

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.

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
1	3	Final revise	13/05/2015	Dat

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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 socioeconomic 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.

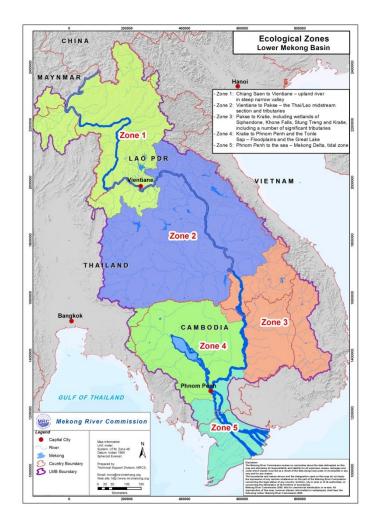
Council Study modelling specific objectives for the first phase are to:

- 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
- 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 (WUP-FIN 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 5 (Will be consider to use 3D-EIA models in some pilot areas in Zon 1-3 if request). 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.

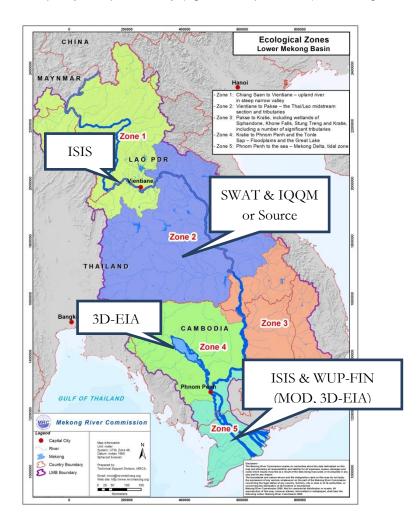


Figure 2-2. Main impact model set-up for the LMB for hydrology, hydraulics, sediments, water quality and productivity.

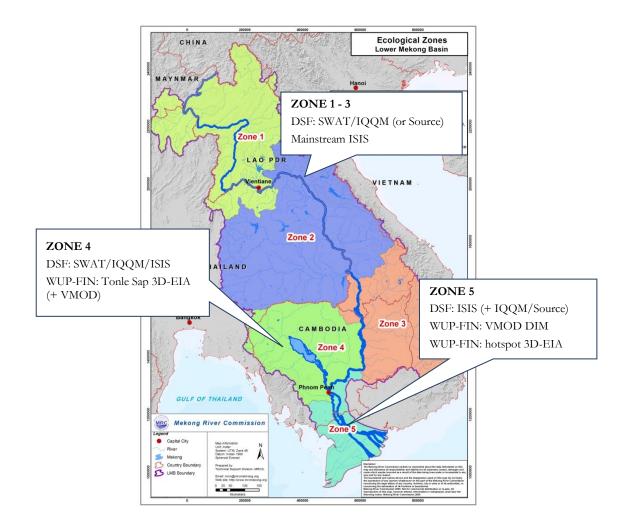


Figure 2-3. List of models used for the Council Study in different zones.

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 eWater for reservoir sedimentation and water quality through integration of loads, parameters and impacts in the DSF.

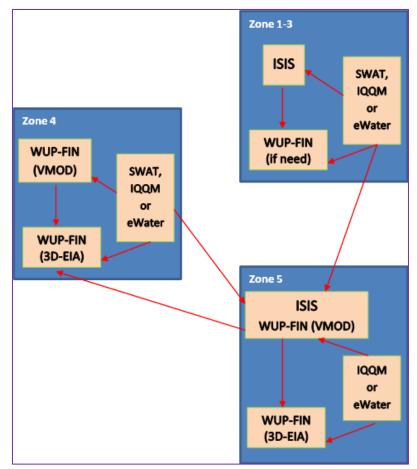


Figure 2-4. Information flow for the Council Study Modelling Framework.

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 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 and 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	
		River sites	Zone 1, 2, 3	ISIS	
Hydraulics		Tonle Sap Great Lake	Zone 4	ISIS	
		Delta	Zone 5	ISIS	
		Hotspots	Zone 5 (Zone 1-3 iff need)	WUP-FIN (3D-EIA)	
Flooding		Tonle Sap Great Lake	Zone 4	3WUP-FIN (3D-EIA)	
		Delta	Zone 5	ISIS + WUP-FIN (VMOD)/eWater	
	Sediment	River sites Hotspots	Zone 1, 2, 3 Zone 5 (Zone 1-3 iff need)	SWAT,IQQM/eWater&ISI WUP-FIN (3D-EIA)	
	Accounting	Tonle Sap Great Lake	Zone 4	WUP-FIN (3D-EIA)	
		Delta	Zone 5	ISIS+WUP-FIN (VMOD)	
		River sites	Zone 1, 2, 3	SWAT, eWater	
	Nutrient	Tonle Sap Great Lake	Zone 4	WUP-FIN (3D-EIA)	
Water quality		Delta	Zone 5	ISIS+VMOD	
	Dim	River sites	Zone 1, 2, 3	-	
	Primary Production	Tonle Sap Great Lake	Zone 4	WUP-FIN (3D-EIA)	
	Troduction	Delta	Zone 5	ISIS+WUP-FIN (VMOD)	
		River sites	Zone 1, 2, 3	-	
	Salinity	Tonle Sap Great Lake	Zone 4	-	
		Delta	Zone 5	ISIS+WUP-FIN (VMOD)	
	Operation of Dams	River sites	Zone 1, 2, 3	SWAT&IQQM/eWater	
Hydropower	Sediment Accounting in Dams	River sites	Zone 1, 2, 3	WUP-FIN (3D-EIA), eWater	

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

) DSF for Hydrology and Hydraulic	(b) DSF for Sediment and Water Quality
Purpose is to provide Flood/ Drought Flow Regime and Hydraulics at Key Station on Mekong Mainstream	Purpose is to provide Sediment and Water Quality/Nutrient result at Key Station on Mekong Mainstream
Hydrology / Flow Regime and Hydraulics	Sediment and Water Quality
SWAT/IQQM - Provide daily times series along Mekong mainstream and from Tributary, Energy Production from HP Dam	SWAT/IQQM (Source) - Provide sediment Load (sedimentation and erosion) from tributary to Mekong mainstream including impact from HP Dam and Irrigation management.
ISIS - Provide water level, velocity, and inundated area along Mekong mainstream and in Floodplain	 Provide nutrient concentration from Tributary to Mekong mainstream ISIS - Provide shear stress, sediment concentration, change in grain size and erosion/deposition of river bed along Mekong mainstream. Consider use for temperture and water quality simulation.
ctivity /Main Output and Data Request from MCs	Activity /Main Output and Data Request from MCs
Key Activities 1. Select Baseline (Decision from RTWG) 2. Data Preparation and quality check (Might need support from Member Countries base on baseline selection) 2. Improve SWAT Model Calibration for Flow 3. Improve IQQM Model Calibration for Flow 4. Convert IQQM flow into SOURCE with SWAT plugin and verify flow result for use in Water Quality Component 5. Improve ISIS Model Calibration for Flow/WL and flooding (esp u/s Kratie) Main Output: 1. Daily Flow /Water Level at MK Mainstream at Key station 2. Velocity, flood inundation area in flood plain area. 3. Flow result will be provide at Kratie (Entrance to Tonle Sap and Delta) 4. Flow Model will be further used for Water Quality Component.	 Key Activities Data Preparation and quality check Analysis of Measurement data both Sediment and Water Quality before using for model Calibration Create Sediment rating curves and loads (TSS & Discharge, Nutrient & Discharge) Sediment Calibration SwAT Model Calibration for Sediment supply and delivery Source (IQQM) Model Calibration for Sediment in tributaries ISIS Model Calibration for Sediment and mrphological change in mainstream Nutrient Calibration SwAT Model Calibration for nutrient u/s Kratie and Great Lake Tributaries Source (IQQM) Model Calibration for nutrient u/s Kratie ISIS for water temperature and quality (detail in WUP-FIN 3D) Main Output: Mainstream at Key station (Based on data availble) Sediment and Nutrient result will be provide at Kratie (Entrance to Tonle Sap and Delta) and use as input to WUP-FIN.
 Data request from MCs: Flow/Discharge data at main tributary from 2001 - 2012 Rating Curve/Discharge at Mekong Mainstream (Optional if option to update data is selected) Rainfall and flow data from 2009 - 2012 that can support on verify Sediment result in year 2009 - 2012 (Optional) Operation Rule Curve / Release from Large reservoir from 2001 - 2012 	Data request from MCs: 1. Sediment Rating Curve/ Daily Sediment Suspend at Mekong Mainstream 2. (Optional) Sediment Rating Curve/ Daily Suspended Sediment at main tributary

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

(IF REQUEST)

(C) WUP-FIN models for Hydrology and Hydraulic Analysis

Purpose is to support DSF sediment and water quality modelling and Zone 4 - 5 impact modelling:

- Reservoir sediment and nutrient trapping modelling to be integrated with the DSF

- Integrating detailed sediment and water quality modelling into DSF/IQQM
- Use of the latest meteorological, land use and Integrated Sediment Monitoring data - Upstream hotspot modelling for impact assessment (EIA 3D)

DATA update

MRC, Mekong Delta Study and Global Dataset requirements

- 1. Latest IQQM input files for irrigation, hydropower and water use
- Irrigation areas (province maps) related the IQQM irrigation data.
 Original meteorological station data for 2001 2008 (or 2012)
- TRMM and APHRODITE remote sensing and re-analysis rainfall (+temperature) data to utilise latest MRC Integrated Sediment Monitoring results if 2008-2012 not available
 MRC 2010 land use/land cover map to compare its impact with the 2003 map

- 6. MRC water quality data to 2013
- 7. Mekong Delta Study sediment phosphorus data (possibly also hydromet data).

UPSTREAM MODELS

VMOD

AREA: UMB/LMB to Kratie + D/s Tributaries

OUTPUTS:

- reservoir sediment and nutrient trapping - sediment and nutrient loads and parameters for DSF integration

EIA - 3D

AREA: hotspots only (Vientiane-Nong Khai, Nam Sonkhram and Xe Bang Fai)

OUTPUTS: (1) Time Series and

- (2) Maps water depth
- flow
- flooding indicators

- sediment and nutrient concentration and sedimentation erosion

- othe water quality and productivity indicators(if have)

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

(a) DSF model for Hydraulics

Purpose is to provide Hydraulics result and flood behavior around Tonle Sap Lake

Hydrology / Flow Regime and Hydraulics

SWAT/IQQM - Provide daily flow times series around Tonle Sap tributary, including water consumption

ISIS - Provide flood depth, and flood inundated area around Cambodia Floodplain

(b) DSF model for Water Quality (Salinity)

Purpose is to provide Water Quality (Salinity) resultand salinity instrusion around Tonle Sap Lake

Water Quality (Salinity)

IQQM/ISIS - Provide time series of salinity concentration and mapping salinity instrusion around Cambodia Floodplain.

Activity /Main Output and Data Request from MCs	Activity /Main Output and Data Request from MCs
Key Activities 1. Data Preparation and quality check (Might need support from Member Countries base on baseline selection) 2. Improved SWAT Model Calibration for Flow 3. Improved IQQM Model Calibration for Flow 4. Improved ISIS Model Calibration for Flow 5. Convert IQQM flow into SOURCE and varify flow result (to be compatable with Zone 1-3) Main Output: 1. Daily Flow around at tributary of Tonle Sap Lake 2. Flood depth and flood inundation area around Cambodia Floodplain 3. Flow output will be provide to WUP-FIN model for Water Quality Component.	Key Activities 1. Data Preparation and quality check 2 ISIS Model Calibration for WQ (if any change) Main Output: 1. Daily Salinity concentration around Cambodia Floodplain 2. Salinity Instrusion mapping around Cambodia Floodplain 3. Salinity output will be provide to WUP-FIN model for Water Quality Component.
Data request from MCs: (Optional if have to update the data) Rainfall and flow data from 2009 - 2012 that can support on varify Sediment result in year 2009 - 2012	

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

(C) WUP-FIN models for Sediment and Water Quality

Purpose : to provide result of Impact of modelling on water quality and production around Tonle Sap Lake

Data Requirements	
 Integrated Sediment Monitoring Data Latest Dai fishery catch data 	
Watershed Models from Upstream 1. SWAT/IQQM : provide Result at Kratie : Daily flow, Sediment and Nutrient Loads detail in Figure 3-1 (a, b) 2. VMOD : backup in case SWAT/IQQM not be able to provide some WQ parameters for Water quality that EIA need in Tonle Sap detail in Figure 3-1 (c)	Tonle Sap Watershed Model VMOD: Provide daily water in-flows and sediment and nutrient loads Remark : SWAT model around Great Lake will be varify with flow from VMOD detail in Figure 3-2 (a, b)
TONLE SAP MODEL EIA - 3D Main output : Time Series and Maps of - Water depth, flow - Flooding indicators - BOD and dissolved oxygen - Salinity - Sediment and nutrient deposition - Erosion - Primary production (phytoplankton, periphyton, terrestri - Fish biomass potential - Other water quality (If have)	ial flooded vegetation)

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

IQQM/ISIS - Provide flood depth, and flood inundated area around Mekong Delta.

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

(a) DSF model for Hydraulics

Hydrology / Flow Regime and Hydraulics

Purpose is to provide Hydraulics result and flood behavior around Mekong Delta

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

(b) DSF model for Water Quality (Salinity)

Purpose is to provide Water Quality (Salinity) result and salinity instrusion around Mekong Delta

Water Quality (Salinity)

IQQM/ISIS - Provide time series of salinity concentration and salinity intrusion mapping Mekong Delta.

Activity /Main Output and Data Request from MCs	Activity /Main Output and Data Request from MCs						
Key Activities	Key Activities						
 Data Preparation and quality check. (Might need support from Member Countries base on baseline selection) Improved ISIS Model Calibration for Flow. Convert IQQM flow into SOURCE and varify flow result (to be compatable with Zone 1-3) 	 Data Preparation and quality check. Updating and proving/testing of model for new ISIS version (3.6) ISIS Model Calibration for salinity ISIS Model testing and calibration for other WQ parameters for linking with WUP FIN and coastal impact 						
 Main Output: Flood depth and flood inundation area around Mekong Delta. Flow output will be provide to WUP-FIN model for Water Quality Component. 	 Main Output: 1. Daily Salinity concentration around Mekong Delta. 2. Salinity Instrusion mapping around Mekong Delta. 3. Salinity output will be provide to WUP-FIN model for Water Quality Component. 4. Other WQ test outputs for linking with WUPFIN and coast 						
Data request from MCs:	Data request from MCs:						
(Optional if have to update the data) Rainfall, Water level, Tidal Level, Infrastruture data from 2009 - 2012	(Optional if have to update the data) Salinity measurments and salinity gate operation data after 1998						

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

(C) WUP-FIN models for Sediment and Water Quality

Purpose : to provide result of Impact of modelling on water quality and production around Mekong Delta

DATA and INPUTS		
Data Requirements (MCs+ MRCs, WISDOM, DHI, WWF, H	lydroconsult)	
 Topography as contour lines or DEM for resolving flooding sufficient detail 	with	
2. Land use detailing different economic and natural resource baddies, other agriculture, fisheries, aquaculture	Watershed Models from Upstream 1. SWAT/IQQM - main	
3. Infrastructure affecting flooding, e.g. dykes and gates, also	o future plans	detail in Figure 3-1 (a, b)
4. Water quality monitoring including salinity, sediments and	nutrients	2. VMOD - backup detail in Figure 3-1 (c)
5.Channel Network : ISIS schematization in Cambodian floo Mekong Delta	d plains and	Watershed Model from Tonle Sap
6. Result from ISIS in Delta ISIS <i>hourly</i> flow, Water Level, Sa Indicative sediment and nutrient concentration)	alinity (+	VMOD/EIA detail in Figure 3-2 (c)
Area and Main Output		
Area and Main Output Delta Impact Assessment Model (based on VMOD)	EIA - 3D	
Delta Impact Assessment Model (based on VMOD)	AREA: Hots	pots only (Chaktomuk, Tan Chau, Cao Lanh - Plain of Reeds. Tieu River Estuary)
Delta Impact Assessment Model (based on VMOD) AREA: Mekong Delta	AREA: Hots Vam Cong,	Plain of Reeds, Tieu River Estuary)
Delta Impact Assessment Model (based on VMOD)	AREA: Hots Vam Cong, Main outpu	Plain of Reeds, Tieu River Estuary) it:
Delta Impact Assessment Model (based on VMOD) AREA: Mekong Delta Main output: Time Series and Maps of - Flooding (depth, duration, probability, 100 year flood etc.)	AREA: Hots Vam Cong, Main outpu Time Series	Plain of Reeds, Tieu River Estuary) t: and Maps of
Delta Impact Assessment Model (based on VMOD) AREA: Mekong Delta Main output: Time Series and Maps of - Flooding (depth, duration, probability, 100 year flood etc.) - Salinity	AREA: Hots Vam Cong, Main outpu Time Series	Plain of Reeds, Tieu River Estuary) it: and Maps of th and Flow
Delta Impact Assessment Model (based on VMOD) AREA: Mekong Delta Main output: Time Series and Maps of - Flooding (depth, duration, probability, 100 year flood etc.) - Salinity - Indicative sediment and nutrient deposition - Detailed irrigation demands	AREA: Hots Vam Cong, Main outpu Time Series - Water dep - Flooding in - Salinity	Plain of Reeds, Tieu River Estuary) tt: and Maps of th and Flow ndicators
Delta Impact Assessment Model (based on VMOD) AREA: Mekong Delta Main output: Time Series and Maps of - Flooding (depth, duration, probability, 100 year flood etc.) - Salinity - Indicative sediment and nutrient deposition	AREA: Hots Vam Cong, Main outpu Time Series - Water dep - Flooding in - Salinity - Sediment - Erosion	Plain of Reeds, Tieu River Estuary) it: and Maps of th and Flow

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

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

Table A-1:	Summary of Model for Providing Required Data or Modeling Output for the Council Study
	Cuminary of modol for Fronding Roquined Data of modoling Cupation and Courses

No.	Sector	Location	Zone	Scenarios required	Data required	Outp	out		Mode plicat		Request Tools for Council Study			
NO.	Sector	required	Zone	Scenarios requireu	Data required	TS Data	Мар	1D	2D	ЗD	DSF	WUP-FIN		
					Sediment Load/Transport/Flux	X		х		x	SWAT* + IQQM/eWater* + ISIS*	VMOD*,EIA		
					Bed material/gain size	X	x	-	x		-	VMOD*,EIA		
			70001.0		Bed elevation	X	x	x	x		ISIS*	EIA		
		River sites	Zone 1, 2,	HOBTCD	Suspended Sediment Concentration	X	х	x		x	ISIS*	VMOD*, EIA		
			3		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		х		-	EIA		
					Sediment Load/Transport/Flux	X				х	-	VMOD, EIA		
_					Bed material/gain size	X	x		x		-	VMOD, EIA		
3	Sediment	Delta	Zone 5	HOBTCD	Suspended Sediment Concentration (in size fractions if possible)	X	x			x	-	VMOD, EIA		
					Local sedimentation	X	Х		x		-	VMOD, EIA		
					Local erosion	X	X		x		-	EIA		
					Erosion/Deposition rate in the coastal	x	X		х		-	EIA		
					Sediment load entering Tonle Sap - annual			х			SWAT*+IQQM/eWater * +ISIS	VMOD*		
					Bed material grain size	X	x		x		-	VMOD*, EIA		
		Tonle Sap	Zone 4	HOBTCD	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		

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

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	Outp		Mode plicat		Request Tools for Council Study		
		required				TS Data	Мар	1D	2D	3D	DSF	WUP-FIN
			7000 1 2		Water temperature	X		х			SWAT*+ ISIS*	VMOD*
		River sites	Zone 1, 2,	OBTCD	Conductivity	X		x			SWAT*	VMOD*
			5		Nutrient concentrations	X		x			SWAT*	VMOD*
					Salinity	Х	X	х			ISIS	VMOD, EIA
					Water temperature	X	x				-	VMOD, EIA
					Nutrient concentrations	X	x				-	VMOD, EIA
		Delta	Zone 5	OBTCD	Primary production	X	X				-	VMOD, EIA
4	Water quality	Deita	Zone 5	OBICD	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
					Water temperature	Х	x			х	-	EIA
		Tonle Sap	Zone 4	OBTCD	Conductivity	X	x			x	-	EIA
		Torne Sap	Zone 4		Nutrient concentrations	X	x			x	-	EIA
					Primary production	X	X			x	-	EIA
					Energy Production	X		х			IQQM/eWater	-
			n/a		Operation rule curve (Normal, Optimize,			X			IQQM/eWater	-
5	Hydropower		iiya		Store, Dam break)							
5	nyuropower				Flow release plan	X		X			IQQM/eWater	-
					Weirs and Sluices	X		X			ISIS	-
					Sediment and nutrient trapping	X				Х	-	VMOD*, EIA
	Remark :	Model Name* Model Name**		r recalbration Setup and Calibration in Rij	parian zone and flood plain with support info	ormation f	from m	embe	r cou	ntries.		
		EIA (3D-EIA) is on	v for hotspot	areas IF REOUEST (Nam S	ongkhram, Xe Bang Fai, Tonle Sap Lake, Tie	eu River F	stuarv	etc.)				
					and flow in the Tonle Sap River for estimat					na to	the Tonle Sap Lake	
					erve that floodplain fluxes and sedimentation							

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.

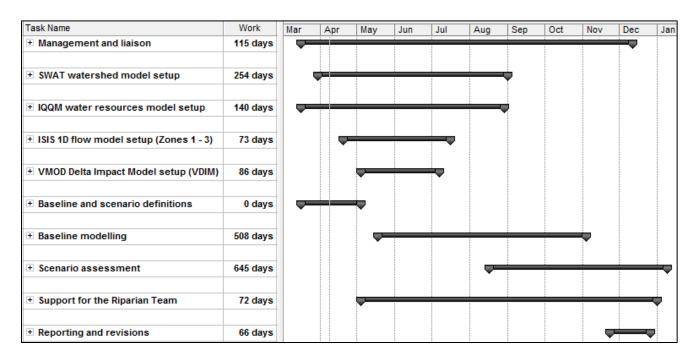


Table B-2. Modelling main human resources. MT Mgr = Modelling Team Manager, TC = Technical Coordinator, DSF TE = DSF Technical Expert.

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
	48 days
impacts on Delta hotspot sedimentation and erosion (EIA 3D)	
impacts on Delta hotspot sedimentation and erosion (EIA 3D) impacts on Delta flooding and salinity 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	Mar	Apr	N	ay	Ju	n	Jul		Aug		Sep		Oct		Nov	Dec
Management and liaison	115 days									-							
consultations and meetings	36 days																
planning phase	7 days		HIC (Jo)														
baseline meeting	1 day			TC (Jo)												
MRC and country meetings	28 days						0									0	
work plan	10 days		🣥 то	C (Jo)													
progress reporting	8 days					1											
+ 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						DSF T	E (Or),D	SF ass	sist te	am[40	0%]					
3S discharge recalibration (incl. IQQM)	15 days	1			DS, DS	F TE (Or)[50%]									
sediment model input data preparation (rating curves)	10 days	1	<u> </u>	Sedimer	t Expert	t (Lois	s)										
sediment model calibration (TSS)	72 days									<u> </u>	SF TE	(Or)[50	%],SV	АТ ТЕ	: (Sri)[2	20%],DSF a	ssist team[60
WUP-FIN model update for hydromet and irrigation up to 2015	20 days			(- wi	JP-FIN Ir	nt.									
WUP-FIN model update for sediment and WQ data up to 2015	6 days			(📄 VVUP	P-FIN II	nt.										
WUP-FIN model resolution increase and hydrological re-calibration	14 days						w.	UP-FIN	Int.								
WUP-FIN channel sediment storage modelling	10 days						_ * _	wu	P-FIN I	nt.							
WUP-FIN sediment model re-calibration including sediment trapping	17 days							*		WUP-	FIN Int.						
WUP-FIN water quality model calibration	20 days								1	i i	 \	VUP-FI	N Int.				
integration of WUP-FIN sediment results into the DSF	25 days								- 2	*	WUP-F	IN Int.,I	DSF TI	E (Or),I	MT Mg	r (Dat)[50%]
integration of WUP-FIN water quality results into the DSF	10 days										Č	DSF	TE (Oi),WUP	-FIN In	t.	
calculation of Tonle Sap sediment and nutrient loads (WUP-FIN)	5 days										ļ	WUP	-EIN Ir	nt.			
IQQM water resources model setup	140 days	1 💭									_						
update into e-Water SOURCE and installation	60 days						SOURC	E Int.									
SOURCE checking, calibration and verification	60 days									:		SOUR	CE Int				
integration of SWAT and IQQM/SOURCE for sediment and WQ simulation	20 days			-	DSF TE (Or)[50)%],SWA	AT TE (S	Sri)[509	%]							
□ ISIS 1D flow model setup (Zones 1 - 3)	73 days			-				_	• 1								
update of the schematisation	20 days	1			VIT Mgr	(Dat),	DSF TE	(To)									
linking with the SWAT/IQQM	4 days	1			DSF T	E (To)											
discharge and WL calibration	10 days	1			بلط	DSF T	E (To)										
suspended load calibration inc. fractions	14 days	1					DSE T	TE (To)									
bed load calibration	10 days	1			[[5	DSF TE	(10)								
calibration for morphological changes	15 days								DSF	TE (To)						

Working Paper: Modelling Detail for support the Council Study

Task Name	Work	Mar	Apr	Ма	ау		Jun	Jul			Aug		Sep	(Oct	No	v	Dec
VMOD Delta Impact Model setup (VDIM)	86 days				-				Π									
adding sediments, salinity and nutrients into the existing flood mapping	20 days			C			WUP-FIN I	Int.										
defining impact functions for agricultural and aquactic/aquaculture production	10 days			Contraction 1	•	UP-I	IN Int.											
building Delta model (DEM, land use, soil, irrigation and dykes)	20 days			C			WUP-FIN I	Int.										
integration of the DIM with the Delta ISIS	6 days						WUP-	FIN Int	¢									
testing and calibration of the model	30 days						<u> </u>	-	WUF	-FIN	Int.,M	IT Mg	r (Dat)[50	0%]				
Scenario Definitions	0 days	-																
data identification	0 days	le 16	/03															
infrastructure definitions for modelling	0 days				04/05				┼┼									
Baseline modelling	508 days								₩			_						
baseline mainstream discharge (SWAT, IQQM)	12 days				- č	þ	SF assist	team	(20 0	%]								
baseline mainstream velocity, shear stress, water levels and Delta salinity (ISIS)	40 days						 0	SFas	sist	tean	a[2009	6]	-	-				
baseline upstream channel sediment and nutrient flow and bed level (ISIS)	60 days												DSF as	sist te	am[400	%]		
baseline upstream hotspot flooding and flow (EIA 3D)	20 days						Č	WUP	FIN	assi	ist tea	ım[40	0%]					
baseline upstream hotspot sedimentation and erosion (EIA 3D)	40 days												1	VUP-FII	l assist	t team	[400%]	
baseline Delta sediment loads (SWAT, IQQM)	20 days													assist	team			
baseline Delta nutrient loads (SWAT, IQQM)	21 days											- č		D SI	assist	t team		
baseline Tonle Sap flood, flow, sed., DO, nutrients, primary and fish prod. (EIA 3D)	60 days															UP-FIN	assist te	am[400%]
baseline Delta hotspot flooding and flow (EIA 3D)	40 days						č	<u> </u>	hup-	FIN a	ssist	team	[400%]					
baseline Delta hotspot sedimentation and erosion (EIA 3D)	60 days													w 📄	UP-FIN a	assist	team[400	%]
baseline Delta flooding and salinity characteristics (VDIM)	75 days							1	*		:		1P MT[20	10 %] ,D	SF assis	st tean	n[50%]	
baseline Delta sediments, nutrients and productivity characteristics (VDIM)	60 days													*		-	ІКМР МТ	200%]

Task Name	Work	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct		Nov	Dec
Scenario assessment	645 days						-					
synthetic "calibration" scenarios for ecological assessment (DSF, WUP-FIN)	63 days						- Te	DSF assist t	eam[40	0%],W	UP-FIN assi	st team[400%
scenario data preparation for SWAT	15 days								DSF	assis	t team	
scenario data preparation for IQQM/SOURCE	15 days								DSF	assis	t team	
scenario data preparation for upstream ISIS	15 days								DSF	assis	t team	
scenario data preparation for downstream ISIS	15 days								DSF	assis	t team	
scenario data preperation for WUP-FIN models	40 days								WUP-FI	N assi	st team[40	0%]
impacts on mainstream discharge (SWAT, IQQM)	20 days									DSF	assist team	n[200%]
impacts on mainstream velocity, shear stress, water levels and Delta salinity (ISIS)	40 days									DSF	assist team	[400%]
impacts on upstream channel sediment and nutrient flow and bed level (ISIS)	50 days										D:	SF assist tea
impacts on upstream hotspot flooding and flow (EIA 3D)	40 days										WUP-FIN a	ssist team[4
impacts on upstream hotspot sedimentation and erosion (EIA 3D)	40 days										는 WUP	-FIN assist te
impacts on Delta sediment loads (SWAT, IQQM)	20 days										DSF assist	team
impacts on Delta nutrient loads (SWAT, IQQM)	40 days									DSF	assist team	[400%]
impacts on Tonle Sap (EIA 3D)	40 days										ten 🔁 🖿	FIN assist te
impacts on Delta hotspot flooding and flow (EIA 3D)	24 days									b -1	VUP-FIN as:	ist team[40
impacts on Delta hotspot sedimentation and erosion (EIA 3D)	48 days										tem 🔰 wu	P-FIN assist
impacts on Delta flooding and salinity characteristics (VDIM)	60 days									*		IKMP MT[20
impacts on Delta sediments, nutrients and productivity characteristics (VDIM)	60 days											<u> </u>
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				1	1	1	1	1			
Reporting and revisions	66 days	-										
Mainstream flow, flooding, sediment and morphology impact report (Zones 1 -3)	5 days											DSF TE (To)
Tonle Sap impact report	5 days										<u> </u>	TC (Jo)
Delta impact report (flow, flooding, sediment, salinity, water quality, productivity)	7 days										_	WUP-FIN I
Hotspot impact report (Zones 1 - 5)	5 days											TC (Jo)
Country consultations based on the reports	16 days											🔁 мті
Modelling and report revisions based on feedback	28 days	1										<u> </u>