

# **DATA 5 : ENVIRONMENTAL IMPACT ASSESSMENT**

**THE STUDY ON STORM WATER DRAINAGE PLAN  
FOR THE COLOMBO METROPOLITAN REGION  
IN  
THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA**

**FINAL REPORT**

**VOLUME V : DATA BOOK**

**DATA 5 : ENVIRONMENTAL IMPACT ASSESSMENT**

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## A. ENVIRONMENTAL IMPACT ASSESSMENT STUDY

### 1. Objectives

The main objectives of the Environmental Impact Assessment (EIA) Study is to assess potential impacts on social/natural environment and pollution caused by the proposed measures in the Weras Ganga sub-basin of the Bolgoda Basin Storm Water Drainage Plan, which consists of the Main Bolgoda Canal and Major Tributaries Improvement, Weras Ganga Channel Improvement, Storm Water Retention Area, and Construction of Storm Water Retention Facilities in Urban Area, and to prepare environmental management & monitoring plan (EMMP) for the necessary actions to the potential environmental impacts.

The EIA for the proposed measures will be proceeded by the project proponent agency under the national EIA system in Sri Lanka. Therefore, the Work does not include acquisition of the approval of the EIA, though the Work shall cover the requirements of the Environmental Guidelines on the Development Study by the JICA and national EIA system regarding to the proposed measures.

Through the social environmental considerations, the Work shall identify settlements potentially affected by the proposed projects including project-affected people to be resettled, collect data on them, and propose necessary assistance for the project-affected people to be covered by the projects.

### 2. Survey Area

The survey area (56 km<sup>2</sup>) is located in the Weras Ganga sub-basin of the Bolgoda basin. Location of the survey area and proposed measures. The Contractor shall confirm to the JICA Study Team on exact boundary and location of the survey area as well as the proposed measures to be environmentally assessed before commencement of the Work.

### 3. Technical Specifications

The following technical specifications are prepared by the JICA Study Team based on the JICA Guidelines on Environment<sup>1</sup>. Before commencement of the Work, a meeting on the technical specifications will be held among CEA, SLLRDC, the JICA Study Team, and the Contractor as a TOR review process under the national EIA system in Sri Lanka in order to fulfill requirements of the EIA system and then to accelerate the EIA process for the project implementation.

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<sup>1</sup> The JICA Guidelines for Environmental Considerations in the Development Study: “V. River & Soil Erosion Control” and “VII. Sewerage System” (unofficial translation from Japanese title)

The Work is conducted with parallel to the feasibility study for the proposed measures, which is prepared by the JICA Study Team. Therefore, the Contractor shall communicate frequently and closely with environment expert and other relevant experts of the JICA Study Team to get updated information of the proposed measures such as detailed drainage plan and facility design.

### **3.1 Environmental Items to be Surveyed**

Main environmental items to be surveyed on both construction stage and operation & monitoring stage of the proposed measures are shown as follows.

#### (1) Social Environment

##### 1) Resettlement

Resettlement caused by the land acquisition for implementation of the proposed measures will be expected to occur in some extent since the proposed measures are located partly at built-up area. People to be resettled who live near the canals and/or low-lying area tend to be low-income and/or live in the under-served settlement. Through the Work, tenurial characteristics of land to be acquired and movable properties to be relocated, and social characteristics of project-affected people, especially people to be resettled shall be identified and inventoried.

Accompanying with the resettlement, improvement of living environment for project-affected peoples to be resettled shall be well considered with combination of any assistance by the project and central/local governments based on the peoples' demand.

##### 2) Economic activities

Economic activities in and around the project sites might be disturbed temporarily or totally by the construction work and/or land acquisition. Potential impacts shall be identified and mitigation measures shall be proposed.

##### 3) Traffic and public facilities

Local traffic flow might be disturbed temporarily by construction vehicles and construction works. Public facilities such as school and hospital in and around the project sites also might be affected. Those potential impacts shall be identified and mitigation measures shall be proposed.

##### 4) Cultural/religious sites

Possibility of disturbance of cultural/religious facilities and activities nearby project sites during construction shall be surveyed as well as any damage to cultural/religious facilities and sites.

##### 5) Waste

Disposal of contaminated bottom sediment dredged from the canal and of other

construction wastes such as residue material and soil has to be treated carefully to avoid both natural and social environmental impacts for the disposal places. Disposal method and place shall be reviewed to identify potential impacts and propose proper measures.

#### 6) Accident

Preventive measures for accident relevant to the construction works shall be proposed by reviewing the similar projects such as the Greater Colombo Flood Control and Environment Improvement Project.

#### (2) Natural Environment

##### 1) Flora and fauna

Change of water flow regime in the canals and marshes in storm will be caused by implementation of the proposed measures in terms of water quality and quantity. It might cause ecological impact to habitat for flora and fauna in the marsh and other site, especially Bellanwila-Attidiya Sanctuary.

Regarding the Bellanwila-Attidiya Sanctuary, proper proposal shall be made to mitigate environmental impact by reviewing past studies and on-going/planned scheme in the sanctuary.

#### (3) Pollution

##### 1) Water pollution

Improvement of water passage in the drains and canals by the proposed measures will cause increase of water flow in the canals in storm, so that wastewater in the canal system flowing down to the marsh and downstream water area might cause both natural and social environmental impact. The Bellanwila-Attidiya Sanctuary will be one of most significant sites to be examined in the sense. Potential impact shall be identified and proper mitigation measures shall be proposed.

##### 2) Air pollution

Dust and emission gas from construction equipments and activities might affect residential area along the project site during construction work. The impact shall be identified and proper mitigation measure shall be proposed.

##### 3) Noise and vibration

Noise and vibration from construction equipments and activities might affect residential area along the project site during construction work. The impact shall be identified and proper mitigation measure shall be proposed.

### 3.2 Collection of Data and Information

The Interim Report of the Study on Storm Water Drainage Plan for the Colombo Metropolitan Region prepared by the JICA Study Team and the IEE Study report

relevant to the Study prepared by a subcontracted local consultant shall be referred in the preparation of the Work.

The Work shall be carried out through collection of information and data in the study area as aforementioned. The information and data collected shall be verified and supplemented through the field survey. The results of the examinations shall not only be described in the text, but also summarized in the maps and drawings with adequate scale, tables and graphs. In addition, the environmental standards and regulations, legal system relating to the implementation of EIA shall be collected and summarized.

In the course of the social environmental considerations in the Work, a Land Acquisition and Resettlement Survey shall be conducted to obtain basic information on project-affected settlements and people.

### 3.3 Field Survey

The following field survey shall be conducted to obtain most updated and proper site information.

#### (1) Water Sampling and Analysis

To grasp broadly water quality and movement of pollutant in the canal system in storm under present conditions, water sampling and analysis shall be conducted at designated locations in the canals and marshes. Locations of the water sampling, sampling items, and timing and frequency of the sampling are shown as follows.

Locations and number of sampling points	12 sampling points in the canals and marshes
Sampling items	pH, DO, BOD, COD, T-N, T-P, NH <sub>4</sub> -N, SS, EC, and Coliform group number (In the water sampling, the following basic data shall be recorded: air temperature, water temperature, water color, odor, water flow and transparency)
Timing and frequency of the water sampling	ordinary times (one time) and after the storm (three times in one hour interval), The water sampling shall be conducted simultaneously (same time in same day) at the all sampling points.

The record of calibration for the measurement and analysis instruments shall be attached with water quality data for quality assurance of the measurement and analysis.

#### Land Acquisition and Resettlement Survey

The Land Acquisition and Resettlement Survey consists of an Inventory Survey on Households to be Resettled and an Inventory Survey on Project-Affected Settlements. The objectives of the Inventory Survey on Households to be Resettled are to identify the land to be acquired and house/structure/movable properties to be relocated by the proposed measures, and to identify residential households to be resettled and to

collect their socio-economic data, opinion on improvement of their living environment, and intention and demand related to the resettlement. The Inventory Survey on Project-Affected Settlements aims to identify potential impact to the settlements where households to be resettled belong to by collecting socio-economic data on the settlements, and to clarify needs on improvement of living environment in terms of the community infrastructure.

#### 1) Extent to be surveyed

For the Inventory Survey on Households to be Resettled, the survey for land to be acquired and project-affected households to be resettled by the proposed measures shall be conducted with extent from present edge of the canal/stream to 10m- and 20m-width for both sides along some 25km-length of the canals in total and proposed retention areas.

All households to be resettled (approximately 2,000 households) shall be surveyed by direct observation and inquiry survey methods. Any properties located in the land to be acquired shall be inventoried such as public/private facilities, factories, and trees. In the place where there is no settlement such as marsh and abandoned cultivated area, land title shall be confirmed and recoded in the inventory with map.

For the Inventory Survey on Project-Affected Settlements, all settlements where the households to be resettled belong to shall be surveyed.

#### 2) Methodologies

At the beginning of the Surveys, the Contractor shall confirm to the JICA Study Team on the exact locations to be surveyed.

In the Inventory Survey on Households to be Resettled, an Inventory of acquired land and house/structures to be relocated, and any socially significant properties such as religious facilities and sacred tree in and around the proposed project sites shall be prepared with the topographical maps with a scale of 1 to 2,000, which both hardcopies and digital data are available from the JICA Study Team. The under-served settlements, community under poverty line, community of squatters, project-affected settlements and structures to be relocated shall be highlighted on the map. Inventory of cultural/religious/historical properties located in the settlement shall be prepared.

At the same time of the confirmation of the lands to be acquired and properties to be relocated at the site, direct inquiry survey to households to be resettled shall be conducted to get the latest and practical information.

In the Inventory Survey on Project-Affected Settlements, direct inquiry survey to leaders/representatives and households of the settlements shall be conducted to get the latest and practical information on relevant settlements where the households to be resettled belong to. Therefore, secondary data such as statistical data will be



obtained from local authority such as GN divisions in the case where the data is not available by the inquiry survey. Information source shall be mentioned in the case where secondary data is used. In addition, boundaries of the settlements shall be drawn on the map with a scale of 1 to 2,000.

### 3) Survey Items

Survey forms with the items to be surveyed for the Land Acquisition and Resettlement Survey are attached in the **Attachments 1 and 2**. Collected data and information shall be sorted and analyzed from the viewpoint of social environmental considerations.

Principally the Surveys shall be conducted based on this specifications prepared by the JICA Study Team. However, the Contractor shall propose additional and/or revised survey items and methodologies to the JICA Study Team from local expert's viewpoints and discuss with the JICA Study Team on a survey plan to be prepared in the Inception Report prior to commencement of the Survey.

### (2) Others

To be proposed and conducted, if necessary such as in case of lack of existing data.

## 3.4 Impact Assessment

Regarding the environmental items surveyed, the magnitude and extent of environmental impacts accompanied by the project implementation shall be estimated and evaluated as quantitatively as possible.

## 3.5 Preparation of Environmental Management and Monitoring Plan

The environmental management and monitoring plan (EMMP) with environmental mitigation measures shall be developed and proposed with cost estimation and drawings.

## 3.6 Preparation of EIA Study Report

The EIA Study report shall be prepared with refer to the contents stipulated in the related laws and regulations of Sri Lanka such as the National Environmental Act No.47 of 1980, its amendments, and CEA guidelines on EIA<sup>2</sup>.

## 4. Results of the Survey

The survey was conducted by subcontracting to the Resource Development Consultants Ltd. The full set of the survey report can be available in the SLLRDC office. Part of the survey results, especially collected data, were shown in the following.

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<sup>2</sup> Guidance for Implementing the Environmental Impact Assessment (EIA) Process, CEA, 1998

## Survey Form 1

### Inventory Survey on Households to be Resettled

Survey Date: \_\_\_\_\_

Question Items	Answers																		
1. Serial No. of the settlement <sup>1</sup>																			
2. Name of settlement																			
3. Serial No. of the house <sup>2</sup>																			
4. Address of the house																			
5. Land area occupied by household (m <sup>2</sup> )																			
6. Area occupied by house (m <sup>2</sup> )																			
7. Type of house based on material used (check appropriate <input type="checkbox"/> as <input checked="" type="checkbox"/> )	a) cottage with plank walls: <input type="checkbox"/> b) permanent houses with plank walls: <input type="checkbox"/> c) brick walled one storey: <input type="checkbox"/> d) brick and concrete two storeys: <input type="checkbox"/> e) others ( _____ ): <input type="checkbox"/>																		
8. Description of the house appearance																			
9. Tenure status of land and house (check appropriate <input type="checkbox"/> as <input checked="" type="checkbox"/> )	a) own land and house: <input type="checkbox"/> b) rent land and own house: <input type="checkbox"/> c) rent land and house: <input type="checkbox"/> d) illegal occupancy of land and own house: <input type="checkbox"/> e) others ( _____ ): <input type="checkbox"/>																		
10. In case where household rent land and/or house, how much for rent?	a) land: _____ (Rs./month) b) house: _____ (Rs./month) c) Total: _____ (Rs./month)																		
11. Land status (check appropriate <input type="checkbox"/> as <input checked="" type="checkbox"/> )	a) privately-owned land: <input type="checkbox"/> b) public land b-1) State land: <input type="checkbox"/> b-2) local authority's land: <input type="checkbox"/>																		
12. Any movable properties in the land such as tree (kind and quantity)	<table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 5%;"></th> <th style="width: 70%;">property</th> <th style="width: 25%;">quantity</th> </tr> </thead> <tbody> <tr> <td>a)</td> <td>_____</td> <td>_____</td> </tr> <tr> <td>b)</td> <td>_____</td> <td>_____</td> </tr> <tr> <td>c)</td> <td>_____</td> <td>_____</td> </tr> <tr> <td>d)</td> <td>_____</td> <td>_____</td> </tr> <tr> <td>e)</td> <td>_____</td> <td>_____</td> </tr> </tbody> </table>		property	quantity	a)	_____	_____	b)	_____	_____	c)	_____	_____	d)	_____	_____	e)	_____	_____
	property	quantity																	
a)	_____	_____																	
b)	_____	_____																	
c)	_____	_____																	
d)	_____	_____																	
e)	_____	_____																	
<b>A. Socio-economic Characteristic of the Household</b>																			
13. Number of household member (person)																			

<sup>1</sup> The No. should be consistent with inventory location map.

<sup>2</sup> The No. should be consistent with inventory location map.

14. Member of household (family position, age, main activity such as occupation and school: ex. father, 45, clerk)	<table border="1"> <thead> <tr> <th data-bbox="641 163 986 203">family position</th> <th data-bbox="986 163 1145 203">age</th> <th data-bbox="1145 163 1407 203">activity</th> </tr> </thead> <tbody> <tr><td>(1) _____</td><td>_____</td><td>_____</td></tr> <tr><td>(2) _____</td><td>_____</td><td>_____</td></tr> <tr><td>(3) _____</td><td>_____</td><td>_____</td></tr> <tr><td>(4) _____</td><td>_____</td><td>_____</td></tr> <tr><td>(5) _____</td><td>_____</td><td>_____</td></tr> <tr><td>(6) _____</td><td>_____</td><td>_____</td></tr> <tr><td>(7) _____</td><td>_____</td><td>_____</td></tr> <tr><td>(8) _____</td><td>_____</td><td>_____</td></tr> </tbody> </table>	family position	age	activity	(1) _____	_____	_____	(2) _____	_____	_____	(3) _____	_____	_____	(4) _____	_____	_____	(5) _____	_____	_____	(6) _____	_____	_____	(7) _____	_____	_____	(8) _____	_____	_____
family position	age	activity																										
(1) _____	_____	_____																										
(2) _____	_____	_____																										
(3) _____	_____	_____																										
(4) _____	_____	_____																										
(5) _____	_____	_____																										
(6) _____	_____	_____																										
(7) _____	_____	_____																										
(8) _____	_____	_____																										
15. Main occupation of household heads (check appropriate <input type="checkbox"/> as <input checked="" type="checkbox"/> )	a) Senior official or manager: <input type="checkbox"/> b) Professional: <input type="checkbox"/> c) Technicians or associate professional: <input type="checkbox"/> d) Clerk: <input type="checkbox"/> e) Sales or service worker: <input type="checkbox"/> f) Skilled agriculture or fishery worker: <input type="checkbox"/> g) Unskilled agriculture or fishery worker: <input type="checkbox"/> h) Craft or related worker: <input type="checkbox"/> i) Plant or machine operator or assembler: <input type="checkbox"/> j) Elementary occupation: <input type="checkbox"/> k) Self-employed storekeeper: <input type="checkbox"/> l) Owner farmer: <input type="checkbox"/> m) Unemployed: <input type="checkbox"/> n) others (_____): <input type="checkbox"/>																											
16. Religion (check appropriate <input type="checkbox"/> as <input checked="" type="checkbox"/> )	a) Buddhist: <input type="checkbox"/> b) Hindu: <input type="checkbox"/> c) Christians: <input type="checkbox"/> d) Muslims: <input type="checkbox"/> e) others 1 (_____): <input type="checkbox"/> f) others 2 (_____): <input type="checkbox"/>																											
17. Ethnicity (check appropriate <input type="checkbox"/> as <input checked="" type="checkbox"/> )	a) Sinhalese: <input type="checkbox"/> b) Sri Lankan Tamils: <input type="checkbox"/> c) Indian Tamils: <input type="checkbox"/> d) Sri Lankan Moors: <input type="checkbox"/> e) others 1 (_____): <input type="checkbox"/> f) others 2 (_____): <input type="checkbox"/>																											
18. Income level (Rp./month) (check appropriate <input type="checkbox"/> as <input checked="" type="checkbox"/> )	a) Rs. 1,000 – 3,000: <input type="checkbox"/> b) Rs. 3,000 – 5,000: <input type="checkbox"/> c) Rs. 5,000 – 7,000: <input type="checkbox"/> d) Rs. 7,000 – 9,000: <input type="checkbox"/> e) Rs. 9,000 – 10,000: <input type="checkbox"/> f) over Rs. 10,000: <input type="checkbox"/>																											
<b><u>B. Infrastructure Coverage</u></b>																												
19. Infrastructure served (check appropriate <input type="checkbox"/> as <input checked="" type="checkbox"/> )	a) electricity: <input type="checkbox"/> b) water supply pipe: <input type="checkbox"/> c) well: <input type="checkbox"/> d) individual toilet: <input type="checkbox"/> e) drain pipe: <input type="checkbox"/> f) others (_____): <input type="checkbox"/>																											
<b><u>C. Issues and Demand on Livelihood and Living Environment</u></b>																												
20. Issues on livelihood and living condition																												
21. Demand on livelihood and living environment to improve living condition																												
<b><u>D. Recognition and Opinion on Storm Water Drainage Improvement</u></b>																												

22. Issue on storm water drainage	
23. Demand on storm water drainage	
<b>E. Recognition and Opinion on Environmental Issues</b>	
24. Recognition of environmental issues (check appropriate <input type="checkbox"/> as <input checked="" type="checkbox"/> )	a) water pollution: <input type="checkbox"/> a-1) If any, describe what kind of the issue arise. (_____ a-2) If any, describe opinion on the issue. (_____ b) air pollution: <input type="checkbox"/> b-1) If any, describe what kind of the issue arise. (_____ b-2) If any, describe opinion on the issue. (_____ c) noise: <input type="checkbox"/> c-1) If any, describe what kind of the issue arise. (_____ c-2) If any, describe opinion on the issue. (_____ d) offensive odor: <input type="checkbox"/> d-1) If any, describe what kind of the issue arise. (_____ d-2) If any, describe opinion on the issue. (_____ e) waste/garbage: <input type="checkbox"/> e-1) If any, describe what kind of the issue arise. (_____ e-2) If any, describe opinion on the issue. (_____ f) other issues (_____) : <input type="checkbox"/> f-1) If any, describe what kind of the issue arise. (_____ f-2) If any, describe opinion on the issue. (_____
25. Opinion on water pollution in the canal including waste dumping practice into the canal	
26. Any opinion on environmental issues	
<b>F. Intention on Resettlement</b>	
27. Acceptability (check appropriate <input type="checkbox"/> as <input checked="" type="checkbox"/> )	a) Fully accept: <input type="checkbox"/> b) Accept with condition(s): <input type="checkbox"/> b-1) If so, describe the condition(s). (_____ c) Not Accept <input type="checkbox"/> c-1) If so, describe the reason. (_____
28. Demand and necessary assistance in case of resettlement	
29. Preference to move near present place (check appropriate <input type="checkbox"/> as <input checked="" type="checkbox"/> )	a) Yes: <input type="checkbox"/> b-1) If yes, describe the reason. (_____ b) No: <input type="checkbox"/>

	b-1) If no, describe the reason. (_____)
	c) Does not matter: <input type="checkbox"/>
30. Location desired to move in case of resettlement (check appropriate <input type="checkbox"/> as <input checked="" type="checkbox"/> )	a) Nearby present location: <input type="checkbox"/> b) Does not matter: <input type="checkbox"/> c) Any location, but desired to apply public housing scheme <input type="checkbox"/>

In addition to the above survey items, the following subjects on the communities/community members shall be observed through the field survey.

31. Degree of concern on resettlement with on-site/off-site infrastructure upgrading	
32. Attitude of answer to the questions such as cautiousness to provision of information	
33. Custom and tradition in the community or area	
34. Conceivable issues/risks and necessary countermeasures in implementation of the resettlement	
35. Social features of community/area in addition to the above survey items	

## Survey Form 2

### Inventory Survey on Project-Affected Settlement

Survey Date: \_\_\_\_\_

Question Items	Answers																																	
1. Serial No. of the Settlement <sup>3</sup>																																		
2. Name of settlement																																		
3. Location of settlement																																		
4. Year of settlement established																																		
5. Type of settlement (check appropriate <input type="checkbox"/> as <input checked="" type="checkbox"/> )	a) high income class residential quarters : <input type="checkbox"/> b) middle income class residential quarters: <input type="checkbox"/> c) Under-served settlement (USS) <sup>4</sup> : c-1) Slum <input type="checkbox"/> c-2) Shanty settlement <input type="checkbox"/> c-3) Old low income flats <input type="checkbox"/> c-4) Relocated housing <input type="checkbox"/> c-5) Old deteriorated quarters <input type="checkbox"/> c-6) Unplanned permanent dwellings <input type="checkbox"/> c-7) Walkup apartments <input type="checkbox"/> c-8) Suburban housing estates <input type="checkbox"/> d) others ( _____ ) <input type="checkbox"/>																																	
6. Type of water body near the settlement (check appropriate <input type="checkbox"/> as <input checked="" type="checkbox"/> )	a) canal/river: <input type="checkbox"/> b) lake/pond: <input type="checkbox"/> c) marsh: <input type="checkbox"/> d) others ( _____ ) <input type="checkbox"/>																																	
<b>A. Socio-economic Characteristic</b>																																		
7. Total number of households (residents) including illegal occupants	a) _____ (households) b) _____ (people) c) average household member (=b/c) ): _____																																	
8. Number of household to be resettled by the proposed projects	a) _____ (households) b) _____ (% of total)																																	
9. Population by age (person)	<table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 60%;"></th> <th style="width: 20%; text-align: center;">male</th> <th style="width: 20%; text-align: center;">female</th> </tr> </thead> <tbody> <tr><td>a) 0 – 5 years old:</td><td style="text-align: center;">_____</td><td style="text-align: center;">_____</td></tr> <tr><td>b) 6 – 12 years old:</td><td style="text-align: center;">_____</td><td style="text-align: center;">_____</td></tr> <tr><td>c) 13 – 19 years old:</td><td style="text-align: center;">_____</td><td style="text-align: center;">_____</td></tr> <tr><td>d) 20 – 29 years old:</td><td style="text-align: center;">_____</td><td style="text-align: center;">_____</td></tr> <tr><td>e) 30 – 39 years old:</td><td style="text-align: center;">_____</td><td style="text-align: center;">_____</td></tr> <tr><td>f) 40 – 49 years old:</td><td style="text-align: center;">_____</td><td style="text-align: center;">_____</td></tr> <tr><td>g) 50 – 59 years old:</td><td style="text-align: center;">_____</td><td style="text-align: center;">_____</td></tr> <tr><td>h) 60 – 69 years old:</td><td style="text-align: center;">_____</td><td style="text-align: center;">_____</td></tr> <tr><td>i) over 70 years old:</td><td style="text-align: center;">_____</td><td style="text-align: center;">_____</td></tr> <tr><td>j) Total</td><td style="text-align: center;">_____</td><td style="text-align: center;">_____</td></tr> </tbody> </table>		male	female	a) 0 – 5 years old:	_____	_____	b) 6 – 12 years old:	_____	_____	c) 13 – 19 years old:	_____	_____	d) 20 – 29 years old:	_____	_____	e) 30 – 39 years old:	_____	_____	f) 40 – 49 years old:	_____	_____	g) 50 – 59 years old:	_____	_____	h) 60 – 69 years old:	_____	_____	i) over 70 years old:	_____	_____	j) Total	_____	_____
	male	female																																
a) 0 – 5 years old:	_____	_____																																
b) 6 – 12 years old:	_____	_____																																
c) 13 – 19 years old:	_____	_____																																
d) 20 – 29 years old:	_____	_____																																
e) 30 – 39 years old:	_____	_____																																
f) 40 – 49 years old:	_____	_____																																
g) 50 – 59 years old:	_____	_____																																
h) 60 – 69 years old:	_____	_____																																
i) over 70 years old:	_____	_____																																
j) Total	_____	_____																																

<sup>3</sup> The No. should be consistent with inventory location map.

<sup>4</sup> The classification of the USS used here corresponds to that in the project report of the Clean Settlement Project of the Ministry of Housing and Urban Development with a survey conducted 1998.

10. Number of households by settlement year (household)	a) Less 1 year: _____ b) 1 – 5 years: _____ c) 6 – 10 years: _____ d) 11 – 20 years: _____ e) 21 – 30 years: _____ f) more than 30 years: _____ g) Total: _____
11. Number of households by income groups (household)	a) Rs. 1,000 – 3,000 _____ b) Rs. 3,000 – 5,000 _____ c) Rs. 5,000 – 7,000 _____ d) Rs. 7,000 – 9,000 _____ e) Rs. 9,000 – 10,000 _____ f) over Rp. 10,000 _____ h) Total: _____
12. Number of households under poverty line	_____ (households) _____ (people) _____ (% of total)
13. Number of female-headed households	_____ (households) _____ (% of total households)
14. Number of illegal occupants	_____ (households) _____ (people) _____ (% of total households)
15. Number of household by title of land and house	a) own land and house: _____ b) rent land and own house: _____ c) rent land and house: _____ d) illegal occupancy of land and own house: _____ e) others ( ): _____ f) Total: _____
16. Number of houses by structure type	a) cottage with plank walls: _____ b) permanent houses with plank walls: _____ c) brick walled one storey: _____ d) brick and concrete two storeys: _____ e) others ( ): _____ f) Total: _____
17. Number of business structure by kind ( <u>Location of the structure shall be plotted on the map.</u> )	a) office: _____ b) factory/workshop: _____ c) shop: _____ d) warehouse: _____ e) others ( ): _____ f) Total: _____
18. Number of public facilities by kind located <b>in</b> the settlement ( <u>Location of the public facilities shall be plotted on the map.</u> )	a) hospital/clinic: _____ b) kindergarten: _____ c) school (grade: ): _____ d) meeting place/community house: _____ e) playground/park: _____ f) public office ( ): _____ g) religious facility ( ): _____ h) streetlight: _____ f) library: _____

19. Number of public facilities by kind located <b>near</b> the settlement and used by residents in the settlement <u>(Location of the public facilities shall be plotted on the map.)</u>	a) hospital/clinic: _____ b) kindergarten: _____ c) school (grade: _____): _____ d) meeting place/community house: _____ e) playground/park: _____ f) public office ( _____): _____ g) religious facility ( _____): _____ h) streetlight: _____ f) library: _____																																																			
20. Number of other kind of structure affected <u>(Location of the public facilities shall be plotted on the map.)</u>	a) ( _____): _____ b) ( _____): _____ c) ( _____): _____ d) Total: _____																																																			
21. Religious population rate	a) Buddhist: _____% b) Hindu: _____% c) Christians: _____% d) Muslims: _____% e) others 1 ( _____): _____% f) others 2 ( _____): _____% Total: 100 %																																																			
22. Ethnicity of household heads	a) Sinhalese: _____% b) Sri Lankan Tamils: _____% c) Indian Tamils: _____% d) Sri Lankan Moors: _____% e) others 1 ( _____): _____% f) others 2 ( _____): _____% Total: 100 %																																																			
23. Main occupation of household heads	<table border="0" style="width: 100%;"> <thead> <tr> <th style="width: 80%;"></th> <th style="text-align: center;">household numbers</th> <th style="text-align: center;">% of total</th> </tr> </thead> <tbody> <tr><td>a) Senior official or manager:</td><td>_____</td><td>_____%</td></tr> <tr><td>b) Professionals:</td><td>_____</td><td>_____%</td></tr> <tr><td>c) Technicians or associate professionals:</td><td>_____</td><td>_____%</td></tr> <tr><td>d) Clerks:</td><td>_____</td><td>_____%</td></tr> <tr><td>e) Sales or service workers:</td><td>_____</td><td>_____%</td></tr> <tr><td>f) Skilled agriculture or fishery workers:</td><td>_____</td><td>_____%</td></tr> <tr><td>g) Unskilled agriculture or fishery workers:</td><td>_____</td><td>_____%</td></tr> <tr><td>h) Craft or related workers:</td><td>_____</td><td>_____%</td></tr> <tr><td>i) Plant or machine operators or assemblers:</td><td>_____</td><td>_____%</td></tr> <tr><td>j) Elementary occupation:</td><td>_____</td><td>_____%</td></tr> <tr><td>k) Self-employed storekeeper:</td><td>_____</td><td>_____%</td></tr> <tr><td>l) Owner farmer:</td><td>_____</td><td>_____%</td></tr> <tr><td>m) Unemployed:</td><td>_____</td><td>_____%</td></tr> <tr><td>n) others1 ( _____):</td><td>_____</td><td>_____%</td></tr> <tr><td>o) others2 ( _____):</td><td>_____</td><td>_____%</td></tr> <tr><td>p) Total</td><td>_____</td><td>100 %</td></tr> </tbody> </table>		household numbers	% of total	a) Senior official or manager:	_____	_____%	b) Professionals:	_____	_____%	c) Technicians or associate professionals:	_____	_____%	d) Clerks:	_____	_____%	e) Sales or service workers:	_____	_____%	f) Skilled agriculture or fishery workers:	_____	_____%	g) Unskilled agriculture or fishery workers:	_____	_____%	h) Craft or related workers:	_____	_____%	i) Plant or machine operators or assemblers:	_____	_____%	j) Elementary occupation:	_____	_____%	k) Self-employed storekeeper:	_____	_____%	l) Owner farmer:	_____	_____%	m) Unemployed:	_____	_____%	n) others1 ( _____):	_____	_____%	o) others2 ( _____):	_____	_____%	p) Total	_____	100 %
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25. No. of houses located in riverside land	_____ (houses) _____ (% of total)																																																			



26. No. of houses frequently inundated in flood season	_____ (houses) _____ (% of total) _____ (average days of inundation) _____ (depth of inundation (cm))
<b><u>B. Current Condition of Infrastructure in the Settlement</u></b>	
27. Road condition (check appropriate <input type="checkbox"/> as <input checked="" type="checkbox"/> )	a) good with asphalt-paved road <input type="checkbox"/> b) fair with gravel-paved road <input type="checkbox"/> c) bad without any pavement <input type="checkbox"/> d) others ( _____ ) <input type="checkbox"/>
28. Drainage facility and operational condition (check appropriate <input type="checkbox"/> as <input checked="" type="checkbox"/> )	a) good with regular maintenance <input type="checkbox"/> b) fair with irregular maintenance <input type="checkbox"/> c) bad without any maintenance <input type="checkbox"/> d) others ( _____ ) <input type="checkbox"/>
29. Number of house by type of latrine	a) household type: _____ b) community type: _____ c) others ( _____ ): _____
30. Percentage of houses by type of water supply	a) water supply to individual house: _____ % b) use of community water supply: _____ % c) others ( _____ ): _____ %
31. Percentage of houses by connection of sewerage system	a) connected: _____ % b) non-connected: _____ % Total: 100%
32. Operation condition of the sewerage (in the case where there is sewerage connection)	a) Good: _____ % b) Fair: _____ % c) No maintenance: _____ % Total: 100%
33. Deposit method of solid waste (check appropriate <input type="checkbox"/> as <input checked="" type="checkbox"/> )	a) direct dumping nearby: <input type="checkbox"/> b) direct dumping into canal: <input type="checkbox"/> c) regular collection by Local Authority: <input type="checkbox"/> d) irregular collection by Local Authority: <input type="checkbox"/> e) others: <input type="checkbox"/> ( _____ )
34. Number of household by type of treatment of domestic wastewater (check appropriate <input type="checkbox"/> as <input checked="" type="checkbox"/> )	a) septic tank: <input type="checkbox"/> b) sewerage system: <input type="checkbox"/> c) seepage: <input type="checkbox"/> d) vacuum vehicle: <input type="checkbox"/> e) direct/indirect discharge into canal: <input type="checkbox"/> f) others ( _____ ): <input type="checkbox"/>
35. Transportation commonly used (check appropriate <input type="checkbox"/> as <input checked="" type="checkbox"/> , and put order by frequency)	Order a) public bus: <input type="checkbox"/> _____ b) mini-bus taxi: <input type="checkbox"/> _____ c) train: <input type="checkbox"/> _____ d) taxi: <input type="checkbox"/> _____ e) privately-owned car: <input type="checkbox"/> _____ f) others ( _____ ): <input type="checkbox"/> _____
<b><u>C. Community Activity</u><sup>5</sup></b>	
36. General activities	
37. Operation and maintenance activities for community infrastructure (check appropriate <input type="checkbox"/> as <input checked="" type="checkbox"/> )	a) community drain <input type="checkbox"/> b) others ( _____ ) <input type="checkbox"/>

<sup>5</sup> The term of “community” here does not only mean a unit of neighborhoods based on their formal/informal linkages, but also areal unit even without formal/informal communication among neighborhoods.

38. Participation of the activities by people (check appropriate <input type="checkbox"/> as <input checked="" type="checkbox"/> )	a) high participation rate <input type="checkbox"/> b) middle participation rate <input type="checkbox"/> c) low participation <input type="checkbox"/>
39. Community center and facility	a) type of facility: _____ b) outline specification of the facility: _____ d) conceivable impact to the facilities: _____
<b><u>D. Community Based Organization (CBO)</u></b> <sup>8</sup>	
40. Name of CBO	
41. Past and on-going activities	
42. Existing of Community Development Council in the settlement (check appropriate <input type="checkbox"/> as <input checked="" type="checkbox"/> )	a) yes <input type="checkbox"/> b) no <input type="checkbox"/>

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<sup>8</sup> The following questions related to the CBO shall be asked in the case where the CBO has already been organized in the settlement.

## **B. WATER QUALITY AND BOTTOM SEDIMENT SAMPLING SURVEY**

### **1. General**

Under the EIA study, water quality testing and bottom sediment analysis were carried out to assess the present water quality in the project area and extent of contamination of the bottom sediments in the canals proposed for improvements.

The water sampling has been carried out at 12 locations. The first sampling (Stage I) was carried out on 15-08-2002 and 21.08.2002 and second sampling (Stage II) on 06-09-2002. The bottom sediment sampling and testing were also carried out at the same locations, except Location no 7, which has been moved to downstream of Elawella road in the Bolgoda canal. The bottom sediment sampling extracting was completed on 12-09-2002.

The samples were collected and brought to the laboratory in accordance with the standard practice. The samples preservation was also carried out according to the standard methods in order to preserve the quality.

The testing of the samples was done at the Environmental Engineering laboratory of the University of Moratuwa under the supervision of the Water Quality Analyst.

### **2. Sampling Locations**

The locations of sampling points for water quality and bottom sediments testing are given in **Table 1** with description and coordinates established with Global Positioning System (GPS).

### **3. Existing Water Quality in the Project Area**

The general parameters and values of parameters tested in respect of 12 sampling locations are for Stage I, given in **Tables 2** and **3**. The same results for Stage II are given in **Tables 4** and **5**.

### **4. Analysis of Water Quality**

The suitability of water quality at each of the locations compared with the CEA standards are given in **Tables 6** and **7** for Stage I, and that for Stage II are given in **Tables 8** and **9**.

**Table 1 Sampling Locations Description and the Coordinates**

Sampling Location	Coordinates of each point		Features in the vicinity
	N	E	
WG L 1	06° 47.700'	9° 54.295'	Kospalana Bridge, Piliyandala
WG L 2	06° 48.138'	79° 54.031'	Culvert on Mola (Mill) Road
WG L 3	06° 48.470	79° 53.678'	At Thelawala Rd.,(Culvert)
WG L 4	06° 49.104	79° 53.917'	Borupana Bridge
WG L 5	06° 48.852	79° 54.123'	Culvert on Gravel road to the right of Borupana Bridge (from Galle Road)
WG L 6	06° 49.275	79° 53.644'	Inside the National Institute of Technology Education (NITE), (Culvert)
#↓ WG L 7	06° 49.745	79° 53.270'	At Attidiya Rd, Gamunu Mawatha, a Small Play Ground
WG L 8	06° 50.465	79° 53.589'	Bellanwila
WG L 9	06° 50.626	79° 53.495'	Bellanwila, Small Bridge
WG L 10	06° 50.686	79° 53.072'	Attidiya, near Bridge construction site
WG L 11	06° 51.524	79° 53.635'	Rattanapitiya, Udyana Rd. Play Ground
WG L 12	06° 51.086	79° 53.859'	Old Kesbewa Rd, Culvert At the point where Canal Crosses the road.

#↓ The bottom sediment sampling locations are the same, except, location no. WGL7 moved to downstream of Elawella Road in Bolgoda canal

## 5. Water Quality – General Observations

The first set of samples was collected under dry weather conditions, while the second set of samples were collected in a rainy period, although there was no rain on the day of sampling.

The samples collected from locations WG-L1 and WG-L3 have very high conductivity (>25,000  $\mu\text{S}/\text{m}$ ), which indicates that the water is saline. This may be due to intrusion of seawater from the Panadura Ganga, at these two locations.

Location WG –L1 is at Kospalana Bridge on the Bolgoda Lake, which is known to have tidal effects.

WG-L3 is in the canal discharging into the Bolgoda Lake on Thelawala Road, Ratmalana. It appears that the salt-water intrusion is happening in this canal too.

Comparing with the proposed standards for inland water quality for designated water uses, it can be observed that the present water quality in any of the canals sampled is not suitable for any of the designated water uses. This is due to the pollution of the canal water by the domestic and industrial wastewater discharges, as indicated in Table 4. As mentioned elsewhere in this report, there is low-income housing located in most of the canal reservations. Many of these do not have proper sanitation, and even

where toilets are available, the other wastewater is directed into the canals for disposal. That is the reason for high BOD and COD values at all the locations. In addition, it was noted that canals at locations L3, L6, L7 and L12 receive wastewater from industries, such as garment washing and metal finishing.

However, the water at WG-L1 is suitable for bathing, fish & aquatic life, drinking water with conventional treatment, and irrigation & agriculture with respect to all the parameters other than BOD & COD, while the water quality at WG-L3 is suitable for bathing, fish & aquatic life, irrigation & agriculture and other uses with respect to all the parameters other than pH, BOD & COD values.

Samples collected from locations WG-L6 and WG-L7 show that they are highly contaminated with Faecal pollution. This water is not suitable even for bathing or irrigation purposes. It is in a highly polluted status, with respect to BOD & COD too. Immediate corrective action needs to be taken to direct the sewage inflows from houses in these areas away from the canal. A survey has to be done to find out if the factories in this area are discharging the toilet waste into the canals too, and immediate corrective action needs to be taken.

Locations WG-L5, WG-L9, WG-L10 & WG-L12 are also having moderate amounts of total and Faecal Coliforms, which indicates contamination by sewage. While WG-L3 is located in an area where industries are present; the other areas are polluted mainly by domestic sewage.

Comparison of the canal water with the proposed CEA Standards for Coastal Water Quality also shows that the water quality at all locations sampled is below these standards too.

At locations WG L6 and WG L7 significant odour was present on both days of sampling and the water was stagnant. It was not possible to insert the secchi disk to measure the transparency, or the depth of water due to the heavy growth of aquatic plants (mainly water hyacinth) at location WG L6 & L7. The very high concentrations of Ammonia in WG L7 show that the odour must be due to the ammonia gas emitted.

The water at location L3 has a very high pH, which shows that some caustic chemical substance is available in this water. Natural waters are not expected to have pH > 8.3 (only carbonate & bicarbonate alkalinity). The source of caustic alkalinity is most likely the garment washing industries in this area.

WG L5 and WG L11 have excessive colour, ( $\geq 100$  Hazen Units). Near both these locations there are solid waste dumping yards, which are not provided with any leachate collector/ prevented facilities. The high colour is likely to be due to the leachate that would be draining in to the canals.

The colour at WG L3 could not be measured using colour disks, as the samples were of a dark blue colour. The Dissolved Oxygen content in samples at locations WG L2, WG L6, WG L7, WG L8, WG L9, WG L11 & WG L12 are less than 2 mg/l.

## 6. Results of Chemical Composition of Bottom Sediments

The results of bottom sediment analysis for metals are given in **Table 10** and sulphates, chlorides and organic contents are given in **Table 11**.

## 7. Analysis of Chemical Composition of Bottom Sediments

The analysis of bottom sediment samples as per standard for Rotterdam, Netherlands is given in **Table 12** based on a classification system given in **Table 13**.

## 8. General Observations on Bottom Sediment Chemical Composition

The comparisons are done based on the standards available for Rotterdam, Netherlands, criteria for use of contaminated soil in England & Canada.

The heavy metals Cd, Cr, Cu, Pb, Ni are the substances that are compared with the standards as those are the available ones in the standards.

Sediments at locations WG L2, WG L3, WG L6 & WG L11 are lightly polluted with respect to heavy metals. Organic content in these locations is also not excessive. Chloride content in these samples is also within the intermediate limit level for beneficial use.

Therefore disposal of dredged material is not likely to cause any harm to the environment. Disposal sites may be used for recreation purposes after stabilization. (*Ref: criteria for use of contaminated soil in England & Canada*)

Stabilization is done to immobilize contaminants, making them resistant to losses by leaching. After material is dredged from a canal, it must be placed on to a containment area that will facilitate the efficient dewatering of the material. Then the material can be placed at required places where filling has to be carried out. Then a proper cover of a suitable soil can be placed on top of it. The permeability of the soil that is selected, as the top cover is most important as cover system is largely intended to retard the inflow of water.

Sediments at locations WG L1, WG L4, WG L5, WG L7, WG L8, WG L9 & WG L10 have Ni concentrations in excess of the test level according to the Netherlands Classification.

These high Ni concentrations are to be expected because there are several metal plating industries in the Ratmalana area, and the wastewater discharged into the canals would contain Nickel compounds. Some of these may be suspensions, which are deposited at low flow locations and some may come out of solution at downstream locations, due to variations in pH or other chemical or biochemical reactions. Therefore they should be categorized as moderately contaminated.

Heavy metals are virtually immobile in undisturbed sediments and as such it is safer for the environment if these sediments are not removed. If it is to be dredged and disposed off on land, then the leachate test has to be carried out to study the suitability of the filled land for beneficial uses.

Dumping of the dredged material in water is not recommended, as the heavy metals are likely to be mobilized.

Sediments at locations WG L1, WG L4 & WG L5 have organic content higher than 10 % which indicates biodegradability.

Sediments at locations WG L8 & WG L9 also have high chloride contents too. Concentration of substances, Fe, Al & Mg are high in all the locations. Those values couldn't be compared, as no standards are available.

## 9. General Observations on Sieve/Hydrometer Analysis

The hydrometer and sieve analysis was carried out for the 11 sampling locations for bottom sediments. The testing was not possible for the sample WG-L2, as it contained much of roots, polythene pieces and waste.

Sediments at locations WG L1, WG L4, WG L5, WG L8 & WG L11 contains a larger percentage of particles which are lesser than size of 0.075 mm. As the finer particle content is much greater at these locations, there is a greater tendency to get the finer particles washed away hence siltation at down stream. Thus dredging in those locations should be avoided during rainy periods, where the flow velocities in the canals would be significant.

Sediments at locations WG L6, WG L9, WG L10 & WG L12 are having moderate amount of particles with a size lesser than 0.075 mm. So the siltation at downstream is possible to a certain extent. Dredging activities in those locations too should be limited to dry periods.

Sediments at locations WG L3 & WG L7 contains a very low percentage of particles with a size lesser than 0.075 mm. Hence there would be no siltation occurring downstream. So dredging activities can be carried out in either period.

If the dredged material is to be used for Land filling, the clay fraction becomes an important parameter as higher clay content would result in higher consolidation and settling effects in the long term. Thus dredged material from locations WG L1, WG L4, WG L5 & WG L8 having higher clay fraction (> 5%) should be used carefully in land filling.

Clay fractions of sediments at WG L6, WG L9, WG L10 & WG L11 are in moderate state. Therefore if the dredging materials at these locations are going to be used for land filling, it is desirable to take necessary action to overcome the possible effect on settlements.

Clay fractions of sediments at WG L3, WG L7 & WG L12 are very low. So there will be no considerable effect of settlements in the case of using dredged material for land filling.

Sieve Analysis / Hydrometer Analysis couldn't be carried out for the sample, WG L2 as it contained much of roots, polythene pieces and waste.

**Table 2 General data of water samples – Stage I**

Location	Date/ Time	Air Temp. ( <sup>0</sup> C)	Transparency Secchi Depth (m)	Depth ( m )	Approx. Water Flow (m <sup>3</sup> s <sup>-1</sup> )	Odour	Main Sources of likely pollution
WG- L 1	15/08/2002 8.40 a.m.	29.2	0.70	1.30	14	Odour less	Domestic waste
WG- L 2	15/08/2002 9.30 a.m.	29.7	0.70	1.00	Stagnant	Odour less	Domestic waste
WG- L 3	15/08/2002 9.50 a.m.	31.4	0.10	0.10	Stagnant	Odour less	Industrial + Domestic waste
WG- L 4	15/08/2002 10.20 a.m.	30.3	0.91	1.40	2	Odour less	Domestic waste
WG- L 5	21/08/2002 8.40 a.m.	25.4	0.89	0.89	Stagnant	Odour less	Domestic waste
WG- L 6	15/08/2002 11.05 a.m.	31.3	0.5	0.5	Stagnant	Significant Odour was Detected	Industrial + Domestic waste
WG- L 7	15/08/2002 11.40 a.m.	31.3	N/M	N/M	Stagnant	Significant Odour was Detected	Industrial + Domestic waste
WG- L 8	15/08/2002 12.20 p.m.	32.6	N/M	N/M	Stagnant	Odour less	Domestic waste
WG- L 9	15/08/2002 12.30 p.m.	31.9	N/M	N/M	Stagnant	Odour less	Domestic waste
WG- L 10	21/08/2002 9.25 a.m.	26.2	0	1.25	Stagnant	Odour less	Domestic waste
WG- L 11	15/08/2002 1.20 p.m.	33.7	0	0.75	0.5	Odour less	Domestic waste
WG- L 12	15/08/2002 1.00 p.m.	31.0	0.5	0.5	0.5	Odour less	Industrial + Domestic waste (Sewage)

N/M - Not Measured (The Secchi disk could not be inserted to measure the transparency and depth as there were lot of aquatic plants grown at these locations)



**Table 3 Results of Water Quality Testing-Stage 1 (weather – dry, warm)**

Location	Parameter												
	Temperature (°C)	PH	Colour (Hazen Units)	Dissolved Oxygen (mg / l)	Conductivity (µs / cm)	Total Suspended Solids (mg / l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	NH <sup>4+</sup> - N (mg / l)	Total N (mg / l)	Total P (mg / l)	Total Coliforms (MPN / 100 ml)	Faecal Coliforms (MPN / 100 ml)
WG-L1	29.8	7.43	10	5.0	35800	15.5	20	33.28	0.333	3.80	< 0.010	130	40
WG-L2	27.7	6.37	20	0.9	1234	6.2	22	33.28	4.000 *	6.68	0.004	170	40
WG-L3	30.4	11.68	-	-	25700	59.6	200	615.68	-	6.31	0.166	40	20
WG-L4	29.6	6.65	20	4.9	3900	2.9	16.5	58.8	0.167	4.12	0.002	220	70
WG-L5	22.0	5.89	120	2.1	2900	2.4	11.5	16.32	0.167	3.80	0.001	300	130
WG-L6	28.5	4.59	70	0.4	885	23.4	610	1159.2	0.835	8.26	0.011	24000	2200
WG-L7	31.2	6.53	20	0.8	1710	8.7	145	407.7	>5.004 *	5.86	0.011	17000	2200
WG-L8	28.5	6.56	15	1.1	3300	2.7	85	141.4	2.170 *	6.48	0.028	220	70
WG-L9	28.1	6.46	50	0.8	964	12.3	64.5	109.2	4.335 *	9.28	0.030	800	140
WG-L10	24.3	7.10	40	2.9	1821	9.0	42.5	57.1	3.670 *	3.23	0.016	10000	340
WG-L11	30.7	6.28	100	1.9	1497	13.5	90	158.1	3.335 *	6.95	0.071	130	20
WG-L12	29.7	6.60	15	0.8	1234	3.8	71.5	117.6	3.000 *	4.99	0.085	10000	170

\* - Determined after dilution Maximum measurable NH<sub>4</sub><sup>+</sup> value (without dilution) = 1.668 mg / l

(-) The colour plates measures the natural color of water samples in Hazen. WG-L3 was contaminated with dyes (effluents from factories), hence its color was due to dissolved particles. Therefore the colour and color changes in titration for dissolved oxygen was unable to detect.

**Table 4 General data of water samples– Stage II**  
 (weather–rained on previous day, cooler)  
 Rainfall on 5-09-2002 – 10.2 mm, (Source Dept of Meteorology)

Location	Date/ Time	Air Temp ( <sup>o</sup> C)	Transparency Secchi Depth (m)	Depth (m)	Approx. Water Flow (m <sup>3</sup> s <sup>-1</sup> )	Odour	Main Sources of likely pollution
WG- L 1	06/09/2002 - 10.00 a. m.	29.5	1.00	1.40	15	Odour less	Domestic waste
WG- L 2	06/09/2002 - 10.40 a. m.	30.7	0.90	1.15	Stagnant	Odour less	Domestic waste
WG- L 3	06/09/2002 - 11.15 a. m.	31.4	0.10	0.10	Stagnant	Odour less	Industrial + Domestic waste
WG- L 4	06/09/2002 - 11.40 a.m.	32.5	0.79	1.30	2	Odour less	Domestic waste
WG- L 5	06/09/2002 - 12.20 p. m.	34.0	0.75	0.75	Stagnant	Odour less	Domestic waste
WG- L 6	06/09/2002 - 1.10 p. m.	32.0	0.55	0.55	Stagnant	Significant Odour was Detected	Industrial + Domestic waste
WG- L 7	06/09/2002 - 1.40 p. m.	34.8	N/M	N/M	Stagnant	Significant Odour was Detected	Industrial + Domestic waste
WG- L 8	06/09/2002 - 3.00 p. m.	35.2	N/M	N/M	Stagnant	Odour less	Domestic waste
WG- L 9	06/09/2002 - 2.45 p. m.	33.2	N/M	N/M	Stagnant	Odour less	Domestic waste
WG- L 10	06/09/2002 - 2.00 p.m.	33.9	0	1.35	Stagnant	Odour less	Domestic waste
WG- L 11	06/09/2002 - 3.35 p.m.	31.9	0	0.70	0.5	Odour less	Domestic waste
WG- L 12	06/09/2002 - 3.10 p. m.	32.4	0.60	0.70	0.5	Odour less	Industrial + Domestic waste (Sewage)

N/M - Not Measured (The Secchi disk could not be inserted to measure the transparency and depth as there were lot of aquatic plants grown at these locations)

**Table 5 Results of Water Quality Testing-Stage II**

Location	Parameter												
	Temperature (°C)	pH	Colour (Hazen Units)	Dissolved Oxygen (mg / l)	Conductivity (µs / m)	Total Suspended Solids (mg / l)	Biochemical Oxygen Demand (mg/l)	Chemical Oxygen Demand (mg/l)	NH <sup>4+</sup> - N (mg / l)	Total N (mg / l)	Total P (mg / l)	Total Coliforms (MPN / 100 ml)	Faecal Coliforms (MPN / 100 ml)
WG-L1	31.5	7.89	10	5.6	50300	12.8	29.5	220.0	0.25	4.957	0.015	170	40
WG-L2	28.3	6.40	30	1.2	7000	7.2	27.5	67.2	2.67 *	7.640	0.200	340	40
WG-L3	32.7	11.2	-	-	1401	35.8	110	460.0	-	6.199	0.723	300	70
WG-L4	30.0	6.70	10	5.2	2200	2.5	43.0	106.4	0.165	3.830	0.018	800	90
WG-L5	30.3	6.80	100	3.1	14500	2.7	58.0	121.6	0.250	3.637	0.010	800	70
WG-L6	28.7	5.54	90	0.9	794	19.6	74.0	326.4	1.000	8.158	0.026	35000	14000
WG-L7	32.5	6.58	20	1.6	1420	9.9	215.0	258.4	>5.004 *	8.229	0.063	90000	14000
WG-L8	29.1	6.52	20	4.2	3400	3.1	95.0	281.2	2.000 *	11.517	0.027	500	110
WG-L9	28.4	6.52	60	1.3	1094	13.8	23.0	28.8	4.335 *	8.048	0.012	800	110
WG-L10	32.5	7.74	40	1.1	1618	6.2	90.0	182.4	3.335 *	5.607	0.020	900	130
WG-L11	31.1	6.50	70	2.3	1325	11.3	105.0	136.8	3.335 *	4.732	0.015	800	110
WG-L12	31.2	6.59	20	4.8	902	19.8	95.0	136.8	3.000 *	4.449	0.020	14000	110

\* - Determined after dilution

Maximum measurable NH<sub>4</sub><sup>+</sup> value (without dilution) = 1.668 mg / l

**Table 6 Suitability of Water at Different Locations for Different Designated Uses, According to Proposed Inland Water Quality Standards of CEA -Stage 1**

PARAMETER	WG L1	WG L2	WG L3	WG L4	WG L5	WG L6	WG L7	WG L8	WG L9	WG L10	WG L11	WG L12
PH	all	All	none	all	7	none	all	all	all	all	all	all
Dissolved Oxygen ( mg/l )	3,4,5,6,7	none	N/M	3,4,5,6,7	none	none	none	none	none	none	none	4,5,6,7
Conductivity (µS / m)	all	All	all	all	all	all	all	all	all	all	all	all
COD (mg / l)	7	7	none	none	3,5,7	none	none	none	none	none	none	none
BOD <sub>5</sub> <sup>20</sup>	none	none	none	none	none	none	none	none	none	none	none	none
NH <sub>4</sub> <sup>+</sup> - N	all	2,3,5,6,7	N/M	all	all	all	2,3,5,6	2,3,5,6,7	2,3,5,6,7	2,3,5,6,7	2,3,5,6,7	2,3,5,6,7
Total P (mg / l)	all	All	all	all	all	all	all	all	all	all	all	all
Total Coliform in 100 ml	all	All	all	all	all	none	4	all	all	4	all	4
Faecal Coliform in 100 ml	all	All	all	2,4,5,6,7	2,4,5,6,7	4,5,6,7	4,5,6,7	2,4,5,6,7	2,4,5,6,7	2,4,5,6,7	all	2,4,5,6,7

**Designated Water Uses:**

- |                                                            |                                                |
|------------------------------------------------------------|------------------------------------------------|
| 1 – Nature Conservation                                    | 5 – Drinking water with conventional treatment |
| 2 – Drinking water with simple treatment                   | 6 – Irrigation & agriculture                   |
| 3 - Bathing                                                | 7 - Minimum Quality (other uses)               |
| 4 – Fish & Aquatic life                                    |                                                |
| All - Suitable for all purposes except nature conversation |                                                |
| None - Not suitable for any purpose                        |                                                |
| N/M - Not measured                                         |                                                |

**Table 7 Suitability of Water at Different Locations According to Coastal Water Quality Standards of CEA, Stage I**

PARAMETER	WG L1	WG L2	WG L3	WG L4	WG L5	WG L6	WG L7	WG L8	WG L9	WG L10	WG L11	WG L12
Colour	4	4	4	4	4	4	4	4	4	4	4	4
Temperature ( ° C )	all	all	all	all	all	all	all	all	all	all	all	all
Transparency	none	none	2,3,4	none	2,3,4	all	N/M	N/M	N/M	2,3,4	2,3,4	2,3,4
PH	2,3,4	none	none	4	none	none	4	4	none	2,3,4	none	4
Dissolved Oxygen ( mg/l )	4	none	-	4	none	none	none	none	none	none	none	none
TSS (mg / l)	4	4	4	4	4	4	4	4	4	4	4	4
BOD <sub>5</sub> <sup>20</sup>	none	none	none	none	none	none	none	none	none	none	none	none
NH <sub>4</sub> <sup>+</sup> - N	2,3,4	none	-	2,3,4	2,3,4	4	none	none	none	none	none	none
Total N (mg / l)	none	2,3,4	2,3,4	none	none	2,3,4	2,3,4	2,3,4	2,3,4	none	2,3,4	none
Total P (mg / l)	none	none	2,3,4	none	none	none	none	none	none	none	2,3,4	2,3,4
Total Coliform in 100 ml	3,4	3,4	3,4	3,4	3,4	none	none	3,4	3,4	none	3,4	none
Faecal Coliform in 100 ml Faecal Coliform in 100 ml	3,4	3,4	3,4	3,4	3,4	none	none	3,4	3,4	4	3,4	3,4

Designated Water Uses

1 – Nature Conservation 2 – Fishery of Shell Fish 3 – Fishery of Fin Fish 4 – Non Consumption

All - Suitable for all purposes except nature conversation

None - Not suitable for any purpose

N/M - Not measured

**Table 8 Suitability of Water at Different Locations for Different Designated Uses, According to Proposed Inland Water Quality Standards of CEA- Stage II**

PARAMETER	WG L1	WG L2	WG L3	WG L4	WG L5	WG L6	WG L7	WG L8	WG L9	WG L10	WG L11	WG L12
PH	all	all	none	all	all	7	all	all	all	all	all	all
Dissolved Oxygen ( mg/l)	all	none	-	all	4,6,7	none	none	3,4,5,6,7	none	none	none	4,5,6,7
Conductivity (µS / m)	all	all	all	all	all	all	all	all	all	all	all	all
COD (mg / l)	none	none	none	none	none	none	none	none	5,6,7	none	none	none
BOD <sub>5</sub> <sup>20</sup>	none	none	none	none	none	none	none	none	none	none	none	none
NH <sub>4</sub> <sup>+</sup> - N	all	2,3,5,6,7	-	all	all	2,3,5,6,7	2,3,5,6	2,3,5,6,7	2,3,5,6,7	2,3,5,6,7	2,3,5,6,7	2,3,5,6,7
Total P (mg / l)	all	all	none	all	all	all	all	all	all	all	all	all
Total Coliform in 100 ml	all	all	all	all	all	none	none	all	all	all	all	none
Faecal Coliform in 100 ml	all	all	2,4,5,6,7	2,4,5,6,7	2,4,5,6,7	4,5,6,7	4,5,6,7	2,4,5,6,7	2,4,5,6,7	2,4,5,6,7	2,4,5,6,7	2,4,5,6,7

Designated Water Uses:

- 1 – Nature Conservation
- 2 – Drinking water with simple treatment
- 3 - Bathing
- 4 – Fish & Aquatic life

- 5 – Drinking water with conventional treatment
- 6 – Irrigation & agriculture
- 7 - Minimum Quality (other uses)

- All – Suitable for all the purposes except nature conservation
- None – Not suitable for any purpose
- N/M – Not measured

**Table 9 Suitability of Water at Different Locations According to Coastal Water Quality Standards of CEA, Stage II**

PARAMETER	WG L1	WG L2	WG L3	WG L4	WG L5	WG L6	WG L7	WG L8	WG L9	WG L10	WG L11	WG L12
Colour	4	4	4	4	4	4	4	4	4	4	4	4
Temperature ( ° C )	1,2,3,4	all	none	all	all	all	none	all	all	none	all	all
Transparency	none	none	all	none	all	all	-	-	-	all	all	none
PH	all	none	none	4	4	none	4	4	4	all	4	4
Dissolved Oxygen ( mg/l )	3,4	none	N/M	3,4	none	none	none	4	none	none	none	4
TSS (mg / l)	4	4	4	4	4	4	4	4	4	4	4	4
BOD <sub>5</sub> <sup>20</sup>	none	none	none	none	none	none	none	none	none	none	none	none
NH <sub>4</sub> <sup>+</sup> - N	all	none	N/M	all	all	4	none	none	none	none	none	none
Total N (mg / l)	none	all	all	none	none	all	all	all	all	all	none	none
Total P (mg / l)	none	all	all	none	none	none	all	none	none	none	none	none
Total Coliform in 100 ml	3,4	3,4	3,4	3,4	3,4	none	none	3,4	3,4	3,4	3,4	none
Faecal Coliform in 100 ml	3,4	3,4	3,4	3,4	3,4	none	none	3,4	3,4	3,4	3,4	3,4

Designated Water Uses:

- 1 – Nature Conservation
- 2 – Fishery of Shell Fish

- 3 – Fishery of Fin Fish
- 4 – Non Consumption  
(Products not suitable for consumption)

- All - Suitable for all purposes except nature conversation
- None - Not suitable for any purpose
- N/M - Not measured

**Table 10 Metal Levels**

Substance	WG L1	WG L2	WG L3	WG L4	WG L5	WG L6	WG L7	WG L8	WG L9	WG L10	WG L11	WG L12
Cr	32.9	27.0	41.5	33.4	22.1	15.2	42.1	41.7	44.4	35.7	67.0	41.9
Cd	3.8	3.4	2.3	3.9	3.7	3.3	3.4	3.1	3.6	3.6	4.2	4.2
Cu	38.4	77.3	11.5	36.7	26.3	11.7	40.8	42.2	44.1	22.8	25.0	35.2
Ni	63.6	32.7	19.8	82.9	75.3	34.2	78.6	57.7	61.3	55.7	33.4	40.2
Pb	48.0	54.7	41.7	50.6	53.6	36.5	29.5	53.9	46.4	60.1	61.4	90.7
Fe	>40000	35764	14936	>40000	38620	14252	40000	40000	34656	13880	>40000	36372
Co	24.9	9.1	2.8	16.7	14.3	N/D	N/D	10.6	13.9	9.8	6.7	8.3
Ag	7.7	8.7	6.9	5.7	5.7	5.8	7.7	6.6	7.3	7.7	5.8	6.1
Al	33030	7656	1704	12884	1974	48736	111836	106296	13772	1578	986.9	Error
Mn	231.8	72.9	59.9	66.1	81.6	80.9	202.7	299.6	191.5	125.9	288.9	149.5
Mg	8352	75276	36408	78148	5452	25728	46348	49868	47804	47264	76412	49272
Na	3954	3030	882	1756	2100	492	848	1696	868	568	532	1540
K	2608	2248	756	2796	2820	1420	2264	2648	2384	2940	2804	2228

*All levels are in mg/ kg dry weight ,*

N/D - Below the detection limit

Note: "error" means orAlatWG-L12 was due to instrumental error



**Table 11 Results of Other Parameters**

Location	Parameter		
	Sulphates (% dry weight)	Chlorides (% dry weight)	Organic Content (% dry weight)
WG L1	0.27	0.35	10.7374
WG L2	0.28	0.06	5.0711
WG L3	0.04	0.04	0.5178
WG L4	0.13	0.07	10.8594
WG L5	0.50	0.09	15.3088
WG L6	0.02	0.02	3.8078
WG L7	0.06	0.06	4.9207
WG L8	0.08	0.09	7.1574
WG L9	0.04	0.05	7.4841
WG L10	0.01	0.09	1.6703
WG L11	0.03	0.05	4.9972
WG L12	0.09	0.31	11.4169

**Table 12 Classification of Sediment Samples Based on Standard List for Rotterdam, Netherlands**

SUBSTANCE	WG L1	WG L2	WG L3	WG L4	WG L5	WG L6	WG L7	WG L8	WG L9	WG L10	WG L11	WG L12
Cr	0	0	0	0	0	0	0	0	0	0	0	0
Cd	2	2	2	2	2	2	2	2	2	2	2	2
Cu	2	2	0	2	0	0	2	2	2	0	0	2
Ni	3	0	0	3	3	0	3	3	3	3	0	2
Pb	0	0	0	0	0	0	0	0	0	0	0	0

**Notations:**

- 0** - Class 0
- 1** - Class 1
- 2** - Class 2
- 3** - Class 3
- 4** - Class 4

CLASS 4

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CLASS 3

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CLASS 2

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CLASS 1

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CLASS 0

**INTERVENTION LEVEL**

**TEST LEVEL**

**LIMIT LEVEL**

**TARGET LEVEL**

- **Target Level:** concentration below this level is considered to be soil or sediment with no risk or threat on environment
- **Limit Level:** for most contaminants, this level represents so-called maximum acceptable risk for public health and ecosystem
- **Test Level:** this is the practical limit below which the sediment is considered to be mildly polluted
- **Intervention Level:** this is the level above which the sediment is considered to be heavily polluted.

**Table 13 Classification System for Sediment Quality, Netherlands**

Classification System for Sediment Quality based on Port of Rotterdam, Netherlands

Substance	Target Level	Limit Level	Test Level	Intervention Level
As	29	55	55	55
Cd	0.8	2	7.5	12
Cr	100	380	380	380
Cu	35	35	90	190
Hg	0.3	0.5	1.6	10
Pb	85	530	530	530
Ni	35	35	45	210
Zn	140	480	720	720
Sum 10 PAH's	1	1	10	40
PCB-28	0.001	0.004	0.03	
PCB-52	0.001	0.004	0.03	
PCB-101	0.001	0.004	0.03	
PCB-138	0.001	0.004	0.03	
PCB-153	0.001	0.004	0.03	
PCB-180	0.001	0.004	0.03	
Sum 6 PCB's	0.02			
PCB-118	0.004	0.004	0.03	
Sum 7 PCB's			0.2	1
Alpha-HCH	0.0025		0.02	
Beta-HCH	0.001		0.02	
Gamma-HCH(lindane)	0.00005	0.001	0.02	
Sum HCH's				2
Hexachlorobutadiene	0.0025	0.02	0.02	
Heptachlor	0.0025			
Heptachlorepoxyde	0.0025			
Heptachlor+epoxyde		0.02	0.02	
Aldrin	0.0025			
Dieldrin	0.0005	0.02		
Sum Aldrin+Dieldrin		0.04	0.04	
Endrin	0.001	0.04	0.04	
A+D+E				4
DDT+DDD+DDE	0.0025	0.01	0.02	4
Hexachlorobenzene	0.0025	0.004	0.02	
Sum pesticides (incl HCB)			0.1	
EOCL	0.1			
Mineral oil	50	1000	3000	5000

**Table 14 Classification System for Sediment Quality, Netherlands, England, Germany, Canada**

Item	Netherlands			England		Germany*	Canada		USA**
	Clean	Mild	Heavy	Food	Recreation		Food	Recreation	
Cr (total)	100	250	800	600	1000	100	120	1000	100
Cr(VI)							-	10	
Co	20	50	300			50			
Ni	50	100	500	70	-	50	32	200	100
Cu	50	100	500	130	-	100	100	300	170
Zn	200	500	3000	300	-	300	220	800	350
As	20	30	50	10	40	20	14	25	20
Mo	10	40	200			5	4	5	
Cd	1	5	20	3	15	3	1-6	4	3
Sn	20	50	300			50			
Ba	200	400	2000			-			-
Hg	0.5	2	10	1	20	2	0.5	1	-
Pb	50	150	600	500	2000	100	60	500	100
Nh4	-	-	-						
PO4	-	-	-						
Sulphide				250	1000				
Sulphur	2	20	200	5000	5000				
Oil	100	1000	5000				-	2	100
pH							-	6-8	

\* Tolerable

\*\* New Jersey