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A STUDY ON THE OPTIMIZATION OF DREDGING ALIGNMENT, PROPOSED RIVER TRAINING AND BANK PROTECTION WORKS AROUND JAJIRA-NARIA

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Abstract

This paper presents the results for finalization of the proposed dredging alignment & design, performance of the bank revetment for bank protection and effectiveness of the required river training works for land reclamation in the Padma river around Jajira & Naria upazila under Shariatpur district using scale modeling. The river reach of 36.0 km of Padma upstream of Padma-Meghna confluence at Chandpur and the river reach of 15km upstream & 5km downstream of confluence along the Meghna have been reproduced in this study. Different application test are conducted with different test scenarios (introducing revetment, dredged channel & T-head groynes) using different discharges. The total length of dredged channel is 11.8 km. It was found that dredged channel is mostly found to be silted up. It is also found that the dredged channel is partially silted up at average annual discharge (30,000 cumec) but at 100-year return period discharge (1,30,000 cumec), it is almost fully silted up. Therefore, if it is intended to maintain the proposed dredged channel, regular maintenance dredging would be required. At the end of the test, the percentage of siltation on average is measured about 70% fully silted of its length (at the upstream) and the rest part partially silted (at the downstream). The proposed revetment (9.35km) tested in different tests works well and it is recommended to implement in the field. It is necessary to implement the bank revetment in the field immediately for the protection of the problem area and to prevent the bank erosion in the coming year. The location, alignment, dimension and spacing of groynes tested in the recommended test is suggested to implement in the field as it provides better result. The proposed groynes are expected to divert the flow towards the mid-stream and to facilitate land reclamation by sedimentation between the groynes.

Keywords: *Padma river, bank protection, dredging, optimization, river training works and land reclamation.*

Introduction

The Padma carries immense volumes of water and constantly shifting its main channel due to the emergence of chars (sand bars) and islands at different locations of the river near Jajira and Naria upazilla in Shariatpur district. Apart from these, it has been eroding vast areas on one bank due to the collective effects of huge current, wave, tidal influences and upstream torrents. The outer (concave) bank of the river is gradually advancing towards the country side and the bend is becoming gradually sharper. This process of bank erosion is typical to the Padma and other major rivers of Bangladesh.

Recently severe bank erosion occurred at Naria. upazilla health complex, bazar, mosque, educational institutions, important roads, homestead etc. have already been engulfed by the river. The Kundeshwar, Sureshwar Launch Ghat Terminal and Chandipur bus stand area are also vulnerable to massive erosion of the Padma river. As a consequence, erosion affected people have been compelled to take shelter elsewhere losing their ancestral homes. Furthermore, education is hampered and hence, poverty is intensified in that region making the people unhappy, upset and frustrated.

Scale modeling is a tool to investigate the hydraulic and morphological impacts of any kind of intervention into a river system or on its floodplains. This tool has been widely used in the field of river engineering to support river management in terms of flood management, bank erosion management and sediment management as well as to provide decision support in optimal planning and design of different water infrastructures.

River dredging has often been employed to manage sediment for keeping the river dynamic and navigable. The overall objective of the physical model study is to investigate the efficacy of dredging options along Sureshwar and neighboring areas under Jajira and Naria upazilla in Shariatpur district and to investigate the hydraulic and morphologic effects of the dredging in relation to changes in flow field, sedimentation and river bank erosion.

Methodology

An overall morphological model investigation is carried out in order to achieve the study objectives. The study area is located at the dynamic Padma-Meghna confluence which

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influences the morphological developments in the study area. Moreover, it appears from the satellite images that the river stretch between Mawa and Chandpur may be considered as a reach where river pattern is braided. Therefore, the model extent should cover a river stretch between Mawa and Chandpur together with a river stretch of the Lower Meghna river starting from the confluence. The length of river reproduced in the overall distorted morphological model is tentatively about 36km along Padma upstream of its confluence with Meghna; about 15km upstream & 5km downstream of confluence along the Lower Meghna.In this scale model, various types of instrument and facilities are needed such as, a sharp-crested weir for measuring flow, point gauge for measuring water level, 3-D current meter for measuring velocity, high resolution camera for taking video and photographic view of model, stopwatch for taking instant time and plastic colored balls (floats) for tracing flow path of flowing water. The discharge in the model is measured using sharp-crested weir at the inflow section using Rebock's formula. Model velocity is quantified by current meter. Water slope can be found by analyzing the water level measurements of different point gauges installed in the model. Flow lines of the stream can be identified by dropping colored balls starting from calibration section and catching them at the end of the model. A stopwatch can be used to calculate surface velocity of the flow. In the scale model, model data requires to be analyzed for interpretation of test results. The initial bathymetry of the model is reproduced based on the collected field survey data collected. The model is calibrated on the basis of prototype water levels, flow velocities and sediment transport data. Manual sediment feeding is done with a view to assess the required rate of sediment feeding during the model run. Continuous monitoring of the model bed is done by taking soundings of the model bed.

Model Setup

An open-air model bed having dimension 100m × 80m of RRI has been selected for overall morphological model development. It provides all kinds of facilities related to model study. Then layout of model is given by grid system. After setting reference grid points in the model, channel planform is given using these grid points and the bed & bank levels are fixed up by levelling instrument as per bathymetry using Rise & Fall method. This requires some cutting and filling of sand from the model bed.

The model is investigated on a mobile bed. The hydraulic similarity is established in the model to a distorted scale. The model is a Froude model and is studied over bathymetry of October/2018. The model is constructed with horizontal scale of 1:600 and vertical scale of 1:80. The model has been designed to fulfil both flow and sediment transport criterion simultaneously. It means the model velocity is higher than the critical flow velocity for the initiation of sediment motion. This is because for any velocity higher than the critical, the scour dimensions are only function of flow direction and structure geometry. The model will, therefore, reproduce the scour holes correctly. The model layout is shown in **Fig.1.**

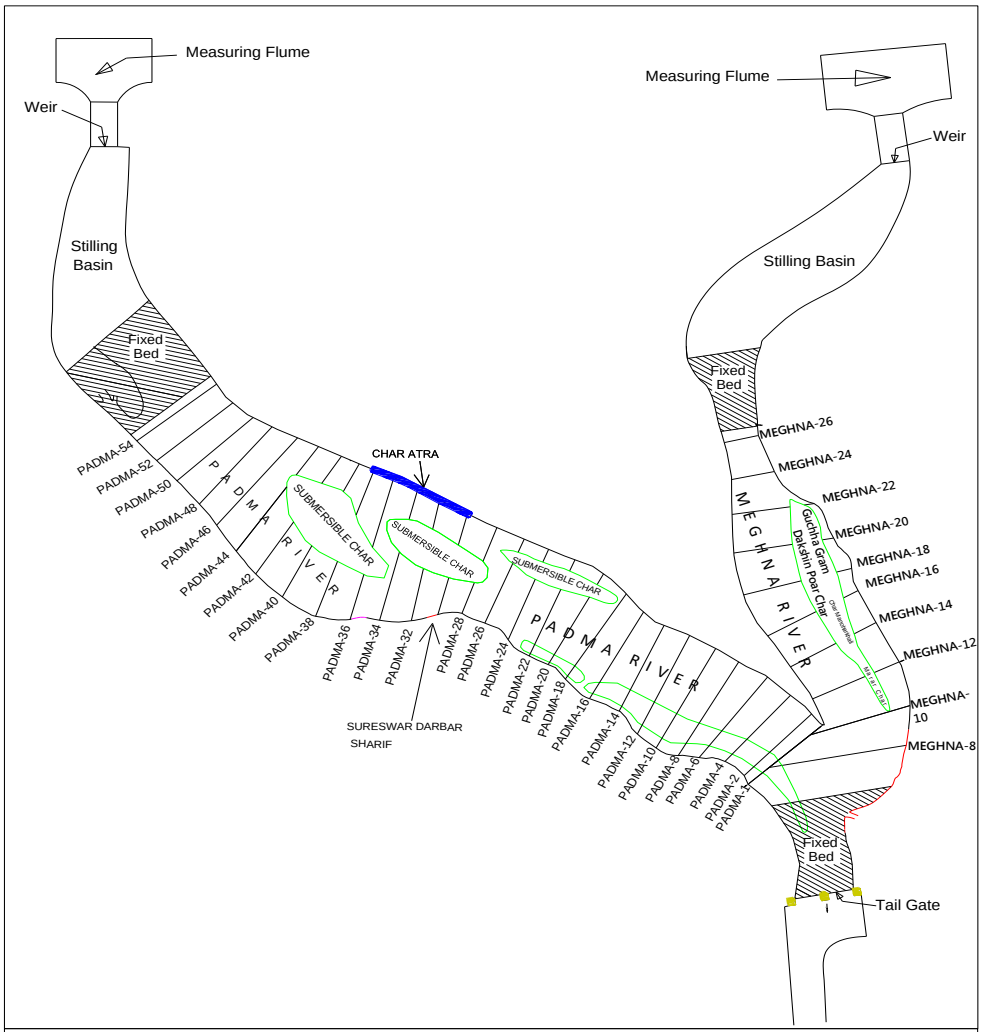

Fig. 1. Layout of the model

Test Scenarios

In this model, calibration test (T0) with existing condition and six application tests (T1-T6) with proposed interventions (dredged channel, revetment & T-head groynes) have been conducted. The proposed test scenarios of these test runs along with various discharge / WL conditions are mentioned in **Table 1.**

Table 1. Test Scenarios of the model

Test No.	Test Program	Flow Conditions
Calibration Test (T0)	Test with existing conditions. The model bed is prepared as per bathymetry of August 2018.	Measured discharge (Q=53,560 cumec) and corresponding water level 4.0 mPWD at C/S24 (3.5 km d/s of Sureshwar Darbar Sharif on the Padma river.
1st application test (T1)	Test as per preliminary design of proposed dredged channel supplied by BWDB + Existing condition	100-year discharge (1,30,000 cumec) and corresponding water level 5.7 mPWD at C/S24.
2nd application test (T2)	Modified alignment/design of dredged channel based on the test result of test T1+ Proposed bank revetment (8.50 km at U/S+0.85 km at D/S=9.35km) supplied by BWDB	100-year discharge (1,30,000 cumec) and corresponding water level 5.7 mPWD at C/S24.
3rd application test (T3)	Bank revetment as tested in T2 + Series of 7 (seven) groynes as proposed by BWDB + No dredging. 3 (three) groynes are big having length of shank & T-head each 1.0 km and the rests are small having length of shank & T-head each 0.5 km. All the groynes are perpendicular to the bankline. U/S & D/S length of T-head of groyne is 0.3L & 0.7L respectively. T-head angle is 60-degree (U/S) & 120-degree (D/S).	100-year discharge (1,30,000 cumec) and corresponding water level 5.7 mPWD at C/S24.
4th application test (T4)	Bank revetment as in test T3 + Modified alignment/design of movable groynes (6 nos.) as proposed by BWDB having shank length 1000m, 1300m, 360m, 400m, 500m & 500m and corresponding T-head length (L) 500m, 400m, 360m, 400m, 500m & 500m respectively) + No dredging. All the groynes are perpendicular to the bankline. U/S & D/S length of T-head of groyne is 0.7L & 0.3L respectively. T-head angle 80-degree (U/S) & 100-degree (D/S).	100-year discharge (1,30,000 cumec) and corresponding water level 5.7 mPWD at C/S24.
5th application test (T5)	Bank revetment as in test T4 + Series of 6 (six) groynes as proposed by BWDB having shank length (L) 1000m, 1300m, 400m, 400m, 500m & 500m and T-head length (L) 500m for each groyne + Dredging as in test T2. All the groynes are perpendicular to the bankline. U/S & D/S length of T-head of groyne is 0.7L & 0.3L respectively. T-head angle 70-degree (U/S) & 110-degree (D/S).	100-year discharge (1,30,000 cumec) and corresponding water level 5.7 mPWD at C/S24.
6th application test (T6)	Bank revetment as in test T5 + Series of 7 (seven) groynes as proposed by BWDB having shank length (L) 1000m, 1300m, 500m, 400m, 400m, 500m & 500m and T-head length (L) 500m for each groyne + Dredging as in test T5. All the groynes are perpendicular to the bankline. U/S & D/S length of T-head of groyne is 0.7L & 0.3L respectively. T-head angle 70-degree (U/S) & 110-degree (D/S).	Average annual discharge (30,000 cumec) and corresponding water level 2.3 mPWD at C/S24. Measured discharge (53,560 cumec) and corresponding water level 4.0 mPWD at C/S24. 100-year discharge (1,30,000 cumec) and corresponding water level 5.7 mPWD at C/S24.

Results and Discussion

The effectiveness of the proposed groynes in test T6 was found best in terms of flow diversion and sediment deposition trend between the groynes with varying discharges and water levels and present river flow pattern (**Fig. 2-4**). The performance of the dredged channel was found better compared to other tests. Dredged channel was found to pass significant amount of flow at the initial stages of model run. The rate of siltation through the channel was observed more during the model run of high discharge and water level, because more sediment is carried out at this condition and the water flow spreads all over the char land. But at the end of the model run the upstream part of the dredged channel found almost to be silted up. That means regular maintenance dredging would be required to keep active the dredged channel if dredging is implemented in the prototype. It also appears from the test that bank revetment is sufficient to combat bank erosion at Jajira-Naria but it could not be useful for land reclamation

T-head groyne and bank revetment together can arrest bank erosion and reclaim land properly. The effectiveness of dredged channel, groynes and bank revetment as observed after model run (T6) is shown in **Fig. 5**. The typical cross section showing silting trend at different discharges is shown in **Fig. 6**. The bed topography at the end of model run is shown in **Fig. 7.**

Tremendous turbulence with eddy and vortex was developed at the existing Sureshwar bank protection area that requires special attention/strengthening. Bank erosion at the downstream of Sureshwar protection was also noticed but in a smaller reach. Bank erosion at the left bank was also prominent in particular with flood discharge.

Fig. 2. Model area before run (T6)

Fig. 3. Flow diversion by the groynes during model run (T6)

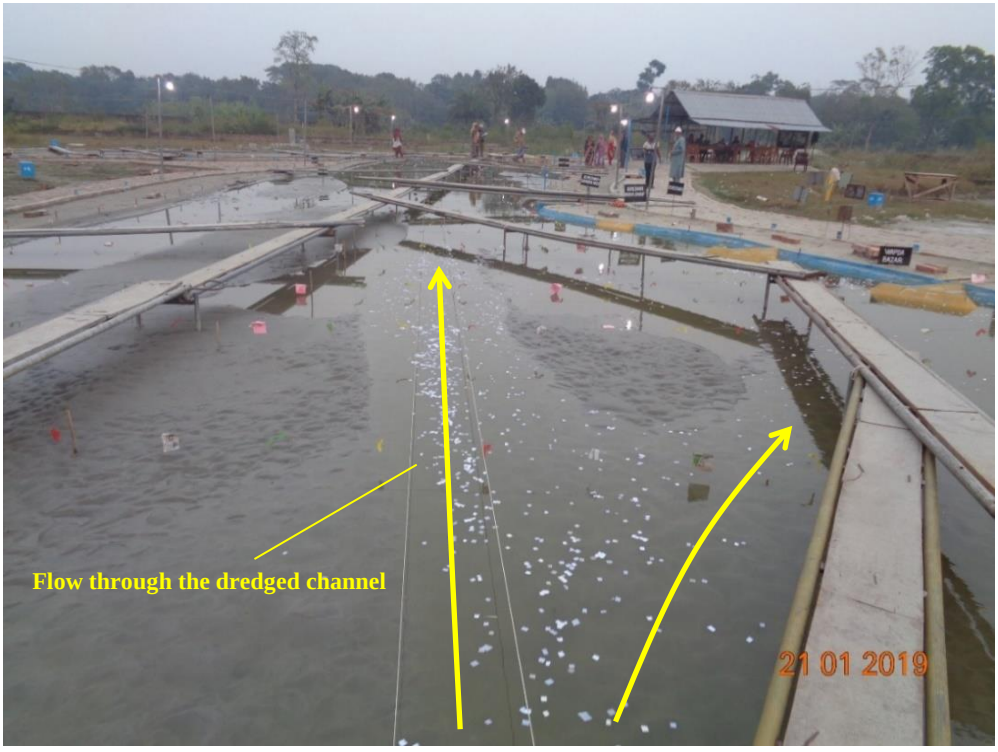

Fig. 4. Flow through the dredged channel at low flow (T6)

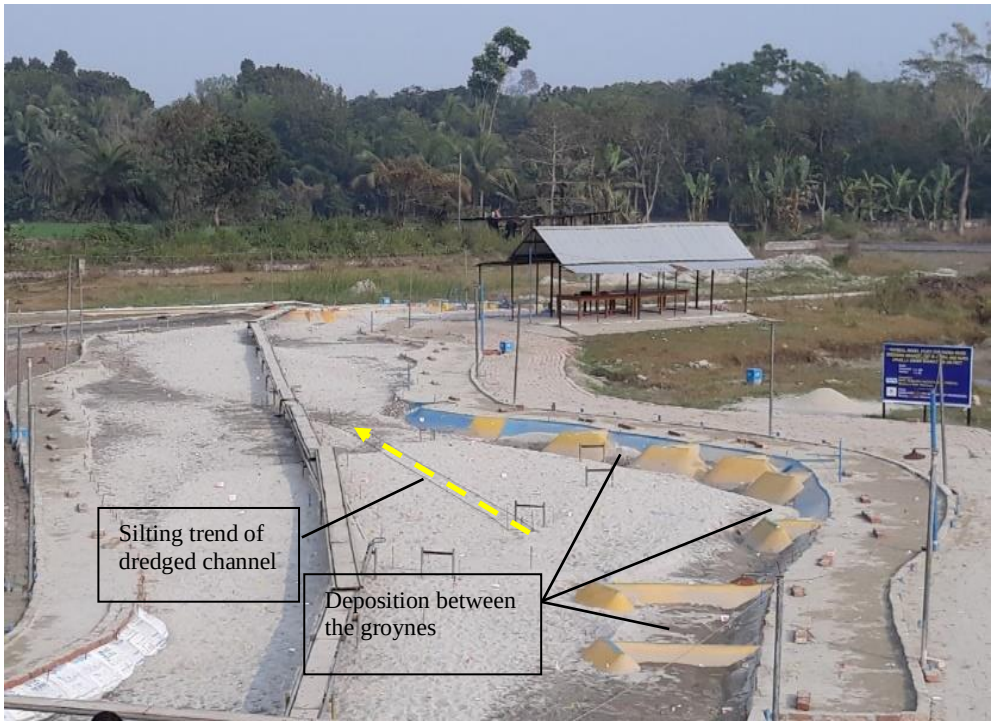

Fig. 5. Effectiveness of dredged channel, groynes & bank revetment as observed after model run (T6)

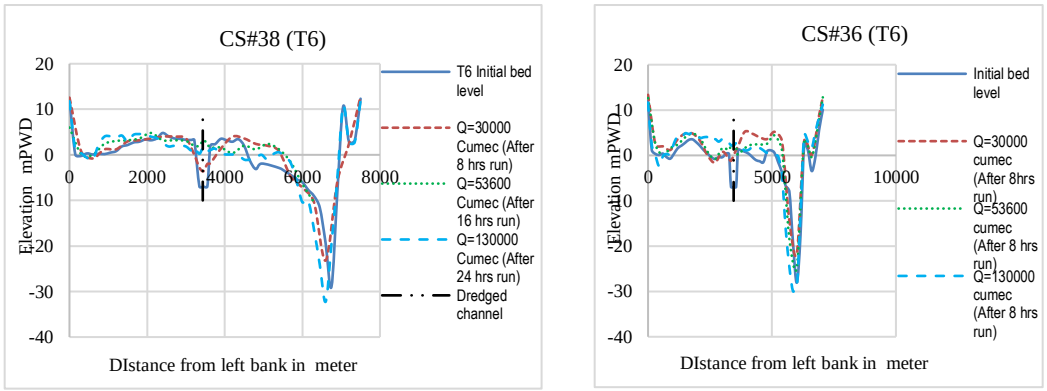

Fig. 6. Typical cross section showing silting trend at different discharges

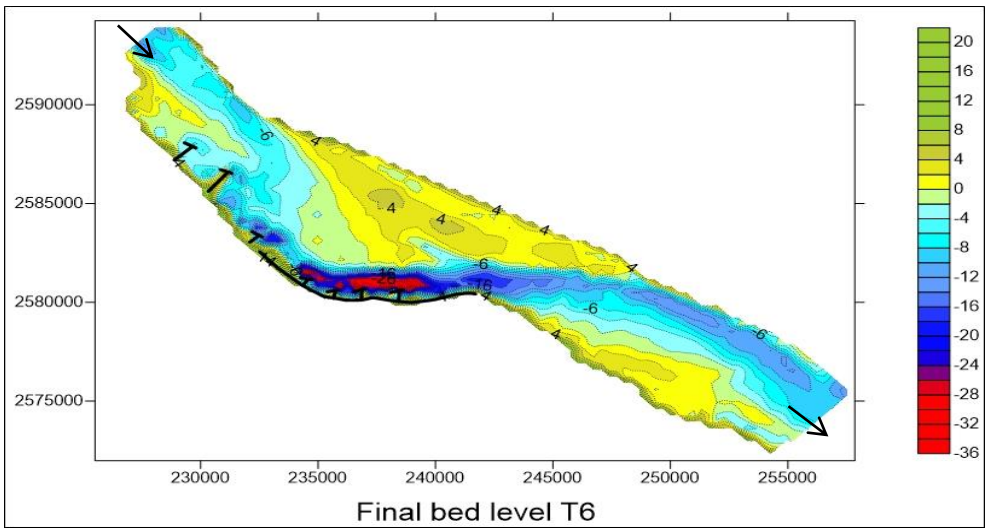

Fig. 7. Bed topography at the end of model run

Conclusion

- It was found from the calibration test that near bank velocity concentration at Naria - Jajira was severe to cause right bank erosion. The flow lines in this test also explains bank erosion will continue at this area if appropriate bank protection measures are not taken immediately.
- Velocity at the left bank in the calibration test was also large enough to cause bank erosion which should be taken into consideration.
- Right bank velocity was found to decrease to some extent due to the proposed dredged channel. Even though the velocity at the right bank was high enough to occur severe bank erosion at Jajira-Naria with 100-year discharge (1,30,000 cumec).
- Velocity as well as discharge was increased along the dredged channel in the beginning but at equilibrium condition of the model test, the dredged channel gradually got silted up. The upstream portion of dredged channel is silted up earlier than the downstream portion.
- The proposed revetment introduced at the right bank is found to working well as found from the model study.
- Near bank velocity measured at R/B for different cross-sections of the river model in test T2 varies 0-3.82m/s.
- Maximum velocity measured around groynes in test T6 (Q=30,000 cumec) is 2.61 m/s at groyne #4.
- Near bank velocity measured at L/B for different cross-sections of the river model in test T6 (Q=53,560 cumec) varies 0.48-1.96m/s.
- Maximum point velocity measured in test T6 (Q=1,30,000 cumec) along different cross-sections of the river model reaches up to about 4.50m/s.
- Near bank velocity measured at L/B for different cross-sections of the river model in test T6 (Q=1,30,000 cumec) varies 1.04-3.54m/s.
- Velocity at some selected points around the proposed revetment in test T6 (Q=1,30,000 cumec) was 0-3.9 m/s but about 4.5 m/s at Sureshwar.
- Maximum velocity measured around groynes in test T6 (Q=1,30,000 cumec) is about 4.75 m/s at groyne #7.

- Maximum scour (qualitatively as the model is distorted) measured around groynes in test T6 (Q=1,30,000 cumec) is 21.04 m (-37.28 mPWD) at groyne #7.

- Deposition occurs between the groynes tested in test T6 which is helpful for land reclamation.

- Flow severely attack the existing revetment at Sureshwar Darbar Sharif and proposed revetment immediate u/s and d/s of it due to the groynes tested in test T6. So due care should be taken before implementing of the groynes in the field.
- The total length of dredged channel is about 11.8 km. Dredged channel is mostly found to be silted up. At the end of the test, the percentage of siltation on average is measured about 70% fully silted (at the upstream) of its length and the rest part partially silted (at the downstream).

- Maximum velocity measured around groynes in test T6 (Q=53,560cumec) was about 3.00 m/s at groyne #6.

Recommendation

The proposed revetment (8.50km & 0.85km respectively at u/s & d/s of existing revetment at Sureshwar) tested in different tests works well and it is recommended to implement in the field. It is necessary to implement the bank revetment in the field immediately for the protection of the problem area and to prevent the bank erosion in the coming year.

Test T6 is the recommended test in this study. The location, alignment, dimension and spacing of groynes tested in this test is recommended to implement in the field as it provides better result. The recommended groynes are expected to divert the flow towards the mid river and to facilitate land reclamation by sedimentation between the groynes.

It is found from the model study that the dredged channel is partially silted up at average annual discharge (30,000 cumec) but at 100-year return period discharge (1,30,000 cumec), it is almost fully silted up. Therefore, if it is intended to maintain the proposed dredged channel, regular maintenance dredging would be required.

The dredging activities can be started from the straight end of dredging alignment as per construction facilities and the hokey shaped portion can be done observing the field condition.

Regular maintenance dredging would be required to make active the Kirtinasha river offtake as some deposition was observed in test T6.

Detailed layout of the recommended revetment, T-head groynes and dredged channel is shown in **Fig. 8**.

Existing bank revetment at Sureshwar requires strengthening since flow concentration, turbulence etc. are severe at that location.

BWDB design office supplied initial dredge section, alignment and location which was optimized by different test runs with the presence of the concerned design and field engineers during tests and accordingly the recommendations are made. However, if it is required to modify the recommended dredging alignment due to the morphological changes in the field, in that case it can be done using the experience of the design engineers and field engineers of BWDB having experience in dredge planning, design and implementation.

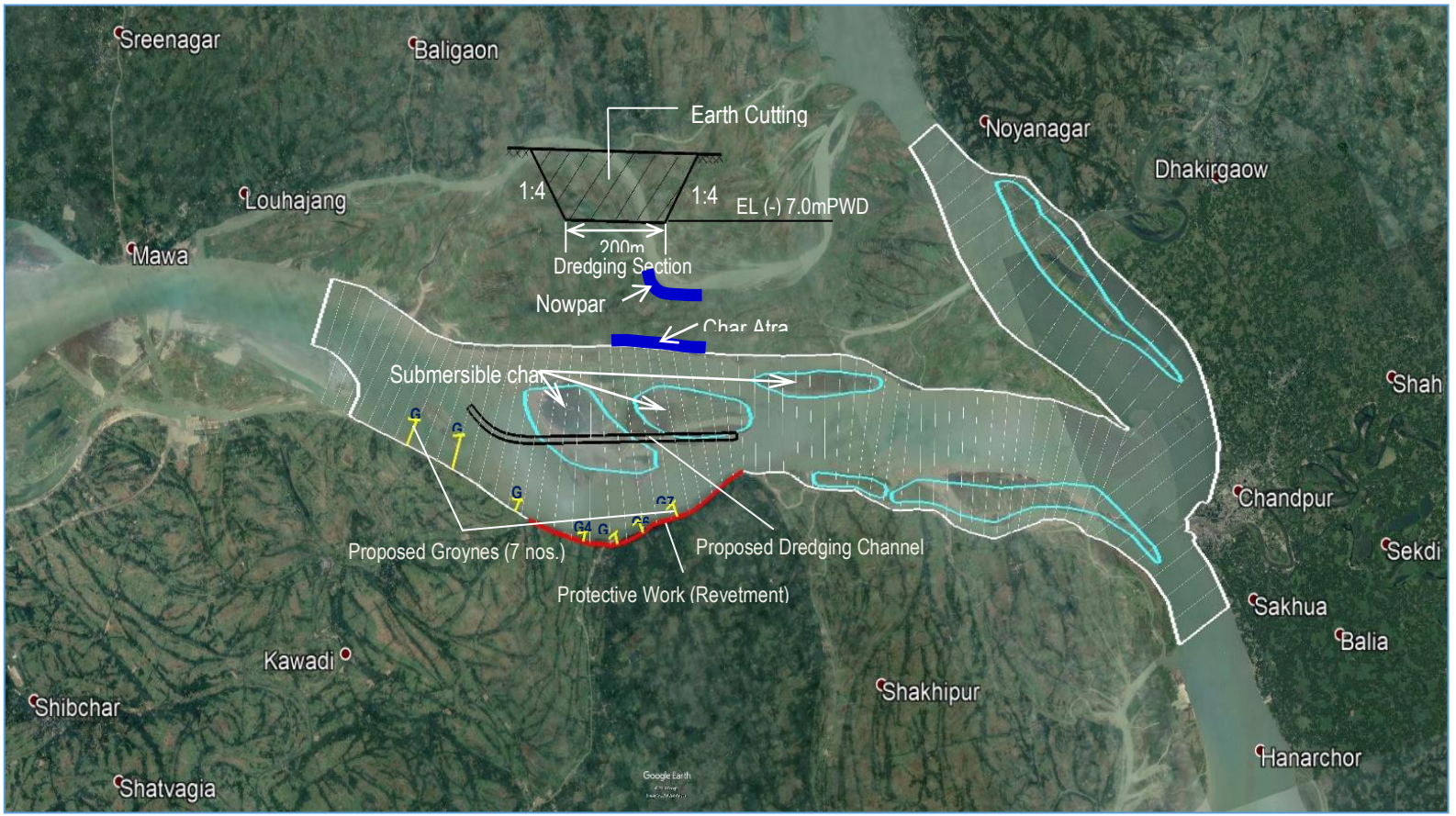

Fig. 8. Detailed layout of the recommended revetment, T-head groynes and dredged channel

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