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The Council Study

Study on the sustainable management and development of the Mekong River, including impacts of mainstream hydropower projects

Work Plan: Formulation of Development Scenarios for the Hydropower Thematic Area

This work plan describes the roadmap and the approach for formulating the development scenarios for the Hydropower thematic area. It includes the following:

- Approved Cumulative Scenarios (2007 Early Development, 2020 DFS, 2040 Planned Development) and Proposed Thematic Sub-scenarios
- Detailed schedule of data collection and analysis including coordination with Member Countries through consultation with appropriate experts of line agencies, national consultations, and regional technical working group
- Detailed data needs including current status, source agencies, and known issues for each proposed development scenario
- Proposed methodology and assumptions to fill data gaps in particular where data are known to be not available
- Personnel roles and responsibilities

Prepared by:

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Contents

1 Introduction

This work plan describes the roadmap and the approach for the formulation of the development scenarios that are going to be assessed under the Council Study. The results of these development scenario assessments will be used as the primary basis to address the overall objective of the Council Study which is to further enhance the ability of the Mekong River Commission (MRC) to advise the Member Countries (MCs) on the positive and negative impacts of water resources development on people, economies and the environment of the Mekong River Basin. This enhanced ability is expected as a result of meeting the following specific objectives of the Council Study:

> Objective 1: Further develop/establish a reliable scientific evidence base on the environment, social and economic consequences (positive and negative) of development in the Mekong River Basin.
>
> Objective 2: Results of the study are integrated into the MRC knowledge base to enhance the Basin Development Planning (BOP) process providing support to the MCs in the sustainable management and development of the Mekong River Basin.
>
> Objective 3: Promote capacity and ensure technology transfer to MCs in the process of designing and conducting of the study.

As such, the formulation of development scenarios is most critical since it defines the extent to which these three objectives can be met. The formulated development scenarios will set the boundary for what new· knowledge will be generated, what knowledge gaps will be dosed, and what uncertainties in the assessments will be minimized (i.e., Objective 1). The assessment methodology and the associated tools (both existing and new) along with the expanded MRC knowledge base will determine the extent of how the current BOP process can be enhanced (i.e., Objective 2). The participatory process adopted in formulating the development scenarios will govern how effective the learning-by-doing approach is with respect to building internal capacity and successfully transferring technology (i.e., Objective 3).

As per the Council Study Concept Note, Terms of Reference (ToR) and Inception Report, the assessments will include the following types:

- An assessment of the cumulative positive and negative impacts of water resource developments in all six selected thematic areas on the triple-bottom-line including clear indications of hotspots when/if relevant, and the thresholds of rapid transition-tipping points-in complex systems such as the Tonle Sap Lake in Cambodia and the Mekong Delta in Cambodia and Viet Nam (i.e., referred hereinafter as the assessment of cumulative development scenarios).
- Assessments for each thematic area summarising the transboundary impacts of developments in the selected thematic areas including cross-cutting impacts on the triple-bottom-line: the environmental, social and economic parameters of interest in the Mekong River Basin (i.e., referred hereinafter as the assessment of **thematic development sub- scenarios**)

In the end, the Council Study will produce a set of clear, strategic, pragmatic and actionable recommendations directly addressing potential uncertainties, risks and the information needs for development planning in the mainstream of the Lower Mekong Basin (LMB) including recommendations for impact avoidance and mitigation measures.

2 Development Scenarios

The development scenarios will be formulated by defining levels of developments in six thematic areas for each scenario. The six thematic areas are:

- Irrigation; including water use, return flows, water quality, proposed diversions, etc.
- Agriculture and Land use; including watershed management, deforestation, livestock and aquaculture, fisheries etc.
- Domestic and Industrial use; including mining, sediment extraction, waste water disposal, urban development, water quality etc.
- Flood protection structures and floodplain infrastructure, including roads on major floodplains
- Hydropower, including potential of alternative energy options.
- Navigation, specifically on infrastructure to aid navigation

The development scenarios will be of two types namely cumulative development scenarios and thematic sub-scenarios.

2.1 Cumulative Scenarios

The cumulative scenarios are based on historic (2007) and planned (2020 and 2040) basin-wide developments in the six thematic areas. These cumulative scenarios will allow the assessment of cumulative positive and negative environmental and socio-economic impacts associated with planned developments by the MCs. The assessment will show the predicted changes in the environmental and socio-economic conditions in the LMB in space and time and potentially reveal clear indications of geographic hotspots and rapid transitions in time as a result of combined developments in the six thematic areas. Along with the results of the assessment of selected thematic sub-scenarios under which impacts of specific-thematic developments can be better understood, realistic, reasonable, and thus actionable development options and management measures can be identified to enhance positive impacts and minimize the negative ones of the planned developments. Strategic measures for long-term negative impact avoidance and risk mitigation can also be identified for development planning considerations by the MCs.

During the 4th RTWG Meeting, the following cumulative development scenarios were approved for the Council Study.

Early Development Scenario/Situation (2007): This scenario covers the period from the beginning of large-scale water resources development until the year 2007 when the flow regime of the Mekong mainstream was considered to be still in its natural state. This scenario includes the water infrastructure and the land use/cover changes in in the six thematic areas by 2007.

Definite Future Scenario (2020): This scenario includes all existing (before and after 2007), undergoing construction, and firmly committed development infrastructure in the six thematic areas which are expected to be in place by 2020.

Planned Development Scenario (2040): This scenario includes all water resources development that is planned in the six thematic areas in the Mekong Basin and are expected to be in place by 2040 assuming these plans are fully implemented.

Below are the list of hydropower dams suggested for each scenario. Confirmation of the status of each dam will be provided by the MC.

2.2 Thematic Sub-Scenarios

The Thematic Sub-Scenarios represent plausible thematic-specific deviations from the 2040 planned Development Scenario. These thematic deviations reflect level of uncertainties in the full implementation of the planned development level for the thematic area of interest as per the 2040 Planned Scenario. These deviations can be due to several factors such as changes in national development policies and priorities, technology, demography, socio economic conditions, global context, etc. The deviations re formulated around the 2040 Planned Scenarios to keep these thematic sub scenarios plausible. It should be noted that while a different level of development is used for the thematic area of interest, the levels of development for the other thematic areas are held equal to the planned 2040 levels.

The assessment of these thematic sub-scenarios will provide the following understanding:

- Sensitivity of impacts to deviations from planned development levels
- Better understanding of impacts of specific development stressors (i.e. closing knowledge gaps}
- On depth analysis of the plans and plausible deviations in the plans (i.e. understand uncertainty and identify measure to minimize deviations)
- Increase understanding and capability to explore options and measures to enhance positive nd mitigate/reduce negative impacts

As per the Inception Report, a maximum of three thematic sub-scenarios per thematic area will be addressed. However, the Thematic Team may identify more than three potential thematic sub-scenarios. Thematic sub-scenarios will be presented to the MCs to get their input and final concurrence.

2.3 Proposed Thematic Sub- Scenarios for the Thematic Area of Hydropower

Below is a proposal with a series of sub-scenarios with description for further consideration of the Member Countries. Some 3 Sub-Scenarios should be selected based on plausibility confidence. Some Mainstream dams like

2.3.1 **HPS1**: This scenario suggests a combination of Tributaries and Mainstream dams from the list of dams in the “Planned Development Scenario (2040)" with some modifications whereas:

(i) assuming that only Sesan 2 HPP built in Cambodia

(ii) Some 6 - 8 Mainstream Dams which mainly are in the Lao PDR,
(iii) about some 80% of Tributary hydropower dams built in Lao PDR;
(iv) All the 13 Chinese dams should be included in this scenario.

In this scenario, it is assumed that all dams operate on "an independent basis" (no Join Operation with minimal coordination) where each hydropower dam will look to maximize their individual energy production.

2.3.2 **HPS2 (JO)**: This scenario is meant to simulate "Joint Operation" among the 6 -8 Mainstream Dams built in cascade in the Lao PDR. This scenario requires a coordinated effort of all Mainstream cascade dams beyond the aim of maximizing their electricity production alone, but to include into the simulation the use of water to operate the navigation lock, fish passages, sediment flushing as well as measure to maintain acceptable water quality during and after sediment flushing. This approach will help to assess whether the amount of water used for the navigation lock, fish passages, sediment flushing would affect significantly the electricity production for each hydropower dam in the Mainstream cascade. This scenario could also help to set a reasonable balance or distribution among these 4 key components (electricity, production, navigation lock, fish passages, sediment flushing) of each dam thus to make the cascade of dams working sustainably.

This scenario suggests a combination of Tributaries and Mainstream dams from the list of dams in the "Planned Development Scenario (2040)" with some modifications whereas:

(i) assuming that only Sesan 2 HPP built in Cambodia
(ii) Some 6 - 8 Mainstream Dams which mainly are in the Lao PDR,
(iii) about some 80% of Tributary hydropower dams built in Lao PDR;
(iv) All the 13 Chinese dams should be included in this scenario.

2.3.3 **HPS3** (**JO)**: The aim of this scenario would be to simulate a "Joint Operation" effort and to add to HP2 the needs to strengthen flood management and flood protection measures throughout the Lower Mekong Basin as well as to maximize navigability from the Delta areas to the far upstream reaches (for example ships should be able to the closest proximities of Jinghong dam or township). In other words the operation rule curves should also take into account flood protection measures in the LMB particularly sea water intrusion in the Delta.

This scenario suggests a combination of Tributaries and Mainstream dams from the list of dams in the "Planned Development Scenario (2040)" with some modifications whereas:

(i) assuming that only Sesan 2 HPP built in Cambodia
(ii) Some 6 - 8 Mainstream Dams which mainly are in the Lao PDR,
(iii) about some 80% of Tributary hydropower dams built in Lao PDR;
(iv) All the 13 Chinese dams should be included in this scenario.

2.3.4 **HPS4 (CD)**: Upper Mekong Dam Scenario: The interest for this scenario is to bring focus on the full set of hydropower projects built on the Lancang River and its implications for the Mekong Mainstream dams in operation in the northern part of Lao PDR. This scenario will

include the additional set of 7 dams located in the upper reaches of the Upper Basin of the Mekong River. These 7 dams are all located in China, in the upper part of the often referred cascade of 6 Chinese hydropower dams. They are listed in the table below.

Dams in the Lancang Hydroelectric Cascade within Yunnan

DAM NAME	INSTALLED CAPACITY (MW)	DAM HEIGHT (M)	STATUS
Gushui	2600	220	Under site preparation
Wunonglong	990	136.5	Under construction
Lidi	420	74	Under construction
Tuoba	1400	158	Under site preparation
Huangdeng	1900	202	Under construction
Dahuaqiao	900	106	Under site preparation
Miaowei	1400	139.8	Under construction

In this scenario it is suggested to use the Tributaries and Mainstream dams from the list of dams in the "Planned Development Scenario (2040)" with some modifications whereas:

(i) assuming that only Sesan 2 HPP built in Cambodia
(ii) Some 6 - 8 Mainstream Dams which mainly are in the Lao PDR,
(iii) about some 80% of Tributary hydropower dams built in Lao PDR;
(iv) All the 13 Chinese dams should be included in this scenario.

3 Data Requirements

The data needed to adequately represent the level of development in the hydropower thematic area associated with the different cumulative development scenarios and thematic development sub-scenarios in Chapter 2 are discussed below.

For each existing and planned hydropower project with at least 10 MW design capacity, the following data are required:

- Location (latitude and longitude)
- Active Storage (km3 or m3)
- Capacity (MW)
- Reservoir operation rule curve

Most if not all of the above data requirements (except for the reservoir operation rule curve) are available within MRCS through the Hydropower Project database. This database was originally developed for BDP2 in May 2008 and has been updated by ISH (???) since then. The current version of the Hydropower Project Database is Q3-2014. Based on this database, the hydropower projects that exist or planned to exist under the different cumulative and thematic sub-scenarios are identified below.

It should be noted that the data on reservoir operation rule curve is a known data gap and is discussed in Chapter 4.

3.1 List of hydropower dams suggested for Early Development Scenario/Situation (2007) – "BS":

Dams in the LMB to use in the simulation:

No.	CODE	Project Name	COD @ 2013	Status @ 2013	Installed Capacity	Annual Energy	Live Storage	Gross Storage
	Lao PDR							
1	L002	Nam Dong	1970	E	1	4.8	0.015	0
2	L003	Xelabam	1970	E	5	25	0.8	0.8
3	L001	Nam Ngum 1	1971	E	155	1025	4700	7003.99
4	L004	Xeset 1	1990	E	45	180	0.3	2.33
5	L009	Nam Ko	1996	E	1.5	5	0.0045	0
6	L005	Theun-Hinboun	1998	E	210	1356	15	29.94
7	L006	Houayho	1999	E	152.1	450	527	674.1
8	L007	Nam Leuk	2000	E	60	215	228.2	345.36
9	L010	Nam Ngay	2002	E	1.2	3	0.674	0.7
10	L008	Nam Mang 3	2004	E	40	138	45	140.73
	Cambodia							
11	C001	O Chum 2	1992	E	1	3	0.12	
	Viet Nam							
12	V014	Dray Hlinh 1	1990	E	12	100	1.5	2.9
13	V003	Yali	1998	E	720	3868.392	779.02	1037.1
14	V004	Se San 3	2006	E	260	1325.354	3.8	92
15	V005	Se San 3A	2007	E	96	479.3	4	80.6
16	V011	Dray Hlinh 2	2007	E	16	94	1.5	2.9
	Thailand							
17	T003	Nam Pung	1965	E	6.3	17	156.8	170
18	T006	Ubol Ratana	1966	E	25.2	56	1695	2250
19	T005	Sirindhorn	1971	E	36	90	1135	1970
20	T001	Chulabhorn	1972	E	40	59	144.5	180
21	T002	Huai Kum	1982	E	1.18	2	20	20
22	T004	Pak Mun	1994	E	136	280	125	225
23	T007	Lam Ta Khong PS	2001	E	500	400	299.6	319.9
		Total			**2,520.48**	**10,175.85**	**9,882.83**	**14,548.35**

Installed Capacity in MW
Annual Energy in GWH
Storage in Million Cubic Meters

Dams in China to include in the "BS" scenario:

1. Manwan Dam
2. Dachaoshan Dam

3.2 List of hydropower dams suggested for Definite Future Scenario (2020) – "DF": Installed capacities are in MW.

Additional Dams to add to the list of dams in the Early Development Scenario/Situation:

Cambodia	Lao PDR	Thailand	Viet Nam
Lower Se San 2	Xeset 2		Plei Krong
	Nam Theun 2		Buon Tua Srah
	Nam Lik 1-2		Buon Kuop
	Nam Ngum 2		Se San 4
	Nam Nhone		Sre Pok 3
	Nam Ngum 5		Sre Pok 4
	Xekaman 3		Se San 4A
	Theun-Hinboun expansion		Sre Pok 4A
	Theun-Hinboun exp. (NG8)		Upper Kontum
	Nam Long		
	Xenamnoy 1		
	Tad Salen		
	Nam Song		
	Nam Sana		
	Xekaman 1		
	Xekaman-Sanxay		
	Nam Lik 1		
	Nam Khan 2		
	Houay Lamphan Gnai		
	Nam Ngiep 2		
	Nam Hinboun		
	Xekatam		
	Nam San 3		
	Nam Beng		
	Nam Mang 1		
	Nam Ou 2		
	Nam Ou 5		
	Nam Ou 6		
	Nam Suang 1		
	Nam Suang 2		
	Nam Kong 2		
	Nam Ngum 3		
	Nam Theun1		
	Nam Ngiep 1		
	Nam Ngiep-regulating dam		
	Xepian-Xenamnoy		
	Xayaburi (L)		
400	**7304.6**	**0**	**1503**

(MW)

Dams on the mainstream to include into the “DF” scenario is:

1. Xayaburi Dam

Dams in China to include in the simulation:

1. Manwan Dam
2. Dachaoshan Dam
3. Jinghong Dam
4. Xiaowan Dam
5. Nuozhadu Dam
6. Gongouqiao Dam

3.3 Planned Development Scenario (2040) – "PD": Installed capacities are in MW.

Additional list of Dams to add to the above two scenarios is shown in the table below:

Cambodia	Lao PDR	Thailand	Viet Nam
Battambang 1	Xe Nam Noy 5		Duc Xuyen
Battambang 2	Nam Chian		
Stung Pursat 1	Nam Pot		
Pursat 2	Nam Phak		
Lower Se San 3	Nam Hinboun 1		
Prek Liang 1	Nam Hinboun 2		
Prek Liang 2	Xe Pon 3		
Lower Sre Pok 3A	Xedon 2		
Lower Sre Pok 4	Nam Tha 1		
Stung Sen	Xekong 4		
Sekong	Nam Kong 1		
Lower Se San 1	Xe Kong 3up		
Lower Sre Pok 3B	Xe Kong 3d		
Lower Prek Chhlaung	Xe Kong 5		
Upper Prek Chhlaung	Nam Ou 1		
Prek Por	Nam Ou 3		
Prek Ter	Nam Ou 4		
	Nam Ou 7		
	Nam Nga		
	Nam Feuang 1		
	Nam Feuang 2		
	Nam Feuang 3		
	Xe Kaman 2A		
	Xe Kaman 2B		
	Xe Kaman 4A		
	Xe Kaman 4B		
	Dak E Mule		
	Nam Khan 1		
	Nam Khan 3		
	Nam Ngum 4A		
	Nam Ngum 4B		
	Nam Ngum, (down) Lower dam		
	Nam Pay		
	Nam Pouy		
	Nam Poun		
	Nam Ngao		
	Nam Ngieu		
	Nam San 3B		
	Nam San 2		
	Nam Pok		
	Xe Bang Fai		
	Xe Neua		
	Nam Theun 4		
	Nam Mouan		
	Xe Bang Hieng 2		
	Xe Set 3		
	Xe Bang Nouan		
	Xe Lanong 1		
	Xe Lanong 2		
	Nam Phak (Houykatam)		
	Xesu		
	Houay Champi		
	Nam Bak 1		
	Nam Bak 2		
	Nam Ham		
	Nam Leng		
	Nam Ngiep (Mouang Mai)		
	Nam Phouan		
	Sekong Downstream		
	Xebanghieng 1		
	Nam Ang Tha Beng		
	Xepian-Houaysoy		
	Nam Kong 3		
	Nam Pha		
1267	4935	0	58

Dams on the mainstream to include into the “PD” scenario are:

Cambodia	Lao PDR	Thailand	Viet Nam
Sambor (Cam)	Don Sahong (L)		
Stung Treng (Cam)	Pakbeng (L)		
3500	Luangprabang (L)		
	Paklay (L)		
	Sanakham (L-T)		
	Sangthong-Pakchom (L-T)		
	Ban Kum (L)		
	Latsua (Phou Ngoy) (L)		
	Thakho (L)		
	8302		

Chinese dams to include into the “PD” scenario include:

1. Manwan
2. DachaoshanDam
3. Jinghong
4. Xiaowan
5. Nuozhadu
6. Gongouqiao
7. Gushui
8. Wunonglong
9. Lidi
10. Tuoba
11. Huangdeng
12. Dahuaqiao
13. Miaowei

3.4 Sub-Scenarios :

In the Sub Scenarios there is reference to some 80% of dams built in Lao PDR. Therefore it is expected that Lao National Consultant will help to identify the appropriate list prior to do the simulation.

4 Handling of Data Gaps

The situation with regard to circumstances having an external cause or origin in part reflects that there are a number of data and knowledge gaps that inhibit detailed analyses of certain issues. These should be discussed further under risks and uncertainties. In the meantime, key preliminaries assumptions regarding Handling of Data Gaps are as follow:

4.1 The operation rule for hydropower project are not available for most hydropower scheme. Consequently, as the methodology used during the BDP2’s Assessment of basin-wide development scenarios will be applied and improved when possible. For example to use a model

to synthetize the operation rule will use a series of monthly flows and the characteristics of a hydroelectric project to develop reservoir operation guidelines to meet the following objectives:

1. Prevent the reservoir from emptying until the end of the driest season on record

a) 2. Allow the reservoir to fill up by the end of the driest wet season on record
b) 3. Maximize annual energy generation

The first two objectives are met by designing a lower boundary to the fraction of live storage that must be maintained. This analysis only involves knowledge of inflow water volumes and the live storage of the reservoir.

The third objective is met by designing an upper boundary that balances the gains in energy production resulting from operating at high reservoir levels (higher head) and the losses of energy resulting from spilled water (lower turbine discharge). This analysis involves knowledge of the plant characteristics, specifically the reservoir volume-elevation relationship, the tail water level of the plant and the installed capacity and design discharge of the plant.

5 Detailed Schedule

The table below shows the overall schedule followed by all the thematic teams in formulating the development scenarios.

Overall Schedule

Activity	Author/Lead	Due Date	Hydropower Thematic Team Specific Notes
Submit Draft Work Plan for the Formulation of Development Scenarios to CS Coordinator	Each Thematic Team	31 May 2015	
Review Draft Initial Work Plans	CS Coordinator and Review Team*	6 June 2015	
Submit Final Draft Work Plan to CS Coordinator		12 June 2015	
Send Letter to CS National Focal Points with the Work Plans	CS Coordinator	17 June 2015	
Follow-up with line agencies in collecting data and conducting small group technical consultations with appropriate experts from line agencies	Thematic Team (separately)	22 June to 24 July 2015 (one month)	Most of the hydropower data required is already in the Hydropower Project Database. Therefore, any follow-up consultations will involve the following: - Reviewing proposed dams under each scenario - Discuss proposed method for

			developing rule curves - Discuss concept and proposed thematic sub-scenarios Targeted one-on-one or small group meetings will be identified. However, it is anticipated that this can be done through the planned national consultations (see below)
Conduct remaining data processing and analysis including identification of remaining data gaps and formulation of thematic sub-scenarios	Thematic Team (in consultation with Review Team)	27 July – 31 July	
Conduct national Consultations (separate meetings with 4 MCs)	All Thematic Teams (together)	3 – 28 August 2015	Present draft formulated scenarios and associated data, and thematic sub-scenarios This will include the following activities: - Reviewing proposed dams under each scenario - Discuss proposed method for developing rule curves - Discuss concept and proposed thematic sub-scenarios
Conduct final data collection, data gap filling and analysis and submit Development Scenarios/Sub-scenarios Data/Map Specification Document to CS Coordinator	Thematic Teams in consultation with Review Team*	31 August – 30 September 2015	Address comments from national consultations
Submit 5th RTWG Briefing Materials	CS Coordinator	2 OCTOBER 2015	Include Scenarios/Sub-scenarios Data/Map Specification Document
Conduct 5th RTWG	All	19 – 23 October 2015	Seek approval of formulated development scenarios

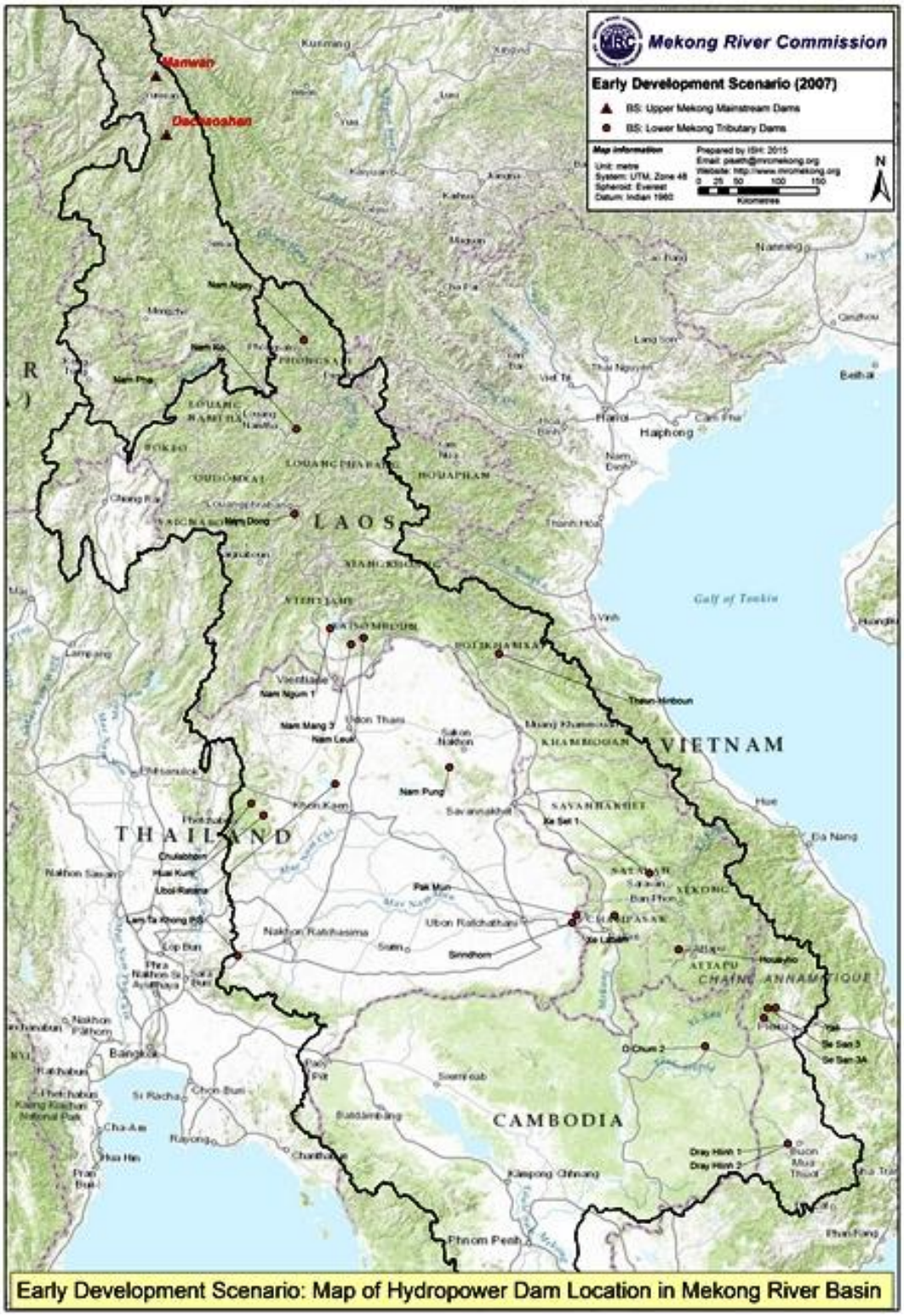
*TTasks of the Review Team will include consolidating (including organizing data in a central repository) and reviewing formulated scenarios of the Thematic Teams and working with the modeling team to incorporate these scenarios in the models.

6 Personnel Roles and Responsibilities

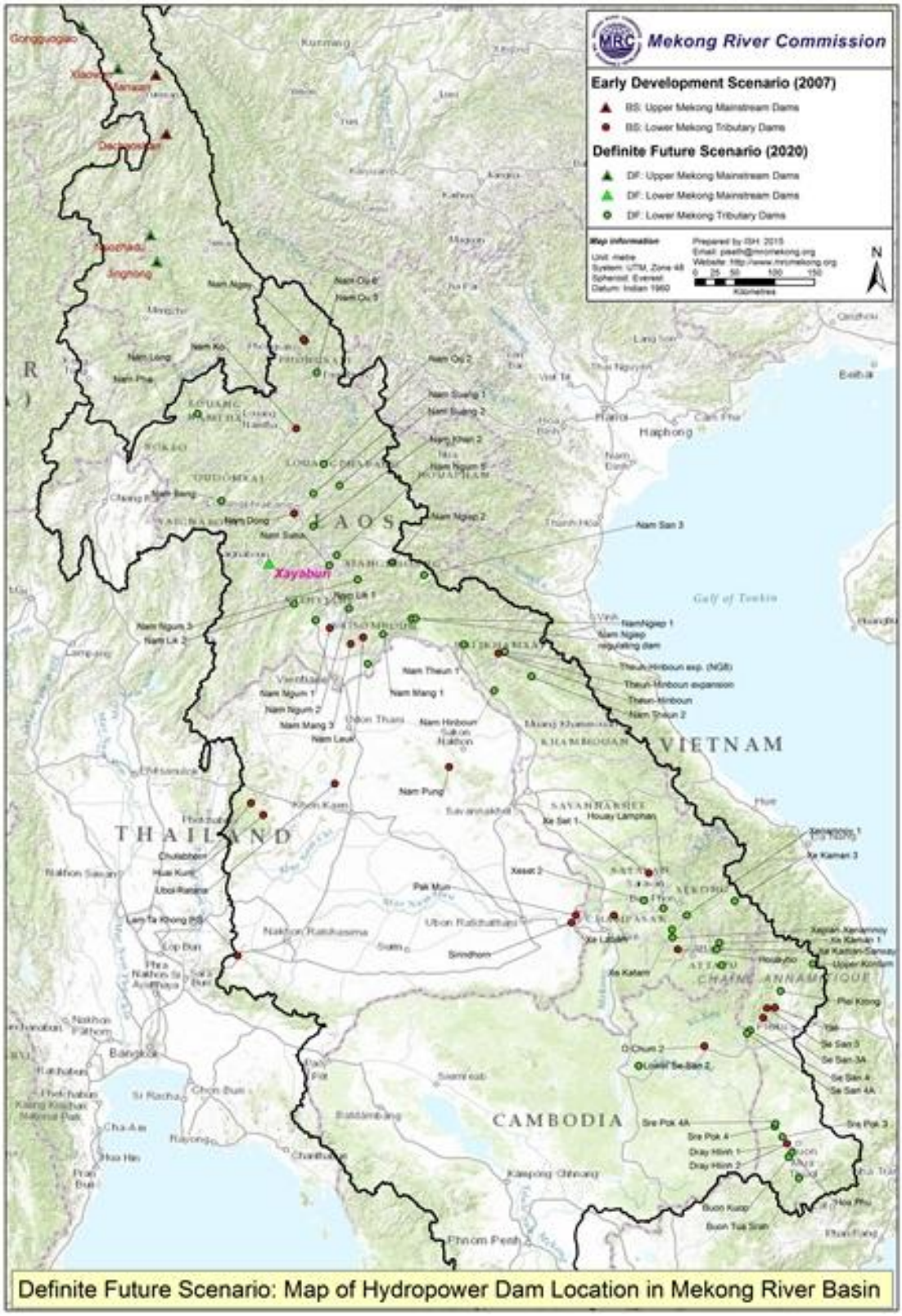
This section should identify the names of the personnel involved and their roles. In particular, it should include the technical lead and national consultants and Programme Management Lead.

MAPS:

Early Development Scenario/Situation (2007)



Definite Future Scenario (2020)



Definite Future Scenario: Map of Hydropower Dam Location in Mekong River Basin

Planned Development Scenario (2040)