ANNEX G4-IA: ENGINEERING ANNEX OF SUBPROJECTS

(For Dr, TI, FMD, WC Subprojects)

[This document, a part of the Guidelines for SSWR Development, will contain hydrological and hydraulic data and analysis for a SSWRD subproject's feasibility study and form the Engineering Annex of the FS Report]

Appendix G4-IA.A

Salient Data, Design and Impact of Subproject

A1 Subproject Processing Information

Subproject Name			**Type**
Location		**Subproject Area:**	
Zone		Gross	ha
District		Net	ha
Upazila			
Union:			
Subproject Processing Dates			**Comments**
Proposal received in IWRMU			
Pre-screening			
Field reconnaissance			
PRA and Social Survey			
Name of PRA Firm/NGO	Date of Assigning Work: Field Work: Date Start: End: PRA Report Completed (date):		
Feasibility Study			
Name of FSDD Firm			Assign Date:
Data Collection			
Multidisciplinary Field Visit Period	Start Date:		End Date:
Pre-Feasibility Report (draft)	Submitted:		Reviewed
Planning Discussion Meeting	Date Held		Place
Pre-Feasibility Report (final)	Submitted:		Finalized:
DLIAPEC Clearance	Date Obtained		
Detail Data Collection			
- *Agricultural*	Date From:		Date To:
- *Fisheries*	Date From:		Date To:
- *Environmental*	Date From:		Date To:
- *Engineering Survey*	Date From:		Date To:
Feasibility Analysis			
Feasibility Report - Draft	Submitted		Reviewed
Feasibility Report – Final Draft	Submitted		Reviewed
Feasibility Report	Submitted		Approved
Environmental Clearance	Date Submitted		
Comments:			

A2 Climatic Design Data of Subproject

Parameters	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Year
Temperature (^{0} C)			**Station Number & Name:**							**Period of Data:**			
Max													
Mean													
Min													
Evaporation, E (mm/day)			**Station Number & Name:**							**Period of Data:**			
Average													
Evapo-transpiration, ETo (mm/day)			**Station Number & Name:**							**Period of Data:**			
Average													
Rainfall, R (mm/month)			**Station Number & Name:**							**Period of Data:**			
Average													
Water Balance (mm/month)													
Water Body													
Crop Land													

A3 Hydrological Design Data of Subproject

A 3.1 Rainfall Data

A. Mean Monthly Rainfall (mm)

Station Number and Name:..... Period of Data:.....

Parameters	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Year
Max													
Mean													
Min													

B. Design Storm Rainfall (Synthesized 5-day 10-year Storm)

Station Number and Name:..... Period of Data:.....

Pre-monsoon (Jan-Jun)						**Monsoon** (Annual)					
Duration (Days)	**1**	**2**	**3**	**4**	**5**	**Duration** (Days)	**1**	**2**	**3**	**4**	**5**
Cumulative Depth (mm)						**Cumulative Depth** (mm)					

A 3.2 River (Outside) Water Level Data

A. Mean Monthly Water Levels (Tidal Zone)

Subproject WL	**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**	
	HTL	**LTL**	**HTL**	**LTL**	**HTL**	**LTL**	**HTL**	**LTL**	**HTL**	**LTL**	**HTL**	**LTL**
Max												
Mean												
Min												
	Oct		**Nov**		**Dec**		**Jan**		**Feb**		**Mar**	
	HTL	**LTL**	**HTL**	**LTL**	**HTL**	**LTL**	**HTL**	**LTL**	**HTL**	**LTL**	**HTL**	**LTL**
Max												
Mean												
Min												
Computational Basis and Procedures												
U/S Stn. Number & Name: **Period of Data:**							**D/S Stn. Number & Name:** **Period of Data:**					
Subproject Data Derived by: Interpolation Extrapolation Correlation	Sketch representation of reference stations and the subproject with distances and other comments, assumptions if any:											

B. Mean Monthly Water Levels (Non-Tidal Zone)

Subproject WL	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**
Max												
Mean												
Min												

Computational Basis and Procedures	
U/S Stn. Number & Name: **Period of Data:**	**D/S Stn. Number & Name:** **Period of Data:**
Subproject Data Derived by: Interpolation Extrapolation Correlation	Sketch representation of reference stations and the subproject with distances and other comments, assumptions if any:

C. High Flood Level (HFL)

Return Period (year)	**Pre-monsoon**	**Monsoon**
2.33		
5		
10		
20		
50		

Computational Basis and Procedures	
U/S Stn. Number & Name: **Period of Data:**	**D/S Stn. Number & Name:** **Period of Data:**
Subproject Data Derived by: Interpolation Extrapolation Correlation	Sketch representation of reference stations and the subproject with distances and other comments, assumptions if any:

A4 Area – Elevation - Storage Relationship of Subproject

Land Elevation[1] (m PWD)	**Cumulative Area** (ha)	**Cum Storage Volume** (ha-m)	**Land Use**
			Permanent Water Body
			Highland and Homesteads

v(1) Usually areas and storage volumes are incremented for incremental land elevations at 0.30 m intervals.

A5 Drainage Rate and Basin WL (From Routing of Design Storm Rainfall)

Season	**Area (ha)**			**LGL** (mPWD)	**Dr Level** (mPWD)	**Dr Rate** (mm/day)	**Basin WL** (mPWD)
	Drainage	**Gr Benefit**	**Damage**				
Pre-monsn							
Monsoon							
Comments:							

A6 Land Type Changes

Average (1:2.33 Year) Monsoon Flood Level in Subproject : ..... mPWD
Design Basin Water Level in Subproject : ..... mPWD

Land Type[1]	**Nature of Flooding**	**Pre-subproject Area** (ha)	**Post-subproject Area** (ha)
Non-cultivated highland	Not flooded		
F0 (d < 0.3 m) Highland	Intermittent		
F1 (0.3< d <0.9 m) Medium	Seasonal		
F2 (0.9< d <1.8 m) Medium	Seasonal		
F3 (d>1.8 m) Lowland	Seasonal >9 month		
Non-cultivated lowland and permanent water bodies	Perennial		
Floodplain Fish Habitat (F2+F3)			
Net Area (F0+F1+F2+F3)			
Gross Area			

(1) Areas of (i) pre-subproject land types are calculated by depths from average Monsoon (annual) Flood Level and (ii) post-subproject land types are calculated from Design Basin Water Level.

A7 FMD Subprojects: Area Benefited in Floods of Different Degrees

Reference Flood / Water Level Condition	WL (m PWD)	Gross Area Below WL (ha)	Net Area Below WL (ha)	Benefit Area for Reference Condition (ha)
Partial Flood Protection (Submersible Embankment) Subprojects				
1:10-yr Pre-Monsoon FL.				
1:2.33-yr Annual HFL				
1:10-yr Annual HFL.				
Pre-Monsoon Basin WL				
Full Flood Protection (High Embankment) Subprojects				
1:2.33-yr Annual HFL				
1:10-yr Annual HFL				
1:20-yr Annual HFL				
Design Basin WL				

A8 Design of Component Works

A. <u>Drainage Khal Re-excavation</u>

Nos	Name of Khal	Length (km)	Design Section Dimensions (m)		Depth of Excavation (average)
			Bed Width	Depth	
1					
2					
3					

B. <u>Embankment Re-sectioning / Upgrading</u>

Nos	Embankment Chainage		Length (km)	Design Section Dimensions (m)			Height above GL (average)
	From	To		Bed Width	Depth	Side Slope	
1							
2							
3							

C. Hydraulic Structures

Nos	Name & Location	Size of Structure		Gate Type	Purpose of Structure
		No of Vents	Vent Size		
1					
2					

A9 Summary Quantities and Cost for Subproject

Nos	Names of Khal / Embankment / Structure	Quantity Km / No	Unit Cost	Estimated Cost (Tk)
A. Re-excavation of Khal				
1				
2				
B. Embankment Re-sectioning / Upgrading				
1				
2				
C. Hydraulic Structures				
1				
2				
D. Others				
1.				
2.				

Total Subproject Cost			

A10 Economic Viability Index

EIRR	
NPV	
B/C	

Appendix G4-IA.B

Hydro-Climatic Data and Analyses for Feasibility Study

B1 Basic Data and Statistical Analyses

A. Climatic Data

Notes and Explanations: Climatic data for study of SSWRD subprojects will usually include Temperature, Evaporation, Evapo-transpiration and Rainfall. Sunshine hours, wind speed, etc may also be needed for certain specific subprojects. It may be adequate to use district level climatic data as required (*refer to requirements in Appendix G4-IA.A, Table A2*) from secondary sources. However, source from where the secondary data have been acquired should be mentioned as foot note under the data Table.

[Provide data table here. Use pages as required]

B. Rainfall Data

Notes and Explanations: **(i)** The Rainfall station that will most closely represent the rainfall at the subproject site shall be identified using hydrological station network map and its name and ID number, location, distance and direction shall be properly mentioned and described. **(ii)** The length of data record used shall also be mentioned. **(iii)** Daily rainfall records for the number of years considered in the analysis shall be arranged in tabular form with rows representing days (1 to 31) and columns representing months. Thus, each year's data will be accommodated in one page. These basic data shall then be organized and analyzed statistically for the required parameters (*refer to requirements in Appendix G4-IA.A, Table A3.1 A, B*). **(iv)** For the design storm rainfall, the process of synthesizing 1-day, 2-day, 3-day, 4-day and 5-day maximum cumulative rainfall amounts for each year from the basic data tables shall be explained/elaborated by referring to the values of the data tables. The series of 1-day rainfall data so obtained shall then be analyzed statistically to obtain the 1-day 10-year maximum rainfall. Similarly, the 2-day maximum cumulative rainfall data series shall be analyzed statistically to obtain the 2-day 10-year maximum cumulative rainfall. The procedure will be repeated for 3-day, 4-day and 5-day cumulative rainfalls also. **(v)** All assumptions made, formulas used and values of coefficients and constants involved should be mentioned and explained and all computations be shown elaborately, preferably arranged in tabular forms.

[Provide basic data and analysis tables here. Use pages as required]

C. Water Level Data

Notes and Explanations: (i) The Water Level station or stations, the records of which will be required to calculate water levels at the subproject site, shall be identified from the hydrological station network map and the names and ID numbers, locations, distances, directions, etc of the stations from the subproject shall be properly mentioned and described. (ii) The length of data record used for analysis shall also be mentioned. (iii) Daily mean WL for non-tidal stations and daily maximum High Tide Level (HTL) and minimum Low Tide Level (LTL) for tidal stations shall be the basic WL data. These basic WL data shall be organized in tabular form, one page for one year's data, with rows representing days (1 to 31 days) and two columns (one for HTL and one for LTL data) for each month. (iv) The basic data shall then be organized and analyzed statistically for the required parameters (*refer to requirements in Appendix G4-IA.A, Table A3.2 A, B, C*). (v) If interpolation or extrapolation between stations is required to calculate subproject water level, derivation of the required mathematical equation to be used for the interpolation or extrapolation should be shown and explained by a layout sketch and distances of the reference stations from the subproject. (vi) All assumptions made, formulas used and values of coefficients and constants involved should be mentioned and explained and all computations be shown elaborately, preferably arranged in tabular forms.

[Provide basic data and analysis tables here. Use pages as required]

B2 Physical and Hydrological Characteristics of Subproject

[This subsection is to be read and worked with ***Subsection 3.2.5: Anticipated Impacts of Different Types of Subprojects*** of the Guidelines Document ***G4: Feasibility Study of Subprojects***]

A.1 Area-Elevation-Storage Characteristics of Subproject

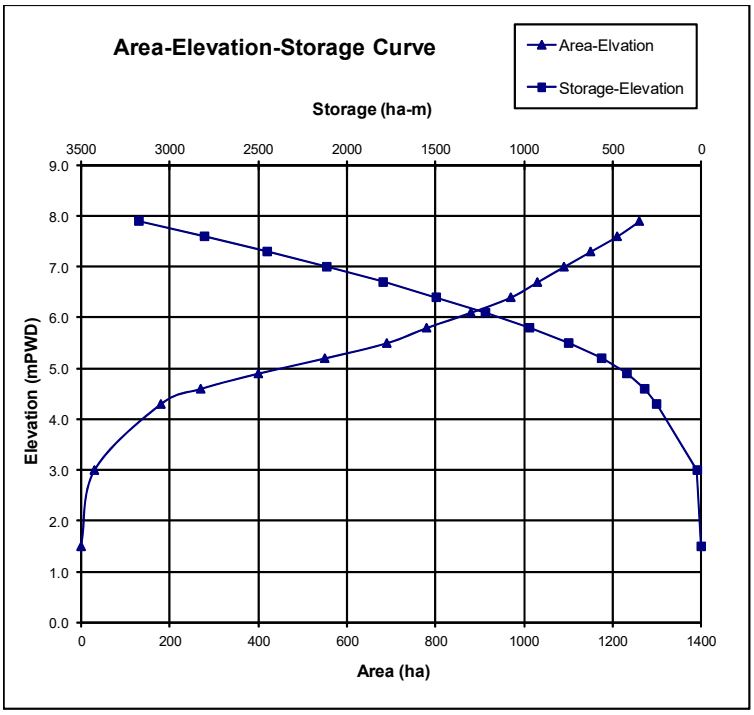
Notes and Explanations: Area within the subproject boundary for each incremental ground elevation of 0.30 m starting from the lowest ground level shall be measured from the 4" to 1 mile topographic map of the subproject area having ground elevation contours at intervals of 30 cm (1-foot). If the subproject area is not surveyed as above, land elevation characteristics of the subproject area shall be established by conducting a survey for ground levels at specified grid points (usually at 100 m) and areas under incremental 0.30 m ground levels as mentioned above shall be determined. The incremental areas are then cumulated to establish a land elevation versus area relationship for the subproject area. Also, the volumes of water that can stand in storage in the subproject area below land elevations incremented as above, by 0.30m above the lowest ground level, shall be calculated. The relationships between cumulated values of ground elevation, area and storage volume are organized in Table for use by computer program for engineering analysis of the data. The relationship shall also be shown in linear graphs drawn with GL in y-axis and Area and Storage Volume in x-axis (giving two x-axes and two graphs in one drawing sheet).

[Provide data table and graph here]

(This is an example data and graph. FS Consultants will provide data and curves for the concerned subproject)

Subproject .....
Upazila: .....
District: .....

Elevation (mPWD)	Area (ha)	Storage (ha-m)
1.5	0.00	0.00
3.00	30.00	22.50
4.30	180.00	252.00
4.60	270.00	319.50
4.90	400.00	420.00
5.20	550.00	562.50
5.50	690.00	748.50
5.80	780.00	969.00
6.10	880.00	1218.00
6.40	970.00	1495.50
6.70	1030.00	1795.50
7.00	1090.00	2113.50
7.30	1150.00	2449.50
7.60	1210.00	2803.50
7.90	1260.00	3174.00



A.2 Land Type Analysis of Subproject

Notes and Explanations: (i) Land Type Classification of the subproject, meaning calculation of lands under the different flood phases of standard land types (F0, F1, F2, F4) for a given WL in the subproject, shall be done by the standard Spreadsheet Program using both pre-subproject and post-subproject WLs. For this, tabulated area-elevation data of the subproject will be used as an input. (ii) For full flood management subprojects, the pre-subproject and post subproject WLs will be different and difference between amounts of lands of respective land types under the two WLs will denote the land type change as the impact of the subproject. (iii) As other type of subprojects (partial FM, drainage, WC, etc) have no impact on land type change, the analysis can be done by using the same Spreadsheet Program by putting the pre-subproject WL also in place of the post-subproject WL. The calculations will give the same land areas under different land types meaning that there will be no land type change.

[Provide calculations of Land Type Analysis here]

(This is an example calculation. FS Consultants will provide calculations of the concerned subproject)

LAND TYPE CLASSIFICATION

	Subproject :	Bansgari											
	Upazilla :	Kalkini											
	District :	Madaripur											
Land elevation (m)	**Cum. area excldg NC lowland (ha)**												
				Gross area =	525.00	**ha**							
			NC high land and homestead area =		90.00	**ha**							
				Non cultivable low land =	10.00	**ha**							
1.20	0.00			Benefited area =	425.00	**ha**							
1.30	5.00												
1.50	25.00												
1.80	82.24			Pre project WL =	3.74	**m**							
2.10	160.81			Post project WL =	3.74	**m**							
2.40	232.55		**Preproject**								**Post Project**		
2.70	305.00		**Land type**	**WL (m)**	**Area(ha)**	**|**	**Area(ha)**	**WL (m)**			**Land type**		
3.00	399.94		Not flooded =	3.74	0.00	**|**	0.00	3.74			**= Not flooded**		
3.30	458.01		F0(0.0-0.3) =	3.44	15.12	**|**	15.12	3.44			**= F0(0.0-0.3)**		
3.60	480.00		F1(0.3-0.9) =	2.84	59.88	**|**	59.88	2.84			**= F1(0.3-0.9)**		
3.90	495.00		F2(0.9-1.8) =	1.94	230.40	**|**	230.40	1.94			**= F2(0.9-1.8)**		
4.20	505.84		F3(1.8+) =		119.60	**|**	119.60				**= F3(1.8+)**		
4.50	515.00		**NC high land and homestead area =**		90.00	**|**	90.00				**= NC high+HS area**		
			NC low land =		10.00	**|**	10.00				**= NC lowland**		
			Total =		525.00	**|**	525.00				**= Total**		
				Land type	***Area(Pre)***		***% NBA***			***Area(Post)***			***% NBA***
				F0------>	***15***	***ha***	***3.53***	***F0------>***		***15***	***ha***		***3.53***
				F1------>	***60***	***ha***	***14.12***	***F1------>***		***60***	***ha***		***14.12***
				F2------>	***230***	***ha***	***54.12***	***F2------>***		***230***	***ha***		***54.12***
				F3------>	***120***	***ha***	***28.24***	***F3------>***		***120***	***ha***		***28.24***
				Benefited area =	***425***	***ha***	**Benefited area =**			***425***	***ha***		

B Design Basin Water Level and Design Drainage Rate of Subproject

Notes and Explanations: Rainfall of the Design Storm (synthesized 5-day 10-year storm) established earlier occurring over the relevant catchment area shall be routed through the drainage channel of the subproject, assuming that there is no obstruction to drainage from downstream WL, to establish an acceptable highest WL in the subproject (usually called Design Basin WL) and the corresponding rate of drainage (the possible maximum drainage rate for use in design of the system), in mm per day, that is required to give the Basin WL using the project specified MS Excel Spreadsheet Program for simplified storm routing and crop damage criteria, usually taken as 5% of cultivated area (excluding permanent water body) unless otherwise decided for any specific subproject, The simplified routing program yields a Basin WL corresponding to crop damage scenario in respect of depth and duration of crop inundation when a trial drainage rate is applied. Thus, an acceptable Design Basin WL is obtained by trial and the corresponding drainage rate is taken as the design drainage rate. Design drainage rate shall be calculated for both (i) pre-monsoon and (ii) monsoon design storms.

[Provide design calculations of the routing program here]

(This is an example calculation. FS Consultants will provide calculations of the concerned subproject)

ANALYSIS OF DRAINAGE RATE

Sub-Project: …… SP No.
Upazila: ……..
District: ……

CRITERIA: ● Design Storm ☒ 10-Yr 5-Day storm recorded at the nearest Rainfall Station
● Crop Damage ☒ Sub-Project WL during design storm may not inundate more than 5% area by depth more than 300mm for duration of more than 3 days.

ASSUMPTIONS: ● Infiltration, Evapo-Transpiration and Depression Storage are neglected.

INPUT DATA:
● Catchment Area (Ha.): 525.00 Gross Area (Ha): 525
● Benefited Area (Ha.): 425.00
● Drainage Level (mPWD): 1.30
● Allowable Damage Area (% of Benefited Area): 5.0%
● Area-Elevation-Storage Data:

	Elevation (m)	Cum. Area (Ha.) including non cultivable low land	Cum. Stor. (Ha-m)
	1.20	6.00	0.00
LGL=>	1.30	15.00	1.05
	1.50	35.00	6.05
	1.80	92.24	25.14
	2.10	170.81	64.59
	2.40	242.55	126.60
	2.70	315.00	210.23
	3.00	409.94	318.97
	3.30	468.01	450.66
	3.60	490.00	594.36
	3.90	505.00	743.61
	4.20	515.84	896.74
	4.50	525.00	1052.86

● Design Storm Rainfall (mm): (Pre-Monsoon)

Days	1	2	3	4	5
Cum Depth	179.00	232.00	266.00	288.00	308.00

● Trial Drainage Rate (mm/day): 65.00

CALCULATIONS FOR DRAINAGE MODULUS (PRE-MONSOON)

Day	Cum RF (mm)	Cum DR (mm)	Cum RO (mm)	Cum. Storage (Ha-m)	WL_{basin} (mPWD)	Basin Dr WL (mPWD)	Basin Dr WL+0.3 (mPWD)	Day with WL for Full Damage	100% Crop Damage (Ha.)	Design Drain. Rate (mm/day)
1	179.00	65.00	114.00	59.85	2.06	1.36	1.66	Day-1		
2	232.00	130.00	102.00	53.55	2.02	1.36	1.66	Day-2		
3	266.00	195.00	71.00	37.28	1.89	1.36	1.66	Day-3	21.25	65.00
4	288.00	260.00	28.00	14.70	1.64	1.36	1.66	-ve		
5	308.00	325.00	-17.00	-8.93	0.00	1.36	1.66	-ve		

Note:
1. A day is counted as "day with WL corresponding to full damage of allowable % of Area" if WL_{basin} > Basin Drainage Level +0.3 for the day.
2. If 3 consecutive days are counted to be crop damage days, crops of land corresponding to allowable % area will be considered fully damaged.
3. If count of crop damage day < 3, rivise trial drainage rate downward.
4. If count of crop damage day > 3, rivise trial drainage rate upward.
5. 21.25 ha crop damage area is including 10 ha permanent water bodies. So, 11.25 ha is actual crop damage area.

Appendix G4-IA.C

SUBPROJECT MAPS

A. Subproject Index Map

Notes and Explanations: The Index Map of the subproject shall be a comprehensive map incorporating almost all information that one might like to find therein. Two Index Maps will be used. The *first* one, identified as ***Figure 1A: Index Map (Google Image)*** shall be based on Google Image of the subproject area and show current position of physical features including rivers, khals, water bodies, roads, bridges, homesteads, crop fields, places, etc. The subproject boundary, all planned physical works and impact area boundaries, etc are shown on the Google Image map using AutoCAD. The *second* one, identified as ***Figure 1B: Index Map (Topography)*** shall be based on the available 4 inch to 1 mile topographic map with 1-foot land elevation contour lines prepared by the Survey of Bangladesh. Important features of the subproject area like subproject area, catchment area and benefit area boundaries, alignment of rivers, khals, important roads, locations of water bodies are copied on this map from the Google image map. As the topographic map is quite old, physical features like rivers, khals, water bodies, roads, homesteads etc of this map may be different from the Google image map which represent the present position correctly. This Index Map will be used for establishing land elevation characteristics of the subproject area. Index Maps shall be in standard A3 size. If necessary, more than one A3 sheets may be used showing match lines with contiguous sheets.

*[The Index Maps shall be attached in the Feasibility Study and IEE/EIA Report of the subproject as **Figure-1A Index Map (Google Image) and Figure-1B (Topography)** as has been discussed in Guidelines **G4 Feasibility Study, Subsection 3.2.1, Para on Figure1: Index Map**]*

B. Base Map

Notes and Explanations: The Base Map of the subproject shall be prepared on LGED Upazila Base Map of scale 1:50000 showing all salient features of the subproject – subproject boundary; rivers, khals, beels and haors; existing roads, bridges and culverts, growth centers/important markets, Union Parishad, etc and importantly all the works proposed under the subproject. This map shows location of the subproject in wider surroundings in the Upazila and presents the setting in relation to communication system, markets, important places and towns, etc. This Map shall also be prepared in A3 size.

*[The Base Map shall be attached in the Feasibility Study and IEE/EIA Report as **Figure-2** as has been referenced in Guidelines **G4 Feasibility Study, Subsection 3.2.1, Para on Figure-2: Base Map**]*

C. Regional Map

Notes and Explanations: The Regional Map for the subproject shall be prepared using topographic map of 1:250,000 scale or hydrological network map (BWDB) howing BWDB's larger water resource projects (if any) and other subprojects of LGED (if any); hydrometric stations used in analysis; main rivers and khals; main roads and railways; District, Upazila and other main towns, etc. This Map shall also be prepared in A3 size.

*[The Regional Map shall be attached in the Feasibility Study and IEE/EIA Report as **Figure-3** as has been referenced in Guidelines **G4 Feasibility Study, Subsection 3.2.1, Para on Figure-3: Regional Map**]*