ANNEX 3
Operation and Maintenance Manual for Hydraulic Structures

BANGLADESH WATER DEVELOPMENT BOARD
THE PEOPLE'S REPUBLIC OF BANGLADESH

OPERATION AND MAINTENANCE MANUAL

June 2017

PREPARED BY
THE JICA EXPERT TEAM
FOR
THE PROJECT FOR CAPACITY DEVELOPMENT OF
MANAGEMENT FOR SUSTAINABLE WATER RELATED
INFRASTRUCTURE

PREFACE

This manual entitled OPERATION AND MAINTENANCE MANUAL is prepared in accordance with RECORD OF DISCUSSIONS ON THE PROJECT FOR CAPACITY DEVELOPMENT OF MANAGEMENT FOR SUSTAINABLE WATER RELATED INFRASTRUCTURE IN THE PEOPLE'S REPUBLIC OF BANGLADESH AGREED UPON BETWEEN BANGLADESH WATER DEVELOPMENT BOARD ("BWDB") AND JAPAN INTERNATIONAL COOPERATION AGENCY ("JICA") dated 25 March, 2013 and approved by the honorable Director General, BWDB on 22 June, 2017.

This manual is prepared as a technical reference for the **"Guidelines for Operation and Maintenance of Permanent Structures of BWDB"** (BWDB O&M Guidelines), which is prepared by BWDB and approved by MoWR in 2010.

This manual consists of eight (8) chapters, in which the Operation and Maintenance (O&M) of water related infrastructures managed by BWDB and describes not only O&M works but also engineering and administrative aspects.

List of Chapters and Contents

Chapter No.	Chapter Title	Contents
1)	Introduction	Scope and application of the manual and definition of water related infrastructures.
2)	Concept of O&M	Scope, present situation, four pillars concepts of O&M.
3)	Basic Scheme Data	Preparation of basic scheme data of O&M
4)	Operational Manual:	Planning and actual work of operation
5)	Maintenance Manual:	Planning and actual work of maintenance
6)	Budget of O&M:	Budget planning of O&M works
7)	Implementation and Monitoring of O&M:	Implementation phase and monitoring type of O&M
8)	Flood Fighting:	Flood fighting during floods as important part of operation works.

BWDB ZONAL MAP

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST IF ANNEXES

1. Introduction

1.1 Scope and Application

This manual was formulated as a reference material for the officials of Bangladesh Water Development Board (hereinafter referred to as "BWDB") under the Project for Capacity Development of Management for Sustainable Water Related Infrastructure (hereinafter referred to as "the Project"), and presents that the basic matters and process of planning, implementation and monitoring of the operation and maintenance (hereinafter referred to as O&M) activities of the water related infrastructures managed by BWDB.

This manual is intended as a guide for the officials of BWDB on planning, implementation and monitoring of the O&M of the water related infrastructures and/or supervising contracting O&M works of the water related infrastructures.

This manual has been compiled through the review of present condition of O&M in the field offices including the related O&M guidelines and the O&M manuals of previous projects, and also through the discussions among the BWDB officials. This manual will be revised based on the accumulated knowledges in the field including the model O&M activities of the Project and the discussions among the BWDB officials.

1.2 Definitions and Functions of Water Related Infrastructures

The water related infrastructures of BWDB taken up in this manual are the river/channel, drainage channel, irrigation canal, those appurtenant structures, such as embankment, bank and foot protection work, groyne/spur dike, road, and bridge/culvert, and the water control structures, such as barrage/large regulator, sluice, regulator, aqueduct, siphon, pump station, and deep/shallow tube well. The definitions and functions of respective structures are presented below:

River/channel: River/channel is a natural watercourse, natural water surface and artificial watercourse which constructed to secure smooth flow. In addition, the rivers have multiple functions: such as, water utilization, flood conveyance, navigation and water amenity.
Drainage channel: a natural or artificial watercourse which remove excess water from the land away.
Irrigation canal: An artificial watercourse to convey irrigation water to the land.

Appurtenant Structures
Embankment: An embankment, sometimes called levee or dike, constructed parallel to the banks of a river, channel, canal, lake or other water body for the purpose of protecting the lands from the damages by flood water, or to confine the stream flow to its regular channel/canal.
Bank, foot and bed protection work: A structure for protection of the bank or the embankment from collapse brought about by erosion, scouring and channel bed degradation. Comprehensive structures of the bank, foot and bed protection are commonly called as **Hard Point**. The bed protection work is commonly called as a **Launching Apron** or **Falling Apron**.
Groyne/ spur dike: A structure to reduce the flow velocity near the bank by directing the flow away from the bank and in order to protect the bank from collapse. There are several types of structures with materials (non-permeable or permeable) and height (non-overflow or overflow). In the Indian sub-continent, **Bandals** are commonly used as a kind of groyne/spur dike.
Road: A way with hard and flat surface, which is usually constructed on the embankment crest, along the in-side toe of embankment, and around the water control structures for inspection,

passage, or access of vehicles, persons and animals.
Bridge/ culvert: A structure carrying pathway or roadway over the watercourse.

Water Control Structures
Dam: A structure constructed across a watercourse to obstruct, direct, retard, or store the flow of water.
Barrage/large regulator: A structure constructed across a watercourse to raise and regulate the water level or to divert it into a watercourse for water use or navigation. In general, structure for navigation use is called as "Navigation Lock".
Sluice: A structure, which allow water to flow under an embankment, road, or similar obstruction, for draining a surplus water of a watercourse, the polder and the inland. In general, the sluice is also called as a "regulator" in BWDB.
Regulator: Regulator, including escape, is constructed to control water flow to different area in the irrigation system and to regulate the water level of canals. The regulator constructed at the beginning of the irrigation canal is called as a Head Regulator. Escape is a kind of regulators that is built at the last point or at any suitable point of a canal for escaping surplus water.
Aqueduct: A structure constructed to convey water over a watercourse.
Siphon: A structure constructed to convey water under a watercourse.
Pump station: Pumping stations are facilities including pumps and equipment for pumping water from lower level to higher level, with the purpose of irrigation or drainage.

2. Concept of O&M

2.1 Objective of O&M

A water resources management project is conducted with certain objectives. After the construction, the objectives of the water resources management project are attained by operating various water related infrastructures constructed in the project. However, the functions of the water related infrastructures cannot be kept well without care, resulting in spreading out of weeds, degradation or aggradation of channel bed, channel bank erosion, damage of the structures, etc. Therefore, such care is important for not only keeping of respective functions of the structures, but also for accomplishing the objectives of the project.
Besides, it sometimes appears as a severe menace to destroy the people's lives and properties. Hence, it is required to maintain and operate the hydraulic structures comprehensively so as to prevent occurrence of damage due to floods, utilize those properly and maintain the normal functions thereof aiming at conservation of the land development of the country, maintenance of the public and promotion of public welfare.

The aims of O&M are;

- **Operation:** Operation of the structures is the efforts to manage and distribute the water resources of the management scheme, in order to fulfill respective functions of the structures.
- **Maintenance:** Maintenance of the structures is the efforts to secure the conservation of the function of structures in good conditions, including rehabilitation works that recover the structure condition to the required condition in the water resources management scheme.

In addition, the maintenance works of BWDB are classified into three (3) categories, that is, the preventive/routine, corrective/periodic and emergency maintenance. Criteria of those maintenance works are as follows:

(1) Preventive/Routine Maintenance

The preventive/routine maintenance comprises all activities carried out to maintain optimal functioning of a facility in order to reduce need for corrective/periodical maintenance and prevent high rehabilitation cost. Its components are:

a) Routine Maintenance

All repeated maintenance works, which are performed on a cyclical basis at planned frequencies e.g.:

- Turf/grass cutting of embankment slopes,
- Removal of vegetation from embankments and obstacles from flood plains and watercourses,
- Removal of sedimentation by excavation or dredging,
- Refilling of scour pits, and
- Pointing and lubrication of iron works and devices.

b) Periodical Works

All jobs, which are performed on a cyclical basis at planned period e.g.:

- Regular inspection campaign of water resources management schemes and structures including reporting etc.
- Replenishment of stocking of construction materials
- Survey of riverbed including sounding
- Inspection of the flood plain and inventory of flood plain occupation.

c) Small Repair Works

This includes small-scale activities necessary for the restoration of a facility to a condition equivalent to its design capacity caused by minor failures, damages and defects e.g.:

- Repair of inspection road pavement,
- Repair of cracks within the embankment,
- Repair of seepage through embankment and along the periphery of structures,
- Raising embankment crest due to settlement and subsidence,
- Repair of slope slides and partial failures,
- Repair of toe and blanket drains in embankments, and
- Repair of cracks and damages on aprons, slope protection, etc.

Priorities are normally established in repair works and they fall into several categories, i.e. emergency, rush and non-rush. Emergency repair must be carried out immediately. Rush within say one (1) month after receipt of notice and non-rush when time is available in the maintenance schedule, but before the next flood.

(2) Corrective/Periodic Maintenance

Corrective or periodic maintenance covers large scale non-emergency work requiring greater resources than the preventive/routine maintenance. Generally, corrective maintenance consists of the special maintenance, rehabilitation and rectification works and includes the following works:

a) Construction of new structures to enhance water resources management
b) Major structure repairs and modifications
c) Replacement or major repairs of gates and hoisting mechanisms
d) Re-sectioning of flood embankments
e) Re-excavation of drainage channels
f) Repair of major erosion including slope protection
g) Breach closing, construction of retired embankment, etc.
h) Bank protection works at the eroded bank to enhance water resources management

(3) Emergency Maintenance

Emergency maintenance is concerned with the unexpected damage due to natural calamities that threaten the water resources project. Emergency situation can be reduced if the preventive/routine and corrective/periodic maintenance works are taken up effectively. Emergency maintenance consists of:

a) Emergency maintenance during calamities (emergency work), and
b) Substantial maintenance after calamities (flood damage repair work).

Corrective/periodic maintenance and emergency maintenance works together are also called asset renewal. This is required to keep the existing water related infrastructure at its intended design and functional use.

The need for an asset renewal program can be a reflection of O&M neglect, but it can also be a result of normal infrastructure depreciation, even with an adequate O&M back up program.

The end of a good preventative maintenance is an aggressive corrective maintenance adopted as part of a formal procedure in an effort to eliminate repressive failure. Review of the failures is required with respect to:

- Redesigning,
- Reconstruction,
- Improving maintenance procedure, and
- Review and changing operational procedure.

To inspect and maintain all parts of water resources management scheme with such regularity in order to eliminate all failures is not practical because the repair cost would not be justified.

Rehabilitation works are based on review of the original design or capacity of a system or structure. It may be related to a single structure only, e.g. sluice, regulator groyne, etc., in which case it is indicated as rectification works.

Rectification works should be avoided as far as possible by preparing and conducting a proper preventative maintenance program.

Following above concepts and criteria as thoroughly as possible, this manual is prepared for Operation and Maintenance of the water related infrastructures managed by BWDB.

2.2 Scope of O&M Activity

Considering the function of the water related infrastructures and the concept of Operation and Maintenance described above, the scope of O&M activity is itemized as follows:

(1) Operation
- a) Operation of channel/canal (monitoring and observation)
  - Water level measurement/ Discharge measurement
  - Checking of river-bed material
  - Water quality observation
  - Compiling and arrangement of data
- b) Operation of water control structure
  - Gate of barrage/large regulator
  - Gate of navigation lock
  - Gate of sluice
  - Gate/stop log of regulator
  - Gate/sluice for aqueduct/siphon
  - Pump of pump station
- c) Administrative management
  - Permission
    Using of river water
    Occupancy of land in channel/canal
    Taking of earth, sand etc. from in channel/canal
    Construction of structure in in channel/canal
  - Approval of river works
  - Restriction of acts and supervision disposition

(2) Maintenance
- a) Channel/coast Survey
  - Periodical cross-section survey
  - Periodical sounding survey
- b) Visual maintenance
  - Turf-cut and weed-cut
  - Sign, fence and DMS post
- c) Patrol and Inspection
- d) Maintenance of river channel/drainage channel/ Irrigation canal
  - Dredging/excavation for maintenance
  - Removal of obstruction
- e) Maintenance of appurtenant structure

- Embankment
- Slope and foot protection works
- Groyne/ spur dike
- Road
- Bridge/ culvert

f) Maintenance of water control structure
- Barrage/ large regulator
- Sluice
- Regulator/ escape
- Aqueduct
- Siphon
- Pump station
- Deep/shallow tube well

g) Maintenance of related structure and equipment
- Housing and office
- Equipment

h) Flood fighting

Detailed description of the above works is presented in the Chapter four (4) and the Chapter Five (5), respectively.

2.3 Present Situation of O&M of BWDB

2.3.1 Present Situation of O&M in BWDB

(1) Infrastructures constructed by BWDB
According to "BWDB Annual Report 2014/2015", BWDB has implemented 790 large and small projects for the water resources management and development in Bangladesh, as shown in Table 2.1. The water resources of 40 % of the country and 50% of the flood affected areas are now developed and managed by the BWDB projects.

Table 2.1 Structures constructed by BWDB till 2014/2015

Number of complete project	790 nos.
Flood control /drainage area	6.310 Million Hectares
Irrigation area	1.585 Million Hectares
Barrage (Tista, Manu, Buri Tista & Tangaon)	4 nos.
Land reclamation area	1,020 Square km
Number of city protection projects	22 nos.
Completed embankment length	11,393 km
Irrigation canal length	5,337 km
Number of hydraulic structures	14,744 nos.
Number of pump houses	20 nos
Number of closer	1,379 nos
Number of bridges/culverts	5,643 nos
Number of Rubber Dam	5 nos.
Dredgers and other related machines	38 sets
Dredging & excavation the river	280 km
Road (made of concrete & soil)	1,070 km

(2) Mandate of BWDB

According to "The Bangladesh Water Development Board Act, 2000" (the BWDB Act 2000), BWDB will only implement and manage projects having a command area of more than 1,000 hectares and the LGED/local authorities will implement and manage the projects with command area of less than 1,000 hectares. Implementation and management of future projects are stipulated as follows under policy of the beneficiary participation in management:

- Management of projects with a command of less than 5,000 hectares shall vest with beneficiary organizations, by whatever name it may be called, formed for this purpose following government guidelines.
- Management of projects with a command of more than 5,000 hectares shall be given in Joint Management Committees comprising of beneficiary organizations formed for their purposes following government guidelines, the Board and other water-related agencies of the Government.

(3) Present Condition of the Hydraulic Structures and O&M Activities in the Field
Based on the field visit results of the Project, the present condition of the hydraulic structures and O&M activities in the field are summarized as follows:

<u>O&M activities in the field</u>

- The O&M division office is conducting the periodical O&M activities by individual manners. The sub divisional engineers and the sectional officer conduct the patrol/inspection periodically, mostly once a month, and report to the executive engineer of the O&M division office.
- The executive engineer judges the necessity of the maintenance works considering the condition of the infrastructures and the required budget for maintenance works.
- According to the information from the office of Director of O&M, the works more than BDT 10 crore (10^7) are recognized as the rehabilitation works in the development budget.
- In some cases, small scale and small budget maintenance works are implemented by the water management organizations (WMO). Coordination with the WMOs is required.
- Technical aspect of the maintenance works are assisted by the office of the Design Circle in charge of respective O&M division offices and the mechanical O&M division office in the Zone.
- Location of the hydraulic structures in the jurisdictional area was known by the executive engineer, sub-divisional engineers and the sectional officers in the O&M division office. However, there is no location map of the all managed structures, except the location maps of the structures for the completed projects. In addition, there are few ledgers of the managed structures in the offices.
- Survey of the maintenance works is done by the staff in the O&M division office. On the other hand, soil mechanics investigation is done by the Ground Water Circle of BWDB/ sub-soil test contractor. Hydrological observation in the jurisdictional area is done by the Hydrology Department of BWDB.

<u>Present condition of the hydraulic structures</u>

- The hydraulic structures along the major rivers are well operated and maintained and good condition. In addition, materials of the repair works have been reserved along the embankment.
- Along the internal rivers including the ring embankment, there are many infrastructures damaged and without repair, such as collapse of embankment including slope protection works, cave-in of the drainage regulator, etc.
- In addition, there are many defects in the structures without any treatment, such as rill erosion of the embankment slope, cracks of embankment, rat/mole holes/tunnels of

embankment, undulation of the embankment crown, undulation/erosion of the slope protection works, corrosion of the gates of the drainage regulators, etc. Those defects are the causes of the serious damages of the infrastructures during the floods.

- The artificial interferences to the infrastructures also can be seen everywhere, such as houses/ cultivation on the berm of embankment, cutting of the embankment body for approach path/road and building, taking-off the gates and hoists, etc. Those interferences also are the causes of the serious damages of the infrastructures during the floods.

SWOT (Strengths- Weaknesses-Opportunities-Threats) Analysis on O&M activities of BWDB

Based on the above results, the SWOT analysis was conducted by the Project as shown in Table 2.2.

Table 2.2 SWOT Analysis on O&M Activities of BWDB

STRENGTHS	**WEAKNESSES**
● BWDB is authorized as the organization for implementation and management of the water resources development projects having a command area more than 1,000 ha. ● BWDB has nationwide offices for management of the hydraulic infrastructures. ● The policies, plans guidelines related to the management of the hydraulic infrastructures are ratified. ● There are many highly trained professional staffs in BWDB.	● Inadequate number of professional staffs in the field level. ● Less motivation of professional staffs in the field level. ● Inadequate data management for the completed projects ● Inadequate skills of the field level professionals in modern logistics (PC, internet connection, software, etc.). ● Inadequate planning on O&M as Management Information System (MIS) not developed yet though planned much earlier ● Inadequate capacity for fund raising for O&M. ● Insufficient budget for O&M compared with the demand. ● Construction bias in BWDB (less priority to O&M in BWDB compared with construction).
OPPORTUNITIES	**THREATS**
● There are high expectations on the hydraulic infrastructure among residents. ● There are assistances from the development organizations/ donor countries. ● There is a global trend in financing and promoting the climate change adaptation. ● There is a global trend in financing and promoting management of hydraulic infrastructures.	● Construction bias in the government (less intention to O&M compared with development) ● Inadequate funding allocation for O&M (Major funds consumed by Padma, Meghna and Jamuna river bank protection works without sufficient maintenance fund following execution). ● Insufficient national budget ● Conflicts among the public related to the water resources management including O&M of the facilities

2.3.2 Efforts to improve O&M of the Structures

(1) Efforts to improve O&M of the Structures

Many projects to improve O&M of the structures of BWDB have been conducted including the following projects:

- Delta Development and settlement Project (DDSP)
- Early Implementation Project (EIP)
- System Rehabilitation Project (SRP)
- Compartmentalization Pilot Project (CPP)
- Dampara Water Management Project (DWMP)
- Coastal Embankment Rehabilitation Project(CERP)
- Khulna-Jessore Drainage Improvement Project(KJDRP)
- Small Scale Water Resources Development Sector Project (SSWRDSP)
- Char Development and Settlement Project(CDSP)
- Coastal Embankment Improvement Project (CEIP)
- Integrated Planning for Sustainable Water Management (IPSWAM)
- South-west Area Integrated Water Resources Planning and Management Project (SAIWRPMP)
- Water Management Improvement Project (WMIP)
- Blue Gold Program

In many projects there have been initiatives to involve farmers/beneficiaries in water management and O&M. Some specific initiatives were a success early on. In the search to cost effective maintenance, the fund generating activities on embankments and leased land look promising.

(2) Acts, Policies and Guidelines related to O&M

Based on the experiences to improve the O&M in BWDB through the previous projects, the following acts, policies and guidelines related to O&M activities are prepared and being enforced:

Table 2.3 Acts, Policies, Guidelines related to O&M activities

Kind	Name of Document/Project	Remarks
Policy	National Water Policy, Jan/1999	By MoWR
Plan	National Water management Plan, Dec/2001	By WARPO
Act	BWDB Act, 2000	
Guideline	Guidelines for participatory Water Management, 2001	Prepared by MoWR
Guideline	Guidelines for Operation and Maintenance of Permanent Structures under BWDB, Oct/2010	Approved by MoWR

2.4 Framework for Integrated O&M

In order to improve the O&M activities more efficient, more flexible and with clearer responsibilities, many project have been conducted and an integrated O&M concept including a beneficiary participation to the water management has been studied, tried and developed. The framework of integrated O&M is accepted by BWDB but not widely applied yet. Now it is a time to apply the integrated O&M to all projects.

Developed framework of integrated O&M is shown in Figure 2.1 and consists of the following four (4) issues under the beneficiary participation:

(1) Basic Scheme data

Prerequisite to improving O&M (water management in general) is reliable and regularly updated scheme data, reflecting the actual status of the water management schemes, including maps and scheme inventories and any other relevant information. Such detailed information on actual scheme conditions is indispensable for planning and conducting the O&M activities. In addition, the basic scheme data are a basic tool for promotion of budget reinforcement for O&M activities.

(2) Budget Procedure

To support the planning of O&M, to protect project infrastructure and water management interests, the timely reservation and release of O&M funds is required. Well defined short and long-term budgeting procedures must be in place at the national and field level O&M agencies. The procedures must reflect the actual requirements emerging from the field at all levels. The O&M budget procedures shall include Needs Based Budgets to support long and short term O&M planning and budgeting. Actual O&M budget should be allocated in accordance with the Needs Basis Budget for the sustainable water management.

(3) Planning Procedure

Timely, efficient and transparent planning is required to ensure that actual water management priorities are met, that the requirements and demands of the system beneficiaries are adequately taken care of and that maintenance activities can start on time. The procedures for the planning of scheme operation and the planning of maintenance must ensure the critical participation of the system users, to guide BWDB in the communications with system users and to protect the water management interests of the farmers.

(4) Monitoring and Supervision

Lastly, the quality of O&M services to be provided by BWDB, i.e. the quality, efficiency and cost-effectiveness of scheme O&M activities, must be ensured, safeguarded and adapted to the actual water management requirements of the schemes. Therefore, effectual monitoring and supervision must be in place.

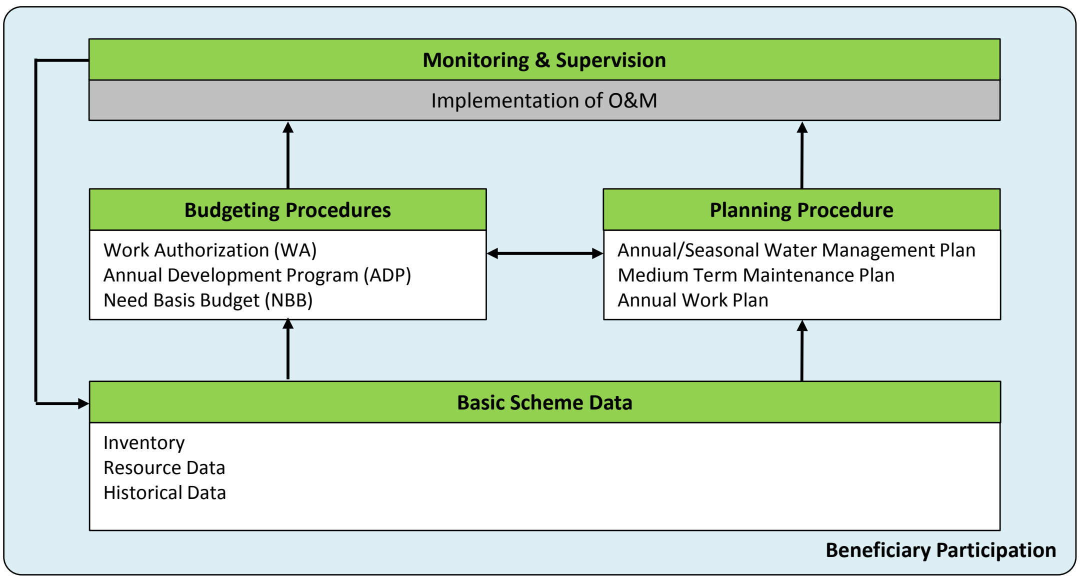


Figure 2.1 Framework of Integrated O&M

3. Basic Scheme Data

3.1 General

As mentioned in the “Chapter 2 Concept of O&M”, the scheme data is a basis of planning, implementation, and monitoring of the O&M activities with efficient, flexible and cost saving manners, in order to optimize the performance of the project scheme. In addition, the scheme data is a core component for promotion of budget reinforcement for O&M activities. Collection and arrangement of the scheme data is basic mandate of BWDB. Without the scheme data, the activities of the O&M of the structures would be inefficient, inflexible and insane, and the performance of the project scheme could not be attained. Since the scheme data become great volume, it is better to establish the database system in respective field offices of BWDB, securing data compatibility with the system in the head office of BWDB. A GIS data established in a field office as a model activity of the Project could be a good reference of BWDB.

The scheme data are divided into three (3) types of data, that is, scheme inventory, resource data, and historical data and respective types of data are as follows:

3.2 Scheme Inventory

The first category of data consists of a complete and updated overview of the inventory of the water management schemes and BWDB organization related to O&M.
The scheme inventory data consist of below:

(1) Hydraulic Infrastructure
The hydraulic infrastructure comprises all the hardware of the actual water management scheme. It is important that not all of the hydraulic structures affecting the scheme are managed by BWDB and some hydraulic structures belong to the other organization, such as LGED, R&H, etc. Thus, structures influencing water management and belonging to LGED or R&H must also be included. Data and information of the hydraulic structures to be collected are the functions of facilities, design and existing dimensions, and those drawings. Those data and information will be collected through the reports of the management scheme during the design and construction stage and through the surveys and investigations in the field.
Representative Terms of Reference of the inventory survey of the hydraulic structures are shown in Annex-1 as a reference material.

(2) Real estate
BWDB has offices, houses, guest houses, stores, water tanks, sheds, etc. A complete and updated list must be available in the schemes, specifying the dimensions and class of the buildings, and the costs of construction.

(3) O&M facilities
The O&M facilities pertain to the inventory of the respective buildings and the equipment and transport facilities used by BWDB staff to carry out their work. The purchase price shall also be included in the data.

(4) Staff list
An updated staffing list must be kept, showing unambiguously how many officers are employed on the schemes either long-term or temporarily. Their designation must be

mentioned, along with the salaries and title to bonuses.

3.3 Resource Data

In order to fulfil BWDB's coordinating and administrative duties, the BWDB officials in charge of management of the scheme need general information on the scheme and the BWDB organization. This is the second category of data. In addition to the normal administrative archives, the following data and information must be kept:

(1) All sorts of BWDB data related to O&M

- BWDB organograms, policy papers and directives
- Approved staffing plan showing the sanctioned number and designation of staff foreseen for the scheme: The actual staffing list should accord with this staffing plan.
- Job descriptions, showing the responsibilities of the respective officers.
- Ex-officio functions of relevant officers, and the meaning of these functions for water management.
- O&M manuals and plans of respective schemes
- Standard Schedule of Rate
- Operation plans and basis of operation plan such as simulation models of schemes under certain climate condition, etc.
- Maintenance plan including ADPs,
- Guidelines for Peoples Participation and Regulations (By-Laws) pertaining to the water users organizations, expressing the lights and duties of the respective bodies.
- Reference literature on procedures to be followed by the respective officers for certain tasks. For example: the steps involved in preparing an ADP proposal on the basis of the field condition and the Standard Schedule of Rates.
- Project Proforma (PP), reports of feasibility and other studies and detailed design, contract documents, as-built drawings concerning the scheme.

(2) Agreements with other agencies

There are two types of agreement as follows:

- Agreements on inter-agency coordination (IAC): Structures under jurisdiction of other agencies, such as LGED, R&H, etc., have sometimes a big impact on the performance of the scheme. Procedures must be worked out how to coordinate interventions in water management by the different agencies.
- Agreements on cooperation between the BWDB and other agencies, like with DAE concerning agricultural extension, or with DoF for monitoring of fish yields, or with Project Council regarding O&M planning.

(3) Documents pertaining to the ownership of the infrastructure

A register must be kept showing the ownership of land on which the hydraulic infrastructure is located. For Government owned land must be indicated which parts are under or eligible for lease contracts with third parties. This information must be supported by maps of adequate scale.

This register may be consulted when during implementation of maintenance works access to the infrastructure) is disputed.

(4) Organization charts of WMOs and other agencies and how they interact

Organization charts of WMOs and other agencies, documenting their organizational frame and the relation with the BWDB.

(5) All relevant maps (administrative maps, jurisdiction maps, layout maps of schemes, contour maps, topographic maps, etc.)
Maps are indispensable aid in the O&M planning and implementation, but also budget requesting and obtaining. There are many kind of maps required for planning, implementing the O&M works. Therefore, it is recommended to establish the GIS database system in respective field offices in order to manage the maps and the inventory data. A model GIS database prepared and used in the Moulvibazar O&M Division Office will be a reference. In addition to the maps, the following data shall be kept in the field:

- Relationship among the geodetic reference systems of the respective maps.
- Topographical reference data: longitudinal profiles and cross section of canals and embankments according to design are to be kept at scheme level. They serve as reference for monitoring of actual dimensions in the field.
- Field elevation: In FCD/I schemes it is important to keep detailed data on field elevation in order to assess the irrigable areas for monitoring scheme performance.
- Zero-levels of gauge plates, and location and levels of bench marks.

3.4 Historical Data

The historical data are the last category of basic scheme data. The historical data comprise findings from monitoring and evaluation exercises and are no longer of immediate use in O&M. After evaluation and assessment of the performance of the scheme these data will be stored in archives. However, at a certain point of time historical data may be consulted to study the effective water management plan.
In addition, the historical data form a link between the O&M components “Basic Scheme Data” and “Implementation and Monitoring”.

The historical data consist of below:

(1) Agro hydrological Records:
Rainfall, river levels, reservoir levels, river flow data, water quality and salinity measurements, depths of water table, ground water level, etc.

(2) Maintenance records/achievements:
Records related to completed maintenance works including ADPs, work contents, the costs, contractors, period of maintenance, etc. Those data may indicate poor quality of work by the contractor (black list of the contractors), in-adequate planning and design of work, in-adequate operation, evaluation of required interval of maintenance work, etc. through the evaluation of those data.

(3) Operation records:
Old operation plans and their amendments, gate or pump operation records, operated water level records, operated ground water level records, irrigated areas, etc.

(4) Financial records:
Staff costs, cost of operation, cost of maintenance, ratio of planned and executed O&M works, revenue from lease of lands (borrow pits/ embankment slopes) and from cost recovery activity, etc.

4. Operation Manual

4.1 General

Operation is the efforts to manage and distribute the water resources of the water management scheme in order to fulfill the expected performance of the scheme directly. Operation activities are divided into two categories. One is a planning of the water management/operation rules of the related structures and the other is the actual activities in the field as itemized in the section of 2.1. Beneficiary participation is indispensable for implementing all of the operation activities smoothly and efficiently.

Details of operation planning and operation activities are explained below:

4.2 Planning of Operation/Water Management

4.2.1 Concept of Planning

The planning of operation is the main focus to integrated water resources management. Main activity of the operation planning includes the preparation of the water management plan of the scheme and will be conducted on an annual basis. The annual water management plan specified how the water management system will be operated, for example, how to and allocate the water to the beneficiaries in the management, when and to what levels the gates of structures will be opened and closed for water allocation and flood control including actions during the emergency condition in the management area. The water management plan provides the framework which is basis of canal water levels and day-to-day structure operation.

During the development stage of the water management scheme, the water management plan including the operation plan of the related structures are drafted by BWDB assisted by the consultants, based on the anticipated conditions, such as land use including cropping and fishery patterns, hydrological condition, water demands from the water users/beneficiaries, drainage of the beneficiary area, etc. Therefore, it is required to modify/fine tune the drafted plans in accordance with changes of the actual condition of the beneficial area, especially demand of the users, in order to get an optimum benefit from the scheme. There are various and haphazard demands from the various water users. In order to coordinate those demands and fine tune the annual water management plan, beneficiary participation is also indispensable during the planning. The WMOs in the scheme will primarily be responsible in the operation planning and coordinate the beneficiaries and finalize the water management plan including operation plan of the related structures, in conjunction with the field offices of BWDB.

4.2.2 Planning Procedure

The water development schemes of BWDB are conducting with various purposes, such as flood control/drainage, town protection, land reclamation, irrigation, fishery, etc. Therefore drafting the water management plan including operation plan of the structures is not one-time excise due to conflicting interest among the beneficiaries in and around the development area. Although the planning procedure of operation varies establishment condition of the WMOs in the area, the basic procedure of the planning is as follows:

1) Drafting the operation plan by BWDB with the WMOs in advance before each season or annually.

2) Each WMO in the area presents a draft plan to the stakeholders.
3) Each WMO give the recommendations/suggestions on the draft plan to WMA/WMF (apex body of WMOs, depend on the size of the development area), based on stakeholders opinion.
4) WMA/WMF at the apex level compiles the recommendations/suggestions of all WMOs and finalizes and approves the annual plan with BWDB.

In case that the large scale revision/modification of the draft plan is required in order to deal with the recommendations/suggestions from all WMOs, such as changing of irrigation area, cropping pattern, fishery pattern, hydrological condition, etc., the highly trained technical experts are necessary. This revision shall be conducted by the WMA and the field office of BWDB with assistance of the consultants.

As the example of the conflicting interests among the beneficiaries, representative conflicts concerning the gate operation are shown below:

Table 4.1 Representative Conflicts Concerning Gate Operation

Period	Gate Operation	Consequence
April – June (beginning of monsoon)	Remains open	• Inundation of Boro/Aus crop in low-lying area along canal/channel. • Benefit of production of crop in high land area. • Benefit of fishery
July – September	Remains close	• Aman crop is protected. • Negative impact fishery • Problem of Jute setting • Scarcity water of Aman crop in high land.
September – October (end of monsoon)	Remains close	• Benefit of fishery • Benefit of source of water in dry season • Drainage problem for Rabi/Boro crop.

4.2.3 Data Required

In order to modify/fine tune the annual water management plan including the operation plan of the related structures, the following data will be required:

Data of natural condition:
- Hydrological and meteorological data (discharge and water level records of the rivers, rainfall records, long-term weather forecast, etc.)
- Map of the beneficiary area with the detailed contour lines

Data/demands from the stakeholders:

Data/demands from the stakeholders shall be determined through the participatory process.
- Land use
- Cropping patterns of the irrigation areas
- Fishery patterns
- Depth of water/water level to be maintained at the end of the monsoon season with the consensus among the stakeholders
- Permissible level of water inside the scheme during monsoon
- Timing of gate operation for fishery
- Provision of gate operation for flushing during monsoon drought

4.3 Operation of Channel/Canal (Monitoring and Observation)

Operation activities of river channels, drainage channels and irrigation canals are the monitoring and observation. The monitoring and observation of river channels, drainage channels and irrigation canals shall be continuously conducted in order to implement the water management plan properly, and to catch the available water resources in the scheme. The monitoring and observation consist of the water level observation, checking of river bed material and water quality observation. Major objectives, proposed location and frequency of the monitoring and observation are summarized below:

(1) Water level observation
Purpose:
River channel: To know the flow condition at the outside of the scheme in order to operate the related structures in the scheme and to prepare the flood fighting. The observation is done by the Water Science Department of BWDB.
Drainage channel: To know the flow condition for operation of the drainage structures. The observation is done by the gate operator of WMOs or BWDB.
Irrigation canal: To know the flow condition for operation of the drainage structures. The observation is done by the gate operator of WMOs or BWDB.
Proposed site
River channel: The bridge site of the river channel at the upstream and downstream sides of the scheme.
Drainage channel: Sluice site
Irrigation canal: sites at the water control structures
Frequency
River channel: Daily (hourly during flood). The bridge site of the river channel at the upstream and downstream sides of the scheme.
Drainage channel: Sluice site
Irrigation canal: sites at the water control structures

(2) Checking of river bed material (sampling and test for grain size distribution)
Purpose:
To get change of the river morphology. The observation is done by the Water Science Department of BWDB or field office of BWDB. Sampling and test for the grain size distribution should follow related technical standard.
Proposed site:
Middle point of riverbed gradient. (If there is no change of the river bed gradient along the scheme, the river bed at the middle point of the scheme is proposed.)
Frequency
5 to 10 year interval or when the river bed material change.

(3) Water quality observation
Purpose:
To confirm whether the water quality of the flow is conformity with the Environmental Standard of Bangladesh or not. When deterioration of water quality is a concern, the observation is done by the Water Science Department of BWDB or the field offices of BWDB in compliance with the technical standard of the water quality tests.
Proposed site:
River channel: At the upstream and downstream sides of the scheme.
Drainage channel: At the sluice

Irrigation canal: at the head regulator and the escape

Frequency

Every year in dry season (in case that deterioration of water quality is a concern)

(4) Compiling and Arrangement of Data

The obtained data from the above should be compiled and arranged for easy use. The compiling and arrangement works will be carried out by using the Data Base System to be implemented in the field office of BWDB.

Records getting through these monitoring and observation also become the basic data of the management, such as water utilization, channel use, water amenity/environment, appropriate water resources development, flood warning and flood fighting, understanding of run-off and flooding mechanism and future water resources development plan.

Let us remember that a natural phenomenon including the hydrological one never occurs twice. Therefore, the execution of the monitoring and observation must be done attentively with sufficient preparation.

4.4 Operation of Water Control Structures

There are various structures constructed in the water resources development schemes of BWDB, sharing flow control functions. Out of those structures of the schemes, the water control structures are required to operate. Functions and operations of those structures are presented below.

4.4.1 Barrage/Large regulator

Barrage/large regulator is a structures with gates constructed across watercourse and managed by the field office of the Mechanical Department of BWDB.

(1) Function:

To raise and regulate the water level in order to divert the flow into the other watercourse for water use. In some cases, the Navigation Lock for the navigation is installed.

(2) Operation:

Operation is done in accordance with the operation rule of the facility. Basic operation is as follows:

- During the dry season: 1 or 2 gates are partially opened. Other gate are closed.
- During the rainy season: All gate structures are opened.

4.4.2 Sluice/Escape

The sluice/escape is a gated structure, which allows water to flow under an embankment, road, or similar obstruction. The scape is constructed at the last point of the irrigation canal. In general, the sluice is also called as a “regulator” in BWDB. The sluice and escape are operated by the operator of WMOs.

(1) Function

- To drain surplus water (storm water) of the drainage channel and the inland area to the river.
- To prevent the runoff/flood from the river flowing into the drainage channel and the

inland area.

(2) Operation

Considering the permissible water level of the inland area as the warning level, the following operation should be conducted. It is recommended that the permissible water level of the inland shall be painted on the wing wall of the gates, in order to facilitate the gate operation properly.

(a) Normal Operation

i) At least one (1) gate of each sluice should be opened when the water level of the river or that of inland is lower than the warning water level.

ii) The gates of each sluice can be operated for the maintenance activities.

(b) Operation during Flood and High-Tide

i) When the water level of the river is higher than the warning water level and that is higher than inland water level, all gates should be soon closed.

ii) When the inland water level is higher than the warning water level and that is higher than the water level of the river, gates should be opened, according to the flow condition (direction, velocity) at each sluice.

iii) During the closed condition of the gates and when the inland water level is higher than the water level of the river, the gate operation should be return to ii).

iv) When the water level of the main river rises again, the gate operation should return to the condition of (b) – i) or (b) – ii).

v) When the flood and high-tide are judged to be passed away, the gate operation against flood/high-tide shall be cancelled.
(Return to condition (a) - i)).

4.4.3 Regulator

Regulator is a gated structure of the irrigation system and basically managed by WMO.

(1) Function

- To control water flow to different area in the irrigation system.
- To regulate the water level of canals for irrigation.
- To prevent the runoff/flood from the river flowing into the irrigation area (head regulator)

(2) Operation

Operation of the gates of the regulator should be conducted in accordance with the determined operation rule.

4.4.4 Pump Station

Pumping stations are facilities including pumps and appurtenant facilities and managed by WMO or the field office of the Mechanical Department of BWDB.

(1) Function

- To pump water from one place to another, with the purpose of irrigation or drainage.

(2) Operation

Operation of the pumps and gates of the pump station should be conducted in accordance with the determined operation rule.

4.4.5 Aqueduct/Siphon

Function and operation of the aqueduct and siphon are as follows:

(1) Function
- To convey water over a watercourse for water use (Aqueduct).
- To convey water under a watercourse for water use (Siphon)

(2) Operation
Operation of the gates of aqueduct/siphon should be conducted in accordance with the determined operation rule.

4.5 Administrative Management

Owner of all water resources including rivers is the Government of Bangladesh. Any acts obstructing the normal function of the water resources shall be restricted. BWDB undertakes activities for the whole of Bangladesh or any part of thereof for development and efficient management of water resources. Therefore, BWDB needs to work into the activities of administrative management of the water resources regarding water sharing, flooding, erosion, those protection works, etc. and use of water from the river or channel which is under a BWDB project. Administrative management of the water resources, especially rivers or channels, under the BWDB projects is basically as follows:

4.5.1 Permission/Approval of Acts

(1) Using of River/Channel Water:
The Ministry of Water Resources (MoWR) permits the water use to the user for the projects under MoWR. BWDB makes a recommendation on the water use to the Ministry.

(2) Occupancy of Land in the River/Channel Area:
The Ministry of Land permits the land use to the user for the BWDB projects with recommendation from BWDB regarding the sustainability of land use against the management of BWDB project.

(3) Taking of Earth, Sand, etc. from the River:
The Ministry of Power, Energy and Mineral Resources permits extraction of the mineral resources from the river. However, if it is within a BWDB project, then recommendation from BWDB is required as to the effectiveness of such extraction.

(4) Navigation in the River:
BIWTA (Bangladesh Inland Water Transport Authority) under the Ministry of Shipping permits the commercial navigation in the river. However, BWDB's recommendation for the commercial navigation is required to secure the sustainability of the river and the structures managed by the BWDB.

(5) River Training Works:
BWDB, LGED and local authorities can conduct the river training works under their jurisdiction. However, BWDB's recommendation is required to secure the sustainability of the river and the structures managed by the BWDB.

(6) Construction Works in the River

For the bridge construction, the Bangladesh Bridge Authority and the Roads and Highways Department under the Ministry of Road Transport and Bridges approve the bridge works of the river. However, BWDB's recommendation on the bridge construction is required from the view points of the hydraulic and hydrological aspects.

For the building construction, the PWD (Public Works Department) under the Ministry of Housing and Public Works approves the building works in the river. However, BWDB's recommendation on that is required to secure the sustainability of the BWDB projects.

4.5.2 Restriction of Act and Supervision of Disposition

Bangladesh police restricts the illegal acts and supervise the disposition of those acts. BWDB shall report the illegal and harmful acts to the police and confirm the disposition of those acts.

5. Maintenance Manual

5.1 General

The water related structures of the water resources development projects are, in a sense, not permanent facilities, since they are planned and implemented generally on the premise that incessant maintenance effort will follow after the completion of the construction works. The premise has possibly been introduced from economical viewpoint based on the past experience.

The technical maintenance is therefore indispensable to sustain the functions, which will be lowered and damaged due to repeated flood flows. Furthermore, some acts of the neighboring people are harmful to the facilities and lower the functions. Such harmful acts should be prohibited or restricted.

In order to maintain the functions of facilities developed by the scheme, it is essential to understand the concept of project plan and functions of facilities.

5.2 Planning of Maintenance

5.2.1 Concept of Planning

As described in the section 2.1, the maintenance works of BWDB are classified into following three categories:

- Preventive/Routine Maintenance
- Corrective/Periodic Maintenance
- Emergency Maintenance

The routine maintenance works are conducted annually, without planning. Small repair works as a preventive maintenance works require little annual planning. If the preventive and routine maintenance works are conducted properly, then demands of the corrective/periodic maintenance works and the emergency maintenance works become less. Emergency works cannot be planned. Therfore, preventive and routine maintenance works is more important than others.

5.2.2 Planning Procedure

Planning Procedure of the maintenance works is as follows:

1) Identification and selection of item to be maintained and repaired:
   Based on the inventory prepared by the WMOs in collaboration with the field office of BWDB, identification and selection of items to be maintained and repaired are ranked and prioritized. Identification, ranking and prioritizing of the maintenance works are the recurrent activity of the planning. Ranking and prioritizing shall be conducted based on the damage degree, temporary countermeasure of damage, importance and benefit of facility in the scheme. For example, high priority shall be given to possible breech site of embankment, and damaged sluice/regulator along the rivers.
2) Clarification of timing of maintenance works: This is important issue in maintenance planning, i.e. when what type of maintenance works can be carried out without hampering the water management in the scheme.
3) Physical planning of maintenance works: This activity is to draw up the physical work

plans prior to the starting of the work.

4) Preparation of medium term maintenance plan: In order to implement the maintenance works efficiently and effectively, the medium term maintenance plan shall be prepared annually as three (3) year moving plan.
5) Preparation of annual maintenance plan: Based on the medium term maintenance plan, the annual maintenance plan shall be prepared and implemented.

If there are accumulated damages of the structures in the scheme and it is difficult to implement the maintenance works within budgets for 3 to 5 years, it is recommended to propose those corrective maintenance works as a rehabilitation project.

5.3 Patrol and Inspection

The maintenance activities start from patrol and inspection of the water related infrastructures in the scheme.

The patrol and inspection clarifies the weak points of facilities, and rapid and proper repair works of the weak points can avoid severe damage on people's lives and properties. The result of inspections shall be recorded simply, if no serious damages and irregularities are found. If serious damages or irregularities of the facilities are found, the conditions shall be recorded in detail, and reported to the field office of BWDB.

The patrol and inspection shall be conducted with the following frequency:

1) Intensive and overall just before severe rain season,
2) Each time after a flood or earthquake or severe wave,
3) At least once a week during severe rain season, and
4) At least once a month during dry season.

The person who inspects the conditions of facilities should know well the design features of the facilities and their functions. Otherwise, he might overlook the irregularities.

After severe damages and irregularities are found by the patrol and inspection, further investigation of the facility, study and design, repair and rehabilitation works as required shall be conducted immediately. The immediate repair would prevent further damages; accordingly it makes the maintenance works easily and economically.

A vehicle should be provided for the patrol and inspection exclusively.

5.4 Maintenance of Channel/Canal

5.4.1 Function

Functions of river channel, drainage channels and irrigation canal are to convey storm water/ irrigation water less than the design discharge smoothly and safely within the specified design high water level (DHWL). Therefore, the channel/canal should be provided with (i) enough cross-sectional area to carry the design discharge within the DHWL and (ii) reasonable planimetric alignment to keep the smooth flow without causing damages to the facilities and structures related to the channel/canal.

5.4.2 Patrol and Inspection:

(1) Damages/Irregularities of Channel/canal:
Maintenance of channel/canal is conducted by visual inspection for sediment deposition, vegetation, riverbed degradation, riverbank erosion, etc.

(a) Sediment deposition
At the selected reaches, fixed-point observation is conducted regularly. Change of channel is grasped comparing the observation result with the past records.

Viewpoint
Sediment in channel/canal is transported downstream by water flow. Therefore, when the flow velocity gets slow and decreases carrying capacity, sediment is deposited on the riverbed. The flow velocity generally slows at the following reaches.

- A reach that riverbed gradient changes form steep to gentle toward downstream
- A confluence where a main stream with gentle gradient meets a tributary with steep gradient
- A backwater reach caused by a crossing structure, e.g. barrage
- A tidal reach
- A reach where cross-sectional area gets wide
- An inside of a curved reach

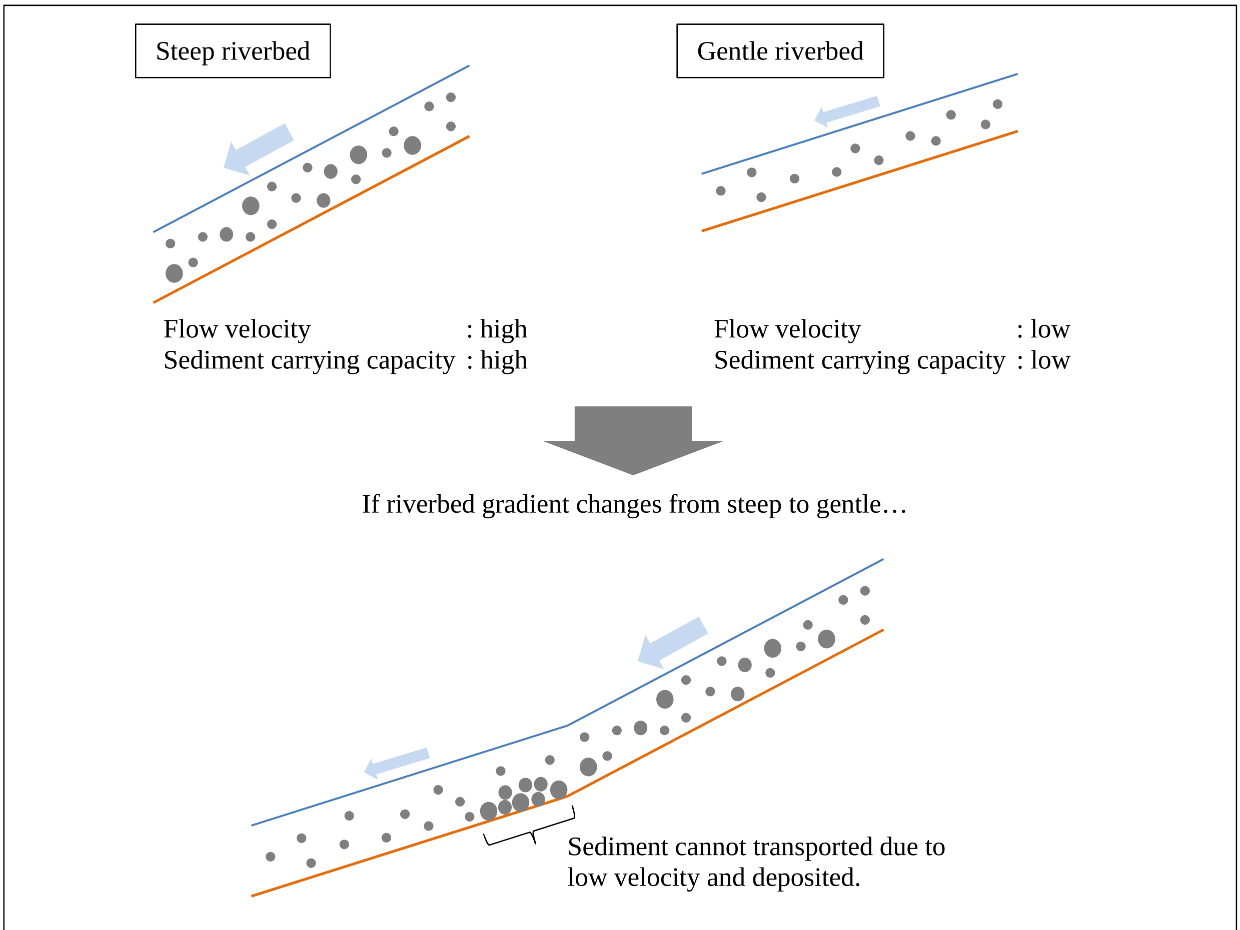


Figure 5.1 Sediment Deposition and Riverbed Gradient

(b) Riverbed degradation and local scoring

In order to grasp riverbed degradation or local scoring damaging river structures, monitoring the condition of topographical change, displacement of structures, etc.

<u>Viewpoint</u>

If riverbed degradation occurs just downstream of river structures, it might cause them to be deformed or to be washed away. Progress of riverbed degradation can be grasped by observing such deformation of the river structures.

Deformation of foundation of bank protection by local scoring

Outflow of foot protection blocks by riverbed degradation

Figure 5.2 Deformation of River Structures due to Riverbed Degradation/Local

(c) Erosion

If river bank erosion progresses, it would causes dike break and land loss along the river. In order to grasp the status of bank erosion and consider the countermeasures, visual inspection is conducted. The places/reaches to be inspected are the following erodible points. The erodible points are generally extracted from planar positional relation.

- Water colliding front, outside of a curved reach, river bank near water route, etc.
- River bank near a bridge pier, river bank at just downstream of river bank protection works
- A reach that river degradation/local scouring progresses, a reach that cross-sectional area suddenly contracts, etc.

River bank erosion at the curved reach

River bank erosion near a bridge pier

Figure 5.3 Deformation of River Structures due to Bank

(d) Others
- Vegetation which may disturb smooth water flow.
- Driftwood.

(2) Illegal/Harmful Acts:
- Construction of illegal structure or earth works (excavation, embankment, etc.) within channel/canal area.
- Illegal land use within the channel/canal area.
- Garbage dumping in channel/canal.

(3) Channel/Canal Water
- Illegal waste water disposal.
- Unusual color or smell of water.
- Many dead fish or aquatic animals floating on water.

5.4.3 Survey of Channel, Canal and Coast

Cross sectional survey of river channel, drainage channel, irrigation canal and coast should be periodically carried out to find the change of profile. Even after the completion of the construction works, the cross section profile of channel, canal, and coast can be changed by not only the change in the condition of catchment area, meteorological condition, the social circumstances, etc. but also the characteristics of channel, canal, and coast.

Periodic cross sectional survey shall be carried out when remarkable change is found or at least once in five (5) years, after severe rain season or severe waves. This survey shall apply the selected bench marks (BM) installed by DBWB. Basic length and interval of survey shall be as follows:

Table 5.1 Periodical Cross-sectional Survey

Location	Length	Interval
River channel	Depend on channel width	500 m
Drainage channel	Depend on channel width	200 m
Irrigation canal	Depend on canal width	200 m
Coast	400 m (incl. foreshore)	500 m

Special attentions shall be paid for the following places:

<u>For river channel/drainage channel/irrigation canal</u>
- Near the bridge, and other river crossing facilities,
- Short-cut portion, especially at upstream and downstream of short cut channel,
- Confluence of tributaries, and
- Concave portion

<u>For coast</u>
- River-mouth
- Concave portion
- Eroded portion

As for the survey of bench marks (BM), the conditions of them should be inspected. If the mark has been damaged or lost, it should soon be repaired or renewed in the same position and its elevation should be surveyed.

For the renewal of lost marks, the coordinates of the mark should be surveyed in advance and put at site based on the reliable neighboring marks.

5.4.4 Dredging/Excavation Works for Maintenance

Dredging/excavation works of deposited materials will be done by contract system in principle. Planning, design, cost estimate and tendering for the dredging/excavation works should be conducted for the contract. Planning and design will be made based on the cross-sectional survey. If needed, additional detailed survey is also conducted. Depth of dredging/excavation shall be determined based on the original design. The excavated/dredged material should be used for filling the scouring site.

5.4.5 Bank Protection for Maintenance

Almost of the bank of river channel, drainage channel and canal are protected generally by the grass grown thereabout. When the grass is washed away, the bank will be eroded rapidly. Bank-protection works against the erosion are required when the stream course approaches the embankment. The protection measures such as slope protection work, gabion, groyne, etc. should be decided, considering the channel/canal condition which is clarified through the periodical inspection and investigation. The bank protection works for maintenance will be done by contract system in principle.

5.4.6 Removal of Obstruction

In recent years, owing to change in social circumstances, many kinds of rubbishes are often dumped into the channel/canal area. These rubbishes aggravate the environment conditions. This circumstance necessitates sweeping rubbishes on embankment, high-water channel, pier of bridge, drainage sluice and escape at need.

Further dumping wastes in the channel/canal area should also be strictly forbidden. It is one of the important activities to guide the public not to dump the garbage into the channel/canal and on the embankment and not to damage the facilities.

Removal of obstruction will be done by force account or contract system depending on the quantity of works.

5.4.7 Visual Maintenance

(1) Turf-cut and Weed-cut

Embankments are covered by sodding for the purpose of protection of embankment slopes. But if it is left as it is, though different in places, usually long-stem plants become surpassing and frequently turf will disappear after gradual diminishing. By this reason, turf-cutting and weed-cutting should be carried out periodically. The surpassing of turf is kept and thereby the protection of embankment slopes can be achieved by executing turf-cutting and weed-cutting repeatedly for the reason that such plant as turf is generally stronger than long-stem plants against cutting. Further turf-cutting and weed-cutting are necessitated by reason that long-stem plants will loosen embankment slope, increase the roughness at banks during flood and thereby decrease the discharge capacity of the channel/canal.

Therefore it is recommendable:

Turf-cutting and weed-cutting is executed at least once a year for embankment by force account considering the climate condition of the area.

(2) Painting of Sign, Fence, etc.

There are some signs, fence, guard posts, portals for the inspection roads, etc. along the river/drain/canal courses, in order to inform the harmful acts for the rivers/drains/canals to inhabitants and to prevent inhabitant from accidents. Those are made of wooden or metallic material. Therefore, painting works of those will be required as the maintenance. The painting works shall be carried out once two (2) year by force account.

5.5 Maintenance of Structures

5.5.1 Embankment

(1) Functions

Functions of embankment are to confine the design storm water/irrigation water within the channel/canal, and accordingly to protect people's livelihood and properties. Therefore, the embankments should be provided with (i) enough height to meet the design high water level (DHWL) equipped with some free-board and (ii) necessary strength and durability against water flows at both ordinary and flood times.

Embankment is generally made of sand and cray. The merits of sand and cray as material of embankment are as follows.

<u>Merit for construction</u>

- Low construction cost
- Availability of material
- Workability for extension, widening, heightening

<u>Merit for material</u>

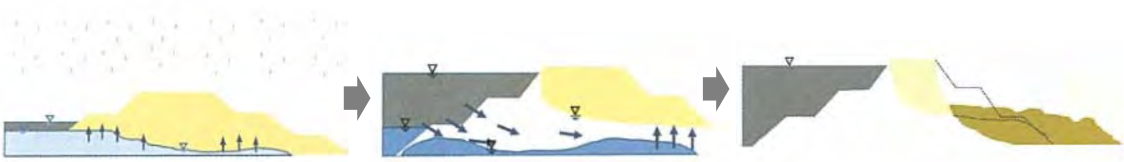
- Durability
- Adjustability for deformation of ground

<u>Merit for O&M</u>

- Easy rehabilitation against sinking
- Quick response after damage

Otherwise, there are some demerits as follows. Inspection of embankment should be conducted considering the followings.

- Quality of material is not homogeneous compared with concrete and metal structures.
- Stability against slide decreases if river water/rain water permeates inside embankment.



1. Water level in embankment is lifted up due to rainfall.
2. Water level in embankment is moreover lifted up due to flood flow.
3. Embankment body slides and collapses.

Figure 5.4 Embankment Slide due to Permeation

- Embankment is eroded by flood flow.
- It is easily collapsed by overflow.

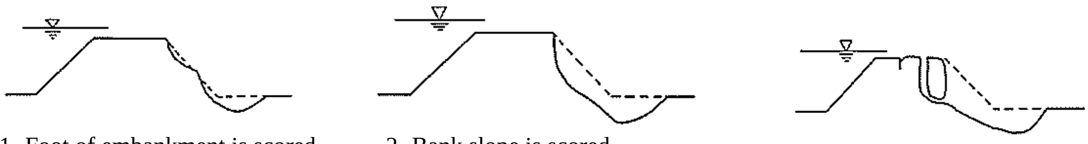


Figure 5.5 Collapse of Embankment due to Overflow

(2) Patrol and inspection
- (a) Damages/Irregularities of Embankment
  - Erosion or scouring of embankment due to river flow.
  - Settlement, cracks, leakage of water or piping, and other damages on embankment.
  - Vegetation on embankment which may damage the embankment.
  - Slope failure of embankment and channel bank.
  - Cave-in on land side slope.
- (b) Illegal/Harmful Acts
  - Cultivation at the embankment foot.
  - Cutting embankment crest and slopes for crossing or water intake.
  - Burning trash on the embankment.
  - Illegal works on the embankment such as public and private facilities, temporary building, piling, excavation, etc.

(3) Preparation for Repair Works

Repair works of damaged portion of embankment are to be conducted by contract system. Planning, surveying, design, cost estimate, tendering and supervision are to be conducted. Other minor maintenance works (routine maintenance) shall be done by force account.

(4) Repair of Embankment Crest

After excavation of damaged portion with cutting slope of 60°, high quality soil with appropriate moisture content should be filled. The soil thus filled should be compacted well by using tamper for small scale damage and compacting by vibration roller or bulldozer for large scale damage. After compaction, sodding should be provided at the shoulder.

(5) Repair of Embankment Slope

Slope repair should be carried out with high quality soil and turf in due order of striping, bench cut, finishing stake, embankment, slope tamping, and driving of support skewer.

(6) Rehabilitation of Slope Failure

Slope failure due to slide is caused by increase in unit weight of soil saturated mainly due to rain water or rising seepage water and also by decrease of shearing resistance against the weight. For the repair of the slope failure, muddy soil and poor quality soil at the site should be removed and replaced by high quality soil and the replaced soil should be well compacted. Leakage proof works or mitigation of the slope gradient should be carried out, if necessary, depending on the cause of failure and the soil quality.

(7) Repair of Cave-in:

The initial cause of cave-in in embankment is an occurrence of voids due to (i) leakage water, (ii) washing away of backfill materials caused by fault of sluice/regulator joint or impervious wall, and (iii) insufficient compaction of refilled soil for built-in facility and backfill sand of

retaining wall, etc. Voids gradually develop into cavities which appear on the embankment crest. Many cases of the cave-in are due to inappropriate construction of structures.
In order to repair, a detailed investigation on the cause of cave-in is indispensable prior to filling up the cave. If a fault is found in structure itself, the embankment body concerned should be removed and reconstructed, except for the case that the structure is possible to be mended from its inside.

(8) Rehabilitation of Crack
Cracks of embankment are usually caused by, (i) excessive saturation due to seepage water, (ii) contraction of embankment using clayey soil and exposure to drought and (iii) earthquake. Before the repair, causes of the cracks should be examined and countermeasures are to be established. For the repair of such cracks, the embankment body should be excavated in V-shape along the crack with slope of 60°, filled with high quality soil, and compacted well with a thickness of 30 cm.

5.5.2 Slope (Bank and Foot) Protection Work

(1) Functions
Functions of slope protection works are to protect the embankment or channel/canal banks from scouring by water flow and other objects transported by the flow. The slope protection work is composed of (i) slope pavement (or revetment), (ii) foundation, and (iii) foot protection.

The functions of the slope pavement are to protect the slope from scouring by water flow, to retain the earth body of embankment and to resist the infiltration of river water into embankment. The functions of the foundation are to bear the weight of slope pavement, to prevent scouring at the foot of slope and to withstand sliding of embankment slope. The foot protection functions to protest the channel bed in front of the foundation works from scouring and to sustain the foundation and slope pavement works.

Pattern of damage of slope protection work is divided in three types as follows.

(a) Riverbed degradation
If scoring occurs in front of slope protection work and it reaches bottom of foundation, foundation would lose bearing capacity and collapsed.

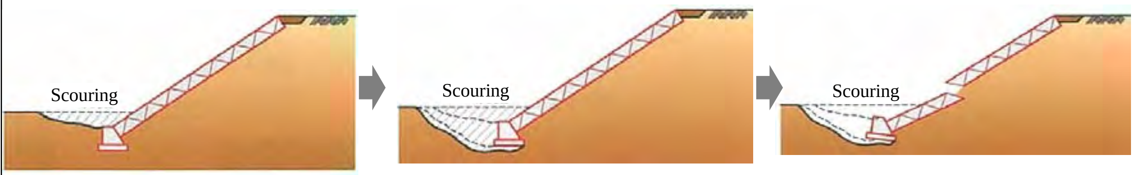


Figure 5.6 Damage of Slope Protection Work Caused by Riverbed Degradation

(b) Suction of backfill material
When water level gets down, backfill material is sucked and hollow is made. Finally, slope protection work would be collapsed.

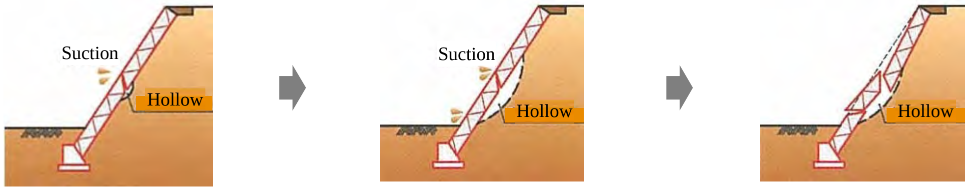


Figure 5.7 Damage of Slope Protection Work Caused by Suction of Backfill Material

(c) Collision of driftwood

During flood, driftwood dash against slope protection work, give damage to its function and cause collapse.

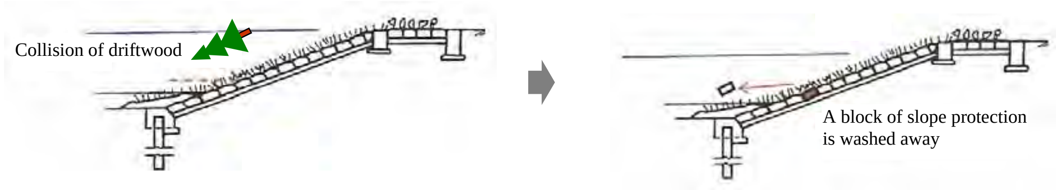


Figure 5.8 Damage of Slope Protection Work Caused by

(2) Patrol and Inspection

(a) Damages and Irregularities

- Any cracks on slope pavement.
- Condition at the slope protection work especially at foot protection works during low water level.
- Condition of riprap for foot protection at the downstream and upstream site of crossing facilities such as barrage/large scale regulator, etc.
- Condition of construction joint, upper and lower ends of the slope protection work.
- New erosion or scouring in front of the slope protection work.

(b) Illegal/Harmful Acts

- Destroying the slope pavement for crossing or water intake
- Burning trash on the slope protection works.
- Extracting the boulders from the foot protection works.

(3) Repair of Slope Protection work

Damage of slope protection work should be repaired immediately. For planning of the repair, causes of damage should carefully be investigated and reflected to the repair works. If new bank erosion is found, countermeasures against erosion should be conducted soon. In planning of the new protection work, influence of the new work to the adjacent reaches or to the downstream reaches should be taken into consideration. The repair works will be conducted by force account or contract system depending on the quantity of works.

5.5.3 Side Drain

(1) Function

Side drains/ditches are installed to collect local drainage water at the foot of embankment to drain into the drainage outlet. In addition, the side drains also function as the boundaries of the embankment area.

(2) Patrol and Inspection

(a) Damage and Irregularities of Side Drain

- Vegetation (Water hyacinth, etc.) which may disturb smooth water flow.
- Severe erosion of drain.

(b) Illegal/Harmful Acts

- Dumping garbage in the drain.
- Barrier put privately in the drain.

(3) Maintenance activities:

(a) Cleaning of drains by neighboring residents (local society oriented), including removal of water hyacinth at least annually. Water hyacinth poses particular problems because of the rate of growth and speed with which they can re-establish after clearance.

(b) Repair or rehabilitation: by force account or contract depending on the quantity of works.

5.5.4 Groyne/Spur Dike

(1) Function

Groyne/ spur dike is a structure to reduce the flow velocity near the bank by directing the flow/wave away from the bank and in order to protect the bank from collapse in an indirect manner. There are several types of structures with materials (non-permeable or permeable) and height (non-overflow or overflow). There are few groynes/spur dikes constructed in Bangladesh. It is recommendable to apply groynes/spur dikes to protect the bank from collapse instead of the slope protection works.

(2) Patrol and Inspection:

(a) Damages and irregularities

In order to grasp the deformation causing functional loss, visual inspection is conducted.

Groyne/super dike sticks out into water flow and so scoring occurs at the point where flow concentrates at, e.g. the tip.

Deformations causing damage are listed as follows.

- Inclination, sliding/overturning, outflow of groyne/super dike
- Sliding, outflow of material, e.g. gabion, block and stake
- Erosion at joint between groyne/super dike and the bank
- Wear of concrete, decay of timber
- Floating up of a stake

Figure 5.9 Outflow of Concrete Block of Groyne/Spur

(b) Illegal/Harmful Acts
- Construction of illegal structure on the groyne
- Burning trash on the groyne.
- Extracting the material from the groyne

(3) Repair of Groyne/Spur Dike
Repair works of damaged portion are to be conducted by contract system or force account. For planning of the repair, causes of damaged should be investigated carefully and reflected to the repair works. If new erosion is found near the groyne/spur dike, countermeasures against erosion should be conducted soon. In planning of the countermeasures, influence of new works to the adjacent bank/coast should be taken into consideration.

5.5.5 Road (Inspection/Access Road)

(1) Function
Inspection/access road is used for periodical patrol and emergency inspection of river channel and hydraulic structures. The road is also used for the maintenance works and flood fighting activities and for the local traffic of residents.

Considering the functions mentioned above, overall public use of the inspection road shall be regulated and the crossing with heavy load shall be avoided.

(2) Patrol and inspection:
(a) Damage and irregularities of inspection road.
(b) Conditions of vegetation and pavement of the road
(c) Conditions for public use.

(3) Maintenance activities:
Repair or rehabilitation of damaged portions of the road by force account or contract depending on the quantity of works.

5.5.6 Bridge/Culvert

(1) Function
Bridge/culvert is a structure carrying pathway or roadway over the watercourse. There are many bridges on the river channels, drainage channels and irrigation canals of the scheme. Those bridges will be operated and maintained by the authorities concerned. However, the field office of BWDB should be carried out the following to maintain channel/canal function.

(2) Patrol and Inspection

(a) Damage and Irregularities

- Scouring of channel/canal bed around pier and abutment.
- Condition of slope protection works around abutment.
- Gaps or cavities between abutment and embankment.
- Drift wood and garbage around pier.

(b) Illegal/Harmful Acts

- Taking of earth, sand, etc. around pier and abutment.
- Mooring of boats and ships to pier.

(3) Maintenance activities

Requirement of the maintenance activities shall be the same as those stipulated in 5.4 “Maintenance of Channel/Canal”, 5.5.1 “Embankment” and 5.5.2 “Slope (Bank and Foot) Protection Work”.

5.5.7 Barrage/Large Regulator

(1) Function

Barrage/large regulator is a gated structure constructed across a watercourse to raise and regulate the water level or to divert it into a watercourse for water use or navigation.

(2) Patrol and Inspection

(a) Damage and Irregularities

- Scouring of channel bed around barrage.
- Condition of slope protection works around abutment of the barrage.
- Gaps or cavities between abutment and embankment.
- Drift wood and garbage around barrage.
- Concrete works: any cracks on concrete and wearing out the concrete..
- Channel bed protection works: condition of boulders/concrete blocks.
- Wing wall: any cracks on concrete, and wearing out the concrete.
- Condition of the joints between the abutment and the upstream and downstream channels.
- Gate and gate leaf: In operation/movable conditions, any damage, rusting, greasing and painting.

(b) Illegal/Harmful Acts

- Taking of earth, sand, etc. around the barrage.
- Mooring of boats and ships to pier.
- Any missing of parts of gate for operation.
- Stone or plank put between pier and gate leaf.

(3) Maintenance activities

Requirement of the maintenance activities shall be the same as those stipulated in 5.4 “Maintenance of Channel/Canal”, 5.5.1 “Embankment”, 5.5.2 “Slope (Bank and Foot) Protection Work”, and 5.5.8 “Sluice and Regulator”.

5.5.8 Sluice and Regulator

(1) Functions:

Sluice is a gated structure, which allows water to flow under an embankment, road, or similar obstruction, for draining a surplus water of a watercourse, the polder and the inland.

Regulator, including escape, is a gated structure constructed to control water flow to different area in the irrigation system and to regulate the water level of canals. The regulator constructed at the beginning of the irrigation canal is called as a Head Regulator. Escape is a kind of regulators that is built at the last point or at any suitable point of a canal for escaping surplus water.

Since the sluices and regulators are holes made across the embankment, damages of the conduit and malfunction of the gate would mean the loss of function of embankment. It should be reminded that most of disaster happens at those structures by seepage of water between conduit and embankment. Special attention shall be paid at those structures during flood times.

Deformation which decreases the function of sluice and regulator is listed as follows.

(a) Suction and leakage
Suction of soil along structural body or leakage at joint of structures could be one reason of the followings.
- Inclination of gate pier and wing wall
- Hollowing around a box culvert
- Deflection, folding or crack of box culvert

Opening at joint of structures

Clock on box culvert

Figure 5.10 Suction and Leakage

(b) Deterioration and corrosion
Deterioration of concrete, water stop rubber, etc. and corrosion of steel should be grasped by visual inspection and be repaired before it gets worsen

Exposed reinforcing bar due to detachment of concrete

Rust of reinforcing bar

Figure 5.11 Deterioration and Corrosion

(c) Sediment deposition and vegetation

If sediment deposition or vegetation proceeds in water course of sluice/regulator, expected discharge cannot be conveyed. And it prevents the gate from closing certainly.

Sediment deposition from apron to box culvert

Vegetation in front of gates

Figure 5.12 Obstruction by Sediment Deposition and

(2) Patrol and inspection:

(a) Damages and Irregularities:

- Gate and gate leaf: In operation/movable conditions, any damage, rusting, greasing and painting.
- Culvert/conduit: Any cracks on concrete.
- Earth works: Any cracks and cave-in.
- Clogging of conduit with garbage, sand gravel, etc.
- Seepage or local scouring.

(b) Illegal/Harmful Acts

- Any missing of parts of gate for operation,
- Stone or plank put between conduit and gate leaf, and
- Barrier put privately at the inlet of conduit.

(3) Maintenance activities:

(a) Repair and rehabilitation of damaged portions by force account or contract system depending on the quantity of works,
(b) Maintenance operation and greasing at four (4) times a year, by caretaker,
(c) Painting of gate leaf at least once (1) a year,
(d) Cleaning works are required at least four (4) times annually and coarse rubbish should

be swept at need,

(e) Replacement of gate leaf should be determined considering the damage/rusted conditions.

5.5.9 Aqueduct and Siphon

(1) Function

Aqueduct is a gated structure constructed to convey water over a watercourse. Siphon is a structure constructed to convey water under a watercourse.

(2) Patrol, Inspection and Maintenance Activities:

Patrol, inspection and maintenance activities of the aqueduct shall be conducted in accordance with 5.5.6 “Bridge/Culvert” and 5.5.8 “Sluice and Regulator”.

Those of the siphon shall be in accordance with 5.5.8 “Sluice and Regulator”.

5.5.10 Pump Station

(1) Function

Pumping station is the facilities including pumps and equipment for pumping water from one place to another, with the purpose of irrigation or drainage.

(2) Patrol, Inspection and Maintenance Activities

The pump station is a large scale and complex facility. Therefore, the maintenance manual was prepared during the construction woks and maintenance of the pump station should be conducted in accordance with the prepared manual.

5.5.11 Hydrological Observation Station, Flood Warning System, etc.

(1) Function

The hydrological observation stations for rainfall and river water level and the equipment related to the flood warning system are key facilities of the O&M activities. All of the O&M activities are conducted based on the information observed from those facilities.

(2) Patrol, Inspection and Maintenance Activities

The hydrological observation stations and the equipment related to the flood warning system are distributed widely in the jurisdictional area of the field office and the observations at the stations are conducted automatically or manually. Information from those facilities is a key of the O&M activities. Therefore, the maintenance of the facilities shall be carried out timely. Periodical patrol by the field office staff at least once a month and daily inspection of the site staff are required, especially during the period from pre-monsoon season to post monsoon season,. Maintenance and update of the equipment shall be conducted timely in accordance with the equipment’s manual.

5.6 Maintenance of Related Structures and Equipment

5.6.1 Housing/Office

The office, operator house, warehouse, rest house, residential building, etc. should be inspected and observed regularly. The necessary maintenance works including rehabilitation and reconstruction should be carried out timely.

5.6.2 Equipment

Vehicles used for patrol, field inspection, hydrological observation and communication and transportation during flood should regularly be inspected and timely be maintained always in good condition.

Construction equipment should always be inspected and timely be maintained to use ordinary activities and flood fighting.

6. Budgeting of O&M

6.1 Budgeting

The O&M budget is prepared based on planning and scheduling. Budgeting and planning cannot be separated. Two essential items of information for budget preparations are:

- Work schedule, and
- Unit rates of the activities involved.

Cost accounts may serve as a best guide in preparation for the budgets. Cost accounts provide detailed information on previous costs of O&M works components. The unit rates should be modified annually in order to cope with inflation effects.

A well prepared O&M budget consists of preliminary estimate of the general needs for the coming three (3) years (the medium term O&M plan) and a detailed estimate for next year (the need basis O&M budget). A budget estimate for a particular year should not be used for the next year, as a detailed estimate is required for each year. As a result, the three (3) years budget must be adjusted annually.

O&M budget should consist of the following components;

- General and administration budget
- Operations budget
- Maintenance budget
- Special budget (for corrective maintenance)

Each component contains cost estimates for manpower, supplies and materials, transport and equipment and others. A standard budgeting procedure of BWDB should be applied, in accordance with the BWDB O&M Guideline and the use of unification forms which are encouraged by BWDB.

Special budget is prepared for projects which do not occur every year and may take more than one year to accomplish.

6.2 Remarks to Budgeting

During the budget preparation, the following points shall be kept in mind:

(1) Beneficiaries participation of O&M activities:

Except the large scale structures such as barrages, large regulators and pump stations, operation and routine maintenance works shall be shared with WMOs as much as possible.

(2) Sharing of O&M activities with other agencies

Sharing the maintenance activities shall be shared with other agencies, such as LGED and local governments. For example, the embankment crest is used as the ordinary road and routine maintenance and periodic maintenance works can be shared with the other agencies.

(3) Revision of O&M plan after allocation of budget

In case that the allocated budget is less than the proposed need basis annual budget, the medium term O&M plan and annual O&M plan should be revised properly.
If there are accumulated damages of the structures in the scheme and it is difficult to implement the maintenance works within budgets for 3 to 5 years, it is recommended to propose those corrective maintenance works as a rehabilitation project.

7. Implementation and Monitoring of O&M

7.1 Implementation of O&M

The Implementation phase in the O&M comprised two distinct types of implementation namely implementation of the water management plan (Operation) and the implementation of the maintenance plan (Maintenance).
These two (2) type of implementation are distinguished by the different nature of each, which inter alia is reflected in the different level of involvement of various parties in the implementation. Operation basically denotes the control of water levels i.e. discharges by operators of the O&M organization with a direct bearing on the water users. Maintenance mainly includes structural works carried out by third parties, supervised by the O&M organization without a direct impact on the water users.
O&M GIS database is introduced in Annex-2 as one of the tool of O&M activities. The User's manual of the O&M GIS database is prepared in the Project.
The implementation of the O&M in general is described in detail in Chapter 4 "Operation Manual" and Chapter 5 "Maintenance Manual".

7.2 Monitoring of O&M

Monitoring implies collection of data, processing those data and reporting the results. In order to monitor the O&M transparently, simply, and effectively, it is recommended to apply the participatory monitoring. It gathers information on key indicators, so that it can be completed within a short period of time and can produce results which are useful for all stakeholders. The five primary types or themes of monitoring are as follows:

Table 7.1 Primary Types of Monitoring of O&M

Type / Theme of Monitoring	Purpose	Indicators	Method
Water Management/ Infrastructural	Plan / assess operation and routine / periodic maintenance	Condition of dykes, sluices, inlets, canals, water level	Joint field observations by WMOs & BWDB
Institutional	Assess the WMO's functioning and relationships	WMO unity, activities, participation	Record / analysis by WMOs & BWDB
Economic	Assess the benefits of Water Management	Cropping patterns, yields, employment	Data from WMOs
Social	Assess the poverty reduction impact and gender issues	Poverty status of WMO members, women's roles	Analysis by WMOs & BWDB
Environmental	Plan / assess the SEMP activities	Environmental action, pollution	Analysis by WMOs & BWDB

The indicators for each of the types of monitoring have been kept simple and low in number, in order for the monitoring to be manageable, sustainable and user-friendly. The rating method developed in this way is based on the traditional "sholo anna" which many people use in rural areas and which all WMO members readily understand. The questions used shall be developed by WMOs and BWDB jointly.

8. Flood Fighting

8.1 General

It is very important to prevent an occurrence of flood disasters. In this connection, periodical patrol, inspection and maintenance shall be carried out. Any signs and indication of failure of structures shall be noted, repaired and rehabilitated. The floods will occur in future. As many parts of the scheme are employed the embankment system, any breach or destruction of embankment brings catastrophic damage to the riparian area. Thus, in order to minimize flood disaster, the operation works during flood time are most important.

Plan of operation works during flood will be made as an emergency preparedness plan through a special institution. In the emergency preparedness plan for flood, the following components shall be included.

- Identification of crucial hazard area
- Availability of emergency personnel
- Stockpile of emergency material and equipment
- Plan to be used in flood fighting
- Evacuation plan

8.2 Preparation for Severe Rainy Season

In this chapter, general and technical descriptions for the flood fighting during emergency period are presented.

The main executing body of the operation and maintenance of the scheme shall be carried out the following preparation before the severe rainy season. The respective government bodies shall share their responsibilities according to their own work divisions through the coordination meeting.

a) Checking of the condition of gates and other structures.
b) To secure of the radio telecommunication and transportation system.
c) To prepare an inventory of the critical parts of the embankment and to observe them regularly and more thoroughly.
d) To secure stockpiles of sandbags, wooden and bamboo piles, woven bamboo mattress, gabion wires, stones and other materials required for emergency actions during floods.
e) To summon the staff of picket and associate members for flood fighting
f) A flood warning guidelines book shall be made available at each flood warning picket.
g) If necessary, simulation training for the staff of picket on flood fighting shall be conducted.

Besides, it is recommended that the field office of BWDB shall prepare, sandbags, bamboo trees, some earth hauling equipment and others related materials as an own-force accounting basis.

8.3 Inspection of Facilities

During the flood time/high tide/severe waves, the following sites should be inspected carefully:

a) the discharge capacity is less,
b) the height of embankment crest or sea dike is lower,

c) the embankment was broken in the past,
d) the former river course,
e) a space or crack occurred in the past,
f) leakage of water or sand boil occurred in the past,
g) flood water/wave attacks violently,
h) the foot of slope protection of river bank/groyne/sea dike is washed away,
i) severe erosion site along the coast,
j) under construction, and
k) river/drainage/coastal structures such as sluiceway, bridge, groyne/spur dike, sea dike, etc.

8.4 Possible Causes of Damage to Embankment and its Countermeasures

8.4.1 Possible Causes of Damage to Embankments

The causes of damage to embankments are classified into the following three (3) categories:

(1) Overflow

The following places are apt to be damaged by overflowing.

(a) where the height of the embankment crest is low,
(b) where the channel be rises, and
(c) upstream parts of facilities crossing the river such as bridges and barrage.

When flood water overflows the embankment crest, the excess water scours the toe at the backside slope and the scouring area enlarges gradually. Finally this scouring breaks the embankment.

(2) Seepage

The seepage water loosens the embankment body and bridges damage or cracking or collapse to the backside slope.

(3) Scouring

The following places are liable to be damaged by scouring.

(a) where flood water attacks due to meandering of the river,
(b) where the slope protection work is damaged, and
(c) downstream parts of the facilities crossing the river such as bridge and barrage.

(4) Others

The embankment with the following conditions are apt to be damaged:

(a) lacking of drainage facilities
(b) mole or rat holes
(c) ponds besides embankment, etc.

If the embankment are in the above case, those are apprehended to be breached. Urgent repair shall be executed immediately. Urgent repair herein defined is a temporary protective structure to minimize and localize the damage of levee and to avoid a breach. As soon as an indication of damage is informed to the executing body, the following maneuvers shall be made:

- To collect information of the extent of damage as precisely as possible, Accessibility to site shall be clarified.
- To prepare an urgent repair plan such as countermeasure, construction method, material, manpower and equipment.

- To summon staff and associate members. It is quite difficult to continue the repair works only by the staff of executing body. Staff from other authorities concerned and sometimes contractor nearby the site are required.
- To secure the works and construction equipment.
- To secure the material such as sandbags, wooden piles, bamboos and soil itself.
- To secure the communication system, handy talky etc. is requisite.
- To secure lighting equipment for night works.

8.4.2 Countermeasures to Prevent Flooding

Technical guidance of flood countermeasures is shown in Annex-3. Those countermeasure are very simple, but applicable and are still valid.

8.5 Evacuation

Instruction for evacuation is one of the important work for flood fighting. The timing of instruction must be judged carefully. The instructions should be disseminated by alarm bell, siren, sound truck or other communication. After receiving the instructions, the inhabitants should evacuate and remove their properties respectively to the public buildings designated by the flood defense board beforehand.

8.6 Transaction of Disaster

When the embankment is broken unfortunately information should be sent to inhabitants and the authorities concerned as soon as possible. Besides, urgent rehabilitation works are necessary to prevent the flood damage spread. After the flood, real rehabilitation works should be carried out considering the cause of break.

The field office of BWDB and WMOs shall execute the following actions after flood.

a. To make an inventory of the damage caused by flood such as: total life loss, total property loss of the inhabitants, total damaged houses, buildings and other infrastructures.
b. To draw a flood map including the date of occurrence, location, and extent of the inundation area, inundation depth and duration.
c. To evaluate the cause of flood.
d. To make a draft emergency maintenance plan and budget for implementation.
e. To submit them (items a, b, c and d) to the Authorities for information and approval.

Terms of Reference
on
Inventory Survey of Hydraulic Structures
in
Moulvibazar O&M Division, Chittagong O&M Division-1, Chittagong O&M Division-2, and Cox's Bazar O&M Division, BWDB

1. General

Bangladesh Water Development Board (hereinafter referred to as "BWDB" is the main organization responsible for the water resources development and management of the People's Republic of Bangladesh. BWDB has implemented over 700 large and small projects for the water resources management and development in the country, and operation and maintenance of the constructed structures become the main issue of BWDB.

Inventory survey of the hydraulic structures managed by BWDB is conducted with the purpose of preparation of the ledgers of the managed structures as the basic data for preparation of efficient operation and maintenance plans in the O&M divisions.

Objective O&M divisions of the inventory survey are the following four divisions:

(1) Moulvibazar O&M Division,
(2) Chittagong O&M Division-1,
(3) Chittagong O&M Division-2, and
(4) Cox's Bazar O&M Division.

Completed water development schemes in the above divisions are listed in Table 1, Table 2, Table 3 and Table 4, respectively.

In addition, district maps of Moulvibazar, Chittagong and Cox's bazar, which are related to the above O&M divisions, are presented in Figure 1, Figure 2 and Figure 3, respectively.

2. Scope of Works

(1) Objective Area:
Jurisdictional areas of the Moulvibazar O&M division (Figure 1), Chittagong O&M Division-1 (Figure 2), Chittagong O&M Division-2 (Figure 2), and Cox's Bazar O&M Division (Figure-3)

(2) Objective Hydraulic Structures
Objective hydraulic structures are the hydraulic structures developed by the BWDB, as followed:
- River channel
- Drainage channel
- Irrigation canal
- Appurtenant Structure
  Embankment, Bank and foot protection work, groin/ spur dike, road, bridge/culvert,
- Water Control Structures
  Barrage/large regulator, sluice/escape, aqueduct, siphon, pump station

(3) Scope of the Works

Scope of the works of each O&M Division is as follows:

a. To clarify the approximate locations of all hydraulic structures constructed and maintained by the O&M Division Office (the O&M office) through the interviews with the officials of the O&M office and local peoples.
b. To conduct the field investigation of the hydraulic structures in the jurisdictional area of the O&M office, in order to clarify the precise location, basic dimensions and existing condition of the structures.
c. To summarize the field data and records and to provide report.

(4) Coordination System

Coordination system of the Services shall refer to WGS84.

(5) Equipment for Inventory Survey

During the inventory survey in the field, the following equipment shall be applied:

a. Portable GPS (or mobile phone with the GPS function and the GPS application)
b. measurement tape
c. Ranging rod (red and white rod) or equivalent
d. Digital camera

(6) Data provided by the Project

Regarding the Moulvibazar O&M Division, the preliminary GIS data including the maps with a scale of 1:25,000 are provided by the JICA Expert Team of the Project for Capacity Development of Management of Sustainable Water Related Structure.

3. Specification of the Services

3.1 Collection of data and information in Each O&M Office and Local Peoples

Through the interview with the officials of each O&M office and the local peoples in each O&M division, the following data and information shall be collected as much as possible:

a. Boundary of water resources management schemes: approximate boundaries of respective schemes, except the boundaries of the schemes investigated by IWM/WMIP.
b. Channel (river channel, drainage channel, irrigation canal): Name, jurisdictional extent, management body of ordinary O&M
c. Appurtenant Structure (embankment, bank and foot protection work, groin/ spur dike, road, bridge/culvert): Approximate location and dimension, present condition of the structures
d. Water control structures (Barrage/large regulator, sluice/escape, aqueduct, siphon, pump station): Approximate location and dimension, present condition of the structures.

If there are preliminary rehabilitation plans in the O&M offices, information related to the preliminary rehabilitation plans shall be collected and shall be included in the report.

3.2 Inventory survey in the field

Referring the data and information collected, the inventory survey of each O&M Division shall be conducted. The inventory surveys of the structures include recording the location, measurement and sketch, and taking the pictures through the following manners, and Form 1 shall be applied to recording the survey data:

a. Channel (river channel, drainage channel, irrigation canal):

As for the channels, the following item shall be surveyed at the upstream end and the downstream end of the jurisdiction of the O&M Office, and at the major bridge sites crossing the channels:

Channel (river channel, drainage channel, irrigation canal)

Coordinates	Layout/sketch	Picture
N XX YY ZZ.Z E XX YY ZZ.Z	Location map (sketch)	Upstream view of the channel Downstream view of the channel * Ranging rod shall be included in the pictures

b. Appurtenant structures

Embankment:

The following items shall be clarified at every about 2.0 km and the damaged site of embankment.

Embankment (every about 2.0 km)

Coordinates	Layout/sketch	Picture
N XX YY ZZ.Z E XX YY ZZ.Z	Cross section profile with crest width, Slope gradient (river side, land side), height, and berm width if exist (river side, land side)	Upstream view of the embankment (inland side, crest, river-side) Downstream view of the embankment (inland side, crest, river-side) * Ranging rod shall be included in the pictures

Embankment (damaged site)

Coordinates	Layout/sketch	Picture
N XX YY ZZ.Z E XX YY ZZ.Z (at the center of damaged site)	Plan with damaged extent (length) Cross-section with remained crest width	View from downstream site View from upstream site * Ranging rod shall be included in the pictures

Bank and foot protection work:

Coordinates	Layout/sketch)	Picture
Downstream site N XX YY ZZ.Z E XX YY ZZ.Z Upstream site N XX YY ZZ.Z E XX YY ZZ.Z	Cross section profile with slope gradient, slope length, and materials of the bank and foot protection.	View from the upstream site, View from the downstream site, Partial views for the materials of the works. * Ranging rod shall be included in the pictures
In case of damage	Damage location, length and width shall be indicated in the above plan	View of damaged site.

Groin/ spur dike:

Coordinates	Layout/sketch)	Picture
N XX YY ZZ.Z E XX YY ZZ.Z (at the river bank site of each groin)	Pan of alignment including length and direction, Cross section profile with crest width, height and slope gradients of both sides.	Full view from the river bank, Partial view for the materials of the work * Ranging rod shall be included in the pictures
In case of damage -	Damage location, length and width shall be indicated in the above plan	View of damaged site.

Road:

Coordinates	Layout/sketch	Picture
Downstream site N XX YY ZZ.Z E XX YY ZZ.Z Upstream site N XX YY ZZ.Z E XX YY ZZ.Z	Pan of alignment with direction Cross section profile with road width, height, slope gradients of both sides, existence of the pavement and its materials.	Views from the upstream and downstream ends, * Ranging rod shall be included in the pictures
In case of damage N XX YY ZZ.Z	Damage location, length and width shall be indicated in the above plan	View of damaged site.

E XX YY ZZ.Z (at the center of damaged site)		

Bridge/culvert:

Coordinates	Layout/sketch	Picture
N XX YY ZZ.Z E XX YY ZZ.Z (at the center of the bridge/culvert)	Pan with length and width, Section including connection with both bank	view from the river bank, sectional view of the bridge/ culvert * Ranging rod shall be included in the pictures
In case of damage	Damage location, length and width shall be indicated in the above plan	view of damage

c. Water control structures

Barrage/large regulator:

Coordinates	Layout/sketch	Picture
Right bank N XX YY ZZ.Z E XX YY ZZ.Z Left bank N XX YY ZZ.Z E XX YY ZZ.Z	Layout plan with width of gates, Section including width and height of each gate.	Full view of the barrage/large regulator, sectional view of the barrage/ large regulator Picture of guide plate/nameplate (if exist) * Ranging rod shall be included in the pictures
In case of damage	Damage location, length and width shall be indicated in the above plan	view of damage

Regulator/sluice/escape:

Coordinates	Layout/sketch	Picture
N XX YY ZZ.Z E XX YY ZZ.Z (at the center of the structure)	Layout plan with the inlet, outlet and gate Section including width and height of vent.	Full view of the structure, view of inlet, view of outlet. * Ranging rod shall be included in the pictures
In case of damage	Damage location, length and width shall be indicated in the above plan	view of damage

Aqueduct:

Coordinates	Layout/sketch	Picture
N XX YY ZZ.Z E XX YY ZZ.Z (at a bank)	Layout plan of structure Section including dimensions of the water way.	Full view of the structure, Sectional view of the structure * Ranging rod shall be included in the pictures
In case of damage	Damage location, length and width shall be indicated in the above plan	view of damage

Siphon:

Coordinates	Layout/sketch	Picture
N XX YY ZZ.Z E XX YY ZZ.Z (at the inlet or outlet of the structure)	Layout plan of the structure Section including dimensions of the water way.	Full view of the structure View of the inlet, view of outlet. * Ranging rod shall be included in the pictures
In case of damage	Damage location, length and width shall be indicated in the above plan	view of damage

Pump station:

Coordinates	Layout/sketch	Picture
N XX YY ZZ.Z E XX YY ZZ.Z (at the center of the embankment)	Layout plan of the structure, buildings with the number of the pumps, the capacity of each pump, If there is other appurtenant structure, the appurtenant structure shall be surveyed in accordance with the guidance of the structure.	Full view of the pump station, sectional view of the inlet and outlet, view of pump 8if possible) * Ranging rod shall be included in the pictures
In case of damage	Damage shall be indicated in the above plan	view of damage

3.3 Summary of field data and records and Reporting

Location of hydraulic structures in respective water management schemes shall be plotted in the maps. All of data and records collected in the field shall be arranged by use of the Form 2.

The reports shall be compiled as the following volumes:

Vol. 1: Inventory Survey of Hydraulic Structures in Schemes related to Manu River in Moulvibazar O&M Division
Vol. 2: Inventory Survey of Hydraulic Structures in Other Schemes in Moulvibazar O&M Division
Vol. 3: Inventory Survey of Hydraulic Structures in Chittagong O&M Division-1
Vol. 4: Inventory Survey of Hydraulic Structures in Chittagong O&M Division-2
Vol. 5: Inventory Survey of Hydraulic Structures in Cox's Bazar O&M Division

The Reports shall be included:

- Location maps of the hydraulic structures of respective schemes including the boundaries of schemes.
- List of schemes including the numbers of the structures.
- Records (Form 2) of the investigated structures.
- Other information from the office and field, if any.

4. Quantity and Schedule of the Services (Tentative)

(1) Quantity of the Services
The quantity of the services is shown in Table 5.

(2) Schedule of the Services
Draft schedule of the Services are shown in Table 6.

Table 1 Completed Water Resources Development Schemes in Moulvibazar O&M Division Office

No.	Scheme Name	Project Type	Location (Upazilla/District)	Gross Area/ Net Area (ha)	Imple. Period	Direct Cost (Lakh Tk)
1 *1	Barachara Irrigation Project	DI	Kulaura/ Moulvibazar	2,000/ N.A.	1999-2000	212.00
2 *1,*2	Dewarachara FCD Sub-Poject	FCD	Kamalganj/ Moulvibazar	4,450/ 4,450	1998-2004	255.18
3 *1	Hail Haor Project	FCD	Moulvibazar Sadar & Sreemangal/ Moulvibazar	24,372/ 18,176	1981-1989	1,069.42 & Wheat 1,500MT
4 *1,*2	Hamhami Chara Sub-Project	FCD	Moulvibazar Sadar, Kamalgonj/ Moulvibazar	2,594/ 1,294	1988-1991	145.10 & Wheat 490 MT
5 *1	Manu Left Embankment Project	FCD	Moulvibazar Sadar/ Moulvibazar	16,000/ 16,000	1982-1986	408.24
6 *1,*2	Manu River FCD Project Phase-I	FCD	Kulaura/ Moulvibazar	3,075/ 2,567	1989-1993	159. 00 & Wheat 4480 MT
7 *1,*2	Manu River FCD Project Phase-II	FCD	Kulaura & Rajnagar/ Moulvibazar	5,200/ 1,500	1994-1998	201.53 & Wheat 4563 MT
8 *1	Manu River Project	FCDI	Rajnagar & Moulvibazar Sadar/ Moulvibazar	24,178/ 19,028	1975-1983	7,258.00
9 *1	Phanai River WCS (not functioning)	I	Kulaura/ Moulvibazar	1,500/ 1,200	1983-1985	157.89
10 *1,*2	Shaka Borak Project	FCD	Moulvibazar Sadar/ Moulvibazar	4,520/ 3,800	1988-1993	113.87 & Wheat 390 MT
11 *1,*2	Sharifpur FCD System	FCD	Kulaura/ Moulvibazar	1,822/ 1,214	1987-1995	145.00 & Wheat 1100 MT
12 *1	Tarapasa Premnagar Flood Control Embankment Project	FC	Rajnagar/ Moulvibazar	8,000/ 6,500	1994-1996	211.50
13 *3	Bank Protection Work for Manu River Left Bank from bashat to Manumukh	BP	Moulvibazar Sadar/ Moulvibazar	11,480/ -	1982-1999	751.58
14 *3	Moulvibazar Town Protection Project	TP	Moulvibazar Sadar/ Moulvibazar	1,500/ -	1992-1999	1618.38
15 *3	Protection Work of Area adjacent to Manu Mukh Bazar	BP	Moulvibazar Sadar/ Moulvibazar	8,000/ -	1994-1999	110.81
16 *3	Bank Protection Work of Manu River up to Balikandhi Palpur in the Right Bank	BP	Moulvibazar Sadar/ Moulvibazar	1,500/ -	1995-1998	303.00
17 *3	Protection of Territory of Bangladesh from erosion of Juri River	BP	Juri/ Moulvibazar	2,470/ -	2003-2005	551.90
18 *3	Kaminiganj Bazar Protection Project from erosion of Juri River	BP	Juri/ Moulvibazar	1,422/ -	2002-2004	195.88
19 *3	Early Flood Control and Drainage Project in Haor Area	FCD	Moulvibazar Sadar, Rajnagar/ Moulvibazar	22,672/ 11,578	2011 – On going	1,452.98

Source:
- *1: Scheme Database Inventory and Mapping (contract package No: BWDB/S4), Water Management Improvement Project (WMIP), IWM
- *2: Database and mapping already conducted by WMIP/IWM

*3: Information from the Moulvibazar O&M Division Office
Note:
DI: Drainage and Irrigation, FCD: Flood control and drainage, FCDI: Flood control, drainage and irrigation,
I: Irrigation, FC: Flood Control, BP: Bank protection, TP: Town protection

Table 2 Completed Water Resources Development Schemes in Chittagong O&M Division-1

No.	Scheme Name	Project Type	Location (Upazilla/District)	Gross Area/ Net Area (ha)	Imple. Period	Direct Cost (Lakh Tk)
1	CEP-Polder 62	FCD	Patenga, Pahartali, Bandar/ City Corporation & Sitakundu/ Chittagong	5,600/ 5,600	1965-1996	11,300.00
2	CEP-Polder 63/1A	FCD	Anwara/ Chittagong	6,560/ 6,560	1967-1970	427.00
3	CEP-Polder 63/1B	FCD	Anwara/ Chittagong	6,030/ 6,030	1980-1981	176.00
4	Bhellapara Sub-Project	FCDI	Patiya/ Chittagong	1,100/ 800	1986	
5	Halda Extension irrigation Project	I	Hathazari/ Chittagong	2,820/ 1,820	1986-2005	4,137.64
6	Fatikchari Flood Control and Irrigation Project	FCDI	Fatikchari/ Chittagong	11,000/ 9,500	1980-1985	998.00
7	Dhurang Irrigation Project	DI	Fatikchari/ Chittagong	1,680/ 1,020	1953-1963	
8	Mondakani Irrigation Project	DI	Fatikchari, Hathazari/ Chittagong	390/ 290	1981-1983	73.00
9	Sialbukka Khal WRS	I	Fatikchari/ Chittagong	1,625/ 1,200	1981-1983	26.00
10	Katakhali Hilimili Irrigation Project	FCDI	Satkania, Lohangora/ Chittagong	1,625/ 1,200	1981-1983	39.00
11	Sobhandandi Flood Control, Drainage and Irrigation Project	FCDI	Patiya, Dhandanaish/ Chittangong	7,500/ 5,500	1975-1982	805.05
12	Nitchintapur Irrigation project	I				
13	Lalotia Irrigation Project	I				
14	Madachara WCS Project	DI	Stkania/ Chittagong	1,000/ 720	1986-1987	37.00
15	Dalu Khal FC Project	FCDI	Lohagora/ Chittagong	6,000/ 6,000	1980-1990	
16	Tankabati Khal Embankment	I	Lohagora/ Chittagong	4,000/ 800	1987-1988	
17	Srimal Khal Embankment	I		2,000/ 1,700	1988-1989	
18	Soalock Khal WRS	I		650/ 650	1982-1984	26.00
19	Hangar Khal Fllod Control & Irrigation Project	FCDI	Satkania & Lohagora/ Chittagong	4,300/ 2,500	1983-1988	112.00
20	Sangu River Project	FCDI	Satkania, Chandraniah & Lohagora/ Chittagong	8,500/ 7,000	1988-1989	
21	Fllod Control Embankment on both banks of Srimai Khal	FCD	Patiya/ Chittagong	5,900/ 5,000	1989	

Source:
*1: Scheme Database Inventory and Mapping (contract package No: BWDB/S4), Water Management Improvement Project (WMIP), IWM
Note:
DI: Drainage and Irrigation, FCD: Flood control and drainage, FCDI: Flood control, drainage and irrigation,
I: Irrigation,

Table 3 Completed Water Resources Development Schemes
in Chittagong O&M Division-2

No.	Scheme Name	Project Type	Location (Upazilla/District)	Gross Area/ Net Area (ha)	Imple. Period	Direct Cost (Lakh Tk)
1	CEP Polder 61/ 1 (Sitiakundu)	FCD	Sitakunda/ Chittagong	7,600/ 6,300	1962-1970	500.00
2	CEP Polder 61/ 2	FCD	Misarai/ Chittagong	17,000/ 15,500	1969-1987	291.00
3	CEP Polder 64/ 1A (Bashkhali)	FCD	Banshkahli/ Chittagong	5.600/ 4,700	1963-1987	352.00
4	CEP Polder 64/ 1B (Bashkhali)	FCD	Banshkahli/ Chittagong	8,000/ 7,200	1963-1987	240.00
5	CEP Polder 64/ 1C (Bashkhali) (Part)	FCD	Banshkahli/ Chittagong	1,800/ 1,450	1963-1987	139.00
6	CEP Polder 64/ 2A (Sandwip)	FCD	Banshkahli/ Chittagong	3,750/ 3,750	1963-1987	100.00
7	CEP Polder 72 (Sandwip)	FCD	Sandwip/ Chittagong	18,000/ 16,500	1963-1987	826.00
8	Prevention of Saline Water Intrusion and Drainage Project neat Sonaichari Area	FCD	Sitakunda/ Chittagong	1,160/ 1,335	2002-2007	1,998.38
9	Mohamaya irrigation Project	I	Misarai/ Chittagong	4,800/ 3,360	2001-2010	2,623.23 & Wheat 732 MT
10	Hinguli Chara Irrigation Project	I	Misarai/ Chittagong	600/ 500	1984-1986	32.00
11	Laximichara Irrigation Project	I	Misarai/ Chittagong	400/ 300	1983-1986	16.00
12	Gobaniachara WSC		Misarai/ Chittagong	400/ 400	1984-1985	26.00
13	Sonaichari WCS	DI	Ramgarh/ Khagrachari	200/ 180	1982-1986	38.00

Source:
*1: Scheme Database Inventory and Mapping (contract package No: BWDB/S4), Water Management Improvement Project (WMIP), IWM

Note:
DI: Drainage and Irrigation, FCD: Flood control and drainage, I: Irrigation,

Table 4 Completed Water Resources Development Schemes
in Cox's Bazar O&M Division-2

No.	Scheme Name	Project Type	Location (Upazilla/District)	Gross Area/ Net Area (ha)	Imple. Period	Direct Cost (Lakh Tk)
1	CEP Polder 64/ 2A (Pekua)	FCD	Pakua/ Cox's Bazar	3,750/ 3,750	1961-1967	100.00
2	CEP Polder 64/ 2B (Pekua)	FCD	Pakua/ Cox's Bazar	7,736/ 5,974	1961-1967	160.00
3	CEP Polder 65	FCD	Chakaria/ Cox's Bazar	6,649/ 6,649	1961-1967	145.00
4	CEP Polder 65/A	FCD	Chakaria/ Cox's Bazar	806/ 806	1985-1986	34.00
5	CEP Polder 65/A-1	FCD	Chakaria/ Cox's Bazar	2,800/ 2,280	1988-1994	1,391.00
6	CEP Polder 65/A-3	FCD	Chakaria/ Cox's Bazar	604/ 604	1982-1984	124.00
7	CEP Polder 66/1 (Kurushkul)	FCD	Cox's Bazar Sadar/ Cox's Bazar	4,930/ 2,852	1962-1967	599.00
8	CEP Polder 66/2	FCD	Cox's Bazar Sadar/ Cox's Bazar	2,621/ 2,400	1962-1969	239.00
9	CEP Polder 66/3 (Cox's Bazar)	FCD	Cox's Bazar Sadar/ Cox's Bazar	4,832/ 3,719	1963-1969	237.00
10	CEP Polder 66/4 (Chakaria)	FCD	Cox's Bazar Sadar/ Cox's Bazar	4,120/ 4,120	1978-1994	54.00

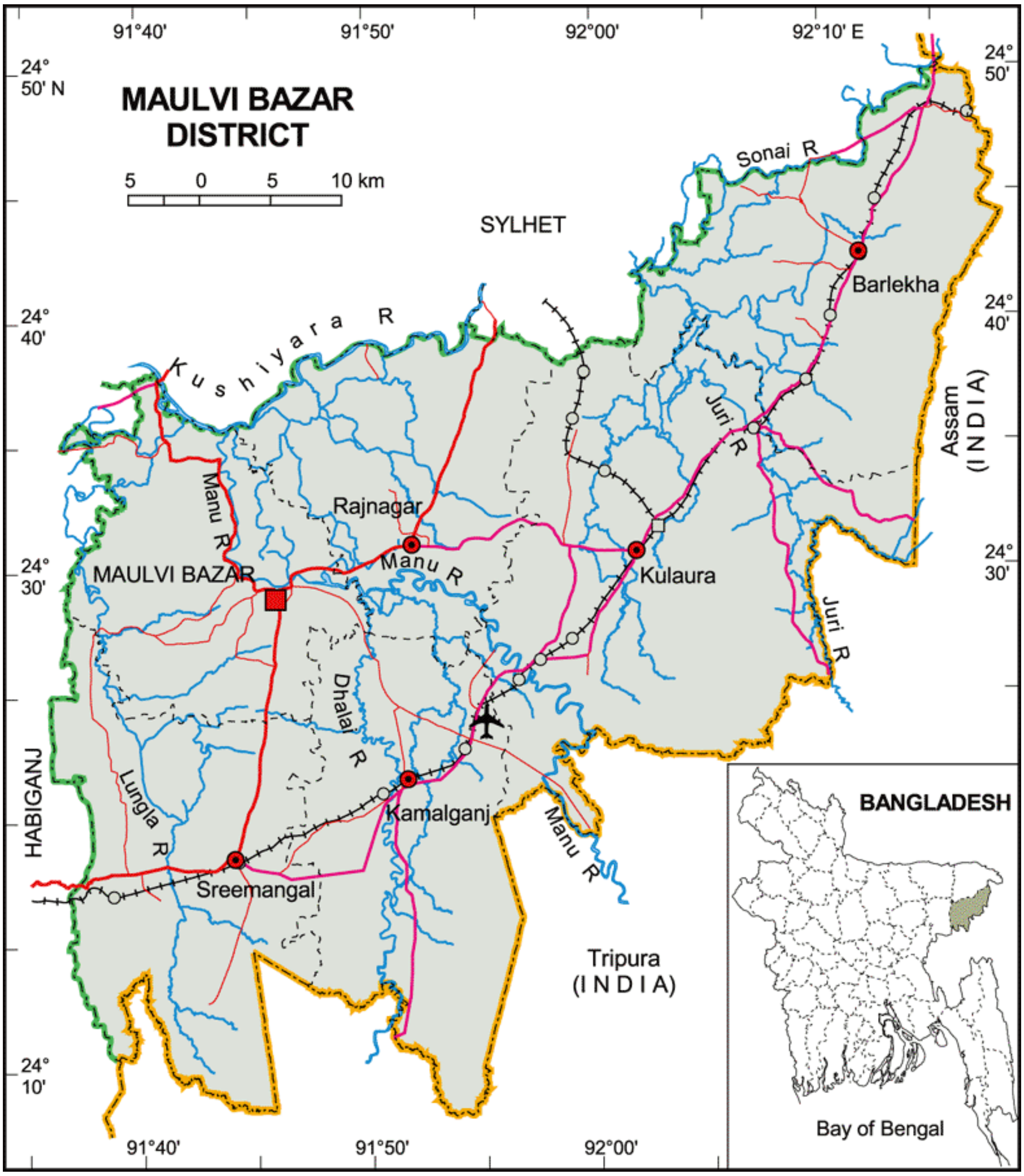
No.	Scheme Name	Project Type	Location (Upazilla/District)	Gross Area/ Net Area (ha)	Imple. Period	Direct Cost (Lakh Tk)
11	CEP Polder 67 (Knila)	FCD	Taknaf/ Cox's Bazar	1,680/ 1,600	1969-1973	54.00
12	CEP Polder 67/A (Teknaf)	FCD	Taknaf, Ukhiya/ Cox's Bazar	1,500/ 1,320	1986-1989	80.00
13	CEP Polder 67/B (Hnla)	FCD	Taknaf/ Cox's Bazar	900/ 900	1984-1989	62.00
14	CEP Polder 68 (Extension)	FCD	Taknaf/ Cox's Bazar	3,500/ 3,000	1967-1974	108.00
15	CEP Polder 69 (Phase-1)	FCD	Moheshkhali/ Cox's Bazar	1,800/ 1,200	1981-1984	1,626.00
16	CEP Polder 69 (Phase-2)	FCD	Moheshkhali/ Cox's Bazar	1,780/ 1,780	1963-1966	45.00
17	CEP Polder 69 (North East)	FCD	Moheshkhali/ Cox's Bazar	860/ 558	1981-1984	54.00
18	CEP Polder 70 (Matherbari)	FCD	Moheshkhali/ Cox's Bazar	3,023/ 3,023	1962-1965	186.00
19	CEP Polder 71 (Kutubdia)	FCD	Kutubdia/ Cox's Bazar	6,694/ 5,444	1961-1966	143.00
20	Matamuhuri Irrigation Project (Pilot)	I	Chakaria/ Cox's Bazar			
21	Harbangchara Irrigation Project	DI	Chakaria/ Cox's Bazar	2,200/ 2,200	1989-1992	94.00

Source:

*1: Scheme Database Inventory and Mapping (contract package No: BWDB/S4), Water Management Improvement Project (WMIP), IWM

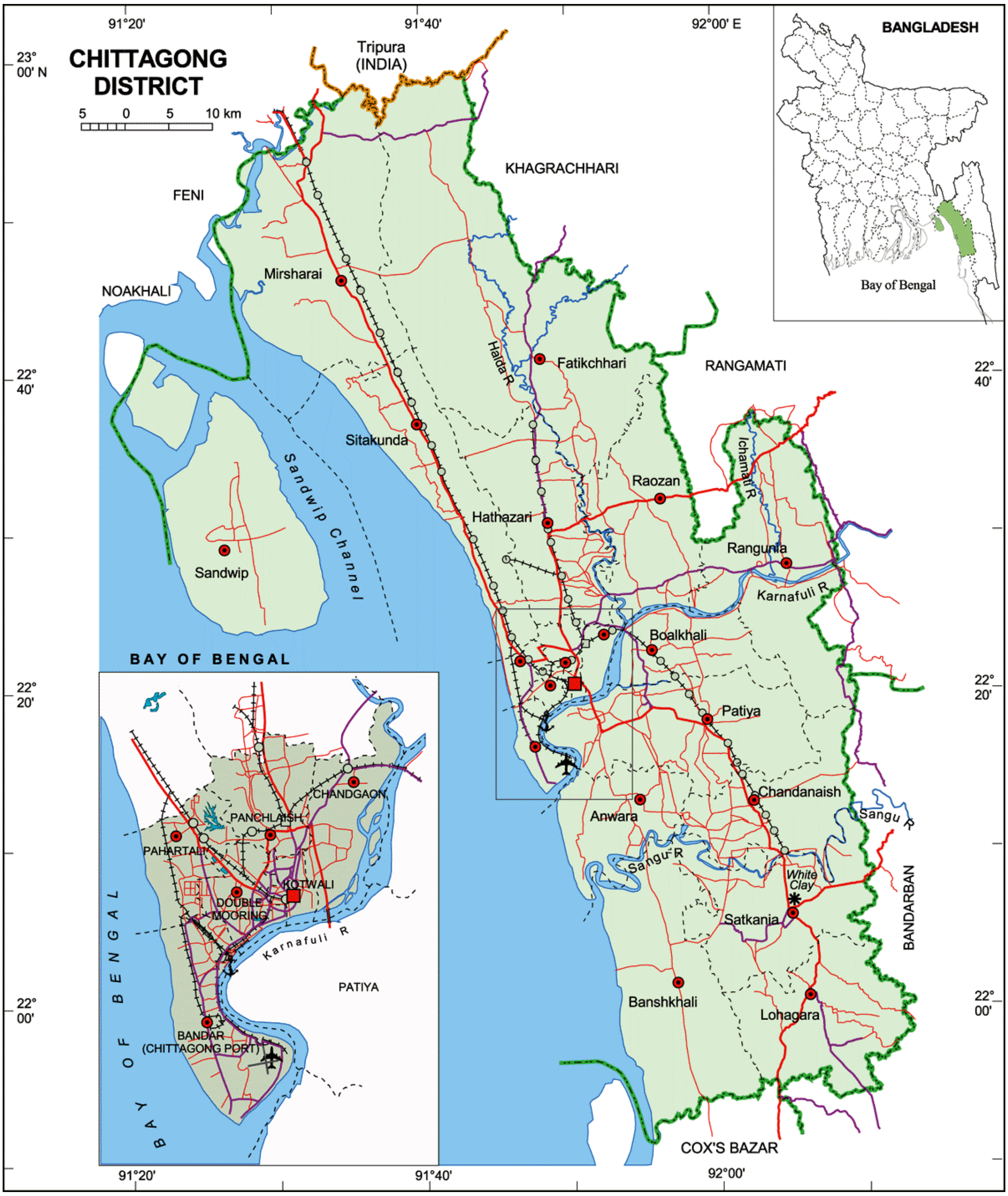
Note:

DI: Drainage and Irrigation, FCD: Flood control and drainage, I: Irrigation,



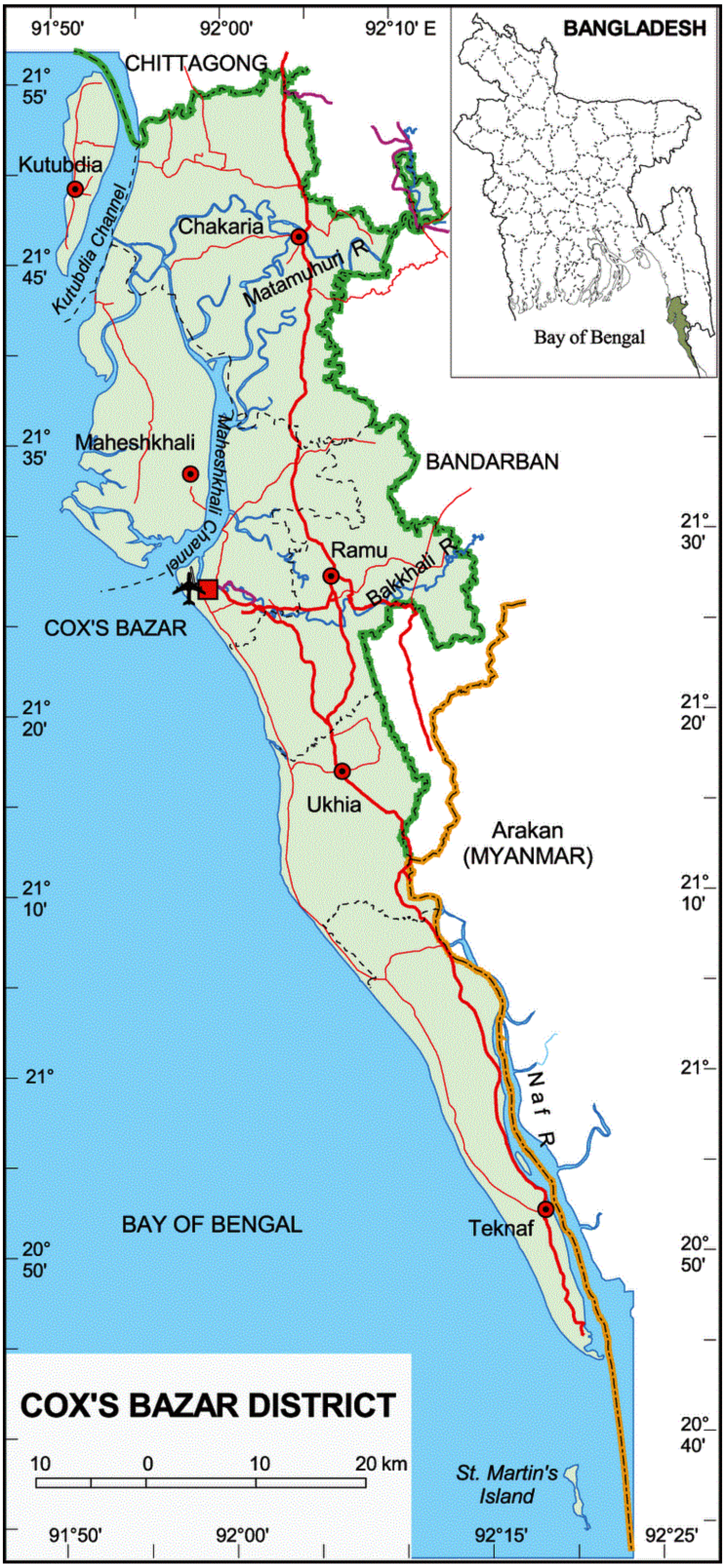
Source: BWDB

Figure 1 Map of Moulvibazar District



Source: BWDB

Figure 2 Map of Chittagong District



Source: BWDB

Figure 3   Map of Cox's Bazar District

FORM 1 (Field Datasheet)

Sheet No.:

Scheme Name:	Kind of Structure
Structure Name	Location(Coordinates): N , E
Layout/Sketch/, Dimensions, etc.	

FORM 2 (for Report: A3 size)

Sheet No.:

Scheme Name:	Kind of Structure
Structure Name	Location(Coordinates): N , E
Layout/Sketch/, Dimensions, etc.	Photographs

Table 5 Quantities of the Services

Item	Unit	Amount	Remarks
1. Inventory Survey in Moulvibazar O&M Division			
1.1 Collection of Data & Information	LS		
1.2 Inventory Survey in the Field	LS		
1.3 Summary of Field Data & Record/ Reporting	LS		
1.4 Direct Cost	LS		
1.5 Sub-total of 1			
2. Inventory Survey in Chittagong O&M Division-1			
2.1 Collection of Data & Information	LS		
2.2 Inventory Survey in the Field	LS		
2.3 Summary of Field Data & Record/ Reporting	LS		
2.4 Direct Cost	LS		
2.5 Sub-total of 2			
3. Inventory Survey in Chittagong O&M Division-2			
3.1 Collection of Data & Information	LS		
3.2 Inventory Survey in the Field	LS		
3.3 Summary of Field Data & Record/ Reporting	LS		
3.4 Direct Cost	LS		
3.5 Sub-total of 3			
4. Inventory Survey in Cox's Bazar O&M Division			
4.1 Collection of Data & Information	LS		
4.2 Inventory Survey in the Field	LS		
4.3 Summary of Field Data & Record/ Reporting	LS		
4.4 Direct Cost	LS		
4.5 Sub-total			
Total of 1 - 4			

Table 6 Schedule of the Services

No.	Survey								
		Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1	Inventory Survey in Moulvibazar O&M Division								
2	Inventory Survey in Chittagong O&M Division-1								
3	Inventory Survey in Chittagong O&M Division-2								
4	Inventory Survey in Cox's Bazar O&M Division								
	Report		▲ MB(Manu)		▲ CG-1&2	▲ CB	▲ MB(other)		

O&M GIS DATABASE

1. Generals

The basic information of the hydraulic structure, such as location, specification, damaged record and maintenance records, is important element for long term operation and maintenance of structure. For the purpose of efficiently accumulate and grasp the specification of hydraulic structure such as location, photo etc., the GIS database has been developed for BWDB O&M division officer to use and manage under the daily work. In consideration of operation by O&M division officer who doesn't have the specific computer knowledge, the GIS database has been prepared for simple structure system and not necessary to specific knowledge like System program.

- The application of GIS

The application of GIS database has been adapted by Quantum GIS (hereinafter referred to as the QGIS). The application is open source application and every user can download by website at "http://qgis.org/ja/site/". The version of current GIS database is 2.18.3.

- The layer structure

GIS database has a view function by overlaying information as layer system on the Map. The main layers are hydraulic structure, Embankment, Revetment and related damaged condition information linked with inventory sheet. As the others layer, it is included the basic map information layer like administration boundary, road infrastructure and natural condition like river, haor and topographic data. The layer list and "Table of contents" are shown in Table 1 and Figure 1.

Table 1 The Layers structure of the GIS Database

Classification	Layer	Source	Reference
Specification of hydraulic structure	Embankment, Canal (line data)	IWM, SOB, field inspection	The data items are originally from WMIP database and collected from field inspection.
	Other hydraulic structure point data (ex. Regulator, Pipe Sluice)	IWM, SOB, field inspection	The data items are originally from WMIP database and collected from field inspection. The layer is linked with Inventory sheet
Damage records of hydraulic infrastructure	Embankment, Channel, Canal (line data)	Field inspection	Linked with inventory sheet
	Other hydraulic infrastructure point data (ex. Regulator, Sluice)	Field inspection	The information of damaged record is including inventory sheet of specification of hydraulic structure layer
Natural condition	River	IWM, SOB	Classified with main and small river

Classification	Layer	Source	Reference
	Lake, Haor	Existing Survey reports	
Infrastructure	Road	IWM, SOB, LGED	
	Railway	SOB	
Topographic data	Digital elevation map(DEM)	USGS	SRTM 1 arc sec (30m) resolution Digital Elevation Map and Hill shade.
Administration boundary	District boundary	SOB	
Other	Existing project area	IWM	Project area conducted by the BWDB or Donor aid

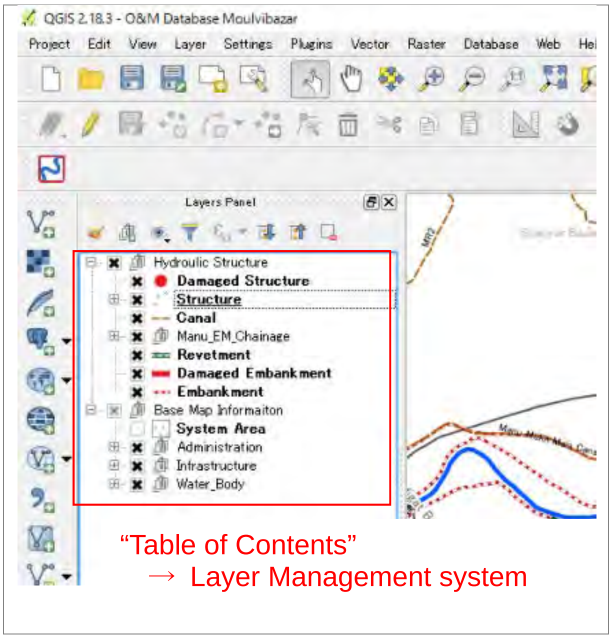


Figure 1　The Layers structure of the GIS Database

➢ The general view function of the GIS database

The GIS database mainly consists of "Table of Contents" and "Map View" part. The "Table of Contents" is the layer management by open tree system. The "Map View" part is managed by geographic coordinate system. The detailed operation is introduced and explained in the user's manual.

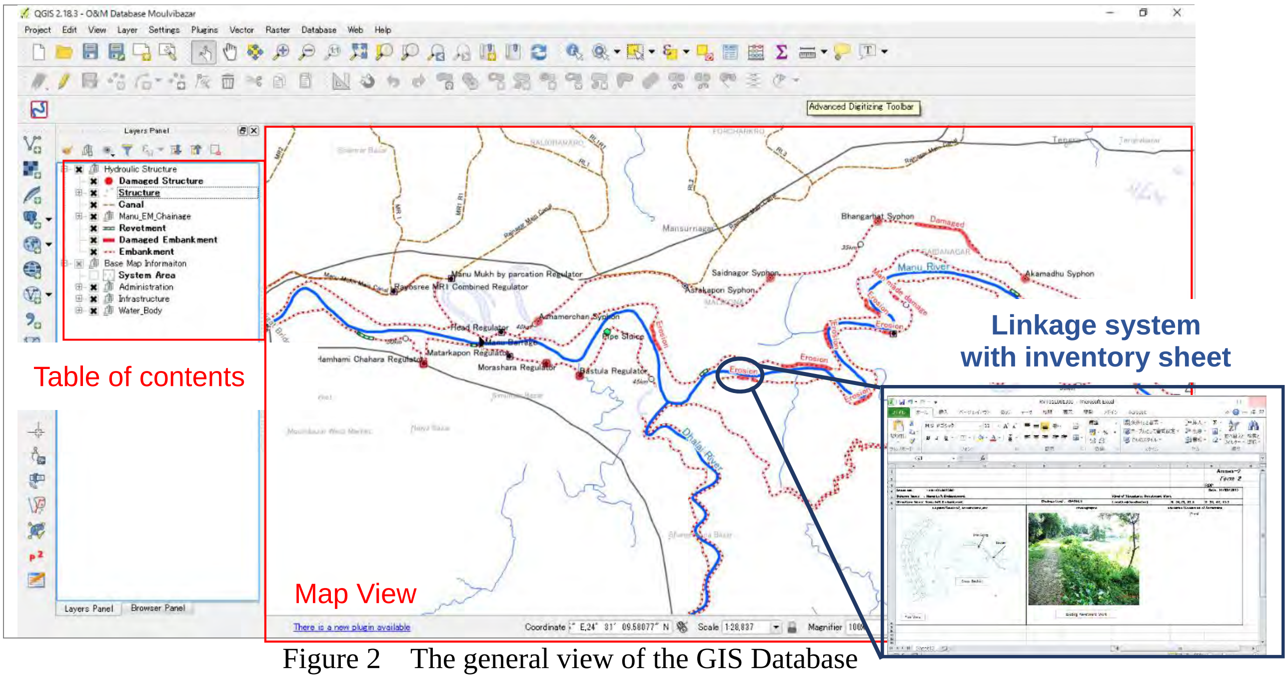


Figure 2 The general view of the GIS Database

2. User's Manual

For the purpose of managing the GIS database, the User's manual has been prepared. The main content of this manual is focused on basic operation procedure for using O&M GIS database; updating existing data and add new information from current database system. The user's manual is not for general operation manual for QGIS.

The user's manual is composed as step by step operation process, namely it recommends that the user must completely follow each steps of explanation.

3. Advanced use of GIS database

The GIS database has been developed for management of hydraulic structure with inventory. However, in this chapter, the advanced activity is proposed as follows.

i. The database has the function of overlaying the satellite image. If the user downloads the "Open Layer plugin", the satellite image introduced by "Google Satellite" is overlaid with existing layer.

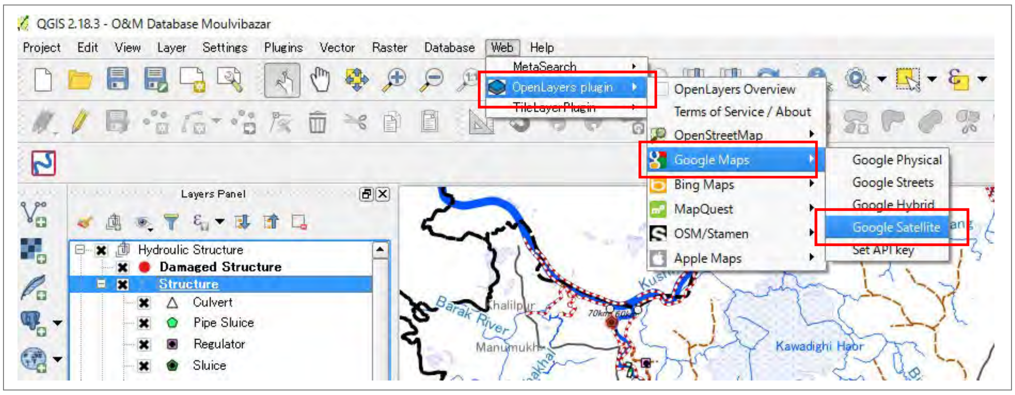


Figure 3 The general view of the GIS Database

ii. The digital elevation model is useful to evaluate the topography. The Shuttle Radar Topography Mission (SRTM) produces the digital elevation model as 1 arcsec (30 m) mesh model. By using this digital elevation model, the deformation area like haor will be defined in GIS map.

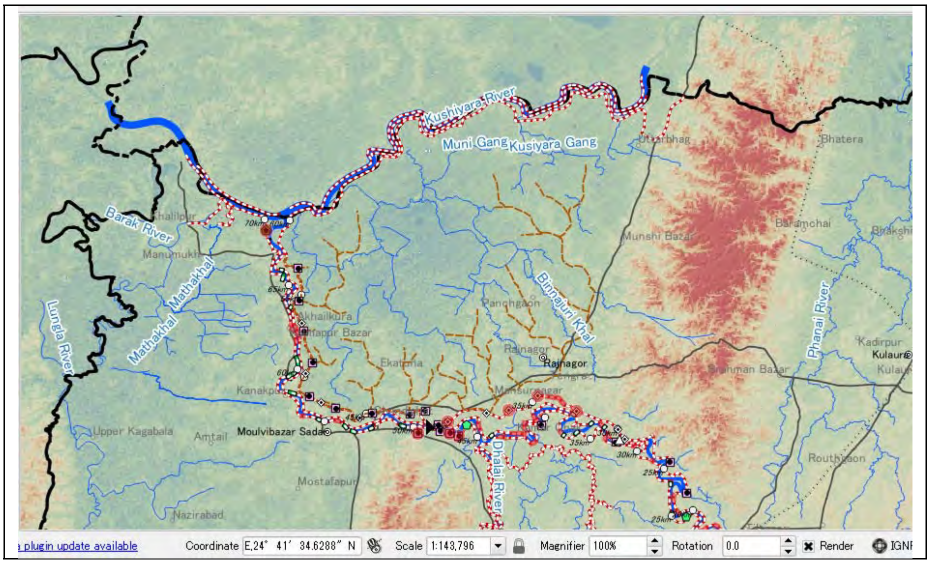


Figure 4 Topographic Map by Digital Elevation Model(DEM)

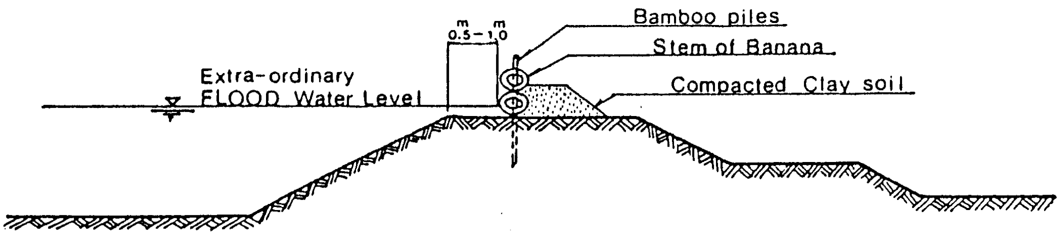
iii. MIKE 11 is the quality river modeling package. The result of modeling is extracted by GIS dataset as Shape file polygon. By using GIS application, the result ex. flood area can be overlaid and analyzed to topographic and infrastructure information.

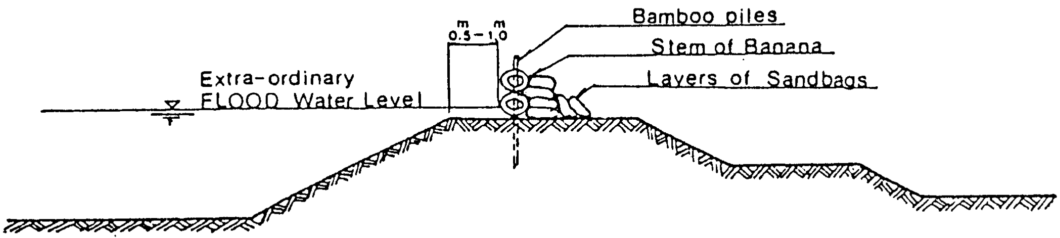
TECHNICAL GUIDANCE OF FLOOD COUNTER MEASURES

1. Overflow

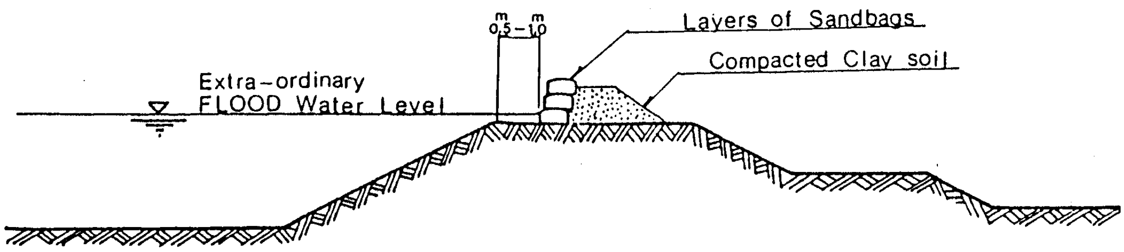
(1) Increasing embankment height with sand/earth filling gunny bags only. This method is simple and basic method against overflow. It is important to stockpile the gunny bags sufficiently in the field offices or the field warehouses. If the gunny bags are not able to maintain, the following methods shall be applied.

(2) To place the stem of Banana with bamboo piles along the overflow portion, further temporary additional embankment for the water stopper shall be executed behind the stem of Banana.

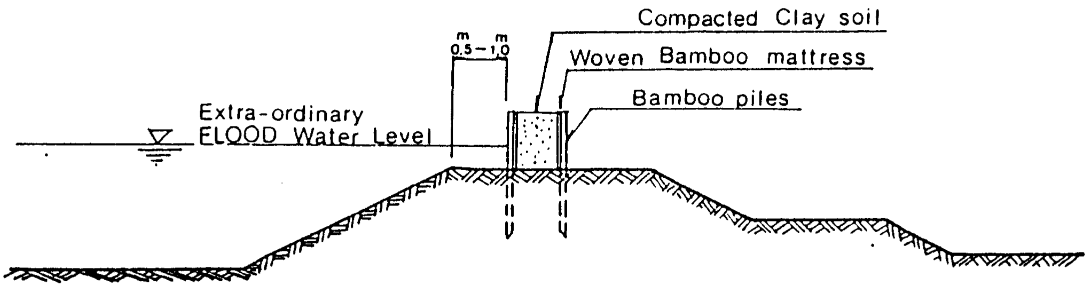




(3) The overflow water is protected by layers of sandbags (filled with sand/soil up to 60%) reinforced by dumping of compacted clay soil behind them to prevent the overflow of flood water over the embankment.

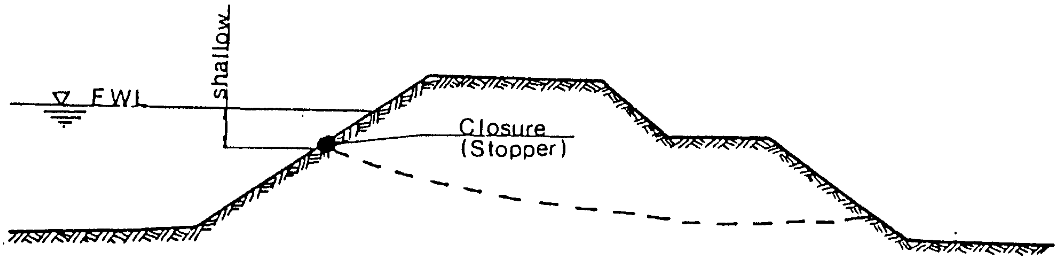


(4) The overflow water is protected by woven bamboo mattress reinforced by driven bamboo stick and dumping of compacted clay soil. However, this method is seldom implemented because it is time consuming for the preparation.



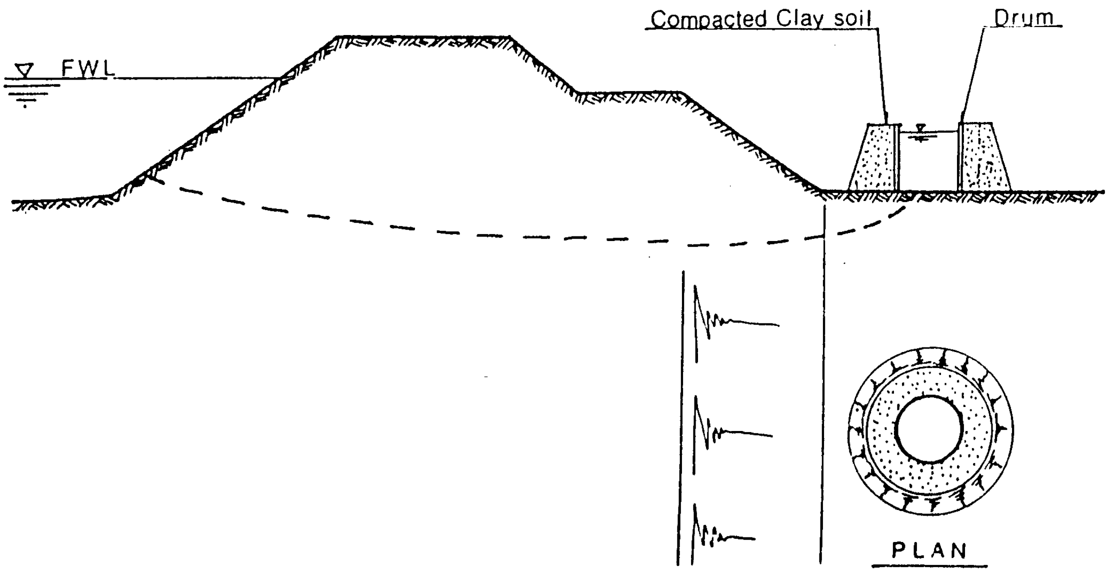
2. Seepage/Leakage

(1) Direct method
If possible, close the hole with a sack closure of old clothes. The hole spot can be identified from the existence of a water vortex (eddy).

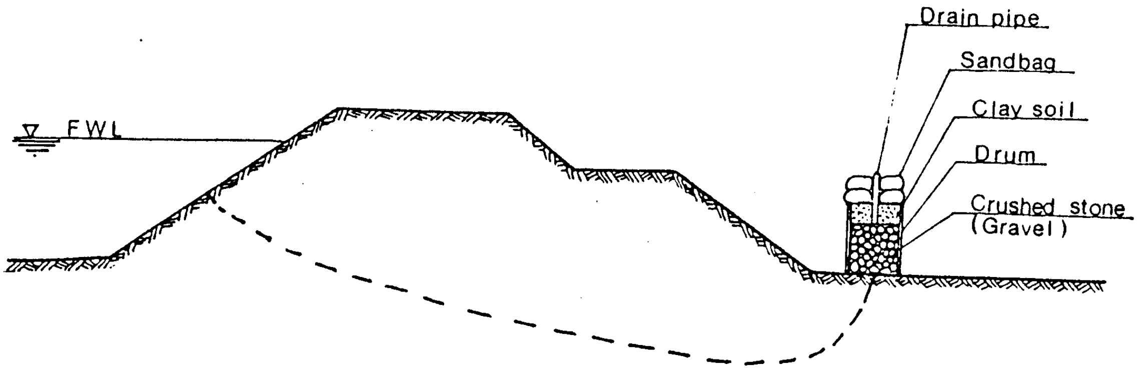


(2) Indirect method
If direct closing of the hole is impossible to be carried out, due to the depth of the hole spot, then prevention of seepage/leakage shall be carried out behind the embankment.

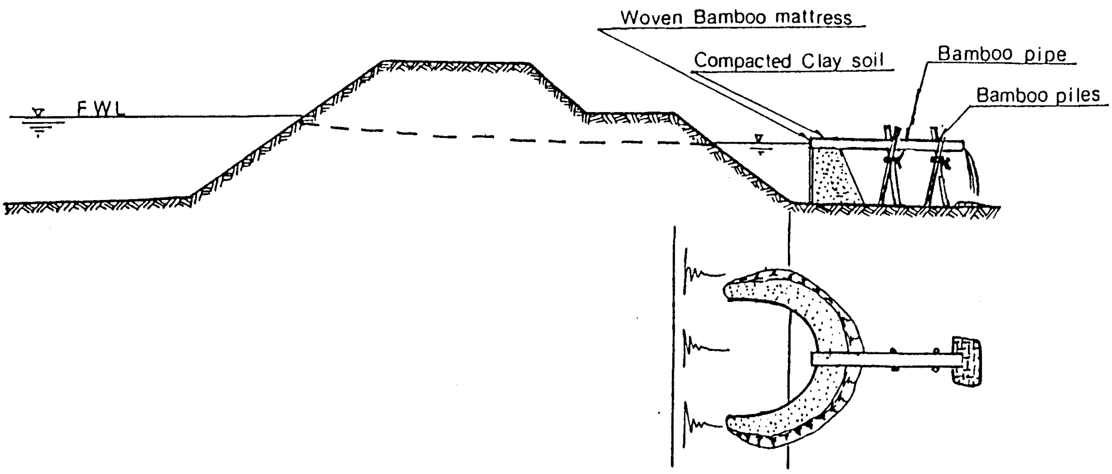
(a) If seepage/leakage occurs just locally then seepage/leakage water shall be collected placing a drum behind the embankment, which is reinforced by dumping of compacted clay soil surrounding the drum. The existence of the drum causes lowering of the water level difference between the water in front and behind the embankment. So the seepage/leakage water force becomes lower and piping can be overcome.



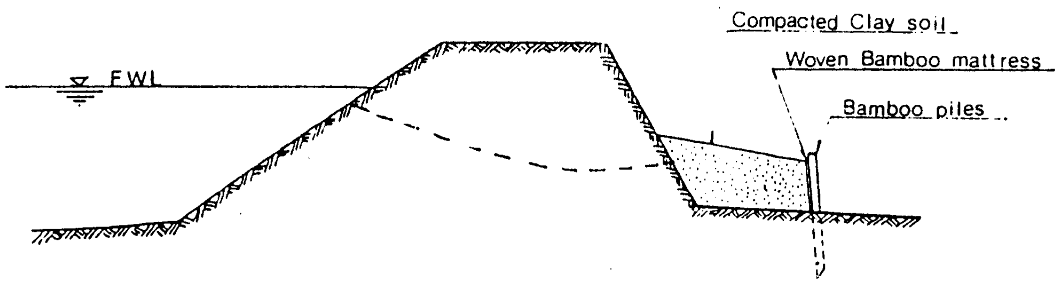
(b) If the aforementioned method is not be able to prevent piping then the drum shall be filled with crushed stone functioning as a counterweight and filter. Clay soil is placed compacted on the above crushed stone, then sandbags are placed on it. Besides, it is equipped with a drain pipe to drain the seepage/leakage water.



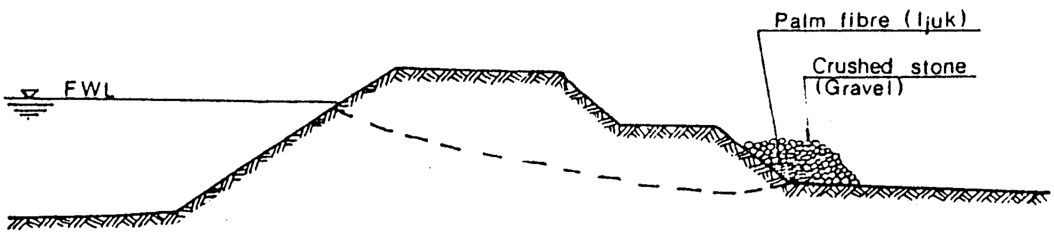
(c) If some leakage/seepage appeared along the toe of the embankment then timber/woven bamboo matters is placed surrounding the leakage/seepage. The mattress is reinforced by driven piles and compacted clay soil.



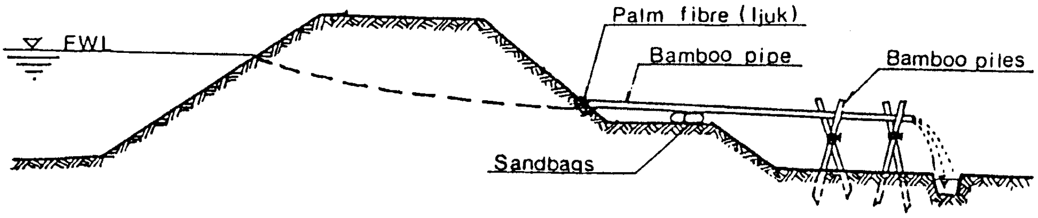
(d) If the outflow of leakage/seepage water from the steep back side of a embankment will cause sliding of the embankment slope, then that leakage/seepage spot shall be dumped and compacted with clay soil. Besides, it is supported by the woven bamboo mattress fixed at a bamboo pile.



(e) The place of the leakage/seepage closed by palm fibre layer functioning as a filter to protect moving of the foundation material. The palm fibre layer is protected by dumping of crushed stone.

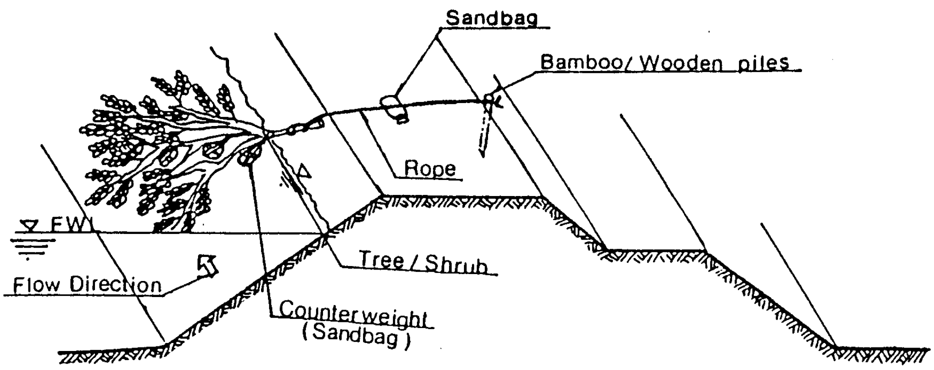


(f) At the place of leakage/seepage, bamboo pipe will be provided to release leakage/seepage water from the toe of the embankment. At the top of the bamboo pipe, palm fibre will be provided functioning as a filter.

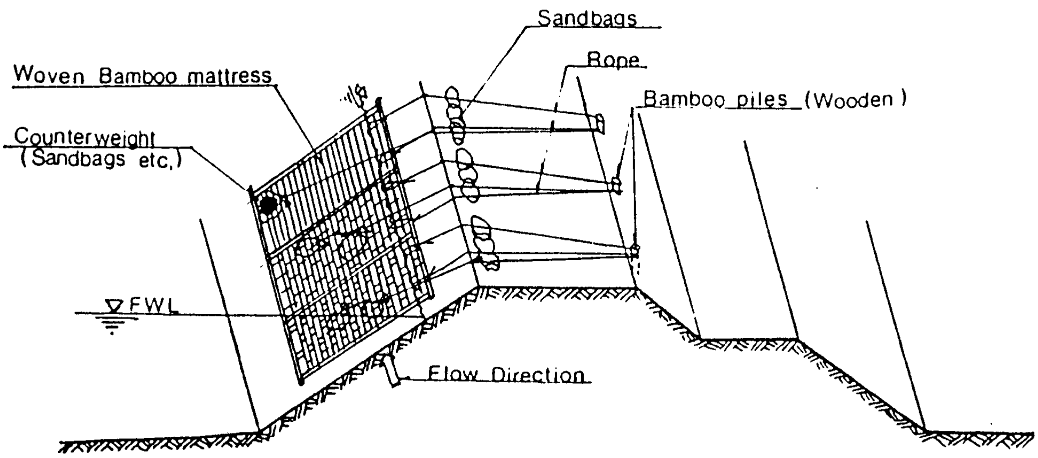


3. Scouring

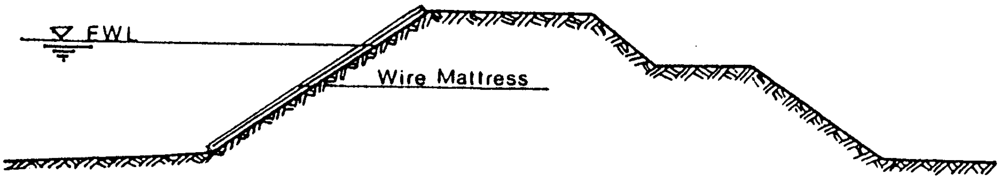
(1) To prevent scouring caused by turblent flow, a tree stem including its branches shall be provided at the front side slope of the embankment. At the front end a counterweight shall be provided to prevent washing out by the waterflow while the tail end of the tree shall be fixed on a pile driven in the embankment body.



(2) Another method is the use of woven bamboo mattress provided with a counterweight at the tail end and fix the front end at a pile driven in the embankment body.

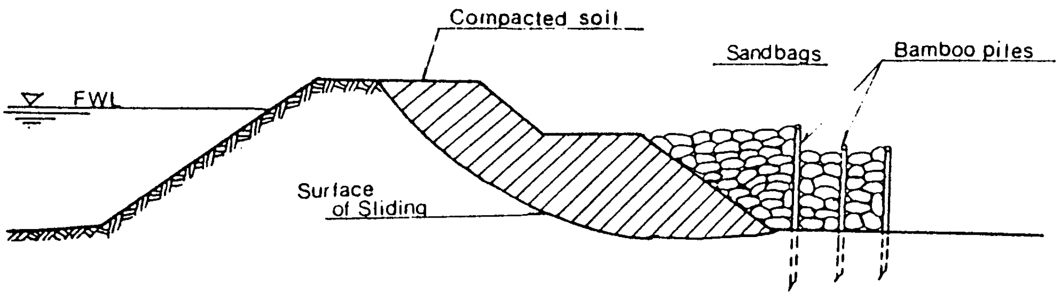


(3) The third method is by providing a wire mattress at the embankment slope. However, this method is time consuming, during the execution as well as during the preparation.

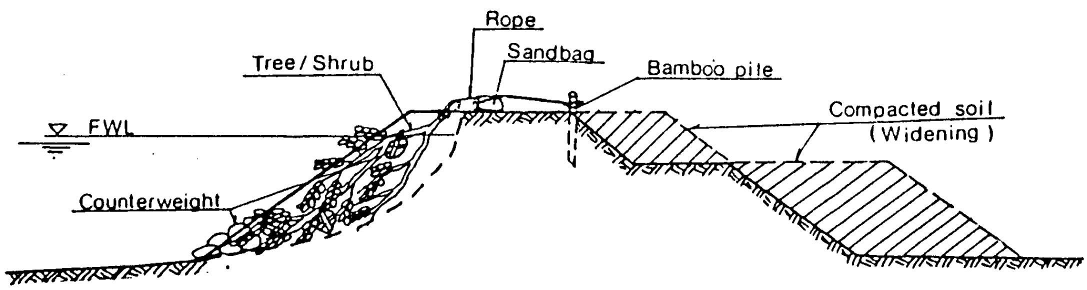


4. Sliding

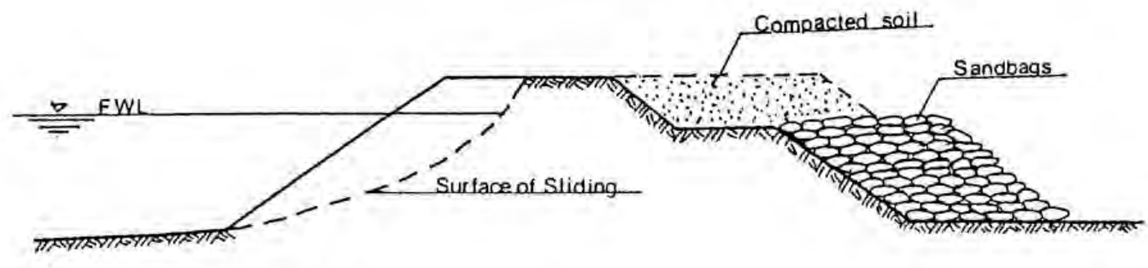
(1) If sliding occurs at the backside of the embankment, then after dumping of compacted soil on it that place shall be provided with a counterweight which consists of sandbags with driven piles.



(2) If sliding occurs at the front side of the embankment, to avoid a breach, the damaged position shall be provided with a tree stem including its branshes. The tail end of tree fixing on a bamboo pile driven in the embankment body, while the front end of tree to be equipped with a stone counterweight. The back side of the embankment should strengthened with widening of the embankment crest by dumping of compacted soil.

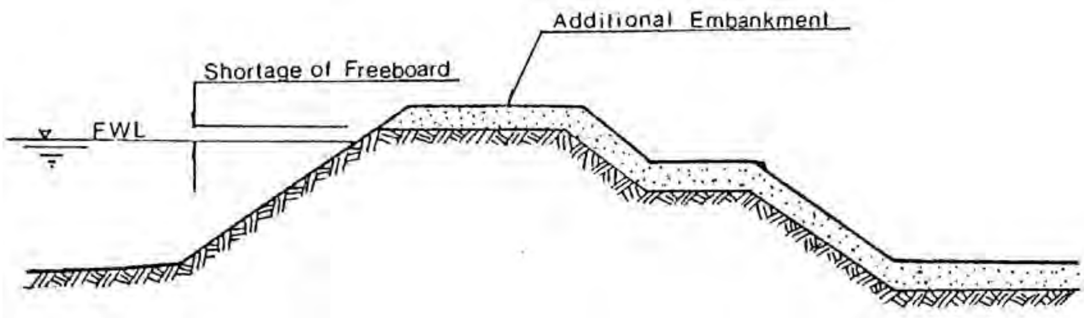


(3) Sliding at the front side of the embankment, may also be prevented by construction of the emergency embankment which consist of sandbags, and compacted clay soil, as same as the original height at the backside of the damaged embankment.

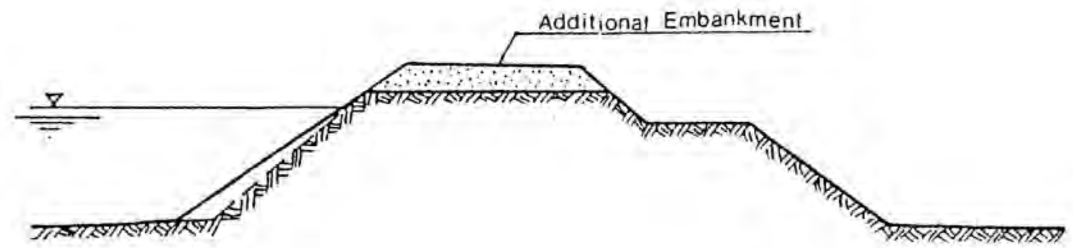


5. Settlement of Embankment

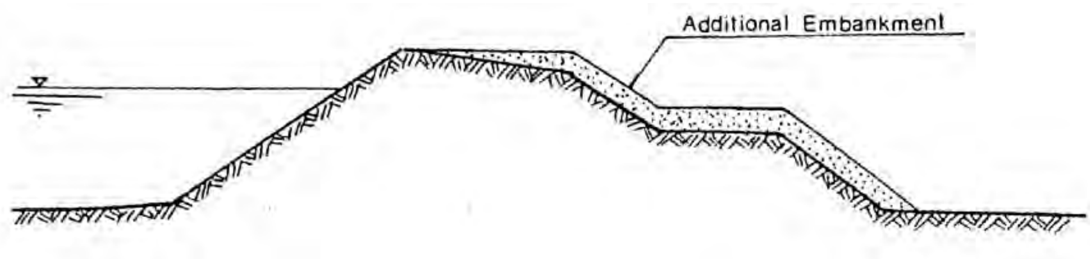
(1) Settlement of the whole embankment: additional embankment (heightening)



(b) Settlement of the front side of the embankment

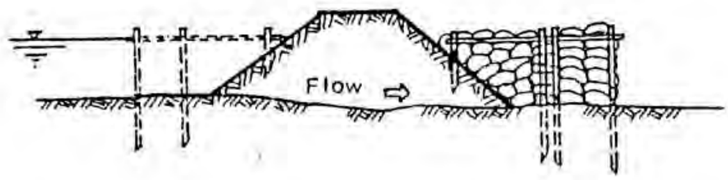


(3) Settlement of the back side of the embankment

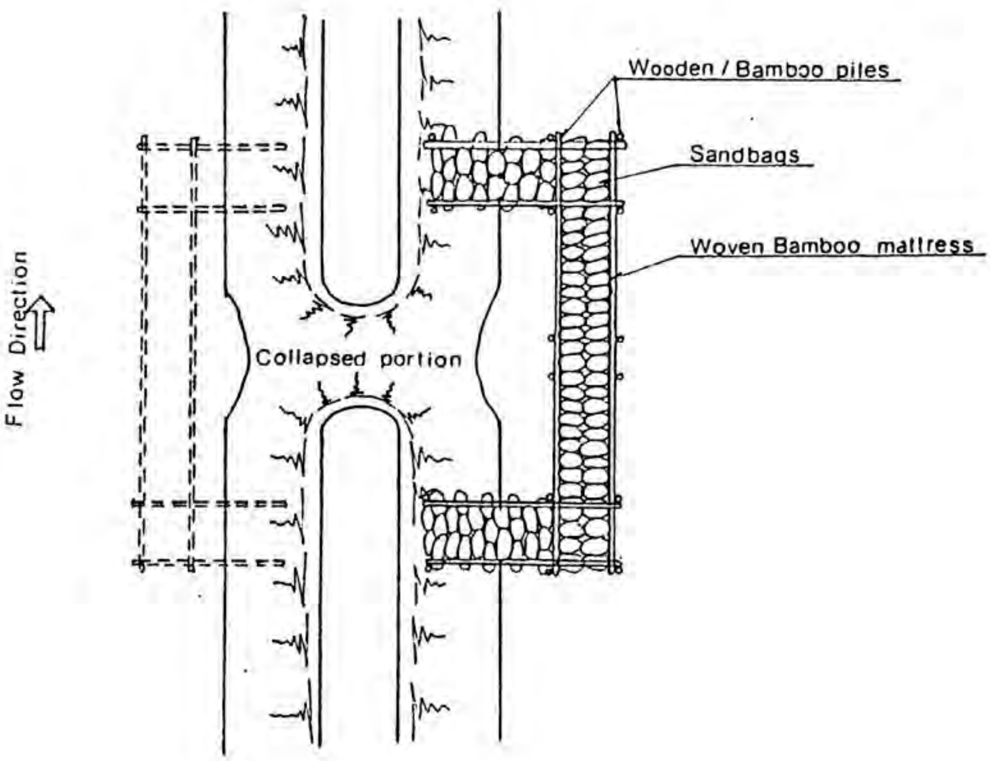


6. Breach of Embankment

To prevent the possible next flood flow, an emergency embankment is constructed which consisting of staple of sandbags reinforced by driven piles.



CROSS SECTIONAL VIEW



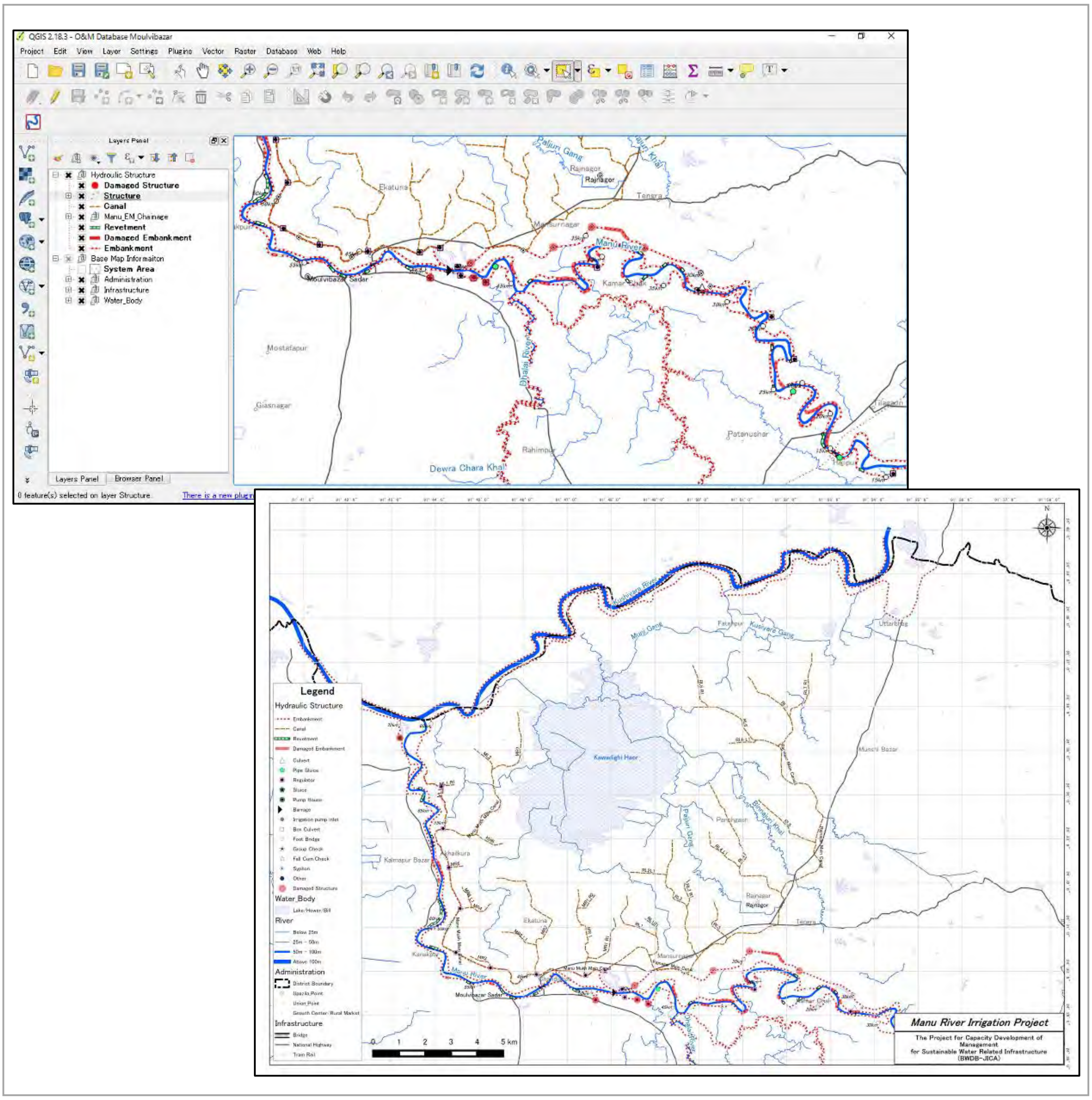
PLAN

ANNEX 4

User’s’ Manual for O&M GIS Database

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE USER’S MANUAL for O&M GIS Database



THE PROJECT FOR CAPACITY DEVELOPMENT OF MANAGEMENT FOR SUSTAINABLE WATER RELATED INFRASTRUCTURE

IN

THE PEOPLE’S REPUBLIC OF BANGLADESH

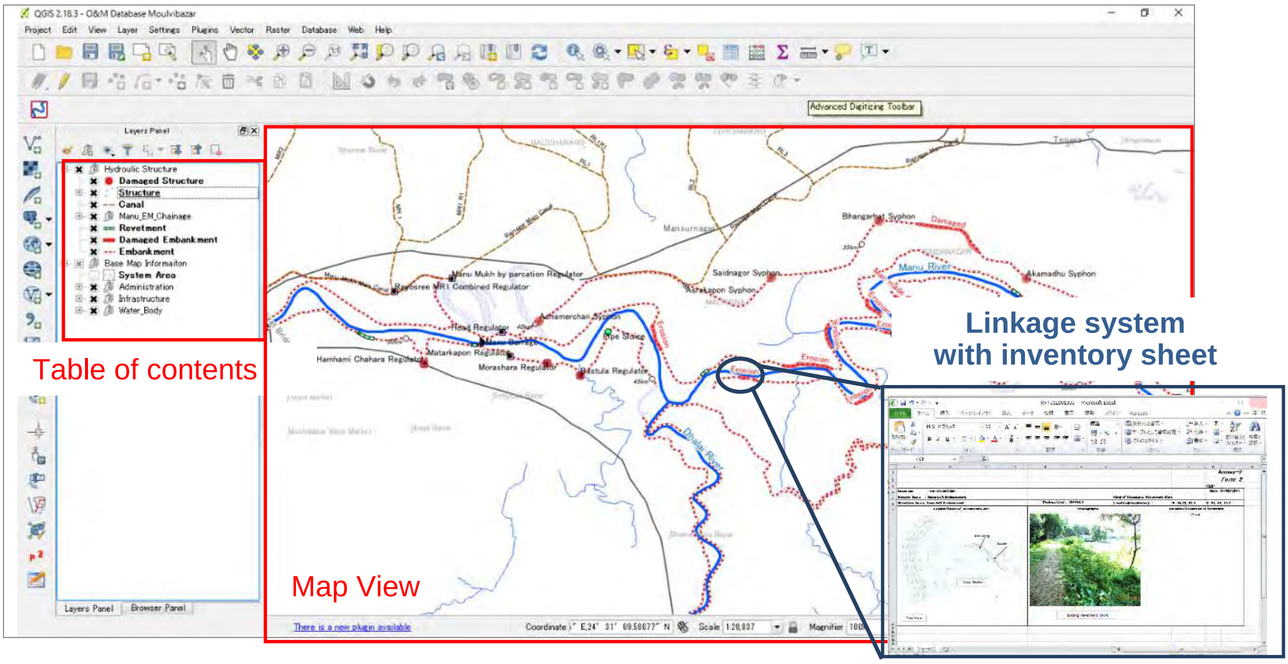
Table of Contents

1 Generals of GIS database

The basic information of the hydraulic structure, such as location, specification, damaged record and maintenance records, is important element for long term operation and maintenance of structure. For the purpose of efficiently accumulate and grasp the specification of hydraulic structure such as location, photo etc., the GIS database has been developed for BWDB O&M division officer to use and manage under the daily work. In consideration of operation by O&M division officer who doesn't have the specific computer knowledge, the GIS database has been prepared for simple structure system and not necessary to specific knowledge like System program.

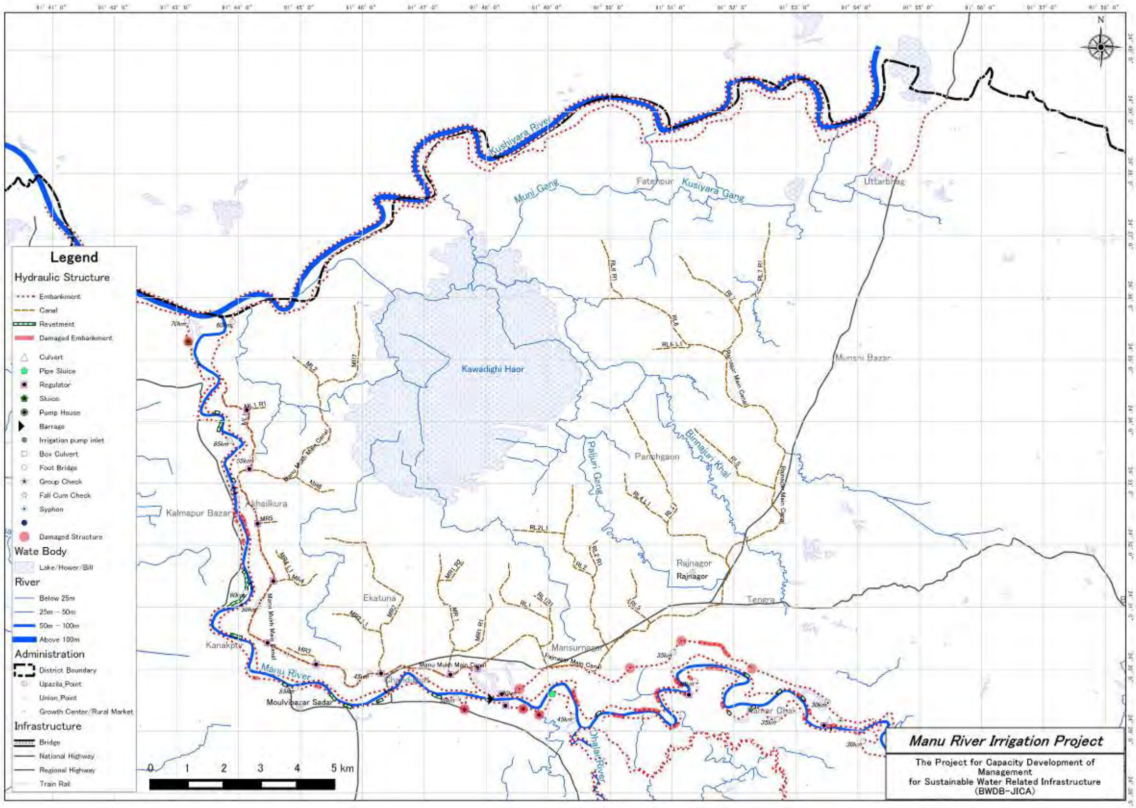
1.1 The general view function of the GIS database [●●]

The GIS database mainly consists of "Table of Contents" and "Map View" part. The "Table of Contents" is the layer management by open tree system. The "Map View" part is managed by geographic coordinate system. Additionally, each object of hydraulic structure and damaged embankment is linked with inventory sheet on GIS database. The detailed operation is introduced as follows chapter.

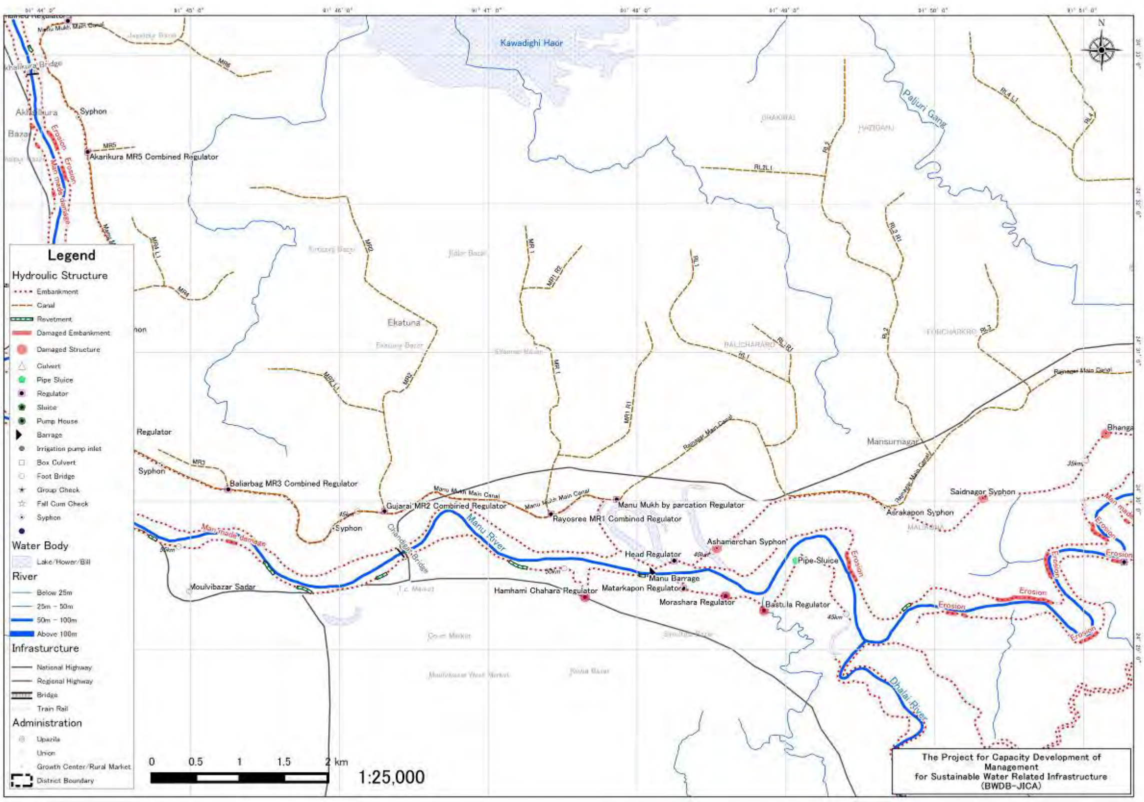


1.2 Formal format map function [●●]

The GIS database has the function of developing the formal format map function. In this O&M GIS database, two kind of formal format map has been prepared as Area based formal map and Inspection format map. Area based formal maps has two kind of maps "Manu irrigation project", "”Manu river". Inspection formal map has also two kinds of maps "Landscape_25,000","Portrait_25,000". The detail operation method is introduced in Chapter 3.3.



Map of Manu River Irrigation Project



Sample Map of Field Inspection (Landscape)

1.3 Concept and usage of the User's Manual [●●]

For the purpose of management of the GIS database, the User's manual has been prepared. The main contents of this manual are focused on basic operation of updating existing data and add new information from current database system and are not for general user's manual of Quantum GIS.

The user's manual is composed as step by step operation process, namely it recommends that the user must completely follow each steps of explanation.

✓ **The usage of the manual by user purpose**

The target user of this database is civil engineer who engages to manage hydraulic infrastructure. The usage of the manual is difference depending on the user; the user who mainly use <u>only to view</u> for obtaining the hydraulic information from this database and who <u>view and update</u> the information to maintain the database. In this Manual, each chapter is categorized by the above user purpose. The categorization is shown in below table of contents.

The user only for viewer

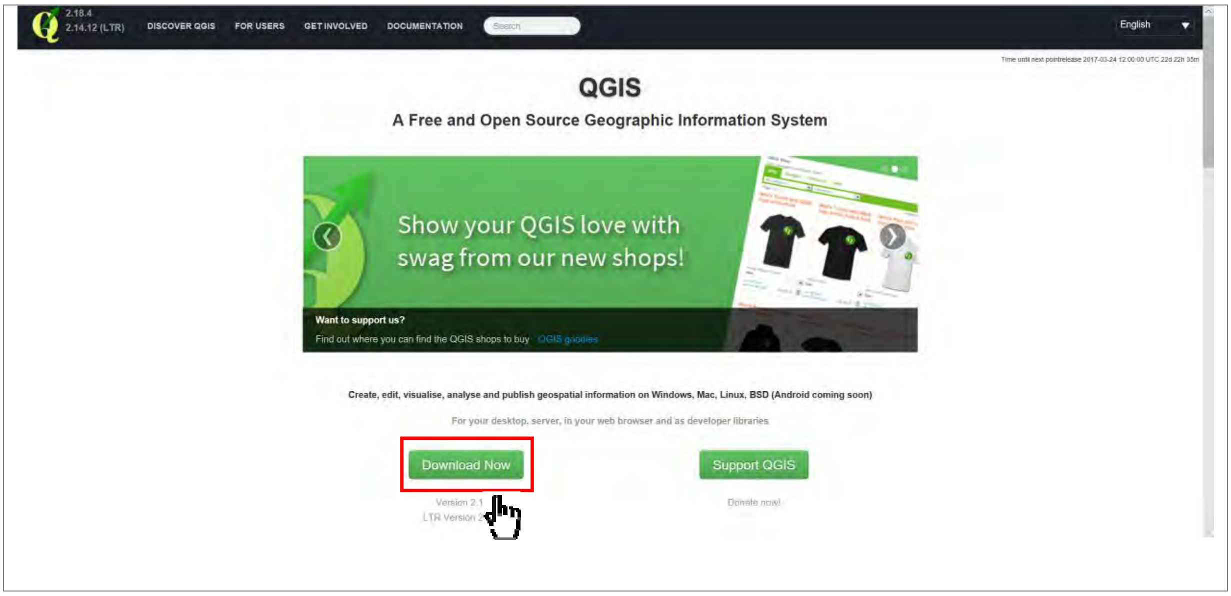
The user for maintenance and updating

In the each table contents, the difference of above role is expressed by color symbol; [●●] ,[●]. The meaning of the symbol; [●●] is targeted for viewer and for maintenance and updating. The symbol; [●] is for maintenance and undating.

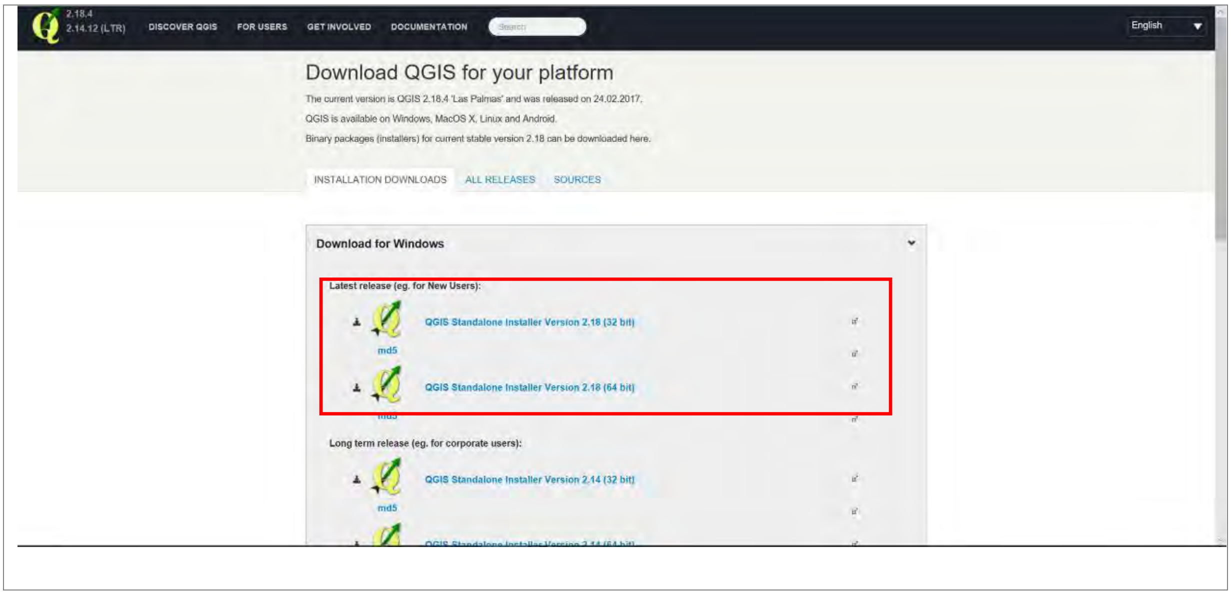
2 Installation and Setting

2.1 Installation of QGIS [●]

The application of GIS database has been adapted by Quantum GIS (hereinafter referred to as the QGIS). The application is open source application and every user can download by website at "http://qgis.org/ja/site/". The version of current GIS database is 2.18.3.



URL: http://qgis.org/en/site/

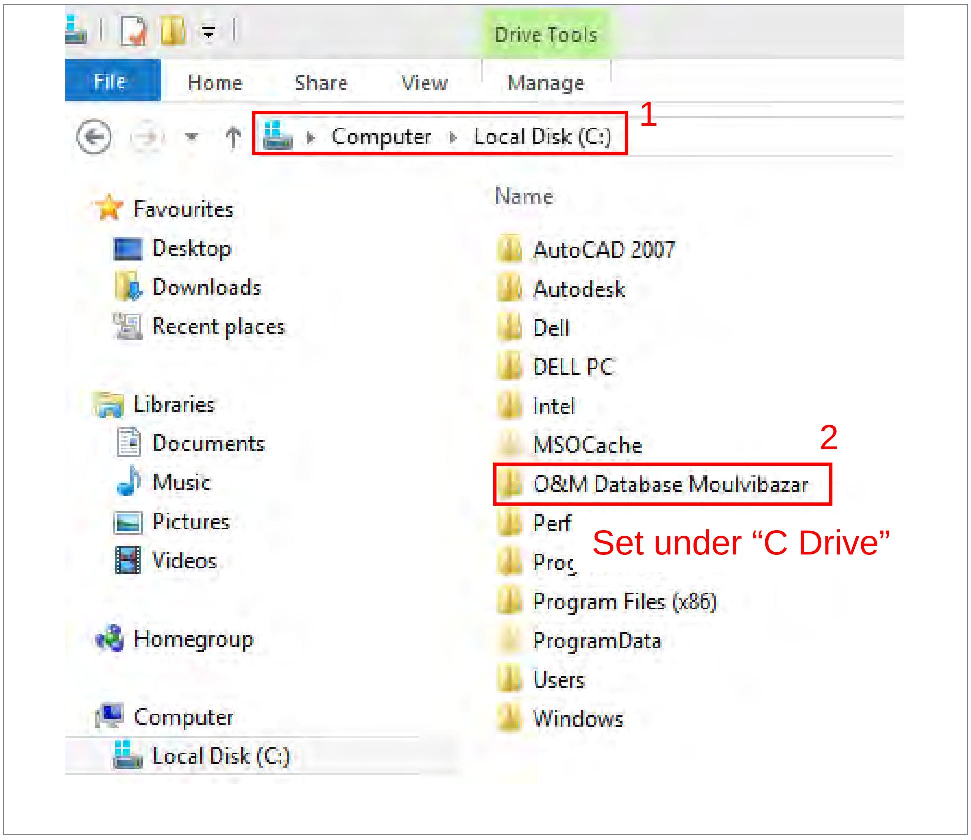


URL: http://qgis.org/en/site/

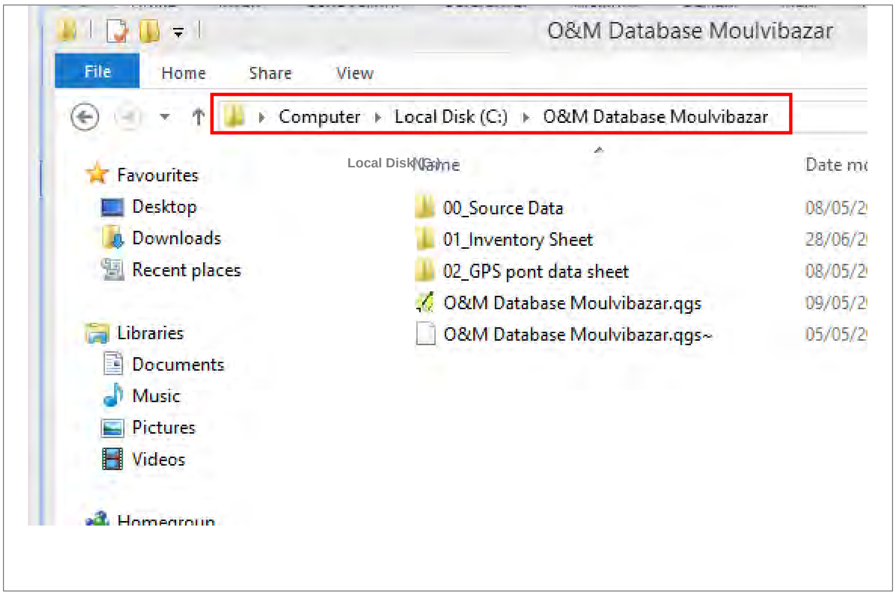
2.2 First setting [●]

The operation folder for GIS database is in "O&M Database Moulvibazar". The folder must be set under "(C) Drive".

1-1.



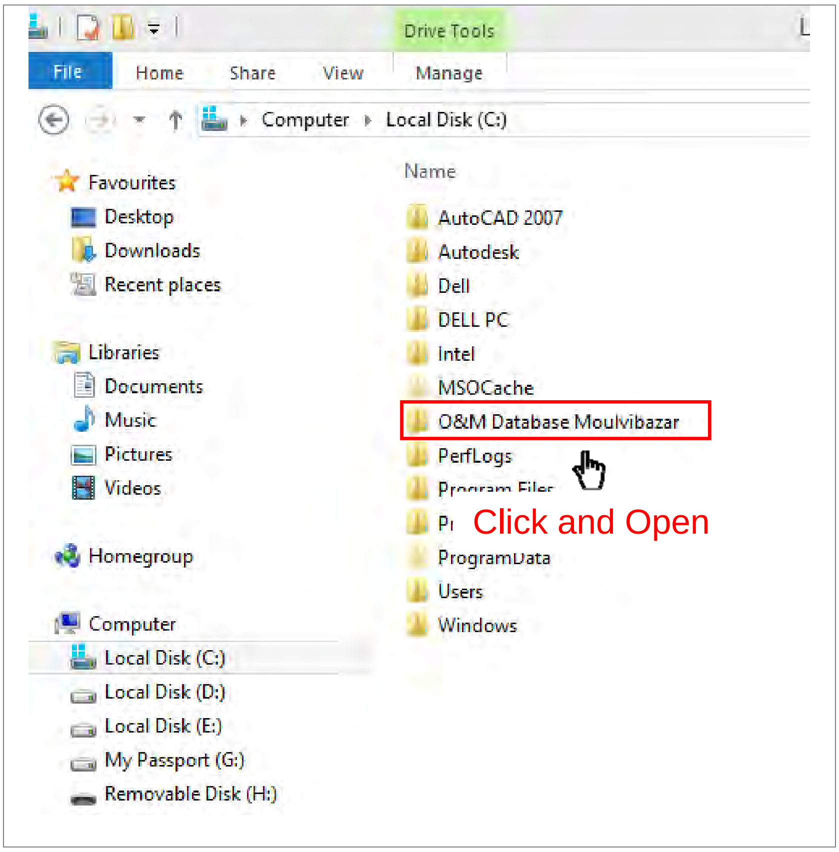
1-2.



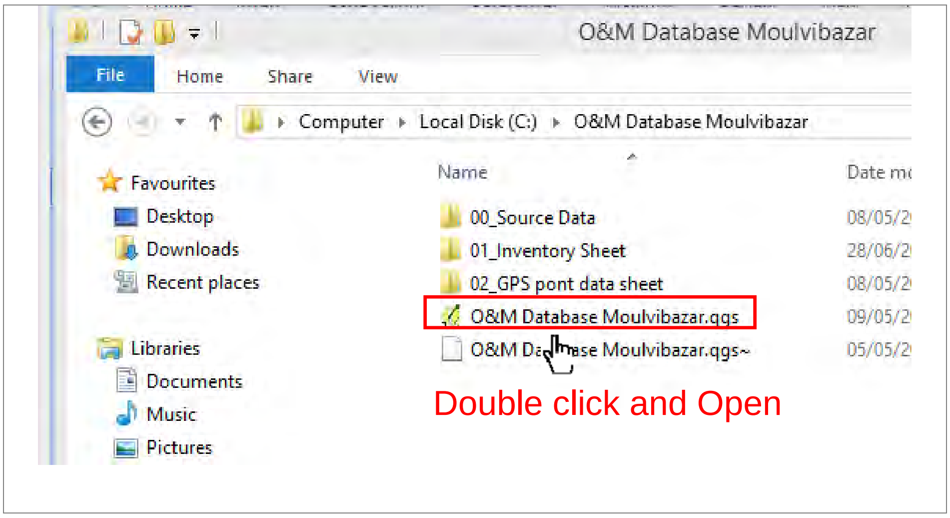
3 View Operation

3.1 Basic view operation[●●]

1-1. Open O&M Moulvibazar Database



1-2.


O&M Database Moulvibazar
File
Home
Share
View
Computer
Local Disk (C:)
O&M Database Moulvibazar
Favourites
Desktop
Downloads
Recent places
Libraries
Documents
Music
Pictures
Name
00_Source Data
01_Inventory Sheet
02_GPS pont data sheet
O&M Database Moulvibazar.qgs
Double click and Open

1-3.

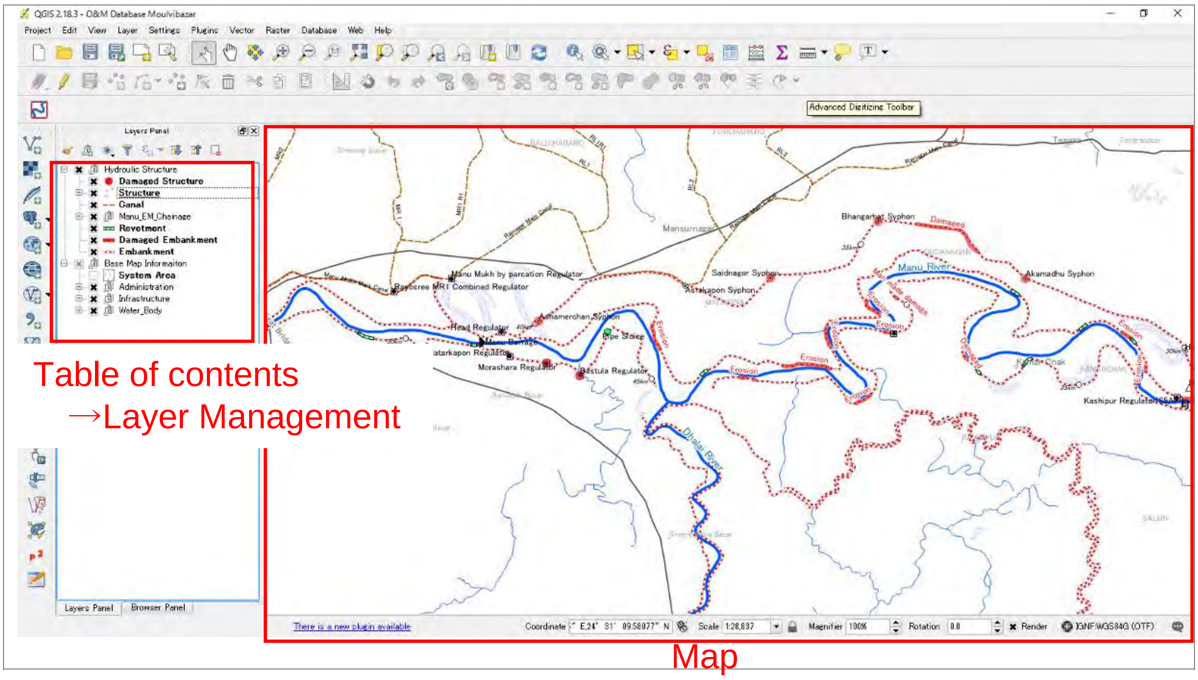
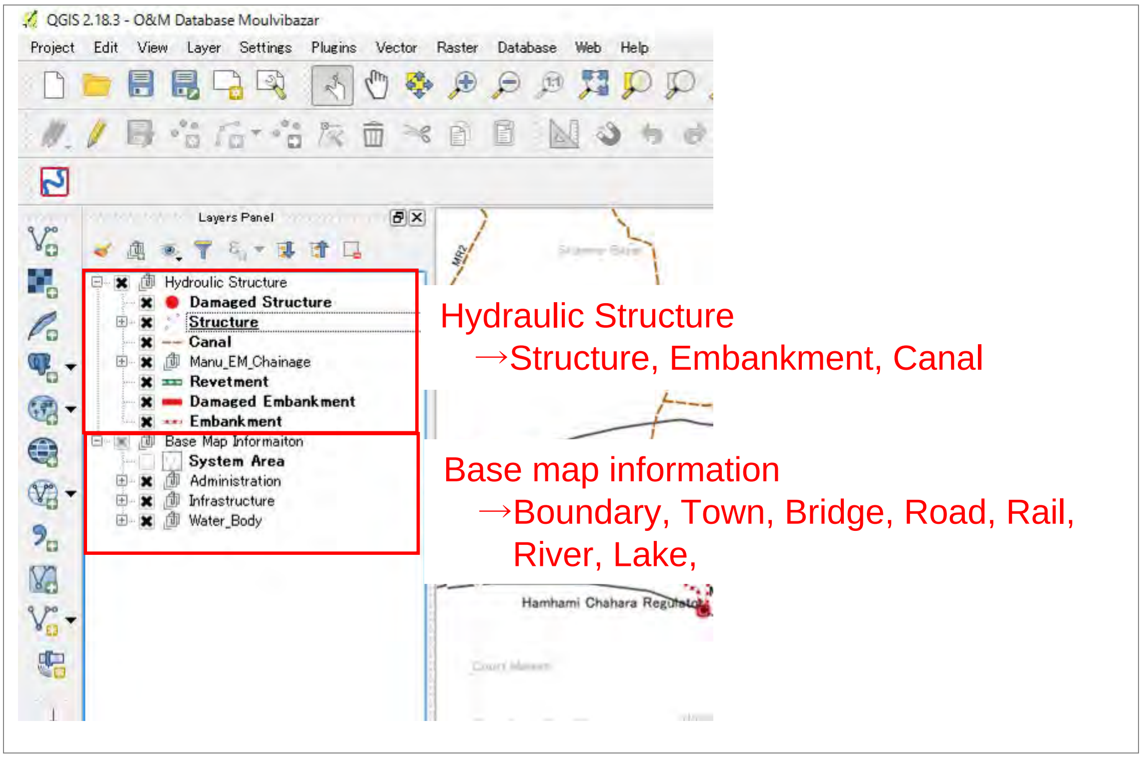
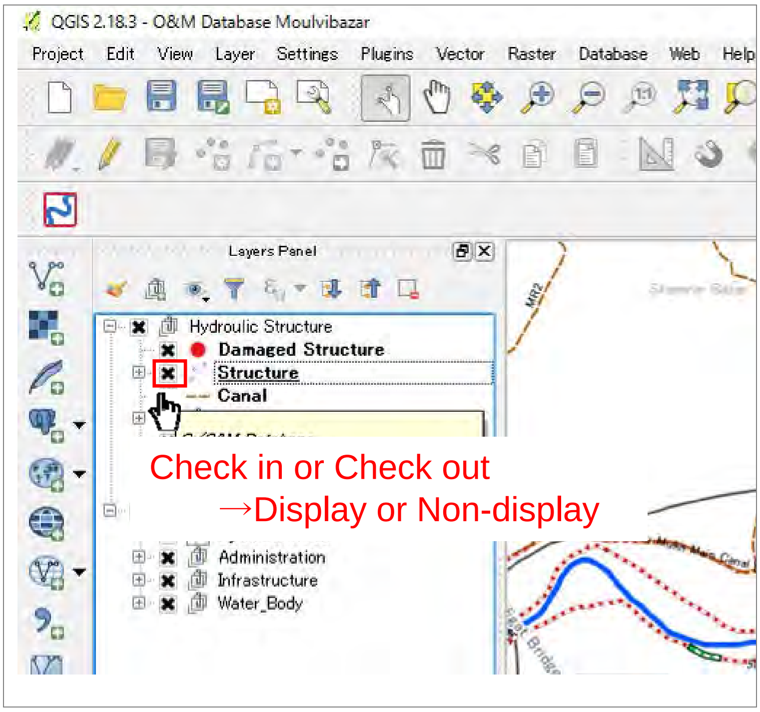


Table of contents
→Layer Management
Map

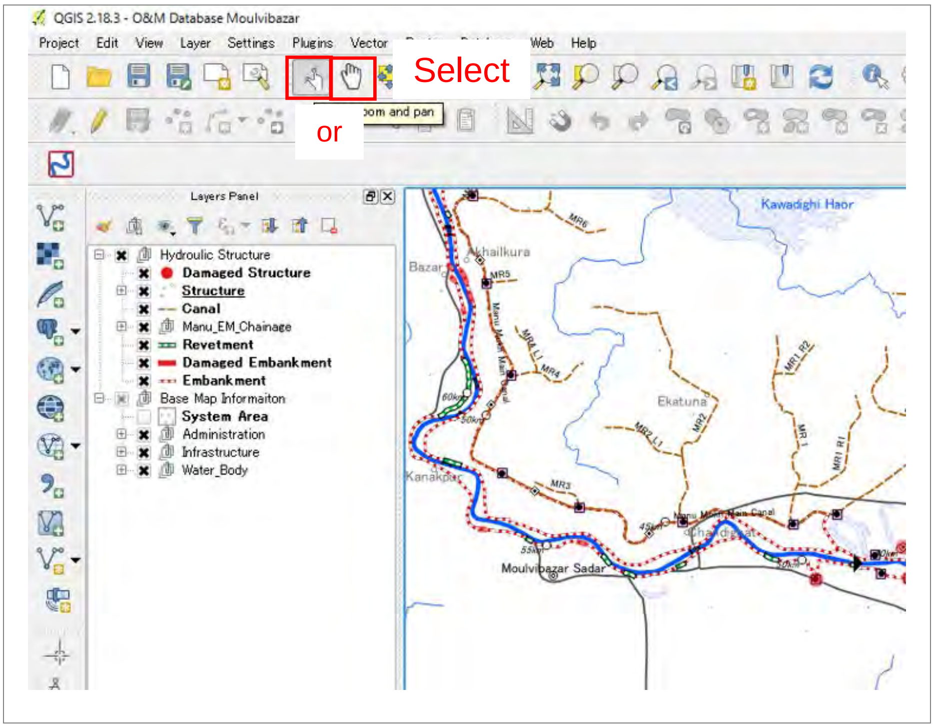
1-4.


QGIS 2.18.3 - O&M Database Moulvibazar
Project Edit View Layer Settings Plugins Vector Raster Database Web Help
Layers Panel
Hydraulic Structure
Damaged Structure
Structure
Canal
Manu_EM_Chainage
Revetment
Damaged Embankment
Embankment
Base Map Informaiton
System Area
Administration
Infrastructure
Water_Body
Hydraulic Structure
→Structure, Embankment, Canal
Base map information
→Boundary, Town, Bridge, Road, Rail, River, Lake,
Hamhami Chahara Regulator

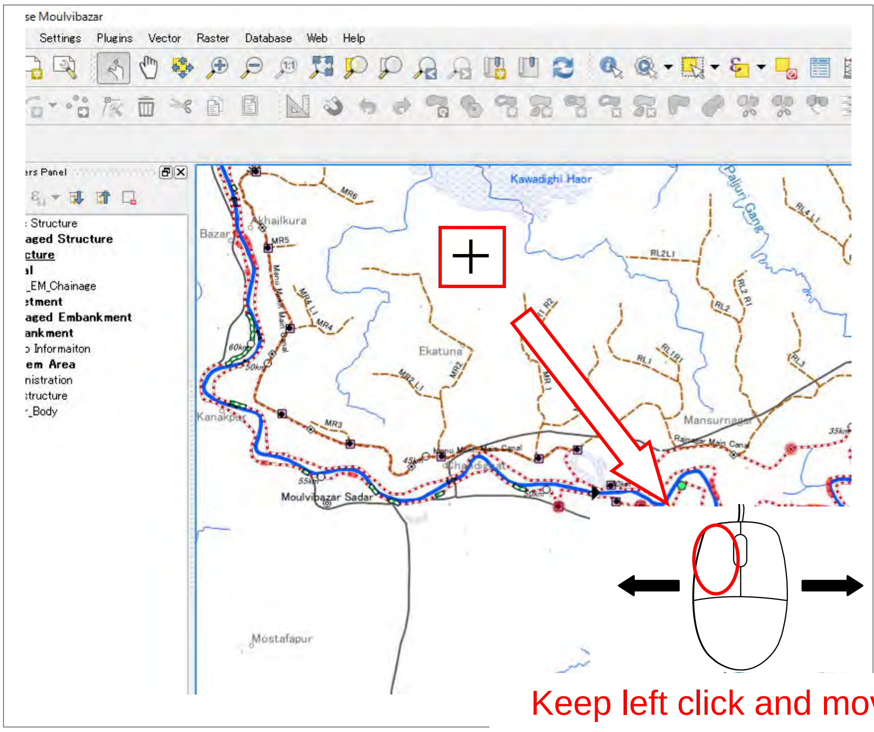
2-1.


QGIS 2.18.3 - O&M Database Moulvibazar
Project Edit View Layer Settings Plugins Vector Raster Database Web Help
Layers Panel
Hydroulic Structure
Damaged Structure
Structure
Canal
Check in or Check out
→Display or Non-display
Administration
Infrastructure
Water_Body

3-1. Map move, Zoom up and Zoom down

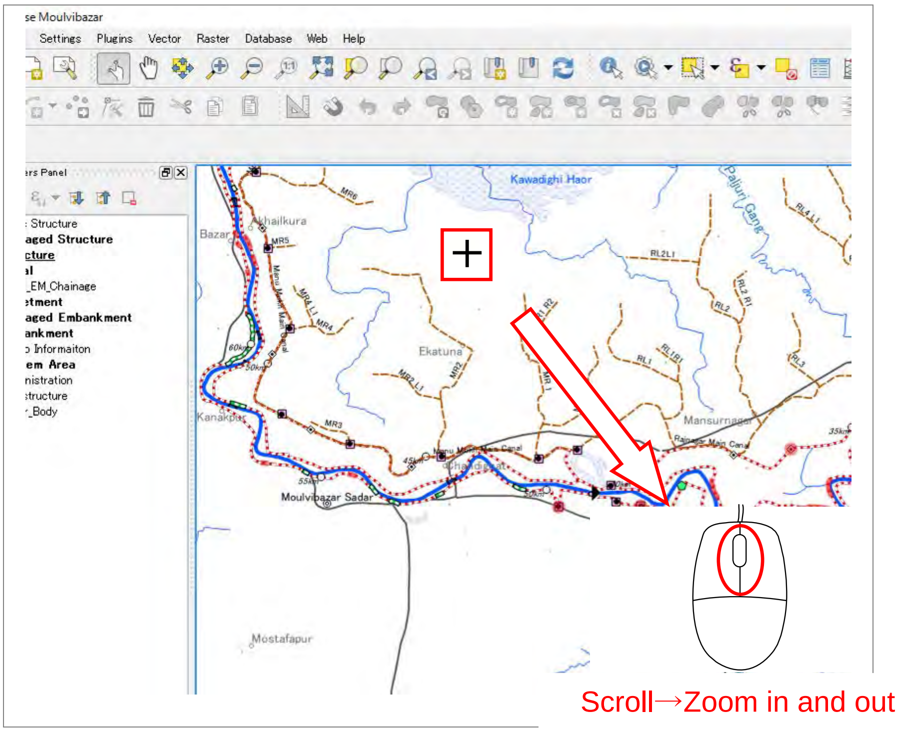


3-2.

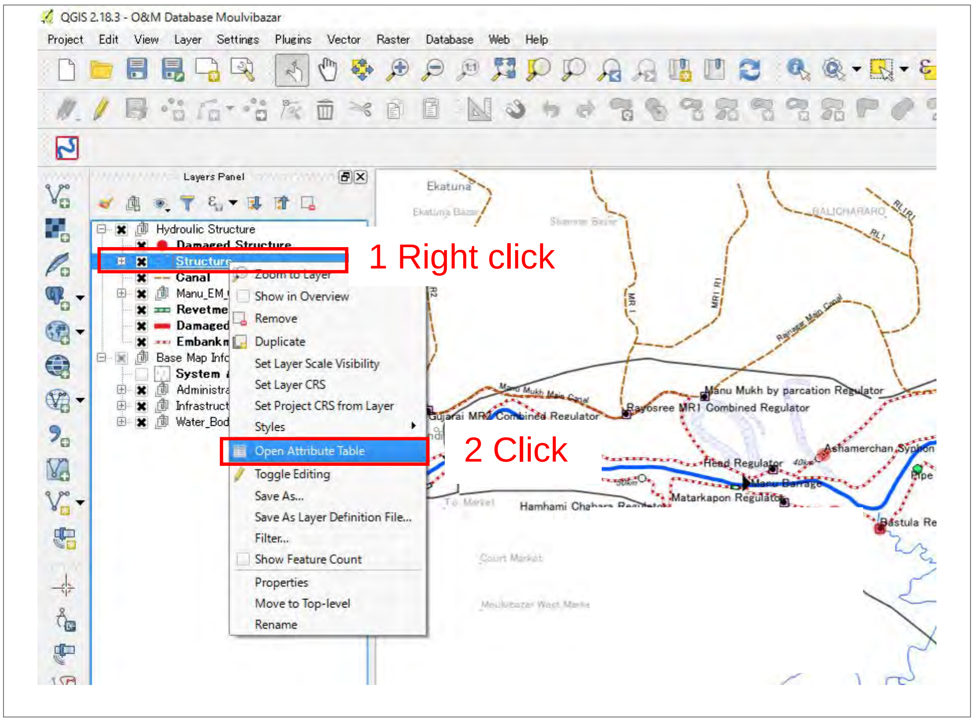


Keep left click and move
→Map move

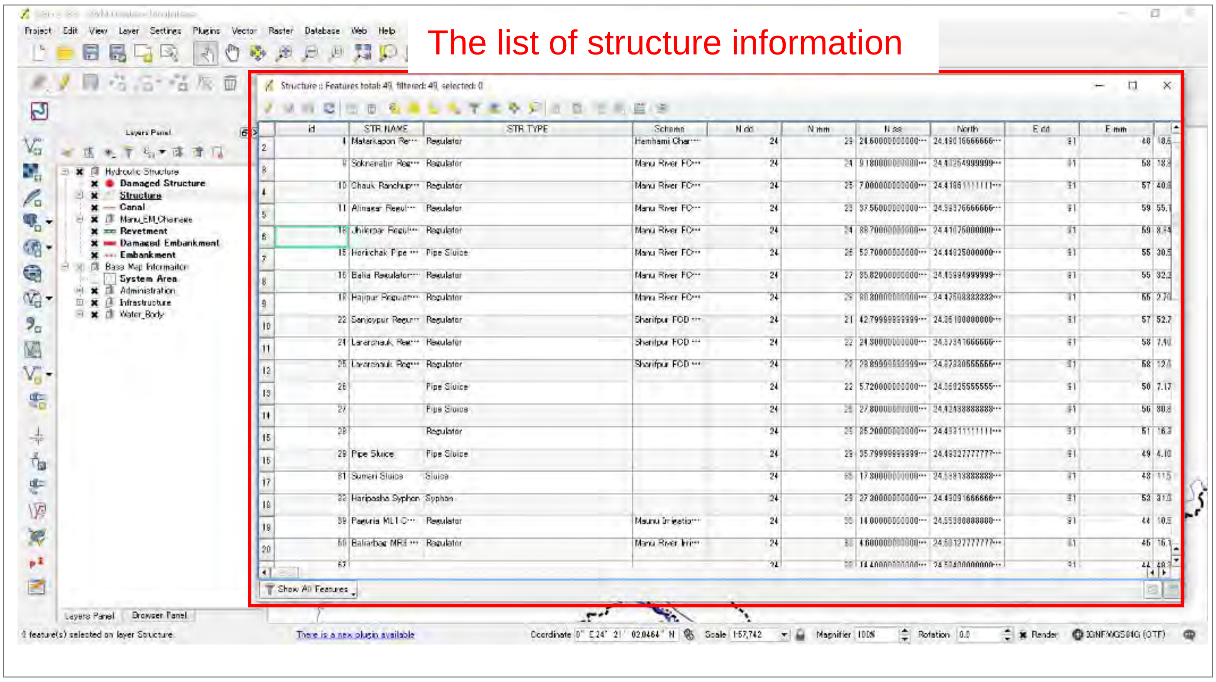
3-3.



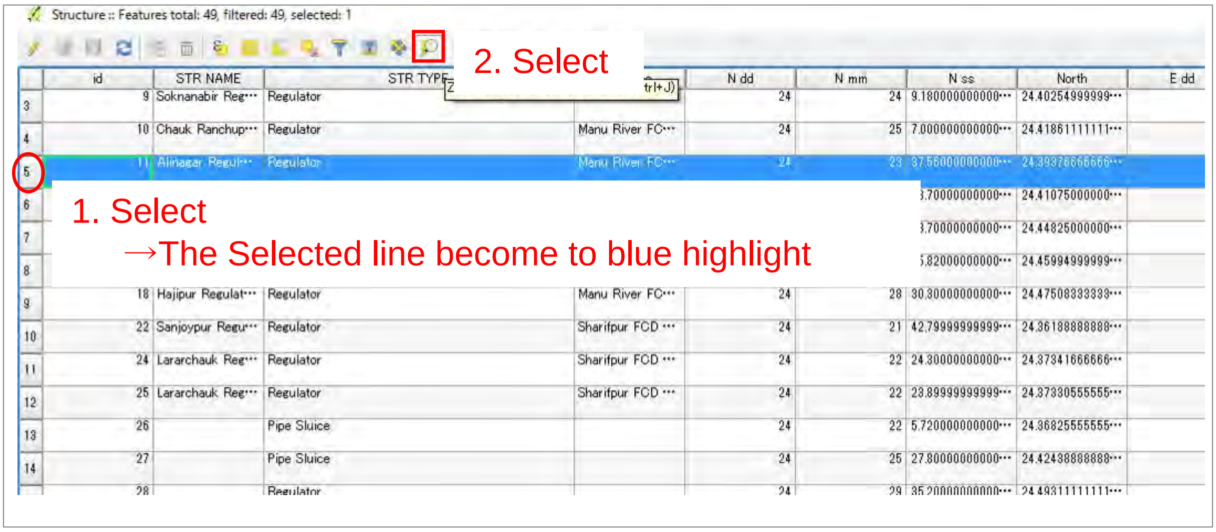
4-1. Use "Open Attribute table"



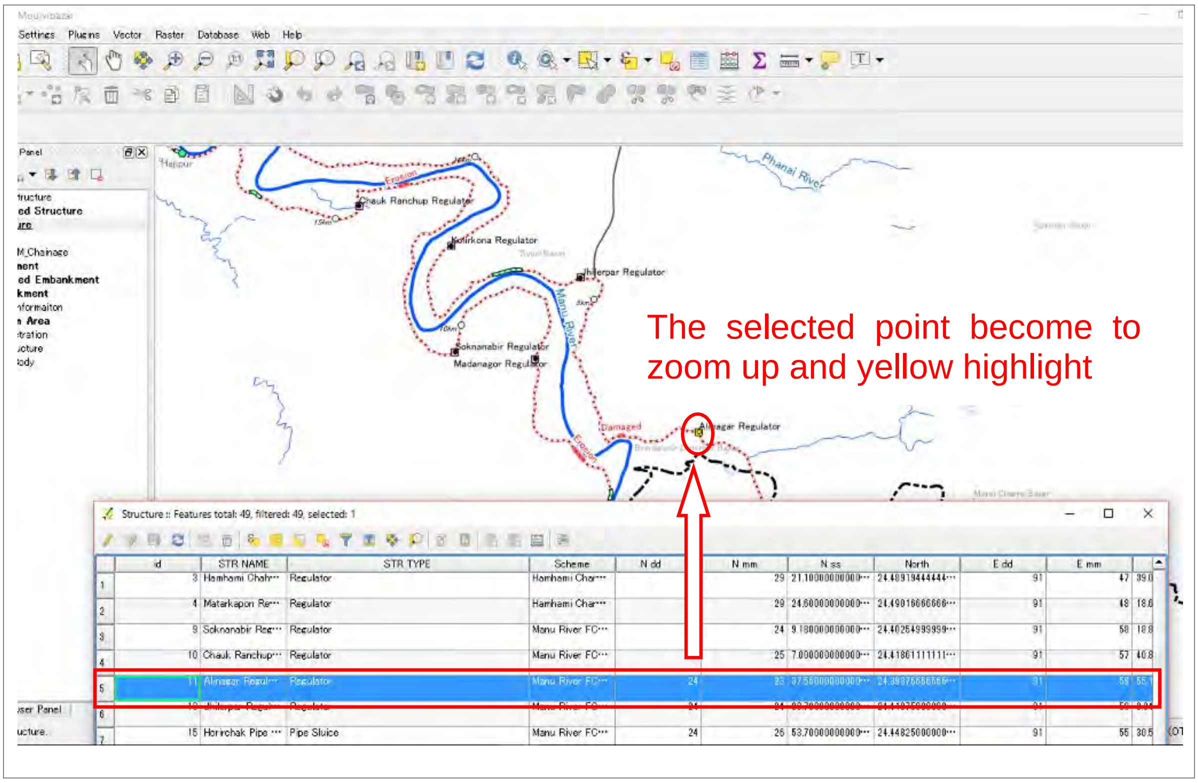
4-2.



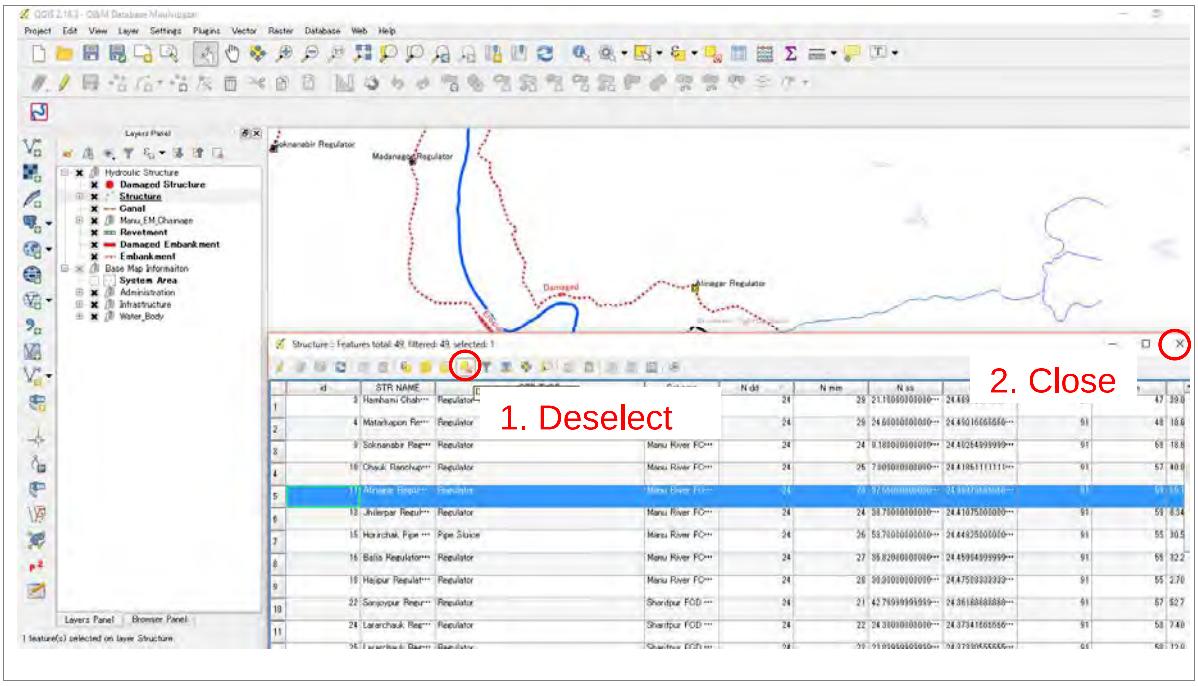
5-1. Select object from “Open attribute table”



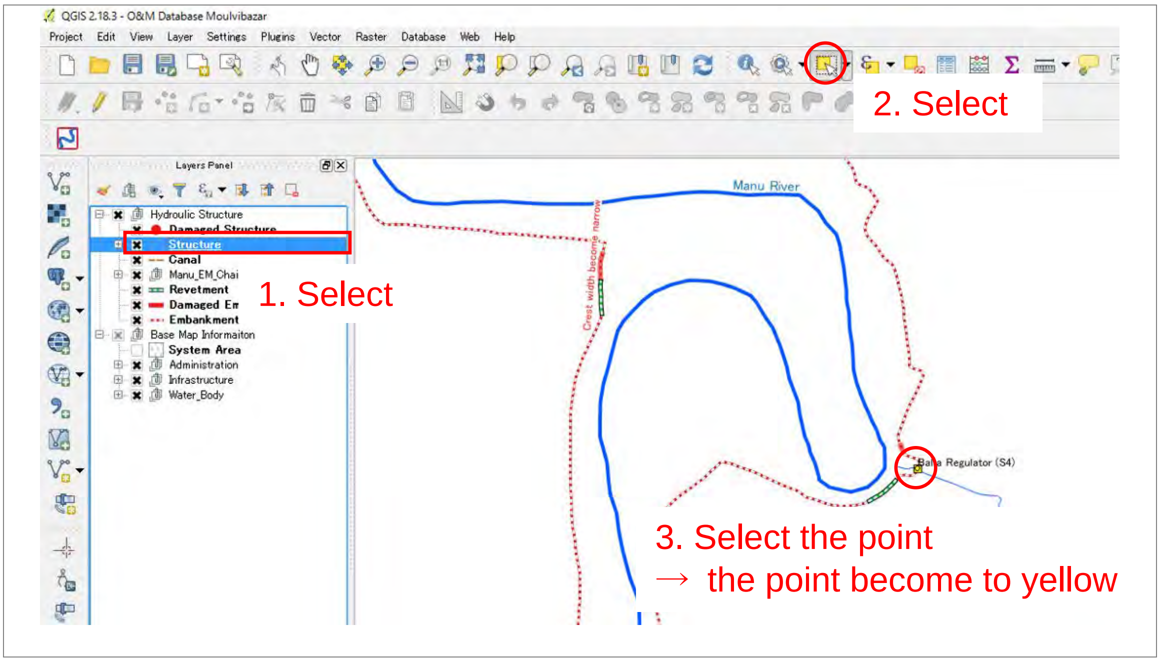
5-2.


The selected point become to zoom up and yellow highlight

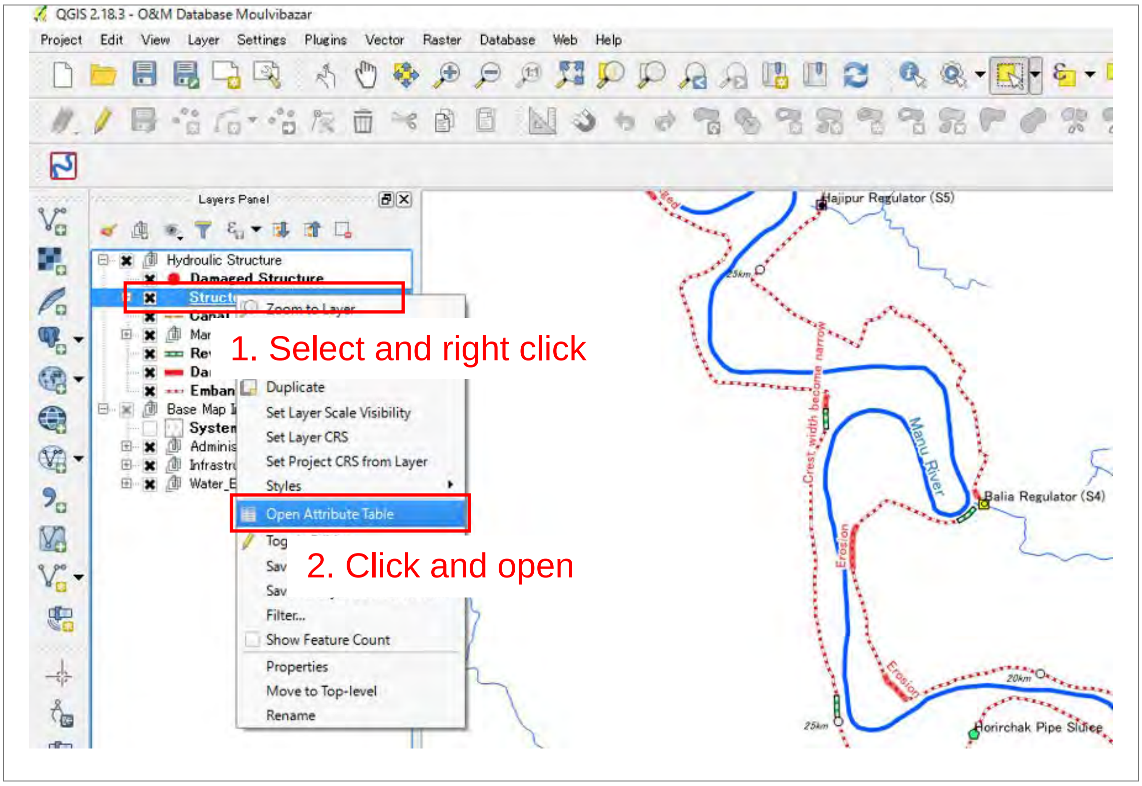
5-3.


1. Deselect
2. Close

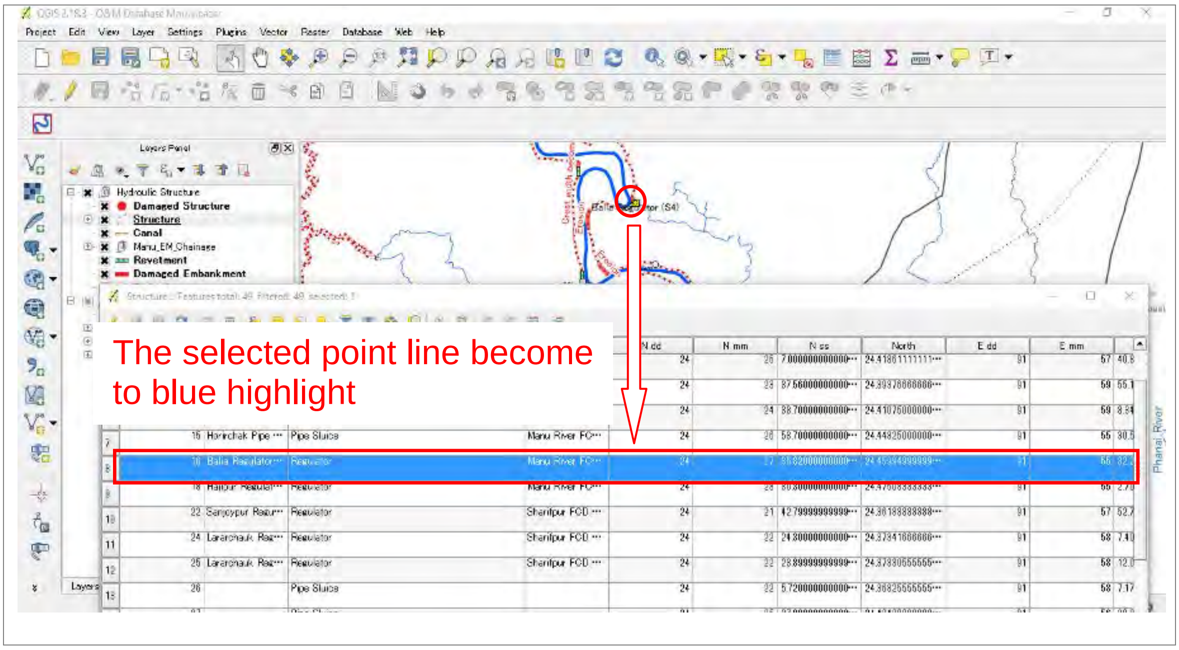
6-1. Select Object to "Open attribute table"



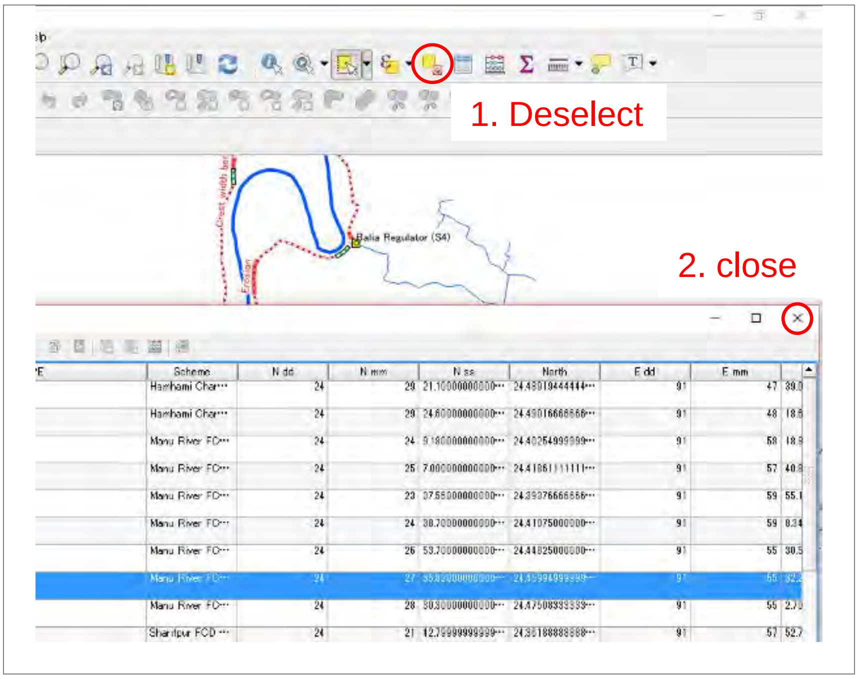
6-2.



6-3.


The selected point line become
to blue highlight

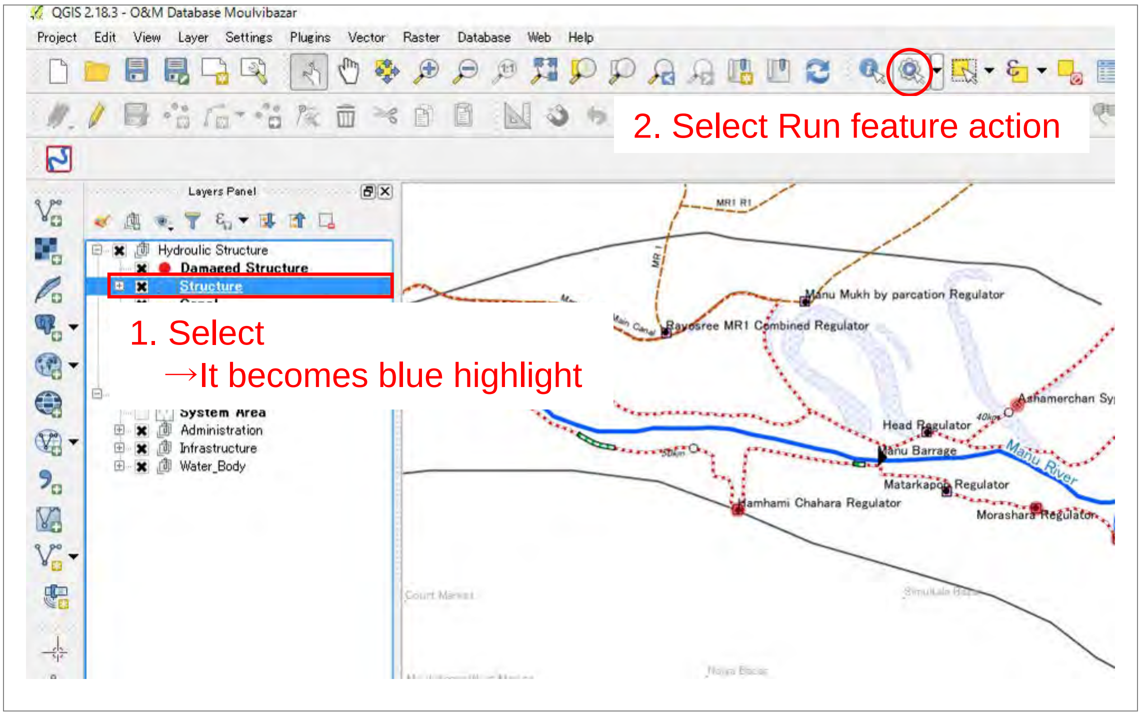
6-4.


1. Deselect
2. close

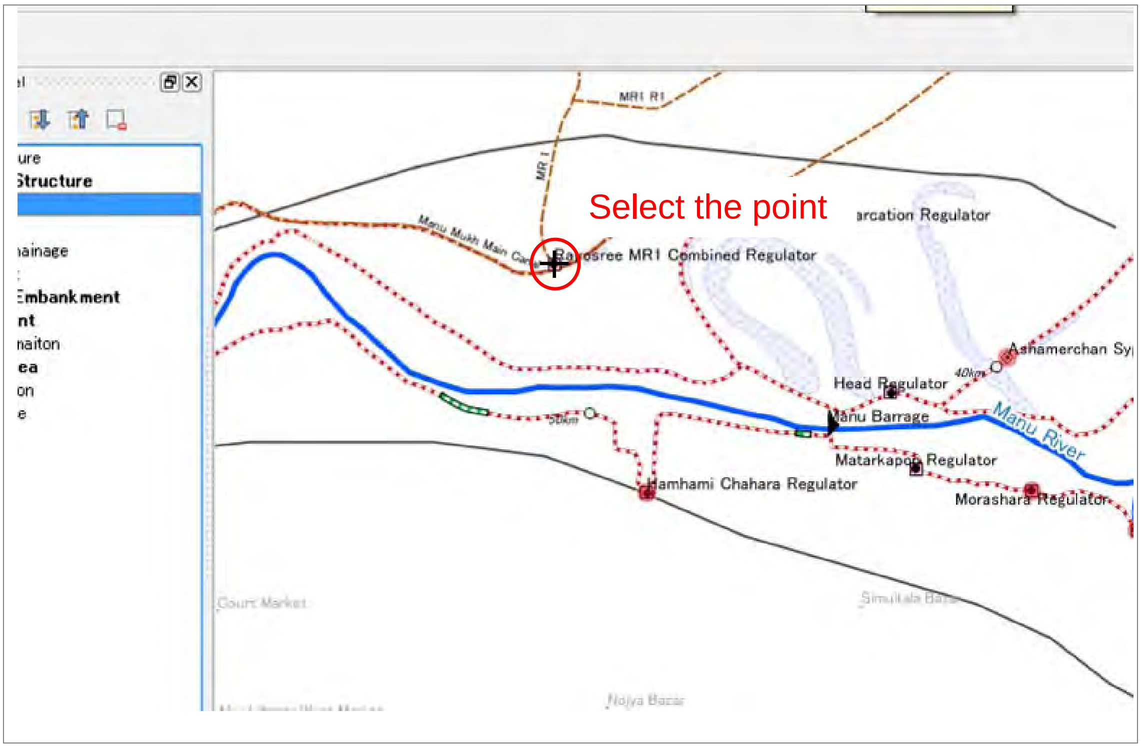
3.2 Linkage with Inventory sheet[●●]

The database has the linkage function with each hydraulic structure, revetment, Damaged Embankment. The operation is as follows,

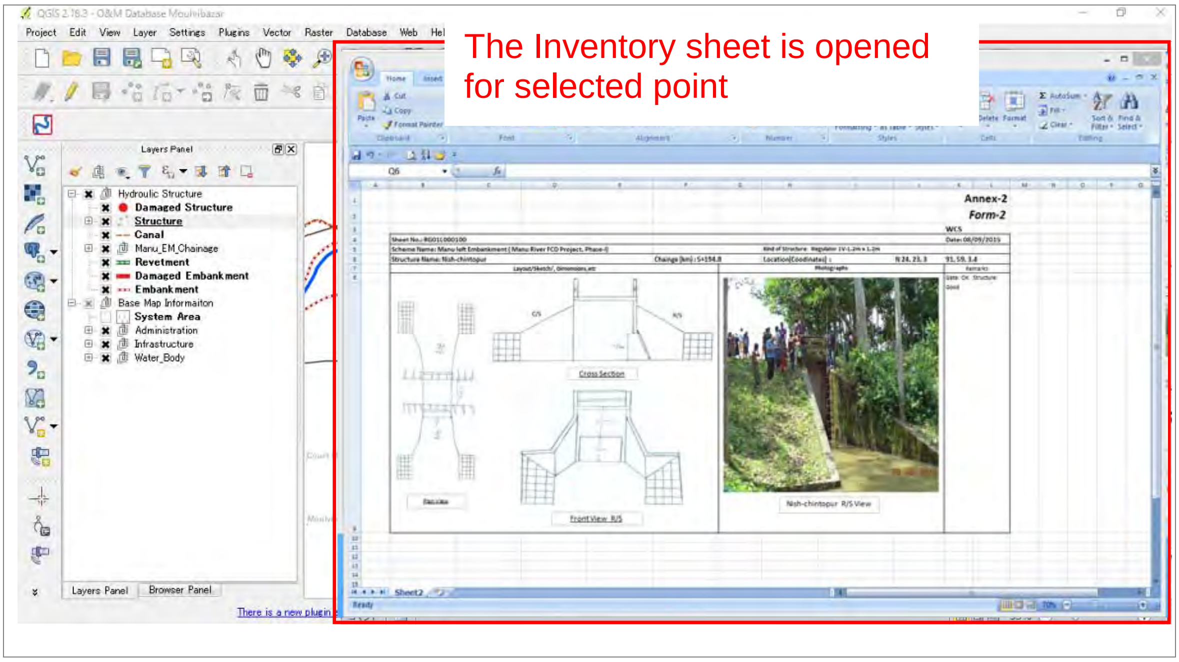
1-1. Linkage with Inventory sheet of Hydraulic structure



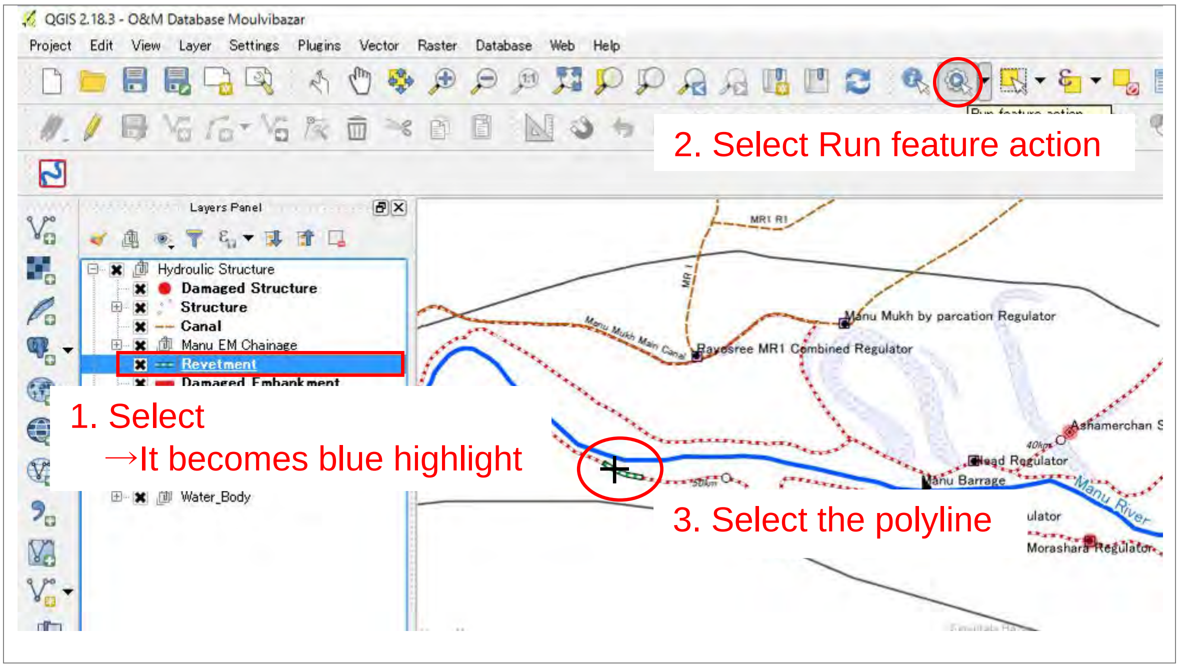
1-2.



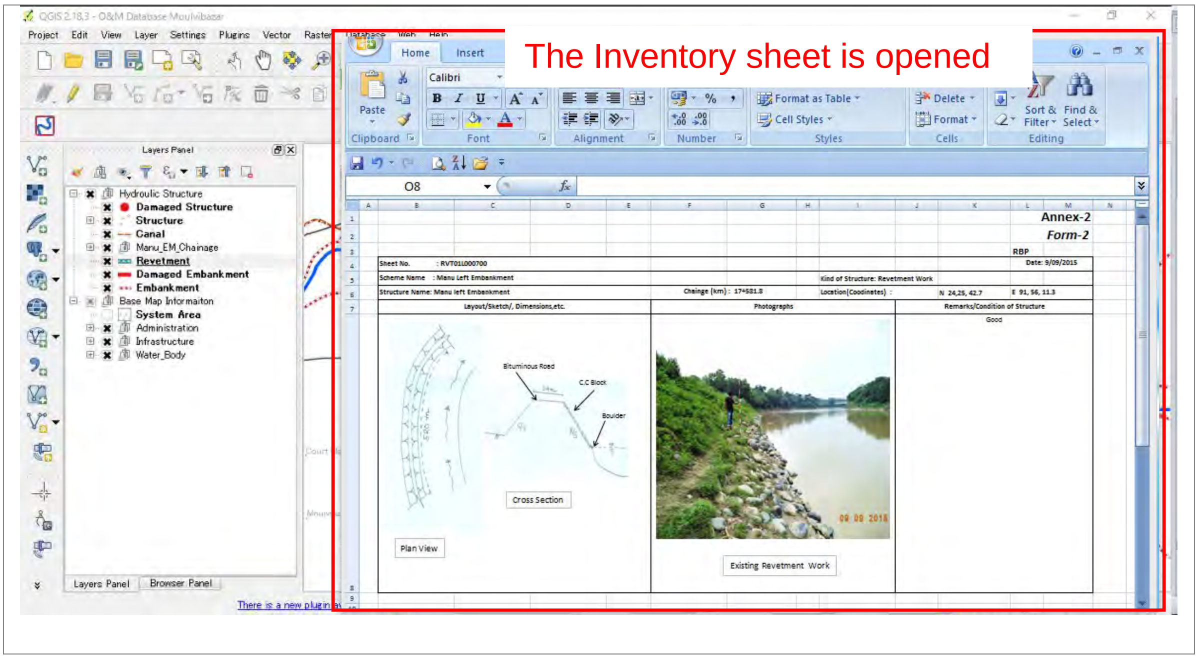
1-3.



2-1. Linkage with Inventory sheet of <u>Revetment</u> (same operation of <u>Damaged Embankment</u>)



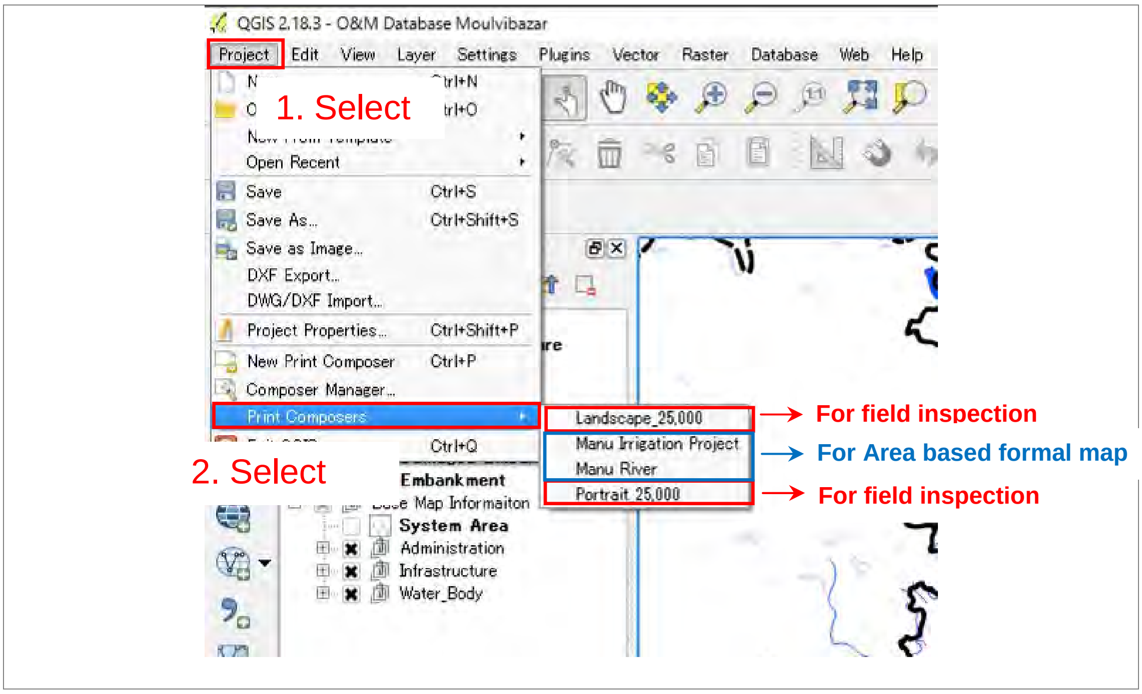
2-2.



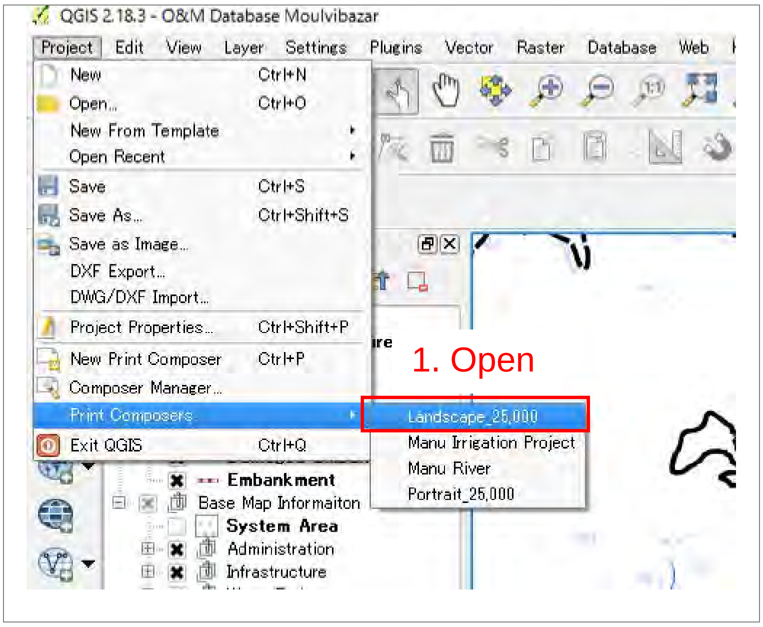
3.3 Operation of formal format map [●]

The GIS database has the function of displaying "Area based formal map", "Field inspection format Map" and export as JPG file. The process is as follows,

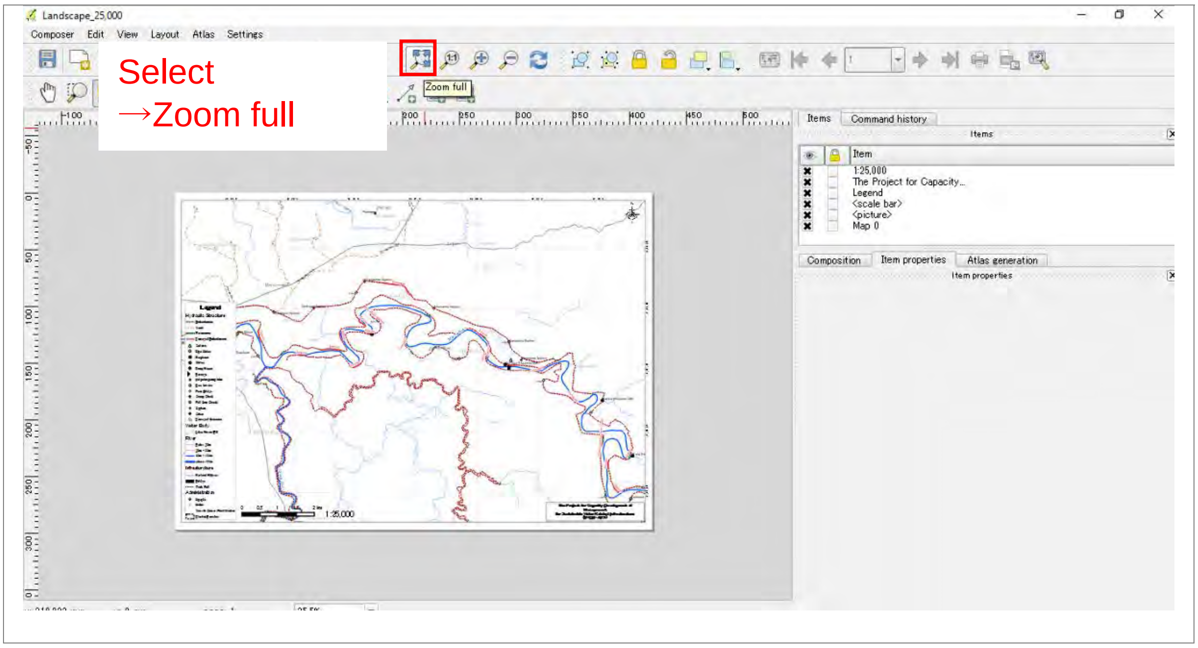
1-1.



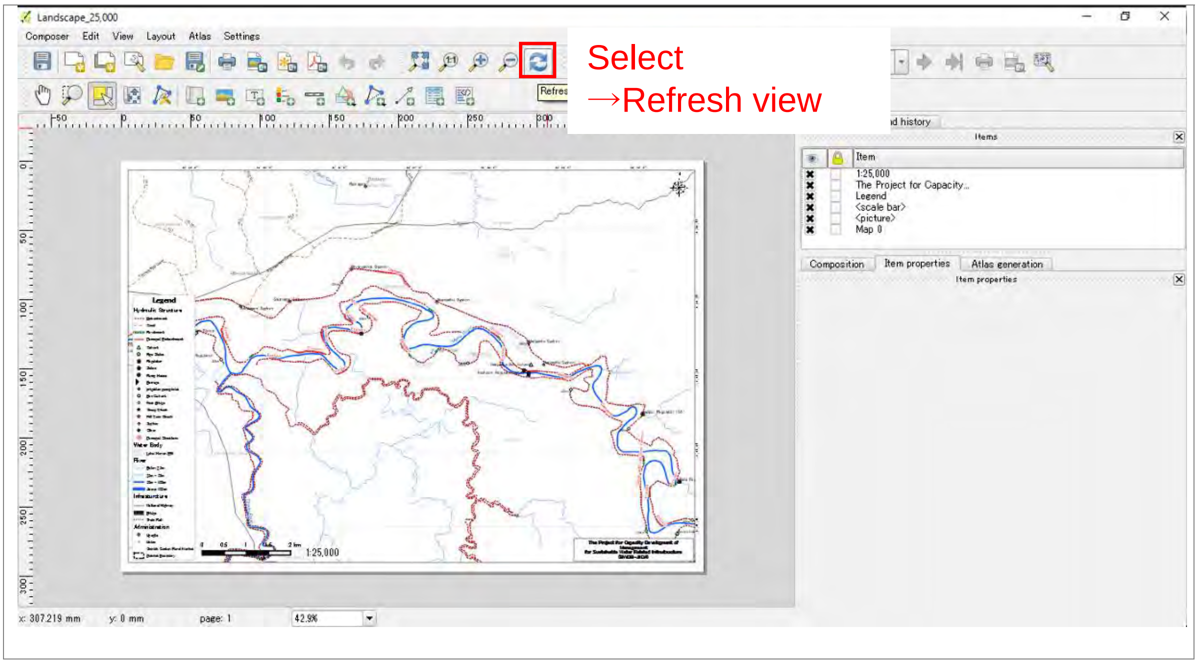
2-1. Open and operating Field Inspection Map



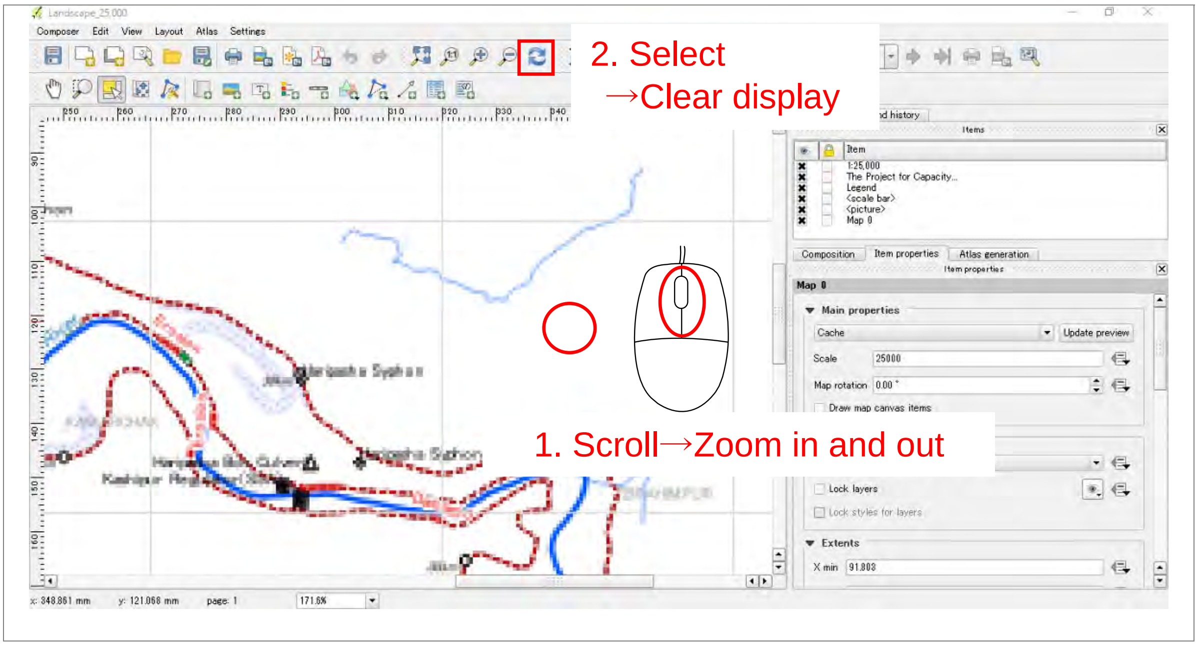
2-2.



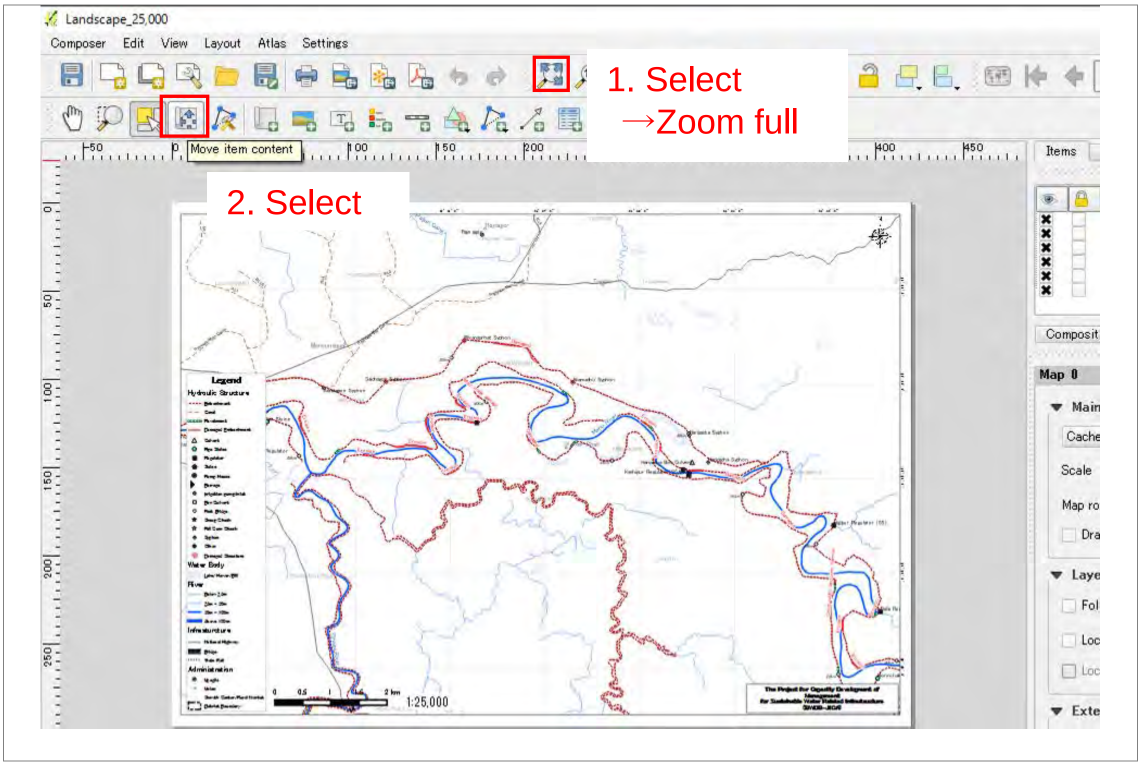
2-3.



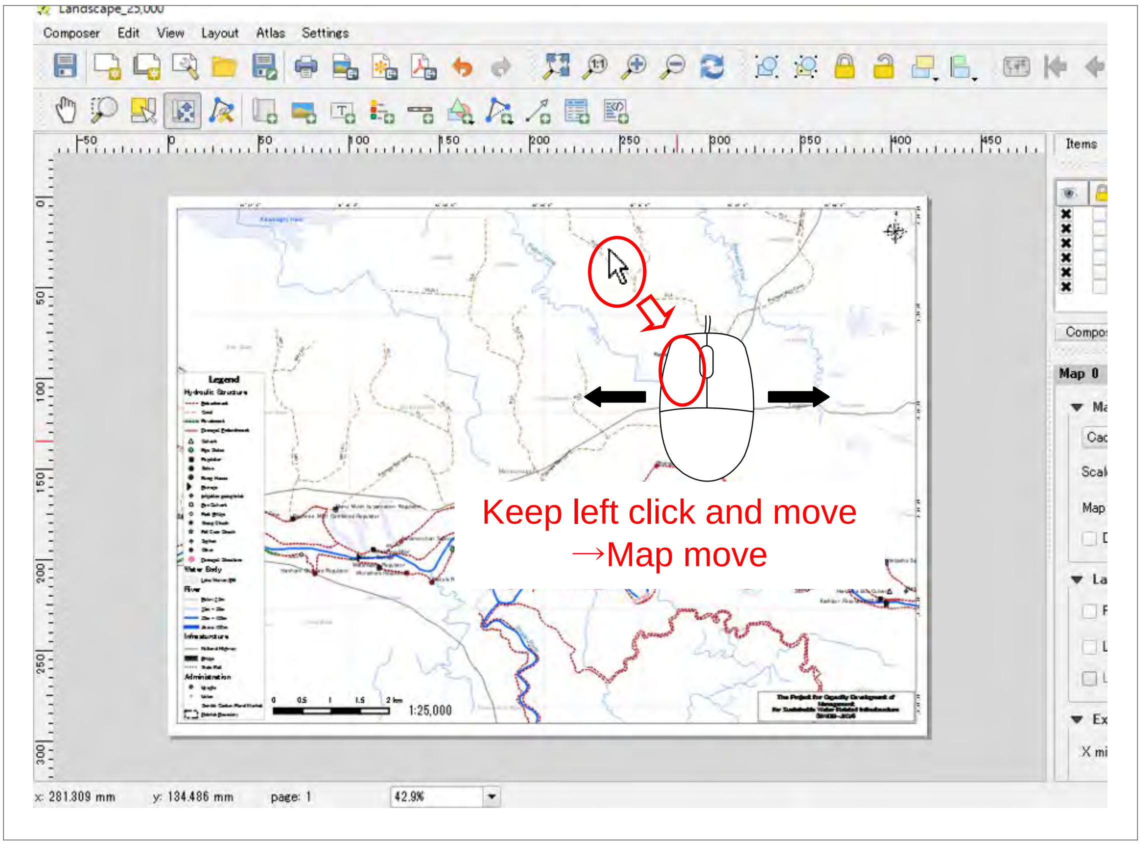
2-4. Zoom in or Zoom out Map



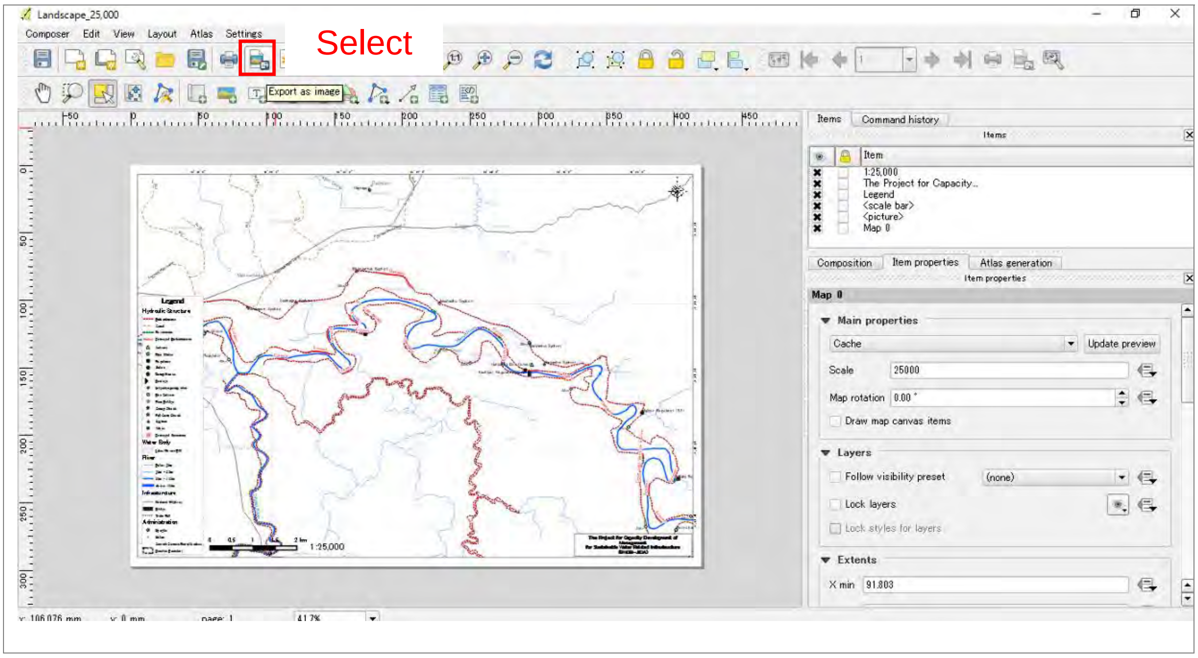
3-1. Move item contents for adjustment the place (the function is for Inspection Map)



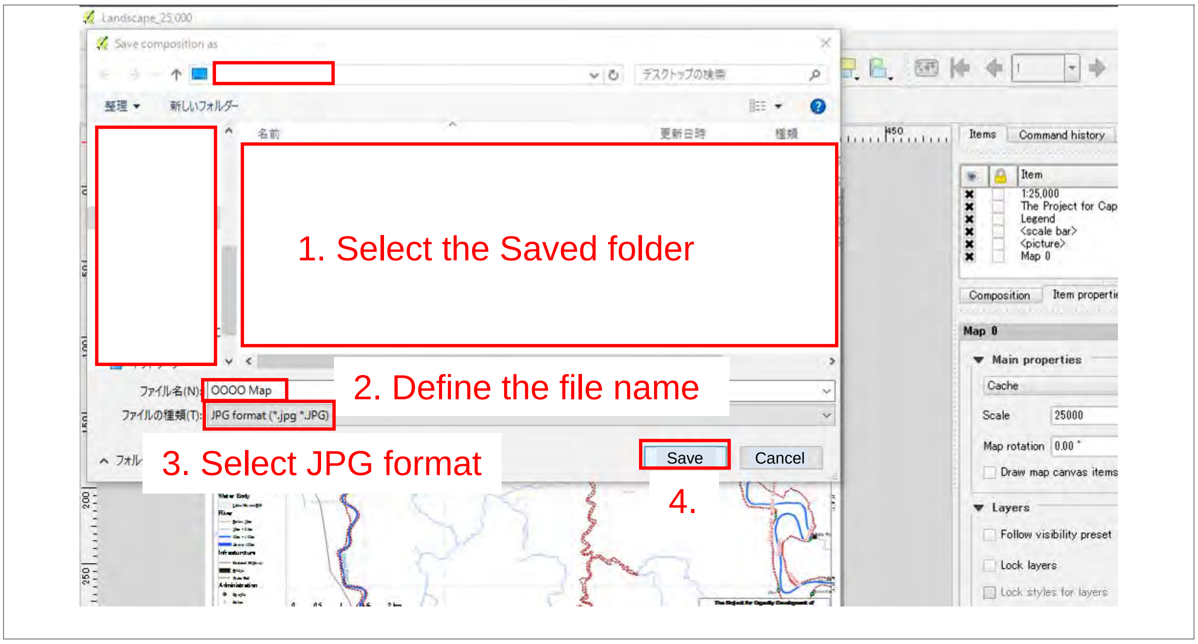
3-2.



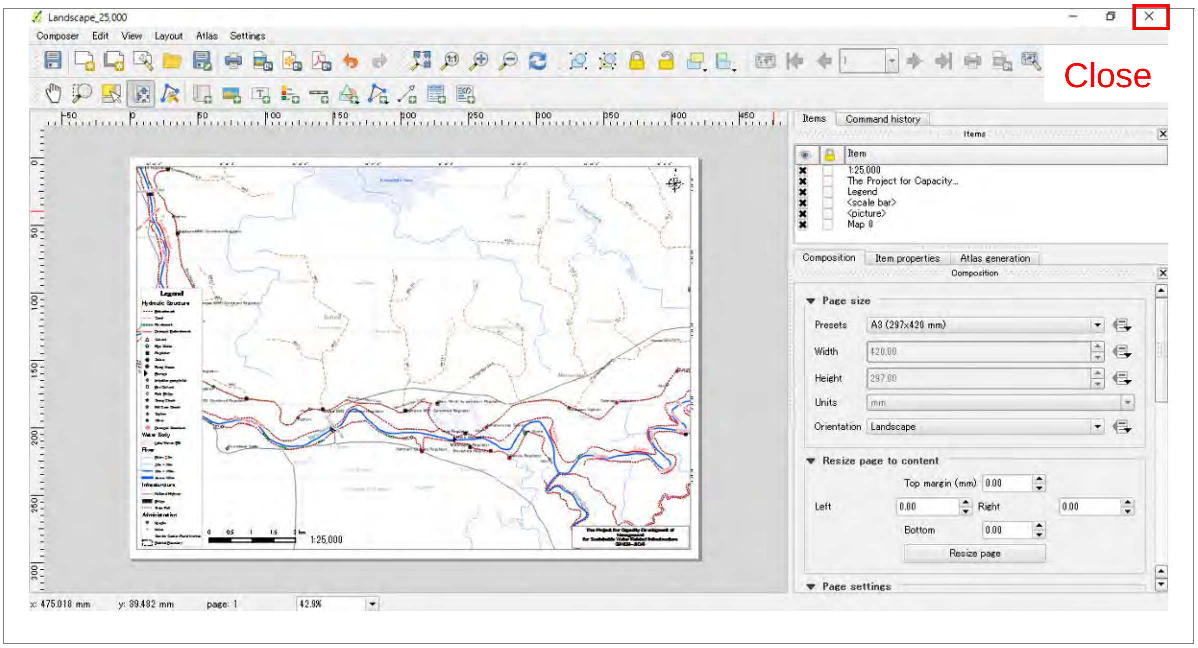
4-1. JPG export function



4-2.



5. Close Map function

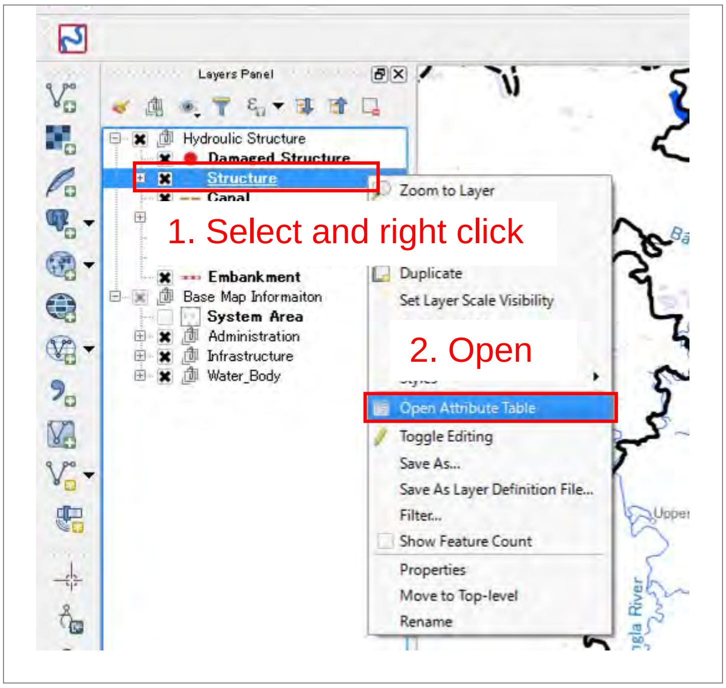


4 Edit operation

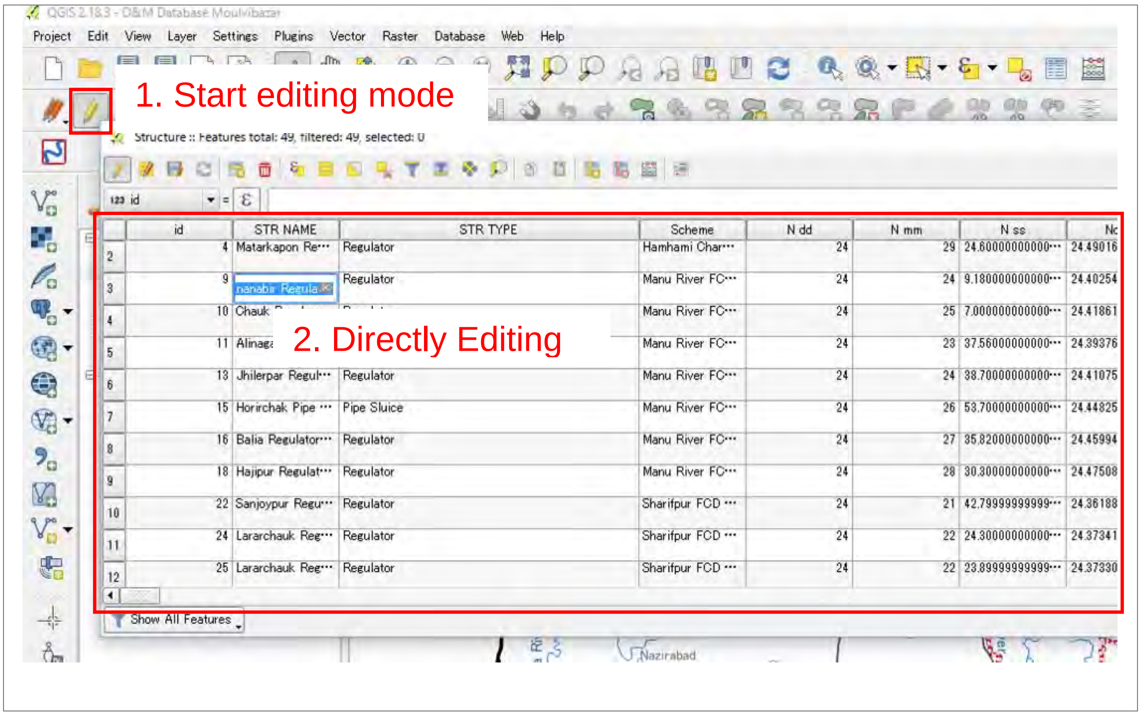
4.1 Edit "Open attribute table" [●]

The open attribute table has the information including the name of Structure, Structure damaged condition. The user directly changes information by editing the open attribute table. The process is as follows,

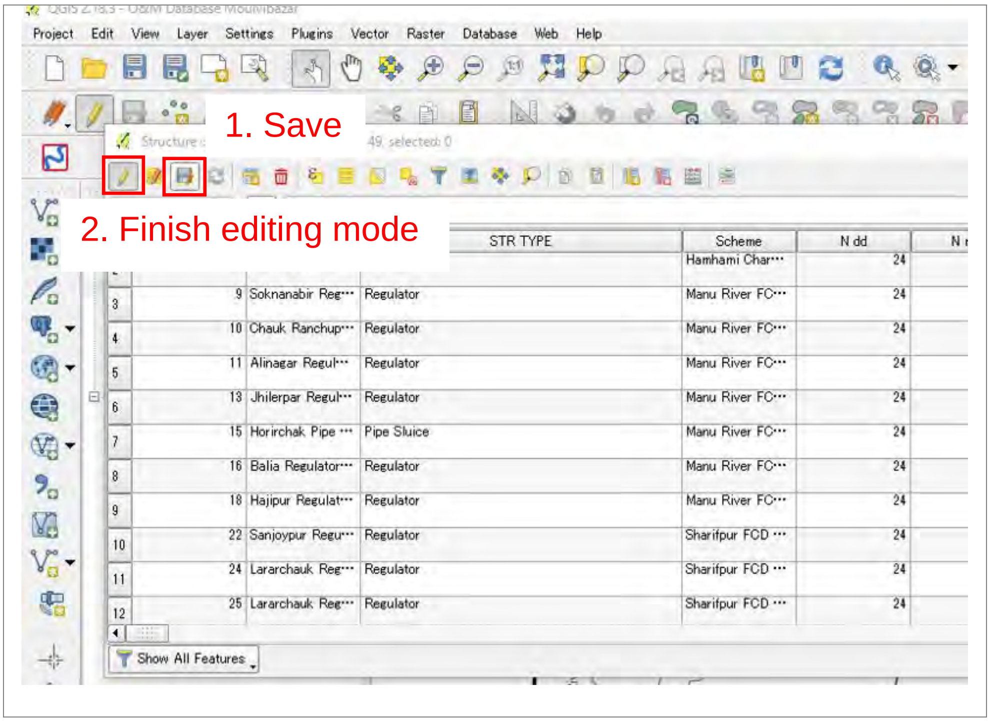
1-1.



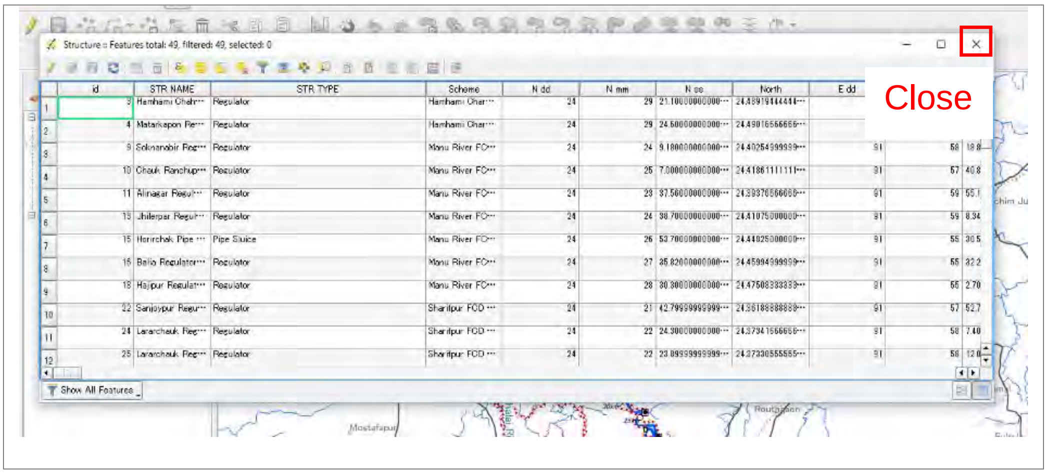
1-2.


1. Start editing mode
2. Directly Editing

1-3.


1. Save
2. Finish editing mode

1-4.

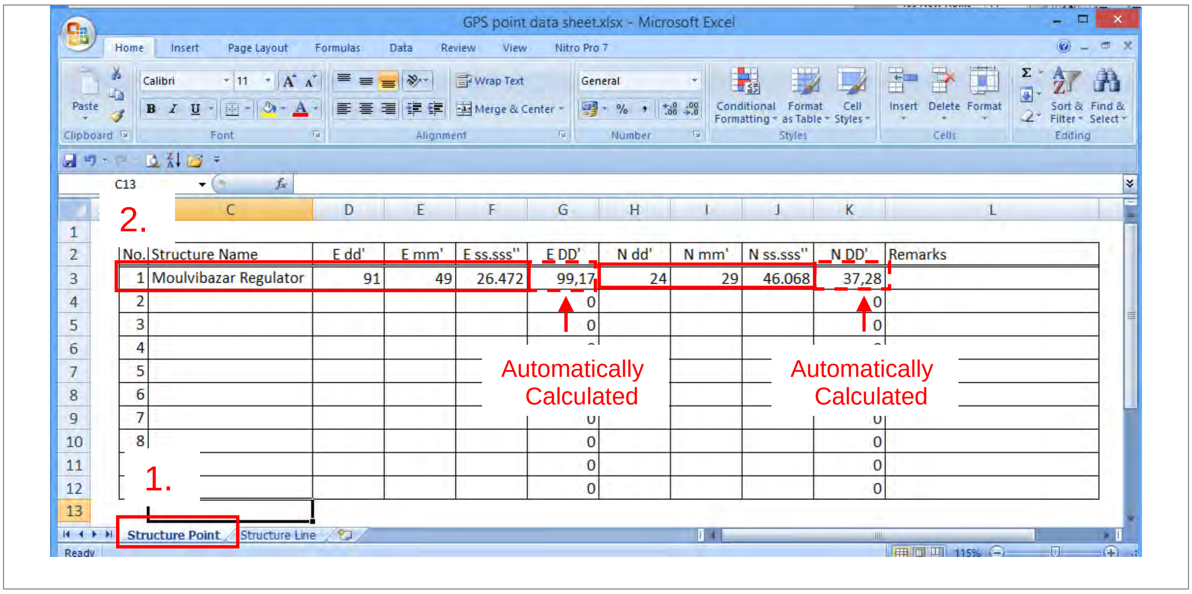


4.2 Add structure point [●]

The capture is to introduce how to edit the Structure point like Culvert, Pipe Sluice, Regulator and damaged point.

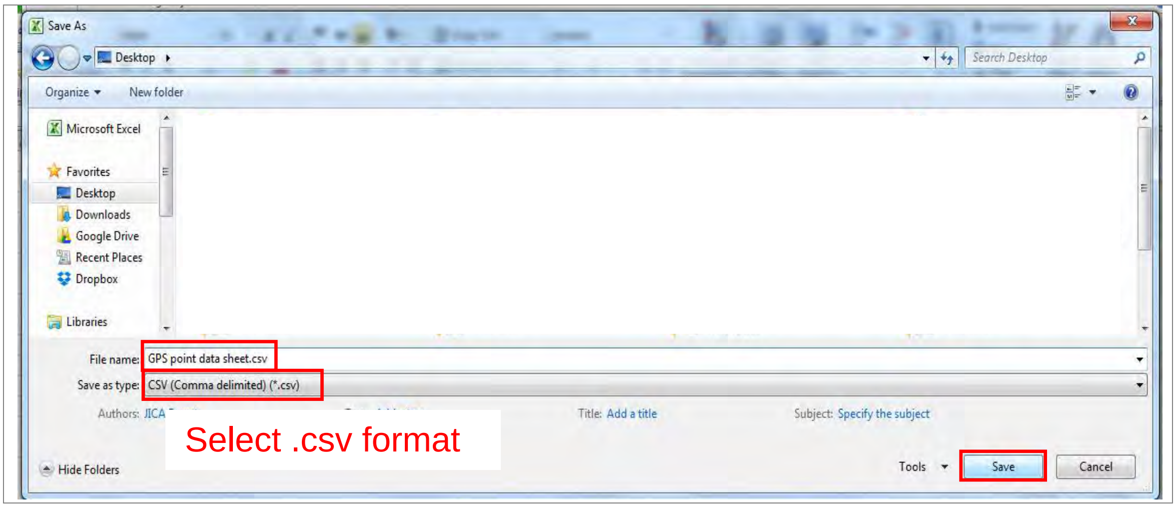
The structure point is collected in the field inspection and took placement point data by GPS.

1.1 After collecting the GPS point, open the Structure Point tab in the excel sheet "GPS point data sheet.xlsx" and fill in the "Structure Name", "Longitude", "Latitude".

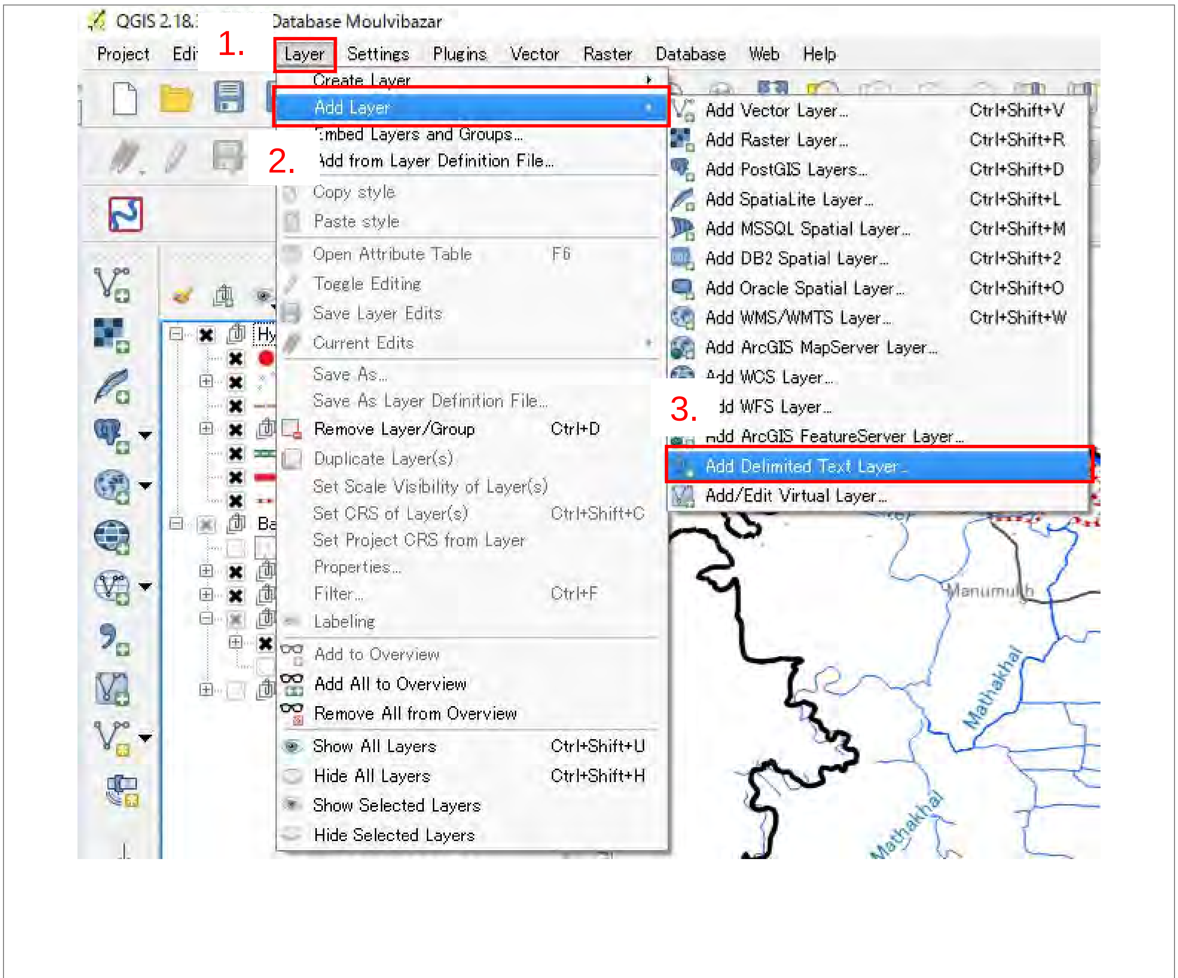


✓ GPS point data sheet is saved under "C:¥O&M Database Moulvibazar¥02_GPS pont data sheet"

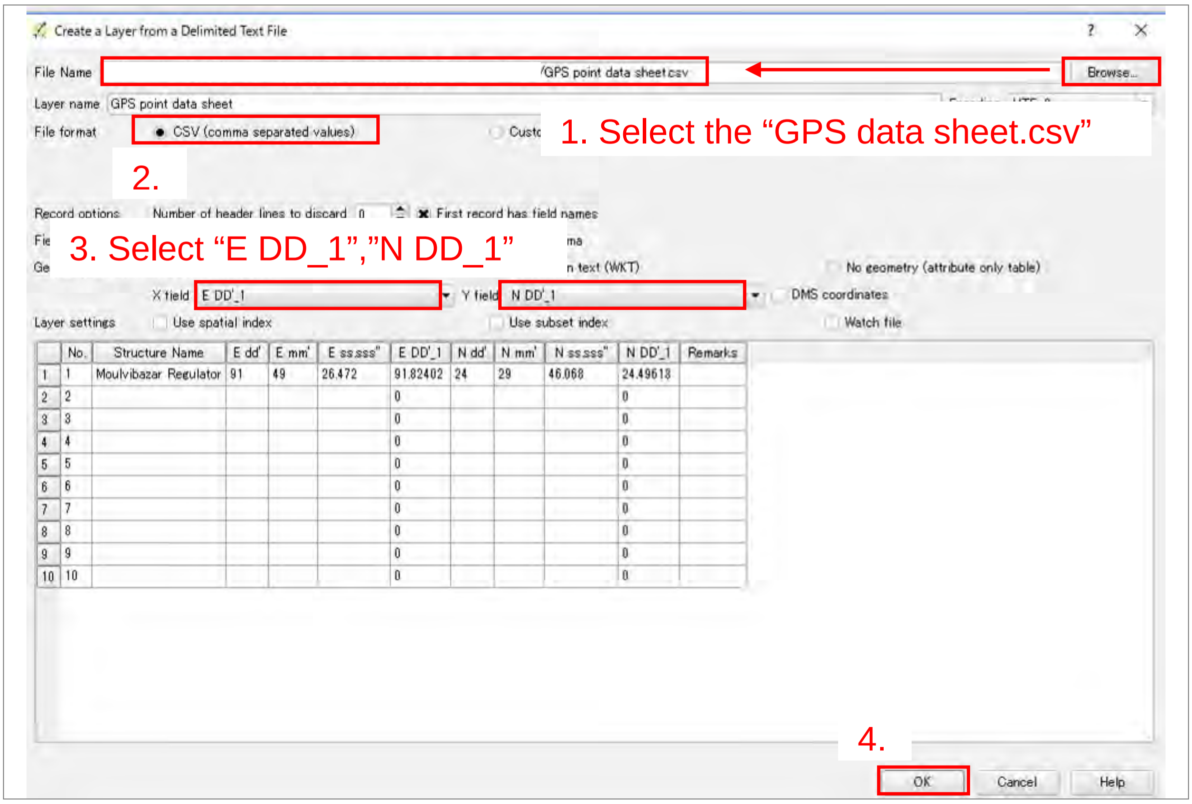
1.2 After filling in the information, save csv format as "GPS point data sheet.csv".



1-3. Import "GPS point data sheet.csv" to GIS database as follows



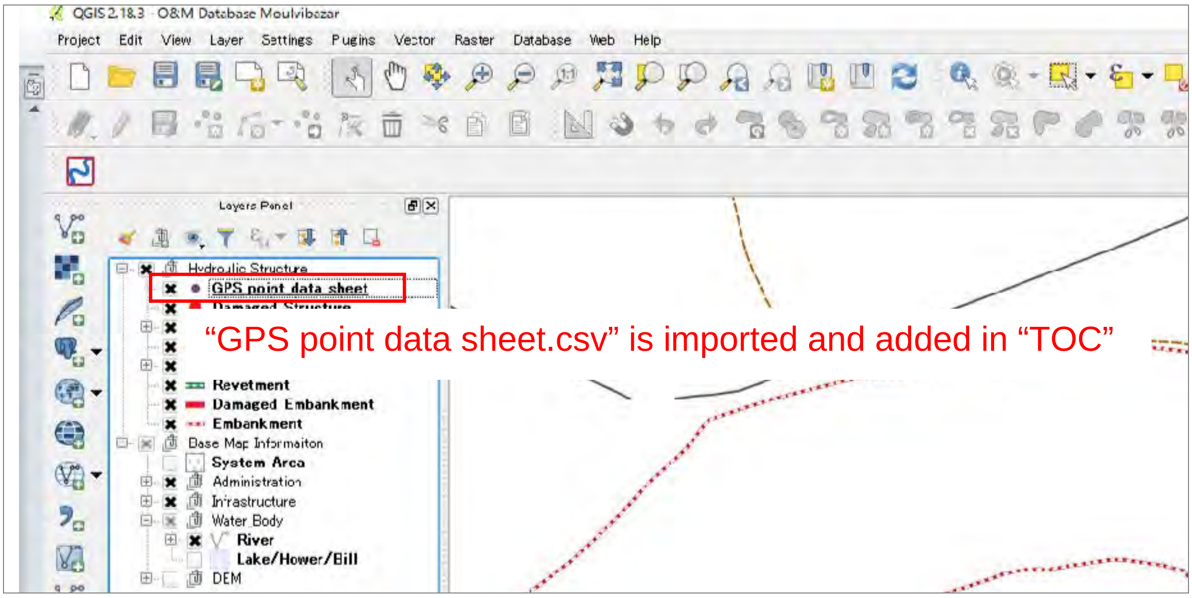
1-4.



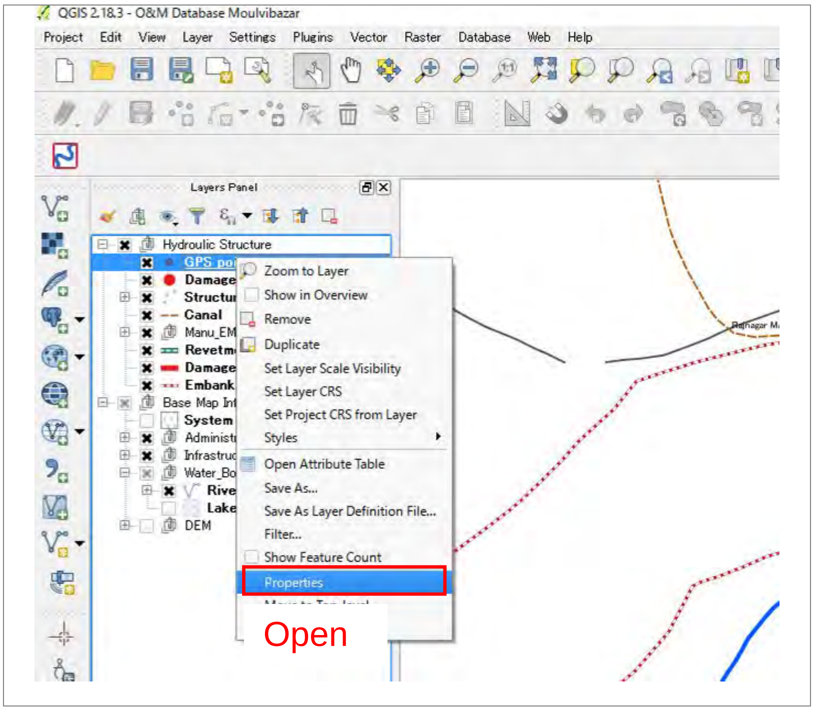
1-5.

Set the "WGS84" as coordinate reference system

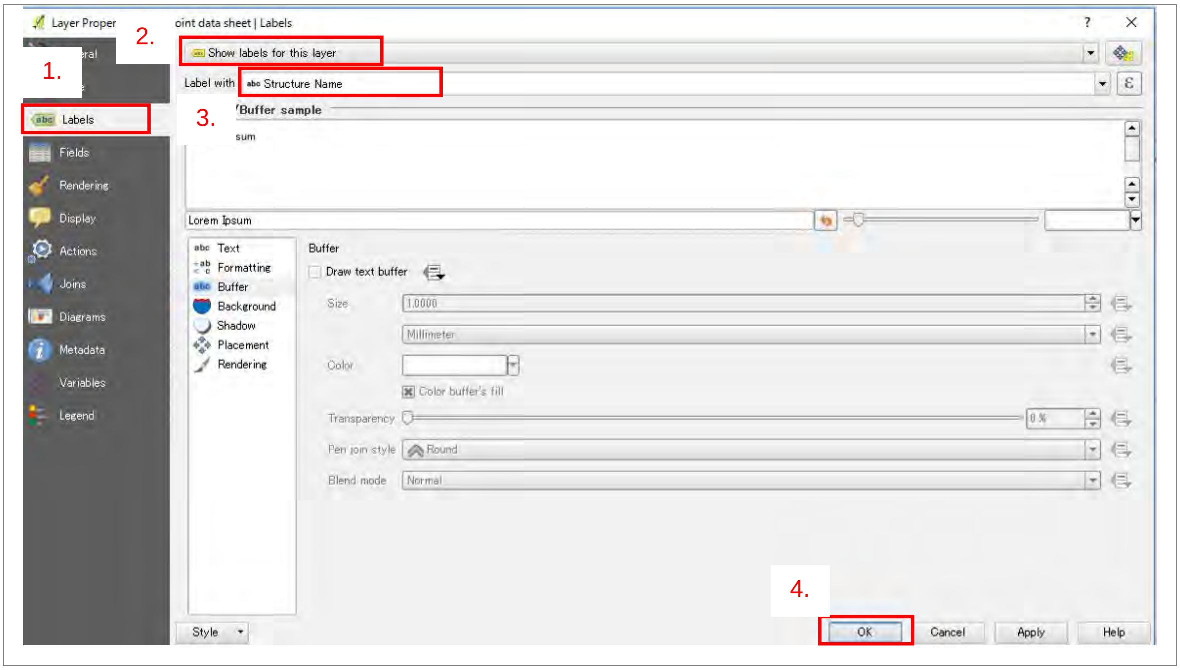
1-6.



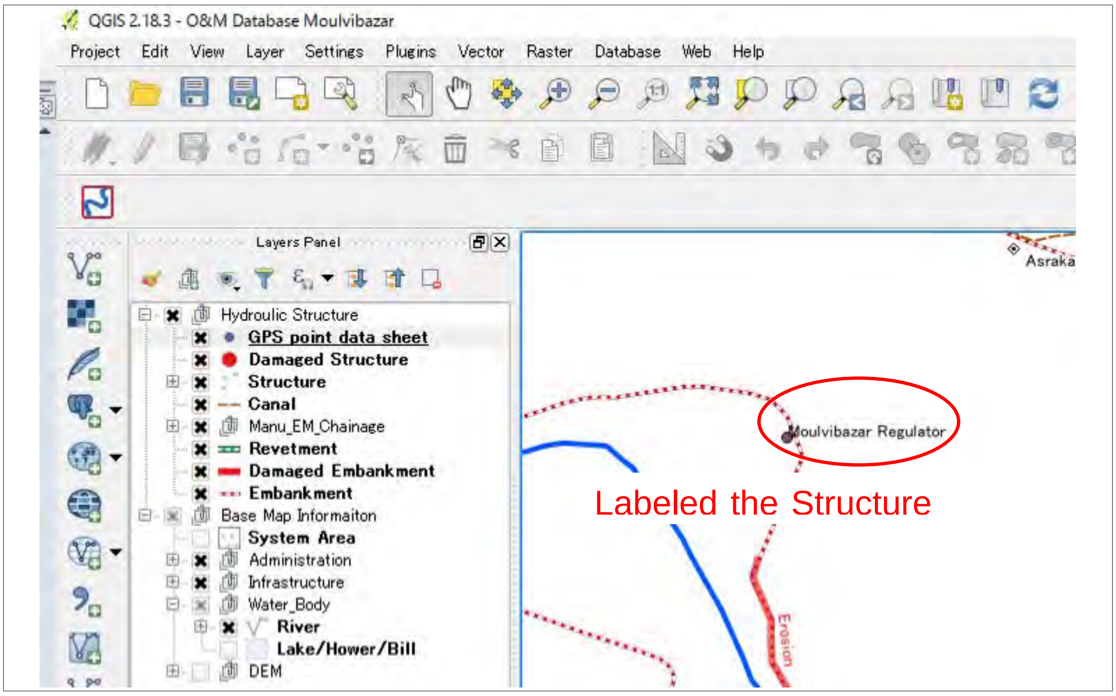
1-7.


QGIS 2.18.3 - O&M Database Moulvibazar
Project Edit View Layer Settings Plugins Vector Raster Database Web Help
Layers Panel
Hydroulic Structure
Zoom to Layer
Show in Overview
Remove
Duplicate
Set Layer Scale Visibility
Set Layer CRS
Set Project CRS from Layer
Styles
Open Attribute Table
Save As...
Save As Layer Definition File...
Filter...
Show Feature Count
Properties
Open

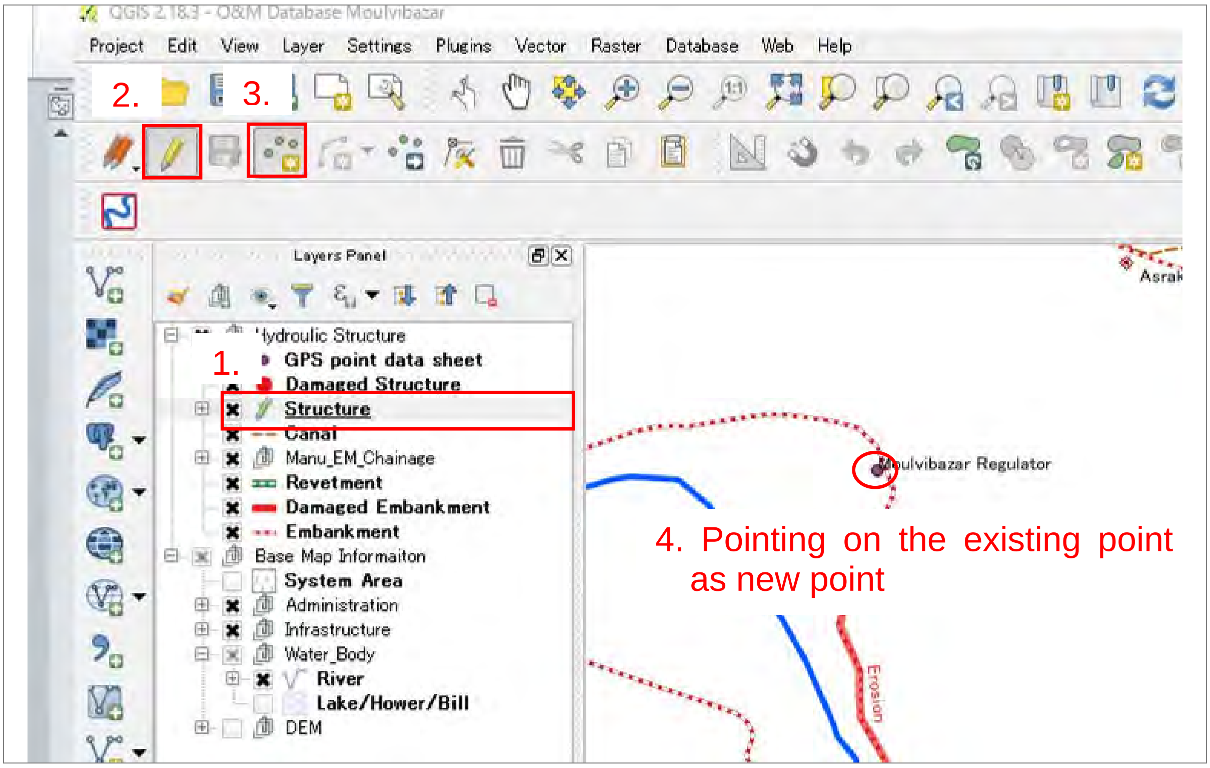
1-8.


1.
2.
3.
4.
Show labels for this layer
Label with
Structure Name
Labels
Fields
Rendering
Display
Actions
Joins
Diagrams
Metadata
Variables
Legend
Lorem Ipsum
Text
Formatting
Buffer
Background
Shadow
Placement
Rendering
Draw text buffer
OK
Cancel
Apply
Help

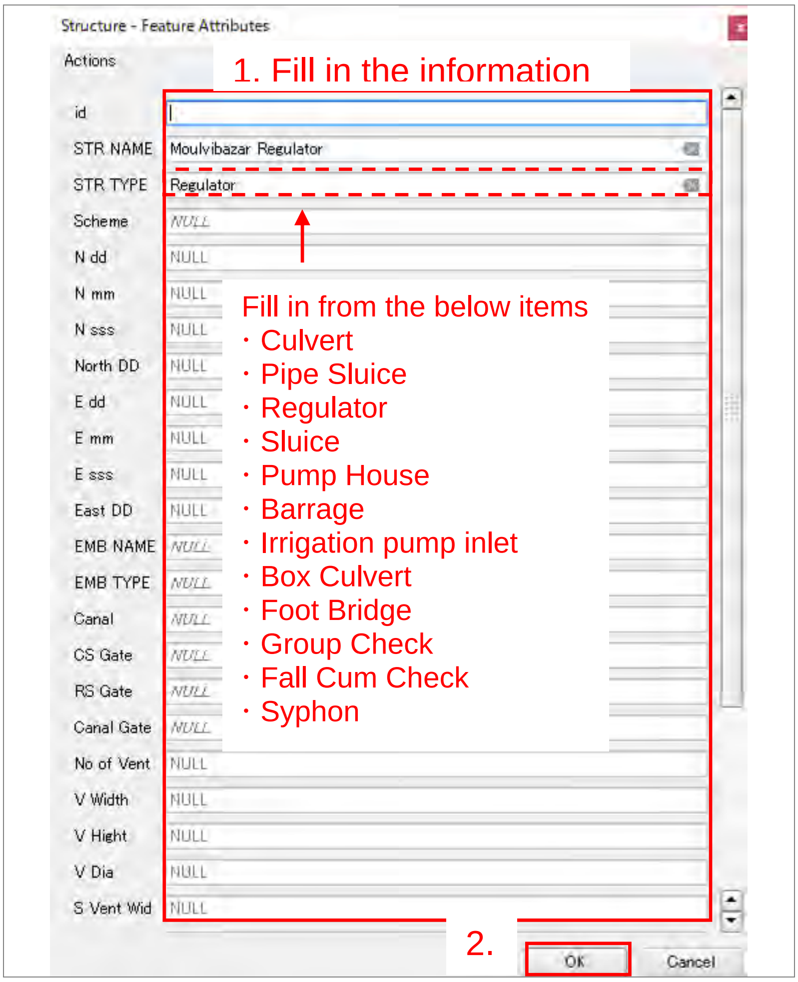
1-9.



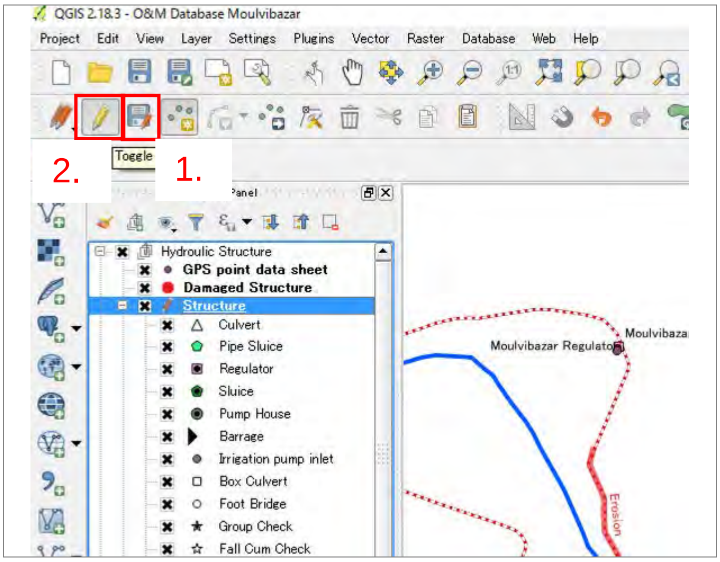
1-10. Start Editing



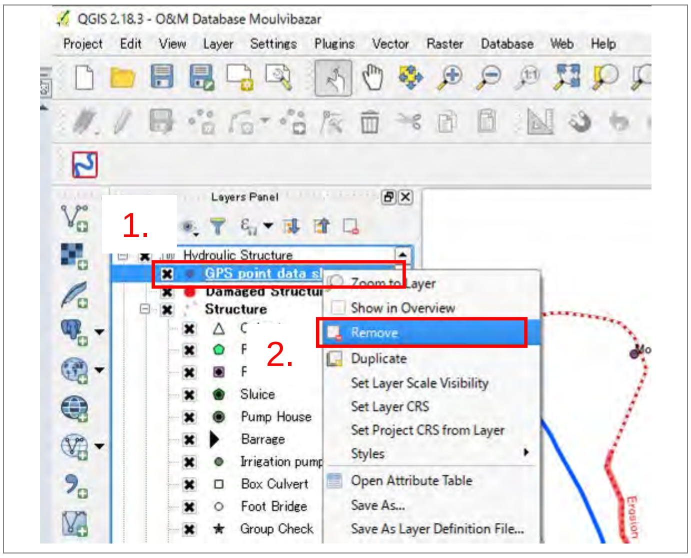
1-11.



1-12. Stop editing



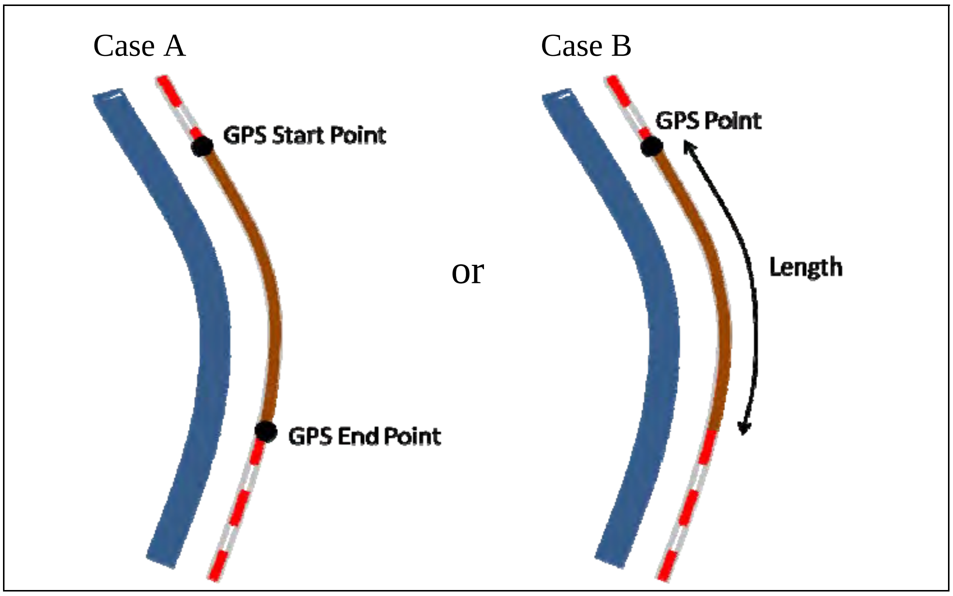
1-13. Remove the "GPS point data sheet.csv"



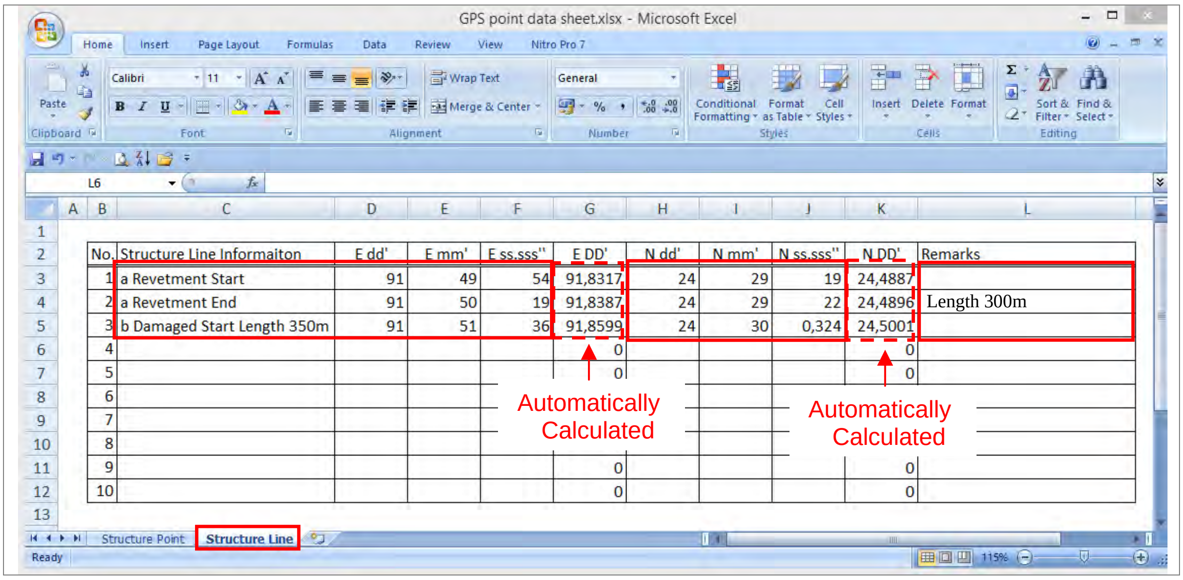
4.3 Add structure line [●]

The capture is to introduce how to edit the Structure line for revetment and damaged embankment.

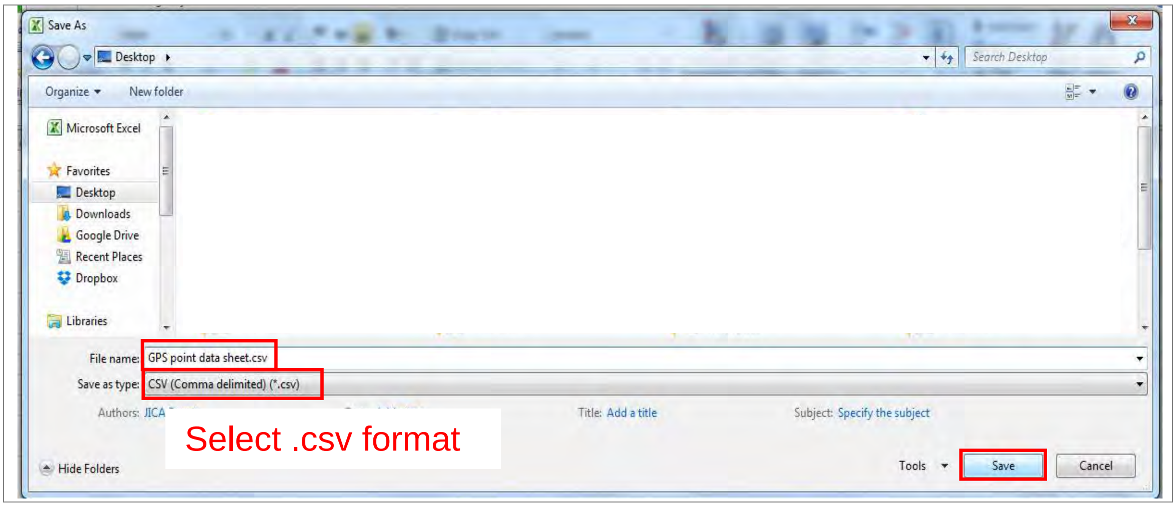
The new revetment or damaged embankment placement data is collected in field inspection. In the field, two types of placement data is collected bellows; Case A or Case B.



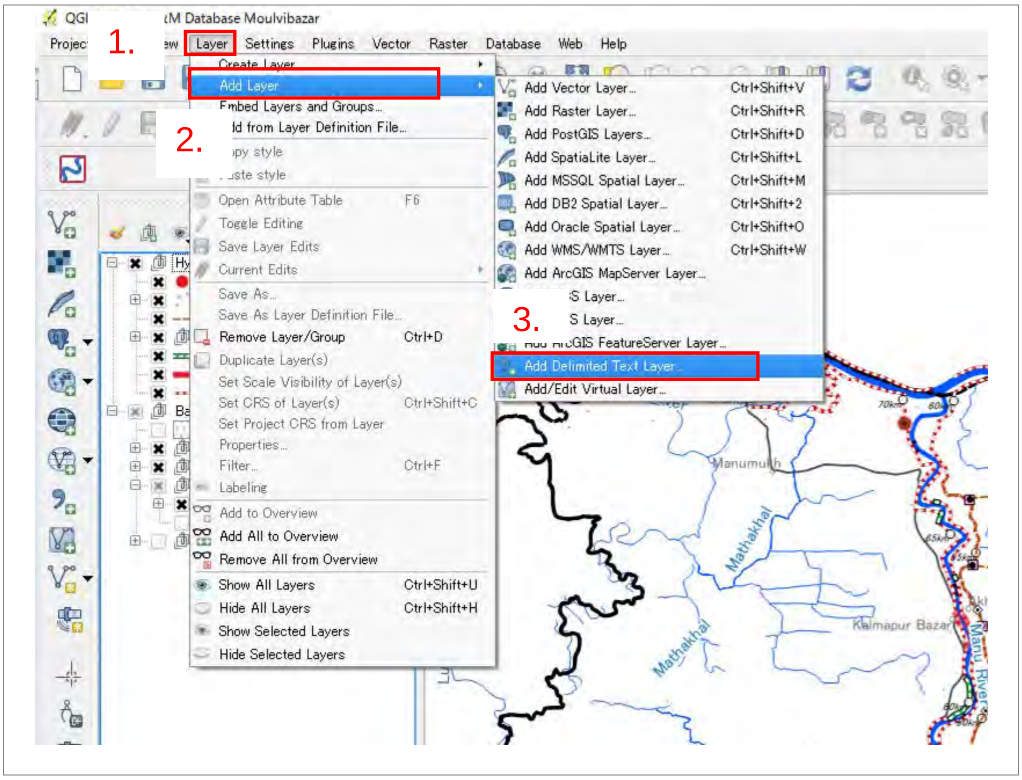
1-1. After collecting the data, Fill in “GPS Point” and “Length” in the “GPS Point data sheet.xlsx”.



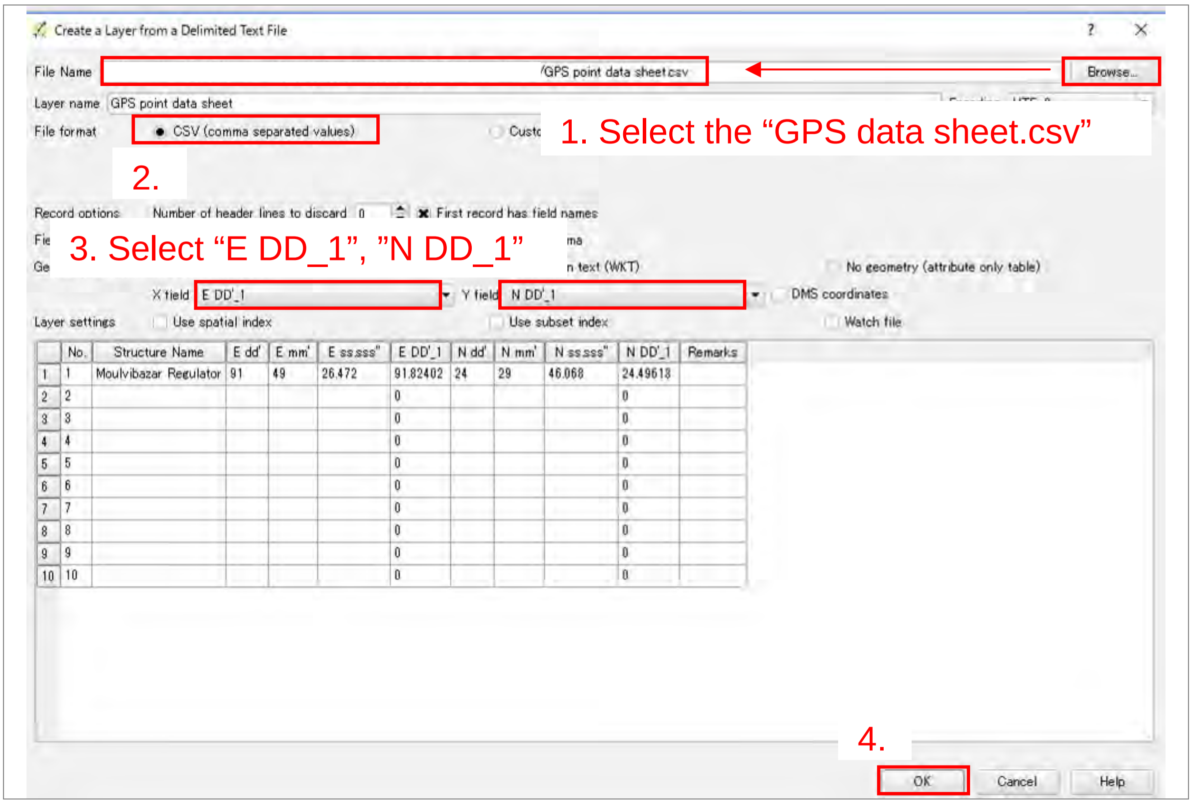
1-2. After filling in the information, save csv format as “GPS point data sheet.csv”.



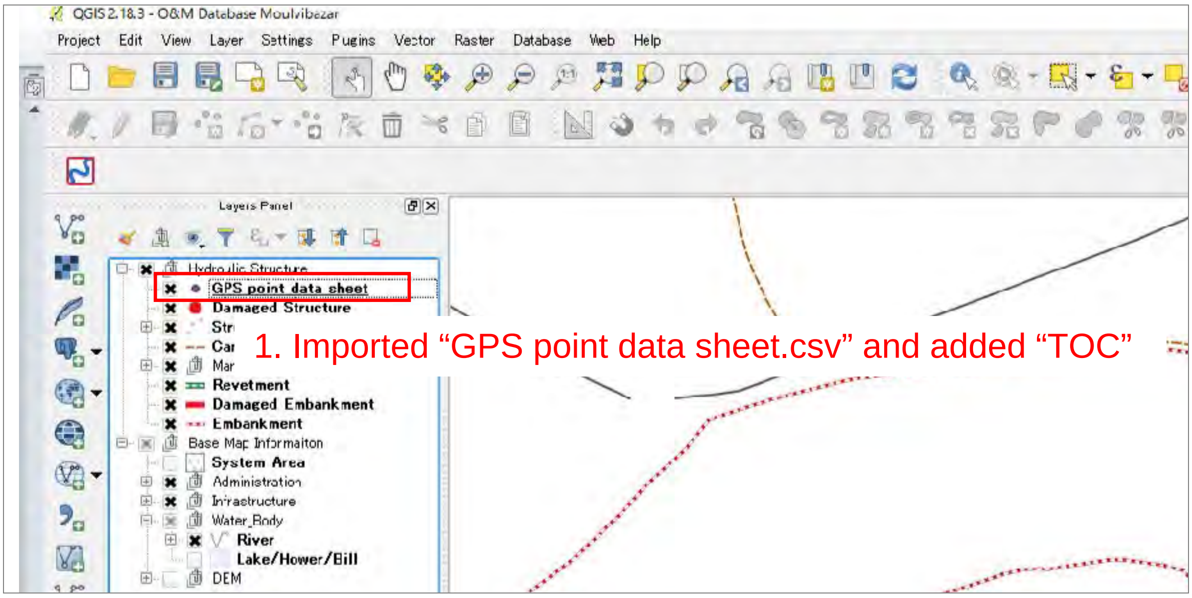
1-3. Import to GIS database from "GPS point data sheet.csv" as follows,



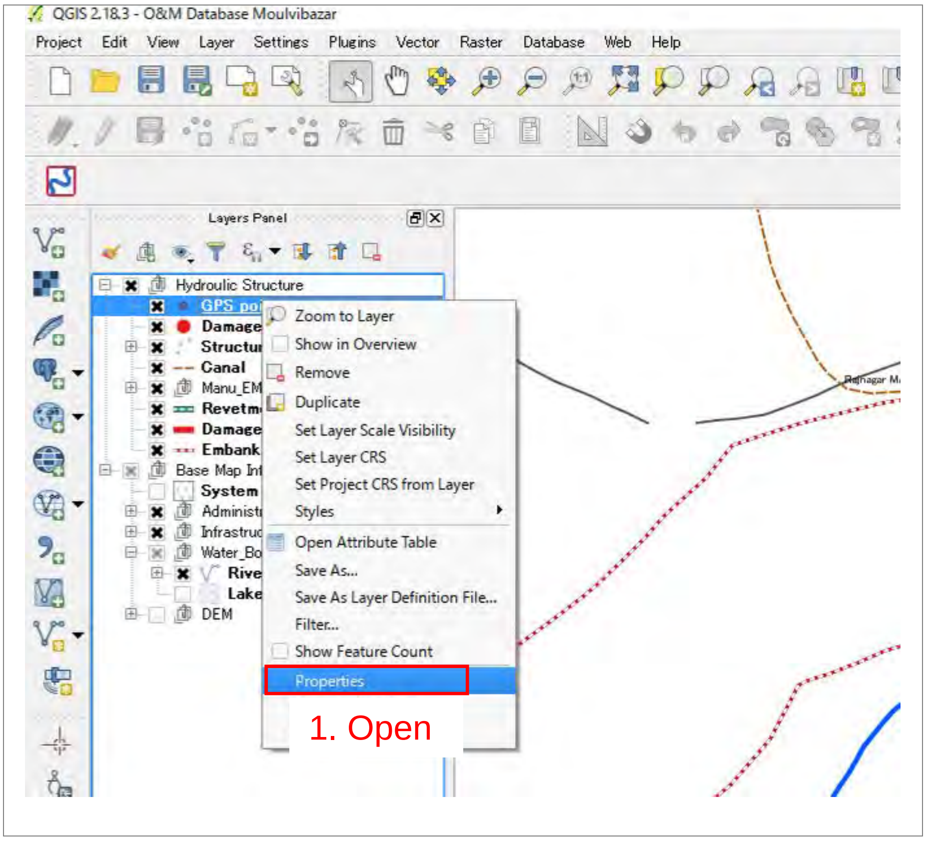
1-4.



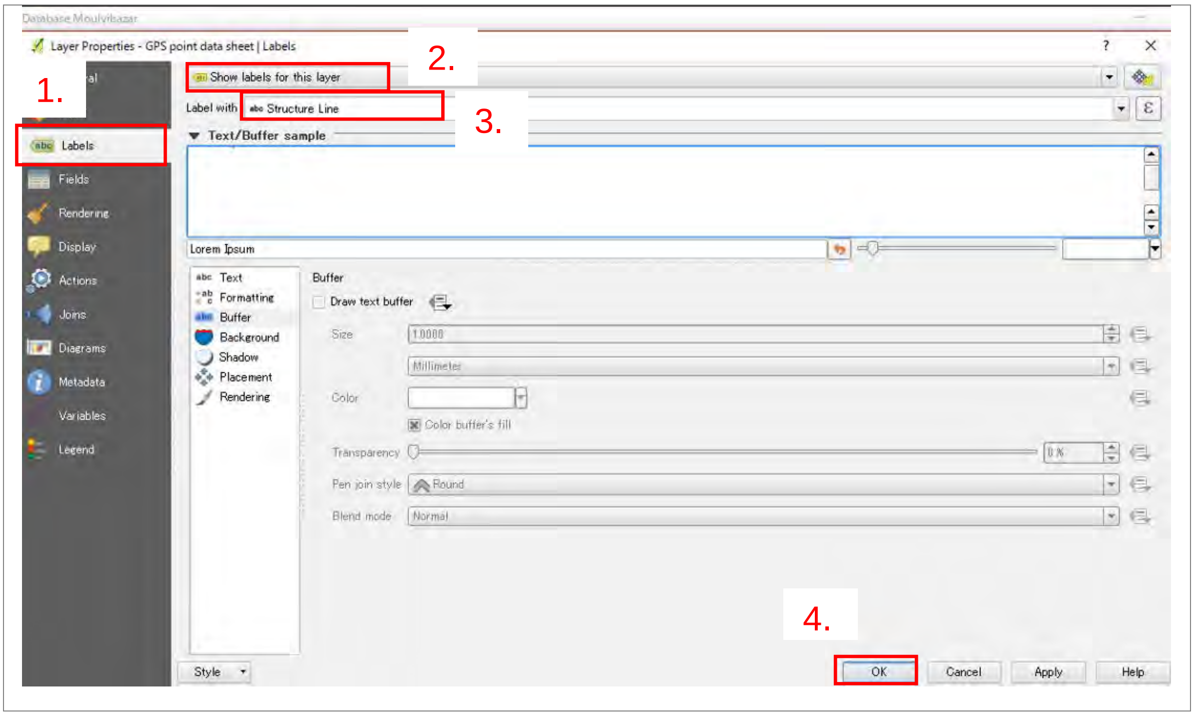
1-5.


QGIS 2.18.3 - O&M Database Moulvibazar
Project Edit View Layer Settings Plugins Vector Raster Database Web Help
Layers Panel
Hydroulic Structure
GPS point data sheet
Damaged Structure
Revetment
Damaged Embankment
Embankment
Base Map Informaiton
System Area
Administration
Infrastructure
Water_Body
River
Lake/Hower/Bill
DEM
1. Imported "GPS point data sheet.csv" and added "TOC"

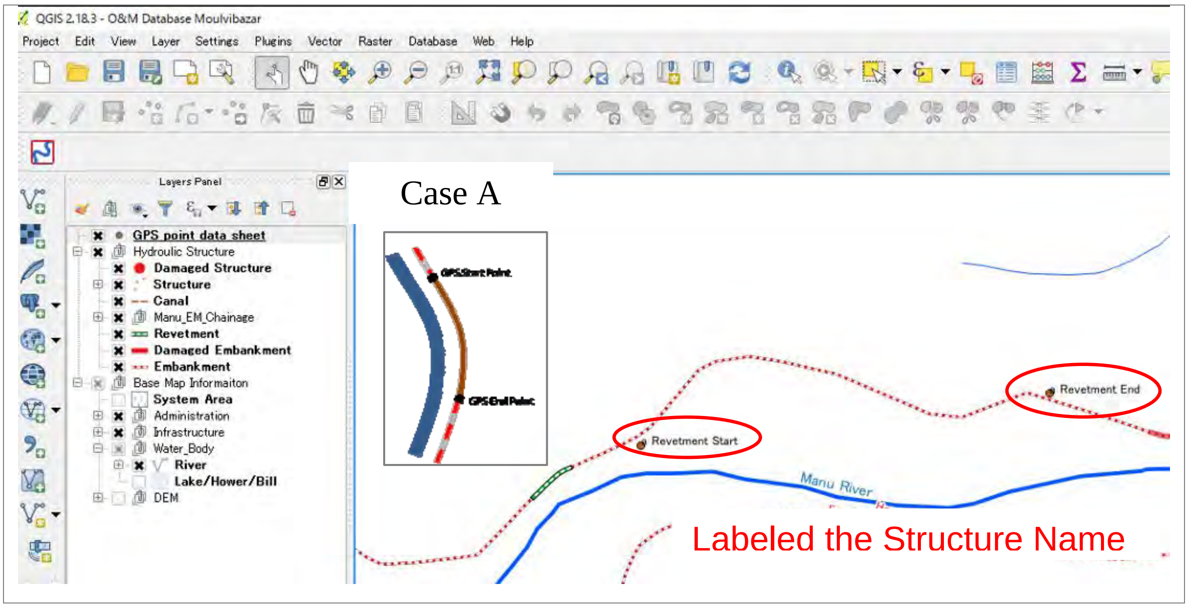
1-6.


QGIS 2.18.3 - O&M Database Moulvibazar
Project Edit View Layer Settings Plugins Vector Raster Database Web Help
Layers Panel
Hydroulic Structure
Zoom to Layer
Show in Overview
Remove
Duplicate
Set Layer Scale Visibility
Set Layer CRS
Set Project CRS from Layer
Styles
Open Attribute Table
Save As...
Save As Layer Definition File...
Filter...
Show Feature Count
Properties
1. Open

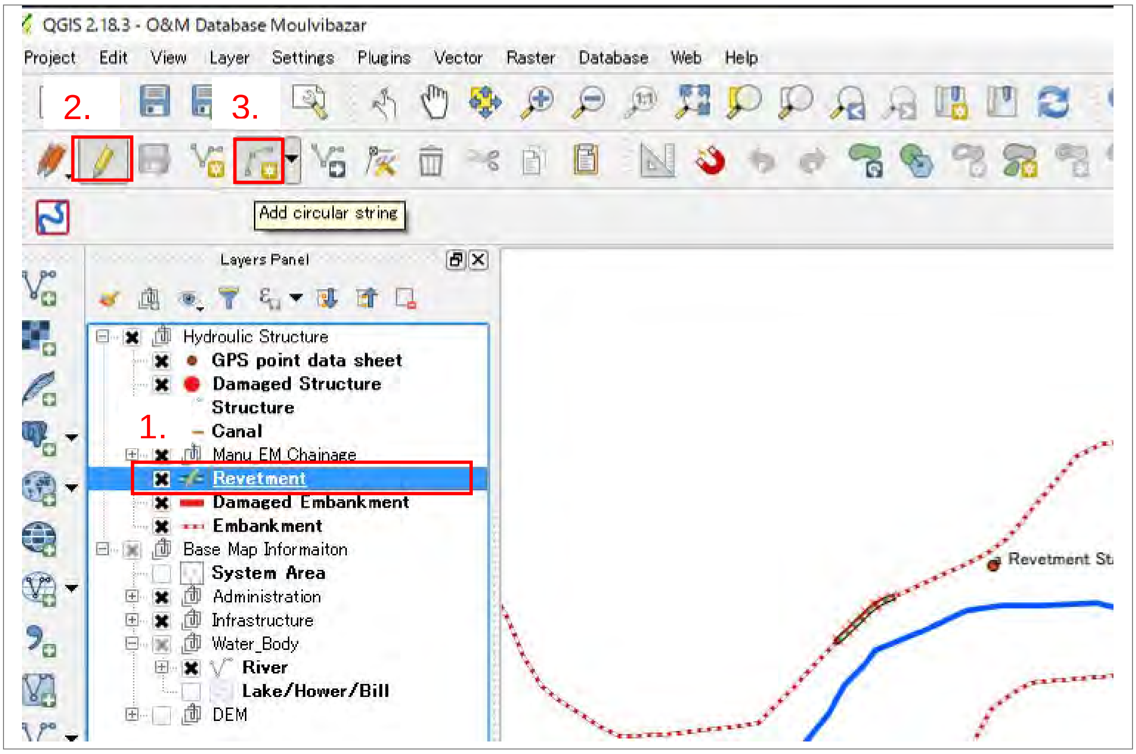
1-7.



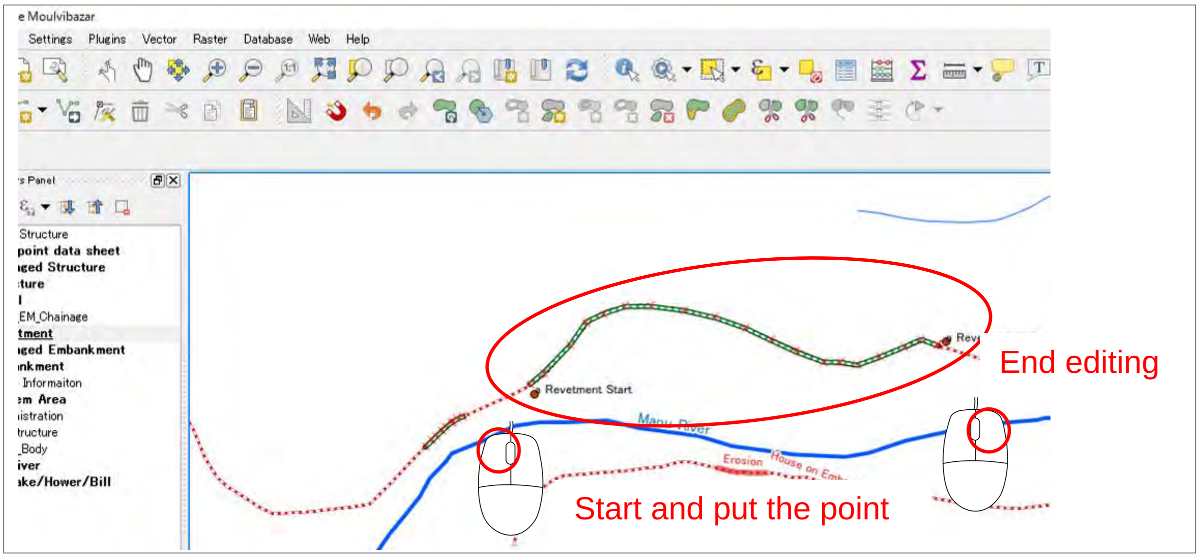
2-1. Add line for Revetment - Case A -



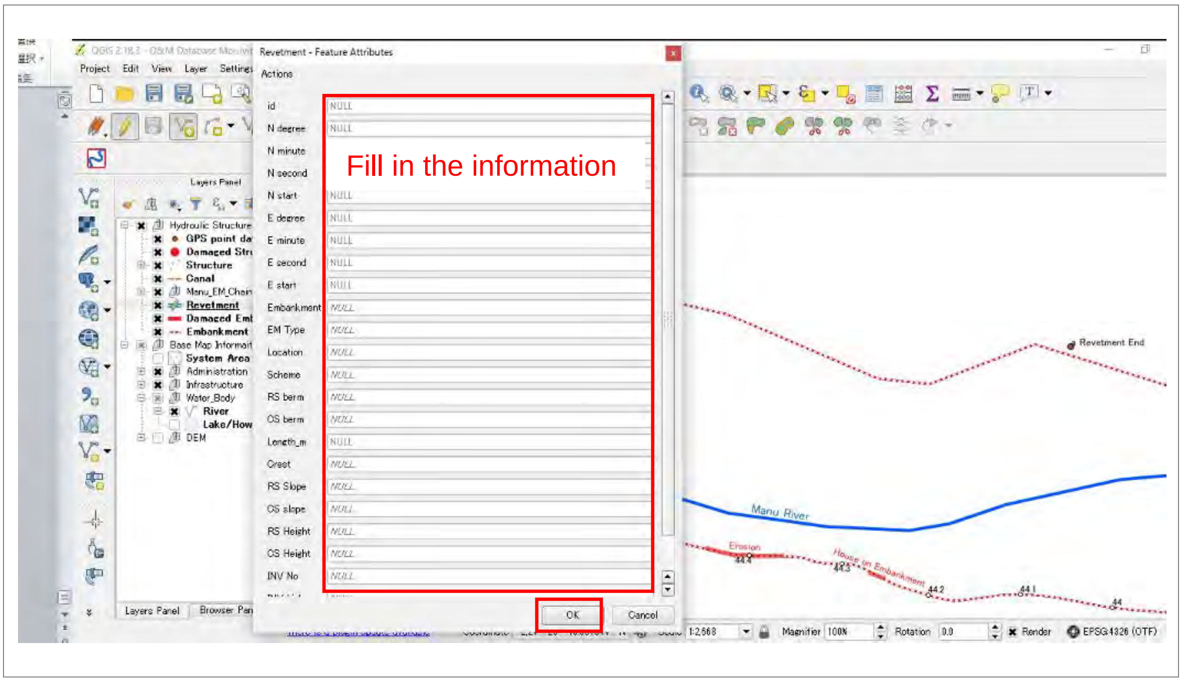
2-2. Start editing mode for Revetment layer



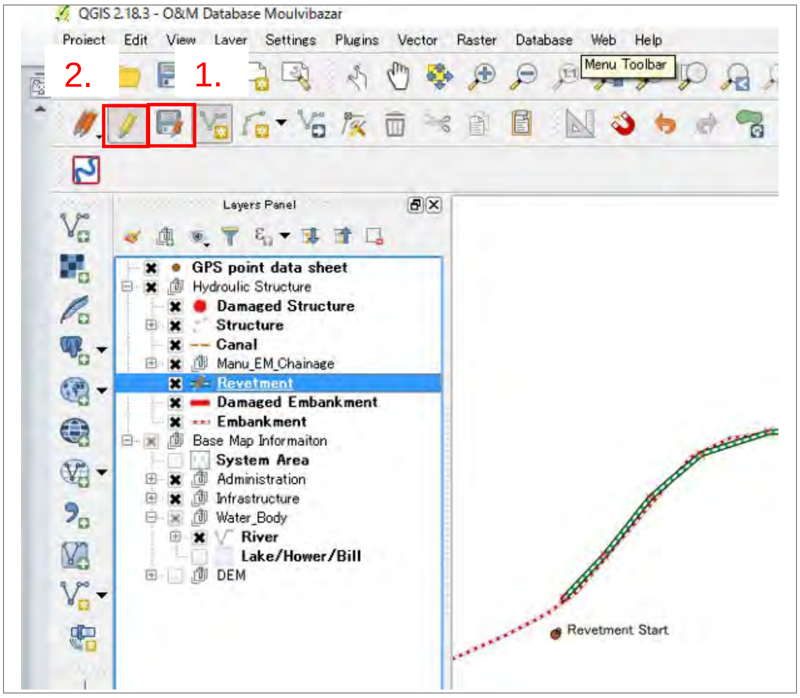
2-3.



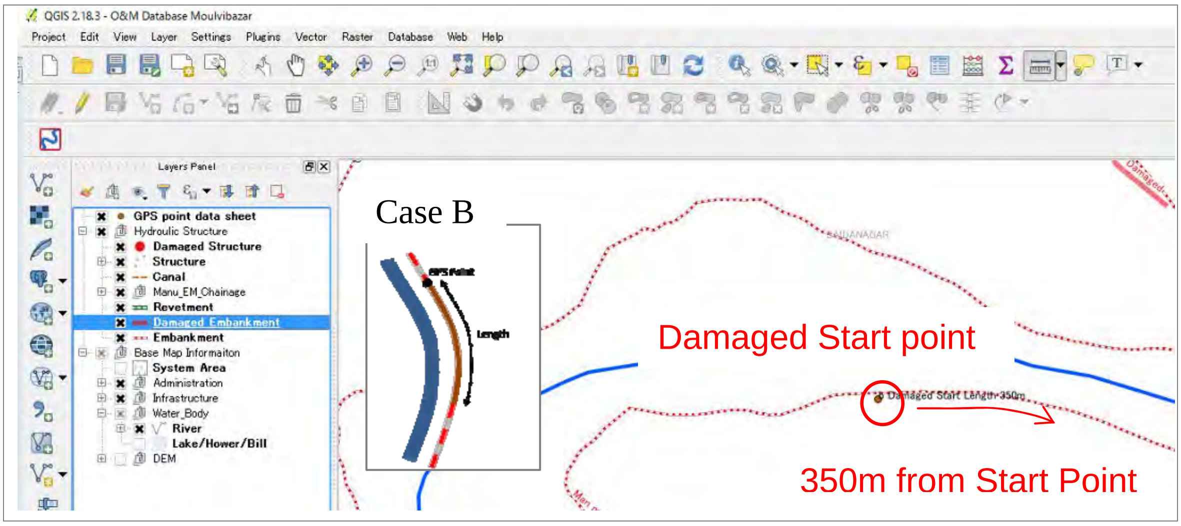
2-4.



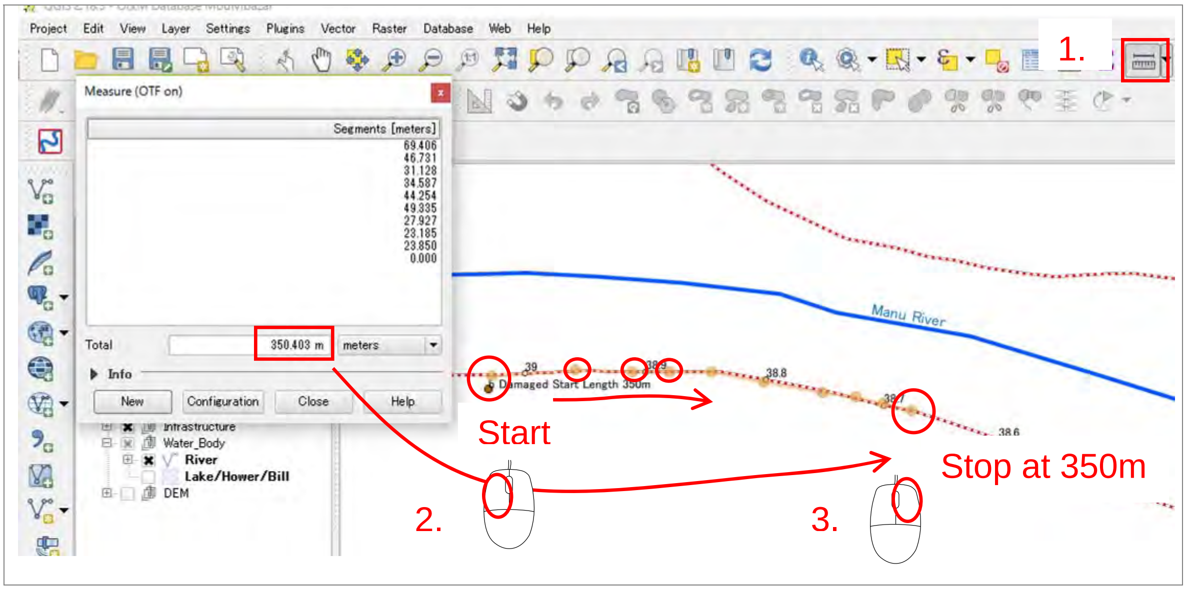
2-5. Finish the editing mode



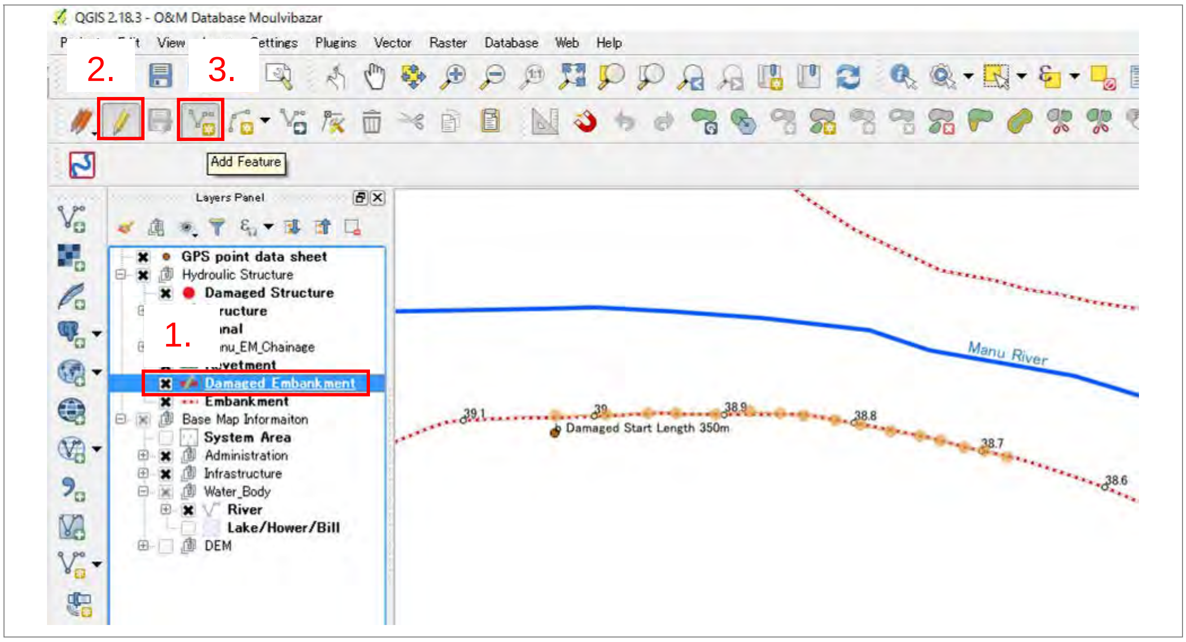
3-1. Add line for Damaged Embankment - Case B -



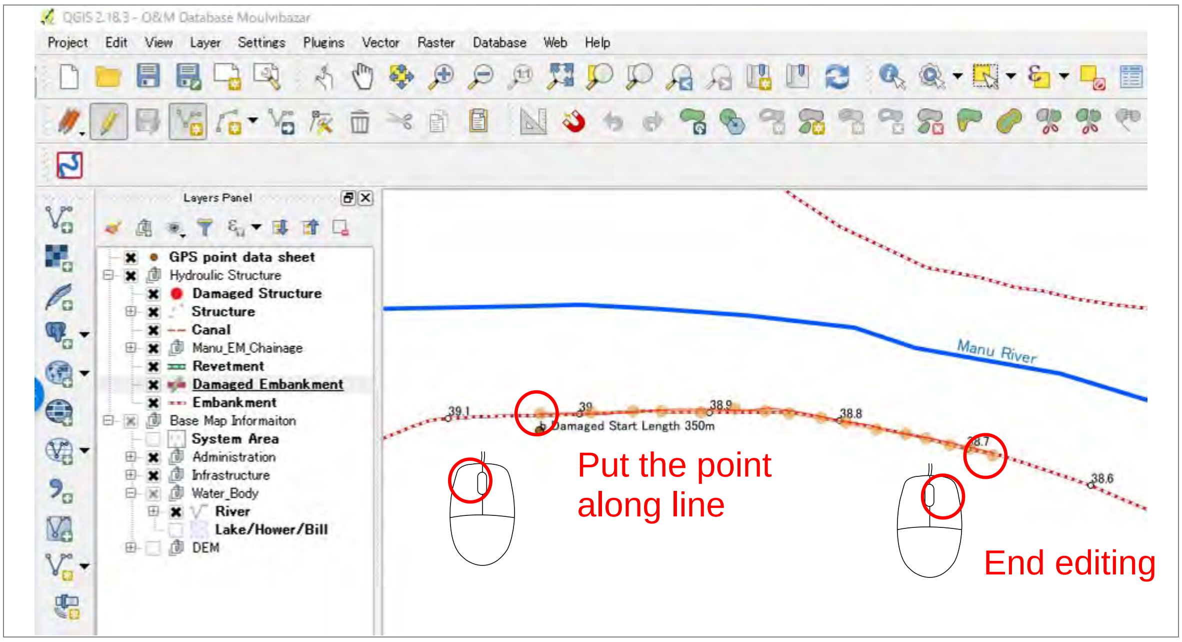
3-2. Measure the line length



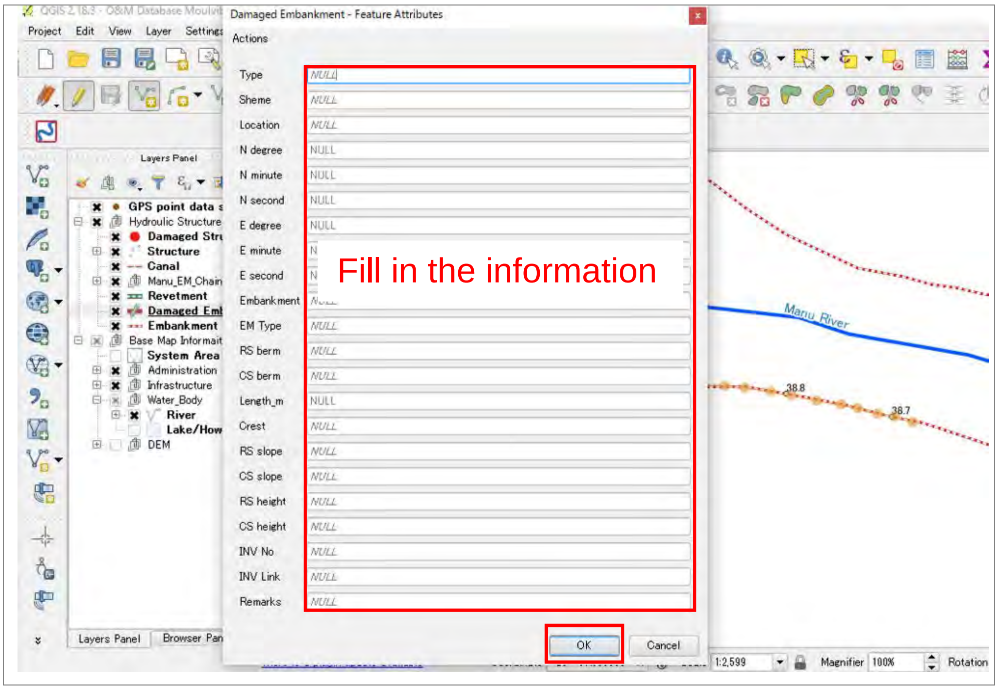
3-3. Start editing



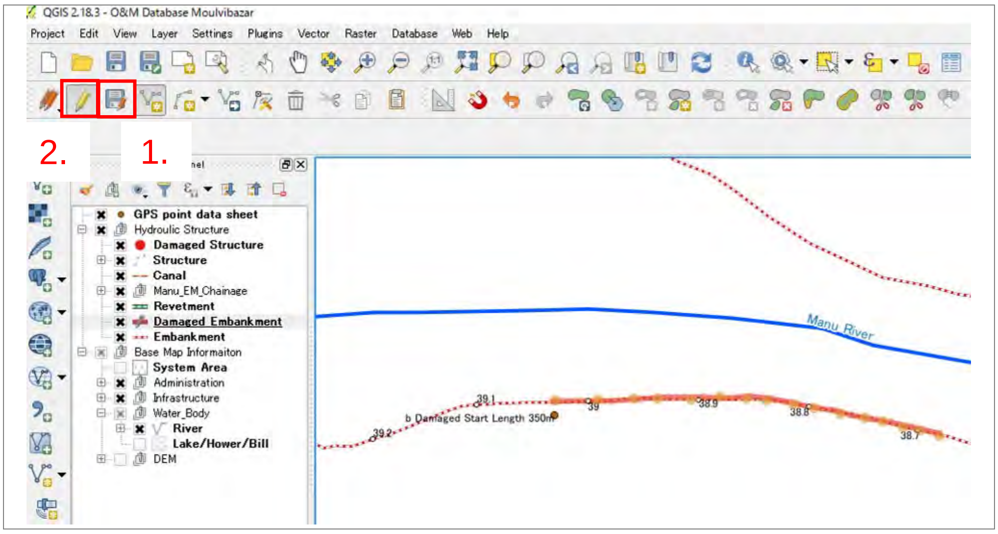
3-4.



3-5.

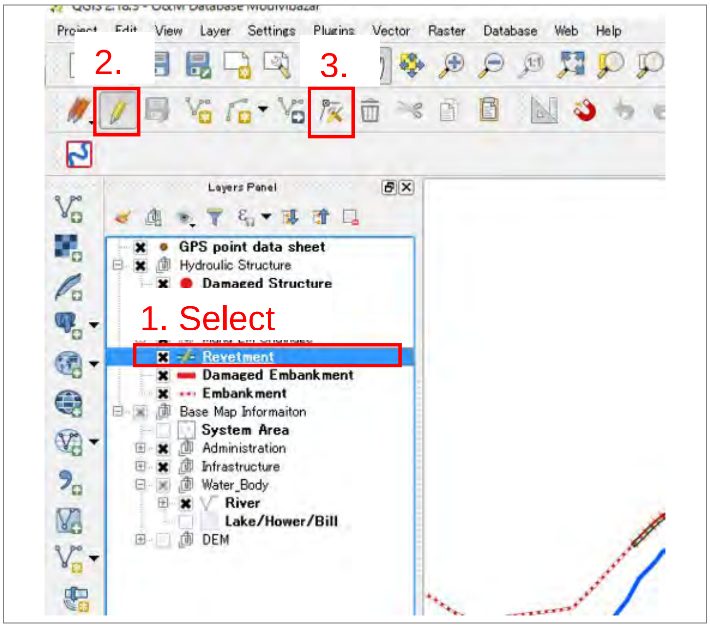


3-6. Finish editing

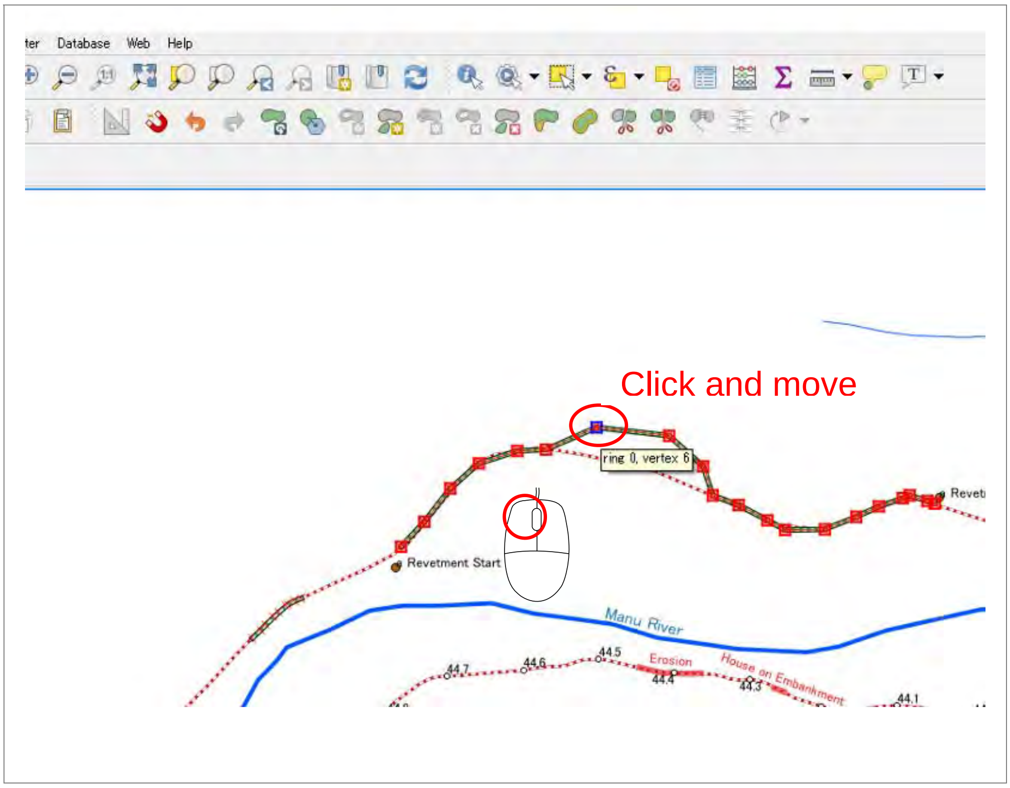


- Additional operation -

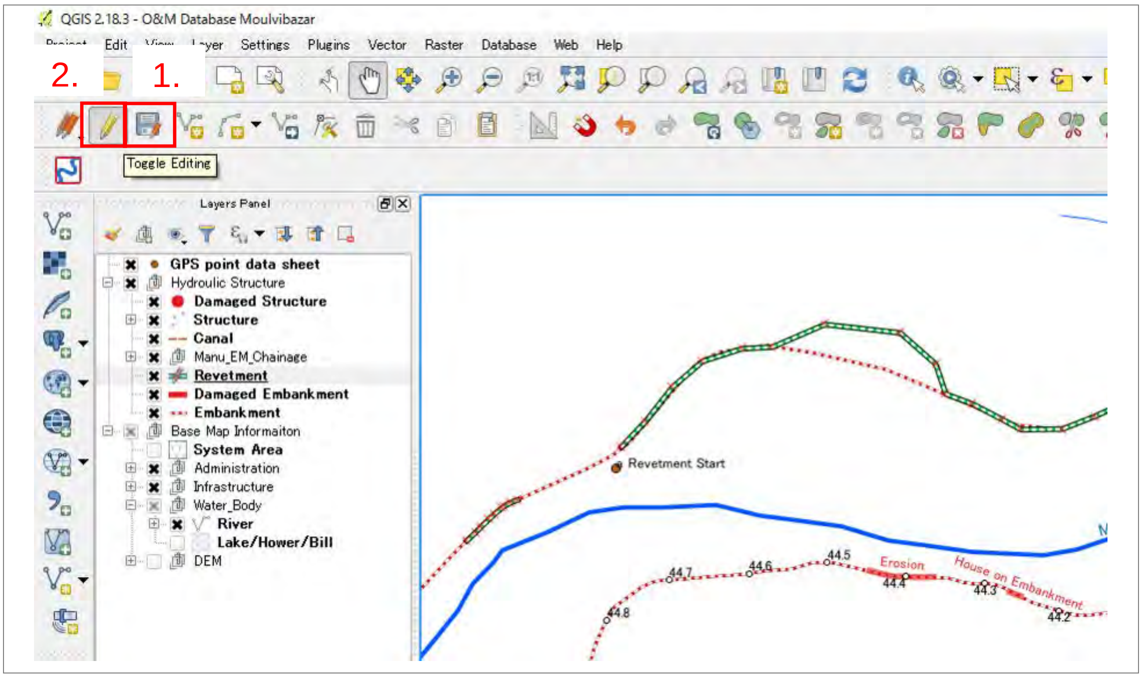
(4-1. Editing line)



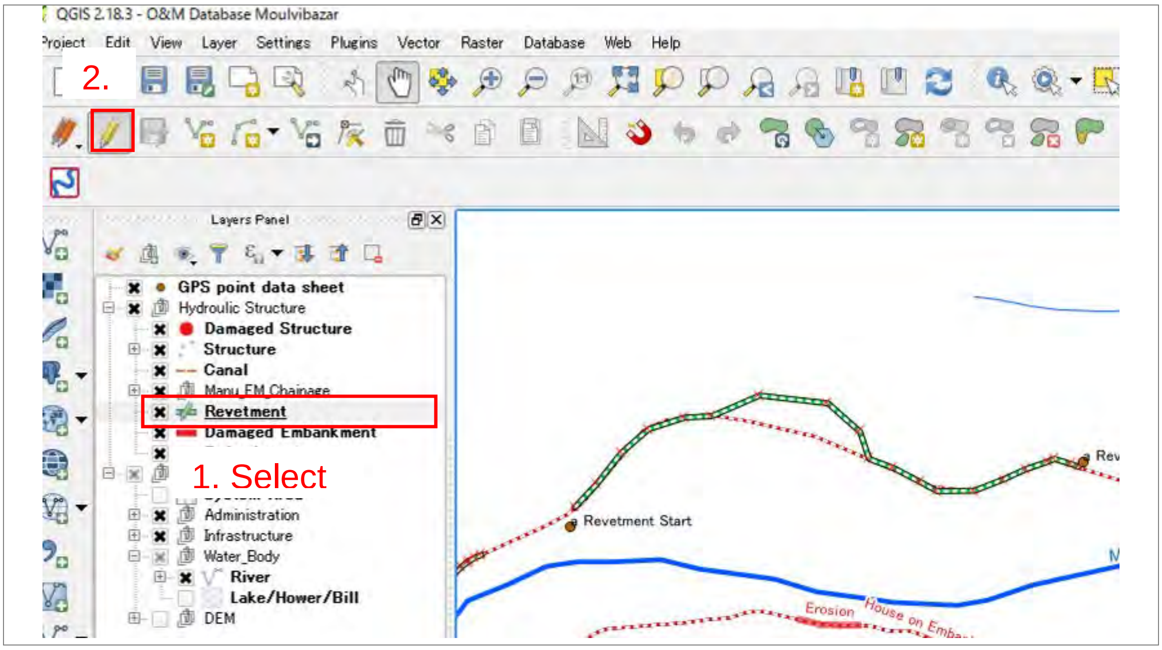
(4-2.)



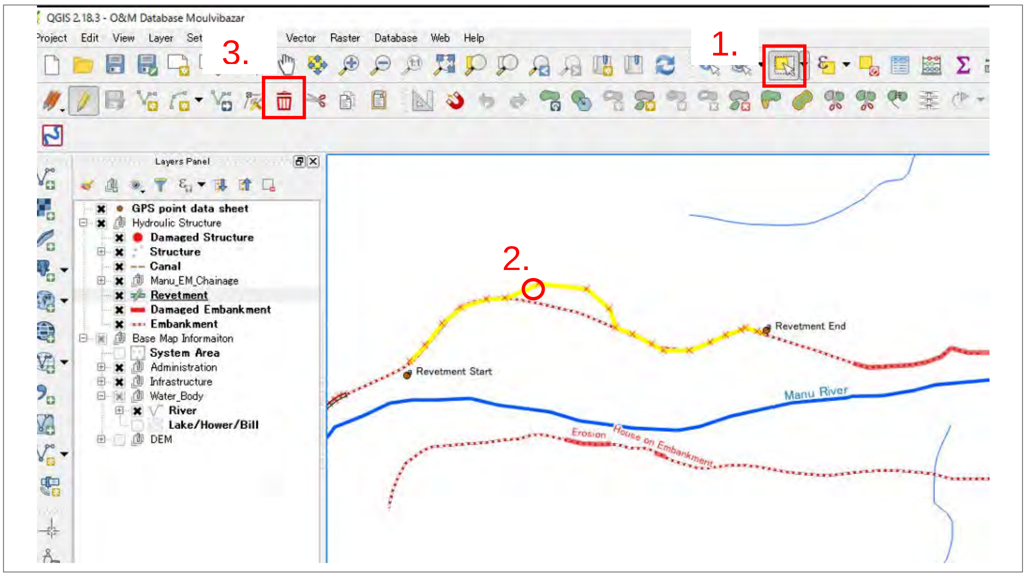
(4-3. Finish the editing)



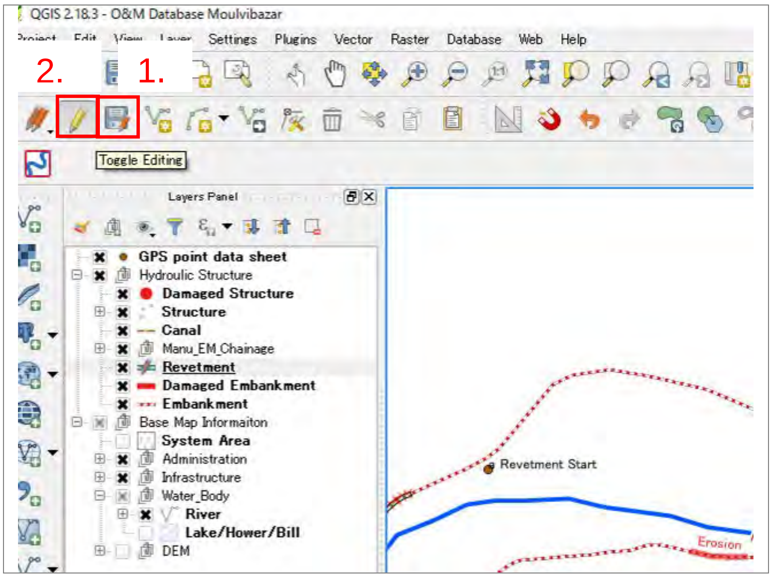
(5-1. Remove the line)



(5-2.)



(5-3. Finish editing)

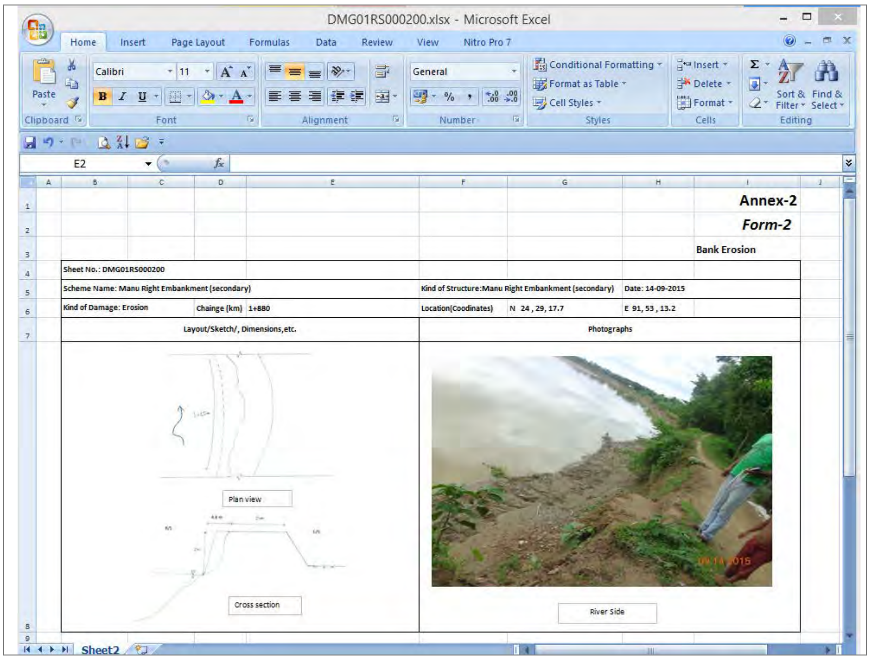


4.4 Set of Inventory sheet connection[●]

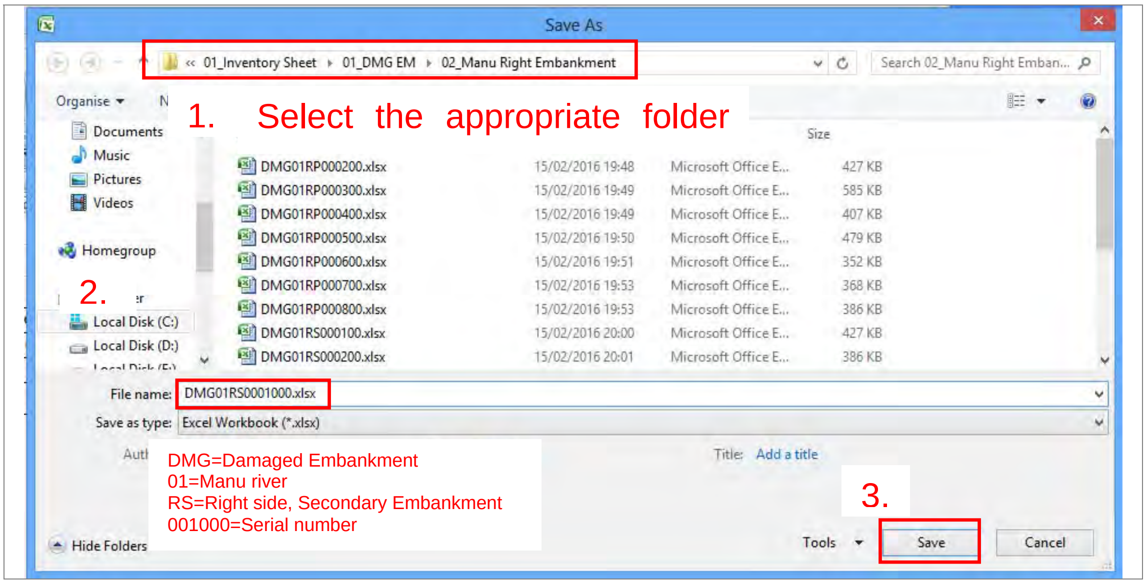
The structure point, Revetment line, Damaged Embankment line linked with Inventory sheet. The capture is introduced how to connect inventory sheet to targeted point or line.

1-1. Preparation of Inventory sheet by excel format.

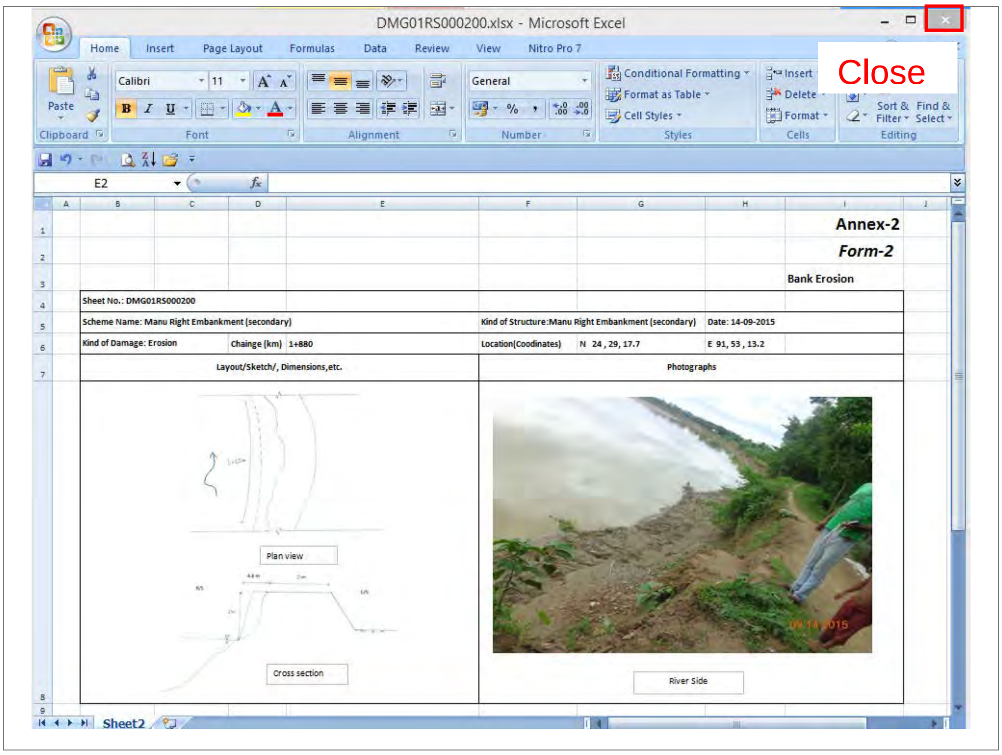
The inventory sheet is developed by field inspection. The sample of Damaged Embankment Inventory sheet is shown as follows,



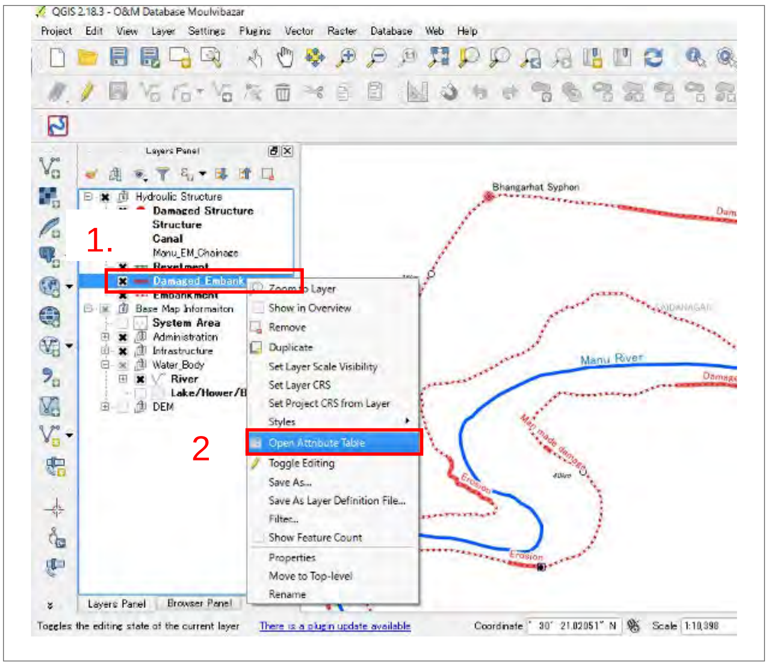
1-2. Save the Inventory sheet file



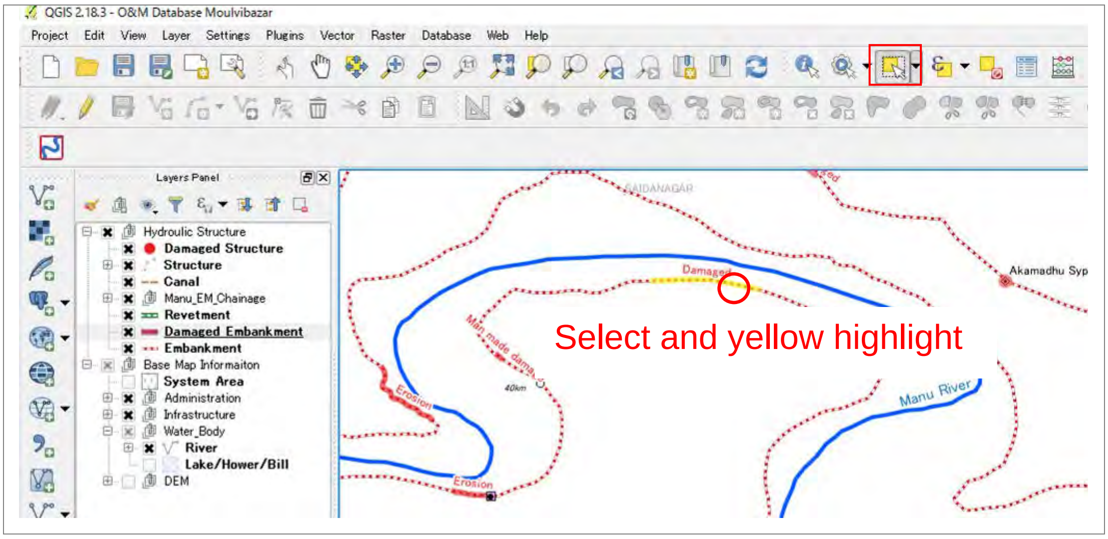
1-3. Close the Excel file



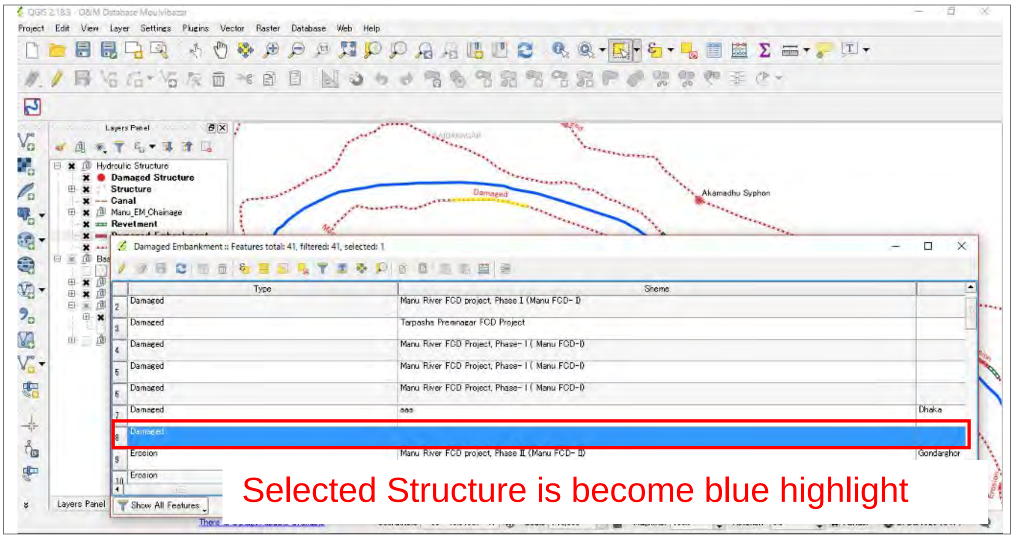
2-1.Open "Open Attribute table" in O&M GIS database



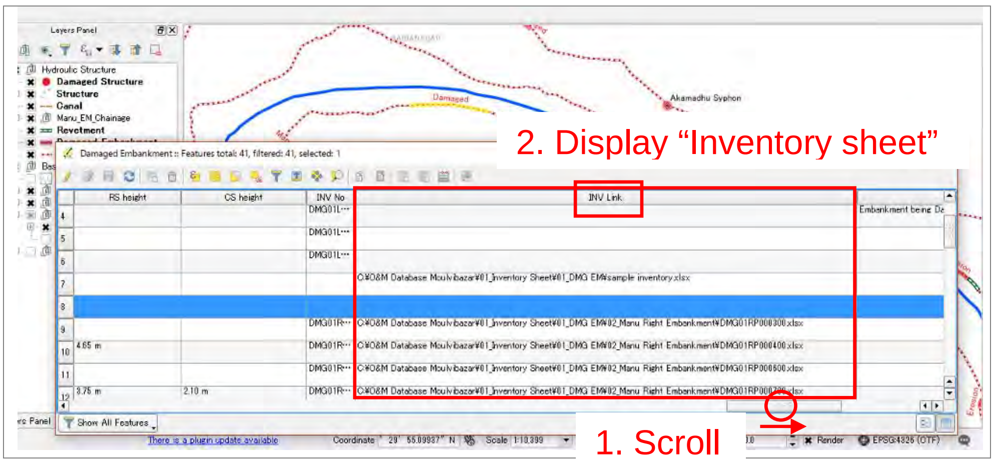
2-2.


QGIS 2.18.3 - O&M Database Moulvibazar
Select and yellow highlight

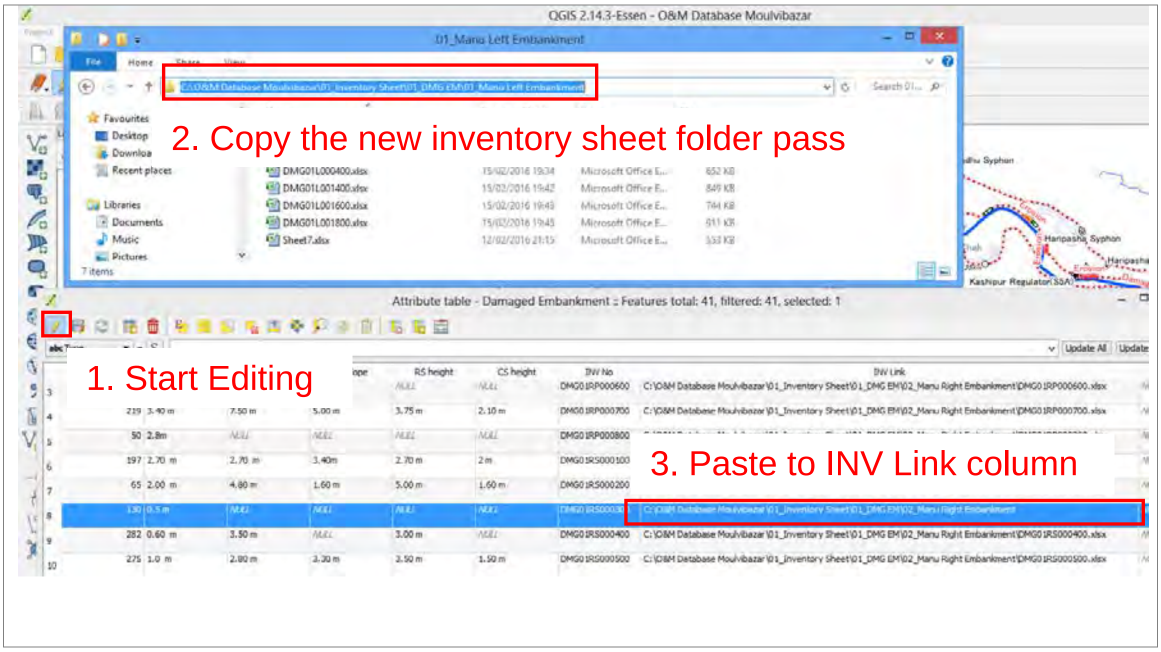
2-3.


Damaged Embankment :: Features total: 41, filtered: 41, selected: 1
Selected Structure is become blue highlight

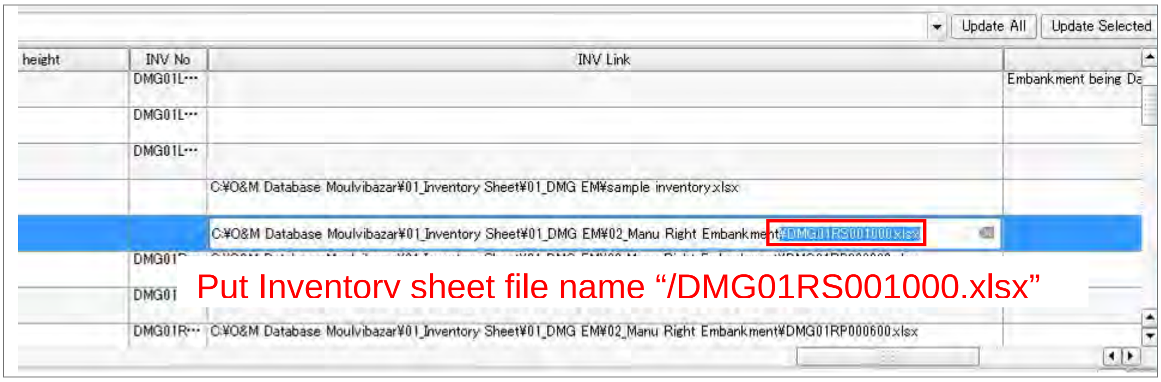
2-4.


2. Display "Inventory sheet"
INV Link
1. Scroll

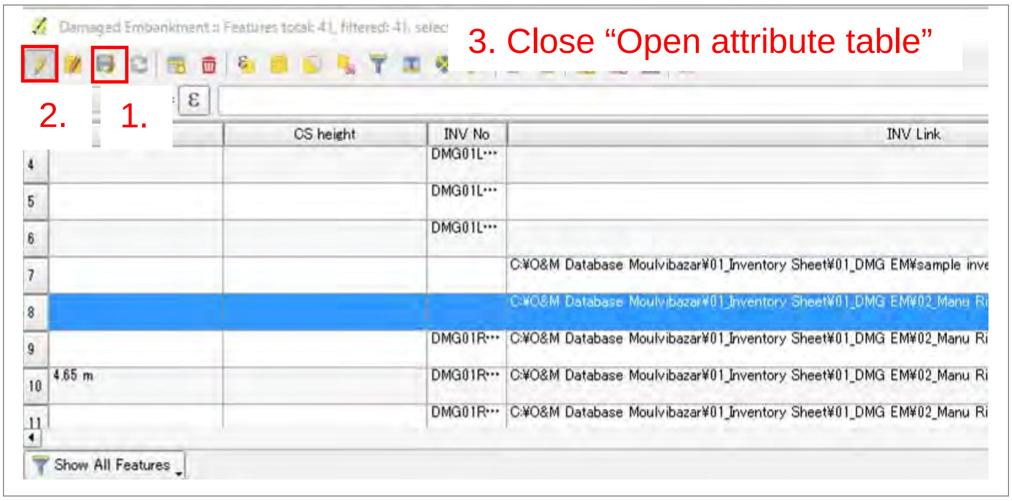
2-5.



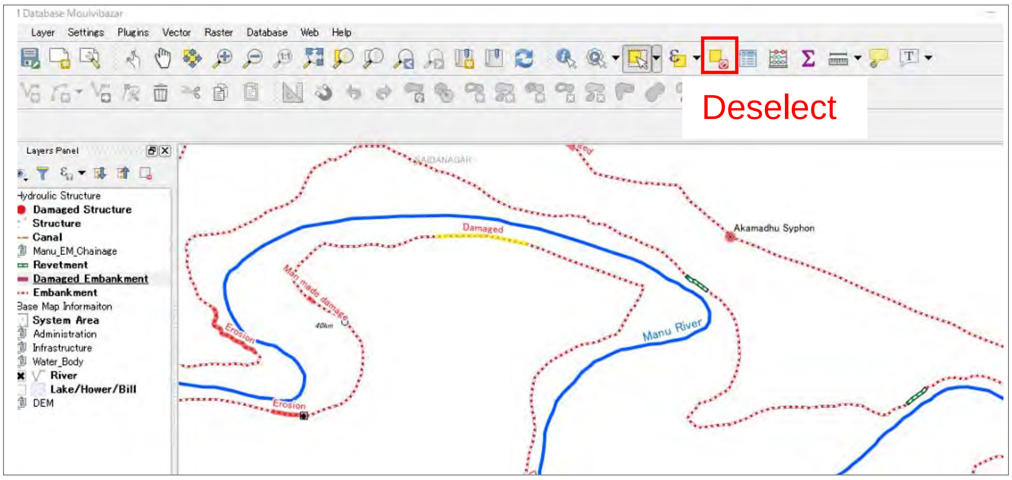
2-6.



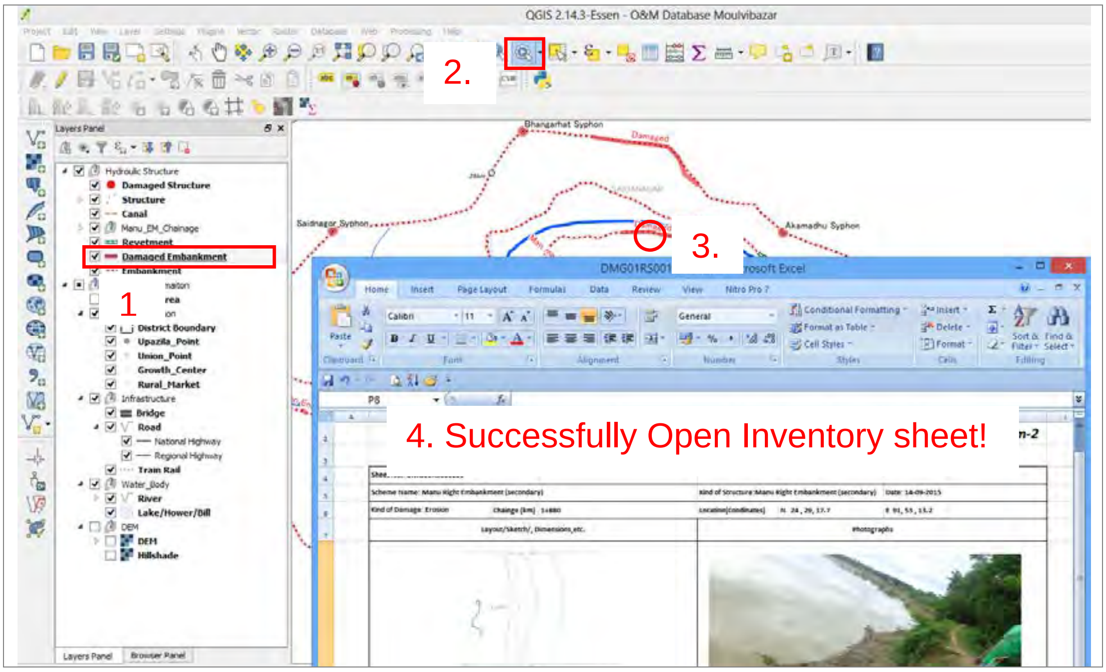
2-7. Save, finish editing mode and close "Open attribute table"



2-8. Save, finish editing mode and close "Open attribute table"



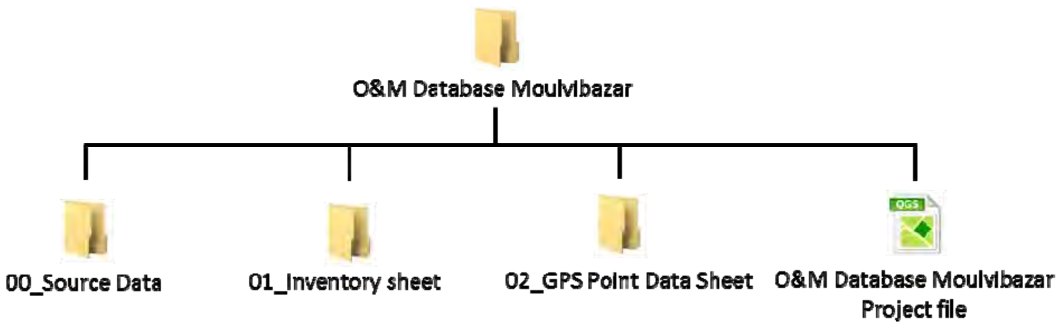
3-1. Confirmation to open Inventory sheet



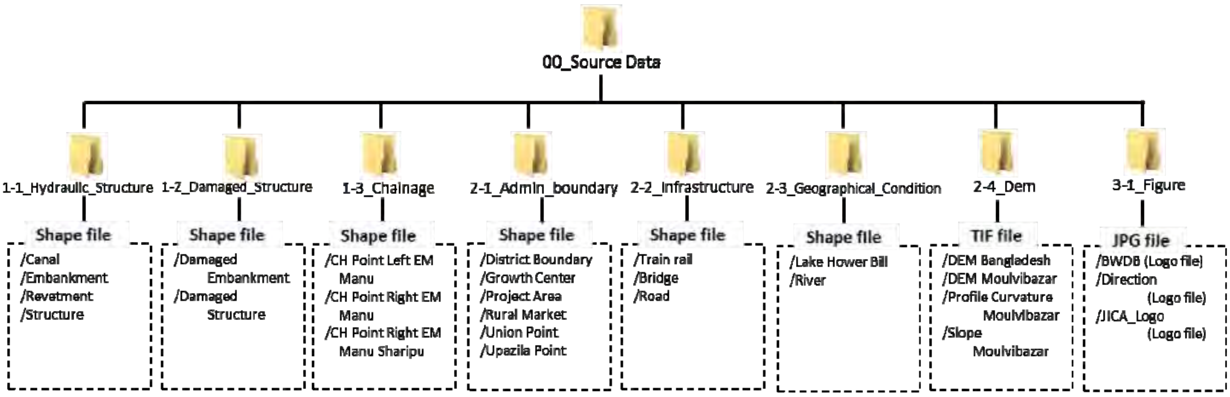
5 Data setting

5.1 Folder structure[●]

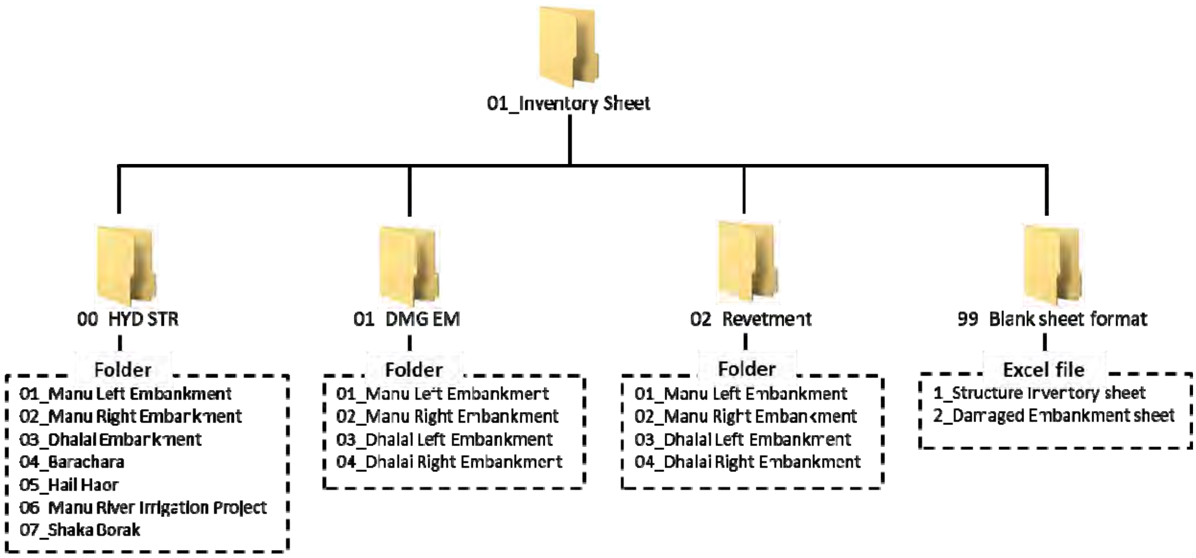
The stock folder for all data is “O&M Database Moulvibazar” directly under Local disk (C:). There are three folders and one project file to open QGIS software.



The “**00_Source Data**” folder stocks the main data regarding to GIS database file like GIS shape file. The folders under the “00_Source Data” folder are categorized by types of file. The 1-1 to 1-3 of beginning folder name are the stock folder of Hydraulic Structure in table of contents in GIS database. On the other hand, the 2-1 to 2-4 are base map information. The tree system is shown in below figure.



The "**01_Inventory Sheet**" folder is to stock the each inventory sheet of hydraulic structure and damaged embankment categorized by each folder. Moreover, each folder is breakdown to lower folder differentiated by embankment or project scheme. Each excel file is linked with Hydraulic structure point, polyline and Damaged polyline in the database. Blank sheet format for new inventory sheet is also prepared under "99_Blank sheet format".

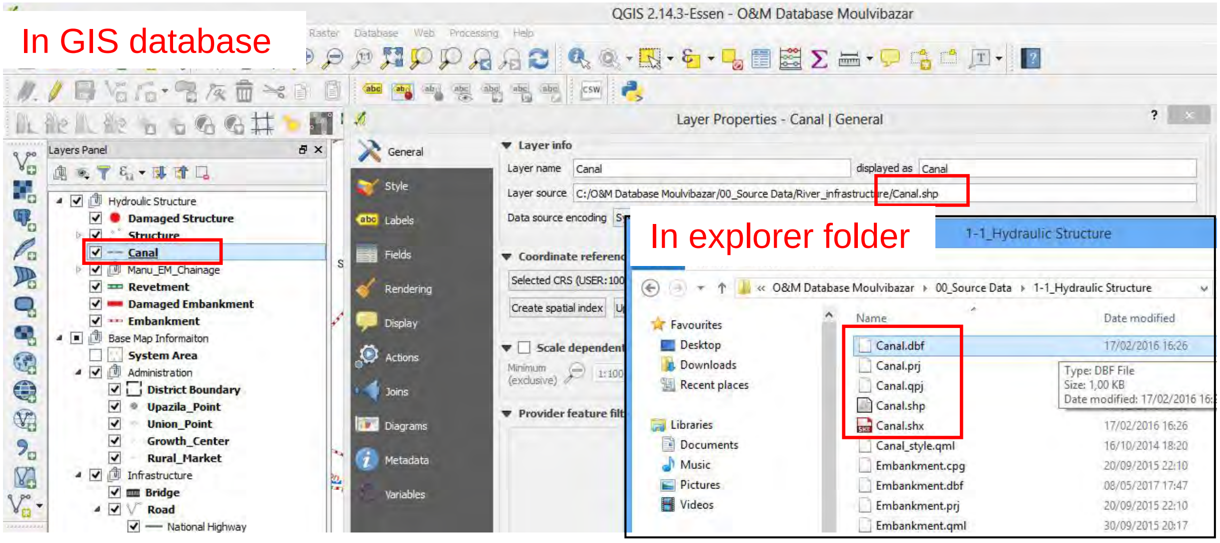


The "**02_GPS Point Data Sheet**" folder is to stock folder of GPS point data sheet.xlsx. The sheet is used to import the coordinate GPS point to the database as reference of new point and line data. The detail way to usage is shown in chapter 4.2, 4.3.

The "O&M Database Moulvibazar" is the project file to execute the database.

5.2 Structure of shapefile [●]

If the shapefile is shown in under the explorer folder, the shapefile consists of several files. On the other hand, the user deals with one shapefile in GIS database. The canal shapefile is shown in as sample case.



ANNEX 5

Action Plan for Dissemination and Effective Use of Manuals

BANGLADESH WATER DEVELOPMENT BOARD
THE PEOPLE'S REPUBLIC OF BANGLADESH

ACTION PLAN
FOR
DISSEMINATION AND EFFECTIVE USE OF MANUALS

JUNE 2017

PREPARED BY
THE PROJECT FOR CAPACITY DEVELOPMENT OF MANAGEMENT FOR SUSTAINABLE WATER RELATED INFRASTRUCTURE

Source: Home page of BWDB

ZONAL MAP OF BWDB

TABLE OF CONTENTS

LIST OF ATTACHMENTS

1. Introduction

1.1 Background of Project

Bangladesh is located in one of the largest deltas in the world with three mighty rivers, namely the Ganges, the Brahmaputra and the Meghna. These cause 112 billion m^3 surface water flow in wet season (July to September), 3.7 billion m^3 in dry season (January to March) and 1 to 1.5 billion tons of sediments carried annually. In addition to this geographical condition, hydrological and meteorological issues such as floods, flash floods, tides, intense and continuous rainfall, cyclones, etc. are responsible for the damage of embankment.

As a result, 22% of the country's area is affected by floods annually and 60% of the country experiences a massive flood in almost every 10 year. About 11,000 km of embankments provide flood protection and support livelihoods and communication development. Embankments are vital to protect the peoples and their assets from flood disasters. Around 15 to 20% of the total embankments are damaged annually which is equivalent to around BDT 2 billion.

The construction of earthen embankment in Bangladesh has been conducted in the less expensive form to protect properties from flood water in rainy season. However, the constructed earthen embankment failed every year in many places. Frequent repair and renovation are required and they need a huge amount of cost annually.

Concerning the above situation, the Government of the People's Republic of Bangladesh (hereinafter referred to as “GOB”) requested the Government of Japan (hereinafter referred to as “GOJ”) to provide the technical cooperation on the “Capacity Development on Management for Sustainable Water Related Infrastructure” in 2011.

In response to the request, the GOJ approved the implementation of a project in 2012 and JICA dispatched a detailed planning survey team to clarify the framework of the technical cooperation for the Project on the Capacity Development on Management for Sustainable Water Related Infrastructure (hereinafter referred to as “the Project”). JICA and the authorities concerned of the GOB concluded the Minutes of Meeting (hereinafter referred to as “M/M”) in October 2012 and the Record of Discussions (hereinafter referred to as “R/D” in March 2013 on the Project. The Project has started in August 2013 and will complete in September 2017.

1.2 Objective of the Project

Expected goals which will be attained after the project completion and outputs of the Project are summarized below:

<u>Expected goals which will be attained after the project completion</u>
<u>Overall Goal:</u>
To achieve water-related disaster risk reduction through proper management of the infrastructures
<u>Goal of the Project:</u>
To improve the capacities of BWDB on embankment engineering in terms of design, construction and operation & maintenance methods

<u>Outputs of the Project</u>
(1) Design for sustainable river embankment is introduced.
(2) Construction method and procedure of river embankment is improved.
(3) Operation and maintenance (hereinafter referred to as “O&M”) system for the river infrastructures is ensured.

1.3 Necessity of Action Plan

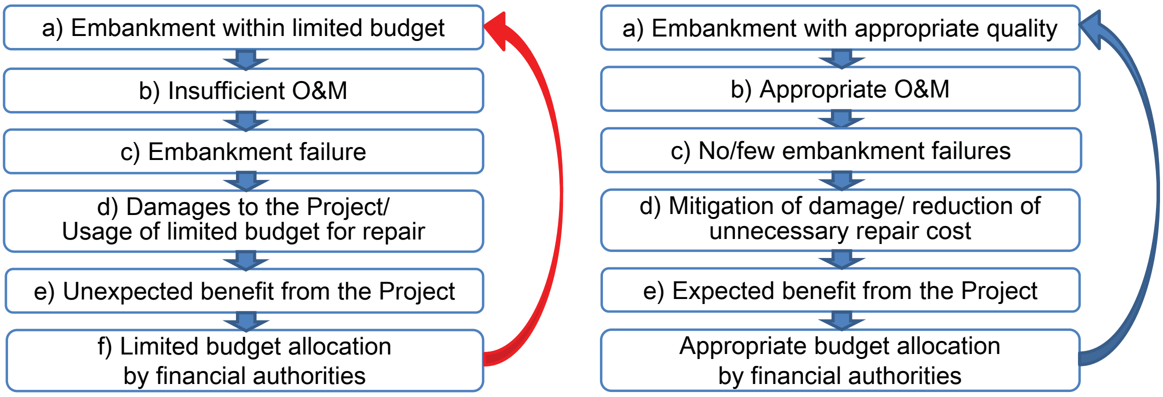
As stated in b) of (2) in Article 5 of "The Bangladesh Water Development Board Act, 2000", BWDB develop standards and guidelines for the operation and maintenance of all water management structures pursuant to Article 6 (Functions of the Board). Through the project activities including implementation of the pilot project and trial run of model O&M activities, the manuals for embankment design, embankment construction, and O&M of hydraulic structures, which include the English versions and the Bengali versions, have been prepared as the outputs of the Project. However, successful activities are not the goal of the Project. In order to attain and sustain the expected goals mentioned in the preceding section, it is indispensable for BWDB to disseminate the manuals, to use the manuals effectively, and to update the manuals timely and continuously.

This action plan for dissemination and effective use of manuals (hereinafter referred to as "the Action Plan") has been prepared based on the series of discussions among the officials of BWDB. The Action Plan represents concrete efforts of respective organizations of BWDB to disseminate the manuals, to use the manuals effectively, and to update the manuals timely and continuously, after the completion of the Project.

3. Basic Strategies for Preparation of Action Plan

3.1 Major Issues on Preparation of Action Plan

At present, it is said BWDB has inadequate budget and staff for mitigation of recurring flood damages, except the projects assisted by the development partners. Consequently, the negative spiral of management of embankment is taking place, as shown in Figure 1. That is, a spiral of a) providing the embankment within a limited budget and inappropriate quality, → b) insufficient O&M for keeping the function of embankment, → c) recurrent embankment failures, → d) recurrent damages in the project area and usage of the limited budget for repairs, → e) unexpected and underperforming benefit from the projects, → f) less budget allocation to the embankment management activities by the financial authorities, and return to a).



Present (negative spiral) Desirable Future

Figure 3.1 Present and Desirable Future of Embankment Management

Accordingly it is considered necessary to change the spiral to the flow of a) providing the embankment of appropriate quality even with high cost, → b) appropriate O&M for keeping the functions of the river embankment, → c) no or few damage to embankment and the project area, → d) mitigation of flood damage and reduction of unnecessary repair cost, → e) expected benefit from the project, → f) appropriate budget allocation by the financial authorities, and return to a).
That is to say the present spiral should be changed to "reduction of total cost/life cycle cost of water-related infrastructure".

In order to remedy the negative spiral on embankment management, many efforts have been conducted by BWDB, such as implementation of the rehabilitation projects, enhancement of public participation in O&M, recruitment of officials, etc.
In this context, the manuals for embankment design, embankment construction, and O&M of hydraulic structures have been prepared through the project activities, in order to facilitate enhancing the capacities of BWDB on embankment engineering. However, preparation and authorization of the manuals will not achieve the capacity enhancement of BWDB without dissemination and effective use of the manuals.

Major issues/restrictions on the embankment management activities in BWDB are summarized as follows:

(1) Inadequate Number of Technical Staff
Organization reform of BWDB had progressed since 1990s. At present, the number of the staff of BWDB has become less than approved setup by the government. Especially, it is serious in the field offices. This is one of the causes leading to capacity reduction in the field level and the embankment

management becomes difficult. In order to deal with this situation, recruitment of the new staffs has been conducted. However, it took so long to recruit the staff up to the set up and to train the new staff skills with their capacities as same as those of the senior engineers. Therefore it is difficult to apply the manuals to all activities at the same time. Accordingly, it is required to apply the manuals to the actual activities, such as construction and O&M of the jurisdictional structures, enhancing the trial practices **in a stepwise manner** and with the present staffs.

(2) Insufficient Budget
At present, insufficient budget for the construction works and O&M works is the most serious problem in the field level. Therefore, the appropriate protection works cannot be planned during the design stage, and actual allocation of the O&M budget is less than 20 % of the demand. In addition, almost of the O&M cost is consumed for the emergency works to deal with recurrence flood damages. In consideration of this situation, it is required for BWDB to make the management plan based on the basic data, in order to use the budget efficiently and also to secure sufficient budget. Therefore, it is required to arrange basic data of the managed structures in the jurisdictional areas of respective field offices, such as inventory and damage and repair records, **in a stepwise manner** and **within reasonable scope with current resources**, and to prepare the management plan.

(3) Users of Respective Manuals
In consideration of distribution of the tasks and responsibilities in BWDB, primary users of respective manuals in BWDB are as follows:

- Design Manual: Technical staffs of the Design Directorate who are in charge of design of the structures.
- Construction Manual: Technical staffs in the field offices including the Circle offices and the Zone offices (the offices in field), who are in charge of supervision of the construction works.
- O&M Manual: Technical staffs of the offices in field, who are in charge of O&M of the structures in their jurisdictional area.

The technical staffs of the Design Directorate are in charge of design of all structures of BWDB, including embankment. Therefore, the technical staffs of the Design Directorate are required to understand the design of embankment as the primary users of the Design Manual. However, they are required to design the embankment in consideration of construction and O&M of embankment. Therefore, they are required to understand also construction and O&M method of the embankment as the secondary users of the construction and O&M manuals, in order to enhance the capacities of the embankment design.
The technical staffs of the offices in the field are in charge of construction and O&M of the structures including embankment in the field, and they are required to understand the construction and O&M method of embankment. Construction and O&M of embankment are implemented based on the design of embankment. Therefore, in order to enhance the capacities of the construction and O&M of embankment, the technical staffs of the offices in the field are required also to understand the design method of embankment.

As the results, the target officials of dissemination and effective use of the manuals are as follows:

Table 3.1 Target Officials of BWDB on Dissemination and Effective Use of Manuals

Manual	Target Officials
Design Manual	Main: Technical staffs of the Design Directorate Sub: Technical Staffs of the offices in field and the head offices excluding the Design Directorate.

Manual	Target Officials
Construction Manual	Main: Technical Staffs of the offices in field Sub: Technical staff in the head office including Design Directorate
O&M Manual	Main: Technical Staffs of the offices in field Sub: Technical staff in the head office including Design Directorate

In order to facilitate understanding of respective manuals by technical staffs of BWDB with different knowledge and experience, it is required to conduct the following activities:

- To hold the official seminars of respective manuals for technical staffs,
- To conduct the trial run on application of respective manuals in the representative projects/areas in a stepwise manner and within the current resources,
- To share the pros and cons on application of respective manuals, and
- To update respective manuals including additional explanation to the respective manuals based on the trial runs.

Out of the officials of BWDB, there are potential users of respective manuals, such as, technical staffs of other authorities, engineers of consulting firms, engineers of construction companies, senior members of WMOs, etc. The technical staffs of other authorities are in charge of embankment management with the beneficiary areas less than 1,000 ha. The engineers of the consulting firms design and supervise the embankment works under the BWDB or the other authorities. The engineers of the construction companies manage the construction works under supervision of the BWDB or other authorities. The senior members of WMOs are in charge of O&M of the small structures in their beneficially areas. In order to achieve water-related disaster risk reduction, which is the Overall Goal of the Project, it is also required that the manuals are disseminated to such potential users and applied to the works by such potential users. Dissemination of the manuals to the potential users will be made through the trial application of the manuals by BWDB.

3.2 Basic Strategies of Action Plan

In consideration of the above issues, the action plan for dissemination and effective use of the manuals is prepared through the discussions in BWDB. The following basic strategies are applied to preparation of the action plan.

- The Action Plan should be prepared as a road map to realize and sustain the desirable cycle of the embankment management and the overall goal of the Project.
- The Action Plan should be prepared within the existing resources and organization structure of BWDB.
- The manuals should be disseminated to the staffs of BWDB and public through the circulars of BWDB, training courses, on-line, etc.
- The manuals should be applied to the actual works step by step through the trial runs.
- The trial run of application of the manuals should be expanded step by step from those in the representative projects, works or areas, within reasonable scope with current resources.
- The trial run should be reviewed yearly and the supplementary explanation of the manuals should be compiles, in order to use those effectively.
- The Action Plan should be reviewed yearly and revised as appropriate.
- The manuals should be updated periodically, for example once five (5) years or once ten (10) years, based on the accumulated supplementary explanation and information.

4. Action Plan

4.1 Road Map of Action Plan

In accordance with the above basic strategies, outline of the Action Plan is drafted as shown Table 4.1, below:

Table 4.1 Outlines of Action Plan

Item	Design Manual	Construction Manual	O&M Manual
Planning Period	10 years	10 years	10 years
Office in Charge	Chief Engineer, Design, in association with Chief Planning, Chief Engineer, Hydrology, Chief Training and Staff Development, and Zonal Chief Engineers.	Chief Monitoring in association with Chief Planning, Chief Engineer, Design, Chief Engineer, Hydrology, Chief Training and Staff Development, and Zonal Chief Engineers.	Chief Engineer, Design, in association with Chief Monitoring, Chief Engineer, O&M, Chief Engineer, Hydrology, Chief Training and Staff Development, and Zonal Chief Engineers.
Target Officials	・Main: Technical staff in Design Directorate ・Sub: All tech staffs excluding staff of Design Directorate	・Main: Technical staff in field ・Sub: Technical staff in the head office including Design Directorate	・Main: Technical staff in field ・Sub: Technical staff in the head office including Design Directorate
Dissemination	・Dissemination through the circulars of BWDB, training courses, on-line, etc. ・Training of manuals should be included as a part of the existing official training courses of BWDB.		
Application of Manuals	・Trial runs on application of manuals in all of the design works of BWDB, except the works with the development partners. ・During the trial run period, respective trial run results should be reviewed by respective officials. ・Duration of trial run period shall be 3 years at least. ・Duration of trial run period shall be determined based on feedback from previous trial runs. ・Surveys of representative cased of the new embankment failures should be conducted annually and the manual should be verified through those surveys.	・Stepwise trial run on application of manuals in the representative projects, without special fund and exclusive staffs ・During the trial run period, each O&M offices shall have at least a trial run. ・During the trial run period, respective trial run results should be reviewed by respective officials. ・During the trial run period, trial run results should be reviewed by respective design engineers. ・In case of a project/O&M Circle/year, trial run period become 3 years. ・Duration of trial run period shall be determined based on feedback from previous trial runs.	・Stepwise trial run in a certain area, without special fund and exclusive staffs. Trial run will be as follows: (1) inventory surveys of managed structures in a certain area, (2) preparation of GIS database if the resources allows, (3) long-term and medium-term O&M planning, (4) trial run of O&M, and return to (1). Cycle up to whole jurisdictional area of each office. ・In case of 20 % of the jurisdictional area yearly, duration of trial run period will be 5 years. ・Trial run should be expand to all of the jurisdictional area. ・During the trial run period, respective trial run results should be reviewed by respective officials.
Effective use of Manual	・During the trial run period, pros and cons of trial runs should be compiled and shared among relevant staff of BWDB as the supplemental explanation and information of the manuals, through the BWDB circular, regular training courses, and on-line.		
Update of Action Plan	・As appropriate based on the yearly review results of trial runs.		
Update of Manual	・Manual update based on the supplemental explanation and information, finding through the surveys of embankment failures (every 5 years or 10 years, depend on the accumulation of information and findings.)	・Manual and technical specification update based on the accumulated explanation and information and new construction methods (once 10 years)	・Manual update based on the accumulated explanation and information (once 10 years)

As shown in above Table 4.1, the Action Plan consists of five (5) components, that is,

(1) Plan for Design Manual of Embankment
(2) Plan for Construction Manual of Embankment
(3) Plan for O&M Manual of Hydraulic Structures
(4) Plan for updating manuals (embankment failure survey) and
(5) Plan for training on manuals.

In accordance with the above outlines of the Action Plan, a road map for realization of desirable cycle of embankment management is made as shown in Figure 4.1. In addition, implementation schedule of respective activities of the Action Plan is proposed as shown in Table 4.2.

The Action Plan which includes concrete efforts of respective organization of BWDB are presented hereunder.

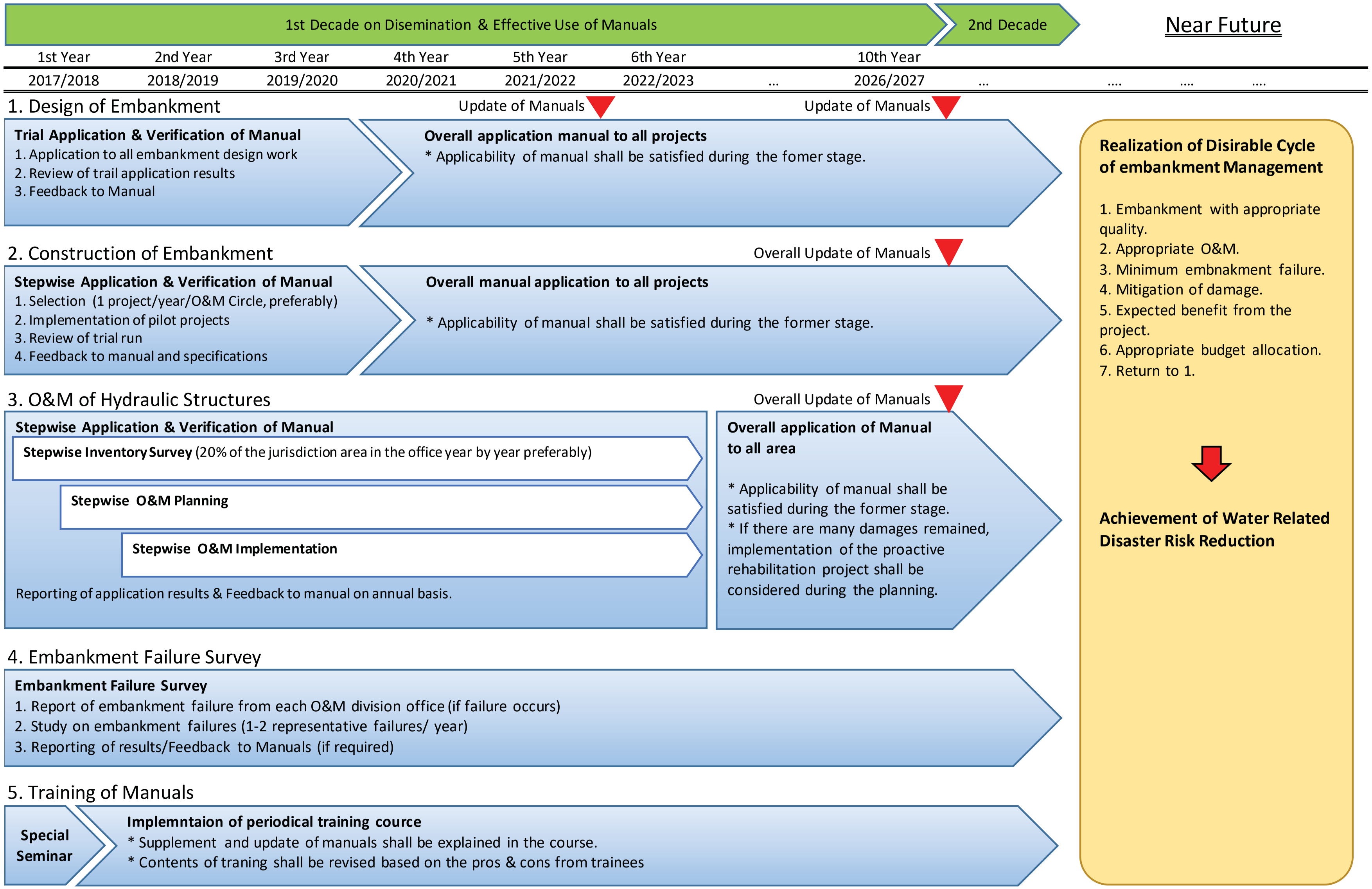


Figure 4.1 Road Map for Realization of Dissemination and Effective Use of Manuals

Table 4.2 Implementation Schedule of Action Plan

Engineering Aspect/Activities	Fiscal Year								Desirable Future
	2017/2018	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023	:::	2026/2027	
	1st	2nd	3rd	4th	5th	6th	:::	10th	
1. Embankment Design									
(1) Trial application and verification of manual: 3 fiscal years									No damage due to design.
1) Application to all embankment design works									Appropriate budget of the works.
2) Review of trial application									New research can be conducted.
3) Feedback to manual (supplementary explanation and information)									
(2) Overall application of manual to all projects									
(3) Overall revision of manual									
2. Embankment Construction									
(1) Step-wise application and verification of manual (3 fiscal years)									No damage due to construction.
1) Selection of Pilot Project (1 pilot project/year/O&M circle preferably)									Appropriate budget of construction.
2) Implementation of pilot projects									
3) Review of trial run									
4) Feedback to manual/specifications (supplemental explanation and information of manual/ specifications)									
(2) Overall application of manual to all projects									
(3) Overall revision of manual									
3. O&M of Hydraulic Structures									
(1) Step-wise application and verification of manual (6 years)									No damage due to O&M. Decrease
1) Selection of pilot area (20% of the area of each O&M div. office, preferably)									of emergency works. Demand-base
2) Inventory survey and compilation of inventory sheets									budget of O&M, including those of
3) Step-wise planning (5 years)									offices, tools and equipment.
4) Step-wise implementation (5 years)									
5) Review of trial run (annual basis)									
6) Feedback to manual (supplementary explanation and information)									
(2) Overall application of manual to O&M									
(3) Overall revision of manual									
4. Embankment Failure Survey (Every fiscal year)									
(1) Embankment failure/damage report (O&M division office: if occur)									
(2) Study on cause of embankment failure (1-2 failures/year)									
(3) Feedback to manual (supplementary explanation and information)									
5. Training of Manuals									
(1) Special seminar/workshop (by the Project)	▲								
(2) Trainings in BWDB's regular training courses									No information gap among the head
									office and field offices.

4.2 Implementation Structure of Action Plan

The Action Plan should be conducted by the following organization structure, in accordance with the office regulation in BWDB.

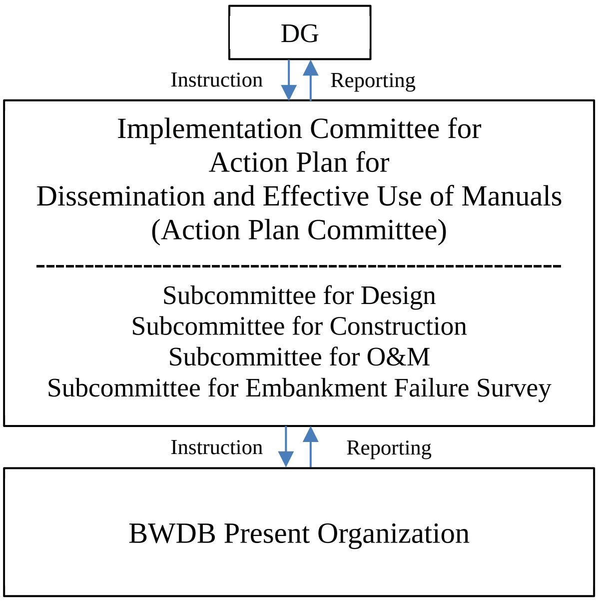


Figure: 4.2 Organization Structure for Implementation of Action Plan

Tasks and responsibilities of respective officials/offices in BWDB are as follows:

(1) Director General (DG)

- To appoint the members of the "Implementation Committee for Action Plan for Dissemination and Effective Use of Manuals (hereinafter referred to as "Action Plan Committee"), and members of subcommittees for design, construction, OM and embankment failure survey.
- To instruct coordination and monitoring the activities of the Action Plan to the Action Plan Committee.
- To receive and review the annual report of the Action Plan from the Action Plan Committee.
- To issue the circulars related to the manuals proposed by the Action Plan Committee.
- To arrange for updating the Action Plan based on the recommendation from the Action Plan Committee.

(2) Action Plan Committee

The Action Plan Committee is established by DG of BWDB in order to coordinate and monitor the activities of the Action Plan, report and recommend to the DG, as follows:.

- To coordinate and monitor all of activities of the Action Plan through the subcommittees
- To receive and review the annual reports and circulars from the subcommittees.
- To compile the annual report of the Action plan, including the circulars related to the manuals and recommendation of revision of the Action Plan.
- To submit the annual report of the Action Plan

The implementation Committee shall include the following officials:

Table:4.3 Proposed Member of Implementation Committee for Action Plan

No.	Name	Job Position	Remarks
1.	ADG Planning	Chair Person	He will guide and coordinate the members' activities.
2.	ADG West	Member	
3.	ADG East	Member	
4.	ADG Administration	Member	
5	ADG Finance	Member	
6.	Chief Planning	Secretary	
7.	Chief Engineer, Design	Member	in charge of design aspect
8.	Chief Engineer, O&M	Member	in charge of monitoring aspect of O&M
9.	Chief Engineer, Hydrology	Member	
10.	Chief Monitoring	Member	
11.	Chief Training and Staff Development	Member	in charge of training aspect
12-20.	Chief Engineers, Respective Zones (9 Zones)	Member	in charge of construction and O&M aspects

(3) Subcommittees under Action Plan Committee

The Subcommittees consisting of design, construction, O&M and embankment failure survey are established by DG under the Action Plan Committee to assist coordination and monitoring the activities of the Action Plan. Tasks and responsibilities of each subcommittee are as follows:

Design Subcommittee

- To coordinate and monitor all of activities of the Action Plan related to the design manual.
- To receive and review the annual reports of Action Plan related to the design manual from the Design Directorate and submit to the Action Plan Committee.
- To prepare the circulars and revision of the Action Plan related to the design manual and submit those to the Action Plan Committee, if required.

Construction Subcommittee

- To coordinate and monitor all of activities of the Action Plan related to the construction manual.
- To receive and review the annual reports of Action Plan related to the construction manual from respective O&M zone offices and submit to the Action Plan Committee.
- To prepare the circulars and revision of the Action Plan related to the Construction manual and submit those to the Action Plan Committee, if required.

O&M subcommittee

- To coordinate and monitor all of activities of the Action Plan related to the O&M manual.
- To receive and review the annual reports of Action Plan related to the O&M manual from respective O&M zone offices and submit to the Action Plan Committee.
- To prepare the circulars and revision of the Action Plan related to the O&M manual and submit those to the Action Plan Committee, if required.

Embankment failure survey subcommittee

- To receive the embankment failure report through the member of the Action Plan Committee.
- To select the representative failure cases for study.
- To conduct the study with technical staffs in corresponding field office and the representative staffs of the Design Directorate and prepare report.
- To submit the survey report to the Action Plan Committee.
- To prepare the circulars related to the update/ revise the manuals and submit those to the Action Plan Committee, if required.

4.3 Plan for Design Manual for Embankment

All of the embankment design works in BWDB have been done or supervised by the Design Directorate in accordance with the design criteria stipulated in the Standard Design Manual and other reference guidelines, within the existing resources of the Design Directorate. During preparation of the design manual for the embankment, all of the technical staffs had joined the discussion and review the draft manual. Therefore, the design manual for embankment will be applied to the embankment design as usual.
The Action Plan for the design manual mainly prepared to use the manual effectively and to update the manual efficiently. As shown in Table 4.2, there are 3 stages of the Action plan for design manual, consisting of (1) trial application and verification of manual, (2) overall application of manual, and (3) update of manual. The points of attention to respective stages are as follows:

(1) Stage 1: Trial application and verification of manual

- Trial application: Target design works for the trial run shall be all of the embankment design works in BWDB, except the works with the development partners. Because the embankment design works with the development partners will apply higher criteria of embankment.
- Review of trial run: After completion of design, each design work shall be reviewed/evaluated and the report of evaluation result shall be prepared and submitted to the Design subcommittee through Chief Design. Sample format of the report is shown in Attachment 1-1.
- Feedback to the manual: After receiving the reports of trial run, the results shall be compiled and evaluated in the Design subcommittee. If there are supplementary explanation and information required to the manual, the Design subcommittee shall prepare the supplementary explanation and information as the circular in order to share the information in BWDB. The compiled report and circular shall be submitted to the Action Plan Committee.
- Trial application period: at least 3 years preferably.
- Revision of the Action Plan: During implementation of the Action Plan, the Action Plan shall be revised if required.

(2) Stage 2: Overall application of manual to all project

- After the trial application period, all embankment design will be conducted in accordance with criteria of the manual.
- Before the overall application period, supplementary explanation and information made through the former stage shall be shared among the technical staff in the Design Circle.
- In case the supplementary explanation and information are required to the manual during the design works, the report of evaluation result shall be prepared and shall be submitted to the Design subcommittee. After evaluation of the report in the Design subcommittee the Design subcommittee shall prepare the circular for the supplemental explanation and information to the manual if required.

(3) Stage 3: Update of the manual

- The manual shall be revised /updated once 10 years, based on the supplementary explanation and information of the manual accumulated during the action plan and findings through the embankment failure survey.
- In order to revise/update the manual, the working committee shall be established. The members shall consist of not only the representative members of the Design Circle, but also representative members within and without BWDB.
- It is recommended that the first revision of manual shall be conducted in the 5th year preferably, based on the supplementary explanation and information accumulated during the trial application

period.

4.4 Plan for Construction Manual of Embankment

The construction works of the embankment in BWDB are managed by the field offices, that is, the zonal offices, the circle offices, and the O&M division offices. In consideration of the condition of those offices, application of the construction manual to the actual is planned step by step through the trial run within reasonable scope with current resources,
The Action Plan for the construction manual consists of (1) stepwise application and verification of the manual, (2) overall application of manual to all projects and (3) overall revision of the manual, as shown in Table 4.2 before. The points of attention to respective stages are as follows:

(1) Stage 1: Stepwise application and verification of manual

- Selection of the pilot project: In consideration of the current resources of each O&M circle, one or two representative embankment works in each O&M Circle shall be selected as the pilot project year by year preferably.
- Implementation of the pilot project: The pilot projects shall be implemented in accordance with the manual. As the pilot projects are the first experience for the technical staffs of the respective field offices, the experienced engineers in the O&M Zones and the head office of BWDB shall assist the technical staff of the field offices for implementation of the pilot projects. The counterpart members of the Project including the technical staffs of Moulvibazar O&M division office will also be able to assist implementation of the pilot projects.
- Review of trial run: After completion of construction works, each pilot project shall be reviewed/evaluated in each field office and the report of evaluation result shall be prepared and submitted to the Construction Subcommittee through Chief Engineers of respective O&M Zones and respective O&M Circles. Sample format of the report is shown in Attachment 1-2.
- Feedback to the manual: After receiving the reports of trial run, the results shall be compiled and evaluated in the Construction Subcommittee. If there are supplementary explanation and information required to the manual and the specifications, the Construction Subcommittee shall issue the supplementary explanation and information as the circular in order to share the information in BWDB. The compiled report and circular shall be submitted to the Action Plan Committee.
- Trial application period: Each O&M division office shall conduct at least a pilot project. Therefore, trial application period is 3years preferable.
- Revision of the Action Plan for Construction: During implementation, the plan shall be revised if required.

(2) Stage 2: Overall application of manual to all project

- After the trial application period, all embankment works will be conducted in accordance with the construction manual and the specifications.
- Before the overall application period, supplementary explanation and information made through the former stage shall be shared among the technical staffs in all field offices of BWDB.
- In case the supplementary explanation and information are required to the manual, the report of evaluation result shall be prepared and submitted to the Construction Subcommittee. After evaluation of the report in the Construction Subcommittee, the Subcommittee shall issue the circular for the supplemental explanation and information to the manual if required.

(3) Stage 3: Update of the manual
- The manual shall be revised /updated once 10 years, based on the supplementary explanation and

information of the manual accumulated during the action plan and findings through the embankment failure survey.

- In order to revise/update the manual, the working committee shall be established. The members shall consist of not only the representative members of the field offices, but also representative members within and without BWDB.

4.5 Plan for O&M of Managed Structures

The hydraulic structures of BWDB including embankment are managed by the field offices, that is, the zonal offices, the circle offices, and the O&M/mechanical division offices. However, almost of the field offices have not be able to conduct appropriated O&M activities due to insufficient resources including budget.

In consideration of this situation, it is required for BWDB to make the management plan based on the basic data, in order to use the budget efficiently and also to secure sufficient budget. Therefore, it is required to arrange basic data of the managed structures in the jurisdictional areas of respective field offices, such as inventory and damage and repair records, in a stepwise manner and within reasonable scope with current resources, and to prepare the management plan.

The Action Plan for the O&M manual consists of (1) stepwise application and verification of the manual, (2) overall application of manual to O&M and (3) overall revision of the manual, as shown in Table 4.2 before. The points of attention to respective stages are as follows:

(1) Stage 1: Stepwise application and verification of manual

The O&M activities is the recurrent cycle that is, the basic data preparation, management planning based on the basic data, and implementation of management based on the plan. Trial run of application of the O&M manual will be expanded step by step through the following manners:

- Selection of the pilot area: In consideration of the manpower and budget of the each field office, pilot area of the stepwise application of manual shall be selected. About 20% of the jurisdictional area of the field office is preferable as a pilot area in a year.
- Inventory survey and compilation of inventory sheets: Inventory survey of the pilot area shall be conducted by the technical staffs of the field office and the inventory sheets shall be compiled and kept in the office. If resources of the field office allows, the GIS database shall be prepared.
- Stepwise planning: Based on the inventory data, the management plan consisting the long-term and medium term plans in the pilot area shall be prepared considering the annual budget. If the surveyed damages of the structures require huge budget compared with the annual budget, a special rehabilitation project shall be considered and proposed to BWDB.
- Stepwise Implementation: Based on the management plan of the pilot area, the O&M activities shall be implemented applying the manual.
- Above trial run shall be expanded up to the whole jurisdictional area of the field office.
- Review of trial run: Trial run shall be reviewed/evaluated in each field office annually. The reports of evaluation result shall be prepared by each field office and submitted to the O&M subcommittee through the concerned O&M Zone office and O&M Circle office. Sample format of the report is shown in Attachment 1-3.
- Feedback to the manual: After receiving the annual reports of trial run, the results shall be compiled and evaluated in the O&M subcommittee. If there are supplementary explanation and information required to the manual and the specifications, the O&M Subcommittee shall issue the supplementary explanation and information as the circular in order to share the information in BWDB. The compiled report and circular shall be submitted to the Action Plan Committee.
- Trial application period: The trial run is expanded up to the whole jurisdictional area. In case of a pilot area with 20% of the managed area, the trial period will be 6 years.
- Revision of the Action Plan for O&M: During implementation of the Action Plan for O&M, the

plan shall be revised in consideration of available resources in the field offices.

As a sample of Terms of Reference for inventory survey, Terms of Reference on inventory survey of hydraulic structures of water resources schemes along the Manu River in Moulvibazar O&M division office, BWDB is shown in Attachment 2.

(2) Stage 2: Overall application of manual to all project

- After the trial application period, all O&M of the structures will be conducted in accordance with the O&M manual.
- Before the overall application period, supplementary explanation and information made through the former stage shall be shared among the technical staffs in all field offices of BWDB.
- In case the supplementary explanation and information are required to the manual in this stage as same as the former stage, the report of evaluation result shall be prepared by the field office and submitted to the O&M Subcommittee. After evaluation of the report in the O&M Subcommittee, the Subcommittee shall issue the circular for the supplemental explanation and information to the manual if required.

(3) Stage 3: Update of the manual

- The manual shall be revised /updated once 10 years, based on the supplementary explanation and information of the manual accumulated through the action plan implementation and findings through the embankment failure survey.
- In order to revise/update the manual, the working committee shall be established. The members shall consist of not only the representative members of the field offices, but also representative members within and without BWDB.

4.6 Embankment Failure Survey

At present, the constructed earthen embankment failed every year in many places. To mitigate this situation, the manuals of design and construction of embankment and O&M of structures have been prepared in the project. In order to update and revise the prepared manuals, it is important for BWDB to investigate the causes and mechanism of such embankment failures continuously. Process of the embankment failure survey are shown in Table 4.2, and the point attention of the survey are as follows:

- Embankment failure/damage in the managed area of the field offices are reported to the members of the embankment failure survey subcommittee through the BWDB’s ordinary organization.
- The subcommittee shall select one (1) or two (2) representative cases as the embankment failure survey in a year.
- Members of the subcommittee, technical staffs in correspondent field offices and the representative staff form the Design Directorate shall conduct the survey and submit the report to the Subcommittee.
- If there are new findings in the survey required to update or revise the manuals, the Subcommittee shall prepare the circular and submit the report and circular to the Action Plan Committee.
- The Action Plan Committee shall submit the report and the circular to DG. After review by DG, DG shall issue the circular.

4.7 Trainings on Manual

In order to disseminate and use the manuals effectively, periodical training courses of officials in BWDB shall be planned as a part of the existing official training courses of BWDB.

(1) Preparation of Training Courses

The training courses shall be prepared by the Design, Construction and O&M subcommittees, and

coordinated by representatives of the office of Chief Training and Staff Development.
There are many regular technical training courses in BWDB. Although the manuals are the basic regulations in the technical aspect of BWDB, it is difficult to establish new training course at present. Therefore, the training courses on the manuals shall be planned as a part of the existing official training courses of BWDB.
Trainers of the training on the manuals shall be selected among the counterpart members of the Project.

(2) Contents and Target Officials of Training on Manuals
Target officials of the training are the technical staff of BWDB below the executive engineers. Because the executive staffs over the executive engineers are well experienced and educated through the actual works. On the other hand, the technical staffs below the executive engineers are few experienced in the actual works. Therefore, it is difficult for those technical staff to apply the manuals to the actual works.
Contents and target officials on the training are summarized as follows:

Table 4.4 Target Officials of Training on Manuals

Manual: Contents	Target Officials
Design: Outline of manual (function of embankment, causes of damages of embankment, outline of design of embankment, etc.)	Technical staff in Design Directorate in order to enhance the capacity of the embankment design, Technical staff in the head office of BWDB in order to plan and monitor the managed structures, and Technical staffs in the field offices including the Circle offices and the Zone offices (the offices in field), in order to enhance the capacity of monitoring of embankment in field.
Construction: Outline of manual (work flow of embankment works, selection of material including the laboratory tests, etc.)	Technical staffs in the offices in field, in order to enhance the capacity of the construction supervision of the embankment works, Technical staff in head office of BWDB in order to plan and monitor the managed structures, and Technical staffs in the Design Directorate to enhance the capacity of the embankment design.
O&M: Outline of manual (function of structures, outline of O&M works, etc.)	Technical staffs in the offices in field, in order to enhance the capacity of O&M of the managed structures, Technical staff in head office of BWDB in order to plan and monitor the managed structures, and Technical staffs in the Design Directorate to enhance the capacity of the design of the structures.

(3) Training Material

The following manuals had been prepared during the project period:

- Design manual of embankment (English Version)
- Design manual of embankment (Bengali Version)
- Construction manual of embankment (English Version)
- Construction manual of embankment (Bengali Version)
- O&M manual of hydraulic structure (English Version)
- O&M manual of hydraulic structure (Bengali Version)

In addition to the manuals, the explanatory materials of the manuals had been prepared as the material of the seminar in July 2017 by the JICA Expert Team. Those materials are shown in Attachment 3 respectively. Those materials shall be used as those of training courses.

LIST OF ATTACHMENTS

Attachment 1-1: Format of Report on Trial Run (Design Manual of Embankment)

Report on Trial Run (Design Manual of Embankment)

Name of Works:	
Location:	
Design Circle:	
Office in Charge of Construction:	
Review/Evaluation of Trial Run	
1. Were there any difficulties during design? (For example: material, land, set-back, foundation ground, etc.) (1) (2)	
2. How to solve those difficulties? (1) (2)	
3. Was the explanation or other contents in the manual appropriate for solving the above difficulties? (1) Appropriate/Not appropriate (2) Appropriate/Not appropriate	
4. Reasons in case of “Not appropriate” in above 3. (1) (2)	
5. Do you need/expect any supplemental information or update in the manual through this trial run? (1) (2)	

* Design drawing of the trial run shall be attached.

Attachment 1-2: Format of Report on Trial Run (Construction Manual of Embankment)

Report of Trial Run (Construction Manual of Embankment)

<table>
<tr><td>Name of Works:</td><td></td></tr>
<tr><td>Location:</td><td></td></tr>
<tr><td>Design Circle:</td><td></td></tr>
<tr><td>Office in Charge of Construction:</td><td></td></tr>
<tr><td>Name of Contractor</td><td></td></tr>
<tr><td>Construction Period:</td><td>Scheduled: -
Actual: -</td></tr>
<tr><td colspan="2">Review/Evaluation of Trial Run</td></tr>
<tr><td colspan="2">1. Progress Control: Were the construction works implemented as same as the construction plan?
Yes /No
In case of No: Discrepancy plan and actual result, and causes:</td></tr>
<tr><td colspan="2">2. Were the construction works conducted in accordance with the construction manual?
If could not follow the manual, please summarize the actual condition or countermeasures.

(1) Selection of embankment material: Yes or No

(2) Selection of construction machinery /Compaction method: Yes or No.

(3) Quality control for compaction: Yes or No.</td></tr>
<tr><td colspan="2">3. Were there any problems with the residents during construction works?
Yes or No
In case of yes, please itemize problems
(1)

(2)</td></tr>
<tr><td colspan="2">4. How do you think about measures to conduct the construction works in accordance with the manual and specifications?
(1)

(2)</td></tr>
</table>

* Please attach the drawings (plan, representative cross-section profile) and photographs after construction.

Attachment 1-3: Format of Report on Trial Run (O&M manual)

Report on Trial Run (O&M manual)

Name of Division Office:	
Fiscal year:	
Review/Evaluation of Trial Run	
1. Progress of Trial Run (1) Inventory Survey: Total % of managed area (2) Management planning: Total % of managed area (3) Implementation of O&M: Total % of managed area	
2. Inventory survey of structures Are there any difficulties on conducting the inventory survey? (for example: budget, tools (camera, GPS, etc.), map, and others) (1) (2)	
3. Management Planning (1) Could you estimate the repair budget for the damaged structures by using the inventory survey data? Yes or No, In case of No, please summarize reasons. (2) Is the estimated budget bigger than the allocated budget? Yes or No. In case of Yes, Please itemize How to prepare the management plan? (3) Did you request the budget based on the management plan? Yes or No. In case of No, please itemize the reason.	
4. Implementation of O&M Did you conduct the O&M activities based on the management plan in accordance with the manual? Yes or No In case of No: Please itemize the reason:	
5. Do you need/expect any supplemental information or update in the manual through this trial run?	

Terms of Reference
on
Inventory Survey of Hydraulic Structures
of
Water Resources Development Schemes along the Manu River
in
Moulvibazar O&M Division, BWDB

1. General

Bangladesh Water Development Board (hereinafter referred to as "BWDB" is the main organization responsible for the water resources development and management of the People's Republic of Bangladesh. BWDB has implemented over 700 large and small projects for the water resources management and development in the country, and operation and maintenance of the constructed structures become the main issue of BWDB.

Inventory survey of the hydraulic structures managed by BWDB will be conducted with the purpose of preparation of the ledgers of the managed structures as the basic data for preparation of efficient operation and maintenance plans in the O&M divisions.

Inventory Survey of the hydraulic structures of the water resources development schemes along the Manu River in the Moulvibazar O&M Division is conducted as the trial case of the inventory survey.

Completed water development schemes in the Moulvibazar O&M Division are listed in Table 1, and the district map of Moulvibazar is presented in Figure 1.

2. Scope of Works

(1) Objective Area:
Jurisdictional areas of the Moulvibazar O&M division (Figure 1) along the Manu River

(2) Objective Hydraulic Structures
Objective hydraulic structures are the hydraulic structures constructed by the BWDB, as follows:
- River channel
- Drainage channel
- Irrigation canal
- Appurtenant Structure
  Embankment, Bank and foot protection work, groin/ spur dike, road, bridge/culvert,
- Water Control Structures
  Barrage/large regulator, sluice/escape, aqueduct, siphon, pump station

(3) Scope of the Works
Scope of the works is as follows:

a. To clarify the approximate locations of all hydraulic structures constructed and maintained by the Moulvibazar O&M Division Office (the O&M office) through interviews with the officials of the O&M office and with local people.
b. To conduct the field investigation of the hydraulic structures in the jurisdictional area of the O&M office along the Manu River, in order to clarify the precise location, basic

dimensions and existing condition of the structures.

c. To summarize the field data and records and to provide report.

(4) Coordination System

Coordination system of the Services shall refer to WGS84.

(5) Equipment for Inventory Survey

During the inventory survey in the field, the following equipment shall be applied:

a. Portable GPS (or mobile phone with the GPS function and the GPS application)
b. measurement tape
c. Ranging rod (red and white rod) or equivalent
d. Digital camera

(6) Data provided by the Project

Regarding the Moulvibazar O&M Division, the preliminary GIS data including the maps with a scale of 1:25,000 are provided by the JICA Expert Team of the Project for Capacity Development of Management of Sustainable Water Related Structure.

3. Specification of the Services

3.1 Collection of data and information in the O&M Office and Local Peoples

Through the interview with the officials of the O&M office and the local peoples in the O&M division, the following data and information shall be collected as much as possible:

a. Boundary of water resources management schemes: approximate boundaries of respective schemes, except the boundaries of the schemes investigated by IWM/WMIP.
b. Channel (river channel, drainage channel, irrigation canal): Name, jurisdictional extent, management body of ordinary O&M
c. Appurtenant Structure (embankment, bank and foot protection work, groin/ spur dike, road, bridge/culvert): Approximate location and dimension, present condition of the structures
d. Water control structures (Barrage/large regulator, sluice/escape, aqueduct, siphon, pump station): Approximate location and dimension, present condition of the structures.

If there are preliminary rehabilitation plans in the O&M office, information related to the preliminary rehabilitation plans shall be collected and shall be included in the report.

3.2 Inventory survey in the field

Referring the data and information collected, the inventory survey for the completed water management schemes along the Manu River in the O&M Division shall be conducted. The inventory surveys of the structures include recording the location, measurement and sketch, and taking the pictures through the following manners, and Form 1 shall be applied to recording the survey data:

a. Channel (river channel, drainage channel, irrigation canal):

As for the channels, the following item shall be surveyed at <u>the upstream end</u> and <u>the downstream end</u> of the jurisdiction of the O&M Office, and <u>at the major bridge sites</u> crossing the channels:

Channel (river channel, drainage channel, irrigation canal)

Coordinates	Layout/sketch	Picture

N XX YY ZZ.Z E XX YY ZZ.Z	Location map (sketch)	Upstream view of the channel Downstream view of the channel * Ranging rod shall be included in the pictures

b. Appurtenant structures

Embankment:

The following items shall be clarified at every about 2.0 km and the damaged site of embankment.

Embankment (every about 2.0 km)

Coordinates	Layout/sketch	Picture
N XX YY ZZ.Z E XX YY ZZ.Z	Cross section profile with crest width, Slope gradient (river side, land side), height, and berm width if exist (river side, land side)	Upstream view of the embankment (inland side, crest, river-side) Downstream view of the embankment (inland side, crest, river-side) * Ranging rod shall be included in the pictures

Embankment (damaged site)

Coordinates	Layout/sketch	Picture
N XX YY ZZ.Z E XX YY ZZ.Z (at the center of damaged site)	Plan with damaged extent (length) Cross-section with remained crest width	View from downstream site View from upstream site * Ranging rod shall be included in the pictures

Bank and foot protection work:

Coordinates	Layout/sketch)	Picture
Downstream site N XX YY ZZ.Z E XX YY ZZ.Z Upstream site N XX YY ZZ.Z E XX YY ZZ.Z	Cross section profile with slope gradient, slope length, and materials of the bank and foot protection.	View from the upstream site, View from the downstream site, Partial views for the materials of the works. * Ranging rod shall be included in the pictures
In case of damage	Damage location, length and width shall be indicated in the above plan	View of damaged site.

Groin/ spur dike:

Coordinates	Layout/sketch)	Picture
N XX YY ZZ.Z E XX YY ZZ.Z (at the river bank site of each groin)	Pan of alignment including length and direction, Cross section profile with crest width, height and slope gradients of both sides.	Full view from the river bank, Partial view for the materials of the work * Ranging rod shall be included in the pictures
In case of damage -	Damage location, length and width shall be indicated in the above plan	View of damaged site.

Road:

Coordinates	Layout/sketch	Picture
Downstream site N XX YY ZZ.Z E XX YY ZZ.Z Upstream site N XX YY ZZ.Z E XX YY ZZ.Z	Pan of alignment with direction Cross section profile with road width, height, slope gradients of both sides, existence of the pavement and its materials.	Views from the upstream and downstream ends, * Ranging rod shall be included in the pictures
In case of damage N XX YY ZZ.Z E XX YY ZZ.Z (at the center of damaged site)	Damage location, length and width shall be indicated in the above plan	View of damaged site.

Bridge/culvert:

Coordinates	Layout/sketch	Picture
N XX YY ZZ.Z	Pan with length and width,	view from the river bank,

E XX YY ZZ.Z (at the center of the bridge/culvert)	Section including connection with both bank	sectional view of the bridge/ culvert * Ranging rod shall be included in the pictures
In case of damage	Damage location, length and width shall be indicated in the above plan	view of damage

c. Water control structures

Barrage/large regulator:

Coordinates	Layout/sketch	Picture
Right bank N XX YY ZZ.Z E XX YY ZZ.Z Left bank N XX YY ZZ.Z E XX YY ZZ.Z	Layout plan with width of gates, Section including width and height of each gate.	Full view of the barrage/large regulator, sectional view of the barrage/ large regulator Picture of guide plate/nameplate (if exist) * Ranging rod shall be included in the pictures
In case of damage	Damage location, length and width shall be indicated in the above plan	view of damage

Regulator/sluice/escape:

Coordinates	Layout/sketch	Picture
N XX YY ZZ.Z E XX YY ZZ.Z (at the center of the structure)	Layout plan with the inlet, outlet and gate Section including width and height of vent.	Full view of the structure, view of inlet, view of outlet. * Ranging rod shall be included in the pictures
In case of damage	Damage location, length and width shall be indicated in the above plan	view of damage

Aqueduct:

Coordinates	Layout/sketch	Picture
N XX YY ZZ.Z E XX YY ZZ.Z (at a bank)	Layout plan of structure Section including dimensions of the water way.	Full view of the structure, Sectional view of the structure * Ranging rod shall be included in the pictures
In case of damage	Damage location, length and width shall be indicated in the above plan	view of damage

Siphon:

Coordinates	Layout/sketch	Picture
N XX YY ZZ.Z E XX YY ZZ.Z (at the inlet or outlet of the structure)	Layout plan of the structure Section including dimensions of the water way.	Full view of the structure View of the inlet, view of outlet. * Ranging rod shall be included in the pictures
In case of damage	Damage location, length and width shall be indicated in the above plan	view of damage

Pump station:

Coordinates	Layout/sketch	Picture
N XX YY ZZ.Z E XX YY ZZ.Z (at the center of the embankment)	Layout plan of the structure, buildings with the number of the pumps, the capacity of each pump, If there is other appurtenant structure, the appurtenant structure shall be surveyed in accordance with the guidance of the structure.	Full view of the pump station, sectional view of the inlet and outlet, view of pump 8if possible) * Ranging rod shall be included in the pictures
In case of damage	Damage shall be indicated in the above plan	view of damage

3.3 Summary of field data and records and Reporting

Location of hydraulic structures in respective water management schemes shall be plotted in the maps. All of data and records collected in the field shall be arranged by use of the Form 2.

The reports shall be compiled as the following volumes:

* Inventory Survey of Hydraulic Structures in Schemes related to Manu River in Moulvibazar O&M Division

The Reports shall be included:

- Location maps of the hydraulic structures of respective schemes including the boundaries of schemes.
- List of schemes including the numbers of the structures.
- Records (Form 2) of the investigated structures.
- Other information from the office and field, if any.

4. Quantity and Schedule of the Services (Tentative)

(1) Quantity of the Services

The quantity of the services is shown in Table 2.

(2) Schedule of the Services

Draft schedule of the Services are shown in Table3.

Table 1 Completed Water Resources Development Schemes
in Moulvibazar O&M Division Office

No.	Scheme Name	Project Type	Location (Upazilla/District)	Gross Area/ Net Area (ha)	Imple. Period	Direct Cost (Lakh Tk)
1 *1	Barachara Irrigation Project	DI	Kulaura/ Moulvibazar	2,000/ N.A.	1999-2000	212.00
2 *1,*2	Dewarachara FCD Sub-Poject	FCD	Kamalganj/ Moulvibazar	4,450/ 4,450	1998-2004	255.18
3 *1	Hail Haor Project	FCD	Moulvibazar Sadar & Sreemangal/ Moulvibazar	24,372/ 18,176	1981-1989	1,069.42 & Wheat 1,500MT
4 *1,*2	Hamhami Chara Sub-Project	FCD	Moulvibazar Sadar, Kamalgonj/ Moulvibazar	2,594/ 1,294	1988-1991	145.10 & Wheat 490 MT
5 *1	Manu Left Embankment Project	FCD	Moulvibazar Sadar/ Moulvibazar	16,000/ 16,000	1982-1986	408.24
6 *1,*2	Manu River FCD Project Phase-I	FCD	Kulaura/ Moulvibazar	3,075/ 2,567	1989-1993	159. 00 & Wheat 4480 MT
7 *1,*2	Manu River FCD Project Phase-II	FCD	Kulaura & Rajnagar/ Moulvibazar	5,200/ 1,500	1994-1998	201.53 & Wheat 4563 MT
8 *1	Manu River Project	FCDI	Rajnagar & Moulvibazar Sadar/ Moulvibazar	24,178/ 19,028	1975-1983	7,258.00
9 *1	Phanai River WCS (not functioning)	I	Kulaura/ Moulvibazar	1,500/ 1,200	1983-1985	157.89
10 *1,*2	Shaka Borak Project	FCD	Moulvibazar Sadar/ Moulvibazar	4,520/ 3,800	1988-1993	113.87 & Wheat 390 MT
11 *1,*2	Sharifpur FCD System	FCD	Kulaura/ Moulvibazar	1,822/ 1,214	1987-1995	145.00 & Wheat 1100 MT
12 *1	Tarapasa Premnagar Flood Control Embankment Project	FC	Rajnagar/ Moulvibazar	8,000/ 6,500	1994-1996	211.50
13 *3	Bank Protection Work for Manu River Left Bank from bashat to Manumukh	BP	Moulvibazar Sadar/ Moulvibazar	11,480/ -	1982-1999	751.58
14 *3	Moulvibazar Town Protection Project	TP	Moulvibazar Sadar/ Moulvibazar	1,500/ -	1992-1999	1618.38
15 *3	Protection Work of Area adjacent to Manu Mukh Bazar	BP	Moulvibazar Sadar/ Moulvibazar	8,000/ -	1994-1999	110.81
16 *3	Bank Protection Work of Manu River up to Balikandhi Palpur in the Right Bank	BP	Moulvibazar Sadar/ Moulvibazar	1,500/ -	1995-1998	303.00
17 *3	Protection of Territory of Bangladesh from erosion of Juri River	BP	Juri/ Moulvibazar	2,470/ -	2003-2005	551.90
18 *3	Kaminiganj Bazar Protection Project from erosion of Juri River	BP	Juri/ Moulvibazar	1,422/ -	2002-2004	195.88
19 *3	Early Flood Control and Drainage Project in Haor Area	FCD	Moulvibazar Sadar, Rajnagar/ Moulvibazar	22,672/ 11,578	2011 – On going	1,452.98

Source:

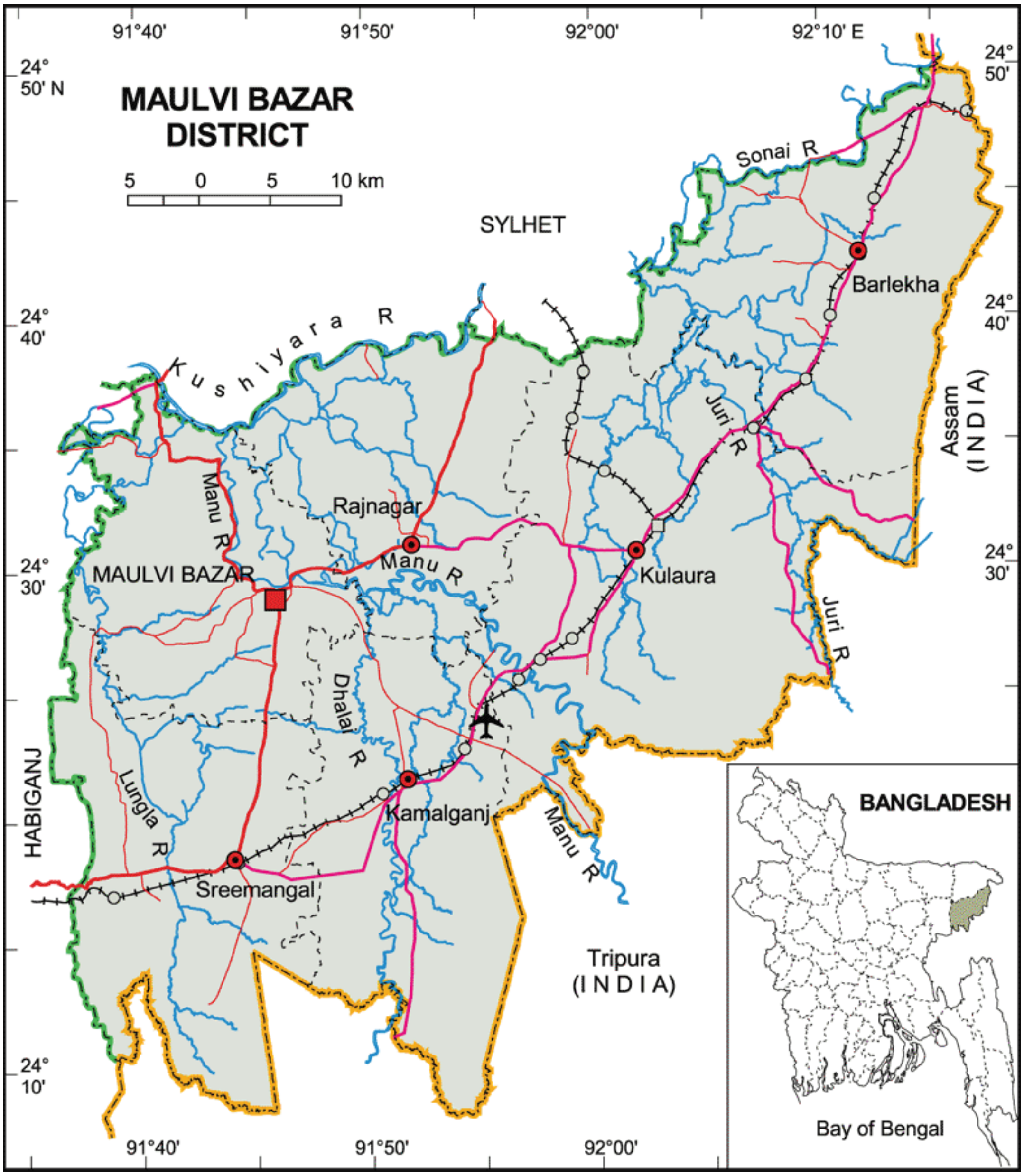
*1: Scheme Database Inventory and Mapping (contract package No: BWDB/S4), Water Management Improvement Project (WMIP), IWM

*2: Database and mapping already conducted by WMIP/IWM

*3: Information from the Moulvibazar O&M Division Office

Note:

DI: Drainage and Irrigation, FCD: Flood control and drainage, FCDI: Flood control, drainage and irrigation,
I: Irrigation, FC: Flood Control, BP: Bank protection, TP: Town protection



Source: BWDB

Figure 1 Map of Moulvibazar District

FORM 1 (Field Datasheet)

Sheet No.:

Scheme Name:	Kind of Structure
Structure Name	Location(Coordinates): N , E
Layout/Sketch/, Dimensions, etc.	

FORM 2 (for Report: A3 size)

Sheet No.:

Scheme Name:	Kind of Structure	
Structure Name	Location(Coordinates): N , E	
Layout/Sketch/, Dimensions, etc.		Photographs

Table 2 Quantities of the Services

Item	Unit	Amount	Remarks
Inventory Survey No.1 in Moulvibazar O&M Division			
1. Collection of Data & Information	LS		
2. Inventory Survey in the Field	LS		
3. Summary of Field Data & Record/ Reporting	LS		
4. Direct Cost	LS		
5. Total of 1 – 4			

Table 3 Schedule of the Services

Survey							
	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Inventory Survey No. 1 in Moulvibazar O&M Division							
Report		▲ MB(Manu)					

The Project for Capacity Development of Management for Sustainable Water Related Infrastructure

Project Period: Aug. 2013 – Sep.2017 (Original: Jul. 2016): 4 years +

Expected Goals which will be attained after the Project Completion

(1) Goal of the Proposed Plan

To improve the capacities of BWDB on embankment engineering in terms of Design, Construction and Operation & Maintenance methods

(2) Goal which will be attained by utilizing the Proposed Plan

To achieve water-related disaster risk reduction through proper management of the infrastructures

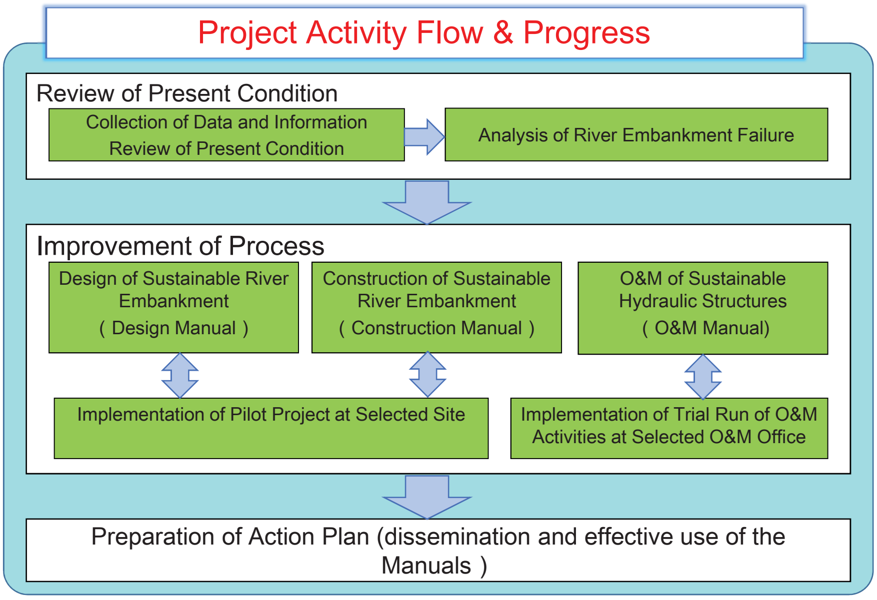
Outputs

(1) Design for sustainable river embankment is introduced

(2) Construction method and procedure of river embankment is improved

(3) Operation and Maintenance (hereinafter referred to as "O&M") system for the river infrastructures is ensured

1



2

Scope/Application and Target User of Manuals

Manual	Scope/Application	Target Users
Design Manual	Update of design standard of embankment in "Standard Design Manual" of BWDB	Main: Tech. staff of Design Directorate Sub: Other tech. staff in BWDB
Construction Manual	Supplement of the "Technical Specification for Civil Works" and the "Standard Schedule of Rate Manual"	Main: Tech. Staff in field in BWDB, engineers related to construction of embankment Sub: Other staff in BWDB
O&M Manual	Technical reference for the "Guidelines for Operation and Maintenance of Permanent Structures of BWDB (BWDB O&M Guideline)"	Main: Tech. Staff in field in BWDB Sub: Other staff in BWDB

3

Design Manual for River Embankment

2017. 7.13

JICA Expert Team

1

Relation; Standard Design Manual & This Design Manual

1995 Standard Design Manual

1. General
2. Hydraulic Design
3. Structural Desing of R.C.Concrete member
4. Prestressed Concrete
5. Foundation Design
6. Irrigation Structures
7. Embankment
8. Pipe Structure
9. Road Structure
10. Bank Protection and River Training Works
11. Design Criteria of Gates and Hoist

2010 Guideline for River Bank Protection

2017 Design Manual for River Embankment in Bangladesh

2

Application of Design Manual

Preface
Section 1. Prerequisites concerning River Embankment Design
Section 2. Basics of Embankment Design
⇒ At least Design Basics need to be observed.
Section 3. Design specification
⇒ Design specification should be used.
Section 4. Verification of Embankment Safety
⇒ Verification of Embankment Safety should be done at necessary places.

3

Points considered in Design Manual Preparation

1. Topographical, morphological and soil conditions are considered.
2. Detail explanations is described in each item.
3. Verification of embankment safety should be conducted as needed.
4. Referring to "Guidelines for River Bank Protection prepared in 2010" on Erosion.
5. Verification of Earthquake will be used as reference for the time being.
6. Design Manual of Sea dykes is not included.
7. Design procedure based on sophisticated soil tests are avoided as possible.

4

Persons using Design Manual

1. Designers of River Embankment at Design Circle

2. Supervise Engineers of River Embankment construction at O&M office

3. Inspection, Maintenance Engineers Officers at O&M office

5

Textbook for correct understanding of River Embankment

2017.7.13

JICA Expert Team

6

Overview of Textbook (P3)

1. What kind of characteristics does the river embankment have?
2. What are the causes of river embankment breaches?
3. What is the mechanism of river embankment breaches?
4. What kind of ingenuity of design is being done to prevent from river embankment breaches?

7

1. River embankment is made of soil. (P3)

Why is the river embankment made of soil?

1. Soil located adjacent to construction site is easy and inexpensive to be acquired and carried.
2. Soil does not easily deteriorate.
3. Soil fits easily to the foundation ground and follows the deformation of the foundation ground.
4. Special foundation is not needed because soil is relatively lightweight.
5. It is easy to be repaired and to be extended.

8

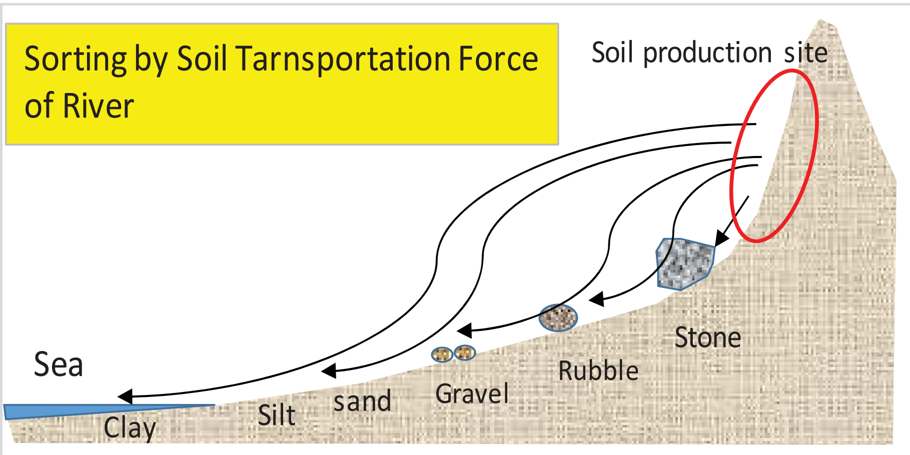
What are the weaknesses of embankment made of soil? (P4)

1. Embankment made of soil lacks homogeneity as material.
2. Embankment made of soil is easily scoured and eroded by running water.
3. Embankment made of soil decreases in strength by penetration of water.
4. Embankment is susceptible to subsidence due to earthquake vibration.

9

3. Soil of ground in Bangladesh (P5)

Ground formation in low-lying area made by river running



10

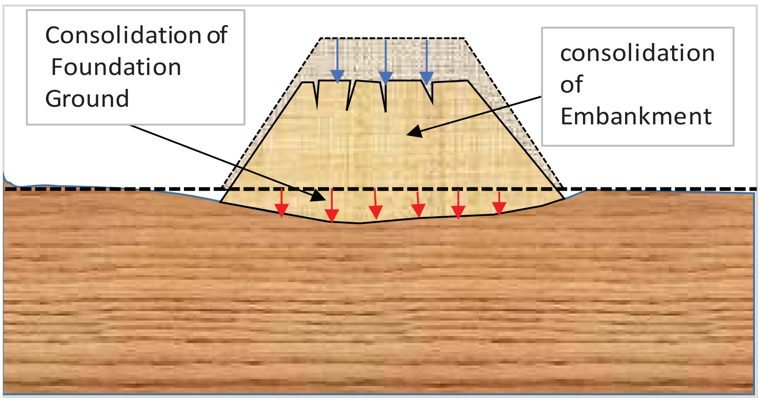
3. Embankment breeches and Embankment Design (P11)

1. Embankment breach by the overflow
2. Embankment breach by permeation of river water and rainfall
3. Embankment breach by erosion of slope
4. Embankment breach by erosion of set back
5. Embankment breach by subsidence

11

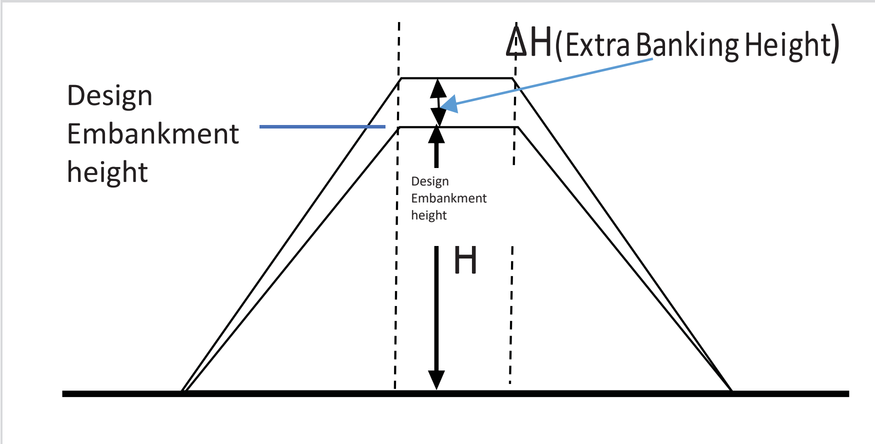
5.1 Embankment breaches by over flow (P13)

(2) Embankment consolidation & Subsidence by consolidation of foundation ground



12

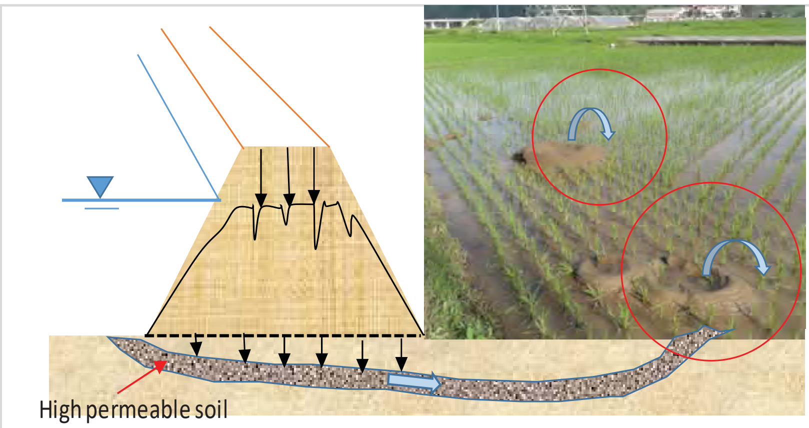
P14



13

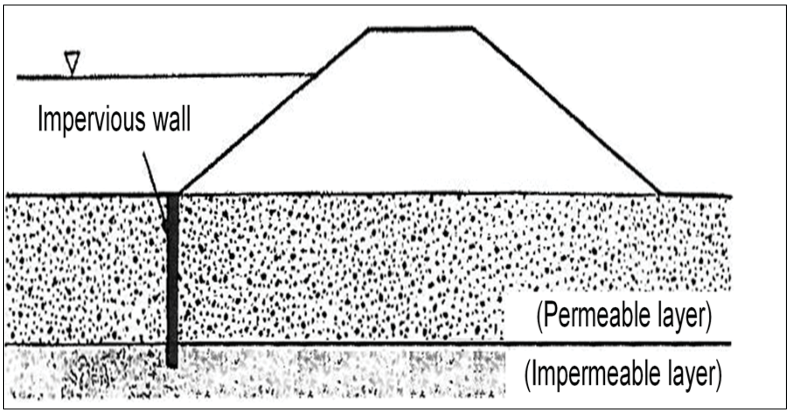
5.1 Embankment breaches by over flow (P14)

(3) Washout of ground soil by seepage water



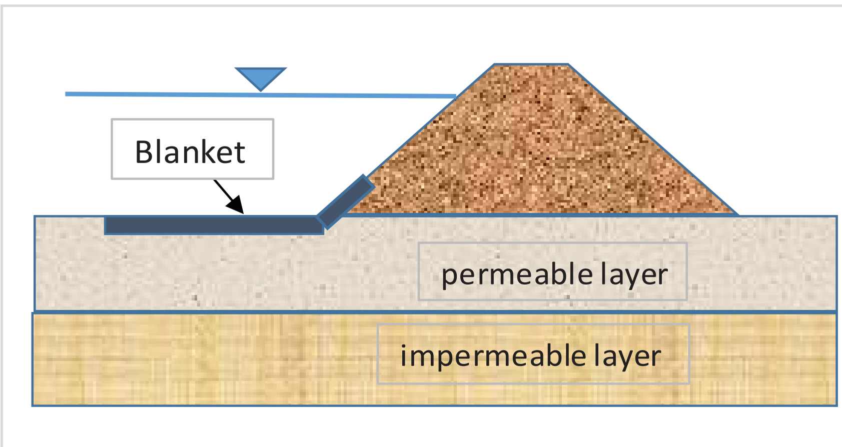
14

Countermeasures against Seepage (P15)



15

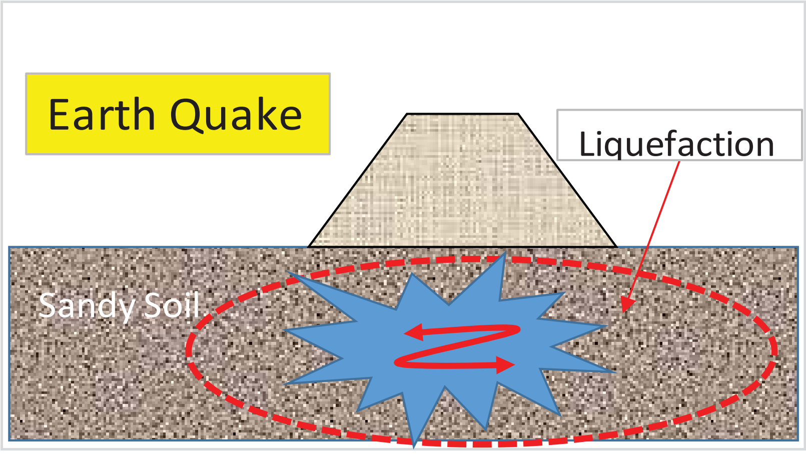
Countermeasures against Seepage (P15)



16

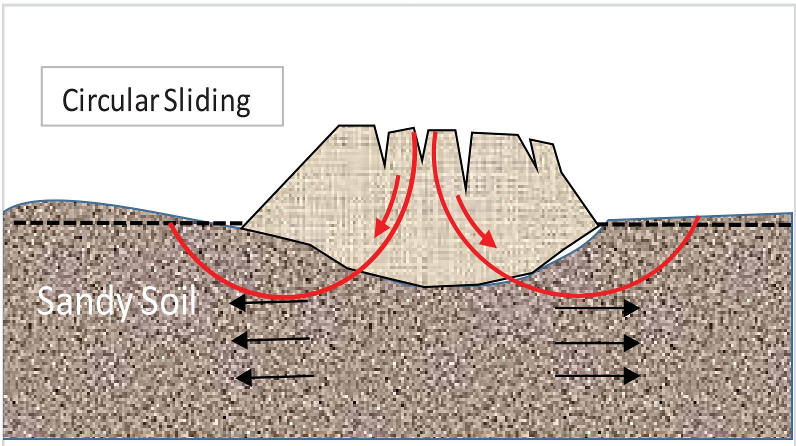
5.1 Embankment breaches by over flow (P16)

(4) Liquefaction of ground by earthquake



17

P16



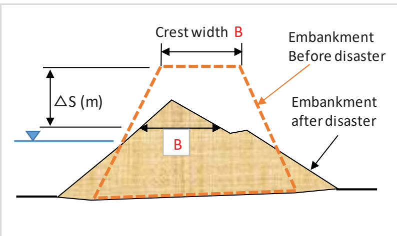
18

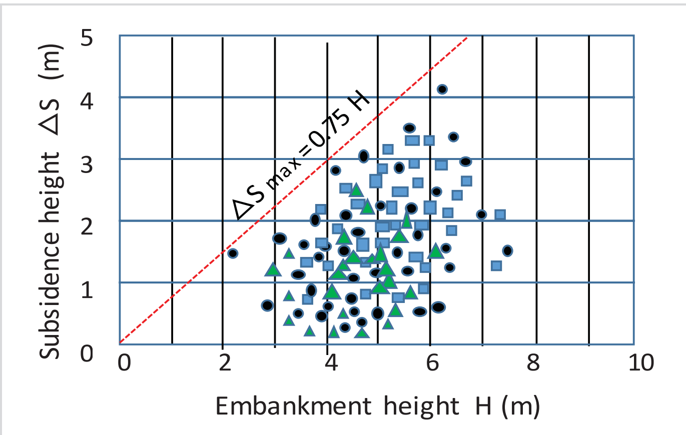
Embankment collapsed by liquefaction in Japan

P16

19

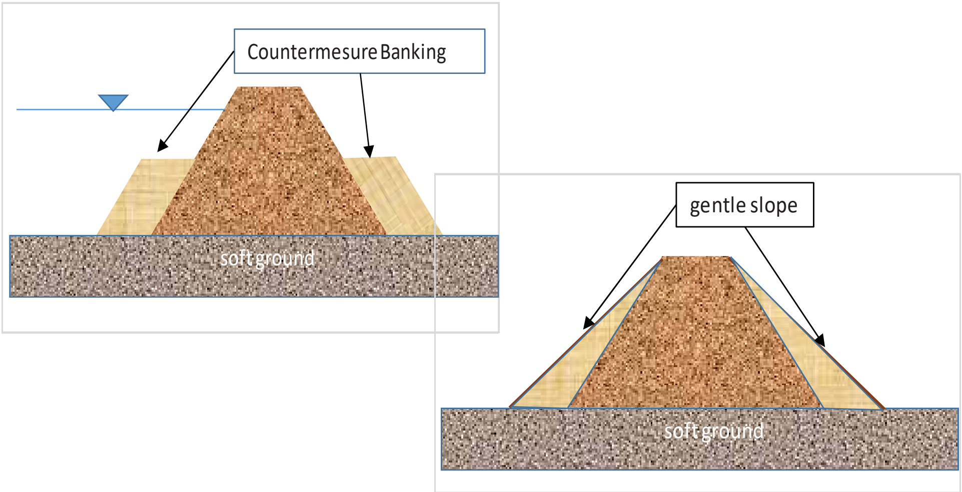
Embankment height ～Subsidence height(P17)





20

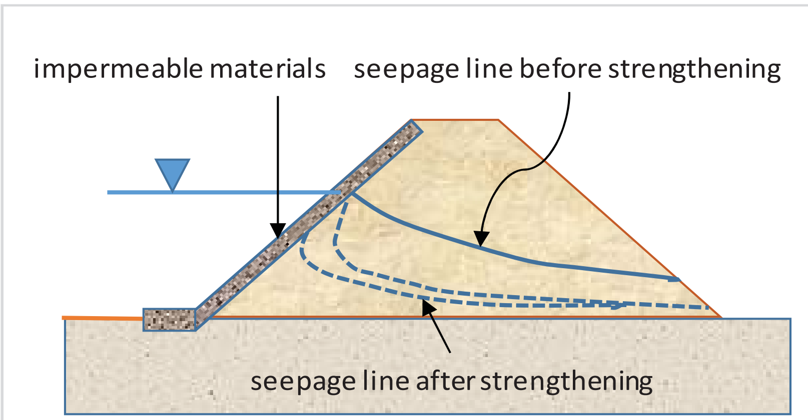
Countermeasure against Earthquake(P18)



21

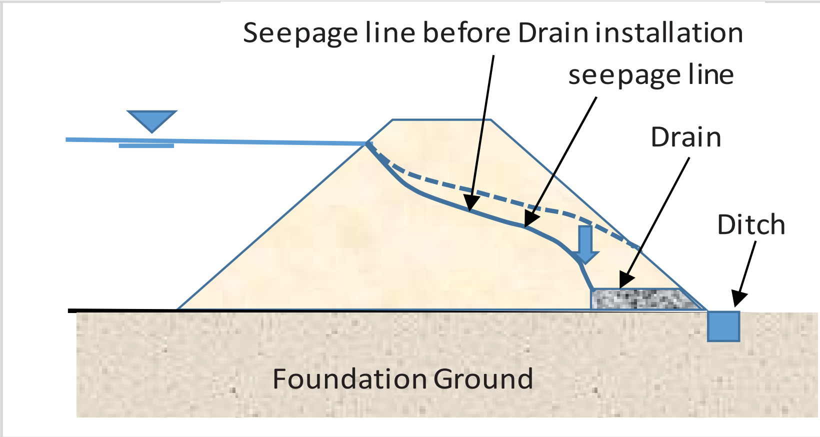
5.2 Damage by permeation of river water and rainfall
(1) Circular sliding and piping by seepage flow

P19



22

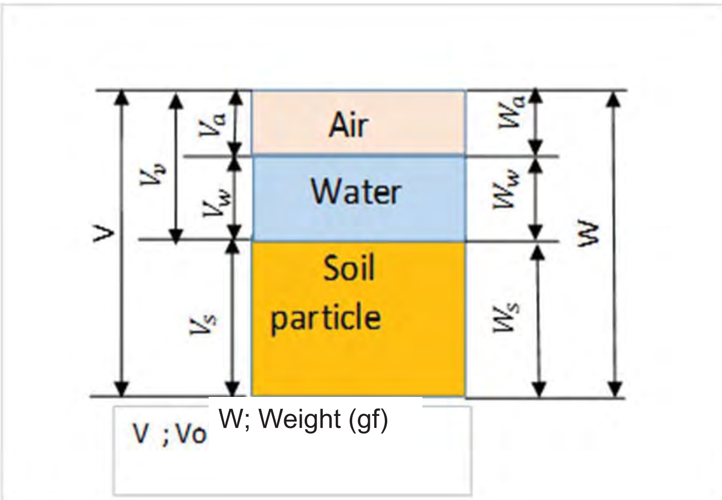
P19



23

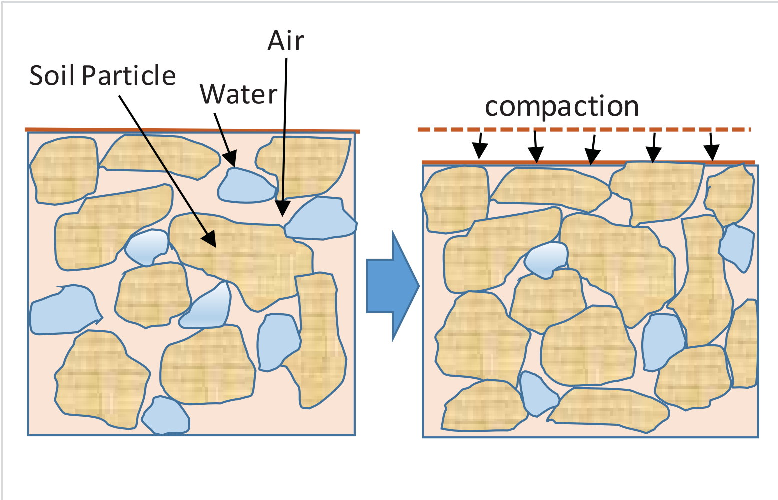
5.2 Damage by permeation of river water & rainfall
(2) Circular sliding by permeation of river water and rainfall

P19



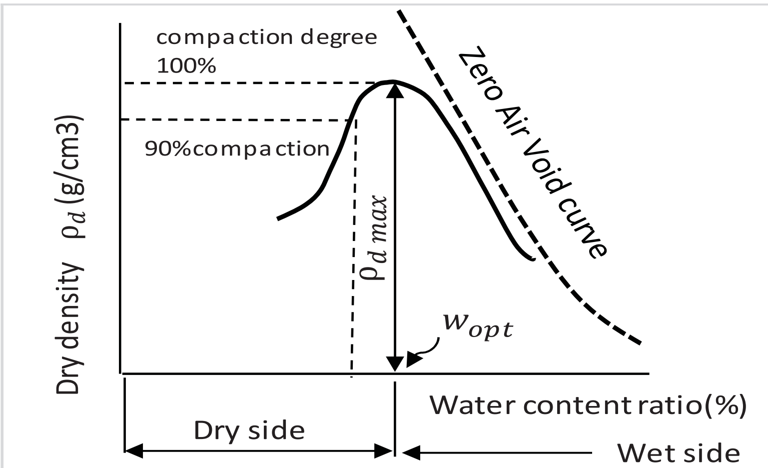
24

P20



25

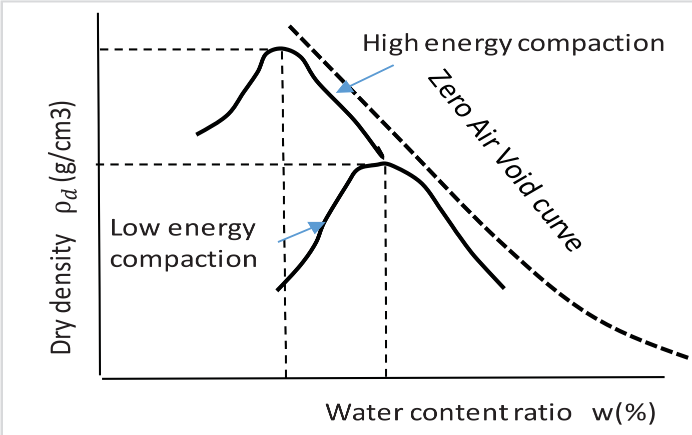
Dry density ～ Water Ratio (P20)



26

Soil density ～Water content ratio (P21)

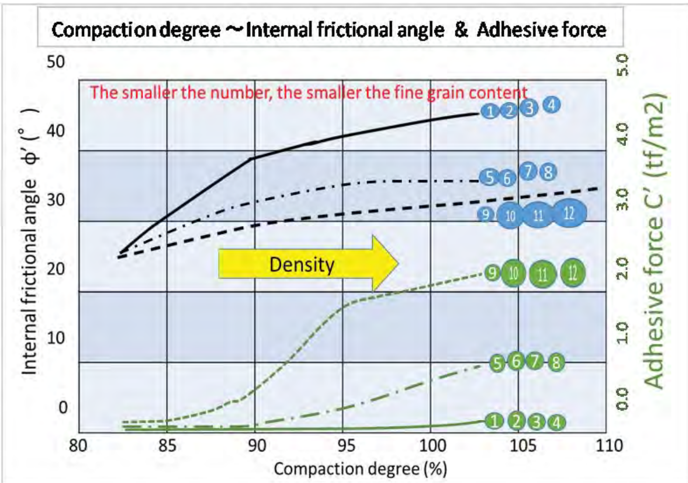
① Compaction with Larger force
② Compaction with Small force



27

Compaction degree ～ Internal friction angle (φ'), Adhesive force (C'.)

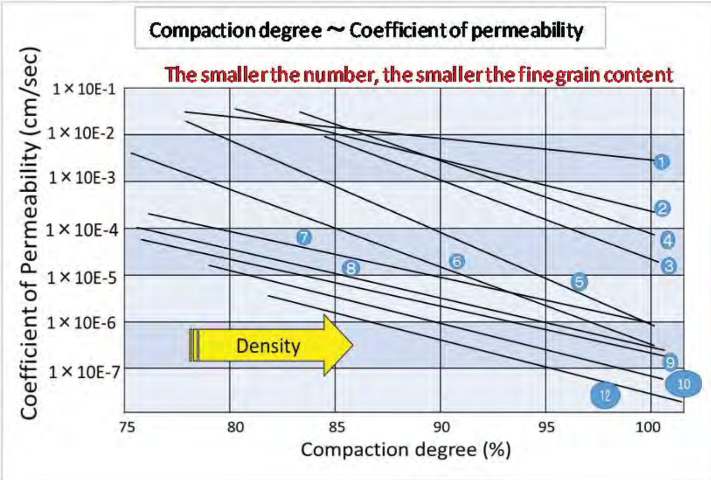
P10



28

Compaction degree ～ Coefficient of permeability

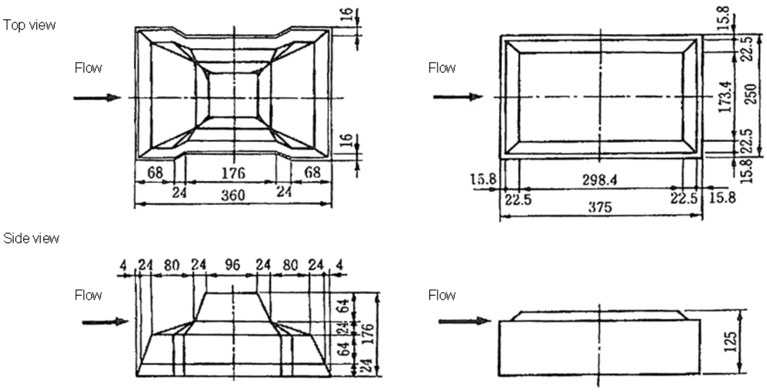
P10



29

5.3 Erosion in slope of embankment (P23)

(2) Covering of slope by Concrete Blocks



Standard Drawing of Block

30

C.C. Blocks with projection at Project site(P24)

Manufacture of C.C.blocks at Moulvibzar

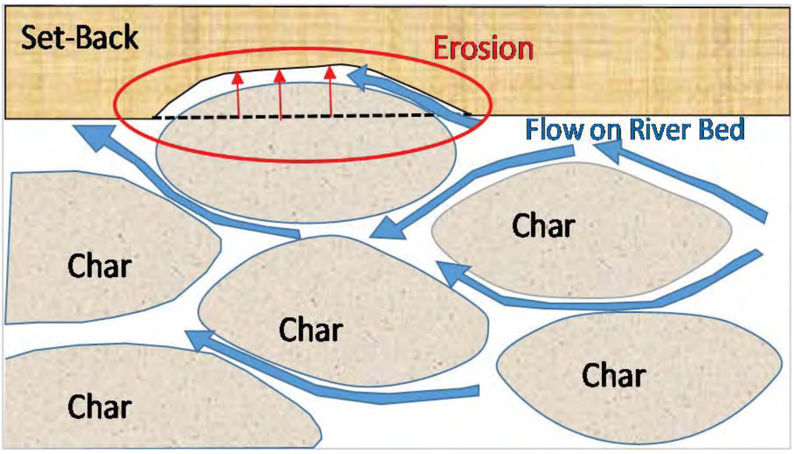
Placing of C.C.blocks at Moulvibazar

31

5.4 Erosion of Set back

(1) Erosion mechanism in braided river (The big Rivers)

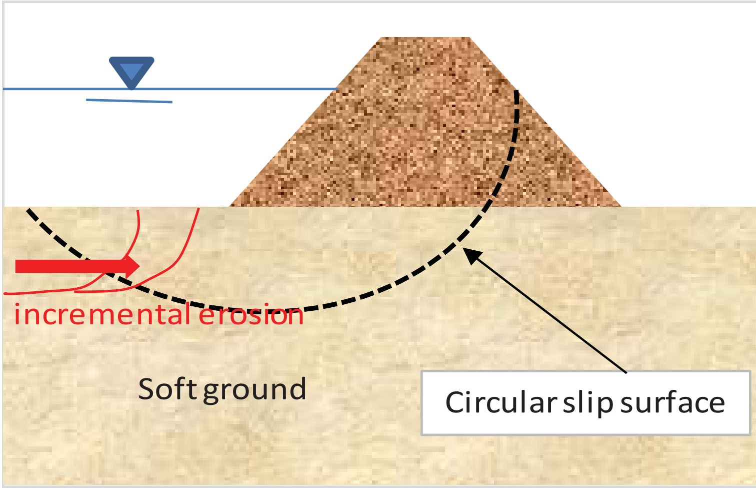
P26



32

5.4 Erosion of Set back (P28)

(3) Erosion of Set back and circular sliding

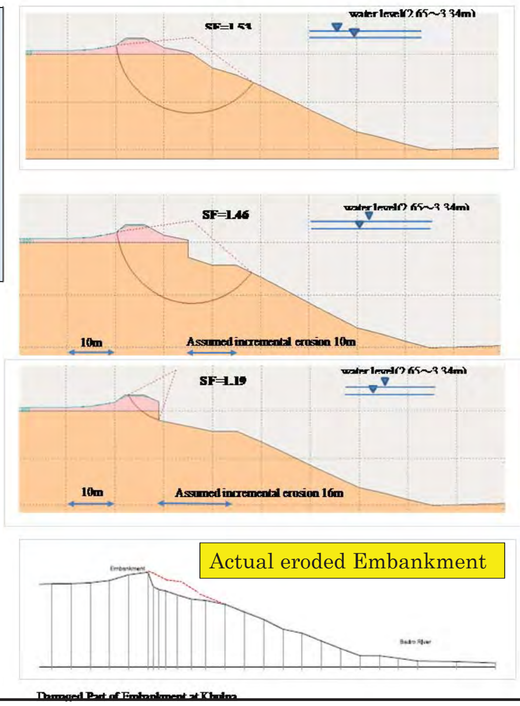


33

Minimum safety rate of circular sliding
&
erosion of set-back

in Khulna

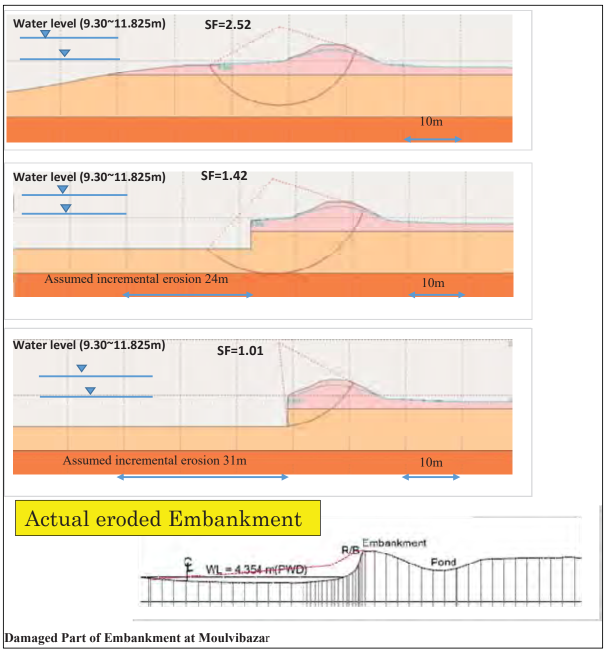
P29



34

Minimum safety rate of circular sliding & erosion of set-back in Moulvibazar

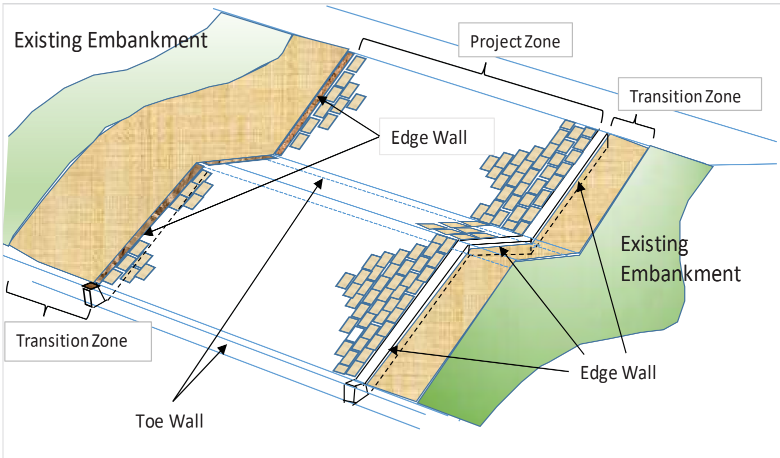
P31



Damaged Part of Embankment at Moulvibazar

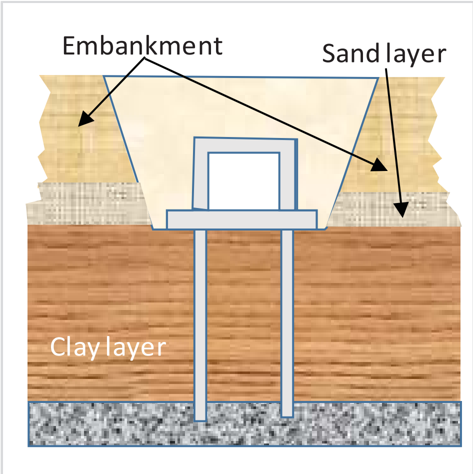
35

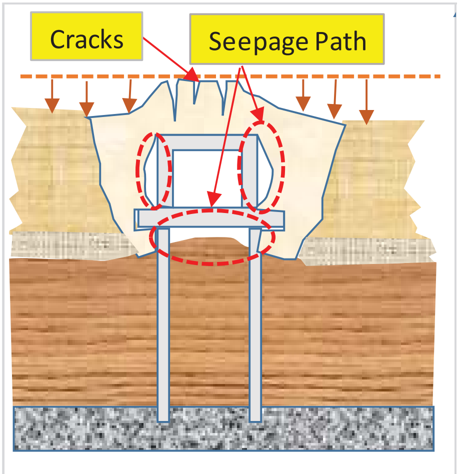
★ After Pilot Project (P26)
Transition zone works and Edge Wall



36

★ After Pirot Project (P33)
Erosion from seepage paths & cracks

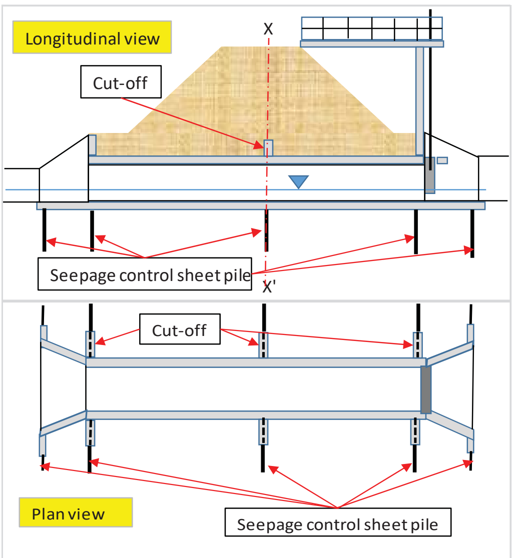




37

★Design of Structure crossing Embankment

P34



38

Textbook
for
correct understanding
of
River Embankment

2017. 7.13

JICA expert team

Table of Contents

1. Purpose of dissemination of Design Manual for River Embankment in Bangladesh

This textbook is for enhancing capabilities of BWDB officers in charge of construction, maintenance and operation of embankment not only to grasp river condition from the aspect of the embankment function and cultivate the ability to take measures to prevent disasters but also to recommend appropriate countermeasures for the recovery of the damaged embankment in the event of a disaster.

For this reason, this textbook shows the grounds for the criteria described in the Design Manual for River Embankment (why such rules are to be established), and it helps to understand from what viewpoint you should normally monitor the embankment.

This textbook explains the river embankment from the following viewpoints to achieve the above purpose.

1) What kind of characteristics does the river embankment have?
2) What are the causes of river embankment breaches?
3) What is the mechanism of river embankment breaches?
4) What kind of ingenuity of design is being done to prevent from river embankment breaches?

2. River embankment is made of soil.

(1) Why is the river embankment made of soil?

River embankment is made of soil located adjacent to construction site for the following reasons because a large amount of soil is needed.

1) Soil located adjacent to construction site is easy and inexpensive to be acquired and carried.
2) Soil does not easily deteriorate.
3) Soil sticks easily to the foundation ground and follows the deformation of the foundation ground.
4) Special foundation is not needed because soil is relatively lightweight.
5) It is easy to be repaired and to be extended.

(2) What are the weaknesses of embankment made of soil?

Embankment should be designed to be stable against external force such as running water and penetration of water because soil has the following weaknesses.

1) Embankment made of soil lacks homogeneity as material. 2) Embankment made of soil is easily scoured and eroded by running water. 3) Embankment made of soil decreases in strength by penetration of water. 4) Embankment is susceptible to subsidence due to earthquake vibration.

3. Soil of ground in Bangladesh

(1) Ground formation in low-lying area by river running

1) Earth and sand turned out in upstream area is carried by river running at the time of flood. Wash force of river can transport stone and gravel in the steep slope reach however can't transport to the midstream area nor downstream area because it is in proportion to river bed slope ($\sqrt{\ }$) . Thus earth and sand turned out in upstream area is sorted to each reach by river wash force and forms the ground in low-lying area which is flood plain.

2) The ground in Bangladesh has been formed by earth and sand transported by river water force of the big rivers which is the Ganges River and the Jamuna River. River slope is very gentle and river flow is very slow because Bangladesh is located at the most downstream end of the river. Furthermore, ground is formed mainly by fine soil which is silt and clay because river water force is week even at the time of flood.

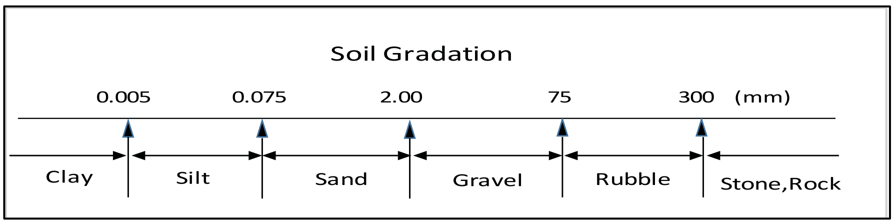
3) A mount of coarse sand carried at the time of flood is remained at the deep stratum of ground and at the river bed of the big rivers. Silt accumulates on sand stratum at the late stage when river flow became week.

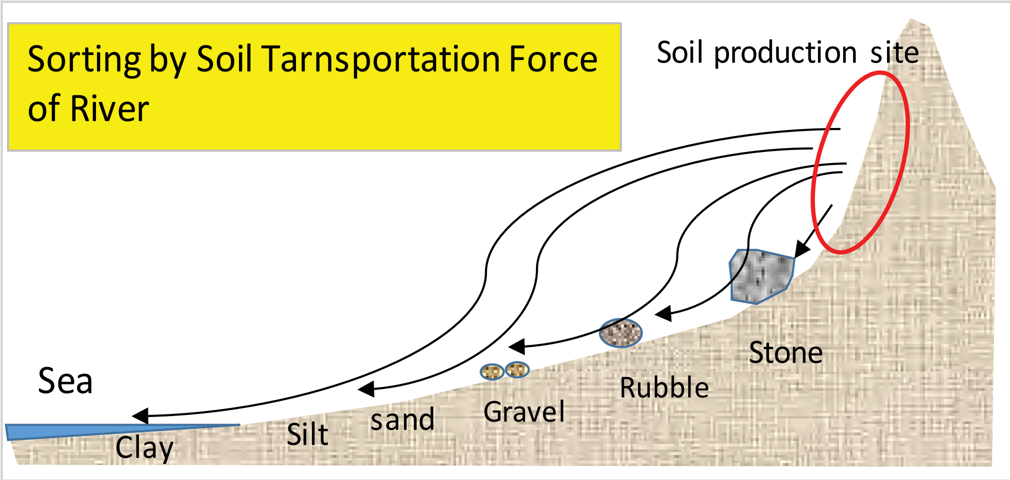
4) For reference, earth and sand is generally classified according to the particle size as follows.

a. Fine grain; Clay (less than 0.005mm), Silt (0.005mm-0,075mm)

b. Coarse grain; Sand (0.075mm-2.0mm), Gravel (2.0mm-75mm)

c. Stone; Coarse Stone (75mm-300mm), Gigantic Stone (300mm-　)

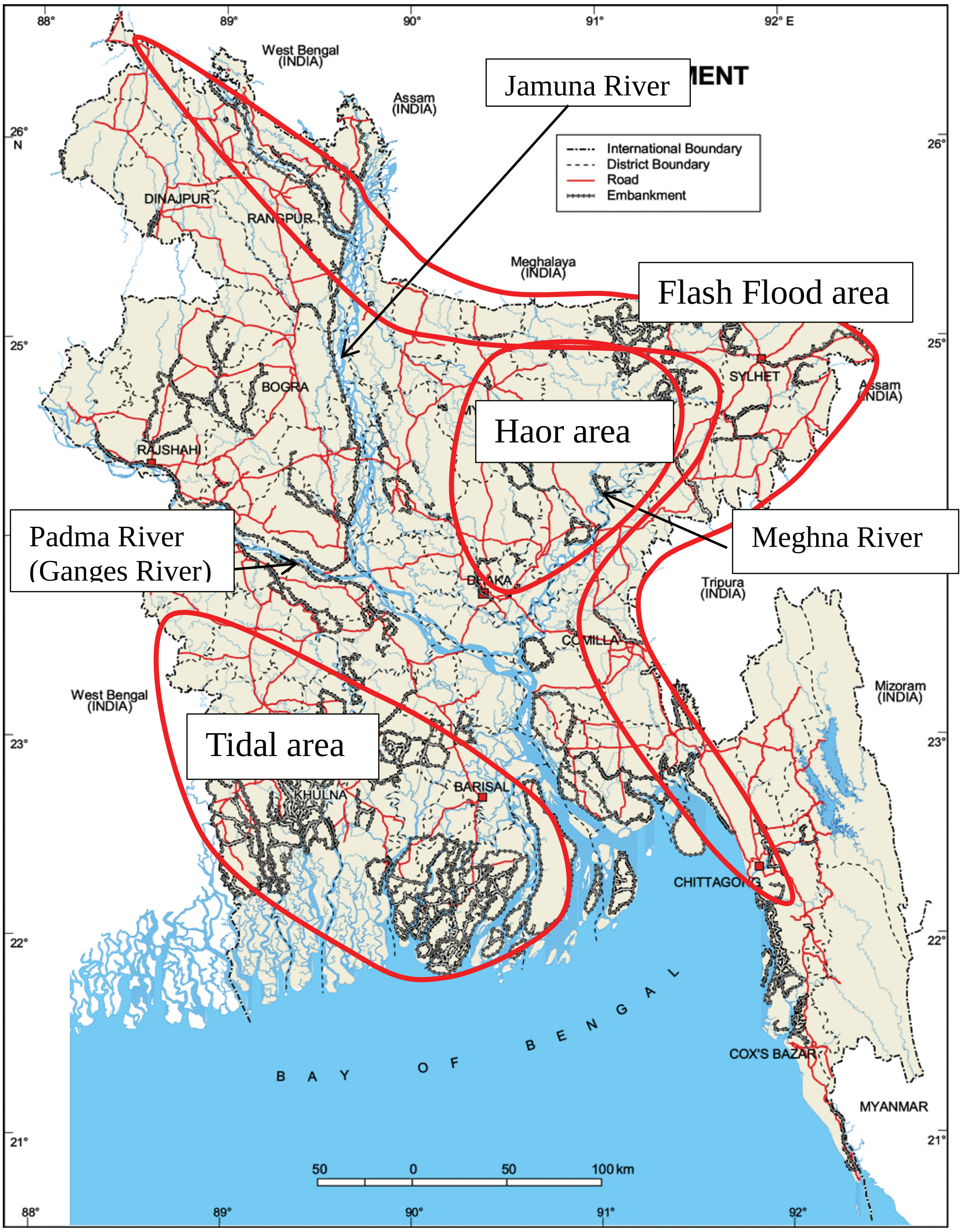




(2) Ground in Haor area and High tide area

1) The low-lying area in the Meghna River Basin located in the northeastern part of the country called "Haor" is located at low altitude. Haor area becomes the basin once it rains in flood season. Therefore, clay categorized in the fine soil which usually runs off to the sea is retained in the Haor area, does not run off from the Meghna River, and the ground in Haor area leads to be formed to the ground with much clay.

2) The ground at high tide area located in southern part of Bangladesh contains a large amount of clay. This is thought that clay fraction once flowed out to the sea is pushed back to the river again by the tide and mixed with the silt to form the ground of the clayey silt.



4. Basic design to keep stability of river embankment

Because the embankment made of soil is vulnerable against penetration and erosion by running river water etc., it is designed to keep stability by taking these drawbacks into account.

(1) Shape of embankment

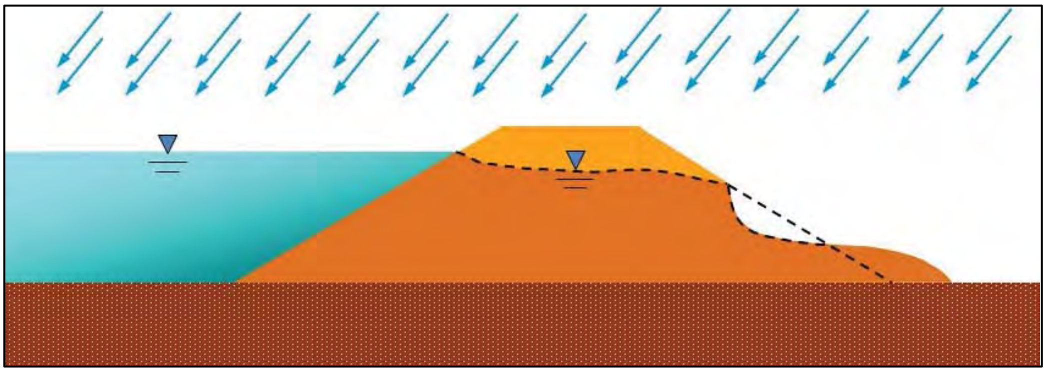
1) Embankment is usually designed to have a trapezoid shape having not only a crest with more than proper length but also slope with gentle gradient (1:2, 1:3).

2) Seepage surface in the embankment formed by river water and rainfall rise over time.

Though depending on the permeability of the ground, it becomes to be stabled when the penetrated water amount from the slope on the river side and the leached water amount to the slope on the country side are even.

When the leaching rate is high and the leaching amount is large, the embankment soil is flown out.

The wider embankment width can make the embankment more stable and the gentler slope on the country side can make amount of flowing out water reduced and the embankment more stable, further circular sliding is unlikely to occur.



(2) Selection of filling material of river embankment

It is desirable for embankment material to satisfy the following conditions.

1) Particle size distribution of material provides high density and large shear strength.

2) Material has high impermeability as much as possible and seepage line is drawn under the toe of embankment.

3) Material has neither characteristics of compressional deformation nor characteristics of swelling, which might have adverse effect on the stability of embankment.

4) Material has high workability and is easy to be compacted.

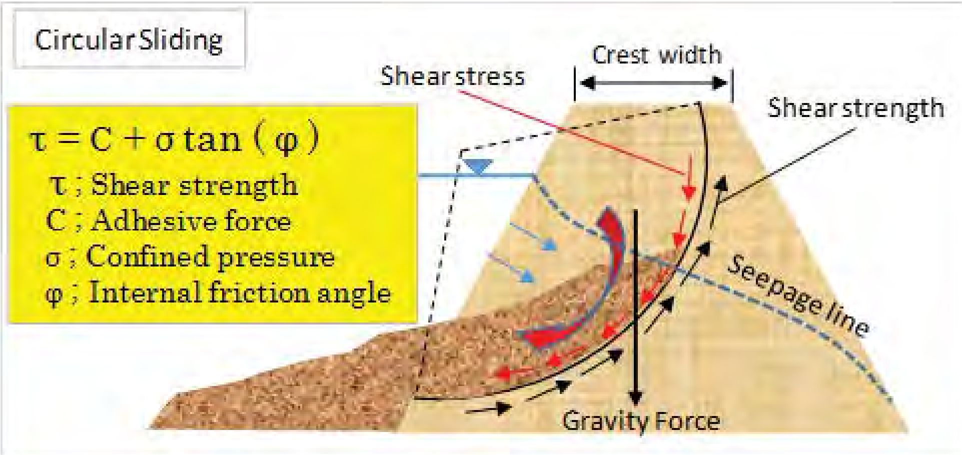
5) Material is stable against environmental change such as permeation and drying, and accordingly slope sliding and cracks on the surface of embankment are less likely to occur.

6) Material contains neither harmful organic matters nor water-soluble.

1) When the slope sliding occurs naturally, it is likely that sliding is the circular sliding. The gentler the slope gradient is, the more unlikely the circular sliding occurs.

The shear strength (τ) of the sliding surface when the circular sliding occurs can be expressed by the adhesive force (C),the internal friction angle (ϕ) and the constraining pressure (σ),those of which are the property of the soil, at the point as follows, The larger C& ϕ as a soil characteristics are, the stronger the shear strength becomes.

$$\tau = C + \sigma \tan (\phi)$$



2) In order to suppress penetration, it is better for embankment material to include as much clay as possible which has low permeability. However, it is better that embankment material includes proper sand from the stand point of workability. Because the higher the density of soil is, not only the larger the shear strength of soil is, but also the lower the permeability is. Therefore the compaction in order to remove the air and water is effective. For these reasons, it is appropriate for the embankment material to be appropriately mixed components of various particle sizes such as clay content and sand content.

3) However, The ground in Bangladesh consists of the fine soil mainly composed of silt, it is difficult for construction of embankment to use the soil which the various sizes of soil are mixed properly. In the case where proper soil for embankment soil can't be obtained, the countermeasure to make up for its weakness is needed. In the case that the embankment is made of clayey soil, the surface of embankment is desirable to be covered by another proper soil or the vegetation because cohesive soil is vulnerable against sunshine and rainfall. On the other hand, in the case that embankment is made of sandy soil or sand, the surface of the embankment is desirable to be covered by clay which is impermeable and by vegetation on such a clayey soil.

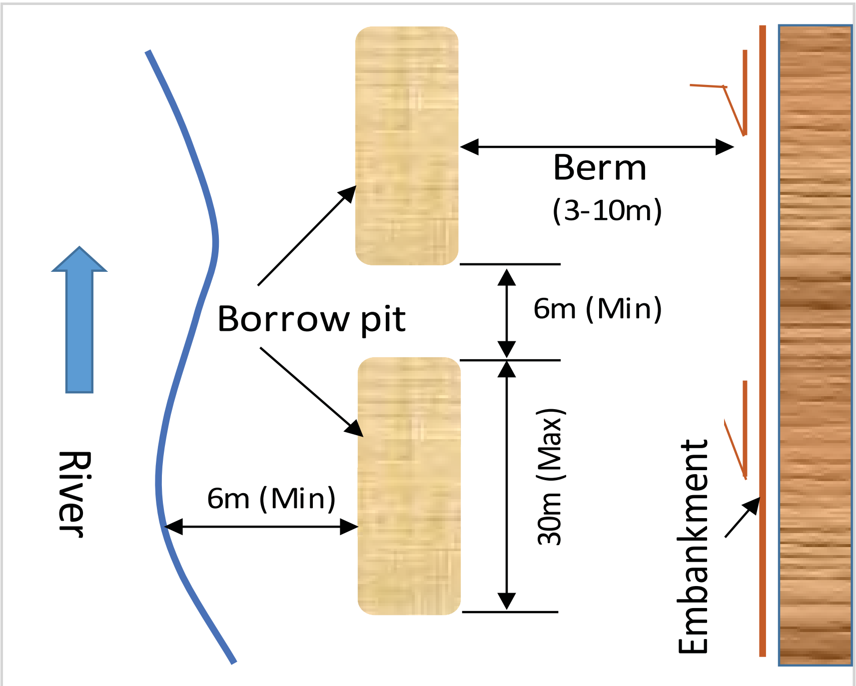
4) Because a large amount of earth and sand is needed to construct long embankment, the borrow pits are set up on the set-back neighboring to the construction site of

embankment. In the case where a large amount of soil is obtained by excavating from the place on the set-back where is parallel to the embankment.

The following attentions are to be needed, because there is the concern that the embankment is scoured by the river flow which is increased by deepening of water depth in front of embankment.

a. The borrow pit should be kept a certain distance from the embankment

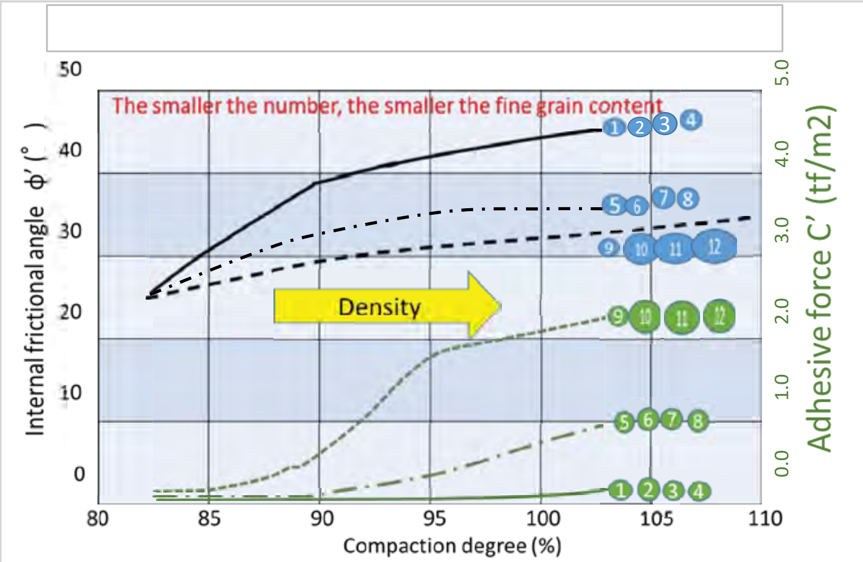
b. The partition wall should be provided in each borrow pit at a certain distance.



(3) Compaction of embankment

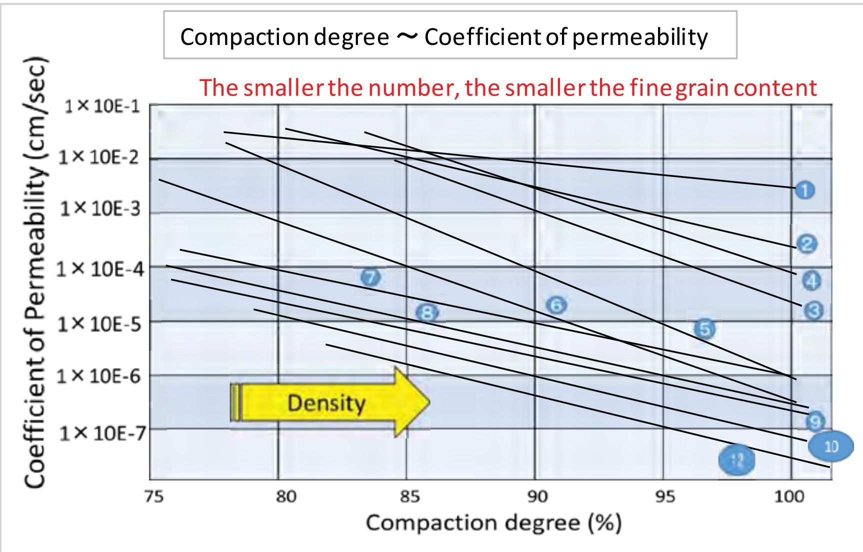
1) The following figure shows the relation between the compaction degree and internal friction angle (ϕ ’), adhesive force (C’.) The number is the number of the test piece, the smaller the number is, the lower the content of the fine-grained soil (Clay or Silt) is and the more the sand content is.

According to this result, the higher the degree of compaction is, the larger ϕ and C is, this means the shear strength becomes higher.



2) The following figure shows that the relation between the coefficient of permeability and the degree of compaction. The smaller the number of the test piece is, the more the content of the fine grained soil is and the less the sand content is. From this result, the higher the degree of compaction is, the lower the coefficient of permeability is.

That is to say, this figure shows that it is more difficult for the soil which contains much fine grained soil to make the coefficient of permeability lower by compaction.



3) 1),2) above means that compaction of soil is effective not only to enhance the shear strength but also to lower the permeability when piling up the earth of embankment. However, if the soil which contains much clay is used for materials of embankment to lower the permeability, it becomes hard to heighten the degree of compaction. Therefore, the material of embankment should be generally the materials that clay

and sand are mixed properly.

5. Embankment breeches and Embankment Design

The factors of embankment breaches are categorized to the following 5 types.

1) Embankment breach by the overflow
2) Embankment breach by permeation of river water and rainfall
3) Embankment breach by erosion of slope
4) Embankment breach by deterioration of strength of ground foundation with the erosion of set back
5) Embankment breach by subsidence beneath of the base and crevice of the sides of the river crossing structure (Sluice Gate etc.).

5.1 Embankment breaches by over flow

(1) Overflow by the flood which exceeds the design Flood Water Level

1) How is the design discharge decided?

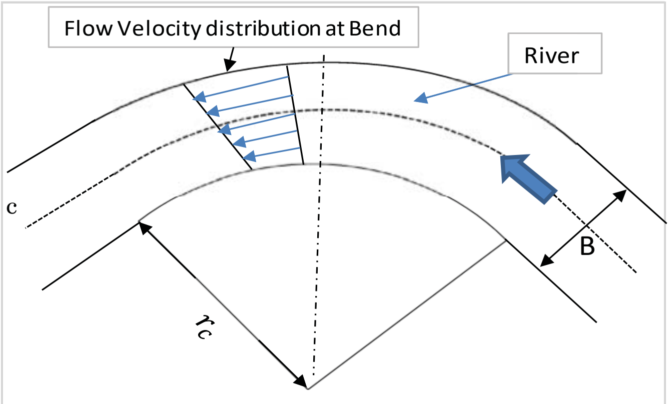
The higher embankment can prevent from overflow, however since the amount of soil in case of construction of the embankment with high crest level increases with the square of the height, making a high embankment will cause a significant increase in cost.

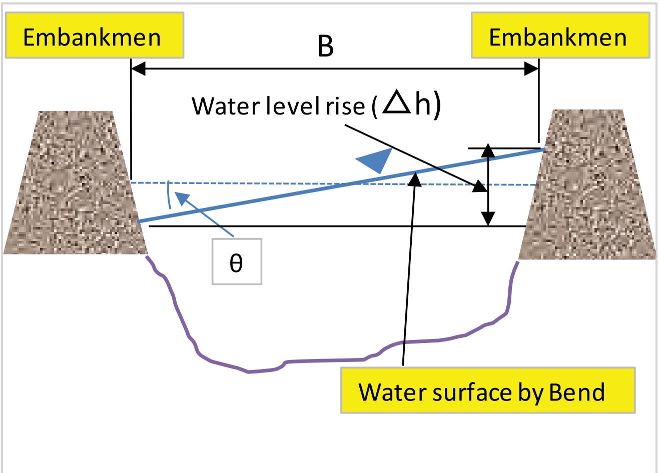
Therefore, the height of embankment is designed by the Design Flood Water Level which is figured out of based on the tolerable frequency of flood.

The flood which occurs once in 20 years is called "20-year probability flood", the flood which occurs once in 100 years is called "100-year probability flood", the Design Flood Water Level which is represented by frequency scale is decided based on the important level of the defensive areas etc.

2) Water level rise at the outer bank due to bend of river

Since water level rises at the outer bank of the bend of meandering river due to centrifugal force, it is necessary to take this into consideration in the Design Flood Water Level. The rise in the water level on the outer bank is obtained by the following equation with the balance between gravity and centrifugal force.





$$\Delta h = \frac{B \cdot v^2}{g \cdot r_c}$$

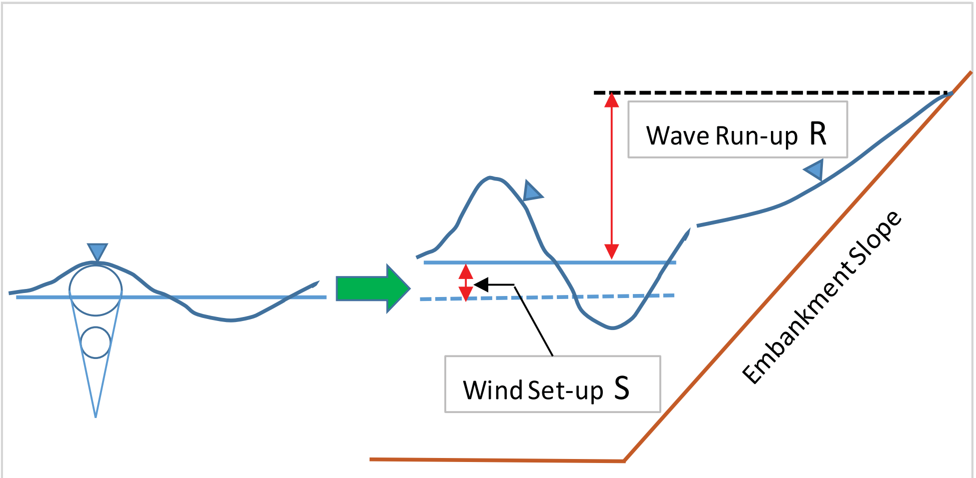
3) Additional water level to Design Flood Water Level (Free Board)

Since embankment is generally made of soil because of cost effectiveness and easy reparation, it is extremely vulnerable against overflow. In actual rivers, because the temporary water level fluctuation due to the fluctuation on the river bed, the wind set up which is the water level rise induced by the wind and the wave run up on the slope of embankment occur in the case that there is a broad water area in front of the embankment, the crest height of embankment should be decided not only by adding such water level rises but also in consideration with the safety of the embankment against flowing down objects driftwoods and the safety of patrol the time of floods, the height which should be added to the Design Flood Water Level is called “Free Board”

4) Water level rise by Wind Wave

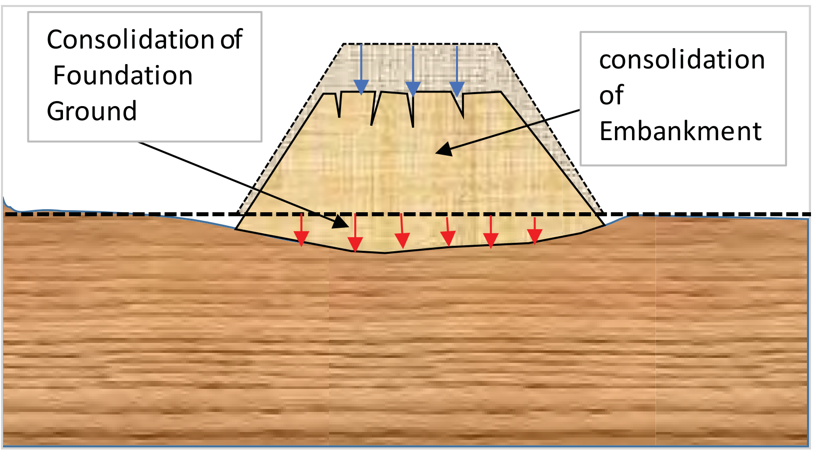
Wave is caused by wind which blows on a sufficiently broad water area (including large rivers). The development of wind waves is influenced by the speed of the wind blowing on the surface of the water, its duration time and the blowing distance. The higher the wind speed is, the longer the duration time and the blowing distance are, the wave height of wind waves is generally larger and the cycle becomes longer.

Accordingly, the larger wave possibly occurs in the broader water area. However, Waves cannot develop infinitely even if the water area is wide enough. As the rate of progression of wave approaches the wind speed, the rate of absorbing energy from the wind decreases, hardly develops and approaches one saturation state.

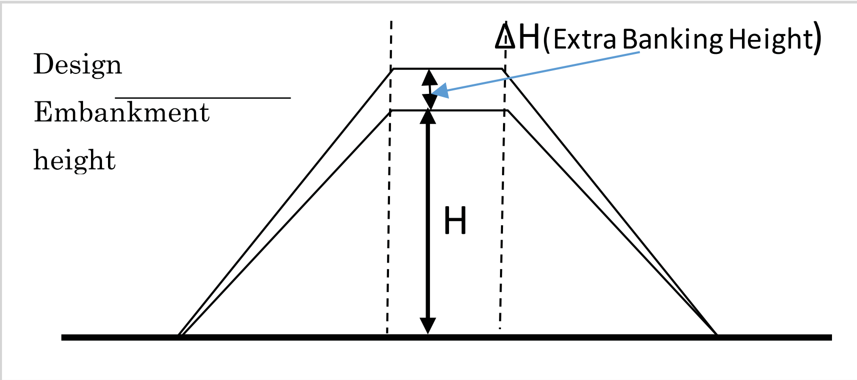


(2) Embankment consolidation and subsidence by consolidation of foundation ground

1) Because the embankment is made of soil, the compression of embankment occurs after banking. In addition, if the foundation ground is clayey soil and the weight of the embankment is loaded on it, resulting in consolidation subsidence over a long period of time. Especially in the case that the foundation ground is soft ground, the consolidation subsidence amount becomes large.



2) Therefore, when constructing embankment, extra banking in consideration with the estimated future subsidence of foundation ground should be implemented.



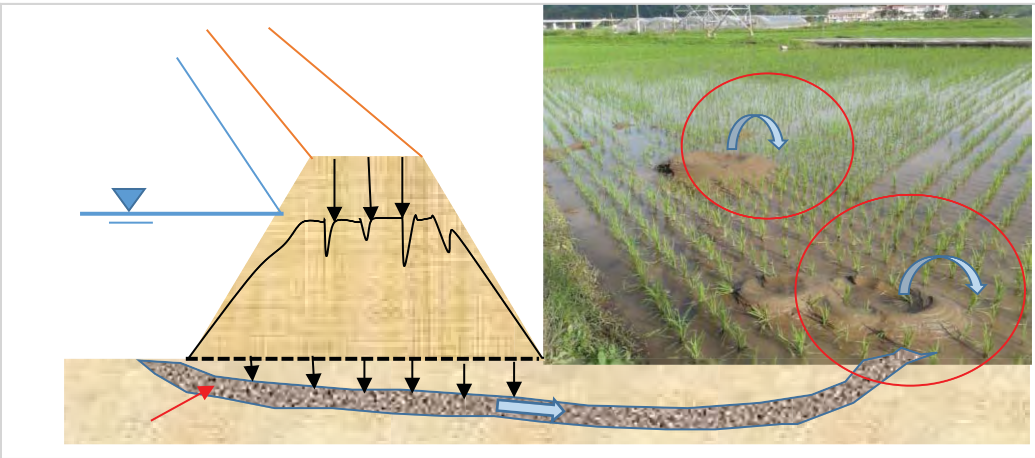
3) Consolidation subsidence amount of foundation ground can be estimated by calculation. In addition, the table by which the extra banking amount embankment height can be easily obtained is prepared in Japan.

Embankment body soil type		Extra Banking Height (cm)			
		Normal soil		Sandy soil	
Ground soil quality		Normal soil	Sandy soil	Normal soil	Sandy soil
Average embankment height	~3m	20	15	15	10
	3~5m	30	25	25	20
	5~7m	40	35	35	30

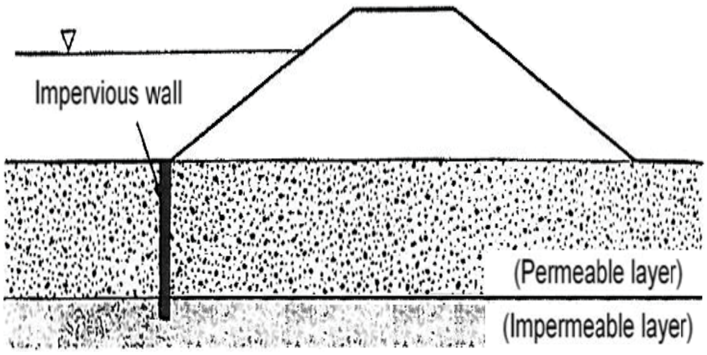
(3) Washout of ground soil by seepage water

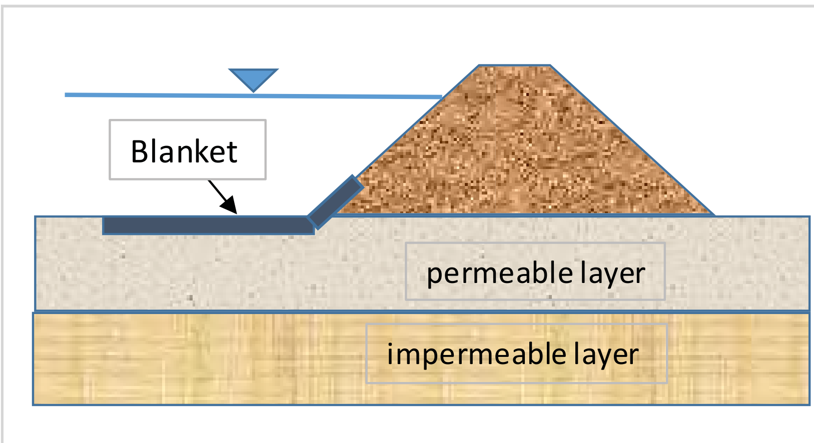
1) When the embankment is made of low permeable soil but foundation ground is consist of sandy soil, there are some cases that seepage water washes out of the ground at land side by the water pressure due to the river water rise in the flood time. It leads to the subsidence of the embankment.

2) The following picture shows the hole spouting sand emerged at the rice field behind the embankment after flooding. In the case that such hole was found, it must be the evidence that the holes can be made by the spouting of sand caused by seepage water in the foundation ground.



3) There are two types of countermeasures. One is the method of shielding the permeable layer of the foundation ground by implementing the impervious wall in the ground, the other is the method of decreasing the water pressure by extending “penetration pass length” by providing impermeable cover layer on the set back in front of the embankment.

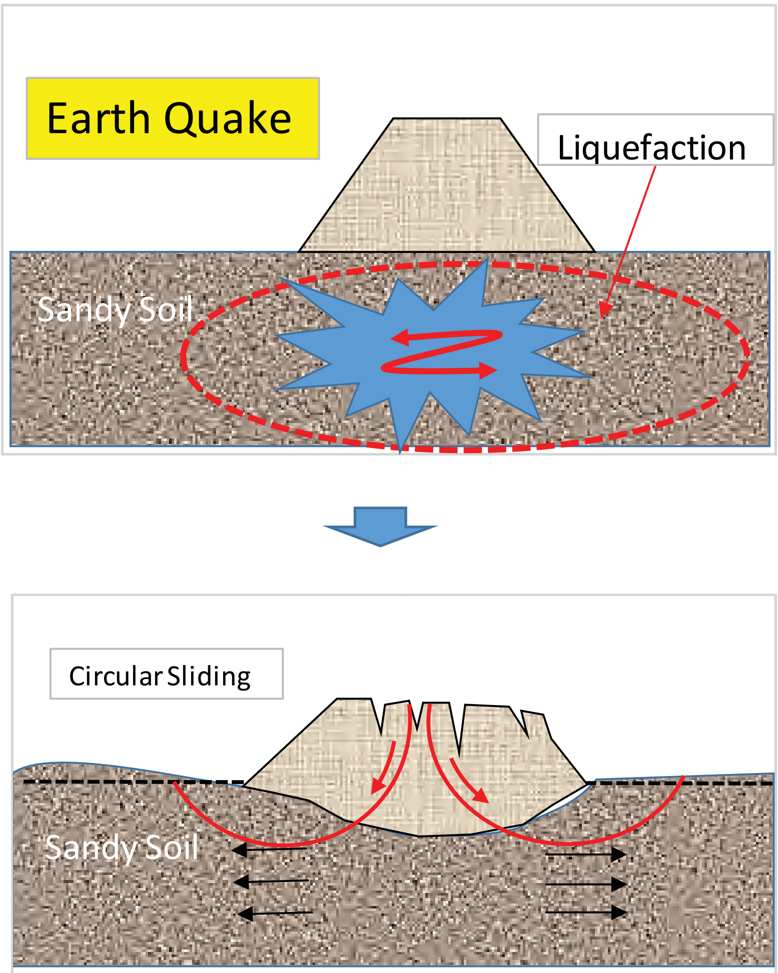




(4) Liquefaction of ground by earthquake

1) In the case that the foundation ground (20m layer beneath the embankment) is made of sandy soil, there is a possibility that the foundation ground subsides due to the liquefaction by the vibration of earthquake.

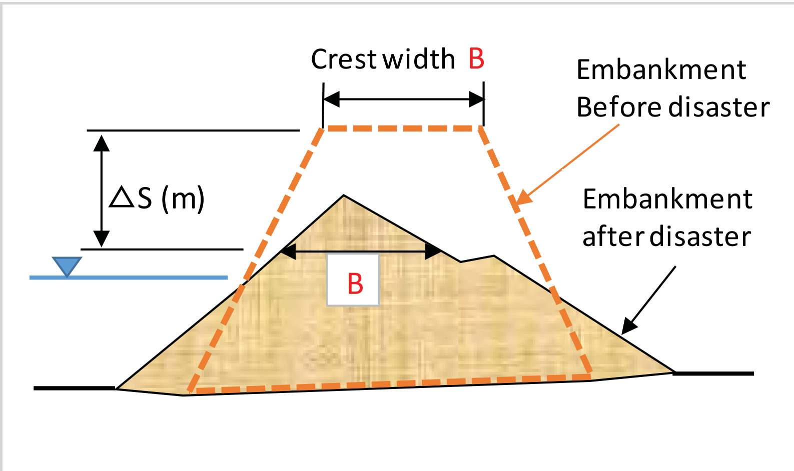
2) The liquefaction phenomenon is a phenomenon in which sandy ground with high groundwater level becomes liquid form by vibration at the time of an earthquake, which lowers the bearing capacity of the foundation ground, circular sliding including the foundation part occurs. It leads to the embankment subsidence. For this reason, a secondary disaster due to overflow of river water is assumed in low land areas.

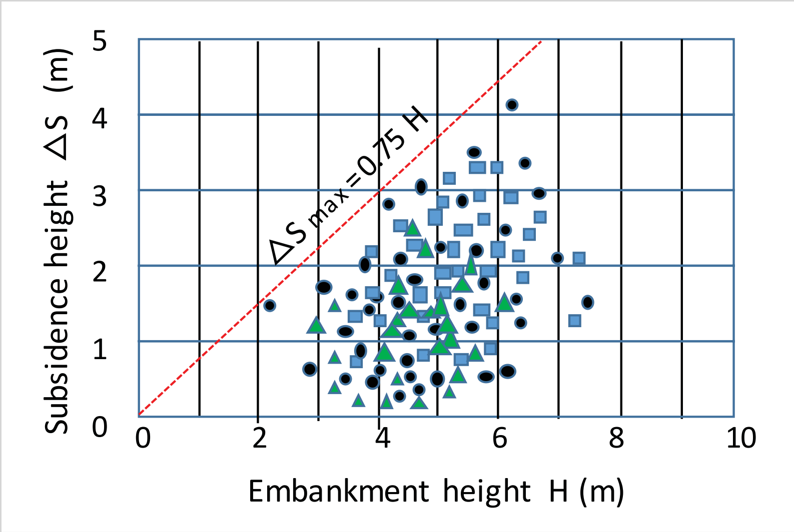


The embankment collapse by the liquefaction in the foundation ground

Photo; 1995, The Yodo River in Hyogo prefecture of the west area in Japan

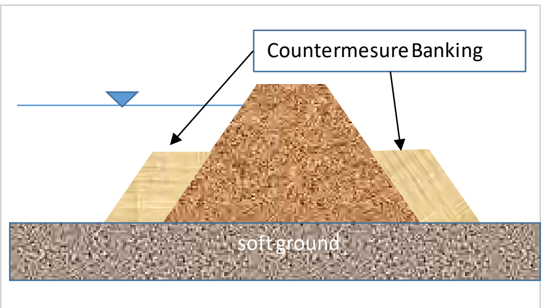
3) The following figure shows the relation between subsidence height and embankment height. According to this, the maximum subsidence height of the embankment is less than 75% of the previous embankment height.

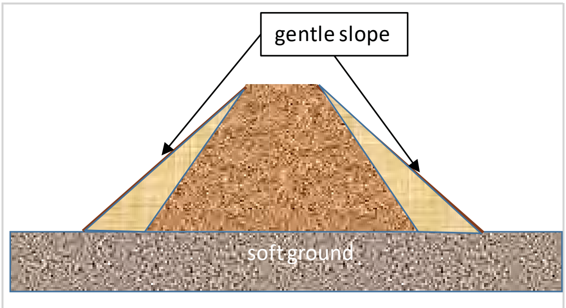




4) Bangladesh is located at the most downstream end of the large river, it means not only that the overall land area of Bangladesh is the low land, but also that the water level of river is kept to be high for a long time at the flood time. Therefore, attention should be paid because the embankment subsidence is likely to cause a large disaster.

5) There are some countermeasures against earthquake, one of which is the way to provide the banking at the both sides of embankment and the other is the way to constrain the occurrence of the circular sliding by making the slope of embankments gentler. In the important river damaged in Japan, the method of driving the steel piles to the bottom of the liquefaction layer at the end of slope of the both sides of embankment was also taken.

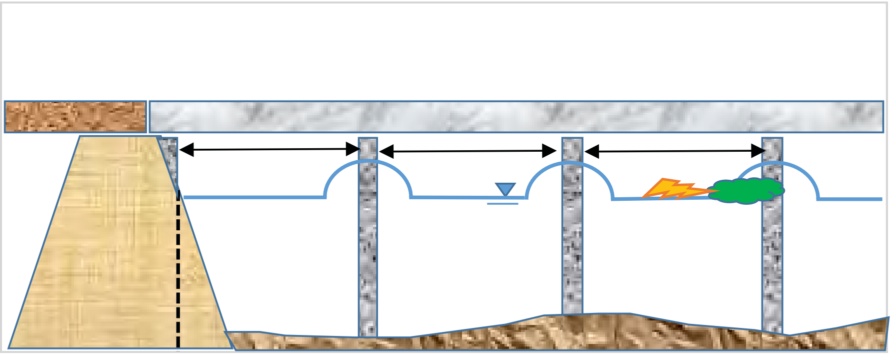




(5) Local water level rise by the river crossing structure such as bridge

The piers of the bridge constructed across the river are the large obstacle against the river flow and make a local water rise at the time of floods. When the interval between the abutment and the pier, or between the piers, is narrow, the flowing down objects from the upper stream are obstructed and accumulate. As a result, the river water level rises due to the obstruction of the flowing cross section.

Therefore, the location of the pier should be kept adequate distance from the abutment and the other piers.



5.2 Damage to the embankment by permeation of river water and rainfall

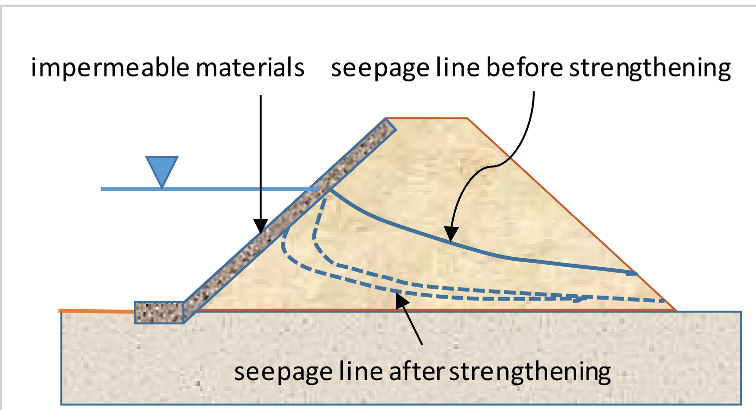
(1) Circular sliding and piping by seepage flow

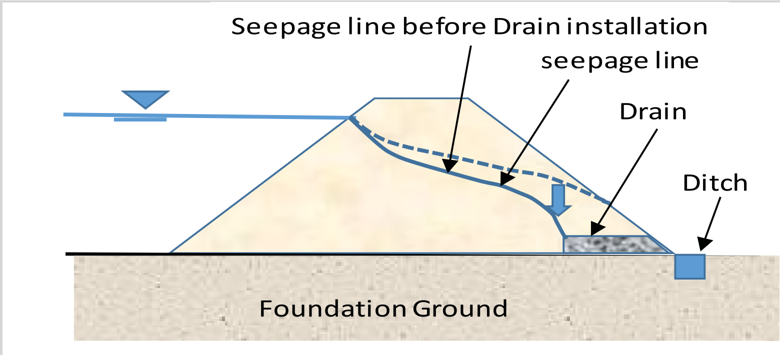
1) Damage to the embankment by permeation into the embankment body of river water or rainfall at the time of flooding is caused by circular sliding due to reducing the apparent strength of embankment soil caused by increasing the pore water pressure in the embankment soil.

2) The other type of damage to embankment by permeation into the embankment body of river water or rainfall at the time of flooding is caused by seepage of embankment soil out of the embankment slope on the land side, generally called “piping” caused by seepage surface rising.

The countermeasure against piping is the method in which the surface of embankment is covered by low permeable layer such as clay, or filter drain is provided at the down end of embankment slope on the land side to drain permeated water out of embankment body and to lower the seepage surface.

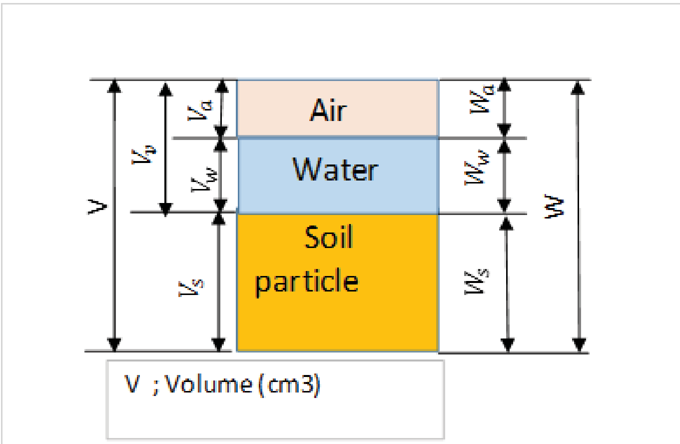
..

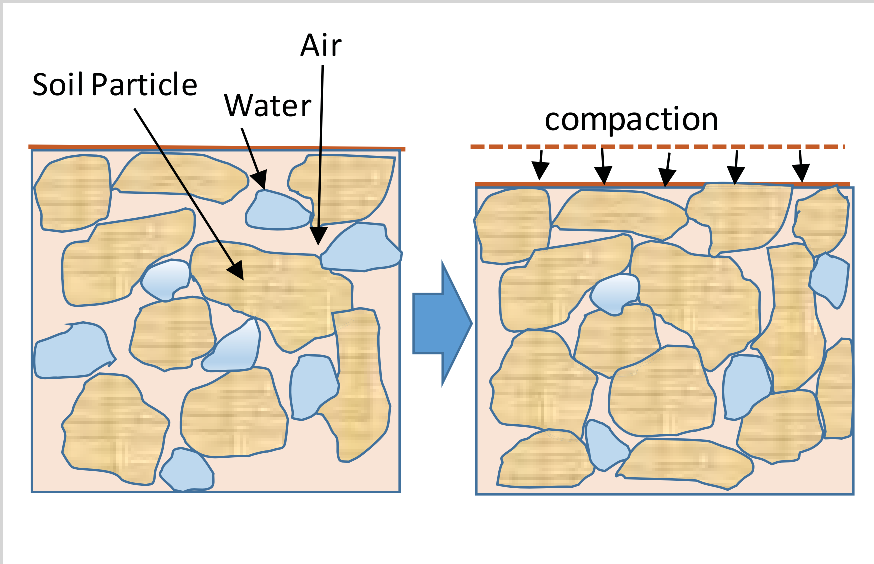




(2) Circular sliding by permeation of river water and rainfall

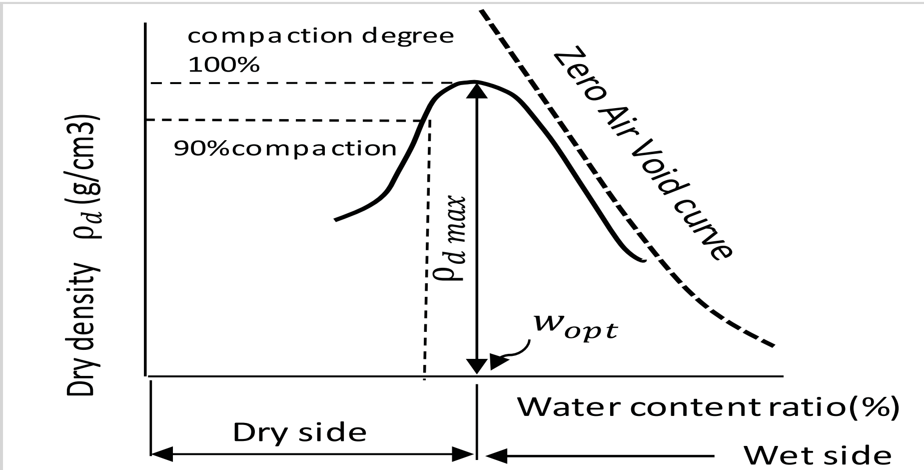
1) Soil consists of three elements which are soil, water and air existing between soil particles. The characteristics of soil such as deformation and shear strength are influenced by the mixture ratio of 3 elements.





2) The following figure shows that the relation between dry density and water ratio. By this figure, it is understandable that the dry density of the soil becomes the largest at the condition of some water content ratio (water content ratio; water weight contained in relation to the weight of the soil particle in a certain volume).

The soil with this condition has strong durability against water permeance even if compaction condition change.



3) Because the soil of the embankment which has been filled contains large amount of air and water besides soil particle, and in this state those of which make the apparent strength (adhesive strength, internal friction force) of soil lower together with the water which is permeated into the voids of soil particles, it could cause circular sliding of embankment.

4) Because river embankment is desired to be kept the state at the maximum dry density and the optimum moisture content, it is needed to implement the compaction

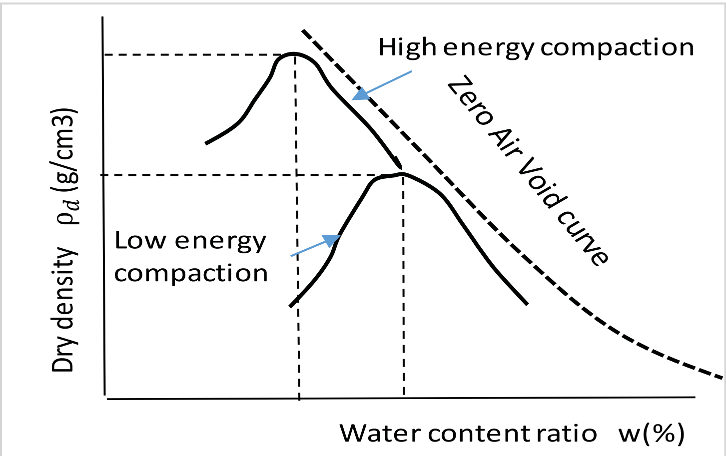
(to push out the air and the water in the embankment soil) for increasing the embankment shear strength.

5) In the case of river embankment construction, 90% as an average value and 80% as a lower limit value for the degree of compaction are generally used.

Reference; degree of compaction;

The actual soil particle density against maximum dry density.

6) The following figure shows the relation between the soil density and water content ratio in the case of compaction with larger force and the case of compaction with small force. Even with the same soil materials, the soil compacted with a large external force has less water and the density tends to be higher (the compaction curve is displayed from the lower right to the upper left).



Reference; Zero air void curve;

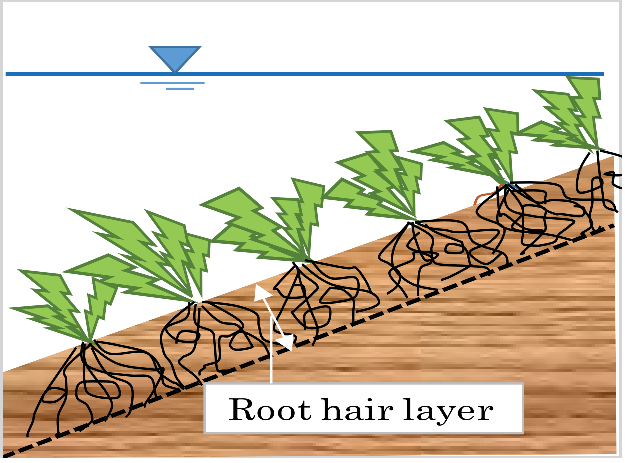
The curve which shows the soil dry density and water content ratio in the case that there is no void because the void of soil is completely filled with water.

5.3 Erosion in slope of embankment

(1) Covering on slope by Vegetation

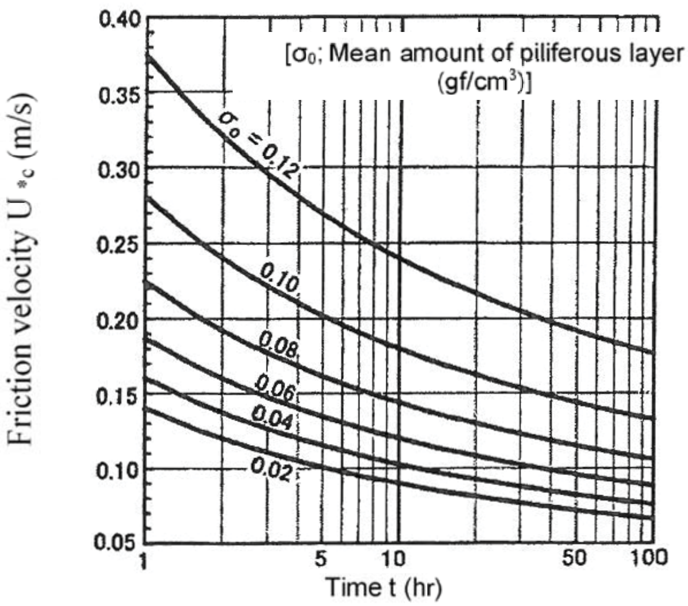
1) The river embankment slope in general should be covered by vegetation such as lawn to protect from erosion by river flow and rainfall.

In the case of vegetation with not so high stem, the main part which plays a role of anti-erosion against water flow is the root hair layer. The root hair layer which is exposed from soil by erosion of water flow can reduce the sweep flow strength.



2) The more the root hair amount near the embankment slope is, the higher the anti- erosion strength becomes. The following figure shows the relation between the sweeping strength (Friction Velocity; U_{*G}) and the endurance time (t) by the mean amount of root (piliferous) layer hair (σ_0) in the case that allowable erosion depth is 2cm The more the root hair amount near the embankment slope is, the higher the anti- erosion becomes.

Therefore, it is clear that the vegetation with more root hair on the embankment slope is more appropriate.



3) In addition, "lawn grass" which is a perennial grass of Gramineae is suitable as a vegetation of embankment because the root density does not wither because it grows and spreads "root hair" in shallow layers without roots deeply entering. Furthermore, although grass grows by growing and broadens the root, it is important to mow lawn

grass. If not, lawn grass will be expelled out by the weeds like annual grass.

4) Although the embankment slope is generally covered by vegetation, the slope on the river side is sometimes covered by concrete blocks from the stand point of anti-erosion against water flow. According to the experiment which is implemented by the Public Works Research Institute in Japan, vegetation covering is useful against river flow of less than about 2m/s.

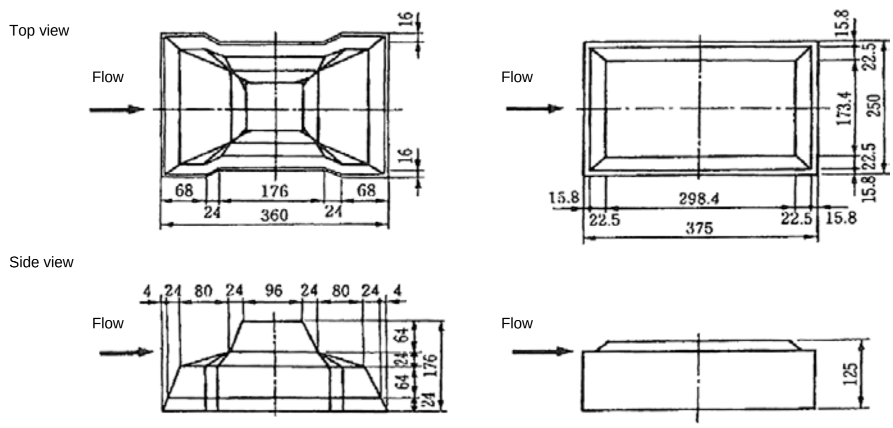
(2) Covering of slope by Concrete Blocks

1) Placing parts of slope protection blocks

The river gradients in Bangladesh are gentle in general. However, the flow velocity of the big rivers with deeper water depth is rapid in proportion to water depth, furthermore, slope erosion is likely to be caused at the outer bank of meandering small rivers by acceleration due to the bend and the secondary flow. In such case, the concrete block should be placed as a slope covering.

2) Slope protection blocks with projection

If the slope protection blocks with no projection are placed in some reach, the flow velocity becomes faster in the reach than the other reaches because of the less roughness degree. It results in the occurrence of erosion on the embankment at the downstream side of the reach where the slope protection blocks with no projection are placed. Therefore, the slope protection blocks should be the blocks with projection to prevent from the occurrence of the gaps of roughness degree between the block placed in the reach and the upstream and downstream embankment.



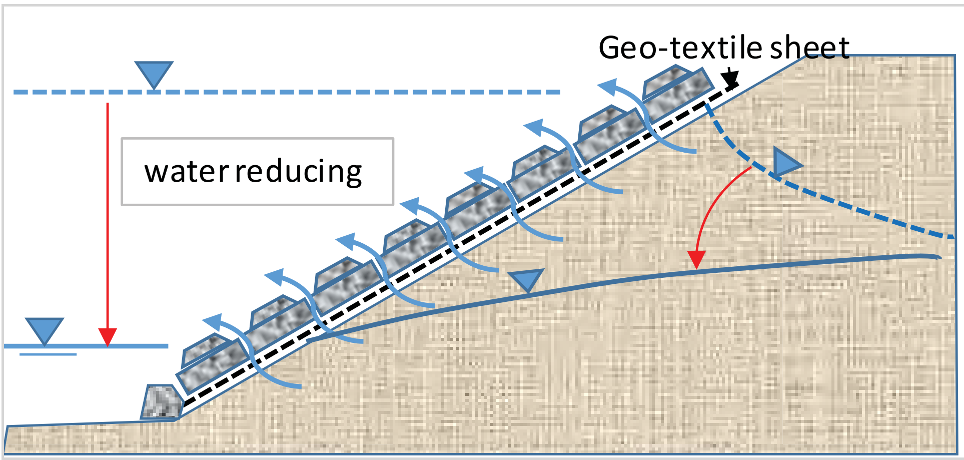
Block A Block B
Standard Drawing of Block

Manufacture of C.C. block with projection at Pilot Project site in Moulbvibazar

Placing of C.C. block with projection at Pilot Project site in Moulbvibazar

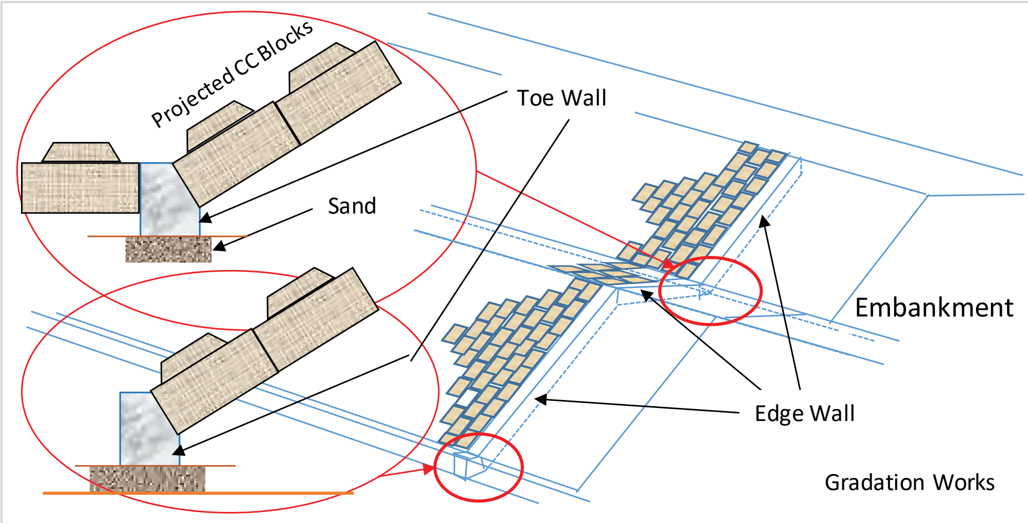
3) Block placement with open joint

Because the water which permeated into the embankment during the flood is likely to remain in the embankment as a residual water even after the river water level drops sharply at the end stage of flood, it can weaken the embankment and cause the circular sliding of embankment slope on the river side. Therefore, for discharging the residual water, the sediment discharge preventive works such as the geo-textile should be provided underneath the slope protection block, and the slope protection blocks should not be connected by cement each other.



4) Toe wall (Foundation work for slope protection blocks)

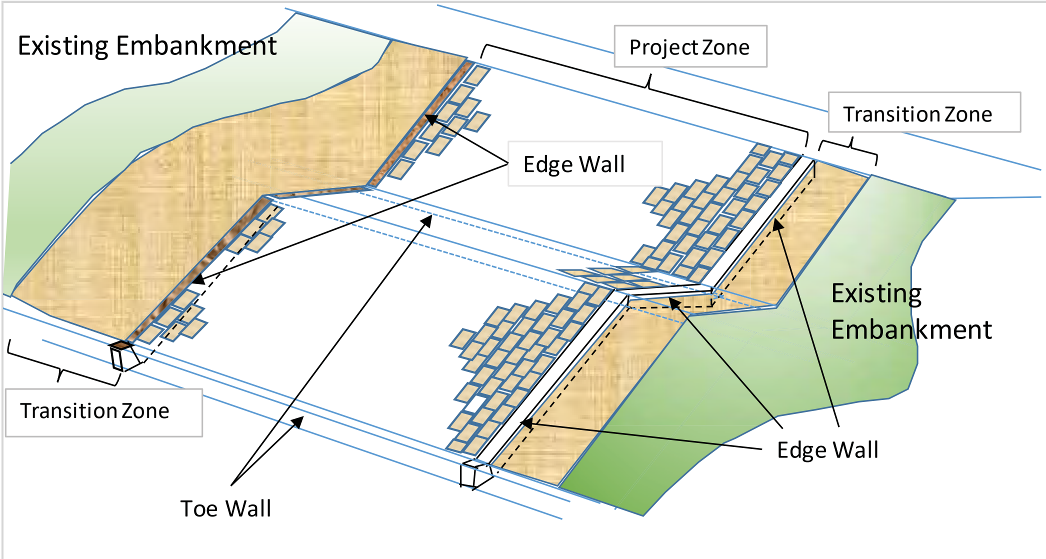
The slope protection block placed as a countermeasure against the erosion on the slope is designed to stabilize against the flow by the bottom friction between block and the embankment surface. However, it is concern that slope protection blocks could slip down due to the fluctuation of the river flow partially, the toe wall should be provided at the down end of the slope protection blocks not only to support the slope protection blocks and prevent from sliding, but also to protect the foundation from erosion and prevent embankment materials discharge. In the case that there is not sufficient set back distance, the height of the toe wall is decided in consideration with the deepest river bed height of neighboring river bed.



5) Transition zone works and Edge Wall

In case that new embankment and adjacent existing embankment differ in sectional shape, sectional profile in the transition zone between the new and existing embankments should be changed smoothly in order to avoid occurrence of eddies due to sudden change of profile. Moreover, roughness in the transition zone should be also changed smoothly. The slope protection works in the transition zone should be with flexibility and appropriate roughness, such as CC blocks with projection, etc.

In addition, the slope protection work should be provided with the edge walls at the both ends to secure the stability of slope protection blocks against erosion.



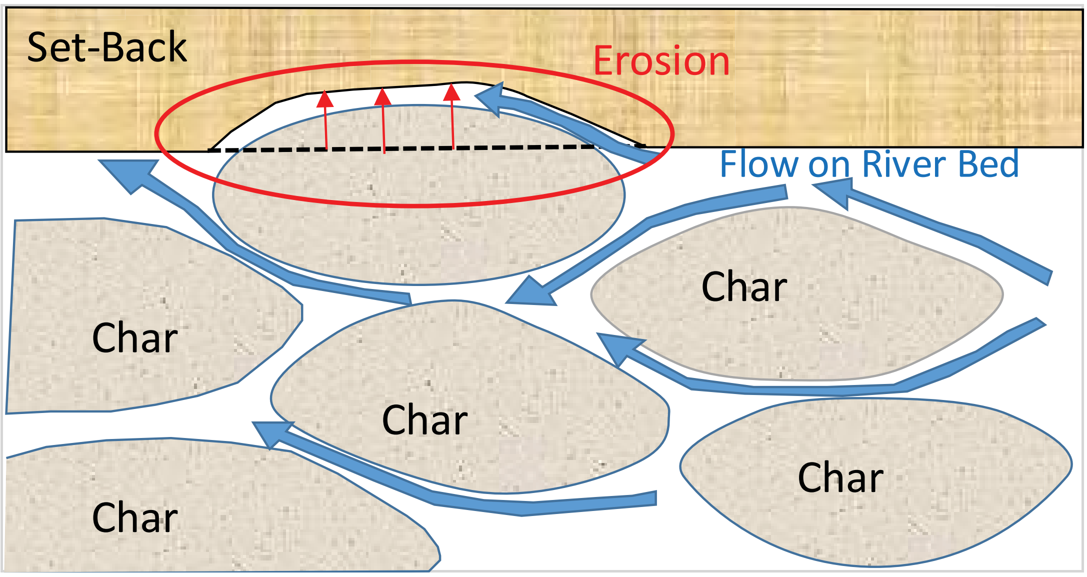
5.4 Erosion of Set back

(1) Erosion mechanism in braided river (The big Rivers)

1) The river beds of the big rivers generally present braided river channel, there are many large sand bars (Char) on the river bed. The erosion of sand bar at the upstream edge and the sediment of soil at the downstream edge are repeated continuously, sand bar apparently looks like to moves toward downstream.

2) Sand bar shows such the shape that the center of which is high and the outer edge parts is low, the rapid flow along the fringe is generated.

3) The erosion of the big rivers is estimated to occur at the place where the outer edge parts touch the set back or the embankment. The erosion force is very enormous, erosion may occur with a width of several hundred meters due to one flood.

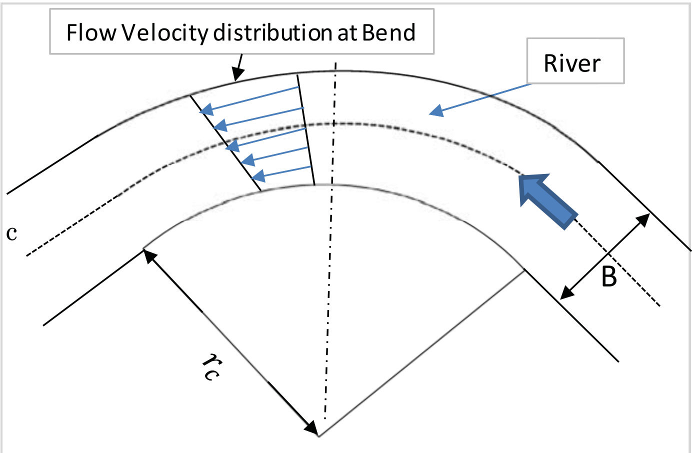


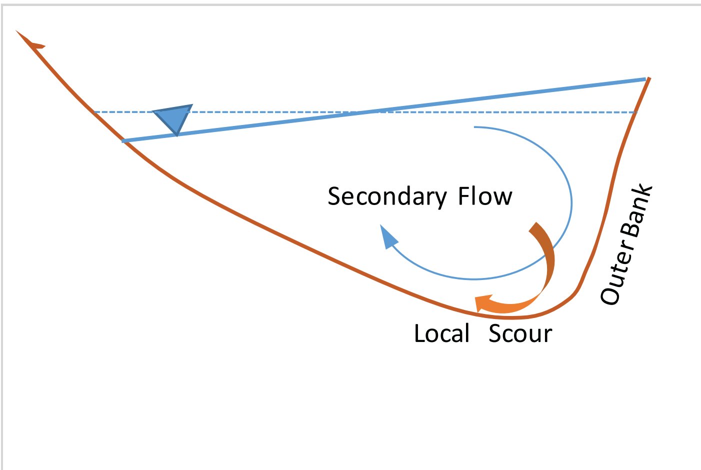
(2) Erosion mechanism in meandering river

1) In general, rivers meander with the passage of time in the low-lying section. Many Flash Flood rivers that have upstream areas in Indian countries and become rapidly gentle riverbed gradients across national boundaries are typical of meandering rivers.

2) In the meandering river, the flow velocity outer bank of the bend part becomes earlier and the flow velocity inside of the bend part becomes slower. In addition, in the curved part, the water level on the outer bank rises and "secondary flow" in the direction perpendicular to the flow (direction crossing the river) occurs and encourages "local scouring" of the embankment foot.

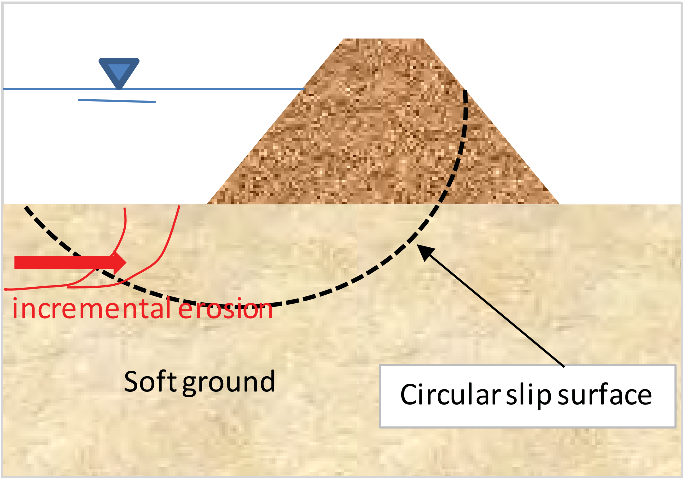
3) Due to such action, large river bank erosion occurs on the outer bank of the bend part of the meandering river.





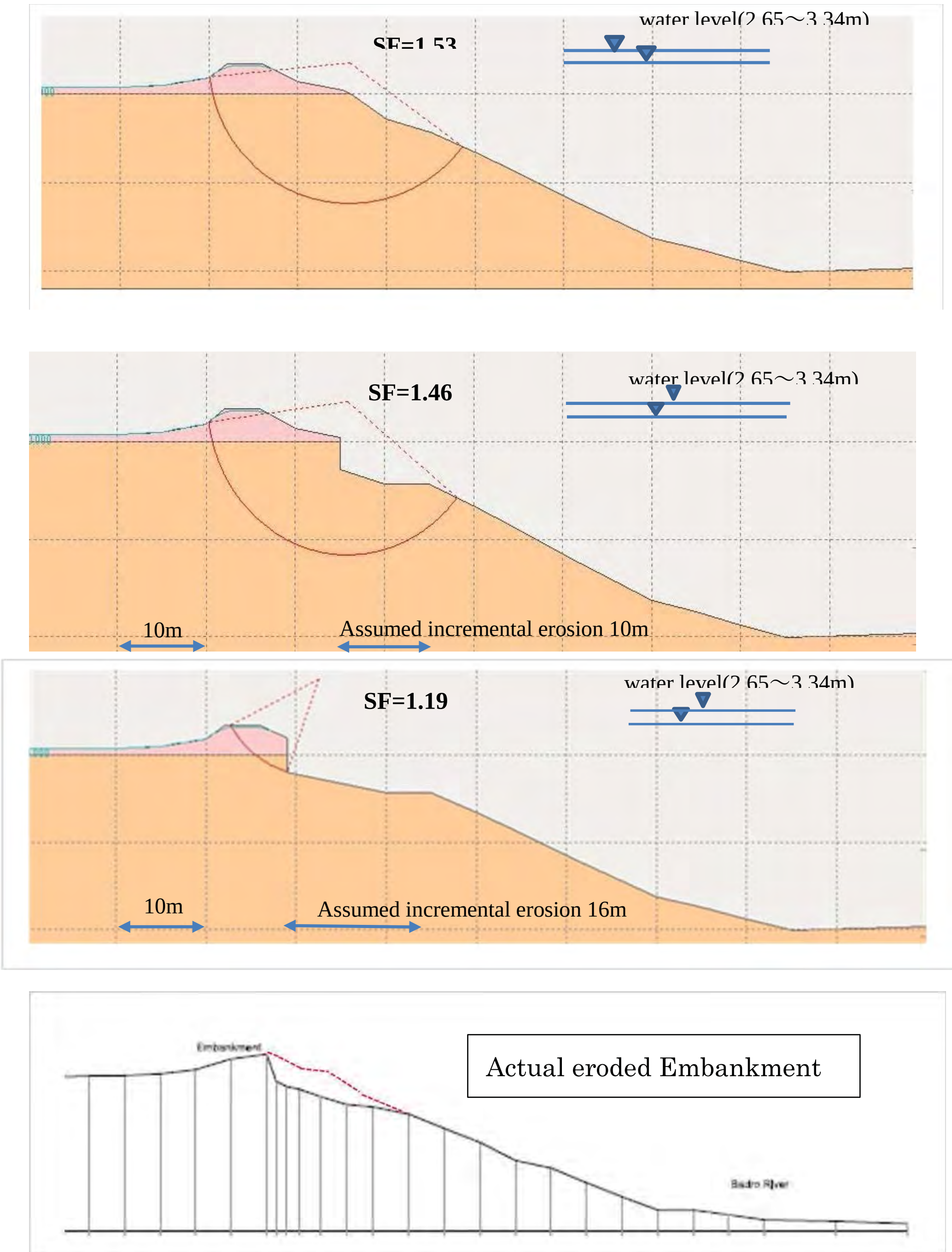
(3) Erosion of Set back and circular sliding

1) As the erosion of river bank progresses and the Set Back distance decreases, the embankment gradually lose stability and eventually collapse due to circular sliding.



2) The following figures shows the simulation result of change of the minimum safety rate of circular sliding of the embankment in Khulna in the case that erosion of set back progresses by 10m,16m.

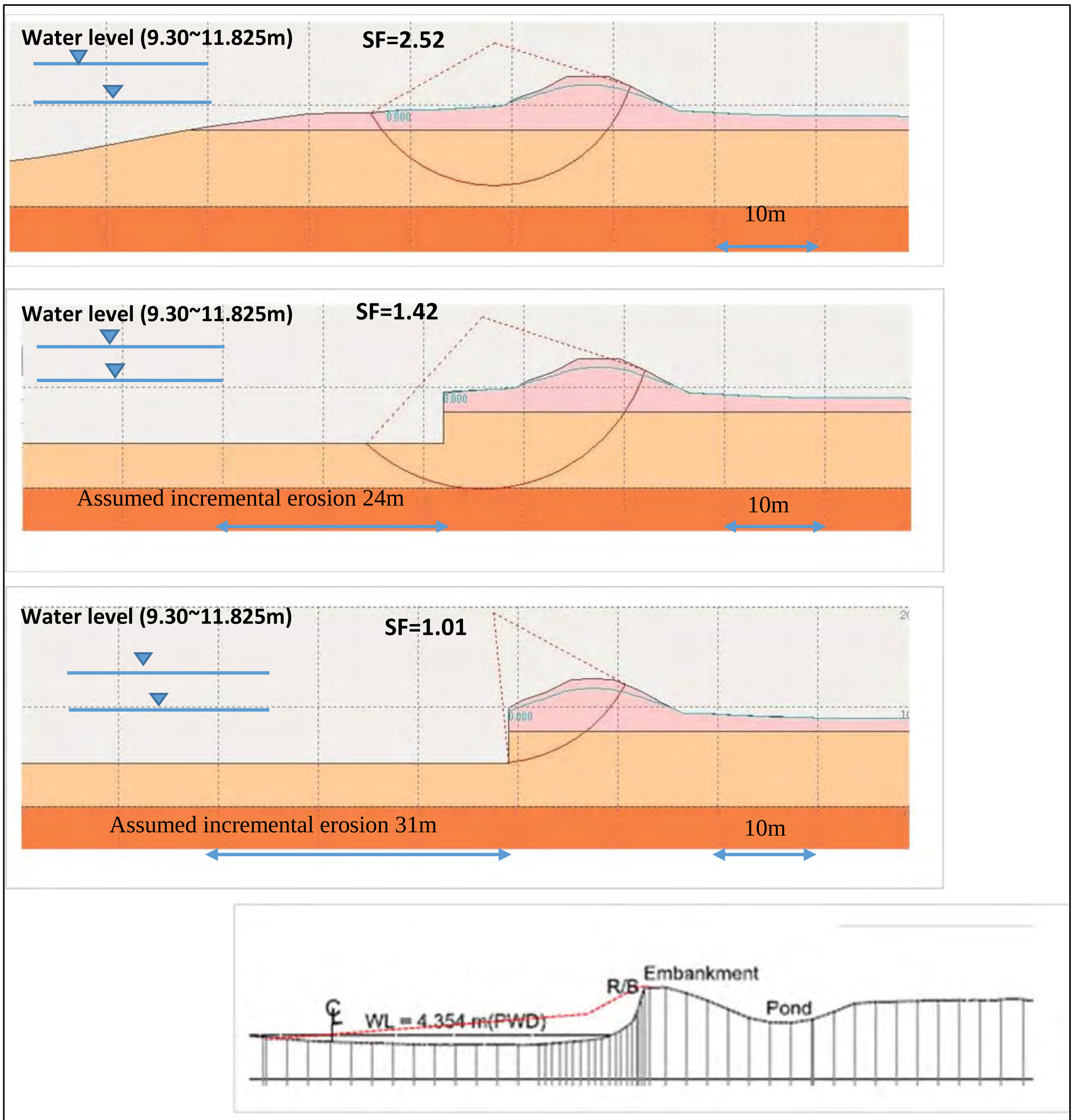
When the erosion width of the river bank has advanced to 16 m, the minimum circular sliding safety factor is 1.19, and it is assumed that the circular sliding safety rate will be close to 1.0 and circular sliding will occur when the erosion further progresses a little further. The situation of embankment of the embankment in this case shows a shape close to the actual sectional shape of the damaged part.



Damaged Part of Embankment at Khulna

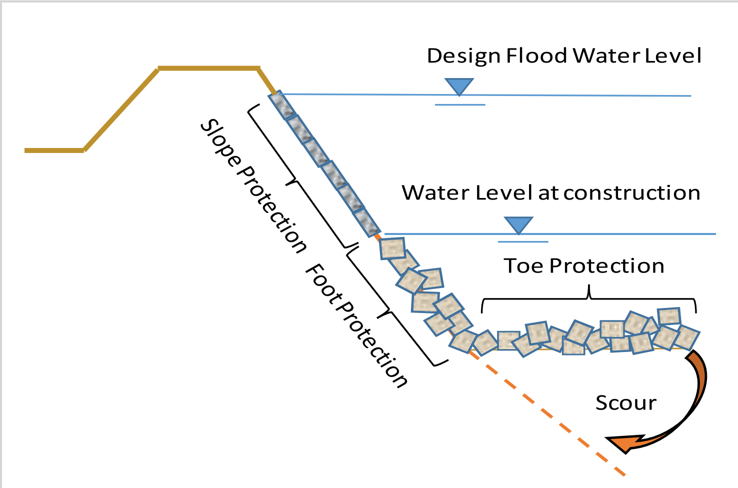
3) Likewise, in the embankment of the Flash Flood River (Moulvibazar), we simulated the minimum circular sliding safety rate when the river bank erosion width was advanced to 24 m and 31 m. As a result, when the river bank erosion width becomes 31 m, the minimum circular sliding safety rate becomes 1.01, and if erosion is further advanced from this, the circular sliding is assumed to occur. The arcuate sliding cross

section of the embankment at this point has a shape close to the sectional shape of the damaged part.



Damaged Part of Embankment at Moulvibazar

4) According to the simulation of the two embankments, it is inferred that circular sliding of embankment including the ground occurred because the bearing capacity of the foundation ground declined due to the erosion of the set back. Since the ground of the country is made of soil mainly composed of fine silt, the bearing capacity of the foundation ground is weak, and the embankment is likely to become unstable unless a certain set back distance is secured.



(4) Countermeasures against erosion

Regarding river erosion measures, there is "Guideline for River Bank Protection" prepared by BWDB in 2010, the design method of river bank erosion countermeasures, erosion protection work are described, it should be referred.

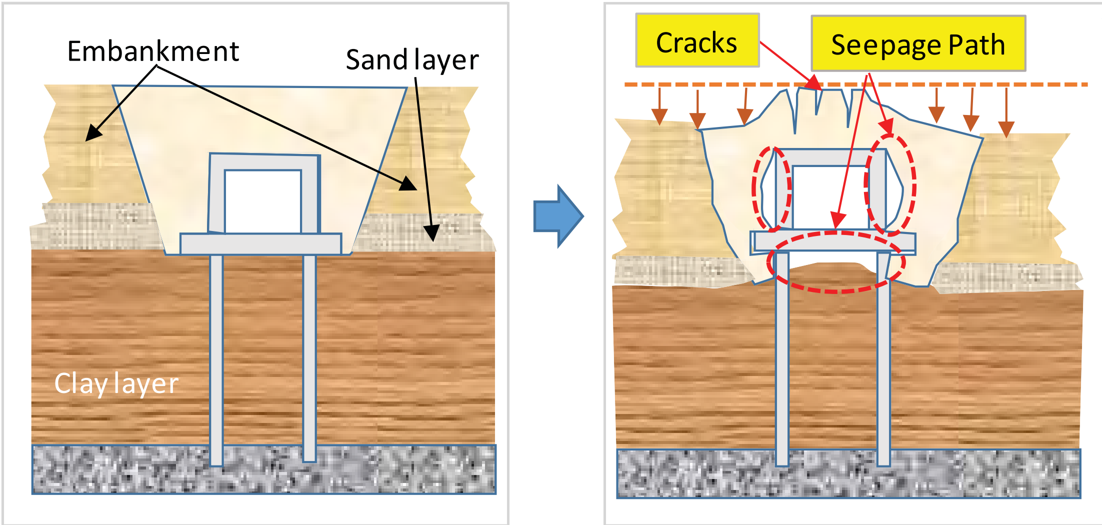
5.5 Erosion from seepage paths around structure crossing embankment (Ex; Sluice Gate)

(1) Occurrence of seepage paths at contact faces and cracks at crest

Sluice gate and Water gate are concrete structure with rigid foundation, support pile foundation is used to prevent from the subsidence of the structures. On the other hand, Embankment is a soil structure, constructed on the ground directly.

For this reason, it is difficult to stably adhere the joint portion of the embankment compactly with the structure for a long period of time. There are likely to be seepage paths at the joint portion and cracks at crest of embankment. Those will be a weakness against flooding.

Particularly in areas where the foundation ground is soft ground, cracks and seepage paths are likely to occur in the embankments around the structure due to uneven settlement of structures and embankments. Those are leading to failures of embankment during flooding.



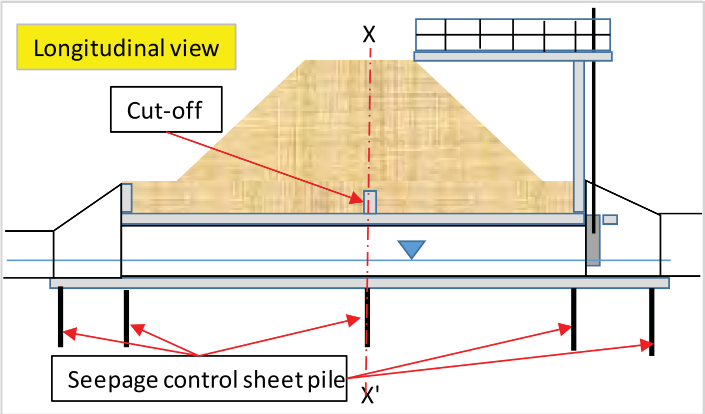
(2) Design of Crossing Structure of Embankment

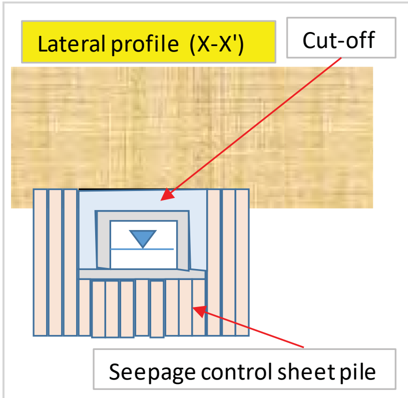
In the junction between embankment and structure, cracks and seepage paths along the structure are likely to be developed due to difference in consolidation between the surrounding embankment and the foundation ground of structure.

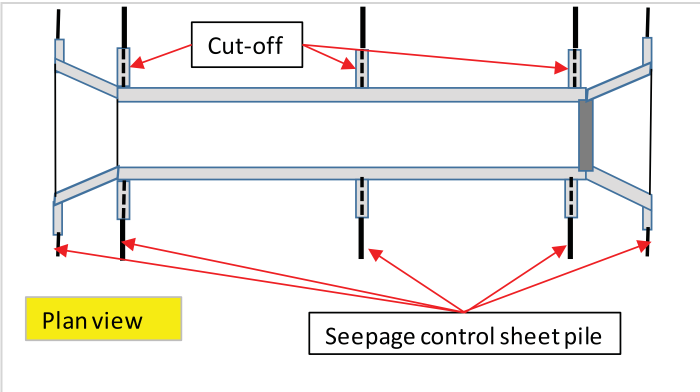
If the seepage flow increases due to development of cracks and seepage paths, the Soil material of embankment and foundation ground will be sucked out, which may lead to collapse of the embankment.

In particular, cracks is easily developed right under the bottom plate of the structure, cracks and loose compaction area inside the backfill soil, and uneven and cracks at the embankment crest.

In order to prevent above "piping", the crossing structure shall be constructed with "cut-off" wall having an appropriate length of 1 m or more in width. The cut-off wall prevents piping phenomena by prolonging the creep length and lowering the osmotic pressure of the structure. In case of wider embankment and longer crossing structure, it is necessary to provide two or more cut-off walls.


Longitudinal view
X
Cut-off
Seepage control sheet pile
X'


Lateral profile (X-X')
Cut-off
Seepage control sheet pile


Cut-off
Plan view
Seepage control sheet pile

Work Shop / Seminar
On
The Project for Capacity Development of Management for Sustainable Water Related Infrastructure

Explanation of Construction Manual (Revision)

After the Pilot Repair Works

13th July, 2017

Johji Koizumi
Project Manager, Pilot Repair Works of Manu River Flood Control Embankment in Moulvibazar District
& a member of JICA Expert Team

1

1. Objective/Application and Revision of Construction Manual

(1) Objective of Construction Manual

- As a document stipulating the construction works of the embankment of BWDB, there are two (2) documents, namely Technical Specification for Civil Work (TS of BWDB) and Standard Schedule of Rates Manual (SSoRM). For practical aspect, TS of BWDB is a part of the contract documents of the civil works of BWDB and SSoRM is utilized for cost estimation including drafting bill of quantities for tendering and contracting of the civil works.

⋆ ***Technical Specification for Civil Work (TS of BWDB)***

⋆ ***Standard Schedule of Rates Manual (SSoRM)***

2

(1) Objective of Construction Manual

- On the TS of BWDB and SSoRM, necessary work items and specifications are described including requirements of qualities of the works for river embankment/revetment works. But the details of the frequencies and procedures for quality control methods and tests are not drafted in the both Standards. Draft of Construction Manual is intended to mainly script the method of construction plan including prior necessary investigations for planning and safety measurements including the prevention for third parties damages. Those are not described in the both Standards.

⋆ ***Detail of Quality Control methods and tests***

⋆ ***Construction planning, incl. Progress Control***

⋆ ***Safety Control measurements***

3

(1) Application of Construction Manual

This Construction Manual supplements to the Technical Specification for Civil Work (TS of BWDB) and

Standard Schedule of Rates Manual (SSoRM) and effects the improvement of river embankment in Bangladesh. The Manual describes and focus on especially for Quality Control, Safety and Progress Management on construction.

The Manual is hoped to assist enhancing the capability regarding construction technique of not only BWDB officials but also other engineers in charge of river embankment construction.

4

(2) Revision based on learning from the Pilot Repair Works

1) Implementation of Pilot Works for proving Manuals

- It was made a Contract as JICA BD Office is procuring entity and selected local company is Contractor. Designing and supervising have been conducted jointly by BWDB and JICA Expert Team. Outline; period 2015.11.25 - 2017.5.23, Contract Price Tk 64.868million, Bank length 233m, Toe Protection with Sand-Cement mortar gunny bag mound & CC-block and Slope Protection by ordinary CC-block & projected CC-block and others.

5

(2) Revision based on learning from the Pilot Repair Works (PRW)

２）Introduction of examples for Quality Control

- Trial Fabrication for S-C motor gunny bag, Trial construction for compaction, Soil test for proposed imported material and Safety event

３）Counter measures for delay of the Works

- The Works was countered unavoidable increase of water level & inclement weather and it was forced to Time Extension.
- By this experience and learning, additional description for Progress Management and the counter measures for Time extension / delay of works.

6

2. Content of Construction Manual

- Preface - Background of Draft of Construction Manual for River Embankment -
- Section 1 Objective of the Construction Manual
- Section 2 Application Scope of the Construction Manual
- Section 3 Usage of the Construction Manual
- **Section 4 Importance of Progress Control**

<Examples of Pilot Repair Works sated in Construction Manual (Revision)

- Chapter 1 General items of Supervision for construction (100 General)
- Section 1.1 Surveys for Existing Condition
- Section 1.3 Progress Control
- 1.3.1 Progress Plan
- **1.3.2 Control for Construction Progress (Example in PRW)**
- Section 1.4 Supervision of Construction

7

2. Content of Construction Manual

- Chapter 2 Preparation & Temporary Works (200 Site Preparation)
- Section 2.1 Surveys & Profile Stake
- Section 2.2 Temporary Access Road
- Section 2.3 Temporary Construction Yards

- Chapter 3 Earth Works (300 Earth Works)
- Section 3.1 General items of Earth Works
- Section 3.2 Excavation
- Section 3.3 Management of embankment material & Transportation

- Section 3.4 Embankment for river bank
- 3.4.6 Trial Construction for compaction **(Example in PRW)**
- Section 3.5 Earth works on Slope
- Section 3.6 Earth works accompanying structure construction

- Chapter 4 Protection Works for river embankment (500 Protective Works)

8

2. Content of Construction Manual

- Section 4.1 Toe protection works
- 4.1.2 Gunny bags (**Trial fabrication for S-C gunny bag**)
- Section 4.2 Slope Protection
- Chapter 5 Safety
- Section 5.1 Safety Prevention Facilities
- Section 5.2 Safety Management
- 5.2.3 Preventing accidents on construction site (**Safety Gather**ing)
- Section 5.3 Flood Prevention
- 5.3.3 Temporary Prevention Measures for Slope (**Example in PRW)**
- Chapter 6 Inspection
- Section 6.1 Inspection for Construction
- 6.1.1 Objective and Notes of Inspection
- 6.1.2 Inspection types

9

3. Record of Pilot Repair Works

(1) Outline

Period 2015.11.25 - 2017.5.23,

Contract Price Tk64.868million,

Bank length 233m, Toe Protection with Sand-Cement mortar gunny bag mound & CC-block and Slope Protection by CC-block with projection part and other

(2) Progress Charts

Initial Progress Chart and Actual executed Progress Chart

(3) Photographs of construction

10

Before

Manu River

23rd February, 2014

11

After

Manu River

25th March, 2017

12

(1) Outline of the Pilot Repair Works

1) Commencement date: 25 November, 2015
Intended Completion Date: Original 15 May, 2016
Extended to 30 May, 2017

2) Contract value; Original= Taka 55,431,843.91-
Revised= Taka 64,868,710.86.-

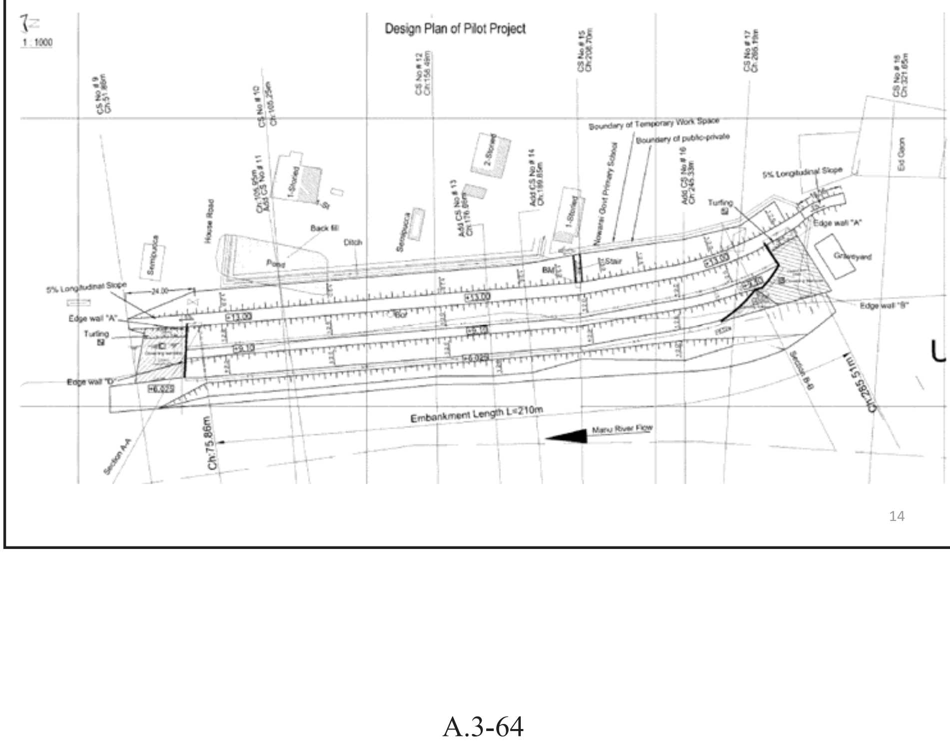
3) Supervising: SV Team consist s of JET and officers from BWDB, O&M Office Moulvibazar

4) Quantities of work items of the Works are shown below summary table;

13

Proposed design plan

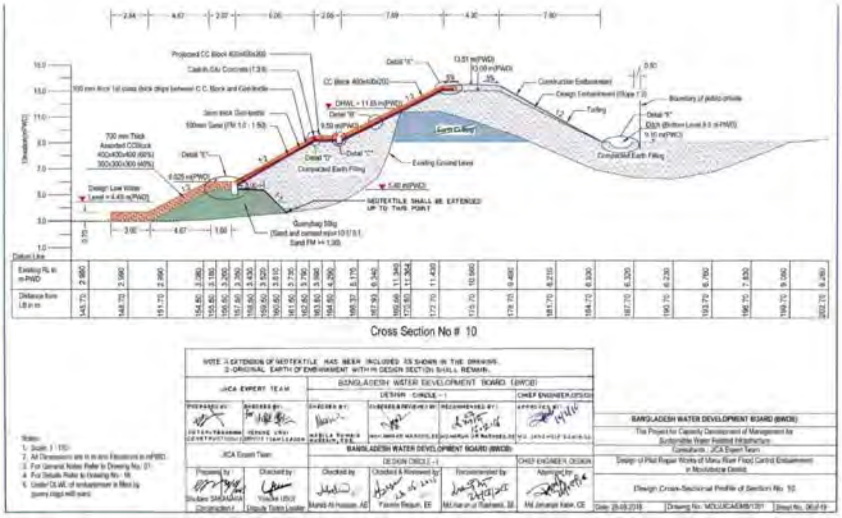
Location of the Works (Final Inspection)



14

Typical Cross Section

Typical cross section of the Works (Final Inspection)



15

Table Draft of Record of Final Measurement of work items in Bill of Quantities

Updated on 2017.05.17
First wrote on 2017.04.14

Item No. of BoQ & Code No. of SSoRM (Standard Specification of Rates Manual) and Outline of description of work item			Configured Unit Price of the Contract & design/amended/executed quantities in the BoQ					Contract Amount (BDT)			
BoQ Item no.	SSoRM Item Code (if any)	Outline of description for work Item	Measure-mint Unit	Quantities: Original Design / Contract	Quantities: Amended Q'ty after Variation 5	Quantities: Executed Q'ty after Final Measurement	Contract Unite Price (BDT)	Original Contract Amount (.=5a*6)	Amended Amount after VO-5 (.=5b*6)	Proposed Final Contract Amount (.=5c*6)	Remarks
1	2	3	4	5a	5b	5c	6	7			
		1. Preparatory works									
		Control Survey									
1		Control Survey: providing Bench Mark etc	L/S	1	1	1	23,195.494	23,195.494	23,195.494	23,195.494	
2		Additional sectional survey	No	13	26	24	2,462.291	32,009.783	64,019.566	59,094.984	Variation No.5
3	04-100	Manufacturing and supply RCC boundary pillar	No	18	18	14	907.292	16,331.256	16,331.256	12,702.088	
4	04-110	Fixing posision, boundary pillar	No	18	18	14	43.846	789.228	789.228	613.844	
5		Mobilization and Demobilization	L/S	1	1	1	350,906.188	350,906.188	350,906.188	350,906.188	
		<Item no.1 - 5. 1. Preparatory works Sub-Total >			[illegible]	423,231.949				0.000	446,512.398
		2. Temporary works and Trial construction							0.000	0.000	
6		Temporary Access Road	L/S	1	1	1	588,808.688	588,808.688	588,808.688	588,808.688	
7		Temporary Construction Yards	L/S	1	1	1	350,906.188	350,906.188	350,906.188	350,906.188	
		< Practical Training for Quality Control >						0.000	0.000	0.000	
8		Sampling material from borrow pit	No	2	2	2	23,195.494	46,390.988	46,390.988	46,390.988	
9		Grading test for sample from borrow pit	Each	6	6	4	5,947.563	35,685.378	35,685.378	23,790.252	
10		Labo. test for compaction [ASTM D698]	Each	6	6	4	14,393.101	86,358.606	86,358.606	57,572.404	
11	04-180	Leveling and compaction for trial test area	Sqm	476	476	476	25.256	12,021.856	12,021.856	12,021.856	
12	16-410-10	Trial embankment; Earth work by carried	Cum	366	366	42	264.876	96,944.616	96,944.616	11,124.792	
13		Provide bulldozer (15-18 ton) for trial test	Mon	1	1	1	234,809.768	234,809.768	234,809.768	234,809.768	
14		provide hand roller (800kg-3ton) for trial test	Mon	1	1	1	208,164.688	208,164.688	208,164.688	208,164.688	
15		Measuring water content (Fry pan-method) of trial	No	108	108	21	5,947.563	642,336.804	642,336.804	124,898.823	
16		Field density test by sand replace method of trial	No	54	54	20	14,393.101	777,227.454	777,227.454	287,862.020	
17	specific	CCblock;40*40*20with projection part for trial	No	30	30	30	220.874	6,626.220	6,626.220	6,626.220	
18		Compressive test for concrete as trial	No	6	6	6	1,784.269	10,705.614	10,705.614	10,705.614	
19	40-460-10	Sand cement (10:1) gunny bags as trial fabrication	No	60	60	133	90.796	5,447.760	5,447.760	12,075.868	
20	40-470-10	Sand-cement (8:1) gunny bags as trial fabrication	No	60	60	72	132.106	7,926.360	7,926.360	9,511.632	

16

BoQ Item no	SSoRM Item Code (if any)	Outline of description for work Item	Measure-mint Unit	Quantities: Original Design Contract	Quantities: Amended Qty after Variation-5	Quantities: Executed Qty after Final Measurement	Contract Unite Price (BDT)	Original Contract Amount (=5a*6)	Amended Amount after VO-5 (=5b*6)	Proposed Final Contract Amount (=5c*6)	Remarks
1	2	3	4	5a	5b	5c	6	7			
21		Compressive test for sand-cement gunny bag as tri	No	18	18	18	1,427.415	25,693.470	25,693.470	25,693.470	
22		Equipment and apparatus for Fry pan-method	Set	2	2	2	14,393.101	28,786.202	28,786.202	28,786.202	
23		Measure water construction content on site	No	864	864	273	356.854	308,321.856	308,321.856	97,421.142	[illegible]
24		Apparatus for sand replacement method	Set	1	1	1	356.854	356.854	356.854	356.854	
25		Standard sand for replacement	No	10	10	2	1,011.086	10,110.860	10,110.860	2,022.172	
26		Competent geo-Technician	Day	81	81	81	2,616.928	211,971.168	211,971.168	211,971.168	
27		Assitance staff for geo-testing	Day	162	162	162	1,011.086	163,795.932	163,795.932	163,795.932	
28		Laboratory compaction test [ASTM D698]	No	3	3	0	1,011.086	3,033.258	3,033.258	0.000	
29		Field Density Test (sand replacement) [ASTM 1556]	No	216	216	211	356.854	77,080.464	77,080.464	75,296.194	[illegible]
		< Additional Investigation for existing soil condition of excavated section>						0.000	0.000	0.000	
30	16-150	Excavation for expose the existing bank	Cum	253	253	20	158.845	40,187.785	40,187.785	3,176.900	
31		Sampling material from existing bank	No	6	6	2	5,947.563	35,685.378	35,685.378	11,895.126	
32		Grading test for sample from existing bank	No	6	6	2	594.756	3,568.536	3,568.536	1,189.512	
33		Labo. test for compaction [ASTM D698]	No	3	3	2	1,011.086	3,033.258	3,033.258	2,022.172	
34		Field Density Test (sand replacement) [ASTM 1556]	No	18	18	3	356.854	6,423.372	6,423.372	1,070.562	
35		Measure water construction content on site	No	18	18	3	475.805	8,564.490	8,564.490	1,427.415	
		< Quality Control for concrete >						0.000	0.000	0.000	
36		Sampling the test pieces	No	93	93	108	1,665.318	154,874.574	154,874.574	179,854.344	
37		Compressive syrength test	No	93	93	108	1,665.318	154,874.574	154,874.574	179,854.344	
38		Designing for concrete mix as trial	No	2	2	1	72,560.263	145,120.526	145,120.526	72,560.263	
39		Making test piece and compressive test for trial	No	24	24	6	5,947.563	142,741.512	142,741.512	35,685.378	
		<Item no.6 - 39 2. Temporary works and Trial construction >							0.000	0.000	
			[illegible]	4,634,885,087					0.000	0.000	3,079,248,951 [illegible]
		3. Earth work, excavation							0.000	0.000	
40	16-130	Cutting & excavation in all kinds of soil	Cum	7,600	2,499	4,957	130.349	990,652.400	325,742.151	646,139.993	[illegible]
		4. Earth work, Embankment						0.000	0.000	0.000	
41	16-410-10	Filling & embankment earth work by carried earth	Cum	17,682	13,664	15,727	264.876	4,683,537.432	3,619,265.664	4,165,704.852	[illegible]
		5. Toe Protection, CC-block						0.000	0.000	0.000	
42	40-190-35	Manufacture CC-block, 1:3:6mix,40*40*40cm	No	16,998	16,998	16,990	527.837	8,972,173.326	8,972,173.326	8,967,950.630	
43	40-320-20	Labour chrage for dumping in position CCblock	Cum	1,088	1,088.000	1,087.360	1709.873	1,860,341.824	1,860,341.824	1,859,247.595	
44	40-190-50	Manufacture CC-block, 1:3:6mix,30*30*30cm	No	26,861	26,861	26,851	227.643	6,114,718.623	6,114,718.623	6,112,442.193	

17

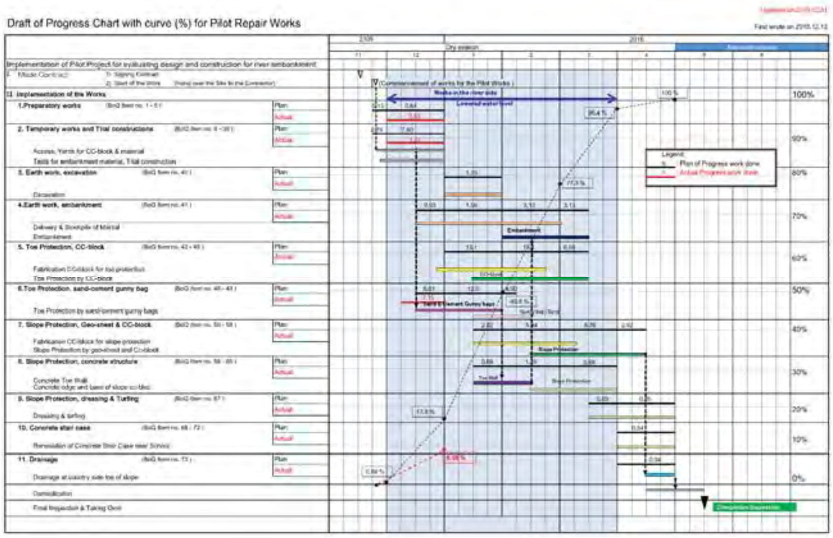
BoQ Item no.	SSoRM Item Code (if any)	Outline of description for work Item	Measure-mint Unit	Quantities: Original Design Contract	Quantities: Amended Qty after Variation-5	Quantities: Executed Qty after Final Measurement	Contract Unite Price (BDT)	Original Contract Amount (=5a*6)	Amended Amount after VO-5 (=5b*6)	Proposed Final Contract Amount (=5c*6)	Remarks
1	2	3	4	5a	5b	5c	6	7			
45	40-320-20	Labour chrage for dumping in position CCblock	Cum	725	725	724.977	1709.873	1,239,657.925	1,239,657.925	1,239,618.598	
		<Item no.42-45. 5. Toe Protection, CC-block>			[illegible]	18,186,891.598		0.000		0.000	18,179,258.926 [illegible]
		6. Toe Protection, sand-cement gunny bag						0.000	0.000	0.000	
46	40-460-10	Sand cement (10:1) gunny bags	No.	44,035	0	0	90.796	3,998,201.860	0.000	0.000	
47	40-470-10	Sand cement (8:1) gunny bags	No.	66,053	110,088	111,210	132.106	8,725,997.618	14,543,285.328	14,691,508.260	
73	VO-3	[illegible]	No	0	110,088	111,210	25.800	0.000	2,840,270.400	2,869,218.000	Variation No.3
48	40-400-10	Supply new gunny bags at site	No	11,590	16,390	11,680	41.633	482,526.470	682,364.870	486,273.440	
49	40-130-10	Labour chrage for gunny bags with sand or earth	No	11,590	16,390	11,680	9.551	110,696.090	156,540.890	111,555.680	
		<tem no 46 - 49 6. Toe Protection, sand-cement gunny bag						0.000	0.000	0.000	
					[illegible]	13,317,472.038					18,138,555.380 [illegible]
		7. Slope Protection, Geo-sheet & CC-block						0.000	0.000	0.000	
50	specific	Manufacturing CCblock;40*40*20with projection part	No	21,284	21,284	18,555	220.874	4,701,082.216	4,701,082.216	4,098,317.070	
51	40-220-20	Labour chrage for protective works in lying CC block	Cum	745	745	654.064	1,850.188	1,378,390.060	1,378,390.060	1,210,141.364	
52	40-190-40	Manufacturing CCblock;40*40*20	No	6,521	6,521	10,630	274.469	1,789,812.349	1,789,812.349	2,917,605.470	
53	40-220-20	Labour chrage for protective works in lying CCblock	Cum	209	209	340.160	1,850.188	386,689.292	386,689.292	629,359.950	
54	28-140-30	Gap filled concrete 1:3:6mix	Cum	16	16	52.216	7,047.252	112,756.032	112,756.032	367,979.310	
55	40-600-40	Supplying and placing geotextile fabric	Sqm	4,940	6,084	6,248.3	239.992	1,185,560.480	1,460,111.328	1,499,551.813	
56	40-630-20	Supplying and laying jhama chips, 40 to 20mm	Cum	221	221	255.8	3,248.904	718,007.784	718,007.784	831,020.910	
57	40-630-30	ditto but , 20 to 5mm	Cum	221	221	255.868	3,569.219	788,797.399	788,797.399	913,248.921	
58	40-650-10	Supplying and laying sand as filter, FM.1.0 to 1.5	Cum	442	442	499.02	611.504	270,284.768	270,284.768	305,152.726	
		<tem no 50 - 58 7. Slope Protection, Geo-sheet & CC-block >						0.000	0.000	0.000	
					[illegible]	11,331,380.380					12,772,377.341 [illegible]
		8. Slope Protection, concrete structure						0.000	0.000	0.000	
59	28-140-30	Toe Wall:RCC work, mix1:2:4, cylinder strength 18KN/mm2	Cum	104	104	92.600	7,047.252	732,914.208	732,914.208	652,575.535	
60	36-300-10	Toe Wall:Form work for concreting and water tight shuttering	Sqm	496	496	441.050	458.563	227,447.248	227,447.248	202,249.211	
61	28-120-10	Toe Wall:Cement cocrete work in leanest mix 1:3:8	Cum	9	9	7.670	7,254.525	65,290.725	65,290.725	55,642.207	
62	360-370	Toe Wall Form work in expansion joints 25mm plank	Sqm	56	56	21.280	704.037	39,426.072	39,426.072	14,981.907	
63	280-140	2nd Toe Wall:concrete wall 1:2:4mix	Cum	42	42	39.520	7,047.252	295,984.584	295,984.584	278,507.399	
64	360-300	2nd Toe Wall: Form work	Sqm	224	224	208.000	458.563	102,718.112	102,718.112	95,381.104	
65	40-610-20	2nd Toe Wall:Supplying and laying jhama chips, 40 to 20mm	Cum	7	7	6.240	3,248.904	22,742.328	22,742.328	20,273.161	
66	36-370	2nd Toe Wall: construction joint	Sqm	21	21	7.900	704.037	14,784.777	14,784.777	5,561.892	
		<tem no.59 - 66 8. Slope Protection, concrete structure >						0.000	0.000	0.000	

18

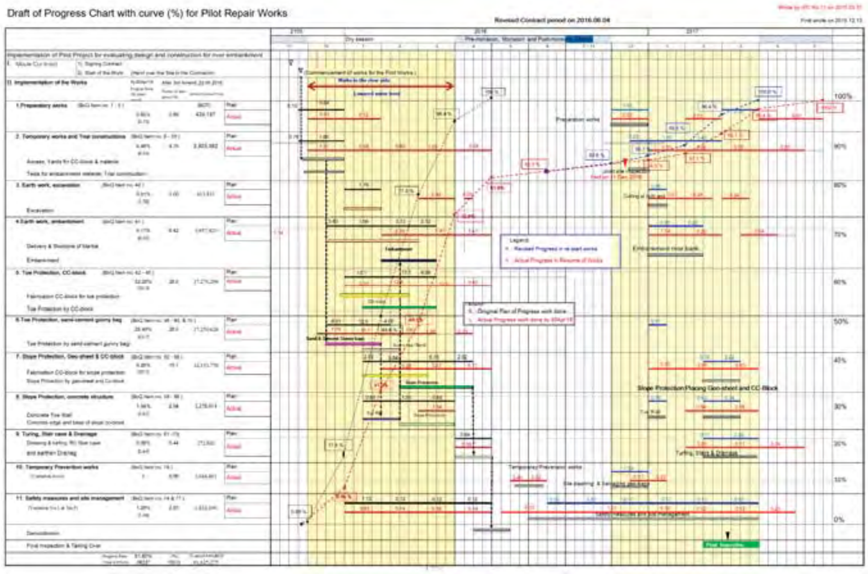
BoQ Item no.	SSoRM Item Code (if any)	Outline of description for work Item	Measurement Unit	Quantities: Original Design / Contract	Quantities: Amended Q'ty after Variation 5	Quantities: Executed Q'ty after Final Measurement	Contract Unite Price (BDT)	Original Contract Amount (=5a*6)	Amended Amount after VO-5 (=5b*6)	Proposed Final Contract Amount (=5c*6)	Remarks
1	2	3	4	5a	5b	5c	6		7		
						1,501,308.064					1,325,172.417
		9. Turing, Stair case & Drainage						0.000	0.000	0.000	
67	480-10	Fine dressing and close turfing of the slope	Sqm	1,937	1,937	1,937	22.363	43,317.131	43,317.131	43,317.131	
68	28-140-30	Stair: RCC work mix1:2:4, cylinder strength 18KN/mm2	Cum	7	7	7.9	7,047.252	49,330.764	49,330.764	55,673.291	Variation No.7
69	36-300-10	Stair:Form work for concreting and water tight shuttering	Sqm	13	13	17	458.563	5,961.319	5,961.319	7,795.571	Variation No.7
70	76-100-20	Stair:M.S work for reinforcement with M.S bar	kg	639	639	726	85.189	54,435.771	54,435.771	61,847.214	Variation No.7
78	52-110-20	Dismantling of refocement concrete, incl remove	Cum	0	0	3.617	3,077.354	0.000	0.000	11,130.789	Variation No.7
71	28-140	Edge Wall: 1:2:4 concrete	Cum	21	21	12.09	7,047.252	147,992.292	147,992.292	85,201.277	
72	36-300-10	Edge Wall: Form work	Sqm	88	88	48.4	458.563	40,353.544	40,353.544	22,194.449	
73	16-150	Drainage work,earth excavation of foundation trenches	Cum	135	135	0	158.845	21,444.075	21,444.075	0.000	
		<Item no.67 - 73 : 9 Turing, Stair case & Drainage>				362,834.886		0.000		0.000	287,139.722
		10. Temporary Prevention works						0.000	0.000	0.000	
76	VO-4	Temporary Prevention works	L/S	0	1	0.9090925631	4,266,672.987	0.000	4,266,672.987	3,878,800.682	Variation No.6
		11. Safety measures and site management						0.000	0.000	0.000	
74	VO-1	Safety fence/gate and safety measures	L/S	0	1	1	1,568,480.00	0.000	1,568,480.000	1,568,480.000	
77	VO-5	Site management during Time Extension	L/S	0	1	1	361,200.00	0.000	361,200.000	361,200.000	
		<Item no.74&77: 11. Safety fence/gate and safety measures>						0.000	0.000		
						0.000					1,929,680.000
Day Work								0.010	0.000	0.000	
									0.000		
		Original , Amended and Final Contract Amount						53,451,843.914	65,110,614.935	**64,868,710.861**	
		Retension: 5% of Proposed design Contract Amount								3,243,435.543	

(2) Progress Charts

Original Progress Chart (as of December 2015)



Latest Progress Chart (up to Completion of 23 May 2017)



21

(3) Photos of construction for Pilot Repair Works

(3)-1. Trial Fabrication for sand-cement mortar gunny bag

Ph1 Measuring weight/volume of material; cement, sand and water

Ph2 Checking workmanship after mixing sand cement

1) Fabrication of S-C GB on 2nd December, 2015

22

2) Inspection Sand-Cement Gunny Bag

After 7 days curing on 9th December, 2015

Ph3 & Ph4 Dropping from 1 m above the ground, and check the strength against the impact

Inspection was carried out Workability and Condition of hardening by 1) measuring unity weigh 2) dropping test 3) scratch surface and other observation

23

3) After 14 days curing on 16th December, 2015

Ph5 & Ph6 Measuring weight and volume and find out unit weight

4) Outcome from the result of Trial Fabrication

Water cement ratio (proposed mixture)

Sand : Cement	Unit Water		Remarks	Sand Type
8 : 1	220 Kg/M3		cemet:225kg/M3 sand:1,797kg/M3	Medium
material of mixing	Site proportion of mixture as per batch of Mixer (Kg)			W/C=
As per one butch (half bag of cemet)	W:Water	C: Cement	S: aggregate(sand)	0.979
	24.5 kg	25.0 kg	200 kg	

24

(3)-2. Construction of sand-cement mortar gunny bag

Ph7. On 21 Dec 2015, duping S-C GB started from the down stream

25

3-2. Construction & Dumping of sand-cement mortar gunny bag

Ph8. On 8 Jan 2016, ditto from the down & middle stream, 2,390bags dumped

26

3-2. Construction & Dumping of sand-cement mortar gunny bag

Ph9. Photo taken on 04.02.2016 from the down-stream. Water decreased due to Manu barrage gates closed and water level found 4.20 m(PWD).

27

3-2. Construction & Dumping of sand-cement mortar gunny bag

Ph10. Condition of S-C GB mound before dumping of CC blocks and before placing of additional Geo- sheets and local sand filled GB. @2016.02.16

28

3-2. Construction & Dumping of sand-cement mortar gunny bag

Ph11. Additional Geo-Textile sheets laid on S-C GB mound
(inner half part of mound). @2016.02.16

29

3-2. Construction & Dumping of sand-cement mortar gunny bag and CC-block

Ph12. One big block (40*40*40cm) is carrying by four (04) nos. labors
@2016/02.19

30

3-2. Construction of sand-cement mortar gunny bag

Ph13. On embankment river side slope ch. 10 – 30m, RL 6.00m(PWD) base preparation is running by plate compactor for layer by layer filling and compaction.@2016.03.11

31

(3)-3 Work Shop on 23 Jan 2016, Safety Gathering

Ph14. Safety Gathering were conducted on the occasion of Work Shop on 23 January, 2016

312

3-3 Work Shop on 23 Jan 2016, Safety Gathering

Ph15. Project Manager address Safety information: All the workers and participants of Work Shop attend the Meeting

33

3-3 Work Shop on 23 Jan 2016, Safety Gathering

Ph16. "Shabar Age Nirapatta" Call

34

(3)-4. Trial Compaction Test for embankment

1) Objective of Trial Compaction

Ph17. Compaction by bulldozer

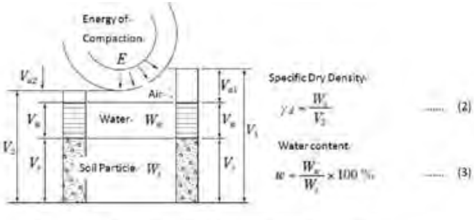


Figure 3.4.2 Proportion of soil structure (image illustration)

By the compaction energy, such as rolling by compactor, soil will be consolidated and water and air will be exhausted. Then soil will increase its density with crushing its particle and changing its alignment. The enough compacted soil is not likely to be soft against seeping water and become larger in its strength and bearing capacity, and is also to decrease

< quoted from "Draft of Construction manual">

- 47 -

Decision of standard construction method
(by **Trial construction** or others)

- Method of compaction (spreading thickness, passing number of compaction)
- Compaction machinery (Type and weight)
- Construction water content

35

2) Step 1: Use of Plate Compactor

Ph18. Compaction by plate rammer

Step1: Use of relatively small compaction equipment (Plate Compactor) suitable for the site where is relatively narrow

Different ***thicknesses*** and
Different numbers of ***passes***
for compaction

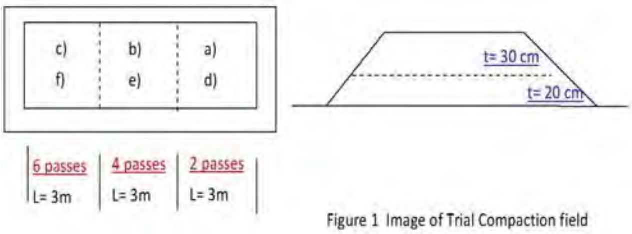


Figure 1 Image of Trial Compaction field

36

2) Step 1: Use of Plate Compactor ….. (2)

<u>Basic conditions</u> of Step 1;
1) Material from borrow pit No.1
2) Optimum Moisture Content
   Wopt : 18.9 (%)
3) Maximum Dry Density
   MDD: 16.28 (kN/m3) = 1.66 (g/cm3)
4) Compaction by Plate Compactor
   (110kg model)

Ph19. Field Density test by sand replacement method

<u>Field Density Test</u>:
1) Degree of compaction (DC) (criteria: not less than 85%)
   DC = Field Dry Density / Maximum Dry Density (MDD)*100 (%)
2) Sand-replacement method (ASTM D1556)
3) Water content measured by Fry-pan method

37

4) Step 3: Use of Bulldozer

<u>Basic conditions of Step 3</u>;
1) Material from borrow pit No.1 & No.2
2) Optimum Moisture Content
   Wopt : 18.78 (%)
3) Maximum Dry Density
   MDD: 16.23 (kN/m3) = 1.655 (g/cm3)
4) Compaction by Bulldozer
   (5 ton, D3 CAT Caterpillar)

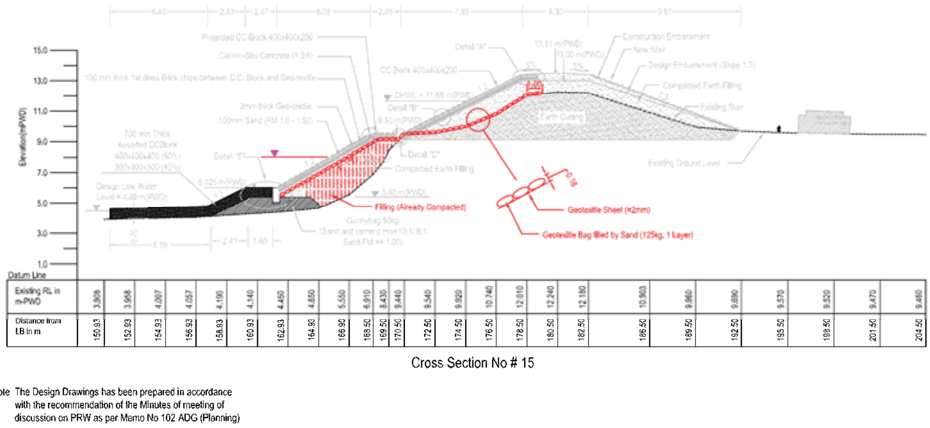
Ph20 & 21. Laying by Bulldozer & Field Density test by sand replacement method

⋆Field Density tests were carried out on;

a) 2 passes compaction by bulldozer and 1 pass compaction by Plate Compactor
b) Only 2 passes compaction by bulldozer

38

(3)-5. Temporary Prevention works



Temporary covering the slope by geo-sheet and geo-bags

39

3-5. Temporary Prevention works

Ph22 & 23. Carrying of geo-bags and placing of geo-bags on toe of TPW (intermediate berm at around 9.00 m(PWD)
@2016.06.10 WL = 9.05 m

40

(3)-6. Slope Protection works

Ph24 ⋆Down-stream lower slopes are preparing and compacting by bulldozer and excavator. @2017.01.22

41

3-6. Slope Protection works

Ph25 At up-stream/ original soil area, lower slope of embankment are preparing by cutting and filling with compaction by 7 kg hammer. @2017.01.22

42

3-6. Slope Protection works

Ph26 & 27 Slope protection works sag in some places are doing correction. @2017.02.01

3-6. Slope Protection works

Ph28 Toe Wall construction at up-stream transition end & curing concrete @2017.02.15

Ph29 View of intermediate berm projected cc blocks laying works from up-stream towards down-stream @2017.02.15

3-6. Slope Protection works

Ph30 Elevation level of 11.65m (DHWL) on the top of projected cc blocks on 2nd slope checked – found ok. @2017.03.1

45

3-6. Slope Protection works

=Intermediate Inspection Step-1; lower Part (6.025 – 9.5 m, up to berm)=

Ph31 At down-stream the SE, DC2 expressing his knowledge with everybody on Final Inspection Step-1 @2017.03.11

46

3-6. Slope Protection works

Ph32 Spot levels checked today at up-stream transition area covered Zones (A) and (B) @2017.03.21

47

3-6. Slope Protection works

Ph33 Placing projection CC-blocks for Slope Protection and transition are in down stream. @2017.03.27

48

(3)-7. Supplementary protection for out-off up stream

Ph34. View of up-stream, connection of PRW up-stream with the up-stream temporary protection. Taken from opposite bank @2017.03.09

49

Ph35. View of up-stream, connection of PRW up-stream with the up-stream temporary protection. Taken from opposite bank @2017.03.09

50

Ph36. View from opposite bank: up-stream of PRW beneath grave yards.
@2017.03.09

51

Ph37. Up-stream of PRW temporary protection works. Taken from opposite bank up-stream of grave yards. @2017.03.09

52

Construction Manual (Revision)

Base on the learning from Pilot Repair Works, following articles are added and revised Construction Manual

Preface -Background of Draft of Construction Manual for River Embankment-

Section 4 Importance of Progress Control

Introduction of Examples in Pilot Repair Works:

1. Handling Schedule Delays for Section 1.3.2
2. Trail Compaction in embankment work for Section 3.4.6
3. Trail Fabrication of Sand-Cement mortar gunny bag for Section 4.1.2
4. Safety Activities for Section 5.2.3
5. Temporary Prevention Measures for Slope for Section 5.3.3

53

Extraction / introduction of articles of Section4 in Preface and 3)"Handling for Schedule Delay" in Sub-clause 1.3.2 " Control of Construction Progress" on Section 1.3 Progress Control

Section 4 Importance of Progress Control

It is without saying that importance of planning and implementation of the works to complete the project as per planned time schedule for the benefit of the benificeries of society.

But some projects implementation are found delay or suspended due to unavoidable situation and other reason, resulting with considarable losses or damages to the society.

To avoid such event, it is required; i) well study and good planning, ii) proper time management, and iii) taking counter-measures for such events.

This Manual is expressed for such issues in Section 1.2 Construction Plan and Section 1.3 Progress Control for your referenece.

54

Section 1.3 Progress Control

1.3.2 Control for Construction Progress

3) **Handling Schedule Delays**

If any delay to the schedule arises, it is important to ***ascertain the cause***, ***decide how to deal with it and act quickly.***

The following items are to be detailed how to handle delays.

a) Revise work procedures (improve work efficiency)
b) Shift work order
c) Change work times and crew numbers
d) Change the machinery to be used
e) Other considerations

Moreover, rework is a surprisingly frequent and major cause of construction delays. Rework results from careless planning and insufficient management of the work, and therefore care needs to be taken. It is also important to promptly consult with related parties to determine necessary measures for delays that occur due to land issues, disasters, and changes to the shape of the site.

55

2. Anlaysis of the cause of delay

JICA Expert team made a report of the Delay on April 2016 as below;

Report on Progress of Pilot Repair Works (PRW) and Possible Time Extension

26/Apr/2016: JICA Expert Team

1. General

After the rare rainfalls on 28th and 29th of March, the construction works of the pilot repair works (the PRW) has stopped tentatively due to the higher water level at the work site. In this context, the Director of the Design Circle 1, members of the JICA Expert Team and management team of the Contractor of the PRW (T.S.S) discussed the present condition including the possible time extension of the PRW on 19/Apr/2016. This Report presents the summary of Progress and the possible time extension of the PRW, based on the discussion results.

3. Hydrological condition around the PRW

In order to grasp the existing hydrological condition around the PRW, the water level data and rainfall data are collected. Locations of the observation sites are shown in Figure 2.

(1) Water Level and Rainfall at Moulvibazar
Data of the water level and Rainfall at Moulvibazar during the dry season (Jan-May) from 2007 to the present are shown in the following table and figure.
Table 1 Summary of monthly rainfall and rainy days (from 2006/2007 to 2015/2017)
Figure 3 Water Level at Moulvibazar (Jan May from 2007 to 2016)

56

Manu
SW202
Moulvi Bazar

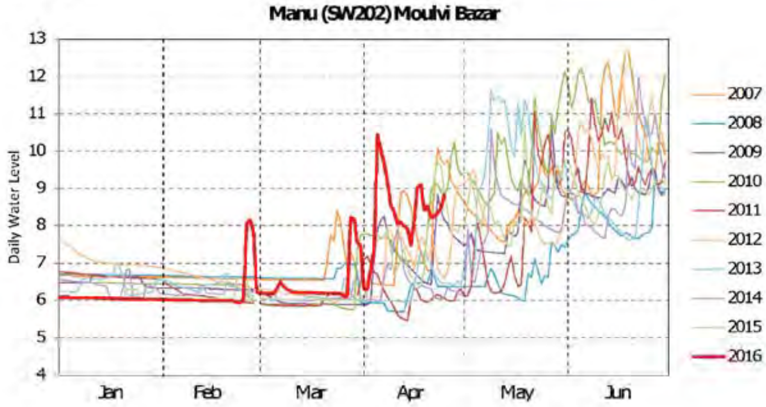


Figure 3 Water Level of Manu River (SW202, Moulvi Bazar)

Note: Moulvibazar station is located at the upstream site of the Pilot Project Site. (refer to Figure 2). WL of the Pilot Site are below about 1.5m from WL of Moulvibazar Station, in case of no backwater from Kushiyara River.

57

Kushiyara
SW175.5
Sherpur

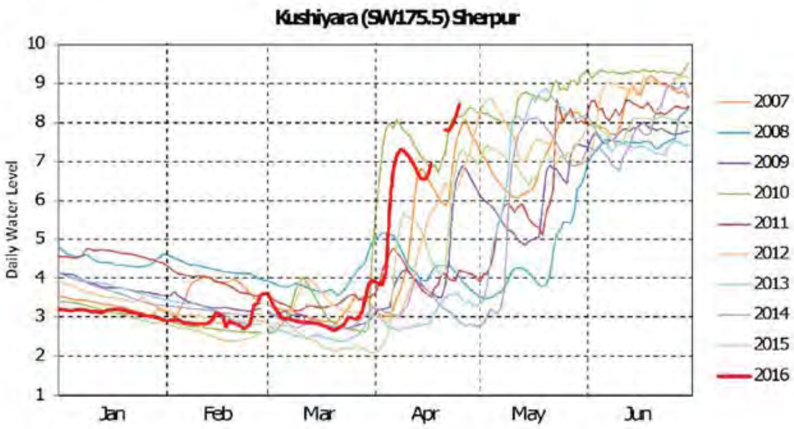


Figure 4 Water Level of Kushiyara River (SW175.5, Sherpur)

Note: Sherpur station is located at the downstream site of the Pilot Project Site. (refer to Figure 2).

58

<Extracted P.28 of Construction Manual>

4. Result and Learnings

1) Up to the end of March 2017, all Toe and Slope Protection works in the river side have been completed.

2) Unfortunately, due to unavoidable circumastances, extra ordinaly early rain fall attacked to north-east regions of Bangladesh including Moulvibazar site and other reasons, the Work had to be extended to another few weeks. Actual completion date was the latter half of May 2017.

3) Importance of planning shedule

When procuring entity consider and design the construction period for the project, past years hydrogical data at the proposed construction site, including water level and rain fall, should be studied carefully.

4) Plural seasons of construction period

If the work volume/scale is relatively large and/or expecution capability of the work-force is limited and the due to site condition, 2 years or more years construction period is to be recommended . For instant first year, the Works includs only for Toe Protection works and earth work/embankment works, and second year the Slope Protection works are carried out.

59

☆ Dhanyabad !!

60

The Project for Capacity Development of
Management for Sustainable Water Related Infrastructure

O&M Manual

July 13, 2017
JICA Expert Team

1

Project outline

Project Title:	The Project for Capacity Development of Management for Sustainable Water Related Infrastructure
Period:	August 2013 – October 2017
Project purpose:	To improve the capacities of BWDB on embankment engineering in terms of design, construction and operation & maintenance methods

Output:
1. Design for sustainable river embankment is introduced.
2. Construction method and procedure of river embankment is improved.
3. Operation and maintenance system for the river infrastructures is ensured
   - O&M manual
   - GIS database of damage and maintenance

2

Preface

O&M Manual is prepared as a technical reference for the
"Guidelines for Operation and Maintenance of Permanent Structures of BWDB",
which is
prepared by BWDB and approved by MoWR in 2010.

3

The manual presents the basic matters and process of planning, implementation and monitoring of O&M activities.

Four pillars concepts of O&M
1. Basic Scheme Data
2. Budget Procedure
3. Planning Procedure
4. Monitoring and Supervision

Chapter	
1. Introduction	...f
2. Concept o...	...ncepts of O&M.
3. Basic Sche...	
4. Operation...	
5. Maintenan...	...nance
6. Budget of...	
7. Implemen... Monitoring of O&M	... O&M including the organizations.
8. Flood Fighting	Flood fighting during floods as important part of operation works.

Basic Scheme Data
1. Scheme inventory

...M should be
...d on planning and

Flood fighting is an emergency response during flood, generally using sand bags, bamboo, etc.

4

Contents of this presentation

5

Contents of this presentation

6

Contents of this presentation

1. Introduction

1.1 Scope and Application
1.2 Definitions and Functions of water Related Infrastructures

1.1 Scope and Application

O&M Manual

- is formulated as a reference material for the officials of BWDB,
- presents that basic matters and process of planning, implementation and monitoring of the operation and maintenance (O&M) activities of the water related infrastructures managed by BWDB,
- is intended as a guide for the officials of BWDB on planning, implementation and monitoring of the O&M of the water related infrastructures and/or supervising contracting O&M works of the water related infrastructures,
- is compiled through the review of present condition of O&M in the field offices including the related O&M guidelines and the O&M manuals of previous projects, and also through the discussions among the BWDB officials and
- will be revised based on the accumulated knowledges in the field.

9

2. Concept of O&M

2.1 Objective of O&M
2.2 Scope of O&M Activity
2.3 Present Situation of O&M of BWDB
2.4 Framework for Integrated O&M

10

2.1 Objective of O&M (1)

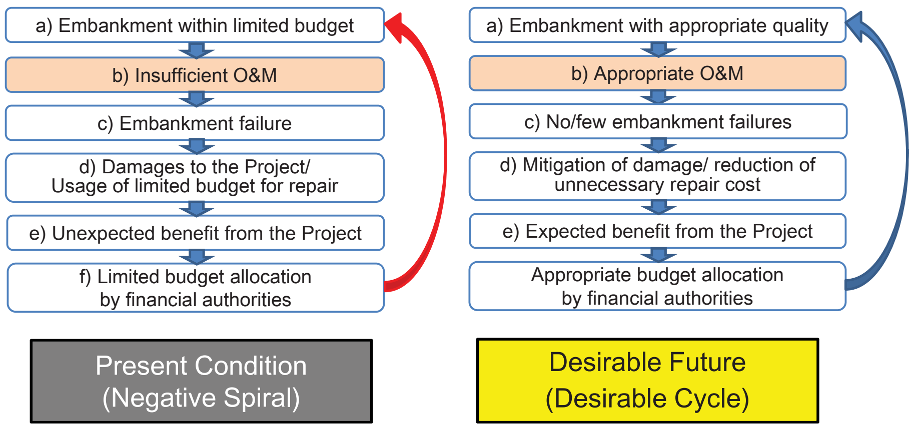
The objectives of the water resources management project are attained by operating various water related infrastructures constructed in the project.

However, the functions of the water related infrastructures cannot be kept well without care.

Therefore, such care is important for not only keeping of respective functions of the structures, but also for accomplishing the objectives of the project.

11

2.1 Objective of O&M (2)



Design: 1-2 years
Construction: 1-3 years
OM: Over 50 years

12

2.1 Objective of O&M

The aims of O&M are;

Operation
Operation of the structures is the efforts to manage and distribute the water resources in order to fulfill respective functions of the structures.

Maintenance
Maintenance of the structures is the efforts to secure the conservation of the function of structures in good conditions, including rehabilitation works that recover the structure condition to the required condition in the water resources management scheme.

13

2.1 Objective of O&M

The maintenance works of BWDB are classified into three 3 categories.

Preventive/Routine Maintenance
The preventive/routine maintenance comprises all activities carried out to maintain optimal functioning of a facility in order to reduce need for corrective/periodical maintenance and prevent high rehabilitation cost.

Corrective/Periodic Maintenance
Corrective or periodic maintenance covers large scale non-emergency work requiring greater resources than the preventive/routine maintenance.

Emergency Maintenance
Emergency maintenance is concerned with the unexpected damage due to natural calamities that threaten the water resources project.

14

2.2 Scope of O&M Activity

The scope of O&M activity is itemized as follows:

Operation

a) Operation of channel/canal (monitoring and observation)
- Water level measurement/ Discharge measurement
- Checking of river-bed material
- Water quality observation
- Compiling and arrangement of data

b) Operation of water control structure
- Gate of barrage/large regulator
- Gate of navigation lock
- Gate of sluice
- Gate/stop log of regulator
- Gate/sluice for aqueduct/siphon
- Pump of pump station

c) Administrative management
- Permission (using of river water, occupancy of land in channel/canal, taking of earth, sand from in channel/canal, construction of structure in channel/canal)
- Approval of river works
- Restriction of acts and supervision disposition

15

2.2 Scope of O&M Activity

Maintenance

a) Channel/coast Survey
- Periodical cross-section survey
- Periodical sounding survey

b) Visual maintenance
- Turf-cut and weed-cut
- Sign, fence and DMS post

c) Patrol and Inspection

d) Maintenance of river channel/drainage channel/ Irrigation canal
- Dredging/excavation for maintenance
- Removal of obstruction

e) Maintenance of appurtenant structure
- Embankment
- Slope and foot protection works
- Groyne/ spur dike
- Road
- Bridge/ culvert

f) Maintenance of water control structure
- Barrage/ large regulator
- Sluice
- Regulator/ escape
- Aqueduct
- Siphon
- Pump station
- Deep/shallow tube well

g) Maintenance of related structure and equipment
- Housing and office
- Equipment

h) Flood fighting

16

2.3 Present Situation of O&M in BWDB

Present situation of O&M activities in the field

- The O&M division office is conducting the periodical O&M activities by individual manners. The sub divisional engineers and the sectional officer conduct the patrol/inspection periodically, mostly once a month, and report to the executive engineer of the O&M division office.
- The executive engineer judges the necessity of the maintenance works considering the condition of the infrastructures and the required budget for maintenance works.
- The works more than BDT 10 crore (10^7) are recognized as the rehabilitation works in the development budget.
- In some cases, small scale and small budget maintenance works are implemented by WMO.
- Technical aspect of the maintenance works are assisted by the office of the Design Circle in charge of respective O&M division offices and the mechanical O&M division office in the Zone.
- There is no location map of the all managed structures, except the location maps of the structures for the completed projects.
- Survey of the maintenance works is done by the O&M division office. Soil mechanics investigation is done by the Ground Water Circle of BWDB/sub-soil test contractor. Hydrological observation in the jurisdictional area is done by the Hydrology Department of BWDB.

17

2.3 Present Situation of O&M in BWDB

Present condition of the hydraulic structures

- The hydraulic structures along the major rivers are well operated and maintained and good condition.
- Along the internal rivers including the ring embankment, there are many infrastructures damaged and without repair.
- There are many defects in the structures without any treatment, such as rill erosion of the embankment slope, cracks of embankment, rat/mole holes/tunnels of embankment, undulation of the embankment crown, undulation/erosion of the slope protection works, corrosion of the gates of the drainage regulators, etc. Those defects are the causes of the serious damages of the infrastructures during the floods.
- The artificial interferences to the infrastructures also can be seen everywhere, such as houses/ cultivation on the berm of embankment, cutting of the embankment body for approach path/road and building, taking-off the gates and hoists, etc. Those interferences also are the causes of the serious damages of the infrastructures during the floods.

18

2.3 Present Situation of O&M in BWDB

SWOT Analysis on O&M activities of BWDB

STRENGTHS	WEAKNESSES
• BWDB is authorized as the organization for implementation and management of the water resources development projects having a command area more than 1,000 ha. • BWDB has nationwide offices for management of the hydraulic infrastructures. • The policies, plans guidelines related to the management of the hydraulic infrastructures are ratified. • There are many highly trained professional staffs in BWDB.	• Inadequate number of professional staffs in the field level. • Less motivation of professional staffs in the field level. • Inadequate data management for the completed projects • Inadequate skills of the field level professionals in modern logistics. • Inadequate planning on O&M as MIS not developed yet though planned much earlier • Inadequate capacity for fund raising for O&M. • Insufficient budget for O&M compared with the demand. • Construction bias in BWDB.
OPPORTUNITIES	**THREATS**
• There are high expectations on the hydraulic infrastructure among residents. • There are assistances from the development organizations/ donor countries. • There is a global trend in financing and promoting the climate change adaptation. • There is a global trend in financing and promoting management of hydraulic infrastructures.	• Construction bias in the government (less intention to O&M compared with development) • Inadequate funding allocation for O&M (Major funds consumed by Padma, Meghna and Jamuna river bank protection). • Insufficient national budget • Conflicts among the public related to the water resources management including O&M of the facilities.

19

2.3 Present Situation of O&M in BWDB

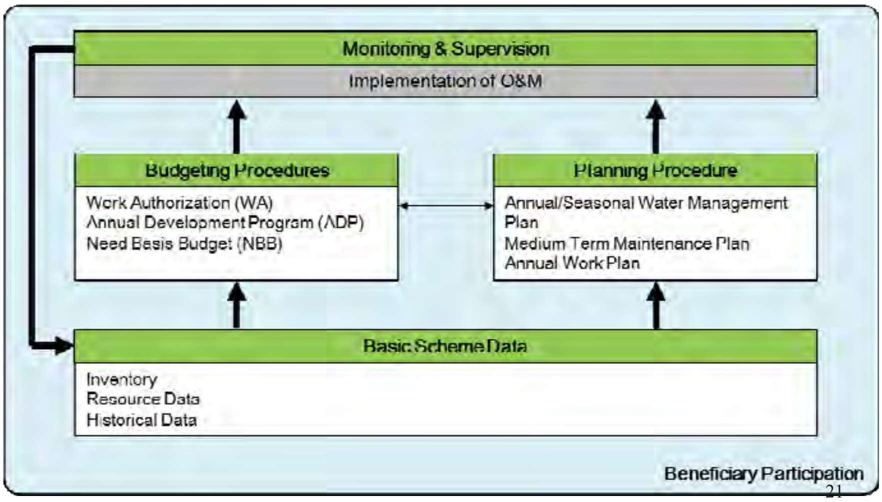
Acts, Policies and Guidelines related to O&M

Policy	National Water Policy, Jan/1999	By MoWR
Plan	National Water management Plan, Dec/2001	By WARPO
Act	BWDB Act, 2000	
Guideline	Guidelines for participatory Water Management,2001	Prepared by MoWR
Guideline	Guidelines for Operation and Maintenance of Permanent Structures unde r BWDB, Oct/2010	Approved by MoWR

20

2.4 Framework for Integrated O&M

The Draft O&M Manual is based on the framework of O&M developed through previous projects: 4 Pillars + Beneficiary Participation



21

3. Basic Scheme Data

3.1 General
3.2 Scheme Inventory
3.3 Resource Data
3.4 Historical Data

22

3.1 General

The scheme data

- is a basis of planning, implementation, and monitoring of the O&M activities with efficient, flexible and cost saving manners, in order to optimize the performance of the project scheme and
- is a core component for promotion of budget reinforcement for O&M activities.

The scheme data are divided into three 3 types of data.

1. Scheme Inventory
2. Resource Data
3. Historical Data

23

3.2 Scheme Inventory

The scheme inventory data consists of …

(1) Hydraulic Infrastructure

Data and information of the hydraulic structures to be collected are the functions of facilities, design and existing dimensions, and those drawings.

(2) Real Estate

The list of offices, houses, guest houses, stores, water tanks, sheds, etc. must be updated, specifying the dimensions, class of the buildings and construction costs.

(3) O&M Facilities

The O&M facilities pertain to the inventory of the respective buildings and the equipment and transport facilities used by BWDB staff to carry out their work.

(4) Staff List

A staffing list must be updated, showing how many officers are employed on the schemes either long-term or temporarily.

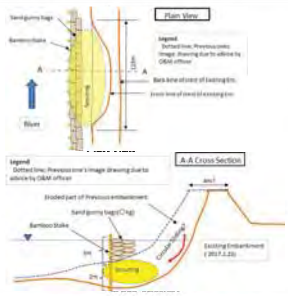
24

3.2 Scheme Inventory: Sample of Inventory of River Structures (1)

Sheet No.: RVT01RS000400

Scheme Name: Manu Right Embankment (secondary) Kind of Structure: Revetment Work (secondary) Date:15-09-2015

Structure Name: Manu Right Embankment Chainge (km) 11+120 Location(Coodinat:N 24, 29 , 17.9 E 91, 49 , 49.8

Layout/Sketch/, Dimensions,etc.	Photographs	Remarks/Condition of Structure
	 Existing Revetment Work Manu Right	Temporary protection work , needs revetment

We should do the followings from the information provided by the inventory sheet;

- Understand the structure of the facility,
- Confirm whether the facility is functioned or not,
- Judge the urgency of repair work,
- Estimate quantity and cost of repair work roughly.

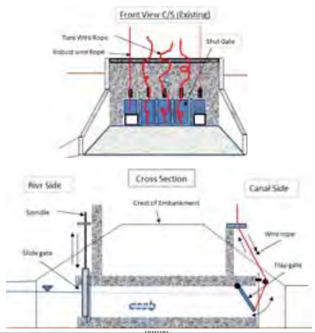
25

3.2 Scheme Inventory: Sample of Inventory of River Structures (2)

Sheet No. : RG01L000900 Date: 14/09/20

Scheme Name : Manu left Embankment Kind of Structure: Regulator 5V−1.5m x 1.5m

Structure Name: Hamhami Chhara Regulator (Hamhami Chhara Stinge (km) : 48+854.8 Location(Coodinates) : N 24,29, 21.1 E 91, 47, 39.0

Layout/Sketch/, Dimensions,etc	Photographs	Remarks
	 Hamhami Chhora Regulator R/S  Hamhami Chhora Regulator C/S View	Gate: R/S steel rope and pulleys damaged Structure: Good

Inventory sheet should describe which parts are damaged and what is the effect.
For instance;

- 2 gates remain opening so flood water come into the landside from the river,
- This regulator can’t control water because all gates are closed.

26

3.3 Resource Data

The BWDB officials in charge of management of the scheme need general information on the scheme and the BWDB organization.

The following data and information must be kept as resource data.

(1) All sorts of BWDB data related to O&M
Organograms, policy papers, guidelines, staffing plan, job descriptions, O&M manual, operation plan, reports of feasibility study and detailed design, etc.

(2) Agreements with other agencies
- Agreements on inter-agency coordination (IAC)
- Agreements on cooperation between the BWDB and other agencies

(3) Documents pertaining to the ownership of the infrastructure
A register must be kept showing the ownership of land on which the hydraulic infrastructure is located.

27

3.3 Resource Data

(4) Organization charts of WMOs and other agencies and how they interact
Organization charts of WMOs and other agencies, documenting their organizational frame and the relation with the BWDB.

(5) All relevant maps
Administrative maps, jurisdiction maps, layout maps of schemes, contour maps, topographic maps, etc.

28

3.4 Historical Data

The following data and information must be kept as historical data.

(1) Agro hydrological Records
Rainfall, river levels, reservoir levels, river flow data, water quality and salinity measurements, depths of water table, ground water level, etc.

(2) Maintenance records/achievements
Records related to completed maintenance works including ADPs, work contents, the costs, contractors, period of maintenance, etc.

(3) Operation records
Old operation plans and their amendments, gate or pump operation records, water level records, ground water level records, irrigated areas, etc.

(4) Financial records
Staff costs, O&M cost, ratio of planned and executed O&M works, revenue from lease of lands and from cost recovery activity, etc.

29

4. Operation Manual

4.1 General
4.2 Planning of Operation/Water Management
4.3 Operation of Channel/Canal (Monitoring and Observation)
4.4 Operation of Water Control Structures
4.5 Administrative Management

30

4.1 General

Operation activities are divided into 2 categories.

1. Planning of operation/water management
2. Actual operation in the field

31

4.2 Planning of Operation/Water Management

(1) Concept of Planning

The planning of operation is the main focus to integrated water resources management.

The WMOs in the scheme will primarily be responsible in the operation planning and coordinate the beneficiaries and finalize the water management plan including operation plan of the related structures, in conjunction with the field offices of BWDB.

32

4.2 Planning of Operation/Water Management

(2) Planning Procedure

The basic procedure of the planning is as follows:

1) Drafting the operation plan by BWDB with the WMOs in advance before each season or annually.

2) Each WMO in the area presents a draft plan to the stakeholders.

3) Each WMO give the recommendations/suggestions on the draft plan to WMA/WMF based on stakeholders opinion.

4) WMA/WMF at the apex level compiles the recommendations/suggestions of all WMOs and finalizes and approves the annual plan with BWDB.

33

4.2 Planning of Operation/Water Management

(3) Required Data

In order to modify/fine tune the annual water management plan including the operation plan of the related structures, the following data will be required.

Data of natural condition:
- Hydrological and meteorological data
- Map of the beneficiary area with the detailed contour lines

Data/demands from the stakeholders:
- Land use
- Cropping patterns of the irrigation areas
- Fishery patterns
- Depth of water/water level to be maintained at the end of the monsoon season with the consensus among the stakeholders
- Permissible level of water inside the scheme during monsoon
- Timing of gate operation for fishery
- Provision of gate operation for flushing during monsoon drought

34

4.3 Operation of Channel/Canal (Monitoring and Observation)

Operation activities of river channels, drainage channels and irrigation canals are the monitoring and observation. The monitoring and observation of river channels, drainage channels and irrigation canals shall be continuously conducted in order to implement the water management plan properly, and to catch the available water resources in the scheme.

The monitoring and observation consist of

- Water level observation,
- Checking of river bed material and
- Water quality observation.

35

4.3 Operation of Channel/Canal (Monitoring and Observation)

(1) Water level observation

[R]: river channel, [D]: drainage channel and [I]: irrigation canal.

Purpose

[R] : To know the flow condition in order to operate the related structures and to prepare the flood fighting. The observation is done by the Water Science Department of BWDB.

[D] : To know the flow condition for operation of the drainage structures. The observation is done by the gate operator of WMOs or BWDB.

[I] : To know the flow condition for operation of the drainage structures. The observation is done by the gate operator of WMOs or BWDB.

Proposed site

[R] : The bridge site of the river channel at the up/downstream sides

[D] : Sluice site

[I] : Sites at the water control structures

Frequency

[R] : Daily (hourly during flood). The bridge site of the river channel at the up/downstream sides

[D] : Sluice site

[I] : Sites at the water control structures

36

4.3 Operation of Channel/Canal (Monitoring and Observation)

(2) Checking of river bed material

Purpose
To get change of the river morphology.
The observation is done by the Water Science Department of BWDB or field office of BWDB.
Sampling and test for the grain size distribution should follow related technical standard.

Proposed site
Middle point of riverbed gradient

Frequency
5 to 10 year interval or when the river bed material change

37

4.3 Operation of Channel/Canal (Monitoring and Observation)

(3) Water quality observation

Purpose
To confirm whether the water quality of the flow is conformity with the Environmental Standard of Bangladesh or not. When deterioration of water quality is a concern, the observation is done by the Water Science Department of BWDB or the field offices of BWDB in compliance with the technical standard of the water quality tests.

Proposed site
River channel: at the upstream and downstream sides of the scheme
Drainage channel: at the sluice
Irrigation canal: at the head regulator and the escape

Frequency
Every year in dry season

38

4.3 Operation of Channel/Canal (Monitoring and Observation)

(4) Compiling and Arrangement of Data

The obtained data from the above should be compiled and arranged for easy use. The compiling and arrangement works will be carried out by using the Data Base System to be implemented in the field office of BWDB.

Records getting through these monitoring and observation are the basic data of the management, such as water utilization, channel use, water amenity/environment, appropriate water resources development, flood warning and flood fighting, understanding of run-off and flooding mechanism and future water resources development plan.

39

4.4 Operation of Water Control Structures

(1) Barrage/Large regulator

Function:
To raise and regulate the water level in order to divert the flow into the other watercourse for water use.

Operation:
Operation is done in accordance with the operation rule of the facility.

- During the dry season: 1 or 2 gates are partially opened. Other gate are closed.
- During the rainy season: All gate structures are opened.

40

4.4 Operation of Water Control Structures

(2) Sluice/Escape

Function:

- To drain surplus water (storm water) of the drainage channel and the inland area to the river.
- To prevent the runoff/flood from the river flowing into the drainage channel and the inland area.

Operation:

(a) Normal Operation

i) At least 1 gate of each sluice should be opened when the water level of the river or that of inland is lower than the warning water level.

ii) The gates of each sluice can be operated for the maintenance activities.

continue

41

4.4 Operation of Water Control Structures

Operation:

(b) Operation during Flood and High-Tide

i) When the water level of the river is higher than the warning water level and that is higher than inland water level, all gates should be soon closed.

ii) When the inland water level is higher than the warning water level and that is higher than the water level of the river, gates should be opened, according to the flow condition (direction, velocity) at each sluice.

iii) During the closed condition of the gates and when the inland water level is higher than the water level of the river, the gate operation should be return to ii).

iv) When the water level of the main river rises again, the gate operation should return to the condition of i) or ii).

v) When the flood and high-tide are judged to be passed away, the gate operation against flood/high-tide shall be cancelled.

42

4.4 Operation of Water Control Structures

(3) Regulator

Function:
- To control water flow to different area in the irrigation system
- To regulate the water level of canals for irrigation
- To prevent the runoff/flood from the river flowing into the irrigation area

Operation:
Operation of the gates of the regulator should be conducted in accordance with the determined operation rule.

43

4.4 Operation of Water Control Structures

(4) Pump Station

Function:
- To pump water from one place to another, with the purpose of irrigation or drainage.

Operation:
Operation of the pumps and gates of the pump station should be conducted in accordance with the determined operation rule.

44

4.4 Operation of Water Control Structures

(5) Aqueduct/Siphon

Function:
- To convey water over a watercourse for water use (Aqueduct)
- To convey water under a watercourse for water use (Siphon)

Operation:
Operation of the gates of aqueduct/siphon should be conducted in accordance with the determined operation rule.

45

4.5 Administrative Management

Owner of all water resources including rivers is the Government of Bangladesh. Any acts obstructing the normal function of the water resources shall be restricted.

Therefore, BWDB needs to work into the activities of administrative management of the water resources regarding water sharing, flooding, erosion, those protection works, etc. and use of water from the river or channel which is under a BWDB project.

46

4.5 Administrative Management

(1) Permission/Approval of Acts

- Using of river/channel water
- Occupancy of land in the river/channel area
- Taking of earth, sand, etc. from the river
- Navigation in the river
- River training works
- Construction works in the river

(2) Restriction of Act and Supervision of Disposition

Bangladesh police restricts the illegal acts and supervise the disposition of those acts. BWDB shall report the illegal and harmful acts to the police and confirm the disposition of those acts.

47

5. Maintenance Manual

5.1 General
5.2 Planning of Maintenance
5.3 Patrol and Inspection
5.4 Maintenance of Channel/Canal
5.5 Maintenance of Structures
5.6 Maintenance of Related Structures and Equipment

48

5.1 General

- The technical maintenance is indispensable to sustain the functions, which will be lowered and damaged due to repeated flood flows.
- Furthermore, some acts of the neighboring people are harmful to the facilities and lower the functions.
- Such harmful acts should be prohibited or restricted.

49

5.2 Planning of Maintenance

(1) Concept of Planning

The maintenance works of BWDB are classified into …

- Preventive/Routine Maintenance
- Corrective/Periodic Maintenance
- Emergency Maintenance

If the preventive and routine maintenance works are conducted properly, then demands of the corrective/periodic maintenance works and the emergency maintenance works become less.

Therefore, emergency works cannot be planned. Therefore, preventive and routine maintenance works is more important than others.

50

5.2 Planning of Maintenance

(2) Planning Procedure

1) Identification and selection of item to be maintained and repaired

↓

2) Clarification of timing of maintenance works

↓

3) Physical planning of maintenance works

↓

4) Preparation of medium term maintenance plan

↓

5) Preparation of annual maintenance plan

51

5.3 Patrol and Inspection

The maintenance activities start from patrol and inspection of the water related infrastructures

Frequency of patrol and inspection:

1) Intensive and overall just before severe rain season,
2) Each time after a flood or earthquake or severe wave,
3) At least once a week during severe rain season, and
4) At least once a month during dry season.

The immediate repair would prevent further damages; accordingly it makes the maintenance works easily and economically.

52

5.4 Maintenance of Channel/Canal

(1) Function

River channel, drainage channels and irrigation canal are to convey storm water/irrigation water less than the design discharge smoothly and safely within the specified design high water level (DHWL).

Therefore, the channel/canal should be provided with

(i) enough cross-sectional area to carry the design discharge within the DHWL

(ii) Reasonable planimetric alignment to keep the smooth flow without causing damages to the facilities and structures related to the channel/canal.

53

5.4 Maintenance of Channel/Canal

(2) Patrol and Inspection

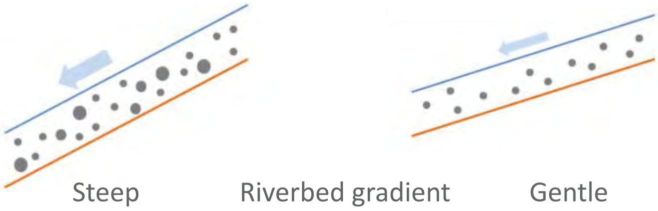
Sediment deposition

- At the selected reaches, fixed-point observation is conducted regularly.
- Sediment in channel/canal is transported downstream by water flow.
- Therefore, when the flow velocity gets slow and decreases carrying capacity, sediment is deposited on the riverbed.

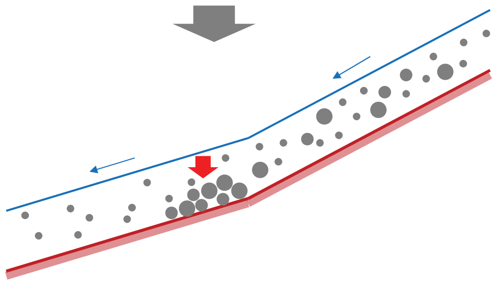
54

5.4 Maintenance of Channel/Canal

Sediment carrying capacity



Steep	Riverbed gradient	Gentle
High	Flow velocity	Low
High	Sediment carrying capacity	Low



55

5.4 Maintenance of Channel/Canal

56

5.4 Maintenance of Channel/Canal

Riverbed degradation and local scoring
In order to grasp riverbed degradation or local scoring damaging river structures, monitoring the condition of topographical change, displacement of structures, etc. is conducted.

If riverbed degradation occurs just downstream of river structures, it might cause them to be deformed or to be washed away.

(Left) Deformation of foundation of bank protection by local scoring
(Right) Outflow of foot protection blocks by riverbed degradation

57

5.4 Maintenance of Channel/Canal

Erosion
The places/reaches to be inspected are the following erodible points. The erodible points are generally extracted from planar positional relation.

- Water colliding front, outside of a curved reach, river bank near water route, etc.
- River bank near a bridge pier, river bank at just downstream of river bank protection works
- A reach that river degradation/local scouring progresses, a reach that cross-sectional area suddenly contracts, etc.

River bank erosion at the curved reach

58

5.4 Maintenance of Channel/Canal

(3) Survey of Channel, Canal and Coast

Cross sectional survey of river channel, drainage/irrigation canal and coast should be periodically carried out to find the change of profile.

Periodic cross sectional survey shall be carried out when remarkable change is found or at least once in 5 years, after severe rain season or severe waves.

Periodical Cross-sectional Survey

Location	Length	Interval
River channel	Depend on channel width	500 m
Drainage channel	Depend on channel width	200 m
Irrigation canal	Depend on canal width	200 m
Coast	400 m (incl. foreshore)	500 m

59

5.4 Maintenance of Channel/Canal

(4) Dredging/Excavation Works for Maintenance

Dredging/excavation works of deposited materials will be done by contract system in principle.

Planning and design will be made based on the cross-sectional survey.
Depth of dredging/excavation shall be determined based on the original design.
The excavated/dredged material should be used for filling the scouring site.

60

5.5 Maintenance of Structures

61

5.5.1 Embankment

(1) Function

Functions of embankment are to confine storm water/irrigation water within the channel/canal, and accordingly to protect people's livelihood and properties. Therefore, the embankments should be provided with (i) enough height to meet the design high water level equipped with some free-board and (ii) necessary strength and durability against water flows at both ordinary and flood times.

62

5.5.1 Embankment

Embankment is generally made of soil.

There are some merits in making of soil.

For construction
- Low construction cost
- Availability of material
- Workability for extension, widening, heightening

For material
- Durability
- Adjustability for deformation of ground

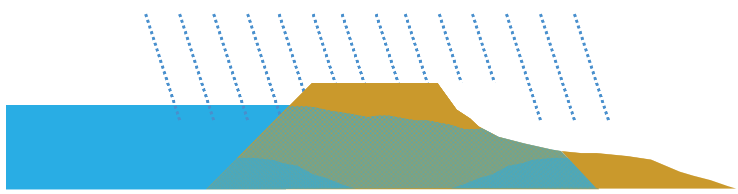
For O&M
- Easy rehabilitation against sinking
- Quick response after damage

63

5.5.1 Embankment

What is the demerit in making embankment of soil?

- Quality of material is not homogeneous compared with concrete and metal structures.
- Stability against slide decreases if river water/rainwater permeates inside embankment.



64

5.5.1 Embankment

- Embankment is eroded by flood flow.

65

5.5.1 Embankment

- It is easily collapsed by overflow.

66

5.5.1 Embankment

(2) Patrol and inspection

Damages/Irregularities of Embankment
- Erosion or scouring of embankment due to river flow.
- Settlement, cracks, leakage of water or piping, and other damages on embankment.
- Vegetation on embankment which may damage the embankment.
- Slope failure of embankment and channel bank.
- Cave-in on land side slope.

Illegal/Harmful Acts
- Cultivation at the embankment foot.
- Cutting embankment crest and slopes for crossing or water intake.
- Burning trash on the embankment.
- Illegal works on the embankment such as public and private facilities, temporary
- building, piling, excavation, etc.

67

5.5.1 Embankment

(3) Repair

Embankment Crest
- After excavation of damaged portion with cutting slope of 60°, high quality soil with appropriate moisture content should be filled.
- The soil filled should be compacted well by using tamper, vibration roller or bulldozer.
- After compaction, sodding should be provided at the shoulder.

Embankment Slope
- Slope repair should be carried out with high quality soil and turf in due order of striping, bench cut, finishing stake, embankment, slope tamping, and driving of support skewer.

68

5.5.1 Embankment

(3) Repair

Cave-in

- The initial cause of cave-in in embankment is an occurrence of voids due to (i) leakage water, (ii) washing away of backfill materials and (iii) insufficient compaction of refilled soil for built-in facility and backfill sand of retaining wall, etc.
- Voids gradually develop into cavities which appear on the embankment crest.
- In order to repair, a detailed investigation on the cause of cave-in is indispensable prior to filling up the cave. If a fault is found in structure itself, the embankment body concerned should be removed and reconstructed.

69

5.5.1 Embankment

(3) Repair

Crack

- Cracks of embankment are usually caused by…
  - ✓ excessive saturation due to seepage water,
  - ✓ contraction of embankment using clayey soil and exposure to drought
  - ✓ earthquake.

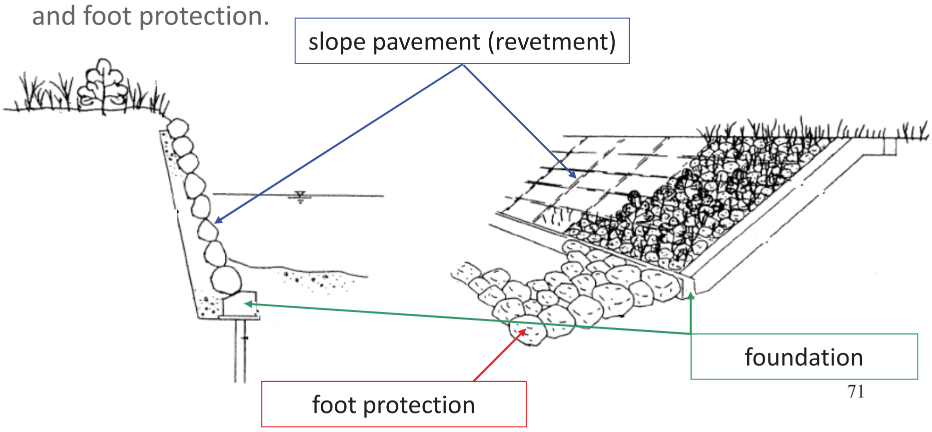
- Before the repair, causes of the cracks should be examined and countermeasures are to be established. For the repair of such cracks, the embankment body should be excavated in V-shape along the crack with slope of 60°, filled with high quality soil, and compacted well with a thickness of 30 cm.

70

5.5.2 Slope (Bank and Foot) Protection Work

(1) Functions

Functions of slope protection works are to protect the embankment or channel/canal banks from scouring by water flow and other objects transported by the flow.
The slope protection work is composed of slope pavement, foundation and foot protection.

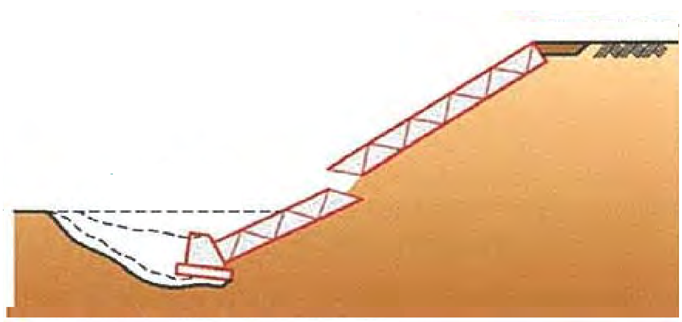


71

5.5.2 Slope (Bank and Foot) Protection Work

Pattern of damage of slope protection work is …

Riverbed degradation
If scoring occurs in front of slope protection work and it reaches bottom of foundation, foundation would lose bearing capacity and collapsed.

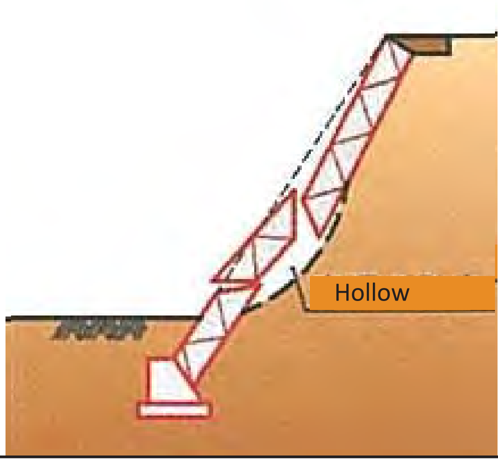


72

5.5.2 Slope (Bank and Foot) Protection Work

Suction of backfill material

When water level gets down, backfill material is sucked and hollow is made. Finally, slope protection work would be collapsed.

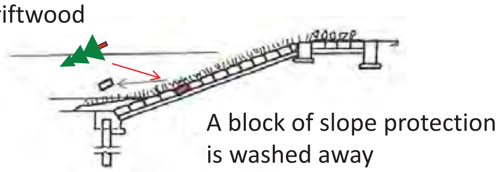


73

5.5.2 Slope (Bank and Foot) Protection Work

Collision of driftwood

During flood, driftwood dash against slope protection work, give damage to its function and cause collapse.



74

5.5.2 Slope (Bank and Foot) Protection Work

(2) Patrol and Inspection

Damages and Irregularities
- Any cracks on slope pavement.
- Condition at the slope protection work especially at foot protection works during low water level.
- Condition of riprap for foot protection at the downstream and upstream site of crossing facilities such as barrage/large scale regulator, etc.
- Condition of construction joint, upper and lower ends of the slope protection work.
- New erosion or scouring in front of the slope protection work.

Illegal/Harmful Acts
- Destroying the slope pavement for crossing or water intake
- Burning trash on the slope protection works.
- Extracting the boulders from the foot protection works.

75

5.5.2 Slope (Bank and Foot) Protection Work

(3) Repair

- For planning of the repair, causes of damage should carefully be investigated and reflected to the repair works.
- If new bank erosion is found, countermeasures against erosion should be conducted soon.
- In planning of the new protection work, influence of the new work to the adjacent reaches or to the downstream reaches should be taken into consideration.
- The repair works will be conducted by force account or contract system depending on the quantity of works.

76

5.5.3 Side Drain

(1) Function

- Side drains/ditches are installed to collect local drainage water at the foot of embankment to drain into the drainage outlet.
- The side drains also function as the boundaries of the embankment area.

(2) Patrol and Inspection

Damage and Irregularities of Side Drain
- Vegetation (Water hyacinth, etc.) which may disturb smooth water flow.
- Severe erosion of drain.

Illegal/Harmful Acts
- Dumping garbage in the drain.
- Barrier put privately in the drain.

77

5.5.3 Side Drain

(3) Maintenance activities

- Cleaning of drains by neighboring residents, including removal of water hyacinth at least annually.
- Water hyacinth poses particular problems because of the rate of growth and speed with which they can re-establish after clearance.
- Repair or rehabilitation: by force account or contract depending on the quantity of works.

78

5.5.4 Groyne/Spur Dike

(1) Function

- To reduce the flow velocity near the bank by directing the flow/wave away from the bank

- Types of structures

Materials	non-permeable
	permeable
Height	non-overflow
	overflow

- It is recommendable to apply groynes/spur dikes to protect the bank from collapse instead of the slope protection works.

79

5.5.4 Groyne/Spur Dike

(2) Patrol and Inspection

Damages and irregularities
In order to grasp the deformation causing functional loss, visual inspection is conducted.
Groyne/super dike sticks out into water flow and so scoring occurs at the point where flow concentrates at, e.g. the tip.
Deformations causing damage are ...

- Inclination, sliding/overturning, outflow of groyne/super dike
- Sliding, outflow of material, e.g. gabion, block and stake
- Erosion at joint between groyne/super dike and the bank
- Wear of concrete, decay of timber
- Floating up of a stake

80

5.5.4 Groyne/Spur Dike

(2) Patrol and Inspection

Illegal/Harmful Acts
- Construction of illegal structure on the groyne
- Burning trash on the groyne.
- Extracting the material from the groyne

(3) Repair

- Repair works of damaged portion are to be conducted by contract system or force account.
- If new erosion is found near the groyne/spur dike, countermeasures against erosion should be conducted soon.
- In planning of the countermeasures, influence of new works to the adjacent bank/coast should be taken into consideration.

81

5.5.6 Bridge/Culvert

(1) Function

- Bridge/culvert is a structure carrying pathway or roadway over the watercourse.
- Bridges will be operated and maintained by the authorities concerned.
- However, the field office of BWDB should conduct maintenance activities to maintain channel/canal function.

82

5.5.6 Bridge/Culvert

(2) Patrol and Inspection

Damage and Irregularities

- Scouring of channel/canal bed around pier and abutment.
- Condition of slope protection works around abutment.
- Gaps or cavities between abutment and embankment.
- Drift wood and garbage around pier.

Illegal/Harmful Acts

- Taking of earth, sand, etc. around pier and abutment.
- Mooring of boats and ships to pier.

83

5.5.8 Sluice and Regulator

(1) Function

- Sluice is a gated structure, which allows water to flow under an embankment, road, or similar obstruction, for draining a surplus water of a watercourse, the polder and the inland.
- Regulator, including escape, is a gated structure constructed to control water flow to different area in the irrigation system and to regulate the water level of canals.
- The regulator constructed at the beginning of the irrigation canal is called as a Head Regulator.
- Escape is a kind of regulators that is built at the last point or at any suitable point of a canal for escaping surplus water.

84

5.5.8 Sluice and Regulator

Deformation which decreases the function of sluice and regulator is …

Suction and leakage
Suction of soil along structural body or leakage at joint of structures could be one reason of the followings.

- Inclination of gate pier and wing wall
- Hollowing around a box culvert
- Deflection, folding or crack of box culvert

Opening at joint (left) and clack on box culvert (right)

85

5.5.8 Sluice and Regulator

Deterioration and corrosion
Deterioration of concrete, water stop rubber, etc. and corrosion of steel should be grasped by visual inspection and be repaired before it gets worsen.

Exposed reinforcing bar due to detachment of concrete (left) and rust of reinforcing bar (right)

86

5.5.8 Sluice and Regulator

Sediment deposition and vegetation

If sediment deposition or vegetation proceeds in water course of sluice/regulator, expected discharge cannot be conveyed. And it prevents the gate from closing certainly.

Sediment deposition from apron to box culvert (left)
and Vegetation in front of gates (right)

87

5.5.8 Sluice and Regulator

(2) Patrol and inspection

Damages and Irregularities

- Gate and gate leaf: In operation/movable conditions, any damage, rusting, greasing and painting.
- Culvert/conduit: Any cracks on concrete.
- Earth works: Any cracks and cave-in.
- Clogging of conduit with garbage, sand gravel, etc.
- Seepage or local scouring.

Illegal/Harmful Acts

- Any missing of parts of gate for operation,
- Stone or plank put between conduit and gate leaf, and
- Barrier put privately at the inlet of conduit.

88

5.5.8 Sluice and Regulator

(3) Maintenance activities

- Repair and rehabilitation of damaged portions by force account or contract system depending on the quantity of works,
- Maintenance operation and greasing at four (4) times a year, by caretaker,
- Painting of gate leaf at least once (1) a year,
- Cleaning works are required at least four (4) times annually and coarse rubbish should be swept at need,
- Replacement of gate leaf should be determined considering the damage/rusted conditions.

89

5.5.10 Pump Station

(1) Function

- Pumping station is the facilities including pumps and equipment for pumping water from one place to another, with the purpose of irrigation or drainage.

(2) Patrol, Inspection and Maintenance Activities

- The pump station is a large scale and complex facility.
- Therefore, the maintenance manual was prepared during the construction woks.
- Maintenance of the pump station should be conducted in accordance with the prepared manual.

90

5.5.11 Hydrological Observation Station, Flood Warning System, etc.

(1) Function

- The hydrological observation stations for rainfall and river water level and the equipment related to the flood warning system are key facilities of the O&M activities.
- All of the O&M activities are conducted based on the information observed from those facilities.

(2) Patrol, Inspection and Maintenance Activities

- Information from those facilities is a key of the O&M activities.
- Therefore, the maintenance of the facilities shall be carried out timely.
- Periodical patrol by the field office staff at least once a month and daily inspection of the site staff are required, especially during the period from pre-monsoon season to post monsoon season.
- Maintenance and update of the equipment shall be conducted timely in accordance with the equipment's manual.

91

6. Budgeting of O&M

92

6.1 Budgeting

O&M budget is prepared based on planning and scheduling.
So budgeting and planning cannot be separated.

O&M budget consists of …

- General and administration budget
- Operation budget
- Maintenance budget
- Special budget (for corrective maintenance)

Each component contains cost estimates for manpower, supplies and materials, transport and equipment and others.

93

6.2 Remarks to Budgeting

3 points for budget preparation are…

(1) Beneficiaries participation of O&M activities
Except the large scale structures, operation and routine maintenance works shall be shared with WMOs as much as possible.

(2) Sharing of O&M activities with other agencies
The maintenance activities shall be shared with other agencies, such as LGED and local governments. If the embankment crest is used as the road, routine/periodic maintenance works can be shared with the other agencies.

(3) Revision of O&M plan after allocation of budget
In case that the allocated budget is less than the proposed need basis annual budget, the medium term O&M plan and annual O&M plan should be revised properly.

94

7. Implementation and Monitoring of O&M

7.1 Implementation of O&M
7.2 Monitoring of O&M

95

7.2 Monitoring of O&M

Monitoring implies collection of data, processing data and reporting the results.
5 primary types or themes of monitoring are as follows…

Type/Theme of Monitoring	Purpose	Indicators	Method
Water Management/ Infrastructural	Plan / assess operation and routine / periodic Maintenance	Condition of dykes, sluices, inlets, canals, water level	Joint field observations by WMOs & BWDB
Institutional	Assess the WMO's functioning and Relationships	WMO unity, activities, Participation	Record / analysis by WMOs & BWDB
Economic	Assess the benefits of Water Management	Cropping patterns, yields, Employment	Data from WMOs
Social	Assess the poverty reduction impact and gender issues	Poverty status of WMO members, women's roles	Analysis by WMOs & BWDB
Environmental	Plan / assess the SEMP activities	Environmental action, pollution	Analysis by WMOs & BWDB

96

8. Flood Fighting

97

8.2 Preparation for Severe Rainy Season

In this manual, general and technical descriptions for the flood fighting during emergency period are presented.

Before rainy season, the following preparation should be carried out.

a) Checking of the condition of gates and other structures.
b) To secure of the radio telecommunication and transportation system.
c) To prepare an inventory of the critical parts of the embankment and to observe them regularly and more thoroughly.
d) To secure stockpiles of sandbags, wooden and bamboo piles, woven bamboo mattress, gabion wires, stones and other materials.
e) To summon the staff of picket and associate members for flood fighting
f) A flood warning guidelines book shall be made available at each flood warning picket.
g) If necessary, simulation training for the staff of picket on flood fighting shall be conducted.

98

8.3 Inspection of Facilities

During the flood time/high tide/severe waves, the following sites should be inspected.

a) the discharge capacity is less,
b) the height of embankment crest or sea dike is lower,
c) the embankment was broken in the past,
d) the former river course,
e) a space or crack occurred in the past,
f) leakage of water or sand boil occurred in the past,
g) flood water/wave attacks violently,
h) the foot of slope protection of river bank/groyne/sea dike is washed away,
i) severe erosion site along the coast,
j) under construction, and
k) river/drainage/coastal structures such as sluiceway, bridge, groyne/spur dike, dike, etc.

99

8.4 Possible Causes of Damage to Embankment and its Countermeasures

(1) Possible Causes of Damage to Embankments

The causes of damage to embankments are…overflow, seepage, souring, etc.

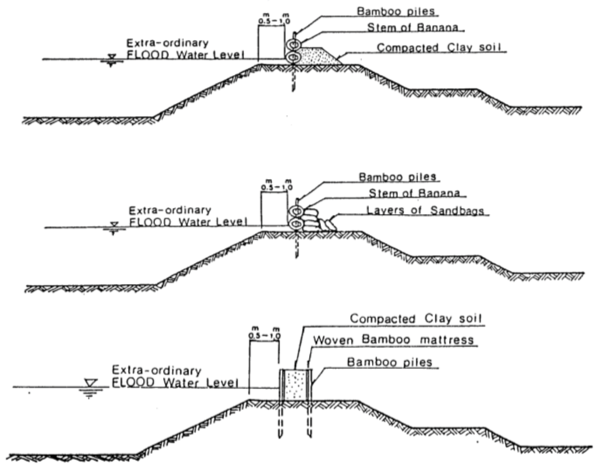
- To collect information of the extent of damage as precisely as possible, accessibility to site shall be clarified.
- To prepare an urgent repair plan such as countermeasure, construction method, material, manpower and equipment.
- To summon staff and associate members. It is quite difficult to continue the repair works only by the staff of executing body. Staff from other authorities concerned and sometimes contractor nearby the site are required.
- To secure the works and construction equipment.
- To secure the material such as sandbags, wooden piles, bamboos and soil itself.
- To secure the communication system, handy talky etc. is requisite.
- To secure lighting equipment for night works.

100

8.4 Possible Causes of Damage to Embankment and its Countermeasures

(2) Countermeasures to Prevent Flooding

a. Overflow

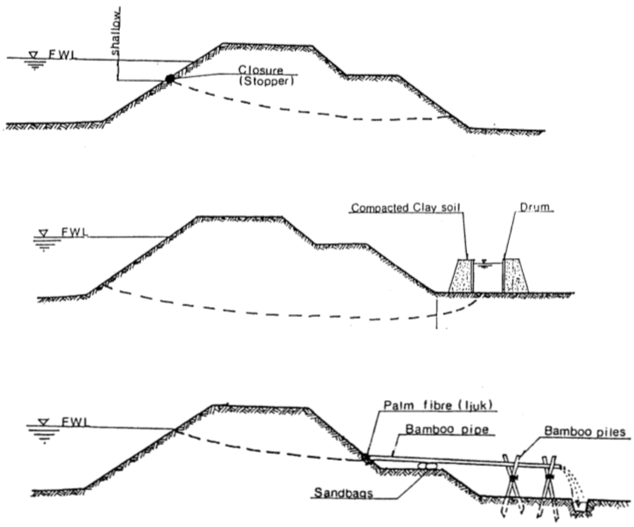


101

8.4 Possible Causes of Damage to Embankment and its Countermeasures

(2) Countermeasures to Prevent Flooding

b. Seepage/Leakage

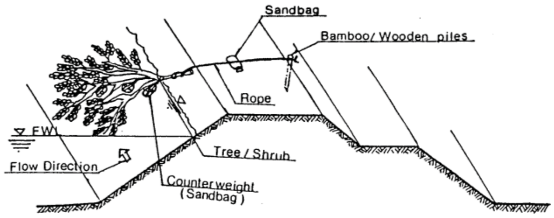


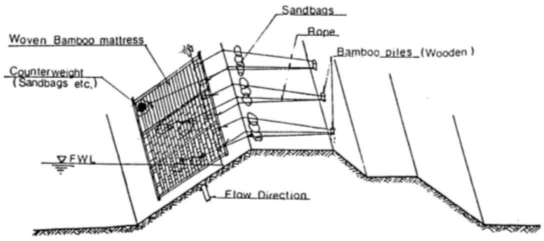
102

8.4 Possible Causes of Damage to Embankment and its Countermeasures

(2) Countermeasures to Prevent Flooding

c. Scouring



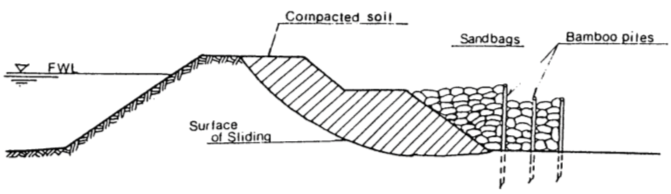


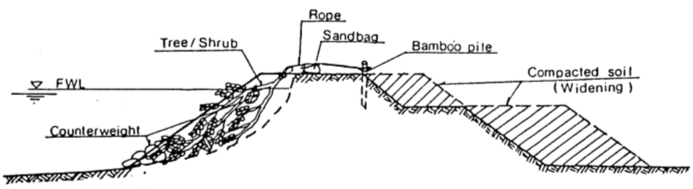
103

8.4 Possible Causes of Damage to Embankment and its Countermeasures

(2) Countermeasures to Prevent Flooding

d. Sliding



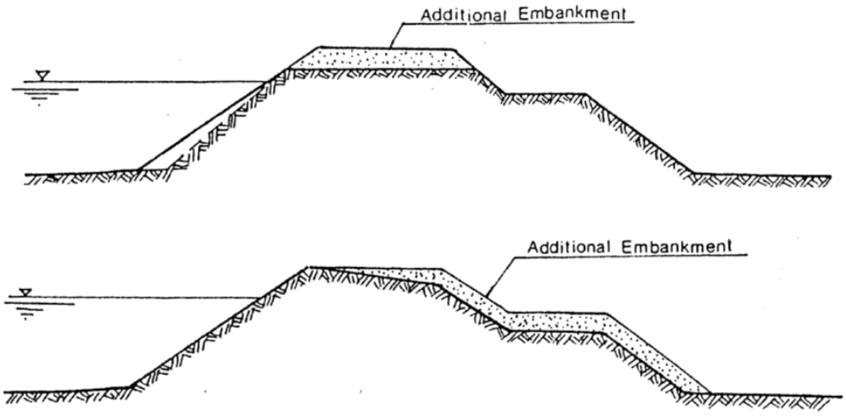


104

8.4 Possible Causes of Damage to Embankment and its Countermeasures

(2) Countermeasures to Prevent Flooding

e. Settlement of Embankment



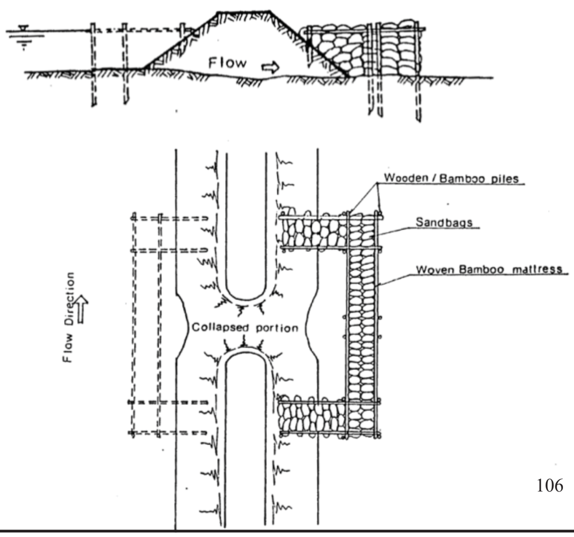
105

8.4 Possible Causes of Damage to Embankment and its Countermeasures

(2) Countermeasures to Prevent Flooding

f. Breach of Embankment

Cross-sectional View



Plan View

106

Thank you very much

107