KATHMANDU UNIVERSITY

SCHOOL OF ENGINEERING
DEPARTMENT OF CIVIL ENGINEERING

Final Report on

Rehabilitation, Modernization an Urbanization (RUM)

Of

Sunkoshi Small Hydropower Plant(2.5MW)

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Lastly, we would like to convey our sincere gratitude to the project coordinator and the site manager for their steadfast assistance, expertise, and dedication during this project. Their contributions have been crucial to the project's success from the beginning.

Sincerely,
Group 9
CIEG (III/II)

ABSTRACT

We, the students of Civil Engineering of Kathmandu University analyzing the Rehabilitation upgradation and Modernization (RUM) of Sunkoshi Hydropower plant for the fulfillment of our project, under the supervision of Er. Santosh Chaudhary, Department of Civil Engineering.

The old hydropower station's RUM is incredibly economical, environmentally benign, and satisfies sustainability standards. Because of the state of the economy, the availability of river water flow, and the availability of already-existing infrastructure, only careful replacement of parts like approach canals, settling basins, penstocks, and other components can extend the life of power plants and increase efficiency, peak power, and energy availability.

The goal of the project is to analyze the various hydropower components and develop an RUM formulation that will allow for the optimization, modernization, and upgrading of the hydropower plant's capacity. Rehabilitating components like the settling basin and approach canal is part of the project. In a similar vein, the project involves updating certain components, such as head variation and discharge.

This Sunkoshi hydropower plant RUM project will be successful in improving and optimizing both plant quality and quantity. It is also feasible in terms of finances and technology.

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CHAPTER 1: INTRODUCTION

1.1 Background

1.1.1 Hydropower development in Nepal

Nepal has one of the highest hydropower potentials per capita in the world, Nepal is a country rich in hydro resources. Roughly 83,000 MW is the estimated theoretical power potential. However, the economically feasible potential has been evaluated at approximately 43,000 MW. In Sundarijal, a second hydropower plant (640 KW) was built in 1936 following the establishment of the first hydropower plant (500 MW) in 1911. In a similar vein, the 1939-founded Morang Hydropower Company constructed the 677 KW Sikarbas Hydroplant in Chisang Khola in 1942; however, a landslide in the 1960s destroyed the plant.

After the process of development planning was started, hydropower development became an official enterprise. 20 MW more hydropower was to be added under the First Five-year Plan (1956–61). The goal was not met, though. Certain advancements were made during the Second Three-year Plan (1962–1965). Electricity production, transmission, and distribution fell under the purview of HMG's Electricity Department until 1962. Following its establishment in 1962, the transmission and distribution of electricity fell under the purview of Nepal Electricity Corporation (NEC). Generation of electricity fell under the purview of the Department of Energy. The country's hydropower generation capacity was increased in 1965 with the construction of the Panauti Hydroplant (2400 KW), following a lengthy interval since the establishment of the Chisang Hydroplant. and the 21,000 KW Trishuli Hydroplant in 1967. Then came a series of hydroelectric projects. In 1974, the Eastern Electricity Corporation was founded. The Small Hydropower Development Board was founded in 1977. In 1985, there was another institutional restructuring as the Nepal Electricity Authority (NEA) was established through the combination of the Electricity Department, Nepal Electricity Corporation, and all development boards, with the exception of the Marshyangdi Hydropower Development Board. Since then, the NEA has been in charge of producing, distributing, and transmitting electricity. The Department of Electricity Development, the Water and Energy Commission and its Secretariat (established in 1976), the 1981-established policymaking body, and other public sector organizations are also involved in the hydropower industry. Of late, the private sector is also emerging as an important player in the hydropower development. Independent Power Producers (IPPs) have been the ongoing institutional innovations in the power sector of Nepal, with the IPPs signing power purchase agreements (PPA) with the NEA to sell electricity.

Just 0.7 percent of the potential hydropower has been generated to date, or 556.8 MW. Traditional energy sources like fuel wood, agricultural waste, and animal dung account for 88 percent of Nepal's total energy consumption, while commercial sources like solar, hydropower, and petroleum make up the remaining 12 percent. In Nepal, seventy-five percent of the energy used for commerce comes from hydropower. The majority of the electricity needs in urban and semi-urban areas have been met by hydropower plants. The years 1981–1990 and 1991–2000 saw the production of 180.3 MW (32.4 percent of the total) and 125.9 MW (22.6 percent of the total), respectively. These two decades saw the highest growth in hydropower production, with 195.3 MW (35.1 percent of the total) produced between 2001 and 2005.The period since 1981 produced 501.5 MW (90.1 percent of the total), implying that only 55.3 MW (9.9 percent of the total) was produced during the entire period of 1911-1980 .

Table 1: Decadewise Development of Hydropower Generation Cumulative

Decade	Mega Watts	% of Total	Mega Watts	% of Total
1911-1920	0.5	0.1	0.5	0.1
1921-1930	0.0	0.0	0.5	0.1
1931-1940	0.6	0.1	1.1	0.2
1941-1950	0.0	0.0	1.1	0.2
1951-1960	0.0	0.0	1.1	0.2
1961-1970	27.5	4.9	28.6	5.1
1971-1980	26.7	4.8	55.3	9.9
1981-1990	180.3	32.4	235.7	42.3
1991-2000	125.9	22.6	361.5	64.9
2001-2005	195.3	35.1	556.8	100.0
Total	*556.8*	*100.0*		

Source: Compilations from NEA Publications.

1.1.2 Small Hydroplants In Nepal

Large-scale hydropower projects in Nepal have faced resistance due to environmental issues with the dams, including flooding, siltation, poor effects on river water quality, damage to riparian ecosystems, disputes over monopsony buyers, and the fact that the projects depend on costly foreign contracting companies. While Nepal's urban electricity demand is expected to increase at an average annual rate of 15 percent, medium- to large-scale hydropower (above 1000 KW) is still the most likely option for meeting this demand. However, small hydropower presents an appealing alternative to conventional power systems in rural and remote areas as a means of achieving rural electrification. Due to the fact that only 33% of the population has access to the national grid for electricity, numerous significant micro-hydro projects have been developed to satisfy the needs of rural areas. Small hydropower is therefore crucial to Nepal's future energy supply because it is an affordable, renewable energy source with minimal environmental effects. As a result, micro-hydro systems are gaining popularity as a source of energy in rural areas, which are cut off from the energy grid that supplies major cities with power from large hydropower stations. Micro-hydro power generation is actually just one of the four components; the other three are solar energy schemes, bio-gas generation, and upgraded stoves to meet the local fuel needs. One of the many villages in the Annapurna region that uses the Modi Khola river to generate electricity is Ghandruk. This village serves as an example of a micro-hydro project. In the dry season, the stream is only a meter wide, but it produces 50 KW of power, which is sufficient to light every home in the village with electricity and cook for 20% of the population. The main goal of these kinds of micro hydro projects is to maximize the use of domestic resources and expertise while developing hydropower potential in a sustainable and environmentally friendly manner. Small hydropower plants (up to 1000 KW) generate 8.4 MW of the total electricity generated, while medium-sized hydroplants (above 1000 KW) generate 548.4 MW; these shares are 1.5 percent and 98.5 percent, respectively (Annexes I, II, and III, with Annex IV providing the details of the hydropower projects under construction). The following tables (Table 2 &3) and figures 5,6,7 and 8 provide the distribution of small and medium-sized hydropower plants.

Table 2 : Distribution of Small Hydroplants (up to 1000 KW)

Kilowatts	No. of Plants	% of Total
1 – 100	8	22.2
101 – 200	14	38.9
201 – 300	6	16.7
301 – 400	3	8.3
401 – 500	3	8.3
501 – 600	1	2.8
601 – 700	1	2.8
Total	36	100.0

Source: Compilation from NEA Publications

1.1.3 Sunkoshi Small Hydropower

Sunkoshi Small Hydropower Plant is located in Dhuskun of Sindhupalchok District in central Nepal, 90 km north east of Kathmandu along Araniko highway About 3 hrs. of ride from Kathmandu University.It downstream where the Sunkoshi and Bhotekoshi Rivers meet. Sunkoshi hydropower (2.5 MW) was constructed by Sanima hydropower pvt Ltd.

Construction on the plant began in 2003 and it was complete in 2005.The plant is a Run- Of-River project with installed capacity of 2.5 MW, design flow of 2.7 m3/s and gross head of 124.5m.This is only project in Nepal to utilize pressurized Glass Fibre reinforced Plastic (GRP) pipe for flow conduction.The Project Headworks is situated on the Sunkoshi Khola 3.5 km above its confluence with the Bhotekoshi River in Dhuskun VDC. A broad crested diversion weir diverts the flow to a desander basin, after which it follows a 2949m long rectangular lined canal 13 cross drainage structures exist to ensure that the canal does not obstruct any natural drains. At the end of the canal, a forebay connects the canal to a steel penstock pipe of 0.9m diameter and 289.5m length. The penstock pipe has an end bifurcation and leads the water to the powerhouse The powerhouse is situated about 300m downstream from the confluence of Sunkoshi and Bhotekoshi River. It hosts 2 turbines (Turgo) of 1500 KW capacity each. It is 6m in width and 16m in length.

Figure 1 : Powerhouse

Figure 2 : Settling Basin

The Coordinates of the project site is 27^0 46' 49.2" N and 85^0 54' 57.1" E. The site is located at Dhuskun, Sindupalchowk nearly 90 km north east of Kathmandu.

1.1.3.1 Catchment Area

An area of catchment is a unit of hydrology. If it doesn't evaporate, every precipitation drop that falls into a catchment area eventually ends up in the same river that flows to the sea. It might, however, take a very long time. Watersheds divide catchment areas from one another. A watershed is a naturally occurring boundary that runs along an area's highest points. Catchments are further subdivided along the lines of elevation into smaller catchments. With QGIS, the catchment area is drawn and found out to be 83.17 km^2.

The area covering by hydropower structure and catchment are given as follows:

1. Bhotekoshi
2. Barhabise
3. Tripurasundari
4. Balefi
5. Lisangkhu
6. Pakhar
7. Sunkoshi

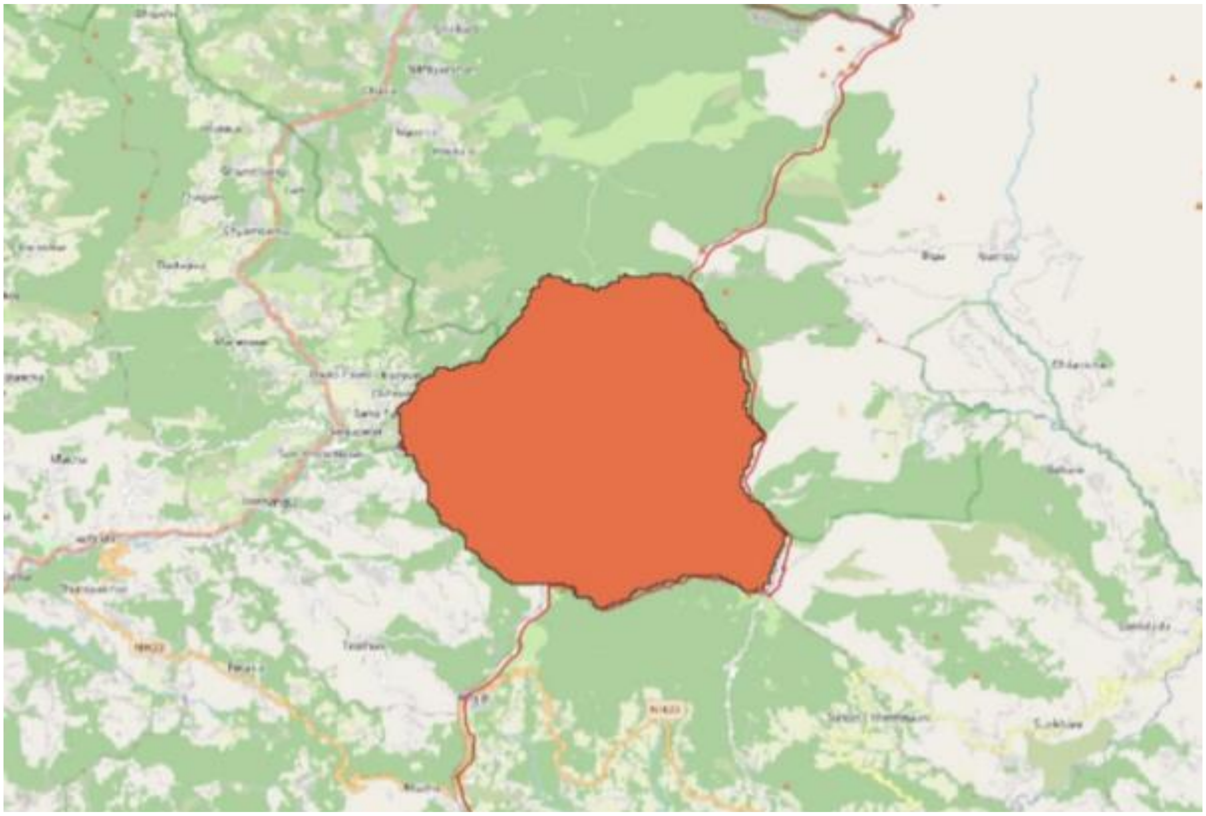


Figure 3 : Catchment Area

1.1.3.2 Salient Features of Sunkoshi small Hydropower:

Table 3 : Salient featurs of Sunkoshi small Hydropower

Type	Run of River Hydropower
Location	Dhuskun,Sindhupalchok District
Installed capacity	2.5MW
Net energy	14.38 GWh
Gross head	124.50 m
Catchment area	$81 km^2$
Average annual flow	5.77m3/s
Design discharge	2.7 m^3/s
Design floods (100 years)	325.00 m^3/s
Weir length	36m
Intake orifice size	1.50 m x 0.30 m (2 x 4 nos)
Approach canal	
Length	220.00 m
Size	1.60 m x 1.50 m
Slope	1:530
Settling Basin	
Length (including transition)	77.00 m
Settling chambers	2 nos., 4.50 m wide each
Settling length	45.00 m
Flushing discharge	1.08 m^3/s
Particle size to be settled	0.2 mm
Particle trapping efficiency	90%
Sediment flushing gate size	2 nos. 0.6m x 0.6m
POWERHOUSE	
Type	Surface
Size	18.00 m wide and 24.00 long
Turbine axis level	825.50 m amsl
TAILRACE	
Type	Open canal structure
Length	43.00 m
Tail water level	819.00 m amsl
ELECTRO-MECHANICAL EQUIPMENTS	
Turbine	
Turbine type	Turgo
Model	XJA – 60A/2 x14.5
Number of units	2 nos.
Rated capacity	1317 kW each
Efficiency	85%
Turbine inlet valve	Gate valve
Powerhouse crane	Overhead travelling crane
Capacity	10 tons

Generator	
Model	SFW 1250-10/ 1430
Rated Output	1250 kW each
Rated frequency	50 hz
Rated Current	143.2 A
Rated Voltage	6300 V
Power factor	0.8
Rated speed	750 rpm
Insulation Degree	F/F
Main Transformer	
Model	S93150-11/6.3
Rated Capacity	3150 kVA
Voltage	6.3 kV to 11 kV
Service Power Transformer	
Model	S9-M-63/6kV
Rated Capacity	63 kVA
Excitation Transformer	
Model	ZSJ-50/ 6 kVA
Rated capacity	50 kVA
Transmission line	
Line length	6.3km long, 11kV, single circuit
Switchyard	17 m x 15 m (approx.)
POWER AND ENERGY	
Design discharge	2.70 m^3/s
Gross head	125.5 m
Net head at full flow	117.5 m
Installed capacity	2.6 MW
Total energy per year	14.38 GWh
Power evacuation	At 11 kV Sunkoshi Substation, Phurketar, Lamosanghu, NEA HT switchboard 11 kV, 25 kA with copper Bus bar rated 2000 A consisting of incomer panel

1.1.3.3 Contour Map

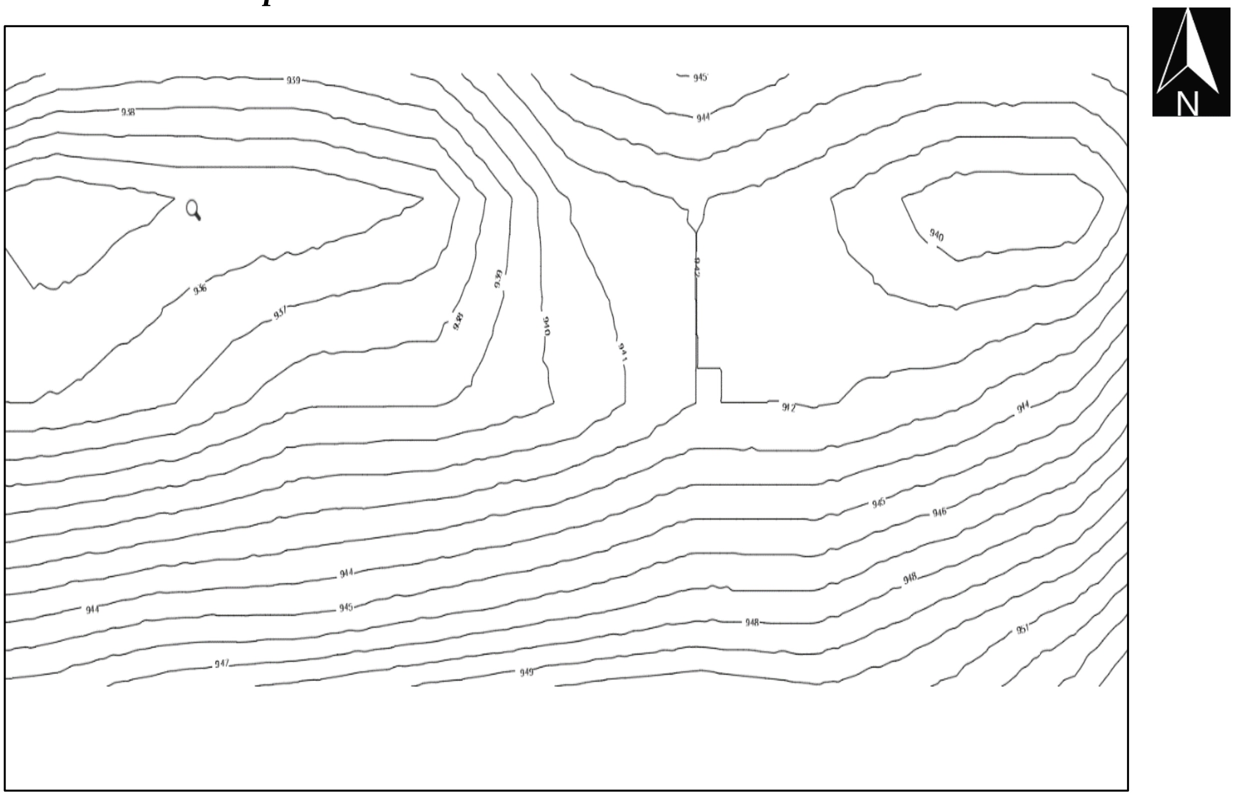


Figure 4 : Contour Map

Table 4 : Project Boundary

Project Boundary	
Latitude(E)	Departure(N)
85^{0} 53' 00"	27^{0} 46' 00"
85^{0} 56' 00"	27^{0} 46' 00"
85^{0} 53' 00"	85^{0} 56' 00"
85^{0} 56' 00"	85^{0} 56' 00"

1.2 Rehabilitation, Upgradation and Maintanance

1.2.1 Introduction

A new hydropower plant's construction necessitates a large financial amount , a lenghly legal procedure, and years of construction and production.Rather, maintaining, modernizing, and repairing an existing hydropower plant is highly affordable, environmentally benign, and satisfies sustainability requirements.It also requires less time to complete. RUM is crucial for current hydropower because of this.The HPP's main features and facility are covered in the rehabilitation studies, along with suggestions for enhancements.Upgrading entails enhancing design performance, whereas maintenance entails protecting the hydropower's componentry through routine inspection and replacement as needed.This endeavor will lead to the possibility of increasing installed capacity, which will prolong the life and improve the sustainability of the power plant.With little effort, we can also produce energy that is dependable and consistent.

1.2.2 Rehabitation

Restoring everything that has been harmed to its original condition is known as rehabilitation. The restoration of reservoirs, canals, intake structures, forebays, surge tanks, penstocks, and turbines is necessary for hydropower plant components. After the devastating landslide at Jure, the hydroelectric plant was completely destroyed. Sanima Hydropower Company promptly restored the power plant to operation after completing the necessary repairs on their own.

1.2.3 Upgradation

Upgrading (equipment or machinery) is the process of taking anything to a higher level, particularly by adding or removing parts. Among the improvements are:

1. Increasing turbine efficiency
2. Increasing the generator
3. Increase in head,
4. Increase in discharge

Sunkoshi Small hydropower plant need all of the above upgradation. Since its installed capacity is 2.5 MW, it can be upgraded.

1.2.4 Maintanance

In order to maintain the best possible operation, dependability, and efficiency of the hydropower facility, comprehensive maintenance is required. Hydropower maintenance can be characterized as

<u>Preventive Maintenance:</u> Regular maintenance is crucial for preventing downtime and minimizing operational disruptions in hydropower plants. This includes routine inspections, lubrication, cleaning, and calibration of equipment to identify and address potential issues before they grow.

<u>Corrective Maintenance:</u> In addition to preventive measures, hydropower facilities require prompt attention to repair unexpected breakdowns or malfunctions. Corrective maintenance involves

quickly diagnosing problems and implementing solutions to restore operations with minimal downtime.

1.2.5 Objectives of RUM

1. To identify and classify issues
2. To redesign the Sunkoshi HPP
3. To update the Sunkoshi HPP
4. To Increase the installed capacity of the Sunkoshi HPP

1.2.6 Advantage of RUM

Hydropower projects that undergo rehabilitation, modernization, and maintenance (RUM) have various benefits that guarantee the continued safety, efficiency, and environmental friendliness of the current hydropower infrastructure. The following are some main advantages:

1. Increased Efficiency and Output
2. Cost-Effectiveness
3. Environmental Benefits
4. Enhanced Safety and Reliability
5. Energy Security and Reliability
6. Economic and Social Benefits
7. Technological Advancements

1.3 Current Status of the Components of sunkoshi small hydropower

The Sunkoshi Small Hydropower Plant, located in the Sindhupalchowk District of Nepal, has faced significant challenges in recent years. Initially completed in 2005, the plant has an installed capacity of 2.5 MW and utilizes a run-of-river design. This project is notable for being the first in Nepal to use pressurized Glass Fibre Reinforced Plastic (GRP) pipes for flow conduction.

In recent years, the plant has been severely impacted by natural disasters. In August 2014, a massive landslide at Jure blocked the Sunkoshi River, creating a temporary lake that inundated the hydropower plant for over a month. This flooding caused extensive damage to the infrastructure, including the powerhouse, turbines, switchyard, and penstock pipes. The machinery was buried under sand and mud, and transmission lines were destroyed. Efforts to assess and repair the damage have been ongoing, with estimates suggesting that a complete overhaul may be required to bring the plant back into operation. In 2015, Massive earth quake hits the hydropower which leads to damage to the components and structure including powerhouse, settling basin, penstock pipe Later the sanima hydropower Ltd renovate the hydropower and it come in operation. The plant has faced challenges, such as the 2014 Sunkoshi blockage, which completely submerged the facility and caused significant damage. However, it has since been repaired and remains operational.

Through our investigation from various mediums and field visit, we can say that the gavel trap was damaged that need to be repair. Not only this, Settling basin was in Bad condition, it need to be clean and maintenance is needed. Penstock pipe was in good stage.

1.3.1 Need of RUM in Sunkoshi Small Hydropower

The components' poor performance is the result of their actual capability being lost. Low performance of hydropower can be attributed to a number of factors, including water-born debris like mosses and grass, and human nature's tendency to disregard the environment, which has led to garbage being thrown near water sources due to open approach canals. Comparably, the main issues with this hydropower are the sediment issue and the absence of a flushing pump, which will have an immediate impact on the hydropower's output. Hence for the sake of replacing these old components with the new ones, upgrading the components and redesign of the Approach canal and settling basin with flushing pump in order to enhance their performance, RUM of this hydropower is essential.

1.3.2 Scope

1. Advance technology will be used for the better management and maintenance of powerplant
2. The Hydroelectric generating capacity can be increased.
3. Optimum utilization of resources
4. Increasing the capacity of Settling Basin.
5. Increasing the capacity of Approach Canal

1.3.3 Limitations

1. Water demands for drinking and irrigation purposes are not considered during the hydrological analysis.
2. We may not be able to test and analysis all of electro-mechanical components of the hydropower.
3. We may not be able to get all the required data for the RUM of the hydropower plant.
4. Detail study of the Approach canal was not done due to structure are buried under fertile land

1.4 Need of RUM in Sunkoshi Small Hydropower

The components have lost their actual capability leading to their poor performance. Also the human nature of disregarding the environment has become one of the reasons, leading this hydropower towards its degrading condition., garbage thrown near water source due to open approach canal , and water born debris including mosses, grass etc. are some of the reasons behind low performance of hydropower. Similarly, In this hydropower, the major concern part is that there is a sediment problem in the hydropower and lack of Flushing Pump which will directly affect the performance of the hydropower. Hence for the sake of replacing these old components with the new ones, upgrading the components , and redesign of the settling basin with flushing pump in order to enhance their performance, RUM of this hydropower is essential.

1.4.1 Scope

1. Advance technology will be used for the better management and maintenance of powerplant
2. The Hydroelectric generating capacity can be increased.
3. Optimum utilization of resources

4. Increasing the capacity of Settling Basin.
5. Increasing the capacity of Approach Canal

1.4.2 Limitations

1. Water demands for irrigation and drinking are not taken into account when performing a hydrological analysis.
2. It's possible that we won't have time to test and examine every electro-mechanical hydropower component.
3. It's possible that we won't have access to all the information needed for the hydropower plant's RUM.
4. Because the Approach canal's structure is buried beneath fertile land, a detailed study of the canal was not completed.

CHAPTER 2 :LITERATURE REVIEW

Hydropower plant efficiency and sustainability depend heavily on RUM activities. Hydropower operators may contribute to a stable and sustainable electricity supply by ensuring the longevity and optimal performance of their facilities through a methodical approach to remodelling, upgrades, and maintenance. Although the 2.5 MW Sunkoshi hydropower project was completed 19 years ago, it was not adequately maintained. The hydropower was already experiencing a decrease in production. Although the machineries and power house were not changed, periodic maintenance and repairs were carried out.

According to research and analysis on these hydropower sources, frequent maintenance and machine upgrades can boost the Sunkoshi hydropower's power production efficiency.

2.1 Types of Hydropower Project

2.1.1 Classification based on functional basis or operation

Hydropower plant can also be classified on the basis of actual operation in meeting the demand as

- Isolated plant
- Grid connected (interconnected) plant

It has a constant demand of its own at the remote power plant. Numerous micro and mini hydros are in isolated systems in Nepal's rural areas. A system's isolation makes operation challenging because of the extreme demand volatility within it. A grid connection system operates by connecting multiple projects to a single grid and controlling them from a single point. The Independent National Power System (INPS) in Nepal is the hub for all project connectivity.The load centre located in Swichatar, Kathmandu, operates the grid, which is owned by NEA.The grid connected power plant is further divided into

- Base load power plant
- Peak load power plant

Continuous operation of base load power plants ensures the necessary base load is available all year round. The Run-of-River plants serve as base load plants in the Nepali system. However, in developed countries, coal-fired or nuclear power facilities serve as base load generators.

A plant that is designed and built to produce maximum load during daytime peak hours or during peak season is known as a peak load plant. Peaking Run-of-River (PRoR) projects are utilised in Nepal to manage daily peak flows, while for the larger peak storage plant, Kulekhani, is operated. Because nuclear and coal plants are difficult to adjustments, hydropower plants are employed for peaking load plants in developed nations. A hydropower plant may stop and restart operations in a matter of minute.

2.1.2 Classification based on storage capacity

Hydropower plants can be classified on the basis of whether they provide a storage reservoir or not as below:

RoR/ PRoR river plants

RoR plants are those that do not regulate the source river's hydrograph in a seasonal manner. A perennial river that offers a sufficient flow all year round is home to a run-off river plant. In a system like this, a weir is built across the river to keep the water level and outflow consistent for the downstream power plant. In order to operate at maximum efficiency during peak hours, ROR plants can be built with pondage, which can control the daily or weekly hydrograph and store water (partial or full). These types of plants are known as peaking run of river plant PRoR.

Plants like Marsyangdi, Kaligandaki, Middle-Marsyangdi, Sunkoshi Panauti and Upper Tamakoshi are PRoR type whereas plant like Khimti-I, Bhotekoshi, Indrawati III and Khudi are RoR type.

Storage plants

Storage plants are often those that have the ability to control a river's hydrograph by one or more seasons.For example, the Kulekhani HPP is a project that deals with storage. In these plants, over-storage from the rainy season to the dry season is allowed by the construction of a dam that creates an enormous reservoir. These plants are typically found along rivers that are non perennial. Usually, these are high head or medium head plants. Although storage plants have a large upfront cost, they offer a far more controlled and effective use of the water that is available. The following types of storage plants are possible.

Pumped storage

Plants with water bodies or reservoirs upstream and downstream of the power plant collect water in the u/s reservoir by pumping water from the d/s reservoir during off-peak hours using less expensive energy, then use that water to create power during peak hours.

Peaking run-of-river hydropower projects (PRoR)

Hydropower projects that use peaking run-of-river (PRoR) technology are intended to produce electricity in response to variations in the demand for electricity by regulating the daily flow of the river on an hourly basis. During dry seasons, when the river's flow is less than the intended discharge, this capacity will be reached by regularly ponding water at the headworks. The facility will function as a ROR plant to aid with bed load flushing during the rainy season when the river discharge exceeds the design discharge.

PRoR schemes must have installed capacity large enough to handle flows greater than the predictable river flow in order to achieve peak load coverage.During dry season ,peak requirements will typically be fixed for around 4 to 6 hours of operation based on site conditions and optimisation. The layout of peaking run-of-river project is same as that of run-of-river schemes i.e. three possible options are

- Peaking run-of-river with canal system
- Peaking run-of-river with pipe option
- Peaking run-of-river with tunnel option.

2.2 Hydrology

The scientific study of water on Earth and other planets, including the water cycle, water resources, and the sustainability of environmental watersheds, is known as hydrology. Surface water hydrology, groundwater hydrology (hydrogeology), and marine hydrology are the three branches of hydrology. Water plays a vital role in several areas of hydrology, such as hydrometeorology, surface hydrology, hydrogeology, drainage-basin management, and water quality.

CHAPTER 3: METHODOLOGIES

The following techniques have been used by us to complete our work efficiently.

3.1 Preliminary Research

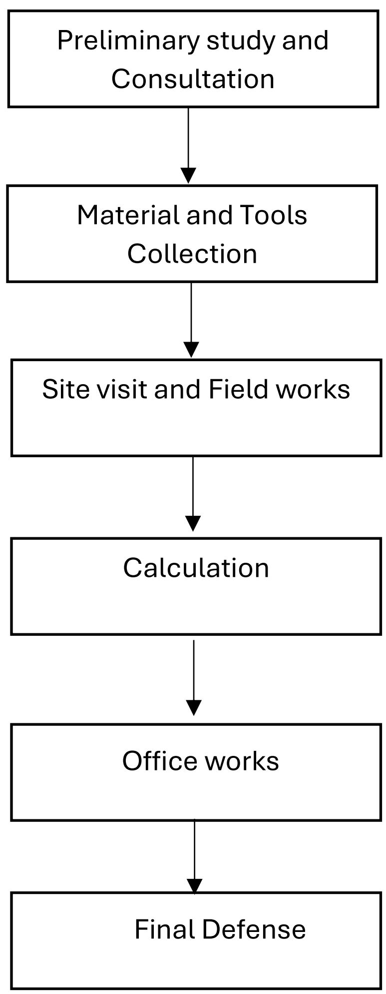
Study work is required in order to learn about our individual projects, and we have conducted the research in the following two ways:

Primary source:

In addition to talking about the project with the esteemed teacher and seniors, we also consulted DHM for discharge data.

Secondary source:

To acquire additional information and concepts, we use articles, research papers, and other online resources



a. Preliminary Study and Consultation

To fully understand the project, a thorough preliminary study had been conducted during that time. We looked through and referred to applicable books, articles, design guidelines and codes, reports, drawings, and findings that appeared relevant to our project. A preliminary investigation was conducted to determine the project's viability at the designated location. A thorough analysis was conducted of hydropower-related reference textbooks.

Additionally, we conferred with our supervisor, and all tasks were completed in accordance with the project supervisor's concerns and recommendations.

b. Materials and tools collections

The necessary equipment and instruments for the hydropower survey are gathered from college

c. Site visits and field works

We went to the Sunkoshi hydropower site and used the Total Station to finish the topographic survey of the penstocks and power house.

d. Planning and calculations

We discussed our project with our instructors and teachers, and we followed their advice and guidelines. The process and protocols that came across this project were smoothen out by such consultation as it was practiced at every step of the project. We looked through books, investigated various hydropower projects, were supervised and gathered information by observation and analysis.

e. Office works

The RUM project was designed using the topography survey data and the discharge and rainfall data of the site area that were obtained from DHM. Following the data collection, the project's hydraulic design and hydrological analysis were completed. The design discharge and the likely maximum flood at the location were estimated by analyzing the available discharge data.

f. Final defense

Final defense of RUM project was done on 12^{th} July, 2024.

CHAPTER 4 : HYDROLOGICAL ANALYSIS

4.1 Flow Duration Curve

For the flood duration curve, we extracted the hydrological data of last 18 years of Sunkoshi Station from Department of Hydrology and Meteorology (DHM).

Table 5: Calculation for Flow Duration Curve

Month	Discharge Q (m3/s)	Q in descending order (m3/s)	Rank	Frequency (N/n)	prof of ex(1/F)	Discharge(Q) (m3/s)
Jan	0.847	15.032	1	12.00	8.33	15.03
Feb	0.715	11.279	2	6.00	16.67	11.28
Mar	0.669	9.056	3	4.00	25.00	9.06
Apr	0.766	3.942	4	3.00	33.33	3.94
May	1.326	3.517	5	2.40	41.67	3.52
June	3.942	1.576	6	2.00	50.00	1.58
July	11.279	1.326	7	1.71	58.33	1.33
Aug	15.032	1.014	8	1.50	66.67	1.01
Sep	9.056	0.847	9	1.33	75.00	0.85
Oct	3.517	0.766	10	1.20	83.33	0.77
Nov	1.576	0.715	11	1.09	91.67	0.72
Dec	1.014	0.669	12	1.00	100.00	0.67

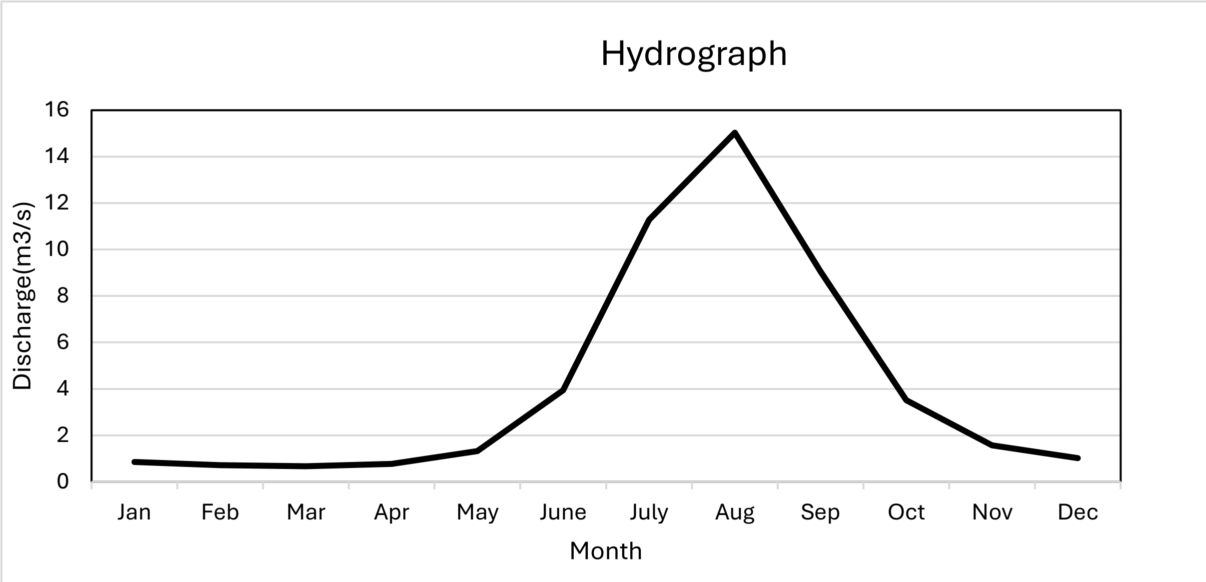


Figure 5 : Hydrograph

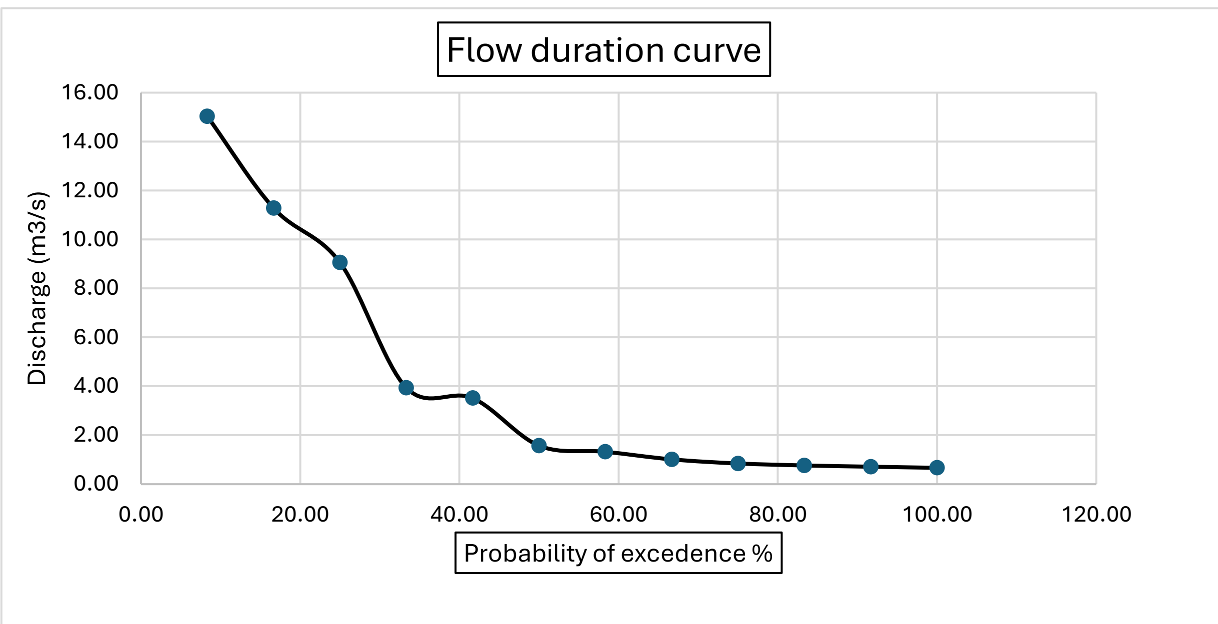


Figure 6 : Flow Duration Curve

4.2 Calculation of Power and Energy

Power and Energy calculation is done using the head of 117.5m and the design discharge is kept maximum of 3.602 m^3/s which is 40% of exceedance i.e. Q40, without any modification and upgrade. The combined efficiency is taken as 86%. The dry season outage and wet season outage is taken as 3% and 5% respectively.

Table 5 : Calculation of Power and Energy

Month	River Flow	Available Flow	Days	Design Flow	Net Head	Generation Capacity (KW)	Dry Season Energy (kWh)	Wet season energy (kWh)
Jan	0.85	0.78	31	0.78	117.5	773.3	558084.9	
Feb	0.76	0.65	29	0.65	117.5	642.5	433738.9	
Mar	0.67	0.60	31	0.60	117.5	596.9	430743.4	
Apr	0.77	0.69	30	0.69	117.5	693.0		474024.4
May	1.32	1.23	31	1.25	117.5	1248.2		882189.9
Jun	3.94	3.88	30	3.60	117.5	3570.7		2442334.5
Jul	11.28	11.21	31	3.60	117.5	3570.7		2523745.6
Aug	15.03	14.97	31	3.60	117.5	3570.7		2523745.6
Sep	9.06	8.99	30	3.60	117.5	3570.7		2442334.5
Oct	3.52	3.45	31	3.45	117.5	3420.0		2417316.7
Nov	1.58	1.50	30	1.50	117.5	1495.9		1023244.6
Dec	1.01	0.95	31	0.95	117.5	938.9	677556.9	
						Total Seasonal Generation, (kWh)	2100124.1	14728935.7
						Total Annual Generation, (gWh)	2.100124131	14.7289357
						Total Energy	16.82905983	
						Rate, 11 per kWh	185119658.1	

Table 6: Return periods

Return period(Yr)	Discharge(m3/s)	
	MHSP 1997	WECS/DHM 1990
5	234.28	5.12
20	358.77	10.38
50	450.94	14.87
100	527.68	18.89
1000	853.17	37.01

Table 7 : Return Periods

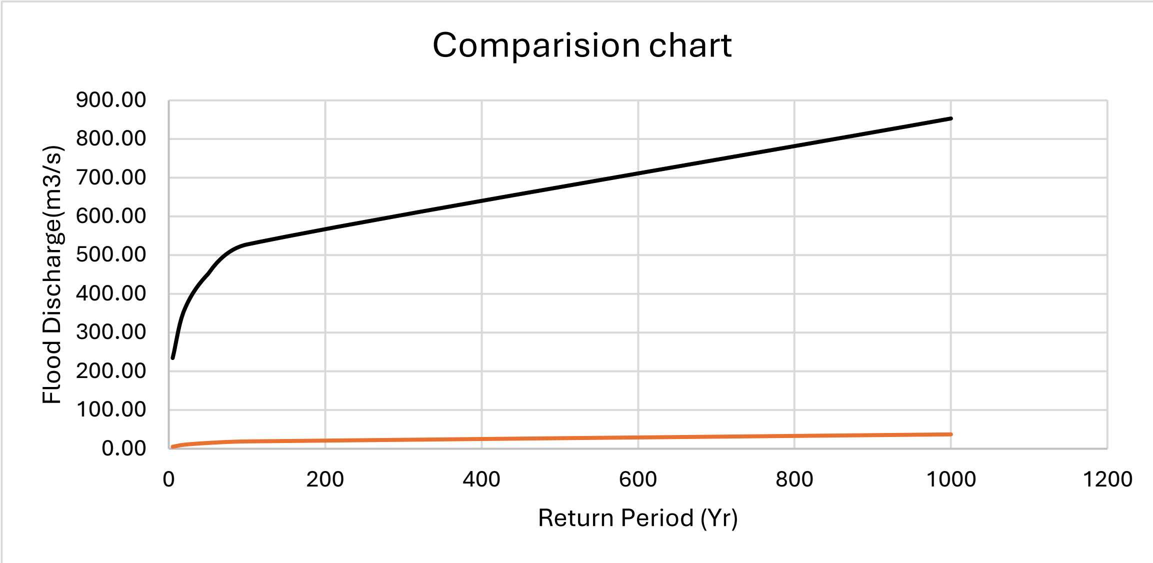


Figure 7 : Flood Analysis

CHAPTER 5: STUDY OF THE ALTERNATIVES

5.1 Alternative

The first option is to simply restore the project without making any upgrades or changes. It essentially relates to all of the rehabilitation work that must be done right away in order for the project to function properly. This includes upkeep of the headworks, sediment excavation, river training projects, dam construction, canal leak prevention, and clearing the forebay of debris. This also includes swapping out the generators, transformers, and turbines for the two units. In this option, a new control unit and visually pleasing finishing are also anticipated. Stated differently, this alternative won't involve any upgrades, so the anticipated outcome after applying it will be the same 3.6 MW of power.

5.2 Alternative 2

Another option is to build a separate intake and use a nearby river to increase the reservoir's water inflow. The current project's forebay receives this water directly. It consists of all the standard rehabilitation exercises that must be performed in an alternate setting.

1. Due to increased water inflow, increase in annual energy production is assumed as this increases operation time of the plant.

CHAPTER 6: DESIGN OF COMPONENT

6.1 Design of approach canal

Discharge(Q)=3.602m^3/s

$S_o = 0.0065$, N=0.01

For the most economical rectangular section, b=2y

A=by=2y^2

P=b+2y=4y

R=$\frac{A}{P}$=0.5y

Q=$\frac{1}{N} A\ R^{\frac{2}{3}} S_o^{\frac{1}{2}} \Longrightarrow$ 3.602=$\frac{1}{0.01} * (2y^2) * (0.5y)^{\frac{2}{3}}$*$0.0065^{\frac{1}{2}}$

$y = 0.67m$

$b = 1.34m$

So, Dimensions of economical trapezoidal channel is
Width (b) = 1.34 m
Depth of flow(y) =0.67 m
Area of flow (A) = 0.897 m^2
Wetted perimeter (P) = 2.68 m
Hydraulic radius (R) =0.335 m
Slope of the bed of the channel (S) = 0.0065
Discharge (Q) = 3.602 m^3/s
Velocity (v) = 0.7 m/s

Top width (B) = b = 1.34 m

6.2 Design of settling Basin

For plan area of settling basin

Using the general equation as given below

Plan area of the basin (A_s) = 1.5Q / w

where, Q is the design discharge of one basin = 3.602 m^3/s

Let w is the fall velocity of the particle = 0.02 m/s

A_s = 1.5 * 3.602 / 0.02 = 270.15m^2

Use the L/B ratio is 8

where, L is the length of the basin and B is the breadth of the basin

From the above calculation LB = 270.15m^2

B = L/8

Lx L/8=270.15

or, L^2 = 270.15 * 8 = 2161.2

So. Length of the basin (L) = 46.48m

Hence, for the breadth of the basin, B = 46.48/8

So, Breadth of the basin, (B) = 5.81m

Check the Basin width by the following equation

B = 4.75$\sqrt{Q}$ = 4.75$\sqrt{3.602}$ = 9.01m

Adopt smaller dimension for easement of the flushing purpose, So, basin width (B) = 5.81m

For the depth of settling basin

Calculating the limiting flow velocity (V) in the basin by V_c = a$\sqrt{d}$

where, d = size of particle to be removed in mm.

For particle of size 0.2mm diameter, limiting velocity V_c = 0.44$\sqrt{d}$ = 0.44$\sqrt{0.2}$ = 0.196m /sec.

Adopting the horizontal component of velocity 0.196m /sec

So, depth of settling basin is $H = \frac{Q}{V.B} = \frac{3.602}{0.196 \times 5.81}$ =3.16m

But, from the Continuity Equation $Q = A \times V$

$$A = \frac{Q}{V}$$

$$H = \frac{Q}{V \times B} = \frac{3.602}{0.15 \times 5.81} = 4.12m$$

Hence, Adopt the Height of the basin (H) = 4.13m (Take the maximum of both)

Compute the sediment depth in the basin

Sediment concentration = 5Kg/m^3

Density of sediment = 2600Kg/m^3

Let, Detention time for sediment = 6hrs

So, Sediment load = Q*T*C = 3.602 * 6 * 60 * 60 * 5 = 389016kg

Let, Packing factor of sediment in submergence(β) = 0.5

Volume of sediment =$\frac{Sediment\ load}{Density*\beta} = \frac{389016}{2600*0.5} = 299.24m^2$

Then, we have, basin plan area = $270.15m^2$

So, height of sediment, h_s = 299.24/270.15 = 1.1m

Since, the above calculation is considered for the case of rectangular base, we can recalculate the area for the base with the following shape

From calculation, the angle of inclination of the slope = 40°when the area resembles rectangular base

Check the efficiency

a) From Hazen's Equation

Efficiency η=1-$(1 + mA_{s\frac{\omega}{Q}})^{(\frac{-1}{M})}$

where, m is the performance coefficient = 0.17 (for very good)

η=1-$(1 + 0.17 * 270.15 * \frac{0.02}{3.602})^{(\frac{-1}{0.17})}$=73.71%

Efficiency η = 73.71%

b) From Camp's equation

Cross sectional area (A_X) = (BH) = 5.81 * 4.13 = 24m^2

Wetted perimeter (P) = (2 * 4.13 + 5.81) = 14.07m

(Assume H as only the clear water height)

Hydraulic radius (R) = A_x / P = 24/14.07 = 1.7m

Hence, shear velocity (v^*)= v^*= $\frac{4.2v}{100R^{\frac{1}{6}}} = \frac{4.2*0.15}{1001.7^{\frac{1}{6}}} = 0.00576$

Ratio (w/v^*)=0.02/0.00576 = 3.47

From the Camp's chart for the sedimentation of turbulent flow. Efficiency (β) = 100%

c) From Vetter's equation

1-η=$e^{-\frac{\omega A_S}{Q}}$

where, η is the efficiency of the basin

w is the fall velocity

Q is the design discharge

So, Efficiency (η) = η=1-$e^{-\frac{\omega A_S}{Q}} = 1 - e^{-\frac{0.02*270.15}{3.602}}$=0.7768=77.68%

Hence, from the above 3 equations regarding the calculations of the efficiency of the sedimentation, the calculated plan area was enough to attain 100% efficiency for the case using Camp's equation. So the plan area was taken as 46.48m x 5.81m = 270.15m²

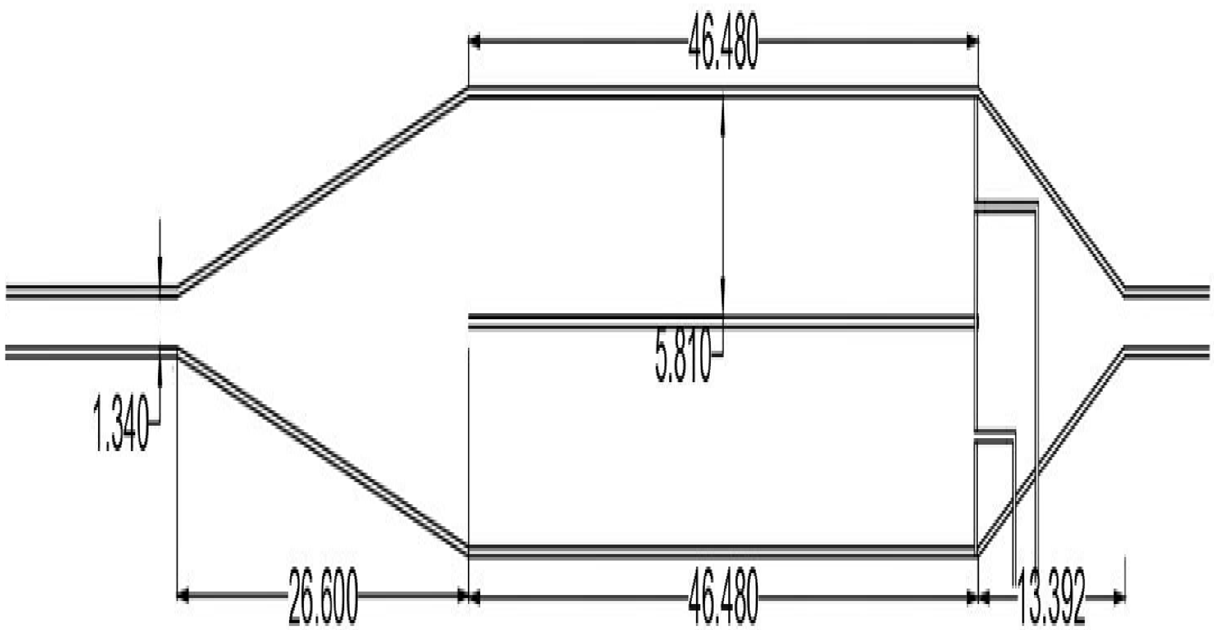


Figure 8 :Plan of Settling Basin

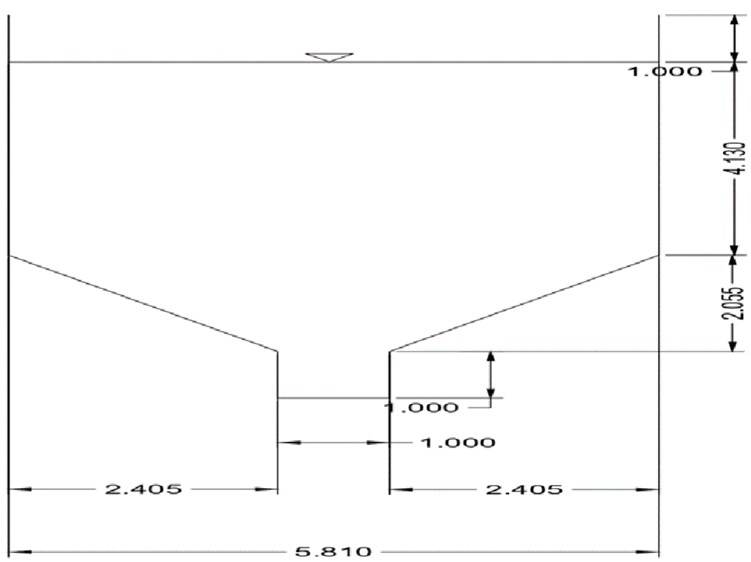


Figure 9 : Cross Section of Settling Basin

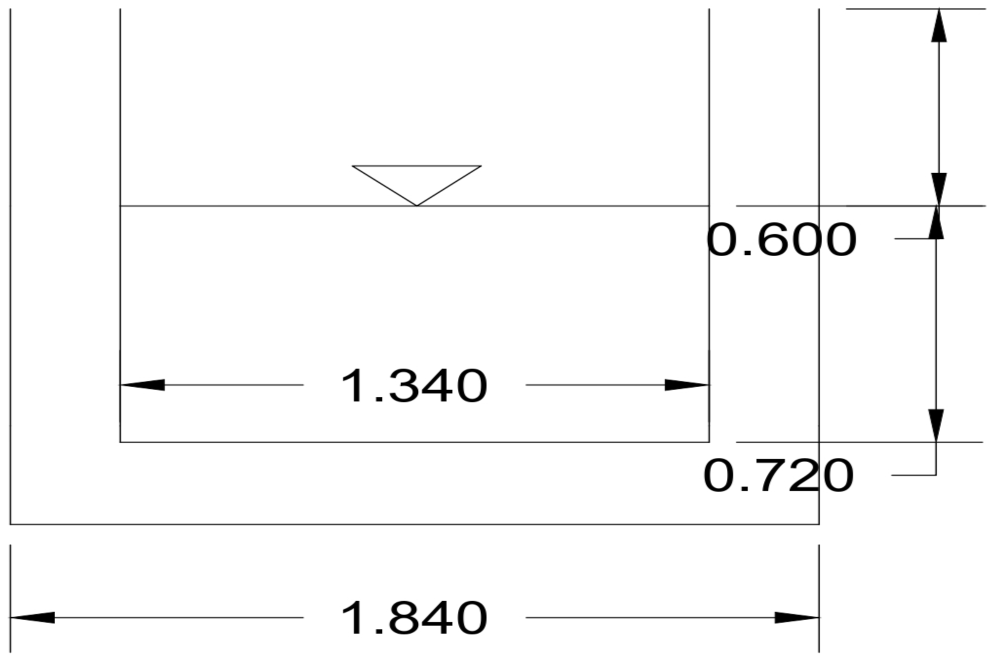


Figure 10 : Autocad Drawing pf Approach canal

CHAPTER 7: ENVIRONMENTAL STUDY

7.1 Physical Environment

7.1.1 Location

Sunkoshi Small Hydropower Plant is located *in* Dhuskun of Sindhupalchok District in central Nepal. It downstream where the Sunkoshi and Bhotekoshi Rivers meet. The Coordinates of the project site is $27^{0}\ 46^{'}\ 49.2^{''}$ N and $85^{0}\ 54^{'}\ 57.1^{''}$ E.

7.1.2 Geography

Geologically, the project area lies in the Lesser Himalayan Zone.The project area consists of the Kuncha Formation and the Benighat Slate of the Nawakot Complex. The Kuncha Formation consists of gritty phyllited medium grained to gritty quartzites. The proportion of quartzite and phylllite varies according to startigraphic position.The Benighat Slate consists of laminated carbonaceous slate with frequently occurring carbonate bands named as Jhiku Carbonate.

7.1.3 Hydrology

The water level (700 m) in the proposed reservoir extends up to downhill of the Dhaireni village in the Cha Khola, Near to Bhimtar of the Jhyari Khola, South of Sipaghat in the Indrawati River, Kothe in the Sunkoshi River and Simle and bhadaure in the Balephi Khola.

7.1.4 Seismicity

The Sunkoshi Hydropower Plant is located in a seismically active region, as Nepal lies on a tectonically active zone where the Indian and Eurasian plates meet. This region is prone to earthquakes and associated hazards.One of the most significant events affecting the Sunkoshi Hydropower Plant was the devastating earthquake that struck Nepal on April 25, 2015.

7.2 Socio-economic condition

7.2.1 Population Demography, Ethnicity and caste

At the time of the 1991 Nepal census, Dhuskun of Sindhupalchowk had a population of 3116 and had 665 houses in the village.At the time of 2011 Nepal census, it had population of 4206.Sindhupalchok district is full of multi-caste diversity. Tamang, Chhetri, Newar, Brahmin-Pahadi, Kami,Sherpa, Magar,Sarki, Gurung, Rai, Sonam, Limbu, Tharu,Rajvanshi, Koili, Kayastha, and other castes are living in the different areas of Sindhupalchowk.

7.2.2 Education

Sindhupalchok district has 19 resource centres, 352 child development centres, 45 non-formal adult schools, 35 institutional schools, 12 graduate campuses, 567 community schools, and 602 total schools. The literacy rate of Sindhupalchowk is 68.04% (75.26% male and 61.13% female) according to national census 2078.

7.2.3 Occupation

Most of the people in Sindhupalchok are involved in agriculture and animal husbandry. People here are involved in business, government jobs, teachers, engineers, politicians, tourism industries, etc. The people of Sindhupalchok are earning good income from commercial agriculture and animal husbandry.

7.2.4 Market (Bazar) and Commercial Center

The main commercial centres and markets have helped keep various economic activities running. Different grains, food grains, vegetables, domestic products, and essential items imported from outside are gathered in the market areas of the district. Chautara, Tatopani, Melamchi, Khadichour, Bahrbise, Mude, Jalbire, Dolalghat, Talamarang, Nawalpur, Syaule, Sangachok, Lamosanghu, Tipeni, Chanoute, Bahunepati, Sipaghat, Bhotechour, Tauthli, Sukute, Chehere, Timbu, Irkhu, Melchaur, Galthum, Badegaon, Attarpur, Andheri, Batase, Bhimtar, Gumb, Dhuskun, Kunchok, Marming, Jamire, Phatkashil, Sunkhani, Ramchi, Piskar are the small and big markets and business centres of Sindhupalchowk district.

7.2.5 Health Institutions

According to District Profile -2075, 1 district hospital, 3 primary health centres, 75 health posts, 49 sub-health posts, 219 village home clinics, 5 Ayurveda dispensaries, 9 community health units, and 4 urban health centres in the Sindhupalchowk.

Looking at the overall health status of the district, new technologies are being used in this area. Patients who cannot be treated in health institutions are referred to Dhulikhel in Kavre or various hospitals in the capital.

7.3 Cultural Environment

Dhuskun is likely home to various ethnic groups indigenous to the region. Each group contributes to the cultural tapestry of the area through their distinct languages, customs, and traditional practices. Dhuskun residents likely participate in Hindu and Buddhist rituals and festivals. Temples and shrines dedicated to various deities are integral parts of the village landscape.In Dhuskun, you might find locals engaged in activities like pottery making, weaving, and wood carving, which have been passed down through generations.

CHAPTER 8 : WORK SCHEDULE

Table 8 : Work Schedule

S N	Work Progress	March				April				May				June				July	
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2
1	Consultation and Literature Review																		
2	Material and Tools Collection																		
3	Field Visit																		
4	Office work																		
5	Mid term Presentation																		
6	Final Project Defense and Report Submission																		

	Present Day
	Work Completed

CHAPTER 10: CONCLUSION

After undergoing about 20 years of continuous operation, currently it is in degraded condition. Now, it is functioning with the power production with comparatively very low efficiency. There can be good possibility of rehabilitation of the project and can be further used for next 70 years efficiently if proper modification and maintenance is done. For this, all-stake holder should work in hand in hand to take this project to the proper functioning and operational state. Since, people of Dhuskun, Sindhupalchok, NEA, and Sanima Hydropower Ltd are the stake holders of this project; Kathmandu University could also be a potential Stake holder if it can aid this program in technical aspects. Project has been studied to the feasibility level. This report supplements the details regarding to feasibility study. After detailed field investigations like topographical mapping, field visit, site observation and hydrological data collection, design and layout works were carried out with its project cost estimation. Financial evaluations were also carried out to determine the viability of the project. The conclusions drawn are as following.

1. The RUM project successfully enhanced the efficiency of the Sunkoshi Small Hydropower plant, leading to higher electricity output.
2. Sediment Problem in the Settling Basin was solved.
3. Rehabilitation efforts extended the operational lifespan of the facility, ensuring long-term sustainability.
4. Upgrades reduced downtime and improved the reliability of the power supply.
5. Maintenance activities minimized future repair costs and optimized operational expenses.
6. Implementing modern, eco-friendly technologies reduced the environmental impact of the hydropower plant.

CHAPTER 11: RECOMMENDATIONS

The following studies should be done prior to the construction phase to find the in-depth details. The detailed design would lead to the preparation of the tender documents for various aspects of the Project since the details provided in this section might still need some detailed study on some of the issues as:

- Detailed study survey for waterways and transmission line Geological and geotechnical investigation for major structure locations
- Review of hydrological investigations
- Hydraulic, Structural and Hydro and Electro-mechanical Designs

CHAPTER 12 : REFERENCES

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ANNEX

Photo : Detailing

Photo : Settling Basin

Photo : Approach Canal