Morphological Characteristics and Sediment Transport in an Engineered Tidal Freshwater Marsh System

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INTRODUCTION

Sea level rise poses a risk to tidal freshwater marshes. Understanding whether accretion in marshes can outpace sea level rise involves the interactions of marsh morphology, hydraulics, and sediment transport throughout the marsh. The purpose of this study is to investigate whether the constructed morphology of an engineered freshwater marsh has characteristics that facilitate marsh platform sedimentation.

STUDY SITE

Figure 1: Marsh site before construction in 2008 (*left*). Marsh after construction in 2017 (*right*).

The constructed tidal freshwater marsh is in the Anacostia River, Hyattsville MD. Construction began in 2009 and was completed in 2010 (Figure 1).

HYPOTHESES

Morphology: The constructed marsh drainage density, channel width distribution, and submerged vegetated platforms differ significantly from natural marshes.

Sedimentation: Channel extent and depth limit the transport of sediment into the marsh platform. Sediment will be deposited on channel beds, particularly in locally widened sections of channel and in small channels with shallow depths.

Null Hypothesis: The constructed marsh network and channel characteristics are not significantly different from natural or theoretical marsh channel characteristics.

REFERENCES

1. Langbein, W.B., (1963) The hydraulic geometry of a shallow estuary. *Bulletin of the International Association of Scientific Hydrology*, 8, p 84-94.

METHODS

Cross-section measurements were taken at 13 locations (Figure 2). Tidal stage was measured at 5 locations during an outgoing spring tide to determine water surface slope , S.

Water surface gradient: $S = \frac{(Gh_{up} - Gh_{down})}{\Delta L}$ →

Shear velocity: $u* = \sqrt{gdS}$ →

Rouse number: $\frac{w}{u*} = \frac{\text{particle fall velocity}}{\text{shear velocity}}$

The distribution of channel width was compared to the exponential decrease in width observed in natural marshes and theory.[1]

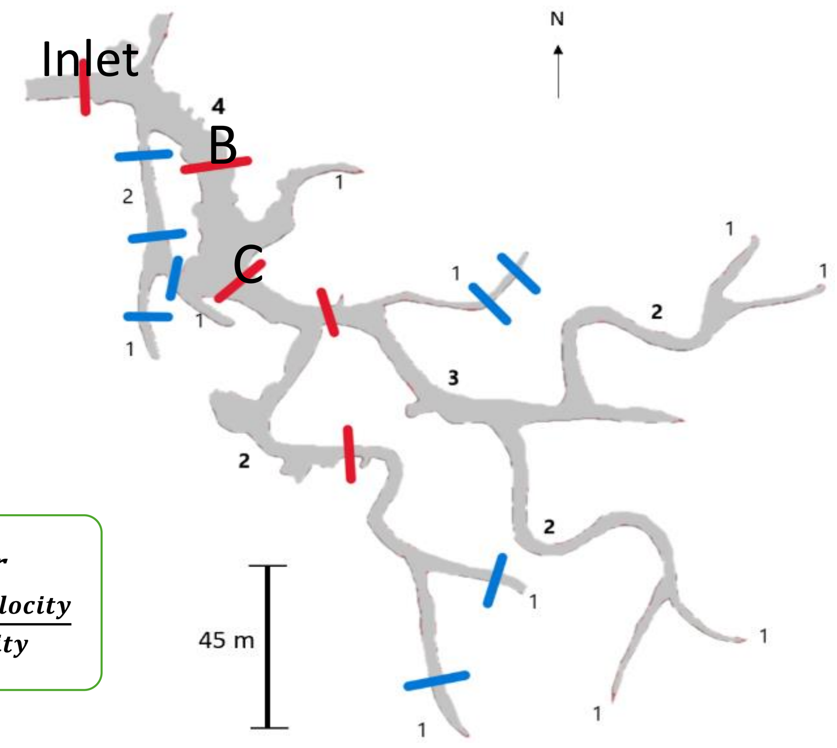


Figure 2: Locations of cross-section measurements.

RESULTS: MORPHOLOGY

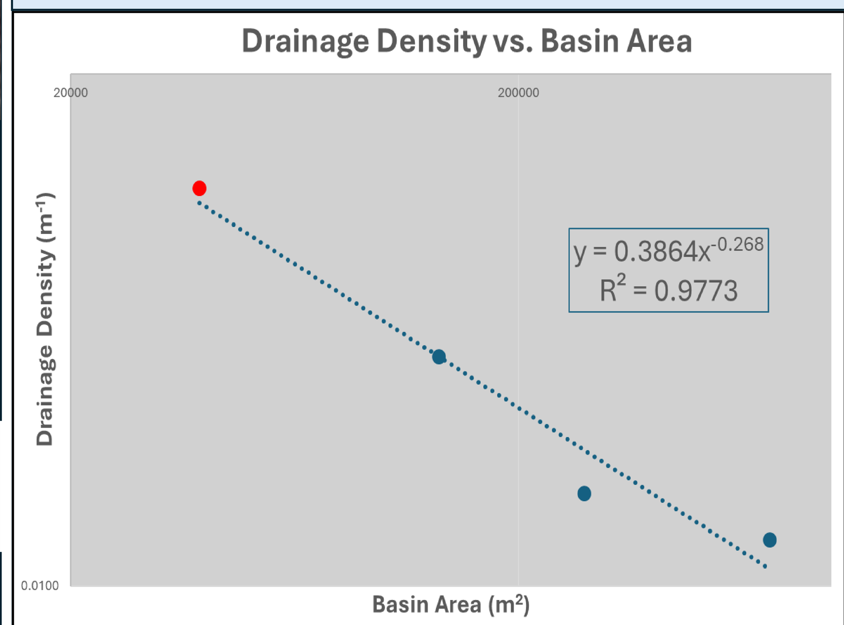
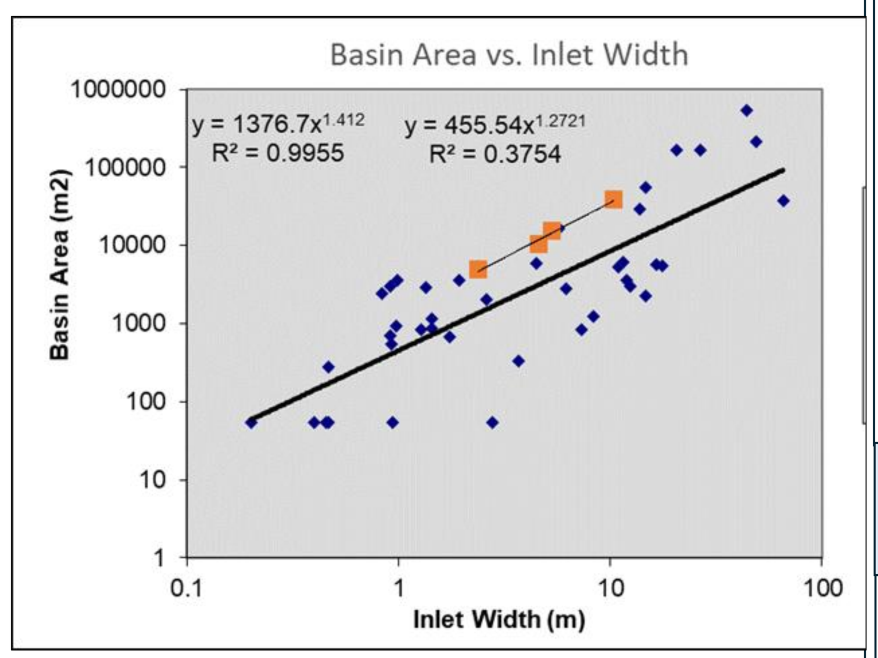


Figure 3 (left): The Anacostia marsh (red) has higher drainage density than the Patuxent marshes (blue), but this is consistent with observed decreases in drainage density with basin area.

Figure 4 (right): Inlet Widths of the Anacostia marshes (red) are within the range of the Width-Basin area relationship of Patuxent marshes but have lower widths than predicted by the average Patuxent relationship.



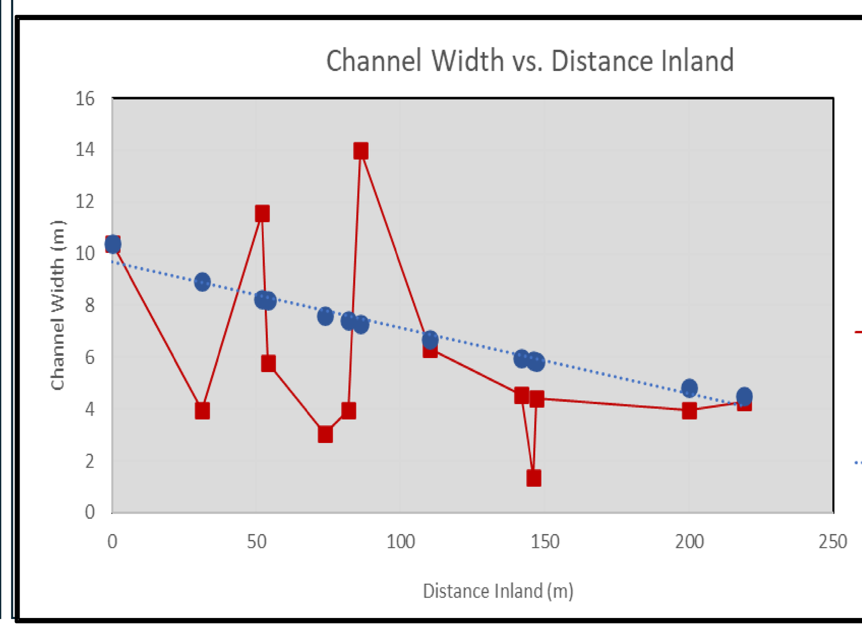


Figure 5 (left): The inlet width is narrower than up-marsh widths. The channel widths (red) do not show a negative exponential decrease with distance into the marsh. The blue line indicates a linear decrease in width. Channel at 50 and 100 meters are wider than the inlet.

RESULTS: SEDIMENT SUSPENSION

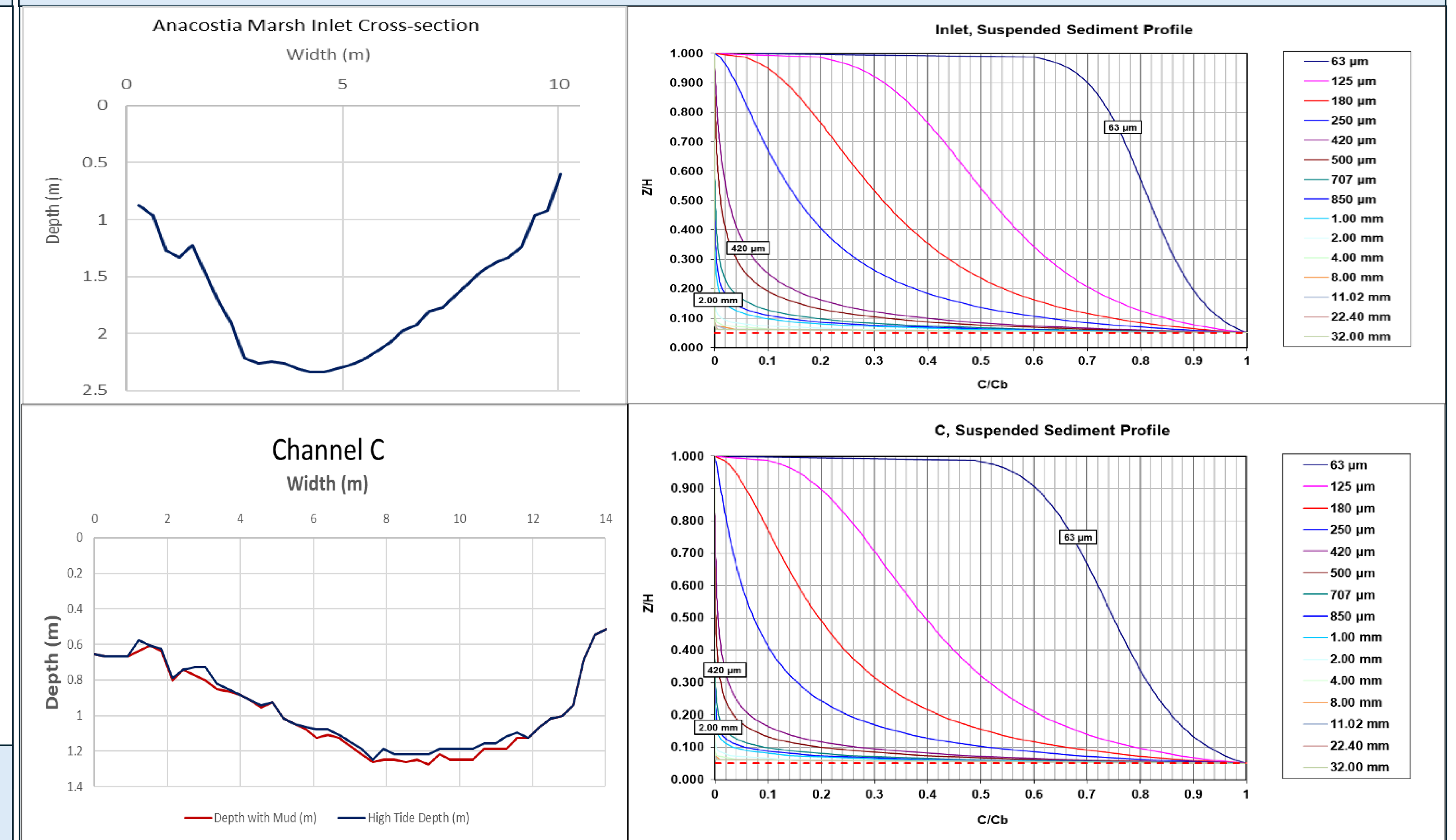


Fig. 6: Channel cross sections and theoretical suspended size distributions for the inlet and Channel C.

At high tide, maximum depth in the inlet was 2.4 m, significantly deeper than the upstream channels (Channel C upstream is 1.2 m deep). Although there is significant submergence of the tidal platform at high tide, the rapid increase in width and decrease in depth up-marsh from the tidal inlet limits the size of sediment that can be transported onto the marsh surface. Sediment deposition was measured at the bed of upstream channels (Figure 6) during the cross-section surveys. The high depth at the inlet would also generate a higher velocity than the shallower cross sections further inland, which may have caused the erosion and widening of the up-marsh channels. The maximum grain size carried onto the marsh platform was 125 μm for the inlet, but only 63 μm for channel C.

CONCLUSIONS

- The main morphological difference between the constructed marsh and natural marshes is the narrow, deep inlet.
- Channel width increased up-marsh from the inlet and a negative exponential distribution of widths was not observed.
- The local channel widening was reflected in the Rouse-Vanoni profiles, with Channel C carrying a smaller suspended sediment concentration than other channels.
- Deposition on channel beds in widened reaches was observed in the field.