OPEN DAY ON DAMS

2023

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PRE-FEASIBILITY STUDY OF MEDIUM-SIZED POTENTIAL HYDROPOWER SITE: CASE STUDY OF GHANA 10 PROJECT

TABLE of CONTENT

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01 - INTRODUCTION

The United Nations Industrial Development Organization (UNIDO) and IRENA (International Renewable Energy Agency) have defined a classification of the hydroelectric plants based on the power generated by the plant in nominal conditions:

HPP Classification	UNIDO	IRENA
Micro-hydro	p < 100 kW	p < 100 kW
Mini-hydro	p < 1 MW	from 100 kW to 1 MW
Small-hydro	p < 10 MW	from 1 MW to 20 MW
Medium-hydro	p > 10 MW	from 20 MW to 100 MW

Pre-Feasibility Study of Medium-Sized Potential Hydropower Site: Case Study of GHANA 10 Project

01 - INTRODUCTION

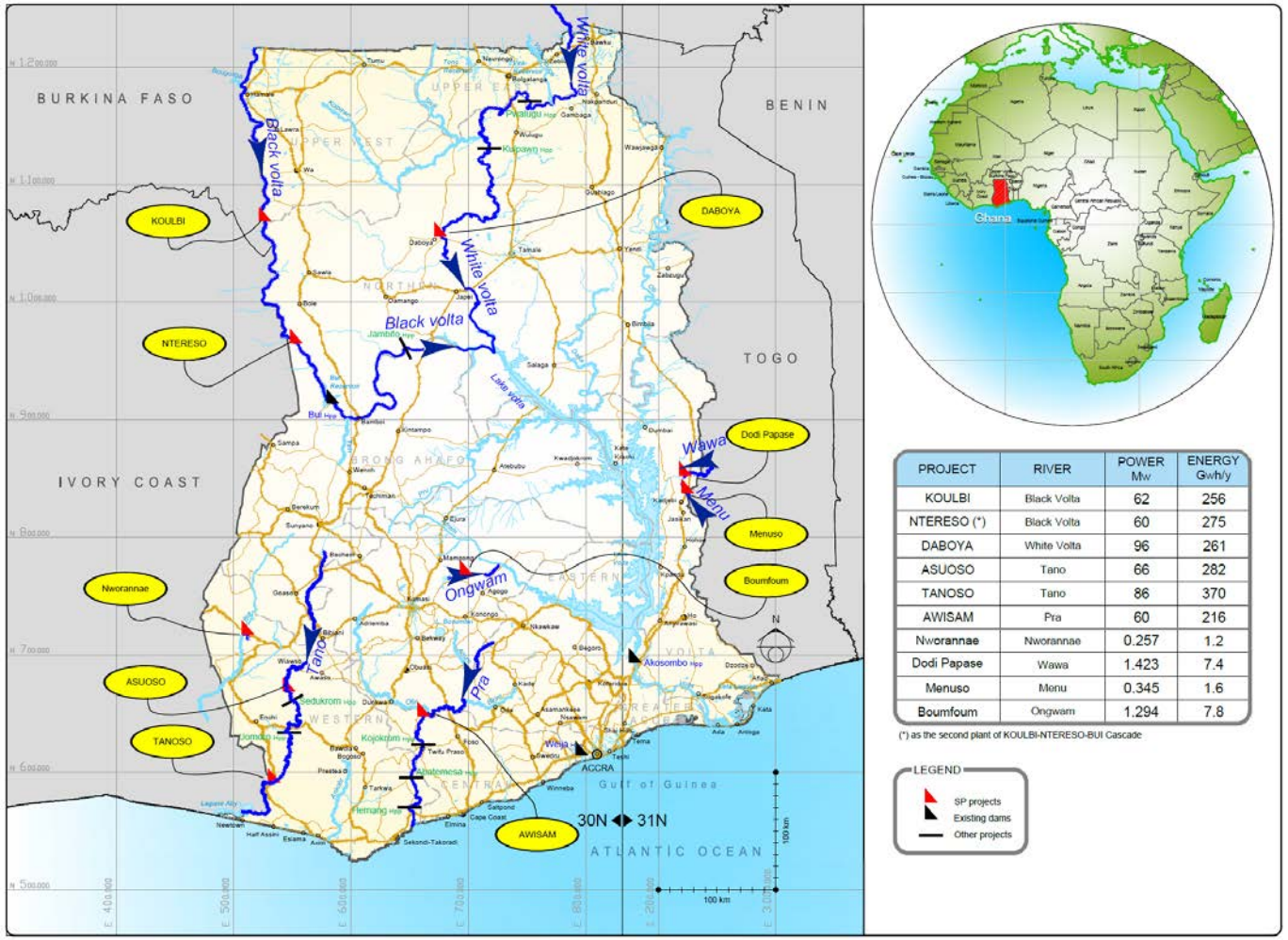
The main objective of the PREFEASIBILITY study is to IDENTIFY hydropower developments that could be recommended for financing in consideration of their technical, environmental, social and financial viability as well as connection to the national grid. Ten (10) plant sites have been studied, including:

Six (6) medium size hpp sites located on the major rivers:

- White Volta river (**Daboya**)
- Black Volta river (**Koulbi and Ntereso**)
- Tano river (**Asuoso and Tanoso**)
- Pra river (**Awisam**)

Four (4) mini and micro-hydro located on minor waterbodies namely:

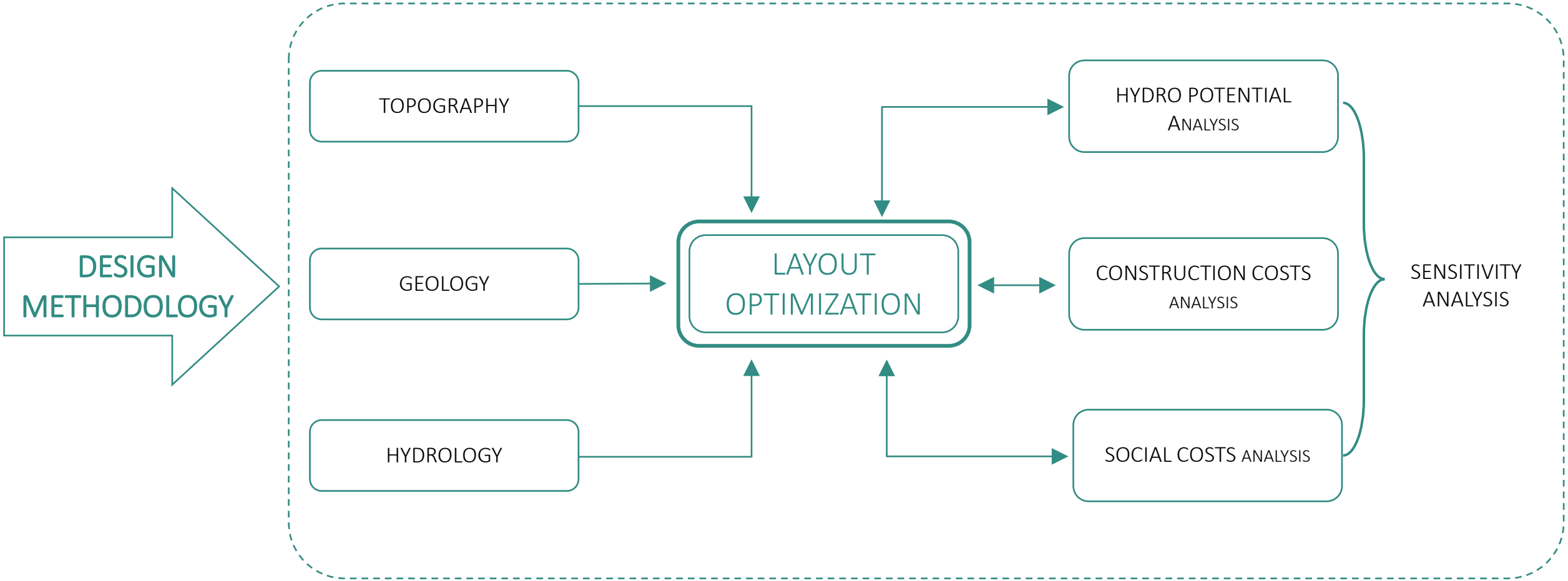
- Ongwam river (**Boumfoum**)
- Nworannare river (**Nworannae**)
- Wawa river (**Dodi Papase**)
- Menu river (**Menuso**)



PROJECT	RIVER	POWER Mw	ENERGY Gwh/y
KOULBI	Black Volta	62	256
NTERESO (*)	Black Volta	60	275
DABOYA	White Volta	96	261
ASUOSO	Tano	66	282
TANOSO	Tano	86	370
AWISAM	Pra	60	216
Nworannae	Nworannae	0.257	1.2
Dodi Papase	Wawa	1.423	7.4
Menuso	Menu	0.345	1.6
Boumfoum	Ongwam	1.294	7.8

(*) as the second plant of KOULBI-NTERESO-BUI Cascade

01 - INTRODUCTION

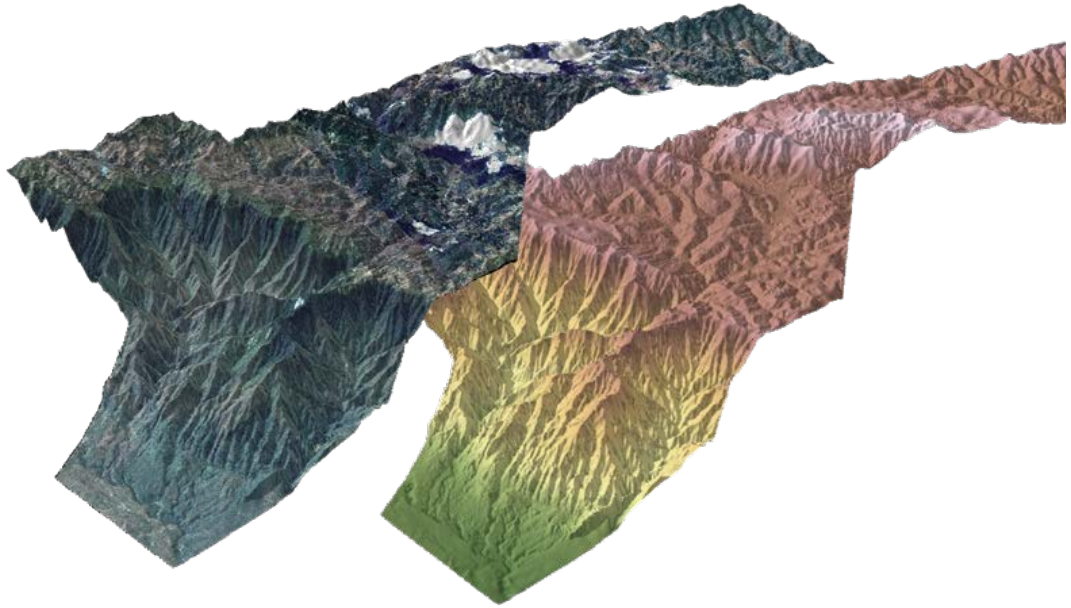


Pre-Feasibility Study of Medium-Sized Potential Hydropower Site: Case Study of GHANA 10 Project

02 – SITE SELECTION STUDY

1 - TOPOGRAPHY → AVAILABLE DATA ANALYSIS →

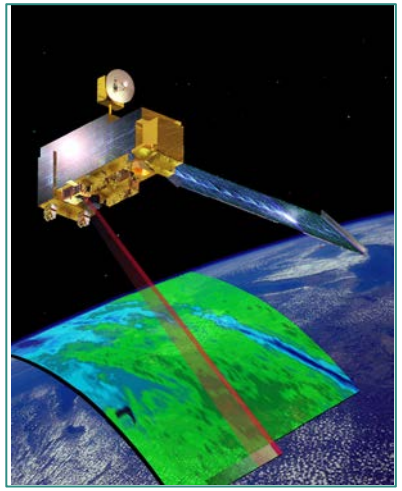
- National Cartography Available
- Regional Topographic Database
- SRTM (Shuttle Radar Topography Mission) cells of 30 m resolution 5-7 m
- ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) as SRTM
- AW3D (Advance Land Observing Satellite World 3D)



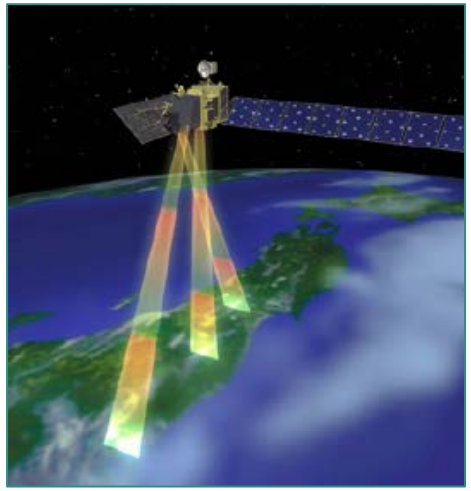
Rumakali HPP, Digital Terrain Model (DTM) from AW3D satellite photogrammetry

SRTM

ASTER



AW3D



02 – SITE SELECTION STUDY

1 - TOPOGRAPHY → SITE VISIT →

- Aerial photogrammetric surveys: by drone, laser-scanning LIDAR, etc.
- Celerimetric surveys using dual-frequency differential GPS on cornerstones, specific areas, river sections, existing buildings, etc… fro the correct geo-referencing and verification of the survey performed

MAPS USED FOR IDENTIFY:

- Project Location
- RESERVOIR
- POSSIBLE DAM ALIGNMENTS
- ACCESS ROADS
- VILLAGES AND CULTIVATED AREAS

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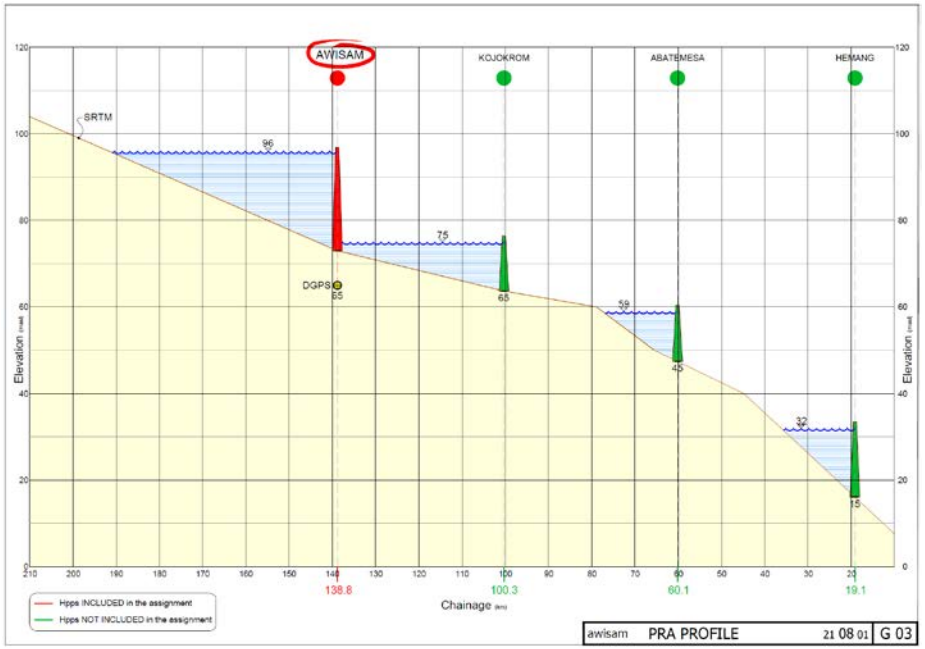
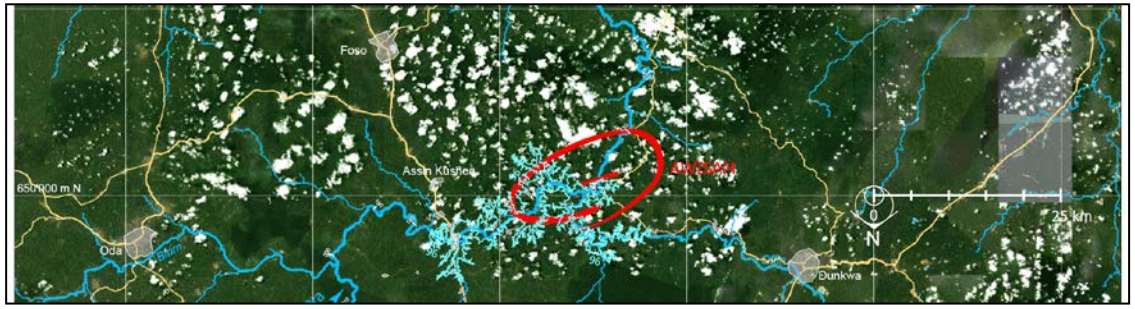
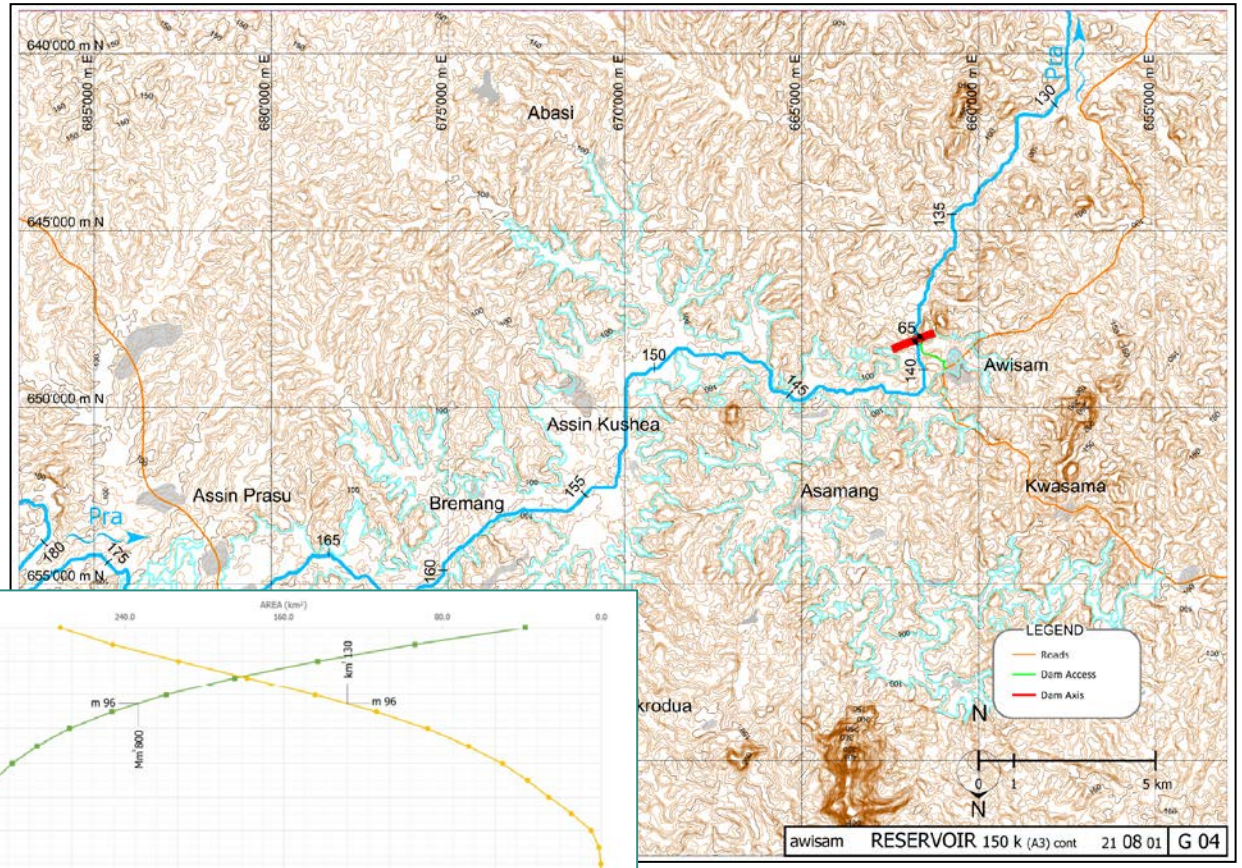
Pre-Feasibility Study of Medium-Sized Potential Hydropower Site: Case Study of GHANA 10 Project

02 – SITE SELECTION STUDY







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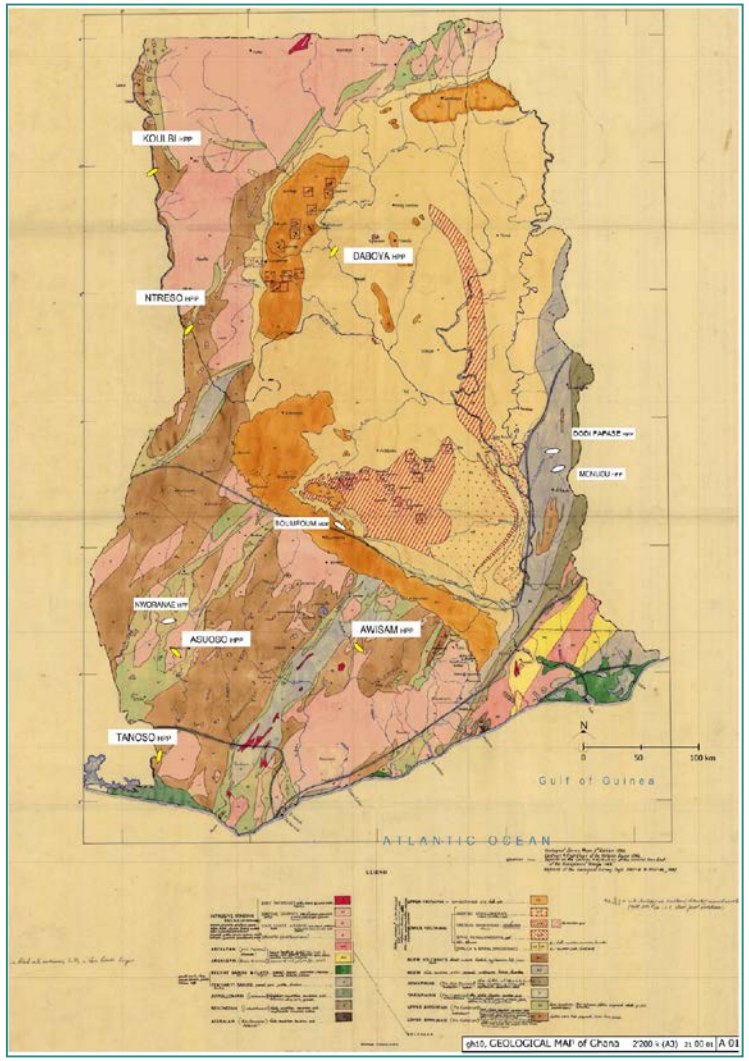
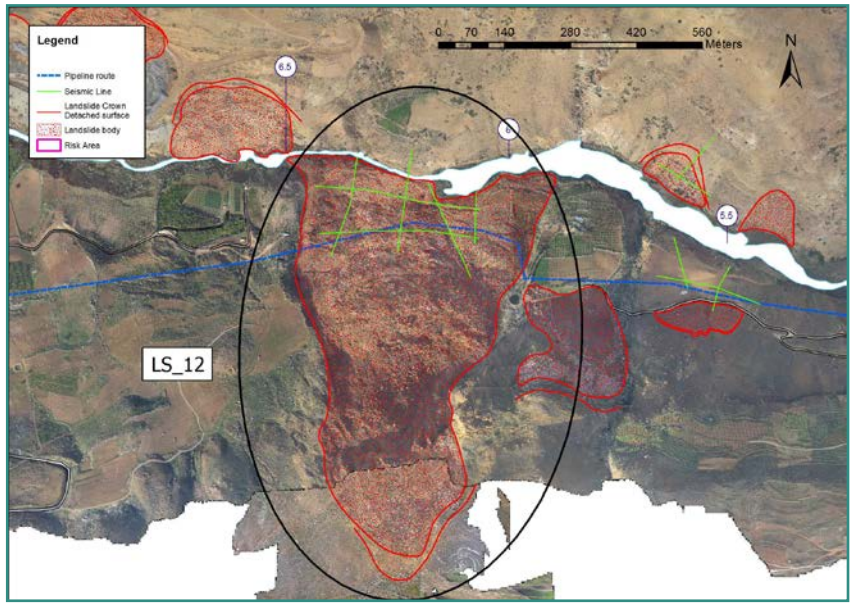
02 – SITE SELECTION STUDY

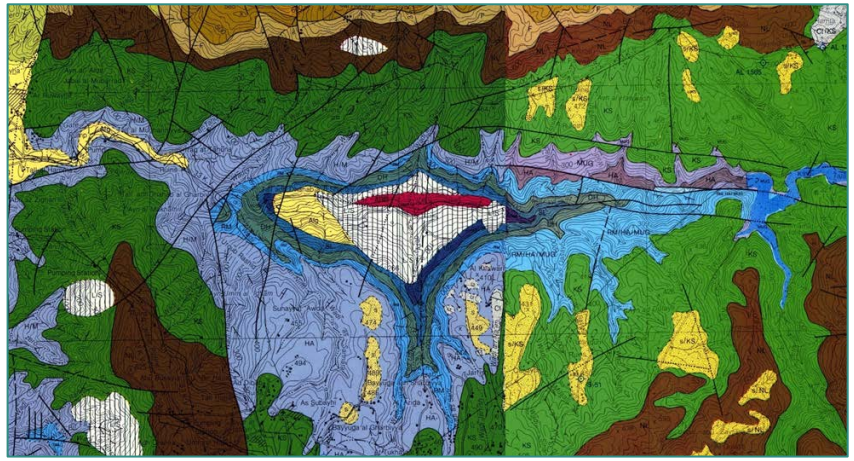
2 - GEOLOGY

AVAILABLE DATA ANALYSIS

- PREVIOUS STUDIES
- LITERATURE DATA
- GEOLOGICAL MAPS
- SATELLITE IMAGERY AND DEM







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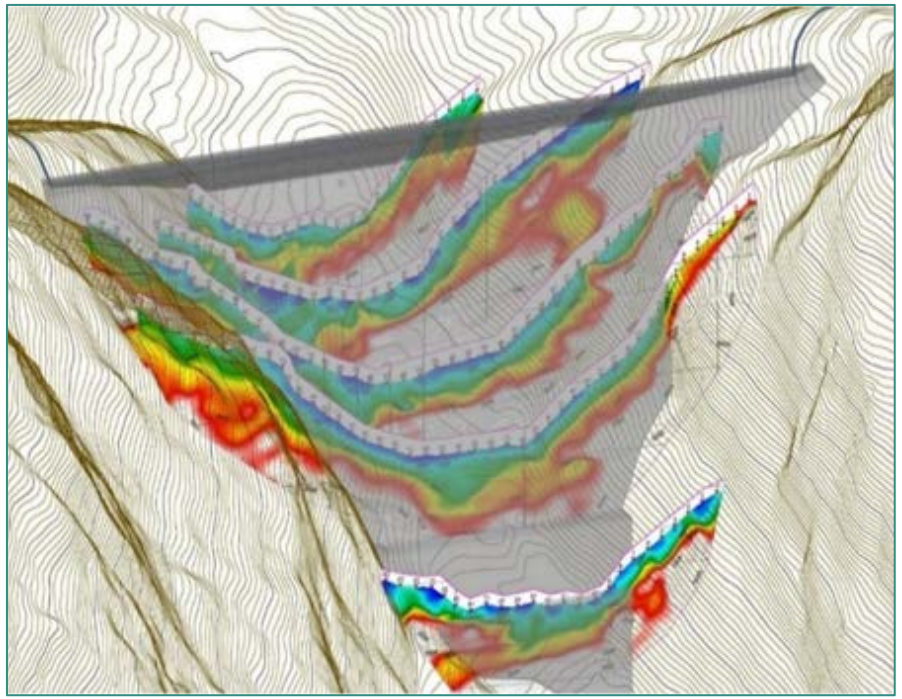
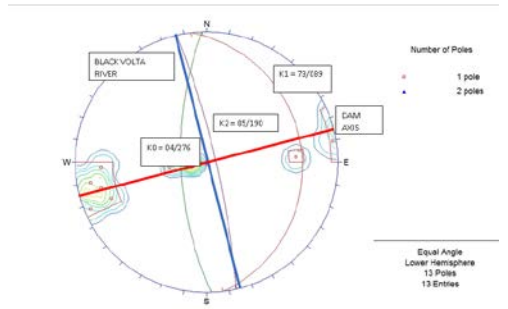
Pre-Feasibility Study of Medium-Sized Potential Hydropower Site: Case Study of GHANA 10 Project

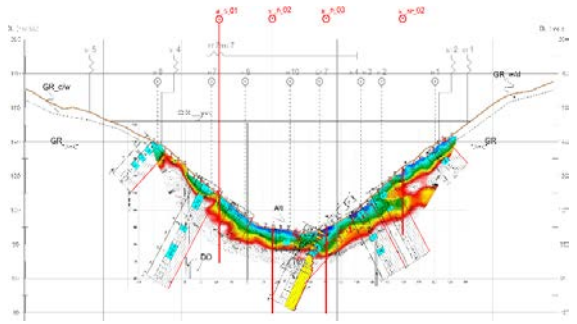
02 – SITE SELECTION STUDY

2 - GEOLOGY → SITE VISIT AND FIELD INVESTIGATIONS →

- Surface Geology and Preliminary Site Investigations
- Geological and Geo-Structural Survey of the areas where the main works will be located and possible construction material sources.
- Defintion of the Investigation program, which can include: Borehioles, SPT and CPT tests, Permeability test, Seismic Survey, Laboratory tests on samples .







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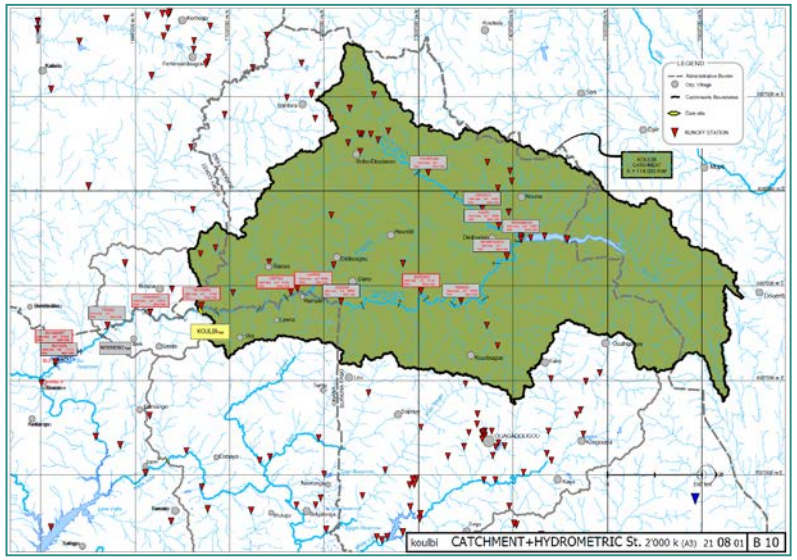
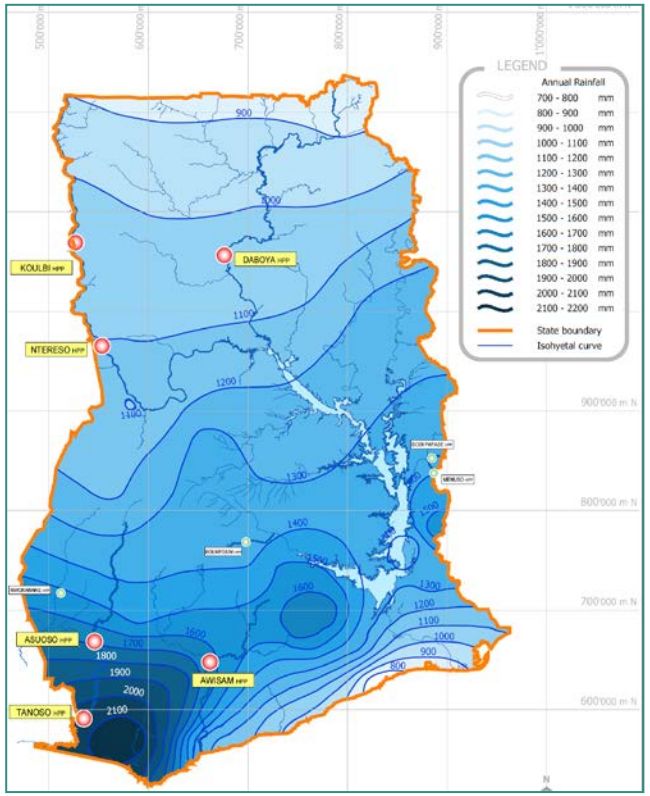
02 – SITE SELECTION STUDY

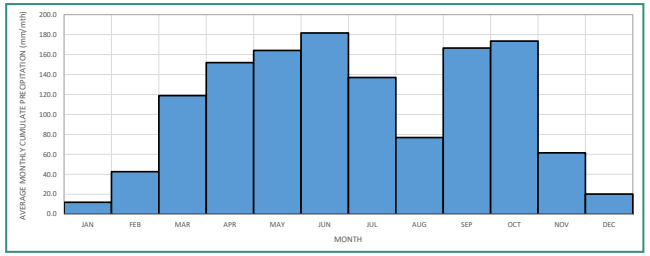
3 - HYDROLOGY

RUNOFF
TO EVALUATE THE PRODUCTIVITY OF A PLANT

FLOODS
FOR SAFE DESIGN OF THE HYDRAULIC WORKS







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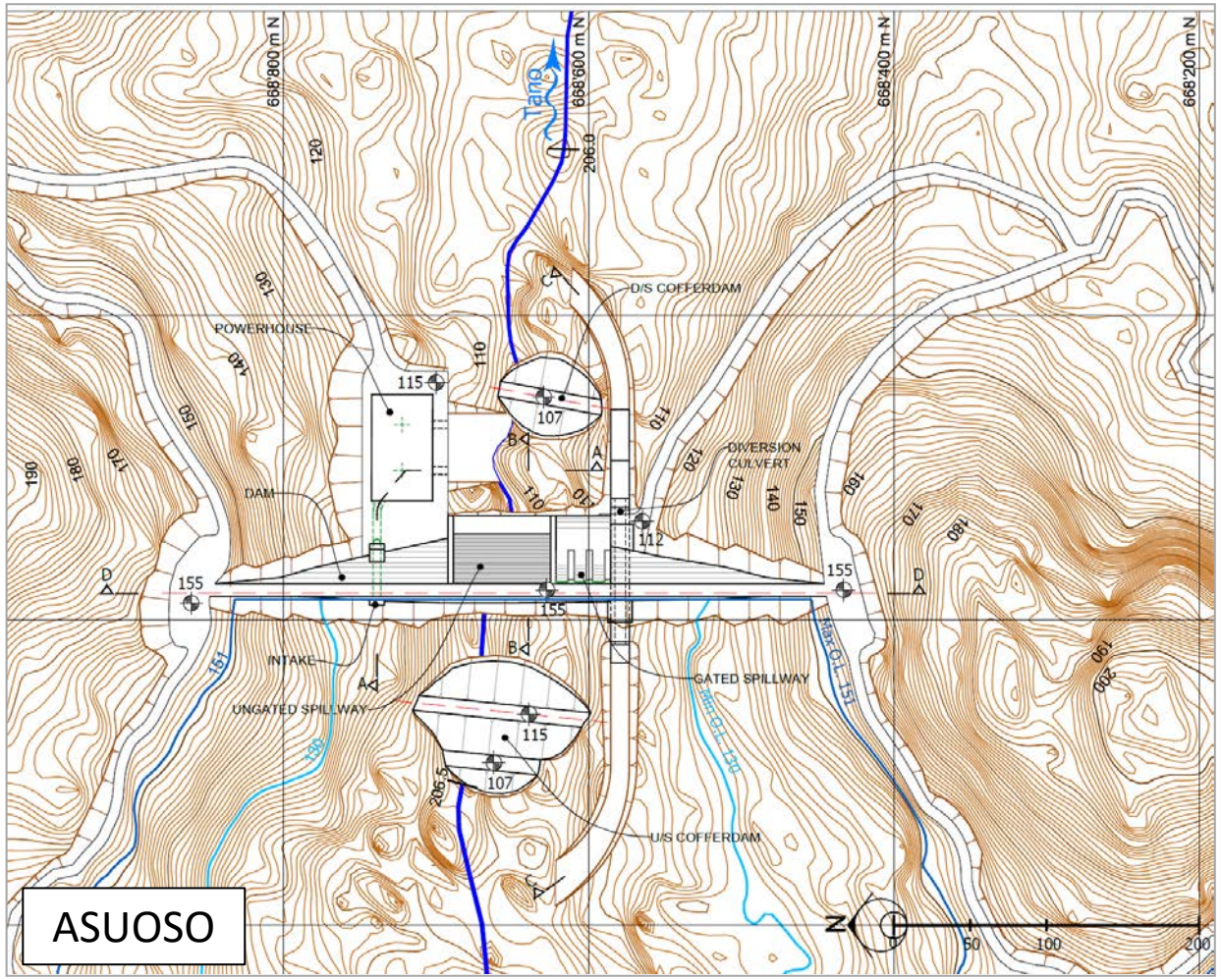
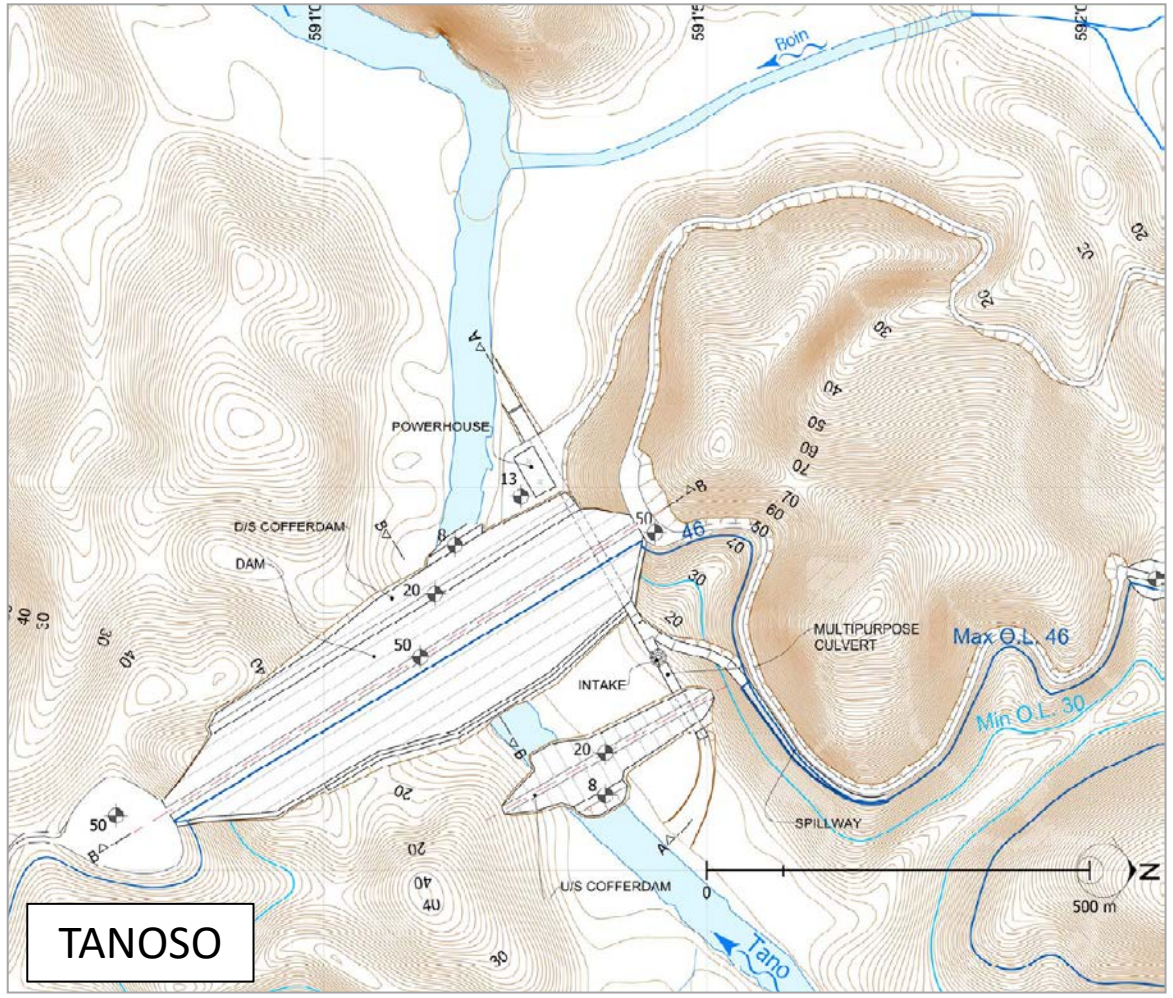
Pre-Feasibility Study of Medium-Sized Potential Hydropower Site: Case Study of GHANA 10 Project

03 – PRELIMINARY LAYOUT

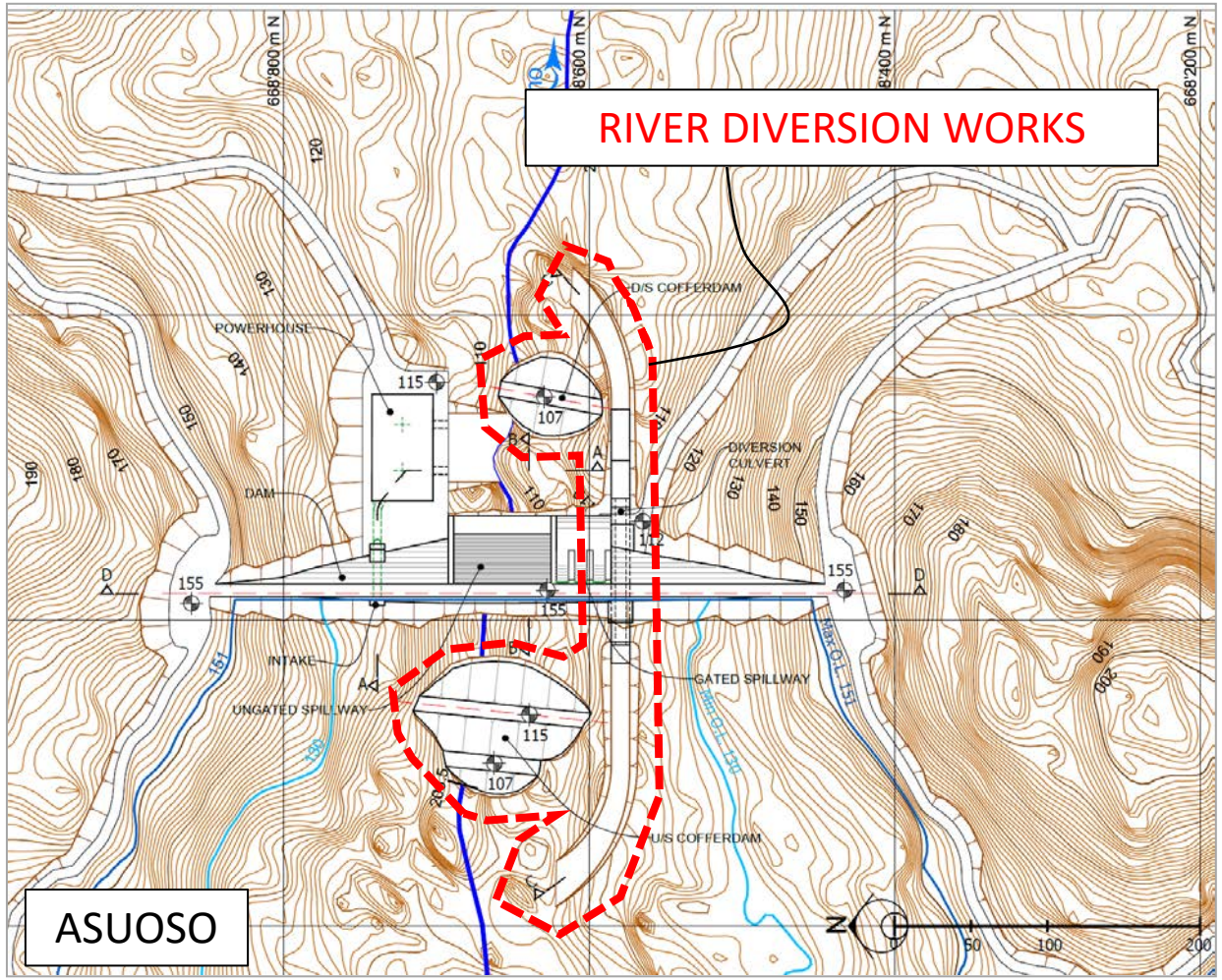


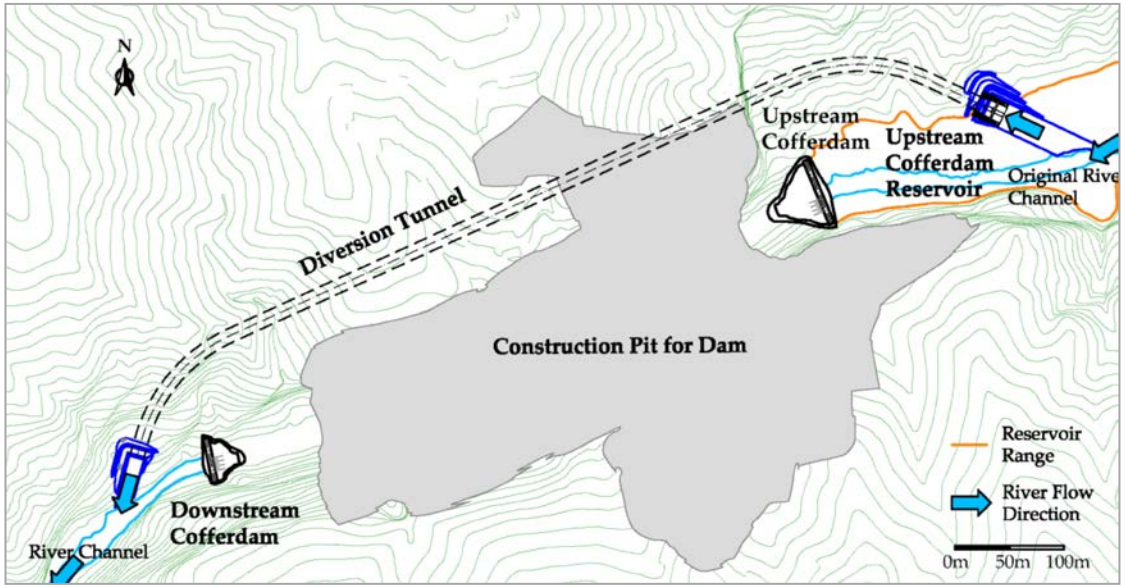
ASUOSO



TANOSO

03 – PRELIMINARY LAYOUT





Diversion is sometimes permanent, but most often temporary, re-routing of water from its original location. It may be required to initiate a project and/or allow a project to proceed.

Pre-Feasibility Study of Medium-Sized Potential Hydropower Site: Case Study of GHANA 10 Project

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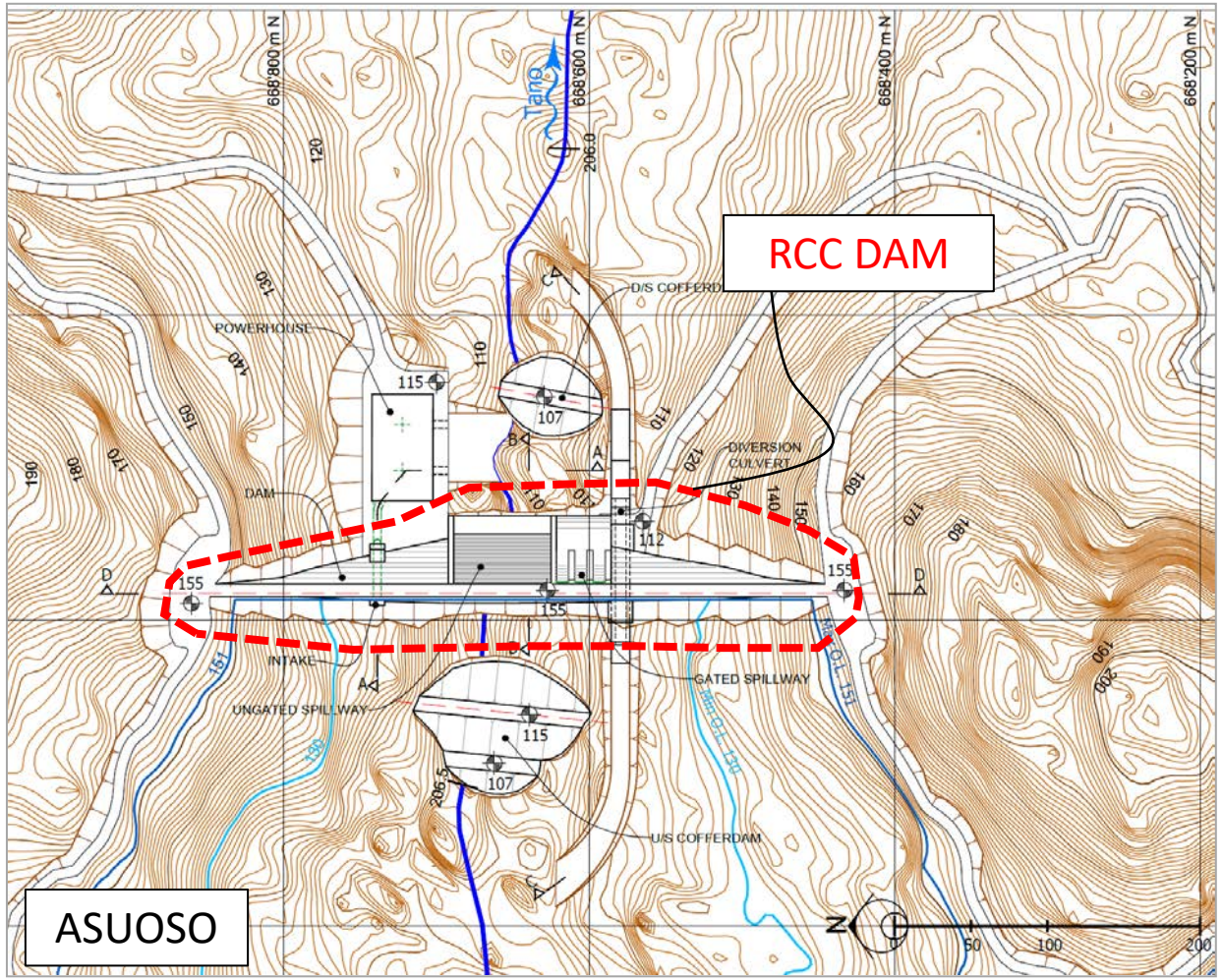
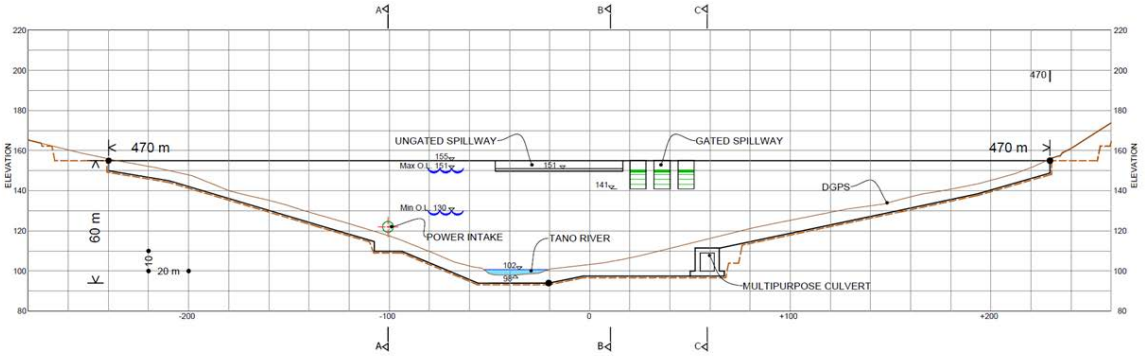
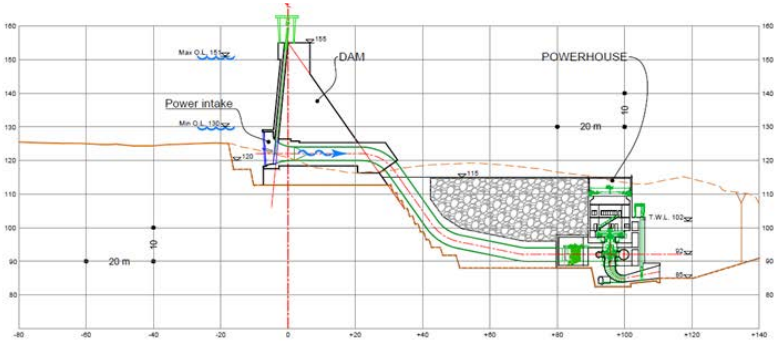
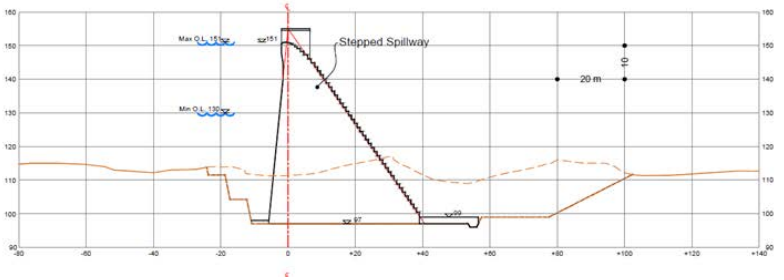




Section A - POWERHOUSE



Section B - STEPPED SPILLWAY



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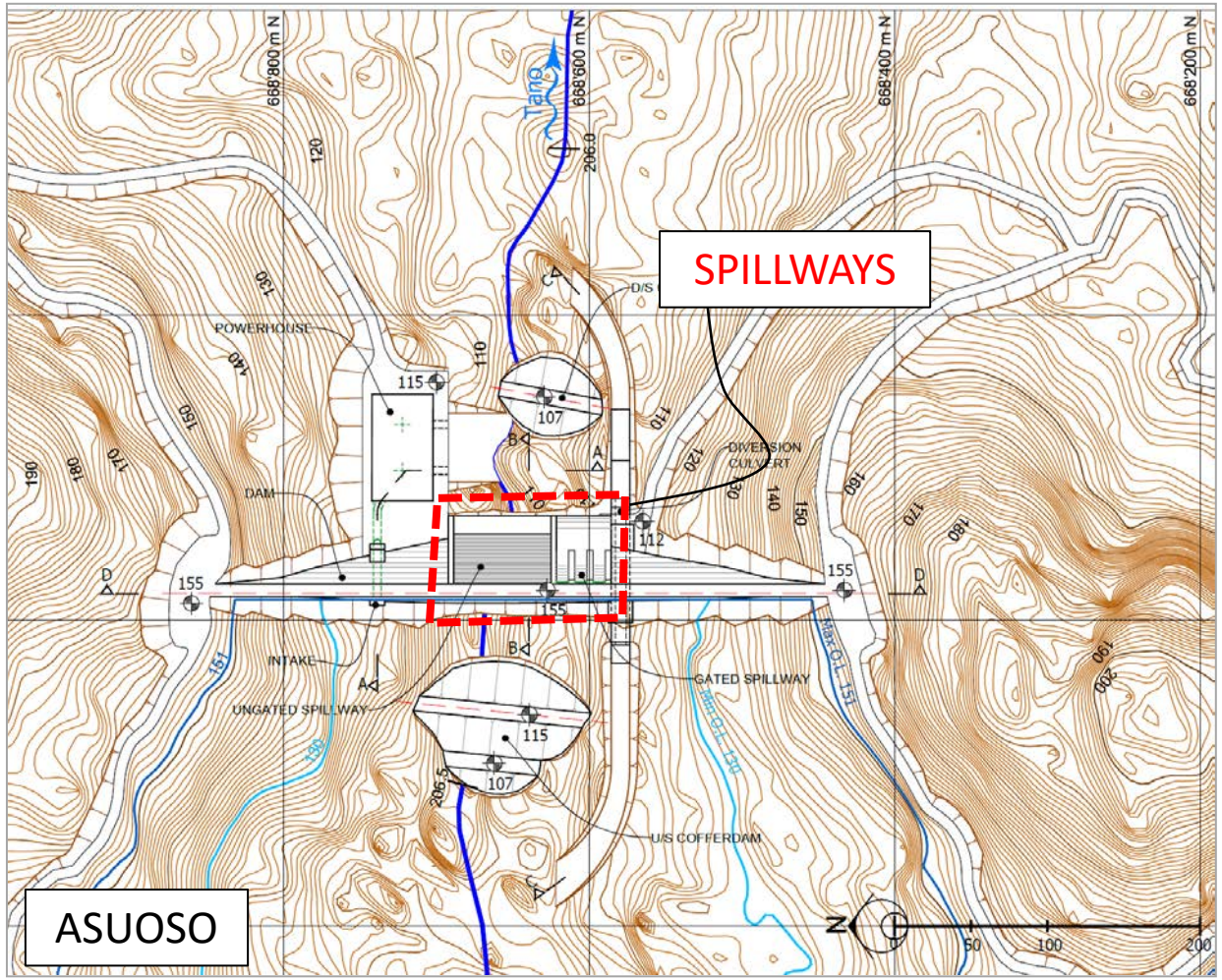
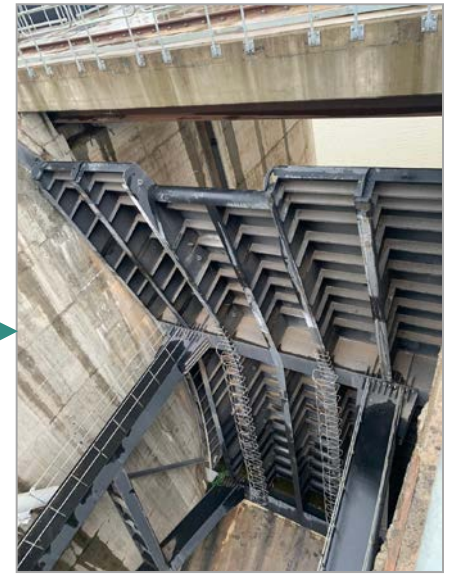


UNGATED SPILLWAY ON DAM BODY

GATED SPILLWAY ON DAM BODY



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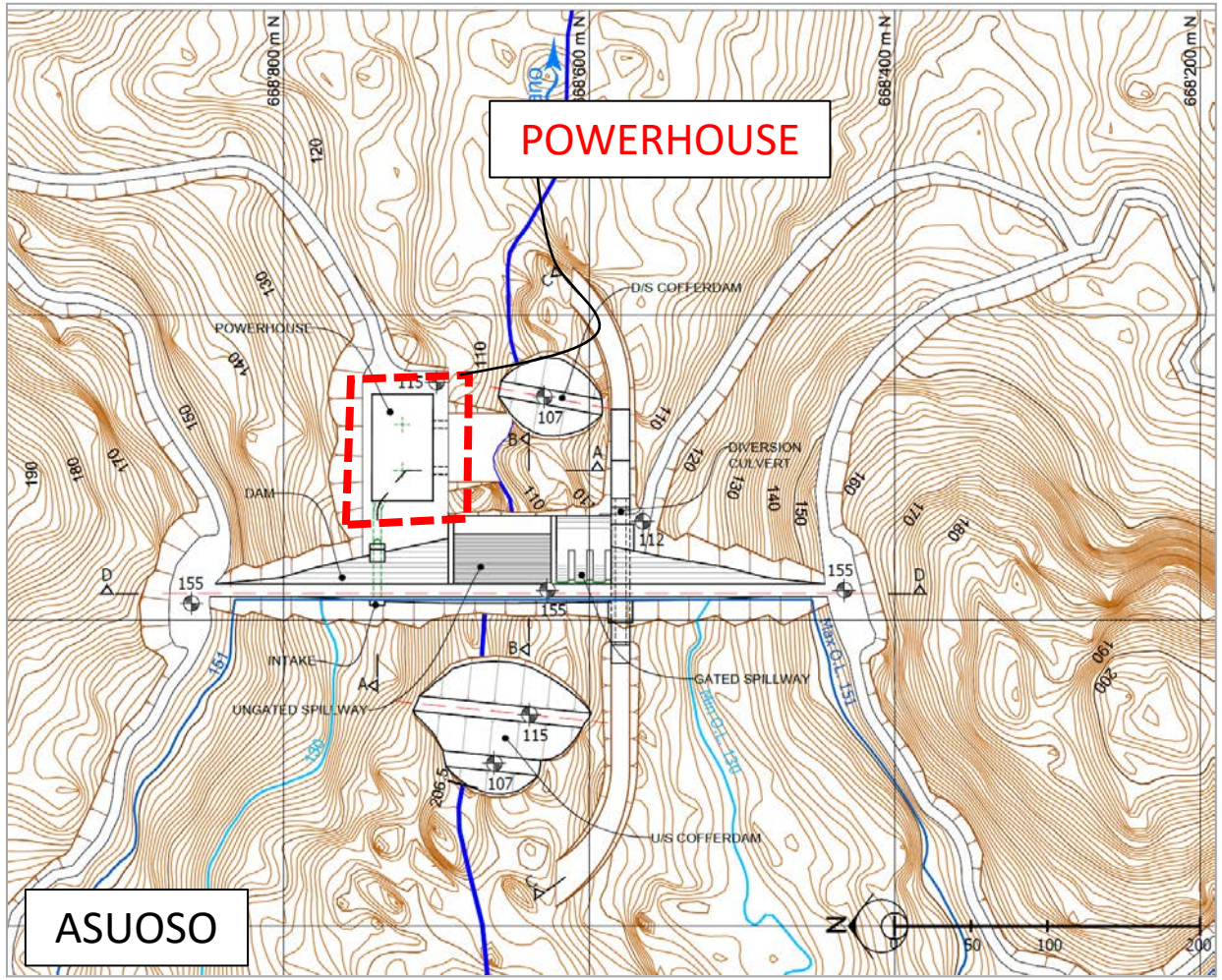
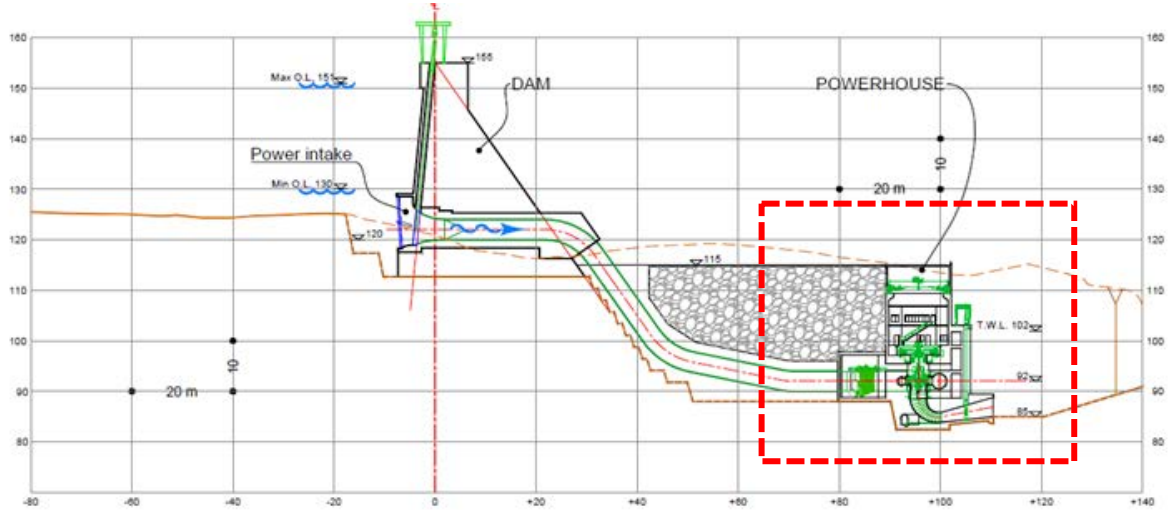
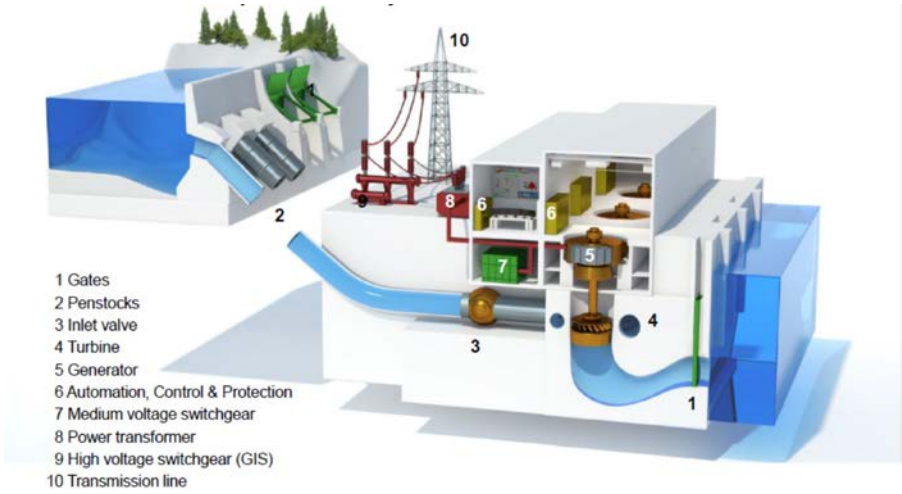
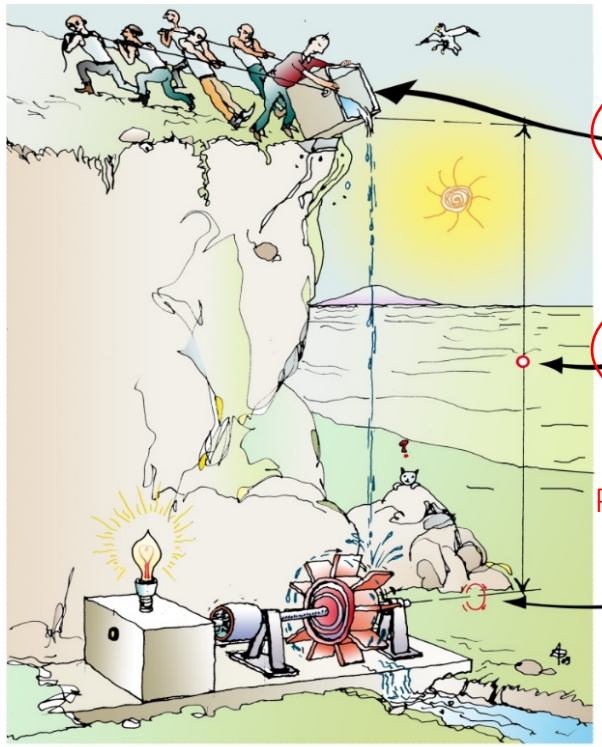






04 – HYDRO POTENTIAL



HYDROLOGY

QUANTITY X — 1 m³ — 1Mm³

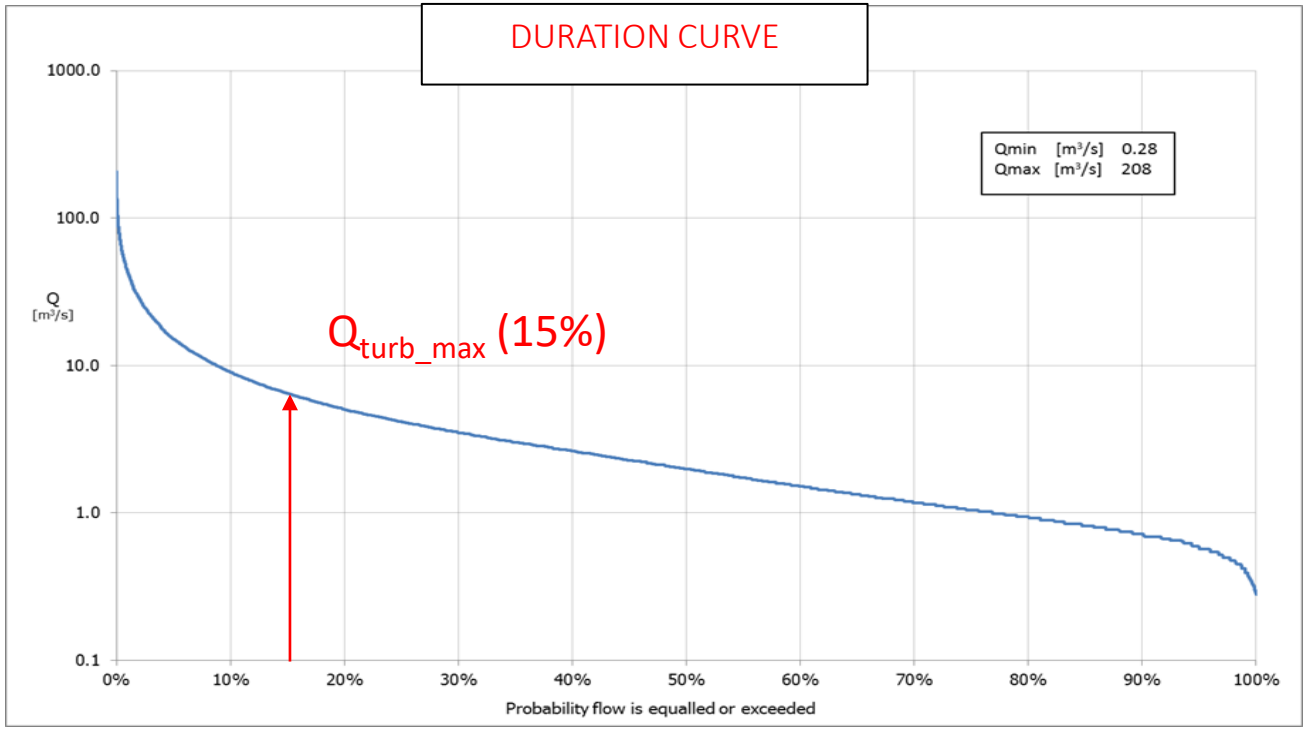
QUALITY Y — 400 m — 400 m

TOPOGRAPHY AND PRELIMINARY LAYOUT

ENERGY E = $\frac{XxY}{400}$ — 1 kwh — 1 MkWh = 1GWh

1 m³ of water falling from 400 m of height produces 1 kwh — (QUANTITY) X, (QUALITY) Y, (ENERGY) E

How can we calculate the Hydro-Electric ENERGY ?
Multiplying QUANTITY x QUALITY and dividing by 400!



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04 – HYDRO POTENTIAL

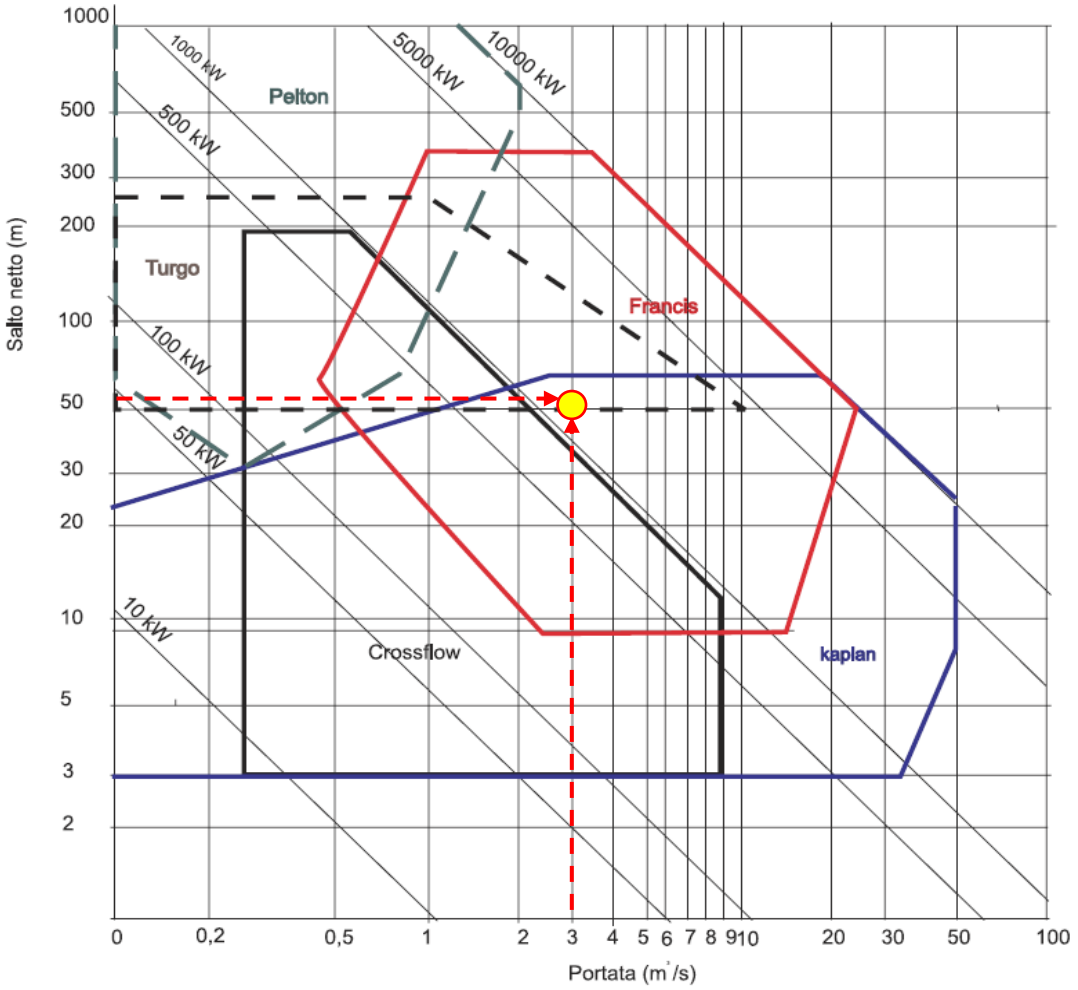

Tabella 3.2 Portata minima della turbina

Tipo di turbina	Q_{min} (% di Q_{max})
Francis a spirale	30
Francis in camera libera	30
Semi Kaplan	30
Kaplan	20
Cross Flow	15
Pelton	10
Turgo	10
Elica	65

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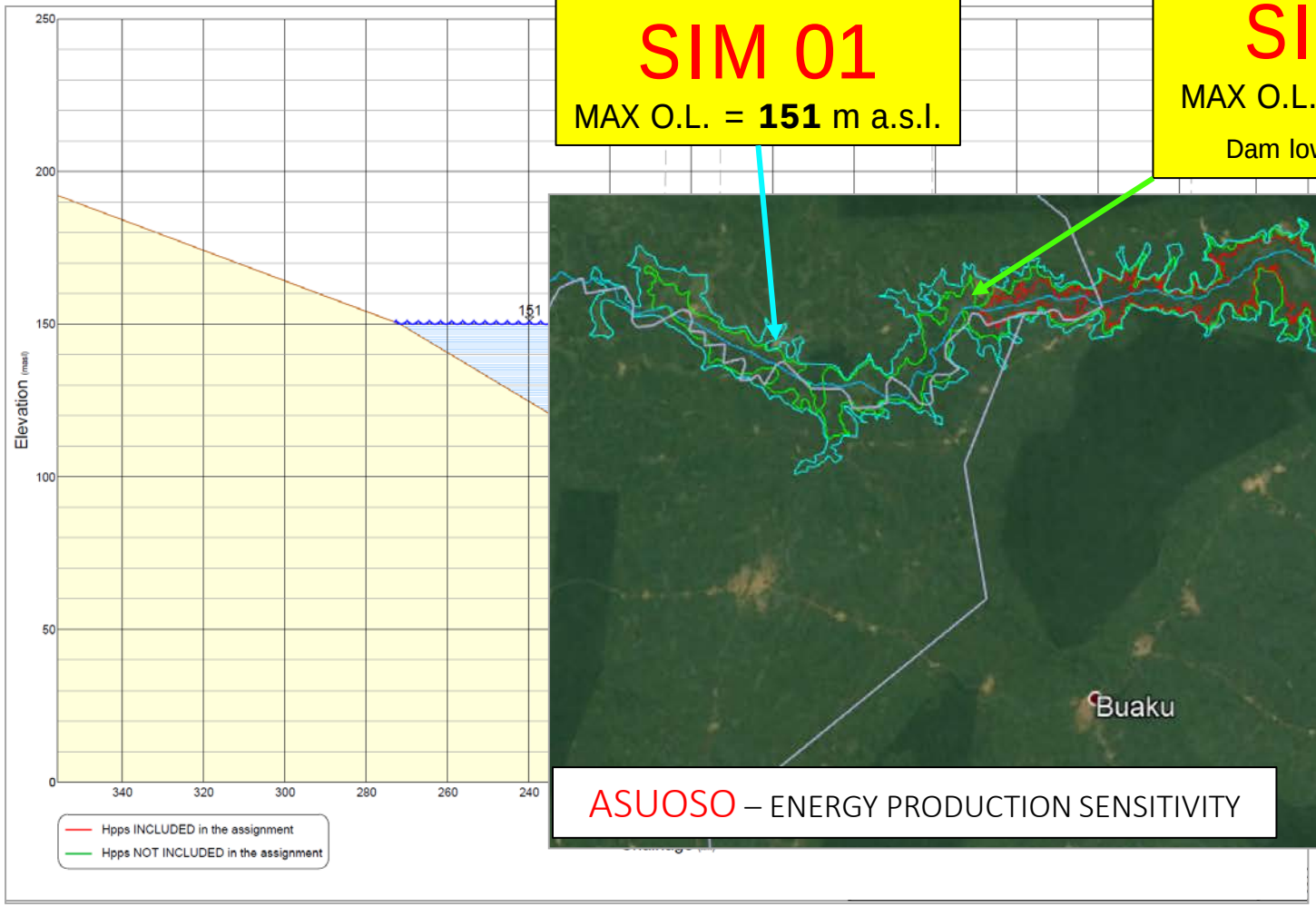
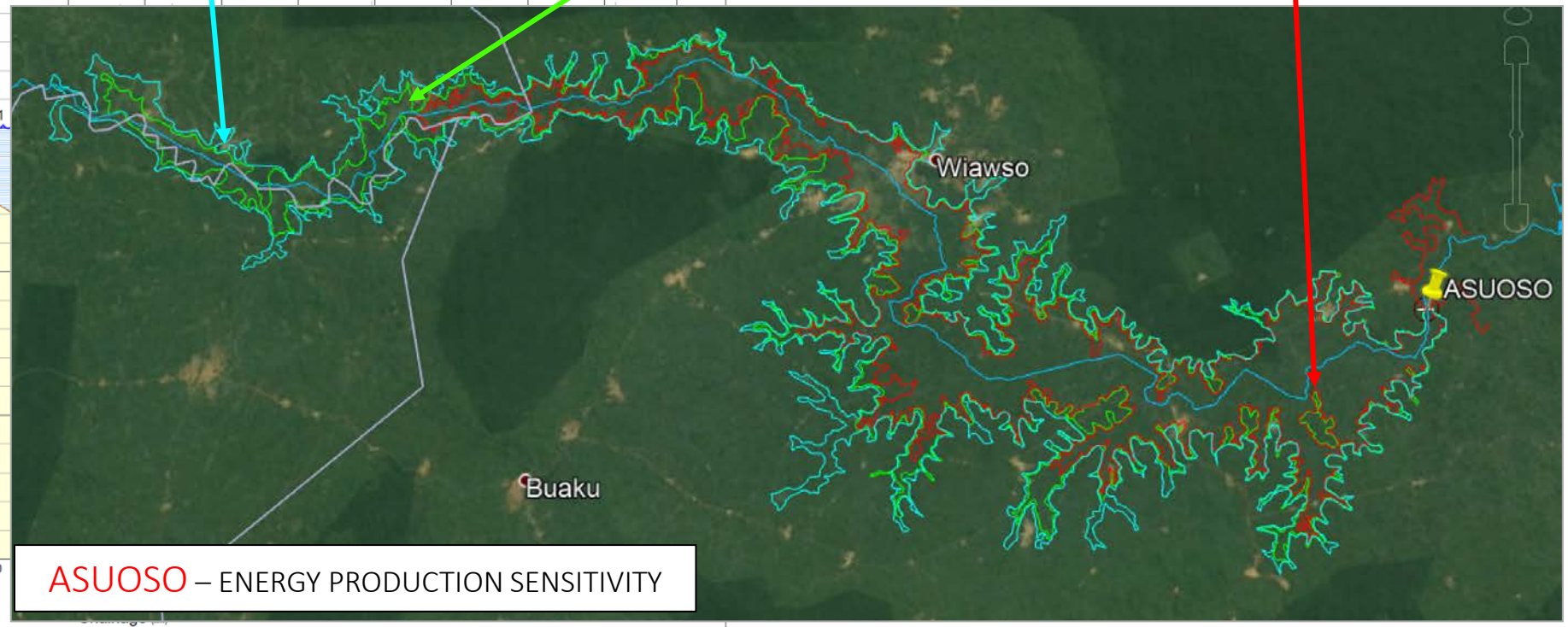
04 – HYDRO POTENTIAL

SIM 01
MAX O.L. = **151** m a.s.l.

SIM 02
MAX O.L. = **146** m a.s.l.
Dam lowering of 5 m

SIM 03
MAX O.L. = **141** m a.s.l.
Dam lowering of 10 m





ASUOSO – ENERGY PRODUCTION SENSITIVITY

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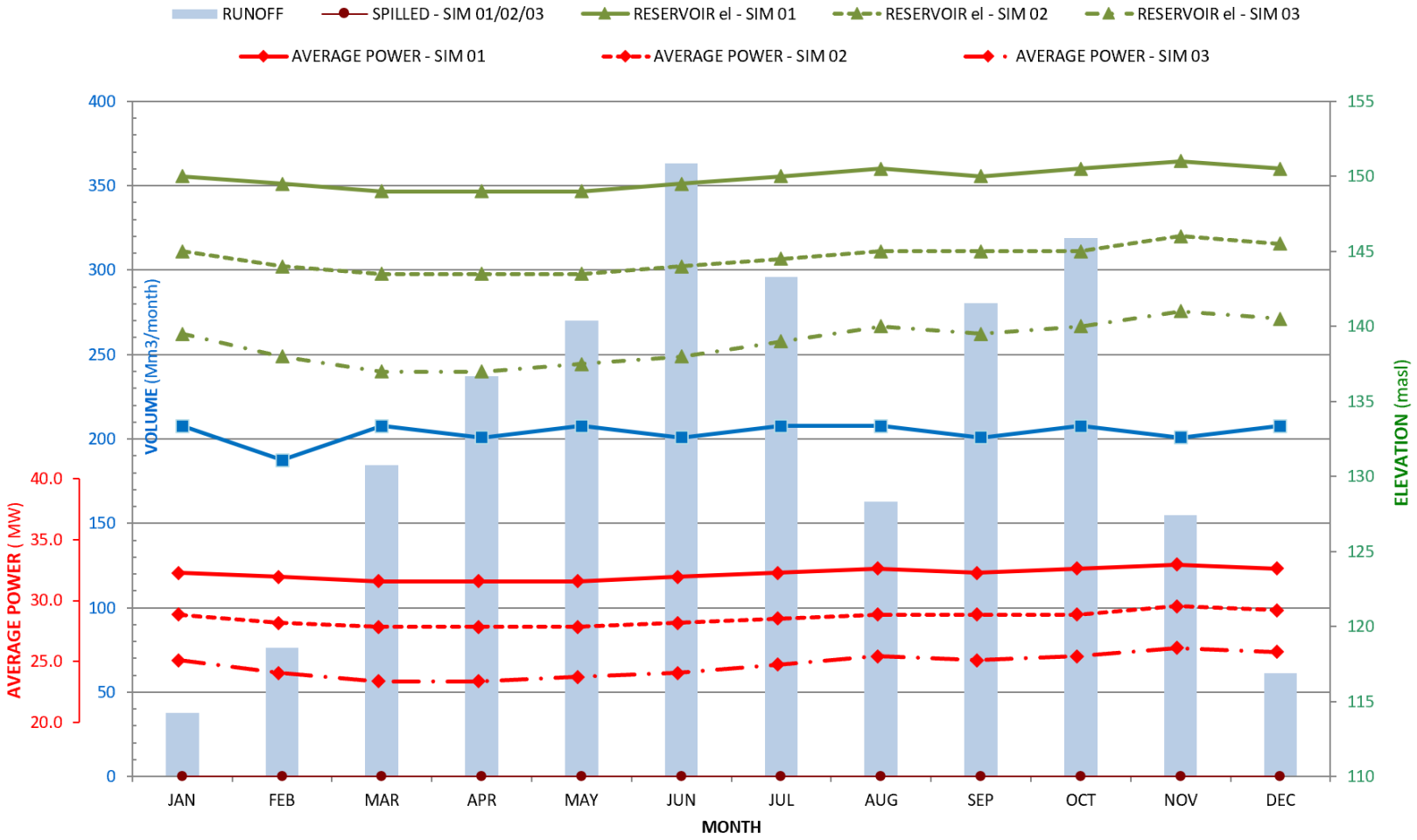
04 – HYDRO POTENTIAL



Simulation	Max O.L. m a.s.l.	P_{MAX} MW	E_{AVG} GWh/y
Sim 01	151	66	282
Sim 02	146	59	250
Sim 03	141	52	216

To be compared with the CONSTRUCTION and SOCIAL costs

ASUOSO – ENERGY PRODUCTION SENSITIVITY

Pre-Feasibility Study of Medium-Sized Potential Hydropower Site: Case Study of GHANA 10 Project

05 – COST ESTIMATION

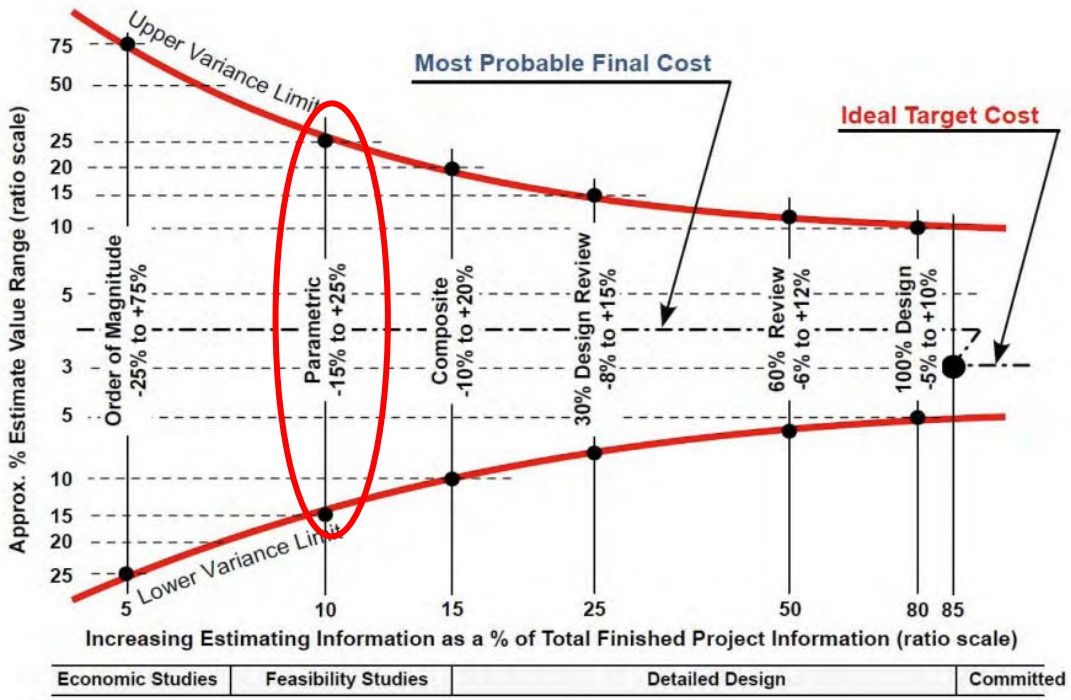
COST ESTIMATION → CONSTRUCTION COSTS

CIVIL WORKS
- DAM
- RIVER DIVERSION WORKS
- SPILLWAYS
- BOTTOM OUTLET
- PENSTOCK
- POWERHOUSE
- ROADS, CAMPS AND INFRASTRUCTURES

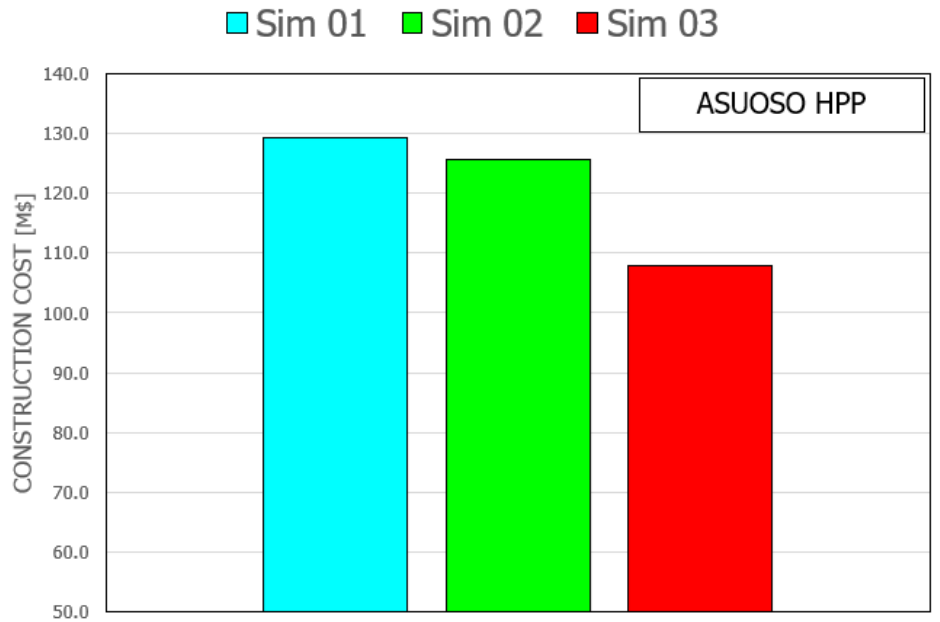
ELECTRO-MECHANICAL EQUIPMENT

→ PARAMETRIC COST ANALYSIS

(based on experience on similar projects)



Estimating Accuracy Trumpet (USSD – United States Society on Dams, 2012)



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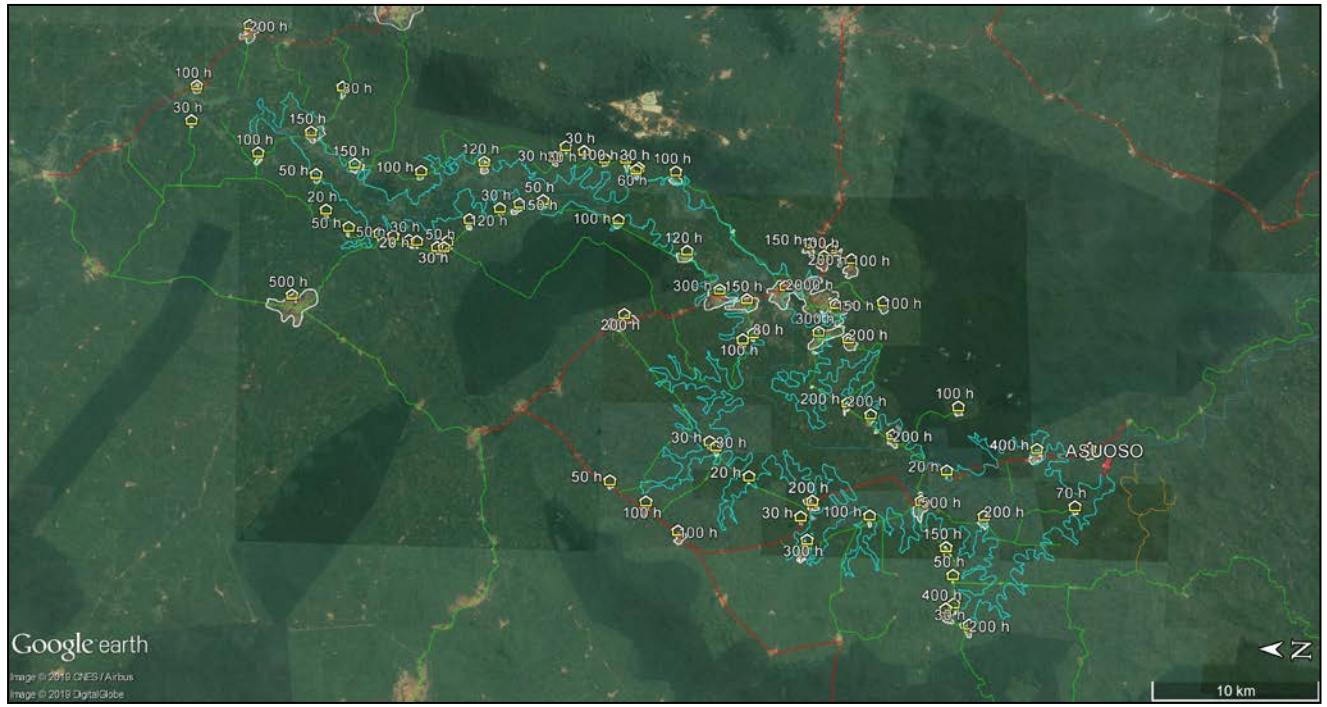
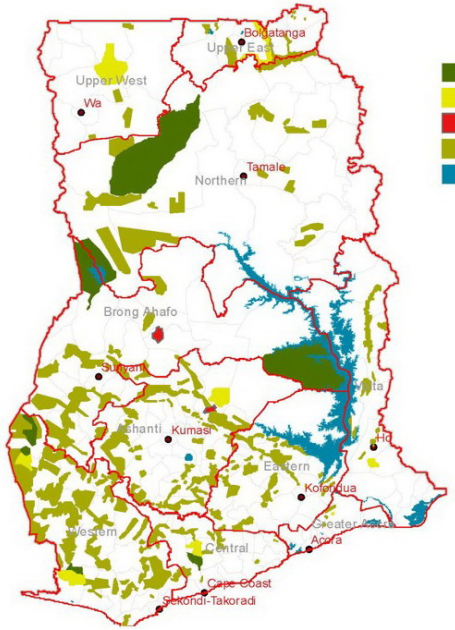
05 – COST ESTIMATION

COST ESTIMATION → SOCIAL COSTS
- ROADS
- BRIDGES
- VILLAGES
- CULTIVATED AREAS

⇒ **ESIA STUDY**
ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT





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06 – ECONOMIC ANALYSIS

ECONOMIC ANALYSIS → **DCFA**
DISCOUNTED CASH FLOW ANALYSIS

DCF analysis attempts to determine the value of an investment today, based on projections of how much money that investment will generate in the future.

$$DCF = \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \frac{CF_n}{(1+r)^n}$$

where:

CF_1 = The cash flow for year one

CF_2 = The cash flow for year two

CF_n = The cash flow for additional years

r = The discount rate

INPUT DATA

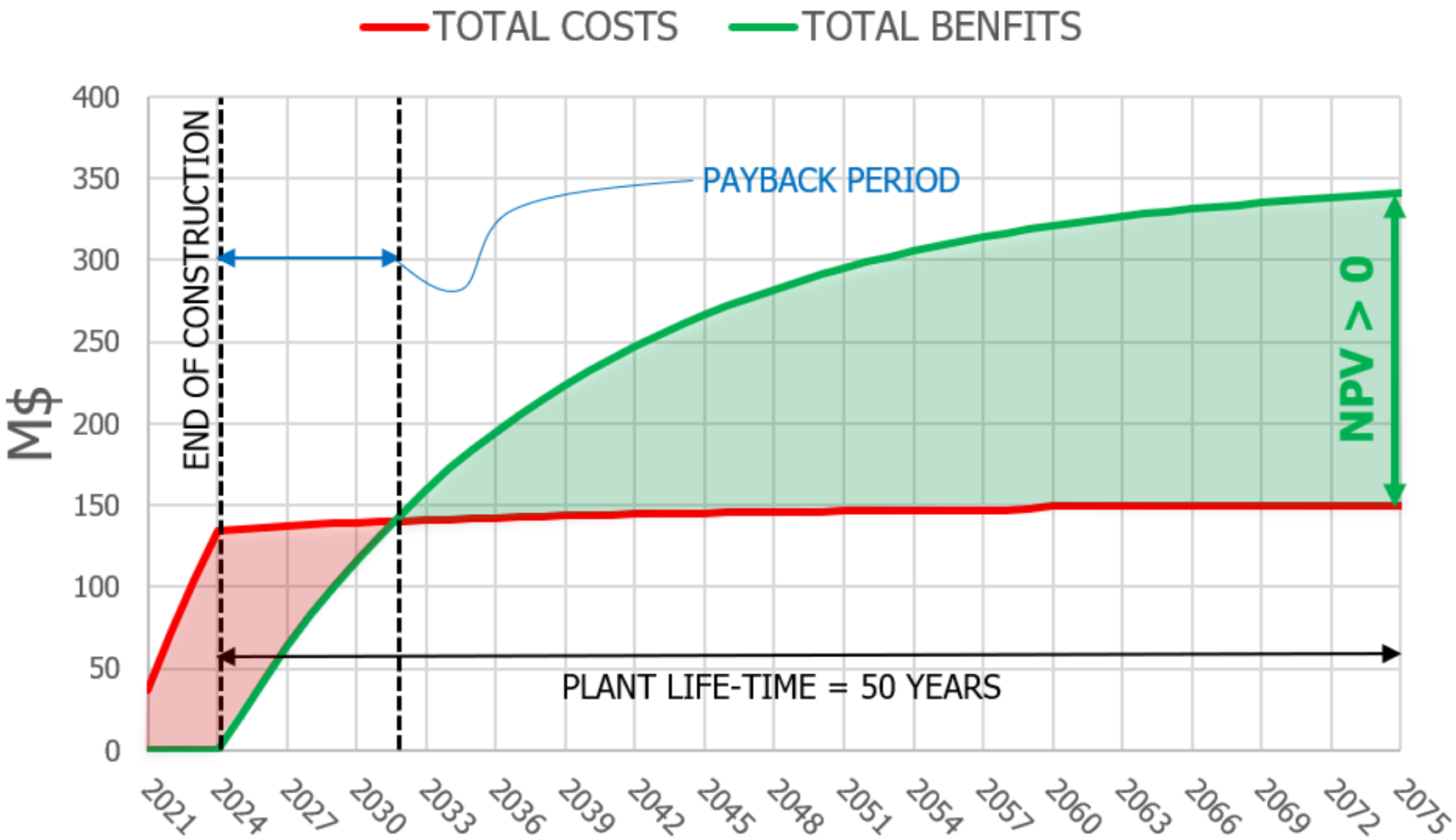
- POWER PLANT LIFE-TIME
- CONSTRUCTION PERIOD
- ENERGY PRICE
- REFERENCE YEAR
- O&M COSTS

⇒ **DISCOUNT RATE**
SENSITIVITY ANALYSIS ⇒

OUTPUT DATA

- **IRR** = INTERNAL RATE OF RETURN
- **B/C** = BENEFIT/COST RATIO
- **PBP** = PAYBACK PERIOD
- **NPV** = NET PRESENT VALUE
- **LCOE** = LEVELIZED COST OF ELECTRICITY

06 – ECONOMIC ANALYSIS



LCOE

(Levelized Cost of Electricity)
[$/KWH]

LCOE is a measure of the average net present cost of electricity generation for a generator over its lifetime

PROJECTS RANKING

www.itcold.it
itcold@iol.it

OPEN DAY ON DAMS

2023

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GRAZIE PER L'ATTENZIONE