive and layered tuffogenes. Medium mountainous mountain-gorge relief type and high mountain denudative relief type that are the point of our interest are distinguished with relief morphological peculiarities and genesis. In the above-mentioned first type, there are determined eight types of relief according to the relief character and its development cycle among which III_1^3, III_1^4 and III_1^5 types cover the study area (see table).

III_1^3 . In accordance with Shavsheti and Karchkhali ridges the south and north-west slopes are dissected with steeply-inclined V-shaped gullies of the affluents of the river Machakhelistskali middle and lower belt which inclination is 30-35°. The slopes are stable, covered with forest and grass plot. Generally, erosion and denudative processes work for relief origination.

III_1^4 . cycle denudative relief is developed on the crests of the west part of Shavsheti ridge at 800 – 900 m height.

The ridge crests are wide, and round in lateral section; sometimes we meet old relicts of plain surfaces.

Thank to dense forest and grass plot, denudative processes which are basic factors for origination of relief are significantly decreased in this part of the ridge.

III_1^5 . In the lower part of the gorge of the river Machakhelistskali there is developed uncompleted cycle of erosive relief. Everywhere along the riverbed we meet low terraces represented with boulders-cobbles with sand fillings. The cross section of the gorge is trough-shaped and between the villages Adjarisaghmarti and Upper Chkhutuneti it is canyon-like.

The lower parts of the slopes are intensively dissected with shallow erosive ravines and rather wide talwegs which end with alluvial cones almost everywhere.

Basic contemporary geodynamic processes that create modern relief are: erosion, accumulation and, rarely, mudflows.

Hydrogeology

According to hydrogeological zoning, the study area belongs to Adjara-Imereti and Trialeti ridges hydrogeological region and covers the south-west part of the sub-region of Adjara-Imereti ridge in this region. Hydrogeological conditions are stipulated by the region climate, relief, lithological composition of the area structural rocks, tectonic and the rocks weathering intensity.

The study area is characterized with a humid, subtropical climate. Average yearly precipitation reaches 2400-3000 mm, and in the mountainous part 2000 – 2200 mm/year. Ground waters in the mountainous part are originated from the infiltration of precipitation, so, they are numerous and abounding in waters in this part than in lowland regions.

As for relief, they are generally two types in the region: mountain-foot and medium mountain relief with deep gorges.

Middle and Upper Eocene volcanogenic water-bearing horizon

The study area is totally built with Middle and Upper Eocene volcanogenic formations which are represented with different quality fractured lava-breccias, andesite-porphyrites, tuff-breccias, tuff-sandstones and tuffs. These sediments have poor water conductive character due to their density so their water bearing ability depends on rocks fracturing and qualities. Here, in weathering zone there is observed intense fracturing which is spread in 10 – 15 m depth then it is decreasing and finally disappearing. Intense and in-depth fracturing are observed within the tectonic faulting zones and their nearby territories. Underground waters are mainly formed in alpine zone and feeding is going by means of atmospheric precipitations and condensation processes. Discharge process takes place in the heads of the rivers, in the middle of the slopes, in the relief local bending points in forms of springs coming out of fractures and deluvial sediments. Water flow rates in these mentioned springs reaches 0.09-0.9 liter/sec. Water temperature depends on the height of spring location and varies within 10-14°C.

According to the chemical compositions, waters are hydro carbonate-chloride-calcium-potassium (natrium)-magnesium and hydro carbonate – sulphate – magnesium – calcium content. Mineralization 124 mg/liter. Generally, the waters are not aggressive.

Alluvial sediments water-bearing complex is met in each gorge of the river including in the gorges of the river Machakhelistskali and its tributaries. There are distinguished two water-bearing horizons such as: water bearing horizon of contemporary, grove alluvial sediments and above-grove I terrace water bearing horizon. The first one is built with cobbles, boulder-cobbles, sandy, sandy-gravel and lean clay-sandy fillings. The suite of this horizon contains ground waters having not deep circulation and their spreading depth doesn't exceed 0.2 – 0.4 m. Thank to the high filtration character of coarse-fragmented sediments, these deposits are abounding in groundwaters. Horizon is generally fed at the expenses of river water and infiltration of atmospheric precipitations, also from the water bearing horizons, which are hypsometrically located higher than they are. Ground waters are potable. Mineralization does not exceed 0.220 g/liter. Water is soft or averagely hard (overall hardness – 1.2 – 4.9 mg/equivalent) and belongs to the hydro carbonate-calcium-magnesium type.

Water bearing horizon of above-grove I terrace that is spread along the Machakhelistskali riverbed is represented with cobbles with sands, lean clay and clay fillings; layers overall average thickness is 2-3 m.; waters in this horizon does not have pressure; average thickness varies from 0.5 to 1.4 m; water flow rate reaches 0.1-1.0 liter/sec.; water regime is firmly connected with atmospheric precipitations. Common mineralization is low and reaches

0.091-0.46 gr/liter. Waters are mainly hydro carbonate-chlorine-calcium compositions. Overall hardness equals to 0.5-1.3 mg and is low; PH – till 6.2.

Eluvial and eluvial-deluvial sediments water-bearing horizons – these horizons are generally associated to crest, flat-plain areas of ridges and hills and also to steep slopes. Ground waters are circulating in the sediments, which are represented with lean clay, clay, crushed stones and different sized boulders. Water is discharged on the surface in forms of springs; their debit is 0.01-0.02 liter/sec, temperature 9-14°C. Waters are potable, sediments are dry – 0.04-0.45 g/liter; overall hardness 0.3-5.7 mg/equiv. PH – 6.0-7.6.

Deluvial sediments and their water-bearing horizons. Mentioned sediments are spread over the mountain slopes and the bottoms and are represented with clay and lean clay with different sized crushed stones admixtures. Their thickness in the lower part of the slopes varies from 2.5 to 10-15 m. Water discharge is going in form of spring; on the steep slopes of the mountains where deluvion has low thickness, water debit reaches 0.08 liter/sec while on the steep slope and in the bottom of mountain, water debit reaches 1-2 liter/sec. Water temperature is 7-15°C; waters are generally carbonate-calcium and sulphate-potassium compositions; overall hardness is 0.55-2.85 g/equ.

Alluvial-proluvial sediments – these sediments are collected at the junction spot of tributaries (alluvial cones) and their water-content ability depends on the water regime of the rivers.

Engineering -Geological -Geotechnical Conditions

Middle and Upper Eocene volcanogenic sedimentary rocks spread over the study area according to their lithological compositions, geological-engineering indicators and hydro geological conditions, also their genesis and ages are divided into independent geological-genetic complexes which represent underground volcanogenic and surface volcanogenic formations. The mentioned complexes after their lithological-analytical analyses and complex laboratorial researches are divided into smaller units – petrographic diversity.

Geological – Genetic Complex of Middle Eocene Lower Part (₽$_2^{2\,a}$) Layered Suite

Given complex is divided into two geological-engineering groups: a) Layered tuffs and tuff-sandstones and b) coarse-fragmented lava breccias and tuff-breccias. Their outcrops on the surface are observed in the mid-belt of the river Machakhelistskali between the villages Machakhela and Kokoleti and cover the Naghvarevi Suite lower and middle horizons spreading area. They are represented with middle layered (layers thickness is -0.3-1 m) and sometimes thin-layered (0.5-0.2 m) fine and coarse-grained gray and brown tuffs and tuff-sandstones, rare thin-layered interlayers of argillites and tuff-breccias. Tuff-breccias have psammitic texture. Main mass of the fragments of effusive rocks is dominant than the cemented mass in rather coarse-grained tuffs and tuff-sandstones; but in the fine-grained - mainly basalt type cement is dominant.

According to the rocks physical-technical characters (see table # 1) they are classified as strong and super-strong rocks.

Among the modern geodynamic processes within the rocks spreading area generally rock collapses and stone-fall processes are expected. Only upper fractured zones of sub-suite of the mentioned rocks are water bearing. Spring water debits don't exceed 0.1 – 0.3 liter/sec. According to the chemical composition the waters are sulphate-hydro carbonate-potassium-calcium composition; overall mineralization is 0.4 g/liter; overall hardness 0.8 mg/eq; PH- 6.5. Ground water regime totally depends on atmospheric sediments activation. *B) Coarse-fragmented lava-breccias and tuff-breccias with lava interlayers* in conformity change sub-suite of the lower tuffs and tuff-sandstones. Their spreading areal in the gorge of the river Machakhelistskali is lower and covers the upper horizon of Naghvareva suite spreading area. Lithologically, sub-suite is represented with coarse-fragmented volcano-clastolites, tuff-breccias where lava interlayers and coverings, rarely tuff interlayers in the upper part of the section play an important role. Tuff-breccias in the mentioned formations are represented with separate layers which thickness varies from 0.5-1 m to 10-12m. Fragmented materials generally are tuffogenic rarely porphyritic compositions. Cement is represented with greenish, fine-grained sandstones or pelitic tuffs. Mostly, fragmented materials surpass cement; weathering process is mostly typical for cement material more often if it is represented with pelitic tuffs. Lava coverings are generally represented with porphyrites, basalts and albitophyres; according to the chemical composition lava rocks and their pyroclastolites are almost homogeneous:

Rocks	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	CaO	MgO	R_2O	Na_2O	Damp	Resid. After heat.	SO_3
Porphyrites	56.1	18.0	6.25	0.45	0.14	5.43	3.09	3.8	4.1	0.91	2.0	NO
Tuff-breccias	57.8	16.0	7.50	0.12	0.12	1.5	2.06	3.0	4.3	0.80	2.1	NO
Tuff	60.0	16.0	5.9	0.15	0.15	1.4	1.5	3.3	4.0	0.55	2.6	NO

All rocks of lava coverings are strong, hard, and massive. Stability of these rocks against weathering and denudation contribute to the formation of high cornices and waterfalls within their spreading area. See the mentioned rocks physical-mechanical properties in the Table # 1. Gravity is the most intense of the contemporary geo-dynamic processes, within the mentioned rocks spreading area that are the source of mudflow; for example: the heads of the right affluent of the river Machakhelistskali are at 1800-2100 m height where glacial weathering dominates; landslides are rare.

Generally, ground waters within the mentioned area have surface-fractured circulation and flows out of tuff-breccias in form of spring. Chemically, waters are sulphate-hydro carbonate-potassium-calcium composition. Overall mineralization is 0.28 gr/liter; overall hardness – 0.7 mg/eq. Carbonate hardness equals to 0.5 mg/eq.; PH = 6.8. Fractured waters regime totally depends on atmospheric precipitation.

Geological-geodynamic complex of undivided Middle and Upper Eocene massive lava breccias and tuff-breccias with lava and tuff interlayers and lenses.

Crest part of Shavsheti ridge and the gorge of the river Machakhelistskali from its mouth to the village Kokoleti are built with the rocks of mentioned complex. This is the spreading lane that approximately covers Mid-Eocene Chidila Suite spreading area.

Lava breccias are generally coarse grained and composed with dark green ordinal porphyritic rocks. Cement is represented with chlorite-limonite-zeolitic materials, rarely porphyrites clayey and chrloritized glassy lava mass.

Tuff-breccias, which cover 30% of the section, are represented with coarse-fragmented and fine-fragmented variety. Fragmented materials are porphyritic composition and rarely we meet tuffogenic composition. Cement is represented with thin-grained tuff-sandstones, sometimes with politic tuff or apron type zeolites.

Tuffs cover 10% of the section and are fine-grained, sometimes lithoclastic, gray, dark gray to black color and consist of andesite-porphyritic lavas. Tuffs are porous and frequently slightly cemented, medium and thick-layered.

Against porosity agents, these rocks (tuff-breccias and tuff) are less stable; so 5-10 m thickness clayey layer is observed within their spreading areas, which contribute to origination of landslide conditions.

Lava interlayers and lenses are represented with andesites and basalts.

Thickness of lava layers and lenses varies from several meter to some ten meters. See physical-chemical properties of above-described rocks in the table # 1.

Exogenic fracturing is widely developed in the rocks of this complex within the working region, which is more intense when their spreading area hypsometrically is at the higher altitudes. From the contemporary geo-dynamic processes, low intense gravity processes are basic within the area where above-mentioned rocks are spread. Underground waters here are also associated with upper-fractured zones of weathering crust. Water debit is low about 0.1-0.3 liter/sec, overall mineralization varies to 0.159 g/liter; chemically, the waters are sulphate-hydro carbonate-potassium-calcium composition. Feeding of underground waters is going at the expense of atmospheric precipitation. Table for the rocks physical-technical properties is given below where geological-genetic units are indicated.

Rocks physical-technical properties

Table # 1

Rock name	Volume weight t/m³	Water absorption %	Ultimate strength		Soften. coefficient	Ultimate strength 15 cycles after freezing kg/cm²	Freeze resistance coefficient
			In dry condit.	In water absor. condit.			
1 a. Layered tuffs and tuff-sandstones (₽ $_2^2$ a)							
Tuffs	2.65	1.54	567	534	0.94	435	0.81
Tuff-sandstones	2.63	1.92	728	641	0.88	574	0.90
Lithoclastic Tuff Unweathered	2.66	0.7	1158	1065	0.92	950	0.89
Lithoclastic Tuff Altered	2.62	1.48	832	715	0.86	602	0.84
Zeolitized micro-tuff-breccias	2.31	5.08	735	482	0.66	446	0.93
1 b. Coarse-fragmented lava breccias and tuff-breccias with lava interlayers (₽ $_2^2$ a)							
Porphyrite - unweathered	2.61-2.7	0.4-1.8	724-1793	522-1246	0.7-0.8	513-939	0.75-0.9
Porphyrite - altered	2.3-2.6	1.8-4.0	355-782	155-672	0.44-0.86	135-586	0.87
Andesites - altered	2.7	0.19	2754	2561	0.93	2484	0.97
Lava breccias – unweathered	2.7-2.82	0.4-0.6	800-2228	581-1951	0.73-0.90	1906	0.98
Lava breccias –	2.5-2.8	3.52	739-1702	289	0.39	-	-

altered							
2. Geological – genetic complex of Middle and Upper Eocene massive lava-breccias, tuff-breccias, lenses and tuffs of lavas (₽ $_2{}^{2\ b+c}$)							
Lava breccias	2.63	3.58	909	885	0.97	-	-
Tuff-breccias – unweathered	2.66	0.7	1158	891	0.77	710	0.8
Tuff-breccias – altered	2.60	1.02	643	508	0.79	398	0.78
Lithoclastic tuffs – unweathered	2.65	0.6	1056	885	0.84	735	0.83
Lithoclastic tuffs – altered	2.62	1.88	832	715	0.86	602	0.84
Porphyrite - unweathered	2.6-2.7	0.6-1.3	1062-1928	913-1581	0.75-0.86	749-1390	0.82-0.88
Porphyrite- altered	2.61	1.83	782	672	0.86	586	0.87

As for description of the quaternary sediments as geological-engineering complex, it is defined with brief description of water-bearing characters of the rocks of this complex that is given in the chapter "Hydrogeology" of the present report.

Contemporary exogenic processes

One of the basic exogenic processes spread over the study area is weathering process that influences on rocky and semi-rocky mass and forms altered zones. Rocks weathering and disruption are going over the whole territory but it reaches its peak in mountain and alpine regions above 400-500 m from the sea level. So, the mountain profile of weathering crust is originated which covers fragmented, crushed, block and crypto-fractured zones. Origination of rockslide and stone-fall processes are associated with these zones.

Stone-fall and rockslide: This group gravity processes are developed on the high, steep slopes of the Machakhelistskali gorge. Stone-falling is more frequent than rockslides. Sources for the stone-fall and rarely minor mudflows are originated in the Mid-Eocene layered tuffogenes and the rockslides are developed in massive and thick-layered volcanogenes. Stone-fall processes are typical nearby the following villages of the gorge of the river Machakhelistskali such as: Adjarisaghmarti, Chikuneti, Chkhutuneti. Their sources are originated and developed on the steep slopes and erosive-gravity cornices. Cornices often have stepped form and are represented with weathered sometimes heavy fractured massive volcanogenes and are characterized with complete development of the weathering crust. Inclinations of the walls of the cornices surpass 45° and generally has southern exposition. Thickness of inert materials accumulated in the bottom reaches 2.0-2.5 m rarely – 5 m. Falling materials are poorly cemented crushed, crushed- gravel and rarely gravel grounds with sand and lean clay fillings. Weathering block (large boulder) zone is developed in massive tuff breccias and lava coverings where weathering and the rocks disintegration processes go with difficulty so, in these zone landslides are expected.

Erosion. Erosion development intensity depends on vertical zoning, relief shape, base rocks overlapping sediments, quantity of atmospheric precipitations, plant cover and others. According to the vertical zoning all erosive types in Adjara are divided into lowland, foot and mountain zones. Study area enters the erosion foot type where gully, side and areal erosions are developed. Coefficient for the line, erosive dismembering in the mentioned zone is 2 km/cm^2 on average. The region basic rivers are inclined at 2° angle and their tributaries – at 2-5°. Alternation of accumulative and washed areas are observed within their boundaries where side erosion is developed in the basic rivers and in their tributaries – bottom erosion. Based on monitoring there was determined that the river outwashes the bank approximately till 0.5-0.7 m a year during flooding.

Snow avalanches. In the river Machakhelistskali water catchment basin, the contribution conditions for origination of the snow avalanches lie in 400-1800 m interval from the sea level. During much snow in winter the avalanches are expected on the slope with lack of plant cover. Such are the territory of the villages: Adjarisaghmarti, Kokoleti and Chikuneti. Probability for development of landslides and mudflows in the middle and lower belt of the gorge of the river Machakhelistskali is low.

Conclusions and recommendations

According to the complexity of geological-engineering conditions the study area belongs to II medium complex category. Region structural rocks are represented with Middle Eocene $₽_2^2$ volcanogenic sedimentary and quaternary formations.

Two geological-engineering-genetic complexes are isolated on the working area the first of which is divided into two geological-engineering groups.

The aim of the project is to drive two derivation tunnels from which the I tunnel will run along the right bank of the river Machakhelistskali between the villages Gorgadzeti and Kokoleti which will cut the rocks of the 1a group of the I Geological-engineering complex that are basically represented with tuffs and tuff-sandstones of Naghvarevi suite lower patch.

Driving of the II tunnel is intended along the left bank of the river Machakhelistskali between the villages Chkhutuneti and Adjarisaghmarti. The tunnel will run through the rocks of Naghvarevi suite middle and upper patches and Chidila suite lower patches which cover 2a group of the I Geological-engineering complex and the rocks of the II Geological-engineering complex and are basically represented with lava breccias, tuff breccias, interlayers of lavas and tuffs.

From structural standpoints, working area represents syncline, steeply inclined to the north direction; tectonic faulting is not identified on the working flank.

Host, unweathered rocks of above-described geological-engineering complexes belong to the rocky group and slightly weathered varieties and some tuffs – to the semi-rocky group. These rocks are known with high solidity, which creates the profitable conditions for safe building and long exploitation of hydro power plants or additional constructions.

Mostly spread exogenic processes over the study area are weathering process and associated phenomena such as stone falling and rockslides. Landslides and mudflows are rare. During a big snow the avalanches are expected on those steeply-inclined slopes that are lack of grass cover.

During the further phases of the works a big attention must be paid on the nearby territory of working area to identify accumulation of weathered materials in the steeply-inclined gorges of the heads of the river Machakhelistskali tributaries, at the bottoms of the slopes and cornices. In case of accumulation of critical mass of the materials and during the long-lasting rains that is frequent in the region, accumulated materials can provoke and cause mudflow; in consequence of above mentioned, conduction of protecting activities against hazardous geological processes during designing-building of engineering constructions must be considered.

Today, study area is located in 8 magnitude seismic zone according to the present seismic zoning scheme of Georgia.

Significant Earthquake Search - sorted by Date

20 Significant Earthquakes where (Latitude <= 42.867 and Latitude >= 40.133) and (Longitude <= 43.567 and Longitude >= 39)

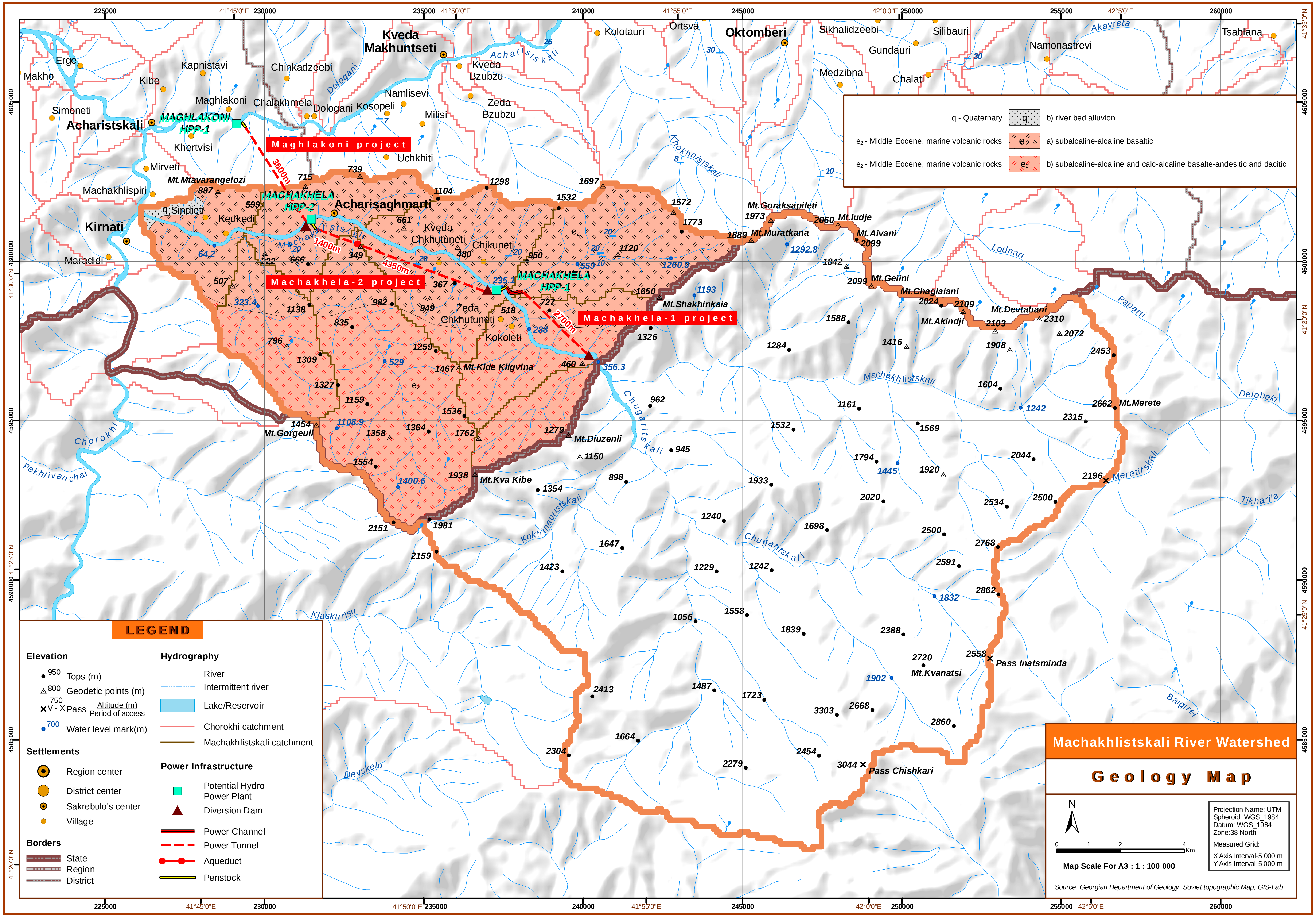
View parameter descriptions and statistical information by clicking on **column headings**.

For additional information about an earthquake event and links to damage photos, click on the links in the **Addl Info** and **Tsu** columns.

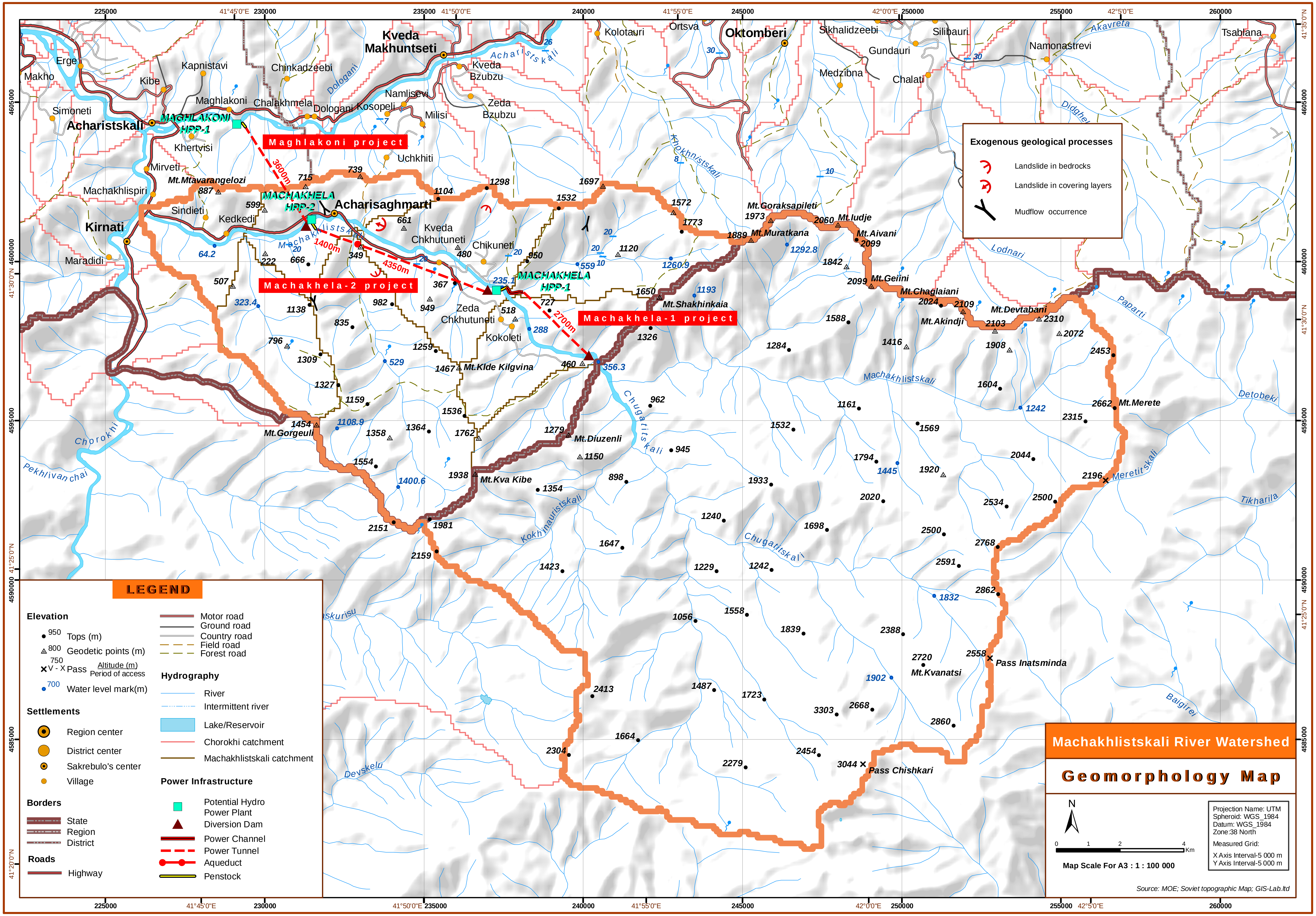
Date						Assoc		Addl EQ Info	Earthquake Location			Earthquake Parameters			Earthquake Effects										Photos
															Deaths		Injuries		Damage		Houses Destroyed		Houses Damaged		
Year	Mo	Dy	Hr	Mn	Sec	Tsu	Vol		Name	Latitude	Longitude	Focal Depth	Mag	MMI Int	Num	De	Num	De	$Mill	De	Num	De	Num	De	
1003								*	TURKEY: KARS, DIGOR, ANI (ARMENIA)	40.500	43.300	20	4.2	7		3				2					
1046								*	TURKEY: ANI (ARMENIA)	40.500	43.500	15	5.5	8		3				3					
1088	4	22						*	GEORGIA: TMOGVI	41.400	43.200	10	5.3			3				3					
1283								*	GEORGIA: SAMTSKHE, DZHAVAKHET	41.700	43.200	14	6.3	9						3					
1707								*	TURKEY: KARS	40.400	43.000					3				3					
1888	9	22	10					*	TURKEY	41.300	43.300		6.1			3				2					
1899	12	31	7	50				*	TURKEY	41.600	43.500		5.6		247	3				2					
1900	7	12	6	25				*	TURKEY: KARS,KARAKURT,KAGIZMAN,DIGOR	40.300	43.100		5.9	8	140	3				3					
1903	5	28	3	58				*	TURKEY: VARGINIS,CARDAHLI,MEHKEREK	40.900	42.700		5.8	8	1000	3				3					
1905	10	21	11	1				*	GEORGIA: CAUCASUS	42.000	42.000	60	7.5												
1925	1	9	17	38	24.0			*	TURKEY: ARDAHAN	41.200	42.800		5.8	8	200	3									
1976	3	25	11	55	39.4			*	TURKEY	41.130	43.010	18	4.8		1	1				2					
1976	4	29	22	18	9.1			*	TURKEY	40.890	42.850	44	5.5		4	1				2					
1983	10	30	4	12	27.1			*	TURKEY: ERZURUM, KARS, KHORASAN, PASINLER, NARMAN	40.330	42.187	12	6.9		1342	4	1142	4	25.000	4		4			
1984	9	18	13	26	1.8			*	TURKEY: E, ERZURUM, OLUR-SENKAYA	40.885	42.219	10	6.4	8	3	1	38	1		2	75000	4			
1984	10	18	9	46	24.6			*	TURKEY: E, SENKAYA	40.545	42.403	60	5.3		3	1	35	1		3	75000	4			
1985	11	7	8	26	21.4			*	TURKEY: ERZURUM, KARS, AGRI, ARTVIN	40.310	42.307	33	4.2				14	1		2	113	3			
1991	5	15	14	28	50.1			*	GEORGIA: KHEKHETI	42.565	43.349	14	4.9	5						2					
1999	12	3	17	6	54.7			*	TURKEY: GORESKEN, ERZURUM PROVINCE	40.358	42.346	19	5.7		1	1	6	1		2			340	3	
2009	9	6	22	41	37.3			*	GEORGIA: NORTHWESTERN	42.660	43.443	15	6.0				1	1		2					

20 events returned.

For more information regarding the Significant Earthquake Database please see the Introduction.



Machakhlistskali River Watershed
Geology Map
q - Quaternary
b) river bed alluvion
e2 - Middle Eocene, marine volcanic rocks
a) subalcaline-alcaline basaltic
e2 - Middle Eocene, marine volcanic rocks
b) subalcaline-alcaline and calc-alcaline basalte-andesitic and dacitic
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level mark(m)
Hydrography
River
Intermittent river
Lake/Reservoir
Chorokhi catchment
Machakhlistskali catchment
Settlements
Region center
District center
Sakrebulo's center
Village
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Power Channel
Power Tunnel
Aqueduct
Penstock
Borders
State
Region
District
Maghlakoni project
Machakhela-2 project
Machakhela-1 project
MAGHLAKONI HPP-1
MACHAKHELA HPP-2
MACHAKHELA HPP-1
3600m
1400m
4350m
2700m
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-5 000 m
Y Axis Interval-5 000 m
Map Scale For A3 : 1 : 100 000
Source: Georgian Department of Geology; Soviet topographic Map; GIS-Lab.
Acharistskali
Kveda Makhuntseti
Oktomberi
Acharisaghmarti
Kirnati
Machakhlistskali
Chugatistskali
Chorokhi
Pass Inatsminda
Pass Chishkari
Mt.Kvanatsi
Mt.Merete


Machakhlistskali River Watershed
Geomorphology Map
Exogenous geological processes
Landslide in bedrocks
Landslide in covering layers
Mudflow occurrence
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) / Period of access
700 Water level mark(m)
Settlements
Region center
District center
Sakrebulo's center
Village
Borders
State
Region
District
Roads
Highway
Motor road
Ground road
Country road
Field road
Forest road
Hydrography
River
Intermittent river
Lake/Reservoir
Chorokhi catchment
Machakhlistskali catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Power Channel
Power Tunnel
Aqueduct
Penstock
Maghlakoni project
Machakhela-2 project
Machakhela-1 project
MAGHLAKONI HPP-1
MACHAKHELA HPP-2
MACHAKHELA HPP-1
3600m
1400m
4350m
2700m
Acharistskali
Kveda Makhuntseti
Oktomberi
Acharisaghmarti
Kirnati
Erge
Makho
Kibe
Kapnistavi
Chinkadzeebi
Simoneti
Maghlakoni
Chalakhmela
Dologani
Kosopeli
Namlisevi
Milisi
Kveda Bzubzu
Zeda Bzubzu
Khertvisi
Uchkhiti
Mirveti
Mt.Mtavarangelozi
Machakhlispiri
Sindieti
Kedkedi
Maradidi
Kveda Chkhutuneti
Chikuneti
Zeda Chkhutuneti
Kokoleti
Mt.Klde Kilgvina
Mt.Gorgeuli
Mt.Diuzenli
Mt.Kva Kibe
Kolotauri
Ortsva
Sikhalidzeebi
Gundauri
Medzibna
Chalati
Silibauri
Namonastrevi
Tsablana
Mt.Goraksapileti
Mt.Muratkana
Mt.Iudje
Mt.Aivani
Mt.Geiini
Mt.Chaglaiani
Mt.Akindji
Mt.Devtabani
Mt.Shakhinkaia
Mt.Merete
Mt.Kvanatsi
Pass Inatsminda
Pass Chishkari
Acharistskali
Dologani
Khokhnistskali
Machakhlistskali
Chugatiskali
Kokhinauristskali
Chorokhi
Pekhlivan chai
Lodnari
Paparti
Detobeki
Meretitskali
Tikharila
Baigirel
Akavreta
Didghel
Devskeli
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-5 000 m
Y Axis Interval-5 000 m
Map Scale For A3 : 1 : 100 000
Source: MOE; Soviet topographic Map; GIS-Lab.ltd

Geological and Geological-Engineering Description of the Rocks Spread Over the Study Region

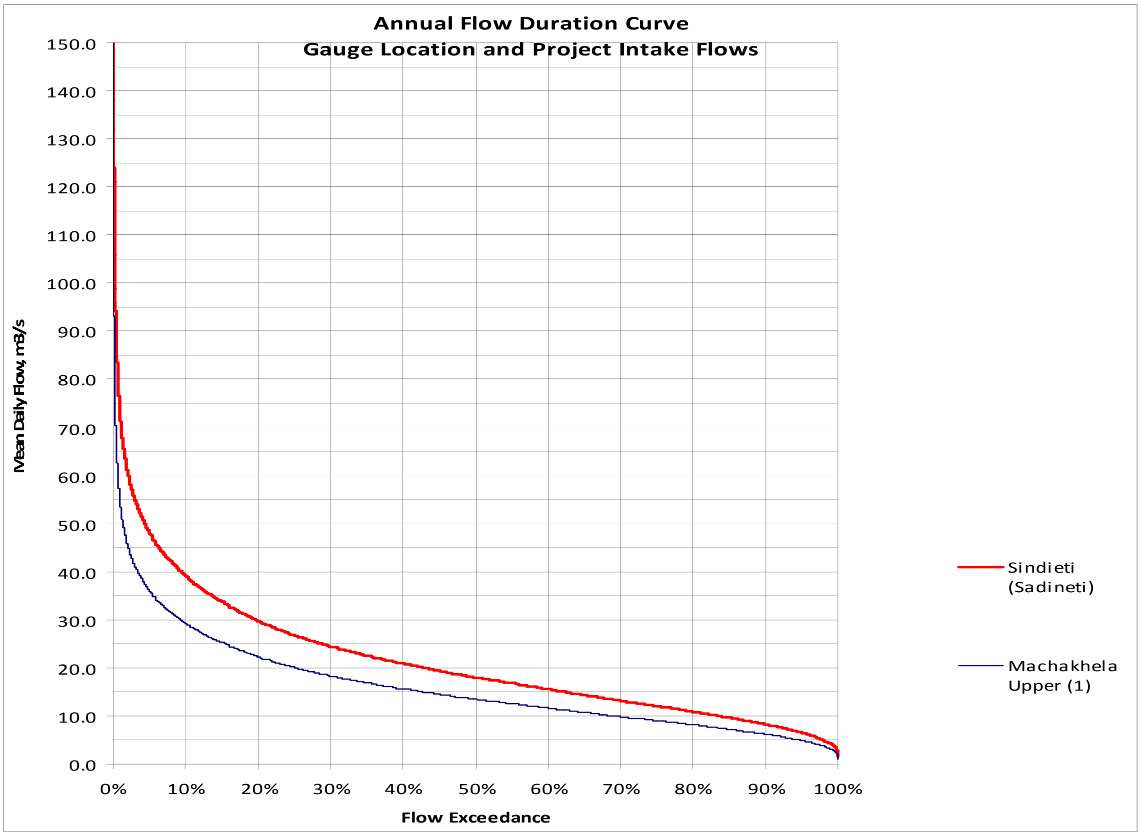
Structural Stage	Geotectonic unit	Formation	Rocks geological-genetic complex	Rocks complexes geological index	Rocks complex geological-engineering group			Rocks physical-mechanical properties				
					Friable-unconsolidated	Semi-rocky	Rocky	Density in natural condition g/cm^3	Hardness coefficient accord. To Protodiakonov	Ground calculation strength	Uniaxial compression strength	Filtration coefficient
	Adjara-Trialeti Folded System	Continental sedimentary	Alluvial-proluvial sediments, riverbed, grove and above-grove alluvial cones materials, boulder-cobbles, boulder, crushed stones, sand-gravel, with lean clay admixture	apQ$_4$	-	-	-	-	-	-	-	0.035
	Adjara-Trialeti Folded System. Adjara Trialeti zone, Abastumani-Boshuri Sub-zone	Volcanogenic sedimentary	1 a. 1. Layered tuffs and tuff-sandstones - Tuffs - Tuff-sandstones	₽$_2^2$				2.65 2.63	6.0 6.0			
			1 b. 2. Lava breccias and tuff-breccias lava interlayers - Lava breccias - Altered lava breccias - Porphyrites Andesites	₽$_2^2$		Altered	Lav.br Porp. Andes.	2.7 2.5 2.7 2.7	15.0 15.0			
			2. Lenses of massive lava breccias, tuffbreccias, lavas and tuffs - Lava breccias - Tuff breccias - Tuff - Porphyrite - Unweathered - altered	₽$_2^2$		tuff	Unweat.	2.63 2.66 2.65 2.6-2.7	6.0 6.0 3 15.0			

Appendix 2

Monthly and Annual Flow Duration Curves

Note related to this Appendix:

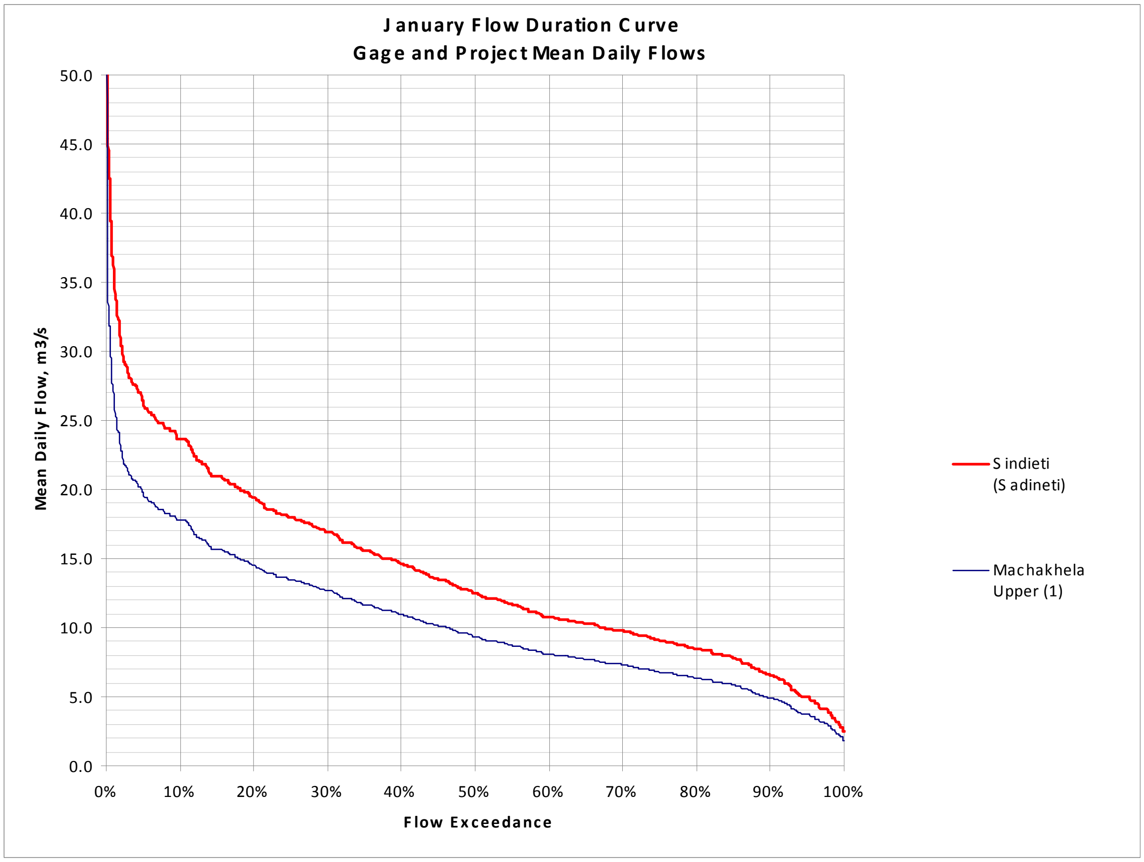
The generation tables following each Flow Duration Curve represent a conservative selection of input data and, therefore, a conservative analysis for monthly and annual HPP generation using this methodology.



Annual.

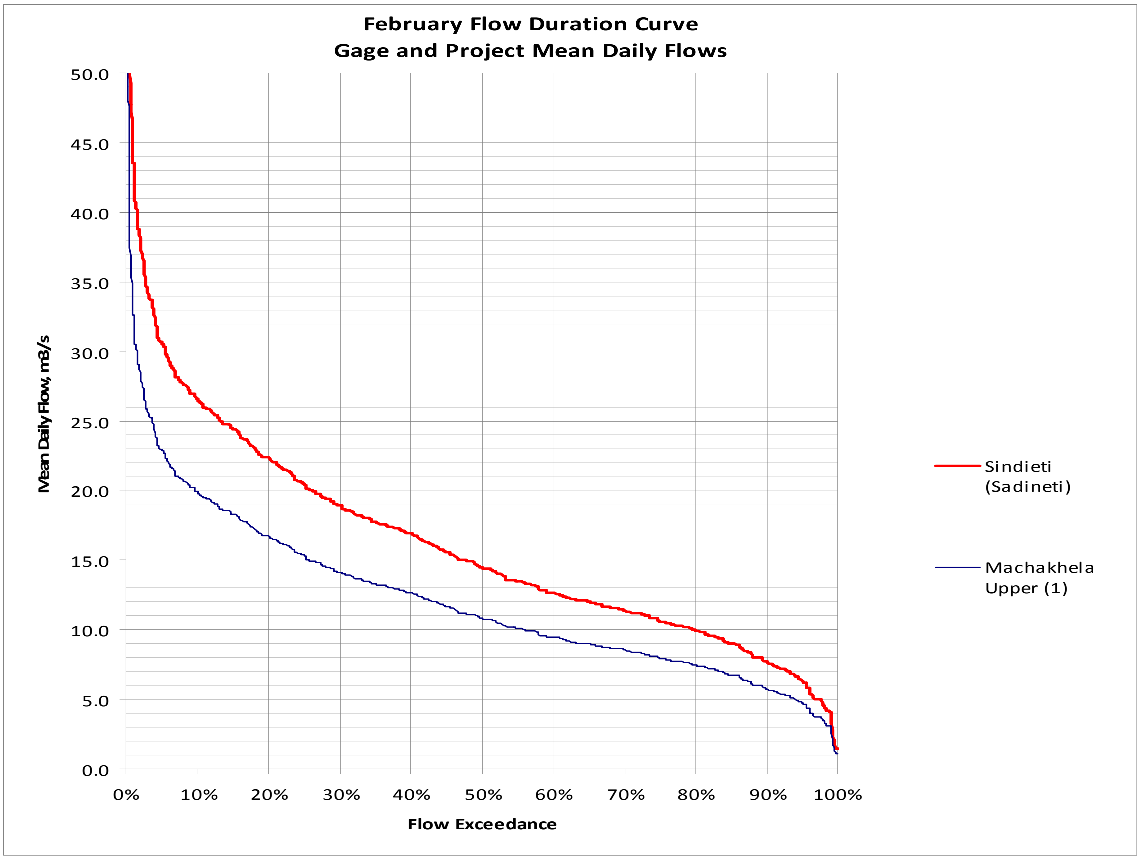
Area under Adjusted Flow Duration Curve in CMS-Hrs	141,371
Select Discharge equal to or exceeded % For HPP	15.40%
Equivalent Total Turbine Discharge at Selected CF in CMS	25.00
Non-useable portion of FDC at selected CF or Exceedance %	14184
Gross Available CMS-HRS for Generation at selected CF	127,187
Annual Average Daily Discharge in CMS	16.15
Select Env/Sanitary Flow as a % of Monthly Avg Dalily Discharge	5.3%
Environmental/Sanitary Flow in CMS	0.86
Non-useable Environmental/Sanitary CMS-HRS	7,496
Net CMS-HRS Available for Generation	119,691
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	236
Gross Head for Generation in Meters	135
Length of Penstock/Pipeline/tunnel in Km	2.7
Head Loss (from daily head loss calculation average) in Meters	2.9
Net Head for Generation in Meters	132.1
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Annual Generation in MWH	131,788

Monthly Summary of FDC Generation based on % Exceedance and Average HPP Unit Efficiency					
Month	Exceedance %	Equivalent Discharge in CMS	Estimated Av Monthly Efficiency	Monthly Env/Sanitary CMS-HRS	Average Monthly Energy in MWH
Jan	1%	24.97	85%	783	7,702
Feb	3%	25.94	85%	821	7,984
Mar	14%	25.00	85%	1,249	11,488
Apr	49%	25.00	85%	576	16,002
May	52%	25.00	85%	398	17,254
Jun	17%	25.00	85%	266	13,486
Jul	5%	24.97	85%	196	10,183
Aug	4%	24.93	85%	254	8,672
Sep	7%	24.85	85%	455	8,762
Oct	7%	25.00	85%	726	10,708
Nov	12%	25.00	85%	759	10,180
Dec	6%	24.89	85%	977	9,459
Annual Average Values	15%	25.05	85%		
FDC Summed Annual Average Generation				7,458	131,880



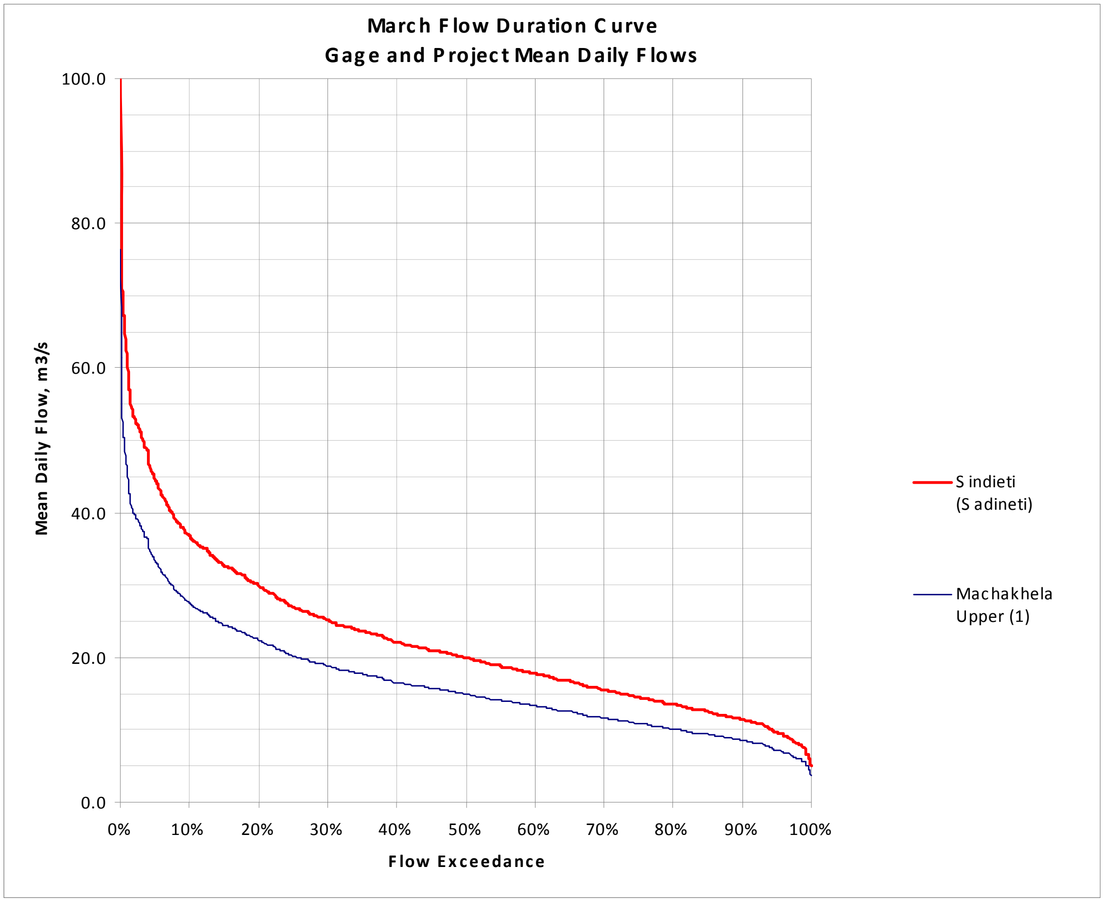
January

Area under Adjusted Flow Duration Curve in CMS-Hrs	7,815
Select Discharge equal to or exceeded % For HPP	1.45%
Equivalent Total Turbine Discharge at Selected CF in CMS	24.97
Non-useable portion of FDC at selected CF or Exceedance %	37
Gross Available CMS-HRS for Generation at selected CF	7,778
Monthly Average Daily Discharge in CMS	10.52
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	10%
Environmental/Sanitary Flow in CMS	1.05
Non-useable Environmental/Sanitary CMS-HRS	783
Net CMS-HRS Available for Generation	6995
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	236
Gross Head for Generation in Meters	135
Length of Penstock/Pipeline/tunnel in Km	2.7
Head Loss (from daily head loss calculation average) in Meters	2.9
Net Head for Generation in Meters	132.1
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	7,702,206
MWh	7,702



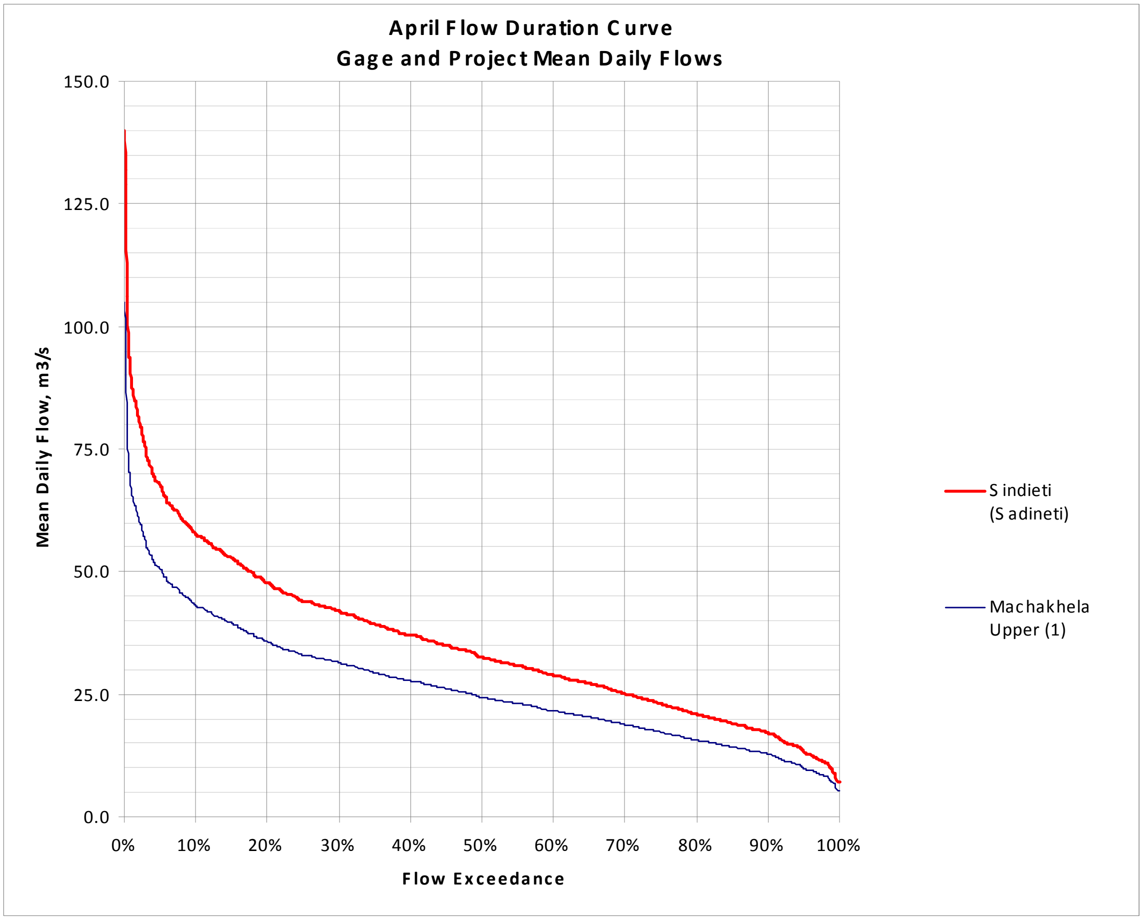
February

Area under Adjusted Flow Duration Curve in CMS-Hrs	8,191
Select Discharge equal to or exceeded % For HPP	2.93%
Equivalent Total Turbine Discharge at Selected CF in CMS	25.94
Non-useable portion of FDC at selected CF or Exceedance %	120
Gross Available CMS-HRS for Generation at selected CF	8,071
Monthly Average Daily Discharge in CMS	12.21
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	10%
Environmental/Sanitary Flow in CMS	1.22
Non-useable Environmental/Sanitary CMS-HRS	821
Net CMS-HRS Available for Generation	7251
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	236
Gross Head for Generation in Meters	135
Length of Penstock/Pipeline/tunnel in Km	2.7
Head Loss (from daily head loss calculation average) in Meters	2.9
Net Head for Generation in Meters	132.1
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	7,983,742
MWh	7,984



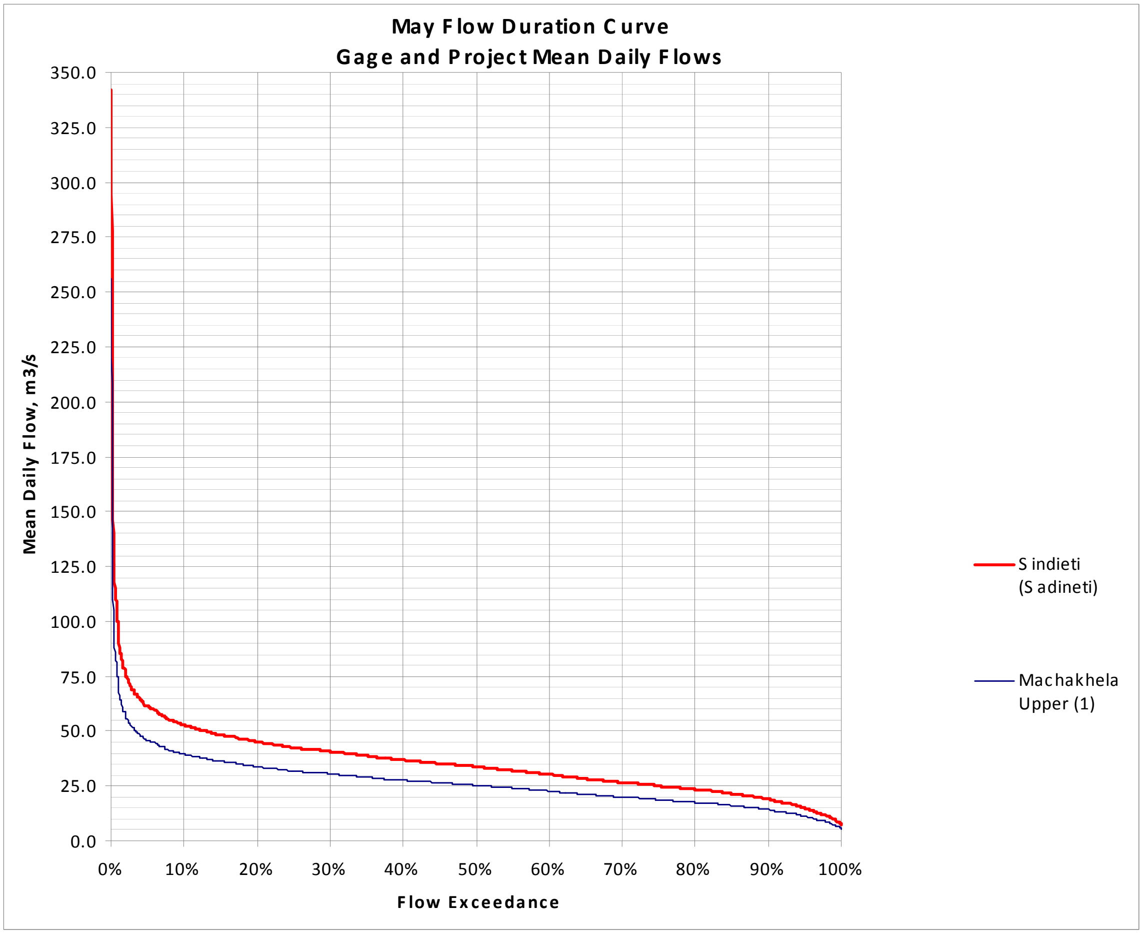
March

Area under Adjusted Flow Duration Curve in CMS-Hrs	12,469
Select Discharge equal to or exceeded % For HPP	14.10%
Equivalent Total Turbine Discharge at Selected CF in CMS	25.00
Non-useable portion of FDC at selected CF or Exceedance %	787
Gross Available CMS-HRS for Generation at selected CF	11,682
Monthly Average Daily Discharge in CMS	16.78
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	10%
Environmental/Sanitary Flow in CMS	1.68
Non-useable Environmental/Sanitary CMS-HRS	1249
Net CMS-HRS Available for Generation	10433
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	236
Gross Head for Generation in Meters	135
Length of Penstock/Pipeline/tunnel in Km	2.7
Head Loss (from daily head loss calculation average) in Meters	2.9
Net Head for Generation in Meters	132.1
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	11,487,844
MWh	11,488



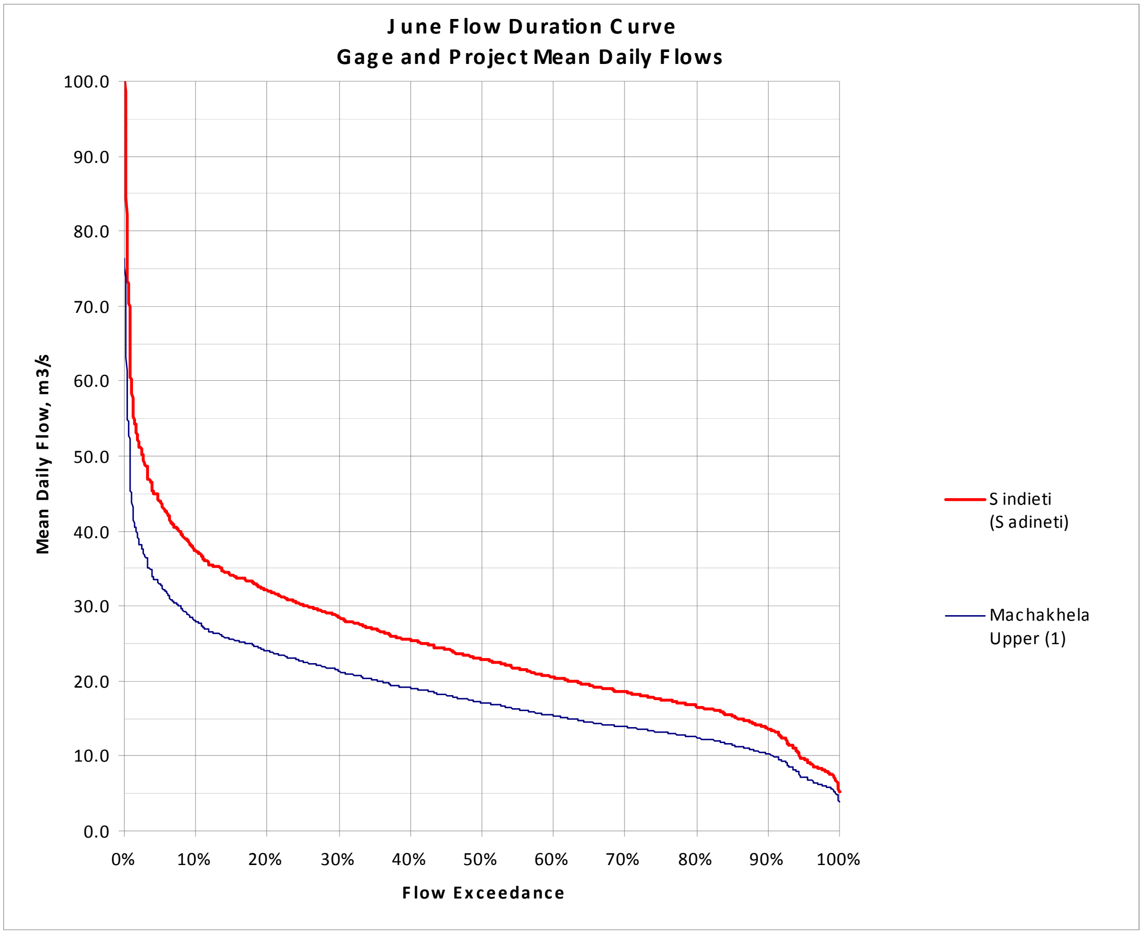
April

Area under Adjusted Flow Duration Curve in CMS-Hrs	19,175
Select Discharge equal to or exceeded % For HPP	49.00%
Equivalent Total Turbine Discharge at Selected CF in CMS	25.00
Non-useable portion of FDC at selected CF or Exceedance %	4066
Gross Available CMS-HRS for Generation at selected CF	15,108
Monthly Average Daily Discharge in CMS	26.65
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	3%
Environmental/Sanitary Flow in CMS	0.80
Non-useable Environmental/Sanitary CMS-HRS	576
Net CMS-HRS Available for Generation	14533
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	236
Gross Head for Generation in Meters	135
Length of Penstock/Pipeline/tunnel in Km	2.7
Head Loss (from daily head loss calculation average) in Meters	2.9
Net Head for Generation in Meters	132.1
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	16,001,562
MWh	16,002



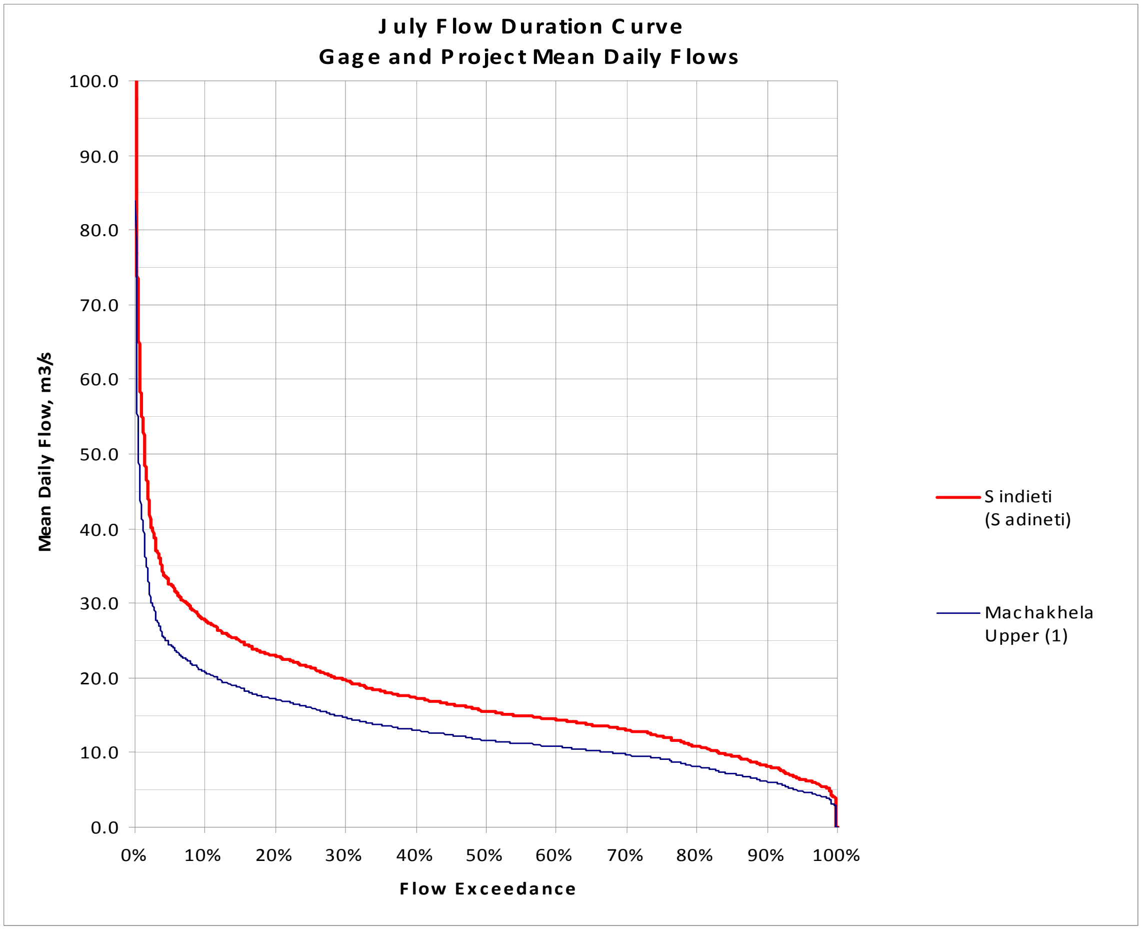
May

Area under Adjusted Flow Duration Curve in CMS-Hrs	19,846
Select Discharge equal to or exceeded % For HPP	51.50%
Equivalent Total Turbine Discharge at Selected CF in CMS	25.00
Non-useable portion of FDC at selected CF or Exceedance %	3778
Gross Available CMS-HRS for Generation at selected CF	16,068
Monthly Average Daily Discharge in CMS	26.76
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	2%
Environmental/Sanitary Flow in CMS	0.54
Non-useable Environmental/Sanitary CMS-HRS	398
Net CMS-HRS Available for Generation	15,670
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	236
Gross Head for Generation in Meters	135
Length of Penstock/Pipeline/tunnel in Km	2.7
Head Loss (from daily head loss calculation average) in Meters	2.9
Net Head for Generation in Meters	132.1
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	17,253,886
MWh	17,254



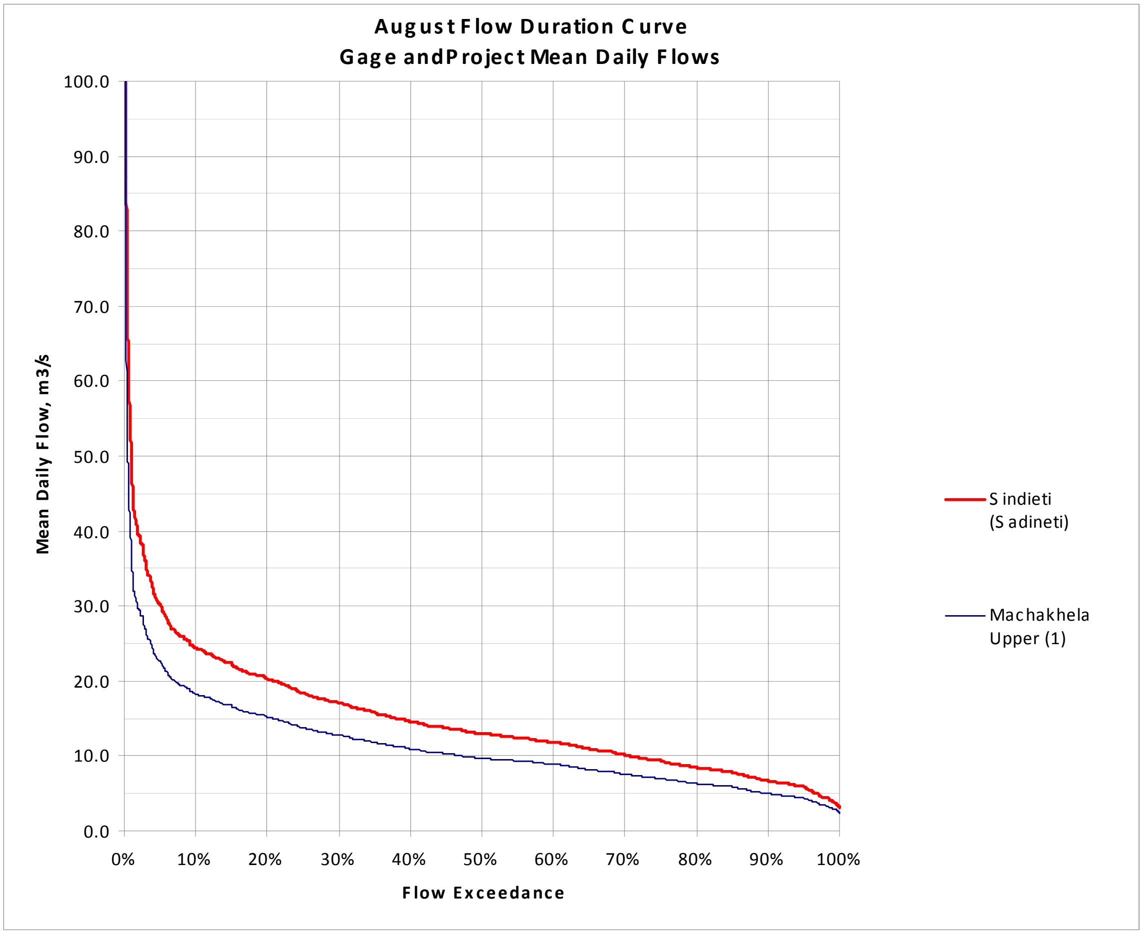
June

Area under Adjusted Flow Duration Curve in CMS-Hrs	13,298
Select Discharge equal to or exceeded % For HPP	17.20%
Equivalent Total Turbine Discharge at Selected CF in CMS	25.00
Non-useable portion of FDC at selected CF or Exceedance %	784
Gross Available CMS-HRS for Generation at selected CF	12,515
Monthly Average Daily Discharge in CMS	18.50
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	2%
Environmental/Sanitary Flow in CMS	0.37
Non-useable Environmental/Sanitary CMS-HRS	266
Net CMS-HRS Available for Generation	12,248
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	236
Gross Head for Generation in Meters	135
Length of Penstock/Pipeline/tunnel in Km	2.7
Head Loss (from daily head loss calculation average) in Meters	2.9
Net Head for Generation in Meters	132.1
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	13,486,371
MWh	13,486



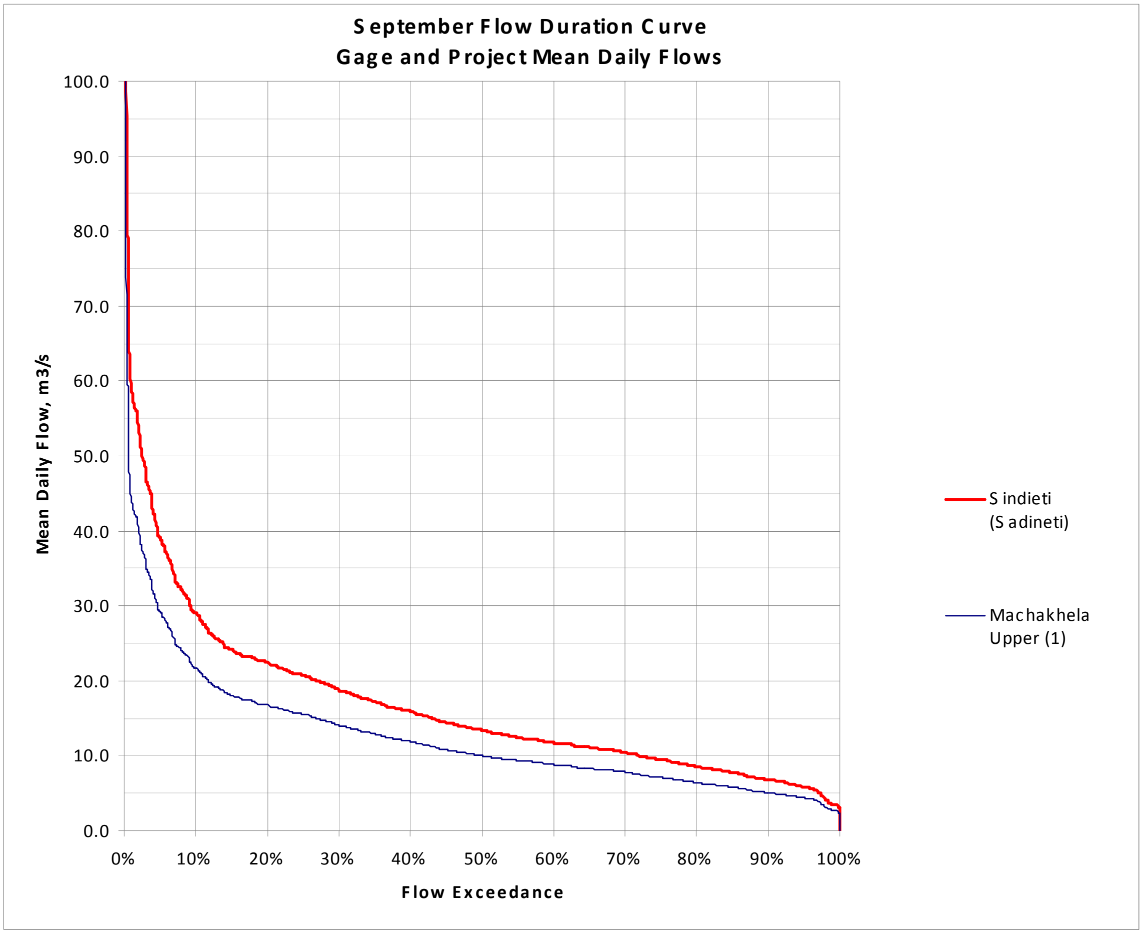
July

Area under Adjusted Flow Duration Curve in CMS-Hrs	9,752
Select Discharge equal to or exceeded % For HPP	4.70%
Equivalent Total Turbine Discharge at Selected CF in CMS	24.97
Non-useable portion of FDC at selected CF or Exceedance %	309
Gross Available CMS-HRS for Generation at selected CF	9,444
Monthly Average Daily Discharge in CMS	13.16
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	2%
Environmental/Sanitary Flow in CMS	0.26
Non-useable Environmental/Sanitary CMS-HRS	196
Net CMS-HRS Available for Generation	9,248
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	236
Gross Head for Generation in Meters	135
Length of Penstock/Pipeline/tunnel in Km	2.7
Head Loss (from daily head loss calculation average) in Meters	2.9
Net Head for Generation in Meters	132.1
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	10,182,753
MWh	10,183



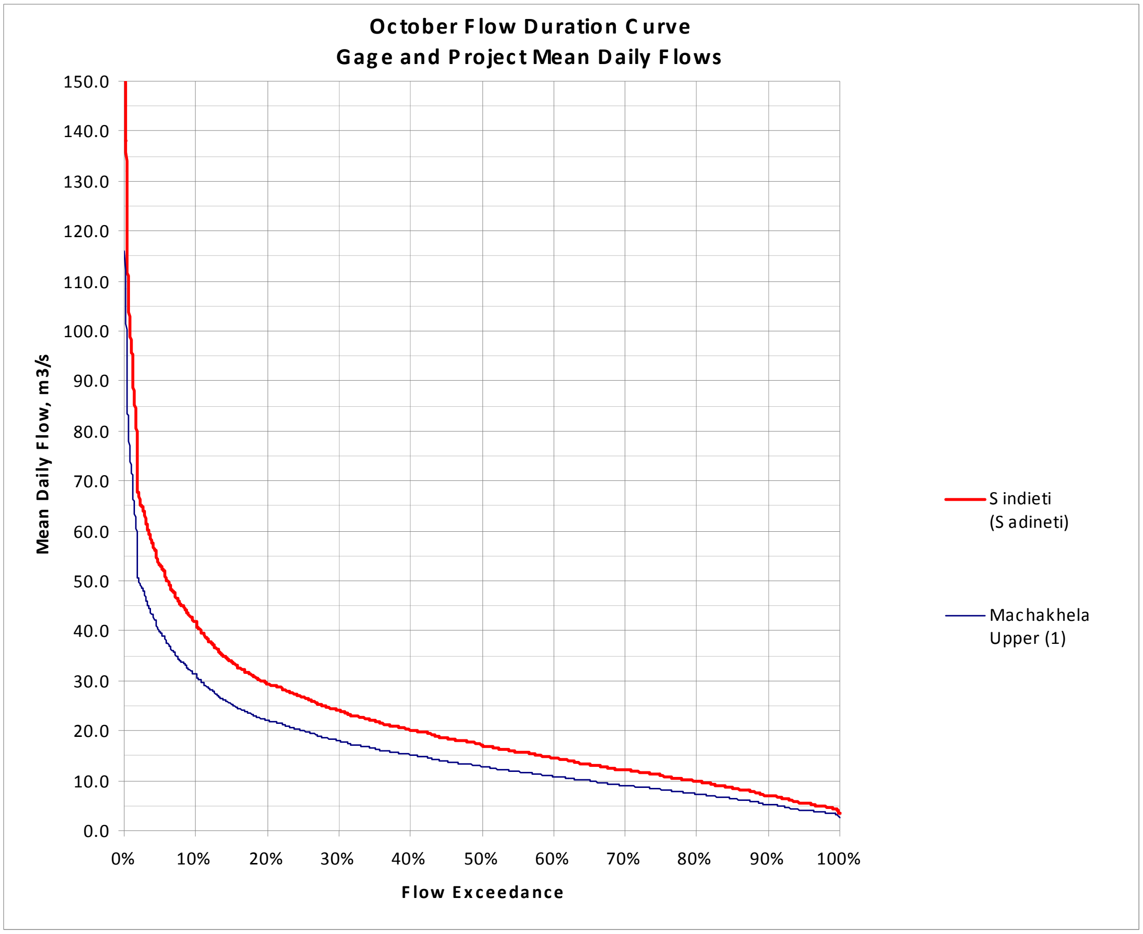
August

Area under Adjusted Flow Duration Curve in CMS-Hrs	8,412
Select Discharge equal to or exceeded % For HPP	3.73%
Equivalent Total Turbine Discharge at Selected CF in CMS	24.93
Non-useable portion of FDC at selected CF or Exceedance %	282
Gross Available CMS-HRS for Generation at selected CF	8,130
Monthly Average Daily Discharge in CMS	11.36
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	3%
Environmental/Sanitary Flow in CMS	0.34
Non-useable Environmental/Sanitary CMS-HRS	254
Net CMS-HRS Available for Generation	7876
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	236
Gross Head for Generation in Meters	135
Length of Penstock/Pipeline/tunnel in Km	2.7
Head Loss (from daily head loss calculation average) in Meters	2.9
Net Head for Generation in Meters	132.1
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	8,672,360
MWh	8,672



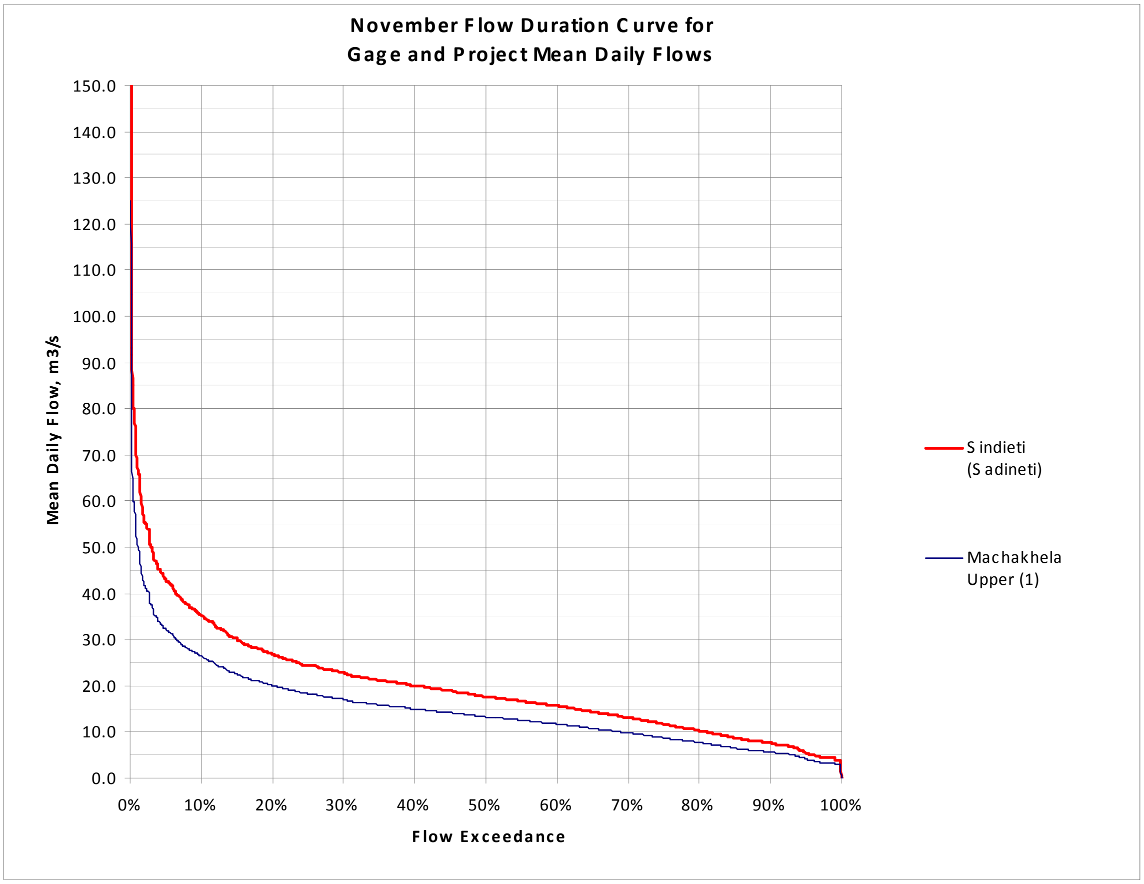
September

Area under Adjusted Flow Duration Curve in CMS-Hrs	9,049
Select Discharge equal to or exceeded % For HPP	7.24%
Equivalent Total Turbine Discharge at Selected CF in CMS	24.85
Non-useable portion of FDC at selected CF or Exceedance %	636
Gross Available CMS-HRS for Generation at selected CF	8,413
Monthly Average Daily Discharge in CMS	12.64
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	5%
Environmental/Sanitary Flow in CMS	0.63
Non-useable Environmental/Sanitary CMS-HRS	455
Net CMS-HRS Available for Generation	7958
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	236
Gross Head for Generation in Meters	135
Length of Penstock/Pipeline/tunnel in Km	2.7
Head Loss (from daily head loss calculation average) in Meters	2.9
Net Head for Generation in Meters	132.1
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	8,762,350
MWh	8,762



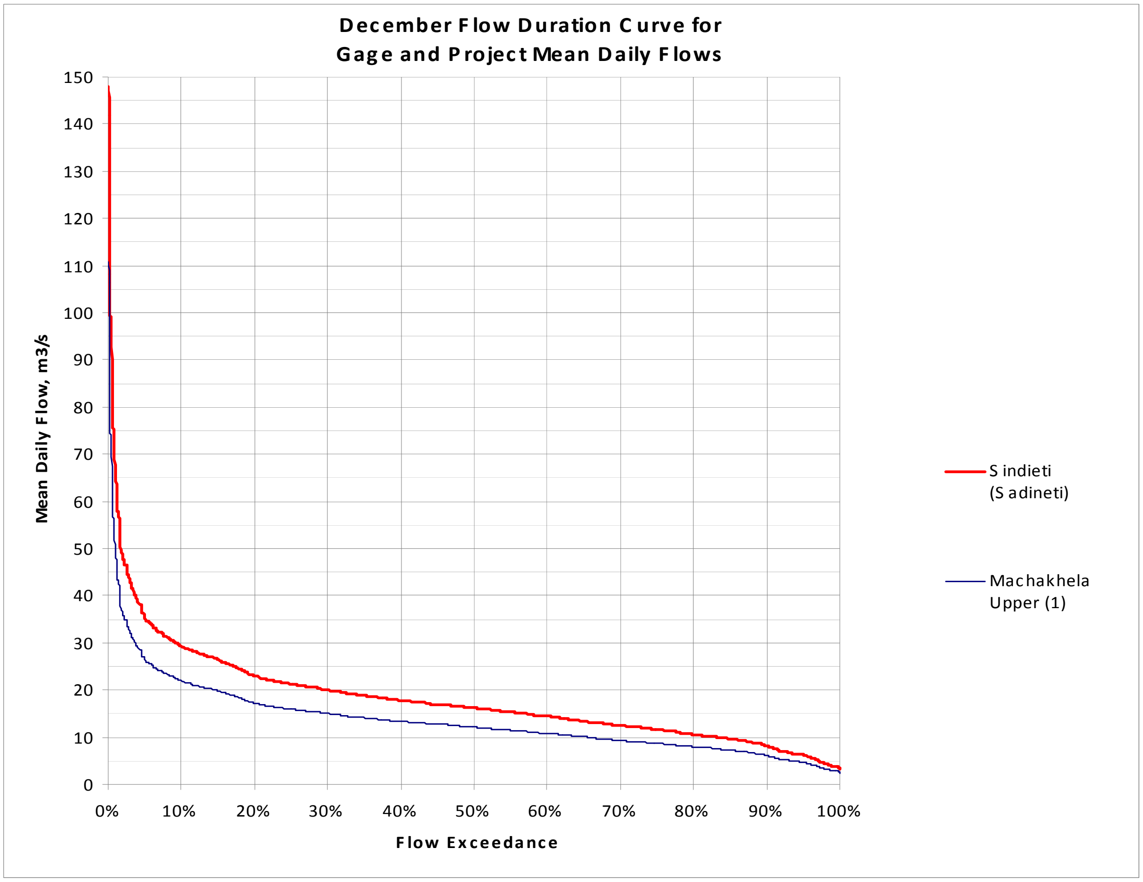
October

Area under Adjusted Flow Duration Curve in CMS-Hrs	12,069
Select Discharge equal to or exceeded % For HPP	15.50%
Equivalent Total Turbine Discharge at Selected CF in CMS	25.00
Non-useable portion of FDC at selected CF or Exceedance %	1618
Gross Available CMS-HRS for Generation at selected CF	10,451
Monthly Average Daily Discharge in CMS	16.26
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	6%
Environmental/Sanitary Flow in CMS	0.98
Non-useable Environmental/Sanitary CMS-HRS	726
Net CMS-HRS Available for Generation	9725
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	236
Gross Head for Generation in Meters	135
Length of Penstock/Pipeline/tunnel in Km	2.7
Head Loss (from daily head loss calculation average) in Meters	2.9
Net Head for Generation in Meters	132.1
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	10,708,306
MWh	10,708



November

Area under Adjusted Flow Duration Curve in CMS-Hrs	10,797
Select Discharge equal to or exceeded % For HPP	11.80%
Equivalent Total Turbine Discharge at Selected CF in CMS	25.00
Non-useable portion of FDC at selected CF or Exceedance %	793
Gross Available CMS-HRS for Generation at selected CF	10,004
Monthly Average Daily Discharge in CMS	15.06
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	7%
Environmental/Sanitary Flow in CMS	1.05
Non-useable Environmental/Sanitary CMS-HRS	759
Net CMS-HRS Available for Generation	9245
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	236
Gross Head for Generation in Meters	135
Length of Penstock/Pipeline/tunnel in Km	2.7
Head Loss (from daily head loss calculation average) in Meters	2.9
Net Head for Generation in Meters	132.1
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	10,179,578
MWh	10,180

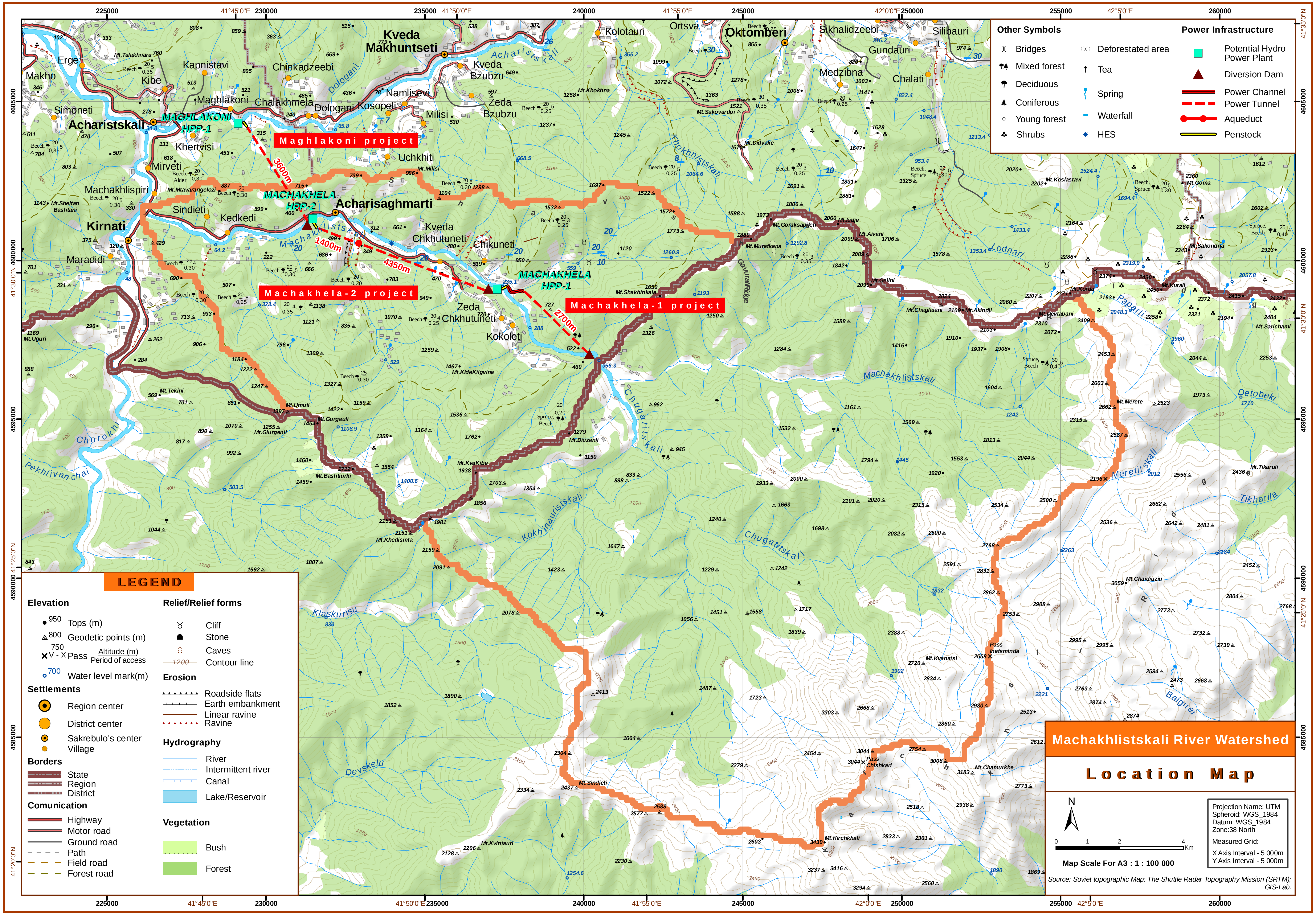


December

Area under Adjusted Flow Duration Curve in CMS-Hrs	10,115
Select Discharge equal to or exceeded % For HPP	6.21%
Equivalent Total Turbine Discharge at Selected CF in CMS	24.89
Non-useable portion of FDC at selected CF or Exceedance %	548
Gross Available CMS-HRS for Generation at selected CF	9,567
Monthly Average Daily Discharge in CMS	13.63
Select Env/Sanitary Flow as a % of Monthly Avg Daily Discharge	10%
Environmental/Sanitary Flow in CMS	1.31
Non-useable Environmental/Sanitary CMS-HRS	977
Net CMS-HRS Available for Generation	8590
Estimated Intake Elevation in Meters	371
Estimated Discharge Elevation in Meters	236
Gross Head for Generation in Meters	135
Length of Penstock/Pipeline/tunnel in Km	2.7
Head Loss (from daily head loss calculation average) in Meters	2.9
Net Head for Generation in Meters	132.1
Input Estimated Average Unit Efficiency in %	85%
Estimated Average Monthly Generation in kWh	9,458,665
MWh	9,459

Appendix 3

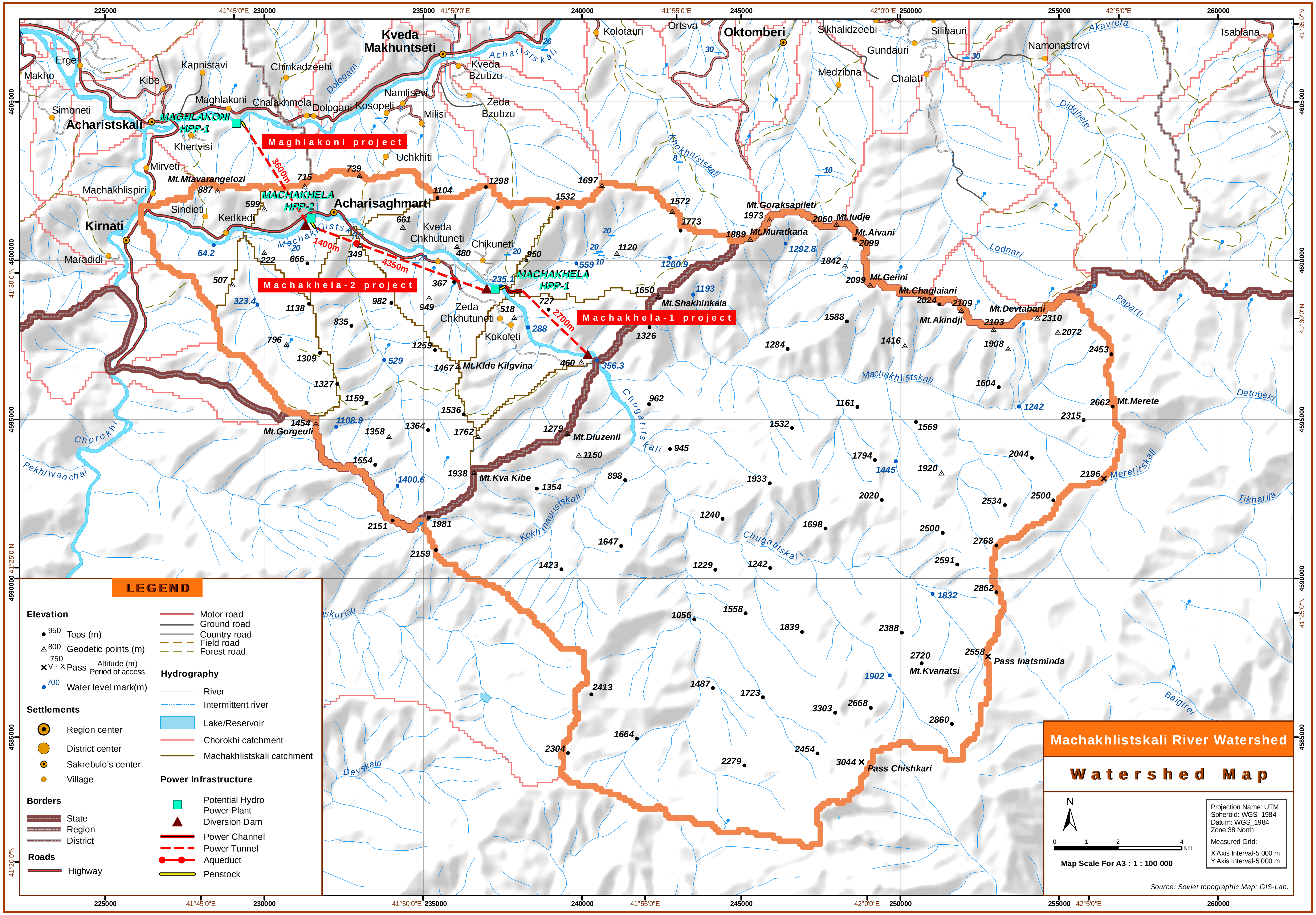
Location Map



Machakhlistskali River Watershed
Location Map
Maghlakoni project
Machakhela-2 project
Machakhela-1 project
MAGHLAKONI HPP-1
MACHAKHELA HPP-2
MACHAKHELA HPP-1
3600m
1400m
4350m
2700m
Acharistskali
Machakhlistskali
Chugatistskali
Chorokhi
Kokhinauristskali
Acharisaghmarti
Kirnati
Kveda Makhuntseti
Oktomberi
Other Symbols
Bridges
Mixed forest
Deciduous
Coniferous
Young forest
Shrubs
Deforestated area
Tea
Spring
Waterfall
HES
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Power Channel
Power Tunnel
Aqueduct
Penstock
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level mark(m)
Settlements
Region center
District center
Sakrebulo's center
Village
Borders
State
Region
District
Comunication
Highway
Motor road
Ground road
Path
Field road
Forest road
Relief/Relief forms
Cliff
Stone
Caves
1200 Contour line
Erosion
Roadside flats
Earth embankment
Linear ravine
Ravine
Hydrography
River
Intermittent river
Canal
Lake/Reservoir
Vegetation
Bush
Forest
Map Scale For A3 : 1 : 100 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval - 5 000m
Y Axis Interval - 5 000m
Source: Soviet topographic Map; The Shuttle Radar Topography Mission (SRTM); GIS-Lab.

Appendix 4

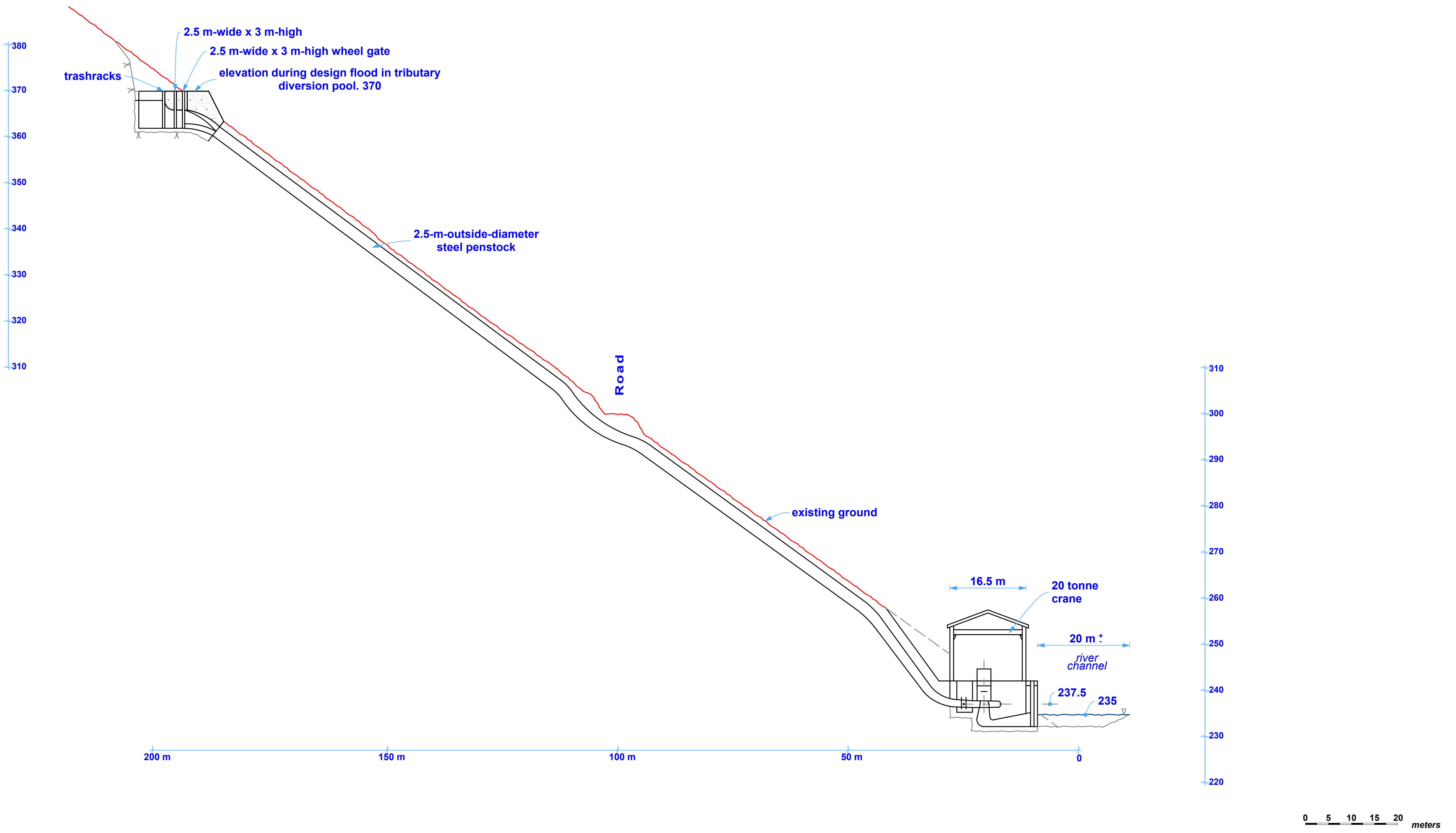
Watershed Map



Machakhlistskali River Watershed
Watershed Map
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level mark(m)
Settlements
Region center
District center
Sakrebulo's center
Village
Borders
State
Region
District
Roads
Highway
Motor road
Ground road
Country road
Field road
Forest road
Hydrography
River
Intermittent river
Lake/Reservoir
Chorokhi catchment
Machakhlistskali catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Power Channel
Power Tunnel
Aqueduct
Penstock
Maghlakoni project
Machakhela-2 project
Machakhela-1 project
MAGHLAKONI HPP-1
MACHAKHELA HPP-2
MACHAKHELA HPP-1
3600m
1400m
4350m
2700m
Acharistskali
Kirnati
Acharisaghmarti
Kveda Makhuntseti
Oktomberi
Machakhlistskali
Chugatistskali
Chorokhi
Mt.Kva Kibe
Mt.Merete
Pass Inatsminda
Pass Chishkari
Mt.Kvanatsi
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-5 000 m
Y Axis Interval-5 000 m
Map Scale For A3 : 1 : 100 000
Source: Soviet topographic Map; GIS-Lab.

Appendix 5

Site HPP Figure

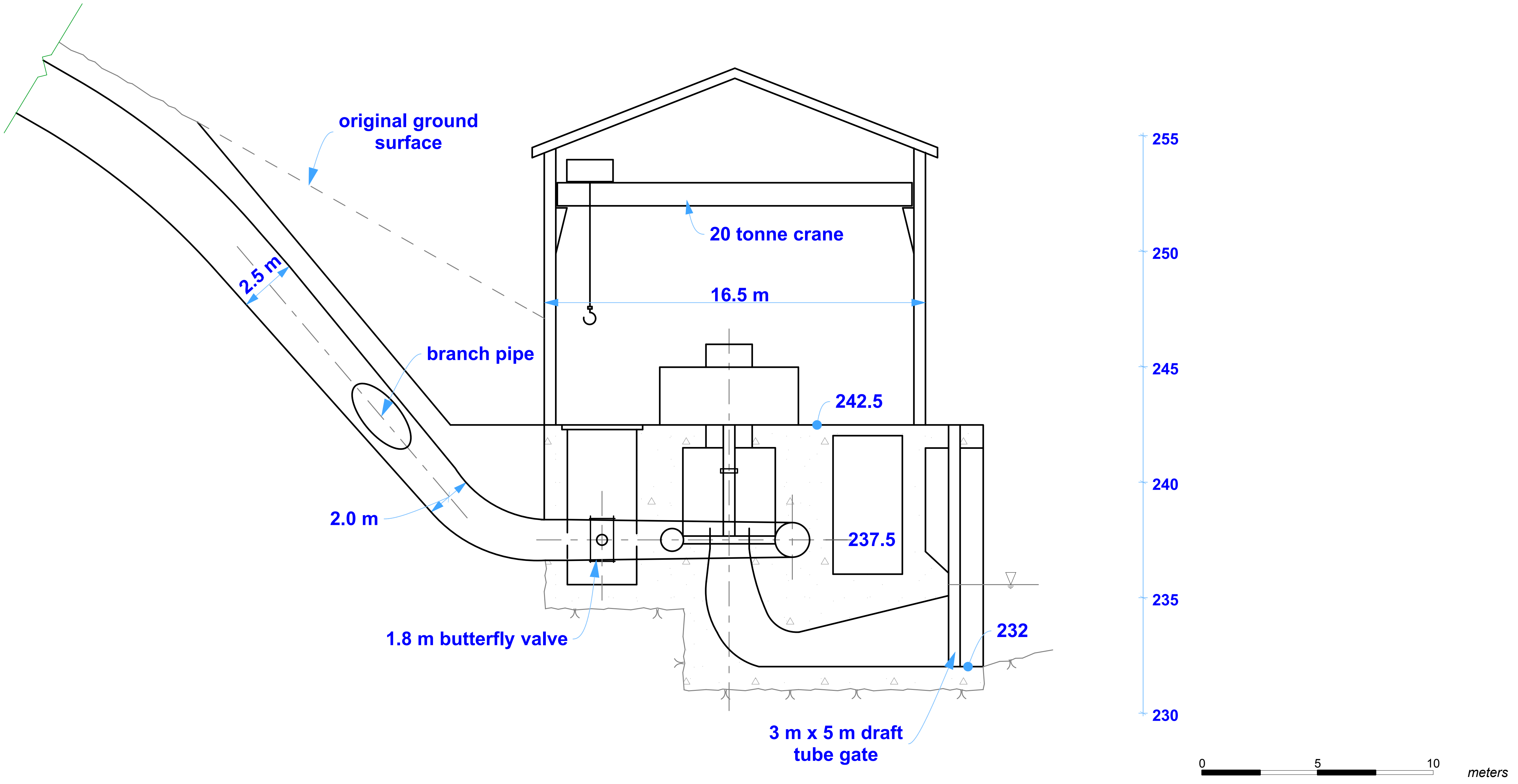


BLACK & VEATCH
Building a world of difference.

Pre-Feasibility Study
Machakhela 1

Penstock Profile

Drawing Scale 1:1000	August 2011



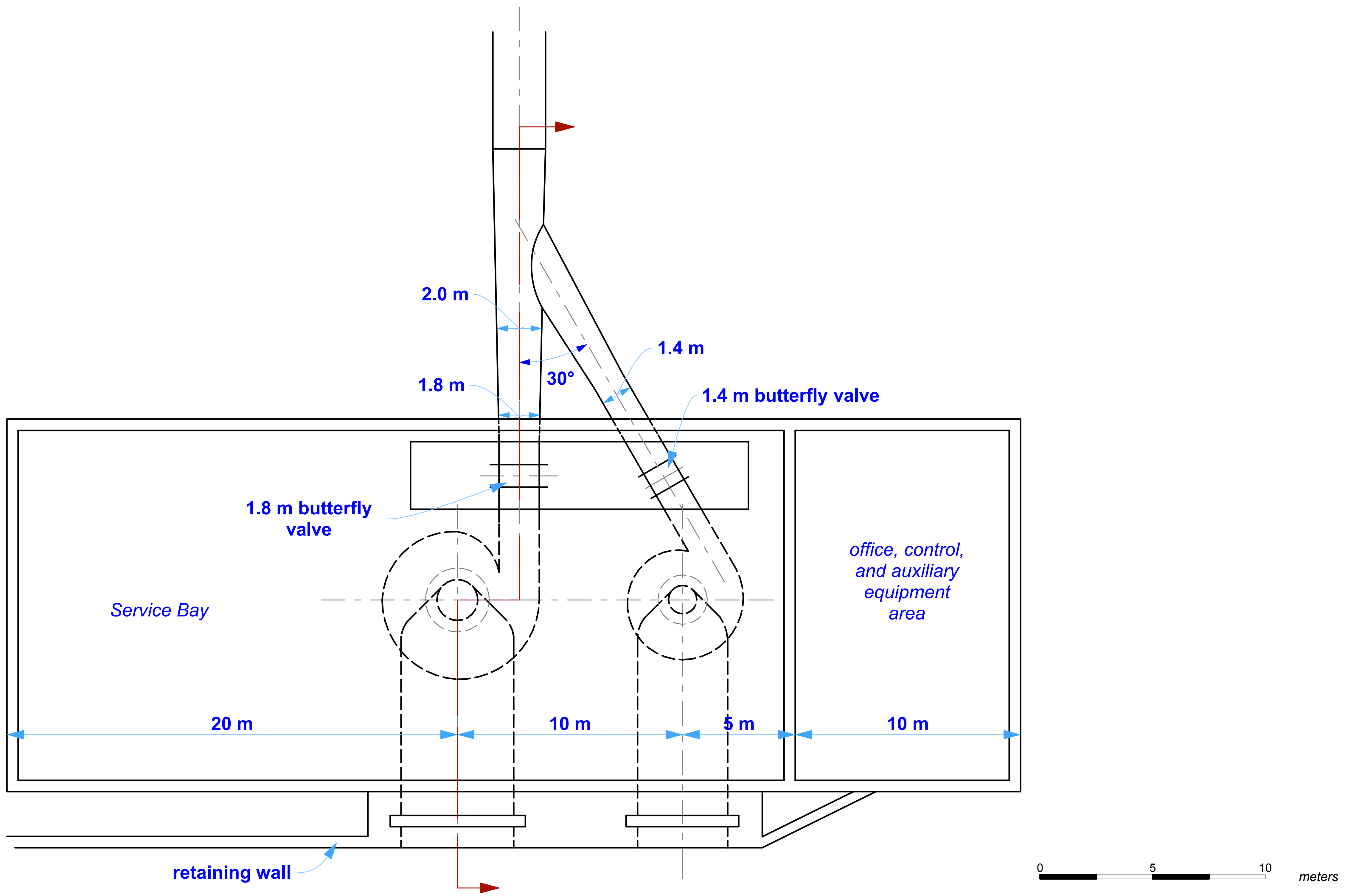
BLACK & VEATCH
Building a world of difference.

Pre-Feasibility Study
Machakhela 1

Powerhouse Cross-Section

Drawing Scale 1:200

August 2011

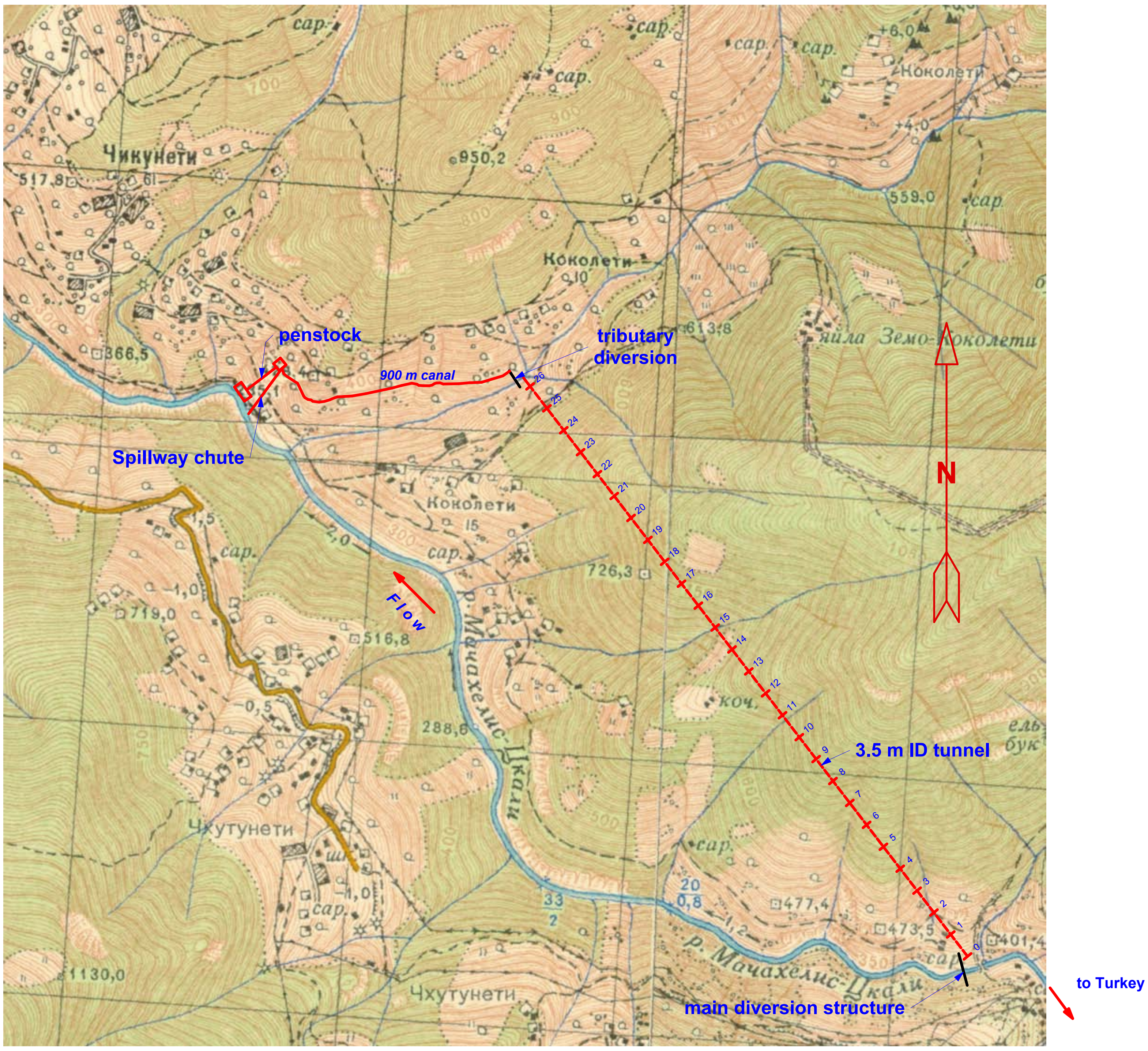


BLACK & VEATCH
Building a world of difference.

Pre-Feasibility Study
Machakhela 1

Powerhouse Plan

Drawing Scale 1:200	August 2011



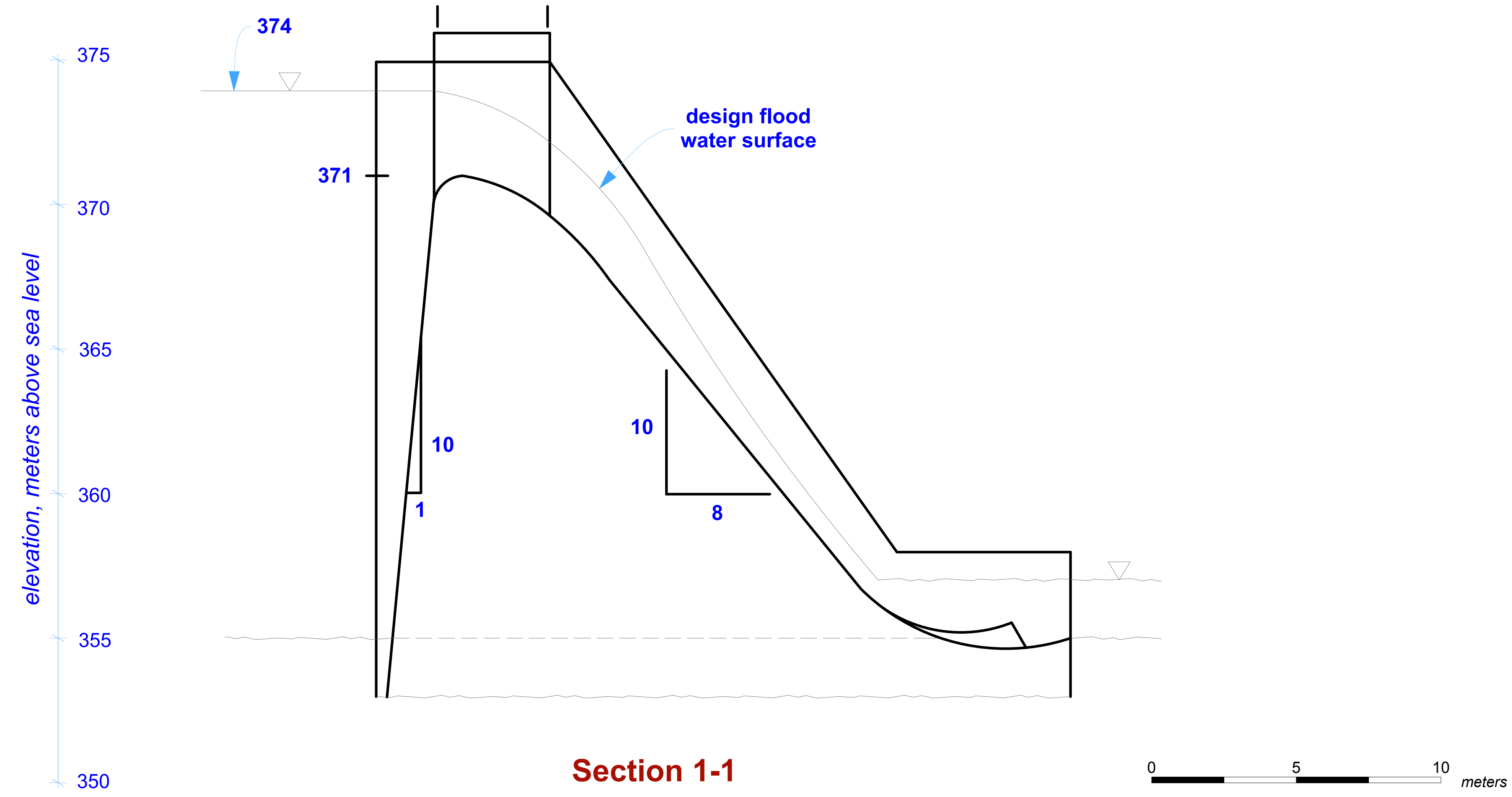
BLACK & VEATCH
Building a world of difference.

Pre-Feasibility Study

Machakhela 1

Project Arrangement

Drawing Scale 1:20,000	August 2011



Section 1-1

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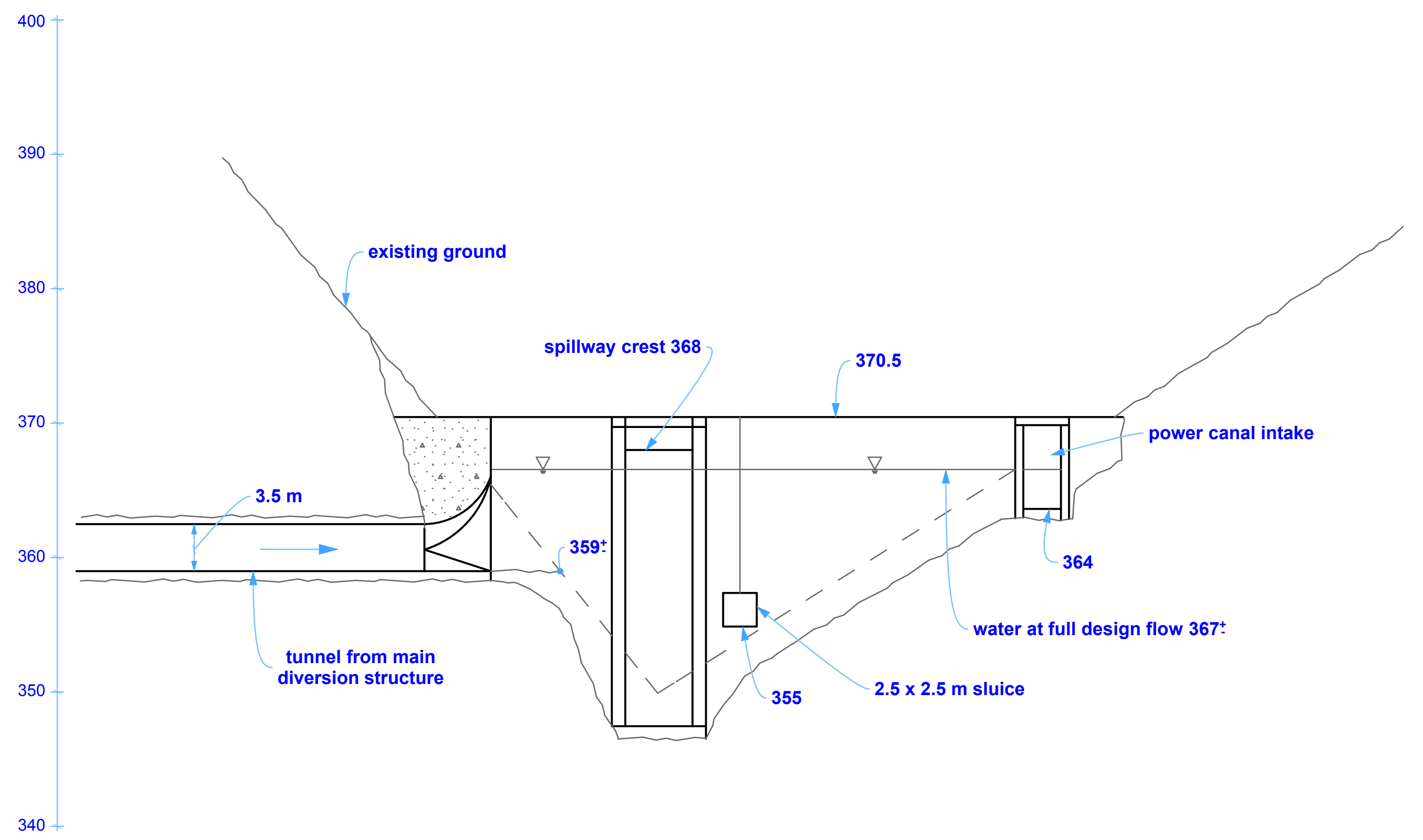
Pre-Feasibility Study
Machakhela 1

Drawing Scale 1:200 August 2011



0 5 10 *meters*

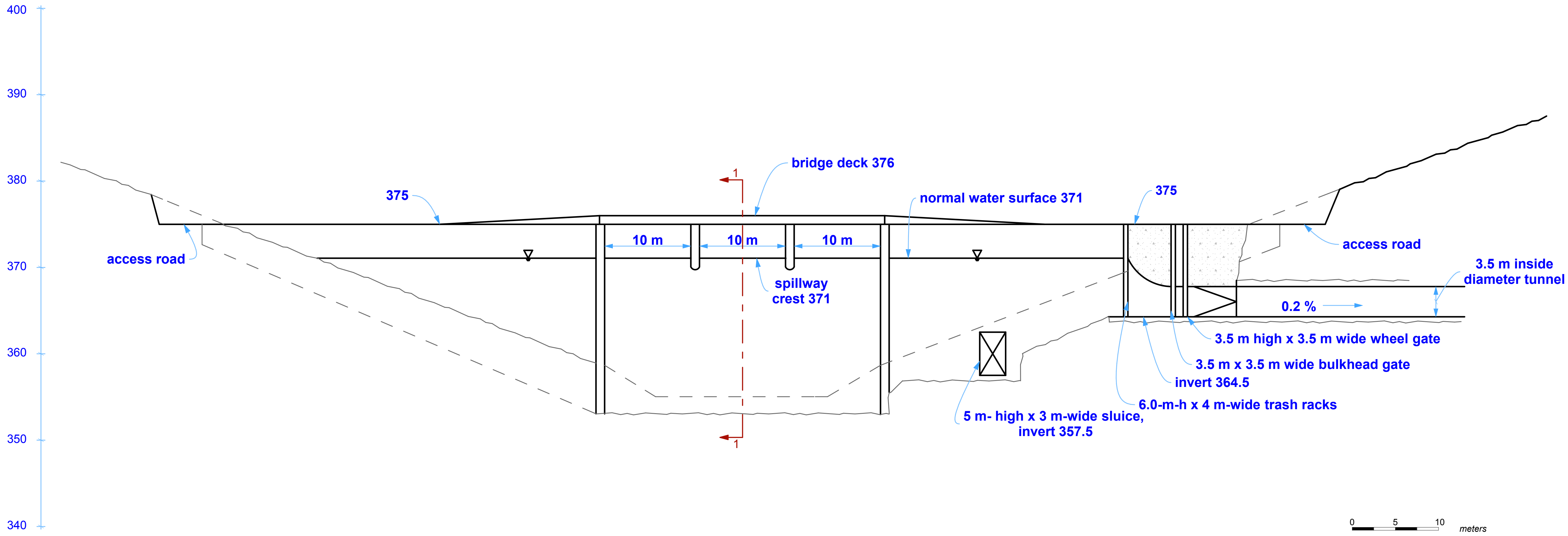
BLACK & VEATCH
Building a **world** of difference.

Pre-Feasibility Study
Machakhela 1

Tributary Diversion Upstream Elevation

Drawing Scale **1:500**

August 2011

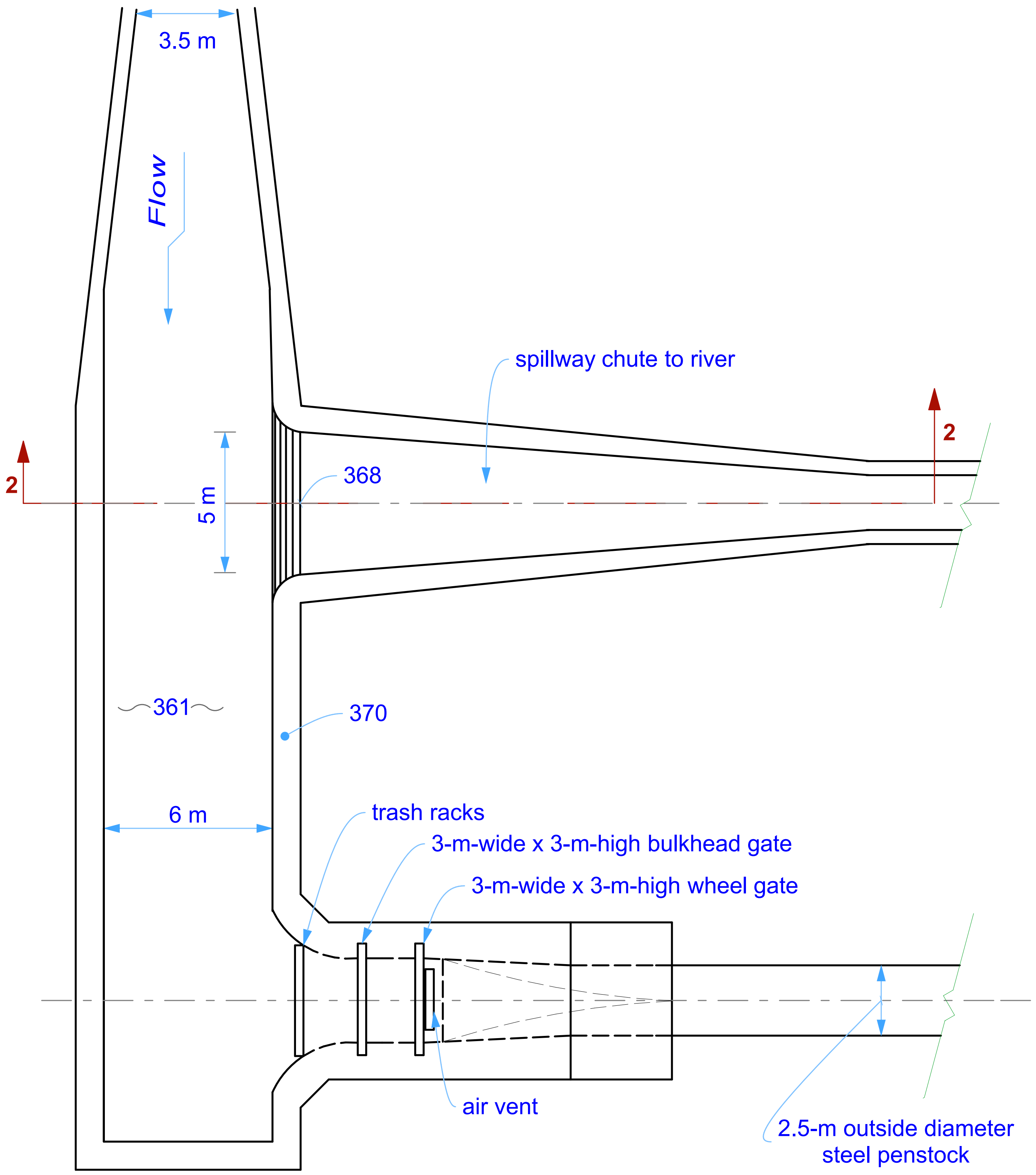


BLACK & VEATCH
Building a world of difference.

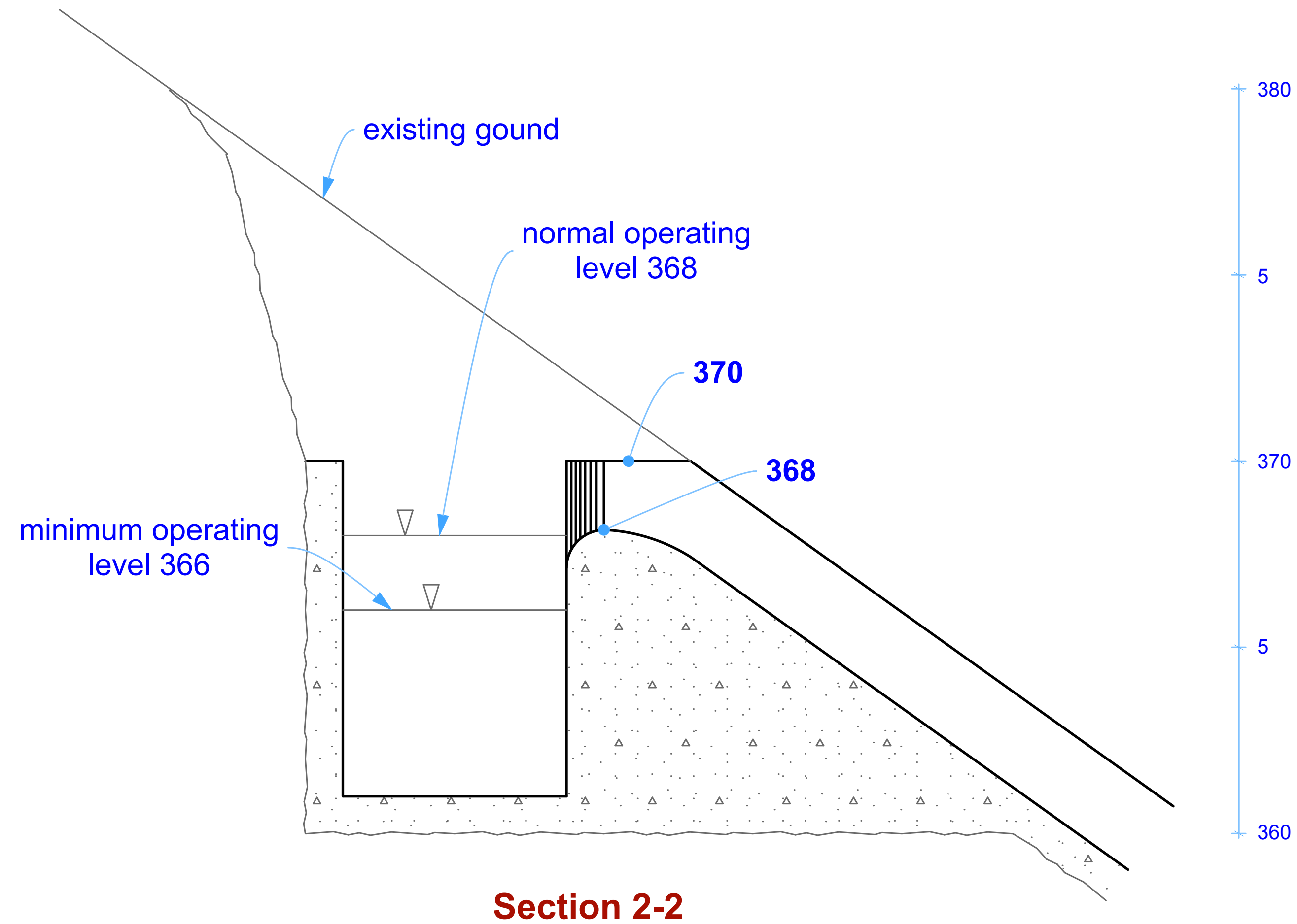
Pre-Feasibility Study
Machakhela 1

Main Diversion Structure
Dam Elevation and Intake Section

Drawing Scale 1:500	August 2011



Plan



Section 2-2

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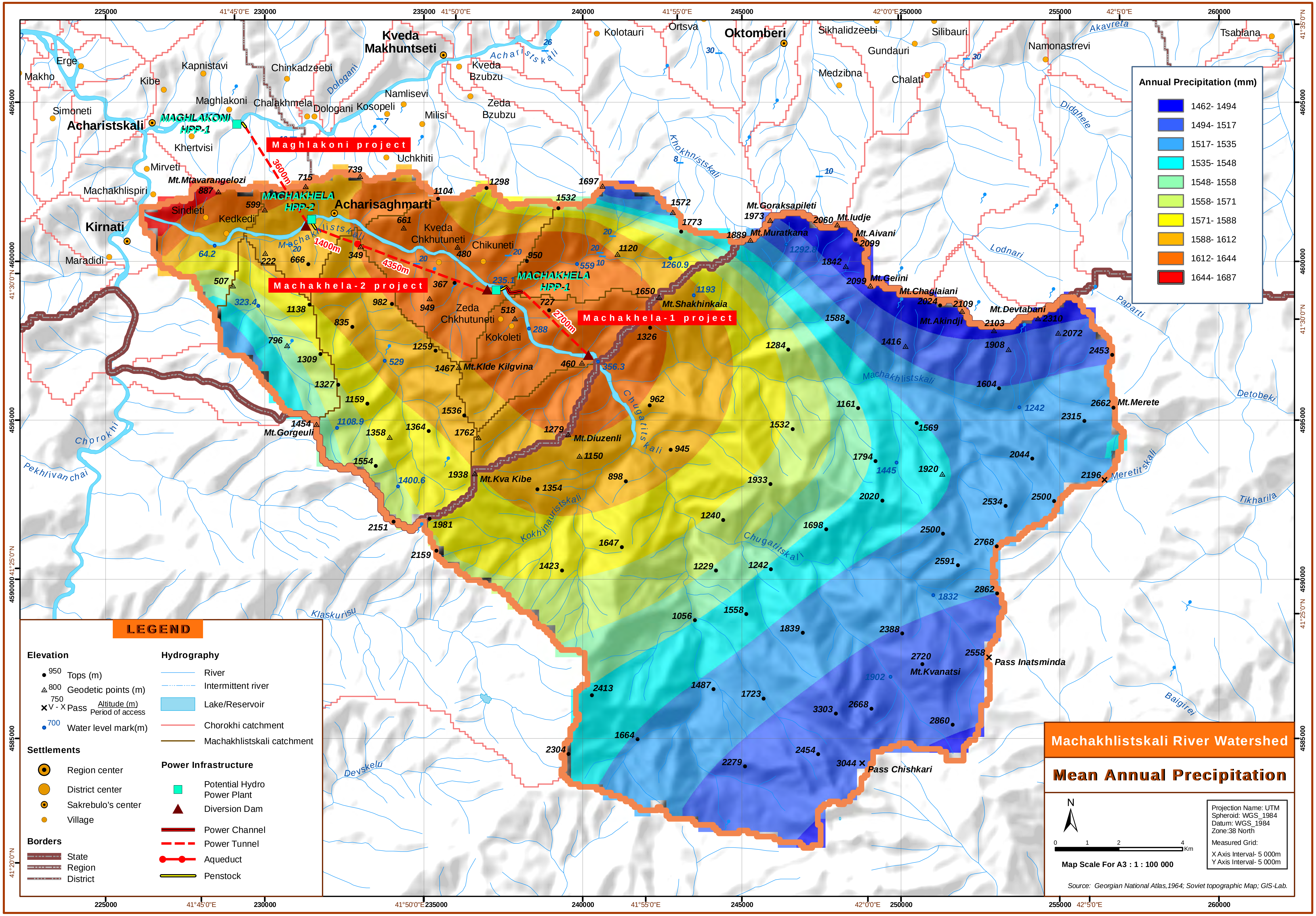
Pre-Feasibility Study
Machakhela 1

Penstock Intake and Forebay
Spillway Plan and Section

Drawing Scale	1:200	August 2011

Appendix 6

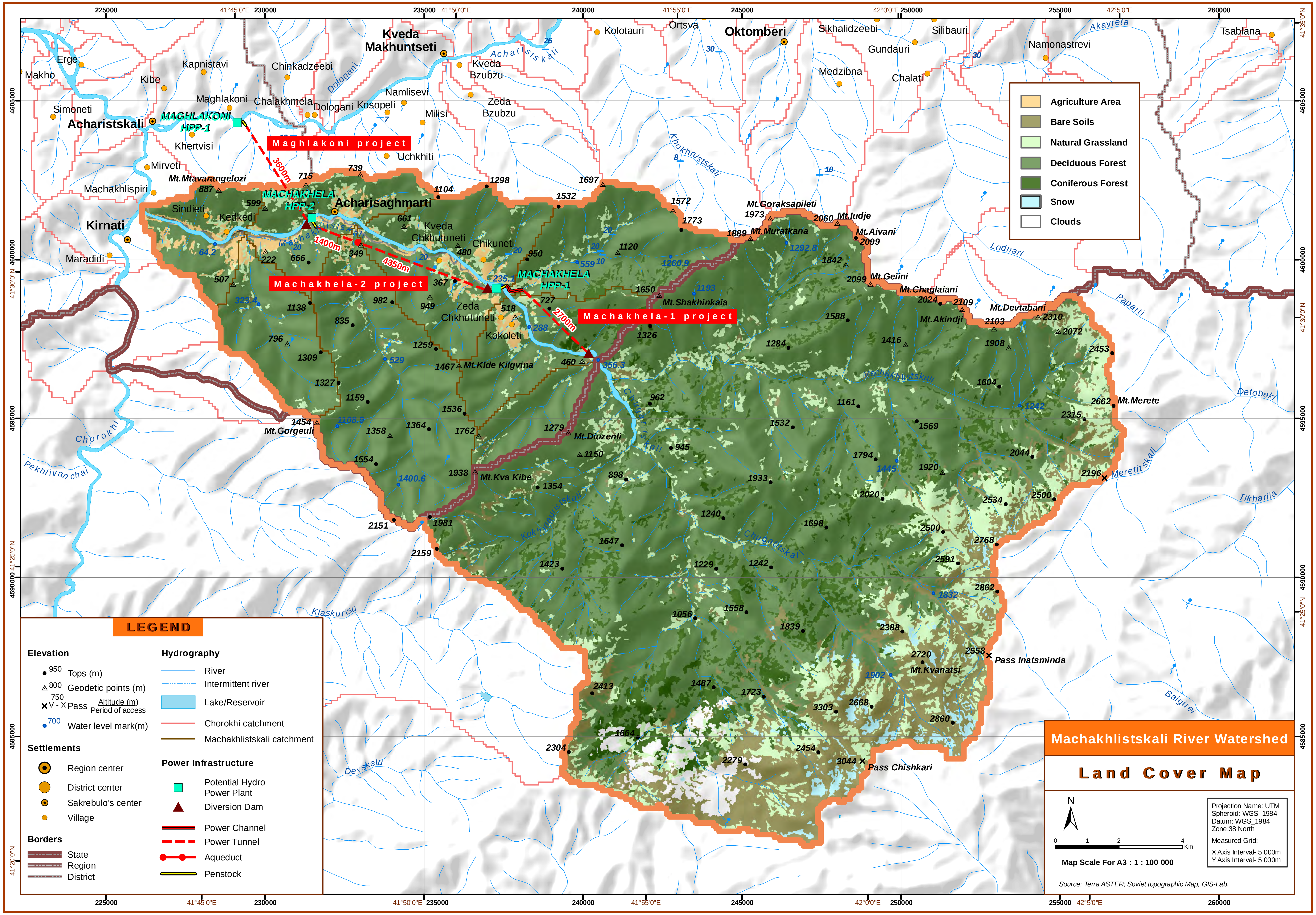
Annual Precipitation Map



Machakhlistskali River Watershed
Mean Annual Precipitation
Annual Precipitation (mm)
1462- 1494
1494- 1517
1517- 1535
1535- 1548
1548- 1558
1558- 1571
1571- 1588
1588- 1612
1612- 1644
1644- 1687
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level mark(m)
Settlements
Region center
District center
Sakrebulo's center
Village
Borders
State
Region
District
Hydrography
River
Intermittent river
Lake/Reservoir
Chorokhi catchment
Machakhlistskali catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Power Channel
Power Tunnel
Aqueduct
Penstock
Maghlakoni project
Machakhela-2 project
Machakhela-1 project
MAGHLAKONI HPP-1
MACHAKHELA HPP-2
MACHAKHELA HPP-1
3600m
1400m
4350m
2700m
Acharistskali
Kirnati
Acharisaghmarti
Kveda Makhuntseti
Oktomberi
Machakhlistskali
Chugatistskali
Kokhinauristskali
Chorokhi
Mt.Gorgeuli
Mt.Kva Kibe
Mt.Kide Kilgvina
Mt.Diuzenli
Mt.Shakhinkaia
Mt.Muratkana
Mt.Goraksapileti
Mt.Iudje
Mt.Aivani
Mt.Gerini
Mt.Chaglaiani
Mt.Akindji
Mt.Devtabani
Mt.Merete
Mt.Kvanatsi
Mt.Mtavarangelozi
Pass Inatsminda
Pass Chishkari
Map Scale For A3 : 1 : 100 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval- 5 000m
Y Axis Interval- 5 000m
Source: Georgian National Atlas,1964; Soviet topographic Map; GIS-Lab.

Appendix 7

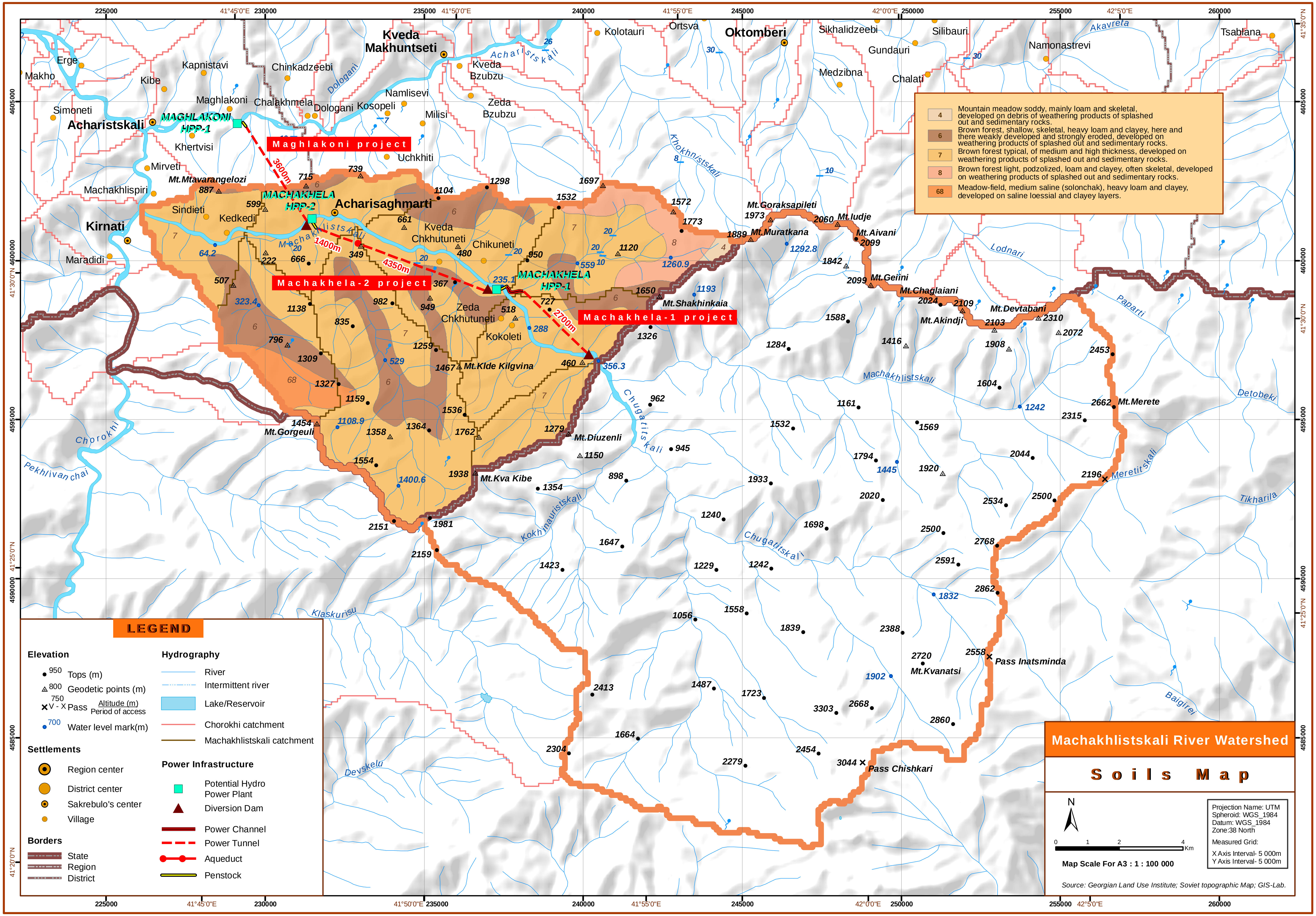
Land Cover Map



Machakhlistskali River Watershed
Land Cover Map
Agriculture Area
Bare Soils
Natural Grassland
Deciduous Forest
Coniferous Forest
Snow
Clouds
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level mark(m)
Settlements
Region center
District center
Sakrebulo's center
Village
Borders
State
Region
District
Hydrography
River
Intermittent river
Lake/Reservoir
Chorokhi catchment
Machakhlistskali catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Power Channel
Power Tunnel
Aqueduct
Penstock
Maghlakoni project
Machakhela-2 project
Machakhela-1 project
MAGHLAKONI HPP-1
MACHAKHELA HPP-2
MACHAKHELA HPP-1
3600m
1400m
4350m
2700m
Kveda Makhuntseti
Oktomberi
Acharistskali
Acharisaghmarti
Kirnati
Acharistskali
Machakhlistskali
Chorokhi
Chugatistskali
Khokhnistskali
Kokhnaulistskali
Meretitskali
Akavreta
Lodnari
Paparti
Detobeki
Tikharila
Baigirei
Klaskurisu
Devskelu
Pekhlivan chai
Dologani
Mt.Gorgeuli
Mt.Kva Kibe
Mt.Kide Kilgvina
Mt.Diuzenli
Mt.Shakhinkaia
Mt.Goraksapileti
Mt.Muratkana
Mt.Iudje
Mt.Aivani
Mt.Geini
Mt.Chaglaiani
Mt.Akindji
Mt.Devtabani
Mt.Merete
Mt.Kvanatsi
Mt.Mtavarangelozi
Pass Inatsminda
Pass Chishkari
N
0 1 2 4 Km
Map Scale For A3 : 1 : 100 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval- 5 000m
Y Axis Interval- 5 000m
Source: Terra ASTER; Soviet topographic Map, GIS-Lab.

Appendix 8

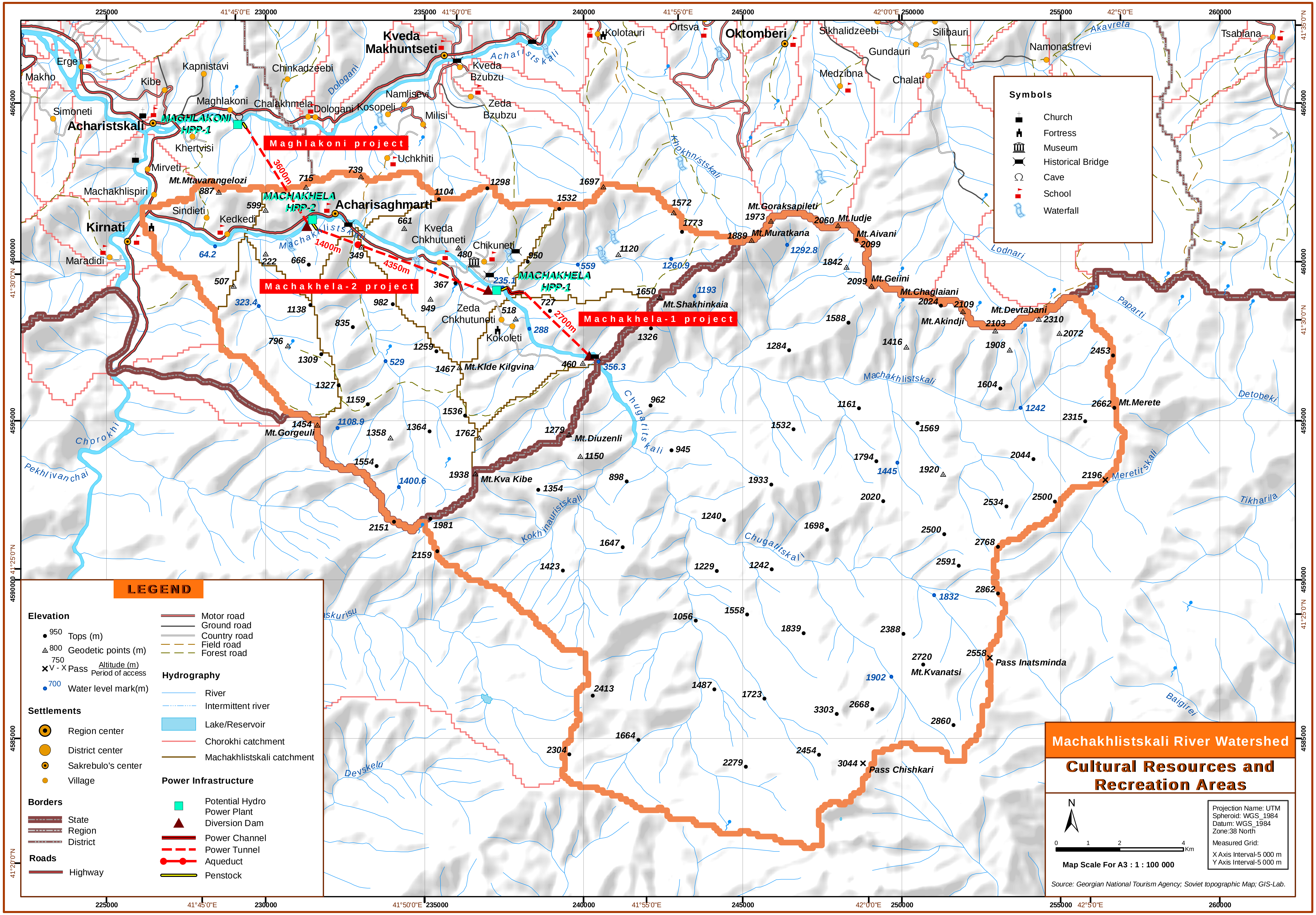
Soils Map



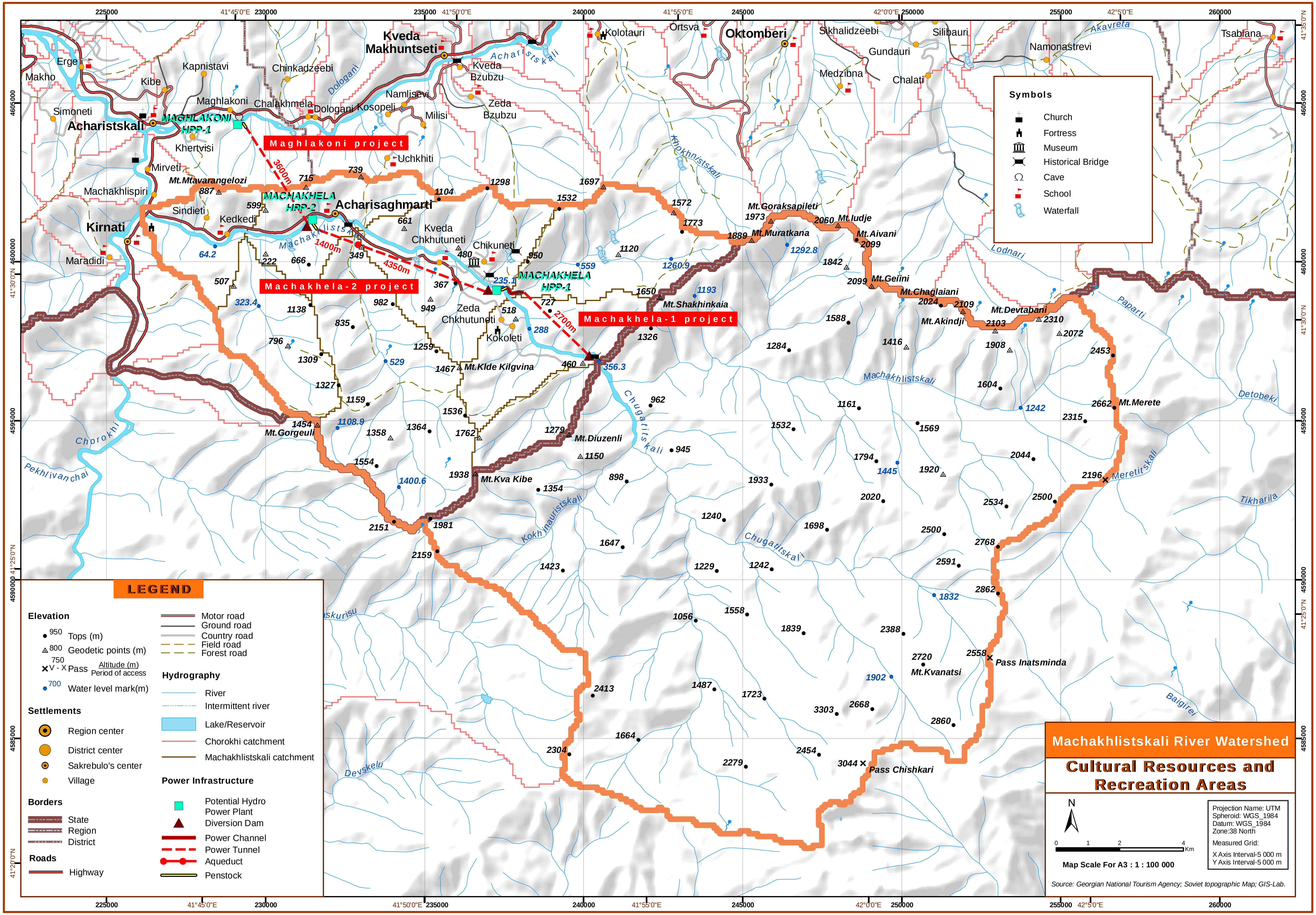
Machakhlistskali River Watershed
Soils Map
4 Mountain meadow soddy, mainly loam and skeletal, developed on debris of weathering products of splashed out and sedimentary rocks.
6 Brown forest, shallow, skeletal, heavy loam and clayey, here and there weakly developed and strongly eroded, developed on weathering products of splashed out and sedimentary rocks.
7 Brown forest typical, of medium and high thickness, developed on weathering products of splashed out and sedimentary rocks.
8 Brown forest light, podzolized, loam and clayey, often skeletal, developed on weathering products of splashed out and sedimentary rocks.
68 Meadow-field, medium saline (solonchak), heavy loam and clayey, developed on saline loessial and clayey layers.
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level mark(m)
Settlements
Region center
District center
Sakrebulo's center
Village
Borders
State
Region
District
Hydrography
River
Intermittent river
Lake/Reservoir
Chorokhi catchment
Machakhlistskali catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Power Channel
Power Tunnel
Aqueduct
Penstock
Maghlakoni project
Machakhela-2 project
Machakhela-1 project
MAGHLAKONI HPP-1
MACHAKHELA HPP-2
MACHAKHELA HPP-1
3600m
1400m
4350m
2700m
Acharistskali
Kirnati
Acharisaghmarti
Kveda Makhuntseti
Oktomberi
Machakhlistskali
Chorokhi
Chugatistskali
Pass Inatsminda
Pass Chishkari
Mt.Kvanatsi
Mt.Merete
Mt.Gorgeuli
Mt.Kva Kibe
Mt.Klde Kilgvina
Mt.Diuzeni
Mt.Shakhinkaia
Mt.Mtavarangelozi
N
0 1 2 4 Km
Map Scale For A3 : 1 : 100 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval- 5 000m
Y Axis Interval- 5 000m
Source: Georgian Land Use Institute; Soviet topographic Map; GIS-Lab.

Appendix 9

Cultural Resources & Recreation Areas



Machakhlistskali River Watershed
Cultural Resources and Recreation Areas
LEGEND
Elevation
950 Tops (m)
800 Geodetic points (m)
750 V - X Pass Altitude (m) Period of access
700 Water level mark(m)
Settlements
Region center
District center
Sakrebulo's center
Village
Borders
State
Region
District
Roads
Highway
Motor road
Ground road
Country road
Field road
Forest road
Hydrography
River
Intermittent river
Lake/Reservoir
Chorokhi catchment
Machakhlistskali catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Power Channel
Power Tunnel
Aqueduct
Penstock
Symbols
Church
Fortress
Museum
Historical Bridge
Cave
School
Waterfall
Maghlakoni project
Machakhela-2 project
Machakhela-1 project
MAGHLAKONI HPP-1
MACHAKHELA HPP-2
MACHAKHELA HPP-1
3600m
1400m
4350m
2700m
Acharistskali
Kirnati
Acharisaghmarti
Oktomberi
Kveda Makhuntseti
Erge
Makho
Kibe
Kapnistavi
Chinkadzeebi
Simoneti
Maghlakoni
Chalakhmela
Dologani
Kosopeli
Namlisevi
Milisi
Kveda Bzubzu
Zeda Bzubzu
Khertvisi
Uchkhiti
Mirveti
Mt.Mtavarangelozi
Machakhlispiri
Sindieti
Kedkedi
Maradidi
Kveda Chkhutuneti
Chikuneti
Zeda Chkhutuneti
Kokoleti
Mt.Klde Kilgvina
Mt.Gorgeuli
Mt.Kva Kibe
Mt.Diuzenli
Kolotauri
Ortsva
Sikhalidzeebi
Gundauri
Medzibna
Chalati
Silibauri
Namonastrevi
Tsablana
Mt.Goraksapileti
Mt.Muratkana
Mt.Iudje
Mt.Aivani
Mt.Gelini
Mt.Chaglaiani
Mt.Akindji
Mt.Devtabani
Mt.Shakhinkaia
Mt.Merete
Mt.Kvanatsi
Pass Inatsminda
Pass Chishkari
Acharistskali
Dologani
Khokhnistskali
Machakhlistskali
Chugatistskali
Kokhinauristskali
Chorokhi
Pekhlivanchai
Lodnari
Paparti
Detobeki
Meretitskali
Tikharila
Baigirei
Akavreta
Devskelu
N
0 1 2 4 Km
Map Scale For A3 : 1 : 100 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-5 000 m
Y Axis Interval-5 000 m
Source: Georgian National Tourism Agency; Soviet topographic Map; GIS-Lab.



Machakhlistskali River Watershed
Cultural Resources and Recreation Areas
LEGEND
Elevation
Tops (m)
Geodetic points (m)
Pass Altitude (m) Period of access
Water level mark(m)
Settlements
Region center
District center
Sakrebulo's center
Village
Borders
State
Region
District
Roads
Highway
Motor road
Ground road
Country road
Field road
Forest road
Hydrography
River
Intermittent river
Lake/Reservoir
Chorokhi catchment
Machakhlistskali catchment
Power Infrastructure
Potential Hydro Power Plant
Diversion Dam
Power Channel
Power Tunnel
Aqueduct
Penstock
Symbols
Church
Fortress
Museum
Historical Bridge
Cave
School
Waterfall
Maghlakoni project
Machakhela-2 project
Machakhela-1 project
MAGHLAKONI HPP-1
MACHAKHELA HPP-2
MACHAKHELA HPP-1
Acharistskali
Kirnati
Acharisaghmarti
Kveda Makhuntseti
Oktomberi
Machakhlistskali
Chugatistskali
Chorokhi
Map Scale For A3 : 1 : 100 000
Projection Name: UTM
Spheroid: WGS_1984
Datum: WGS_1984
Zone:38 North
Measured Grid:
X Axis Interval-5 000 m
Y Axis Interval-5 000 m
Source: Georgian National Tourism Agency; Soviet topographic Map; GIS-Lab.

Appendix 10

Environmental and social impacts Significant Data

Appendix 10: Description of Tables

This appendix presents a tabular summary of potential environmental and social receptor impacts from the development of a hydropower project. These tables are based on the "EU Strategic Environmental Assessment Principles" that uses a subset of categories developed that best fits this level of analysis (Ref: http://ec.europa.eu/environment/eia/home.htm). Sections 2 and 3 and Section 6 of this document present a description of environmental and social baseline conditions. Section 6.2 presents environmental and social impacts and mitigation practices for each impacted receptor. The tables include a range of qualitative values for impacts and recommendations for mitigation practices that are considered standards of practice today. This prefeasibility report does not go into any detail with respect to recommended mitigation practices and should be used as a guideline with respect to the types of practice to be incorporated during a feasibility study for the different phases of the project (construction or operations. Decommissioning has not been included at this time).

The table column headers are described as follows:

Column 1: Receptors

Receptors are the environmental and social category that an impact is evaluated for. For this prefeasibility report these include:

- Water Resources
    - Surface Water Resources
    - Surface Water Quality
    - Flood Risk
- Soils, Geology, and Landscape
- Air Quality
- Biodiversity
    - Terrestial Flora
    - Terrestial Fauna
    - Fisheries
- Community, Socio-Economic, and Public Health
    - Cultural and Historic Assets
    - Population
    - Recreation
    - Public Health

Receptors are evaluated with a Sensitivity level that is defined as follows:

Sensitivity of receptors, based on Value and Vulnerability

Classification	**Sensitivity Level**			
Vulnerability	**High (H)** e.g. potential pathways exist for environmental change in receptors as a result of project, receptor is in a declining condition, and/or dependent on a narrow range of environmental conditions	**Medium (M)** *e.g.* few pathways exist for environmental change in receptors as a result of project, receptor is only expected to recover from disturbance over a prolonged period of time, if at all, or impact potential is high but duration is short	**Low (L)** *e.g.* limited or no pathways exist for environmental change in receptors as a result of project, receptor is in stable or favorable condition &/ or dependent on wide range of environmental conditions	**None (N)** *e.g.* no pathways exist between environmental changes and receptors, receptor is insensitive to disturbance
Value	**High (H)** – receptor is rare, important for social or economic reasons, legally protected, of international or national designation	**Low (L)** – receptor is common, of local or regional designation		

Column 2: Impact
This column is a description of the effect on the receptors during each of the project phases, construction followed by operations.

Column 3: Duration
Duration is the expectation for the length of time an impact will occur to a given receptor. The following table displays the rating values for duration:

Guidelines for determining the period of the project lifecycle

	Duration of effect			
Classification	**Long Term (LG)**	**Medium Term (MD)**	**Short Term (SH)**	**Very Short Term (VSH)**
Guideline	10+ years	3-10 years	1-3 years	<12 months
Project phase	Operation	Operation	Construction (or part thereof)	Part of construction period

Column 4: Risk Level
Risk Level qualitatively addresses the exposure and vulnerability a receptor will have from the project or in some cases how specific risks could cause the project to increase exposure and vulnerability to the receptor. An example of this is Seismic Risk as it pertains to Soils, Geology, and Landscape during each project phase. Risk level also includes whether the impact is Irreversible or Reversible and Temporary or Permanent. The following displays the rating values for Risk Level:

Risk Level Rankings Definitions and Description

Risk Level	Description
Very Low (VL)	Rarely occurs, and/or of very low magnitude, and/or rarely causes significant loss or life or property damage
Low (L)	Can occur during the life of the project, and/or can be of modest magnitude, and/or rarely causes loss of life but can cause property some damage
Medium (M)	Occurs several or more times during the life of a project, and/or of significant magnitude, and/or can cause some loss of life and significant property damage
High (H)	Occurs often or on a regular basis and/or of a very high magnitude, and/or causes large loss of life and major property damage
Irreversible	Impact causes irreversible change to the receptor
Reversible	Impact causes reversible changes to the receptor
Temporary	Impact is of a temporary nature and receptor will return to original conditions after activity concludes
Permanent	Impact from activity is permanent changing the original receptor conditions to a new state.

Column 5: Mitigation Practices

Mitigation practices are guidelines and recommendations for a type of prevention activity that will reduce impacts to a receptor, provide necessary data and information for decisions during a project phase, provide heath and safety guidelines, and environmental prevention practices to minimize impacts to the receptors.

Table-1 Affected Environmental Impacts and Proposed Mitigation Measures Environmental Receptor Category: Water Resources

Water Resources				
Receptors (Vulnerability (H, M, L, None) and Value (H, L)	**IMPACT (Description of effect)**	**Duration (occurs during construction, operation or decommissioning phase and LG/MD/SH/VSH term) and frequency**	**Risk Level (VL, L, M, H, and Irreversible/ reversible; temporary/ permanent**	**Mitigation Practices**
Surface Water Resources (quantity) M/L	**Construction Phase (HPP and Transmission Facility)**: • Altered surface runoff contribution to water courses and ditches, etc as a result of land disturbance • Temporary Diversion of River away from Dam and intake structure • Large construction/tunnel volume debris disposal • Construction of the dam will create a small permanent reservoir changing natural river conditions.	SH SH SH LG	VL/R/T VL/R/T VL/R/T L/IR/P	Very high sediment and bed load transport by upper river. Assume site preparation include in-water, bank side, and/or adjacent property. River flow and river channel may be temporarily redirected for site construction. Well understood process. Few if any uncertainties, assume runoff controls and spill prevention plans and monitoring are included in construction. Locate area for construction debris that can contribute to generation of usable land in the future.
--------------------------- M/L	-- **Operation Phase:** Effects on surface water resources during facility operations	------------------------------ LG	----------------------------------- L/R/T	--- Run of river hydropower operations returns all diverted flow used for generation to the receptor river. Long penstock facilities must meet appropriate receptor guidelines for bypass flows as required.
Surface Water Quality M/L	**Construction Phase(HPP and Transmission Facility)**: • Altered surface runoff water quality to water courses and ditches, etc as a result of land	SH SH	VL/R/T VL/R/T	Very high sediment and bed load transport by upper river. Assume site preparation can include in-water, bank side, and/or adjacent property. River flow and river channel may be temporarily redirected for site construction. Well understood process. Few if any

 ------------------------- M/L	disturbance • Temporary Diversion of River away from Dam and intake structure --- **Operation Phase:** effects on surface water resources during facility operations	 ---------------------------- LG	 ------------------------------------ L/R/T	uncertainties, assume runoff controls and spill prevention plans and monitoring are included during construction. -- Run of river hydropower operations returns all diverted flow used for generation to the receptor river. Long penstock facilities must meet appropriate receptor guidelines for bypass flows as required.
Flooding Risk M/L ------------------------ M/L	**Construction Phase (HPP and Transmission Facility):**Increase to flood discharge from failure of dam during construction --- **Operations Phase:** Prevent failure of dam and other project components in the event of a flood that would severely increase the impact from the flooding event	VSH ------------------------------ VSH	L/R/T ------------------------------------- M/R/T	• Construction to adhere to all design requirements. • Dispose of large volumes of construction debris in locations that will not increase flood levels, or impact floodplain negatively • Design to address appropriate levels of Flood Risk in planning construction phase. • Monitoring of river discharge upstream on main stem and significant tributaries (flash flood warning) • Emergency Evacuation Plan developed • Emergency site shut down plan to be developed. -- Insure all facilities are operating correctly including, spillway gates, trash racks, and shut off gates (tunnel and powerhouse), etc. Monitor Dam for seepage, leaks, and structural integrity. Monitor Tunnel for leaks and structural integrity Prepare Emergency operations plan that includes flooding events Prepare Emergency shut down and evacuation plan.

Table-2 Affected Environmental Impacts and Proposed Mitigation Measures Environmental Receptor Category: Soils, Geology, and Landscape

Soils, Geology and Land Use				
Receptor s	**IMPACT (Description of effect)**	**Duration LG/MD/SH/VSH term)**	**Risk Level (VL, L, M, H, and Irreversible/ reversible; temporary/ permanent**	**Mitigation Practices**
Soils, Geology, Landscape **(Vulnerability (H, M, L, None) and Value (H, L)** H/L ----------------------------- H/L	**Seismic Risk** **Construction Phase (HPP and Transmission Facility)**: Impacts on infrastructure and public due to seismic activity --- **Operation Phase**: Impacts on infrastructure and public due to seismic activity that causes HPP to fail	VSH --------------------------------- VSH	H/R and IR/T and P depending on seismic characteristics --------------------------------------- H/R and IR/T and P depending on seismic characteristics	Well understood process. The project structures to be built in the area have to have appropriate design specifications which are in line with the national and international standards. Severe activity can lead to failure, flooding, property damage and loss of human life. Emergency site shut down and Evacuation plans should be included in construction management planning. --- Well understood process but magnitude is unknown. Severe seismic activity can lead to failure, flooding, property damage and loss of human life downstream of HPP. Emergency site shut down and Evacuation plans downstream should be included in HPP Operations Plan
Soils, Geology, and Landscape **(Vulnerability (H, M, L, None) and Value (H, L)** H/L	**Landslides and Mudslides** **Construction Phase (HPP and Transmission Facility)**: Improper stockpiling of materials, poor siting, of storage and lay down areas, blasting activities and/or destruction of vegetation cover could increase receptor impacts if land slide or mud slide occurs at HPP site or upstream.	VSH	M/R/T	Erosion and sediment control plan (includes issues like: proper site siting and engineering design based on best management practices, accumulated sediment disposal plan, grading and smoothing steep slopes, re-vegetation activities etc) at national and international standards should be developed. Emergency shut down and Evacuation plans should be developed to protect receptors, property, and human life. Early Warning Monitoring to include Weather and watershed and upslope areas from HPP site and

				known land slide and mud slide locations Proper scheduling of construction activities Monitoring of vibration from construction equipment (and blasting activities)
---------------------------- H/L	-- **Operation Phase:** Minimize increasing the impacts from this natural occurrence from HPP operations	------------------------------ SH	-------------------------------------- L/R/T	-- Monitoring site conditions on a regular basis; implementation of pre-prepared emergency shut down and Evacuation plans ; Monitoring of Early Warning system
Soils, Geology, and landscape **(Vulnerability (H, M, L, None) and Value (H, L)** M/H	**Visual impact on landscape Construction Phase (HPP and Transmission Facility)**: Visual impact is important in this mountainous setting and impacts to this receptor are significant. Construction activities may cause visual disturbance of landscape (new project units (e.g. dam, powerhouse) will be constructed. Construction activities may cause removal of vegetation cover, changes in land use pattern. Waste generation due to construction activities may create visual impact on landscape as well as impact on land. Management and disposal of construction debris	SH	VL/R/T	Proper storage and utilization of topsoil and excavation materials. Restoration of soil cover, re-vegetation and reforestation activities to national and international standards Proper scheduling of construction activities. Develop construction management plan. Development appropriate waste management plan which includes management of solid, liquid, hazardous waste material and are in line with national and international environmental regulations. Construction debris should be disposed of according to current accepted practice, local and national laws. Where possible use construction in a sustainable manner that provides opportunities for agriculture, local industry, and does not impact local floodplain
-------------------- M/H	-- **Operation Phase:** No more additional alterations of landscape are expected during the operation phase. Water body such as impoundment may be considered to create pleasant scenery.	--------------------------------- SH	-------------------------------------- VL/R/P	-- Monitoring the landscape restoration activities.

Table-3 Affected Environmental Impacts and Proposed Mitigation Measures Environmental Receptor Category: Air Quality

Air Quality				
Receptor s	**IMPACT (Description of effect)**	**Duration LG/MD/SH/VSH term)**	**Risk Level (VL, L, M, H, and Irreversible/ reversible; temporary/ permanent**	**Mitigation Practices**
Air Quality **(Vulnerability (H, M, L, None) and Value (H, L)** **L/H**	**Construction Phase (HPP and Transmission Facility)**: Construction activities may increase the level of emission in the air and dust, especially under windy conditions.	SH	L/R/T	Well understood process. Air management plan should be developed, which includes activities like construction machinery maintenance scheduling, Exhaust gas quality, water spray on construction site to minimize dust, checking construction equipment and/or benzene quality etc.
-----------------------------	--	---------------------------------	---------------------------------------	--
L/L	**Operation Phase:** During operation there would not be any significant emission level.	VSH	VL/R/T	Ensuring compliance with air management plan, emergency generator exhaust controls.

Table -4 Affected Environmental Impacts and Proposed Mitigation Measures Environmental Receptor Category: Biodiversity

Biodiversity				
Receptor s	**IMPACT (Description of effect)**	**Duration LG/MD/SH/VSH term)**	**Risk Level (VL, L, M, H, and Irreversible/ reversible; temporary/ permanent**	**Mitigation Practices**
Terrestrial flora **(Vulnerability (H, M, L, None) and Value (H, L)** **L/L** **----------------------------** **L/L**	**Construction Phase (HPP and Transmission Facility)**: Project might have following primary and secondary impacts on the terrestrial flora: • Construction of HPP, new roads and/or Transmission lines may cause removal of vegetation (forests, topsoil); • Alien species invading the existing ecosystem; -- **Operation Phase:** There would be minor or no impact on flora during the operation phase	MD -------------------------------- VSH	M/R/T --------------------------------------- VL/R/P	Well understood process. Restoration and reinstatement of soil cover; re-vegetation and/or reforestation activities. --- Monitoring restoration activities.
Terrestrial fauna **(Vulnerability (H, M, L, None) and Value (H, L)** **L/L**	**Construction Phase (HPP and Transmission Facility)**: Project might have following primary and secondary impacts on the terrestrial fauna: • Disruption of sites of breeding and sheltering; • Animal mortality due to construction activities (e.g. accidents and/or mortality of birds due to Transmission lines) • Alien species invading the existing ecosystem;	MD	M/R/T	Wildlife management plan should be developed. Noise management plan. Proper scheduling of construction activities; Monitoring of vibration and blasting activities from construction equipment

 ----------------------------- **L/L**	• number of equipments and/or possible blasting activities may cause the increase the noise/vibration level during the construction process, which may disturb wildlife (affect species behaviour) --- **Operation Phase:** Impacts affecting fauna elements during operation are: • Ecological barrier effect (movement is disabled or hindered • Mortality of animals on roads; • Mortality of birds on power lines	 --------------------------------- VSH	 -------------------------------------- VL/R/P	 --- Implementing and monitoring the wildlife management plan.
Fishery **(Vulnerability (H, M, L, None) and Value (H, L)** **L/L** ----------------------------- **L/L**	**Construction Phase HPP**: Impact on fish species due to construction in the riverbed and altering the river flow through temporary diversion channel, and blasting activities. --- **Operation Phase:** Impacts on fish species due to diverting river flow to the powerhouse (mortality fish species in the turbines/generators). Exposure of bypass section of river to very low to no flow.	MD --------------------------------- MD	M/R/T --------------------------------------- M/R/T	Installing fish protecting/screening facilities at the entrance of the HPP feeding tunnels/channels. Scheduling of construction activities. Avoiding the stock piling in the riverbed. Proper scheduling of construction activities; Monitoring of vibration and blasting activities from construction equipment --- Well understood process. Permanent monitoring of sanitary water flow; compliance with environmental and in-stream flow requirements with monitoring.

Table-5 Affected Environmental Impacts and Proposed Mitigation Measures Environmental Receptor Category: Cultural Resources

Cultural Resources and Recreation				
Receptor s	**IMPACT (Description of effect)**	**Duration LG/MD/SH/VSH term)**	**Risk Level (VL, L, M, H, and Irreversible/ reversible; temporary/ permanent**	**Mitigation Practices**
Cultural and historic assets **(Vulnerability (H, M, L, None) and Value (H, L)** L/H	**Construction Phase HPP and Transmission Facility)**: There are no archaeological and/or cultural heritage sites in the vicinity of the projects. However, during construction works they might occur. Archaeological objects should be protected from damage.	VSH	H/IR/T	Identifying historical and cultural assets. Development of noise and construction management plan. Proper scheduling of construction activities Monitoring of vibration from construction equipment and blasting activities.
L/H	**Operation Phase:** No damage on archaeological/cultural resources is expected from operational phase. Small reservoir behind dam may provide new opportunities for recreational activities	VSH	VL/R/P	N/A

Table-6 Affected Environmental Impacts and Proposed Mitigation Measures Environmental Receptor Category: Community, Socio-Economic and Public Health

Community, Socio-Economic and Public Health				
Receptor s	**IMPACT (Description of effect)**	**Duration (LG/MD/SH/VSH term)**	**Risk Level (VL, L, M, H, and Irreversible/ reversible; temporary/ permanent**	**Mitigation Practices**
Agricultural Land **(Vulnerability (H, M, L, None) and Value (H, L)** M/H	**Construction Phase (HPP and Transmission Facility)**: Impact associated with land acquisition and thereby loss of agricultural land, which may cause loss of income earning means; disposal of debris; limit access to agricultural property	MD	M/R/P	Develop compensation mechanism for occupied agricultural land.; coordinate construction activities to minimize impacts to agricultural properties, appropriate selection of disposal areas, materials storage areas;, Monitoring the implementation of compensation scheme
M/H	**Operation Phase:** New infrastructure (e.g. access roads) may positively impact on local population, provide better access to markets for agricultural products	LG	M/R/P	N/A
Population **(Vulnerability (H, M, L, None) and Value (H, L)** L/H	**Construction Phase (HPP and Transmission Facility)**: Machinery and/or possible blasting activities may cause the increase the noise/vibration level during the construction process, Construction activities cause traffic delays, which affect local population within the vicinity of project. New job opportunities and economic benefits to community	SH	M/R/T	Well understood process. Noise management plan Blast warning plan for construction crews and local residents. Proper scheduling of construction activities Monitoring of vibration from construction equipment (and blasting activities)
L/H	**Operation Phase**: The noise/vibration source during the operation will be generators and turbines located in the powerhouse. Since they are located in the close	N/A	N/A	N/A

	building, it will have not any considerable nuisance.			
Recreation (Vulnerability (H, M, L, None) and Value (H, L) **M/H** **----------------------------** **M/H**	**Construction Phase (HPP and Transmission Facility)**: Visual impact due to construction; activities may impact recreation in the region. Waste generation due to construction activities may create visual impact. Delay or prevent access to recreational locations --- **Operation Phase:** New reservoir and new infrastructure (e.g. better roads) may positively impact on recreational activities	MD -------------------------------- LG	M/R/T -------------------------------------- VL/R/P	Proper scheduling of construction activities. Develop construction management plan. Development appropriate waste management plan which includes management of solid, liquid, hazardous waste management and are in line with national and international environmental regulations. Provide construction schedules and coordinate with recreational locations to minimize access issues for visitors. -- Operations practice should coordinate with recreational activities so as to assure safe access (fishing), adequate water in bypass channels to support in-stream activities, and provide access to river for such activities if project limits access.
Roads, Infrastructure, and Communities **(Vulnerability (H, M, L, None) and Value (H, L)** **L/H** **----------------------------** **L/H**	**Construction Phase (HPP and Transmission Facility)**: It is expected that during construction new access roads will be built. Loads on the existing roads will increase due to construction machinery. Traffic increase will affect Noise, Air Quality, community safety, and Public Health Receptors. Construction provides jobs and economic benefits to community --- **Operation Phase:** It is expected that during operational phase vehicular movement will be increased for maintenance, etc purposes. Consider community health, safety and security issues, as well as	MD -------------------------------- LG	L/R/T -------------------------------------- VL/R/P	Develop construction management plan that addresses materials delivery, storage, noise, and air quality issues that are sensitive to local communities and meet all Georgian environmental and legal requirements. Include job training for local population where appropriate. -- Develop traffic management plan with limited vehicular movement during operational phase. Ensure compliance with local and regional laws that effect the community

	Noise and Air Quality Receptors.			
Public Health **(Vulnerability (H, M, L, None) and Value (H, L)** **M/H** **-----------------------------** **L/H**	**Construction Phase (HPP and Transmission Facility)**: Construction activities might cause health impact to the workers (e.g. construction related accidents). Also see Air Quality, Population Receptors --- **Operation Phase:** Operational activities might cause health impact to the workers and/or local population.	MD ---------------------------------- MD	M/R/P -- M/R/P	Health and safety plan should be in line with national and international standards. Occupational health and safety measures should be identified and implemented. Necessary precautionary measures should be implemented in order to avoid and minimize risk of accidents (e.g. fire, flooding etc) --- Ensure compliance with health and safety plan

Public Awareness Workshop Report

TITLE: Machakhela HPP Public Awareness Workshop with the communities of Adjarisaghmarti, Khelvachauri region, Adjara autonomous republic.

DATE: 18.07.2011

VENUE: Machakhela Valley Secondary School Building

Speakers:

Giorgi Chikovani, HIPP Project, Deputy Chief of Party
Mariam Bakhtadze, HIPP Project Environmental Specialist, Deloitte,
Avtandil Lomiashvili, HIPP Project Engineer, Deloitte,

Facilitated by:

I. Iremashvili, HIPP Project, Outreach and Communication Manager

Background:

The United States Agency for International Development (USAID) through the Hydropower Investment Promotion Project (HIPP) supports development of a minimum 400 MW in new, run-of-the-river hydropower stations in Georgia. This project is managed by Deloitte Consulting. As part of this program, HIPP has identified a cluster of project sites along the Machakhela River. HIPP is now conducting pre-feasibility studies for two projects with a total capacity of 38.3 MW. These two HPP sites are on the River Machakhela in Khelvachauri region along village Chkhutuneti.

The HIPP team is preparing basic technical studies to evaluate the technical and economical feasibility of the projects. As part of this process, public awareness workshop was held in the Building of Adjarisaghmarti Public School with the communities of the Chkhutuneti, Kedkedi and all other villages situated in Machakhela Valley to ensure their involvement at the early planning stage, identify areas of community concern, and gather feedback from local residents.

The project profiles, HIPP information leaflet and special brochure on Machakhela HPP Cascade, also, USAID energy map were used as supportive documentation. Meeting agenda, list of participants and photos are attached to this document as illustrative materials. The text of the brochures distributed among Community members is also attached.

Aim of the Workshop:

- Increase awareness of local communities on small and medium run-of-the-river hydro power plans and promote their support to such activities;
- Inform local community the goal of the project and ensure their involvement at the early planning stage.
- Identify community concerns regarding the possible development of the project and gain their feedback; ensure positive attitude towards the project and increase cooperation perspectives between public and project developers.

Workshop Process:

The purpose of the meetings was to provide information and get the opinions of the locals related to the project. The date, place and the scope of these meeting was preliminary informed and agreed with Khelvachauri local government during HIPP team field visits. Meeting date and venue were agreed with local Municipalities; Public workshop was announced to all communities in Khelvachauri region by local municipality, written advertisements were made at Municipality Building. It was also announced at the Media Workshop organized by HIPP to local press representatives. HIPP team facilitated attendance of the Attorney of all Villages located in Machjakhela Valley on the workshop. Totally 25 community members were attending the workshop (attached see list of participants).

During the workshop HIPP team members provided information about the project in general, and discussed technical characteristics of the proposed HPP project as well as possible environmental and social impact. Issue that project will not create significant impoundment causing displacement of adjacent population was stressed during the workshop.

The HIPP team stressed the importance of public participation at early project design phase. Participants have been asked to express their opinion/attitude towards the project in general as well as impact on environment and socio-economic conditions of their household.

The municipality representatives mentioned a few considerations about the project impacts both environmental and socio-economic point of view.

Key issues/concerns raised by community members were as follows:

- Community members asked to consider Fish path in the project implementation works;

- In 1943, 1962 and 2002 great flashfloods took place on River Machakhela, which harmed agricultural bids, as well as the population. Community member are concerned about the possibility of such flashfloods and requested to consider the mitigation measures in the project;
- Local benefits of project; Community members were interested whether they could benefit from the low electricity tariffs;
- How the hydrological regime will be observed? Is there a risk of empting the river from water?
- Will the local community be able to influence on decision-making process of the project implementation? For instance, change certain component of the project.

CONCLUSIONS:

- The Machakhela public awareness workshop outcome is as follows:
- Community's attitude towards the project development is positive; Community members think they could benefit from development of project in case the project developers properly consider their concerns/suggestions and watershed characteristics. On the other hand, community members are willing to cooperate with HPP project developers. From operation of the HPP local population expects to receive new job opportunities;
- It was agreed that future development of the project would be further discussed with the community members.

Other Needs and Suggestions

For ensuring participatory attitudes and practices in HPP community it would be reasonable to contact the most active members of the community on a regular bases in parallel with the project development and inform them about possible environmental and social implications.

The table below shows the public awareness meeting in Adjaristsaghmarti Public School. (Machakhela Valley)

Table 1. *Pictures of the public awareness workshop*







Attachment A: Public Awareness Workshop Agenda

Public Awareness Meeting for Tskhenistskali HPP Cascade Project

Agenda

14 June, 2011, Alvani Secondary School Building

11:00–11:15	Registration		
	Introductions	**Moderator :**	**Duration**
11.15–11.20	Opening Remarks	HIPP/G. Chikovani	5 min
11:20–11:30	HIPP Project Descriptions	HIPP/A. Lomiashvili	10 min
11:30–12:00	HPP Project Outline	HIPP/A. Lomiashvili	30 min
12:00–12:20	Identified Environmental/Social Issues	HIPP/M. Bakhtadze	20 min
	Questions and Discussion		
12:20–13.45	Discussion • Socioeconomic Issues • Environmental Issues • Public Health & Safety Issues • Construction Issues	Facilitated by HIPP/I.Iremashvili	1 hour and 25 min
13:45–14:00	**Concluding Remarks**	HIPP/Local Municipality	15 min

Attachment B: Attendance list

Event	**Public Awareness Workshop on Machakhela HPP Cascade**	
Dates	18.07.2011	12.00-03.00 pm

First Name, Last Name	Position	Contact Details	Comment
1. Nodar Mortuladze	State Attorney of Machakhela Community	(877) 203870	
2. Qetevan Muakanadze	Teacher of Adjarisaghmarti Public School	(558) 420497	
3. Zhuzhuna Tsintsadze	Director of Adjarisaghmarti Public School	(577) 304211	
4. Roland Mskhaladze	Kedkedi Community Member	(558) 118416	
5. Nugzar Mopinadze	State Attorney of Scurdidi Community	(577) 203871	
6. Tengiz Vartsenadze	State Attorney of Adjarisaghmarti Community	(577) 203869	
7. Otar Mskhaladze	State Attorney of Kedkedi Community	(577) 203868	
8. Irina Tarieladze	Teacher of Adjarisaghmarti Public School	(593) 227952	
9. Zurab Nagervadze	Teacher of Adjarisaghmarti Public School	(599) 262792	
10. Akhmed Kakhnidze	Chkhutuneti Community Member	(555) 625170	
11. Severian Salvadze	Tskhemluri Community Member	(577) 203872	
12. Revaz Kakhidze	Chkhutuneti Community Member	(577) 203874	

13.	Valiko Basiladze	Chikuneti Community Member	(577) 203875	
14.	Tamaz Qoqoladze	Qhoqholeti Community Member	(577) 203876	
15.	Merab Putkaradze	Chkhutuneti Community Member	(558) 562109	
16.	Revaz Shashikadze	Teacher of Kedkedi Public School	(593) 390543	
17.	Vezir Nagervadze	Adjarisaghmarti Community Member	(593) 336598	
18.	Tengiz Kakhidze	State Attorney of Chkhutuneti Community	(577) 203873	
19.	Lamara Nagervadze	Teacher of Adjarisaghmarti Public School	(577) 304210	
20.	Guli Qatamade	Employee of Adjarisaghmarti Public School	(558) 377282	
21.	Tamila Partenadze	Manager, Adjarisaghmarti	(588) 182362	
22.	Ekaterine Mopidze	Housewife, Adjarisaghmarti	(598) 476088	
23.	Nadia Nagervadze	Nurse, Adjarisaghmarti	(593) 913517	
24.	Mindia Nagervadze	Adjarisaghmarti Community member	(593) 252409	
25.	Ilia Partsenadze	Adjarisaghmarti Community member	(593) 504830	

Attachment C: Text of the PAW Brochure on Machakhela HPP Cascade in English

General Description of Hydro Power Investment Promotion Project

By the request of Georgian Government, the United States Agency for International Development (USAID) has been supporting a three year Hydropower Investment Promotion Project (HIPP) since March, 2010. HIPP is implemented by the international consulting company Deloitte Consulting.

Georgia's hydropower potential is largely undeveloped. Currently only 25% of the country's total generation potential has been realized. The country has many rivers that can provide environmentally friendly, run-of-river hydropower projects with high annual plant factors, making them highly attractive to investors.

The goal of the HIPP initiative is to identify investment opportunities and incentivize investors resulting in private sector commitments to construct run-of-river hydropower plants – leading to increased generating capacity, locally produced energy, enhanced energy security, and the elimination of winter imports, greatly reducing the use of natural gas and other fuel sources for electricity production.

To stimulate and secure investment into Georgia's small-and medium-sized hydropower market, Deloitte/HIPP is working with local and international partners in all areas to promote awareness and investment in Georgia's hydropower resources. Key areas of activity include:

- Developing Quality Engineering and Technical Information;
- Providing Targeted and Effective Investor Outreach and Promotion;
- Supporting Institutional Strengthening and Capacity Building; and
- Partnering Programs and Opportunities to Stimulate Investment.

One of the proposed projects under HIPP involves construction of the cascade of two medium sized hydro power plants on the Machakhela River in Adjara region, Western Georgia.

Cascade of Machakhela Hydro Power Plants

General overview

The cascade of HPPs (**Machakhela 1 and Machakhela 2**) will be positioned south west of Kveda Chkhutuneti village, on the Machakhela River, which is characterized by high flows. The Machakhela River rises in the Turkish territory, in the western range of the Karchkhali Mountain and flows into the Chorokhi River by the right tributary. The Machakhelistskali River drains an area of 369 $km^{2.}$ The river is characterized by high flows in spring and autumn, with minimum water levels in winter. Mtirala National park is located within 15 km from the Cascade. Total arch area comprises 15,804 hectares and is in 14 km from Batumi–Tbilisi highway. The Mtirala Mountain is the heaviest precipitation mountain in the post Soviet area. Average annual precipitation index is above 2000 mm and on the sea-directed slope of the Mtirala Mountain the index exceeds 4000 mm.

Access roads, up to 7 km long in total, will be rehabilitated for the HPP construction purposes. Two 5-km-long transmission lines of 35 kV each will be built to transmit electricity generated at the Machakhela HPPs cascade.

1) **Machakhela 1 HPP** will be positioned to the south of Kveda Chkhutuneti village, on the Machakhela River. The HPP will be first stage in a cascade of two HPPs. According to the preliminary assessments, the 18-20 Megawatt (MW) run-of-river, tunnel derivation type Hydro

Power Plant can be built on the river. The site offers seasonally variable average annual generation of about 98 GWh, at a plant factor of about 65 percent.

2) **Machakhela 2 HPP** involves construction of a 16,5 Megawatt (MW) run-of-river, tunnel derivation type Hydro Power Plant (HPP) on the Machakhela River. The HPP will be positioned to the south of **Machakhela 1 HPP**. The HPP will be the second stage in a cascade of two HPPs (**Machakhela 1 and Machakhela 2**). The site offers seasonally variable average annual generation of about 86 GWh, at a plant factor of about 65 percent.

Expected Results

Implementation of the project will support the realization of Georgia's hydro potential. Machakhela HPPs Cascade will substantially increase power generation and help to raise the Country's energy security for a future with sustainable energy resources. Total hydroelectric generation of Machakhela HPP Cascade will amount to more than 35 MW. Realization of the project will create good opportunities for:

- selling electricity inside Georgia supplementing expensive thermal power during winter;
- exporting energy during non-winter months to take advantage of the seasonal differentials in power prices between Georgia and its neighboring countries;
- use of additional renewable energy source that will help to reduce local as well as global carbon oxide emissions to the atmosphere.

Local Community Benefits from Project Implementation

- Local labor forces will be employed during the construction period, as well as after commissioning of the Plant to carry out operations and maintenance works. Job creation will also help the community as most of the people will get training in their proficiencies.
- New high quality access roads will be constructed that will significantly improve the village infrastructure.
- Small gabions will result in more regular water flows in river bed and help minimize flooding.
- Increased reliability of electricity supply and improved energy quality.

PREPARED BY: Irina Iremashvili

APPROVED BY: Michael Jake Delphia, CoP

Appendix 11

Turbine Information

TURBNPRO Version 3 - FRANCIS TURBINE SOLUTION SUMMARY

Solution File Name: c:\georgi~1\hipphy~1\machak~1\machak~1\turbin~1\25c

TURBINE SIZING CRITERIA

Rated Discharge:	588.6	cfs	/	16.7	m3/s
Net Head at Rated Discharge:	426.5	feet	/	130.0	meters
Gross Head:	436.4	feet	/	133.0	meters
Site Elevation:	1148	feet	/	350	meters
Water Temperature:	68	Degrees F	/	20	Degrees C
Setting to Tailwater:	8.2	feet	/	2.5	meters
Efficiency Priority:			5		
System Frequency:			50 Hz		
Minimum Net Head:	426.5	feet	/	130.0	meters
Maximum Net Head:	436.4	feet	/	133.0	meters

FRANCIS TURBINE SOLUTION DATA

Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT
Intake Type: SPIRAL CASE
Draft Tube Type: ELBOW
Runner Diameter: 66.5 inches / 1690 mm
Unit Speed: 300.0 rpm
Multiplier Efficiency Modifier: 1.000
Flow Squared Efficiency Modifier: 0.0000

Specific Speed at Rated Net Head -	(US Cust.)	(SI Units)
At 100% Turbine Output:	25.1	95.7
At Peak Efficiency Condition:	24.0	91.4

SOLUTION PERFORMANCE DATA

At Rated Net Head of: 426.5 feet / 130.0 meters

% of Rated Discharge	Output (KW)	Efficiency (%)	cfs	m3/s
** 109.1	21060	90.8	642.3	18.2
100	19596	92.2	588.6	16.7
* 90.9	17904	92.6	535.1	15.2
75	14613	91.7	441.5	12.5
50	9016	84.8	294.3	8.3
25	3481	65.5	147.2	4.2
+ 47.4	8416	83.5	279.1	7.9

** - Overcapacity
* - Peak Efficiency Condition
+ - Peak Draft Tube Surging Condition

At Maximum Net Head of: 436.4 feet / 133.0 meters

Sigma Allowable	Max. Output (KW)	Efficiency (%)	cfs	m3/s
0.053	21763	90.8	648.8	18.4

At Minimum Net Head of: 426.5 feet / 130.0 meters

Sigma Allowable	Max. Output (KW)	Efficiency (%)	cfs	m3/s
0.053	21060	90.8	642.3	18.2

Solution File Name: c:\georgi~1\hipphy~1\machak~1\machak~1\turbin~1\25c

MISCELLANEOUS DATA

Maximum Runaway Speed (at Max. Net Head):	491 rpm	
Turbine Discharge at:		
Runaway Speed (at Rated Net Head & 100% gate):	263 cfs	7.5 m3/s
Synchronous Speed-No-Load (at Rated Net Head):	46 cfs	1.3 m3/s
Site's Atmospheric Pressure minus Vapor Pressure:	31.8 feet	9.7 meters
Sigma Allowable (at 100% Output & Rated Net Head):	0.040	
Sigma Plant (at 100% Output & Rated Net Head):	0.055	
Maximum Hydraulic Thrust (at Max. Net Head):	85486 lbs	38857 kg
Approximate Runner and Shaft Weight:	19840 lbs	9018 kg
Vel. at Draft Tube Exit (at Rated Head & Discharge):	3.5 fps	1.1 m/s

DIMENSIONAL DATA

Intake Type: SPIRAL CASE

	inches	mm
Inlet Diameter:	72.0	1829
Inlet Offset:	109.3	2776
Centerline to Inlet:	139.1	3532
Outside Radius A:	145.3	3690
Outside Radius B:	138.9	3528
Outside Radius C:	129.4	3286
Outside Radius D:	118.1	3000

Draft Tube Type: ELBOW

	inches	mm
Centerline to Invert:	214.4	5445
Shaft Axis to Exit Length:	319.4	8112
Exit Width:	199.6	5070
Exit Height:	119.8	3042

Shafting Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT

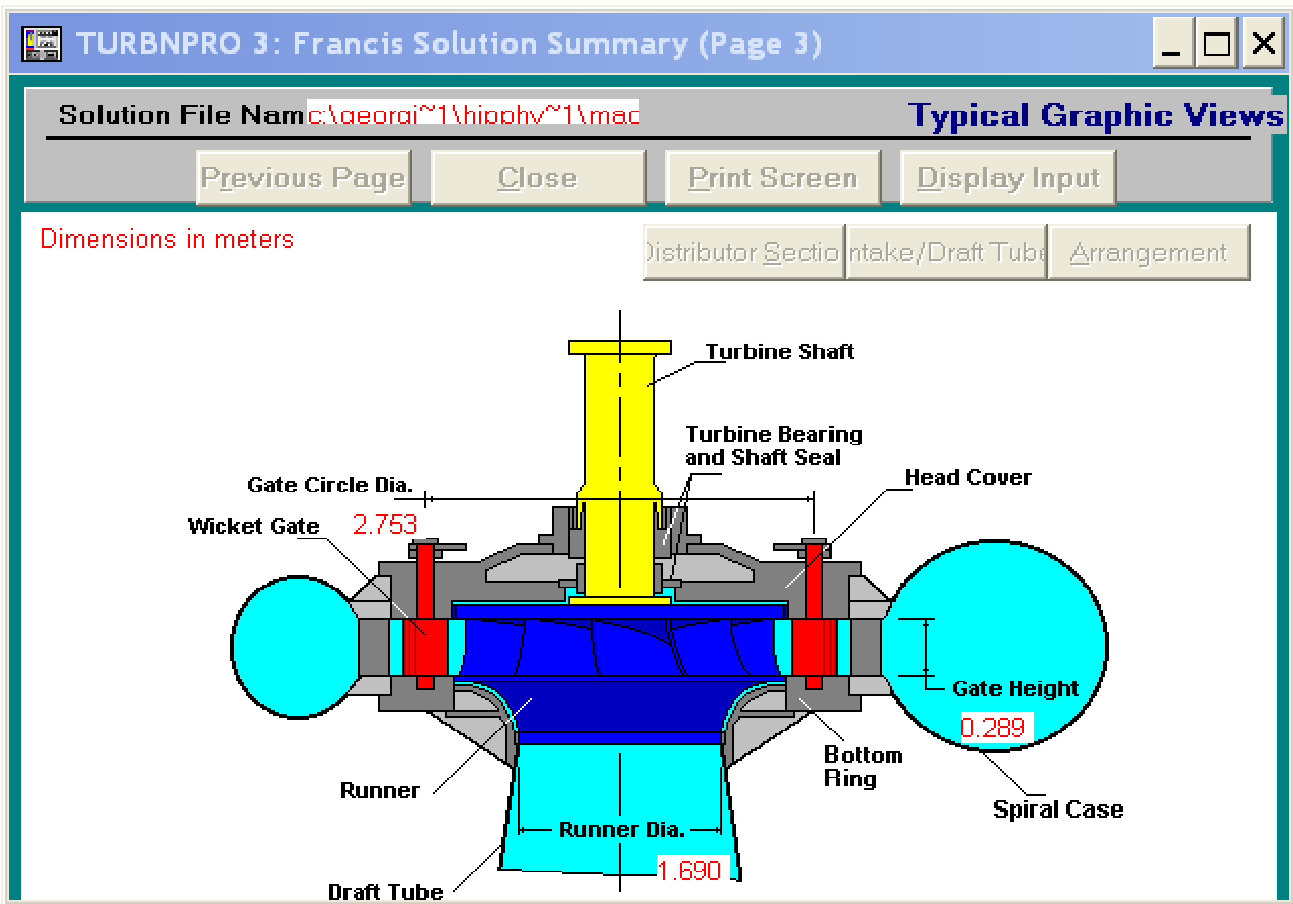
	inches	mm
Centerline to Shaft Coupling:	108.4	2753
Turbine Shaft Diameter:	19.4	492

Miscellaneous:

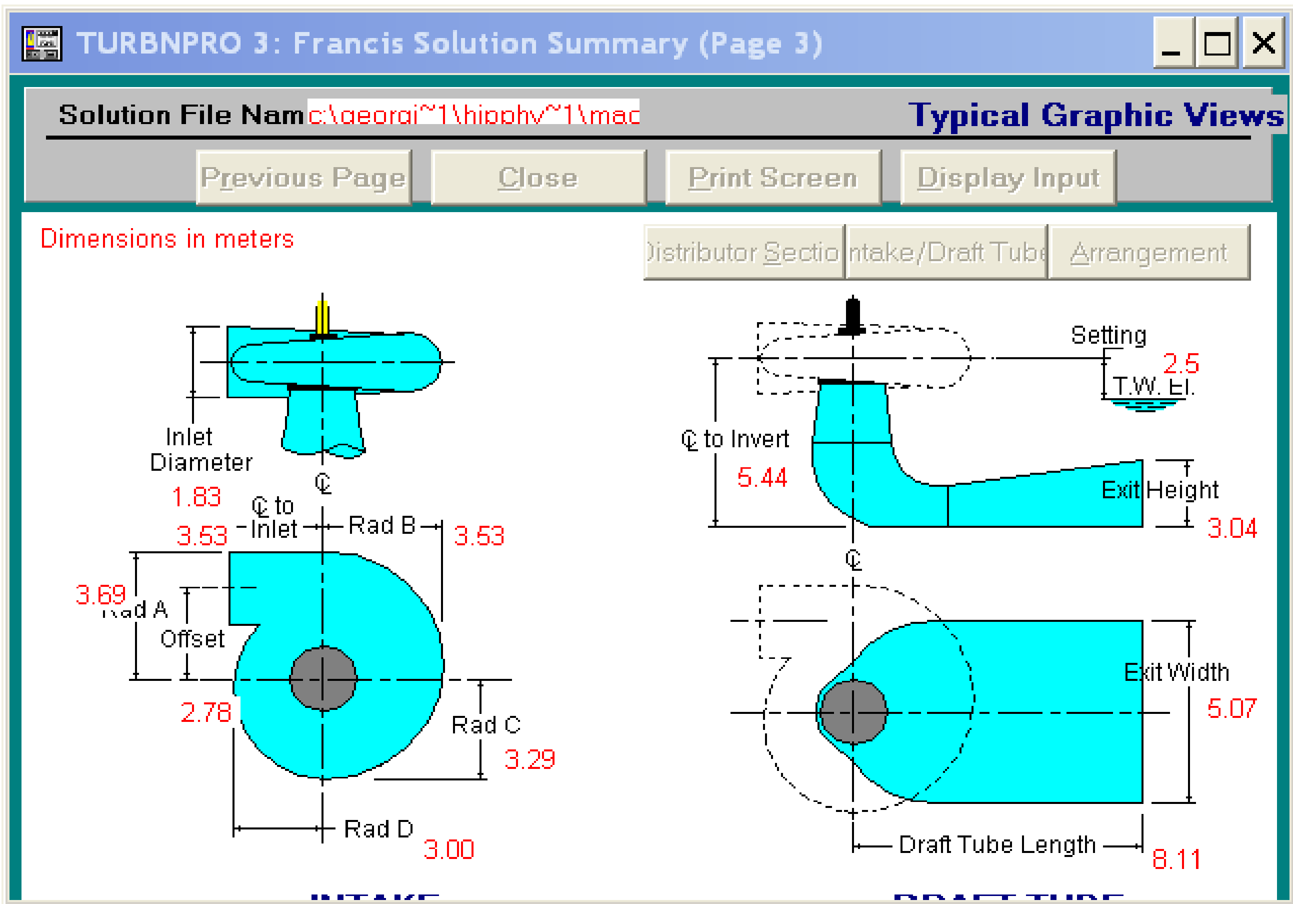
	inches	mm
Wicket Gate Height:	11.4	289
Wicket Gate Circle Diameter:	108.4	2753

**** All information listed above is typical only. Detailed characteristics will vary based on turbine manufacturer's actual designs.

```
Solution File Name: c:\georgi~1\hipphy~1\machak~1\machak~1\turbin~1\25cmsp~1\25m1-l2f.
Runner Diameter:                 1690   mm
Net Head at Rated Discharge:     130.00  meters
Unit Speed:                      300.0  rpm
```

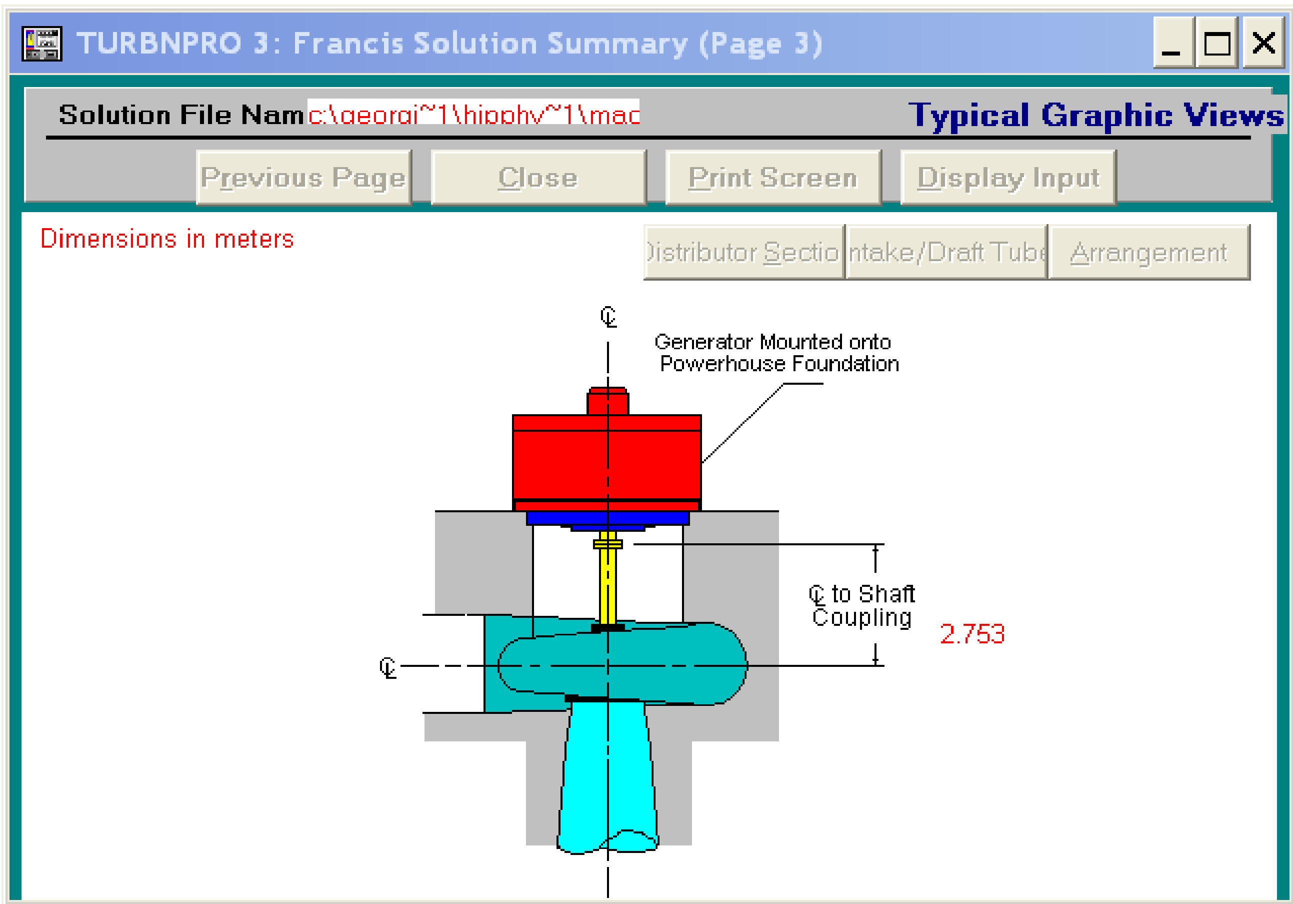


Solution File Name: c:\georgi~1\hipphy~1\machak~1\machak~1\turbin~1\25cmsp~1\25m1-l2f.
Runner Diameter: 1690 mm
Net Head at Rated Discharge: 130.00 meters
Unit Speed: 300.0 rpm



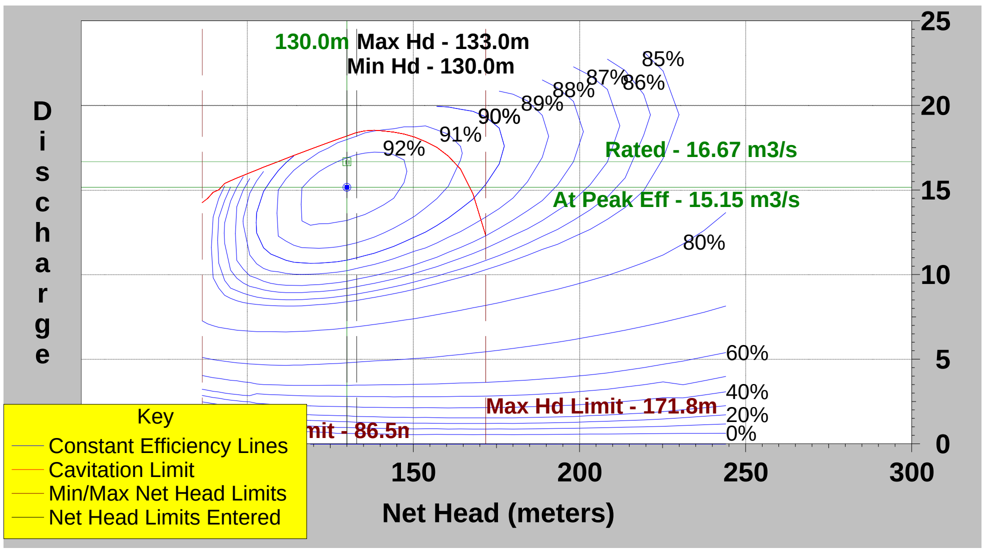
TURBNPRO Version 3.0 - FRANCIS TURBINE SOLUTION GRAPHICS

Solution File Name: c:\georgi~1\hipphy~1\machak~1\machak~1\turbin~1\25cmsp~1\25m1-l2f.
Runner Diameter: 1690 mm
Net Head at Rated Discharge: 130.00 meters
Unit Speed: 300.0 rpm



Solution File Name: c:\georgi~1\hipphy~1\machak~1\machak~1\turbin~1\25cmsp~1\25m1-l2f.

Runner Diameter: 1690 mm
Net Head at Rated Discharge: 130.00 meters
Unit Speed: 300.0 rpm
Peak Efficiency: 92.6 %
Multiplier Efficiency Modifier: 1.000
Flow Squared Efficiency Modifier: 0.0000



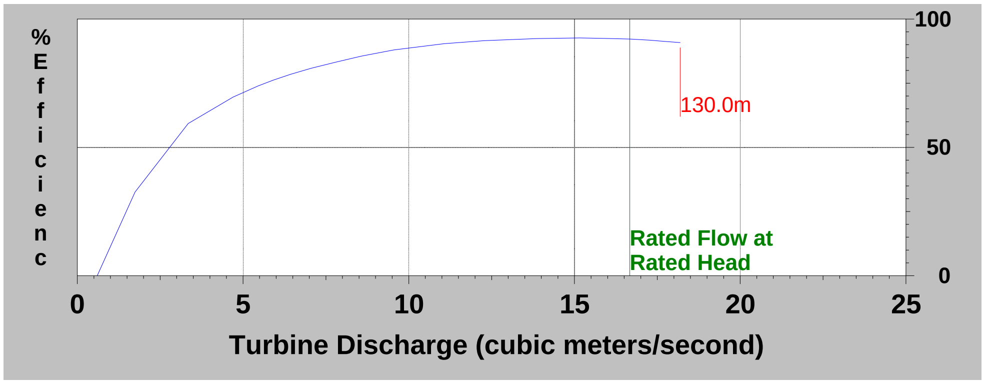
NOTE: Discharge is in cubic meters per second

TURBNPRO Version 3 - FRANCIS TURBINE CROSS PLOT

Solution File Name: c:\georgi~1\hipphy~1\machak~1\machak~1\turbin~1\25cmsp~1\25m1-l2f.
Runner Diameter: 1690 mm
Net Head at Rated Discharge: 130.00 meters
Unit Speed: 300.0 rpm
Multiplier Efficiency Modifier: 1.000
Flow Squared Efficiency Modifier: 0.0000

Performance Data Shown is for a Net Head of: 130

Power (KW)	Efficiency (%)	Discharge (m3/s)	Notes
21060	90.8	18.19	Additional Output Capability
20211	91.7	17.28	Additional Output Capability
19596	92.2	16.67	Rated Flow/Head Condition
19263	92.3	16.37	-
18248	92.5	15.46	-
17908	92.6	15.16	Best Efficiency Condition
17166	92.5	14.55	-
16045	92.2	13.64	-
14901	91.8	12.73	-
13735	91.1	11.82	-
12540	90.1	10.91	-
11309	88.6	10.00	-
10069	86.8	9.09	-
8806	84.4	8.19	-
7563	81.5	7.28	-
6342	78.1	6.37	-
5142	73.9	5.46	-
3966	68.4	4.55	-
2852	61.5	3.64	-
1703	49.0	2.73	Low efficiency; not used in energy calculation
785	33.8	1.82	Low efficiency; not used in energy calculation
101	8.7	0.91	Low efficiency; not used in energy calculation



TURBNPRO Version 3 - FRANCIS TURBINE SOLUTION SUMMARY

Solution File Name: c:\georgi~1\hipphy~1\machak~1\machak~1\turbin~1\25c

TURBINE SIZING CRITERIA

Rated Discharge:	294.1	cfs	/	8.3	m3/s
Net Head at Rated Discharge:	426.5	feet	/	130.0	meters
Gross Head:	436.4	feet	/	133.0	meters
Site Elevation:	1148	feet	/	350	meters
Water Temperature:	68	Degrees F	/	20	Degrees C
Setting to Tailwater:	8.2	feet	/	2.5	meters
Efficiency Priority:			5		
System Frequency:			50 Hz		
Minimum Net Head:	426.5	feet	/	130.0	meters
Maximum Net Head:	436.4	feet	/	133.0	meters

FRANCIS TURBINE SOLUTION DATA

Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT
Intake Type: SPIRAL CASE
Draft Tube Type: ELBOW
Runner Diameter: 49.1 inches / 1247 mm
Unit Speed: 375.0 rpm
Multiplier Efficiency Modifier: 1.000
Flow Squared Efficiency Modifier: 0.0000

Specific Speed at Rated Net Head -	(US Cust.)	(SI Units)
At 100% Turbine Output:	22.1	84.2
At Peak Efficiency Condition:	21.1	80.5

SOLUTION PERFORMANCE DATA

At Rated Net Head of: 426.5 feet / 130.0 meters

% of Rated Discharge	Output (KW)	Efficiency (%)	cfs	m3/s
** 109.1	10438	90.1	320.8	9.1
100	9717	91.5	294.1	8.3
* 90.9	8879	91.9	267.4	7.6
75	7250	91.0	220.6	6.2
50	4495	84.6	147.1	4.2
25	1761	66.3	73.5	2.1
+ 46.2	4063	82.8	135.9	3.8

** - Overcapacity
* - Peak Efficiency Condition
+ - Peak Draft Tube Surging Condition

At Maximum Net Head of: 436.4 feet / 133.0 meters

Sigma Allowable	Max. Output (KW)	Efficiency (%)	cfs	m3/s
0.048	10786	90.1	324.0	9.2

At Minimum Net Head of: 426.5 feet / 130.0 meters

Sigma Allowable	Max. Output (KW)	Efficiency (%)	cfs	m3/s
0.048	10438	90.1	320.8	9.1

Solution File Name: c:\georgi~1\hipphy~1\machak~1\machak~1\turbin~1\25c

MISCELLANEOUS DATA

Maximum Runaway Speed (at Max. Net Head):	607 rpm	
Turbine Discharge at:		
Runaway Speed (at Rated Net Head & 100% gate):	126 cfs	3.6 m3/s
Synchronous Speed-No-Load (at Rated Net Head):	22 cfs	0.6 m3/s
Site's Atmospheric Pressure minus Vapor Pressure:	31.8 feet	9.7 meters
Sigma Allowable (at 100% Output & Rated Net Head):	0.036	
Sigma Plant (at 100% Output & Rated Net Head):	0.055	
Maximum Hydraulic Thrust (at Max. Net Head):	45443 lbs	20656 kg
Approximate Runner and Shaft Weight:	8982 lbs	4083 kg
Vel. at Draft Tube Exit (at Rated Head & Discharge):	3.3 fps	1.0 m/s

DIMENSIONAL DATA

Intake Type: SPIRAL CASE

	inches	mm
Inlet Diameter:	54.0	1372
Inlet Offset:	84.4	2144
Centerline to Inlet:	112.2	2849
Outside Radius A:	111.4	2830
Outside Radius B:	106.5	2705
Outside Radius C:	100.1	2543
Outside Radius D:	91.3	2319

Draft Tube Type: ELBOW

	inches	mm
Centerline to Invert:	159.2	4043
Shaft Axis to Exit Length:	235.7	5986
Exit Width:	147.3	3741
Exit Height:	88.4	2245

Shafting Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT

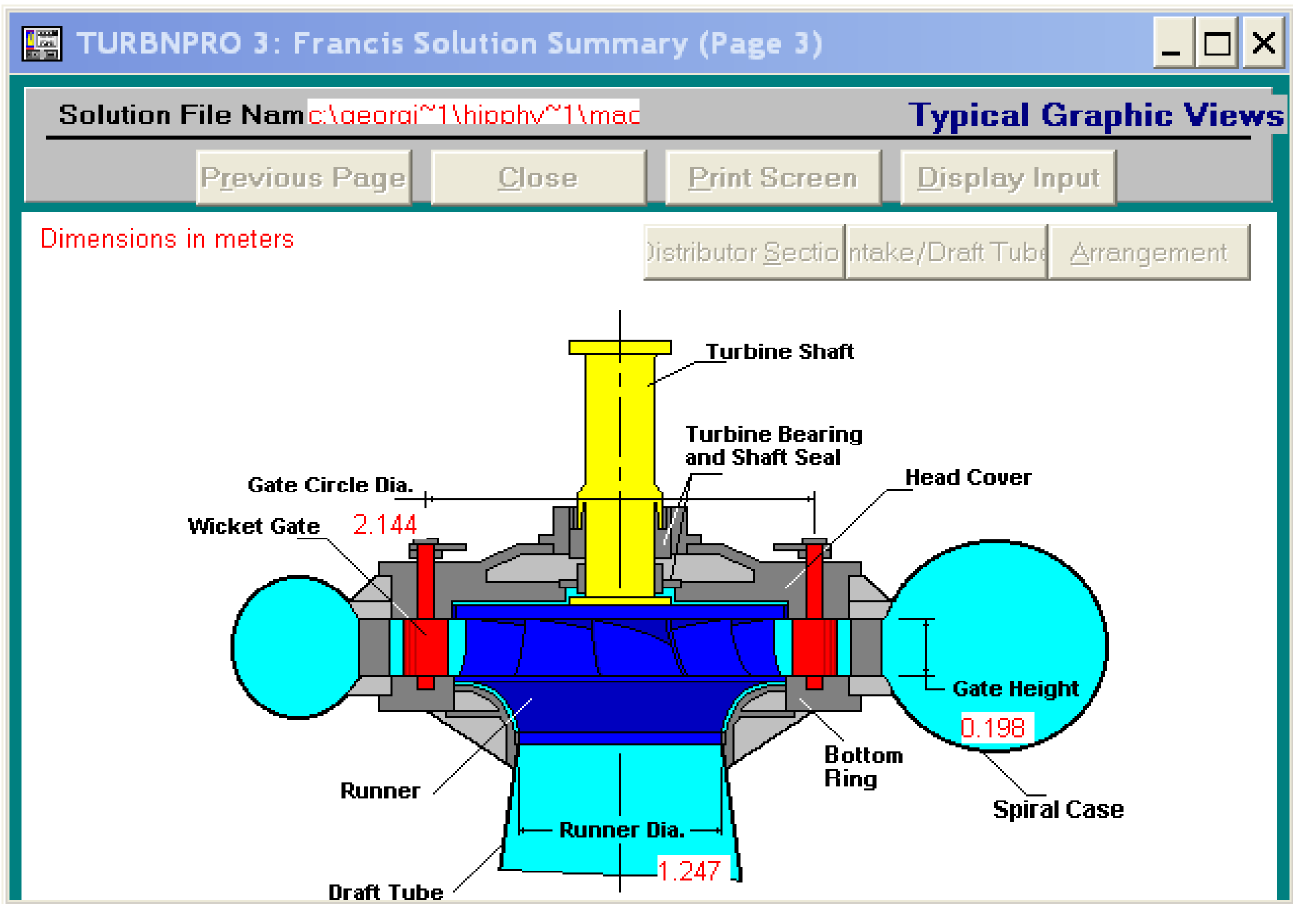
	inches	mm
Centerline to Shaft Coupling:	96.0	2438
Turbine Shaft Diameter:	14.3	362

Miscellaneous:

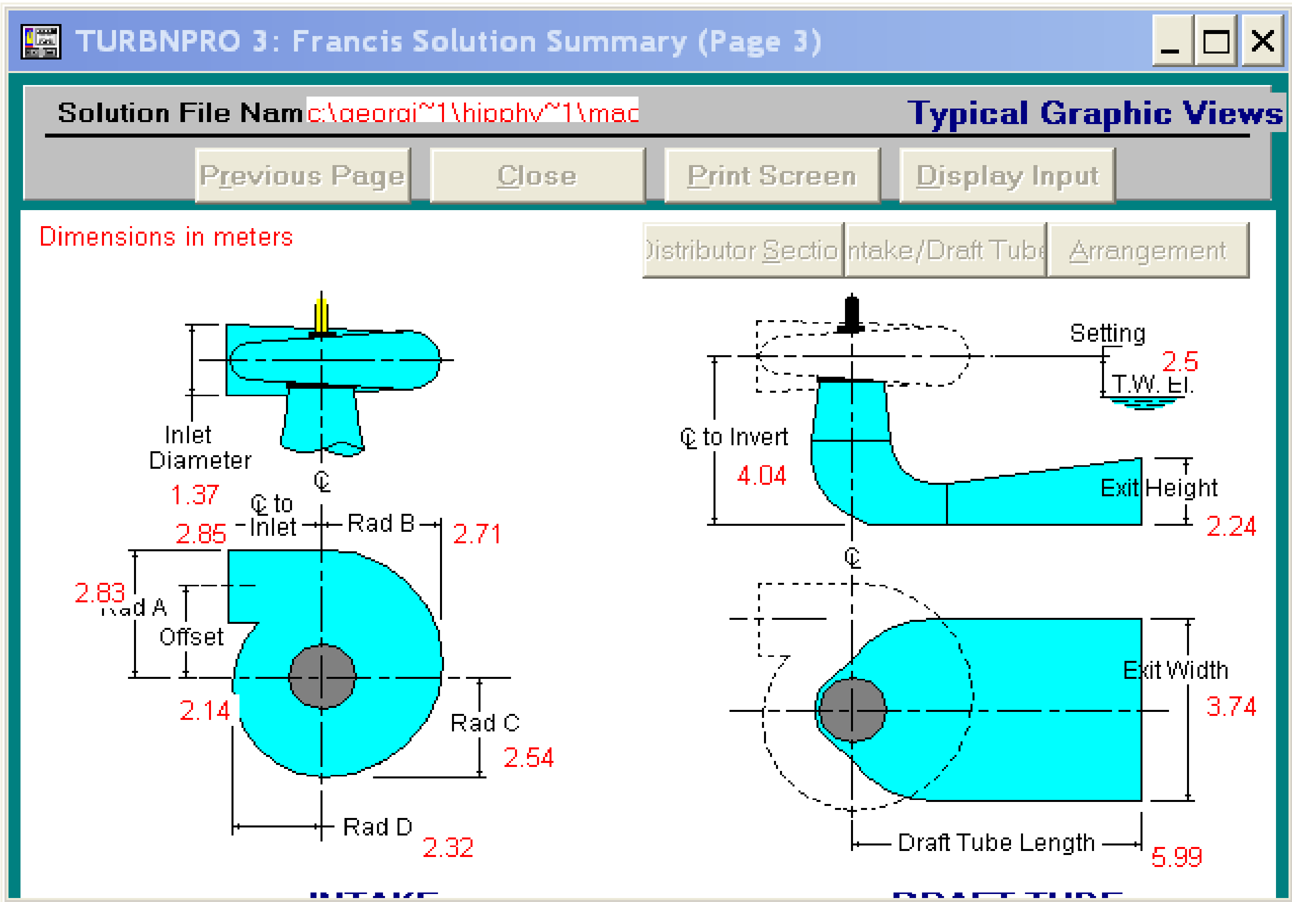
	inches	mm
Wicket Gate Height:	7.8	198
Wicket Gate Circle Diameter:	84.4	2144

**** All information listed above is typical only. Detailed characteristics will vary based on turbine manufacturer's actual designs.

```
Solution File Name: c:\georgi~1\hipphy~1\machak~1\machak~1\turbin~1\25cmsp~1\25m1-s2f.
Runner Diameter:                  1247   mm
Net Head at Rated Discharge:      130.00   meters
Unit Speed:                       375.0   rpm
```



Solution File Name: c:\georgi~1\hipphy~1\machak~1\machak~1\turbin~1\25cmsp~1\25m1-s2f.
Runner Diameter: 1247 mm
Net Head at Rated Discharge: 130.00 meters
Unit Speed: 375.0 rpm



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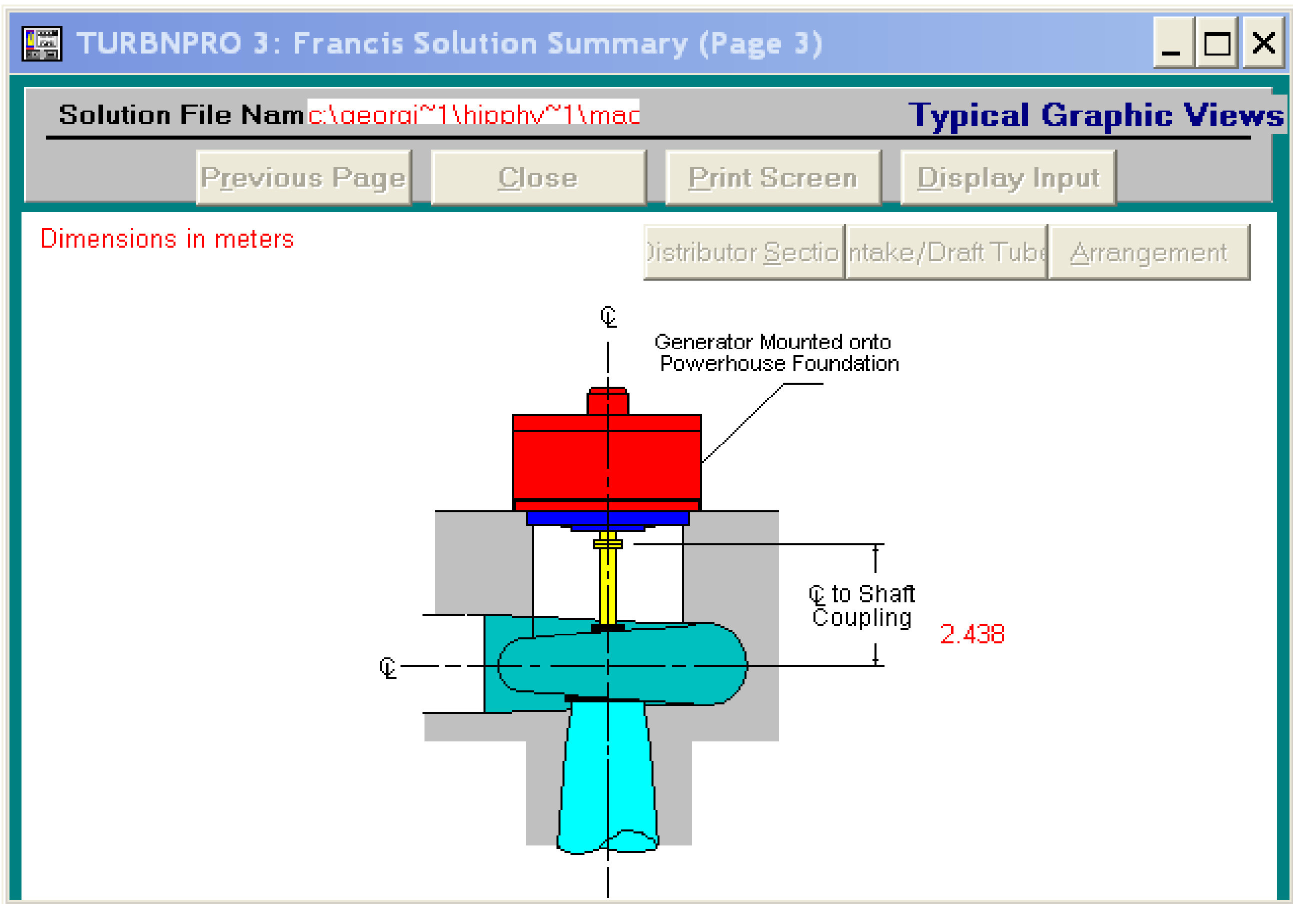
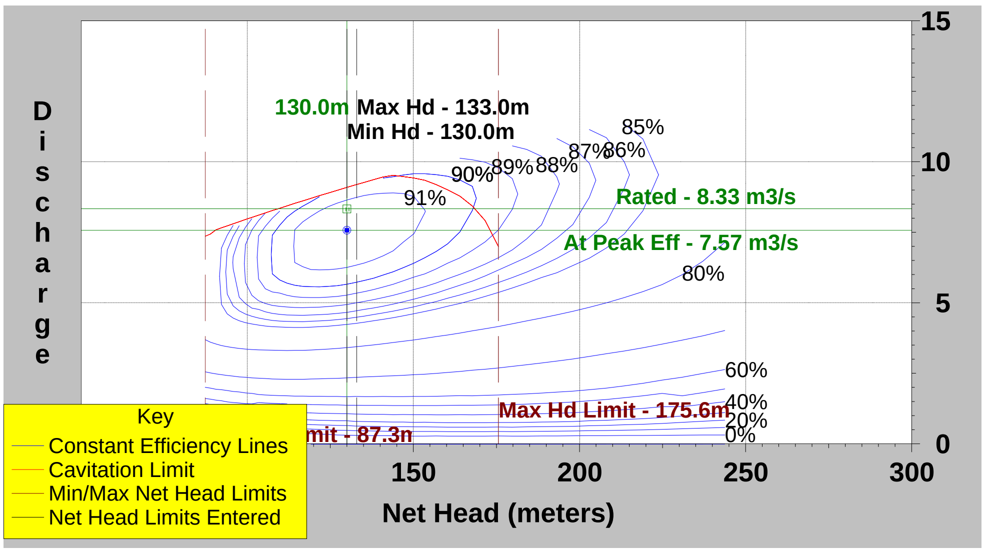
Runner Diameter: 1247 mm
Net Head at Rated Discharge: 130.00 meters
Unit Speed: 375.0 rpm



Solution File Name: c:\georgi~1\hipphy~1\machak~1\machak~1\turbin~1\25cmsp~1\25m1-s2f.

Runner Diameter:	1247 mm
Net Head at Rated Discharge:	130.00 meters
Unit Speed:	375.0 rpm
Peak Efficiency:	91.9 %
Multiplier Efficiency Modifier:	1.000
Flow Squared Efficiency Modifier:	0.0000



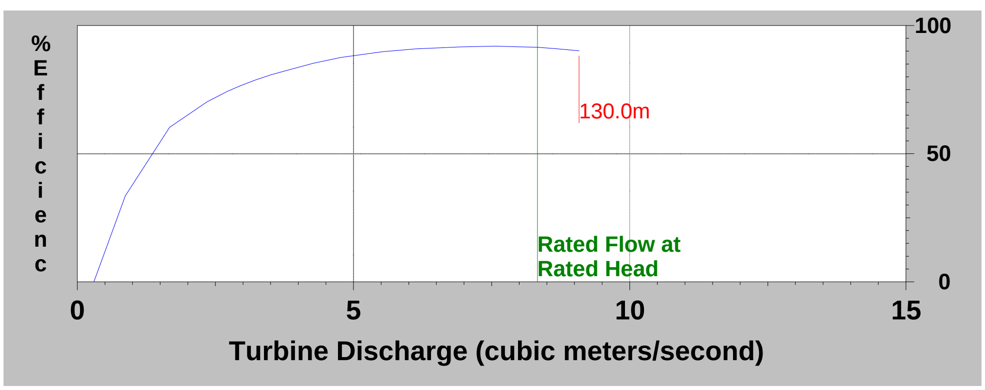
NOTE: Discharge is in cubic meters per second

TURBNPRO Version 3 - FRANCIS TURBINE CROSS PLOT

Solution File Name: c:\georgi~1\hipphy~1\machak~1\machak~1\turbin~1\25cmsp~1\25m1-s2f.
Runner Diameter: 1247 mm
Net Head at Rated Discharge: 130.00 meters
Unit Speed: 375.0 rpm
Multiplier Efficiency Modifier: 1.000
Flow Squared Efficiency Modifier: 0.0000

Performance Data Shown is for a Net Head of: 130

Power (KW)	Efficiency (%)	Discharge (m3/s)	Notes
10438	90.1	9.08	Additional Output Capability
10017	91.0	8.63	Additional Output Capability
9717	91.5	8.33	Rated Flow/Head Condition
9547	91.6	8.18	-
9044	91.8	7.72	-
8876	91.9	7.57	Best Efficiency Condition
8508	91.8	7.27	-
7953	91.5	6.81	-
7388	91.1	6.36	-
6813	90.5	5.90	-
6224	89.5	5.45	-
5619	88.2	5.00	-
5009	86.5	4.54	-
4389	84.2	4.09	-
3777	81.5	3.63	-
3176	78.3	3.18	-
2584	74.3	2.73	-
2000	69.1	2.27	-
1445	62.4	1.82	-
867	49.9	1.36	Low efficiency; not used in energy calculation
402	34.7	0.91	Low efficiency; not used in energy calculation
52	8.9	0.45	Low efficiency; not used in energy calculation



TURBNPRO Version 3 - PELTON TURBINE SOLUTION SUMMARY

Solution File Name: No File Name

TURBINE SIZING CRITERIA

Rated Discharge:	441.4	cfs	/	12.50	m3/s
Net Head at Rated Discharge:	421.3	feet	/	128.4	meters
Gross Head:	436.4	feet	/	133.0	meters
Efficiency Priority:			5		
System Frequency:			50 Hz		
Minimum Net Head:	375.1	feet	/	114.3	meters
Maximum Net Head:	429.9	feet	/	131.0	meters

PELTON TURBINE SOLUTION DATA

Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT
Intake Type: 6 - JET
Runner Pitch Diameter: 102.4 inches / 2602 mm
Unit Speed: 176.5 rpm
Multiplier Efficiency Modifier: 1.000
Flow Squared Efficiency Modifier: 0.0000

	(US Cust.)	(SI Units)
Specific Speed at Rated Net Head (turbine) -		
At 100% Turbine Output:	12.7	48.6
At Peak Efficiency Condition:	11.6	44.4
Specific Speed at Rated Net Head (per jet) -		
At 100% Turbine Output:	5.2	19.8
At Peak Efficiency Condition:	4.8	18.1

SOLUTION PERFORMANCE DATA

At Rated Net Head of: 421.3 feet / 128.4 meters

% of Rated Discharge	Output (KW)	Efficiency (%)	cfs	m3/s
** 116.7	16415	89.3	515.0	14.58
100	14159	89.9	441.4	12.50
* 83.3	11820	90.1	367.8	10.42
75	10621	89.9	331.0	9.38
50	6989	88.8	220.7	6.25
25	3399	86.3	110.3	3.13

** - Overcapacity
* - Peak Efficiency Condition

At Maximum Net Head of: 429.9 feet / 131.0 meters

Max. Output (KW)	Efficiency (%)	cfs	m3/s
16909	89.3	520.2	14.73

At Minimum Net Head of: 375.1 feet / 114.3 meters

Max. Output (KW)	Efficiency (%)	cfs	m3/s
13778	89.3	485.9	13.76

Solution File Name: No File Name

MISCELLANEOUS DATA

Maximum Runaway Speed (at Max. Net Head):	310 rpm
D/B Ratio (Runner Pitch Dia./Bucket Width):	3.10
Maximum Hydraulic Thrust (at Max. Net Head):	24959 lbs / 11345 kg
Hydraulic Thrust per Jet (at Max. Net Head):	12480 lbs / 5673 kg
Estimated Axial Thrust:	63240 lbs / 28746 kg
Approximate Runner and Shaft Weight:	60495 lbs / 27498 kg

DIMENSIONAL DATA

Intake Type: 6 - JET

	inches	mm
Inlet Diameter:	64.0	1626
Nozzle Diameter:	30.9	785
Jet Orifice Diameter:	9.9	251
Needle Stroke:	9.4	238
Inlet Piping Spiral Radius:	217.6	5527

Jet to Jet Included Angle: 60 Degrees

Housing/Discharge Geometry:

	inches	mm
Centerline to Housing Top:	70.3	1786
Housing Diameter:	324.8	8250
Discharge Width:	243.6	6187
Tailwater Depth:	53.0	1347
Discharge Ceiling to T.W.:	61.5	1561
Centerline to Tailwater:	160.6	4079

Shafting Arrangement: VERTICAL WITH RUNNER ON TURBINE SHAFT

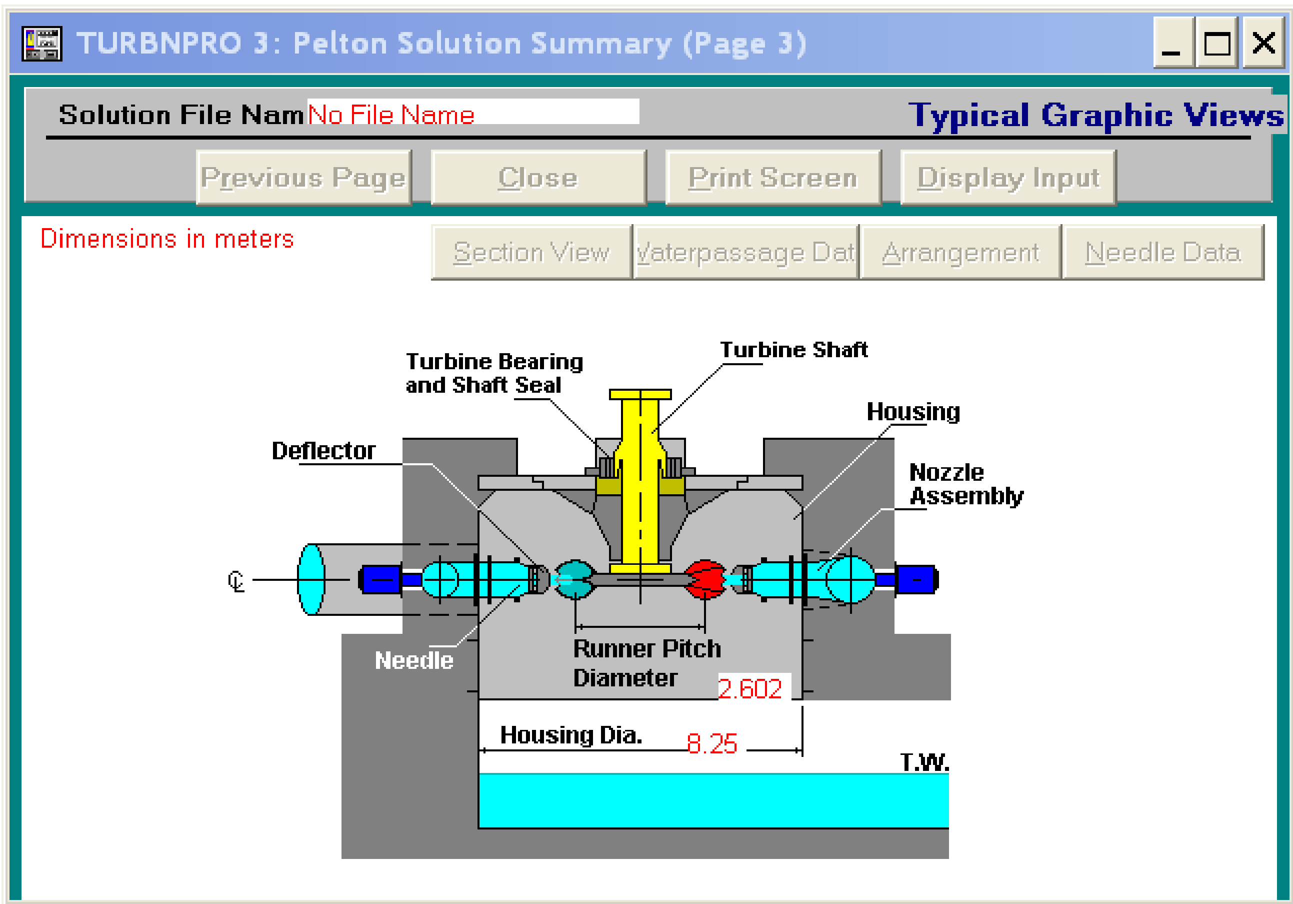
	inches	mm
Centerline to Shaft Coupling:	140.6	3572
Turbine Shaft Diameter:	24.0	609

Miscellaneous:

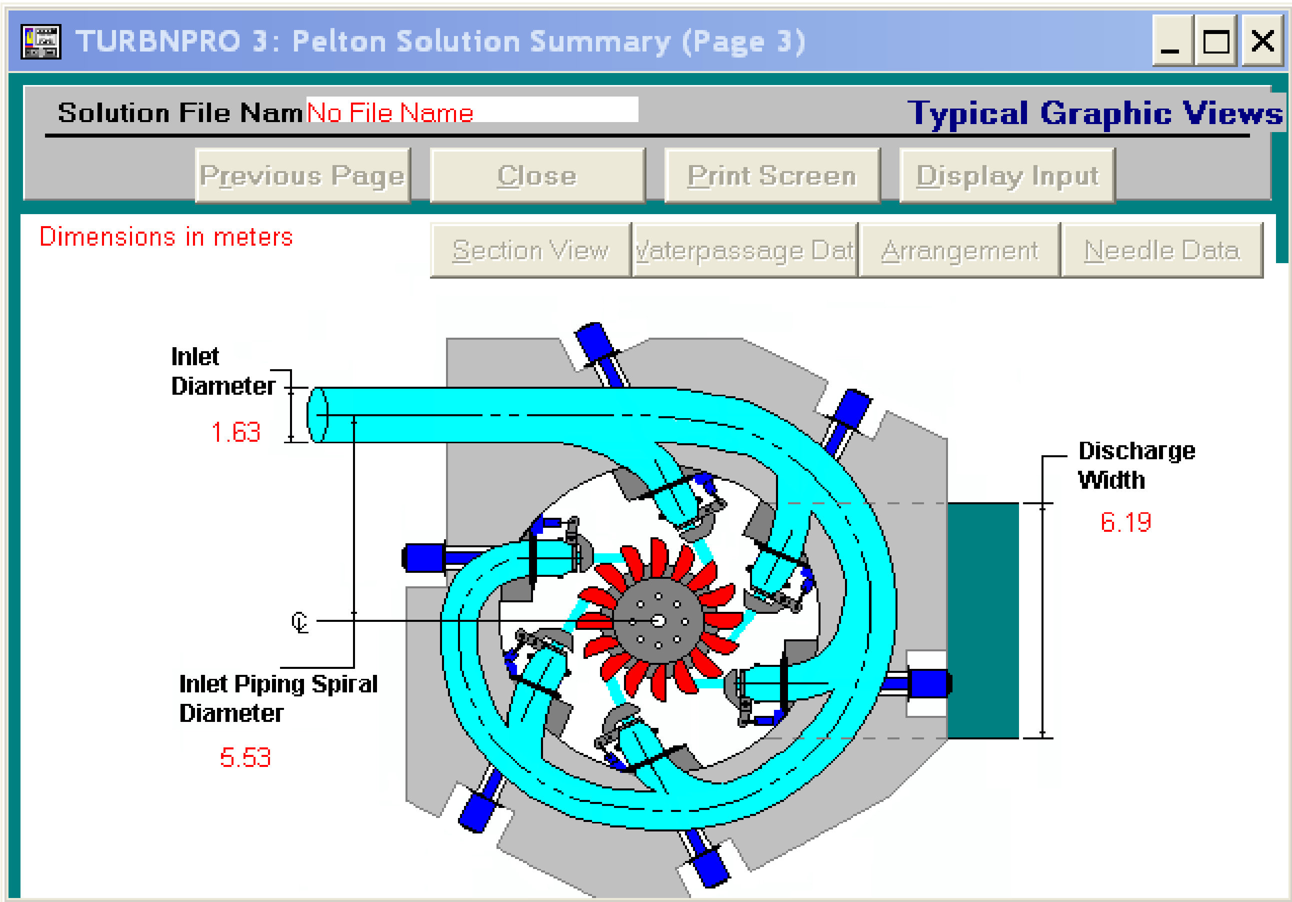
	inches	mm
Runner Outside Diameter:	135.5	3441
Runner Bucket Width:	33.0	839

**** All information listed above is typical only. Detailed characteristics will vary based on turbine manufacturer's actual designs.

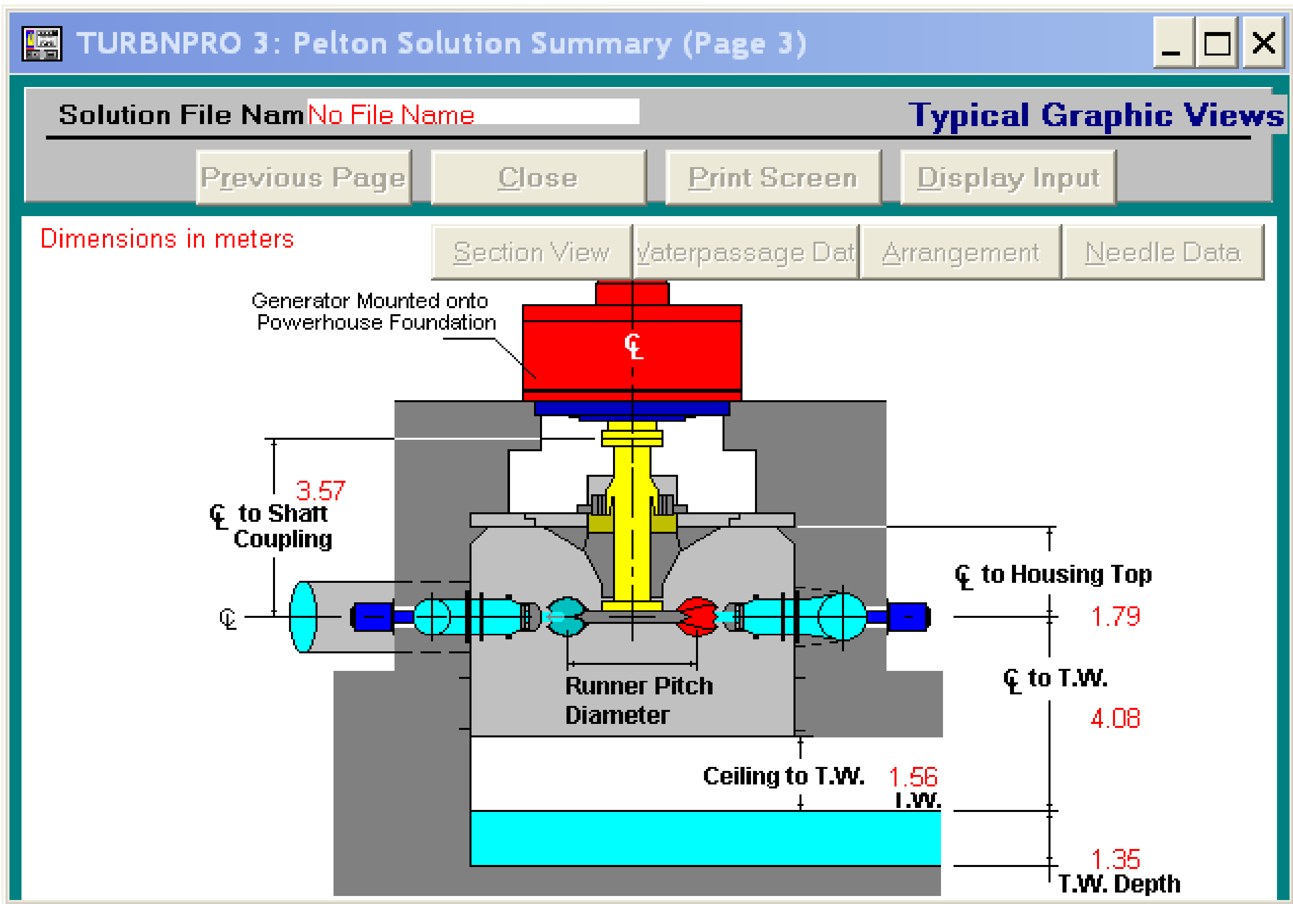
Solution File Name: No File Name
Intake Type: 6 - JET
Runner Diameter: 2602 mm
Net Head at Rated Discharge: 128.40 meters
Unit Speed: 176.5 rpm



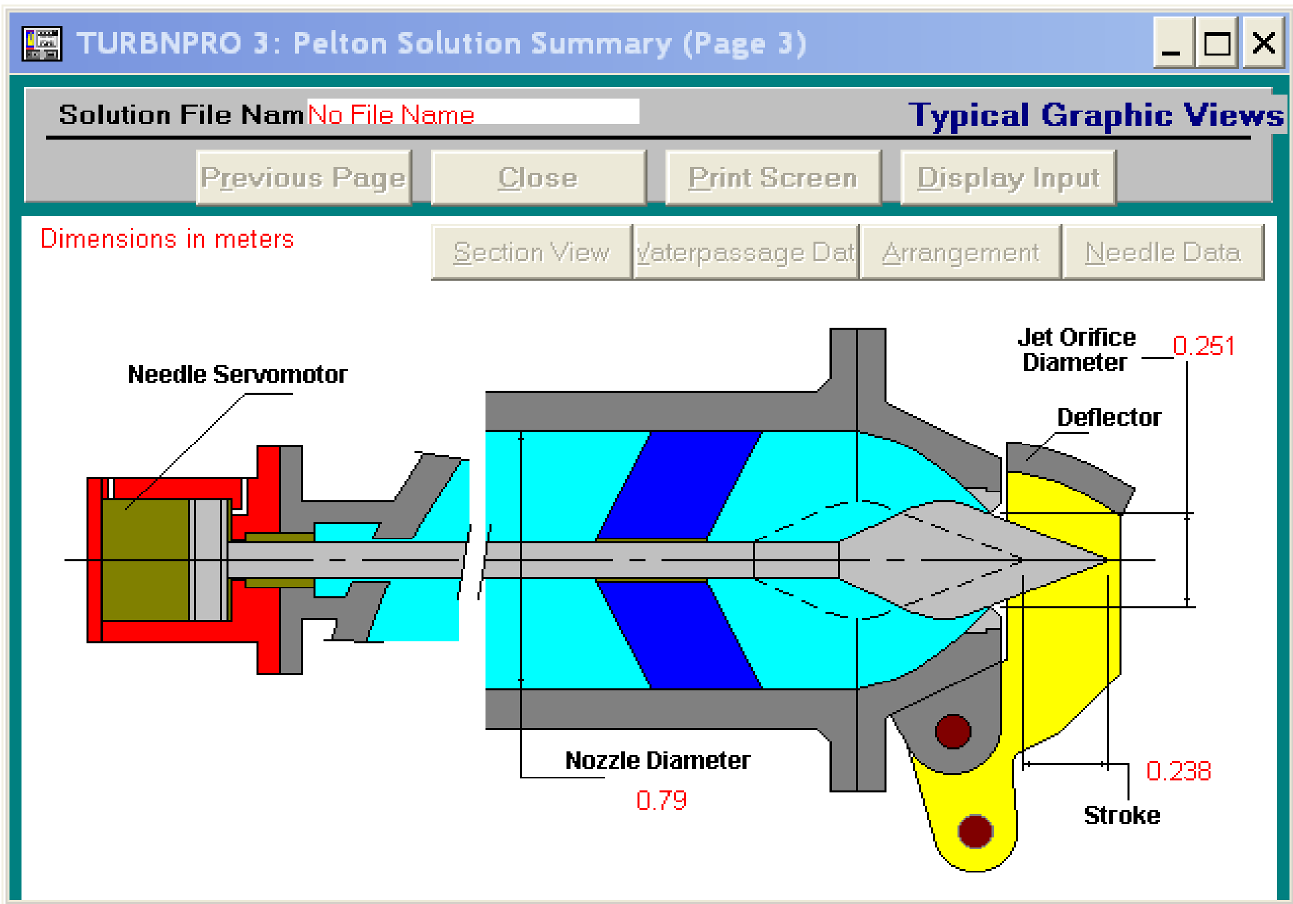
Solution File Name: No File Name
Intake Type: 6 - JET
Runner Diameter: 2602 mm
Net Head at Rated Discharge: 128.40 meters
Unit Speed: 176.5 rpm



Solution File Name: No File Name
Intake Type: 6 - JET
Runner Diameter: 2602 mm
Net Head at Rated Discharge: 128.40 meters
Unit Speed: 176.5 rpm



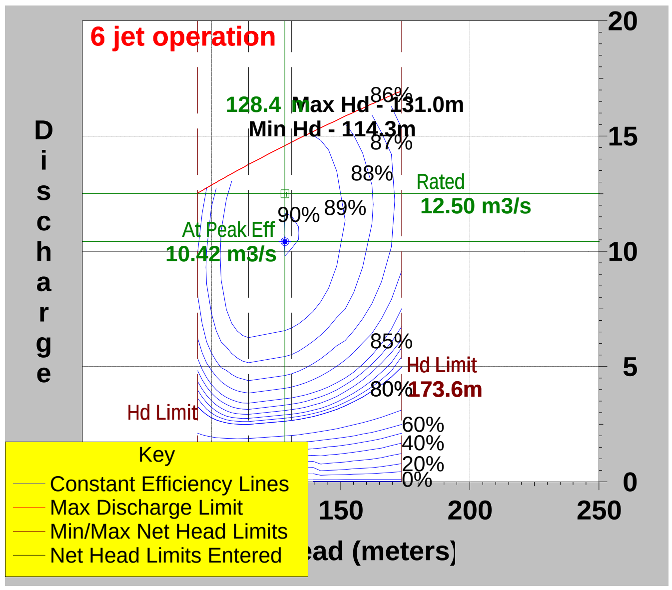
Solution File Name: No File Name	
Intake Type:	6 - JET
Runner Diameter:	2602 mm
Net Head at Rated Discharge:	128.40 meters
Unit Speed:	176.5 rpm



TURBNPRO Version 3 - PELTON TURBINE HILL CURVE

Solution File Name: No File Name

```
Intake Type:                      6 - JET
Runner Pitch Diameter:            2602  mm
Net Head at Rated Discharge:      128.40  meters
Unit Speed:                       176.5  rpm
Peak Efficiency:                   90.1  %
Multiplier Efficiency Modifier:     1.000
Flow Squared Efficiency Modifier:   0.0000
```



NOTE: Discharge is in cubic meters per second

TURBNPRO Version 3 - PELTON TURBINE HILL CURVE

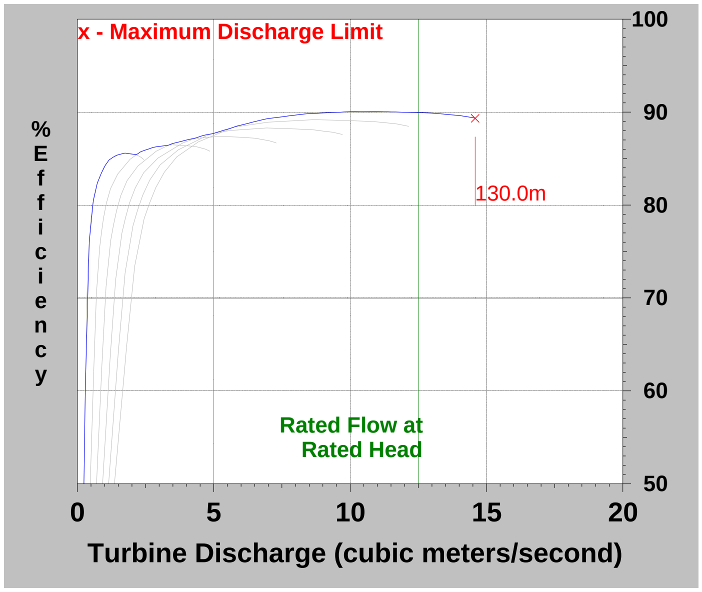
Solution File Name: No File Name
Intake Type: 6 - JET
Runner Pitch Diameter: 2602 mm
Net Head at Rated Discharge: 128.40 meters
Unit Speed: 176.5 rpm
Multiplier Efficiency Modifier: 1.000
Flow Squared Efficiency Modifier: 0.0000

Performance Data Shown is for a Net Head of: 130

Power (KW)	Efficiency (%)	Discharge (m3/s)	Operating Jets	Notes
16615	89.33	14.58	6	Max Discharge Limit
16313	89.50	14.29	6	Additional Output Capability
16003	89.62	14.00	6	Additional Output Capability
15683	89.70	13.71	6	Additional Output Capability
15362	89.77	13.42	6	Additional Output Capability
15041	89.85	13.13	6	Additional Output Capability
14714	89.90	12.83	6	Additional Output Capability
14384	89.92	12.54	6	Additional Output Capability
14054	89.95	12.25	6	-
13724	89.98	11.96	6	-
13392	90.00	11.67	6	-
13060	90.02	11.38	6	-
12728	90.04	11.08	6	-
12396	90.06	10.79	6	-
12064	90.08	10.50	6	-
11969	90.08	10.42	6	Best Efficiency at Net Head
11725	90.06	10.21	6	-
11385	90.02	9.92	6	-
11046	89.98	9.63	6	-
10706	89.94	9.33	6	-
10367	89.90	9.04	6	-
10028	89.86	8.75	6	-
9874	89.18	8.68	5	Best Efficiency for 5 Jet Operation
9690	89.82	8.46	6	-
9346	89.73	8.17	6	-
9002	89.62	7.88	6	-
8658	89.51	7.58	6	-
8315	89.41	7.29	6	-
7973	89.30	7.00	6	-
7819	88.28	6.95	4	Best Efficiency for 4 Jet Operation
7625	89.11	6.71	6	-
7275	88.90	6.42	6	-
6928	88.68	6.13	6	-
6582	88.47	5.83	6	-
6233	88.18	5.54	5	-
5887	87.92	5.25	5	-
5805	87.38	5.21	3	Best Efficiency for 3 Jet Operation
5544	87.67	4.96	4	-
5209	87.51	4.67	4	-
4867	87.23	4.38	4	-
4533	87.04	4.08	3	-
4199	86.83	3.79	3	-
3867	86.62	3.50	3	-
3830	86.48	3.47	2	Best Efficiency for 2 Jet Operation
3535	86.38	3.21	2	-
3209	86.26	2.92	2	-
2881	86.04	2.63	2	-
2551	85.73	2.33	2	-
2225	85.45	2.04	1	-
1910	85.58	1.75	1	-
1895	85.58	1.74	1	Best Efficiency for 1 Jet Operation
1588	85.36	1.46	1	-
1262	84.83	1.17	1	-

TURBNPRO Version 3 - PELTON TURBINE HILL CURVE

Power (KW)	Efficiency (%)	Discharge (m3/s)	Operating Jets	Notes
931	83.39	0.88	1	-
598	80.40	0.58	1	-
222	59.80	0.29	1	Low efficiency; not used in energy calculation



Appendix 12

Forecasted Energy Sales Price

Forecasted Energy Sales Price for

Power Produced by New Georgian HPPs

Contact: Jake Delphia, CoP

HydroPower Investment Promotion Project

August 2011

Forecasted Energy Sales Price for Power Produced by New Georgian HPPs

A. Initial Regional Market Analysis

Newly constructed Georgian hydropower plants have various options for sale of their energy production. This is an initial analysis of the regional power markets – further analysis will be completed in the near future.

1) **Direct energy sales** – for plants less than 13 MW, power sales contracts can be consummated with retail consumers. From our discussions with Alliance Energy Group, we know that the tariff is between USc 5.5 and USc 6.0. The cost of power for large consumers is about USc8.0 cents/kwh, so there is room for the tariff to grow over time.

2) **The sale of power to eligible consumers** also provides an opportunity for future sales. Beside the largest 8 retail consumers, there are several other entities that can purchase power from the plants – 3 distribution (and retail supply) companies, 3 transmission companies, and thermal power producers. In fact, Enguri HPP is an eligible consumer that could purchase power in the lower price time periods and sell in the high priced power periods by using the reservoir for storage of energy. As the price in the Southern Region of Russia increases, then this option will be increasing more viable. The short term energy sales price for energy from Ukraine to the Russian Southern Region in 2010 grew to as high as USc 7.0 cents.

3) **ESCO –** The MoUs and IAs signed by the developers of Georgian HPPs agree to sell energy in Georgia for at least the 3 winter months (December through February). The sales can be to any entity within Georgia. In the worst case, ESCO agrees to pay for energy produced in the winter months for 10 years. The energy sales price is determined by the price paid by ESCO in the previous month for gas-fired generation. This price recently ranged from 8.0 Tetri/kwh to 11.0 Tetri/kwh (or USc 5.0/kwh to USc 6.5/kwh.)

4) **Turkey** – There are several options for sale of power in Turkey.
    a. The spot market was recently created, but volumes have been low so price swings can be significant.
    b. The wholesale power market has been active for many and the prices seem to (but not always) follow the price of natural gas. The prices on the wholesale market range from USc 7.0 cents/kwh to 9.0 USc/kwh. With the growing demand in Turkey and the shrinking reserve margin, the prices are forecasted to increase significantly. Deutch Bank has forecasted the current wholesale power price in Turkey to increase 100% by 2020.
    c. Energy sales to large energy consumers.

d. Energy sales to distribution companies/retail supply companies. This option will be explored on HIPP's September mission to Turkey.

5) **Europe** – Southeast Europe is in an increasing tighter reserve capacity position. Several of the countries are in fact are in capacity deficit. The daily on-peak price of energy ranges from USc 11.0/kwh to USc 16.0/kwh. For this option (Georgia is currently selling to Serbia for spot sales), Georgian HPPs will have to pay the CBT (no more than USc 1.0/kwh as transit fee). For these sales, Georgian HPPs most likely could receive CERs.

6) **Iraq** – Energy sales to Iraq may be limited a few hundred MWs due to the limited interconnection between Turkey and Kurdistan. Iraq has a large deficit of electrical capacity and has a huge program of constructing new gas and oil-fired power plants near oil rigs. New g thermal power plant energy production costs will range in the USc 8.0/kwh to USc 10.0/kwh while the spare oil and gas are available. As the spare gas and oil is used up, then the price of energy will greatly increase as the plants will have to purchase fuel at market prices.

7) **Southern Neighbors** – Georgian and Armenia have agreed to analyze a new double circuit 400 KV line from Gardebani Station to Hrazdan Station for the sole purpose of exporting power from Georgia to Armenia and south and east. There are too many issues to resolve at this time but the option may happen through swap transactions that are not exactly transparent.

B. Estimated Price for Sale of Electricity from HPPs

Attachment 1 provides a review of some viable options. HIPP has decided to use two options for energy sales from future HPPs:

a) Sales to ESCO during the period December through February (winter months)
b) Sales to the Turkish wholesale power market during the remaining nine months.

Both of these options provide a floor for the energy sales price. It is anticipated that the actual energy prices will be higher as other competitive power market options become available.

Sales Price Forecast to ESCO

2011 price - USc 5/kwh (paid at HPP busbar according to Market Rules)

<u>Forecasted Price</u> – 2011 price escalated at 5%/year.

Sales Price Forecast to the Turkish Wholesale Power Market

2011 price – USc 8.5/kwh (paid at the delivery point assumed to be in Western Turkey.)

Forecasted Price – 2011 price escalated at 5%/year.

Attachment 1

Calculation of Net Sales Price/kwh (In USc/kwh) for New Georgian HPP Power Production

	ESCO	Turkish Wholesale Power Market	European Wholesale Power Market	Eligible Consumer (for HPPs less than 13 MW)
Price For Energy	5.0	8.5	11.0	5.5
Georgian Transmission Tariff		0.50	0.50	
Georgian Dispatch Fee		0.15	0.15	
EnergoTrans Estimated Tariff		1.20	1.20	
Turkish Transmission Fee		0.80	0.80	
European CBT			1.00	
Net Price Paid	5.0	5.85	7.35	5.5