WELCOME

Presentation at the National Engineers Association

Bheri Babai Diversion Multipurpose Project (BBDMP)

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Project Director, BBDMP

April 17, 2015

Content

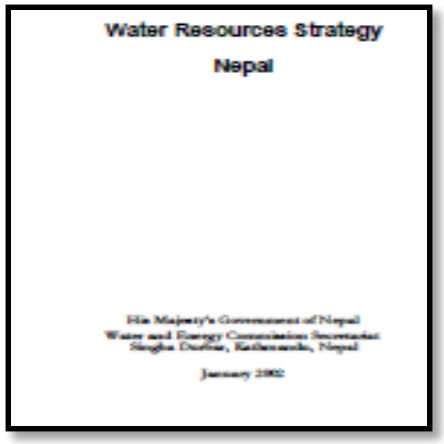
1. **Background**
   (Significance of Irrigation, BBDMP in National context)
2. **Planning**
3. **Investigation**
4. **Design**
5. **Tunnelling Technology**
6. **Present Status**

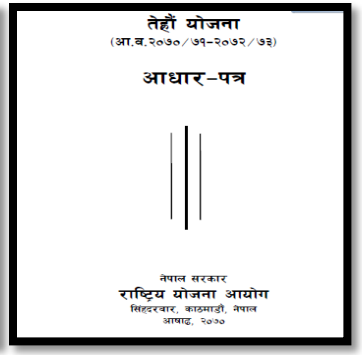
Policy Provisions for Irrigation Development

National Policy Documents

- National Water Resources Strategy 2002
- National Water Plan 2005
- Irrigation Policy 2070
- Millennium Development Goal on Poverty Alleviation
- 13th Plan (2070/2071 to 2072/2073)
- Annual Budget 2071/72

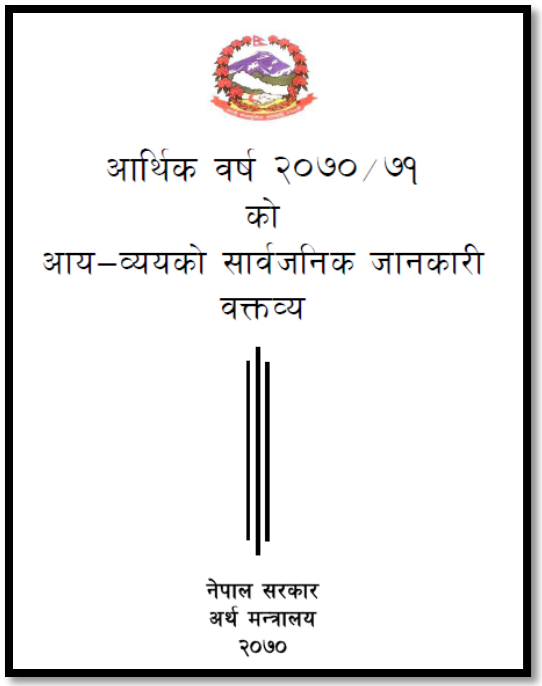
सिंचाइ नीति, २०७०





Focus on
Development of infrastructure for
year round assured Irrigation

BBDMP in Annual Budget



आर्थिक वर्ष २०७०/७१
को
आय–व्ययको सार्वजनिक जानकारी
वक्तव्य

नेपाल सरकार
अर्थ मन्त्रालय
२०७०

आदरणीय दिदीबहिनी तथा दाजुभाइहरू

अब, म आगामी आर्थिक वर्षको बजेटका नीति तथा कार्यक्रमहरू प्रस्तुत गर्न चाहन्छु ।

संविधान सभा निर्वाचन

२९. २०७० साल मंसीर ४ गते संविधानसभाको निर्वाचन सम्पन्न गर्नु सरकारको मुख्य प्राथमिकता हो । निर्वाचनलाई स्वतन्त्र, निष्पक्ष र विश्वसनीय बनाउन सुरक्षा लगायतका आवश्यक सम्पूर्ण व्यवस्थाहरू मिलाइने छ । यसका लागि रु. १६ अर्ब छुट्याएको छु । निर्वाचनमा सहभागी हुन सम्पूर्ण दिदीबहिनी दाजुभाइहरूमा हार्दिक अपील गर्दछु ।

राष्ट्रिय गौरवका आयोजनाहरू

३०. अर्थतन्त्रको जीवनरेखाका रुपमा रहेका ऊर्जा, सडक, रेल, सिंचाई, खानेपानी र पर्यटन क्षेत्रका राष्ट्रिय गौरवका आयोजनाहरूलाई उच्च प्राथमिकता दिई पर्याप्त बजेट विनियोजन गरेको छु । पशुपति क्षेत्र विकास, लुम्बिनी क्षेत्र विकास, राष्ट्रपति पुरे संरक्षण र भेरी-बबई डाइभर्सन आयोजनाहरूलाई समेत राष्ट्रिय गौरवको आयोजनाको रुपमा घोषणा गरी बजेट वृद्धि गरेको छु ।

BBDMP = Project of National Pride

Irrigation Vs Commercial Agriculture

Accepted policy through all periodic plans from beginning till today:

- **Agriculture is mainstay Nepal's economy**
- **Best development option for broad based economic development and improvement of living standard**
- **Existing Vs Potential benefit ~ 3-7:1**

  (Punjab, Costa Rica, Egypt etc, specific area in Nepal)

S.R.I. प्रविधिवाट गरिएको धान खेतीको नतिजा

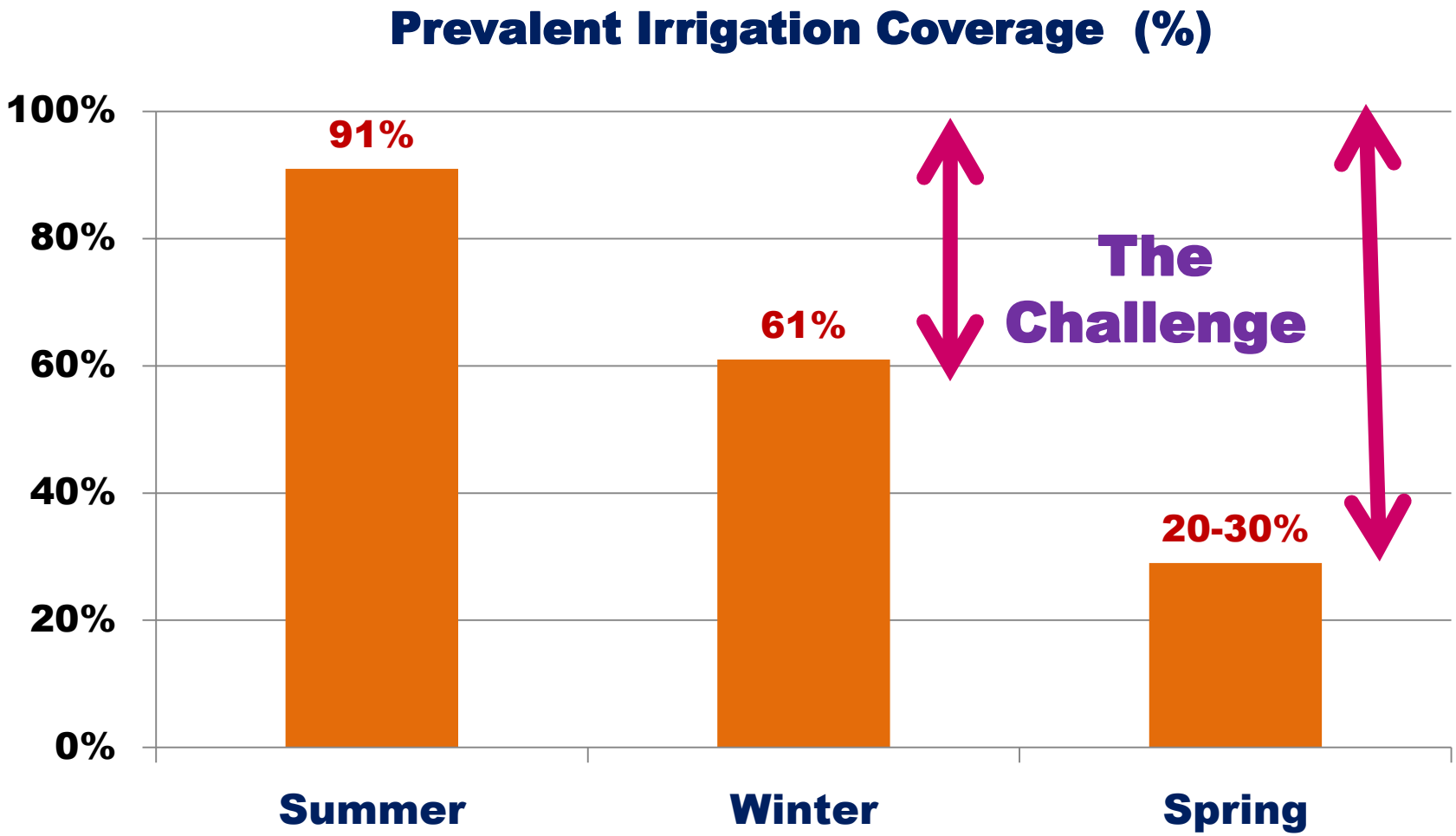
संकलित तथ्यांक	बिन्देश्वरी	रामपुर मसुली
बोटको उचाई (से.मी.)	115-130	125-140
पात संख्या	4-6	5-7
गांज संख्या	35-65	39-85
बालाको लम्बाई (से.मी.)	28-32	33-38
प्रति बाला दाना संख्या	270-314	285-335
बाली तयार हुन लागेको जम्मा दिन	109	133
उत्पादन (मे.ट. प्रति हेक्टर)	9.72	11.25

Round the year assured irrigation

=

necessary condition for commercial agriculture

Fundamental Challenge to Department of irrigation



Annual Volume of Water Resources Vs Utilization

Annual volume of Water (~225 BMC) = Abundant

BUT

Huge Temporal and Spatial variation

Solution

Temporal variation = Storage Projects

Spatial variation = Inter Basin Water Transfer (IBWT)

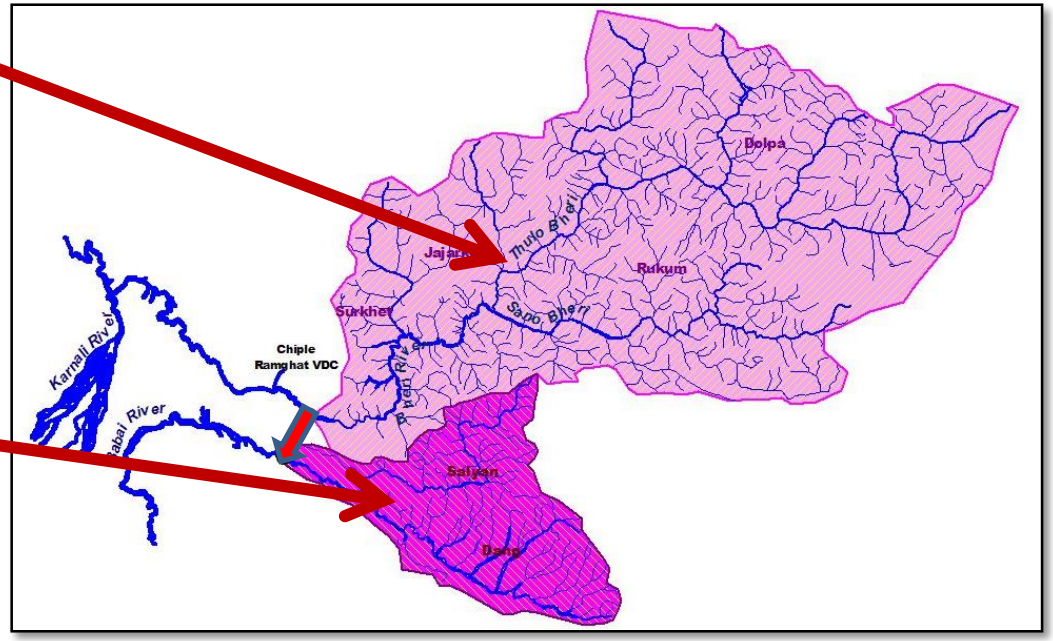
IBWT

Inter Basin Water Transfer (IBWT)

Water from water Surplus river basin

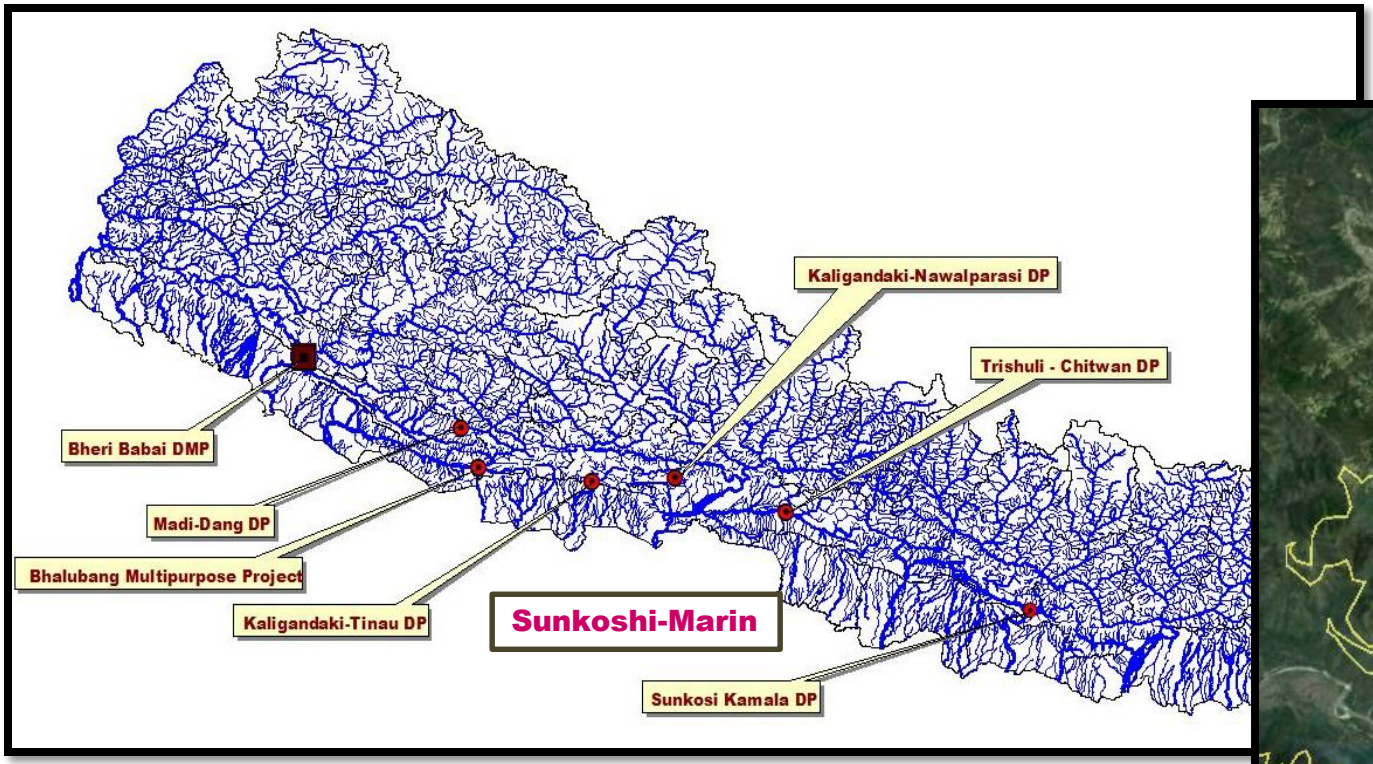
to

water Deficit river basin



Prospective IBWT Projects in Nepal

Inter Basin Water Transfer Projects under consideration by Department of Irrigation



Advantage of BBDMP over others: Both HW site and Powerhouse site are already accessible through Highways

Most advance stage of implementation

Firsts/Significance of BBDMP at national level

- **Nepal's First** large multipurpose, IBWT project
- **First** time mechanized tunneling using TBM in Nepal
- **Paradigm shift** for Department of Irrigation from small/medium towards large multipurpose projects
- **Investigative in nature-**Experience gained in BBDMP will be pave way for other IBWT projects in pipeline
  - Sunkoshi-Marin
  - Kali Gandaki-Tinau
  -
  -

MOTTO

1. WE SHOULD STRIVE TO SUCCEED APPLYING ALL POSSIBLE MEANS

2. WE CANNOT AFFORD TO FAIL

Main objectives of BBDMP

Objective I

Year round irrigation to 51,000 ha of land in Bardia and Banke Districts

Objective II

Generate 48 MW of firm hydropower

How?

1. By diverting and transferring 40 m^3/s water from a snow-fed water surplus Bheri river to water deficit Babai river

2. Utilize the difference in elevation between Bheri and Babai (about 152 m) to generate hydro electricity

Benefit due to BBDMP

Total Annual Benefit

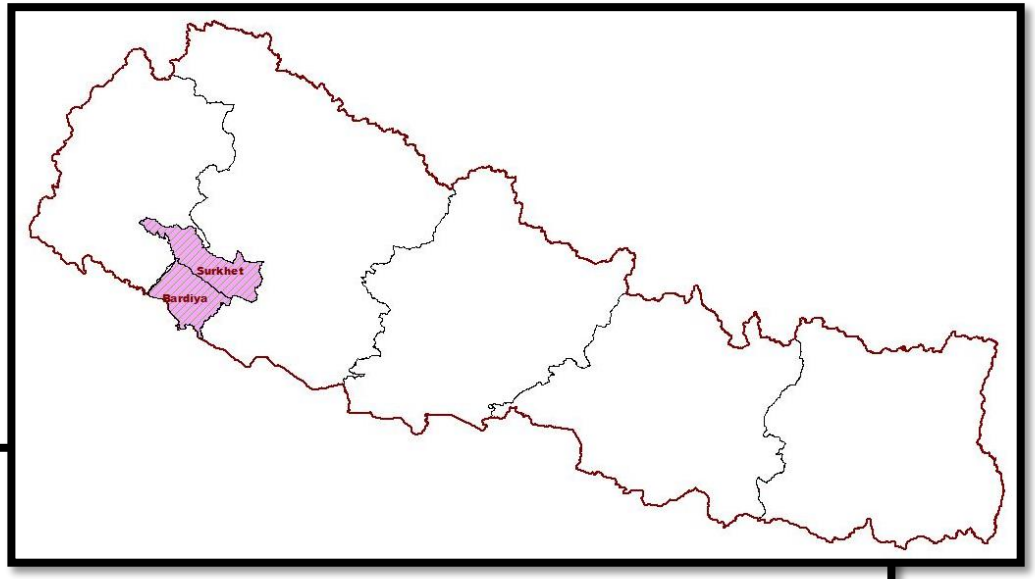
Irrigation (2.2 Billion) + Hydropower (2.1 Billion) = NRS 4.3 Billion

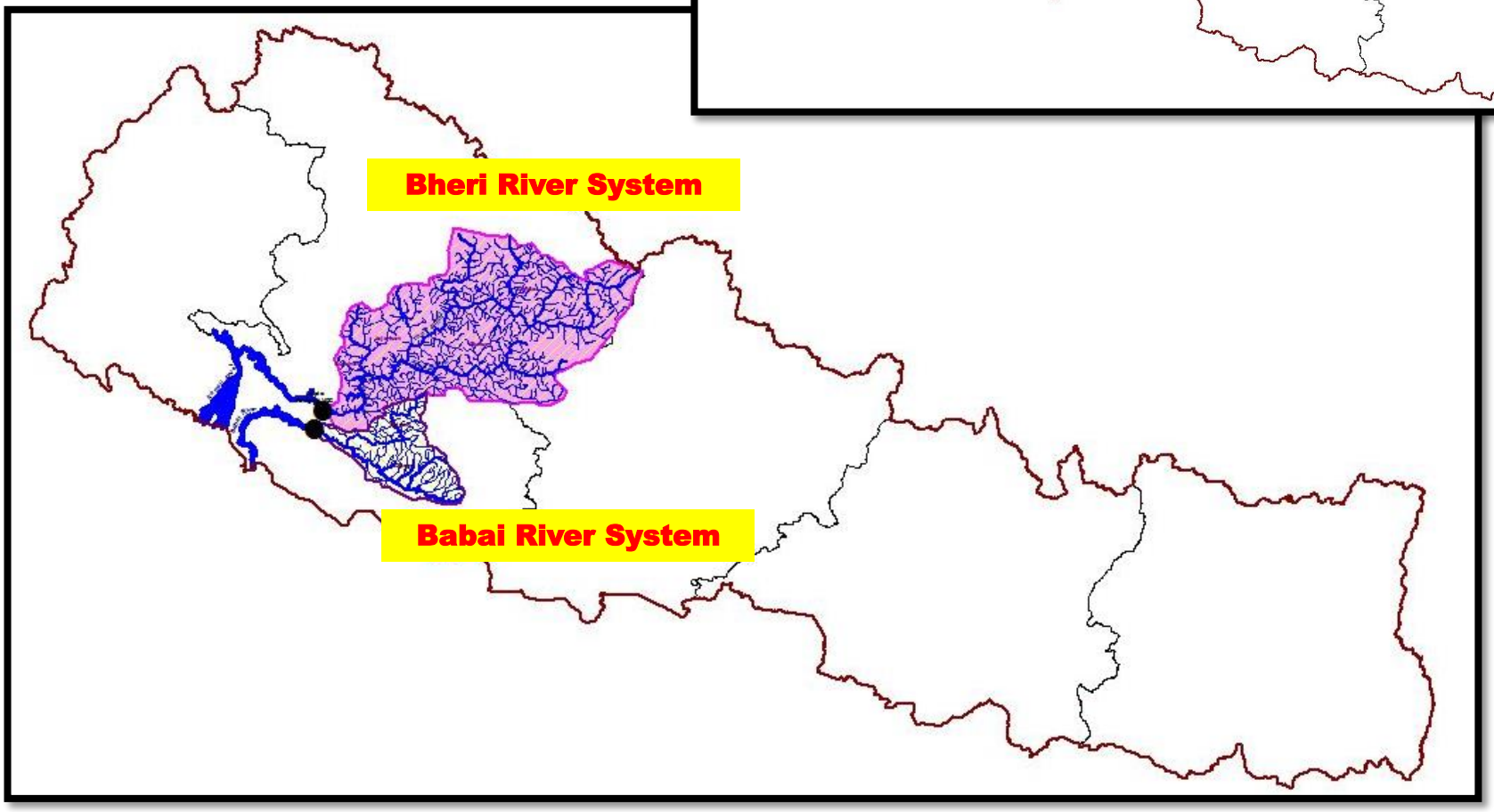
EIRR	- 13.42%
B/C ratio	- 1.36 at 10% discount rate

Note: Computation at 2011 price

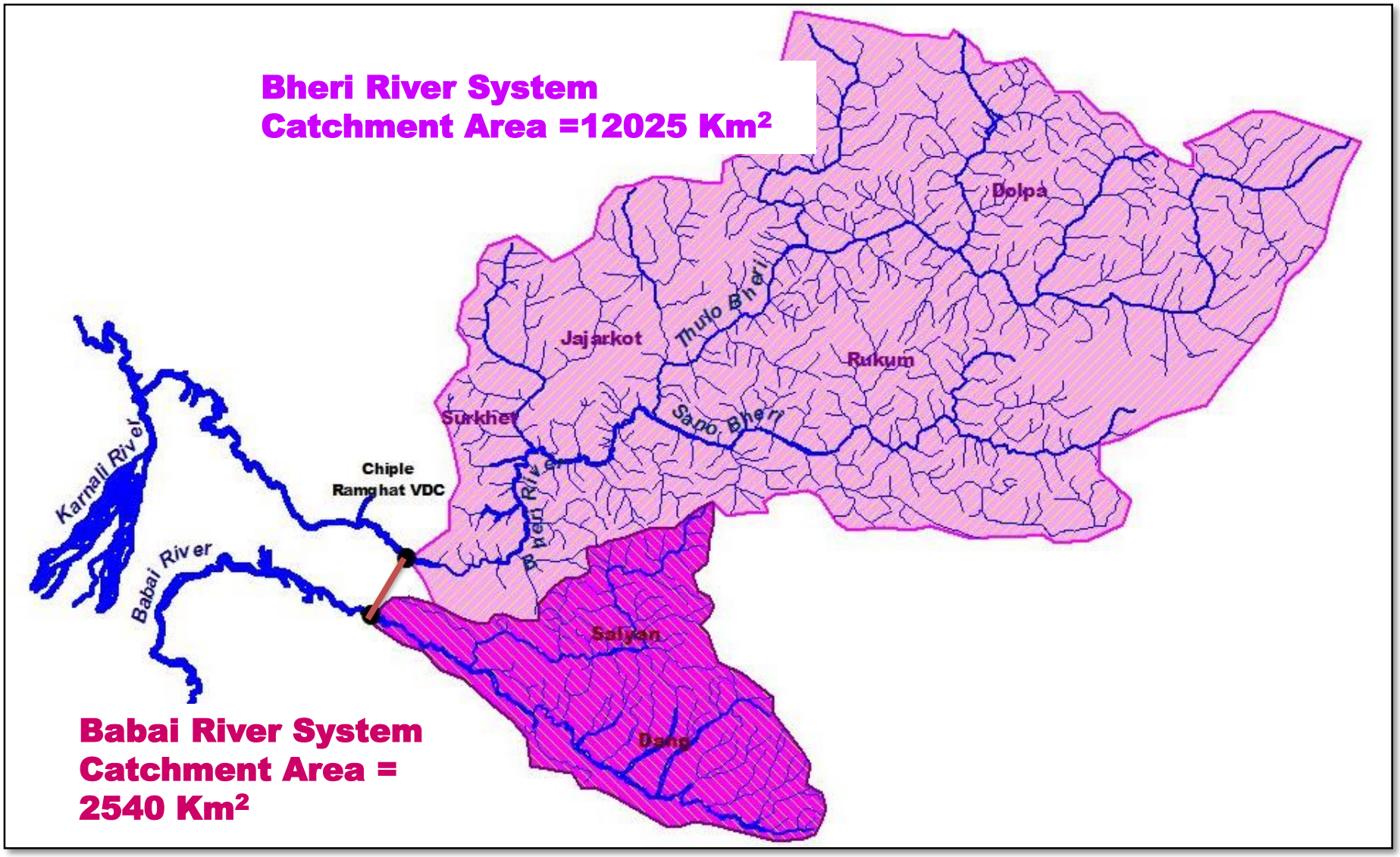
Location

Surkhet and Bardia Districts of Mid Western Dev Region





Bheri and Babai River System and Catchment



Overall Concept

Two Main Components

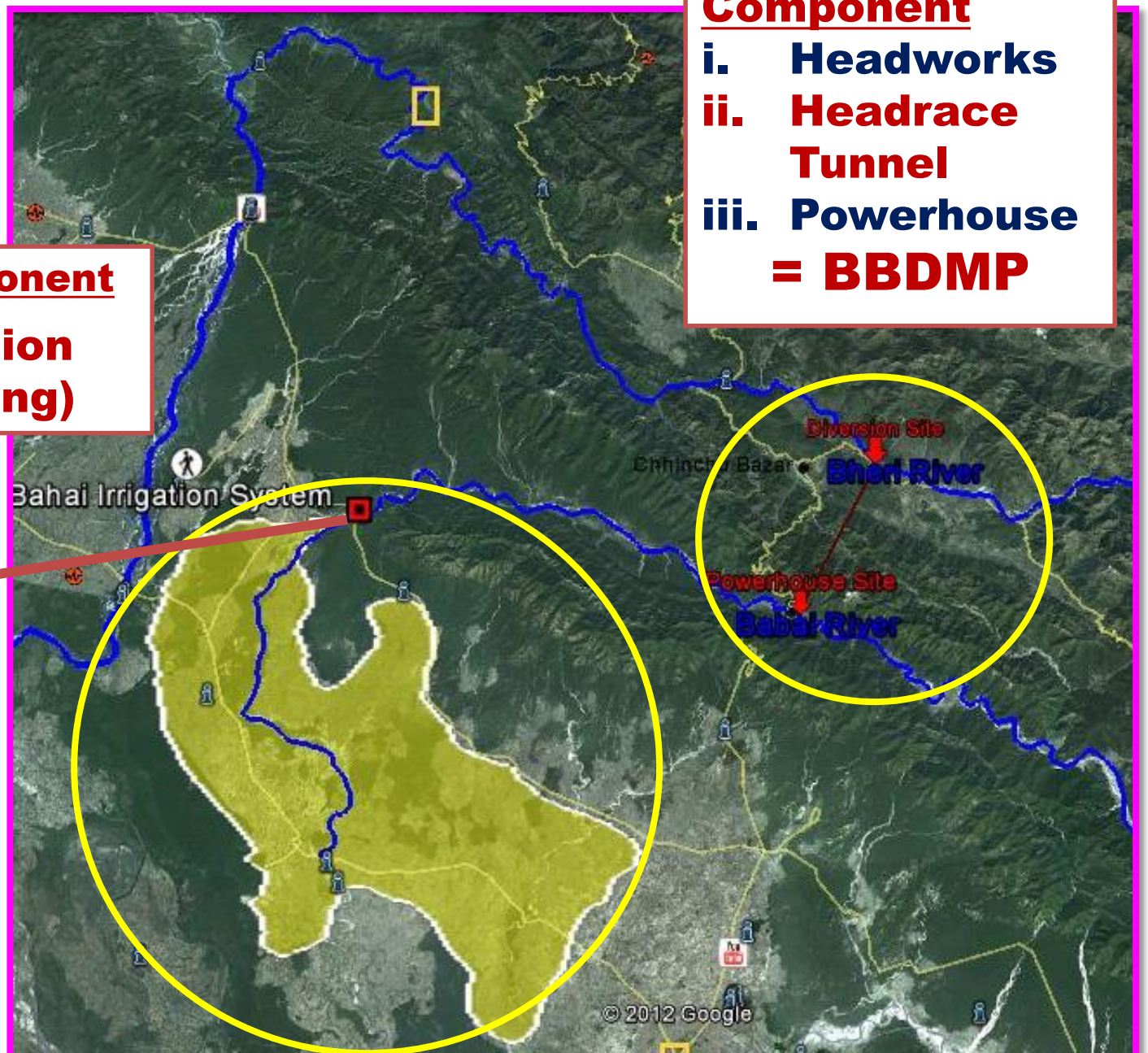
Irrigation Component

= Babai Irrigation Project (Ongoing)

Diversion Component

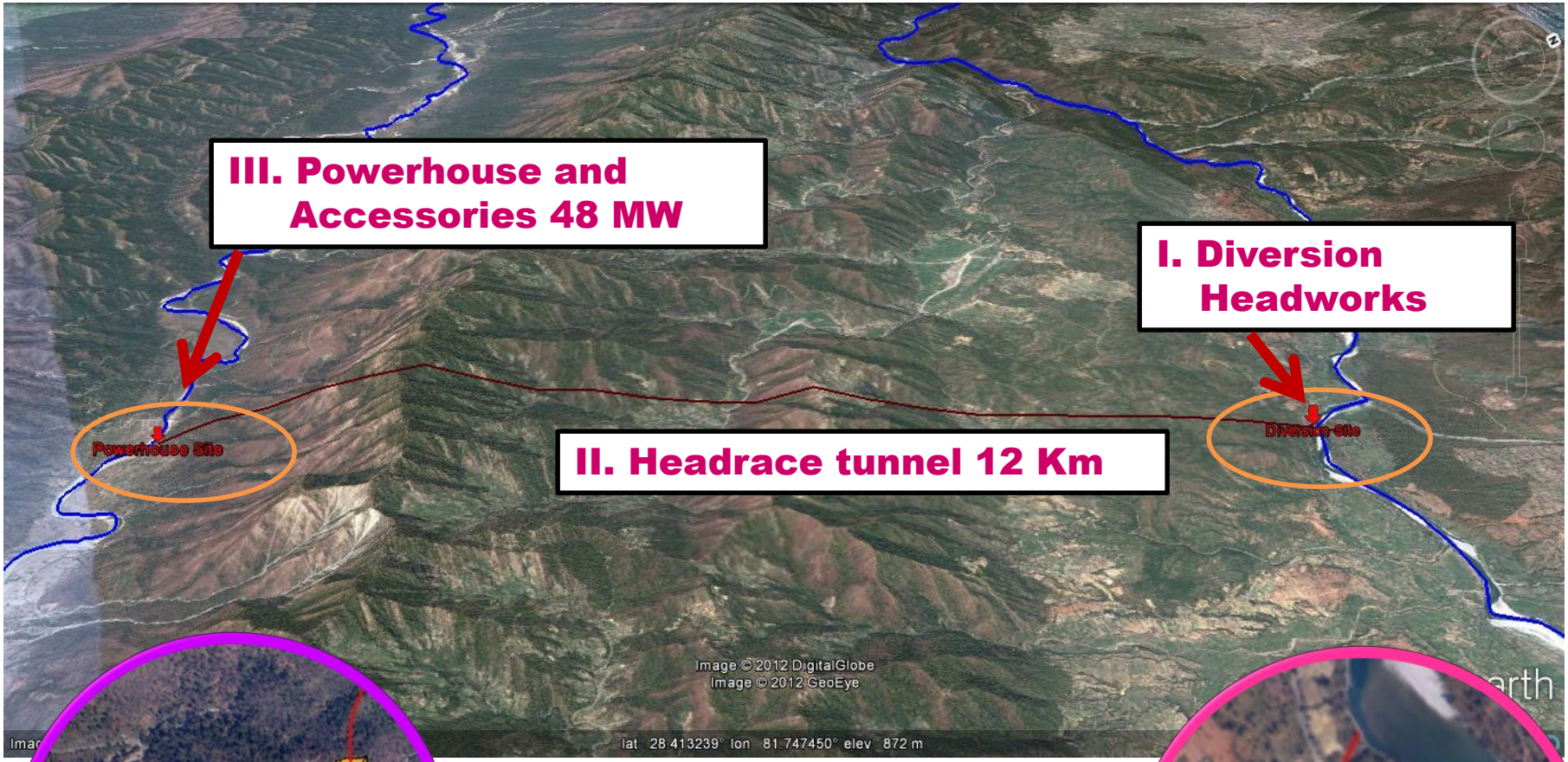
i. Headworks
ii. Headrace Tunnel
iii. Powerhouse

= BBDMP



Planning

General Planning of Main Components



- Access Road 2 Km
- TBM Platform
- Entry Portal
- Starter Tunnel 200 m

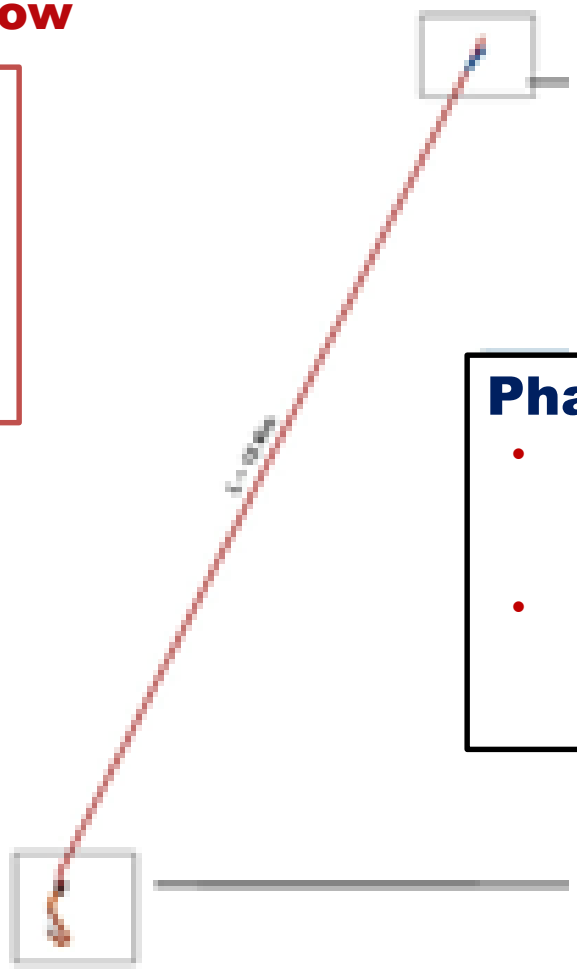
Planning for Construction

Phase wise synchronized construction is planned considering the following:

- **Optimization of time for construction,**
- **Risk due to geological complexity**
- **harmonize funding and cash flow**

Phase I:

- **Headrace tunnel 12 Km**
- **Access Road 2 Km**
- **TBM Platform**
- **Starter tunnel and entry portal**
- **Construction Camp**



Phase II:

- **Diversion Headworks**
- **Powerhouse and accessories**

Time Line of Project Implementation

Construction of Tunnel

- **Expected excavation progress:**
  about 400-500 m/month
- **Overall time for Construction of tunnel: 4.5 years (Including 1 year for fabrication and erection of TBM)**

Headworks/Powerhouse/Irrigation Component

- **Depends on progress of Tunnel construction**
- **Headworks/Powerhouse expected to be initiated 2-3 years after commencement of tunnel construction**

Investigation

Investigation

Drilling

5 drilling holes altogether

- **2 at TBM Platform and 1 at TBM Entry Portal (each of 50 m deep)**
- **1 at Bheri Thrust (176 m deep)**
- **One at outlet portal**

ERT

at fault area (Toli khola area) completed

Investigation

Geological Investigation

Core drilling completed

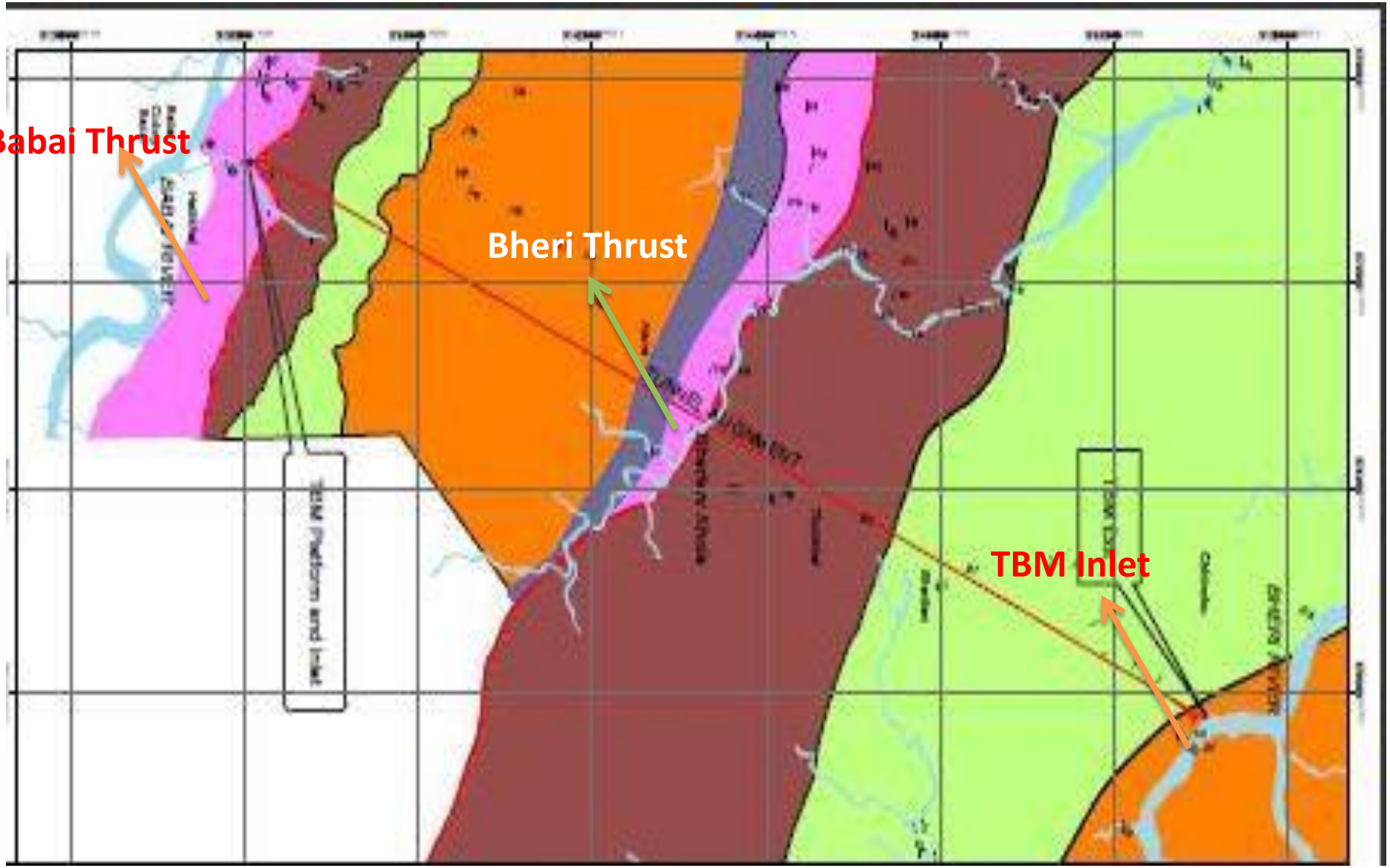
- **TBM entry platform area, Toli khola area**
- **TBM exit area**

ERT at fault area (Toli khola area) completed

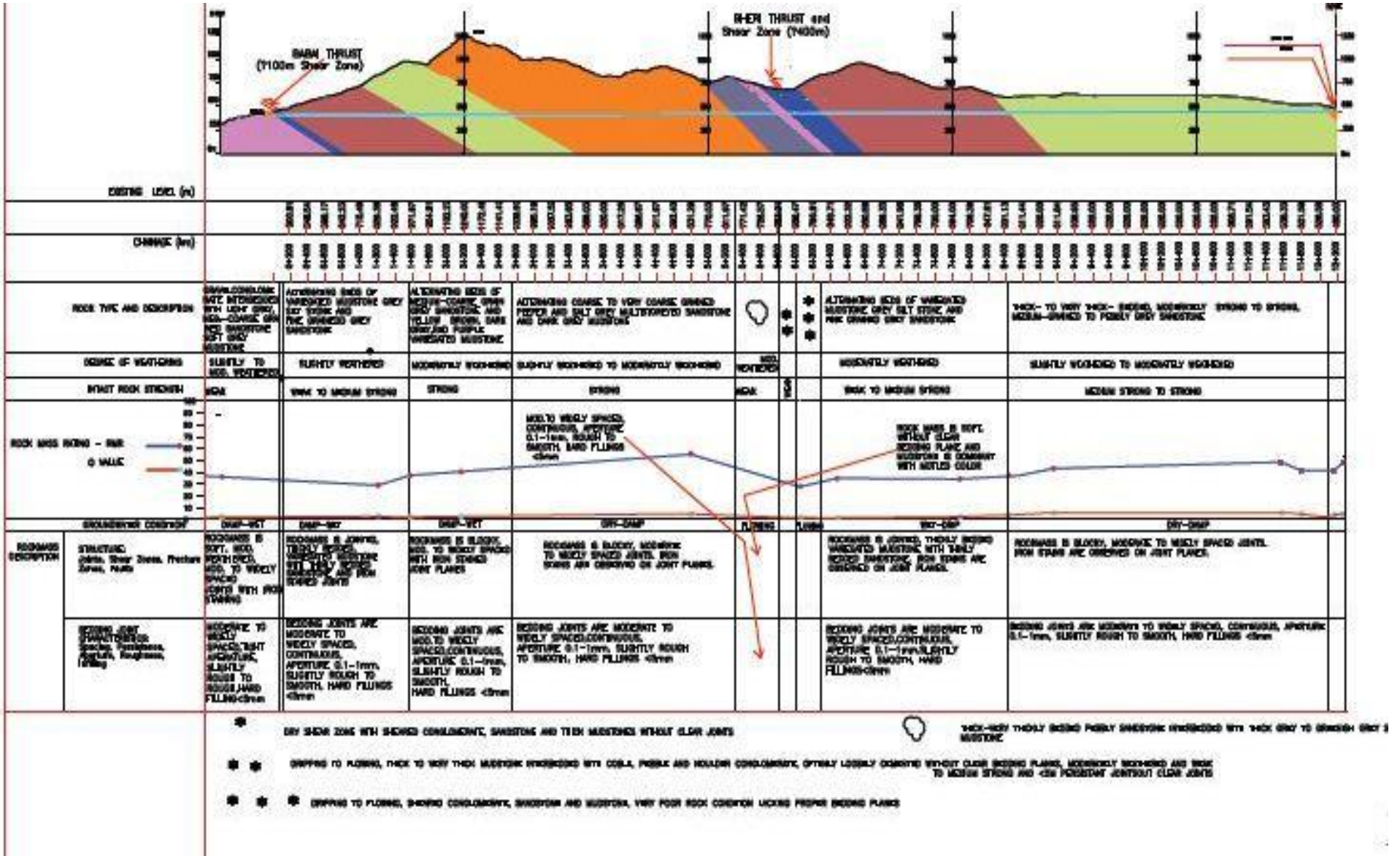
Geological Aspect

- **Geological aspect put together as Geological Baseline Report (GBR)**
- **Expected geology**
  - **Interbedding of mudstone, sandstone and conglomerate repeated at regular interval with varying dominance**
  - **Fault zone is expected at two locations**
  - **Water ingress is not likely**

Geological Map



Geological Cross Section



Geomechanical Tests

S.No	Sample No.	specific gravity	Water Absorption %	sample dimension, mm			Weight gm	Unconfined compressive strength, kg/cm2	Mean Unconfined Compressive Strength (Mpa)
				Length	Breadth	Height			
1	SR-1	2.57	0.33	63.23	59.67	41.9	384.3	318.81	31.88
2	SR-2	2.55	0.36	63.7	63.68	62.73	636.4	175.71	17.57
3	SR-3	2.64	0.37	61.23	64.83	65.93	680.2	404.63	40.46
4	SR-4	2.74	1.08	64.83	66.08	62.83	679.8	155.97	15.60
5	SR-5	2.69	0.43	66.58	63	60.83	629.4	169.93	16.99
6	SR-6	2.66	0.81	66.4	52.87	44.3	401.4	169.93	16.99
7	SR-7	2.66	0.81					500.00	55.00
8	SR-8	2.55	0.57	68.3	65.98	63.7	691.4	553.58	55.36
9	SR-9	2.67	0.81	64.83	65	268.17	712.9	168.55	16.86
10	SR-10	2.73	1.01	64.63	66.18	62.72	679.3	155.90	16.99
11	SR-11	2.56	0.72	58.5	48.23	29.43	161.9	208.27	20.83
12	SR-12	2.64	0.60	67.57	61.53	42.53	420.4	242.85	24.29
13	SR-13	2.59	0.57	60.87	56.03	54.43	451.7	235.19	23.52
14	SR-14	2.65	0.67	64.03	63.83	49.53	457.8	370.57	37.06
19	SR-15	2.61	0.60	67.13	67.2	60.3	581.5	207.38	20.74

Geomechanical Tests.....

Rock type	Formation	Average Minimum UCS (MPa)	Average Maximum UCS (MPa)	Overall Average UCS, (MPa)	Brazzilian Tensile Strength	Cerchar Abrasivity Index(CAI)	Remarks
Lower Siwalik	Sandstone	31.89	48.38	37.60	6.3	1.85	
	Mudstone	15.59	17.79	16.72	2.8	1.17	
Middle Siwalik	Sandstone	13.72	55.38	25.41	3.6	2.54	
	Mudstone	14.68	18.37	16.99	2.1	1.47	
Upper Siwaik	Sandstone	7.04	3.86	5.02	2.1	1.35	
	Mudstone	10.31	5.14	7.86		2.18	
	Conglomerate				4.25	2.89	Pebbly Conglomerate

Hydrogeological Condition

- Estimated Average Permeability : $3.37*10^{-8}$ m/s

- $4.32*10^{-9}$ m/s (eight hydrogeological Zones)

Rate of Inflow is estimated by Dupuit formula (Thiem ,1906) given by:

$$Q=\frac{2\pi K l d_z}{ln\frac{2L}{r_o}}$$

- Rate of Inflow in to the tunnel ranges from 2l/s/m -10l/s/m (no joint has persistence of >200m and conglomerate is cemented)
- Contractual provision for High water ingress (if more than 2000 l/m from 10 m stretch)

Investigations before/during Implementation

- Drift tunnel of 150-200 m (contractor has to built which can later be used to walk the TBM)
- Probing with two drilling assembly mounted in TBM (contractual provision of up to three holes per face)
- Contractual provision of additional geological assessment by the contractor before finalizing the design of TBM

TBM Viability

- **Atlas Copco's Formula:**

Tunnel Length (m)/ Tunnel Diameter (m)* unconfined compressive strength (Pa)

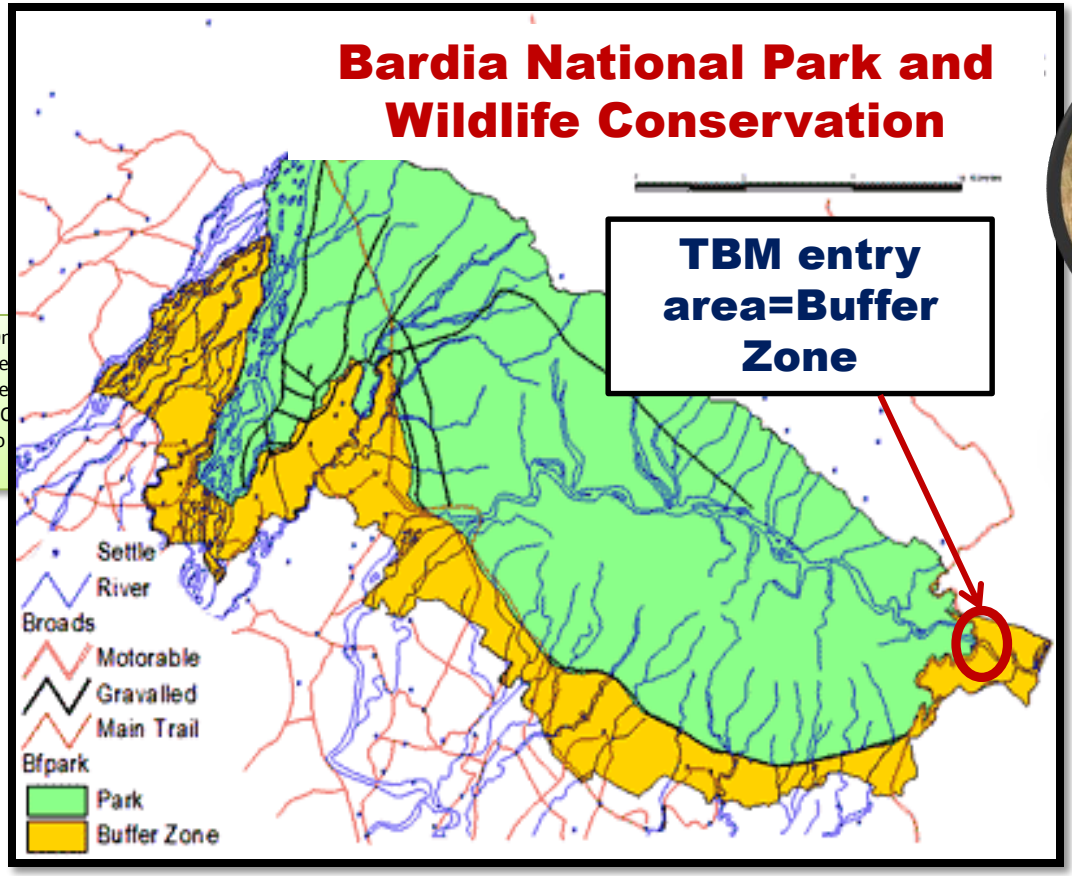
- **Length= 12000 m, UCS= 5 Mpa Excavation Diamtere =5 .1m and the value is 12,**
- **Up to UCS= 19.5 Mpa its more than 3.**
- **Overburden= 22-820 m (likely squeezing spalling)**
- **Rock Class (RMR) = Poor to Fair (29-50)**
- **Standup time= 10 hrs for the span of 2.5 m can be on lower side**
- **Friction Angle=15°- 25° (for 5 m dia tunnel the deformation starts from > 6 m behind the face)**

TBM Proposed

- Double Shield TBM
- Two set of drilling assembly
- Drilling ability in circumference and center of tunnel (48-110mm)
- Pregrouting facilities
- High pressure grouting facilities (up to 10 Mpa)
- Minimum shield length
- Friction resistance up to 25 Mpa
- Overcutting Facility

Design

- Design Discharge
- Cross Section
- Longitudinal Section



Endangered Species

Land Animals: Royal Bengal tiger, one-horned rhinoceros, elephant, swamp deer, black buck;

Rptiles : gharial crocodile, marsh mugger crocodile; fresh-water Gangetic dolphin

Design Discharge determined on Environmental Considerations

Environmental Considerations:

- Need to maintain the allowable limit of minimum 30 cm water depth in Bheri river during April and May, fish migration period
- to ensure protection of aquatic life, long term changes in water temp should not exceed 2 degrees
- to limit water depth variation of 0.3 m in Babai river to maintain the aquatic life and mammals to cross the river in breeding period

Design discharge = 40 m^3/s

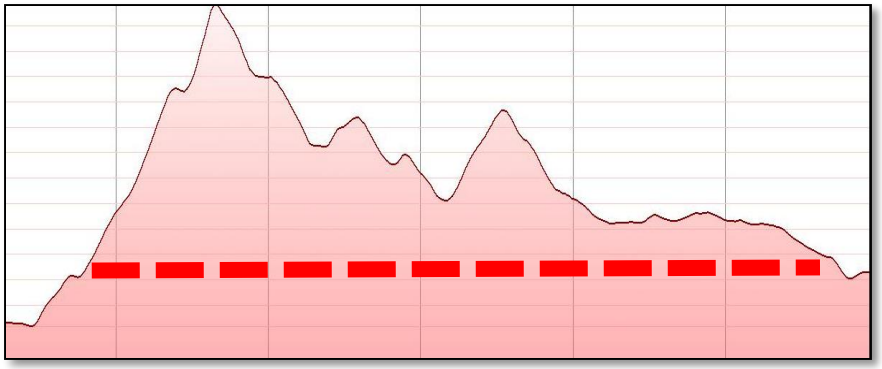
(~ 50% of minimum av annual discharge)

Minimum average annual discharge in Bheri river = 76 m^3/s

Design of Tunnel

Hydraulic design

- Design discharge = 40 m3/s
- Length = 12.2 Km



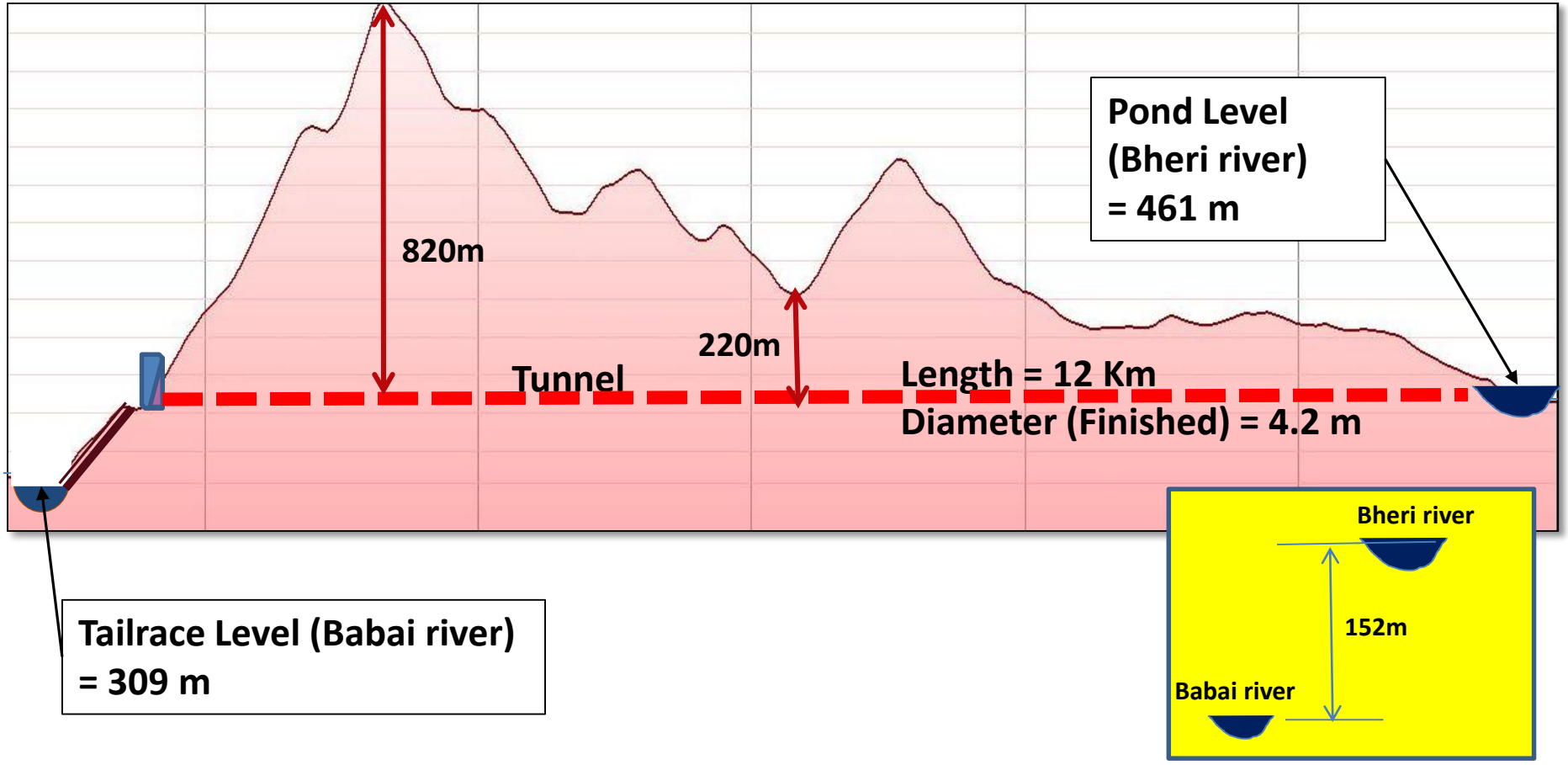
Structural Design :

precast concrete segmental lining throughout the length

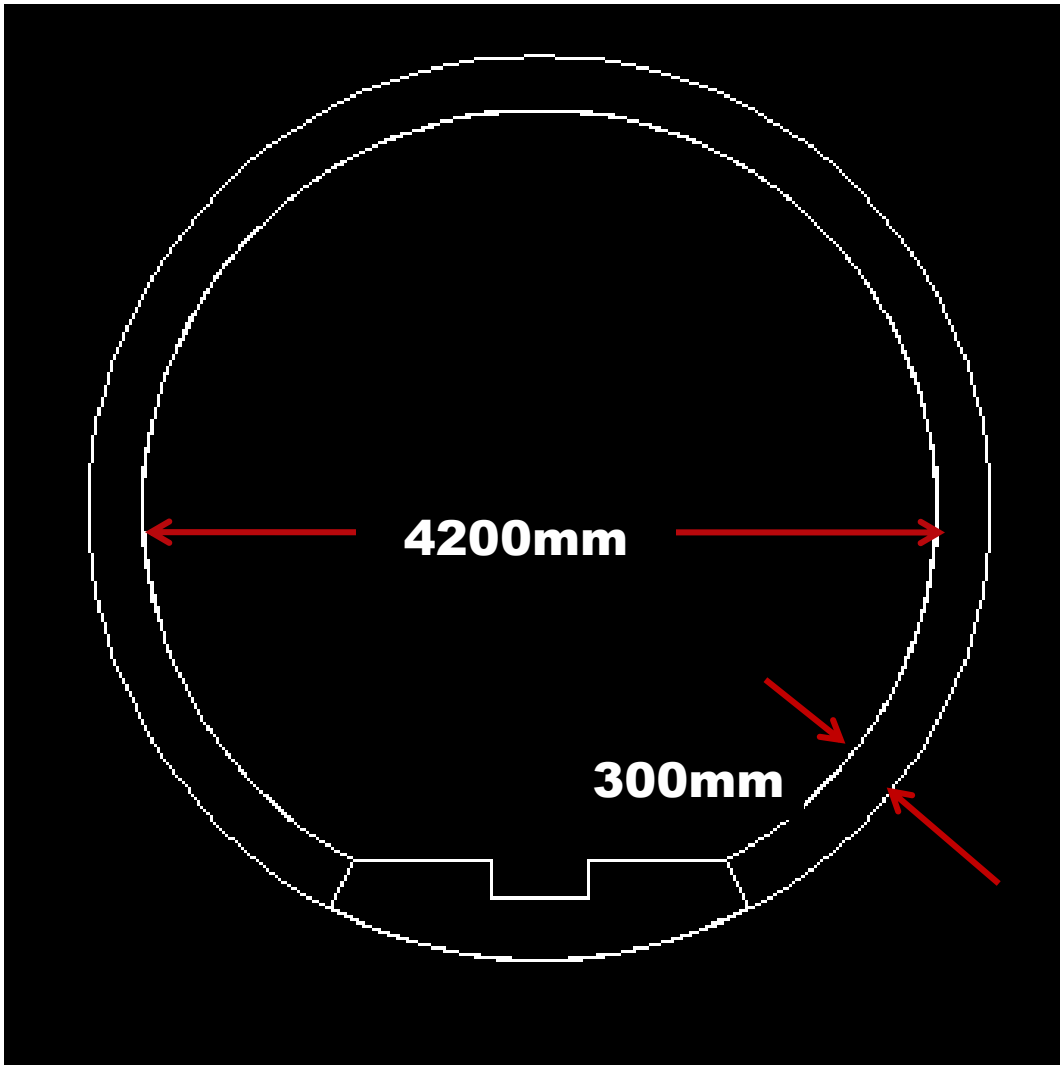
- Hexagonal/Trapezoidal
- Thickness of segment
- Reinforcement
- No of segment per ring
- etc

Will be finalized after review of design proposed by Contractor and reviewed by Consultant/Employer

Longitudinal Features of Tunnel



Cross Sectional Feature of Tunnel



Finished Diameter = 4.2 m

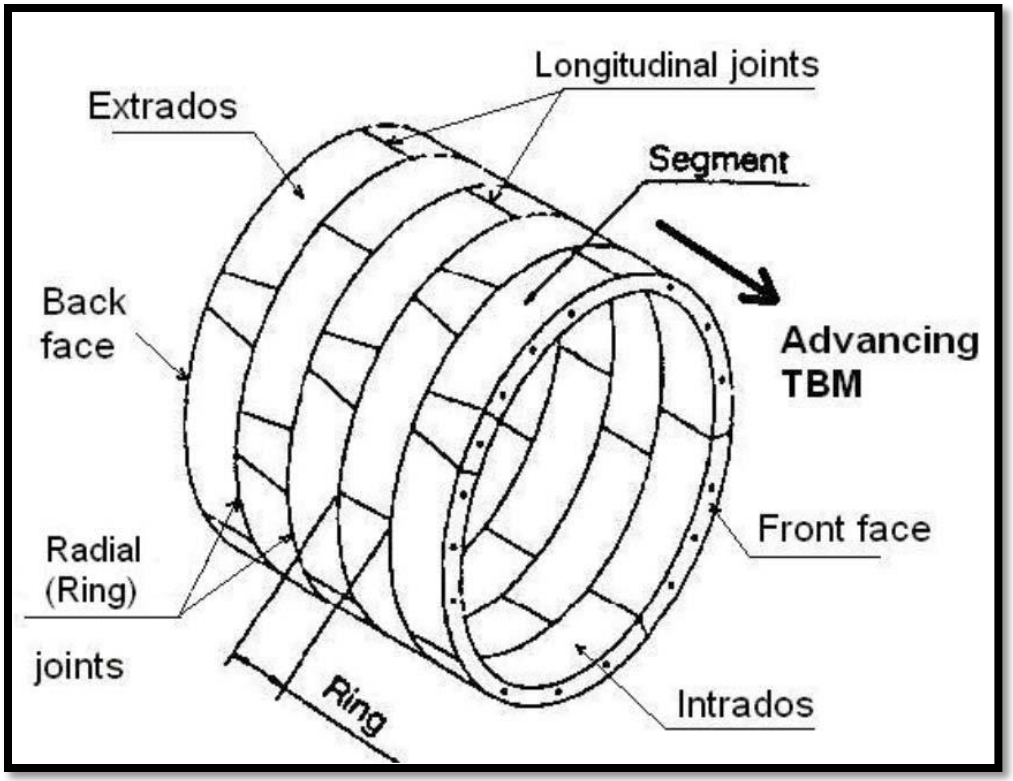
Tunnel lined throughout by Precast Concrete Segmental Lining= 300 mm thick

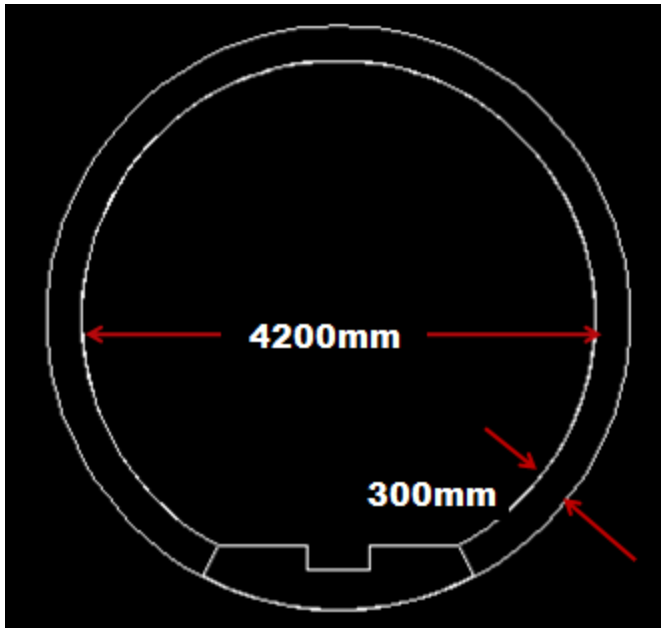
Preliminary ring configuration 5+1 segments per ring

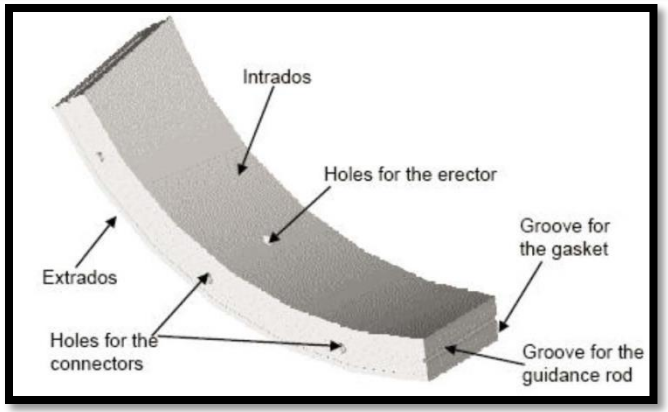
(Will be decided after review of actual design)

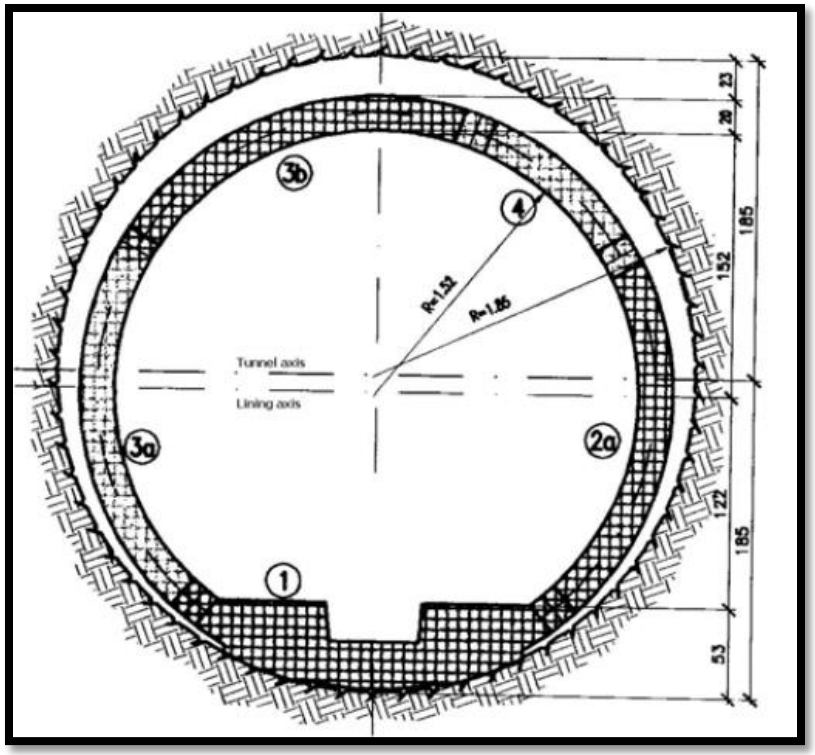
Section and Lining of Tunnel

Precast Concrete Segmental Lining

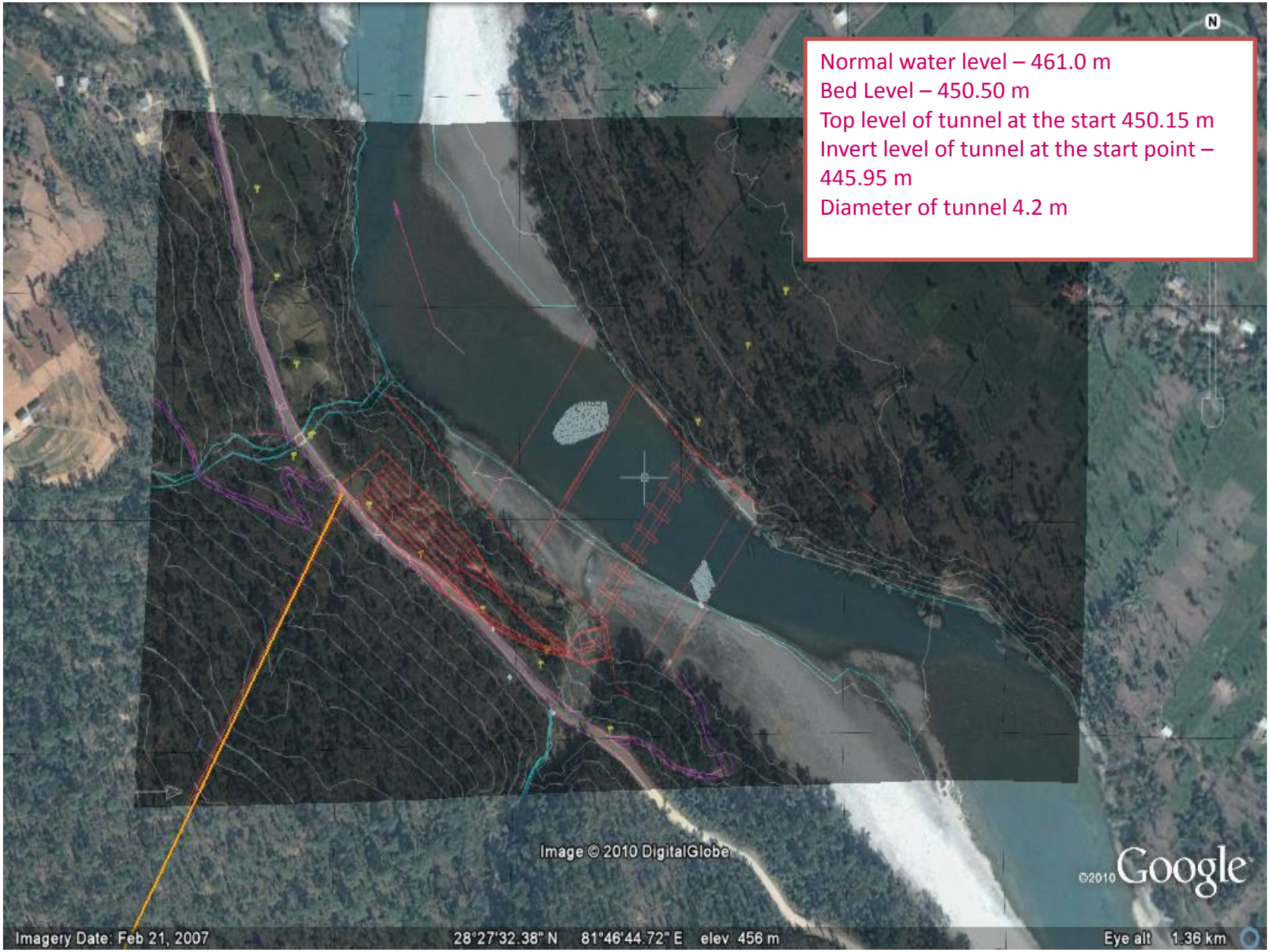






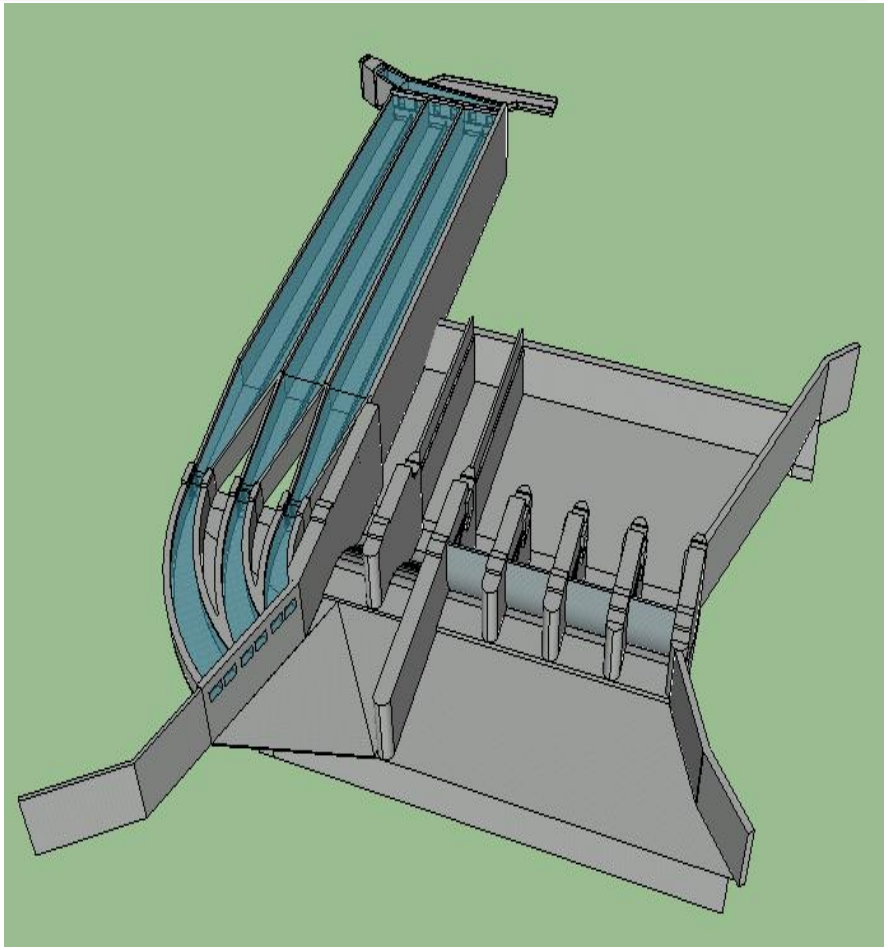


Diversion Headworks



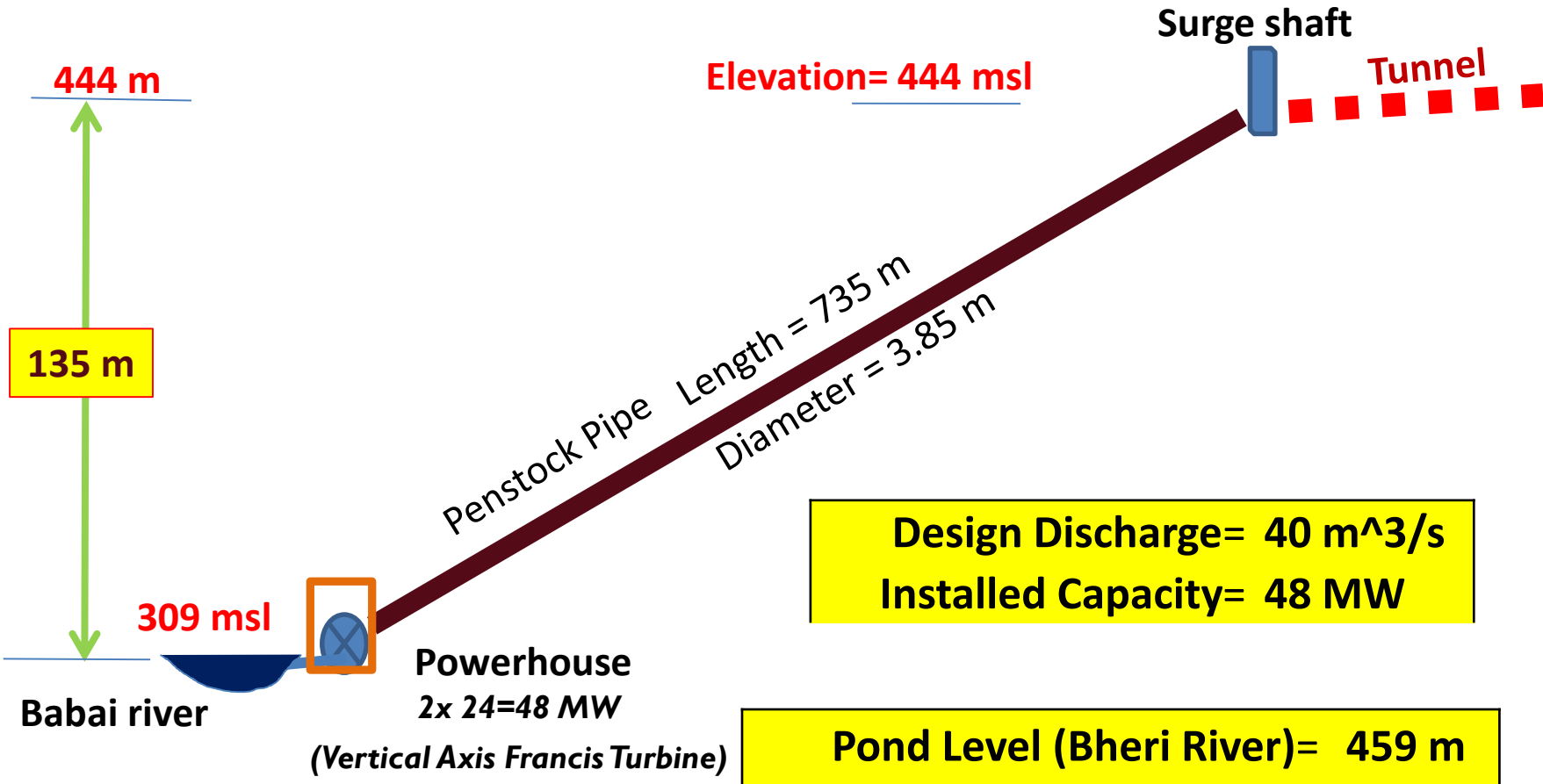
Headworks of BBDP

❖ 3D Model placed in Google Earth



❖ 3D Model of Headworks

Powerhouse Arrangement



Design Discharge= 40 m^3/s
Installed Capacity= 48 MW

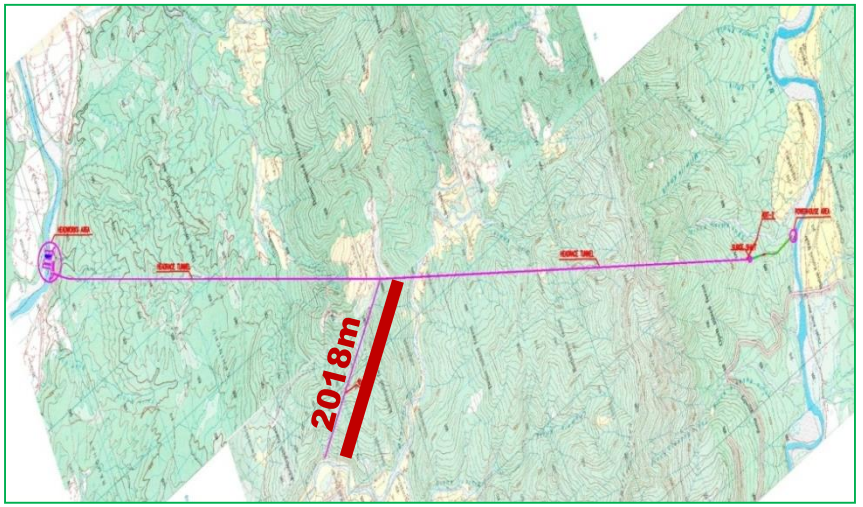
Pond Level (Bheri River)= 459 m
Surge Shaft Head Level = 444 m
Tailrace Level (Babai River)= 309 m
Available Head= 135 m

Tunneling Technology

Cardinal Question: Why TBM instead of Conventional Method

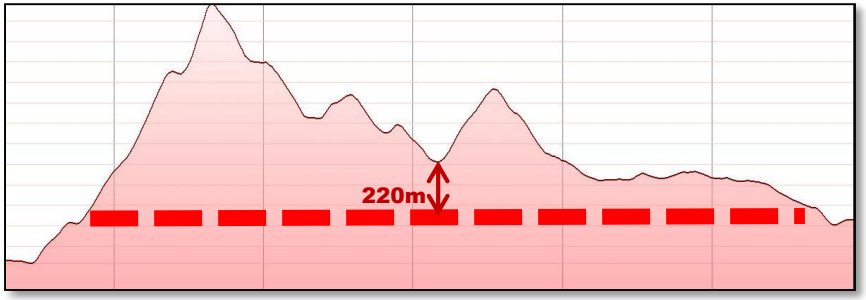
Issue of Adit Tunnel

Topography between Bheri and Babai allow for only one adit tunnel



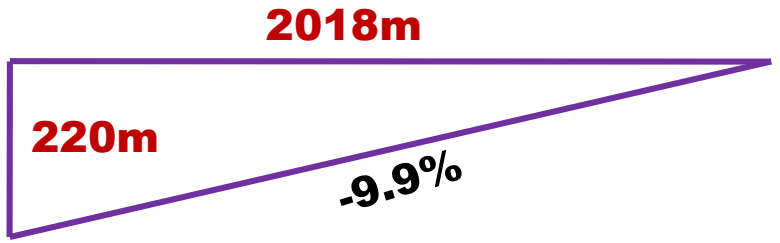
2 Km long with –ive slope of about 10%

Increased difficulty and risk associated with dewatering, mucking, safety, etc



Conventional Method = may be Possible but very Difficult

TBM = Difficult but quite possible



Cardinal Question: TBM Vs Conventional

Some Facts

Particulars	TBM	Conventional
Progress Rate (m/day)	14 – 26 (RME, Bieniawaski, 2008)	5
Construction Period (years)	1.5 + 3=4.5 (TBM Manufacturing)=1.5	6.33
Tunnel Supports	Segmental lining +pea gravel	Temporary and Permanent
Safety	High	Very Low
Cycle Time	Short (~1-2 hrs)	6-8 hrs
Environmental	Friendly	Less friendly
Cost (Including Lining)	~ NRs 10.6 Billion (2014)	~ NRs12 Billion (2011)

Hence,
On account of difficulty, time, cost, safety, environmental considerations TBM tunneling for BBDMP is a more viable option over Conventional Method.

Cardinal Question: WHY TBM instead of Conventional Method

Feasibility study by BPC proposed Drilling and Blasting method but also **recommended to explore the possibility of TBM option and its financial viability**

Wide Consultation with the TBM contractors and manufacturers and TBM Experts and Site visit

Every expert said " YES" to TBM excavation

Visit to TBM tunneling site

TBM construction site visit in Hyderabad, India

Visit I

- DDG/DoI, Project Director in October, 2011

Visit II

- BBDMP Technical staff (SDE, Engineers) June 2012

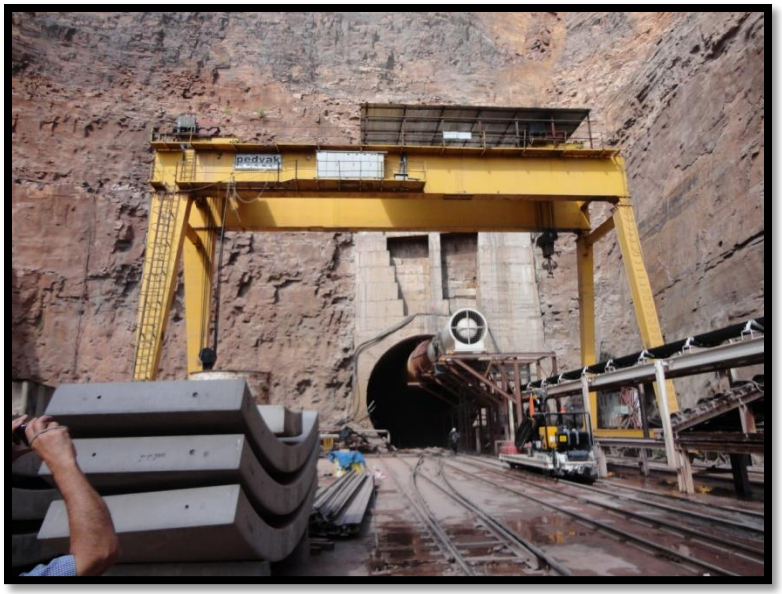
The visit was highly useful in

- Gaining confidence in mechanized tunneling for BBDMP and
- Decision Making to advance BBDMP
- Project Preparation

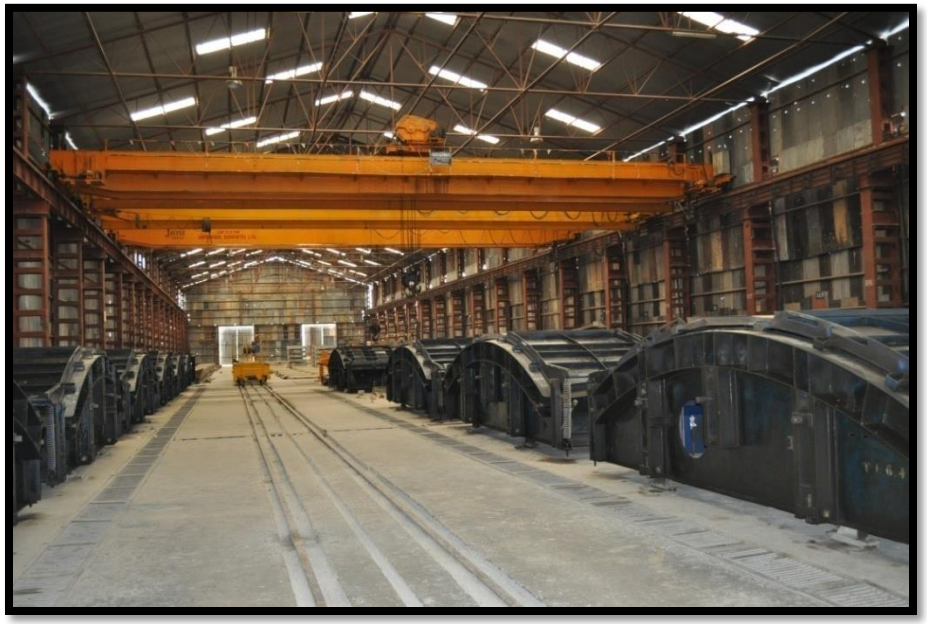
Tunneling Technique

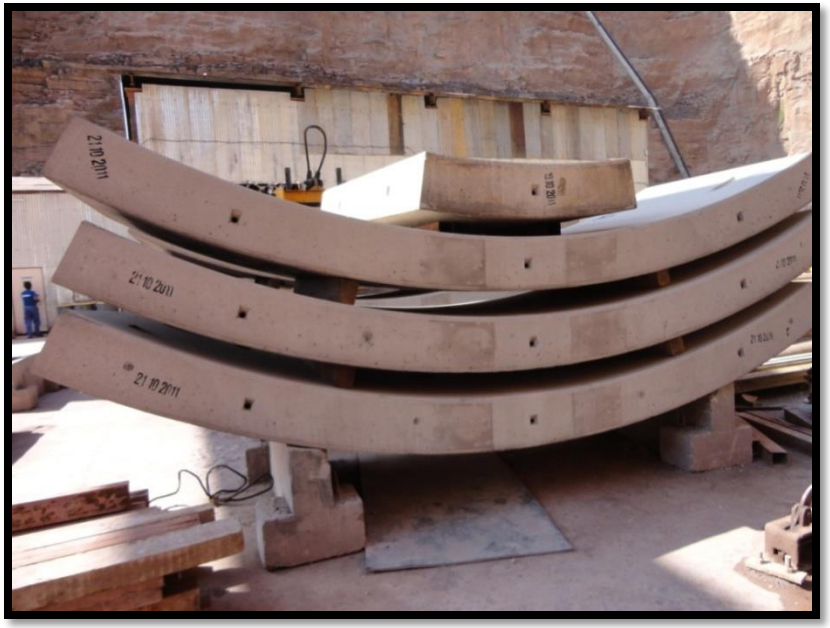
Tunnel Boring Machine (Double Shield TBM) will be used for excavation and also for lining

Precast Segmental Lining



Precast Segment Production, Handling, Stacking





How will the finished tunnel look like?

4 Point Success Mantra for TBM tunnelling

1. Right **Equipment** (TBM and Accessories)

2. Right **People** to run the Equipment (Contractor/Manufacturer)

3. Right **Money**

   (Project of National Pride = Assured Fund)

A devoted tunneller said:

"There are no problems in TBM tunneling; there are only challenges and you have it every day"

4. Right **Attitude**

Sir Alan Muir Wood FREng FRS
1921 – 2009

Distinguished civil engineer

"It has been said that a tunnel is a long cylindrical hole through the ground, with a geologist at one end and a group of lawyers at the other."

"Yet more dire is the present day phenomenon of lawyers at each end."

"Uncertainty is a feature that is unavoidable in tunnelling. But it can be understood and controlled so that it does not cause damaging risk."

Some Facts learned through experience

TBM Technology = NOT a problem

Underground works = Inherent Uncertainties

Contractual issues to address uncertainties is the key to all problem *(Variations/Claims)*

Thus Contract Management to properly address uncertainties is the key to avoid problem

TBM Technology = NOT a problem

Present Status

Present Status (As of April 17, 2015)

Procurement of Contract for Headrace Tunnel :

Contract procured: Agreement held on January 29, 2015

With China Overseas Engineering Group Co. Ltd (COVEC)

Mobilization of Works

- **Foundation stone laying ceremony at the hands of Rt Honorable Prime Minister Sushil Koirala held on April 02, 2015 (2 week earlier)**
- **Contractor mobilized at site.**

Present Status (As of Aprl 9, 2015)

Procurement of Consultancy Services

- **Consultancy service of International consultants required for technical backstopping and assisting in Construction supervision and contract management of TBM tunneling**

- **Request for Proposal (RFP) submitted by 6 Consultants is being evaluated. Technical evaluation completed, called for opening of Financial Proposal on April 26, 2015**

- **Expected date for procurement of Consultant: May, 2015**

Some Personal Observation

A rate opportunity for any Civil engineer/Geologist

Overall development environment and situation NOT as conducive as desired

Principles of Right Attitude

- Sincerity in Action
- Straight forwardness in stature
- Work is Worship is spirit

Mission is Difficult but Possible

Thank You