Mekong River Commission

Technical Support Division
Information and Knowledge Management Programme

Working Paper

Modelling Framework

For the Council Study

Based on the Concept Note: *Modelling Approach in Support of the Council Study*, 15th January 2015.

This paper sets out in more detail than the Concept Note (Jan 2015) the plans for IKMP modelling team to support the council study during 2015. The proven DSF models form the core of the support but an ambitious plan to significantly extend the capacity of the modelling basin wide to include Water Quality (Nutrients) and Sediment (Fine and sand/gravel) in the baseline modelling by the end of September. The modelling work using DSF will be supported by the use of WUP-FIN modelling and development of IQQM to route nutrients into a closely linked SWAT/IQQM platform to be developed by eWater (Source).

The Baseline selection (as set out in the accompanying paper) is key to the programme of work and it is assumed that the option selected can be completed for flow, sediment, nutrients and salinity baseline simulations by the end of August for flow and the end of September for all parameters.

In September scenario setup can begin and it is anticipated that 3 Scenarios can be completed and reported on by the end of November for consultation in December.

The work within the IKMP modelling team will be supported by 8 Modelling Experts from the 4 riparian countries and it is expected that close reporting to countries during the whole process will ensure a good common understanding of the work and acceptance of the models and the modelling results which is seen as critical to the success of the work.

13 April 2015

CONTENTS AMENDMENT RECORD

This report has been issued and amended as follows:

Issue	Revision	Description	Date	Signed
1	0	First Version of the document	8/04/2015	Dat, Ornanong, Jorma, Anthony
1	1	Addition to make clear timelines on baseline and scenario work; clarifications of the framework	09/04/2015	Ornanong, Jorma, Anthony
1	2	Final checking	13/04/2015	Dat, Jorma

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1 Council Study Modelling Objectives

The MRC Council Study overall objectives are:

1. Further understand the environmental, social and economic (both positive and negative) consequences of water resources development;
2. Enhance the BDP process to support Member Countries in the sustainable development of the basin; and
3. Promote capacity building.

The Council Study Hydrologic Assessment Discipline Team led by the Information and Knowledge Management Programme (IKMP) is responsible for carrying out the hydrologic, hydraulic, sediment transport, and water quality modeling required to support the assessment of environmental and socio-economic impacts associated with water resources developments in six thematic areas or development sectors. The six thematic areas include hydropower, irrigation, agriculture and land use change, domestic and industrial water use, navigation, and flood protection. The water resources development impacts will be studied in relation to the climate change also.

Council Study modelling specific objectives for the first phase are to:

1. Support other Council Study components and activities
2. Provide evidence based and quantitative information on Mekong development impacts
3. Identify main (quantitative) knowledge gaps.

If the first phase is successful it is recommended that there will be more specific modelling study with the following activities and objectives:

1. Support sustainable development through close linkage and support to Countries' dialogue and planning processes.
2. Fill-in of identified knowledge gaps with targeted field measurements and focused modelling
3. Provide more detailed Delta impact modelling that can take into account water regulation better and has improved floodplain physical, chemical and biological description (necessitates coupled 1D/3D modelling).
4. Provide more quantitative estimates of morphological changes, their time scales and impacts such as lowering of water table and land subsidence
5. Provide more quantified, detailed and in-depth estimates on productivity changes for agriculture, aquaculture and capture fisheries
6. Provide more quantified coastal productivity and erosion impact estimates
7. Obtain improved understanding of historical changes and their impacts on the Mekong system. The modelling would cover pre-development and different land use, irrigation, hydropower and infrastructure (roads, dykes, channels) development phases.
8. Evaluate alternative development scenarios and their impacts.
9. Evaluate different mitigation measures and their impacts including ISH provided alternative dam plans and operations.

2 Overview of the modelling approach

The Lower Mekong Basin (LMB) can be divided into five zones:

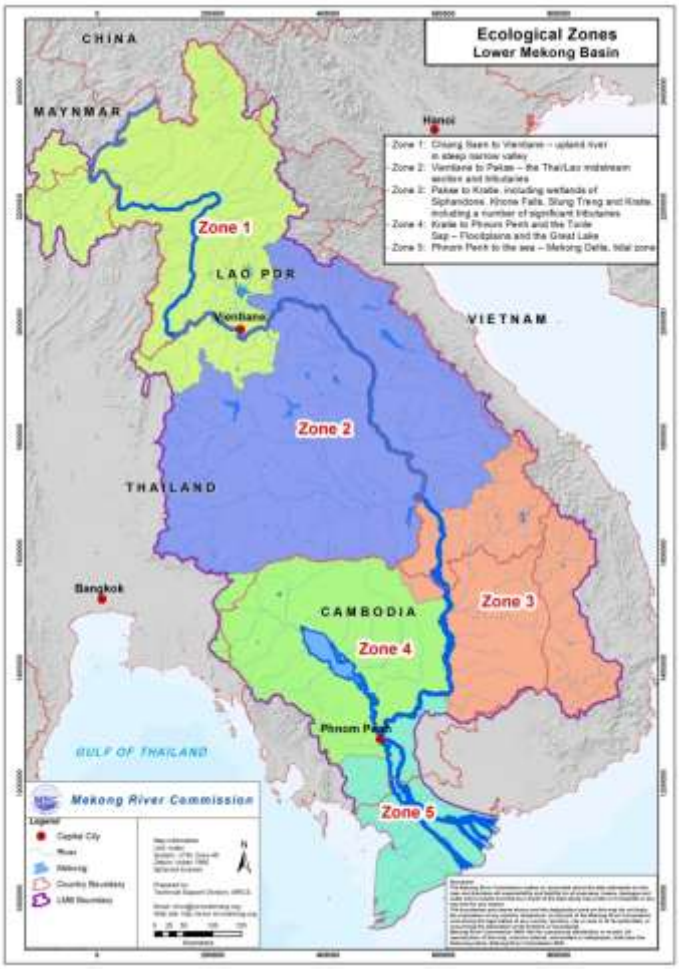


Figure 2-1. Ecological zones in the Lower Mekong Basin

MRC has agreed that the assessment of positive and negative impacts will put emphasis on:

- A corridor on both sides of the mainstream from Chinese border to Kratie (Zones 1 – 3)
- The Cambodian floodplains, especially Tonle Sap River and Lake (Zone 4)
- The Cambodian and Vietnamese Delta (Zone 5)
- The coastal areas directly influenced by the Mekong estuary.

As these areas are fundamentally different in terms of their natural and socio-economic conditions the modelling approach needs to be different for these different zones. The MRC TACT has selected balanced DSF/WUP-FIN option out of alternative approaches for the Council Study and the Countries have agreed for following approach for the different Zones:

- **Zones 1-3**: watershed hydrological (SWAT, IQQM with an additional supplement IQQM by Source Model) and mainstream hydraulic (ISIS) modelling
- **Zone 4**: Tonle Sap hydrological (VMOD) and hydrodynamic (WUP-FIN 3D-EIA) modelling
- **Zone 5**: Delta hydraulic modelling (ISIS integrated with WUP-FIN VMOD Delta Impact Model).

The main impact model setup is presented in Figure 2-2. In Zones 1 – 3 hydrological, sediment, water quality and water resources impacts are modelled with the DSF SWAT and IQQM/Source. A new ISIS implementation on the upper part of the basin is for mainstream hydraulic and sediment impact modelling. In Zone 4 focus is on the Tonle Sap and the existing WUP-FIN 3D-EIA model is used for flooding, sediments, water quality (BOD, DO, nutrients) and productivity impact modelling. Existing 3D-EIA models will be also used in selected hotspot areas in Zones 1 – 5. In the Delta river channel flow, water levels and salinity will be modelled with ISIS. VMOD will be linked with the ISIS and upstream SWAT/IQQM for flooding, sediment, water quality and productivity (agri- and aquaculture) modelling.

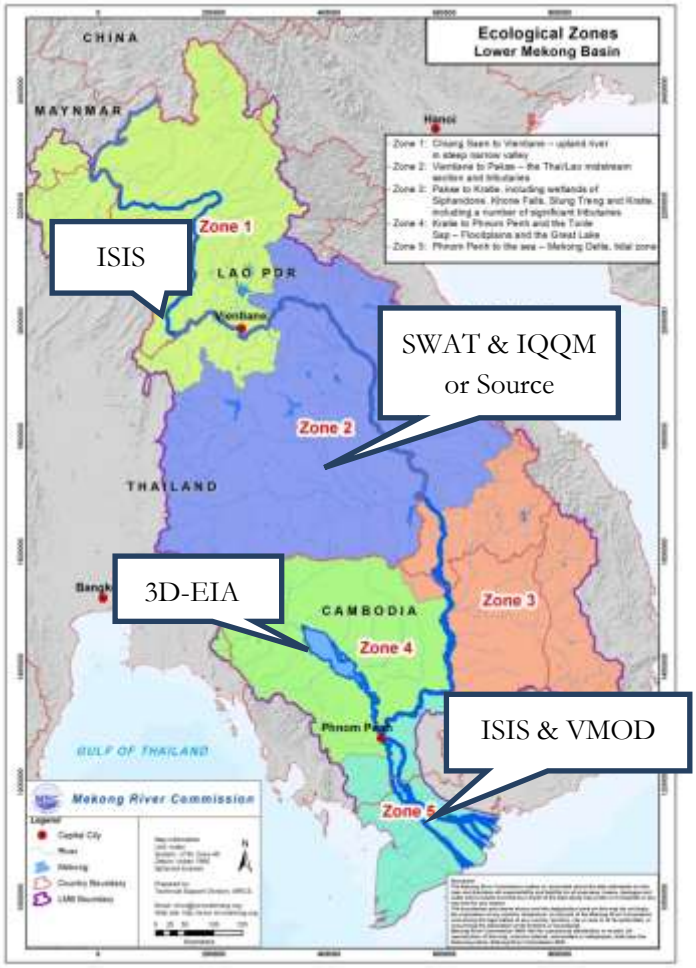


Figure 2-2. Main impact model set-up for the LMB for hydrology, hydraulics, sediments, water quality and productivity.

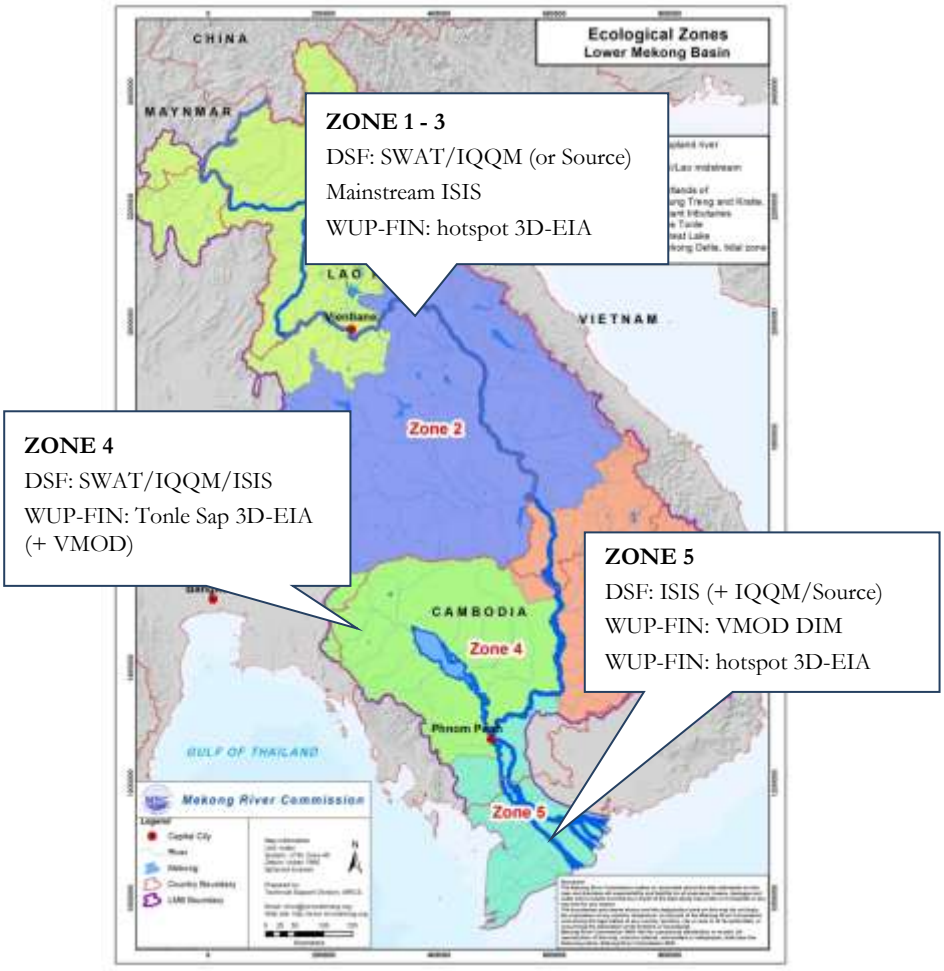


Figure 2-3. List of models used for the Council Study in different zones.

A detailed list of all of the models used for the Council Study is presented in Figure 2-3. The different models are intrinsically connected to each other through the common database (modelling Knowledge Base) and through connections between the models (Figure 2-4): SWAT and IQQM/Source provide discharges and sediment and nutrient loads to the ISIS models (both upstream and downstream). Sediment and water quality concentrations for the downstream modelling are provided by the IQQM/Source. The DSF models provide discharges, water levels and sediment loads for the VMOD Delta Impact Model, Tonle Sap 3D-EIA model and the other hotspot 3D models (e.g. Nam Songkhram, Xe Bang Fai, Chaktomuk, Tan Chau, Tieu River Estuary) except the Tonle Sap VMOD will provide sediment and nutrient loads to the Tonle Sap Lake model. Delta IQQM provides water diversion data to the Delta ISIS model. In the Zones 1 – 3 the DSF will be supported by WUP-FIN for reservoir sedimentation and water quality through integration of loads, parameters and impacts in the DSF.

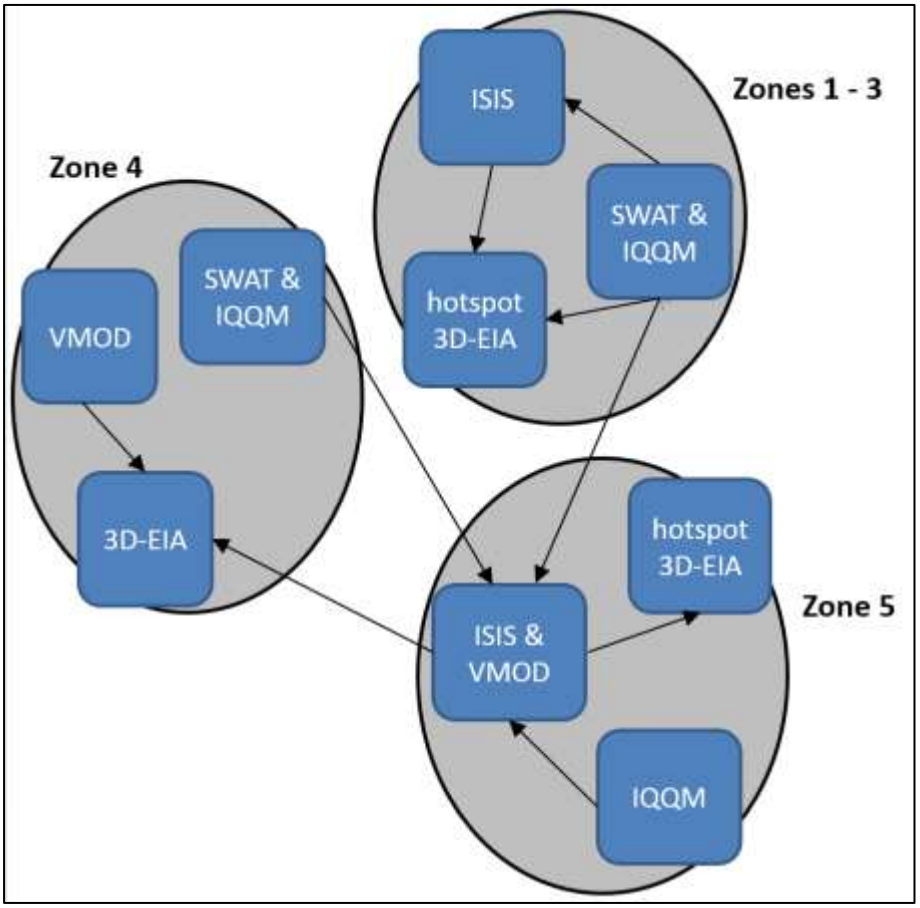


Figure 2-4. Information flow for the Council Study Modelling Framework.

The modelling is implemented between February – December 2015 through combined riparian and country effort. The period April-September is concerned with model upgrading to the agreed baseline and to extend capacity of DSF models, the linkages and simulations with WUP-FIN, and the new IQQM/SWAT flow and water quality modelling to be completed by eWater Source.

The modelling main tasks are:

1. Management and liaison
2. SWAT watershed model setup (deadline end of August)
3. IQQM water resources model setup (deadline end of August)
4. ISIS 1D flow model setup for Zones 1 – 3 (deadline middle of July)
5. Delta VMOD Impact Model setup (deadline beginning of July)
6. Baseline and Scenario Definitions (Council Study defined)
7. Baseline Modelling (deadline end of September except Delta end of October)
8. Scenario Assessment (October – November)
9. Reporting and revisions (November – December).

The main project reports reflecting the main modelling outputs are:

- Baseline Model Documentation
- Mainstream flow, flooding, sediment and morphology impact report (Zones 1 -3)
- Tonle Sap impact report (flow, flooding, sediment, salinity, water quality, productivity)
- Delta impact report (flow, flooding, sediment, salinity, water quality, productivity)
- Hotspot impact report (Zones 1 - 5).

The expert resources include 3 IKMP experts (CS Modelling Manager and two National Modelers), Modelling Technical Coordinator, two riparian DSF Experts, two international DSF Experts, one international Sediment Expert, two international WUP-FIN experts, four DSF riparian assistants, four WUP-FIN riparian assistants and e-water IQQM/eWater team. The riparian assistants have important role in **communicating regularly the modelling approaches, progress and results to the member countries** and providing country feedback.

The proposed modelling work plan is presented in ANNEX B.

There are still some variables that require guidance from the countries that could affect the progression of the modelling work including particularly the selection of the baseline in terms of infrastructure and hydrological period to be used. The available additional information for setting up and improving the baseline models such as additional topographic data, salinity, sediment and flood infrastructure. The details of the Scenarios to be modelled during 2015 will also be decided during consultation and this Workplan must be updated to reflect the agreed requirements.

3 Modelling Work Flow

Detailed model work flow was developed as Figure 3-1 to 3-3 for each study Zone.

Table 3-1: Model configuration for council study. Hot spots are limited 3D model application areas.

Component	Parameter	Location	Zone	Model
Hydrology/Flow regime		River sites, and entrance to Tonle Sap and Delta	Zone 1, 2, 3	SWAT&IQQM (eWater)
Hydraulics		River sites	Zone 1, 2, 3	ISIS
		Tonle Sap Great Lake	Zone 4	ISIS
		Delta	Zone 5	ISIS
Flooding		Hotspots	Zone 1,2,3,5	3D-EIA
		Tonle Sap Great Lake	Zone 4	3D-EIA
		Delta	Zone 5	ISIS + VMOD
Water quality	Sediment Accounting	River sites	Zone 1, 2, 3	SWAT&IQQM&ISIS
		Hotspots	Zone 1,2,3,5	3D-EIA
		Tonle Sap Great Lake	Zone 4	3D-EIA
		Delta	Zone 5	ISIS+VMOD
	Nutrient	River sites	Zone 1, 2, 3	SWAT, VMOD
		Tonle Sap Great Lake	Zone 4	3D-EIA
		Delta	Zone 5	ISIS+VMOD
	Primary Production	River sites	Zone 1, 2, 3	-
		Tonle Sap Great Lake	Zone 4	3D-EIA
		Delta	Zone 5	ISIS+VMOD
	Salinity	River sites	Zone 1, 2, 3	-
		Tonle Sap Great Lake	Zone 4	-
		Delta	Zone 5	ISIS+VMOD
Hydropower	Operation of Dams	River sites	Zone 1, 2, 3	SWAT&IQQM (or eWater)
	Sediment Accounting in Dams	River sites	Zone 1, 2, 3	3D-EIA, VMOD

The MRC DSF will be used as the core model for Council Study (with enhancement by the IQQM development for water quality routing simulation proposed by eWater) but supplemented by the WUP-FIN model on water quality. Annex A describes the output requirement from each sector and specifying which model can provide the required output.

The hydrology and hydraulics outputs for all zones can be provided by the DSF models (SWAT, IQQM and ISIS). However, some parts of the model may need to be set-up and, if necessary, recalibrated in the riparian zone/flood plain in Zone 1-3. The Isis model for Chiang Saen to Pakse will need to be checked and updated to the baseline and proven for 1D sediment simulation in the mainstream linking to outputs from the upstream tributary modelling and output to downstream models including the routing through to Kratie.

The sediment and water quality outputs for all zones can be provided by linking the DSF models (SWAT, IQQM and ISIS) with the WUP-FIN ones (VMOD, 3D-EIA). The combined tools will provide sediment flooding, loads, erosion, salinity, and water temperature, nutrients and agri- and aquaculture productivity. For this part, both DSF and WUP-FIN models need to be calibrated and validated. All parameters will not be available for all areas, for instance productivity will be modelled only in Zones 4 and 5.

Figure 3-1: Baseline Modelling Activity for Zone 1-3 Mekong Mainstream

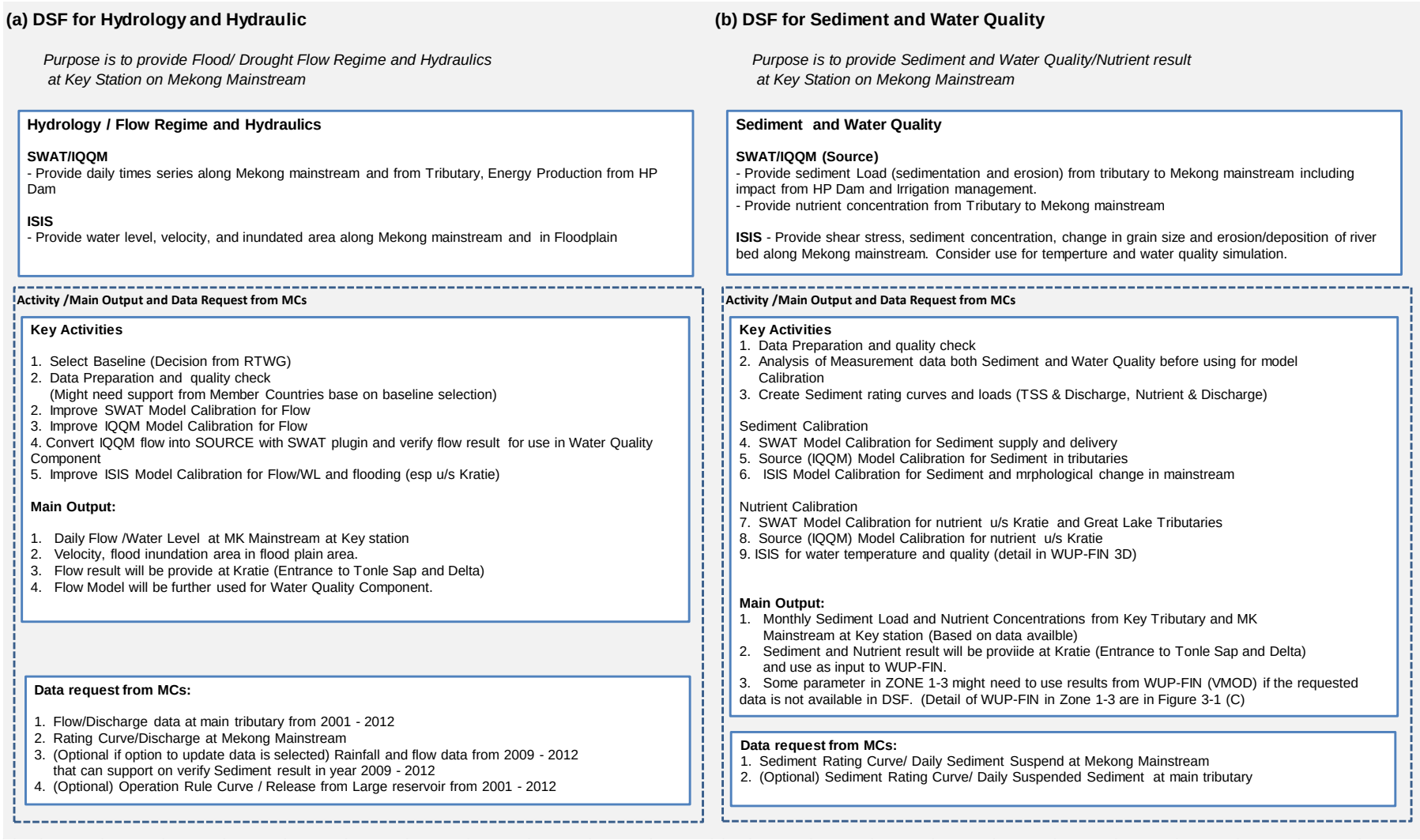


Figure 3-1: Baseline Modelling Activity for Zone 1-3 Mekong Mainstream (Cont'd)

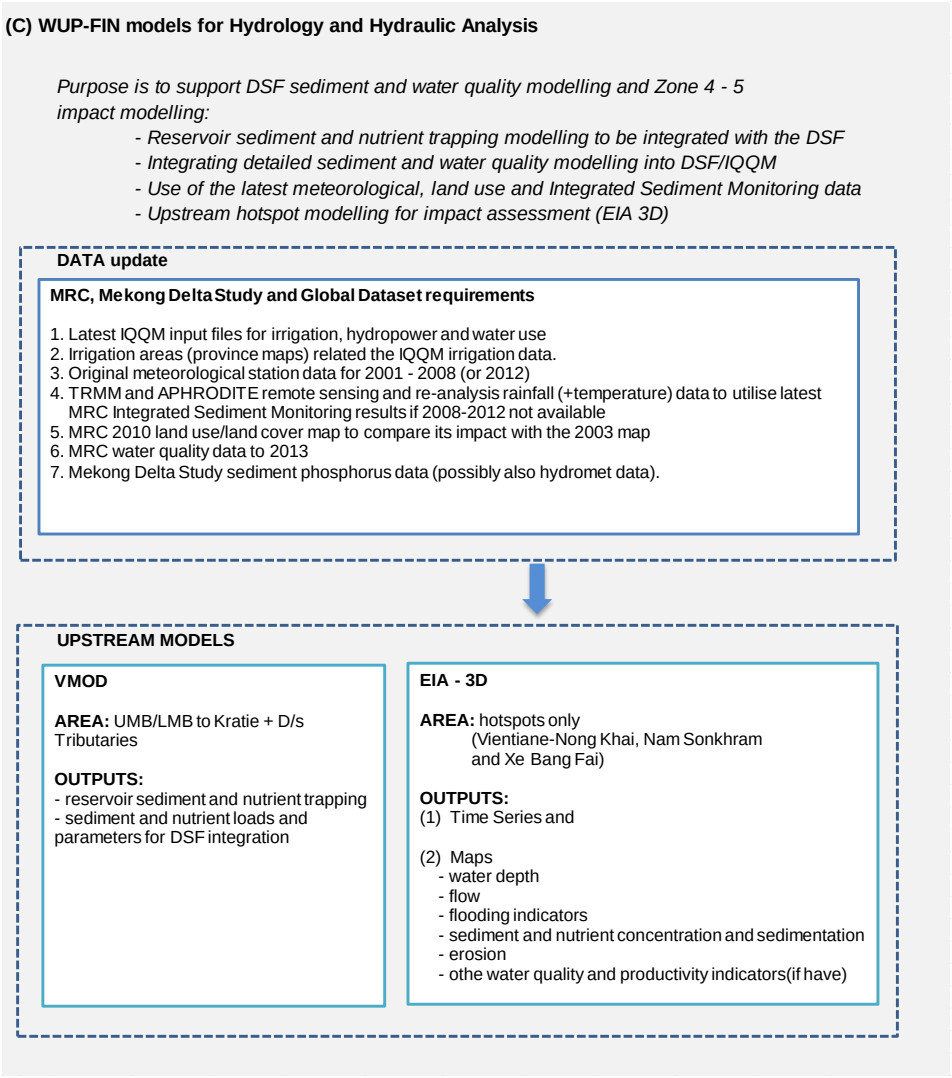


Figure 3-2: Baseline Modelling Activity for Zone 4, TONLE SAP

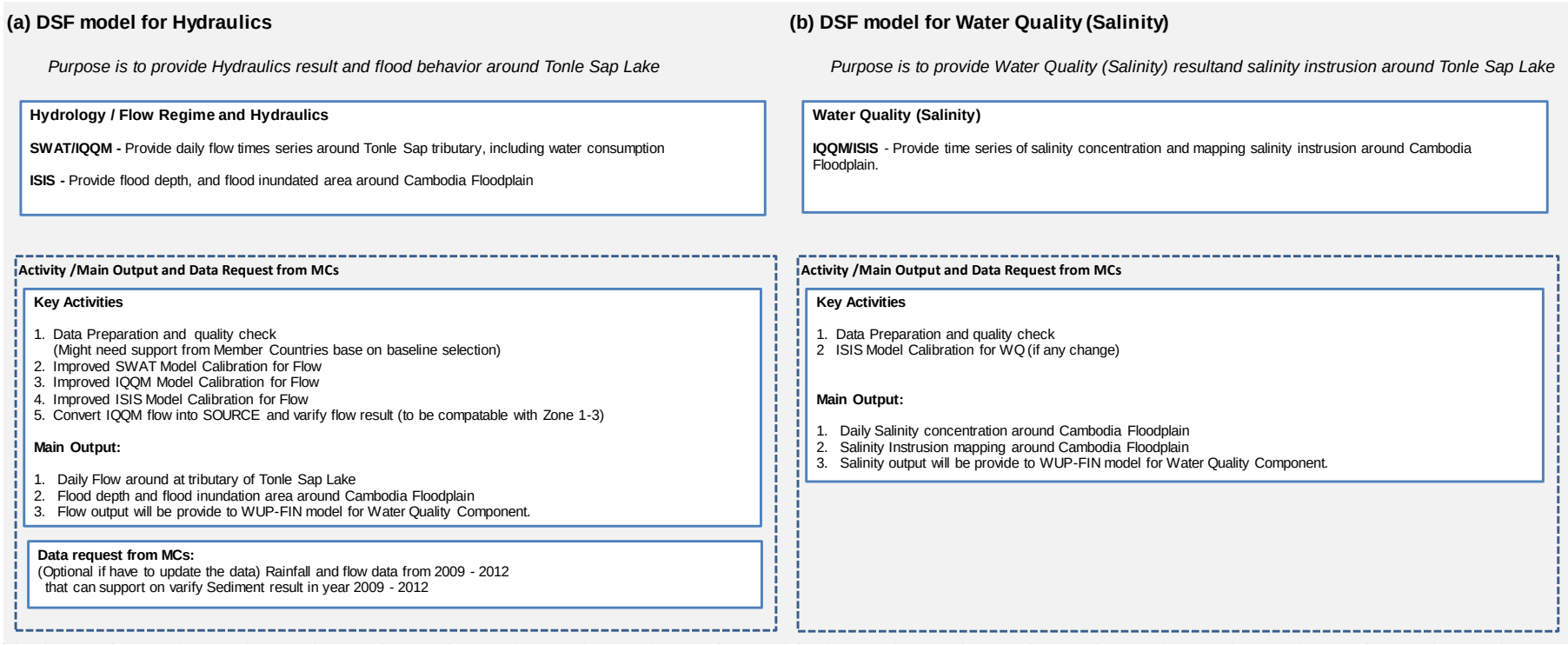


Figure 3-2: Baseline Modelling Activity for Zone 4, TONLE SAP (Cont'd)

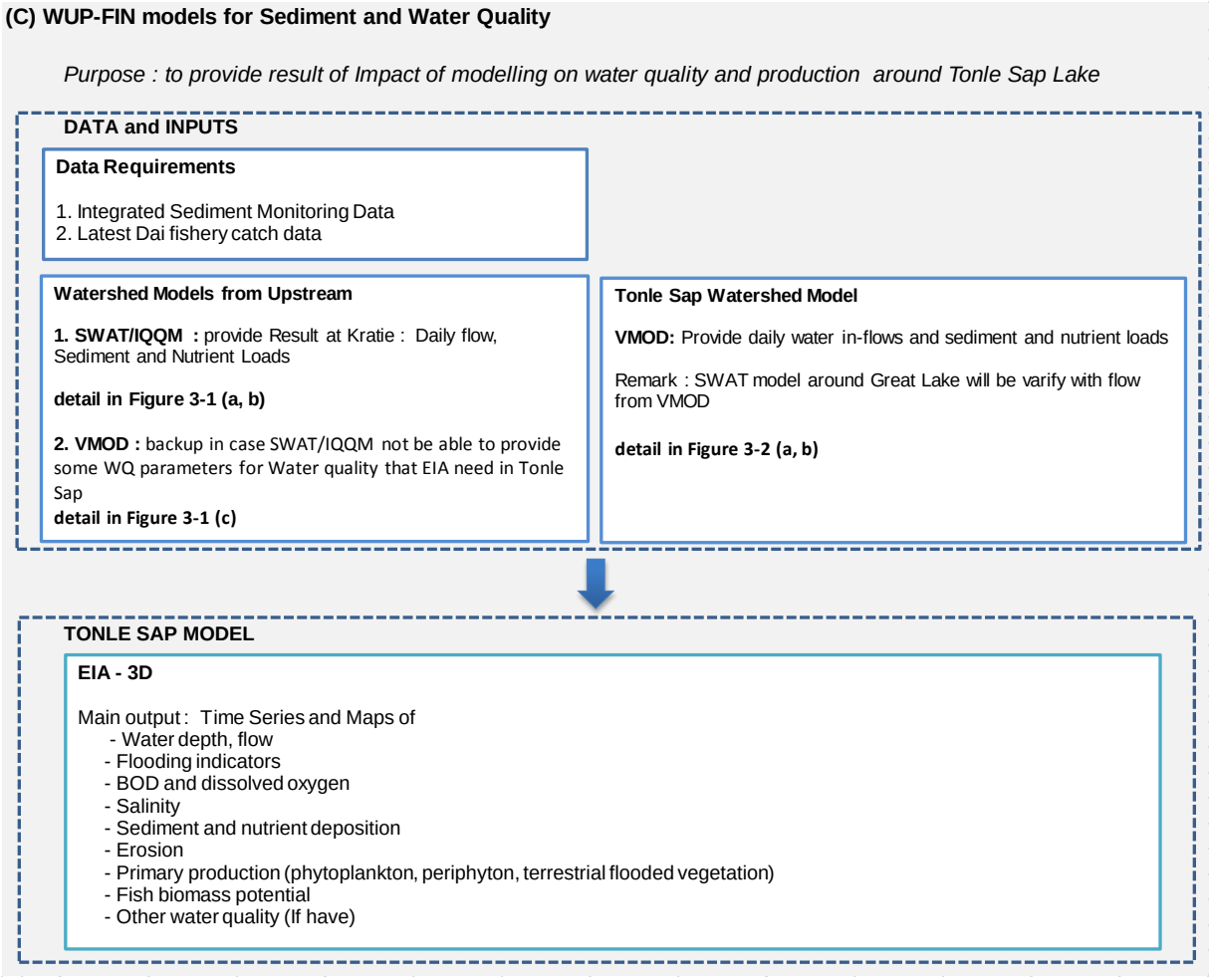


Figure 3-3 : Baseline Modelling Activity for Zone 5, Delta

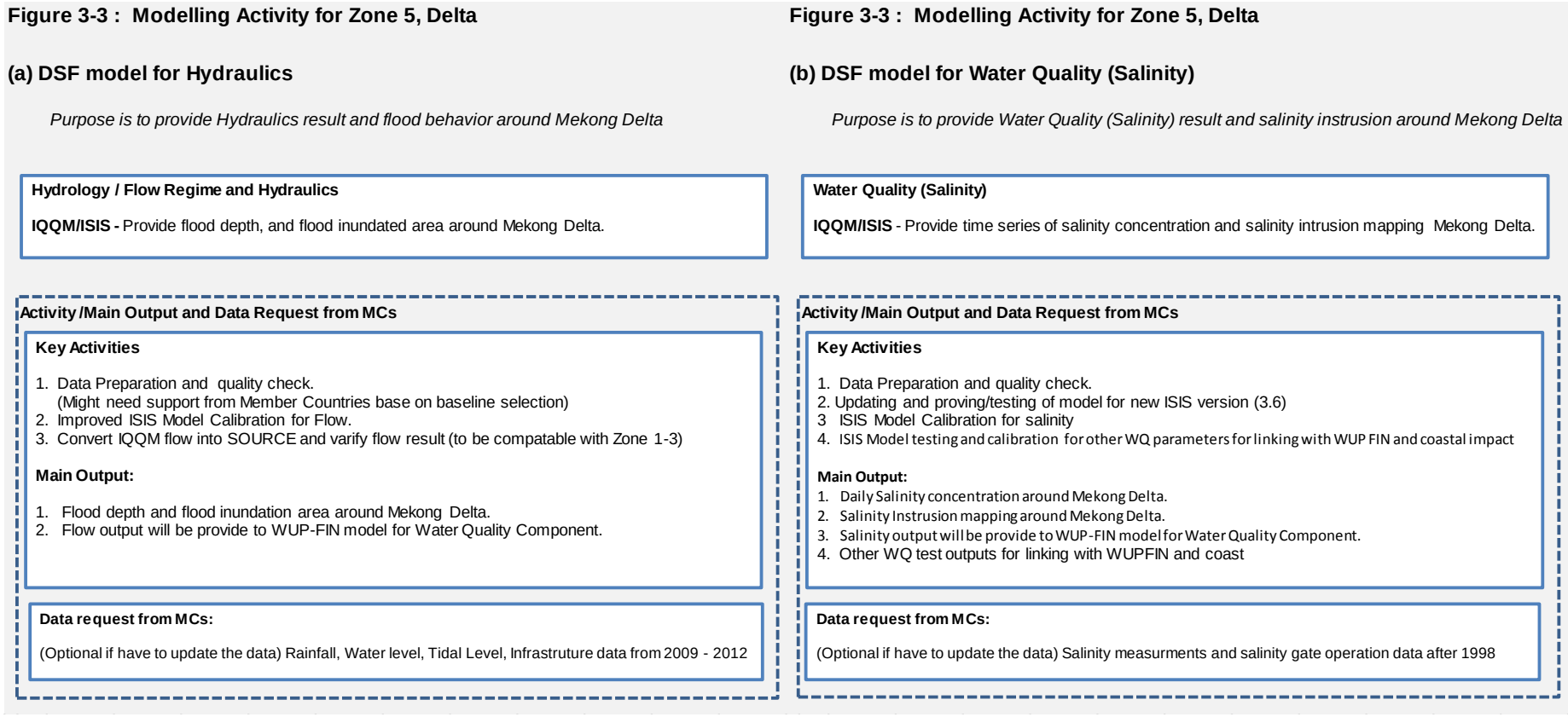
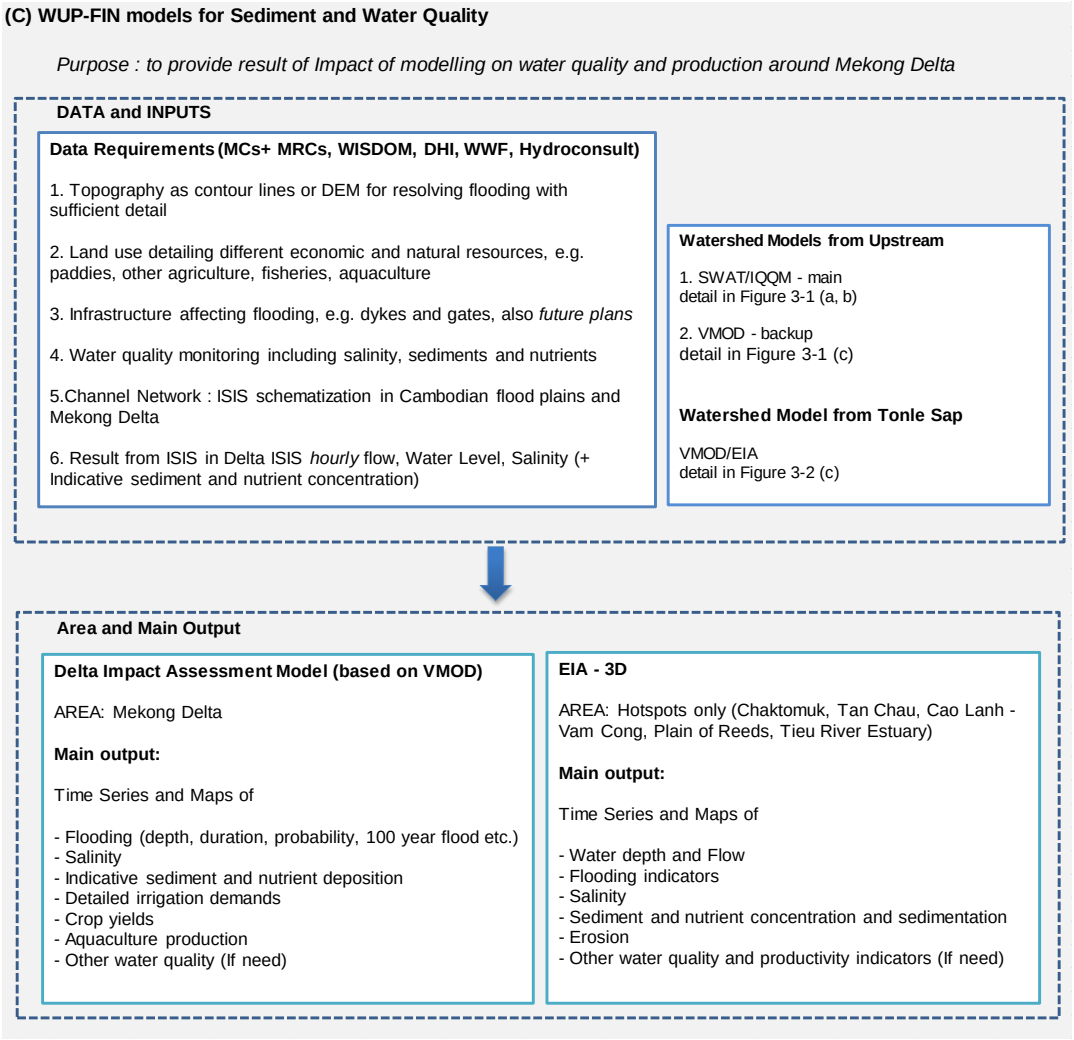


Figure 3-3 : Baseline Modelling Activity for Zone 5, Delta (Cont'd)



Annex

Annex A: Summary of Model for Providing Output for the Council Study

Annex B: Modeling Work Plan to support Council Study

Annex A: Summary of Model for Providing Output for the Council Study

Table A-1: Summary of Model for Providing Required Data or Modeling Output for the Council Study

No.	Sector	Location required	Zone	Scenarios required	Data required	Output		*Model Application*			Request Tools for Council Study	
						TS Data	Map	1D	2D	3D	DSF	WUP-FIN
1	Hydrology/Flow regime	River sites, and entrance to Tonle Sap and Delta	Zone 1, 2, 3	Historic (H), Observed (O), Baseline (B), Thematic (T) and Cumulative (C), plus two DRIFT calibration regimes (D)	Daily time series	x		x			SWAT*&IQQM	-
					Hourly time series for relevant EF sites, according to operating rules of infrastructure	x		x			SWAT*&IQQM	-
2	Hydraulics	River sites	Zone 1, 2, 3	OBTCD	Average velocity	x		x			ISIS*	-
					Maximum velocity	x		x			ISIS*	-
					Maximum depth	x		x			ISIS*	-
					Average depth	x		x			ISIS*	-
					Wetted perimeter	x		x			ISIS*	-
					Lateral connectivity			x				-
					Longitudinal connectivity			x				-
					Riparian zone/floodplain - inundated area		x	x	x		ISIS**	EIA
					Riparian zone/floodplain - average velocity		x	x	x	x	ISIS**	EIA
					Riparian zone/floodplain - maximum velocity		x	x	x	x	ISIS**	EIA
					Riparian zone/floodplain - maximum depth		x	x	x		ISIS**	EIA
					Riparian zone/floodplain - average depth		x	x	x		ISIS**	EIA
				Impacts of changes in channel morphology, e.g., for flood protection/navigation; sand mining	Knock on effects on flow, sediments and channel hydraulics (inundation of secondary channels, riparian areas and/or floodplains)	x		x			ISIS*	-
		Delta	Zone 5	OBTCD	Channel average velocity	x		x			ISIS	-
					Channel maximum velocity	x		x			ISIS	-
					Channel maximum depth	x		x			ISIS	-
					Channel average depth	x		x			ISIS	-
					Extent and timing flooding and inundation in the delta	x	x	x			ISIS	-
				Impacts of changes in morphology/structures	Knock on effects on flow, sediments and water quality (salinity)	x	x	x	x	x	ISIS	EIA
		Tonle Sap	Zone 4	OBTCD	Maximum depth	x		x	x		ISIS	EIA
					Average depth	x		x	x		ISIS	EIA
					Wetted perimeter			x			ISIS	-

Table A-1 : Summary of Model for Providing Required Data or Modeling Output for the Council Study (Cont'd)

No.	Sector	Location required	Zone	Scenarios required	Data required	Output		*Model Application*			Request Tools for Council Study	
						TS Data	Map	1D	2D	3D	DSF	IWRM
3	Sediment	River sites	Zone 1, 2, 3	HOBTCD	Sediment Load/Transport/Flux	X		x		x	SWAT* + IQQM* + ISIS*	VMOD*,EIA
					Bed material/gain size	X	x	-	x		-	VMOD*,EIA
					Bed elevation	X	x	x	x		ISIS*	EIA
					Suspended Sediment Concentration	X	x	x		x	ISIS*	VMOD*, EIA
					Suspended sediment grain size	x	x	x		x	-	VMOD*, EIA
					Local sedimentation	X	X	x	x		SWAT*	EIA
					Local erosion	X	X	x	x		SWAT*	VMOD*, EIA
					Deposition rate on floodplains	x	x		x		-	EIA
		Delta	Zone 5	HOBTCD	Sediment Load/Transport/Flux	X				x	-	VMOD, EIA
					Bed material/gain size	X	x		x		-	VMOD, EIA
					Suspended Sediment Concentration (in size fractions if possible)	X	x			x	-	VMOD, EIA
					Local sedimentation	X	X		x		-	VMOD, EIA
					Local erosion	X	X		x		-	EIA
					Erosion/Deposition rate in the coastal	x	x		x		-	EIA
		Tonle Sap	Zone 4	HOBTCD	Sediment load entering Tonle Sap - annual			x			SWAT*+IQQM* +ISIS	VMOD*
					Bed material grain size	X	x		x		-	VMOD*, EIA
					Suspended Sediment Concentration (in size fractions if possible)	X	x		x		-	VMOD*, EIA
					Local sedimentation	X	X		x		-	EIA
					Local erosion	X	X		x		-	VMOD*, EIA
4	Water quality	River sites	Zone 1, 2, 3	OBTCD	Water temperature	X		x			SWAT*+ ISIS*	VMOD*
					Conductivity	X		x			SWAT*	VMOD*
					Nutrient concentrations	X		x			SWAT*	VMOD*
		Delta	Zone 5	OBTCD	Salinity	X	X	x			ISIS	VMOD, EIA
					Water temperature	X	x				-	VMOD, EIA
					Nutrient concentrations	X	x				-	VMOD, EIA
					Primary production	X	X				-	VMOD, EIA
					Water clarity	X	x	x			ISIS	VMOD, EIA
					Dissolved inorganic nitrogen	X	x				-	VMOD, EIA
					Dissolved inorganic phosporus	X	x				-	VMOD, EIA
					Silicates	X	x				-	VMOD, EIA
		Tonle Sap	Zone 4	OBTCD	Water temperature	X	x			x	-	EIA
					Conductivity	X	x			x	-	EIA
					Nutrient concentrations	X	x			x	-	EIA
					Primary production	X	X			x	-	EIA

Table A-1 : Summary of Model for Providing Required Data or Modeling Output for the Council Study (Cont'd)

5	Hydropower	n/a	Energy Production	X		x			IQQM	-
			Operation rule curve (Normal, Optimize, Store, Dam break)			X			IQQM	-
			Flow release plan	X		X			IQQM	-
			Weirs and Sluices	X		X			ISIS	-
			Sediment and nutrient trapping	X				X	-	VMOD*, EIA

Remark : Model Name* Need Further recalbration
Model Name** Need Model Setup and Calibration in Riparian zone and flood plain with support information from member countries.

EIA (3D-EIA) is only for hotspot areas (Nam Songkhram, Xe Bang Fai, Tonle Sap Lake, Tieu River Estuary etc.)
SWAT+IQQM+ISIS provide concentration in Kratie and flow in the Tonle Sap River for estimates of sediment load entering to the Tonle Sap Lake
VMOD Delta Impact Model in Zone 5 uses DSF results; observe that floodplain fluxes and sedimentation are indicative only in more remote floodplain locations

Annex B: Modeling Work Plan to support Council Study

Table B-1. Council study main tasks and their timing. Zone 1 – 4 baseline modelling will be ready by end of September, Zone 5 requiring upstream inputs by end of October. Scenario assessment preparatory work will be in September and the main scenario modelling work in October – November.

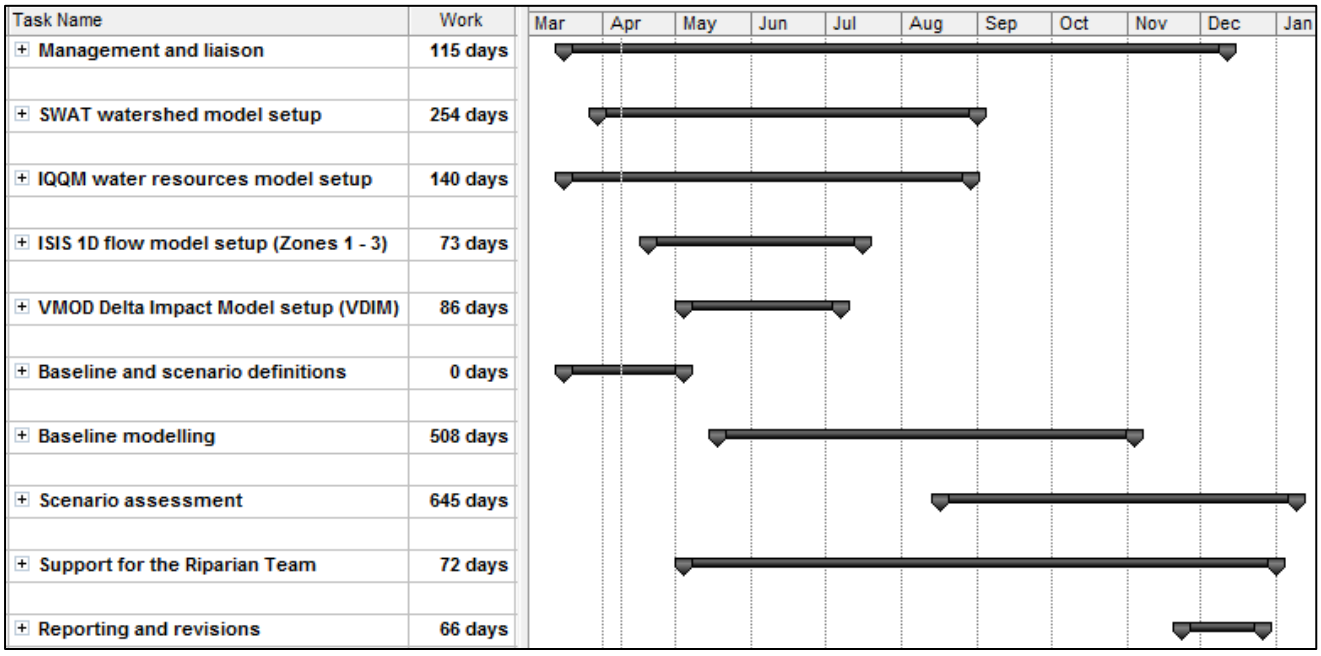


Table B-2. Modelling main human resources. MT Mgr = Modelling Team Manager, TC = Technical Coordinator, DSF TE = DSF Technical Expert.

Resource Name	Work
Unassigned	0 days
MT Mgr (Dat)	110 days
TC (Jo)	100 days
DSF TE (To)	90 days
DSF TE (Or)	100 days
SWAT TE (Sri)	22 days
WUP-FIN Int.	200 days
SOURCE Int.	120 days
Sediment Expert (Lois)	10 days
DSF assist team	480 days
IKMP MT	247 days
WUP-FIN assist team	480 days

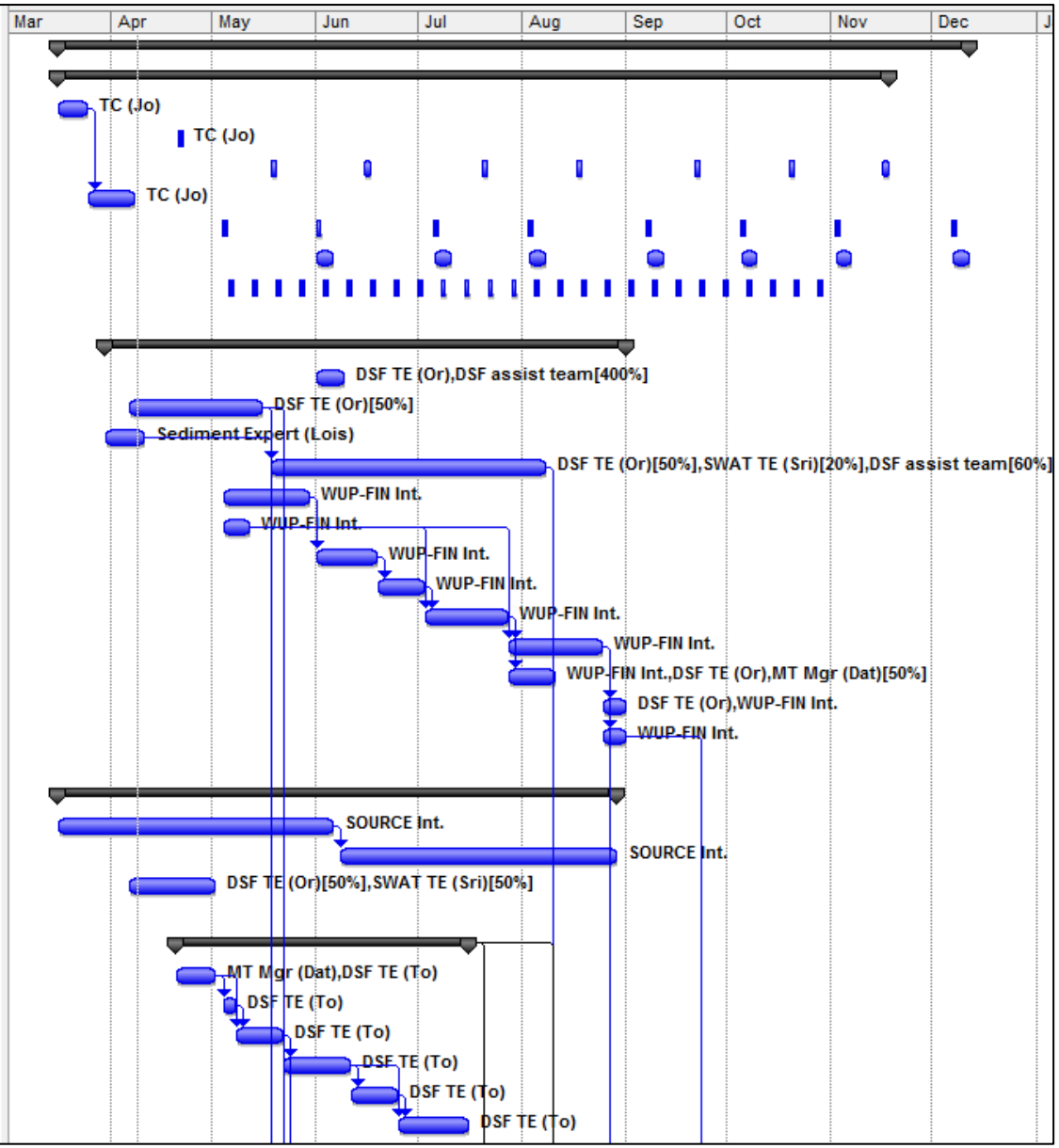
Detailed work plan is presented in the tables below. The proposed work amounts are tentative and need to be checked by the responsible experts. They will also guide the riparian DSF and WUP-FIN Teams and re-schedule them as necessary.

Task Name	Work
Management and liaison	**115 days**
consultations and meetings	**36 days**
planning phase	7 days
baseline meeting	1 day
MRC and country meetings	**28 days**
work plan	10 days
progress reporting	**8 days**
management and liaison	**35 days**
technical coordination and support	**26 days**
SWAT watershed model setup	**254 days**
sediment (tributary 2003 -) and hydromet (2009 - 2012) data update	30 days
3S discharge recalibration (incl. IQQM)	15 days
sediment model input data preparation (rating curves)	10 days
sediment model calibration (TSS)	72 days
WUP-FIN model update for hydromet and irrigation up to 2015	20 days
WUP-FIN model update for sediment and WQ data up to 2015	6 days
WUP-FIN model resolution increase and hydrological re-calibration	14 days
WUP-FIN channel sediment storage modelling	10 days
WUP-FIN sediment model re-calibration including sediment trapping	17 days
WUP-FIN water quality model calibration	20 days
integration of WUP-FIN sediment results into the DSF	25 days
integration of WUP-FIN water quality results into the DSF	10 days
calculation of Tonle Sap sediment and nutrient loads (WUP-FIN)	5 days
IQQM water resources model setup	**140 days**
update into e-Water SOURCE and installation	60 days
SOURCE checking, calibration and verification	60 days
integration of SWAT and IQQM/SOURCE for sediment and WQ simulation	20 days
ISIS 1D flow model setup (Zones 1 - 3)	**73 days**
update of the schematisation	20 days
linking with the SWAT/IQQM	4 days
discharge and WL calibration	10 days
suspended load calibration inc. fractions	14 days
bed load calibration	10 days
calibration for morphological changes	15 days
VMOD Delta Impact Model setup (VDIM)	**86 days**
adding sediments, salinity and nutrients into the existing flood mapping	20 days
defining impact functions for agricultural and aquactic/aquaculture production	10 days
building Delta model (DEM, land use, soil, irrigation and dykes)	20 days
integration of the DIM with the Delta ISIS	6 days
testing and calibration of the model	30 days

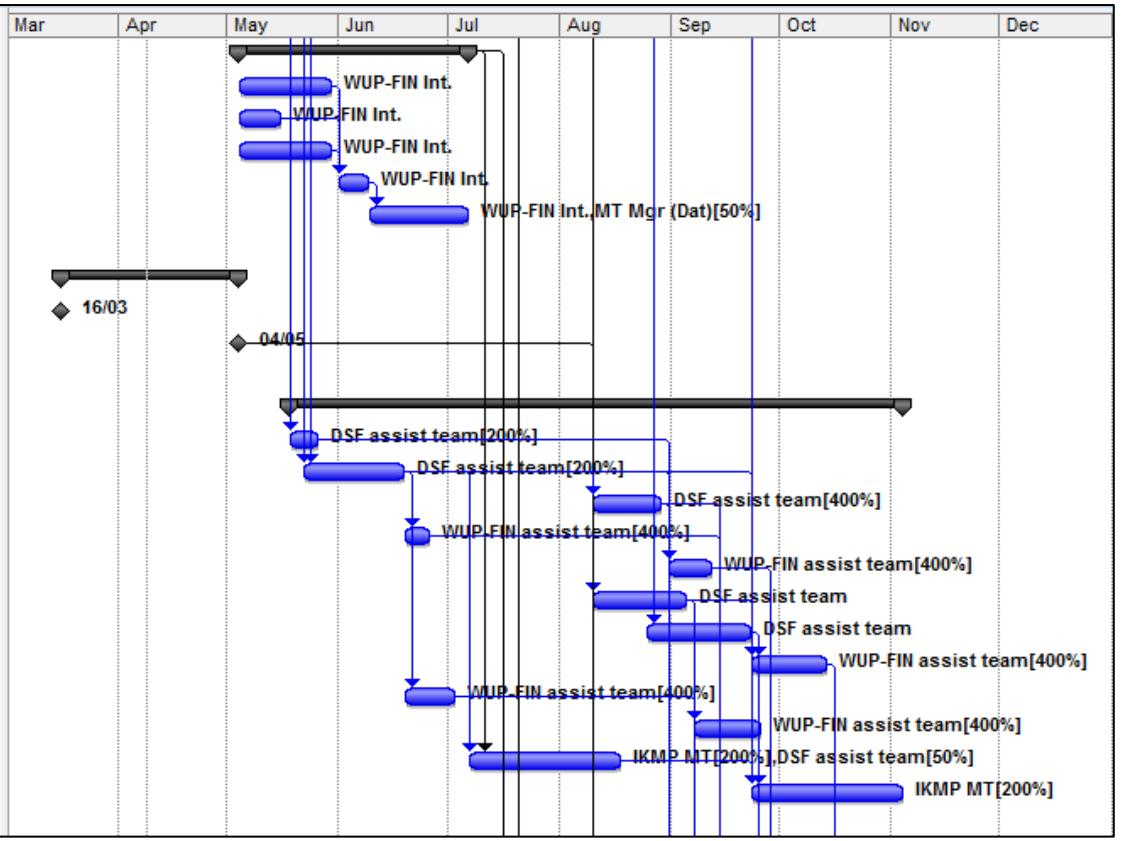
Task Name	Work
Scenario Definitions	**0 days**
data identification	0 days
infrastructure definitions for modelling	0 days
Baseline modelling	**508 days**
baseline mainstream discharge (SWAT, IQQM)	12 days
baseline mainstream velocity, shear stress, water levels and Delta salinity (ISIS)	40 days
baseline upstream channel sediment and nutrient flow and bed level (ISIS)	60 days
baseline upstream hotspot flooding and flow (EIA 3D)	20 days
baseline upstream hotspot sedimentation and erosion (EIA 3D)	40 days
baseline Delta sediment loads (SWAT, IQQM)	20 days
baseline Delta nutrient loads (SWAT, IQQM)	21 days
baseline Tonle Sap flood, flow, sed., DO, nutrients, primary and fish prod. (EIA 3D)	60 days
baseline Delta hotspot flooding and flow (EIA 3D)	40 days
baseline Delta hotspot sedimentation and erosion (EIA 3D)	60 days
baseline Delta flooding and salinity characteristics (VDIM)	75 days
baseline Delta sediments, nutrients and productivity characteristics (VDIM)	60 days
Scenario assessment	**645 days**
synthetic "calibration" scenarios for ecological assessment (DSF, WUP-FIN)	63 days
scenario data preparation for SWAT	15 days
scenario data preparation for IQQM/SOURCE	15 days
scenario data preparation for upstream ISIS	15 days
scenario data preparation for downstream ISIS	15 days
scenario data preperation for WUP-FIN models	40 days
impacts on mainstream discharge (SWAT, IQQM)	20 days
impacts on mainstream velocity, shear stress, water levels and Delta salinity (ISIS)	40 days
impacts on upstream channel sediment and nutrient flow and bed level (ISIS)	50 days
impacts on upstream hotspot flooding and flow (EIA 3D)	40 days
impacts on upstream hotspot sedimentation and erosion (EIA 3D)	40 days
impacts on Delta sediment loads (SWAT, IQQM)	20 days
impacts on Delta nutrient loads (SWAT, IQQM)	40 days
impacts on Tonle Sap (EIA 3D)	40 days
impacts on Delta hotspot flooding and flow (EIA 3D)	24 days
impacts on Delta hotspot sedimentation and erosion (EIA 3D)	48 days
impacts on Delta flooding and salinity characteristics (VDIM)	60 days
impacts on Delta sediments, nutrients and productivity characteristics (VDIM)	60 days

Task Name	Work
Support for the Riparian Team	**72 days**
Support for the DSF Assistance Team	**53 days**
TE/DSF (Tony)	15 days
TE/DSF (Dat)	21 days
TE/DSF (Ornanong)	17 days
Support for the WUP-FIN Assistance Team	**19 days**
WUP-FIN International Team	10 days
TC (Jorma)	9 days
Reporting and revisions	**66 days**
Mainstream flow, flooding, sediment and morphology impact report (Zones 1 -3)	5 days
Tonle Sap impact report	5 days
Delta impact report (flow, flooding, sediment, salinity, water quality, productivity)	7 days
Hotspot impact report (Zones 1 - 5)	5 days
Country consultations based on the reports	16 days
Modelling and report revisions based on feedback	28 days

Task Name	Work
Management and liaison	**115 days**
consultations and meetings	**36 days**
planning phase	7 days
baseline meeting	1 day
MRC and country meetings	**28 days**
work plan	10 days
progress reporting	**8 days**
management and liaison	**35 days**
technical coordination and support	**26 days**
SWAT watershed model setup	**254 days**
sediment (tributary 2003 -) and hydromet (2009 - 2012) data update	30 days
3S discharge recalibration (incl. IQQM)	15 days
sediment model input data preparation (rating curves)	10 days
sediment model calibration (TSS)	72 days
WUP-FIN model update for hydromet and irrigation up to 2015	20 days
WUP-FIN model update for sediment and WQ data up to 2015	6 days
WUP-FIN model resolution increase and hydrological re-calibration	14 days
WUP-FIN channel sediment storage modelling	10 days
WUP-FIN sediment model re-calibration including sediment trapping	17 days
WUP-FIN water quality model calibration	20 days
integration of WUP-FIN sediment results into the DSF	25 days
integration of WUP-FIN water quality results into the DSF	10 days
calculation of Tonle Sap sediment and nutrient loads (WUP-FIN)	5 days
IQQM water resources model setup	**140 days**
update into e-Water SOURCE and installation	60 days
SOURCE checking, calibration and verification	60 days
integration of SWAT and IQQM/SOURCE for sediment and WQ simulation	20 days
ISIS 1D flow model setup (Zones 1 - 3)	**73 days**
update of the schematisation	20 days
linking with the SWAT/IQQM	4 days
discharge and WL calibration	10 days
suspended load calibration inc. fractions	14 days
bed load calibration	10 days
calibration for morphological changes	15 days



Task Name	Work
VMOD Delta Impact Model setup (VDIM)	**86 days**
adding sediments, salinity and nutrients into the existing flood mapping	20 days
defining impact functions for agricultural and aquactic/aquaculture production	10 days
building Delta model (DEM, land use, soil, irrigation and dykes)	20 days
integration of the DIM with the Delta ISIS	6 days
testing and calibration of the model	30 days
Scenario Definitions	**0 days**
data identification	0 days
infrastructure definitions for modelling	0 days
Baseline modelling	**508 days**
baseline mainstream discharge (SWAT, IQQM)	12 days
baseline mainstream velocity, shear stress, water levels and Delta salinity (ISIS)	40 days
baseline upstream channel sediment and nutrient flow and bed level (ISIS)	60 days
baseline upstream hotspot flooding and flow (EIA 3D)	20 days
baseline upstream hotspot sedimentation and erosion (EIA 3D)	40 days
baseline Delta sediment loads (SWAT, IQQM)	20 days
baseline Delta nutrient loads (SWAT, IQQM)	21 days
baseline Tonle Sap flood, flow, sed., DO, nutrients, primary and fish prod. (EIA 3D)	60 days
baseline Delta hotspot flooding and flow (EIA 3D)	40 days
baseline Delta hotspot sedimentation and erosion (EIA 3D)	60 days
baseline Delta flooding and salinity characteristics (VDIM)	75 days
baseline Delta sediments, nutrients and productivity characteristics (VDIM)	60 days



Task Name	Work
Scenario assessment	**645 days**
synthetic "calibration" scenarios for ecological assessment (DSF, WUP-FIN)	63 days
scenario data preparation for SWAT	15 days
scenario data preparation for IQQM/SOURCE	15 days
scenario data preparation for upstream ISIS	15 days
scenario data preparation for downstream ISIS	15 days
scenario data preperation for WUP-FIN models	40 days
impacts on mainstream discharge (SWAT, IQQM)	20 days
impacts on mainstream velocity, shear stress, water levels and Delta salinity (ISIS)	40 days
impacts on upstream channel sediment and nutrient flow and bed level (ISIS)	50 days
impacts on upstream hotspot flooding and flow (EIA 3D)	40 days
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