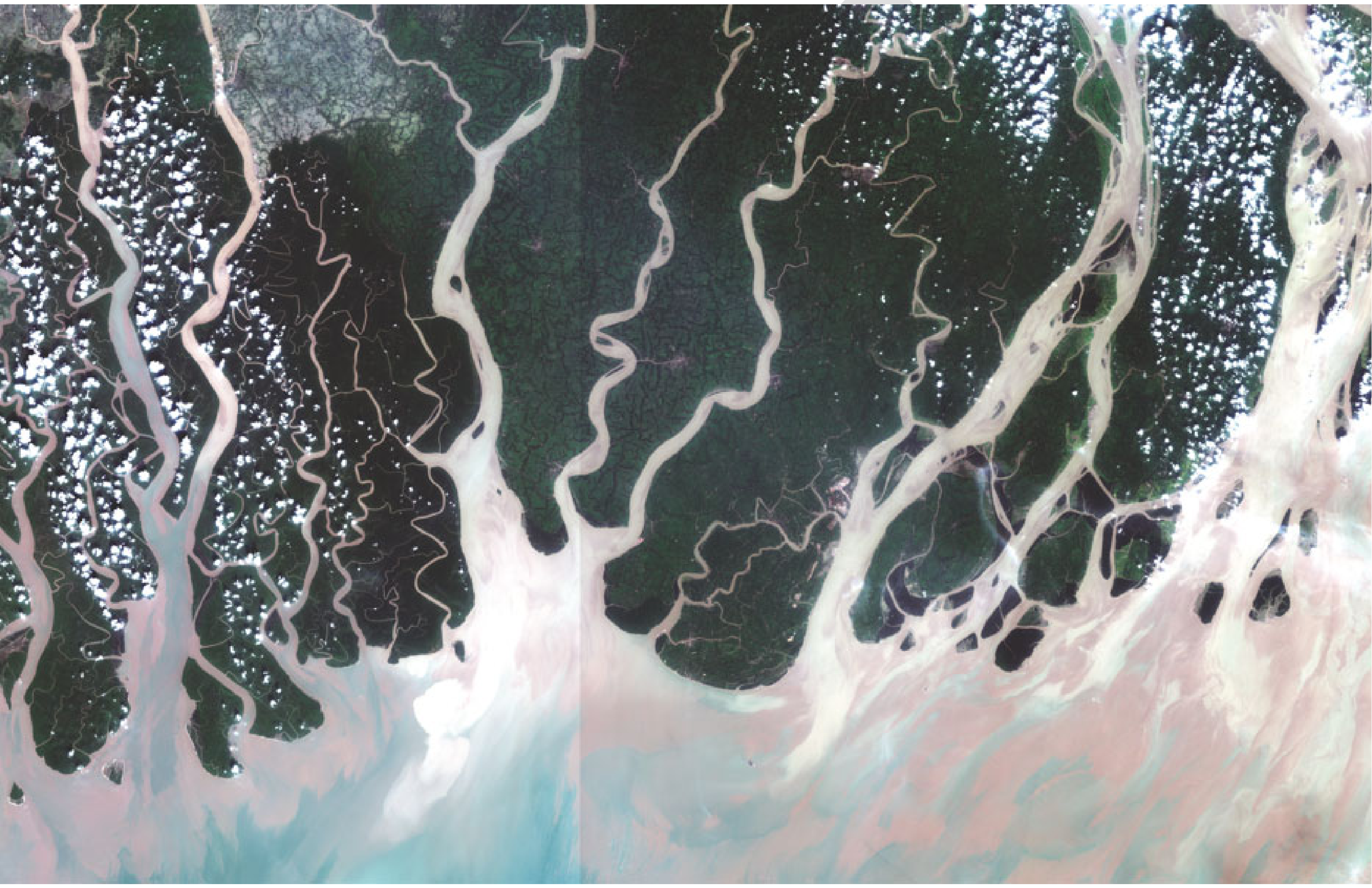
Government of the People's Republic of Bangladesh
Bangladesh Water Development Board (BWDB)

# Coastal Embankment Improvement Project



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## Consultancy Services for Feasibility Studies and Preparation of Detailed Design for the Following Phase (CEIP-2)

### Coastal Embankment Improvement Project II

### Modelling Assessment: Part B Drainage Infrastructure
**Draft Report**
**December 2022**

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# Abbreviations, Acronyms and Units

| | |
|---|---|
| AED | Average Annual Expected Damage |
| ACL | Authorized Crest Level |
| ADCP | Acoustic Doppler Current Profiler |
| AHP | Analytical Hierarchy Process |
| ARIPA | Acquisition and Requisition of Immovable Property Act |
| ARIPO | Acquisition and Requisition of Immovable Property Ordinance |
| AsDB | Asian Development Bank |
| BADC | Bangladesh Agriculture Development Corporation |
| BARI | Bangladesh Agriculture Research Institute |
| BBS | Bangladesh Bureau of Statistics |
| BIWTA | Bangladesh Inland Water Transport Authority |
| BMD | Bangladesh Meteorological Department |
| BoB | Bay of Bengal |
| BoB SAL | Bay of Bengal Salinity |
| BoQ | Bill of Quantities |
| BRRI | Bangladesh Rice Research Institute |
| BTM | Bangladesh Transverse Mercator |
| BWDB | Bangladesh Water Development Board |
| BM | Bench Mark |
| BoBM | Bay of Bengal Model |
| CBA | Cost-Benefit Analysis |
| CC | Climate Change |
| CCL | Cash Compensation Under Law |
| CDPo | Coastal Development Policy |
| CDMP | Comprehensive Disaster Management Program |
| CDS | Coastal Development Strategy |
| CDSP | Char Development and Settlement Project |
| CEGIS | Center for Environmental and Geographic Information Services |
| CEIP | Coastal Embankment Improvement Program / Project |
| CEIP-1 | Coastal Embankment Improvement Program / Project – Phase 1 |
| CEIP-2 | Coastal Embankment Improvement Program / Project – Phase 2 |
| CEP | Coastal Embankment Project |
| CERP | Coastal Embankment Rehabilitation Project |
| CES | Coastal Embankment System |
| CPP- I | Cyclone Protection Project - I |
| CPP- II | Cyclone Protection Project - II |
| CZ | Coastal Zone |
| CZE | Coastal Zone Embankment |
| CZPo | Coastal Zone Policy |

| | |
|---|---|
| CZWMP | Coastal Zone Water Management Program |
| CSPS | Cyclone Shelter Preparatory Study |
| DAE | *Department of Agriculture* Extension |
| DCF | Discounted Cash Flow |
| D&CSC | Design & Construction Supervision Consultants |
| DDC | Development Design Consultants |
| DEM | Digital Elevation Model |
| DHI | Danish Hydraulic Institute Denmark |
| DISREP | Distribution Sector Recovery Program |
| DGPS | Differential Global Positioning System |
| DLR | Director Land Records |
| DoE | Department of Environment |
| DoF | Department of Fisheries |
| DPM | Design Planning & Management |
| DSM | Digital Surface Model |
| DTM | Digital Terrain Model |
| EA | Environmental Assessment |
| EAP | Environmental Action Plan |
| ECA | Environmental Conservation Act |
| ECR | Environmental Conservation Rules |
| ECRRP | Emergency Cyclone Recovery and Restoration Project |
| ED | Executive Director |
| EDP | Estuary Development Program |
| EEWS | Early Erosion Warning System |
| EHS | Environmental, Health, and Safety |
| EIA | Environmental Impact Assessment |
| EMA | External Monitoring Agency |
| EMP | Environmental Management Plan |
| EMF | Environmental Management Framework |
| EPG | Embankment Protection Group |
| EPs | Entitled Persons |
| ES | Embankment Settlers |
| ESS2 | Environmental and Social Standard 2 |
| ESCP | Environmental & Social Commitment Plan |
| ESF | Environmental and Social Framework |
| ESS | Environmental Social Standards |
| FAO | Food and Agricultural Organization |
| FAP-7 | Flood Action Plan-7 |
| FCD | Flood Control & Drainage |
| FCDI | Flood Control Drainage & Irrigation |
| FGD | Focus Group Discussion |

| | |
|---|---|
| FFG | Foreshore Forestry Group |
| FM | Flood Management |
| FO | Field Office |
| FREMIP | Flood and Riverbank Erosion Risk Management Investment Program |
| FWOP | Future-Without-Project |
| FWIP | Future-With-Project |
| GBV | Gender Bases Violence |
| GCC | General Conditions of Contract |
| GCPs | Ground control points |
| GDP | Gross Domestic Product |
| GeoDASH | Geospatial Data Sharing Portfolio |
| GIS | Geographic Information Systems |
| GOB | Government of Bangladesh |
| GO | Government Organization |
| GPP | Guidelines for People's Participation |
| GPS | Global Positioning System |
| GRM | Grievance Redress Mechanism |
| GRRP | Gorai River Restoration Project |
| IA | Implementing Agency |
| IBRD | International Bank for Reconstruction & Development |
| ICB | International Competitive Bidding |
| ICZM | Integrated Coastal Zone Management |
| ICZMP | Integrated Coastal Zone Management Plan |
| ICZMP | Integrated Coastal Zone Management Program |
| IDA | International Development Agency |
| IESCs | Important Environmental and Social Components |
| IPC & WMPs | Infection Prevention Control and Waste Management Plans |
| IRR | Internal Rate of Return |
| INROS | Inros Lackner |
| IoL | Inventory of losses |
| IPCC | Intergovernmental Panel on Climate Change |
| IPSWAM | Integrated Planning For Sustainable Water Management |
| ITC | Information and Communication Technologies |
| IUCN | International Union for Conservation of Nature |
| IWM | Institute of Water Modelling |
| IEE | Initial Environmental Examination |
| KJDRP | Khulna Jessore Drainage Rehabilitation Project |
| KII | Key Informant Interview |
| KMC | Knowledge Management Consultants |
| LAPs | Land Acquisition Plans |
| LGED | Local Government Engineering Department |

| | |
|---|---|
| LGI | Local Government Institution |
| LMP | Labour Management Procedure |
| LRP | Land Reclamation Project |
| MCA | Multi-Criteria Analysis |
| M&E | Monitoring and Evaluation |
| MES | Meghna Estuary Studies |
| MIS | Management information systems |
| MoEF | Ministry of Environment and Forest |
| MoFDF | Ministry of Food and Disaster Management |
| MOWR | Ministry of Water Resources |
| MoL | Ministry of Land |
| MSL | Mean Sea Level |
| NCB | National Competitive Bidding |
| NEP | National Environmental Policy |
| NEMAP | National Environment Management Action Plan |
| NGO | Non Government Organization |
| NHC | Northwest Hydraulics Consultans |
| NWMP | National Water Management Plan |
| OCC | One-stop Crisis Cell |
| O&M | Operation and Maintenance |
| OP | Operation Policies |
| PSC | Project Steering Committee (PSC) |
| RAP | Resettlement Action Plan |
| REA | Rapid Environmental Assessment |
| RMS | Root Mean square |
| RPF | Resettlement Policy Framework |
| RTK | Real Time Kinematic |
| PAP | Project Affected People |
| PAVC | Property Assessment and Valuation Committee |
| PBM | Permanent Bench Marks |
| PD | Project Director |
| PDC | Polder Development Committee |
| PIU | Project Implementation Unit |
| PMU | Project Management unit |
| POM | Project Operations Manual |
| PPCR | Pilot Programme for Climate Resilience |
| PPR | Project Progress Report |
| PMIS | Polder Management Information System |
| PVS | Property Valuation Survey |
| PWD | Public Works Department |

| | |
|---|---|
| PRA | Participatory Rapid Assessment |
| JV | Joint Venture RHDHV-NHC-INROS |
| RAP | Resettlement Action Plan |
| RRA | Rapid Rural Appraisal |
| RCC | Reinforced Cement Concrete |
| RHDHV | Royal HaskoningDHV |
| RoR | Record of Rights |
| SA | Social Assessment |
| SCM | Stakeholders Consultation Meeting |
| SEP | Stakeholder Engagement Plan |
| SIA | Social Impact Assessment |
| SLR | Sea Level Rise |
| SMRPFW | Social Management and Resettlement Policy Framework |
| SPARSO | Space Research & Remote Sensing Organization |
| SPMC | Strategic Planning and Management Consultants |
| SRP | System Rehabilitation Project |
| SRDI | Soil Resource Development Institute |
| SSHSMP | Site-Specific Health and Safety Management Plan |
| SWMC | Surface Water Modelling Centre |
| SWZ | South Western Zone |
| SZ | Southern Zone |
| SOB | Survey of Bangladesh |
| SWRM | South West Region Model |
| SEA | Strategic Environmental Assessment |
| SEAA | Sexual Exploitation and Assault |
| SMRPF | Social Management & Resettlement Policy Framework |
| SWRSAL | South West Region Salinity |
| TRM | Tidal River Management |
| TBM | Temporary Bench Mark |
| ToR | Terms of Reference |
| WARPO | Water Resources Planning Organization |
| WB | World Bank |
| WMA | Water Management Association |
| WMIP | Water Management Improvement Project |
| WRS | Water Retention Structures |
| WSIP | Water Sector Improvement Project |
| WUA | Water Users Association |
| MWh | Megawatt hour |
| | |
| m | Metre |
| cm | Centimetre |

| | |
|---|---|
| ha | Hectare |
| l | Litre |
| mm | Millimetre |
| $m^3/s$ | Cubic metres per second |
| $m^3$ | Cubic metres |
| km | Kilometre |
| $km^2$ | Square kilometres |
| Mt | Mega ton ($10^9$ kilogram) |

# 1 Introduction

## 1.1 Project Description

The intent of the Coastal Embankment Improvement Project – 2 (CEIP-2) is to reduce the flood disaster risk of the Polders within the coastal area of Bangladesh, bringing increased flood security to the communities who live within the Polders. The Polders of Bangladesh are embanked islands surrounded by a complex network of interconnected tidal rivers. The Polders are vulnerable to flooding, which can be caused by irregular cyclone tropical storms (bonna floods), water-logging (jalabaddho floods) and annual monsoon flooding (borsha floods). During CEIP-2, flood risk management structures will be designed and constructed, which will mitigate all three types of flooding within the selected Polders.

The following 13 Polders have been selected for flood risk mitigation infrastructure improvement under CEIP-2 (the associated Thana and District has been listed as well, respectively):

| Sl. No. | Polder No. | Name of Thana | District |
|---|---|---|---|
| 1 | P-7/1 | Assasuni, Shyamnagar | Satkhira |
| 2 | P-7/2 | Assasuni | Satkhira |
| 3 | P-13-14/2 | Koyra | Khulna |
| 4 | P-39/1B | Motbaria | Pirojpur |
| 5 | P-41/5 | Barguna Sadar | Barguna |
| 6 | P-45 | Taitoli | Barguna |
| 7 | P-47/1 | Kalapara | Patuakhali |
| 8 | P-5 | Kaliganj, Shyamnagar | Satkhira |
| 9 | P-4 | Assasuni | Satkhira |
| 10 | P-10-12 | Koyra, Paikgacha | Khulna |
| 11 | P-39/1C | Motbaria | Pirojpur |
| 12 | P-50-51 | Rangabali | Patuakhali |
| 13 | P-55/2D | Dashmina | Patuakhali |

The Polders are situated in two distinct zones: the Shatkira or Southwestern Zone and the Barguna or Southern Zone. The selected Polders are shown in Figure 1-1 and Figure 1-2, as well as the Polders that were the focus of the first phase of this project, CEIP-1.

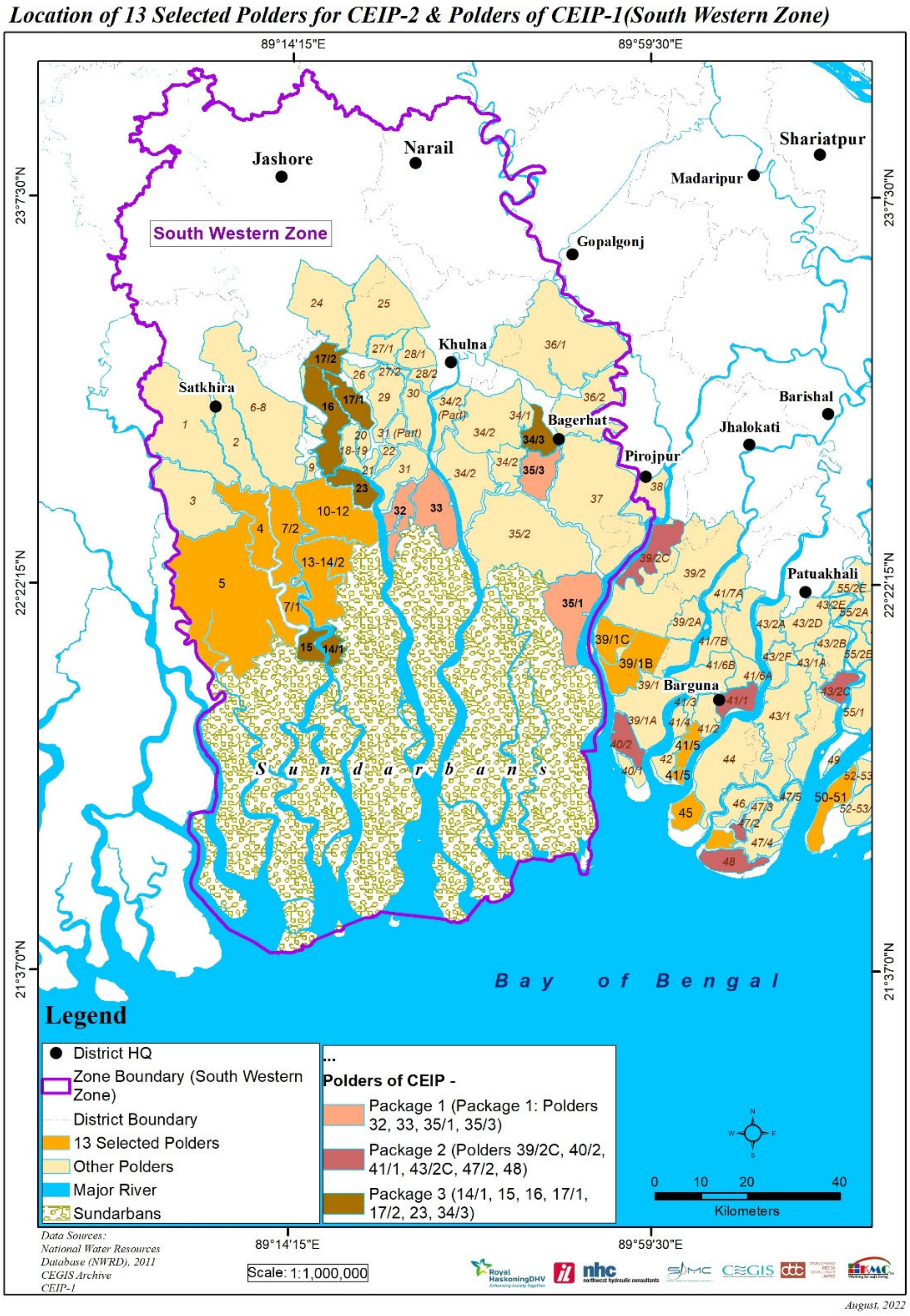


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*Figure 1-1: Six selected Polders for CEIP-2 in the Southwestern Zone.*

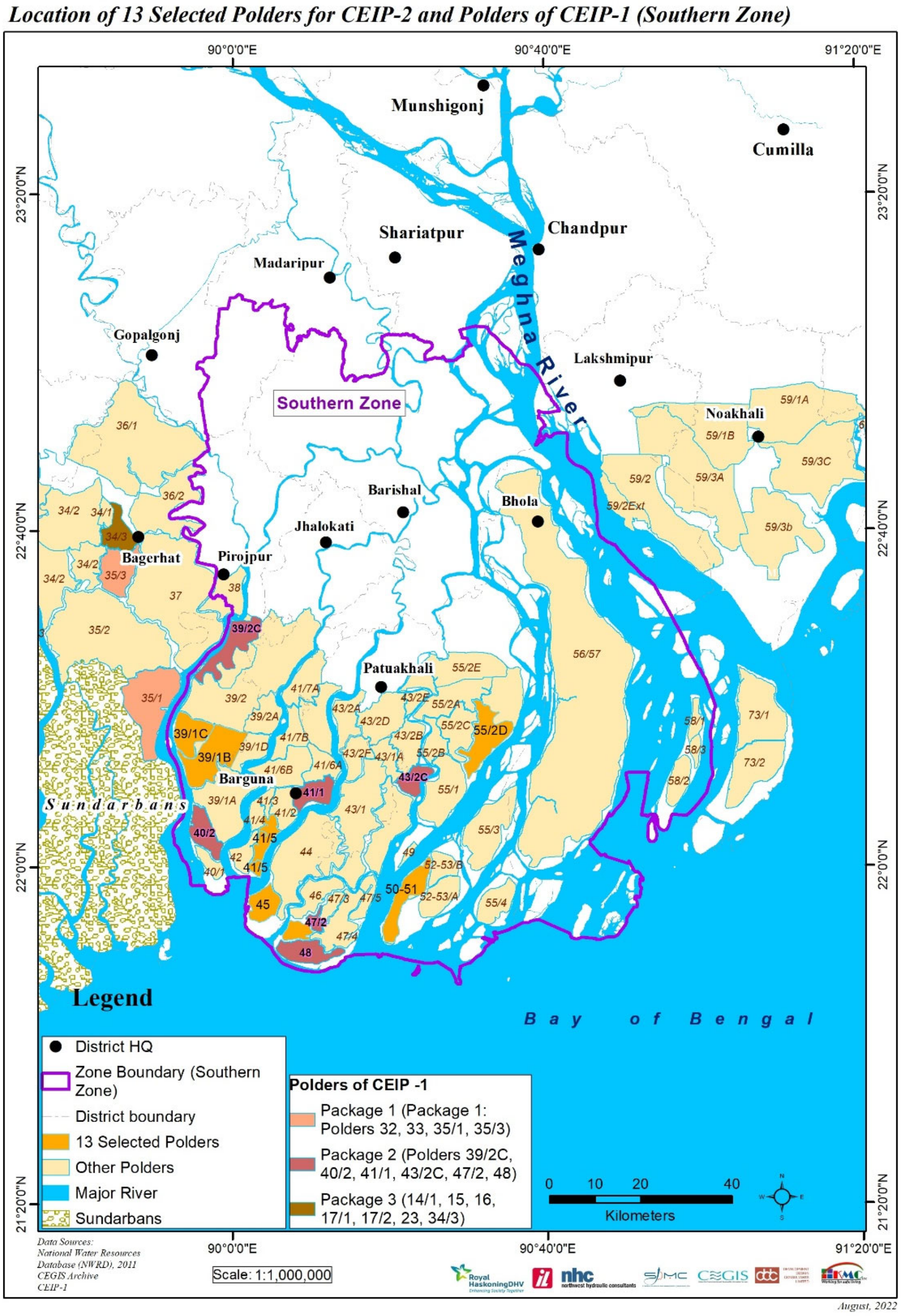



*Figure 1-2: Seven selected Polders for CEIP-2 in the Southern Zone.*

## 1.2 Purpose and Scope of this Report

This report, along with the Morphological Assessment Report and the Modelling Assessment: Part A Embankment Crest Levels report, is *Deliverable 4: Modelling Reports (Storm Surge Modelling and Polder Morphological Analysis and Polder Drainage Modelling) for max. 13 Polders*. This Deliverable meets *Task 2.1 (c) hydraulic/hydrological analysis/modelling, and (e) assessment internal water management polders*.

This report is intended to detail the internal drainage modelling study and summarize the results. The internal drainage modelling study utilized individual 2D Polder drainage models, which will use the boundary data from the 1D regional models (presented in Part A of the modelling study), in order to predict and optimize drainage of rainfall within the Polders to prevent water logging. The intent of the modelling study is to determine the design parameters for the design of the flood risk management structures to be constructed during CEIP-2. As well, this modelling study will identify bottlenecks in the drainage system (clogged khals or outlet capacity at the structures). Specifically, this study will provides the recommended drainage capacity (re-excavation/excavation of khals and regulators) to prevent waterlogging according to the design scenario.

## 1.3 Outline of this Report

This report first summarizes the selected design scenarios for CEIP-2. Next, a summary of the climate change assessment is presented, along with a discussion on how the assessment has been applied to the CEIP-2 drainage modelling assessment. Details of the drainage models are presented in the following chapter. And finally, results of the drainage models are provided, followed by an additional discussion of the results. Results of the drainage model testing the final design are not included in this report.

# 2 Selected Design Scenarios for CEIP-2

The following conditions are assumed to be the design criteria pertaining to the drainage of the Polders (*Figure 2-1*):

- Drainage structures will the necessary capacity so that in three days after a 10-year storm with a five-day duration, with a combined a peripheral river water level of an average monsoon (3-year) and average tide., 95% of the incremental area inundated (i.e excluding the area that cannot be drained by gravity, such as a pond) should have a water depth equal to or less than 300 mm (F0 land).
- The design of the drainage structures will consider projected climatic changes over the structures' lifetime and ground subsidence.

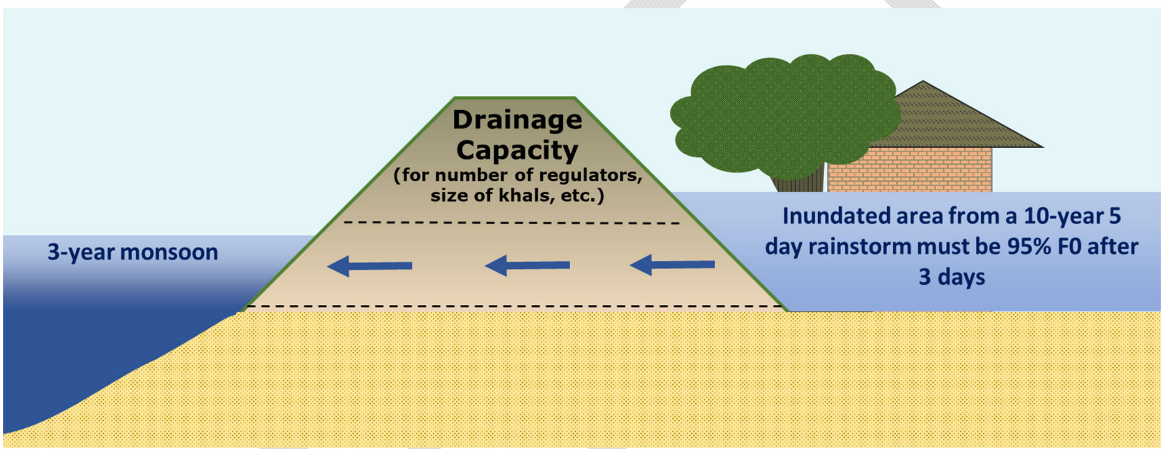



*Figure 2-1: Design conditions for CEIP-2 structures.*

# 3 Climate Change Assessment

Anthropogenic warming of the earth is expected to have significant impacts on the coastal processes of Bangladesh. The designs of CEIP-2 must accommodate the possible changes in future climate conditions, to the best extent possible. The Modelling Report Part A contains a detailed description of the climate change assessment. The following table summarizes the changes in climatic parameters used in this study. See Appendix A1 of the *Modelling Report Part A* for details on how these parameters were determined.

*Table 3-1: Summary of climate change considerations for this study. Results are taken from the most recent IPCC report[1], unless otherwise noted.*

| Parameter | Remarks | Parameter Variation RCP 8.5 Emissions Scenario in 2080 |
|---|---|---|
| Average Temperature | Monthly average temperatures are expected to increase. | Average monthly temperature increase varies throughout the year, with a maximum increase in averaged temperatures in December - February of 4.63°C and 4.95°C in the South central and South western region, respectively. Similarly, the annual average temperature will rise by 4 and 4.2°C in the South central and South western region, respectively. |
| Tropical cyclone wind speed | Tropical cyclone intensity is expected to increase with rising sea temperatures. Due to the increase in intensity, surface winds are expected to increase[2]. | Historic rates increased by 10% |
| Sea level rise | The sea level is expected to rise due to, primarily, thermal expansion of the oceans and glacial ice caps melting. The projections are for the global mean sea level rise. This study has assumed that the global mean sea level rise will equal the local sea level rise along the Bangladesh coastline. | Present day sea level increased by 0.65 m |
| Tidal amplitude and asymmetry | Tidal amplitudes and asymmetries could increase or decrease because of sea level rise. However, other factors, such as loss of intertidal area, can | Unchanged |

[1] IPCC, 2021. Climate Change 2021: *The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, In press, doi:10.1017/9781009157896.

[2] Knutson, T., Camargo, S. J., Chan, J. C. L., Emanuel, K., Ho, C.-H., Kossin, J., et al., 2020. *Tropical Cyclones and 56 Climate Change Assessment: Part II. Projected Response to Anthropogenic Warming*. Bull. Am. Meteorol. Soc. 57 101, E303–E322. doi:10.1175/BAMS-D-18-0194.1.

| Parameter | Remarks | Parameter Variation RCP 8.5 Emissions Scenario in 2080 |
|---|---|---|
| | also change tidal characteristics[3]. According to a study by Pickering et al.[4], there are negligible changes in tidal amplitude at the location of the model boundaries. Therefore, changes in tidal characteristics will in part be included in the modelling results; however, some effects, like bed roughness changes, will not be included. | |
| Rainfall intensity | Extremes in rainfall are expected to increase; this indicates that rainfall events will become more severe. | Monsoon rainfall increased by 11%, and 15% in the Southern and Southwestern Zone, respectively |
| River discharge | With increased rainfall, river discharges are expected to increase. | The expected percent increase in discharge for the Ganges, Brahmaputra, and Upper Meghna is 55%, 29% and 18% respectively |
| Salinity | As sea levels rise, salinity extents could increase in the dry season. | Not considered in the analysis |
| Sediment Flux | With increased rainfall and river discharges, sediment fluxes will increase, however, future sediment fluxes may decrease due to basin wide dynamics[5]. | Qualitatively considered |



[3] LTM, 2020. *Interim Report on the Effect of human interventions on tidal and sediment dynamics in the Pussur-Sibsa basin*. Report prepared by DHI and Deltares in association with IWM and University of Colorado for the Bangladesh Water Development Board.
[4] Pickering, M. D., Horsburgh, K. J., Blundell, J. R., Hirschi, J. J.-M., Nicholls, R. J., Verlaan, M., Wells, N. C., 2017. The impact of future sea-level rise on the global tides, Continental Shelf Research, Volume 142, 2017, Pages 50-68, ISSN 0278-4343, https://doi.org/10.1016/j.csr.2017.02.004.
[5] Sarker, M. H., Aketer, J., Ferdous, M. R., Noor, F., 2009. *Sediment dispersal processes and management in coping climate change in the Meghna Estuary, Bangladesh*, Sediment Problems and Sediment Management in Asian River Basin, Workshop held at Hyderbad, India, September 2009, IAHS Publ. 349.

# 4 Drainage Model Details

Individual drainage models will be created for each of the Polders. The 2D models will simulate overland flow and rainfall runoff. The results of this model will be used to determine the required drainage infrastructure to meet the design standards.

The models described in the Modelling Report Part A[6], Chapter 8 (SOBEK 1D FLOW) have been updated to include each Polder via the overland flow and rainfall runoff modules. Thirteen separate drainage models were developed. Using these models he hydrology and hydraulic conditions within the Polders have been simulated. Within each Polder, the runoff generated from the catchment was routed into the respective drainage khals in proportion to their respective drainage areas, which eventually drained towards the peripheral rivers through the structures (see an example of the a Polder drainage model in *Figure 4-1*). The polder drainage network drains under gravity when the outside river level falls below the internal (polder) water level. The runoff for each of the sub-catchments was calculated following SCS-CN method. The model included existing drainage khals, surveyed cross-section data of the internal drainage channels and existing water control structures within the polder area including detailed catchments distribution for the internal drainage channels and peripheral river systems for developing the polder drainage model.

The drainage structures were included in the model. There are two types of hydraulic structures inside the polders termed as drainage and flushing sluices. During critical periods flushing regulators also drains. The structures were modelling considering their dimensions/size, number of vents and invert levels together with their operating rules of gates. The operation rules were defined such that if riverside water level is higher countryside water level, the gates of the structure are closed automatically, and vice versa.

The design discharge and head difference for determining design parameters for the drainage structure components (number of vents, vent size, sill level etc.) were determined through simulation using 10-year return period 5-days cumulative storm event. The model was once again simulated with climate change to keep average water levels under influence of climate change for the polder adjacent periphery rivers. Trials were done on the basis of tidal forcing to quantify the impact of neap/ spring and ebb/ flow tides. Trials were also done on basis of fixing sill level of the regulators for maintaining acceptable drainage capacity of structure. The models simulated eight days of drainage (five days of the storm, and 3 days of successive drainage). Subsidence will be included in the model by lowering the internal Polder elevations by the estimated subsidence allowance. Soil data is from the Soil Research Development Institute.

[6] The existing calibrated and validated Regional Model of both South West and South Central region of Bangladesh.

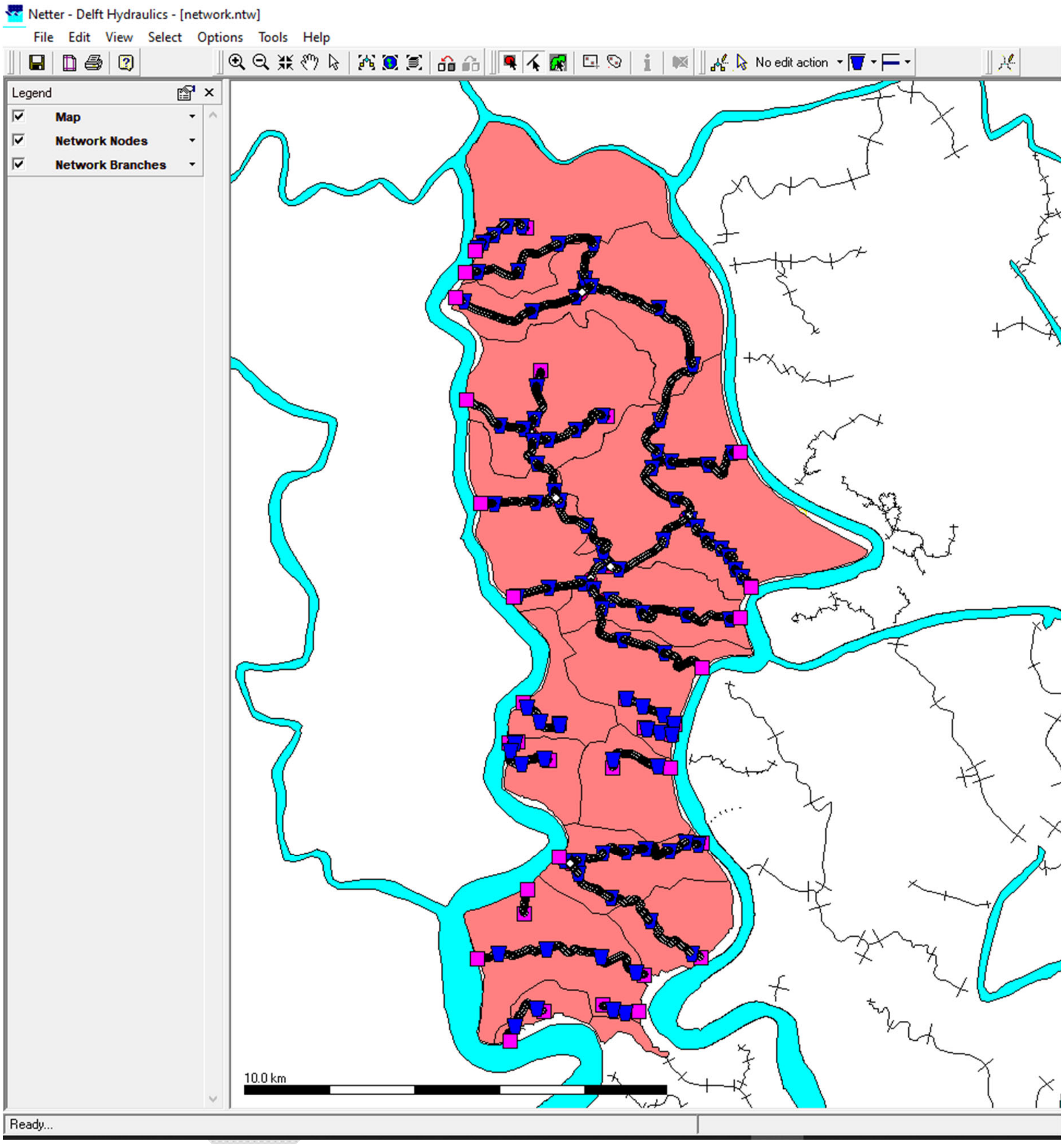



*Figure 4-1: Schematized network and cross section for Polder 7/2 developed in SOBEK.*

## 4.1 Rainfall Analysis to Determine the Design Flood Event

To determine the design rainfall events, daily rainfall data has been analysed. Rainfall data was collected from the following BMD rainfall stations: Khepupara (station ID 112110), Patuakhali (station ID 12103), Satkhira (station ID 11610), Mongla (station ID 41958), Barishal (station ID 11704) and Khulna (station ID 11604) (see *Figure 4-2*). These stations have been selected by analysing the influence of each rainfall station on the selected coastal polders through the Theisen Polygon Technique (see Table 4-1). Mongla station has available data from 1991-2021, while all other stations have data available from 1985-2021 (approximately 36 years of data). Yearly maximum rainfall has been calculated to determine the 1-, 2-, 3-, 4-, and 5-day cumulative rainfall events.

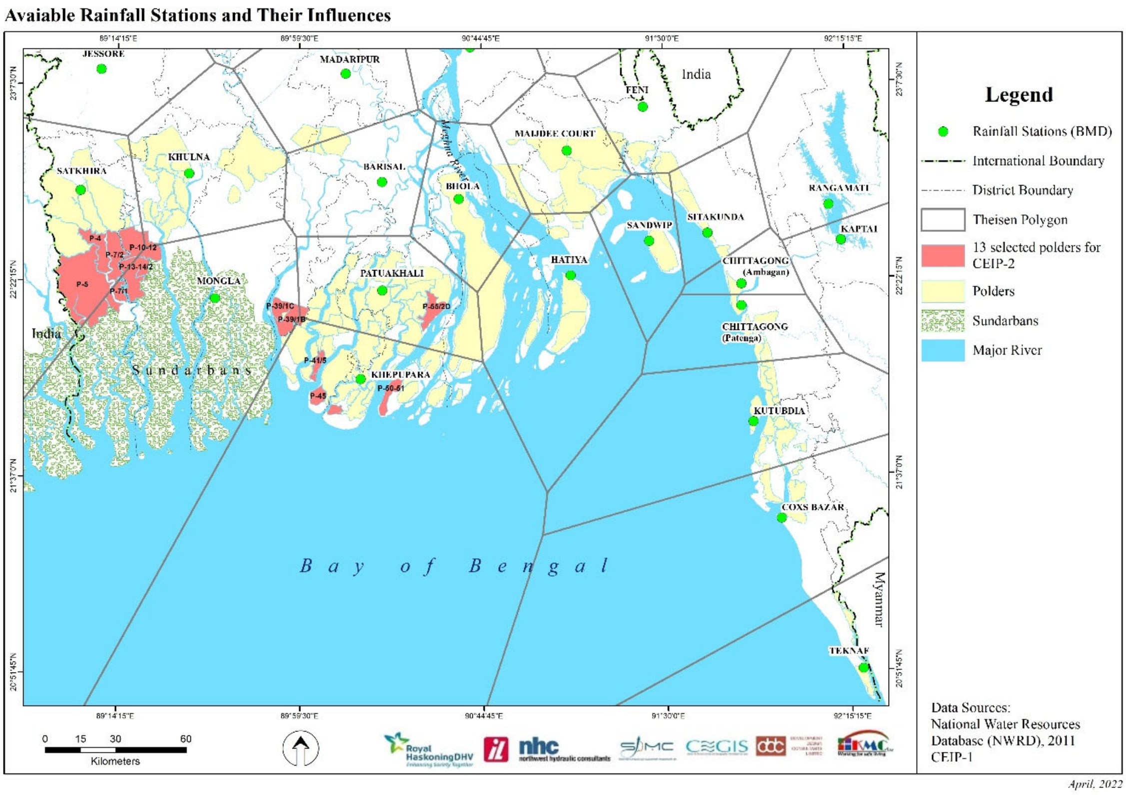



*Figure 4-2: Rainfall data stations.*

*Table 4-1: Influence of rainfall stations on each Polder.*

| ***SL*** | ***Polder Name*** | ***Total Area ($km^2$)*** | ***Rainfall Station*** | ***Influenced Area ($km^2$)*** | ***Precent of Influenced Rainfall Station*** |
|---|---|---|---|---|---|
| 1 | Polder-13-14/2 | 154.998 | Mongla | 129.125 | 83.3 |
| | | | Satkhira | 25.872 | 16.7 |
| 2 | Polder-4 | 102.980 | Satkhira | 102.980 | 100.0 |
| 3 | Polder-41/5 | 37.379 | Khepupara | 37.379 | 100.0 |

| SL | Polder Name | Total Area ($km^2$) | Rainfall Station | Influenced Area ($km^2$) | Precent of Influenced Rainfall Station |
|---|---|---|---|---|---|
| 4 | Polder-5 | 546.000 | Satkhira | 467.294 | 85.6 |
| | | | Mongla | 78.706 | 14.4 |
| 5 | Polder-7/1 | 36.146 | Mongla | 33.653 | 93.1 |
| | | | Satkhira | 2.494 | 6.9 |
| 6 | Polder-7/2 | 109.408 | Satkhira | 109.374 | 99.97 |
| | | | Mongla | 0.035 | 0.032 |
| 7 | Polder-45 | 39.692 | Khepupara | 39.692 | 100.0 |
| 8 | Polder-47/1 | 20.788 | Khepupara | 20.788 | 100.0 |
| 9 | Polder-50-51 | 44.536 | Khepupara | 44.536 | 100.0 |
| 10 | Polder-10-12 | 167.336 | Khulna | 19.969 | 11.9 |
| | | | Mongla | 44.185 | 26.4 |
| | | | Satkhira | 103.182 | 61.7 |
| 11 | Polder-39/1B | 104.413 | Mongla | 81.346 | 77.9 |
| | | | Khepupara | 7.354 | 7.0 |
| | | | Patuakhali | 15.713 | 15.0 |
| 12 | Polder-39/1C | 51.597 | Mongla | 51.597 | 100.0 |
| 13 | Polder-55/2D | 78.927 | Patuakhali | 78.927 | 100.0 |

The yearly maximum rainfall data has been used to determine the different return period rainfall information for all rainfall events (Table 4-2). Five statistical distribution methods have been considered for determining the rainfall for different return period. Gumbel Extreme Value (Gum EV), Log Pearson Type III (LP3) and Long Normal Distribution (LN2), Normal Distribution, General Extreme Value Distribution (GEV) statistical distribution methods have been tested to fit the raw rainfall data. Goodness of fit has been tested with Chi-Square method, Kolmogorov Smirnov and Anderson Darling method. Further details on the rainfall analysis, including the goodness of fit test results are presented in Appendix A1.

*Table 4-2:Summary of rainfall analysis. Rainfall events that will be used for this study are highlighted in orange.*

| Rainfall Intensity Return Period (years) | Historic Rainfall | | | | With Climate Change | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 day rain fall (mm) | 2 days cumulative rainfall (mm) | 5 days cumulative rainfall (mm) | 10 days cumulative rainfall (mm) | 1 day rain fall (mm) | 2 days cumulative rainfall (mm) | 5 days cumulative rainfall (mm) | 10 days cumulative rainfall (mm) |
| **Khepupara (12110)** | | | | | | | | |
| 2.33 | 202 | 262 | 355 | 475 | 232 | 301 | 408 | 546 |
| 5 | 251 | 326 | 443 | 565 | 289 | 375 | 509 | 650 |
| 10 | 283 | 370 | 494 | 613 | 325 | 426 | 568 | 705 |
| 25 | 316 | 420 | 551 | 663 | 363 | 483 | 634 | 762 |
| 50 | 337 | 455 | 590 | 696 | 388 | 523 | 679 | 800 |
| 100 | 354 | 487 | 626 | 725 | 407 | 560 | 720 | 834 |
| **Potuakhali (12103)** | | | | | | | | |
| 2.33 | 142 | 172 | 239 | 326 | 163 | 198 | 275 | 375 |
| 5 | 202 | 227 | 324 | 412 | 232 | 261 | 373 | 474 |
| 10 | 252 | 277 | 373 | 480 | 290 | 319 | 429 | 552 |
| 25 | 314 | 350 | 430 | 564 | 361 | 403 | 495 | 649 |
| 50 | 360 | 411 | 469 | 624 | 414 | 473 | 539 | 718 |
| 100 | 405 | 478 | 504 | 683 | 466 | 550 | 580 | 785 |
| **Satkhira (11610)** | | | | | | | | |
| 2.33 | 121 | 155 | 211 | 293 | 134 | 172 | 234 | 325 |
| 5 | 161 | 219 | 290 | 368 | 179 | 243 | 322 | 408 |
| 10 | 200 | 261 | 341 | 430 | 222 | 290 | 379 | 477 |
| 25 | 261 | 315 | 404 | 507 | 290 | 350 | 448 | 563 |
| 50 | 316 | 354 | 450 | 565 | 351 | 393 | 500 | 627 |
| 100 | 381 | 391 | 492 | 621 | 423 | 434 | 546 | 689 |
| **Khulna (11604)** | | | | | | | | |
| 2.33 | 127 | 172 | 254 | 327 | 141 | 191 | 282 | 363 |
| 5 | 174 | 226 | 326 | 419 | 193 | 251 | 362 | 465 |
| 10 | 221 | 277 | 385 | 495 | 245 | 307 | 427 | 549 |
| 25 | 296 | 349 | 461 | 592 | 329 | 387 | 512 | 657 |
| 50 | 365 | 410 | 517 | 665 | 405 | 455 | 574 | 738 |
| 100 | 448 | 478 | 574 | 737 | 497 | 531 | 637 | 818 |
| **Borishal (11704)** | | | | | | | | |
| 2.33 | 141 | 210 | 270 | 327 | 162 | 242 | 311 | 376 |
| 5 | 178 | 254 | 337 | 420 | 205 | 292 | 388 | 483 |
| 10 | 209 | 282 | 391 | 496 | 240 | 324 | 450 | 570 |
| 25 | 249 | 311 | 458 | 593 | 286 | 358 | 527 | 682 |
| 50 | 279 | 328 | 508 | 665 | 321 | 377 | 584 | 765 |
| 100 | 309 | 341 | 556 | 737 | 355 | 392 | 639 | 848 |
| **Mongla (41958)** | | | | | | | | |
| 2.33 | 127 | 178 | 256 | 308 | 141 | 198 | 284 | 342 |
| 5 | 155 | 215 | 312 | 381 | 172 | 239 | 346 | 423 |
| 10 | 178 | 244 | 356 | 456 | 198 | 271 | 395 | 506 |
| 25 | 210 | 281 | 410 | 574 | 233 | 312 | 455 | 637 |
| 50 | 235 | 308 | 449 | 683 | 261 | 342 | 498 | 758 |
| 100 | 260 | 334 | 487 | 813 | 289 | 371 | 541 | 902 |

## 4.2 Land Use Mapping

Within each Polder, the land usage will impact the drainage. Therefore, it is important to accurately map the special extents of the various uses of the land within the Polders. CEGIS has created land use maps for all of the Polders within the study. The methodology followed during land use map preparation is provided in Appendix-5 (A-5). An example is shown below for Polder 10-12. The land use maps for every Polder are shown in Appendix A2.

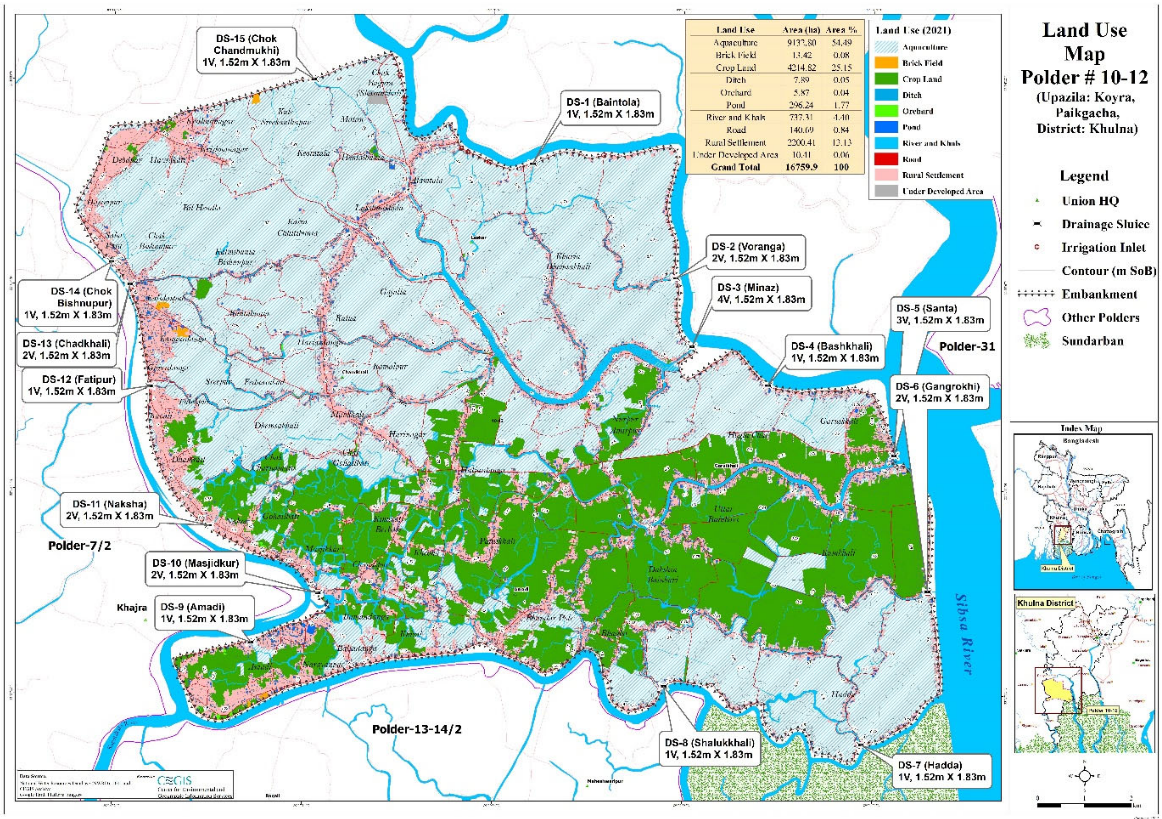



*Figure 4-3: Example of the land use maps which have been create for each Polder. This inserted map is for Polder 10-12.*

## 4.3 Catchment Delineation

Catchment boundaries will determine the distribution of the total rainfall that will be passed through each drainage structures. CEGIS has delineated the catchment boundaries within each Polder. An example catchment delineation map is shown below for Polder 10-12. The methodology followed during land use map preparation is provided in Appendix-5 (A-5). The catchment delineation maps for every Polder are shown in Appendix A3.

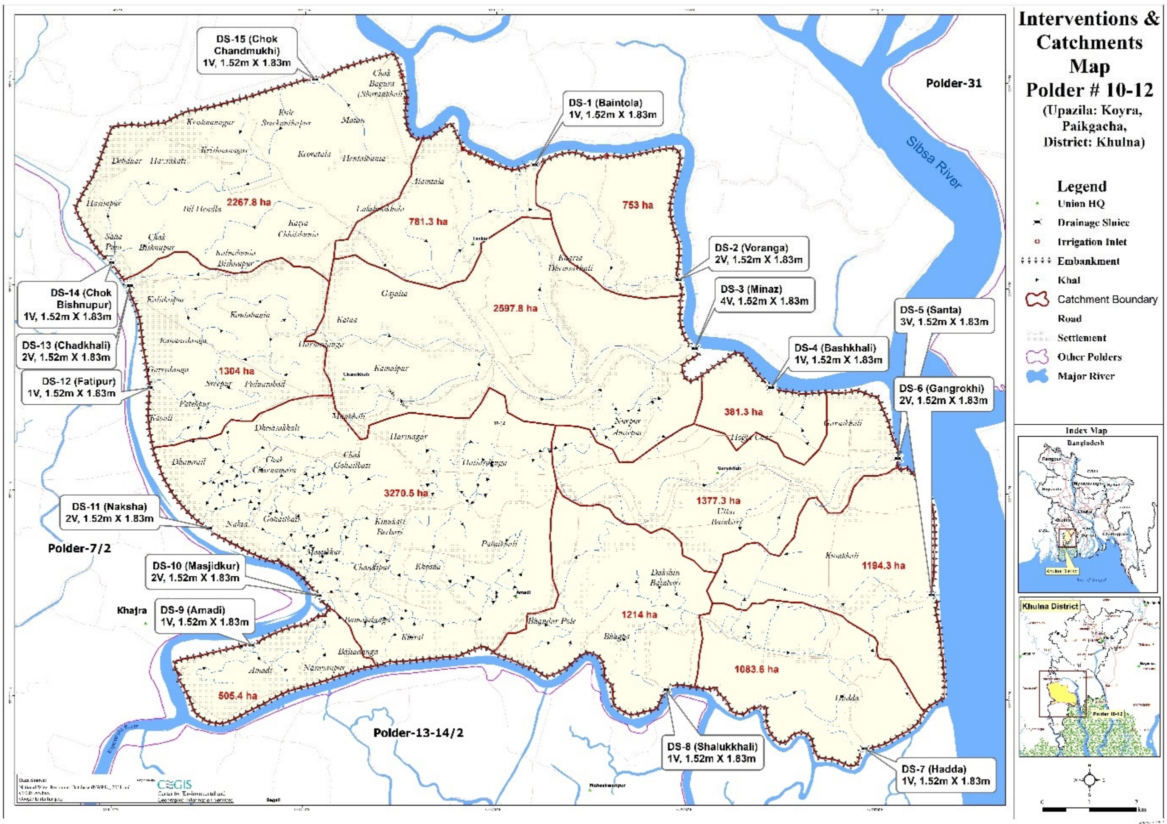



*Figure 4-4: Example of the catchment delineation maps which have been create for each Polder. This inserted map is for Polder 10-12*

Outcome of the drainage model has been shown in the map at Annex 3

## 4.4 Drainage Model Simulations

Table 4-3 outlines the model simulations that have been run.

*Table 4-3: Simulations for the drainage model.*

| Structures | Upstream boundary[1] | Downstream Boundaries[2] | | Rainfall event | Duration | No. of Runs |
|---|---|---|---|---|---|---|
| | | Sea Level | Astronomical Tides | | | |
| Existing Drainage Structures | Average flood (~3-year flood) | Present day levels | Average tidal period | 10-year storm for 5 days | 5 days rainstorm + 3 days drainage = 8 days total | 13 |
| | Average flood (~3-year flood) with climate change | Future levels considering 0.65 m increase due to climate change and land subsidence | Average tidal period | 10-year storm for 5 days with climate change | 5 days rainstorm + 3 days drainage = 8 days total | 13 |
| | Average flood (~3-year flood) | Present day levels | Average tidal period | 25-year storm for 5 days | 5 days rainstorm + 3 days drainage = 8 days total | 13 |
| | Average flood (~3-year flood) with climate change | Future levels considering 0.65 m increase due to climate change and land subsidence | Average tidal period | 25-year storm for 5 days with climate change | 5 days rainstorm + 3 days drainage = 8 days total | 13 |
| Proposed Structures | Average flood (~3-year flood) | Present day levels | Average tidal period | 10-year storm for 5 days | 5 days rainstorm + 3 days drainage = 8 days total | 13 |
| | Average flood (~3-year flood) with climate change | Future levels considering 0.65 m increase due to climate change and land subsidence | Average tidal period | 10-year storm for 5 days with climate change | 5 days rainstorm + 3 days drainage = 8 days total | 13 |
| | Average flood (~3-year flood) | Present day levels | Average tidal period | 25-year storm for 5 days | 5 days rainstorm + 3 days drainage = 8 days total | 13 |
| | Average flood (~3-year flood) with climate change | Future levels considering 0.65 m increase due to climate change and land subsidence | Average tidal period | 25-year storm for 5 days with climate change | 5 days rainstorm + 3 days drainage = 8 days total | 13 |
| | | | | | **Total** | **104** |

**Notes:** [1]The average flood is determined from the historic regional model, described in the Modelling Assessment Part A Section 8.

[2]The downstream boundary has been determined from the Bay of Bengal model.

# 5 Drainage Model Results

## 5.1 Existing Drainage Structures

This section contains the outcomes of drainage model simulation for the base and climate change condition analysing the existing structures. For the climate change scenario (or future scenario) 65 cm of sea level rise, 30 cm of land subsidence for polders of the South Central Region and 15 cm of land subsidence for polders of the South West Region was included.

For each of the Polders, the existing structures sill level, and size, the design discharge, the critical water levels, and the catchment area has been recorded in the following Polder specific tables. The results from the 10-day and 25-day storm are provided for each Polder.

Based on the hydraulic conditions of the 5-day 10 Year Return Period storm event, the required number of vents, vent size and invert level has been calculated. These values are also included in the table. During calculation of vent particulars an additional flow of 20% was considered due to uncertainty such as blockage of flow due to debris. This is why the proposed vent particulars also comply with the 5-day 25-year storm event. The proposed vent size and invert level revisions were based on:

- Average minimum water level of the monsoon period
- Average maximum water level of the monsoon period
- Tidal Range
- Head Difference
- Basin Water Leve/Upstream Water Level
- Drainage Time (Calculated)

Note that the required number of vents do not account for the existing structures. These recommendations are preliminary in nature and are subject to change based on detailed design considerations.

In addition to the following table of results, the maximum velocity and discharge through individual khals during the design event within the Polders are presented in Appendix A4.

### 5.1.1 Polder 13-14/2

| Polder No. | Name of Thana | District |
|---|---|---|
| P-13-14/2 | Koyra | Khulna |

*Figure 5-1: Model domain of the drainage model developed in SOBEK for P13-14/2.*

*Table 5-1: Drainage results for the drainage sluices of Polder 13-14/2 considering climate change (10-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Kushadanga | DS-8 (structure_13-14-2_9) | -2.00 | 1V (1.52×1.83) | 11.81 | 2.33 | -0.35 | 565.00 | -0.97 | 2V (1.50×1.80) | -0.75 |
| 2 | Gariabari | DS-12 (Gariabari) | -2.00 | 2V (1.52×1.83) | 7.87 | 2.25 | -0.35 | 346.00 | -0.83 | 2V (1.50×1.80) | -0.70 |
| 3 | Koyra | structure_13-14-2_16 | -2.00 | 1V (1.52×1.83) | 14.54 | 1.86 | -0.25 | 720.00 | -0.83 | 2V (1.50×1.80) | -0.75 |
| 4 | Kashikhal | DS-2 (structure_13-14-2_1) | -2.00 | 2V (1.52×1.83) | 20.92 | 2.11 | -0.35 | 1200.00 | -0.92 | 3V (1.50×1.80) | -0.75 |
| 5 | Hajotkhali | DS-1 (North Bathkashi) | 0.00 | 3V (0.91) | 8.31 | 1.85 | -0.30 | 300.00 | -0.87 | 1V (1.50×1.80) | -0.85 |
| 6 | 2 No. Koyra | DS-3 (Koyra) | -2.00 | 1V (1.52×1.83) | 8.27 | 2.33 | -0.35 | 370.00 | -0.92 | 1V (1.50×1.80) | -0.85 |
| 7 | Gobra | DS-3A (structure_13-14-2_3) | -2.00 | 1V (1.52×1.83) | 8.83 | 1.99 | -0.35 | 400.00 | -0.92 | 1V (1.50×1.80) | -0.90 |
| 8 | Hogla | DS-5 (Hogla) | -2.00 | 3V (0.91) | 30.97 | 2.25 | -0.35 | 1800.00 | -0.89 | 3V (1.50×1.80) | -0.85 |
| 9 | Gobindapur | DS-4 (structure_13-14-2_4) | -2.00 | 1V (1.52×1.83) | 6.34 | 2.02 | -0.30 | 300.00 | -1.01 | 1V (1.50×1.80) | -0.85 |
| 10 | Khorolkathi | DS-10 (Khorolkathi) | -2.00 | 5V (1.52×1.83) | 45.33 | 1.88 | -0.17 | 2800.00 | -0.81 | 6V (1.50×1.80) | -0.75 |
| 11 | Nowani | DS-9 (Nowani New) | -2.00 | 1V (1.5×1.8) | 9.50 | 2.36 | -0.38 | 440.00 | -0.91 | 1V (1.50×1.80) | -0.85 |
| 12 | Narayanpur | DS-7 (Narayanpur) | -2.00 | 2V (1.52×1.83) | 27.79 | 2.30 | -0.30 | 1600.00 | -0.50 | 4V (1.50×1.80) | -0.70 |
| 13 | Bhagali | DS-6 (structure_13-14-2_7) | -2.00 | 2V (1.52×1.83) | 26.91 | 2.22 | -0.33 | 1600.00 | -0.78 | 4V (1.50×1.80) | -0.70 |
| 14 | Laloha | DS-5A (Lalua Khal) | -1.00 | 1V (1.52×1.83) | 13.83 | 2.28 | -0.33 | 600.00 | -1.01 | 2V (1.50×1.80) | -0.75 |
| 15 | SuthiBazar (13 and 15) | DS-11 (Suthi Bazar) | -2.00 | 1V (1.52×1.83) | 46.54 | 2.26 | -0.33 | 2700.00 | -0.81 | 3V (1.50×1.80) | -0.75 |

*Table 5-2: Drainage results for the drainage sluices of Polder 13-14/2 considering climate change (25-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Kushadanga | DS-8 (structure_13-14-2_9) | -2.0 | 1V (1.52×1.83) | 13.37 | 2.83 | 0.15 | 565.00 | -0.97 | 2V (1.50×1.80) | -0.75 |
| 2 | Gariabari | DS-12 (Gariabari) | -2.00 | 2V (1.52×1.83) | 8.78 | 2.75 | 0.15 | 346.00 | -0.83 | 2V (1.50×1.80) | -0.70 |
| 3 | Koyra | structure_13-14-2_16 | -2.00 | 1V (1.52×1.83) | 16.50 | 2.36 | 0.25 | 720.00 | -0.83 | 2V (1.50×1.80) | -0.75 |
| 4 | Kashikhal | DS-2 (structure_13-14-2_1) | -2.00 | 2V (1.52×1.83) | 23.86 | 2.88 | 0.15 | 1200.00 | -0.92 | 3V (1.50×1.80) | -0.75 |
| 5 | Hajotkhali | DS-1 (North Bathkashi) | 0.00 | 3V (0.91) | 9.29 | 2.55 | 0.20 | 300.00 | -0.87 | 1V (1.50×1.80) | -0.85 |
| 6 | 2 No. Koyra | DS-3 (Koyra) | -2.00 | 1V (1.52×1.83) | 9.24 | 2.83 | 0.15 | 370.00 | -0.92 | 1V (1.50×1.80) | -0.85 |
| 7 | Gobra | DS-3A (structure_13-14-2_3) | -2.00 | 1V (1.52×1.83) | 9.88 | 2.49 | 0.15 | 400.00 | -0.92 | 1V (1.50×1.80) | -0.90 |
| 8 | Hogla | DS-5 (Hogla) | -2.00 | 3V (0.91) | 35.74 | 3.20 | 0.15 | 1800.00 | -0.89 | 3V (1.50×1.80) | -0.85 |
| 9 | Gobindapur | DS-4 (structure_13-14-2_4) | -2.00 | 1V (1.52×1.83) | 7.32 | 2.52 | 0.20 | 300.00 | -1.01 | 1V (1.50×1.80) | -0.85 |
| 10 | Khorolkathi | DS-10 (Khorolkathi) | -2.00 | 5V (1.52×1.83) | 52.38 | 3.33 | 0.33 | 2800.00 | -0.81 | 6V (1.50×1.80) | -0.75 |
| 11 | Nowani | DS-9 (Nowani New) | -2.00 | 1V (1.5×1.8) | 10.70 | 2.86 | 0.12 | 440.00 | -0.91 | 1V (1.50×1.80) | -0.85 |
| 12 | Narayanpur | DS-7 (Narayanpur) | -2.00 | 2V (1.52×1.83) | 32.21 | 2.00 | 0.20 | 1600.00 | -0.50 | 4V (1.50×1.80) | -0.70 |
| 13 | Bhagali | DS-6 (structure_13-14-2_7) | -2.00 | 2V (1.52×1.83) | 31.11 | 2.88 | 0.17 | 1600.00 | -0.78 | 4V (1.50×1.80) | -0.70 |
| 14 | Laloha | DS-5A (Lalua Khal) | -1.00 | 1V (1.52×1.83) | 15.63 | 2.88 | 0.17 | 600.00 | -1.01 | 2V (1.50×1.80) | -0.75 |
| 15 | SuthiBazar (13 and 15) | DS-11 (Suthi Bazar) | -2.00 | 1V (1.52×1.83) | 53.84 | 2.89 | 0.17 | 2700.00 | -0.81 | 3V (1.50×1.80) | -0.75 |

### 5.1.2 Polder 7/1

| Polder No. | Name of Thana | District |
|---|---|---|
| P-7/1 | Assasuni, Shyamnagar | Satkhira |


*Figure 5-2: Model domain of the drainage model developed in SOBEK for P7-1.*

*Table 5-3: Drainage results for the drainage sluices of Polder 7-1 considering climate change (10-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Su-vadrakati | DS-1 (Suvadrakati/Ruyeer Beel) | -2.558 | 1V(2.32×2) | 8.20 | 2.07 | -0.55 | 387.74 | -1.03 | 2V (1.50×1.80) | -0.90 |
| 2 | Padmapukur | DS-9 (Padma Pukur) | -1.963 | 1V(1.83×1.9) | 9.50 | 2.19 | -0.55 | 450.00 | -1.03 | 2V (1.50×1.80) | -0.90 |
| 3 | Chandipur 2 | DS-3 structure_7-1_6 | -2.155 | 2 Pipe | 11.61 | 2.16 | -0.55 | 584.76 | -1.03 | 2V (1.50×1.80) | -0.90 |
| 4 | Chandipur 1 | DS-2 structure_7-1_5 | -1.79 | 1V | 8.43 | 2.16 | -0.55 | 389.18 | -1.03 | 2V (1.50×1.80) | -0.90 |
| 5 | Kamalkati 1 | DS-8 structure_7-1_3 | -2.52 | 1V(2.184×2.1) | 14.10 | 2.07 | -0.55 | 729.30 | -1.03 | 2V (1.50×1.80) | -0.90 |
| 6 | Kamalkati 2 | DS-7 (Kamalkathi) | -2.73 | 1V | 14.10 | 2.08 | -0.50 | 729.30 | -1.03 | 2V (1.50×1.80) | -0.90 |
| 7 | Jhapa | DS-6 (Jhapa) | -2.2 | 1 Pipe | 3.11 | 2.00 | -0.50 | 68.60 | -0.89 | 1V (1.50×1.80) | -0.90 |
| 8 | Patakhali | DS-5 (West Patakhali) | 1.138 | 1V(1×1) | 6.33 | 2.00 | -0.50 | 274.58 | -0.89 | 1V (1.50×1.80) | -0.80 |
| 9 | West patakhali | DS-4 (Pakakhali) | -2.167 | 1 Pipe | 6.35 | 2.10 | -0.50 | 265.03 | -0.89 | 1V (1.50×1.80) | -0.80 |

*Table 5-4: Drainage results for the drainage sluices of Polder 7-1 considering climate change (25-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Su-vadrakati | DS-1 (Suvadrakati/Ruyeer Beel) | -2.558 | 1V(2.32×2) | 9.17 | 2.55 | -0.15 | 387.74 | -1.03 | 2V (1.50×1.80) | -0.90 |
| 2 | Padmapukur | DS-9 (Padma Pukur) | -1.963 | 1V(1.83×1.9) | 10.47 | 2.55 | -0.15 | 450.00 | -1.03 | 2V (1.50×1.80) | -0.90 |
| 3 | Chandipur 2 | DS-3 structure_7-1_6 | -2.155 | 2 Pipe | 13.08 | 2.68 | -0.15 | 584.76 | -1.03 | 2V (1.50×1.80) | -0.90 |
| 4 | Chandipur 1 | DS-2 structure_7-1_5 | -1.79 | 1V | 9.41 | 2.66 | -0.15 | 389.18 | -1.03 | 2V (1.50×1.80) | -0.90 |
| 5 | Kamalkati 1 | DS-8 structure_7-1_3 | -2.52 | 1V(2.184×2.1) | 15.94 | 2.77 | -0.15 | 729.30 | -1.03 | 2V (1.50×1.80) | -0.90 |
| 6 | Kamalkati 2 | DS-7 (Kamalkathi) | -2.73 | 1V | 15.94 | 2.56 | -0.10 | 729.30 | -1.03 | 2V (1.50×1.80) | -0.90 |
| 7 | Jhapa | DS-6 (Jhapa) | -2.2 | 1 Pipe | 3.28 | 2.45 | -0.10 | 68.60 | -0.89 | 1V (1.50×1.80) | -0.90 |
| 8 | Patakhali | DS-5 (West Patakhali) | 1.138 | 1V(1×1) | 7.02 | 2.50 | -0.10 | 274.58 | -0.89 | 1V (1.50×1.80) | -0.80 |
| 9 | West patakhali | DS-4 (Pakakhali) | -2.167 | 1 Pipe | 7.02 | 2.40 | -0.10 | 265.03 | -0.89 | 1V (1.50×1.80) | -0.80 |

### 5.1.3 Polder 7/2

| Polder No. | Name of Thana | District |
|---|---|---|
| P-7/2 | Assasuni | Satkhira |


*Figure 5-3: Model domain of the drainage model developed in SOBEK for P7-2.*

*Table 5-5: Drainage results for the drainage sluices of Polder 7/2 considering climate change (10-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Chandi Banuhdanga | DS-7 (Bamondanga) | -1.92 | 2V(1.8×1.5) | 20.92 | 2.00 | -0.65 | 1244 | -1.0 | 3V (1.50×1.80) | -0.90 |
| 2 | Anulia Sluice Gate | DS-Churdanga | -1.11 | 1V(1.8×1.5) | 13.50 | 2.10 | -0.65 | 876 | -1.0 | 2V (1.50×1.80) | -0.80 |
| 3 | Tuiardanga | DS-6 (Tuiardanga) | -<br>2.109 | 2V(1.8×1.5) | 6.33 | 2.10 | -0.65 | 292 | -1.0 | 1V (1.50×1.80) | -0.80 |
| 4 | Maanik Khali Khal | DS-5 (Godaipur) | -1 | 1V(1.8×1.5) | 8.83 | 2.00 | -0.65 | 447 | -1.1 | 2V (1.50×1.80) | -0.70 |
| 5 | Anulia Sluice Gate | DS-4 (Nayakhali) | -1.24 | 1 Barrel (0.91) | 11.50 | 2.40 | -0.65 | 563 | -1.0 | 2V (1.50×1.80) | -0.70 |
| 6 | Anulia Sluice Gate | DS-3 (Nayakhali) | 0 | 1 Barrel (1) | 6.00 | 2.35 | -0.65 | 280 | -1.0 | 1V (1.50×1.80) | -0.70 |
| 7 | Gorali | DS-2 (Gorali) | -0.32 | 2 Brrel (0.91) | 10.61 | 2.30 | -0.60 | 592 | -1.0 | 2V (1.50×1.80) | -0.70 |
| 8 | Kobodakko Sluice Gate | DS-Kalyanpur | -2.43 | 2V(1.8×1.5) | 9.61 | 2.10 | -0.60 | 517 | -0.8 | 2V (1.50×1.80) | -0.70 |
| 9 | Horiskhali | DS-1 (Horiskhali) | -1.11 | 1 Barrel (0.91) | 18.92 | 1.65 | -0.60 | 1210 | -1.0 | 3V (1.50×1.80) | -0.75 |
| 10 | Bordal Khal | DS-13 (Nakna) | -0.85 | 1V(1.8×1.5) | 18.92 | 2.00 | -0.60 | 1213 | -1.0 | 3V (1.50×1.80) | -0.75 |
| 11 | Rawtara Sluice Gate | DS-12 (Uttar Aksira) | -2.45 | 2V(1.8×1.5) | 27.79 | 2.41 | -0.60 | 1762 | -0.9 | 4V (1.50×1.80) | -0.75 |
| 12 | Horimodon Khal | DS-11 (Bagali) | -1.31 | 1V(1.8×1.5) | 9.50 | 2.10 | -0.60 | 489 | -1.0 | 2V (1.50×1.80) | -0.70 |
| 13 | Godaipur Sluice Gate | DS-10 (Bholanathpur) | -2.12 | 2V(1.8×1.5) | 14.10 | 2.17 | -0.60 | 957 | -1.0 | 3V (1.50×1.80) | -0.80 |
| 14 | Kalki | DS-9 (Kalki) | | 2V(1.83×1.52) | 6.33 | 2.29 | -0.60 | 270 | -0.9 | 3V (1.50×1.80) | -0.70 |

*Table 5-6 Drainage results for the drainage sluices of Polder 7/2 considering climate change (25-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Chandi Banuhdanga | DS-7 (Bamondanga) | -1.92 | 2V(1.8×1.5) | 23.86 | 2.40 | -0.15 | 1244 | -1.0 | 3V (1.50×1.80) | -0.90 |
| 2 | Anulia Sluice Gate | DS-Churdanga | -1.11 | 1V(1.8×1.5) | 14.47 | 2.50 | -0.15 | 876 | -1.0 | 2V (1.50×1.80) | -0.80 |
| 3 | Tuiardanga | DS-6 (Tuiardanga) | -2.109 | 2V(1.8×1.5) | 7.02 | 2.50 | -0.15 | 292 | -1.0 | 1V (1.50×1.80) | -0.80 |
| 4 | Maanik Khali Khal | DS-5 (Godaipur) | -1 | 1V(1.8×1.5) | 9.88 | 2.40 | -0.15 | 447 | -1.1 | 2V (1.50×1.80) | -0.70 |
| 5 | Anulia Sluice Gate | DS-4 (Nayakhali) | -1.24 | 1 Barrel (0.91) | 12.47 | 2.80 | -0.15 | 563 | -1.0 | 2V (1.50×1.80) | -0.70 |
| 6 | Anulia Sluice Gate | DS-3 (Nayakhali) | 0 | 1 Barrel (1) | 6.77 | 2.75 | -0.15 | 280 | -1.0 | 1V (1.50×1.80) | -0.70 |
| 7 | Gorali | DS-2 (Gorali) | -0.32 | 2 Brrel (0.91) | 12.08 | 2.70 | -0.10 | 592 | -1.0 | 2V (1.50×1.80) | -0.70 |
| 8 | Kobodakko Sluice Gate | DS-Kalyanpur | -2.43 | 2V(1.8×1.5) | 11.08 | 2.50 | -0.10 | 517 | -0.8 | 2V (1.50×1.80) | -0.70 |
| 9 | Horiskhali | DS-1 (Horiskhali) | -1.11 | 1 Barrel (0.91) | 21.86 | 2.05 | -0.10 | 1210 | -1.0 | 3V (1.50×1.80) | -0.75 |
| 10 | Bordal Khal | DS-13 (Nakna) | -0.85 | 1V(1.8×1.5) | 21.86 | 2.40 | -0.10 | 1213 | -1.0 | 3V (1.50×1.80) | -0.75 |
| 11 | Rawtara Sluice Gate | DS-12 (Uttar Aksira) | -2.45 | 2V(1.8×1.5) | 32.21 | 2.81 | -0.10 | 1762 | -0.9 | 4V (1.50×1.80) | -0.75 |
| 12 | Horimodon Khal | DS-11 (Bagali) | -1.31 | 1V(1.8×1.5) | 10.47 | 2.50 | -0.10 | 489 | -1.0 | 2V (1.50×1.80) | -0.70 |
| 13 | Godaipur Sluice Gate | DS-10 (Bholanathpur) | -2.12 | 2V(1.8×1.5) | 15.94 | 2.57 | -0.10 | 957 | -1.0 | 3V (1.50×1.80) | -0.80 |
| 14 | Kalki | DS-9 (Kalki) | | 2V(1.83×1.52) | 7.02 | 2.69 | -0.10 | 270 | -0.9 | 3V (1.50×1.80) | -0.70 |

### 5.1.4 Polder 10-12

| Polder No. | Name of Thana | District |
| --- | --- | --- |
| P-10-12 | Koyra, Paikgacha | Khulna |

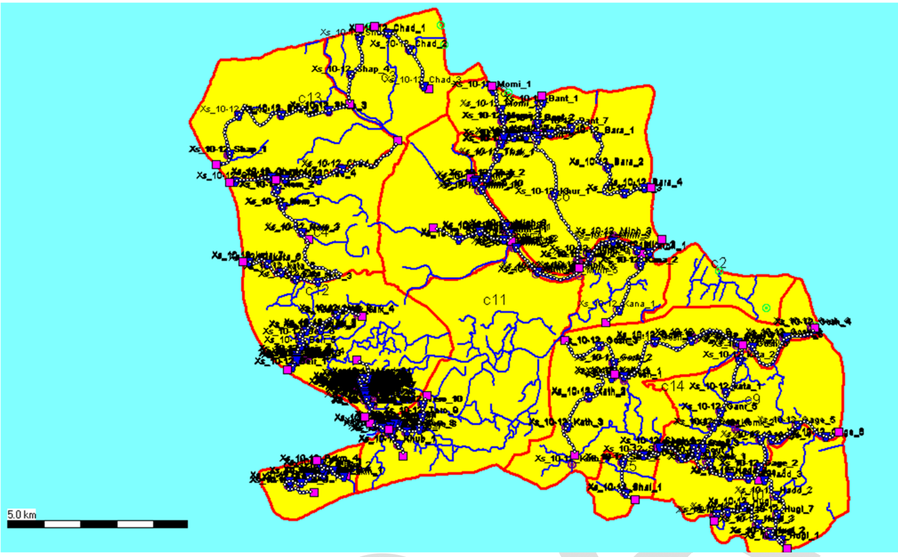



*Figure 5-4: Model domain of the drainage model developed in SOBEK for 10-12.*

*Table 5-7: Drainage results for the drainage sluices of Polder 10-12 considering climate change (10-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Amadi Sluice Gate | structure_10-12_6 | -0.09 | 1V (2*1.6) | 6.1 | 1.9 | -0.45 | 356 | -1.0 | 2V (1.50×1.80) | -0.40 |
| 2 | Bashakhali Sluice Gate | DS-5 (Sutarkhali) | -0.68 | 1V (3*1.6) | 8.1 | 1.85 | -0.45 | 437 | -1.0 | 2V (1.50×1.80) | -0.40 |
| 3 | Cokchadmukhi Sluice Gate | DS-15 (Chok Chandmukhi) | -0.97 | 1V (3.3*2.7) | 14.0 | 1.87 | -0.45 | 911 | -1.1 | 3V (1.50×1.80) | -0.60 |
| 4 | Hudda Sluice Gate | DS-12 (Fatipur) | -0.42 | 1V (2*1.7) | 17.7 | 1.98 | -0.45 | 1129 | -1.0 | 2V (1.50×1.80) | -0.40 |
| 5 | Khoriya Minaj Chok Sluice Gate | DS-8 (Shalukkhali) | -0.77 | 4V (3*1.6) | 4.7 | 1.93 | -0.45 | 257 | -1.0 | 2V (1.50×1.80) | -0.40 |
| 6 | Voriga Gate Sluice Gate | DS-2 (Voranga) | -1.04 | 2V (6.6*1.5) | 27.4 | 1.96 | -0.45 | 1681 | -1.0 | 4V (1.50×1.80) | -0.40 |
| 7 | Bantola Bazar Sluice Gate | structure_10-12_18 | 1.61 | 1V (1.8*1.5) | 28.5 | 1.88 | -0.45 | 1756 | -0.8 | 3V (1.50×1.80) | -0.40 |
| 8 | Komkhali Sluice Gate | DS-1 (Baintola) | -0.99 | 2V (3*1.6) | 9.5 | 1.96 | -0.40 | 509 | -1.0 | 2V (1.50×1.80) | -0.40 |
| 9 | Hudda Sluice Gate | DS-6 (Gangrokhi) | -0.45 | 1V (2*1.6) | 19.6 | 1.82 | -0.40 | 1324 | -1.0 | 3V (1.50×1.80) | -0.60 |
| 10 | Mosodkor Sluice Gate | DS-7 (Hadda) | -1.39 | 2V (2*1.6) | 17.4 | 1.97 | -0.40 | 1144 | -0.9 | 3V (1.50×1.80) | -0.40 |
| 11 | Naksha Piyara Khali | DS-10 (Masjidkur) | 0.07 | 2V (1.8*1.5) | 34.0 | 1.98 | -0.40 | 2221 | -1.0 | 4V (1.50×1.80) | -0.40 |
| 12 | Fotepur Sluice Gate | DS-11 (Naksha) | -0.65 | 1V (4*2) | 23.5 | 1.94 | -0.40 | 1640 | -1.0 | 3V (1.50×1.80) | -0.50 |
| 13 | Shahpara Sluice Gate | structure_10-12_3 | -1.41 | 1V (3.3*2.1) | 20.4 | 1.88 | -0.40 | 1439 | -0.9 | 3V (1.50×1.80) | -0.50 |
| 14 | Shanta Sluice Gate | DS-5 (Shanta) | -1.93 | 3V (3*1.6) | 28.7 | 1.85 | -0.40 | 1951 | -0.9 | 4V (1.50×1.80) | -0.60 |

*Table 5-8: Drainage results for the drainage sluices of Polder 10-12 considering climate change (25-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Amadi Sluice Gate | structure_10-12_6 | -0.09 | 1V (2*1.6) | 7.74 | 2.4 | 0.15 | 356 | -1.0 | 2V (1.50×1.80) | -0.40 |
| 2 | Bashakhali Sluice Gate | DS-5 (Sutarkhali) | -0.68 | 1V (3*1.6) | 10.09 | 2.35 | 0.15 | 437 | -1.0 | 2V (1.50×1.80) | -0.40 |
| 3 | Cokchadmukhi Sluice Gate | DS-15 (Chok Chandmukhi) | -0.97 | 1V (3.3*2.7) | 18.13 | 2.37 | 0.15 | 911 | -1.1 | 3V (1.50×1.80) | -0.60 |
| 4 | Hudda Sluice Gate | DS-12 (Fatipur) | -0.42 | 1V (2*1.7) | 22.90 | 2.48 | 0.15 | 1129 | -1.0 | 2V (1.50×1.80) | -0.40 |
| 5 | Khoriya Minaj Chok Sluice Gate | DS-8 (Shalukkhali) | -0.77 | 4V (3*1.6) | 5.91 | 2.43 | 0.15 | 257 | -1.0 | 2V (1.50×1.80) | -0.40 |
| 6 | Voriga Gate Sluice Gate | DS-2 (Voranga) | -1.04 | 2V (6.6*1.5) | 35.04 | 2.46 | 0.15 | 1681 | -1.0 | 4V (1.50×1.80) | -0.40 |
| 7 | Bantola Bazar Sluice Gate | structure_10-12_18 | 1.61 | 1V (1.8*1.5) | 36.51 | 2.38 | 0.15 | 1756 | -0.8 | 3V (1.50×1.80) | -0.40 |
| 8 | Komkhali Sluice Gate | DS-1 (Baintola) | -0.99 | 2V (3*1.6) | 11.82 | 2.46 | 0.20 | 509 | -1.0 | 2V (1.50×1.80) | -0.40 |
| 9 | Hudda Sluice Gate | DS-6 (Gangrokhi) | -0.45 | 1V (2*1.6) | 25.66 | 2.32 | 0.20 | 1324 | -1.0 | 3V (1.50×1.80) | -0.60 |
| 10 | Mosodkor Sluice Gate | DS-7 (Hadda) | -1.39 | 2V (2*1.6) | 22.61 | 2.47 | 0.20 | 1144 | -0.9 | 3V (1.50×1.80) | -0.40 |
| 11 | Naksha Piyara Khali | DS-10 (Masjidkur) | 0.07 | 2V (1.8*1.5) | 44.08 | 2.48 | 0.20 | 2221 | -1.0 | 4V (1.50×1.80) | -0.40 |
| 12 | Fotepur Sluice Gate | DS-11 (Naksha) | -0.65 | 1V (4*2) | 30.97 | 2.44 | 0.20 | 1640 | -1.0 | 3V (1.50×1.80) | -0.50 |
| 13 | Shahpara Sluice Gate | structure_10-12_3 | -1.41 | 1V (3.3*2.1) | 26.95 | 2.38 | 0.20 | 1439 | -0.9 | 3V (1.50×1.80) | -0.50 |
| 14 | Shanta Sluice Gate | DS-5 (Santa) | -1.93 | 3V (3*1.6) | 37.53 | 2.35 | 0.20 | 1951 | -0.9 | 4V (1.50×1.80) | -0.60 |

### 5.1.5 Polder 4

| Polder No. | Name of Thana | District |
|---|---|---|
| P-4 | Assasuni | Satkhira |


*Figure 5-5: Model domain of the drainage model developed in SOBEK for P-4.*

*Table 5-9: Drainage results for the drainage sluices of Polder 4 considering climate change (10-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Bemara Khal | 2413003/STR0001 | -1.216 | 2V (0.91) | 2.4 | 2.0 | -0.5 | 258.6 | -0.90 | 1V (1.50×1.80) | -0.90 |
| 2 | Gutiakhali khal | 2413003/STR0013 | -1.584 | 2V (0.91) | 1.9 | 2.1 | -0.5 | 213.9 | -1.00 | 1V (1.50×1.80) | -0.90 |
| 3 | Balir Jhaki | 2413003/STR0004 | -1.554 | 2V (0.91) | 5.0 | 2.3 | -0.5 | 507.5 | -0.90 | 2V (1.50×1.80) | -0.90 |
| 4 | Bolabunia khal | 2413003/STR0016 | -1.828 | 3V (0.91) | 2.8 | 1.9 | -0.5 | 282.3 | -0.90 | 2V (1.50×1.80) | -0.90 |
| 5 | Basukhali khal | 2413003/STR0017 | -3.316 | 2V (2*2) | 5.2 | 1.9 | -0.5 | 532.2 | -0.90 | 2V (1.50×1.80) | -0.90 |
| 6 | Latakhali khal | 2413003/STR0014 | -1.996 | 1V (2*2) | 5.5 | 1.9 | -0.5 | 592.0 | -0.90 | 2V (1.50×1.80) | -0.90 |
| 7 | Doyar Khal | <Null> | -0.667 | 1V (1*1) | 3.5 | 2.0 | -0.5 | 355.6 | -0.90 | 1V (1.50×1.80) | -0.90 |
| 8 | Salur Khal | 2413003/STR0002 | -1.232 | 4V (1*1) | 12.0 | 2.2 | -0.5 | 1214.5 | -0.90 | 3V (1.50×1.80) | -0.90 |
| 9 | Haribhanga Khal | 2413003/STR0012 | -1.799 | 1V (2*2) | 2.1 | 2.1 | -0.5 | 221.5 | -0.85 | 1V (1.50×1.80) | -0.90 |
| 10 | Gazipur Khal | 2413003/STR0009 | -1.323 | 1V (2*2) | 6.4 | 1.9 | -0.5 | 663.7 | -0.85 | 2V (1.50×1.80) | -0.90 |
| 11 | Kalimakhali Khal | 2413003/STR0007 | -1.251 | 2V (0.91) | 2.4 | 2.0 | -0.5 | 249.7 | -0.85 | 1V (1.50×1.80) | -0.90 |
| 12 | Kola Khal | 2413003/STR0006 | -1.995 | 1V (2*2) | 5.8 | 2.2 | -0.5 | 597.6 | -0.85 | 2V (1.50×1.80) | -0.90 |
| 13 | Latakhali khal | 2413003/STR0015 | -2.738 | 3V (0.91) | 1.7 | 2.2 | -0.5 | 173.4 | -0.85 | 1V (1.50×1.80) | -0.90 |
| 14 | Gorer Khal | 2413003/STR0010 | -1.632 | 2V (0.91) | 6.7 | 2.0 | -0.5 | 695.8 | -0.85 | 2V (1.50×1.80) | -0.90 |
| 15 | Nasimabad Khal | 2413003/STR0008 | -1.248 | 2V (0.91) | 3.8 | 2.0 | -0.5 | 391.6 | -0.85 | 1V (1.50×1.80) | -0.90 |

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 16 | Batuabeel khal | 2413003/STR0023 | -1.233 | 1V (2*2) | 4.4 | 2.2 | -0.5 | 477.3 | -0.85 | 2V (1.50×1.80) | -0.90 |
| 17 | Nayonjoli khal | 2413003/STR0021 | -1.746 | 1V (2*2) | 6.7 | 2.2 | -0.5 | 690.4 | -1.00 | 2V (1.50×1.80) | -0.90 |
| 18 | Puijala Khal | 2413003/STR0005 | -1.244 | 1V (2*2) | 7.1 | 2.3 | -0.5 | 732.8 | -1.00 | 2V (1.50×1.80) | -0.90 |
| 19 | Galghesia | 2413003/STR0011 | -1.761 | 1V (1*1) | 5.7 | 1.9 | -0.5 | 593.9 | -1.00 | 2V (1.50×1.80) | -0.90 |
| 20 | Srikalas | 2413003/STR0025 | -1.941 | 2V (0.91) | 2.0 | 2.0 | -0.5 | 213.9 | -1.00 | 1V (1.50×1.80) | -0.90 |
| 21 | Basukhali khal | 2413003/STR0019 | | | 5.2 | 1.9 | -0.5 | | -1.00 | 2V (1.50×1.80) | -0.90 |
| 22 | Ziamari khal | 2413003/STR0018 | -3.845 | 1V (0.91) | 0.7 | 2.3 | -0.5 | 70.8 | -1.00 | 1V (1.50×1.80) | -0.90 |

*Table 5-10: Drainage results for the drainage sluices of Polder 4 considering climate change (25-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Bemara Khal | 2413003/STR0001 | -1.216 | 2V (0.91) | 2.4 | 2.0 | -0.5 | 258.6 | -0.90 | 1V (1.50×1.80) | -0.90 |
| 2 | Gutiakhali khal | 2413003/STR0013 | -1.584 | 2V (0.91) | 1.9 | 2.1 | -0.5 | 213.9 | -1.00 | 1V (1.50×1.80) | -0.90 |
| 3 | Balir Jhaki | 2413003/STR0004 | -1.554 | 2V (0.91) | 5.0 | 2.3 | -0.5 | 507.5 | -0.90 | 2V (1.50×1.80) | -0.90 |
| 4 | Bolabunia khal | 2413003/STR0016 | -1.828 | 3V (0.91) | 2.8 | 2.6 | 0.07 | 282.3 | -0.90 | 2V (1.50×1.80) | -0.90 |
| 5 | Basukhali khal | 2413003/STR0017 | -3.316 | 2V (2*2) | 2.2 | 2.7 | 0.07 | 532.2 | -0.90 | 2V (1.50×1.80) | -0.90 |
| 6 | Latakhali khal | 2413003/STR0014 | -1.996 | 1V (2*2) | 5.8 | 2.9 | 0.07 | 592.0 | -0.90 | 2V (1.50×1.80) | -0.90 |
| 7 | Doyar Khal | <Null> | -0.667 | 1V (1*1) | 3.2 | 2.5 | 0.07 | 355.6 | -0.90 | 1V (1.50×1.80) | -0.90 |
| 8 | Salur Khal | 2413003/STR0002 | -1.232 | 4V (1*1) | 6.1 | 2.4 | 0.07 | 1214.5 | -0.90 | 3V (1.50×1.80) | -0.90 |
| 9 | Haribhanga Khal | 2413003/STR0012 | -1.799 | 1V (2*2) | 6.5 | 2.5 | 0.07 | 221.5 | -0.85 | 1V (1.50×1.80) | -0.90 |
| 10 | Gazipur Khal | 2413003/STR0009 | -1.323 | 1V (2*2) | 4.1 | 2.6 | 0.07 | 663.7 | -0.85 | 2V (1.50×1.80) | -0.90 |
| 11 | Kalimakhali Khal | 2413003/STR0007 | -1.251 | 2V (0.91) | 13.9 | 2.8 | 0.07 | 249.7 | -0.85 | 1V (1.50×1.80) | -0.90 |
| 12 | Kola Khal | 2413003/STR0006 | -1.995 | 1V (2*2) | 2.4 | 2.7 | 0.07 | 597.6 | -0.85 | 2V (1.50×1.80) | -0.90 |
| 13 | Latakhali khal | 2413003/STR0015 | -2.738 | 3V (0.91) | 7.4 | 2.5 | 0.07 | 173.4 | -0.85 | 1V (1.50×1.80) | -0.90 |
| 14 | Gorer Khal | 2413003/STR0010 | -1.632 | 2V (0.91) | 2.8 | 2.6 | 0.07 | 695.8 | -0.85 | 2V (1.50×1.80) | -0.90 |
| 15 | Nasimabad Khal | 2413003/STR0008 | -1.248 | 2V (0.91) | 6.7 | 2.8 | 0.07 | 391.6 | -0.85 | 1V (1.50×1.80) | -0.90 |

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 16 | Batuabeel khal | 2413003/STR0023 | -1.233 | 1V (2*2) | 2.0 | 2.7 | 0.07 | 477.3 | -0.85 | 2V (1.50×1.80) | -0.90 |
| 17 | Nayonjoli khal | 2413003/STR0021 | -1.746 | 1V (2*2) | 7.8 | 2.6 | 0.12 | 690.4 | -1.00 | 2V (1.50×1.80) | -0.90 |
| 18 | Puijala Khal | 2413003/STR0005 | -1.244 | 1V (2*2) | 4.4 | 2.6 | 0.12 | 732.8 | -1.00 | 2V (1.50×1.80) | -0.90 |
| 19 | Galghesia | 2413003/STR0011 | -1.761 | 1V (1*1) | 5.2 | 2.8 | 0.12 | 593.9 | -1.00 | 2V (1.50×1.80) | -0.90 |
| 20 | Srikalas | 2413003/STR0025 | -1.941 | 2V (0.91) | 7.8 | 2.7 | 0.12 | 213.9 | -1.00 | 1V (1.50×1.80) | -0.90 |
| 21 | Basukhali khal | 2413003/STR0019 | | | 8.3 | 2.9 | 0.12 | | -1.00 | 2V (1.50×1.80) | -0.90 |
| 22 | Ziamari khal | 2413003/STR0018 | -3.845 | 1V (0.91) | 6.7 | 2.5 | 0.12 | 70.8 | -1.00 | 1V (1.50×1.80) | -0.90 |

### 5.1.6 Polder 45

| Polder No. | Name of Thana | District |
|---|---|---|
| P-45 | Taitoli | Barguna |

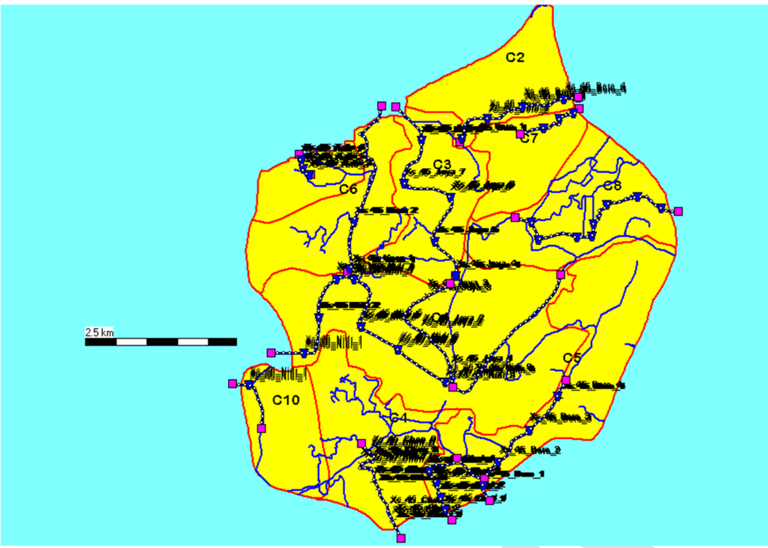



*Figure 5-6: Model domain of the drainage model developed in SOBEK for P-45.*

*Table 5-11: Drainage results for the drainage sluices of Polder 45 considering climate change (10-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Nidra Khal | FS-2 (Baroitoli) | -1.40 | 3 Vents (5.84 X 1.7) | 27.9 | 2.11 | -0.34 | 958 | -0.95 | 4V (1.50×1.80) | -0.95 |
| 2 | Boro Ankujan Para Khal | structure_45_4 | -1.33 | 4 Vents (2.75 X 0.925) | 11.3 | 2.15 | -0.34 | 287 | -0.99 | 3V (1.50×1.80) | -0.95 |
| 3 | Joyal Vanga Khal | DS-3A (Batipara/Joailbhanga) | -1.39 | 2 Vents (6.85 X 1.53) | 13.0 | 2.17 | -0.34 | 343 | -0.89 | 2V (1.50×1.80) | -0.95 |
| 4 | Chon Khola Khal | FS-4 (Sakina) | -0.03 | 1 Vent (1.35 X 0.9) | 15.3 | 2.13 | -0.34 | 419 | -0.95 | 2V (1.50×1.80) | -0.95 |
| 5 | Boro Amkhola Sluice | structure_45_1 | -1.30 | 5 Vents (2.79 X 1.35) | 19.9 | 2.10 | -0.34 | 577 | -0.92 | 3V (1.50×1.80) | -0.90 |
| 6 | Joyal Vanga | structure_45_11 | -0.79 | 1 Vent (5.11 X 1.525) | 13.2 | 2.10 | -0.34 | 350 | -0.92 | 2V (1.50×1.80) | -0.75 |
| 7 | Paoya Para Sluice 1 | FS-2 (Baroitoli) | -0.17 | 1 Vent (Dia = 0.65) | 6.3 | 2.11 | -0.34 | 213 | -0.92 | 1V (1.50×1.80) | -0.75 |
| 8 | Paoya Para Sluice 3 | FS-West Ongujanpara | 0.37 | 1 Vent (2.83 X 0.73) | 12.9 | 2.15 | -0.34 | 440 | -0.92 | 3V (1.50×1.80) | -0.75 |
| 9 | Tatul Baria | structure_45_12 | -0.90 | 1 Vent (5.14 X 1.54) | 4.1 | 1.73 | -0.34 | 142 | -0.92 | 1V (1.50×1.80) | -0.75 |
| 10 | Nidrar Chor | structure_45_3 | -0.23 | 1 Vent (3.885 X 1.185) | 6.8 | 2.05 | -0.34 | 233 | -0.92 | 1V (1.50×1.80) | -0.75 |

*Table 5-12 Drainage results for the drainage sluices of Polder 45 considering climate change (25-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Nidra Khal | FS-2 (Baroitoli) | -1.40 | 3 Vents (5.84 X 1.7) | 32.1 | 2.61 | 0.26 | 958 | -0.95 | 4V (1.50×1.80) | -0.95 |
| 2 | Boro Ankujan Para Khal | structure_45_4 | -1.33 | 4 Vents (2.75 X 0.925) | 12.6 | 2.65 | 0.26 | 287 | -0.99 | 3V (1.50×1.80) | -0.95 |
| 3 | Joyal Vanga Khal | DS-3A (Batipara/Joailbhanga) | -1.39 | 2 Vents (6.85 X 1.53) | 14.5 | 2.67 | 0.26 | 343 | -0.89 | 2V (1.50×1.80) | -0.95 |
| 4 | Chon Khola Khal | FS-4 (Sakina) | -0.03 | 1 Vent (1.35 X 0.9) | 17.1 | 2.63 | 0.26 | 419 | -0.95 | 2V (1.50×1.80) | -0.95 |
| 5 | Boro Amkhola Sluice | structure_45_1 | -1.30 | 5 Vents (2.79 X 1.35) | 22.4 | 2.60 | 0.26 | 577 | -0.92 | 3V (1.50×1.80) | -0.90 |
| 6 | Joyal Vanga | structure_45_11 | -0.79 | 1 Vent (5.11 X 1.525) | 14.7 | 2.60 | 0.26 | 350 | -0.92 | 2V (1.50×1.80) | -0.75 |
| 7 | Paoya Para Sluice 1 | FS-2 (Baroitoli) | -0.17 | 1 Vent (Dia = 0.65) | 7.2 | 2.61 | 0.26 | 213 | -0.92 | 1V (1.50×1.80) | -0.75 |
| 8 | Paoya Para Sluice 3 | FS-West Ongujanpara | 0.37 | 1 Vent (2.83 X 0.73) | 14.8 | 2.65 | 0.26 | 440 | -0.92 | 3V (1.50×1.80) | -0.75 |
| 9 | Tatul Baria | structure_45_12 | -0.90 | 1 Vent (5.14 X 1.54) | 4.7 | 2.23 | 0.26 | 142 | -0.92 | 1V (1.50×1.80) | -0.75 |
| 10 | Nidrar Chor | structure_45_3 | -0.23 | 1 Vent (3.885 X 1.185) | 7.8 | 2.55 | 0.26 | 233 | -0.92 | 1V (1.50×1.80) | -0.75 |

### 5.1.7 Polder 50-51

| Polder No. | Name of Thana | District |
|---|---|---|
| P-50-51 | Rangabali | Patuakhali |


*Figure 5-7: Model domain of the drainage model developed in SOBEK for 50-51.*

*Table 5-13 Drainage results for the drainage sluices of Polder 50-51 considering climate change (10-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Gabbunia Sluice | 2525020/STR0006 | -1.45 | 1V (1.83*1.52) | 6.6 | 1.9 | -0.47 | 409 | -0.65 | 2V (1.50×1.80) | -0.90 |
| 2 | Char Bogla SDS | 2525020/STR0012 | 0.215 | .6D | 2.0 | 1.6 | -0.47 | 122 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 3 | Khas Mohol SDS-1 | 2525020/STR0013 | -0.29 | .9D | 7.5 | 2.2 | -0.47 | 466 | -0.65 | 2V (1.50×1.80) | -0.90 |
| 4 | Char Bogla Sluice | 2525020/STR0001 | 2.303 | 2V (1.83*1.52) | 4.0 | 1.9 | -0.47 | 249 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 5 | Telipara SDS | 2525020/STR0028 | -0.612 | 1V (1.2*.9) | 3.6 | 1.9 | -0.47 | 225 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 6 | Moudubi Sluice | 2525020/STR0002 | -1.486 | 2V (1.83*1.52) | 3.8 | 2.2 | -0.47 | 236 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 7 | Asabaria SDS | 2525020/STR0030 | -0.44 | .9D | 3.2 | 1.9 | -0.47 | 197 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 8 | Nayen Majhi SDS | 2525020/STR0029 | -0.005 | .45D | 1.8 | 2.3 | -0.47 | 112 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 9 | Chatian Para SDS | 2525020/STR0026 | 0.64 | 1V (1.2*0.9) | 2.3 | 2 | -0.5 | 142 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 10 | Chatian Para Sluice | 2525020/STR0004 | -0.979 | 1V (1.83*1.52) | 3.8 | 2.1 | -0.5 | 236 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 11 | Tulatali Sluice | 2525020/STR0010 | -1.401 | 2V (1.83*1.52) | 6.0 | 2.35 | -0.5 | 369 | -0.65 | 2V (1.50×1.80) | -0.90 |
| 12 | Kazir Kanda Sluice | 2525020/STR0003 | -1.702 | 1V (1.83*1.52) | 5.7 | 2.35 | -0.5 | 355 | -0.65 | 2V (1.50×1.80) | -0.90 |
| 13 | Tangibaria Sluice | 2525020/STR0005 | -2.134 | 2V (1.83*1.52) | 13.2 | 1.9 | -0.5 | 817 | -0.65 | 2V (1.50×1.80) | -0.90 |
| 14 | Darrchira Sluice | 2525020/STR0007 | | 1V (1.83*1.52) | 6.6 | 1.9 | -0.55 | 409 | -0.65 | 2V (1.50×1.80) | -0.90 |
| 15 | Char Emerson SDS | 2525020/STR0023 | | .6D | 3.8 | 1.9 | -0.55 | 224 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 16 | Char Halim Sluice | 2525020/STR0008 | | 2V (1.83*1.52) | 10.3 | 1.9 | -0.55 | 643 | -0.65 | 3V (1.50×1.80) | -0.90 |

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 18 | Mollar Char SDS | 2525020/STR0024 | | .6D | 1.9 | 2.2 | -0.55 | 114 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 19 | Tongibaria SDS | 2525020/STR0025 | 0.969 | .6D | 5.8 | 1.9 | -0.55 | 358 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 20 | Madhukhali SDS | 2525020/STR0027 | 0.45 | .45D | 0.7 | 1.89 | -0.55 | 44 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 21 | Char Ganga Sluice | 2525020/STR0009 | | 3V (1.83*1.52) | 3.5 | 1.9 | -0.55 | 488 | -0.65 | 3V (1.50×1.80) | -0.90 |
| 22 | Char Ganga SDS-2 | 2525020/STR0016 | | .45D | 0.5 | 1.9 | -0.55 | 50 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 23 | Char Ganga SDS-3 | 2525020/STR0017 | | .6D | 0.5 | 1.9 | -0.55 | 50 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 24 | Char Ganga SDS-5 | 2525020/STR0019 | | .45D | 0.3 | 1.9 | -0.55 | 42 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 25 | Jahajmara SDS | 2525020/STR0011 | -0.182 | .45D | 3.0 | 2.2 | -0.55 | 182 | -0.65 | 1V (1.50×1.80) | -0.90 |

*Table 5-14: Drainage results for the drainage sluices of Polder 50-51 considering climate change (25-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Gabbunia Sluice | 2525020/STR0006 | -1.45 | 1V (1.83*1.52) | 8.3 | 2.46 | 0.3 | 409 | -0.65 | 2V (1.50×1.80) | -0.90 |
| 2 | Char Bogla SDS | 2525020/STR0012 | 0.215 | .6D | 2.5 | 2.16 | 0.3 | 122 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 3 | Khas Mohol SDS-1 | 2525020/STR0013 | -0.29 | .9D | 9.5 | 2.76 | 0.3 | 466 | -0.65 | 2V (1.50×1.80) | -0.90 |
| 4 | Char Bogla Sluice | 2525020/STR0001 | 2.303 | 2V (1.83*1.52) | 5.1 | 2.46 | 0.3 | 249 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 5 | Telipara SDS | 2525020/STR0028 | -0.612 | 1V (1.2*.9) | 4.6 | 2.46 | 0.3 | 225 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 6 | Moudubi Sluice | 2525020/STR0002 | -1.486 | 2V (1.83*1.52) | 4.8 | 2.76 | 0.3 | 236 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 7 | Asabaria SDS | 2525020/STR0030 | -0.44 | .9D | 4.0 | 2.46 | 0.3 | 197 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 8 | Nayen Majhi SDS | 2525020/STR0029 | -0.005 | .45D | 2.3 | 2.86 | 0.3 | 112 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 9 | Chatian Para SDS | 2525020/STR0026 | 0.64 | 1V (1.2*0.9) | 2.9 | 2.56 | 0.27 | 142 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 10 | Chatian Para Sluice | 2525020/STR0004 | -0.979 | 1V (1.83*1.52) | 4.8 | 2.66 | 0.27 | 236 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 11 | Tulatali Sluice | 2525020/STR0010 | -1.401 | 2V (1.83*1.52) | 7.6 | 2.91 | 0.27 | 369 | -0.65 | 2V (1.50×1.80) | -0.90 |
| 12 | Kazir Kanda Sluice | 2525020/STR0003 | -1.702 | 1V (1.83*1.52) | 7.3 | 2.91 | 0.27 | 355 | -0.65 | 2V (1.50×1.80) | -0.90 |
| 13 | Tangibaria Sluice | 2525020/STR0005 | -2.134 | 2V (1.83*1.52) | 16.7 | 2.46 | 0.27 | 817 | -0.65 | 2V (1.50×1.80) | -0.90 |
| 14 | Darrchira Sluice | 2525020/STR0007 | | 1V (1.83*1.52) | 8.3 | 2.46 | 0.22 | 409 | -0.65 | 2V (1.50×1.80) | -0.90 |
| 15 | Char Emerson SDS | 2525020/STR0023 | | .6D | 4.8 | 2.46 | 0.22 | 224 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 16 | Char Halim Sluice | 2525020/STR0008 | | 2V (1.83*1.52) | 13.1 | 2.46 | 0.22 | 643 | -0.65 | 3V (1.50×1.80) | -0.90 |
| 18 | Mollar Char SDS | 2525020/STR0024 | | .6D | 2.4 | 2.76 | 0.22 | 114 | -0.65 | 1V (1.50×1.80) | -0.90 |

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 19 | Tongibaria SDS | 2525020/STR0025 | 0.969 | .6D | 7.3 | 2.46 | 0.22 | 358 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 20 | Madhukhali SDS | 2525020/STR0027 | 0.45 | .45D | 0.9 | 2.45 | 0.22 | 44 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 21 | Char Ganga Sluice | 2525020/STR0009 | | 3V (1.83*1.52) | 5.5 | 2.46 | 0.22 | 488 | -0.65 | 3V (1.50×1.80) | -0.90 |
| 22 | Char Ganga SDS-2 | 2525020/STR0016 | | .45D | 0.8 | 2.46 | 0.22 | 50 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 23 | Char Ganga SDS-3 | 2525020/STR0017 | | .6D | 0.8 | 2.46 | 0.22 | 50 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 24 | Char Ganga SDS-5 | 2525020/STR0019 | | .45D | 0.5 | 2.46 | 0.22 | 42 | -0.65 | 1V (1.50×1.80) | -0.90 |
| 25 | Jahajmara SDS | 2525020/STR0011 | -0.182 | .45D | 3.8 | 2.76 | 0.22 | 182 | -0.65 | 1V (1.50×1.80) | -0.90 |

### 5.1.8 Polder 55-2D

| Polder No. | Name of Thana | District |
|---|---|---|
| P-55/2D | Dashmina | Patuakhali |

*Figure 5-8: Model domain of the drainage model developed in SOBEK for 55-2D*

*Table 5-15: Drainage results for the drainage sluices of Polder 55-2D considering climate change (10-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Katakhali | structure_55-2D_1 | -2.194 | 2V (1.952*1.45) | 20.3 | 1.96 | -0.37 | 1335 | -0.60 | 3V (1.50×1.80) | -0.90 |
| 2 | Kalarani | structure_55-2D_3 | -2.131 | 2V (1.85*1.65) | 24.9 | 1.92 | -0.37 | 1564 | -0.60 | 4V (1.50×1.80) | -0.90 |
| 3 | Awliapur | structure_55-2D_4 | -2.149 | 1V (1.85*1.65) | 6.4 | 1.92 | -0.37 | 236 | -0.60 | 1V (1.50×1.80) | -0.90 |
| 4 | Pagla Bazar | structure_55-2D_5 | 3.386 | 5V (1.85*1.65) | 37.4 | 2.10 | -0.37 | 1670 | -0.60 | 5V (1.50×1.80) | -0.90 |
| 5 | Chalavangha | structure_55-2D_6 | -1.083 | 1V(1.2*.9) | 9.0 | 2.10 | -0.37 | 350 | -0.60 | 1V (1.50×1.80) | -0.90 |
| 6 | Vuittar Khal | structure_55-2D_10 | -1.341 | 1V(1.2*0.9) | 4.8 | 2.05 | -0.40 | 170 | -0.60 | 1V (1.50×1.80) | -0.90 |
| 7 | Lal gazir Khal | structure_55-2D_12 | -1.123 | 1V(1.2*0.9) | 5.8 | 2.23 | -0.40 | 214 | -0.60 | 1V (1.50×1.80) | -0.60 |
| 8 | Purbo Alipura | structure_55-2D_14 | -1.496 | 1V(1.2*0.9) | 14.9 | 2.05 | -0.40 | 969 | -0.60 | 2V (1.50×1.80) | -0.70 |
| 9 | Tonmay bad | structure_55-2D_16 | -3.045 | 3V(1.85*1.52) | 9.3 | 2.09 | -0.40 | 565 | -0.60 | 2V (1.50×1.80) | -0.90 |
| 10 | Potkar Mar | structure_55-2D_19 | -2.11 | 3V(1.89*1.6) | 8.4 | 2.04 | -0.40 | 530 | -0.60 | 2V (1.50×1.80) | -0.90 |
| 11 | Betagi Sankipur | structure_55-2D_21 | 0.091 | 3V(1.85*1.2) | 4.1 | 1.95 | -0.40 | 140 | -0.60 | 2V (1.50×1.80) | -0.90 |
| 12 | Chair Masua | structure_55-2D_22 | 0.142 | 3V(1.775*1.2) | 4.6 | 2.03 | -0.40 | 162 | -0.60 | 2V (1.50×1.80) | -0.90 |

*Table 5-16: Drainage results for the drainage sluices of Polder 55-2D considering climate change (25-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Katakhali | structure_55-2D_1 | -2.194 | 2V (1.952*1.45) | 25.1 | 2.26 | 0.23 | 1335 | -0.60 | 3V (1.50×1.80) | -0.90 |
| 2 | Kalarani | structure_55-2D_3 | -2.131 | 2V (1.85*1.65) | 30.6 | 2.22 | 0.23 | 1564 | -0.60 | 4V (1.50×1.80) | -0.90 |
| 3 | Awliapur | structure_55-2D_4 | -2.149 | 1V (1.85*1.65) | 7.2 | 2.22 | 0.23 | 236 | -0.60 | 1V (1.50×1.80) | -0.90 |
| 4 | Pagla Bazar | structure_55-2D_5 | 3.386 | 5V (1.85*1.65) | 43.5 | 2.40 | 0.23 | 1670 | -0.60 | 5V (1.50×1.80) | -0.90 |
| 5 | Chalavangha | structure_55-2D_6 | -1.083 | 1V(1.2*.9) | 10.3 | 2.40 | 0.23 | 350 | -0.60 | 1V (1.50×1.80) | -0.90 |
| 6 | Vuittar Khal | structure_55-2D_10 | -1.341 | 1V(1.2*0.9) | 5.4 | 2.35 | 0.20 | 170 | -0.60 | 1V (1.50×1.80) | -0.90 |
| 7 | Lal gazir Khal | structure_55-2D_12 | -1.123 | 1V(1.2*0.9) | 6.6 | 2.53 | 0.20 | 214 | -0.60 | 1V (1.50×1.80) | -0.60 |
| 8 | Purbo Alipura | structure_55-2D_14 | -1.496 | 1V(1.2*0.9) | 18.5 | 2.35 | 0.20 | 969 | -0.60 | 2V (1.50×1.80) | -0.70 |
| 9 | Tonmay bad | structure_55-2D_16 | -3.045 | 3V(1.85*1.52) | 11.3 | 2.39 | 0.20 | 565 | -0.60 | 2V (1.50×1.80) | -0.90 |
| 10 | Potkar Mar | structure_55-2D_19 | -2.11 | 3V(1.89*1.6) | 10.3 | 2.34 | 0.20 | 530 | -0.60 | 2V (1.50×1.80) | -0.90 |
| 11 | Betagi Sankipur | structure_55-2D_21 | 0.091 | 3V(1.85*1.2) | 4.6 | 2.25 | 0.20 | 140 | -0.60 | 2V (1.50×1.80) | -0.90 |
| 12 | Chair Masua | structure_55-2D_22 | 0.142 | 3V(1.775*1.2) | 5.2 | 2.33 | 0.20 | 162 | -0.60 | 2V (1.50×1.80) | -0.90 |

### 5.1.9 Polder 47/1

| Polder No. | Name of Thana | District |
|---|---|---|
| P-47/1 | Kalapara | Patuakhali |


*Figure 5-9: Model domain of the drainage model developed in SOBEK for 47/1.*

*Table 5-17: Drainage results for the drainage sluices of Polder 47/1 considering climate change (10-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Bed Level (mPWD) | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Fafrur Khal | structure_47-1_1 | -0.812 | -0.554 | 4V (3.84*1.225) | 9.41 | 2.14 | -0.45 | 466 | -0.95 | 2V (1.50×1.80) | -0.70 |
| 2 | Mulam | structure_47-1_2 | -2.723 | -1.031 | 6V (3.95*1.2) | 17.47 | 2.05 | -0.45 | 964 | -0.99 | 4V (1.50×1.80) | -0.90 |
| 3 | Uttar Monohorpur | structure_47-1_3 | -1.2 | -0.919 | 1V (4.28*1.7) | 3.22 | 2.1 | -0.45 | 200 | -0.89 | 1V (1.50×1.80) | -0.80 |
| 4 | Gabbria | structure_47-1_4 | -0.734 | -0.93 | 2V (3.95*1.2) | 6.87 | 2.1 | -0.45 | 304 | -0.95 | 2V (1.50×1.80) | -0.80 |
| 5 | Siraj Pur | structure_47-1_5 | | 0.57 | | 2.37 | 2.05 | -0.45 | 148 | -0.92 | 1V (1.50×1.80) | -0.60 |

*Table 5-18: Drainage results for the drainage sluices of Polder 47/1 considering climate change (25-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Bed Level (mPWD) | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Fafrur Khal | structure_47-1_1 | -0.812 | -0.554 | 4V (3.84*1.225) | 11.41 | 2.44 | 0.15 | 466 | -0.95 | 2V (1.50×1.80) | -0.70 |
| 2 | Mulam | structure_47-1_2 | -2.723 | -1.031 | 6V (3.95*1.2) | 21.61 | 2.35 | 0.15 | 964 | -0.99 | 4V (1.50×1.80) | -0.90 |
| 3 | Uttar Monohorpur | structure_47-1_3 | -1.2 | -0.919 | 1V (4.28*1.7) | 4.07 | 2.4 | 0.15 | 200 | -0.89 | 1V (1.50×1.80) | -0.80 |
| 4 | Gabbria | structure_47-1_4 | -0.734 | -0.93 | 2V (3.95*1.2) | 8.18 | 2.4 | 0.15 | 304 | -0.95 | 2V (1.50×1.80) | -0.80 |
| 5 | Siraj Pur | structure_47-1_5 | | 0.57 | | 3.00 | 2.35 | 0.15 | 148 | -0.92 | 1V (1.50×1.80) | -0.60 |

### 5.1.10 Polder 41/5

| Polder No. | Name of Thana | District |
|---|---|---|
| P-41/5 | Barguna Sadar | Barguna |


*Figure 5-10: Model domain of the drainage model developed in SOBEK for 41/5.*

*Table 5-19: Drainage results for the drainage sluices of Polder 41/5 considering climate change (10-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Azizabad | structure_41-5_1 | -0.124 | 1P (.91D) | 0.7 | 1.504 | -0.34 | 45 | -0.89 | 1V (1.20×1.20) | -0.10 |
| 2 | HM Noli Maitha | structure_41-5_2 | -0.964 | 1V (1*1.25) | 1.2 | 1.992 | -0.34 | 78 | -0.89 | 1V (1.20×1.20) | -0.10 |
| 3 | Choto Baliatoli | structure_41-5_3 | -0.952 | 2V (1.7*1.4 | 1.6 | 2.242 | -0.34 | 99 | -0.91 | 1V (1.20×1.20) | -0.10 |
| 4 | Paler Baliatoli | structure_41-5_4 | -0.515 | 3V (.91D) | 4.8 | 1.924 | -0.34 | 303 | -0.94 | 1V (1.50×1.80) | -0.10 |
| 5 | Amlokitola | FS-14 (Amlakitola) | 0.108 | 1P (.91D) | 3.8 | 2.000 | -0.34 | 239 | -0.89 | 1V (1.50×1.80) | -0.10 |
| 6 | Amlokitola | FS-15 (Amlakitola) | 0.108 | 1P (.91D) | 3.8 | 2.12 | -0.34 | 49 | -0.89 | 1V (1.50×1.80) | -0.10 |
| 7 | Charpara | FS-13 (Charpara) | 0.327 | 1P (.91D) | 0.8 | 1.924 | -0.34 | 52 | -0.89 | 1V (0.90×1.20) | 0.30 |
| 8 | Uttar Potakata | FS-13A (Charpara) | -0.595 | 3P (1.25D) | 6.3 | 2.11 | -0.34 | 395 | -0.89 | 1V (1.50×1.80) | -0.30 |
| 9 | Uttar Potakata | structure_41-5_9 | -0.018 | 1P (.91D) | 0.9 | 2.11 | -0.34 | 56 | -0.89 | 1V (0.90×1.20) | 0.30 |
| 10 | Shahatoli | structure_41-5_11 | 0.084 | 1P (.91D) | 1.0 | 1.878 | -0.34 | 62 | -0.91 | 1V (0.90×1.20) | 0.30 |
| 11 | Chaltatali | FS-Chalitatoli New-1 | 0.356 | 1V (1*1) | 2.5 | 1.673 | -0.34 | 155 | -0.91 | 1V (1.20×1.20) | 0.10 |
| 12 | Latakata | FS-4 (Patakata) | 0.4126 | 1P (.91D) | 2.0 | 1.673 | -0.34 | 115 | -0.91 | 1V (1.20×1.20) | 0.10 |
| 13 | Porir Khal | structure_41-5_15 | -0.64 | 2V (1.7*1.4) | 2.0 | 2.12 | -0.34 | 124 | -0.89 | 1V (1.20×1.20) | 0.10 |
| 14 | Bainsomarthon | structure_41-5_16 | -1.325 | 2V (1.7*1.4) | 3.8 | 1.642 | -0.34 | 241 | -0.91 | 1V (1.20×1.50) | -0.40 |
| 15 | Monsatoli | FS-19 (Manoshitola) | 0.407 | 1P (.91D) | 1.9 | 2.18 | -0.34 | 120 | -0.91 | 1V (0.90×1.20) | 0.30 |
| 16 | Khanta Kata | FS-17 (Khontakata) | -0.043 | 1P (.91D) | 1.0 | 1.77 | -0.34 | 64 | -0.89 | 1V (0.90×1.20) | 0.30 |

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 17 | Noli Monsatoli | structure_41-5_20 | -1.298 | 2V (1.7*1.4) | 2.1 | 2.18 | -0.4 | 118 | -0.88 | 1V (1.20×1.20) | 0.30 |
| 18 | Monsatoli | structure_41-5_21 | 0.407 | 1P (.91D) | 1.5 | 2.18 | -0.4 | 95 | -0.88 | 1V (0.90×1.20) | 0.30 |
| 19 | Dhantolar Khal | FS-24 (Manoshitola) | -0.004 | 1P (.91D) | 1.7 | 2.2 | -0.4 | 91 | -0.89 | 1V (0.90×1.20) | 0.30 |
| 20 | Shasatola | structure_41-5_23 | -0.442 | 1P (.91D) | 0.8 | 2.2 | -0.4 | 53 | -0.89 | 1V (0.90×1.20) | 0.30 |
| 21 | Choto Taltoli | structure_41-5_24 | 0.072 | 1P (.82D) | 1.8 | 1.88 | -0.4 | 114 | -0.91 | 1V (0.90×1.20) | 0.30 |
| 22 | Rashid Sikdar | structure_41-5_25 | 0.225 | 1P (.82D) | 2.4 | 1.88 | -0.4 | 148 | -0.91 | 1V (1.20×1.20) | 0.30 |
| 23 | Nalimaitha | structure_41-5_26 | -1.34 | 1P (1.25D) | 1.0 | 1.88 | -0.4 | 66 | -0.88 | 1V (0.90×1.20) | 0.30 |
| 24 | Charpara 1 | FS-Charpara New-1 | 0.919 | 1B (0.65D) | 0.4 | 2.2 | -0.4 | 26 | -0.89 | 1V (0.90×1.20) | 0.60 |
| 25 | Charpara 2 | FS-Charpara New-2 | 0.752 | 1B (0.65D) | 0.6 | 2.2 | -0.4 | 40 | -0.89 | 1V (0.90×1.20) | 0.60 |
| 26 | Chonbunia | FS-10A (Chonbunia) | -0.114 | 1B (0.95D) | 2.8 | 2.14 | -0.4 | 174 | -0.90 | 1V (1.20×1.20) | 0.30 |
| 27 | Maitha | FS-27 (Maittaya) | 0.726 | 1B (0.95D) | 1.4 | 1.9 | -0.4 | 88 | -0.89 | 1V (0.90×1.20) | 0.60 |
| 28 | Char Maitha | FS-Char Maitta | 0.334 | 1B (0.95D) | 1.4 | 1.992 | -0.4 | 87 | -0.89 | 1V (0.90×1.20) | 0.60 |
| 29 | Rakhachandhi | FS-18 (Rakkhachandi) | 0.519 | 1B (0.95D) | 2.1 | 1.66 | -0.4 | 132 | -0.89 | 1V (1.20×1.20) | 0.30 |
| 30 | Basuki | FS-1 (Basuki) | 0.09 | 1B (0.95D) | 4.6 | 1.66 | -0.4 | 296 | -0.89 | 1V (1.20×1.20) | -0.20 |

*Table 5-20: Drainage results for the drainage sluices of Polder 41/5 considering climate change (25-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Azizabad | structure_41-5_1 | -0.124 | 1P (.91D) | 0.9 | 1.904 | 0.16 | 45 | -0.89 | 1V (1.20×1.20) | -0.10 |
| 2 | HM Noli Maitha | structure_41-5_2 | -0.964 | 1V (1*1.25) | 1.6 | 2.392 | 0.16 | 78 | -0.89 | 1V (1.20×1.20) | -0.10 |
| 3 | Choto Baliatoli | structure_41-5_3 | -0.952 | 2V (1.7*1.4 | 2.0 | 2.642 | 0.16 | 99 | -0.91 | 1V (1.20×1.20) | -0.10 |
| 4 | Paler Baliatoli | structure_41-5_4 | -0.515 | 3V (.91D) | 6.2 | 2.324 | 0.16 | 303 | -0.94 | 1V (1.50×1.80) | -0.10 |
| 5 | Amlokitola | FS-14 (Amlakitola) | 0.108 | 1P (.91D) | 4.8 | 2.400 | 0.16 | 239 | -0.89 | 1V (1.50×1.80) | -0.10 |
| 6 | Amlokitola | FS-15 (Amlakitola) | 0.108 | 1P (.91D) | 4.8 | 2.52 | 0.16 | 49 | -0.89 | 1V (1.50×1.80) | -0.10 |
| 7 | Charpara | FS-13 (Charpara) | 0.327 | 1P (.91D) | 1.1 | 2.324 | 0.16 | 52 | -0.89 | 1V (0.90×1.20) | 0.30 |
| 8 | Uttar Potakata | FS-13A (Charpara) | -0.595 | 3P (1.25D) | 8.0 | 2.51 | 0.16 | 395 | -0.89 | 1V (1.50×1.80) | -0.30 |
| 9 | Uttar Potakata | structure_41-5_9 | -0.018 | 1P (.91D) | 1.1 | 2.51 | 0.16 | 56 | -0.89 | 1V (0.90×1.20) | 0.30 |
| 10 | Shahatoli | structure_41-5_11 | 0.084 | 1P (.91D) | 1.2 | 2.278 | 0.16 | 62 | -0.91 | 1V (0.90×1.20) | 0.30 |
| 11 | Chaltatali | FS-Chalitatoli New-1 | 0.356 | 1V (1*1) | 3.2 | 2.073 | 0.16 | 155 | -0.91 | 1V (1.20×1.20) | 0.10 |
| 12 | Latakata | FS-4 (Patakata) | 0.4126 | 1P (.91D) | 2.5 | 2.073 | 0.16 | 115 | -0.91 | 1V (1.20×1.20) | 0.10 |
| 13 | Porir Khal | structure_41-5_15 | -0.64 | 2V (1.7*1.4) | 2.5 | 2.52 | 0.16 | 124 | -0.89 | 1V (1.20×1.20) | 0.10 |
| 14 | Bainsomarthon | structure_41-5_16 | -1.325 | 2V (1.7*1.4) | 4.9 | 2.042 | 0.16 | 241 | -0.91 | 1V (1.20×1.50) | -0.40 |
| 15 | Monsatoli | FS-19 (Manoshitola) | 0.407 | 1P (.91D) | 2.4 | 2.58 | 0.16 | 120 | -0.91 | 1V (0.90×1.20) | 0.30 |
| 16 | Khanta Kata | FS-17 (Khontakata) | -0.043 | 1P (.91D) | 1.3 | 2.17 | 0.16 | 64 | -0.89 | 1V (0.90×1.20) | 0.30 |

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 17 | Noli Monsatoli | structure_41-5_20 | -1.298 | 2V (1.7*1.4) | 2.7 | 2.58 | 0.1 | 118 | -0.88 | 1V (1.20×1.20) | 0.30 |
| 18 | Monsatoli | structure_41-5_21 | 0.407 | 1P (.91D) | 1.9 | 2.58 | 0.1 | 95 | -0.88 | 1V (0.90×1.20) | 0.30 |
| 19 | Dhantolar Khal | FS-24 (Manoshitola) | -0.004 | 1P (.91D) | 2.0 | 2.6 | 0.1 | 91 | -0.89 | 1V (0.90×1.20) | 0.30 |
| 20 | Shasatola | structure_41-5_23 | -0.442 | 1P (.91D) | 1.1 | 2.6 | 0.1 | 53 | -0.89 | 1V (0.90×1.20) | 0.30 |
| 21 | Choto Taltoli | structure_41-5_24 | 0.072 | 1P (.82D) | 2.3 | 2.28 | 0.1 | 114 | -0.91 | 1V (0.90×1.20) | 0.30 |
| 22 | Rashid Sikdar | structure_41-5_25 | 0.225 | 1P (.82D) | 3.0 | 2.28 | 0.1 | 148 | -0.91 | 1V (1.20×1.20) | 0.30 |
| 23 | Nalimaitha | structure_41-5_26 | -1.34 | 1P (1.25D) | 1.3 | 2.28 | 0.1 | 66 | -0.88 | 1V (0.90×1.20) | 0.30 |
| 24 | Charpara 1 | FS-Charpara New-1 | 0.919 | 1B (0.65D) | 0.5 | 2.6 | 0.1 | 26 | -0.89 | 1V (0.90×1.20) | 0.60 |
| 25 | Charpara 2 | FS-Charpara New-2 | 0.752 | 1B (0.65D) | 0.8 | 2.6 | 0.1 | 40 | -0.89 | 1V (0.90×1.20) | 0.60 |
| 26 | Chonbunia | FS-10A (Chonbunia) | -0.114 | 1B (0.95D) | 3.5 | 2.54 | 0.1 | 174 | -0.90 | 1V (1.20×1.20) | 0.30 |
| 27 | Maitha | FS-27 (Maittaya) | 0.726 | 1B (0.95D) | 1.8 | 2.3 | 0.1 | 88 | -0.89 | 1V (0.90×1.20) | 0.60 |
| 28 | Char Maitha | FS-Char Maitta | 0.334 | 1B (0.95D) | 1.8 | 2.392 | 0.1 | 87 | -0.89 | 1V (0.90×1.20) | 0.60 |
| 29 | Rakhachandhi | FS-18 (Rakkhachandi) | 0.519 | 1B (0.95D) | 2.7 | 2.06 | 0.1 | 132 | -0.89 | 1V (1.20×1.20) | 0.30 |
| 30 | Basuki | FS-1 (Basuki) | 0.09 | 1B (0.95D) | 5.9 | 2.06 | 0.1 | 296 | -0.89 | 1V (1.20×1.20) | -0.20 |

### 5.1.11 Polder 39/1B

| Polder No. | Name of Thana | District |
|---|---|---|
| P-39/1B | Motbaria | Pirojpur |

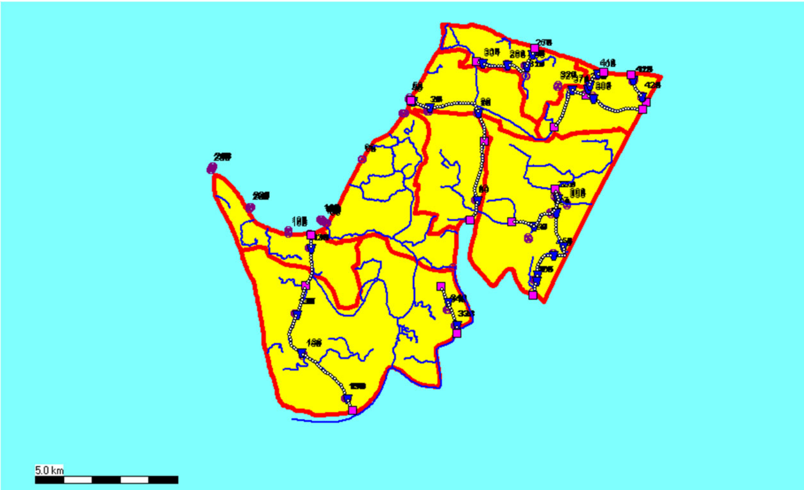



*Figure 5-11: Model domain of the drainage model developed in SOBEK for 39/1B.*

*Table 5-21: Drainage results for the drainage sluices of Polder 39/1B considering climate change (10-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Babur Hat Khal | structure_39-1B_22 | -1.608 | 6V (2*1.6) | 52.8 | 2.00 | -0.20 | 3292 | -0.7 | 6V ((1.50×1.80) | -0.85 |
| 2 | Hultakhali | structure_39-1B_38 | 0.429 | 4V (1.8*1.5) | 32.9 | 1.50 | -0.20 | 2050 | -0.7 | 5V(1.50×1.80) | -0.85 |
| 3 | Passatopura Khal | structure_39-1B_35 | 3.516 | 1V (5.1*2.55) | 11.8 | 1.50 | -0.20 | 744 | -0.7 | 2V(1.50×1.80) | -0.75 |
| 4 | Lebotola Khal | structure_39-1B_13 | -1.281 | 2V (2*1.6) | 20.0 | 1.60 | -0.20 | 1254 | -0.7 | 2V (1.50×1.80) | -0.75 |
| 5 | Kochubaria Khal | structure_39-1B_5 | 3.952 | 2V (6*1.5) | 10.7 | 1.50 | -0.20 | 676 | -0.7 | 2V (1.50×1.80) | -0.75 |
| 6 | Surbo Baria Khal | structure_39-1B_2 | 3.374 | 2V (5.2*1.8) | 11.2 | 1.50 | -0.20 | 696 | -0.7 | 2V (1.50×1.80) | -0.75 |
| 7 | Baranir Khal | structure_39-1B_11 | 2.166 | 4V(2*1.6) | 13.7 | 1.20 | -0.20 | 850 | -0.7 | 3V (1.50×1.80) | -0.90 |
| 8 | Mathbaria Khal | structure_39-1B_27 | 2.871 | 2V (5.3*2) | 11.2 | 1.60 | -0.20 | 698 | -0.7 | 2V (1.50×1.80) | -0.90 |

*Table 5-22: Drainage results for the drainage sluices of Polder 39/1B considering climate change (25-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Babur Hat Khal | structure_39-1B_22 | -1.608 | 6V (2*1.6) | 60.8 | 2.50 | 0.10 | 3292 | -0.7 | 6V ((1.50×1.80) | -0.85 |
| 2 | Hultakhali | structure_39-1B_38 | 0.429 | 4V (1.8*1.5) | 37.8 | 2.00 | 0.10 | 2050 | -0.7 | 5V(1.50×1.80) | -0.85 |
| 3 | Passatopura Khal | structure_39-1B_35 | 3.516 | 1V (5.1*2.55) | 13.6 | 2.00 | 0.10 | 744 | -0.7 | 2V(1.50×1.80) | -0.75 |
| 4 | Lebotola Khal | structure_39-1B_13 | -1.281 | 2V (2*1.6) | 23.0 | 2.10 | 0.10 | 1254 | -0.7 | 2V (1.50×1.80) | -0.75 |
| 5 | Kochubaria Khal | structure_39-1B_5 | 3.952 | 2V (6*1.5) | 12.4 | 2.00 | 0.10 | 676 | -0.7 | 2V (1.50×1.80) | -0.75 |
| 6 | Surbo Baria Khal | structure_39-1B_2 | 3.374 | 2V (5.2*1.8) | 12.8 | 2.00 | 0.25 | 696 | -0.7 | 2V (1.50×1.80) | -0.75 |
| 7 | Baranir Khal | structure_39-1B_11 | 2.166 | 4V(2*1.6) | 15.8 | 1.70 | 0.25 | 850 | -0.7 | 3V (1.50×1.80) | -0.90 |
| 8 | Mathbaria Khal | structure_39-1B_27 | 2.871 | 2V (5.3*2) | 12.9 | 2.10 | 0.25 | 698 | -0.7 | 2V (1.50×1.80) | -0.90 |

### 5.1.12 Polder 5

| Polder No. | Name of Thana | District |
|---|---|---|
| P-5 | Kaliganj, Shyamnagar | Satkhira |

Khal cross section survey data was not available for Polder 5. Therefore, it was not possible to create a numerical model of the drainage patterns within the Polder. Instead, we have performed an analytical analysis using the SCS-CN methodology. This is appropriate for the purposes of preliminary design. The results are shown in the following table.

| Table 5-23: Drainage results for the drainage sluices of Polder 5 | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | 10year Peak Discharge (m3/sec) | 25year Peak Discharge (m3/sec) | Corresponding Water Level During Peak Discharge | | Catchment Area (Ha) | Average LFL at River (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | |
| 1 | no x section/ no khal name souce | 2412003/STR0004 | -2.3 | 1V(1.21m X0.9m ) | 5.4 | 6.3 | N/A | N/A | 624.6 | -1.1 |
| 2 | no x section/ no khal name souce | 2412003/STR0003 | -2.4 | 1V(1.8m X1.5m ) | 7.1 | 8.4 | N/A | N/A | 843.9 | -1.1 |
| 3 | no x section/ no khal name souce | 2412003/STR0002 | -2.372 | 1V(1.37m X1.06m ) | 4.4 | 5.2 | N/A | N/A | 544.0 | -1.5 |
| 4 | no x section/ no khal name souce | 2412003/STR0039 | -1.401 | 1V(2.45m X1.65m ) | 3.7 | 4.3 | N/A | N/A | 414.9 | -1.0 |
| 5 | no x section/ no khal name souce | 2412003/STR0038 | -1.98 | 1V(1.8m X1.5m ) | 4.0 | 4.7 | N/A | N/A | 449.4 | -1.0 |
| 6 | no x section/ no khal name souce | 2412003/STR0037 | -1.945 | 1V(2.45m X1.65m ) | 1.5 | 1.7 | N/A | N/A | 164.0 | -1.0 |
| 7 | no x section/ no khal name souce | 2412003/STR0041 | -2.185 | 2V(1.8m X1.5m ) | 11.9 | 14.2 | N/A | N/A | 1461.4 | -1.5 |
| 8 | no x section/ no khal name souce | 2412003/STR0036 | -2.16 | 1V(2.45m X1.65m ) | 4.4 | 5.2 | N/A | N/A | 495.8 | -1.0 |
| 9 | no x section/ no khal name souce | 2412003/STR0033 | -1.992 | 2V(1.8m X1.5m ) | 6.2 | 7.3 | N/A | N/A | 719.4 | -1.0 |

| Table 5-23: Drainage results for the drainage sluices of Polder 5 | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | 10year Peak Discharge (m3/sec) | 25year Peak Discharge (m3/sec) | Corresponding Water Level During Peak Discharge | | Catchment Area (Ha) | Average LFL at River (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | |
| 10 | no x section/ no khal name souce | 2412003/STR0032 | -2.272 | 1V(1.8m X1.5m ) | 6.2 | 7.3 | N/A | N/A | 721.1 | -1.0 |
| 11 | no x section/ no khal name souce | 2412003/STR0031 | -2.332 | 2V(1.8m X1.5m ) | 8.1 | 9.5 | N/A | N/A | 978.5 | -1.7 |
| 12 | no x section/ no khal name souce | <Null> | -0.471 | 2V(1.2m X0.9m ) | 1.5 | 1.8 | N/A | N/A | 175.2 | -2.1 |
| 13 | no x section/ no khal name souce | 2412003/STR0042 | -1.923 | 1V(1.8m X1.5m ) | 3.3 | 4.0 | N/A | N/A | 429.9 | -1.0 |
| 14 | no x section/ no khal name souce | 2412003/STR0045 | -2.232 | 3V (0.9m) | 23.6 | 28.2 | N/A | N/A | 3048.0 | -1.0 |
| 15 | no x section/ no khal name souce | 2412003/STR0044 | -2.232 | 1V(1.8m X1.5m ) | 23.6 | 28.2 | N/A | N/A | | -1.0 |
| 16 | no x section/ no khal name souce | 2412003/STR0014 | -1.348 | 1V(1.8m X1.5m ) | 2.0 | 2.3 | N/A | N/A | 222.7 | -1.1 |
| 17 | no x section/ no khal name souce | 2412003/STR0009 | -3.036 | 2V(1.8m X1.5m ) | 22.7 | 26.6 | N/A | N/A | 2587.7 | -1.1 |
| 18 | no x section/ no khal name souce | 2412003/STR0013 | -2.834 | 1V(1.82m X1.52m ) | 14.6 | 17.2 | N/A | N/A | 1692.4 | -1.1 |
| 19 | no x section/ no khal name souce | 2412003/STR0019 | -3.469 | 2V(1.8m X1.5m ) | 10.2 | 12.0 | N/A | N/A | 1150.9 | -1.0 |
| 20 | no x section/ no khal name souce | 2412003/STR0016 | -1.68 | 1V(1.82m X1.52m ) | 3.0 | 3.6 | N/A | N/A | 340.8 | -1.1 |
| 21 | no x section/ no khal name souce | 2412003/STR0027 | -2.383 | 2V(1.8m X1.5m ) | 8.0 | 9.4 | N/A | N/A | 940.3 | -1.0 |
| 22 | no x section/ no khal name souce | 2412003/STR0028 | -2.3 | 1V(1.8m X1.5m ) | 8.0 | 9.4 | N/A | N/A | | -1.0 |
| 23 | no x section/ no khal name souce | 2412003/STR0012 | -1.264 | 2V(1.8m X1.5m ) | 9.5 | 11.2 | N/A | N/A | 1144.3 | -1.1 |
| 24 | no x section/ no khal name souce | 2412003/STR0011 | -2.428 | 1V(1.8m X1.5m ) | 11.7 | 13.8 | N/A | N/A | 1354.8 | -1.1 |
| 25 | no x section/ no khal name souce | 2412003/STR0005 | -2.44 | 1V(1.8m X1.5m ) | 8.5 | 10.1 | N/A | N/A | 1035.9 | -1.1 |
| 26 | no x section/ no khal name souce | 2412003/STR0006 | -1.94 | 1V(1.8m X1.5m ) | 6.7 | 7.9 | N/A | N/A | 815.1 | -1.1 |
| 27 | no x section/ no khal name souce | 2412003/STR0008 | -1.501 | 2V(1.8m X1.5m ) | 10.5 | 12.5 | N/A | N/A | 1253.3 | -1.1 |

| Table 5-23: Drainage results for the drainage sluices of Polder 5 | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | 10year Peak Discharge (m3/sec) | 25year Peak Discharge (m3/sec) | Corresponding Water Level During Peak Discharge | | Catchment Area (Ha) | Average LFL at River (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | |
| 28 | no x section/ no khal name souce | 2412003/STR0015 | -2.451 | 2V(1.8m X1.5m ) | 19.6 | 23.1 | N/A | N/A | 2314.6 | -1.1 |
| 29 | no x section/ no khal name souce | 2412003/STR0001 | -2.78 | 4V(1.8m X1.5m ) | 53.4 | 63.3 | N/A | N/A | 6563.0 | -1.5 |
| 30 | no x section/ no khal name souce | 2412003/STR0021 | -2.506 | 1V(1.8m X1.5m ) | 8.0 | 9.4 | N/A | N/A | 932.3 | -1.0 |
| 31 | no x section/ no khal name souce | 2412003/STR0020 | -3.333 | 4V(1.8m X1.5m ) | 46.8 | 54.5 | N/A | N/A | 4903.8 | -1.0 |
| 32 | no x section/ no khal name souce | 2412003/STR0030 | -2.425 | 3V(1.8m X1.5m ) | 10.9 | 12.8 | N/A | N/A | 1281.0 | -1.7 |
| 33 | no x section/ no khal name souce | 2412003/STR0029 | -2.58 | 1V(1.2m X0.9m ) | 10.9 | 12.8 | N/A | N/A | | -1.7 |
| 34 | no x section/ no khal name souce | 2412003/STR0023 | -2.324 | 4V(1.8m X1.5m ) | 72.6 | 85.8 | N/A | N/A | 8682.3 | -1.0 |
| 35 | no x section/ no khal name souce | 2412003/STR0024 | -2.226 | 4V(1.8m X1.5m ) | 72.6 | 85.8 | N/A | N/A | | -1.0 |
| 36 | no x section/ no khal name souce | 2412003/STR0022 | -1.5 | 2V(1.8m X1.5m ) | 19.4 | 22.8 | N/A | N/A | 2260.9 | -1.0 |
| 37 | no x section/ no khal name souce | 2412003/STR0035 | -2.475 | 1V(1.8m X1.5m ) | 2.5 | 3.0 | N/A | N/A | 290.3 | -1.0 |
| 38 | no x section/ no khal name souce | 2412003/STR0017 | -2.315 | 1V(1.82m X1.5m ) | 2.1 | 2.5 | N/A | N/A | 238.8 | -1.1 |
| 39 | no x section/ no khal name souce | <Null> | -1.223 | 1V(1.8m X1.4m ) | 3.8 | 4.4 | N/A | N/A | 433.6 | -1.1 |
| 40 | no x section/ no khal name souce | 2412003/STR0025 | -2.148 | 1V(0.9m X0.9m ) | 0.8 | 0.9 | N/A | N/A | 87.6 | -1.0 |
| 41 | no x section/ no khal name souce | <Null> | -0.492 | 5V(1.2m X0.9m ) | 2.7 | 3.2 | N/A | N/A | 317.2 | -1.0 |
| 42 | no x section/ no khal name souce | 2412003/STR0026 | -2.108 | 1V(1.8m X1.5m ) | 4.2 | 5.0 | N/A | N/A | 477.6 | -1.0 |
| 43 | no x section/ no khal name souce | <Null> | -0.491 | 3V(0.9m X0.9m ) | 2.0 | 2.4 | N/A | N/A | 230.7 | -1.0 |
| 44 | no x section/ no khal name souce | <Null> | -1.186 | 2V(0.9m X0.9m ) | 0.3 | 0.4 | N/A | N/A | 39.9 | -1.0 |
| 45 | no x section/ no khal name souce | <Null> | -1.67 | 1V(1.2m X0.9m ) | 0.2 | 0.2 | N/A | N/A | 21.6 | -1.0 |

| Table 5-23: Drainage results for the drainage sluices of Polder 5 | **Name of Khal on which Sluice is Located** | **Sluice ID No.** | **Existing Sill Level (mPWD)** | **Existing Number of Vents and Size (in m)** | **10year Peak Discharge (m3/sec)** | **25year Peak Discharge (m3/sec)** | **Corresponding Water Level During Peak Discharge** | | **Catchment Area (Ha)** | **Average LFL at River (mPWD)** |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | **Upstream water level (corrected mPWD)** | **Downstream water level (corrected mPWD)** | | |
| 46 | no x section/ no khal name souce | 2412003/STR0018 | -1.469 | 1V(1.8m X1.5m ) | 5.2 | 6.2 | N/A | N/A | 604.9 | -1.0 |
| 47 | no x section/ no khal name souce | 2412003/STR0007 | -1.703 | 1V(1.8m X1.5m ) | 5.5 | 6.5 | N/A | N/A | 671.3 | -1.1 |
| 48 | no x section/ no khal name souce | 2412003/STR0043 | -1.861 | 1V(1.8m X1.5m ) | 3.0 | 3.5 | N/A | N/A | 344.0 | -1.0 |
| 49 | no x section/ no khal name souce | <Null> | -1.453 | 3V(1.2m X0.9m ) | 4.9 | 5.7 | N/A | N/A | 570.4 | -1.0 |
| 50 | no x section/ no khal name souce | <Null> | -2.3 | 2V(1.2m X0.9m ) | 1.9 | 2.2 | N/A | N/A | 211.9 | -1.0 |

### 5.1.13 Polder 39/1C

| Polder No. | Name of Thana | District |
|---|---|---|
| P-39/1C | Motbaria | P-39/1C |

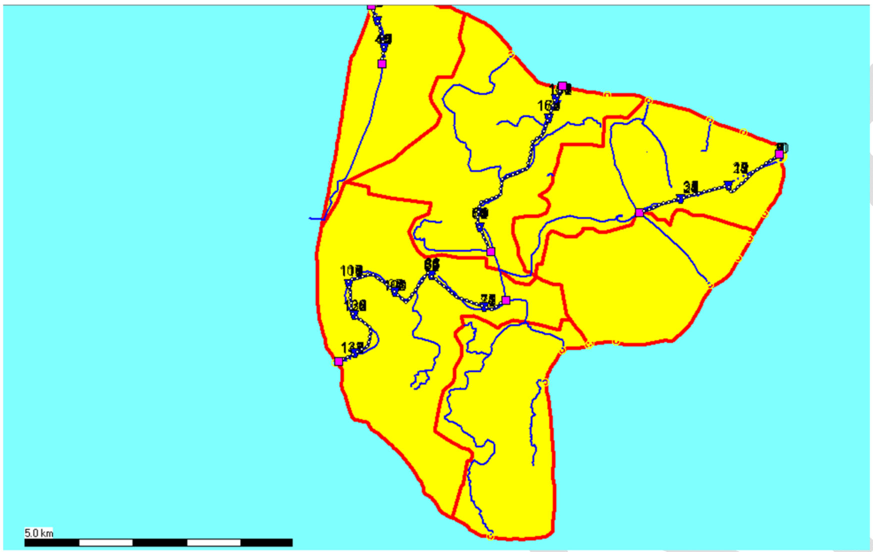


*Figure 5-12: Model domain of the drainage model developed in SOBEK for 39/1C.*

*Table 5-24 Drainage results for the drainage sluices of Polder 39/1C considering climate change (10-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Amragachia Khal | 2524002/STR0001 | 0.104 | 2V(1.6×2) | 20.2 | 2.20 | -0.17 | 1265.72 | -0.70 | 3V (1.50×1.80) | -0.90 |
| 2 | Sona Khali Khal | 2524002/STR0003 | -0.022 | 1V(2×0.6) | 10.8 | 1.70 | -0.20 | 673.20 | -0.70 | 2V (1.50×1.80) | -0.90 |
| 3 | Boro Masua Khal | structure_39-1C_14 (additional required) | -0.934 | 1V(3.8×1.2) | 9.0 | 1.70 | -0.17 | 561.67 | -0.70 | 1V (1.50×1.80) | -0.90 |
| 4 | Thotakhali Khal | 2524002/STR0006 | -3.047 | 3V(6×2.15) | 17.2 | 1.80 | -0.17 | 1082.98 | -0.70 | 3V (1.50×1.80) | -0.90 |
| 5 | South Mithakoli | 2524002/STR0004 | -1.661 | 3V(2×1.6) | 13.1 | 1.70 | -0.17 | 833.00 | -0.70 | 2V (1.50×1.80) | -0.90 |
| 6 | Ulubaria Khal | 2524002/STR0002 | 0.104 | 2V(1.6×2) | 12.1 | 1.70 | -0.17 | 756.06 | -0.70 | 2V (1.50×1.80) | -0.90 |

*Table 5-25: Drainage results for the drainage sluices of Polder 39/1C considering climate change (25-year return period).*

| SL | Name of Khal on which Sluice is Located | Sluice ID No. | Existing Sill Level (mPWD) | Existing Number of Vents and Size (in m) | Peak Discharge (m3/sec) | Corresponding Peak Water Level | | Catchment Area (Ha) | Average LFL in River (mPWD) | Proposed Number of Vent and Size (in m) | Proposed Sill Level (mPWD) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Upstream water level (corrected mPWD) | Downstream water level (corrected mPWD) | | | | |
| 1 | Amragachia Khal | 2524002/STR0001 | 0.104 | 2V(1.6×2) | 23.3 | 2.65 | 0.33 | 1265.72 | -0.70 | 3V ((1.50×1.80) | -0.90 |
| 2 | Sona Khali Khal | 2524002/STR0003 | -0.022 | 1V(2×0.6) | 12.4 | 2.15 | 0.30 | 673.20 | -0.70 | 2V(1.50×1.80) | -0.90 |
| 3 | Boro Masua Khal | structure_39-1C_14 (additional required) | -0.934 | 1V(3.8×1.2) | 10.3 | 2.15 | 0.33 | 561.67 | -0.70 | 1V(1.50×1.80) | -0.90 |
| 4 | Thotakhali Khal | 2524002/STR0006 | -3.047 | 3V(6×2.15) | 19.8 | 2.25 | 0.33 | 1082.98 | -0.70 | 3V ((1.50×1.80) | -0.90 |
| 5 | South Mithakoli | 2524002/STR0004 | -1.661 | 3V(2×1.6) | 15.1 | 2.15 | 0.33 | 833.00 | -0.70 | 2V ((1.50×1.80) | -0.90 |
| 6 | Ulubaria Khal | 2524002/STR0002 | 0.104 | 2V(1.6×2) | 13.9 | 2.15 | 0.33 | 756.06 | -0.70 | 2V (1.50×1.80) | -0.90 |

# A1 Rainfall Analysis

Different rainfall event has been analyzed from the daily rainfall data to determine the consecutive rainfall effects of BMD rainfall stations (Khepupara, Patuakhali, Satkhira, Mongla, Khulna and Barishal). The subjected polders and the area under influence of the BMD stations around the polders are shown in the map (shown in Section 9.2). The stations have been selected by analyzing the influence of each rainfall station on the selected coastal polders through the Thiessen Polygon Technique. Yearly maximum rainfall data for 36 years (1986-2021) has been calculated for determining 1-day, 2-day, 3-day, 4-day, 5-day and 10-day cumulative rainfall events.

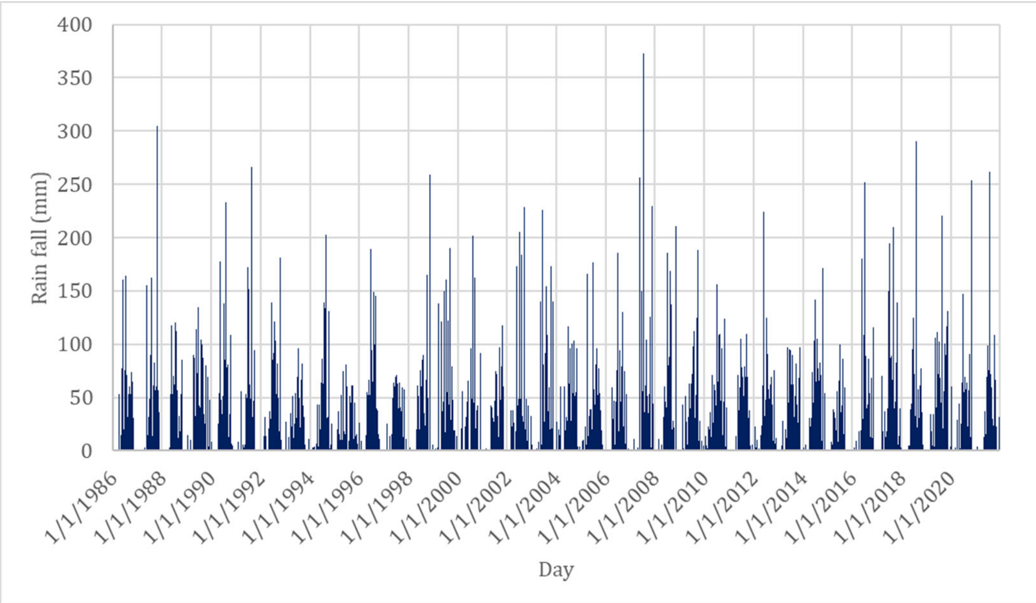
These 36 (1986-2021) years of yearly maximum rainfall data have been taken into consideration and CEGIS has used them to determine the different return period rainfall information for all rainfall events. Five statistical distribution methods have been considered for determining the rainfall for different return period. Gumbel Extreme Value (Gum EV), Log Pearson Type III (LP3) and Long Normal Distribution (LN2), Normal Distribution, General Extreme Value Distribution (GEV) statistical distribution methods have been tested to fit the raw rainfall data. Goodness of fit has been tested with Chi-Square method, Kolmogorov Smirnov and Anderson Darling method. Seven different return periods (1 in 2.33, 1 in 5, 1 in 10, 1 in 20, 1 in 25, 1 in 50 and 1 in 100 year) have been considered to estimate the design rainfall. Among them, 1 in 50-year rainfall is considered as design rainfall for designing any structure according to BWDB design manual. However, in this study, a 5-day storm with 10-year rainfall intensity has been considered for planning and designing the polder water management system for the future.

This Appendix details the rainfall analysis and shows the results of the statistical data analysis for all the rainfall stations.

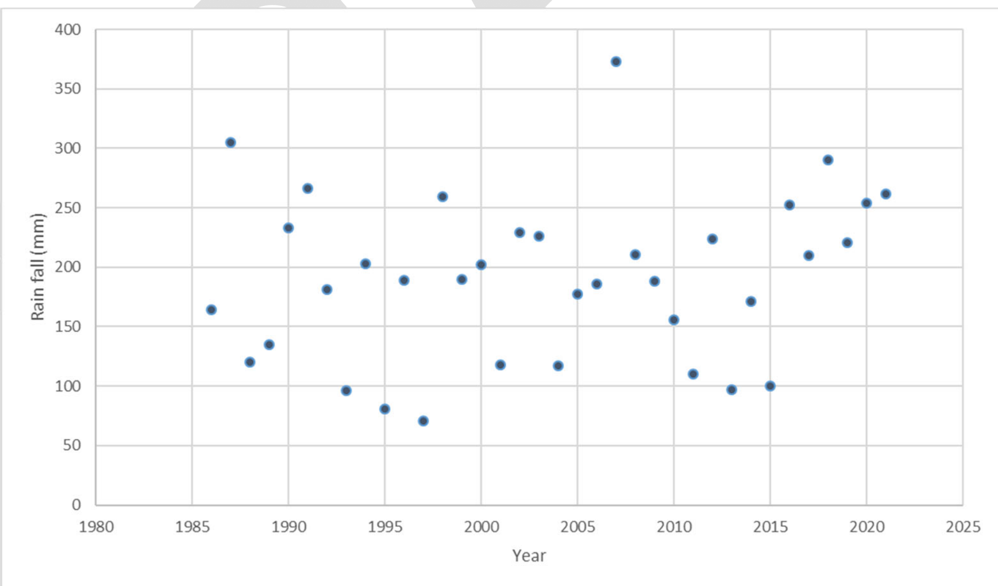
## A1.1 Khepupara (12110)

### *Analysis of Daily rainfall: Khepupara*

The daily rainfall data of Khepupara station has been collected from BWDB database. The data was checked and used for further analysis. Rainfall information of a few days was missing. At first, 36 years of rainfall data has been used for analysing the yearly maximum rainfall. Pivot Chart method has been applied for the analysis.




Daily Rainfall at Khepupara (12110)




Yearly Maximum Rainfall at Khepupara (12110)

### *Determination of design flood event (Khepupara-12110)*

The Khepupara rainfall station is influencing the study area. Therefore, design rainfall event has been calculated using the rainfall information of Khepupara. Different rainfall event has been analysed from the daily rainfall data to determine the consecutive rainfall effects in the study area. Analysis indicates that yearly maximum rainfall data for 36 years (1986-2021) has been calculated for determining 1-, 2-, 3-, 4-, 5- and 10-day cumulative rainfall events. The table below shows the yearly maximum rainfall event for the last 36 years.

Yearly maximum rainfall of Khepupara for different rainfall event

| Year | 1-day | 2-day | 3-day | 5-day | 10-day |
|---|---|---|---|---|---|
| 1986 | 164 | 182 | 239 | 321 | 423 |
| 1987 | 305 | 365 | 423 | 469 | 476 |
| 1988 | 120 | 214 | 233 | 324 | 499 |
| 1989 | 135 | 183 | 206 | 281 | 385 |
| 1990 | 233 | 236 | 239 | 292 | 382 |
| 1991 | 266 | 380 | 423 | 492 | 574 |
| 1992 | 181 | 250 | 256 | 268 | 377 |
| 1993 | 96 | 127 | 174 | 253 | 313 |
| 1994 | 203 | 309 | 329 | 344 | 523 |
| 1995 | 81 | 157 | 197 | 272 | 277 |
| 1996 | 189 | 377 | 390 | 401 | 594 |
| 1997 | 71 | 127 | 136 | 205 | 353 |
| 1998 | 259 | 309 | 391 | 462 | 567 |
| 1999 | 190 | 237 | 313 | 327 | 465 |
| 2000 | 202 | 234 | 264 | 312 | 396 |
| 2001 | 118 | 175 | 184 | 232 | 318 |
| 2002 | 229 | 303 | 353 | 470 | 541 |
| 2003 | 226 | 300 | 308 | 403 | 609 |
| 2004 | 117 | 176 | 205 | 256 | 304 |
| 2005 | 177 | 291 | 334 | 395 | 504 |
| 2006 | 186 | 237 | 265 | 296 | 447 |
| 2007 | 373 | 383 | 515 | 601 | 643 |
| 2008 | 211 | 324 | 369 | 400 | 466 |
| 2009 | 188 | 246 | 277 | 306 | 471 |
| 2010 | 156 | 255 | 368 | 500 | 629 |
| 2011 | 110 | 186 | 249 | 392 | 515 |
| 2012 | 224 | 240 | 276 | 325 | 457 |
| 2013 | 97 | 193 | 212 | 279 | 539 |
| 2014 | 171 | 209 | 256 | 280 | 312 |
| 2015 | 100 | 127 | 147 | 225 | 390 |
| 2016 | 252 | 341 | 404 | 448 | 515 |
| 2017 | 210 | 265 | 323 | 365 | 524 |
| 2018 | 290 | 386 | 458 | 646 | 741 |
| 2019 | 221 | 250 | 259 | 352 | 509 |
| 2020 | 254 | 364 | 418 | 423 | 481 |
| 2021 | 262 | 337 | 401 | 461 | 570 |

It has been observed by the Goodness-of-fit test that GEV method gives the best result for 1-day rainfall compared to other methods. It means GEV method fitted well with the yearly maximum rainfall for the daily rainfall information. However, when we consider 2-, 3- and 5-days cumulative rainfall, Log Pearson Type 3 (LP3) method gives the lower values compared to the rest of the two other methods. Different scenario has been observed during calculation of design rainfall for 10-days cumulative rainfall. It has been observed that Normal Method provides the best results. It is already determined that the polder water management system will be designed for 5-days cumulative rainfall event and 1 in 10-year return periods rainfall considered as design rainfall. To be conservative, the GEV method has been taken for ensuring the safety of the polder under the extreme flood event condition. Considering this, the water management system of the Polder-41/5, Polder-45, Polder-47/1, Polder-50-51, Polder-39/1B will be designed for 520 mm design rainfall.

Different statistical distribution methods have been tested for fitting the hydrological conditions which has been described in the earlier section. The following tables presents the suitable statistical distribution method contains the design rainfall. The design rainfall (1 in 10 year) for 1-day hydrological rainfall event has been estimated 295 mm which is the nearest rainfall 290 mm happened in 2018. Similarly, the design rainfall for 5-days cumulative rainfall has been estimated 504 mm and nearest rainfall is 500 mm already happened in 2010. It indicates that the computed design rainfall is 0.8% higher than the yearly maximum rainfall of 2010. This statistic confirms that during generation of design runoff for the design rainfall events, 1% additional rainfall should be added with the daily rainfall data of 2010 for getting the expected design runoff.

Rainfall for different return periods in Khepupara (in mm)

| | 1 Day Rain fall(mm) | | | | | 2 Day Rain Fall(mm) | | | | | 3 Day Rain Fall(mm) | | | | | 5 Day Rain fall (mm) | | | | | 10 Day Rain fall (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RP | Gumbles | LP3 | LN2 | Normal | GEV | Gumbles | LP3 | LN2 | Normal | GEV | Gumbles | LP3 | LN2 | Normal | GEV | Gumbles | LP3 | LN2 | Normal | GEV | Gumbles | LP3 | LN2 | Normal | GEV |
| **2.3** | 193 | 262 | 185 | 191 | 202 | 260 | 262 | 257 | 260 | 270 | 303 | 299 | 297 | 300 | 310 | 367 | 355 | 363 | 363 | 364 | 478 | 479 | 478 | 475 | 495 |
| **5** | 249 | 326 | 242 | 249 | 251 | 324 | 326 | 318 | 325 | 326 | 379 | 377 | 369 | 379 | 379 | 451 | 443 | 437 | 451 | 441 | 566 | 566 | 561 | 565 | 570 |
| **10** | 295 | 370 | 289 | 279 | 283 | 376 | 370 | 367 | 359 | 364 | 441 | 429 | 427 | 420 | 428 | 520 | 494 | 495 | 496 | 504 | 637 | 621 | 625 | 613 | 617 |
| **20** | 339 | 319 | 335 | 304 | 309 | 426 | 400 | 413 | 387 | 395 | 501 | 473 | 482 | 454 | 470 | 586 | 560 | 550 | 534 | 563 | 706 | 662 | 684 | 652 | 654 |
| **25** | 353 | 420 | 350 | 312 | 316 | 441 | 420 | 428 | 395 | 403 | 520 | 488 | 499 | 464 | 482 | 607 | 551 | 567 | 545 | 582 | 728 | 682 | 702 | 663 | 664 |
| **50** | 396 | 455 | 396 | 333 | 337 | 490 | 455 | 472 | 418 | 427 | 578 | 529 | 552 | 492 | 517 | 671 | 590 | 618 | 576 | 640 | 795 | 723 | 756 | 696 | 691 |
| **100** | 439 | 487 | 442 | 352 | 354 | 538 | 487 | 516 | 439 | 447 | 636 | 568 | 604 | 518 | 547 | 735 | 626 | 667 | 604 | 697 | 861 | 760 | 809 | 725 | 617 |

Goodness of Fit Test (1-day Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.09 | 0.30 | 1.21 | 2 |
| 2 | Gumbel Max | 0.13 | 1.01 | 6.05 | 6 |
| 3 | Log-Pearson 3 | 0.10 | 0.39 | 4.69 | 5 |
| 4 | Lognormal | 0.14 | 0.76 | 3.45 | 4 |
| 5 | Lognormal (3P) | 0.10 | 0.35 | 2.09 | 3 |
| 6 | Normal | 0.10 | 0.28 | 0.73 | 1 |

Goodness of Fit Test (2-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.08 | 0.34 | 2.13 | 3 |
| 2 | Gumbel Max | 0.12 | 0.88 | 3.26 | 6 |
| 3 | Log-Pearson 3 | 0.08 | 0.37 | 0.86 | 2 |
| 4 | Lognormal | 0.11 | 0.51 | 0.23 | 1 |
| 5 | Lognormal (3P) | 0.08 | 0.43 | 2.43 | 4 |
| 6 | Normal | 0.10 | 0.44 | 3.21 | 5 |

Goodness of Fit Test (3-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.09 | 0.25 | 0.33 | 1 |
| 2 | Gumbel Max | 0.11 | 0.53 | 2.51 | 5 |
| 3 | Log-Pearson 3 | 0.09 | 0.26 | 2.34 | 3 |
| 4 | Lognormal | 0.09 | 0.32 | 1.81 | 2 |
| 5 | Lognormal (3P) | 0.09 | 0.30 | 2.38 | 4 |
| 6 | Normal | 0.09 | 0.25 | 0.33 | 1 |

Goodness of Fit Test (5-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.09 | 0.21 | 1.29 | 3 |
| 2 | Gumbel Max | 0.09 | 0.24 | 1.04 | 1 |
| 3 | Log-Pearson 3 | 0.09 | 0.22 | 1.27 | 2 |
| 4 | Lognormal | 0.10 | 0.26 | 1.46 | 4 |
| 5 | Lognormal (3P) | 0.10 | 0.21 | 1.89 | 5 |
| 6 | Normal | 0.14 | 0.60 | 2.67 | 6 |

Goodness of Fit Test (10-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.08 | 0.26 | 1.21 | 4 |
| 2 | Gumbel Max | 0.14 | 1.17 | 3.25 | 6 |
| 3 | Log-Pearson 3 | 0.09 | 0.30 | 0.91 | 2 |
| 4 | Lognormal | 0.12 | 0.53 | 2.17 | 5 |
| 5 | Lognormal (3P) | 0.09 | 0.29 | 0.93 | 3 |
| 6 | Normal | 0.08 | 0.24 | 0.55 | 1 |

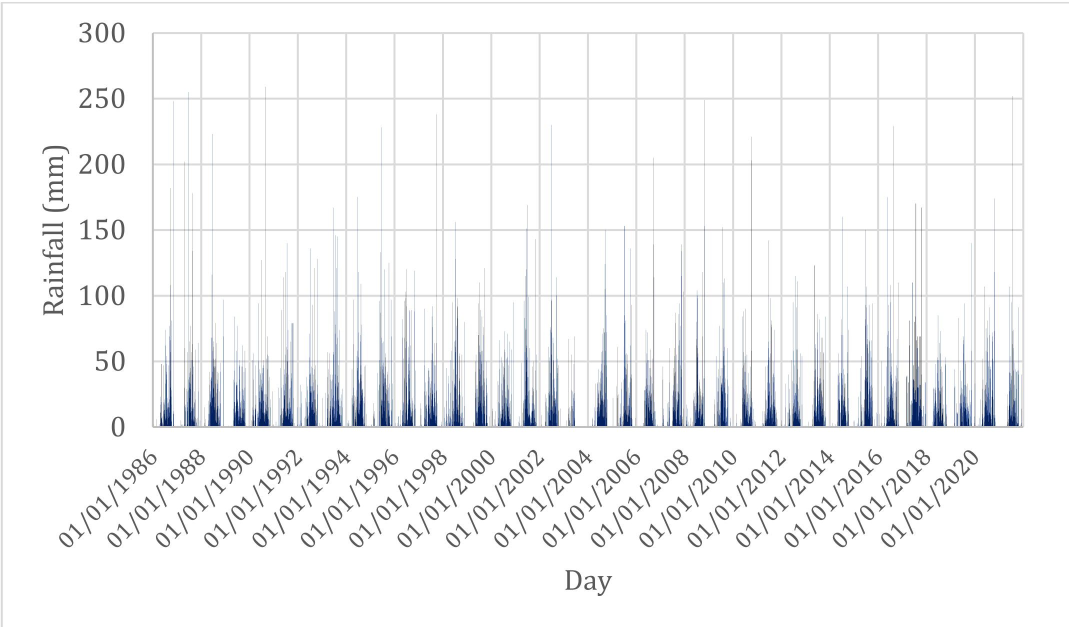
Summary of Goodness of fit test:

| Hydrological Events | 1day rain fall (mm) | 2 days cumulative rainfall | 3 days cumulative rain fall | 5 days cumulative rainfall | 10 days cumulative rainfall |
|---|---|---|---|---|---|
| Return period | GEV | LP3 | LP3 | GUM | Normal |
| 2.33 | 202 | 262 | 299 | 367 | 475 |
| 5 | 251 | 326 | 377 | 451 | 565 |
| 10 | 283 | 370 | 429 | **520** | 613 |
| 20 | 309 | 400 | 473 | 586 | 652 |
| 25 | 316 | 420 | 488 | 607 | 663 |
| 50 | 337 | 455 | 529 | 671 | 696 |
| 100 | 354 | 487 | 568 | 735 | 725 |

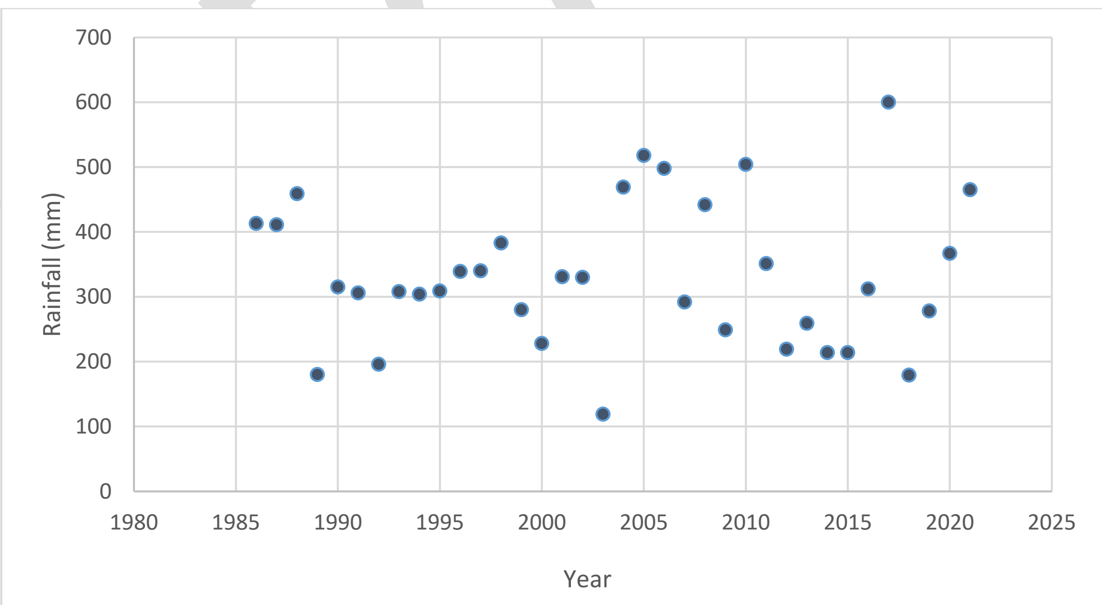
## A1.2 Potuakhali (12103)

*ANALYSIS OF DAILY RAIN FALL:*

The daily rainfall data of Patuakhali station has been collected from BWDB database. The data was checked and used for further analysis. Rainfall information of a few days was missing. At first, 36 years of rain fall data has been used for analysing the yearly maximum rainfall. Pivot Chart method has been applied for the analysis.




Daily Rainfall at Potuakhali (12103)




Yearly Maximum Rain fall at Potuakhali

### *Determination of design flood event (Potuakhali-12103)*

Design rainfall of Potuakhali station event has been calculated using the rainfall information of Potuakhali. Different rainfall event has been analysed from the daily rainfall data to determine the consecutive rainfall effects in the study area. Analysis indicates that, yearly maximum rainfall data for 36 years (1986-2021) has been calculated for determining 1-day, 2-day, 3-day, 4-day, 5-day and 10-day cumulative rainfall events. The following tables shows the yearly maximum rainfall event for the last 36 years and the rainfall for the various return periods.

Yearly maximum rainfall of Potuakhali for different rainfall event

| Year | 1-day | 2-day | 3-day | 5-day | 10-day |
|---|---|---|---|---|---|
| 1986 | 248 | 290 | 333 | 413 | 576 |
| 1987 | 255 | 312 | 375 | 411 | 510 |
| 1988 | 223 | 265 | 381 | 459 | 538 |
| 1989 | 84 | 109 | 133 | 180 | 248 |
| 1990 | 259 | 284 | 293 | 315 | 331 |
| 1991 | 140 | 190 | 204 | 306 | 380 |
| 1992 | 136 | 165 | 186 | 196 | 306 |
| 1993 | 167 | 224 | 277 | 308 | 408 |
| 1994 | 175 | 233 | 278 | 304 | 417 |
| 1995 | 228 | 245 | 262 | 309 | 566 |
| 1996 | 120 | 207 | 266 | 339 | 393 |
| 1997 | 238 | 302 | 309 | 340 | 386 |
| 1998 | 156 | 217 | 281 | 383 | 542 |
| 1999 | 121 | 164 | 175 | 280 | 423 |
| 2000 | 95 | 124 | 177 | 228 | 321 |
| 2001 | 169 | 226 | 246 | 331 | 543 |
| 2002 | 230 | 302 | 307 | 330 | 522 |
| 2003 | 69 | 95 | 100 | 119 | 179 |
| 2004 | 150 | 229 | 301 | 469 | 609 |
| 2005 | 153 | 306 | 354 | 518 | 713 |
| 2006 | 205 | 344 | 458 | 498 | 512 |
| 2007 | 139 | 249 | 287 | 292 | 470 |
| 2008 | 249 | 402 | 439 | 442 | 563 |
| 2009 | 152 | 159 | 183 | 249 | 378 |
| 2010 | 221 | 424 | 482 | 504 | 527 |
| 2011 | 142 | 166 | 235 | 351 | 501 |
| 2012 | 115 | 155 | 214 | 219 | 285 |
| 2013 | 123 | 246 | 247 | 259 | 406 |
| 2014 | 160 | 161 | 181 | 214 | 312 |
| 2015 | 160 | 161 | 181 | 214 | 312 |
| 2016 | 229 | 245 | 306 | 312 | 347 |
| 2017 | 340 | 496 | 538 | 600 | 928 |
| 2018 | 85 | 136 | 148 | 179 | 299 |
| 2019 | 140 | 198 | 226 | 278 | 348 |
| 2020 | 174 | 292 | 365 | 367 | 374 |
| 2021 | 252 | 325 | 388 | 465 | 558 |

Rainfall(mm) for different return periods in Potuakhali

| | 1 Day Rain fall(mm) | | | | | 2 Days Cumulative Rain Fall(mm) | | | | | 3 Days Cumulative Rain Fall(mm) | | | | | 5 Days Cumulative Rain fall (mm) | | | | | 10 Days Cumulative Rain fall (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RP | Gumbles | LP3 | LN2 | Normal | GEV | Gumbles | LP3 | LN2 | Normal | GEV | Gumbles | LP3 | LN2 | Normal | GEV | Gumbles | LP3 | LN2 | Normal | GEV | Gumbles | LP3 | LN2 | Normal | GEV |
| **2.3** | 177 | 159 | 174 | 186 | 180 | 243 | 166 | 212 | 256 | 243 | 284 | 246 | 237 | 299 | 286 | 336 | 289 | 331 | 353 | 342 | 450 | 379 | 450 | 471 | 452 |
| **5** | 227 | 223 | 223 | 226 | 225 | 316 | 236 | 338 | 316 | 309 | 367 | 435 | 306 | 367 | 362 | 427 | 583 | 420 | 426 | 424 | 567 | 980 | 560 | 567 | 555 |
| **10** | 267 | 271 | 263 | 253 | 257 | 376 | 275 | 440 | 355 | 360 | 435 | 602 | 363 | 411 | 419 | 500 | 869 | 493 | 475 | 484 | 663 | 1687 | 648 | 630 | 634 |
| **20** | 306 | 294 | 301 | 276 | 286 | 433 | 333 | 436 | 388 | 408 | 499 | 768 | 418 | 448 | 471 | 571 | 1138 | 563 | 515 | 536 | 755 | 2750 | 731 | 682 | 705 |
| **25** | 319 | 338 | 314 | 282 | 295 | 451 | 320 | 592 | 397 | 422 | 520 | 870 | 436 | 459 | 487 | 593 | 1365 | 585 | 527 | 551 | 784 | 3116 | 757 | 697 | 727 |
| **50** | 357 | 395 | 352 | 301 | 319 | 506 | 352 | 732 | 424 | 466 | 583 | 1131 | 491 | 490 | 534 | 662 | 1883 | 653 | 560 | 596 | 873 | 4820 | 838 | 741 | 792 |
| **100** | 394 | 457 | 389 | 317 | 342 | 562 | 381 | 890 | 449 | 507 | 646 | 1438 | 545 | 518 | 578 | 730 | 2529 | 721 | 591 | 637 | 962 | 7197 | 917 | 780 | 853 |

It has been observed by the Goodness-of-fit test that GEV method gives the best result for 1-day design rainfall compared to other methods. It means GEV method fitted well with the yearly maximum rainfall for the daily rainfall information. When we consider 2-days, 3-days and 10-days cumulative rainfall, GEV method gives the best values compared to the rest of the methods. Different scenario has been observed during calculation of design rainfall for 5-days cumulative rainfall. It has been observed that Log Normal (3P) Method provides the best results. It is already determined that the polder water management system will be designed for 5-days cumulative rainfall event and 1 in 10-year return periods rainfall considered as design rainfall. As there is lots of investment and safety involved, Log Normal (LN 2P) method has been taken for ensuring the safety of the polder under the extreme flood event condition. Considering this, the water management system of the Polder-41/7, Polder-54, Polder-55/2D will be designed for 493 mm design rainfall.

Different statistical distribution methods have been tested for fitting the hydrological conditions which has been described in the earlier section. The following tables present the suitable statistical distribution method contains the design rainfall. The design rainfall (1 in 10 year) for 1-day hydrological rainfall event has been estimated 257 mm which is the nearest rainfall 257mm happened in 2004. Similarly, the design rainfall for 5-days cumulative rainfall has been estimated 493 mm and nearest rainfall is 413 mm already happened in 2004. It indicates that the computed design rainfall is 19% higher than the yearly maximum rainfall of 2004. This statistic confirms that during generation of design runoff for the design rainfall events, 19% additional rainfall should be added with the daily rainfall data of 2004 for getting the expected design runoff.

Goodness of Fit Test (1-day Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.12 | 0.47 | 4.96 | 6 |
| 2 | Gumbel Max | 0.15 | 0.71 | 0.46 | 1 |
| 3 | Log-Pearson 3 | 0.12 | 0.46 | 4.88 | 5 |
| 4 | Lognormal | 0.13 | 0.50 | 0.53 | 2 |
| 5 | Lognormal (3P) | 0.13 | 0.55 | 4.52 | 4 |
| 6 | Normal | 0.14 | 0.63 | 3.19 | 3 |

Goodness of Fit Test (2-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.08 | 0.26 | 1.17 | 2 |
| 2 | Gumbel Max | 0.11 | 0.44 | 5.09 | 6 |
| 3 | Log-Pearson 3 | 0.09 | 0.26 | 1.78 | 4 |
| 4 | Lognormal | 0.11 | 0.36 | 0.47 | 1 |
| 5 | Lognormal (3P) | 0.09 | 0.26 | 2.15 | 5 |
| 6 | Normal | 0.11 | 0.40 | 1.70 | 3 |

Goodness of Fit Test (3-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.09 | 0.24 | 6.98 | 6 |
| 2 | Gumbel Max | 0.10 | 0.27 | 4.23 | 2 |
| 3 | Log-Pearson 3 | 0.10 | 0.25 | 4.82 | 4 |
| 4 | Lognormal | 0.10 | 0.29 | 4.40 | 3 |
| 5 | Lognormal (3P) | 0.10 | 0.23 | 6.96 | 5 |
| 6 | Normal | 0.14 | 0.52 | 0.88 | 1 |

Goodness of Fit Test (5-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.10 | 0.30 | 0.26 | 2 |
| 2 | Gumbel Max | 0.10 | 0.34 | 0.26 | 5 |
| 3 | Log-Pearson 3 | 0.10 | 0.33 | 0.26 | 3 |
| 4 | Lognormal | 0.10 | 0.33 | 0.26 | 1 |
| 5 | Lognormal (3P) | 0.09 | 0.30 | 0.26 | 4 |
| 6 | Normal | 0.14 | 0.79 | 6.08 | 6 |

Goodness of Fit Test (10-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.12 | 0.59 | 0.00 | 1 |
| 2 | Gumbel Max | 0.18 | 1.69 | 4.21 | 4 |
| 3 | Log-Pearson 3 | 0.12 | 4.52 | N/A | |
| 4 | Lognormal | 0.13 | 0.67 | 1.98 | 3 |
| 5 | Lognormal (3P) | 0.13 | 0.66 | 1.93 | 2 |
| 6 | Normal | 0.23 | 2.73 | 7.09 | 5 |

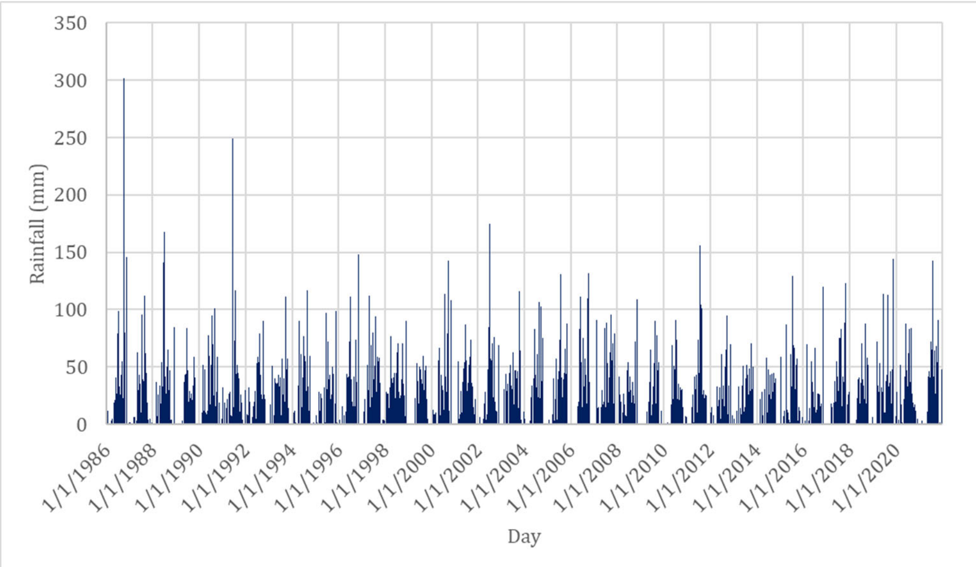
Summary of Goodness of fit test

| Hydrological Events | 1day rain fall (mm) | 2 day cumulative rainfall | 3 days cumulative rain fall | 5 days cumulative rainfllall | 10 days cumulative rainfllall |
|---|---|---|---|---|---|
| Return period | GEV | GEV | GEV | LN (3P) | GEV |
| 2.33 | 180 | 243 | 286 | 331 | 452 |
| 5 | 225 | 309 | 362 | 420 | 555 |
| 10 | 257 | 360 | 419 | 493 | 634 |
| 20 | 286 | 408 | 471 | 563 | 705 |
| 25 | 295 | 422 | 487 | 585 | 727 |
| 50 | 319 | 466 | 534 | 653 | 792 |
| 100 | 342 | 507 | 578 | 721 | 853 |

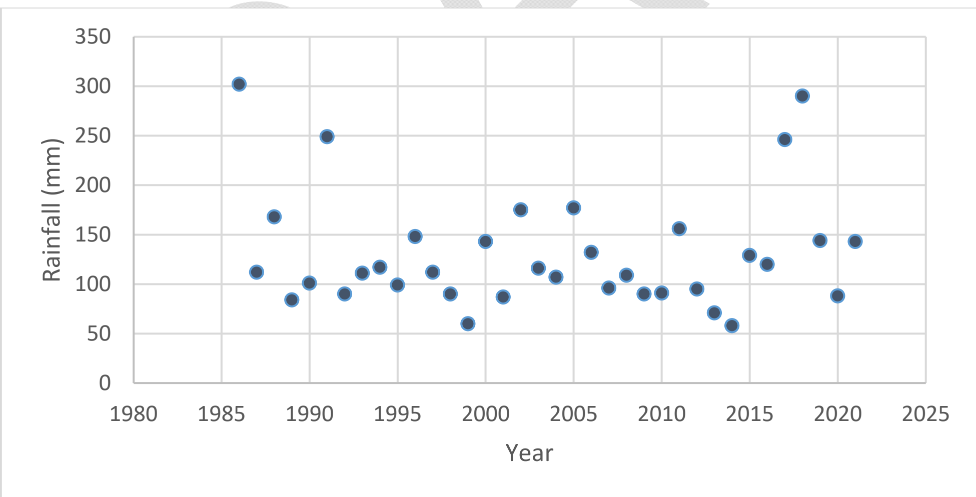
## A1.3 Satkhira (11610)

### *Analysis of Daily Rain Fall:*

The daily rainfall data of Satkhira station has been collected from BWDB database. The data was checked and used for further analysis. Rainfall information of a few days was missing. Thirty-six (36) years of rain fall data has been used for analysing the yearly maximum rainfall. Pivot Chart method has been applied for the analysis.




Daily rainfall at Satkhira




Yearly Maximum Rain fall at Satkhira

### *Determination of design flood event (Satkhira- 11610)*

Design rainfall of Satkhira station event has been calculated using the rainfall information of Satkhira. Different rainfall events have been analysed from the daily rainfall data to determine the consecutive rainfall effects in the study area. Yearly maximum rainfall data for 36 years (1986-2021) has been calculated for determining 1-day, 2-day, 3-day, 4-day, 5-day and 10-day cumulative rainfall events. The following table shows the yearly maximum rainfall event for the last 36 years.

Yearly maximum rainfall of Satkhira for different rainfall event

| Year | 1-day | 2-day | 3-day | 5-day | 10-day |
|---|---|---|---|---|---|
| 1986 | 302 | 438 | 522 | 563 | 601 |
| 1987 | 112 | 157 | 193 | 214 | 377 |
| 1988 | 168 | 297 | 303 | 342 | 419 |
| 1989 | 84 | 104 | 108 | 139 | 201 |
| 1990 | 101 | 152 | 188 | 202 | 247 |
| 1991 | 249 | 271 | 280 | 330 | 375 |
| 1992 | 90 | 135 | 150 | 175 | 188 |
| 1993 | 111 | 111 | 111 | 136 | 206 |
| 1994 | 117 | 119 | 129 | 167 | 225 |
| 1995 | 99 | 119 | 137 | 177 | 225 |
| 1996 | 148 | 279 | 279 | 279 | 279 |
| 1997 | 112 | 112 | 117 | 168 | 214 |
| 1998 | 90 | 123 | 123 | 123 | 179 |
| 1999 | 60 | 96 | 117 | 138 | 229 |
| 2000 | 143 | 270 | 305 | 321 | 397 |
| 2001 | 87 | 95 | 104 | 150 | 240 |
| 2002 | 175 | 189 | 190 | 239 | 394 |
| 2003 | 116 | 151 | 178 | 197 | 263 |
| 2004 | 107 | 147 | 174 | 239 | 390 |
| 2005 | 177 | 175 | 216 | 240 | 289 |
| 2006 | 132 | 167 | 277 | 304 | 355 |
| 2007 | 96 | 164 | 205 | 253 | 276 |
| 2008 | 109 | 132 | 145 | 165 | 184 |
| 2009 | 90 | 122 | 161 | 233 | 301 |
| 2010 | 91 | 161 | 162 | 193 | 238 |
| 2011 | 156 | 261 | 268 | 273 | 376 |
| 2012 | 95 | 160 | 177 | 189 | 215 |
| 2013 | 71 | 88 | 122 | 157 | 215 |
| 2014 | 58 | 84 | 112 | 149 | 217 |
| 2015 | 129 | 165 | 189 | 208 | 322 |
| 2016 | 120 | 138 | 150 | 154 | 195 |
| 2017 | 246 | 290 | 310 | 470 | 696 |
| 2018 | 290 | 123 | 129 | 134 | 167 |
| 2019 | 144 | 190 | 196 | 285 | 340 |
| 2020 | 88 | 116 | 163 | 188 | 270 |
| 2021 | 143 | 153 | 223 | 247 | 325 |

The following table presents the design rainfall for different return periods. It has been observed by the Goodness-of-fit test that GEV method gives the best result for 1-day and 10- days rainfall compared to other methods. It means GEV method fitted well with the maximum rainfall for the daily rainfall information. However, when we consider 2-days cumulative rainfall, Log-normal method gives the lowest values compared to the rest of the methods. Observing the 3-days and 5-days cumulative rain fall, log- pearson seems to be the best method. It is already determined that the polder water management system will be designed for 5-days cumulative rainfall event and 1 in 10-year return periods rainfall considered as design rainfall. As there is lots of investment and safety involved, Log Pearson Type 3 (LP3) method has been taken for ensuring the safety of the polder under the extreme flood event condition. Considering this, the water management system of the Polder-13-14/2, Polder-4, Polder-5, Polder-7/2, Polder-10-12 will be designed for 341 mm design rainfall.

Rainfall(mm) for different return periods in Satkhira

| | 1 Day Rain fall(mm) | | | | | 2 Days Cumulative Rain Fall(mm) | | | | | 3 Days Cumulative Rain Fall(mm) | | | | | 5 Days Cumulative Rain fall (mm) | | | | | 10 Days Cumulative Rain fall (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RP | Gumbles | LP3 | LN2 | Normal | GEV | Gumbles | LP3 | LN2 | Normal | GEV | Gumbles | LP3 | LN2 | Normal | GEV | Gumbles | LP3 | LN2 | Normal | GEV | Gumbles | LP3 | LN2 | Normal | GEV |
| **2.3** | 132 | 120 | 119 | 141 | 121 | 170 | 155 | 155 | 182 | 156 | 194 | 177 | 189 | 207 | 182 | 229 | 211 | 223 | 243 | 214 | 299 | 278 | 293 | 316 | 281 |
| **5** | 180 | 166 | 170 | 180 | 161 | 232 | 213 | 219 | 232 | 207 | 263 | 248 | 245 | 263 | 238 | 305 | 290 | 284 | 305 | 277 | 392 | 375 | 368 | 391 | 359 |
| **10** | 220 | 207 | 205 | 206 | 200 | 282 | 264 | 261 | 265 | 256 | 318 | 296 | 292 | 300 | 292 | 367 | 341 | 334 | 346 | 338 | 467 | 437 | 430 | 442 | 433 |
| **20** | 257 | 245 | 235 | 228 | 245 | 330 | 315 | 301 | 293 | 313 | 372 | 353 | 337 | 330 | 352 | 427 | 406 | 383 | 380 | 406 | 540 | 515 | 489 | 483 | 515 |
| **25** | 269 | 268 | 251 | 234 | 261 | 345 | 340 | 315 | 301 | 333 | 389 | 382 | 351 | 339 | 372 | 446 | 404 | 398 | 390 | 431 | 563 | 513 | 507 | 495 | 543 |
| **50** | 306 | 321 | 286 | 252 | 316 | 392 | 405 | 354 | 324 | 403 | 441 | 453 | 396 | 364 | 442 | 504 | 450 | 446 | 419 | 513 | 634 | 567 | 565 | 530 | 639 |
| **100** | 342 | 380 | 320 | 268 | 381 | 439 | 478 | 391 | 344 | 485 | 493 | 532 | 441 | 387 | 521 | 562 | 492 | 493 | 444 | 607 | 705 | 616 | 621 | 561 | 749 |

The following tables present the suitable statistical distribution method results. The design rainfall (1 in 10 year) for 1-day hydrological rainfall event has been estimated 200 mm which is the nearest rainfall 177 mm happened in 2005. Similarly, the design rainfall for 5-days cumulative rainfall has been estimated 341 mm and nearest rainfall is 321mm already happened in 2000. It indicates that the computed design rainfall is 6.23% higher than the yearly maximum rainfall of 2000. This statistic confirms that during generation of design runoff for the design rainfall events, 6.23% additional rainfall should be added with the daily rainfall data of 2000 for getting the expected design runoff.

Goodness of Fit Test (1-day Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.09 | 0.33 | 0.49 | 3 |
| 2 | Gumbel Max | 0.13 | 0.86 | 1.74 | 4 |
| 3 | Log-Pearson 3 | 0.10 | 0.37 | 0.41 | 2 |
| 4 | Lognormal | 0.12 | 0.64 | 2.10 | 5 |
| 5 | Lognormal (3P) | 0.10 | 0.40 | 0.24 | 1 |
| 6 | Normal | 0.18 | 2.12 | 5.70 | 6 |

Goodness of Fit Test (2-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.10 | 0.33 | 1.85 | 3 |
| 2 | Gumbel Max | 0.16 | 0.99 | 4.81 | 5 |
| 3 | Log-Pearson 3 | 0.10 | 0.35 | 2.55 | 4 |
| 4 | Lognormal | 0.15 | 0.80 | 1.57 | 1 |
| 5 | Lognormal (3P) | 0.09 | 0.33 | 1.59 | 2 |
| 6 | Normal | 0.23 | 2.16 | 4.95 | 6 |

Goodness of Fit Test (3-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.09 | 0.31 | 1.99 | 4 |
| 2 | Gumbel Max | 0.12 | 0.64 | 0.89 | 2 |
| 3 | Log-Pearson 3 | 0.08 | 0.29 | 3.55 | 6 |
| 4 | Lognormal | 0.09 | 0.52 | 0.67 | 1 |
| 5 | Lognormal (3P) | 0.09 | 0.35 | 1.25 | 3 |
| 6 | Normal | 0.18 | 1.52 | 3.49 | 5 |

Goodness of Fit Test (5-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.08 | 0.16 | 0.25 | 1 |
| 2 | Gumbel Max | 0.11 | 0.57 | 0.94 | 5 |
| 3 | Log-Pearson 3 | 0.07 | 0.15 | 0.32 | 3 |
| 4 | Lognormal | 0.08 | 0.42 | 0.45 | 4 |
| 5 | Lognormal (3P) | 0.08 | 0.15 | 0.26 | 2 |
| 6 | Normal | 0.14 | 1.54 | 3.24 | 6 |

Goodness of Fit Test (10-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.08 | 0.31 | 0.91 | 1 |
| 2 | Gumbel Max | 0.10 | 0.65 | 5.00 | 6 |
| 3 | Log-Pearson 3 | 0.08 | 0.28 | 1.10 | 2 |
| 4 | Lognormal | 0.12 | 0.61 | 3.06 | 5 |
| 5 | Lognormal (3P) | 0.08 | 0.24 | 1.46 | 3 |
| 6 | Normal | 0.14 | 1.55 | 1.84 | 4 |

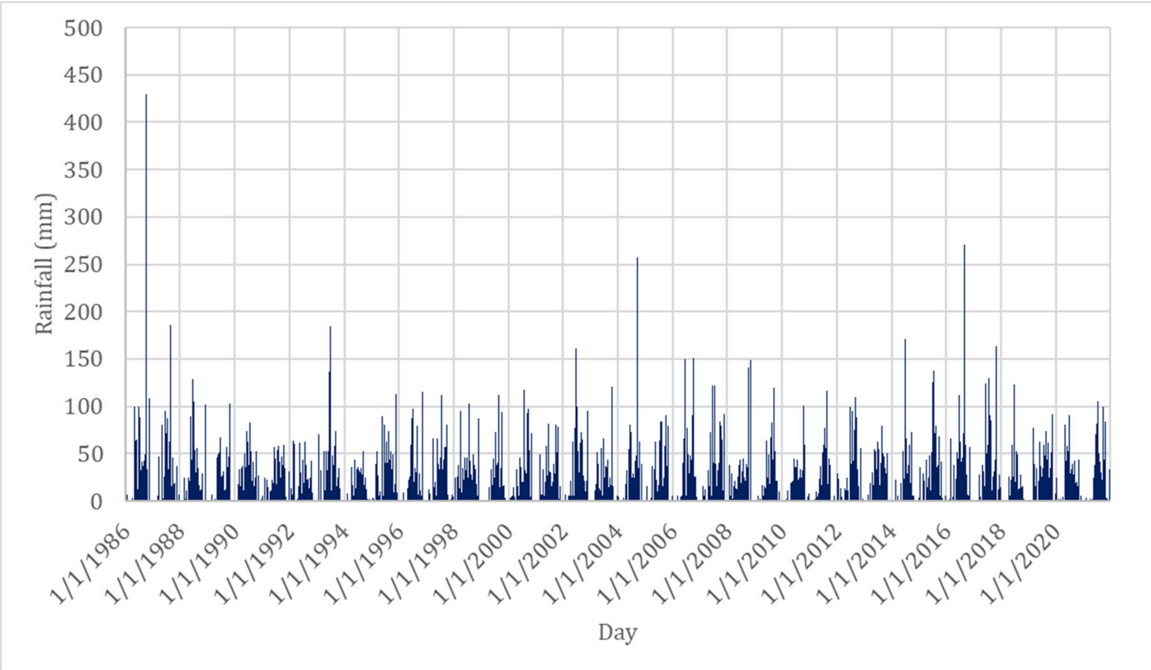
Summary of Goodness of fit test

| Hydrological Events | 1day rain fall (mm) | 2 day cumulative rainfall | 3 days cumulative rain fall | 5 days cumulative rainflall | 10 days cumulative rainflall |
|---|---|---|---|---|---|
| Return period | GEV | Log-Normal | Log-Pearson | Log-Pearson | GEV |
| 2.33 | 121 | 155 | 177 | 211 | 281 |
| 5 | 161 | 219 | 248 | 290 | 359 |
| 10 | 200 | 261 | 296 | 341 | 433 |
| 20 | 245 | 301 | 353 | 406 | 515 |
| 25 | 261 | 315 | 382 | 404 | 543 |
| 50 | 316 | 354 | 453 | 450 | 639 |
| 100 | 381 | 391 | 532 | 492 | 749 |

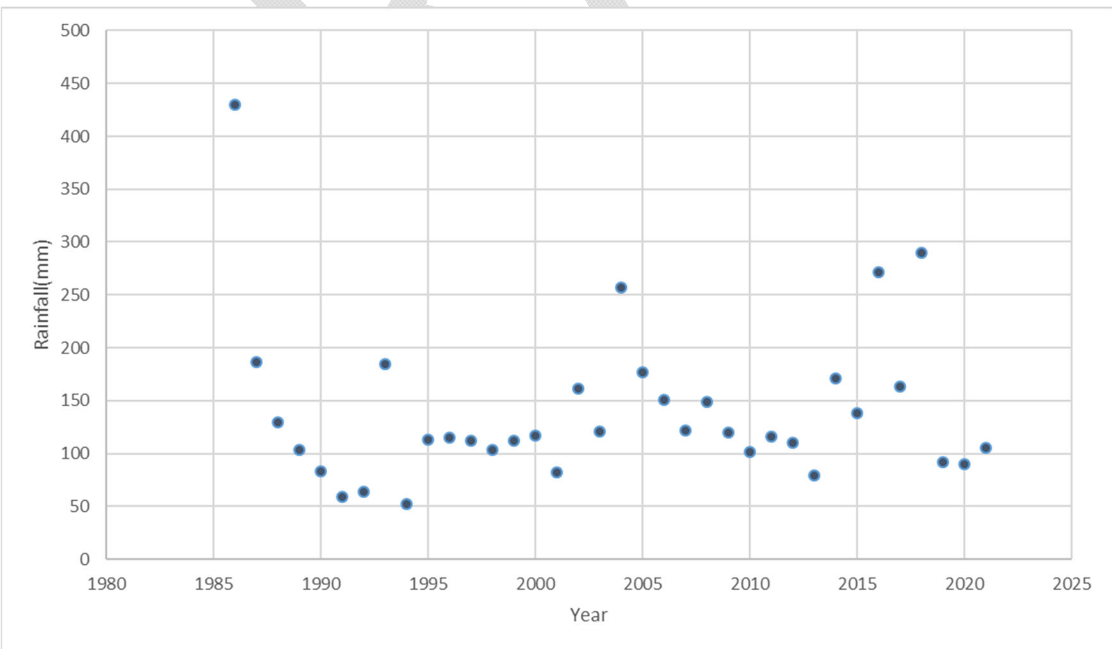
## A1.4 Khulna (11604)

### *Analysis OF Daily Rain Fall:*

The daily rainfall data of Khulna station has been collected from BWDB database. The data was checked and used for further analysis. Rainfall information of a few days was missing. Thirty-six (36) years of rainfall data has been used for analysing the yearly maximum rainfall. Pivot Chart method has been applied for the analysis.




Daily Rainfall of Khulna




Yearly max Rain fall at Khulna

## Determination of design flood event (Khulna-11604)

Design rainfall of Khulna station event has been calculated using the rainfall information of Khulna. Different rainfall event has been analysed from the daily rainfall data to determine the consecutive rainfall effects in the study area. Analysis indicates that, yearly maximum rainfall data for 36 years (1986-2021) has been calculated for determining 1-day, 2-day, 3-day, 4-day, 5-day and 10-day cumulative rainfall events. The table below shows the yearly maximum rainfall event for the last 36 years.

Yearly maximum rainfall of Khulna for different rainfall event

| Year | 1-day | 2-day | 3-day | 5-day | 10-day |
|---|---|---|---|---|---|
| 1986 | 430 | 536 | 607 | 657 | 680 |
| 1987 | 186 | 229 | 266 | 292 | 384 |
| 1988 | 129 | 202 | 243 | 283 | 395 |
| 1989 | 103 | 133 | 133 | 135 | 227 |
| 1990 | 83 | 93 | 103 | 153 | 205 |
| 1991 | 59 | 108 | 137 | 161 | 244 |
| 1992 | 64 | 80 | 83 | 108 | 135 |
| 1993 | 185 | 245 | 246 | 258 | 473 |
| 1994 | 52 | 72 | 80 | 103 | 126 |
| 1995 | 113 | 135 | 178 | 228 | 340 |
| 1996 | 115 | 215 | 220 | 230 | 301 |
| 1997 | 112 | 152 | 189 | 204 | 279 |
| 1998 | 103 | 176 | 179 | 209 | 251 |
| 1999 | 112 | 144 | 206 | 221 | 254 |
| 2000 | 117 | 212 | 222 | 295 | 338 |
| 2001 | 82 | 106 | 121 | 161 | 195 |
| 2002 | 161 | 311 | 350 | 402 | 504 |
| 2003 | 121 | 178 | 201 | 220 | 276 |
| 2004 | 257 | 296 | 324 | 413 | 533 |
| 2005 | 177 | 123 | 149 | 225 | 269 |
| 2006 | 151 | 206 | 297 | 335 | 391 |
| 2007 | 122 | 163 | 186 | 256 | 361 |
| 2008 | 149 | 207 | 255 | 279 | 294 |
| 2009 | 120 | 157 | 194 | 236 | 324 |
| 2010 | 101 | 152 | 177 | 186 | 217 |
| 2011 | 116 | 150 | 206 | 281 | 468 |
| 2012 | 110 | 198 | 242 | 259 | 282 |
| 2013 | 79 | 135 | 152 | 200 | 261 |
| 2014 | 171 | 193 | 231 | 284 | 350 |
| 2015 | 138 | 164 | 261 | 293 | 423 |
| 2016 | 271 | 285 | 285 | 313 | 377 |
| 2017 | 163 | 196 | 215 | 343 | 442 |
| 2018 | 290 | 147 | 173 | 187 | 193 |
| 2019 | 92 | 155 | 175 | 228 | 269 |
| 2020 | 90 | 105 | 122 | 165 | 231 |
| 2021 | 105 | 125 | 154 | 230 | 353 |

The following table presents the design rainfall for different return periods.

Table 303: Rainfall(mm) for different return periods in Khulna

| | 1 Day Rain fall(mm) | | | | | 2 Days Cumulative Rain Fall(mm) | | | | | 3 Days Cumulative Rain Fall(mm) | | | | | 5 Days Cumulative Rain fall (mm) | | | | | 10 Days Cumulative Rain fall (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RP | Gumbles | LP3 | LN3 | Normal | GEV | Gumbles | LP3 | LN3 | Normal | GEV | Gumbles | LP3 | LN3 | Normal | GEV | Gumbles | LP3 | LN3 | Normal | GEV | Gumbles | LP3 | LN3 | Normal | GEV |
| **2.3** | 142 | 189 | 129 | 153 | 127 | 182 | 165 | 182 | 195 | 172 | 213 | 198 | 213 | 227 | 203 | 254 | 239 | 254 | 269 | 245 | 327 | 316 | 327 | 344 | 322 |
| **5** | 202 | 255 | 188 | 202 | 174 | 250 | 235 | 238 | 250 | 226 | 289 | 275 | 279 | 288 | 265 | 335 | 323 | 326 | 335 | 314 | 422 | 419 | 419 | 422 | 410 |
| **10** | 251 | 290 | 230 | 235 | 221 | 306 | 281 | 285 | 287 | 277 | 350 | 323 | 334 | 329 | 319 | 402 | 375 | 385 | 379 | 371 | 499 | 475 | 495 | 473 | 478 |
| **20** | 298 | 278 | 272 | 261 | 276 | 359 | 333 | 331 | 318 | 331 | 410 | 375 | 388 | 363 | 372 | 466 | 431 | 442 | 416 | 428 | 573 | 537 | 569 | 515 | 541 |
| **25** | 313 | 325 | 286 | 269 | 296 | 376 | 341 | 345 | 326 | 349 | 428 | 380 | 405 | 373 | 390 | 486 | 435 | 461 | 426 | 446 | 597 | 534 | 592 | 527 | 560 |
| **50** | 359 | 346 | 329 | 292 | 365 | 428 | 386 | 391 | 352 | 410 | 486 | 420 | 459 | 401 | 446 | 548 | 477 | 517 | 457 | 503 | 669 | 572 | 665 | 563 | 618 |
| **100** | 405 | 364 | 372 | 312 | 448 | 480 | 430 | 437 | 375 | 478 | 544 | 457 | 513 | 427 | 505 | 610 | 517 | 574 | 484 | 561 | 741 | 606 | 737 | 595 | 673 |

Different scenario has been observed during calculation of design rainfall for 1-day and 2-days cumulative rainfall. GEV Method provides the best results. It has been observed by the Goodness-of-fit test that log-normal method gives better result for 3-Days, 5-days and 10-days design rainfall compared to other methods. It is already determined that the polder water management system will be designed for 5-days cumulative rainfall event and 1 in 10-year return periods rainfall considered as design rainfall. As there is lots of investment and safety involved, Log Normal (LN3) method has been taken for ensuring the safety of the polder under the extreme flood event condition. Considering this, the water management system of the Polder-10-12 will be designed for 385 mm design rainfall.

Different statistical distribution methods have been tested for fitting the hydrological conditions which has been described in the earlier section. The tables below present the suitable statistical distribution method contains the design rainfall. The design rainfall (1 in 10 year) for 1-day hydrological rainfall event has been estimated 221 mm which is the nearest rainfall 186 mm happened in 1987. Similarly, the design rainfall for 5-days cumulative rainfall has been estimated 385 mm and nearest rainfall is 343 mm already happened in 2017. It indicates that the computed design rainfall is 12% higher than the yearly maximum rainfall of 2017. This statistic confirms that during generation of design runoff for the design rainfall events, 12% additional rainfall should be added with the daily rainfall data of 2017 for getting the expected design runoff.

Goodness of Fit Test (1-day Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.11 | 0.41 | 0.28 | 1 |
| 2 | Gumbel Max | 0.14 | 1.09 | 7.07 | 5 |
| 3 | Log-Pearson 3 | 0.11 | 0.42 | 1.30 | 2 |
| 4 | Lognormal | 0.14 | 0.55 | 3.75 | 4 |
| 5 | Lognormal (3P) | 0.11 | 0.44 | 2.35 | 3 |
| 6 | Normal | 0.21 | 2.27 | 17.20 | 6 |

Goodness of Fit Test (2-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.08 | 0.26 | 0.67 | 2 |
| 2 | Gumbel Max | 0.11 | 0.61 | 2.55 | 5 |
| 3 | Log-Pearson 3 | 0.08 | 0.29 | 0.66 | 1 |
| 4 | Lognormal | 0.09 | 0.26 | 2.01 | 4 |
| 5 | Lognormal (3P) | 0.08 | 0.26 | 1.06 | 3 |
| 6 | Normal | 0.17 | 1.51 | 8.47 | 6 |

Goodness of Fit Test (3-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.11 | 0.30 | 0.65 | 4 |
| 2 | Gumbel Max | 0.11 | 0.47 | 1.84 | 5 |
| 3 | Log-Pearson 3 | 0.11 | 0.35 | 0.27 | 1 |
| 4 | Lognormal | 0.11 | 0.31 | 0.38 | 2 |
| 5 | Lognormal (3P) | 0.11 | 0.31 | 0.38 | 3 |
| 6 | Normal | 0.14 | 1.16 | 3.64 | 6 |

Goodness of Fit Test (5-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.10 | 0.37 | 0.27 | 4 |
| 2 | Gumbel Max | 0.11 | 0.47 | 0.31 | 5 |
| 3 | Log-Pearson 3 | 0.10 | 0.41 | 0.26 | 3 |
| 4 | Lognormal | 0.10 | 0.37 | 0.24 | 2 |
| 5 | Lognormal (3P) | 0.10 | 0.37 | 0.24 | 1 |
| 6 | Normal | 0.16 | 1.10 | 6.43 | 6 |

Goodness of Fit Test (10-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.06 | 0.14 | 0.38 | 3 |
| 2 | Gumbel Max | 0.06 | 0.16 | 0.56 | 4 |
| 3 | Log-Pearson 3 | 0.07 | 0.15 | 0.37 | 2 |
| 4 | Lognormal | 0.06 | 0.17 | 1.04 | 5 |
| 5 | Lognormal (3P) | 0.07 | 0.14 | 0.37 | 1 |
| 6 | Normal | 0.11 | 0.44 | 3.93 | 6 |

Summary of Goodness of Fit Test

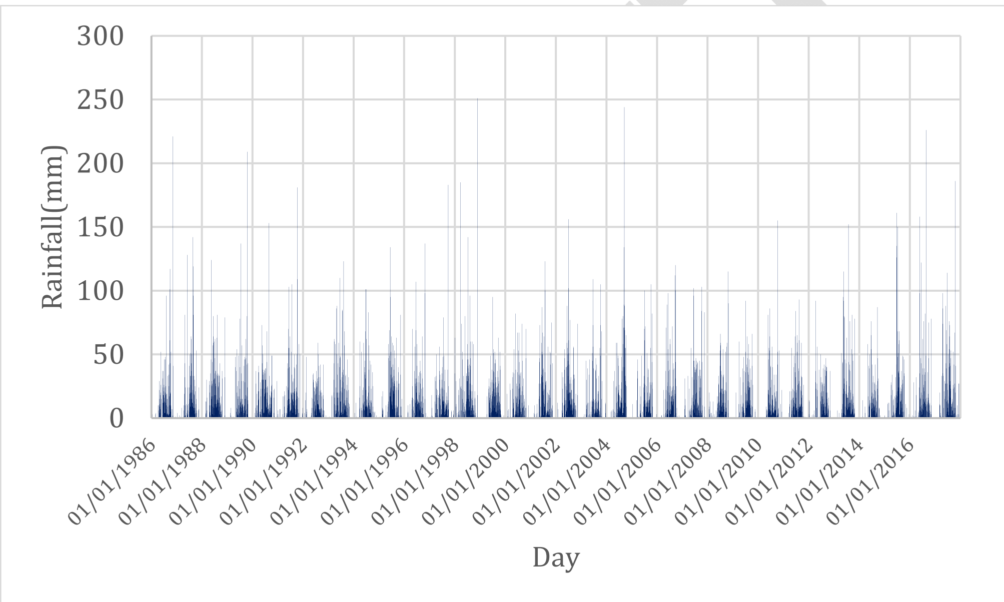
| Hydrological Events | 1day rain fall (mm) | 2 day cumulative rainfall | 3 days cumulative rain fall | 5 days cumulative rainfall | 10 days cumulative rainfall |
|---|---|---|---|---|---|
| Return period | GEV | GEV | LN(3P) | LN(3P) | LN(3P) |
| 2.33 | 127 | 172 | 213 | 254 | 327 |
| 5 | 174 | 226 | 279 | 326 | 419 |
| 10 | 221 | 277 | 334 | 385 | 495 |

| Hydrological Events | 1day rain fall (mm) | 2 day cumulative rainfall | 3 days cumulative rain fall | 5 days cumulative rainfall | 10 days cumulative rainfall |
|---|---|---|---|---|---|
| 20 | 276 | 331 | 388 | 442 | 569 |
| 25 | 296 | 349 | 405 | 461 | 592 |
| 50 | 365 | 410 | 459 | 517 | 665 |
| 100 | 448 | 478 | 513 | 574 | 737 |

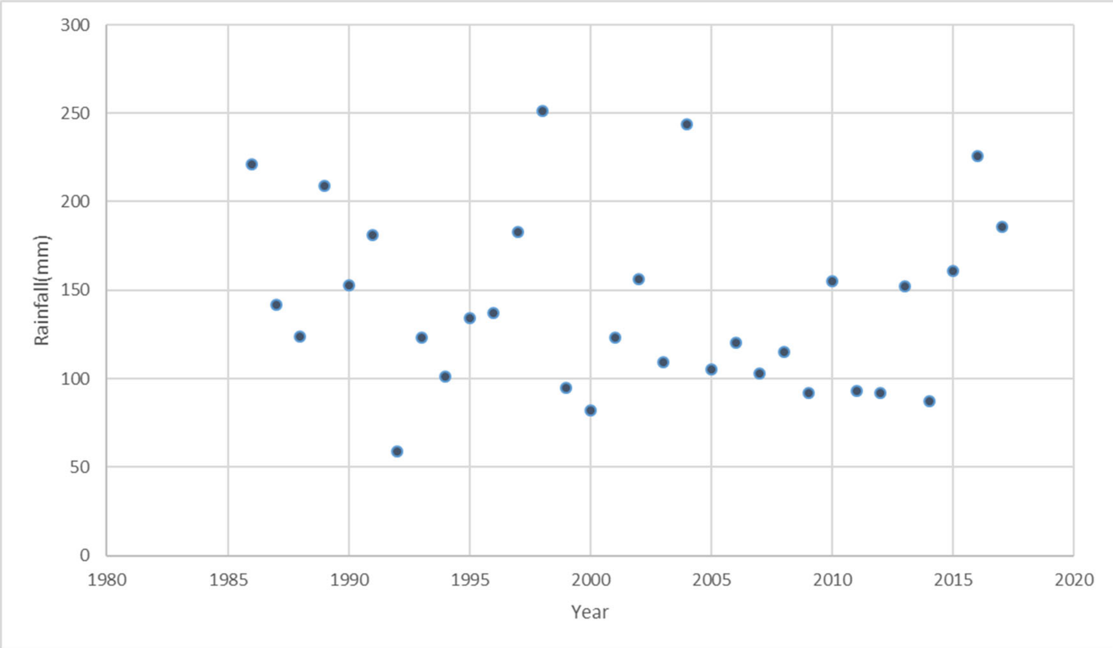
## A1.5 Barisal (11704)

### *Analysis OF Daily Rain Fall:*

The daily rainfall data of Barishal station has been collected from BWDB database. The data was checked and used for further analysis. Rainfall information of a few days was missing. Thirty-six (36) years of rain fall data has been used for analysing the yearly maximum rainfall. Pivot Chart method has been applied for the analysis.




Daily Rainfall at Borishal




Yearly Max rainfall at Borisal

## *Determination of design flood event (Barisal-11704)*

Design rainfall of Barisal station event has been calculated using the rainfall information of Barisal. Different rainfall event has been analysed from the daily rainfall data to determine the consecutive rainfall effects in the study area. Analysis indicates that, yearly maximum rainfall data for 32 years (1986-2017) has been calculated for determining 1-day, 2-day, 3-day, 4-day, 5-day and 10-day cumulative rainfall events. The table below shows the yearly maximum rainfall event for the last 36 years.

Yearly maximum rainfall of Barisal for different rainfall event

| Year | 1-day | 2-day | 3-day | 5-day | 10-day |
|---|---|---|---|---|---|
| 1986 | 221 | 262 | 264 | 306 | 389 |
| 1987 | 142 | 238 | 357 | 390 | 486 |
| 1988 | 124 | 170 | 181 | 278 | 349 |
| 1989 | 209 | 233 | 236 | 236 | 372 |
| 1990 | 153 | 153 | 153 | 164 | 233 |
| 1991 | 181 | 290 | 297 | 300 | 348 |
| 1992 | 59 | 65 | 84 | 110 | 181 |
| 1993 | 123 | 169 | 224 | 250 | 338 |
| 1994 | 101 | 202 | 224 | 230 | 305 |
| 1995 | 134 | 151 | 162 | 192 | 351 |
| 1996 | 137 | 235 | 250 | 251 | 298 |
| 1997 | 183 | 197 | 209 | 240 | 288 |
| 1998 | 251 | 269 | 270 | 299 | 360 |
| 1999 | 95 | 107 | 131 | 162 | 234 |
| 2000 | 82 | 117 | 145 | 166 | 222 |
| 2001 | 123 | 223 | 225 | 272 | 377 |
| 2002 | 156 | 258 | 308 | 362 | 512 |
| 2003 | 109 | 182 | 238 | 288 | 366 |
| 2004 | 244 | 332 | 369 | 575 | 752 |
| 2005 | 105 | 131 | 186 | 256 | 338 |
| 2006 | 120 | 220 | 332 | 382 | 443 |
| 2007 | 103 | 187 | 191 | 249 | 290 |

| Year | 1-day | 2-day | 3-day | 5-day | 10-day |
|---|---|---|---|---|---|
| 2008 | 115 | 205 | 209 | 224 | 332 |
| 2009 | 92 | 144 | 180 | 216 | 280 |
| 2010 | 155 | 207 | 249 | 251 | 255 |
| 2011 | 93 | 154 | 183 | 215 | 331 |
| 2012 | 92 | 129 | 130 | 158 | 211 |
| 2013 | 152 | 210 | 217 | 229 | 415 |
| 2014 | 87 | 124 | 189 | 252 | 286 |
| 2015 | 161 | 296 | 422 | 499 | 563 |
| 2016 | 226 | 275 | 286 | 313 | 388 |
| 2017 | 186 | 227 | 247 | 297 | 380 |

The following table presents the design rainfall for different return periods.

Rainfall(mm) for different return periods in Borishal

| | 1 Day Rain fall(mm) | | | | | 2 Days Cumulative Rain Fall(mm) | | | | | 3 Days Cumulative Rain Fall(mm) | | | | | 5 Days Cumulative Rain fall (mm) | | | | | 10 Days Cumulative Rain fall (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RP | Gum bles | LP3 | LN3 | Nor mal | GEV | Gum bles | LP3 | LN3 | Nor mal | GEV | Gumbl es | LP3 | LN3 | Nor mal | GEV | Gum bles | LP3 | LN3 | Nor mal | GEV | Gum bles | LP3 | LN3 | Nor mal | GEV |
| **2.3** | 143 | 136 | 141 | 150 | 141 | 201 | 203 | 200 | 210 | 210 | 232 | 228 | 231 | 243 | 234 | 273 | 260 | 270 | 286 | 265 | 356 | 339 | 327 | 344 | 349 |
| **5** | 184 | 180 | 178 | 183 | 178 | 252 | 255 | 253 | 251 | 254 | 294 | 292 | 289 | 292 | 289 | 351 | 341 | 337 | 349 | 332 | 449 | 436 | 420 | 422 | 427 |
| **10** | 218 | 206 | 208 | 205 | 209 | 294 | 292 | 295 | 278 | 282 | 344 | 333 | 336 | 325 | 331 | 415 | 387 | 391 | 391 | 389 | 525 | 488 | 496 | 473 | 494 |
| **20** | 250 | 237 | 237 | 223 | 239 | 334 | 302 | 336 | 301 | 304 | 392 | 361 | 381 | 352 | 369 | 476 | 444 | 442 | 426 | 447 | 598 | 562 | 569 | 515 | 560 |
| **25** | 260 | 236 | 246 | 228 | 249 | 347 | 334 | 349 | 307 | 311 | 408 | 379 | 395 | 360 | 380 | 496 | 440 | 458 | 436 | 465 | 621 | 545 | 593 | 527 | 581 |
| **50** | 292 | 256 | 274 | 244 | 279 | 386 | 362 | 389 | 326 | 328 | 455 | 410 | 438 | 383 | 414 | 556 | 475 | 508 | 464 | 525 | 692 | 584 | 665 | 563 | 649 |
| **100** | 323 | 274 | 302 | 257 | 309 | 425 | 388 | 428 | 343 | 341 | 501 | 438 | 481 | 403 | 447 | 615 | 508 | 556 | 490 | 588 | 762 | 619 | 737 | 595 | 718 |

It has been observed by the Goodness-of-fit test that GEV method gives the best result for 1-day rainfall compared to other methods. It means GEV method fitted well with the 1-day rainfall information. However, when we consider 3-days, 5-days and 10 days' cumulative rainfall, Log-normal method gives the lower values compared to the rest of the methods and Log-Pearson gives the best result for 2-days cumulative rainfall. It is already determined that the polder water management system will be designed for 5-days cumulative rainfall event and 1 in 10-year return periods rainfall considered as design rainfall. As there is lots of investment and safety involved, Log-normal (LN2)) method has been taken for ensuring the safety of the polder under the extreme flood event condition.

Different statistical distribution methods have been tested for fitting the hydrological conditions which has been described in the earlier section. The tables below present the suitable statistical distribution method contains the design rainfall. The rainfall (1 in 10 year) for 1-day hydrological rainfall event has been estimated 209 mm which is as same as the 209mm rainfall in 1989. Similarly, the design rainfall for 5-days cumulative rainfall has been estimated 391 mm and nearest rainfall is 390 mm which is closest to the maximum of 5-day cumulative rainfall in 1987. It indicates that the computed design rainfall is 0.25% higher than the yearly maximum rainfall of 1987. This statistic confirms that during generation of design runoff for the design rainfall events, 0.25% additional rainfall should be added with the daily rainfall data of 1987 for getting the expected design runoff.

Goodness of Fit Test (1-day Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.07 | 0.21 | 0.96 | 1 |
| 2 | Gumbel Max | 0.08 | 0.25 | 1.64 | 4 |
| 3 | Log-Pearson 3 | 0.08 | 0.22 | 1.04 | 2 |
| 4 | Lognormal | 0.08 | 0.24 | 1.64 | 5 |
| 5 | Lognormal (3P) | 0.08 | 0.23 | 1.63 | 3 |
| 6 | Normal | 0.13 | 0.68 | 2.50 | 6 |

Goodness of Fit Test (2-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.07 | 0.11 | 0.35 | 2 |
| 2 | Gumbel Max | 0.12 | 0.65 | 1.56 | 6 |
| 3 | Log-Pearson 3 | 0.06 | 0.11 | 0.39 | 3 |
| 4 | Lognormal | 0.11 | 0.40 | 1.49 | 5 |
| 5 | Lognormal (3P) | 0.08 | 0.14 | 0.98 | 4 |
| 6 | Normal | 0.08 | 0.13 | 0.33 | 1 |

Goodness of Fit Test (3-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.09 | 0.14 | 0.74 | 4 |
| 2 | Gumbel Max | 0.08 | 0.21 | 0.45 | 2 |
| 3 | Log-Pearson 3 | 0.09 | 0.17 | 0.97 | 5 |
| 4 | Lognormal | 0.10 | 0.19 | 0.06 | 1 |
| 5 | Lognormal (3P) | 0.08 | 0.14 | 0.99 | 6 |
| 6 | Normal | 0.11 | 0.33 | 0.49 | 3 |

Goodness of Fit Test (5-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.12 | 0.48 | 0.99 | 5 |
| 2 | Gumbel Max | 0.12 | 0.49 | 0.91 | 4 |
| 3 | Log-Pearson 3 | 0.12 | 0.49 | 0.89 | 3 |
| 4 | Lognormal | 0.12 | 0.48 | 0.88 | 1 |
| 5 | Lognormal (3P) | 0.11 | 0.48 | 0.88 | 2 |
| 6 | Normal | 0.17 | 1.10 | 6.15 | 6 |

Goodness of Fit Test (10-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.12 | 0.35 | 3.94 | 5 |
| 2 | Gumbel Max | 0.12 | 0.38 | 2.00 | 1 |
| 3 | Log-Pearson 3 | 0.12 | 0.37 | 3.94 | 4 |
| 4 | Lognormal | 0.12 | 0.34 | 2.11 | 2 |
| 5 | Lognormal (3P) | 0.11 | 0.35 | 3.56 | 3 |
| 6 | Normal | 0.18 | 0.94 | 3.97 | 6 |

Summary of Goodness of fit test

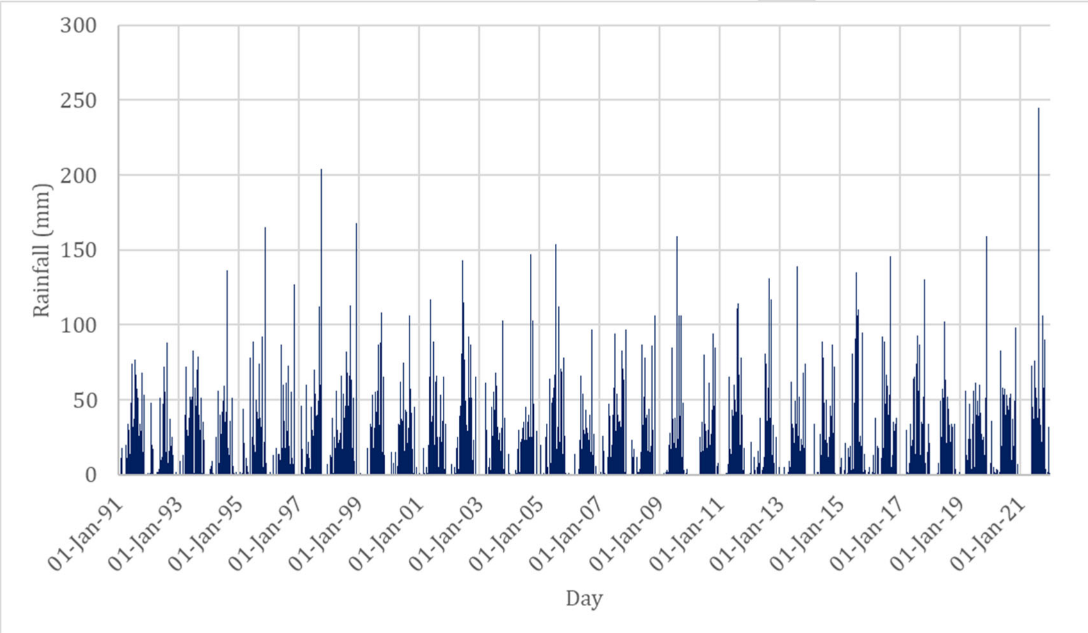
| Hydrological Events | 1day rain fall (mm) | 2 day cumulative rainfall | 3 days cumulative rain fall | 5 days cumulative rainfall | 10 days cumulative rainfall |
|---|---|---|---|---|---|
| Return period | GEV | LP3 | LN3 | LN2 | LN3 |
| 2.33 | 141 | 203 | 231 | 270 | 327 |
| 5 | 178 | 255 | 289 | 337 | 420 |
| 10 | 209 | 292 | 336 | 391 | 496 |
| 20 | 239 | 302 | 381 | 442 | 569 |

| | | | | | |
|---|---|---|---|---|---|
| 25 | 249 | 334 | 395 | 458 | 593 |
| 50 | 279 | 362 | 438 | 508 | 665 |
| 100 | 309 | 388 | 481 | 556 | 737 |

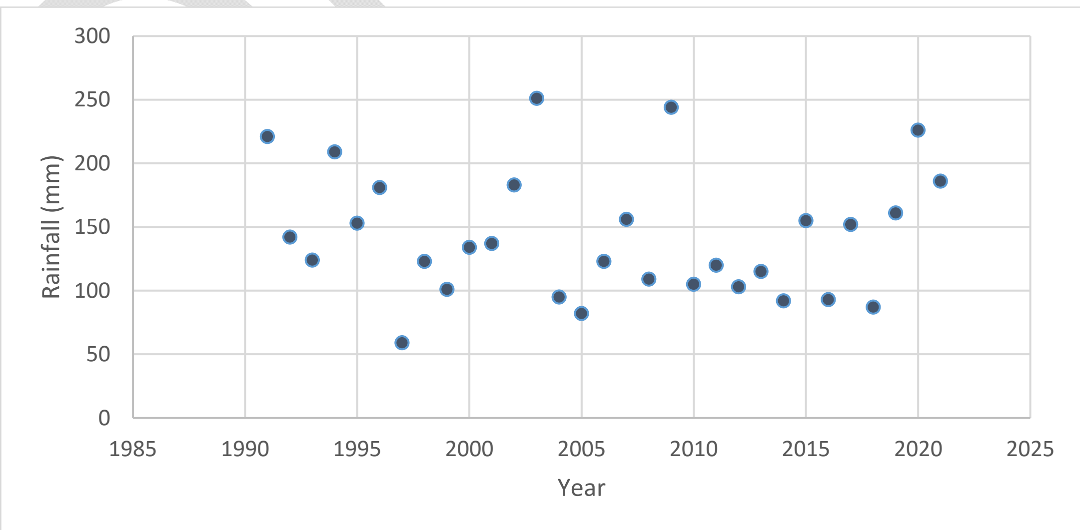
## A1.6 Mongla (41958)

### *Analysis OF Daily Rain Fall:*

The daily rainfall data of Mongla station has been collected from BWDB database. The data was checked and used for further analysis. Rainfall information of a few days was missing. Thirty-one (31) years of rain fall data has been used for analysing the yearly maximum rainfall. Pivot Chart method has been applied for the analysis.




Daily Rain fall of Mongla station




Yearly maximum rainfall at Mongla station

### *Determination of design flood event (Mongla-41958)*

Design rainfall of Mongla station event has been calculated using the rainfall information of Mongla. Different rainfall event has been analysed from the daily rainfall data to determine the consecutive rainfall effects in the study area. Yearly maximum rainfall data for 31 years (1991-2021) has been calculated for determining 1-day, 2-day, 3-day, 4-day, 5-day and 10-day cumulative rainfall events. The table below shows the yearly maximum rainfall event for the last 31 years.

Yearly maximum rainfall of Mongla for different rainfall event

| Year | 1-day | 2-day | 3-day | 5-day | 10-day |
|---|---|---|---|---|---|
| 1991 | 77 | 107 | 135 | 191 | 264 |
| 1992 | 88 | 113 | 117 | 151 | 186 |
| 1993 | 83 | 130 | 182 | 227 | 336 |
| 1994 | 136 | 173 | 180 | 270 | 297 |
| 1995 | 165 | 191 | 213 | 213 | 235 |
| 1996 | 127 | 244 | 251 | 251 | 296 |
| 1997 | 204 | 223 | 228 | 252 | 271 |
| 1998 | 168 | 205 | 229 | 326 | 426 |
| 1999 | 108 | 183 | 234 | 245 | 291 |
| 2000 | 106 | 116 | 141 | 148 | 198 |
| 2001 | 117 | 129 | 168 | 210 | 317 |
| 2002 | 143 | 211 | 228 | 293 | 475 |
| 2003 | 103 | 158 | 193 | 206 | 260 |
| 2004 | 147 | 191 | 225 | 345 | 450 |
| 2005 | 154 | 199 | 242 | 299 | 353 |
| 2006 | 97 | 148 | 243 | 294 | 327 |
| 2007 | 97 | 138 | 176 | 214 | 286 |
| 2008 | 106 | 139 | 142 | 155 | 240 |
| 2009 | 159 | 179 | 208 | 251 | 297 |
| 2010 | 94 | 167 | 212 | 249 | 258 |
| 2011 | 114 | 196 | 249 | 343 | 539 |
| 2012 | 131 | 194 | 272 | 299 | 355 |
| 2013 | 139 | 149 | 170 | 177 | 219 |
| 2014 | 89 | 125 | 137 | 175 | 308 |
| 2015 | 135 | 241 | 263 | 321 | 390 |
| 2016 | 135 | 241 | 263 | 321 | 390 |
| 2017 | 146 | 156 | 186 | 195 | 256 |
| 2018 | 260 | 340 | 394 | 590 | 782 |
| 2019 | 102 | 148 | 199 | 239 | 280 |
| 2020 | 159 | 231 | 265 | 265 | 265 |
| 2021 | 98 | 148 | 154 | 169 | 268 |

These 31 years' yearly maximum rainfall data have been taken into consideration and used to determine the different return period rainfall information for all rainfall events. The following table presents the design rainfall for different return periods.

Table 303: Rainfall(mm) for different return periods in Mongla

| | 1 Day Rain fall(mm) | | | | | 2 Days Cumulative Rain Fall(mm) | | | | | 3 Days Cumulative Rain Fall(mm) | | | | | 5 Days Cumulative Rain fall (mm) | | | | | 10 Days Cumulative Rain fall (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RP | Gumbles | LP3 | LN2 | Normal | GEV | Gumbles | LP3 | LN2 | Normal | GEV | Gumbles | LP3 | LN2 | Normal | GEV | Gumbles | LP3 | LN2 | Normal | GEV | Gumbles | LP3 | LN2 | Normal | GEV |
| 2.3 | 130 | 123 | 130 | 135 | 127 | 180 | 173 | 180 | 187 | 178 | 212 | 207 | 212 | 220 | 216 | 257 | 242 | 256 | 270 | 252 | 331 | 302 | 328 | 347 | 308 |
| 5 | 162 | 156 | 156 | 161 | 155 | 221 | 216 | 215 | 220 | 215 | 258 | 254 | 252 | 256 | 255 | 328 | 313 | 312 | 326 | 310 | 427 | 400 | 400 | 425 | 381 |
| 10 | 188 | 177 | 176 | 178 | 178 | 255 | 241 | 242 | 242 | 244 | 295 | 279 | 283 | 281 | 282 | 385 | 359 | 356 | 364 | 359 | 506 | 469 | 456 | 476 | 456 |
| 20 | 213 | 202 | 195 | 192 | 202 | 287 | 272 | 267 | 260 | 272 | 331 | 310 | 312 | 301 | 305 | 440 | 414 | 397 | 395 | 407 | 581 | 546 | 509 | 518 | 543 |
| 25 | 221 | 203 | 201 | 196 | 210 | 297 | 271 | 274 | 265 | 281 | 342 | 308 | 321 | 307 | 312 | 458 | 415 | 410 | 404 | 423 | 605 | 561 | 526 | 531 | 574 |
| 50 | 245 | 221 | 218 | 208 | 235 | 328 | 292 | 298 | 280 | 308 | 377 | 326 | 348 | 324 | 331 | 511 | 457 | 449 | 429 | 472 | 679 | 633 | 576 | 566 | 683 |
| 100 | 269 | 239 | 236 | 218 | 260 | 360 | 311 | 321 | 294 | 334 | 412 | 342 | 373 | 339 | 348 | 565 | 496 | 487 | 453 | 522 | 752 | 704 | 625 | 598 | 813 |

Different scenario has been observed during calculation of design rainfall for 2-days, 3-days and 10 days cumulative rainfall. It is seen that GEV Method provides the best results. Gumbel method provides the best fitted result for 1-day Rainfall events. It has been observed by the Goodness-of-fit test that log-normal method gives better result for 5-Days design rainfall compared to other methods. It is already determined that the polder water management system will be designed for 5-days cumulative rainfall event and 1 in 10-year return periods rainfall considered as design rainfall. As there is lots of investment and safety involved, Log Normal (LN) method has been taken for ensuring the safety of the polder under the extreme flood event condition. Considering this, the water management system of the Polder-39/1C, Polder-39/1B, Polder-10-12, Polder-7/2, Polder-7/1, Polder-5 will be designed for at least 356 mm design rainfall.

Different statistical distribution methods have been tested for fitting the hydrological conditions which has been described in the earlier section. The tables below present the suitable statistical distribution method contains the design rainfall. The design rainfall (1 in 10 year) for 1-day hydrological rainfall event has been estimated 188 mm which is the nearest rainfall 168 mm happened in 1998. Similarly, the design rainfall for 5-days cumulative rainfall has been estimated 356 mm and nearest rainfall is 345 mm already happened in 2004. It indicates that the computed design rainfall is 3% higher than the yearly maximum rainfall of 2004. This statistic confirms that during generation of design runoff for the design rainfall events, 3% additional rainfall should be added with the daily rainfall data of 2004 for getting the expected design runoff.

Goodness of Fit Test (1-day Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.10 | 0.27 | 0.25 | 2 |
| 2 | Gumbel Max | 0.09 | 0.29 | 0.13 | 1 |
| 3 | Log-Pearson 3 | 0.11 | 0.27 | 0.57 | 4 |
| 4 | Lognormal | 0.11 | 0.33 | 0.58 | 5 |
| 5 | Lognormal (3P) | 0.11 | 0.28 | 0.70 | 6 |
| 6 | Normal | 0.12 | 0.77 | 0.53 | 3 |

Goodness of Fit Test (2-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.08 | 0.19 | 0.18 | 1 |
| 2 | Gumbel Max | 0.09 | 0.20 | 0.24 | 3 |
| 3 | Log-Pearson 3 | 0.09 | 0.20 | 0.28 | 4 |
| 4 | Lognormal | 0.09 | 0.21 | 0.19 | 2 |
| 5 | Lognormal (3P) | 0.10 | 0.22 | 0.29 | 5 |
| 6 | Normal | 0.11 | 0.48 | 0.49 | 6 |

Goodness of Fit Test (3-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.10 | 0.37 | 0.54 | 3 |
| 2 | Gumbel Max | 0.13 | 0.54 | 0.42 | 2 |
| 3 | Log-Pearson 3 | 0.10 | 0.38 | 1.91 | 6 |
| 4 | Lognormal | 0.11 | 0.39 | 1.89 | 4 |
| 5 | Lognormal (3P) | 0.11 | 0.39 | 1.89 | 5 |
| 6 | Normal | 0.10 | 0.41 | 0.20 | 1 |

Goodness of Fit Test (5-day Cumulative Rainfall)

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.09 | 0.28 | 0.34 | 3 |
| 2 | Gumbel Max | 0.10 | 0.35 | 0.44 | 4 |
| 3 | Log-Pearson 3 | 0.10 | 0.33 | 0.34 | 1 |
| 4 | Lognormal | 0.08 | 0.28 | 0.55 | 5 |
| 5 | Lognormal (3P) | 0.09 | 0.34 | 0.34 | 2 |
| 6 | Normal | 0.12 | 0.88 | 0.61 | 6 |

Goodness of Fit Test (10-day Cumulative Rainfall).

| SL | Distribution | Kolmogorov Smirnov | Anderson Darling | Chi-Squared | Rank |
|---|---|---|---|---|---|
| 1 | Gen. Extreme Value | 0.12 | 0.29 | 0.74 | 1 |
| 2 | Gumbel Max | 0.14 | 0.83 | 5.16 | 5 |
| 3 | Log-Pearson 3 | 0.12 | 0.38 | 1.11 | 2 |
| 4 | Lognormal | 0.14 | 0.63 | 4.33 | 4 |
| 5 | Lognormal (3P) | 0.11 | 0.31 | 1.27 | 3 |
| 6 | Normal | 0.18 | 1.76 | 9.67 | 6 |

Summary of Goodness of Fit test:

| Hydrological Events | 1day rain fall (mm) | 2 day cumulative rainfall | 3 days cumulative rain fall | 5 days cumulative rainfall | 10 days cumulative rainfall |
|---|---|---|---|---|---|
| Return period | Gumbel | GEV | GEV | LN | GEV |
| 2.33 | 130 | 178 | 216 | 256 | 308 |
| 5 | 162 | 215 | 255 | 312 | 381 |
| 10 | 188 | 244 | 282 | 356 | 456 |
| 20 | 213 | 272 | 305 | 397 | 543 |
| 25 | 221 | 281 | 312 | 410 | 574 |
| 50 | 245 | 308 | 331 | 449 | 683 |
| 100 | 269 | 334 | 348 | 487 | 813 |

# A2 Land Use Maps for Every Polder

The land use maps of the selected polders have been specially generated for Coastal Embankment Improvement Project - Phase II (CEIP-II) using high resolution WorldView 3 satellite images available in the Google Earth Platform. Most of the images were acquired in 2020 or 2021. The spatial resolution of the images is 0.3 meter.

The study area consists of different land uses or land covers such as agricultural crops, aquacultures, rivers and khals, mudflats or intertidal areas, ponds, ditch, orchards, mangrove plantation, rural settlements, urban areas, under construction areas, brickfields and roads etc. A land use or land cover classification system relevant with the project were developed before interpretation from images. The land use or land cover classes are mutually exclusive and totally exhaustive. The definition of each classes is given in the below table.

The above mentioned classes were identified from the images using visual interpretation technique. The boundaries of the identified features were delineated using on screen digitization technique. After digitization, the land use or land cover database edited and topological errors were checked.

Definition of Land use or land cover classes

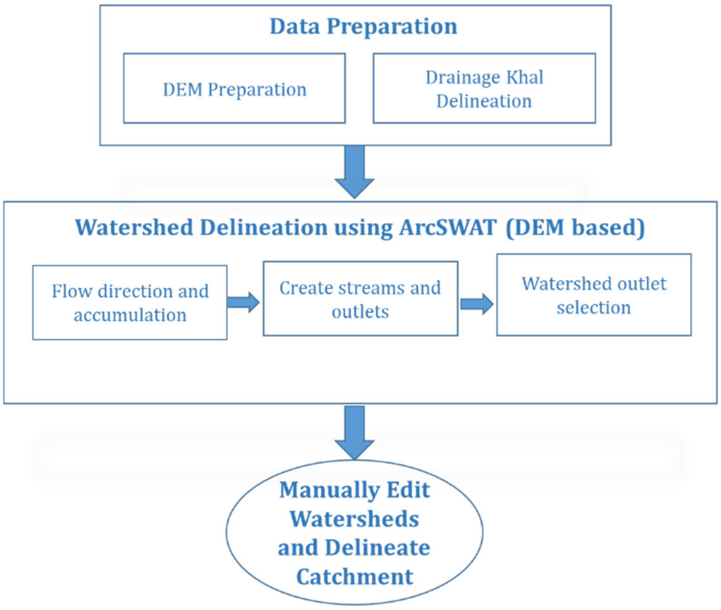
| No | Class | Description |
|---|---|---|
| 1 | Urban Areas | This category describes built-up areas where non-linear artificial constructions cover the land with an impervious surface. The constructed materials may be made up of either of "Hard Materials" or "Light Materials". A percentage cover can be specified by the user. |
| 2 | Rural Settlements | Geographic areas of clustered or linear rural dwellings (mainly wooden and tin roof) covered by fruit trees and other plantation and functionally might be linked with small scale vegetables gardens, open spaces and ponds around the dwellings. |
| 02 | Road | A road is a linear path for the transportation of traffic, typically with a better surface for use by cars and pedestrians.<br>In contrast to streets, roads serve primarily as means of transportation. |
| 03 | Brickfields | Geographic areas used for bricks production |
| 04 | Crop Land | This class includes permanent agriculture lands cultivated with a single herbaceous crop in a year and the same herbaceous crop is cultivated in the same land for several years. This class includes permanent agriculture lands which are cultivated with more than one herbaceous crops (Two or Three) in different growing season sequentially (crop diversified in time) within a year and the same crop rotation is practiced in the same land for several years. |
| 05 | Under construction area | Disposal of materials particularly sand, mud for construction. |
| 06 | Mangrove Forests | The geographical area dominated by halophytic trees with a canopy cover of 85% to 100% and tree height vary from 5m - 17m. The forest floor inundated twice daily by brackish water. |

| No | Class | Description |
|---|---|---|
| 07 | Mangrove Plantation | Mangrove plantations on newly accreted land in the estuaries of the Bay of Bengal to provide protection against natural calamities and land erosion. |
| 08 | Herb Dominated Areas | The geographic area which is dominated by grass with very little to no woody vegetation is called herb dominated area. These types of vegetation are generally found in newly accreted land, year round fallow land or adjacent to the international boundary of Bangladesh. The coverage is 20 - 100%. |
| 09 | Orchards and Other Plantations | Land dominated with tree species for harvesting fruits. In general, trees are even-aged, planted and managed in rows and cover a large enough area. Marginal land plantations (road, railway, embankment, and canal side) are also included in this class. |
| 10 | Aquaculture | Fresh Water Aquaculture and Brackish Water Aquaculture are term as Aquaculture. Generally, fresh water ponds used for year round aquaculture whereas large brackish water ponds used for year round brackish water aquaculture. |
| 11 | Rivers and Khals | Naturally flowing freshwater which serves as water drainage channels. |
| 12 | Ponds | A pond is an artificial surface of standing water that is usually smaller than a lake and has a regular shape. The ponds more than 0.3 hectare will be include in the class "Ponds" but the ponds functionally related with rural settlement will be included in the class "Rural Settlement (RS)" |
| 13 | Ditch | A little ditch that has been dug at the side of a road or field to collect or transport water. |
| 14 | Mud Flats or Intertidal Areas | Mud flats or intertidal areas are wet land soil near the estuary. It is submerged and exposed twice daily by tidal water. |
| 15 | Sand | Beaches are narrow, gently sloping strip of natural land that lies along the coasts, which are composed of sand. Sand bar are sand deposits within the river channels or in the estuary which are emerging as islands. |

The following pages show the land use maps for every Polder.

# A3 Catchment Deliniation for Every Polder

Catchment of the polders under CEIP-II project was generated focusing on the position of the existing drainage structures (Sluices, regulators, SDS etc.) for the purpose of drainage modelling. For this, catchment delineation was accomplished using automatic watershed delineation tool of ArcSWAT (see the below figure).




**Data Preparation:** Before setting up the model all the model input data have been prepared. Survey Data has been used to generate the DEM of the polders. For generating the drainage Khals, Onscreen digitization has been used using Google Earth Imagery. The DEM is 30m resolution and all the GIS layers were projected in Bangladesh Transverse Mercator (BTM). For better output, the DEM was made hydrologically corrected using the drainage khals.

**Watershed Delineation:** After preparing all the data, DEM based model setup was done to delineate the basin and sub-basin boundaries. For delineating the watershed more effectively, the drainage khals were incorporated with the DEM. Automatic flow direction, flow accumulation and stream network was generated using ArcSWAT. From this, streams and outlets of the streams were generated. As the main objective is to delineate the catchment area of the drainage structures, generated outlets near the structures were selected and automatic watersheds delineation was executed. After that, the watersheds were manually edited (considering the DEM, flow direction of the drainage Khal, roads and settlements position) and catchment area for each drainage structure (outlet) were delineated.

The following pages show the catchment maps for every Polder.

# A4 Velocity and Discharge Map for Polders

The following figures show the maximum velocity and discharge through the khals during the design event.

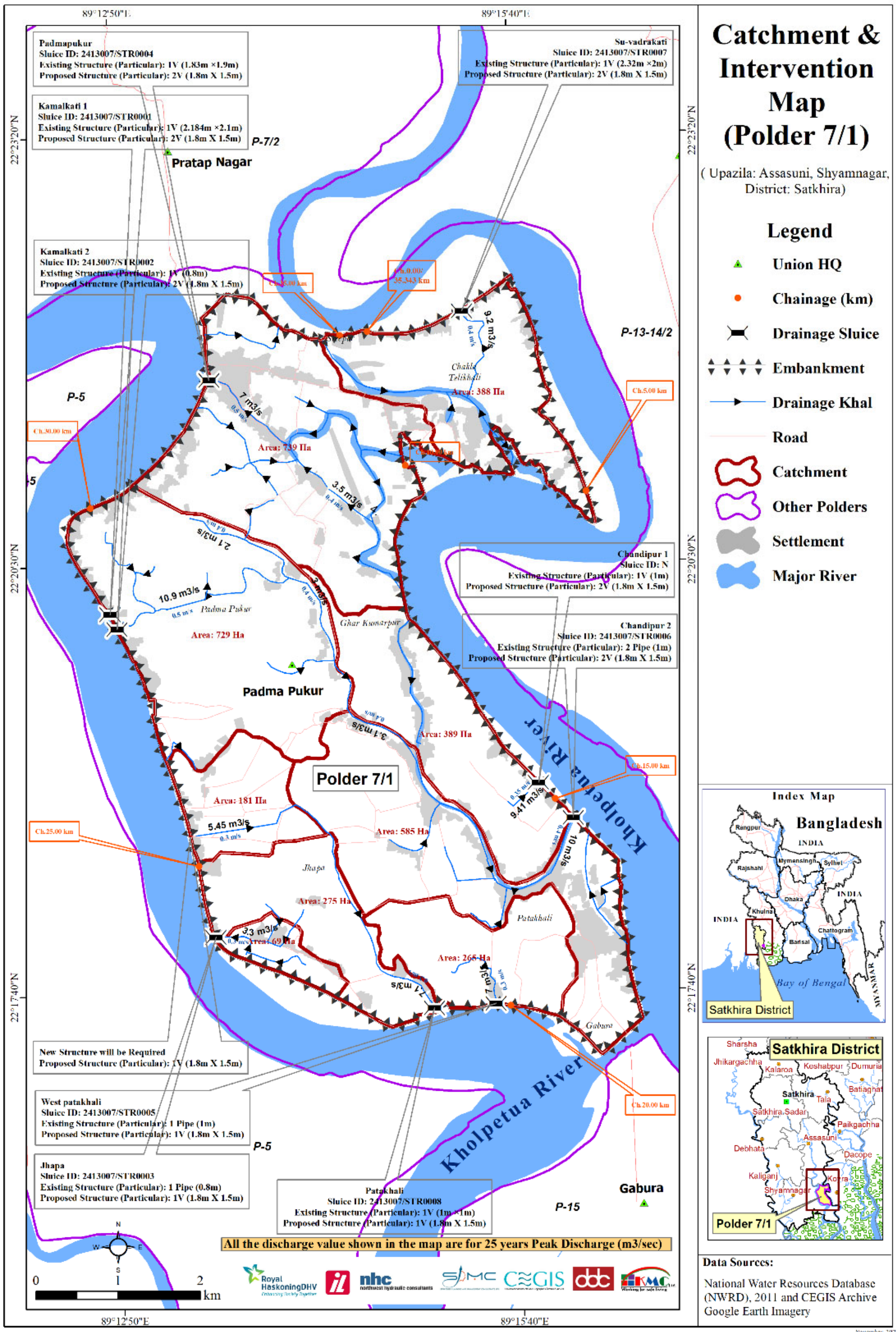



*Figure: Catchment Delineation Map of Polder 7_1*

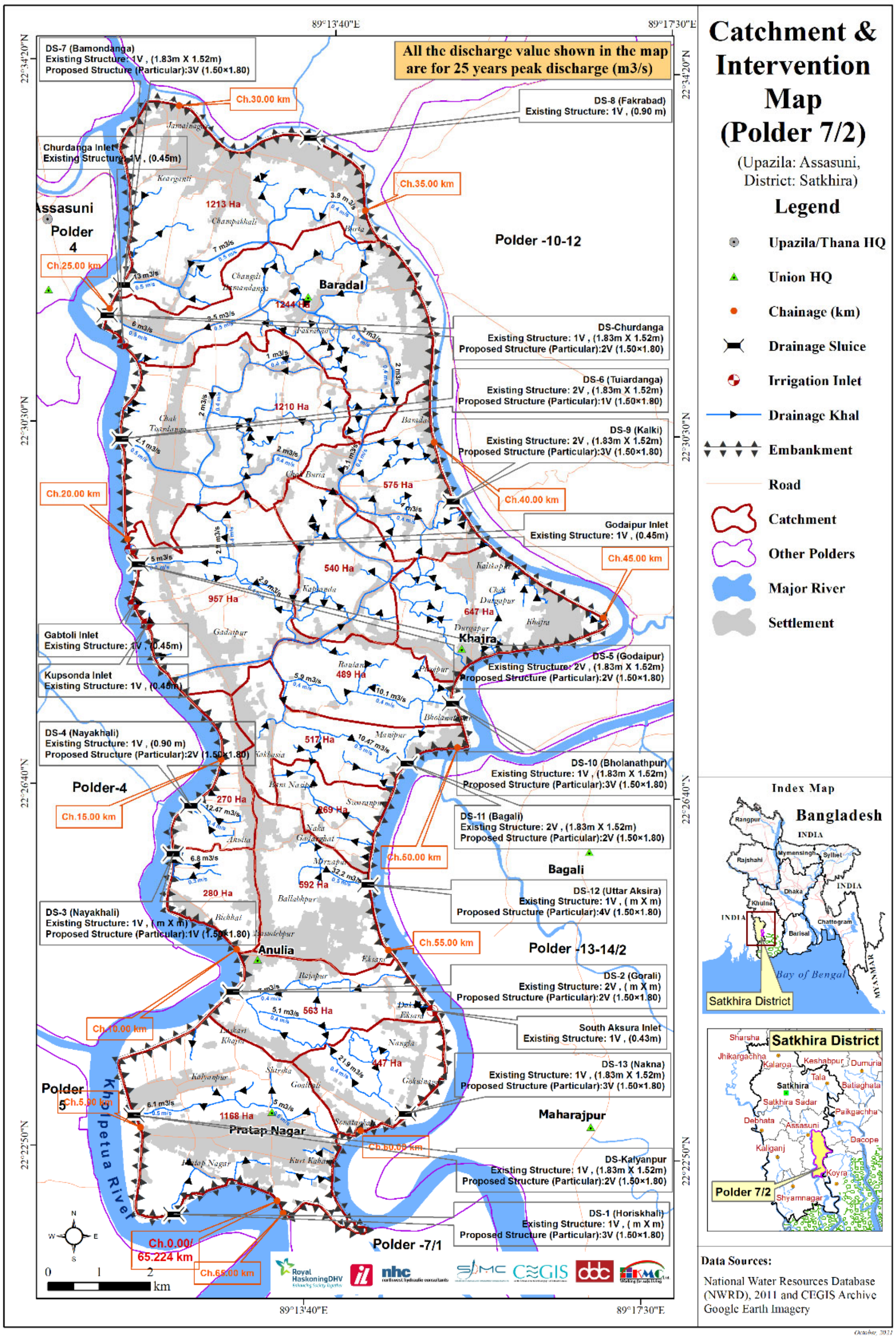



Figure: Catchment Delineation Map of Polder 7_2

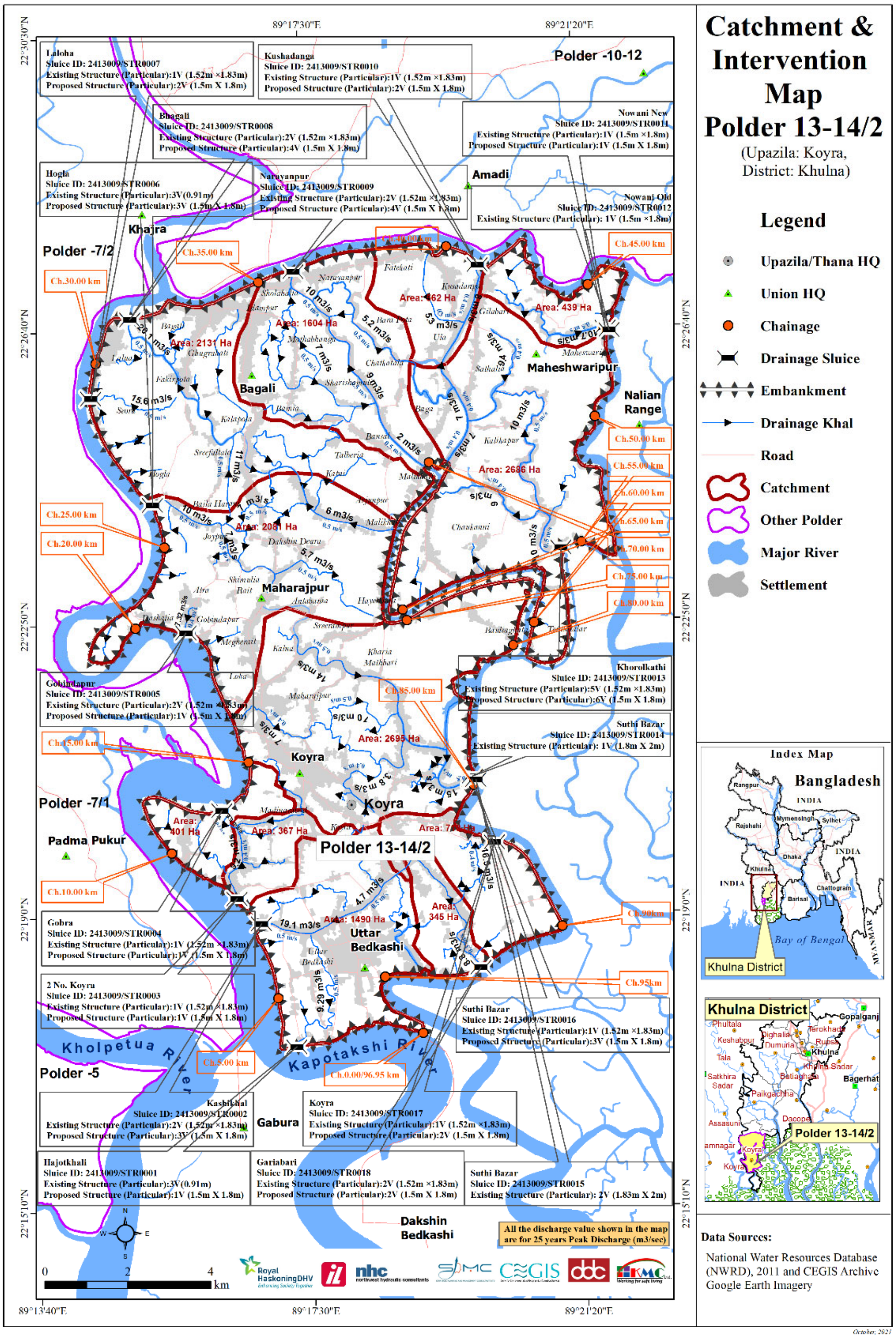



Figure: Catchment Delineation Map of Polder 13_14/2

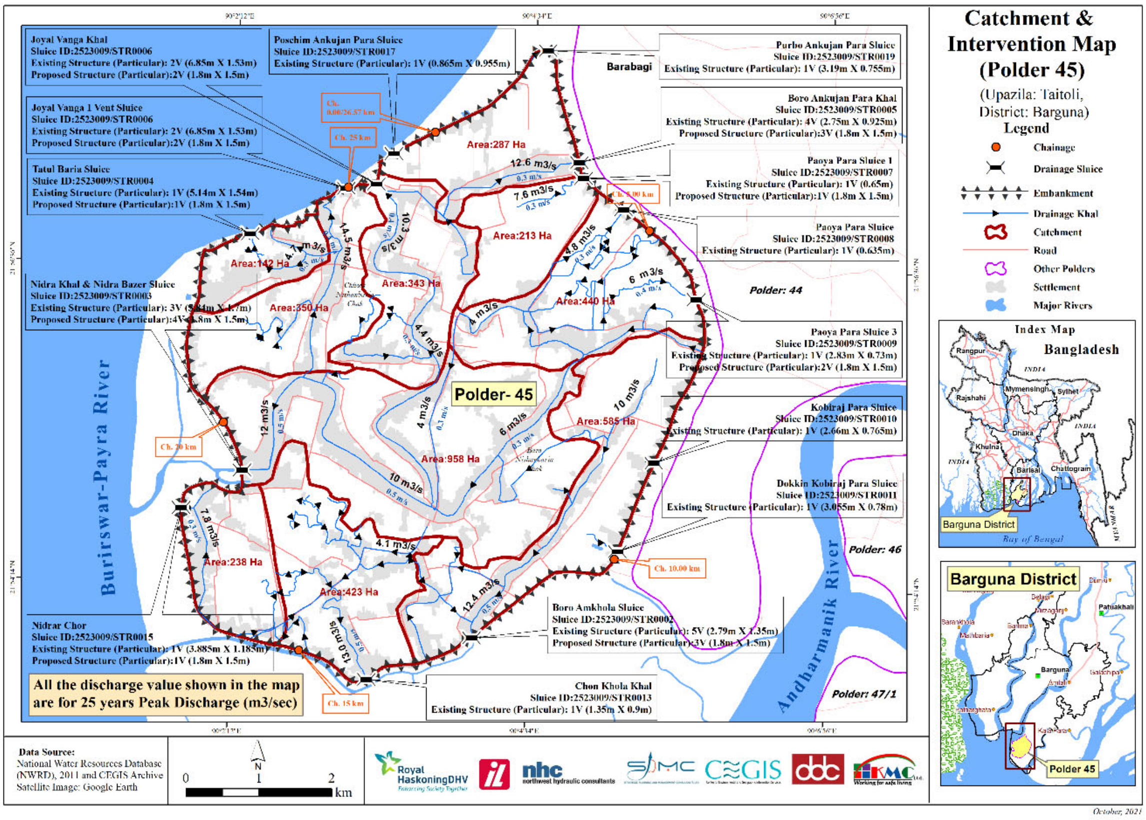



*Figure: Catchment Delineation Map of Polder 45*

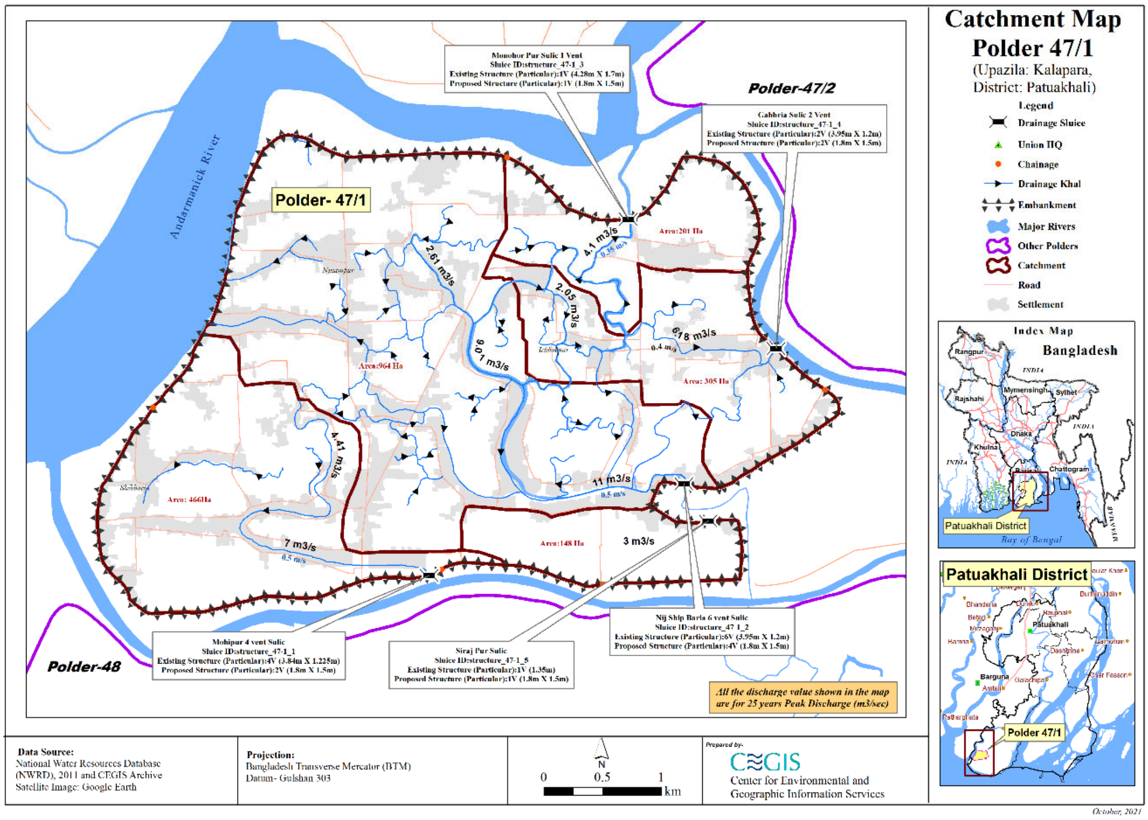



*Figure: Catchment Delineation Map of Polder 47/1*

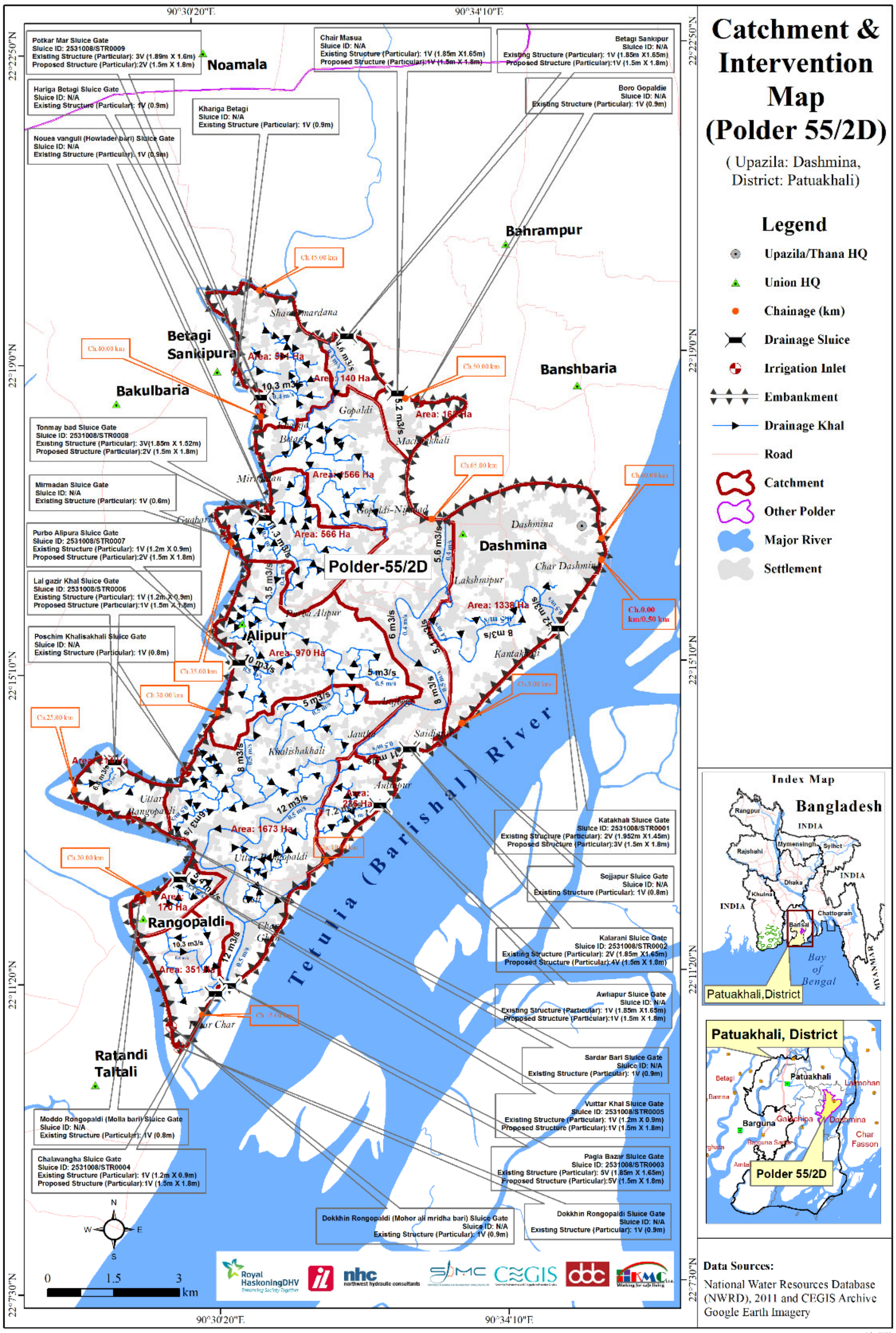



*Figure: Catchment Delineation Map of Polder 55_2D*

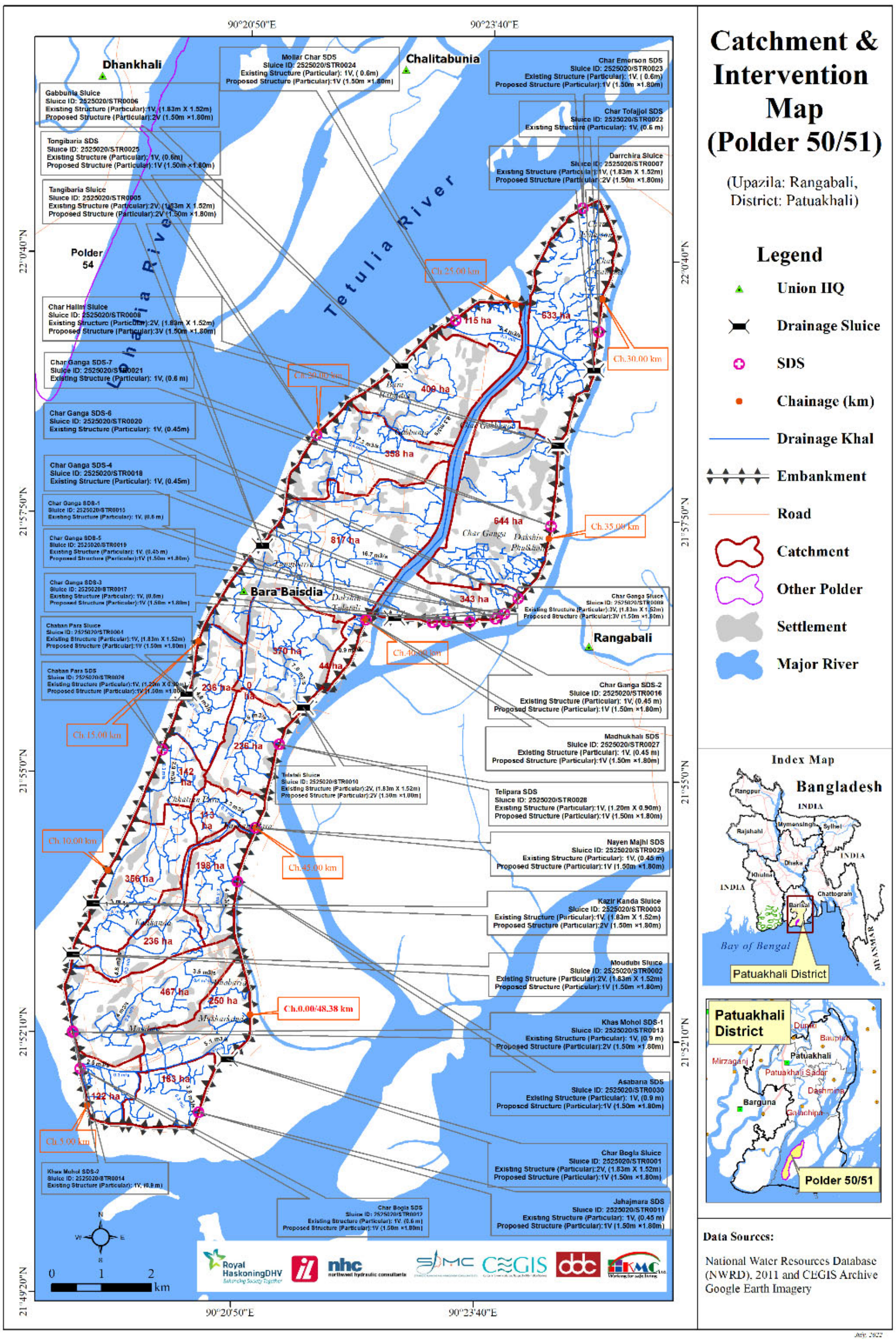



*Figure: Catchment Delineation Map of Polder 50_51*

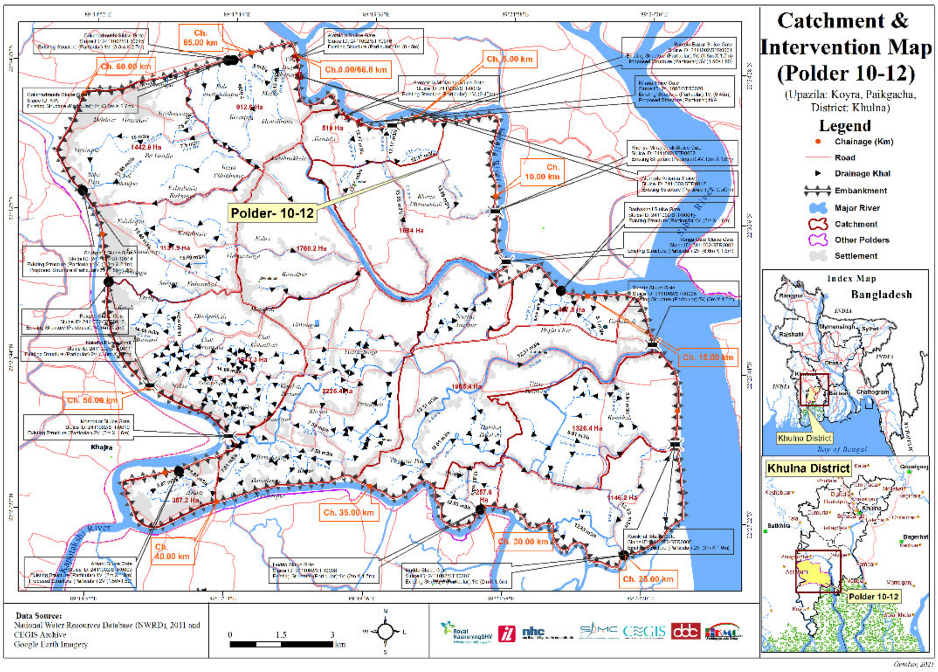



*Figure: Catchment Delineation Map of Polder 10-12*

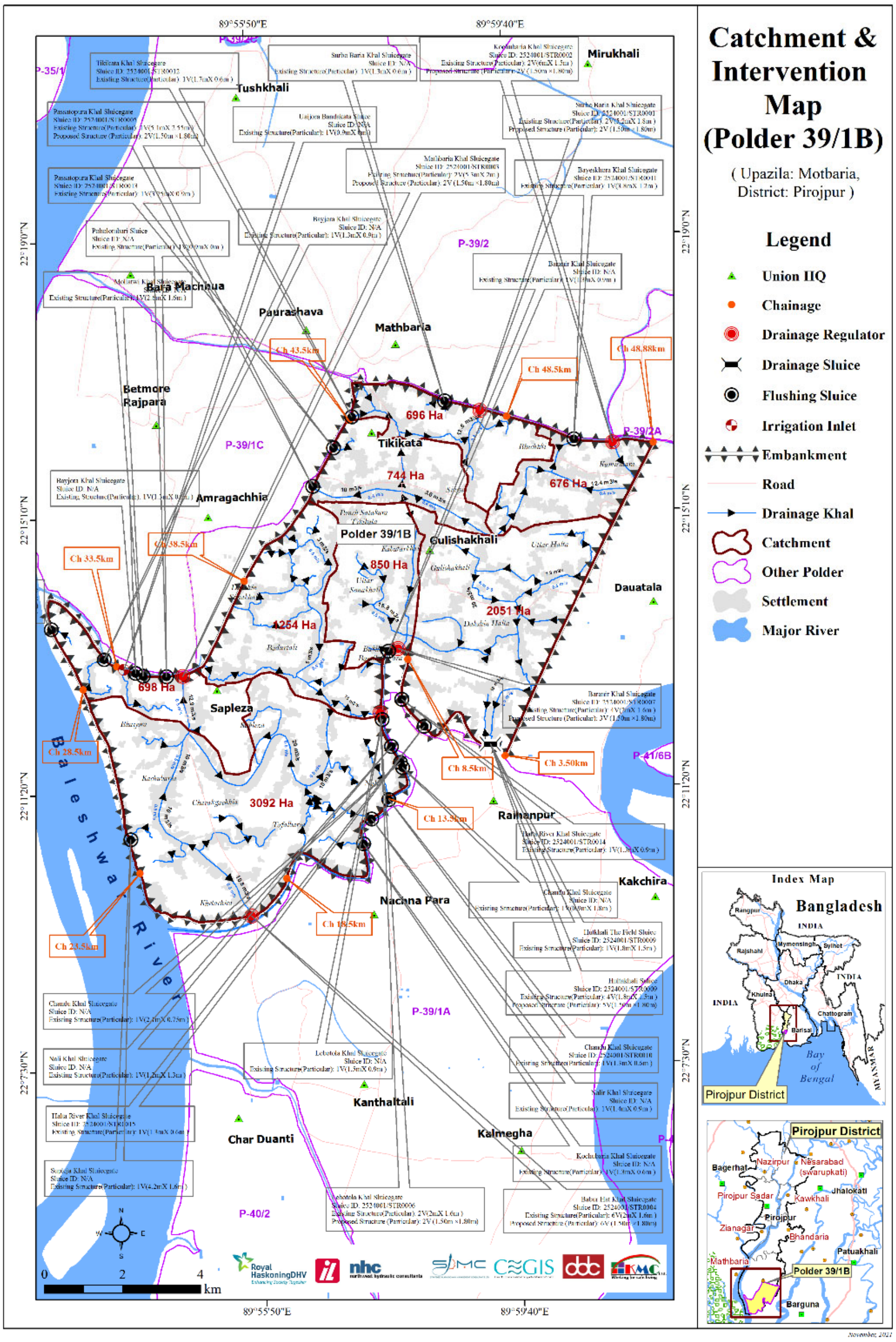



*Figure: Catchment Delineation Map of Polder 39/1B*

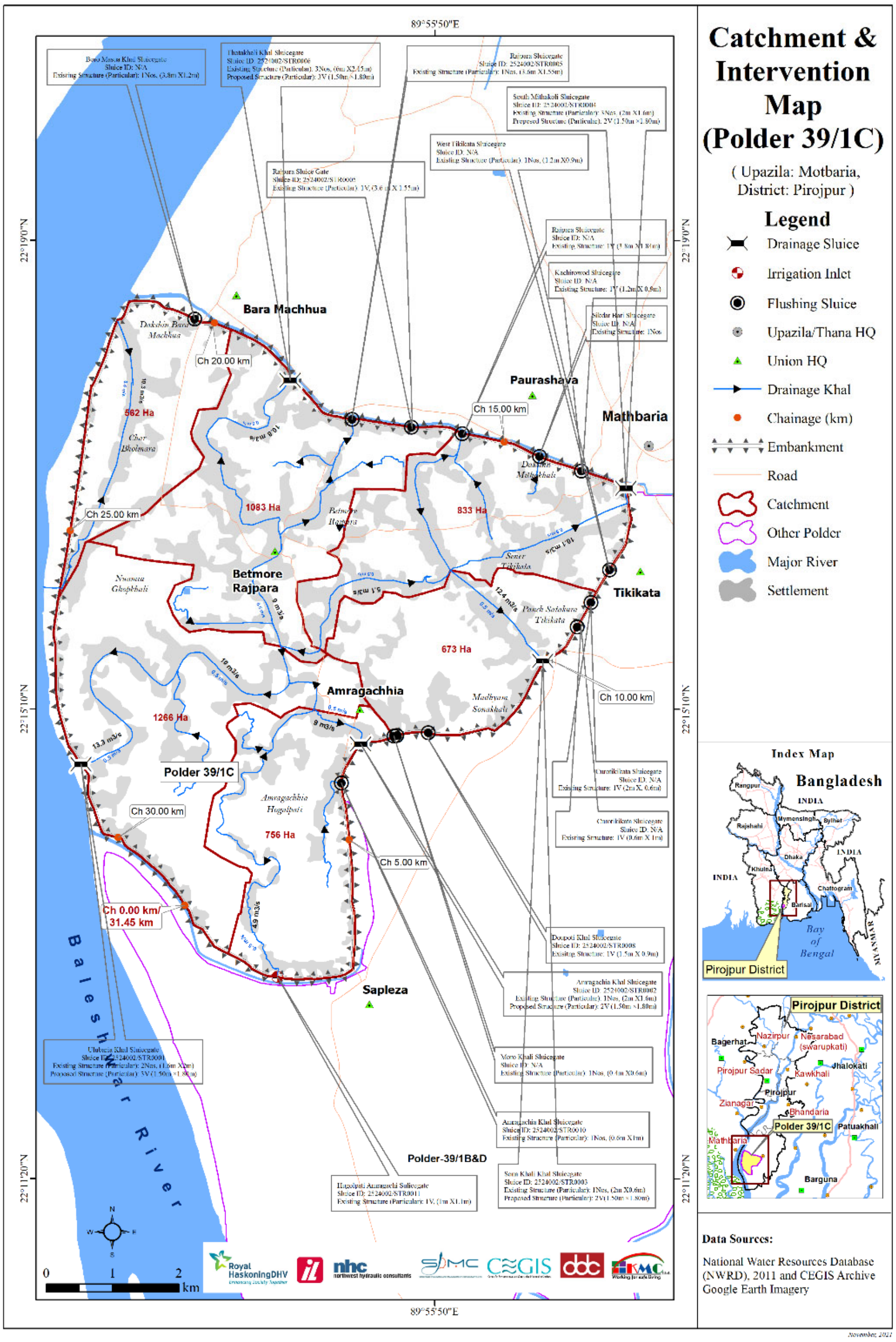



*Figure: Catchment Delineation Map of Polder 39/1C*

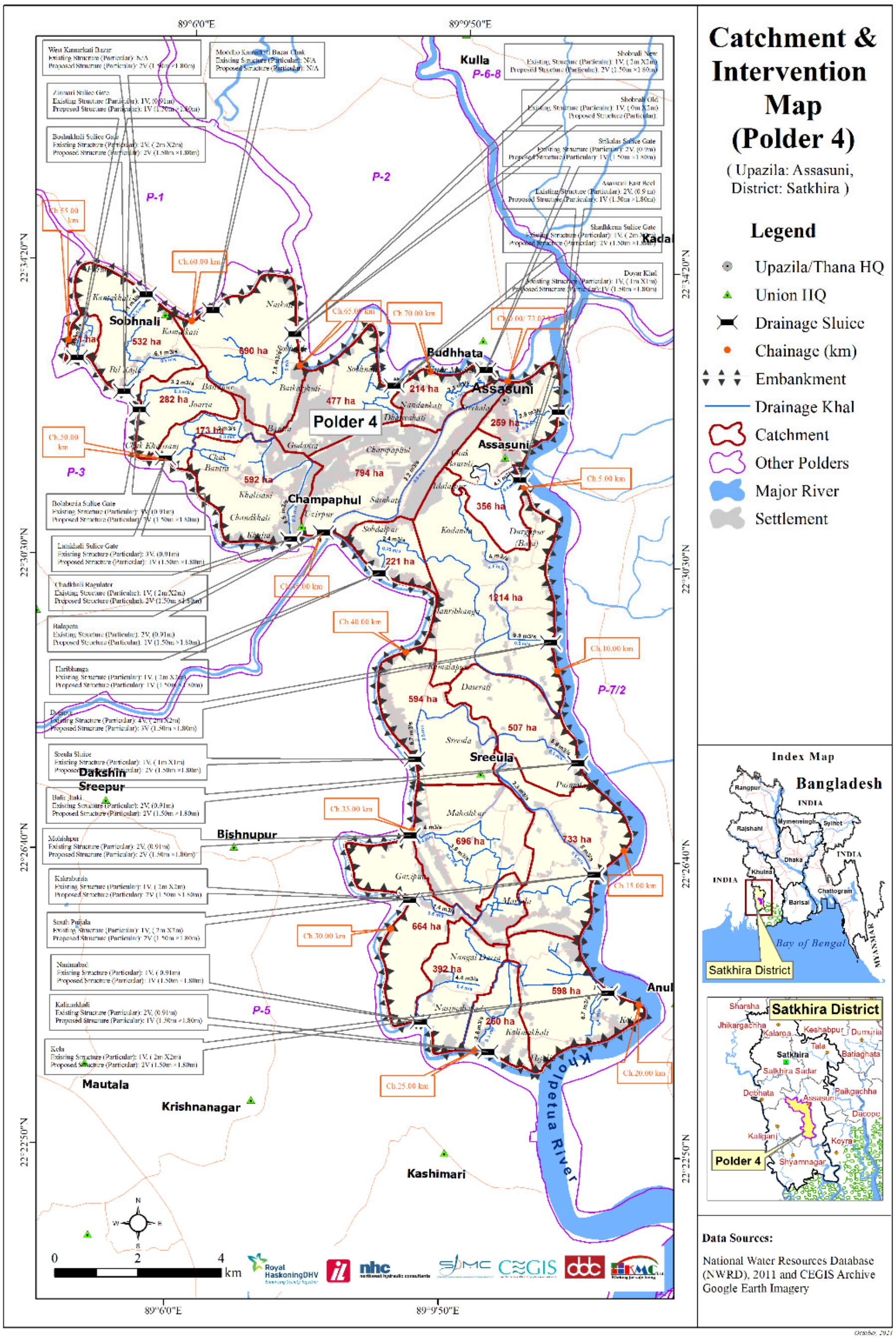



*Figure: Catchment Delineation Map of Polder 4*

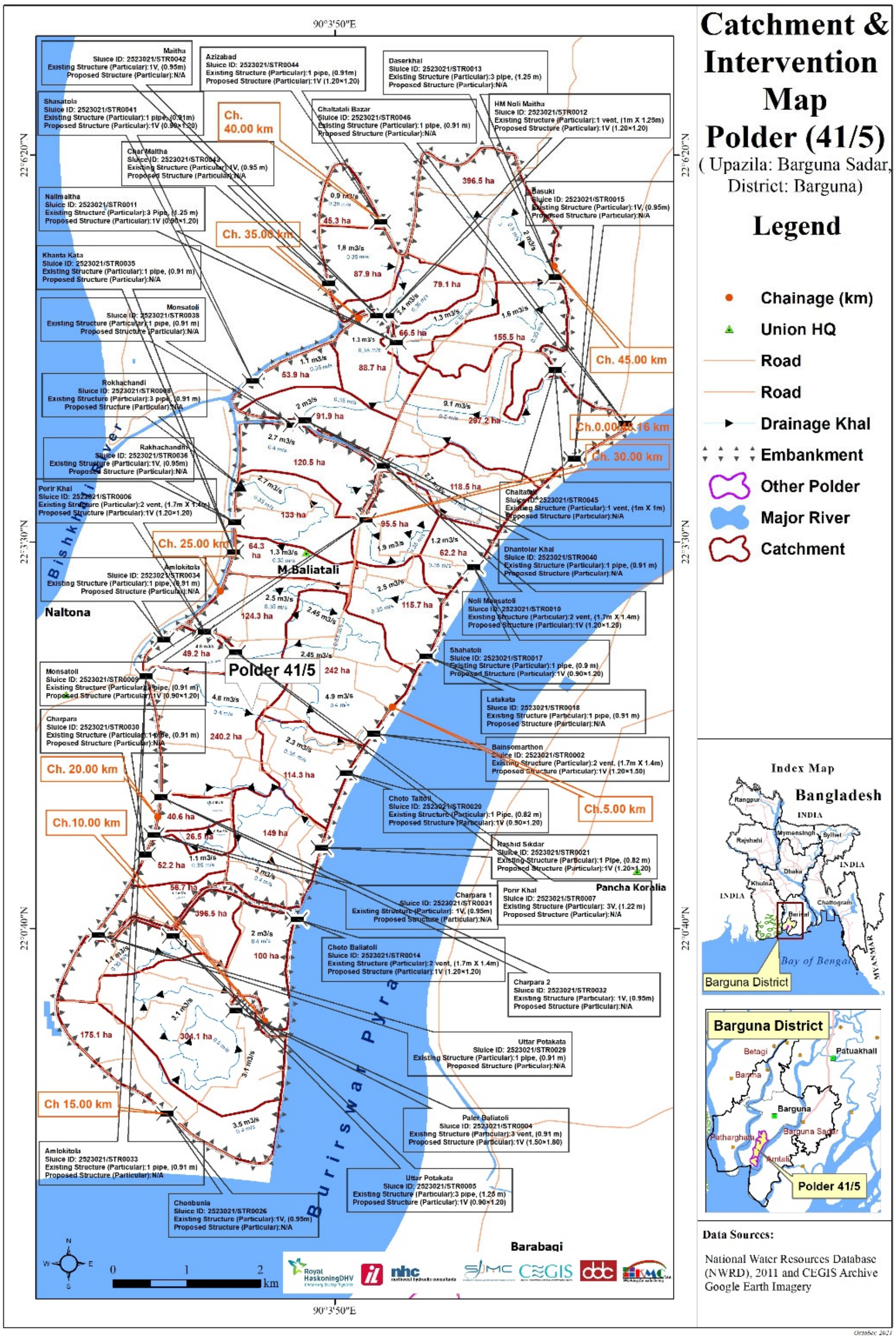
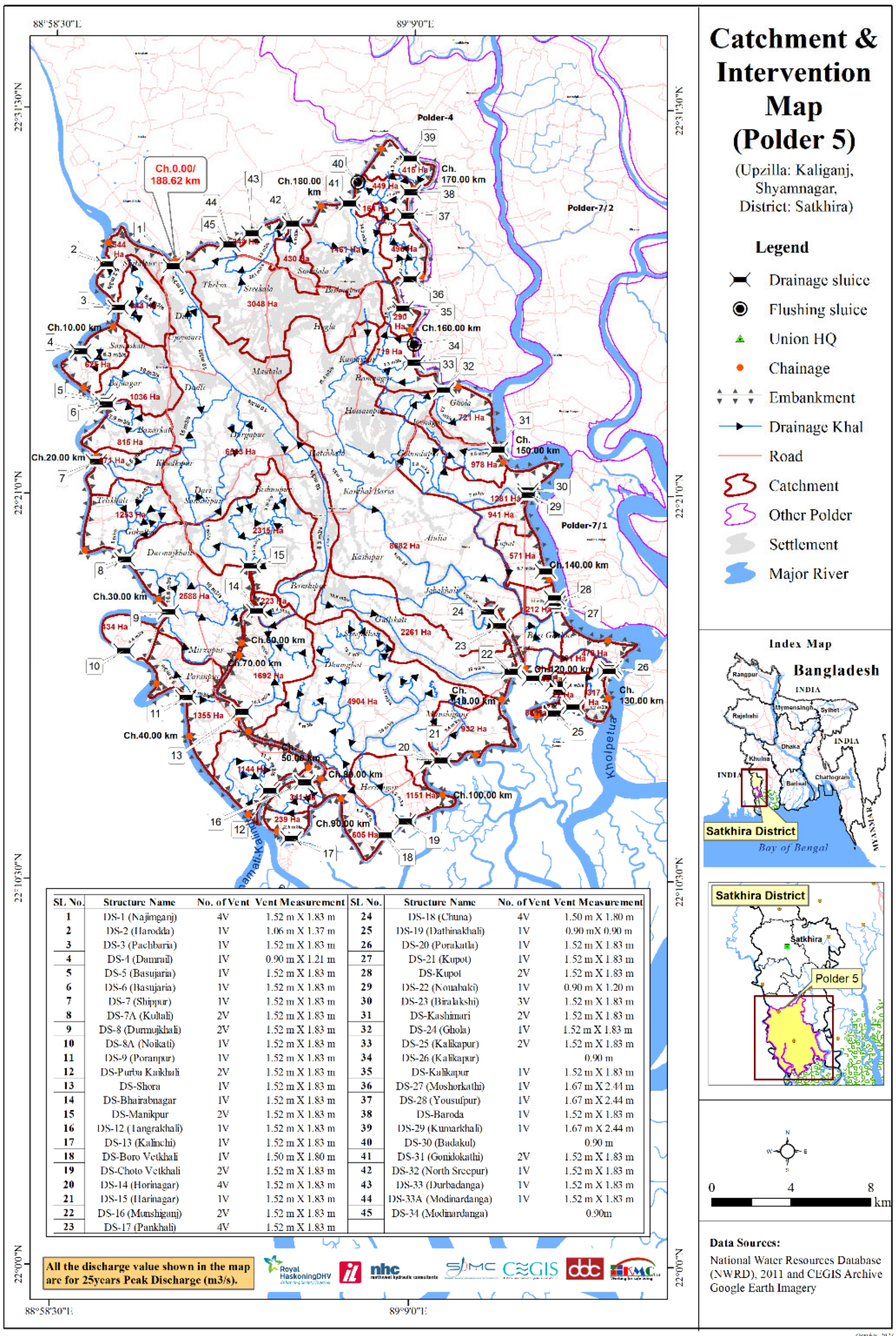



*Figure: Catchment Delineation Map of Polder 41/5*




| SL No. | Structure Name | No. of Vent | Vent Measurement | SL No. | Structure Name | No. of Vent | Vent Measurement |
|---|---|---|---|---|---|---|---|
| 1 | DS-1 (Najimganj) | 4V | 1.52 m X 1.83 m | 24 | DS-18 (Chuna) | 4V | 1.50 m X 1.80 m |
| 2 | DS-2 (Harodda) | 1V | 1.06 m X 1.37 m | 25 | DS-19 (Dathinakhali) | 1V | 0.90 mX 0.90 m |
| 3 | DS-3 (Pachbaria) | 1V | 1.52 m X 1.83 m | 26 | DS-20 (Porakatla) | 1V | 1.52 m X 1.83 m |
| 4 | DS-4 (Damrail) | 1V | 0.90 m X 1.21 m | 27 | DS-21 (Kupot) | 1V | 1.52 m X 1.83 m |
| 5 | DS-5 (Basujaria) | 1V | 1.52 m X 1.83 m | 28 | DS-Kupot | 2V | 1.52 m X 1.83 m |
| 6 | DS-6 (Basujaria) | 1V | 1.52 m X 1.83 m | 29 | DS-22 (Nonabaki) | 1V | 0.90 m X 1.20 m |
| 7 | DS-7 (Shippur) | 1V | 1.52 m X 1.83 m | 30 | DS-23 (Biralakshi) | 3V | 1.52 m X 1.83 m |
| 8 | DS-7A (Kultali) | 2V | 1.52 m X 1.83 m | 31 | DS-Kashimari | 2V | 1.52 m X 1.83 m |
| 9 | DS-8 (Durmujkhali) | 2V | 1.52 m X 1.83 m | 32 | DS-24 (Ghola) | 1V | 1.52 m X 1.83 m |
| 10 | DS-8A (Noikati) | 1V | 1.52 m X 1.83 m | 33 | DS-25 (Kalikapur) | 2V | 1.52 m X 1.83 m |
| 11 | DS-9 (Poranpur) | 1V | 1.52 m X 1.83 m | 34 | DS-26 (Kalikapur) | | 0.90 m |
| 12 | DS-Purba Kaikhali | 2V | 1.52 m X 1.83 m | 35 | DS-Kalikapur | 1V | 1.52 m X 1.83 m |
| 13 | DS-Shora | 1V | 1.52 m X 1.83 m | 36 | DS-27 (Moshorkathi) | 1V | 1.67 m X 2.44 m |
| 14 | DS-Bhairabnagar | 1V | 1.52 m X 1.83 m | 37 | DS-28 (Yousufpur) | 1V | 1.67 m X 2.44 m |
| 15 | DS-Manikpur | 2V | 1.52 m X 1.83 m | 38 | DS-Baroda | 1V | 1.52 m X 1.83 m |
| 16 | DS-12 (Tangrakhali) | 1V | 1.52 m X 1.83 m | 39 | DS-29 (Kumarkhali) | 1V | 1.67 m X 2.44 m |
| 17 | DS-13 (Kalinchi) | 1V | 1.52 m X 1.83 m | 40 | DS-30 (Badakul) | | 0.90 m |
| 18 | DS-Boro Vetkhali | 1V | 1.50 m X 1.80 m | 41 | DS-31 (Gonidokathi) | 2V | 1.52 m X 1.83 m |
| 19 | DS-Choto Vetkhali | 2V | 1.52 m X 1.83 m | 42 | DS-32 (North Sreepur) | 1V | 1.52 m X 1.83 m |
| 20 | DS-14 (Horinagar) | 4V | 1.52 m X 1.83 m | 43 | DS-33 (Durbadanga) | 1V | 1.52 m X 1.83 m |
| 21 | DS-15 (Harinagar) | 1V | 1.52 m X 1.83 m | 44 | DS-33A (Modinardanga) | 1V | 1.52 m X 1.83 m |
| 22 | DS-16 (Munshiganj) | 2V | 1.52 m X 1.83 m | 45 | DS-34 (Modinardanga) | | 0.90m |
| 23 | DS-17 (Pankhali) | 4V | 1.52 m X 1.83 m | | | | |

*Figure: Catchment Delineation Map of Polder 5*

# A5 Area Elevation Curves

Data Sources: Survey Data

Survey datum: Meter PWD (mPWD)

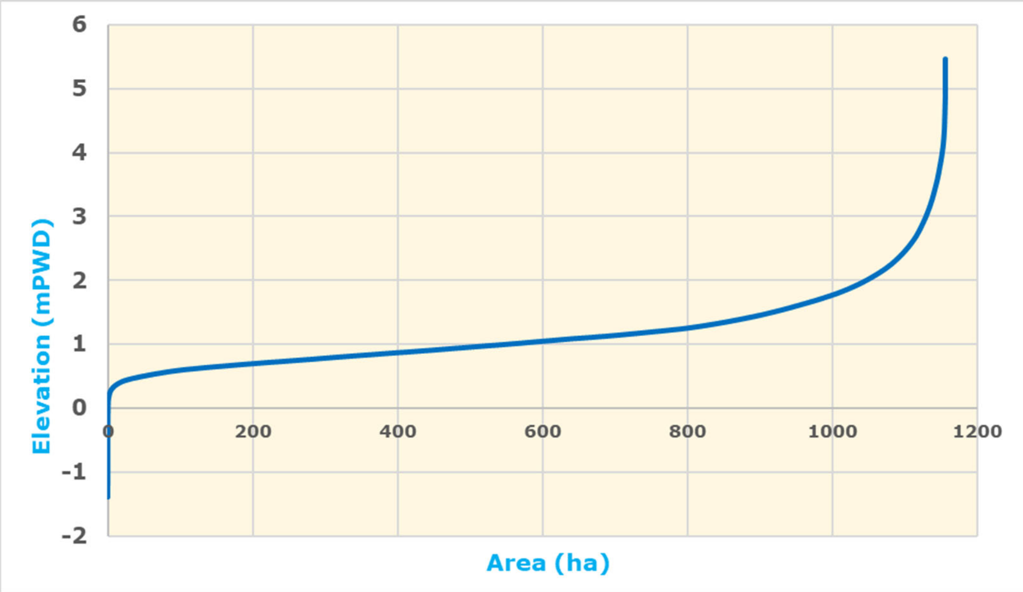



Figure A5.1: Area Elevation Curve of Polder 4

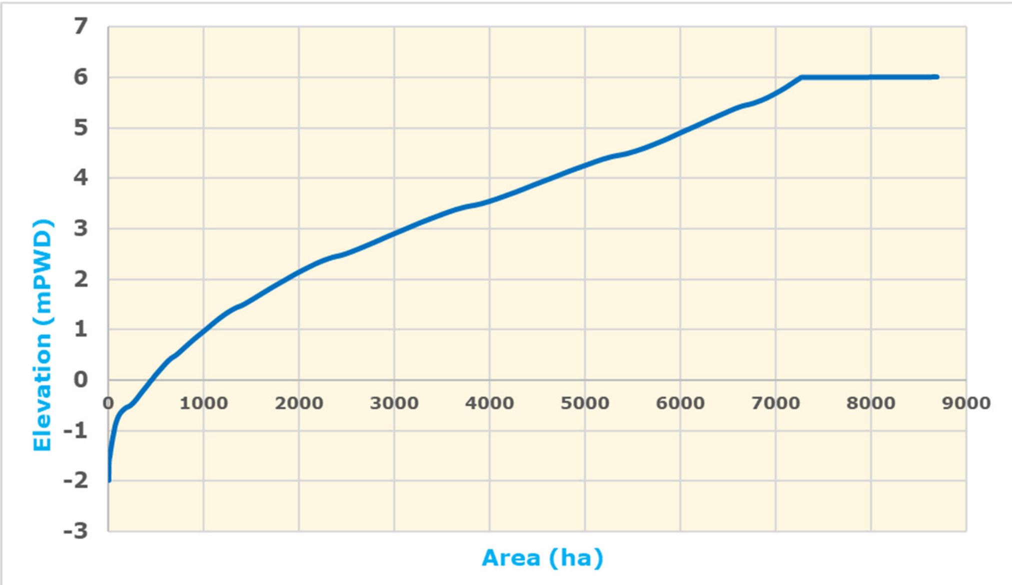



Figure A5.2: Area Elevation Curve of Polder 5

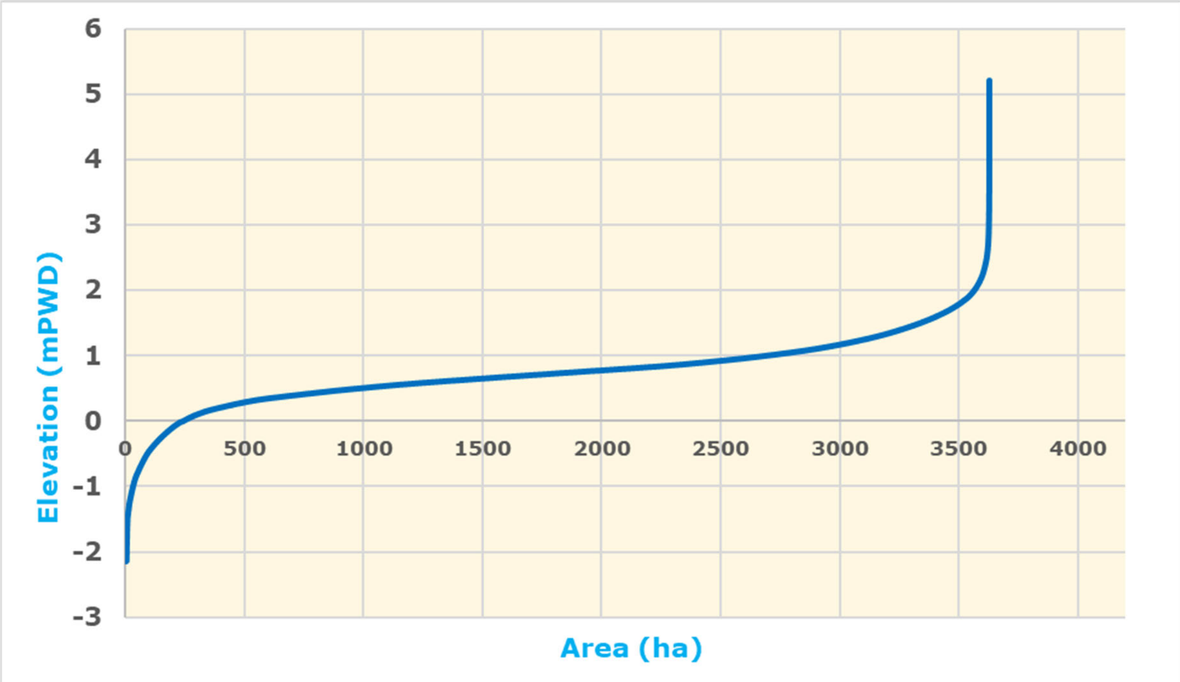



Figure A5.3: Area Elevation Curve of Polder 7/1

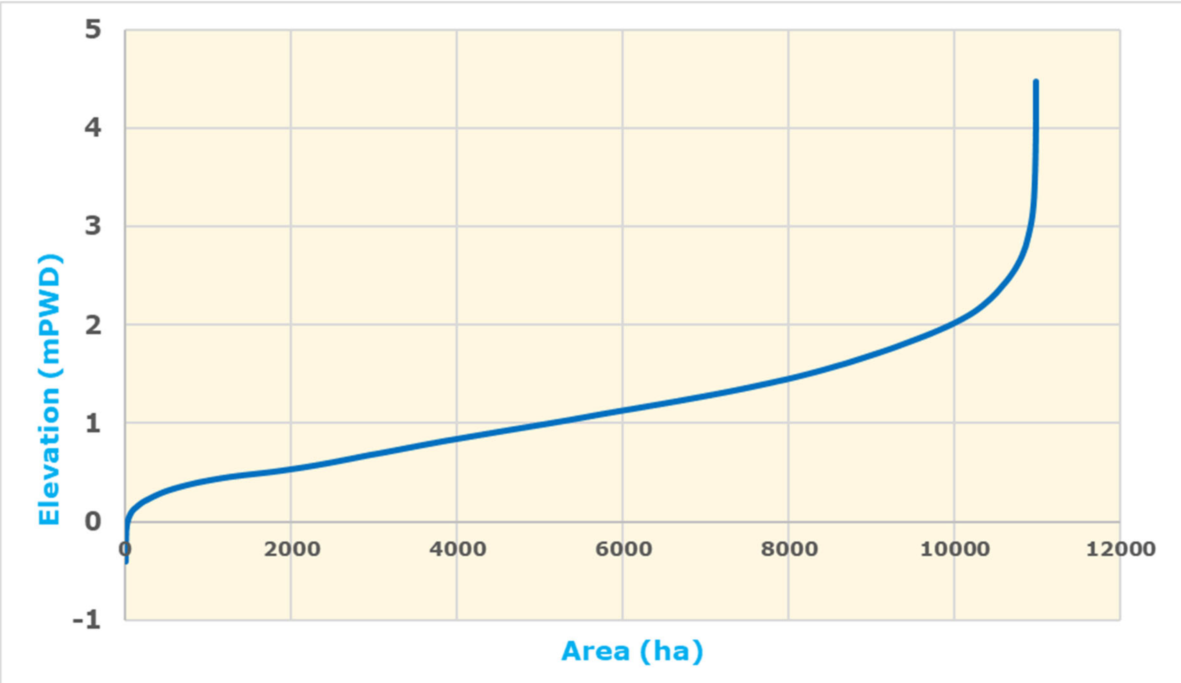



Figure A5.4: Area Elevation Curve of Polder 7/2

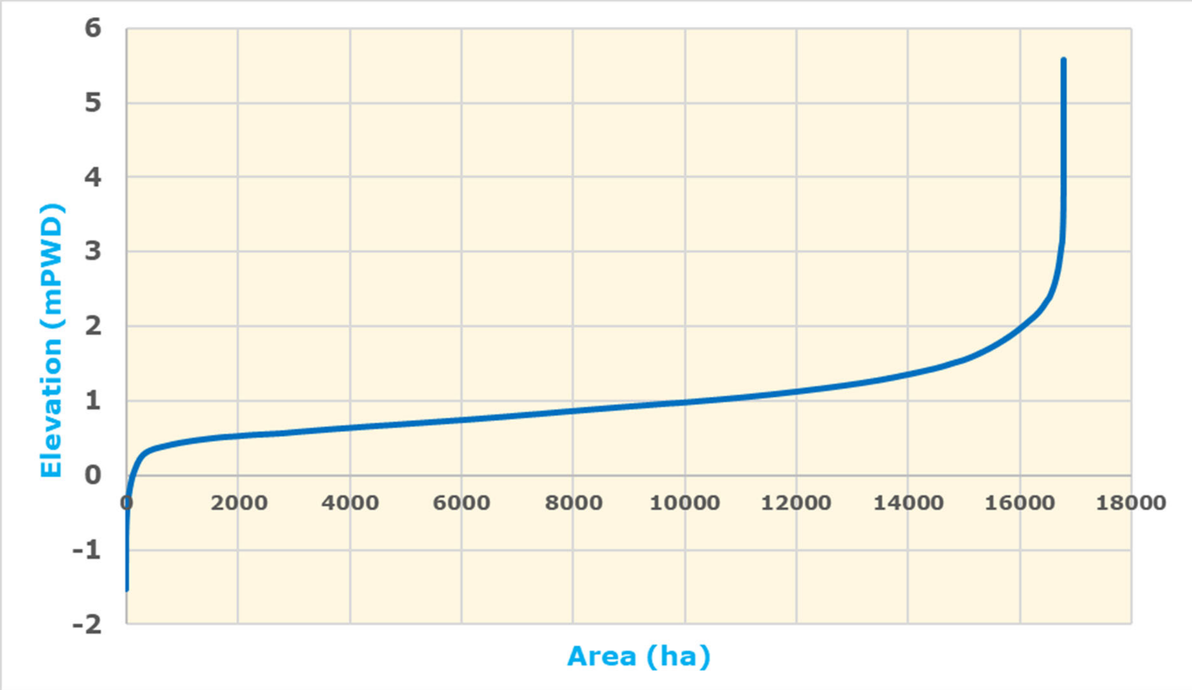



Figure A5.5: Area Elevation Curve of Polder 10/12

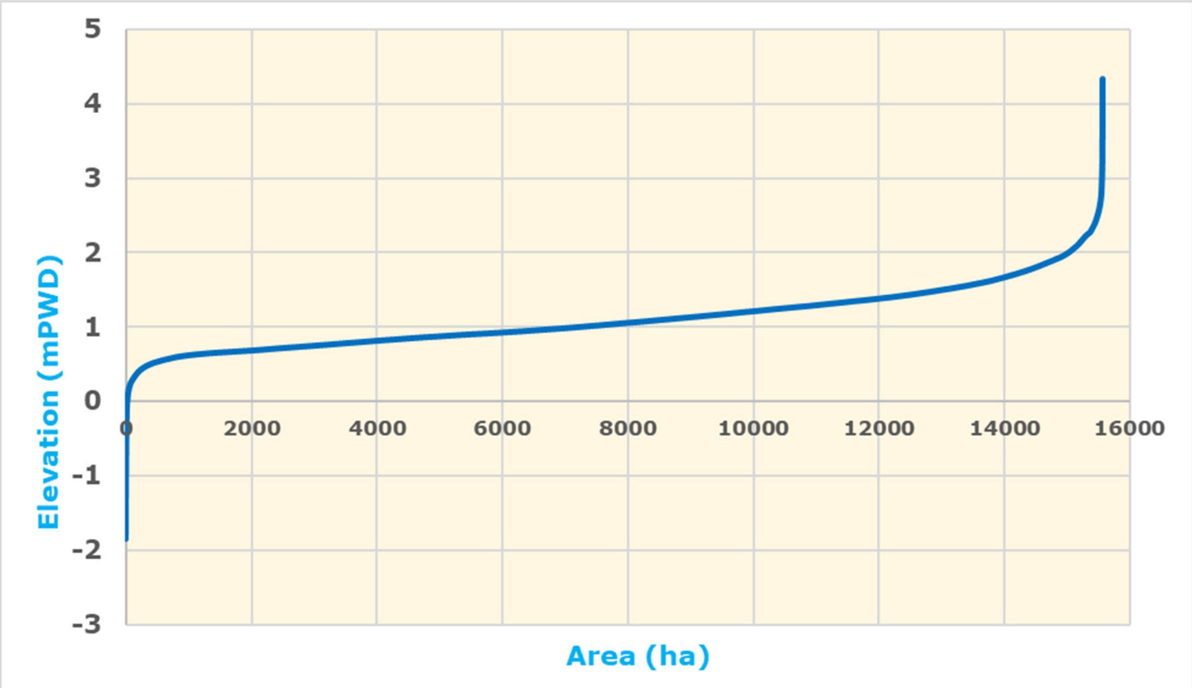



Figure A5.6: Area Elevation Curve of Polder 13-14/2

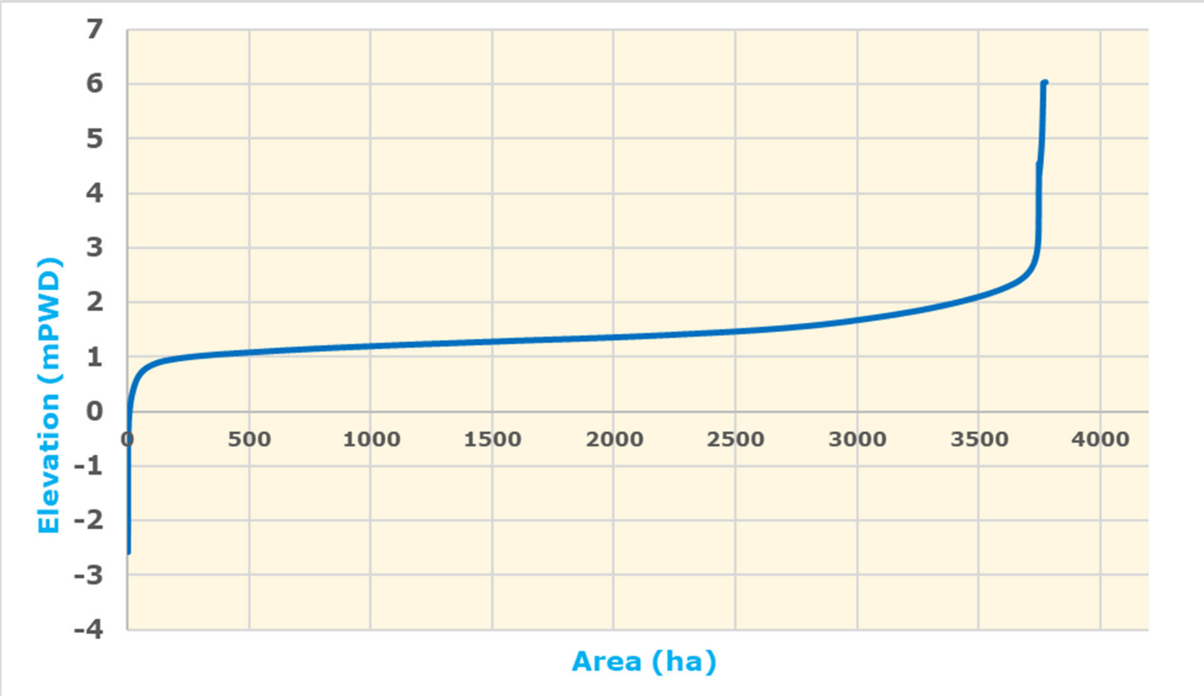



Figure A5.7: Area Elevation Curve of Polder 41/5

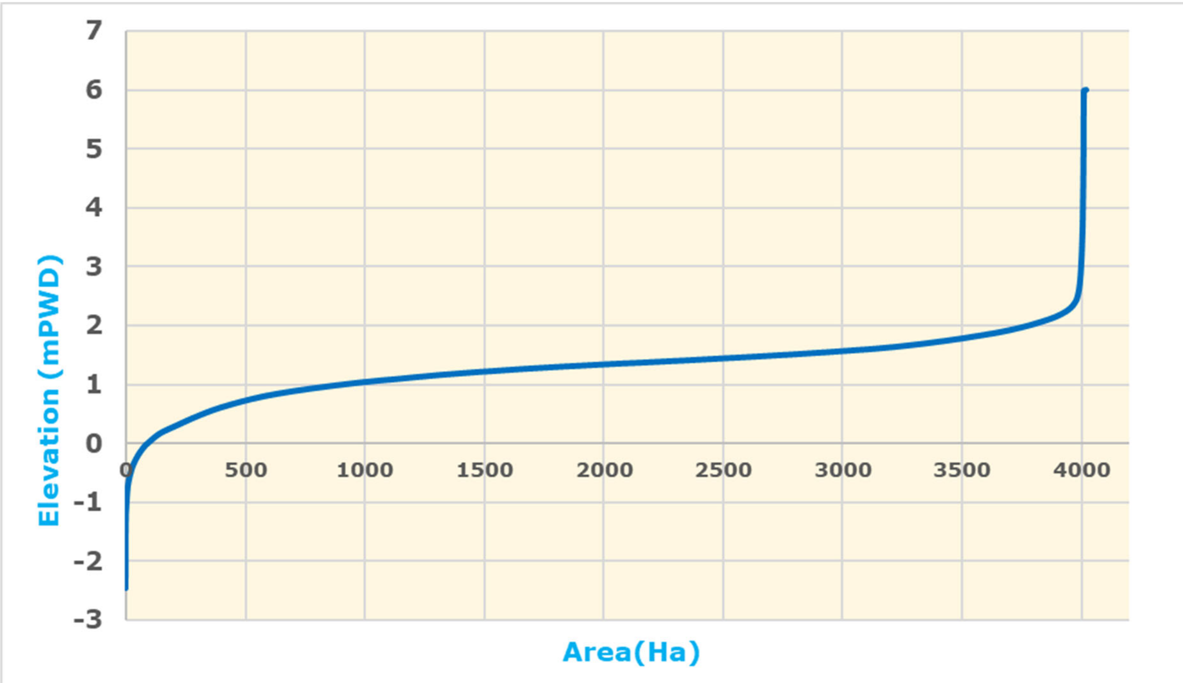



Figure A5.8: Area Elevation Curve of Polder 45

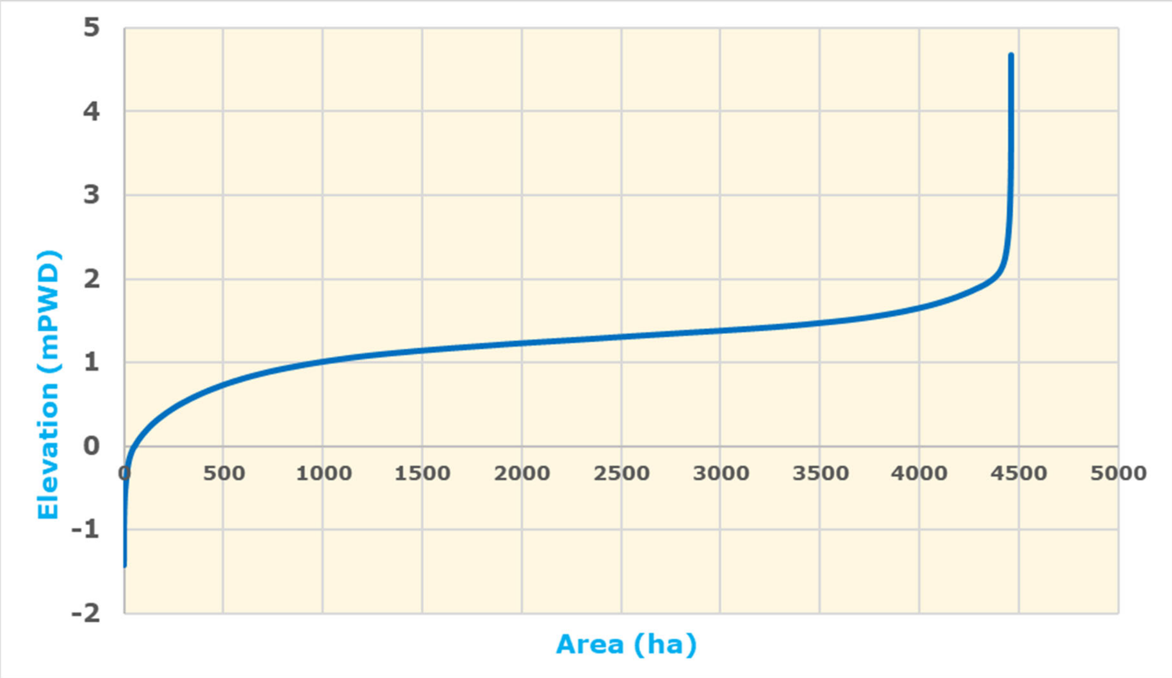



Figure A5.9: Area Elevation Curve of Polder 50-51

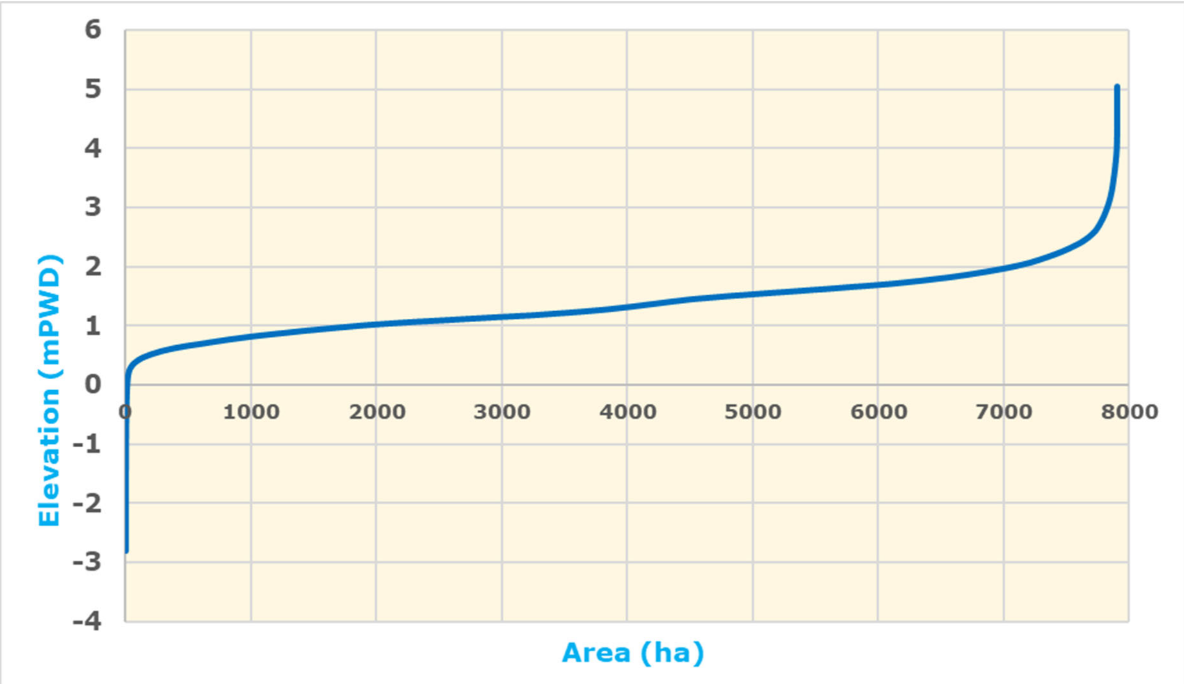



Figure A5.10: Area Elevation Curve of Polder 55/2D

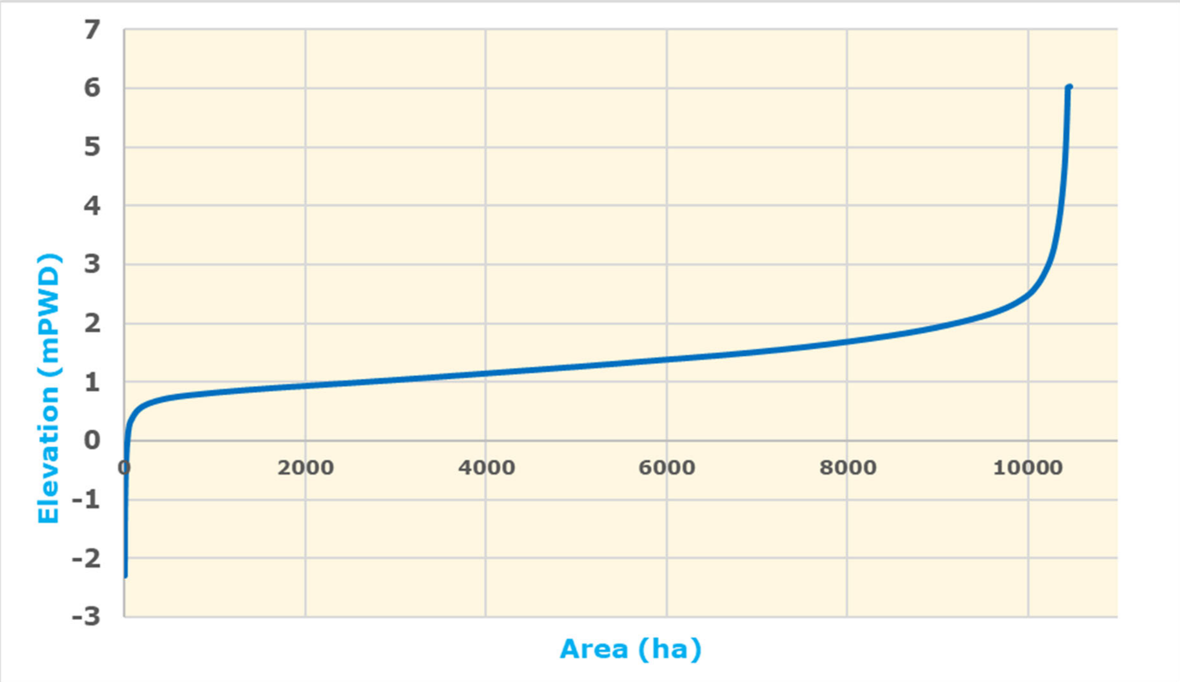



Figure A5.11: Area Elevation Curve of Polder 39/1B

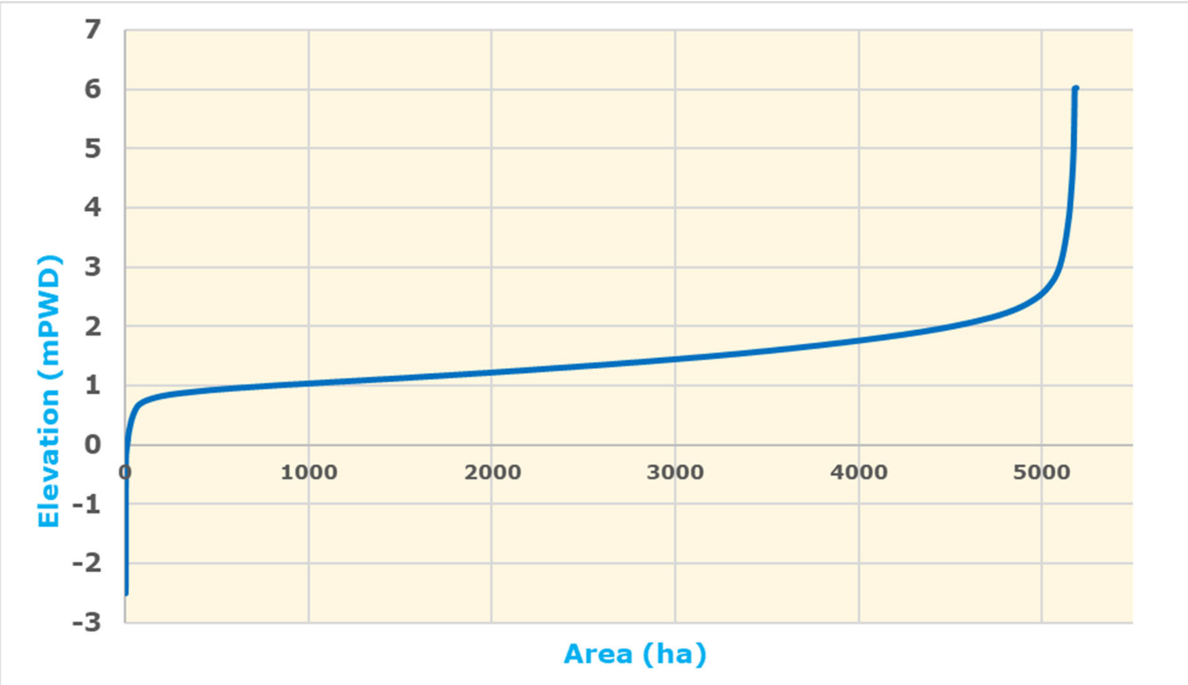



Figure A5.12: Area Elevation Curve of Polder 39/1C

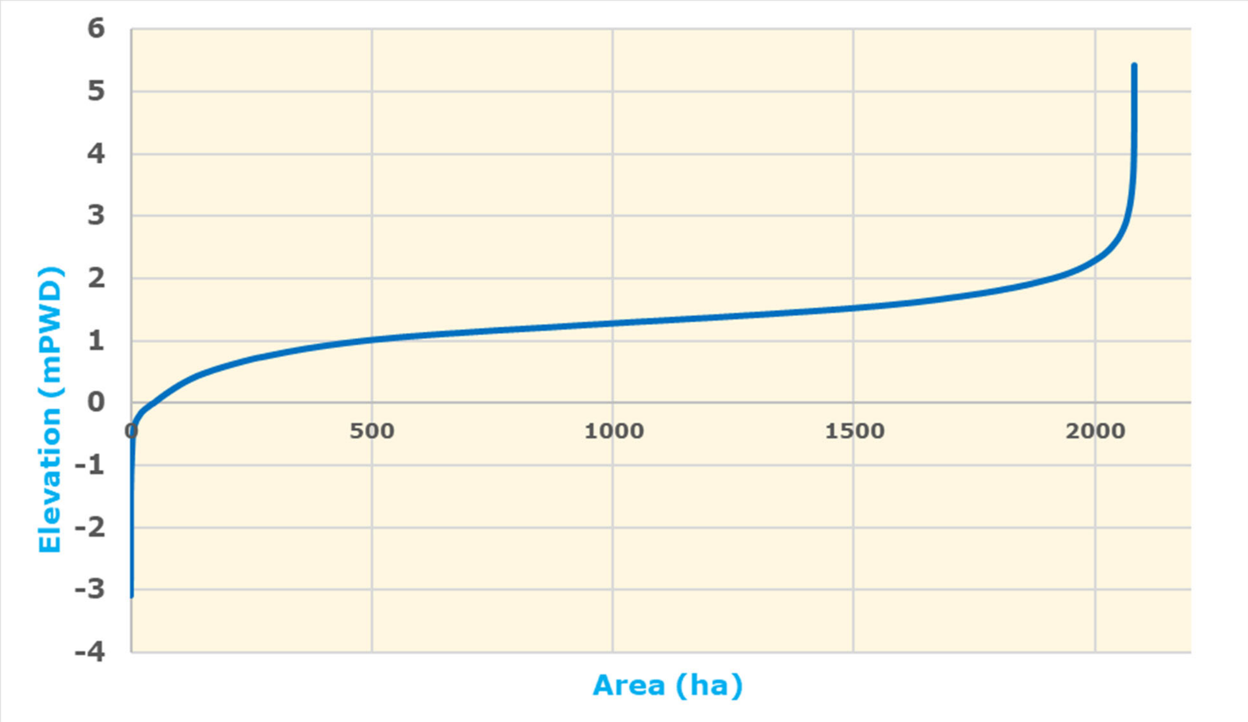



Figure A5.13: Area Elevation Curve of Polder 47/1