APPENDIX A

Habitat Valuation

Appendix A

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NOYES CUT, GEORGIA
Section 1135 Study

Restoring Tidal Exchange in a Complex Estuarine Environment

Problems and Objectives: The Satilla River estuary contains a complex network of tidal channels. From 1900 to 1939, eight man-made cuts were made between natural channels to increase the accessibility of the tidal creeks (Figure 1 below). These cuts changed the circulation patterns in the estuary and (1) altered local patterns of tidal exchange; (2) disrupted gradual salinity gradients from the headwaters to the mouth of the creeks; and (3) reduced access to headwaters for estuarine species due to channel sedimentation. Dover and Umbrella Creeks are the primary creeks within the system and serve as both key habitats and primary routes for movement of organisms and water. Salinity gradients provide a variety of estuarine animals the directional cues for local movement and long-distance migration essential for completing their life cycles. The overarching goals of this potential Section 1135 restoration project are to restore key estuarine habitats for resident species (e.g., blue crabs) and increase connectivity for migratory species (e.g., striped bass).

Alternatives: To achieve these goals, this project will alter the hydrodynamic environment, which will in turn restore salinity gradients, reduce local sedimentation issues, and increase connectivity for local biota. Preliminary alternatives focus on closing a combination of one or more man-made cuts (e.g., Noyes, Bull Whirl, Dover) to alter tidal exchange in Dover and Umbrella Creeks (Figure 2). Closing cuts is anticipated to restore historic conditions of salinity regimes and increase connectivity for local fauna.

Currently, salinity gradients are altered by a large volume of Satilla River water entering through the short pathway of Noyes Cut. This large volume of estuarine water overwhelms the freshwater that enters the headwater area and causes the salinity to be nearly constant throughout most of Dover Creek. Additionally, tidal flows through multiple creeks and cuts causes a tidal node where sediment deposition clogs channels. Reduced tidal exchange through man-made cuts should restore water depths in Dover and Umbrella Creeks, which have silted in as a result of changes in circulation patterns. This sedimentation has restricted access to portions of the rivers by shrimp, shellfish, and migratory fish.

Another benefit of closing Noyes, Bull Whirl and/or Dover Cuts would be restoration of a natural tidal exchange distribution from downstream to upstream as typically occurs in unaltered tidal creeks. This distribution should eventually redistribute the sediments, create a sandier, deeper creek bottom, and restore gradual salinity gradients from headwaters to mouth. Salinity gradients are key not only for maintaining tidal exchange processes (e.g., sediment, nutrients, carbon) but also serve as important cues for orienting migratory fauna.

Evaluation of Alternatives: The estuarine species historically found in Dover and Umbrella Creeks include shrimp (white and brown), river herring, American shad, blue crabs, eastern oyster, and striped bass. All of these species may benefit from the restoration of tidal exchange, water depths, and salinity gradients in the area. Shad, herring, and striped bass require freshwater for spawning, while blue crabs, oysters, and shrimp require brackish water for successful reproduction. Potential indirect long-term benefits of restoring depths and flows in the study area may include increased dissolved oxygen (DO) levels; decreased Total Suspended Solids (TSS); improved nutrient exchange between the Satilla River, St. Andrews Sound, and the Atlantic Ocean; and Essential Fish Habitat (EFH) for offshore species dependent on estuarine environment for early life stages. In addition to the intended ecosystem benefits, ancillary benefits would include the return of commercial fishing and crabbing and sport fishing in Dover and Umbrella Creeks for the aforementioned species. Residential deep water access would also be restored to residential developments adjacent to the estuary that currently have access only at high tide.

Savannah District proposes to quantify some of the benefits from each alternative by calculating the amount of tidal exchange (exchange volume) in multiple locations throughout Dover and Umbrella Creeks. Exchange volume serves as an important surrogate for the restoration of salinity gradients, which influence the wide variety of species occurring in the estuary. Additionally, exchange volumes may be used to assess the predictability of the salinity regime in the estuary and the degree to which it represents the unaltered condition needed for estuarine fauna (i.e., expected upstream-to-downstream, fresh-to-saline patterns).

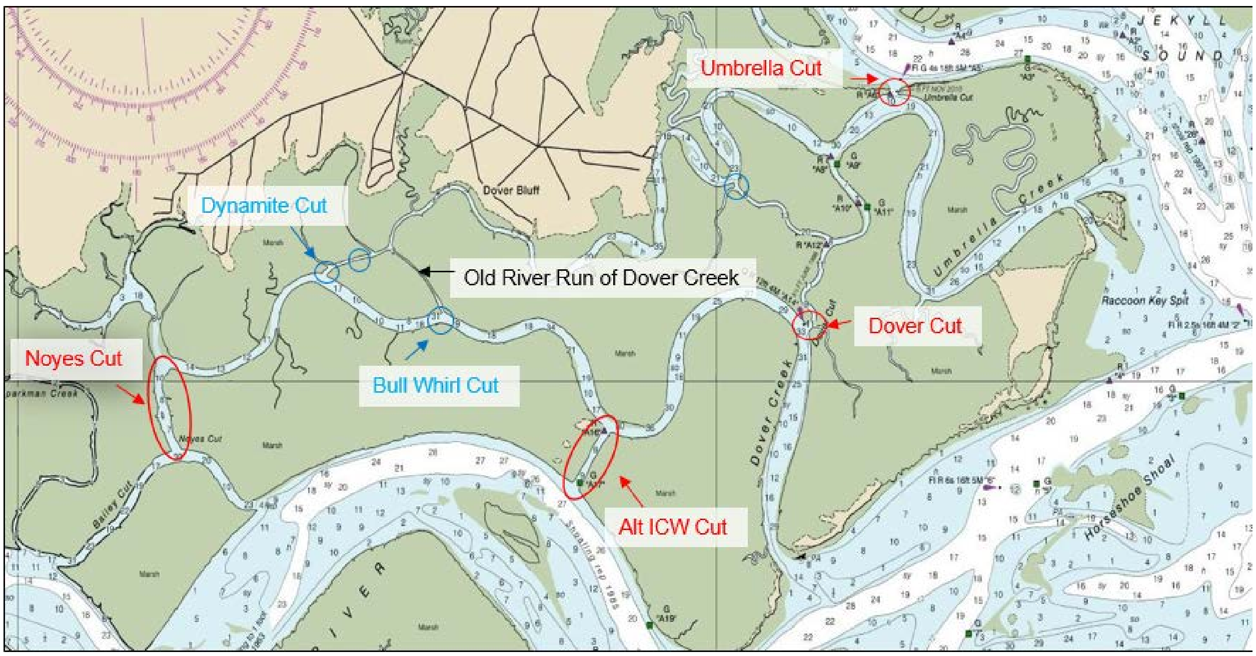

Figure 1: Satilla River estuary with series of navigation cuts. Congress authorized cuts depicted in red. Blue cuts were created by local citizens.

The following table calculates the amount of benefit for each alternative from the amount of flow change (flux). Each column represents the change in flow at the specific data point, which is multiplied by the corresponding acreage (Figure 2) represented by the data point. The total of habitat units for each alternative is the result of cumulative total of flow change throughout the 10 data points/habitat areas.

Delta Change from Base Condition, in terms of CMS %.
A negative number reflects a reduction in flux. Positive number reflects a gain in flux.

Alternative 1	Env 4 (860 Ac.)	Env 5 (166 Ac.)	Env 6 (215 Ac)	Env 7 (297 Ac)	Env 8 (489 Ac)	Env 9 (555 Ac)	Env 10 (474 Ac)	Env 11 (282 Ac)	Env 12 (744 Ac)	Env 13 (437 Ac)		Avg Annual
Noyes	% Change	% Change	% Change	% Change	% Change	% Change	% Change	% Change	% Change	% Change		HUs
Mean Tide Flood	22%	-5%	-129%	5%	3%	5%	3%	2%	26%	1%	179	493
Mean Tide Ebb	-9%	-9%	-19%	17%	6%	21%	17%	15%	75%	14%	807	
Alternative 6	ENV4	ENV5	ENV6	ENV7	ENV8	ENV9	ENV10	ENV11	ENV12	ENV13		
Dynamite/ORR Combo	% Change	% Change	% Change	% Change	% Change	% Change	% Change	% Change	% Change	% Change		
Mean Tide Flood	0%	-21%	145%	34%	14%	-6%	-5%	-3%	11%	-3%	450	1330
Mean Tide Ebb	3%	3%	778%	87%	34%	-9%	-8%	-7%	29%	-6%	2210	
Alternative 7	ENV4	ENV5	ENV6	ENV7	ENV8	ENV9	ENV10	ENV11	ENV12	ENV13		
Combo (Dyn/ORR/Noyes)	% Change	% Change	% Change	% Change	% Change	% Change	% Change	% Change	% Change	% Change		
Mean Tide Flood	21%	-24%	155%	36%	15%	-3%	-4%	-3%	27%	-3%	797	1780
Mean Tide Ebb	-8%	6%	796%	88%	33%	10%	7%	7%	74%	6%	2764	

Table 1: Calculation of Habitat Units

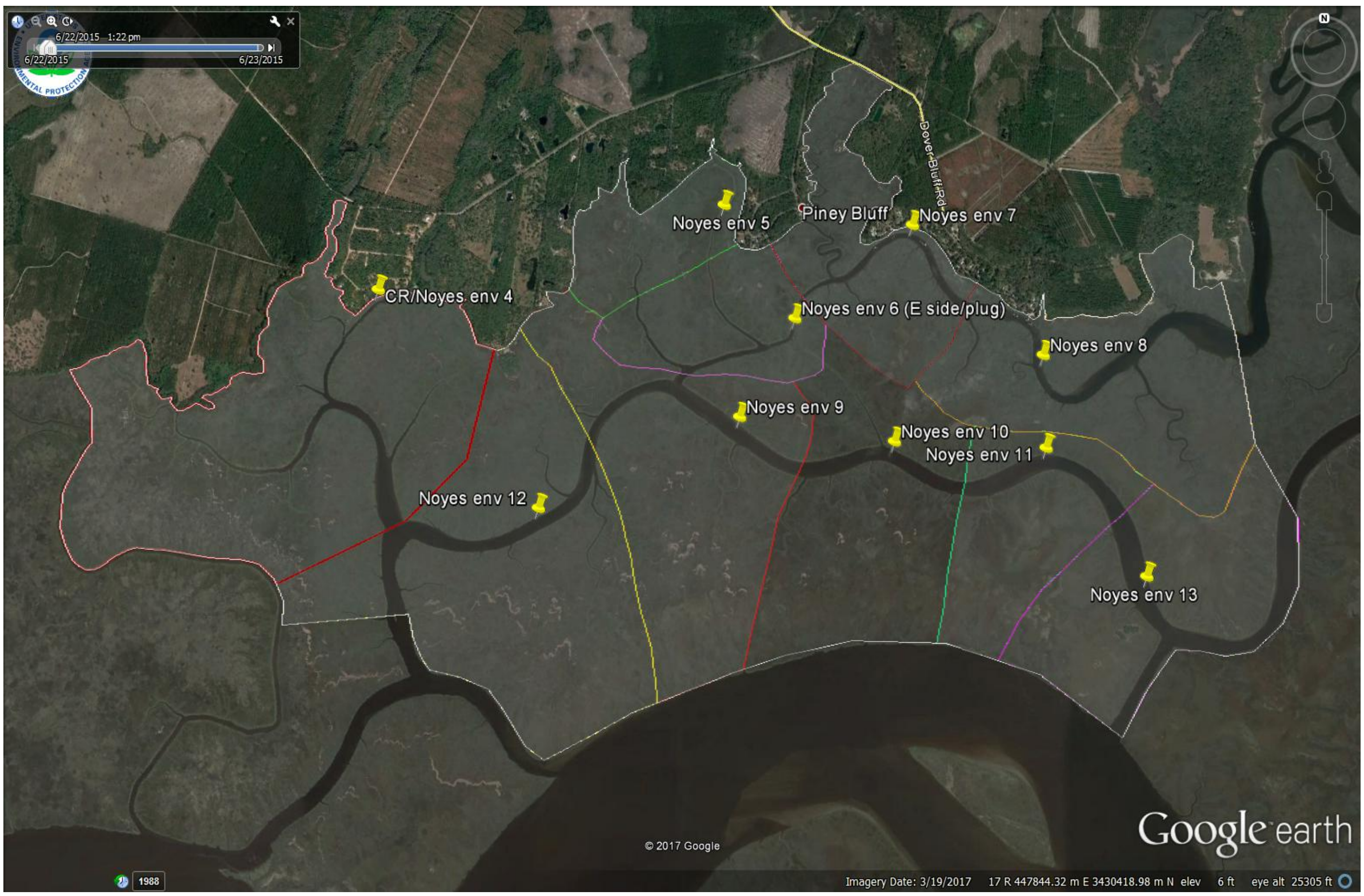

Figure 2 - 10 Habitat Areas With Associated Data Points

Engineering Appendix

Noyes Cut

Nov-2017

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1. Introduction

In April of 2016, USACE Savannah District Contracted with Dynamic Solutions LLC to develop a calibrated hydrodynamic model using ADH and a representative coupled sedimentation transport model. Dynamic Solutions delivered the completed model code, associated documentation and model output for the base condition and seven selected alternative project runs. Details for model development can be located in the *Hydrodynamic and Sediment Transport Modeling Report, DSLLC, January 2017*. USACE Engineering Division and Planning Division are tasked with jointly evaluating the output in accordance with project goals, and making a recommendation plan of action.

2. Project Goals

USACE Savannah District and the Non Federal Sponsors (GADNR and Satilla Riverwatch Alliance) entered into a Project Management Plan in February 2015. The plan outlined specific problems and objectives that should be evaluated during the course of the study. The problems are summarized below, in no particular order.

2.1 Ecological Habitat Restoration

2.1.1 Restore salinity gradient in Dover Creek

Over time, it is the hypothesis that the salinity gradient in Dover Creek has flattened out more similarly to the Satilla River, reducing fish and crab habitat. In addition, evaluate the salinity gradient and opportunities for improvement in adjacent tidal creeks.

2.1.2 Increase Tidal Exchange throughout the system

Increasing tidal exchange at various locations throughout the system will be beneficial for ecological restoration, as well as put downward pressure on shoaling rates. The change in flushing volume will be evaluated, with increases in flux viewed as being overall positive to the system.

2.2 Eliminate shoaling in Umbrella Creek-

Umbrella Creek is located at the Dover Bluff Community. Residents have experienced significant shoaling and reduction in dock and recreation in Umbrella Creek over the past ~80 years. A key component of selection an alternative is reverse this long term trend of accretion in Umbrella Creek, and if possible create an environment where the channel will scour out and restore conveyance over time.

3. Alternative Analysis Methodology

3.1 Alternatives to be evaluated

The following combinations of alternatives were evaluated during a 4-month simulation within the hydrodynamic and sedimentation model. The sediment and hydrodynamic models are de-coupled, and require separate execution of the code. Run-time (computing power) and file output size are legitimate considerations, as the output below is approximately 500GB and required 60+ hours of continuous computing time on a super computer. A run time of 4-months encapsulated a full range of tidal conditions under normal flow periods, and provides a good picture of how the system will react subject to the alternatives. Multi-year sedimentation simulations were determined to not be feasible or beneficial to simulate.

The series of closure combinations were simulated by assigning a new material type to the nodes at each cut location, and switching that material type to OFF. This allows greater stability in model computations, and greater flexibility and uniformity in creating closures. This method acts as an infinite vertical wall, which mimics a full closure structure at an elevation above the high tide line. While consideration was given to realism when inserting the cuts, it is important to note that to objective is to block flow. Design level parameters, such as width, elevation, tie in length, materials, etc. were not evaluated.

Hydrodynamic validation statistics were performed by DSLLC and can be found in Table 6 on page 41 of the *Hydrodynamic and Sediment Transport Modeling Report, DSLLC, January 2017*. The error percentages compared to the calibration stations were calculated for water level (rRMS ~5%), velocity (rRMS ~11%), and salinity (rRMS ~21%). These values are indicative of the compounding uncertainty, with the most uncertainty being exhibited with the salinity constituent. Additionally, the salinity rRMS in Dover Creek (calibration station #3) was calculated at 33%, which is higher than the other four calibration stations, each of which were ~20%.

- BASE – baseline / no alternative / existing conditions models
- ALT1 – Noyes Cut closed
- ALT2 – Old River Run (ORR) Closed
- ALT3 – Noyes and Old River Run (ORR) Closed
- ALT4 – Dynamite Cut Closed
- ALT5 – Noyes and Dynamite Closed
- ALT6 – Dynamite and Old River Run (ORR) Closed
- ALT7 – Noyes and Dynamite and Old River Run (ORR) Closed

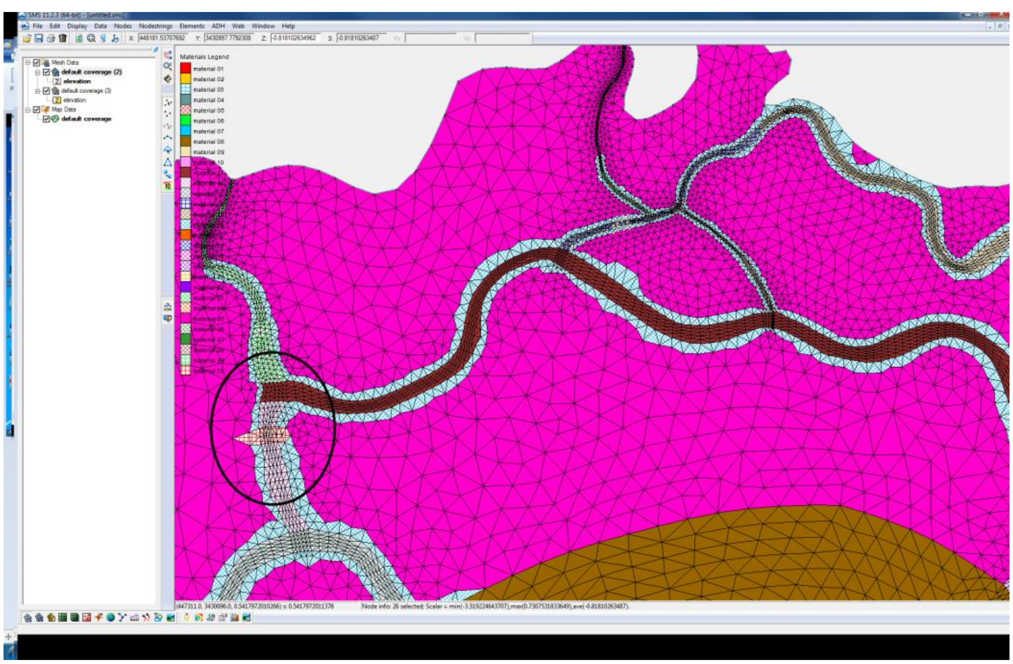

Figure 1 : Noyes Cut Closure Model Representation (Alternative 1)

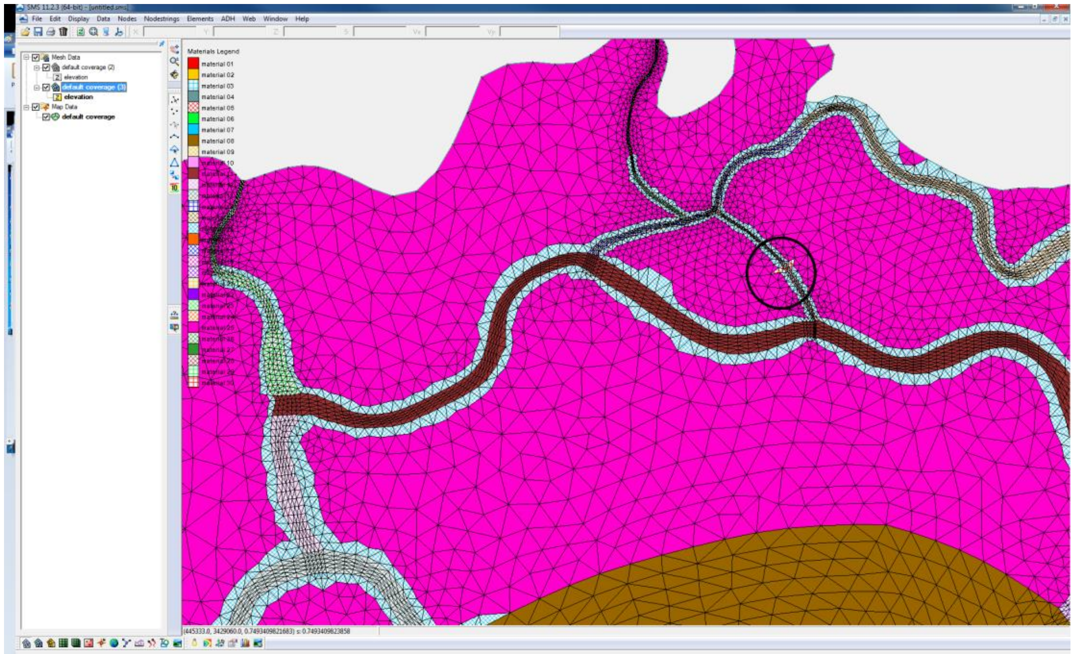

Figure 2 : ORR Closure Model Representation (Alternative 2)

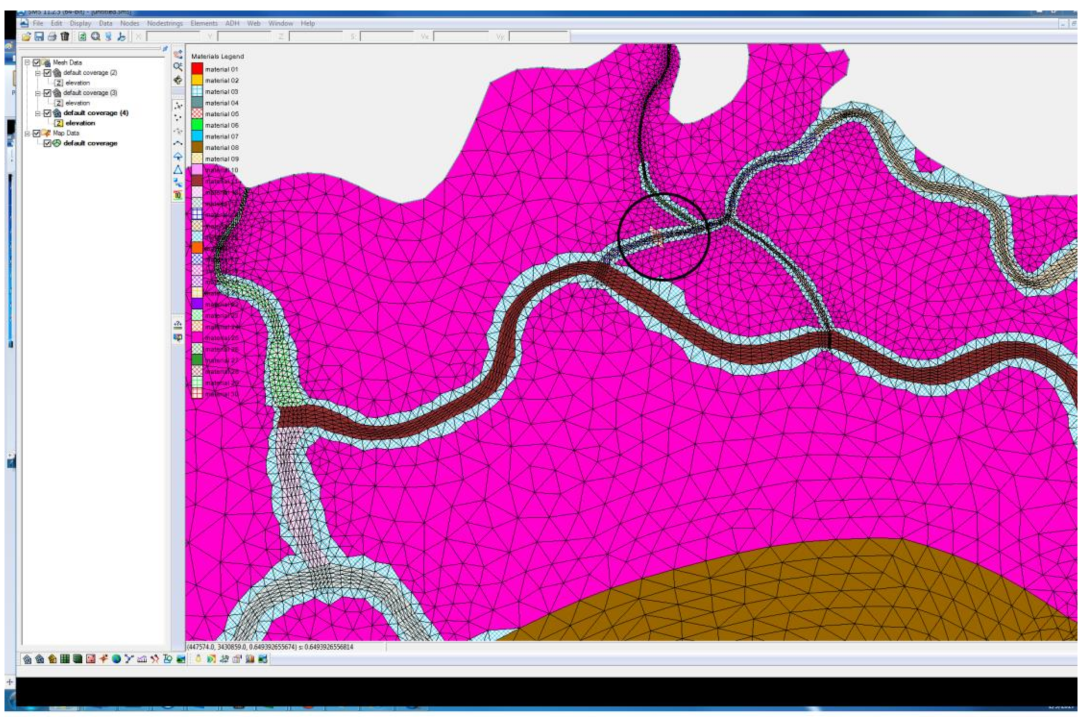

Figure 3 : Dynamite Cut Closure Model Representation (Alternative 3)

3.2 Environmental Analysis Points

Model output is effectively continuous in both space and time. High resolution mesh within channels, and an adaptive time-step with the ability to write output at any time-step desired. One-hour output was selected to a compromise between efficiency and resolution needs. Output can viewed and analyzed in any way the user desires. In order to do a comparison of each alternative versus USACE Biologists needed to develop a series of points within the system and model domain to compare outputs for salinity and change in flux. Fourteen points were ultimately selected, and are shown below.

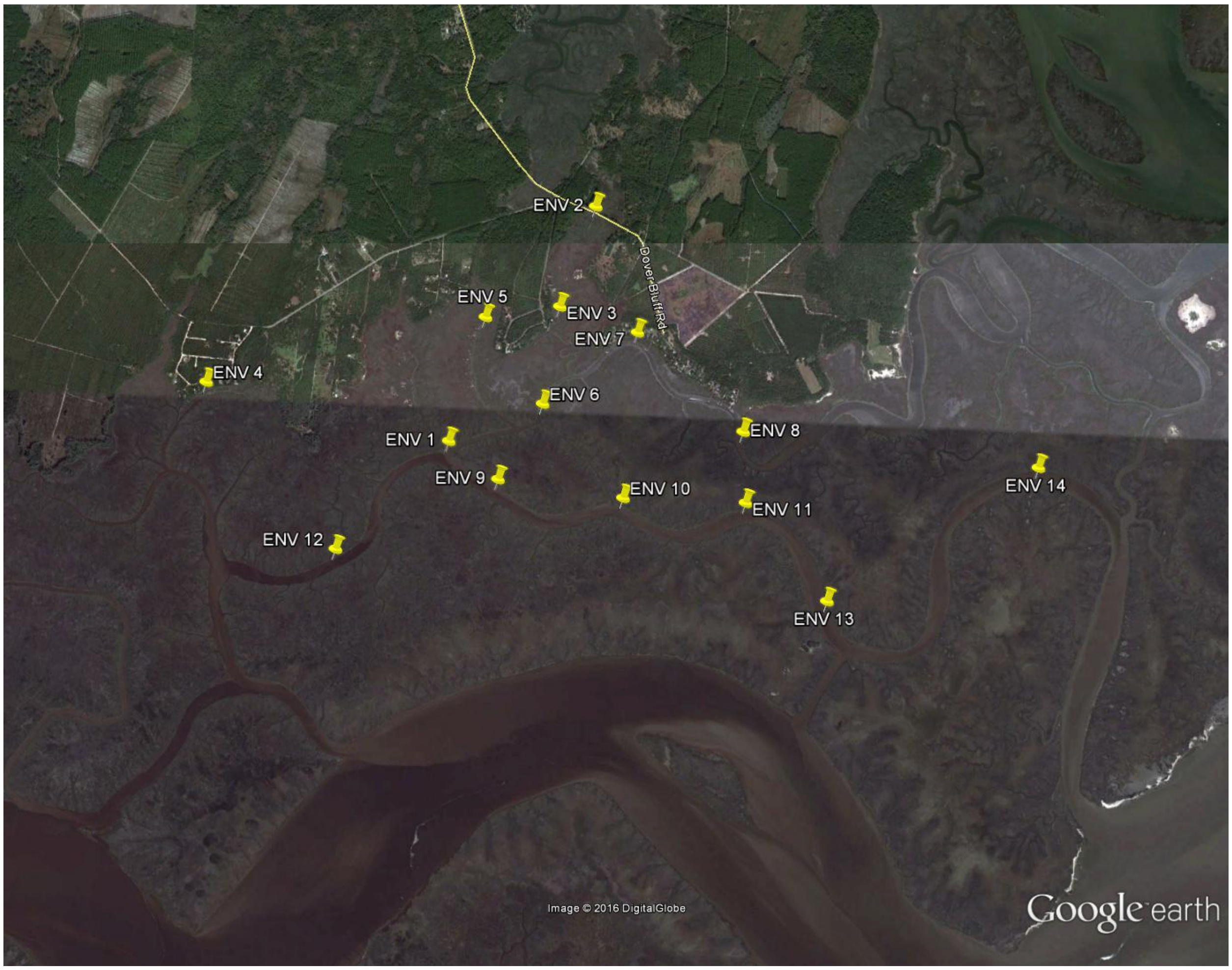

Figure 4 : Environmental Analysis Points

3.3 Daily Average Salinity

The calculated model output values for salinity (ppt) was exported into excel with the following parameters:

- 15-minute time series intervals
- Entire model simulation duration of 4-months, 04/01/2016 – 07/31/2016
- Each of the 14 ENV analysis points
- Base Case Scenario, and seven alternatives

The data was organized in a pivot table to calculate daily average salinity for the base condition and each alternative. The daily averages for each alternative were then compared to the daily average of the base condition. The differences in daily average salinity were expressed in terms of a percent change and assigned a graded color scale, so that trends at each location could be easily compared between alternatives. Green represents an INCREASE in salinity (darker green is higher % increase), where red represents a DECREASE (Darker red is a lower % increase). Monthly averages are displayed here for simplicity. Biologists are utilizing the following data in evaluation of the alternative.

		Umbrella Creek - Upstream -> Downstream						Dover Creek - Upstream -> Downstream							
		Sal12	Sal9	Sal10	Sal11	Sal13	Sal14	Sal1	Sal6	Sal7	Sal8	Sal2	Sal3	Sal4	Sal5
April	Alt1	45.1%	149.6%	16.0%	12.5%	10.0%	10.9%	25.0%	31.2%	4.8%	-50.1%	22.2%	8.5%	94.1%	56.2%
	Alt2	37.9%	44.6%	41.3%	37.4%	31.1%	10.1%	42.1%	48.6%	19.6%	8.7%	16.9%	22.2%	25.7%	67.6%
	Alt3	23.3%	5.5%	-0.7%	-3.3%	-4.7%	0.1%	10.9%	19.6%	3.1%	1.2%	11.7%	8.7%	64.5%	31.1%
	Alt4	-0.4%	-9.4%	-9.8%	-11.0%	-13.0%	-15.3%	0.4%	53.1%	-6.1%	-10.0%	7.8%	12.8%	8.1%	104.4%
	Alt5	30.7%	6.5%	0.0%	-4.7%	-7.6%	-2.1%	20.3%	94.9%	11.2%	3.5%	30.2%	31.6%	90.1%	167.8%
	Alt6	5.6%	-3.2%	-5.1%	-6.3%	-7.7%	-9.0%	2.9%	45.2%	-19.8%	-26.4%	-4.6%	-6.1%	20.6%	97.5%
	Alt7	30.1%	8.6%	1.4%	-2.5%	-4.9%	-5.2%	19.1%	74.2%	-5.2%	-12.7%	10.3%	11.2%	74.6%	141.7%
May	Alt1	-12.9%	41.7%	-17.5%	-14.4%	-10.9%	-3.4%	-18.0%	-18.5%	-17.6%	-48.7%	-14.4%	-21.7%	-6.8%	-22.1%
	Alt2	12.5%	6.4%	3.5%	1.5%	-0.1%	-2.7%	7.6%	9.2%	-1.1%	-2.9%	1.5%	-1.7%	22.0%	5.7%
	Alt3	-9.5%	-15.0%	-13.9%	-11.1%	-8.0%	-4.0%	-13.4%	-12.5%	-12.7%	-7.2%	-5.5%	-13.1%	-4.5%	-18.7%
	Alt4	7.7%	-2.7%	-4.5%	-6.3%	-8.1%	-11.5%	-0.4%	15.7%	-14.8%	-13.6%	-7.6%	-7.9%	11.6%	17.1%
	Alt5	-5.0%	-14.8%	-14.7%	-13.8%	-12.4%	-10.1%	-8.1%	25.9%	-7.5%	-7.4%	-0.5%	0.9%	9.7%	26.9%
	Alt6	24.0%	9.0%	4.7%	2.6%	1.8%	1.3%	8.2%	11.1%	-23.6%	-26.0%	-10.5%	-19.8%	34.8%	16.9%
	Alt7	2.0%	-6.6%	-5.8%	-3.3%	-0.4%	1.3%	-0.9%	22.7%	-12.0%	-12.1%	-6.0%	-5.6%	17.4%	24.9%
June	Alt1	-25.2%	-0.1%	-17.0%	-12.6%	-8.7%	-4.5%	-21.2%	-21.0%	-26.1%	-37.5%	-20.9%	-29.2%	-10.5%	-19.2%
	Alt2	-9.9%	-8.8%	-7.0%	-6.0%	-5.5%	-2.6%	-8.1%	-3.6%	-3.2%	-2.5%	-5.3%	-6.4%	10.1%	-4.9%
	Alt3	-19.9%	-16.9%	-12.5%	-7.8%	-3.6%	0.6%	-16.4%	-14.6%	-17.7%	-13.4%	-12.2%	-20.0%	2.3%	-13.4%
	Alt4	-5.3%	-6.8%	-6.0%	-5.7%	-5.9%	-6.6%	-4.0%	3.4%	-17.1%	-12.3%	-9.8%	-10.6%	7.4%	4.5%
	Alt5	-18.7%	-18.0%	-14.4%	-10.7%	-7.4%	-3.3%	-13.7%	7.0%	-14.0%	-8.6%	-8.4%	-7.5%	6.4%	6.3%
	Alt6	9.4%	4.6%	4.0%	3.5%	3.4%	3.1%	6.5%	9.0%	-15.4%	-11.8%	-9.2%	-9.7%	21.0%	10.2%
	Alt7	-17.8%	-16.4%	-12.3%	-7.9%	-4.3%	-1.0%	-11.9%	3.4%	-17.8%	-13.7%	-8.0%	-11.4%	9.7%	7.2%
July	Alt1	-19.7%	1.8%	-6.9%	-1.8%	2.2%	4.3%	-11.5%	-12.7%	-16.9%	-26.4%	-16.0%	-21.1%	-12.4%	-16.1%
	Alt2	-7.1%	-3.9%	-1.3%	0.1%	0.8%	1.7%	-2.9%	-0.1%	3.8%	2.9%	1.5%	1.3%	9.3%	-1.9%
	Alt3	-17.9%	-12.4%	-7.7%	-2.9%	1.3%	5.7%	-12.1%	-12.8%	-12.1%	-8.7%	-8.8%	-15.0%	-1.2%	-16.3%
	Alt4	6.0%	3.5%	4.5%	4.6%	3.9%	1.1%	4.9%	10.2%	-3.6%	-4.5%	-1.5%	-1.4%	13.1%	10.0%
	Alt5	-15.2%	-11.9%	-7.7%	-3.9%	-0.7%	1.0%	-9.4%	9.1%	-1.8%	-1.7%	0.8%	2.0%	4.5%	9.2%
	Alt6	13.9%	10.7%	12.9%	14.1%	14.2%	11.4%	11.9%	19.1%	3.1%	0.9%	4.0%	4.7%	22.5%	19.1%
	Alt7	-17.4%	-13.5%	-8.6%	-3.5%	0.8%	3.4%	-10.6%	5.6%	-5.0%	-5.1%	-1.1%	-1.4%	1.8%	6.7%

Figure 5 : Monthly Average Salinity Change

Observations to consider

- All Alternatives generally show an increase in salinity during April, and a decrease in May-July.
- Alternative 3 (Noyes + ORR) is not necessarily additive of Alternative 1 (Noyes) + Alternative 2 (ORR)
- Point Sal4 (farthest north in small tidal creek, near River Marsh residential areas off Lampadoshia Road) tends to experience generally more saline environment over all alternatives and months.
- Point Sal8 (just east of Dover Bluff Community dock in Umbrella Creek) tends to experience generally fresher environment over all alternatives and months.
- Changes in the salinity magnitude are most substantial for Alternative 1 and Alternative 3
- Changes in the salinity magnitude are least substantial for Sal11, Sal13 and Sal14, all of which are ocean ward.
- Alternative 2 produces a generally more saline May, while other Alternatives produce fresher.
- Alternative 4 produces a generally more saline July, while other Alternatives produce fresher.
- Freshwater inflow was much higher during April than June/July (see inflow boundary condition graph below). This high amount of fresh water interacts somewhat freely with the project area under current conditions. Since both Alternatives 1 (Noyes) and Alternative 3 (Noyes + ORR) consist of blocking that fresh water source, the salinity change on a percentage basis is magnified during periods of high flow.

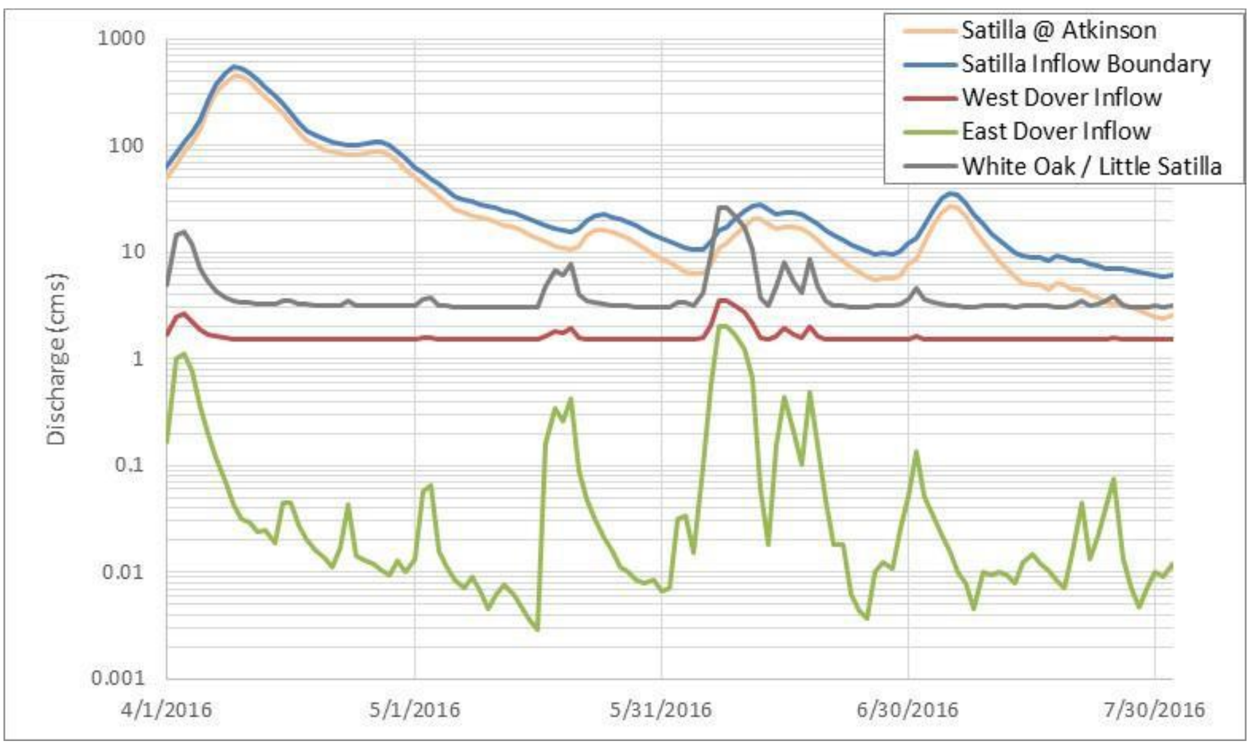

Figure 6 : Freshwater Inflow Boundary Conditions

3.4 Salinity Gradient Change

While daily average and monthly average salinity is important to consider, of the higher concern is restoring the salinity gradient within Dover Creek. The hypothesis is that due to Noyes cut, the salinity gradient of Dover Creek has flattened over time to match the Satilla. An objective of this study is to generate a mild salinity gradient in Dover Creek, and in nearby tidal creeks.

To accomplish this profile graphs are a better tool than quantitative averaging and comparisons. Salinity profiles were developed under the following parameters:

- Three reach locations: Dover Creek, West Tributary and East Tributary.
- Maximum spring high tide (time = 3045:00, 06-April-2016 09:00 PM)

Many of the smaller tidal creeks were not input into the model mesh domain, because they require a disproportionate number of nodes, runtime and file size in relation to the overall final output. DSLLC initially recommended that the West Tributary, East Tributary, and ORR be omitted from the mesh because of negligible impacts. Since part of the model objective specifically wanted to evaluate ecological impacts of tidal creeks, these two reaches were added. ORR was also later added since it was listed under the alternatives.

Figure 7 : Selected Transects for Gradients

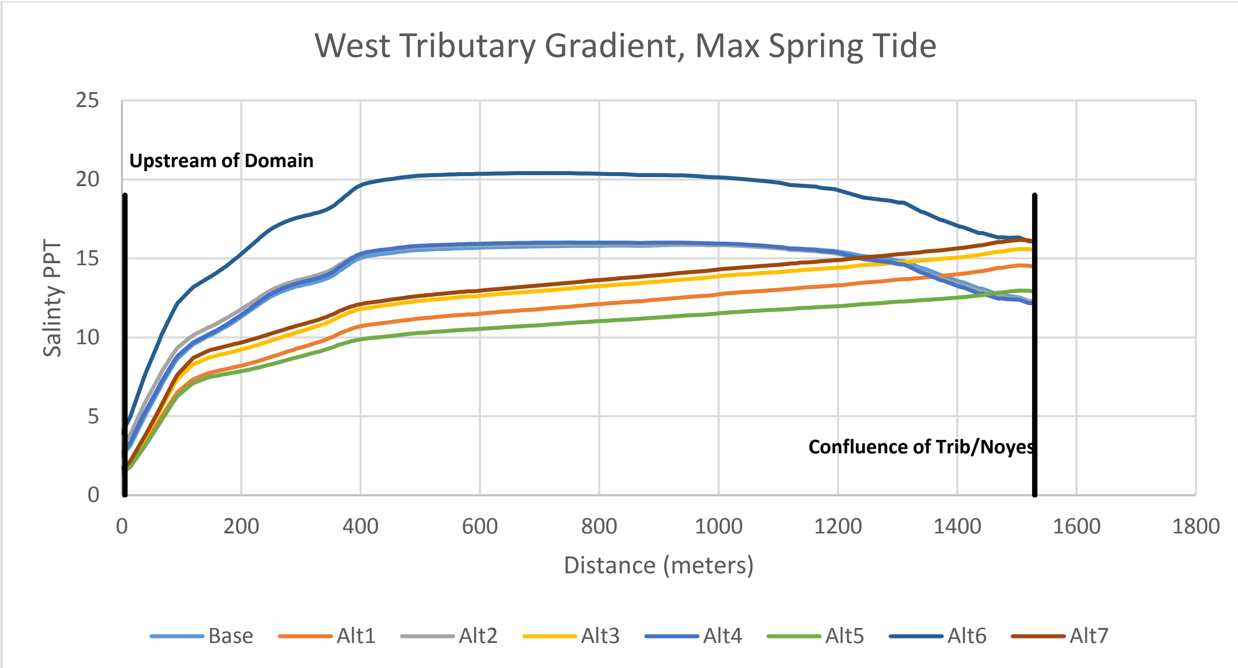

Figure 8 : West Tributary Salinity Gradient

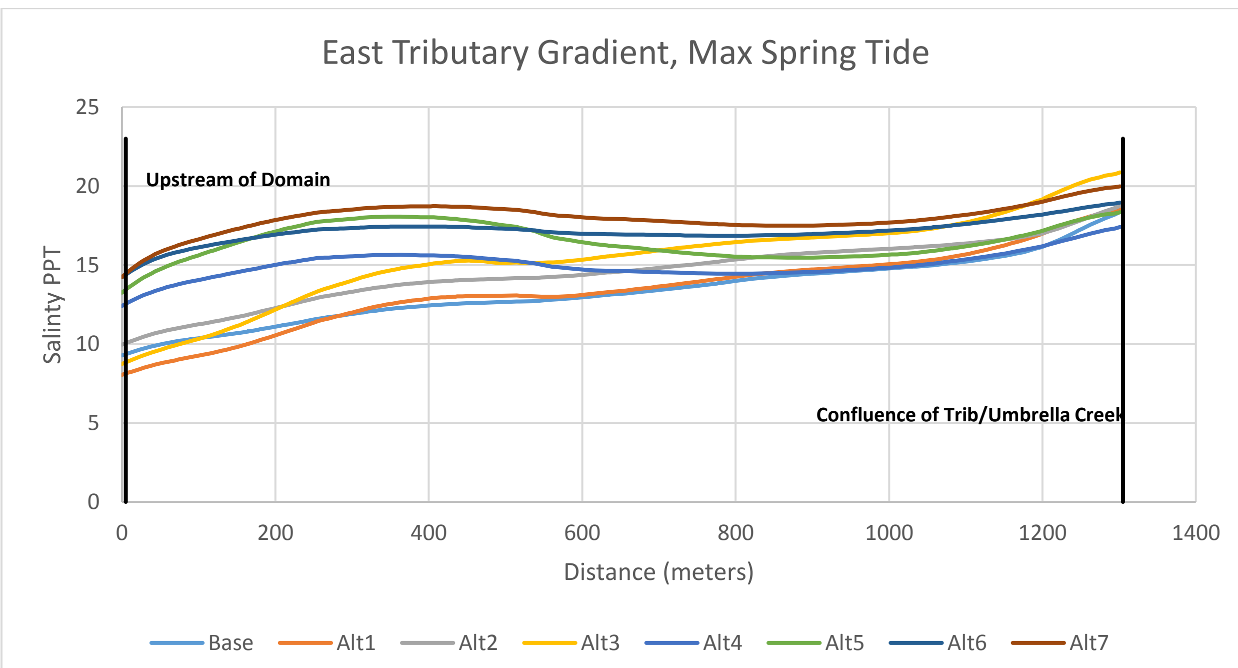

Figure 9 : East Tributary Salinity Gradient

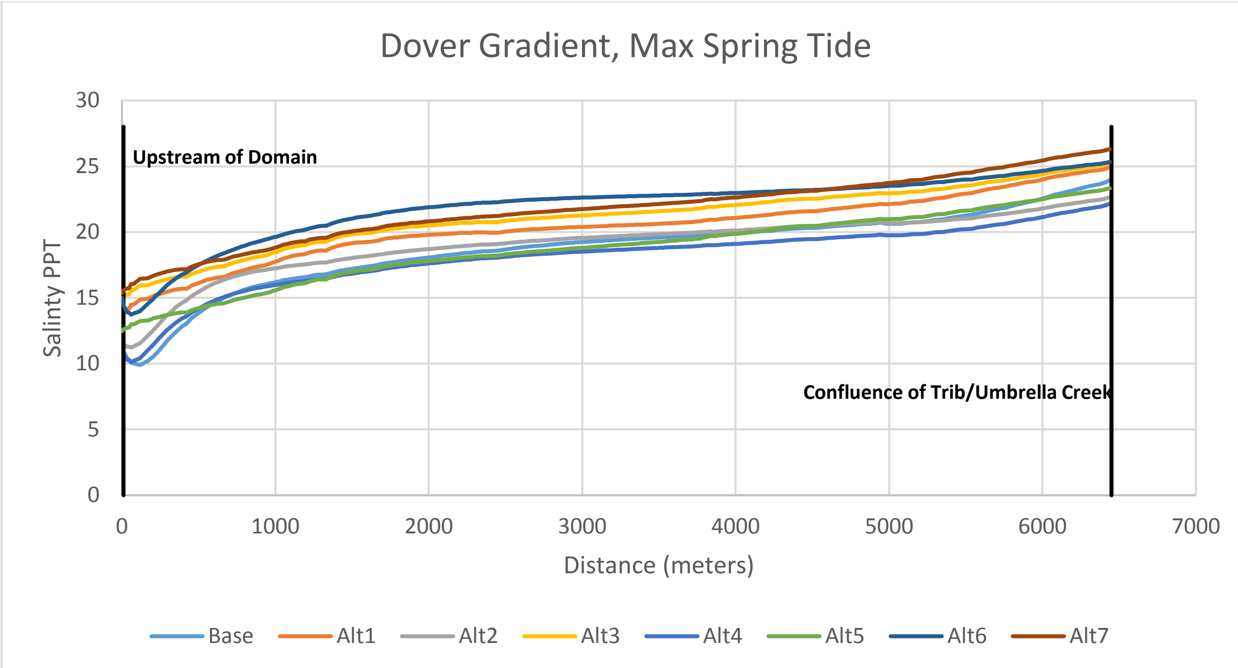

Figure 10 : Dover Creek Salinity Gradient

Observations to consider

- These profiles represent a snapshot in time during spring high tide.
- The assumption currently is that Dover Creek experience no gradient of salinity, however that does not appear to be the case during a maximum spring tide condition
- None of the alternatives selected change the gradient (slope) of the salinity profile in Dover Creek or the East Tributary
- ALT2, ALT4 and ALT6 do not substantially change the base case salinity gradient in the West Tributary from the base condition. (None contain Noyes Cut)
- ALT1, ALT3, ALT5 and ALT7 do restore a salinity gradient in the West Tributary from the base condition. (All contain Noyes Cut)

3.5 Flux Change

USACE biologists required change in flushing volume, or volumetric flux, as a component of assessing the ecological lift associated with each alternative. The hydrodynamic model output was evaluated for Δflux between the base condition and each alternative, at each environmental location shown in Figure 4, for a variety of tidal conditions. The Δflux was obtained by multiplying the scalar dataset of depth and the vector dataset of velocity, over a cross sectional length under varying 6-hour time periods. This yields an increase or decrease in flux, in units of CMS (cubic meters per second) and percent change. A conditional formatting color scheme was applied on the percent change to quickly visualize the major changes in key locations. Dark green represents the largest percent increase, dark red represents the largest percent decrease. A screenshot of the associated excel summary is shown below.

			Umbrella Creek – Upstream -> Downstream												Dover Creek – Upstream -> Downstream											
Alternative 1			ENV12		ENV9		ENV10		ENV11		ENV13		ENV14		ENV1		ENV6		ENV7		ENV8		ENV4		ENV5	
			Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change
Spring Tide Flood	3040	3045	33.735	43.37%	16.302	8.26%	10.736	4.32%	5.9243	2.11%	3.2947	1.06%	1.3284	0.33%	-5.513	-19.40%	-11.16	-371.73%	2.9542	7.75%	4.1018	4.42%	-0.071	-6.43%	-0.011	-0.87%
Spring Tide Ebb	3071	3076	52.085	116.48%	42.081	26.57%	42.842	20.19%	44.751	17.62%	45.863	15.59%	9.7709	2.61%	-7.333	-24.40%	0.4096	17.55%	6.6799	26.53%	9.3897	14.27%	-0.05	-1.51%	0.0493	3.60%
Neap Tide Flood	3971	3976	-6.412	-16.15%	-7.003	-10.28%	-7.17	-8.89%	-7.298	-7.90%	-7.424	-7.11%	-1.187	-0.69%	-0.363	-4.92%	-1.561	-52.02%	0.4377	4.61%	0.8779	3.11%	-0.005	-0.32%	0.009	2.84%
Neap Tide Ebb	4002	4007	-7.201	-16.53%	-5.882	-8.68%	-4.98	-6.38%	-5.173	-5.91%	-5.373	-5.43%	4.3702	2.55%	0.2771	3.96%	-1.911	-81.88%	0.6007	6.78%	0.2681	1.03%	0.0554	2.26%	-0.019	-1.86%
Mean Tide Flood	3350	3355	11.408	26.02%	5.4257	5.25%	4.161	3.25%	2.8027	1.89%	1.9853	1.19%	1.1352	0.48%	-3.552	-20.71%	-3.861	-128.67%	0.8793	4.59%	1.4104	2.81%	0.2048	21.90%	-0.034	-5.03%
Mean Tide Ebb	3380	3385	25.5	74.66%	22.333	21.13%	23.057	17.16%	23.927	15.16%	24.957	13.76%	4.3611	1.79%	-6.421	-25.98%	-0.44	-18.88%	2.6757	17.34%	2.8754	6.33%	-0.262	-8.86%	-0.105	-9.29%
Alternative 2			ENV12		ENV9		ENV10		ENV11		ENV13		ENV14		ENV1		ENV6		ENV7		ENV8		ENV4		ENV5	
			Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change
Spring Tide Flood	3040	3045	-0.628	-0.81%	1.2262	0.62%	-2.86	-1.15%	-2.39	-0.85%	-2.462	-0.79%	-0.694	-0.17%	1.7077	6.01%	0.6424	4.42%	0.5803	1.52%	0.3323	0.36%	0.0041	0.37%	-0.002	-0.18%
Spring Tide Ebb	3071	3076	-0.542	-1.21%	3.2145	2.03%	-0.886	-0.42%	-0.195	-0.08%	-0.477	-0.16%	0.2073	0.06%	2.3742	7.90%	0.2919	5.79%	0.9576	3.80%	1.4861	2.26%	0.0018	0.05%	0.0095	0.69%
Neap Tide Flood	3971	3976	-0.172	-0.43%	0.628	0.92%	-0.378	-0.47%	-0.415	-0.45%	-0.353	-0.34%	0.1436	0.08%	0.7326	9.92%	0.2578	8.59%	0.2679	2.82%	0.4341	1.54%	-0.01	-0.64%	0.007	2.23%
Neap Tide Ebb	4002	4007	-0.032	-0.07%	1.0097	1.49%	0.5027	0.64%	-0.229	-0.26%	0.5159	0.52%	-0.021	-0.01%	0.6783	9.70%	-0.418	-17.93%	0.1268	1.43%	0.1782	0.68%	0.0045	0.18%	-0.064	-6.24%
Mean Tide Flood	3350	3355	-0.281	-0.64%	0.9144	0.88%	-1.182	-0.92%	-1.277	-0.86%	-1.304	-0.78%	0.535	0.23%	1.1727	6.84%	0.4929	9.01%	0.4578	2.39%	0.3652	0.73%	0.0007	0.08%	-0.003	-0.44%
Mean Tide Ebb	3380	3385	0.086	0.25%	1.0689	1.01%	-1.622	-1.21%	-1.347	-0.85%	-1.344	-0.74%	-0.988	-0.41%	1.3428	5.43%	0.3541	21.44%	0.2867	1.86%	0.3142	0.69%	0.0059	0.20%	0.0273	2.41%
Alternative 3			ENV12		ENV9		ENV10		ENV11		ENV13		ENV14		ENV1		ENV6		ENV7		ENV8		ENV4		ENV5	
			Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change
Spring Tide Flood	3040	3045	34.041	43.77%	17.876	9.06%	9.0494	3.64%	4.6703	1.66%	2.1159	0.68%	0.5852	0.15%	-3.531	-12.42%	3.1918	21.96%	3.7914	9.95%	4.8065	5.18%	-0.061	-5.53%	-0.01	-0.82%
Spring Tide Ebb	3071	3076	52.892	118.28%	45.837	28.94%	42.553	20.06%	44.593	17.55%	45.815	15.57%	9.9646	2.66%	-4.842	-16.11%	4.9469	98.08%	7.8597	31.22%	10.738	16.32%	-0.033	-0.99%	0.0916	6.69%
Neap Tide Flood	3971	3976	-7.03	-17.71%	-7.226	-10.61%	-8.319	-10.31%	-8.256	-8.94%	-8.193	-7.84%	-1.697	-0.98%	0.0377	0.51%	0.3942	13.14%	0.2776	2.92%	0.2935	1.04%	0.0088	0.54%	0.0104	3.31%
Neap Tide Ebb	4002	4007	-5.672	-13.02%	-2.501	-3.69%	-2.204	-2.82%	-1.876	-2.14%	-1.503	-1.52%	-0.818	-0.48%	1.9184	27.43%	0.0702	3.01%	1.2732	14.38%	2.0586	7.90%	0.1292	5.26%	-0.079	-7.76%
Mean Tide Flood	3350	3355	11.297	25.77%	6.4967	6.28%	3.2456	2.54%	1.9097	1.29%	1.1502	0.69%	1.4737	0.63%	-2.392	-13.94%	1.687	30.84%	1.3308	6.94%	1.6921	3.38%	0.225	24.06%	-0.035	-5.14%
Mean Tide Ebb	3380	3385	25.173	73.70%	23.716	22.44%	21.146	15.74%	22.115	14.01%	23.039	12.70%	3.0667	1.26%	-4.947	-20.01%	3.4021	205.96%	3.0715	19.91%	3.3362	7.34%	-0.341	-11.55%	-0.11	-9.68%
Alternative 4			ENV12		ENV9		ENV10		ENV11		ENV13		ENV14		ENV1		ENV6		ENV7		ENV8		ENV4		ENV5	
			Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change
Spring Tide Flood	3040	3045	4.8586	6.25%	-8.752	-4.43%	-4.601	-1.85%	-2.954	-1.05%	-2.46	-0.79%	-0.111	-0.03%	-14.76	-51.94%	5.5063	37.88%	4.7955	12.58%	4.4585	4.80%	-0.001	-0.10%	0.0566	4.62%
Spring Tide Ebb	3071	3076	5.6007	12.52%	-8.603	-5.43%	-4.246	-2.00%	-4.037	-1.59%	-4.568	-1.55%	-1.511	-0.40%	-17.2	-57.22%	10.862	215.35%	12.83	50.96%	15.035	22.85%	-0.109	-3.27%	0.0346	2.53%
Neap Tide Flood	3971	3976	3.0539	7.69%	-3.841	-5.64%	-3.456	-4.28%	-3.548	-3.84%	-3.599	-3.45%	-1.43	-0.83%	-6.032	-81.71%	4.3902	146.29%	4.2945	45.19%	4.6521	16.47%	-0.008	-0.48%	-0.003	-0.86%
Neap Tide Ebb	4002	4007	2.0359	4.67%	-4.072	-6.01%	-2.818	-3.61%	-3.45	-3.94%	-2.651	-2.68%	-2.155	-1.26%	-5.921	-84.67%	6.5523	280.81%	7.7573	87.61%	9.424	36.16%	-0.012	-0.49%	-0.021	-2.04%
Mean Tide Flood	3350	3355	4.3803	9.99%	-7.226	-6.99%	-4.267	-3.34%	-3.004	-2.03%	-2.205	-1.32%	-0.265	-0.11%	-12.17	-70.98%	5.7751	105.56%	4.6427	24.23%	4.8573	9.69%	0.0136	1.45%	-0.138	-20.56%
Mean Tide Ebb	3380	3385	8.6465	25.31%	-10.75	-10.18%	-7.511	-5.59%	-7.529	-4.77%	-7.669	-4.23%	-4.007	-1.64%	-18.52	-74.91%	10.142	613.96%	10.167	65.91%	11.47	25.25%	0.0222	0.75%	0.0136	1.20%
Alternative 5			ENV12		ENV9		ENV10		ENV11		ENV13		ENV14		ENV1		ENV6		ENV7		ENV8		ENV4		ENV5	
			Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change
Spring Tide Flood	3040	3045	34.714	44.63%	7.1533	3.62%	4.5168	1.82%	0.9922	0.35%	-0.966	-0.31%	0.1956	0.05%	-16.88	-59.39%	7.1105	48.92%	6.7521	17.71%	7.8696	8.48%	-0.073	-6.57%	0.0217	1.77%
Spring Tide Ebb	3071	3076	52.916	118.34%	29.646	18.72%	32.746	15.43%	34.674	13.65%	35.722	12.14%	5.6877	1.52%	-20.95	-69.69%	12.882	255.40%	15.934	63.29%	19.365	29.44%	0.0044	0.13%	-0.12	-8.73%
Neap Tide Flood	3971	3976	-6.898	-17.38%	-13.59	-19.95%	-13.08	-16.22%	-13.02	-14.09%	-12.92	-12.37%	-3.57	-2.07%	-6.052	-81.97%	4.3794	145.93%	4.2135	44.34%	4.44	15.72%	0.0102	0.62%	-4E-04	-0.14%
Neap Tide Ebb	4002	4007	-6.895	-15.83%	-11.59	-17.12%	-9.195	-11.79%	-9.212	-10.53%	-9.211	-9.30%	-4.026	-2.35%	-5.868	-83.91%	6.6493	284.97%	7.7894	87.98%	9.5749	36.74%	0.0924	3.76%	-0.02	-1.96%
Mean Tide Flood	3350	3355	11.826	26.97%	-3.365	-3.25%	-2.594	-2.03%	-3.159	-2.13%	-3.507	-2.09%	-0.385	-0.16%	-13.1	-76.37%	6.6704	121.93%	5.4002	28.18%	5.8564	11.69%	0.1983	21.21%	-0.129	-19.16%
Mean Tide Ebb	3380	3385	24.709	72.34%	9.7218	9.20%	12.763	9.50%	13.843	8.77%	14.857	8.19%	-0.43	-0.18%	-19.17	-77.53%	10.703	647.96%	10.437	67.66%	11.334	24.95%	-0.221	-7.49%	0.0367	3.24%
Alternative 6			ENV12		ENV9		ENV10		ENV11		ENV13		ENV14		ENV1		ENV6		ENV7		ENV8		ENV4		ENV5	
			Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change
Spring Tide Flood	3040	3045	5.6702	7.29%	-6.915	-3.50%	-7.147	-2.87%	-4.652	-1.66%	-3.521	-1.13%	-1.105	-0.28%	-14.26	-50.18%	7.1151	48.95%	6.3681	16.71%	5.7794	6.22%	0.0096	0.87%	0.0659	5.38%
Spring Tide Ebb	3071	3076	6.1157	13.68%	-7.048	-4.45%	-8.268	-3.90%	-7.813	-3.08%	-7.77	-2.64%	-3.962	-1.06%	-17.45	-58.06%	13.62	270.03%	16.715	66.40%	19.319	29.37%	-0.092	-2.78%	-0.141	-10.32%
Neap Tide Flood	3971	3976	3.7104	9.35%	-3.249	-4.77%	-4.305	-5.34%	-4.462	-4.83%	-4.414	-4.22%	-1.402	-0.81%	-5.98	-81.00%	5.5754	185.79%	5.3915	56.73%	5.7076	20.21%	-0.006	-0.37%	0.0004	0.14%
Neap Tide Ebb	4002	4007	2.5578	5.87%	-3.305	-4.88%	-3.774	-4.84%	-4.458	-5.09%	-3.572	-3.61%	-1.749	-1.02%	-5.889	-84.21%	8.7236	373.87%	10.048	113.48%	12.058	46.27%	-0.009	-0.35%	0.0956	9.39%
Mean Tide Flood	3350	3355	4.9827	11.37%	-6.364	-6.15%	-6.149	-4.81%	-4.834	-3.26%	-4.194	-2.51%	-1.454	-0.62%	-11.87	-69.19%	7.9492	145.30%	6.5604	34.23%	6.8299	13.63%	-0.003	-0.37%	-0.144	-21.33%
Mean Tide Ebb	3380	3385	9.7839	28.64%	-9.327	-8.82%	-10.64	-7.92%	-10.68	-6.77%	-10.91	-6.02%	-5.397	-2.21%	-18.26	-73.87%	12.854	778.17%	13.348	86.52%	15.656	34.47%	0.0872	2.95%	0.034	3.00%
Alternative 7			ENV12		ENV9		ENV10		ENV11		ENV13		ENV14		ENV1		ENV6		ENV7		ENV8		ENV4		ENV5	
			Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change	Δ Flux	% Change
Spring Tide Flood	3040	3045	34.794	44.74%	8.5662	4.34%	1.6745	0.67%	-0.929	-0.33%	-2.62	-0.84%	0.1565	0.04%	-16.14	-56.79%	8.775	60.37%	8.3999	22.04%	9.1817	9.89%	-0.066	-5.98%	0.0465	3.79%
Spring Tide Ebb	3071	3076	52.855	118.20%	31.058	19.61%	28.952	13.65%	31.136	12.26%	32.462	11.03%	4.5947	1.23%	-20.59	-68.51%	15.815	313.54%	19.784	78.59%	23.768	36.13%	-0.027	-0.82%	-0.144	-10.53%
Neap Tide Flood	3971	3976	-7.039	-17.73%	-13.93	-20.45%	-15.04	-18.64%	-15	-16.24%	-14.89	-14.25%	-4.842	-2.80%	-6.1	-82.62%	5.5474	184.85%	5.3254	56.04%	5.5398	19.61%	0.0112	0.68%	-0.01	-3.31%
Neap Tide Ebb	4002	4007	-7.136	-16.38%	-11.72	-17.30%	-11.31	-14.50%	-11.34	-12.96%	-11.26	-11.38%	-4.94	-2.88%	-5.923	-84.70%	8.815	377.79%	10.008	113.03%	12.026	46.14%	0.079	3.22%	0.0555	5.45%
Mean Tide Flood	3350	3355	11.77	26.85%	-2.89	-2.80%	-4.533	-3.54%	-4.859	-3.28%	-4.912	-2.93%	-0.175	-0.07%	-12.98	-75.68%	8.4792	154.99%	6.8686	35.84%	7.5012	14.97%	0.1945	20.79%	-0.164	-24.30%
Mean Tide Ebb	3380	3385	25.163	73.67%	10.807	10.22%	9.0974	6.77%	10.412	6.60%	11.574	6.38%	-1.811	-0.74%	-18.73	-75.77%	13.151	796.16%	13.552	87.85%	15.104	33.25%	-0.223	-7.55%	0.0683	6.03%

Figure 11 : Flux Change all Alternatives

4. Sedimentation Alternative Impacts

Since one of the two main objectives of the study is to evaluate which alternative is most likely to reverse shoaling in Umbrella Creek, and conceptual sedimentation model was developed. The specific means and methods for model development are discussed at length in the DSLLC Final Report, from January 2017. A fully validated sediment model requires a significant amount of site specific data, which was not collected during this effort. The model results should be interpreted only on a base-to-plan basis, and not as absolute quantities. Additionally, due to the compounding uncertainties and model duration simulation, long term sediment transport patterns and how the system will ultimately react to any cut closures is impossible to predict with confidence.

Each scenario was examined using multiple dataset outputs, in order of confidence. Datasets with the lowest uncertainty are evaluated first, and descending into other useful but more uncertain model outputs. The outputs that are evaluated are listed below, in order of confidence.

- Velocity
- Shear Stress
- Bed Displacement
- TSS

Additionally, each alternative was assessed visually and qualitatively by examining the time-series outputs of each dataset.

The sediment model was started on 1-March-1995 to allow time for spin-up of the sediment bed. This amount of time is sufficient for the sediment bed to adjust vertically to achieve quasi-equilibrium conditions and to adjust bed sediment distributions and parameters across the model domain. The analysis on outputs that follow are computing using outputs from 1-April-1995 to 31-June-1995.

Areas of which these datasets were examined

- Umbrella Creek
- Dover Creek
- ORR
- Noyes Cut (Bed Displacement only)

Evaluation of existing and plan tidal nodes, location and magnitudes as well.

4.1. Velocity

Sediment movement is driven primarily by higher velocities. The velocity output dataset does not contain any specific sedimentation input parameters or output, thereby reducing the amount of built in uncertainty. Velocity output is therefore the first piece of information to analyze when estimating sedimentation patterns. Since spring tides produce the highest velocity magnitudes, most of the particle mobility occurs during spring tides. A flood spring tide within the model occurs for a 6 hours period between T3040 and T3045 on May 6th 2016. As such, a snapshot of the velocity profile was extracted at T=3043 along three reaches for the base condition and each of the 7 alternatives.

Umbrella Creek

Longitudinal orientation for the profile shown is such that the stationing begins on the west side at the confluence of Dover, and extends a distance of 4935 meters east toward the ocean. The vertical black lines represent the first dock at approximately station 1690 and the last dock at station 2980.

In the area of interest between the two docks, it appears that alternative 4, alternative 5 and alternative 6 are the only ones that increase the velocity. Velocity increases on the order of .1 to .15 m/s are experienced. In addition, these alternatives seem to eliminate the tidal node experienced in the base condition at approximately station 1000. Zero velocities are still experienced under alternatives 4, 5, and 7 at station 400 due to rock closure. The common thread in these alternatives is all of them contain Dynamite Cut closure.

Dover Creek

Longitudinal orientation for the profile shown is such that the stationing begins on the west confluence with Noyes cut, and extends a distance of 6440 meters east to the Alternate AIWW.

The velocity on Dover Creek appears to increase from the base condition at alternative 1, alternative 2, alternative 4 and alternative 6. The largest velocity increases are experienced within the first 2000 meters, on the order of .3 to .4 m/s. At approximately station 2000 to 4000, the velocity increases are on the order of ~.1 m/s, and further ocean ward velocity changes are close to zero. There is not necessarily any common thread in these four alternatives in terms of which closures are implemented.

ORR

Longitudinal orientation for the profile shown is such that the stationing begins on the northwest confluence with Dover Creek, and extends a distance of 900 meters southeast to the Umbrella Creek.

The velocity criteria for ORR is different than that of Dover Creek and Umbrella Creek. In the larger creeks, the objective is a higher velocity to reduce shoaling and possibly scour. The objective in looking at velocity in ORR is to determine if the cut would continue to close or open back up with the implementation of any selected alternative. The model clearly shows that for alternative 1, the velocity in ORR stays largely the same as the base condition. The velocity increases dramatically for alternative 4 and alternative 5, which is not desirable. Neither of these alternatives have closing ORR as a component. The velocity in dramatically decreases in alternative 2, alternative 3, alternative 6, and alternative 7. All of these have closing ORR as a component (at station ~550). This indicates that there is a likelihood of ORR re-opening in the future for alternative 4 or alternative 5, thereby negating any future habitat lift.

Figure 12 : Umbrella Creek Transect - Velocity

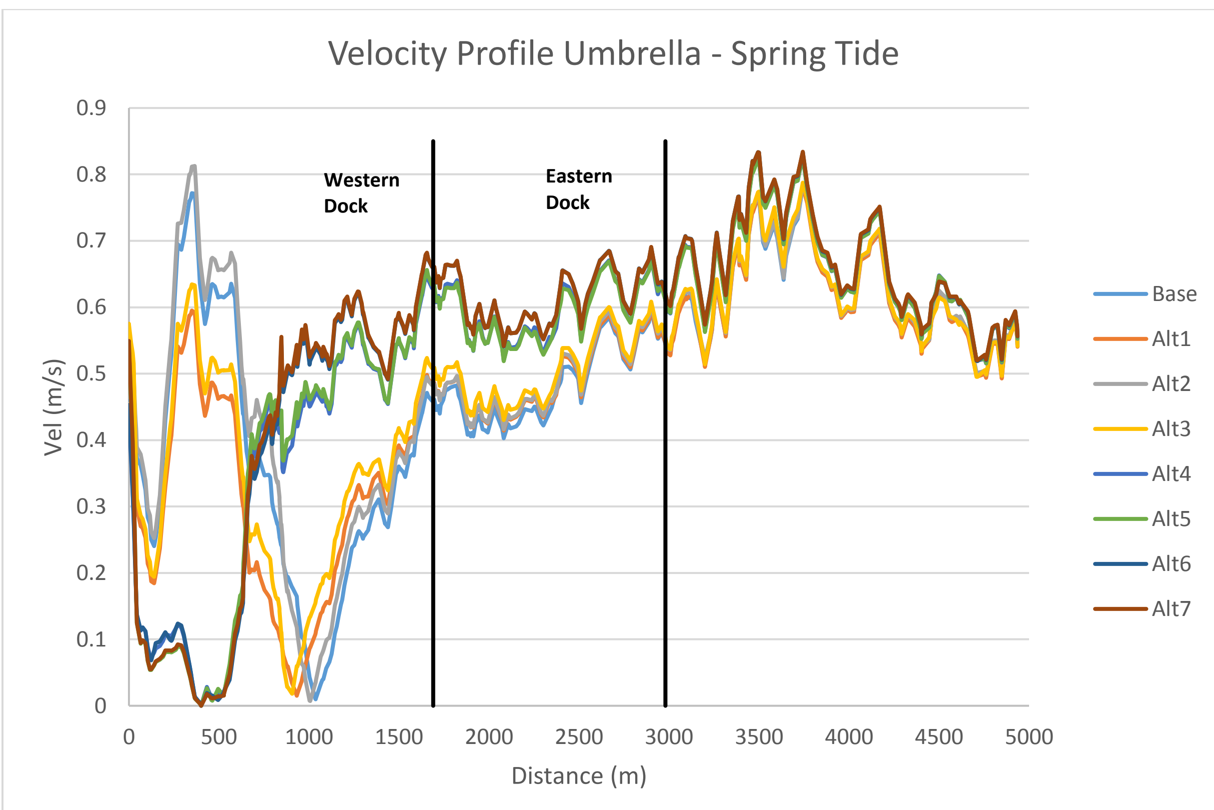

Figure 13 : Velocity Profile Umbrella Creek, Spring Tide, Base + 7 Alts

Figure 14 : Dover Creek Transect - Velocity

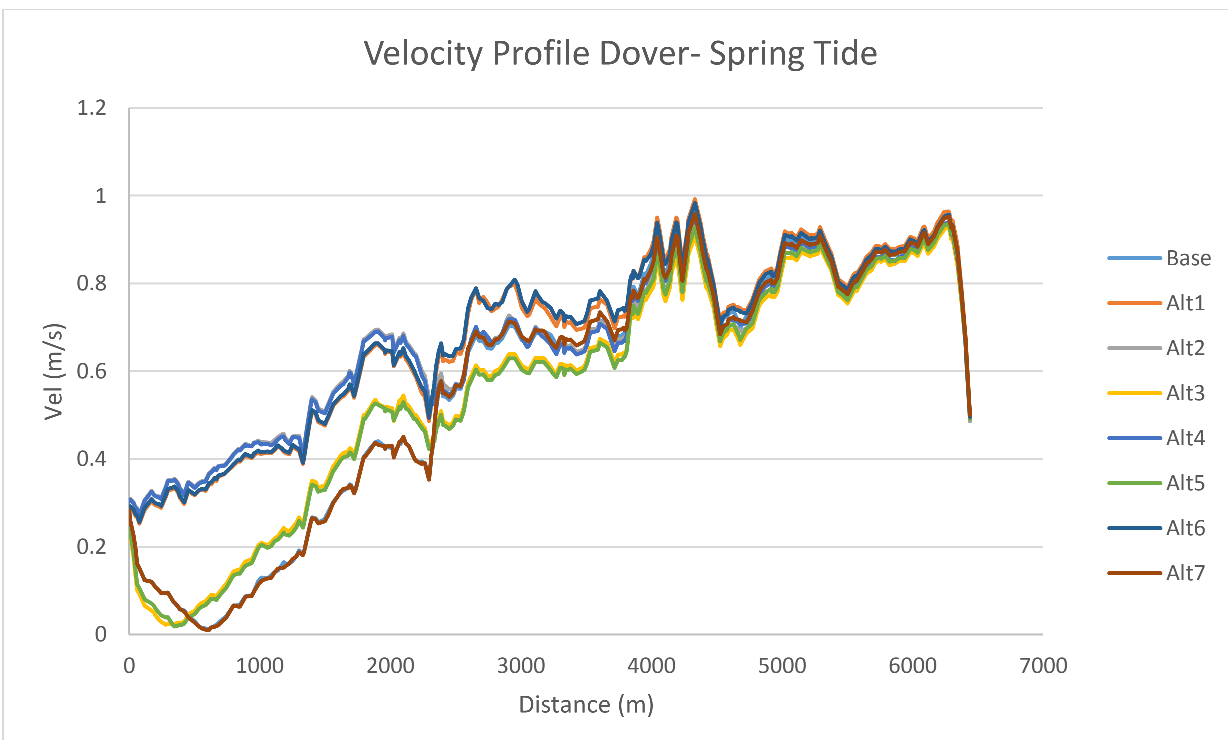

Figure 15 : Velocity Profile Dover Creek, Spring Tide, Base + 7 Alts

Figure 16 : ORR Transect

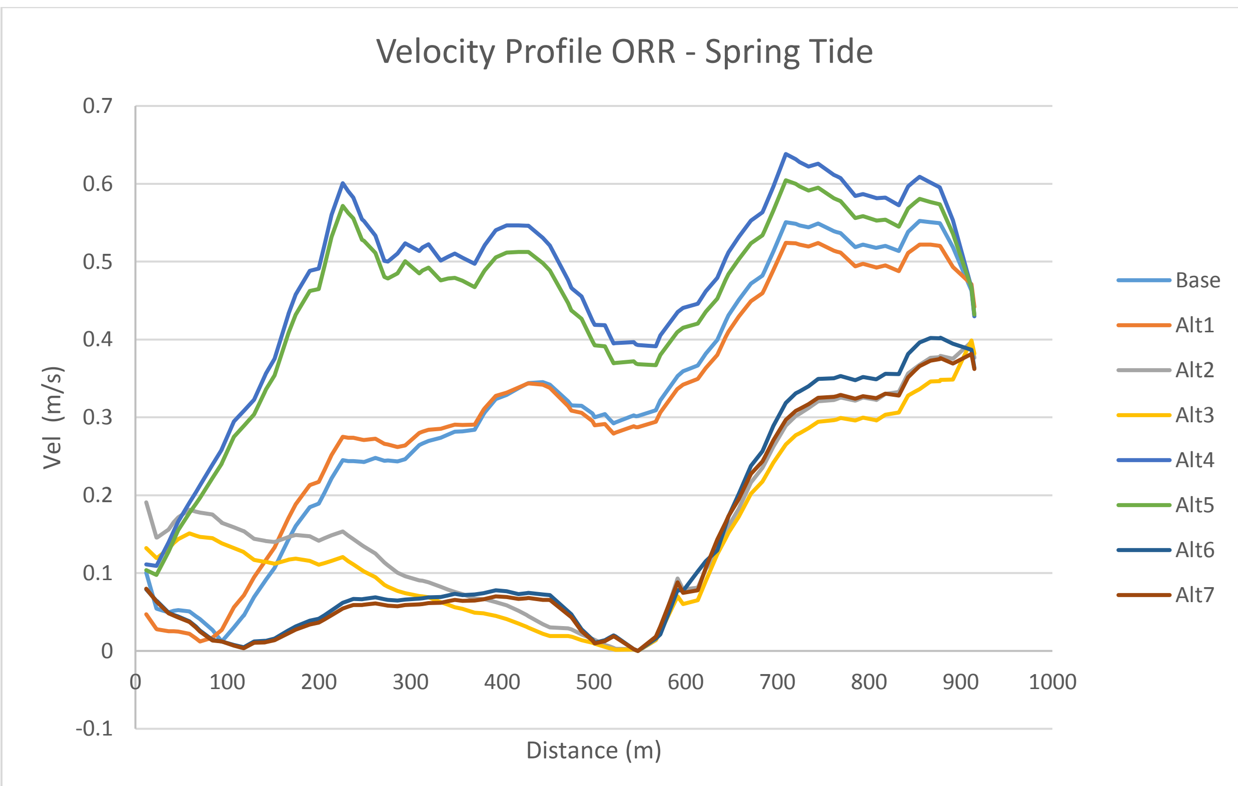

Figure 17 : Velocity Profiles ORR, Spring Tide, Base + 7 Alts

4.2 Shear Stress

The model output dataset with the second highest confidence (second lowest uncertainty) in relation to sediment transport is shear stress (bed shear, or BSH). Chart shows non-exceedance probability on the vertical and modeled output shear stress on the horizontal. Critical shear stress (Tau-Critical, or T_{cr}) is the value of shear stress that must be experienced for a particle to mobilize. In the model, this is estimated to be 0.8, but there is a lot of uncertainty and the plans should be evaluated on how each curve looks as a whole. The model output for shear stress is a reach-averaged value taken from seven points in Umbrella, two points in ORR, and a single point in Noyes.

The curves are saying that (Y-axis) percent of the time, the reach average shear stress is lower than (X-axis) value. So, curves that are further DOWN are saying that lower non-exceedance (higher exceedance) chance that the modeled shear stress does not exceed the shear on the X-axis.

As an example in Umbrella Creek: There is a 99.7 % chance that the experienced shear is lower than the T_{cr} of 0.8 in the base condition. There is a 90.9 % chance that the experienced shear is lower than T_{cr} of 0.8 in the Alternative 7 condition. Similarly, 80% of the time, the shear stresses do not exceed 0.2 in the base condition. 80% of the time, the shear stresses do not exceed 0.35 in the Alternative 7 condition.

Therefore, in general, curves that are further to the down and further to the right experience higher erosive forces, and curves that are further up and to the left experience lower erosive forces.

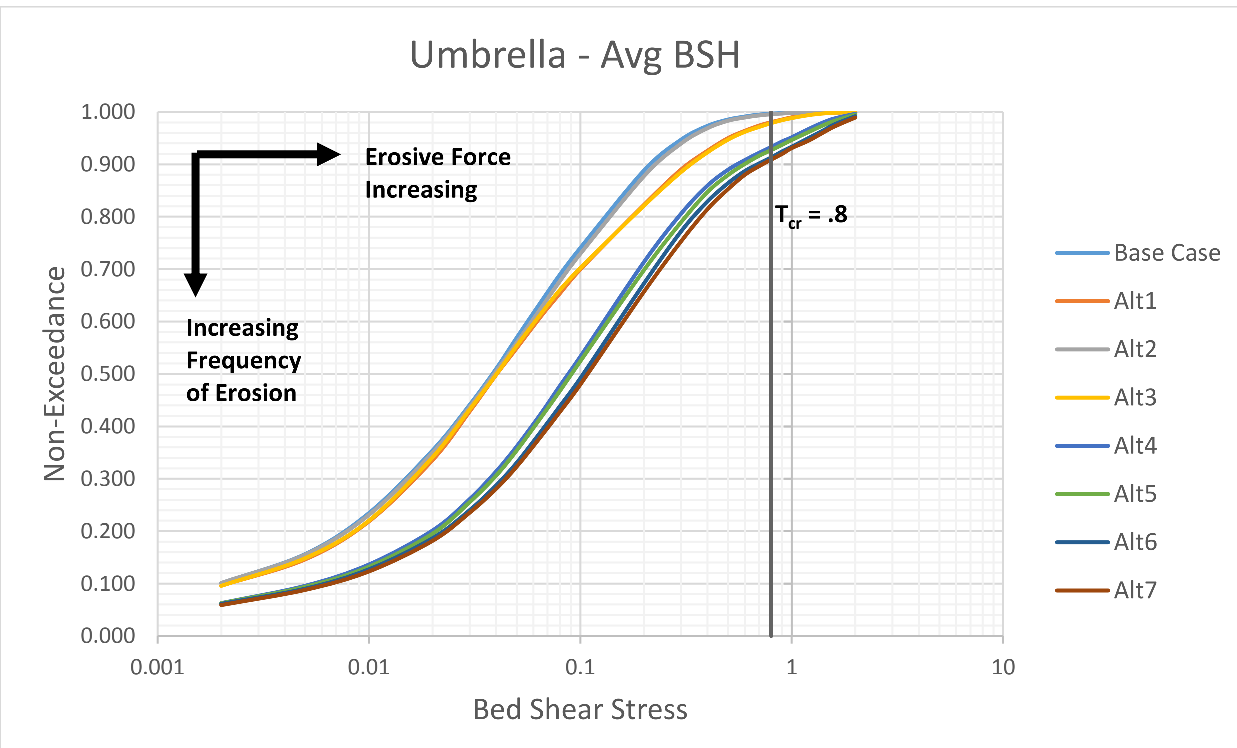

Figure 18 : Non-exceedance Bed Shear Stress – Umbrella Creek

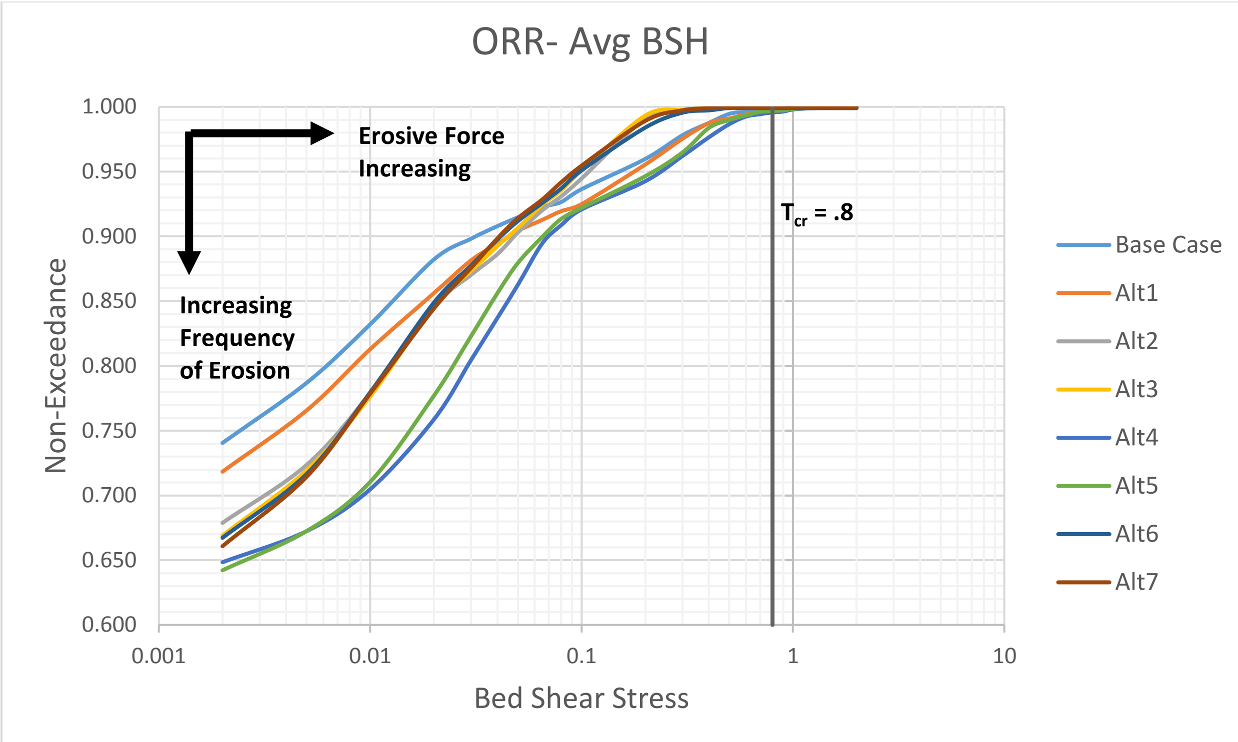

Figure 19 : Non-exceedance Bed Shear Stress – ORR

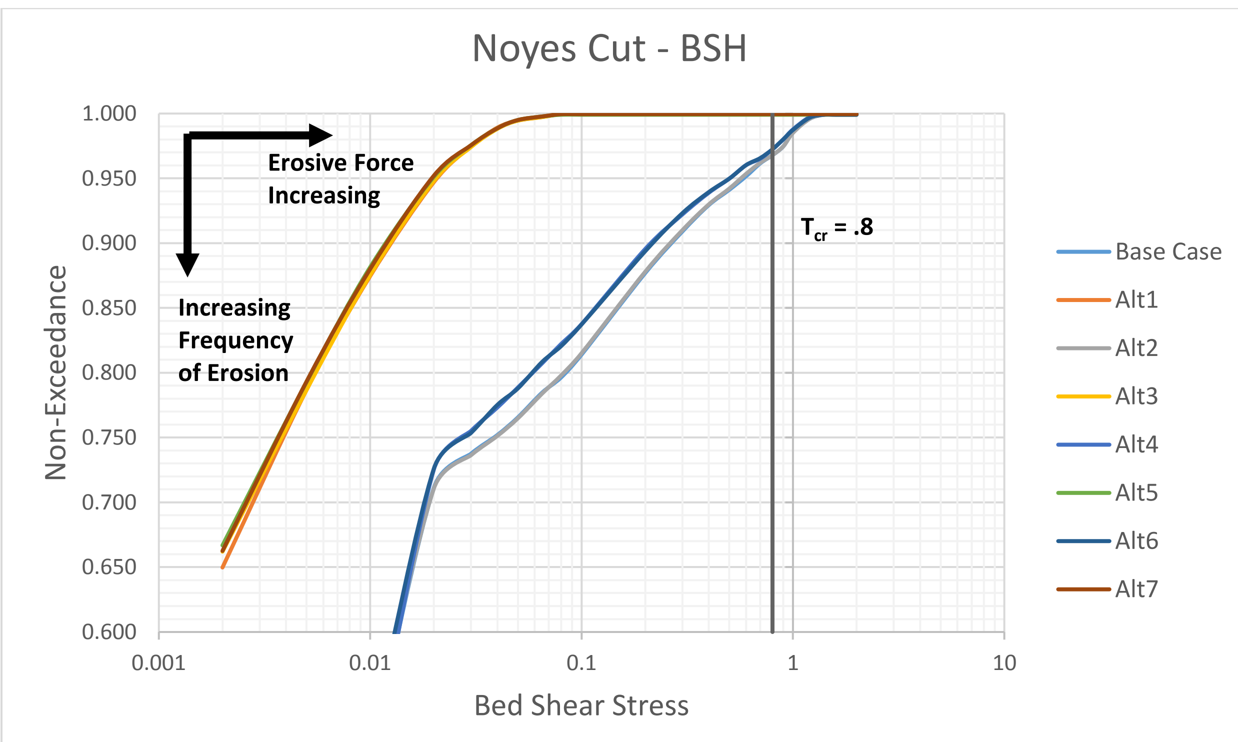

Figure 20 : Non-exceedance Bed Shear Stress – Noyes Cut

Observations to consider

- As discussed above, this is the output dataset with the second lowest uncertainty
- As discussed above, these output datasets can show the trend and direction of erosive forces between base and alternatives, but the uncertainty in T_{cr} makes it difficult to say an area will certainly erode and in what amount of time.
- Umbrella Creek is the primary area of concern for increase shoaling. The average reach bed shear graphs in Figure 18. The average bed shear does not increase substantially from the base condition for alternative 1, alternative 2, or alternative 3. The average bed shear does increase substantially for alternative 4, alternative 5, alternative 6, and alternative 7. Alternative 7 shows the largest increase in bed shear, although it is not substantially more than alternatives 4-6.
- ORR reach is not a large shoaling concern, however it has been closing off at a relatively rapid pace in recent years (as determined from aerial imagery). It is important to evaluate how this reach will react with other changes to the system. If ORR were to begin to scour and re-open, realized project benefits may be negated. Figure 19 shows that shear stress increases from base condition in alterative 1, alternative 4 and alternative 5. None of these alternatives have "close ORR" as a component. Alternative 2, alternative 3, alternative 6 and alternative 7 do show some more frequent shear stresses of 0.1 to 0.5 Pa, however these are lower than the assumed 0.8 PA critical stress level.
- The Noyes Cut reach does not seem to be impacted much at all under any alternative that does not contain a closure within Noyes Cut. Alternative 1, alternative 3, alternative 5, and alternative 7 all experience a significant reduction in shear stress, due to each of these alternatives having a closure within Noyes Cut.

4.3 Bed displacement

Figure 21 : Noyes Cut Transect

The model output dataset with the lowest confidence (most uncertainty) in relation to sediment transport is bed displacement (DPL). This output dataset is built upon the velocity model, bed shear model, critical shear stress, and sediment parameters. Each of these have their own level of uncertainty, therefore bed DPL contains uncertainty at least as high as the sum of the other uncertainty.

Bed displacement in particular should be viewed in base-to-plan comparisons. At the beginning of a model simulation, the hydrodynamics cause the bathymetry and sediment layers to change immediately to somewhat of a stable condition. Therefore, large scour areas that appear on the profiles should not necessarily be construed as areas of scour.

Bed displacement is the only sedimentation output dataset that shows cumulative effects of an area throughout the simulation period. Output such as velocity, bed shear, and salinity are instantaneous in time and space. As such, the DPL profiles on Figure 22 - Figure 27 show total displacement on the final day of the 4-month simulation.

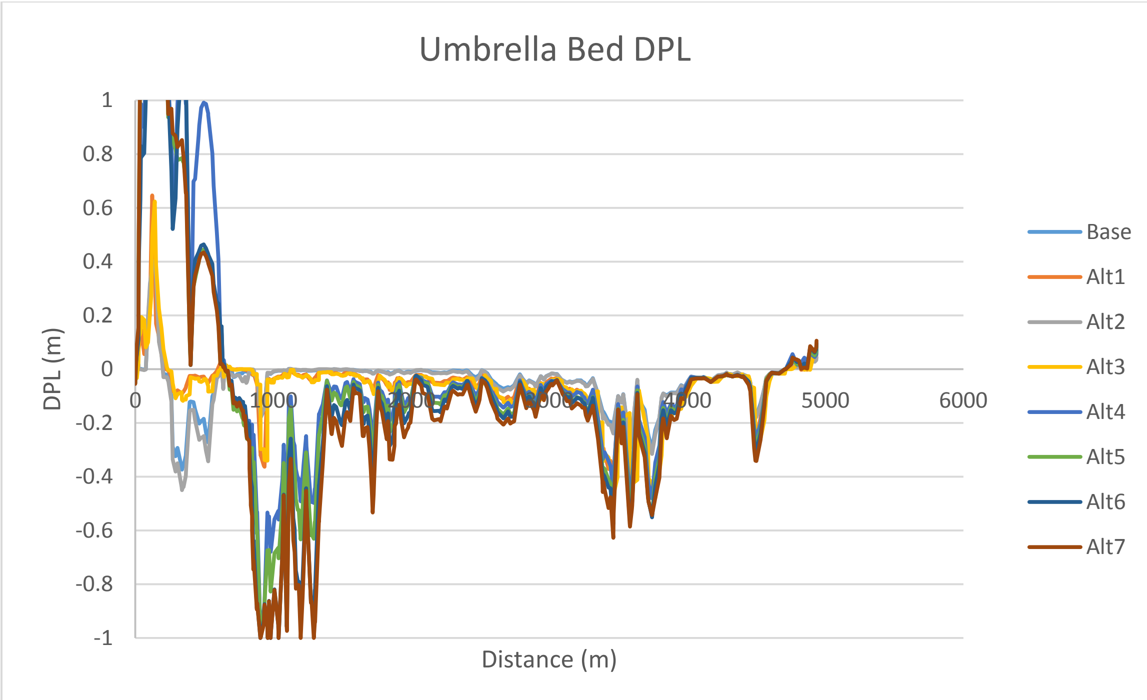

Figure 22 : Umbrella Creek Bed DPL

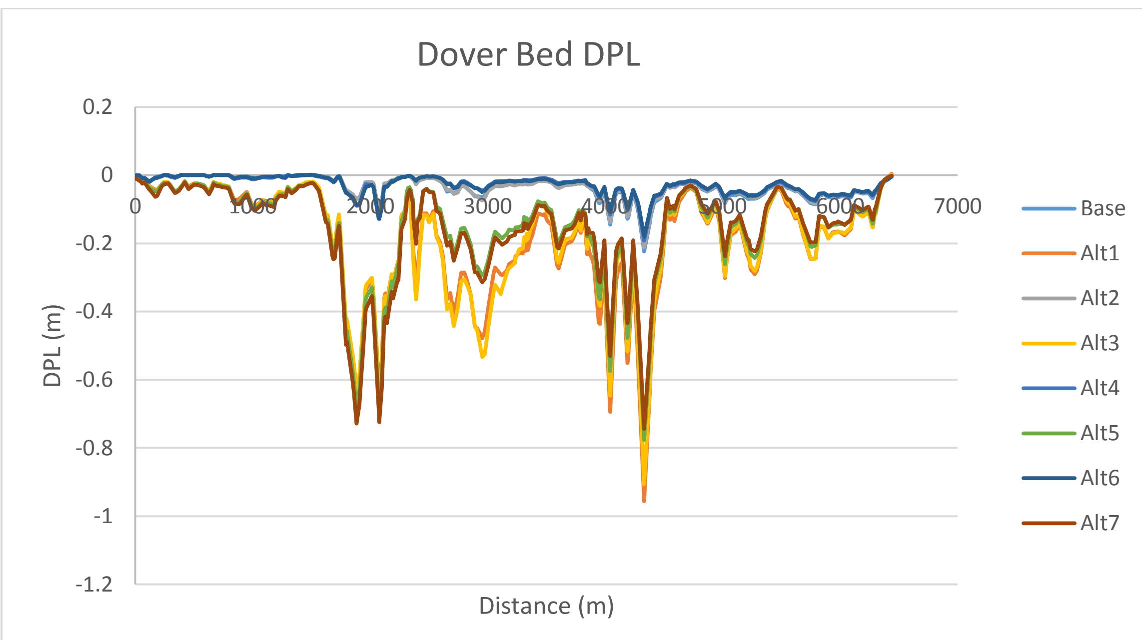

Figure 23 : Dover Creek Bed DPL

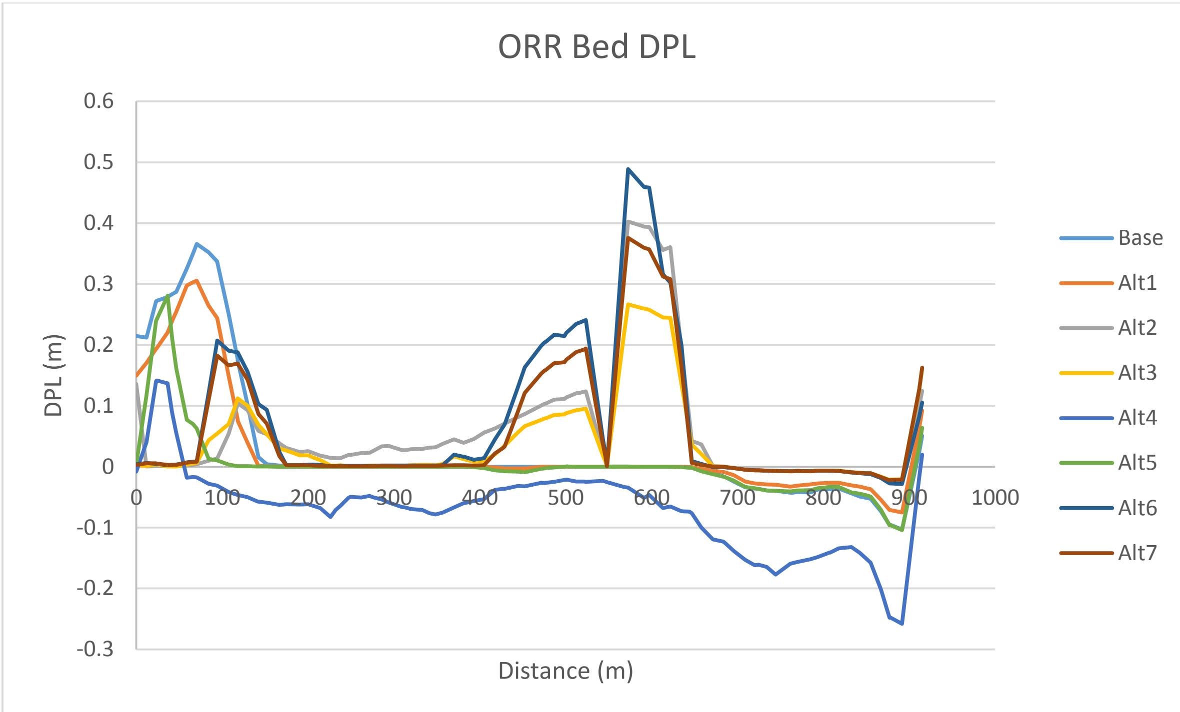

Figure 24 : ORR Bed DPL

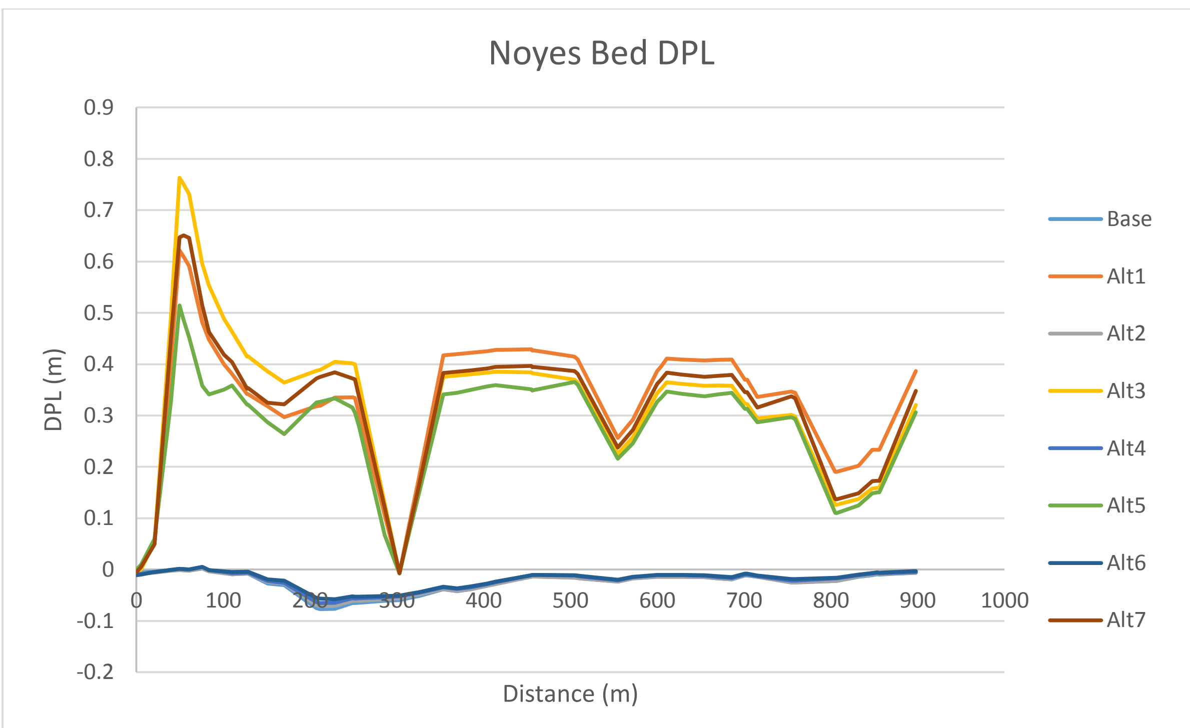

Figure 25 : Noyes Cut Bed DPL

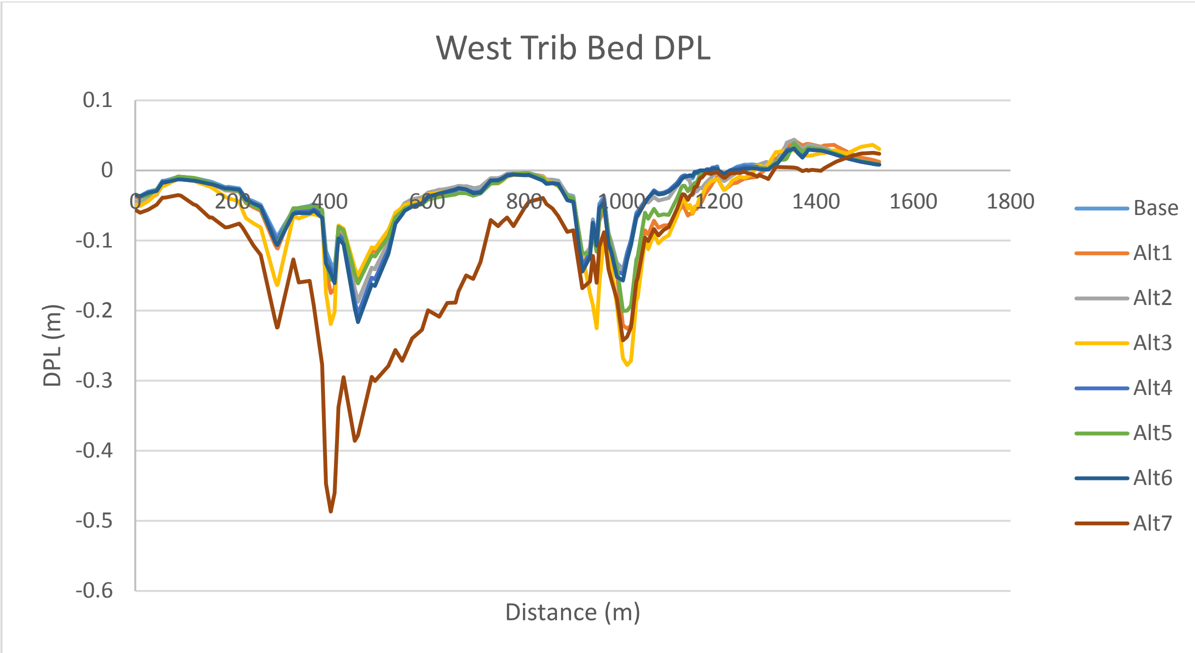

Figure 26 : West Tributary Bed DPL

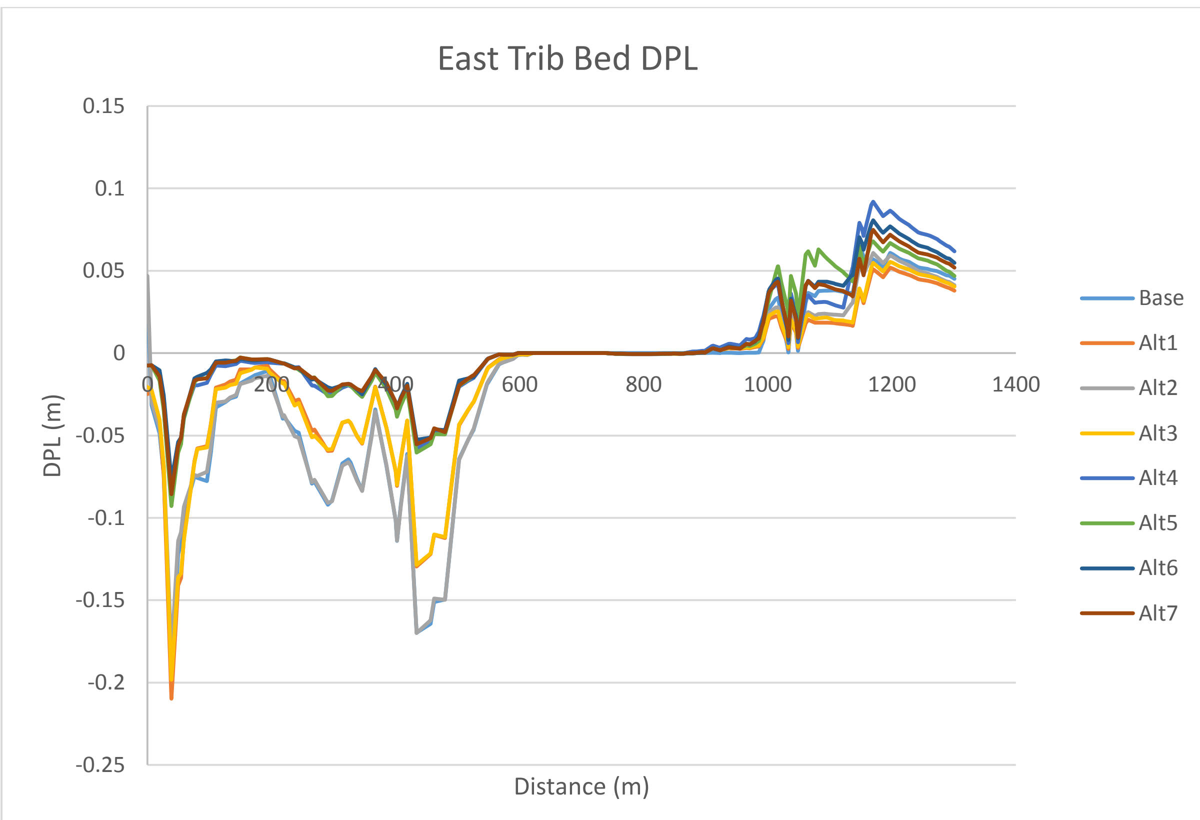

Figure 27 : East Tributary Bed DPL

Observations to consider

- As discussed above, this is the output dataset with the lowest uncertainty
- As discussed above, it is critical to view the outputs as base-to-plan comparison.
- The West Tributary appears to have negligible change from base condition in alternatives 1-6. Alternative 7 appears to be the only alternative with significantly more scour.
- The East Tributary appears to have negligible change from base condition in alternatives 2-3. All other alternatives produce additional deposition.
- Umbrella Creek appears to have negligible change from base condition in alternatives 1-3. All other alternatives produce more scour than the base condition, with alternative 7 showing the largest change.
- Dover Creek appears to have negligible change from base condition in alternative 2, alternative 4, and alternative 6. All other alternatives produce similar amounts of scour.
- ORR appears to have negligible change from base condition in alternative 1 and alternative 5. Alternative 4 appears to dramatically increase the scour rate along the whole reach. Alternative 2, alternative 3, alternative 6 and alternative 7 appear to induce shoaling in the vicinity of the closure location.
- Noyes Cut appears to have negligible change from base condition in alternative 2, alternative 4 and alternative 6. All remaining alternatives appear to induce shoaling in the vicinity of the closure location.

5. Civil Design Project Features

5.1 Design Requirements

The basis of design requirements for each plug location is to block tidal flow in an effective and cost efficient manner. Each plug should reduce velocities in the channel, alter the salinity regime favorably, and trap sediment on both sides to create marshland. The structures must tie in to marshland far enough to prevent side cutting around the structures and negating benefits.

5.2 Conceptual Design

The conceptual design at each closure location is virtually identical, with the exception of material volume required. The alternatives analysis are simple different combinations of closures to alter flow patterns. Each closure structure consists of a PZC-13 sheet piling at the marsh tie in points, and GDOT Type-1 Armor rock placed in a trapezoidal shape through the centerline of the structure across the channel. Sheet pile is used at the marsh tie-in to minimize environmental impacts. The crest width of rock placement will be 6', with 3:1 (H:V)side sloped to channel bottom closure. The crest elevation has been set at 3' NAVD88, which will act as a complete barrier to flow approximately 90% of the time, except for spring tide conditions.

5.3 Construction Methods

Construction will be completed primarily from barges. There will likely be multiple barges at any given time, for material storage and pile driving. The tie in length into the marshland will be as long as possible given the constraint of arm length from the barges, and is estimated to be approximately 40'. No machinery would be used in the delicate marshlands to minimize adverse impacts.

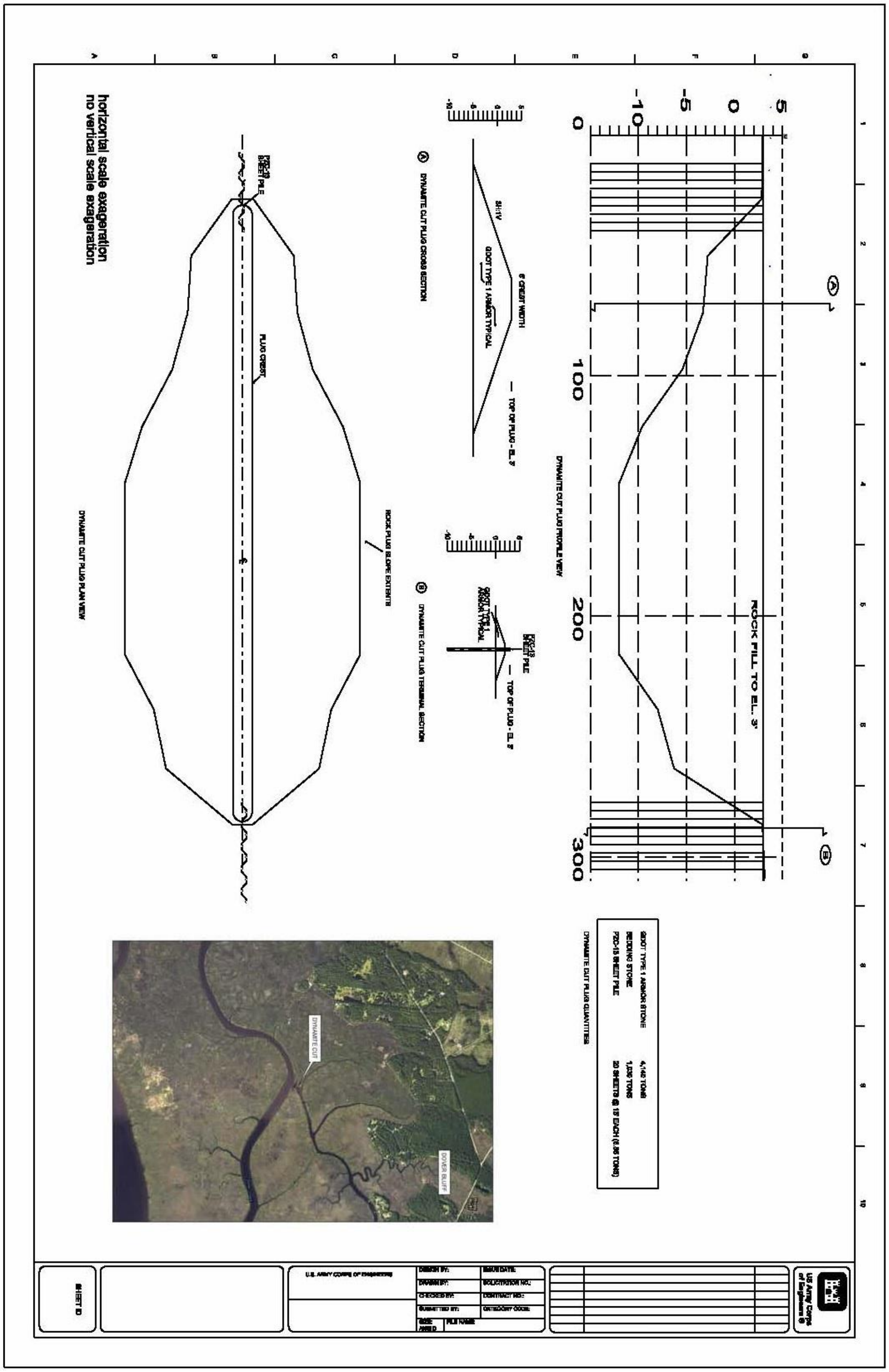

Figure 28 : Dynamite Cut Plansheet

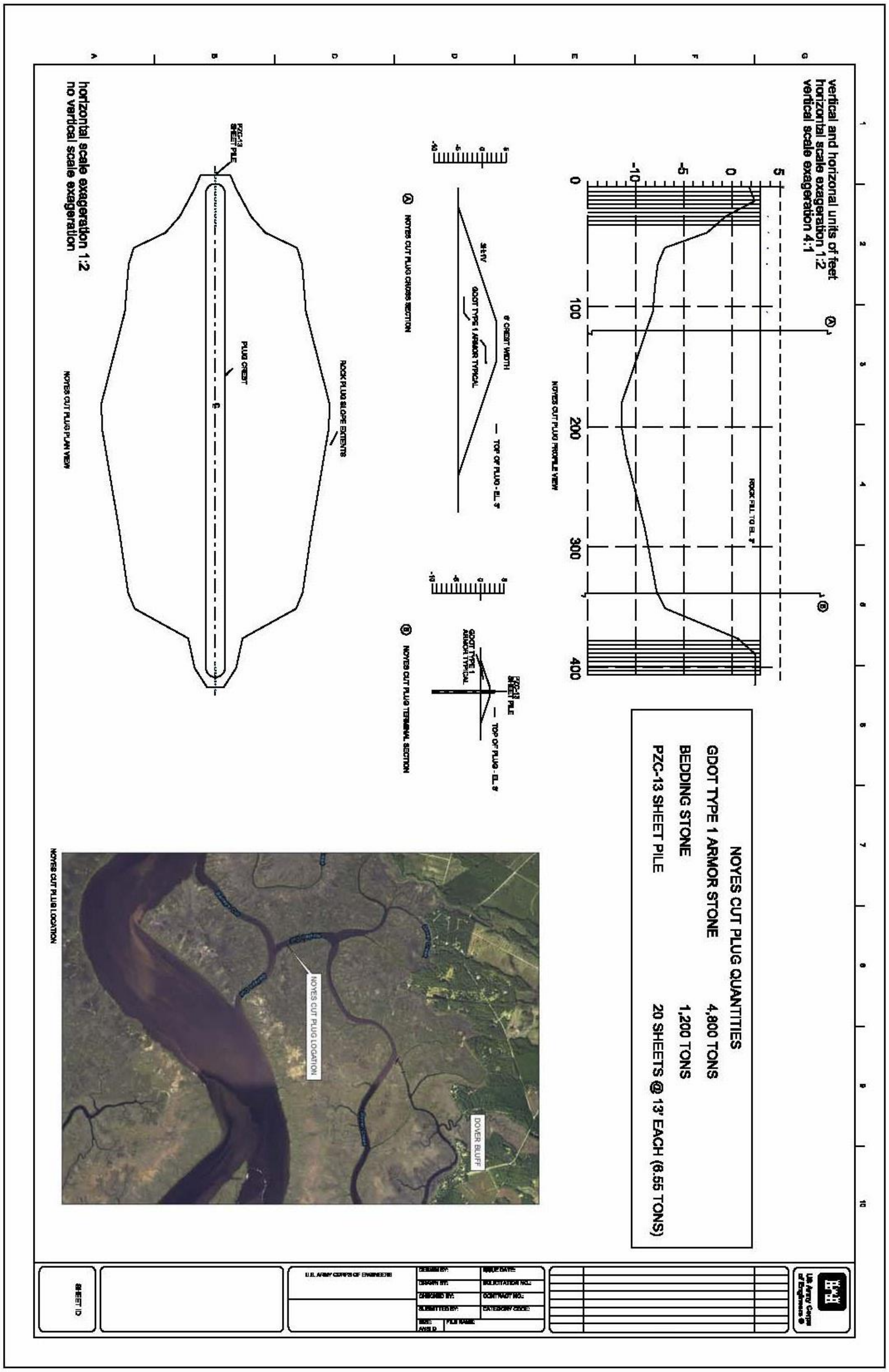

Figure 29 : Noyes Cut Plansheet

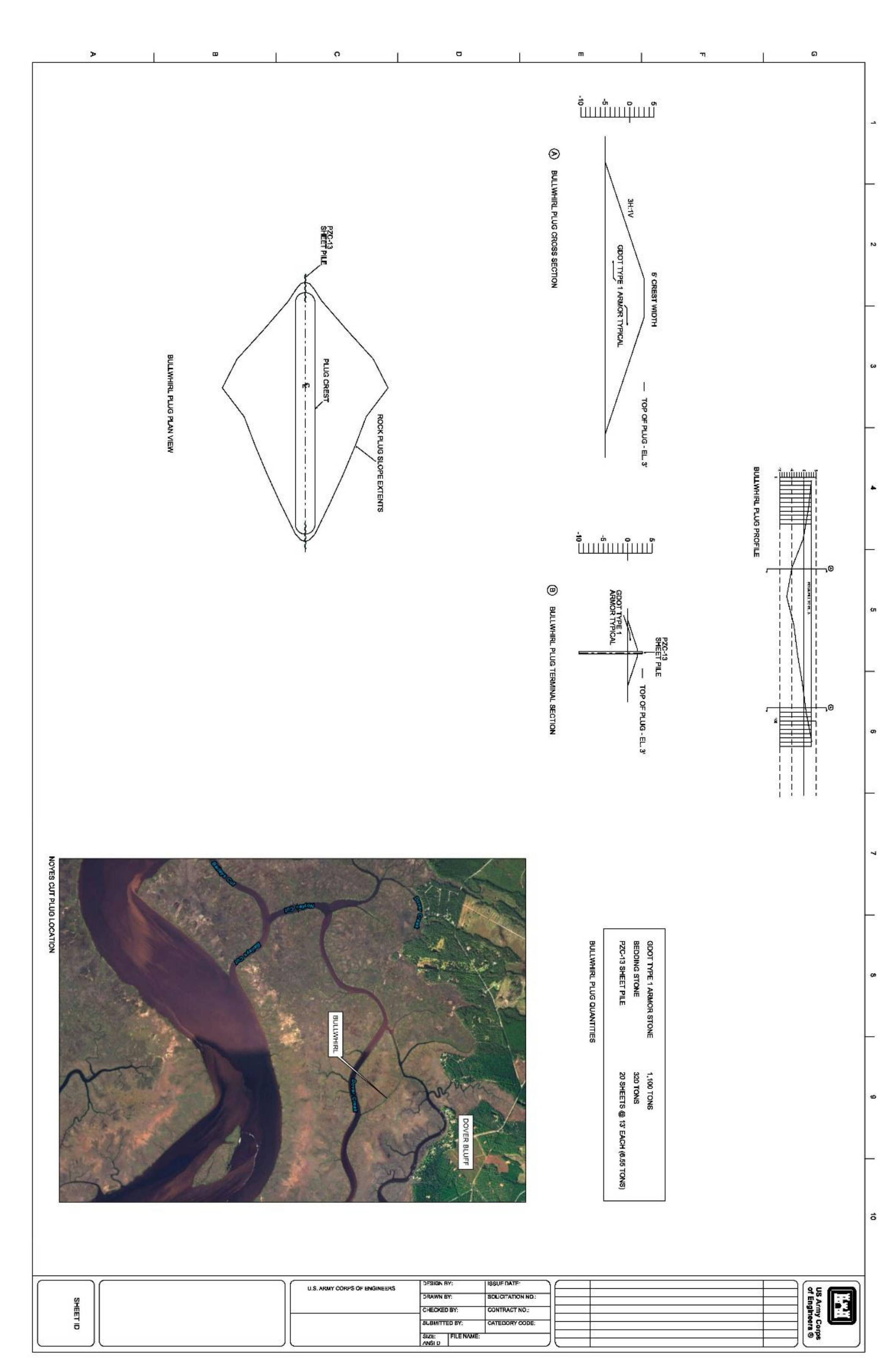

Figure 30 : ORR Plansheet

5.4 Quantity Estimate Summary

Construction quantities were generated based on the design template, bathymetric surveys and rock template designs shown in Figure 28 - Figure 30. Quantities were used to develop screening level costs for use in economics appendix and Benefit-Cost ratio. More details on costs can be found in the Cost Engineering appendix.

DESCRIPTION	UNITS	QUANTITY
Noyes Cut		
Sheet Pile End Walls - Materials	TON	6.56
Sheet Pile End Walls - Installation	SF Wall	604.11
Bedding Stone	TON	1200.00
Rip Rap, GDOT Type 1	TON	4800.00
ORR		
Sheet Pile End Walls - Materials	TON	6.56
Sheet Pile End Walls - Installation	SF Wall	604.11
Bedding Stone	TON	320.00
Rip Rap, GDOT Type 1	TON	1100.00
Dynamite Cut		
Sheet Pile End Walls - Materials	TON	6.56
Sheet Pile End Walls - Installation	SF Wall	604.11
Bedding Stone	TON	1030.00
Rip Rap, GDOT Type 1	TON	4140.00

Figure 31 : Quantity Estimates

6. Supplemental Information

6.1 Regional Geology

The proposed restoration property is in eastern Camden County, in the marshlands north of the Satilla river and near the St Andrews Sound. Camden County is located in the Satilla Coastal Lowland Plain(or Satilla Plain), a subset of the Coastal Plain Physiographic Province. The Satilla Plain is a low marine terrace approximately 20-35 miles wide bordering the Atlantic Ocean. The western edge is marked by a 20-40 ft high escarpment and marked by sandy flat plains and longleaf pines. The eastern coastline edge is an irregular network of sea-islands, sounds, tidal river and marshes. There are two classes of swampland, the upland swamp and the tidal swamp. The project is located in the tidal swamp area, and is partially submerged at high tide.[1]

6.2 Sea Level Rise

For the study area, sea level is predicted to rise 9 inches over the 50-year period of analysis. The tidal marsh in the study area would be very adaptable to increases in sea level rise due to the large tidal range, available sediment supply, and the ability of the existing marsh to create its own sediment from detritus (NOAA 2011). Therefore, no decrease in tidal marsh habitat is projected in the without project condition for the 50-year period.

6.3 Model Stratification

For the study area, the 2-D depth-averaged ADH model code was selected over the 3-D version. The relatively shallow estuaries and the semi-diurnal tide conditions suggest that the system is well mixed and that this assumption is appropriate. The area of the domain where this may not be a good assumption is in the main Satilla River reach, where depths are large enough for stratification. However, there is no hydraulic or environmental analysis being done on model outputs on the Satilla River reach.

The TSS data that was collected in 1995 at the Satilla River anchor stations was in the form of TSS profiles. These profiles were depth averaged for comparison to the 2-D model. A 3-D model would have been useful in this instance as well, however the overall benefits 2-D assumption outweigh the gains to be captured by using a 3-D model.

6.4 Climate

The climate is mild with hot humid summers and abundant yearly rainfall. Brief frost and freeze events occur in winter. Snowfall is rare, occurring on average less than once per year. Winters are usually short and mild with occasional cold periods of short duration. Average daily winter temperatures range from 46 to 65°F and average 55°F. Summers are long, hot, and typically very wet. Average daily summer temperatures range from 75 to 91°F and average 83°F. Average annual precipitation is approximately 50 inches. The average rainfall intensity from 1988 to 1997 was 4.28 inches. Maximum rainfall generally occurs in August.

---

[1] Vaughn, T. Wayland, Otto Veatch, and Llyod William Stephenson. *Preliminary Report on the Geology of the Coastal Plain of Georgia*. Bulletin No. 26. Atlanta: Foore & Davies, 1911. USGS & EPD, 4 Dec. 2009. Web. 1 Aug. 2017. Pages 36-39

6.5 Climate Change

USACE screening level climate change vulnerability assessment (VA) tool was utilized to assess the potential impacts and likelihood of climate change impacts to this region. The tool operates on a HUC-4 level spatial scale, and it used to quickly assess climate change vulnerably. The tool can be found on https://maps.crrel.usace.army.mil/apex/f?p=170:2:963367691217::NO:::

The parameters that were used are as follows:

Division: South Atlantic

District: Savannah

HUC: - Altamaha-St Mary's HUC0307

Business line: Ecosystem Restoration

> Indicators under selected business line: At Risk Freshwater Plants, Mean Annual Runoff, Monthly Cov, Runoff Precipitation, Sediment, Macroinvertebrates, Flood Magnification, Low Flow Reduction

Climactic Data Source: CMIP-5 (2014)

Threshold: 20%

ORness: 0.7[2]

[2] Specifies how risk-averse the analysis should be. Value should be between 0.5 and 1.0. Higher ORness values weigh the more vulnerable indicators more heavily, resulting in greater perceived vulnerability overall (more risk-averse). Lower ORness values weigh all indicators in a business line more equally, resulting in lower perceived vulnerability overall because less vulnerable indicators average out more vulnerable indicators (less risk-averse). Typical value is 0.7

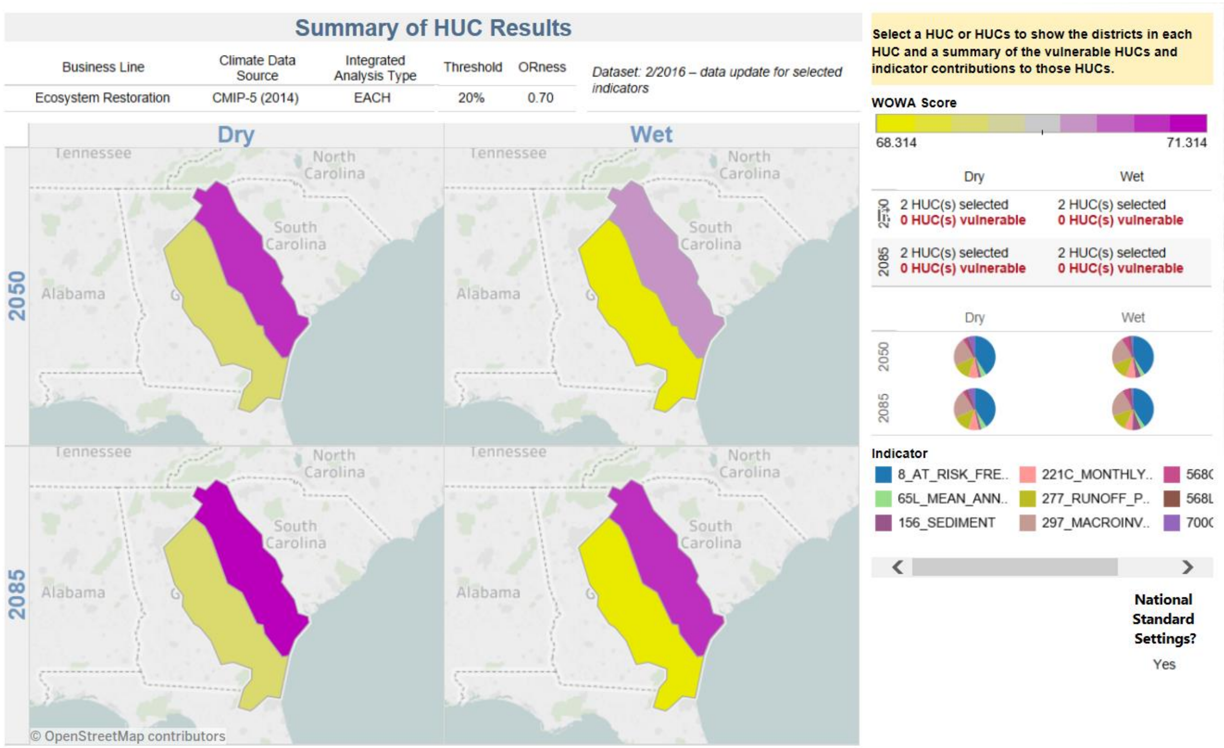

Figure 32 : HUC0307 Summary Results

WOWA Scores[3]:

	Dry	Wet
2050	69.154	68.314
2085	69.139	68.459

The WOWA Score of the Altamaha-St Mary's watershed is a standardized way to compare climate change vulnerability to other basins throughout the United States. The WOWA score for the basins throughout the country under the Flood Risk Reduction Business line ranges from 54.69 to 89.84. **Figure 33** shows how the project basin is related to the rest of the country.

The Altamaha-St Mary's watershed WOWA score does not exceed the vulnerability threshold for the Ecosystem Restoration business line, and is at a relatively low risk for impacts to climate change compared to the rest of the continental United States.

[3] WOWA stands for "Weighted Ordered Weighted Average," which reflects the aggregation approach used to get the final score for each HUC. After normalization and standardization of indicator data, the data are weighted with "importance weights" determined by the Corps (the first "W"). Then, for each HUC-epoch-scenario, all indicators in a business line are ranked according to their weighted score, and a second set of weights (which are the OWA weights," are applied, based on the specified ORness level. This yields a single aggregate score for each HUC-epoch-scenario called the WOWA score. WOWA contributions/indicator contributions are calculated after the aggregation to give a sense of which indicators dominate the WOWA score at each HUC.

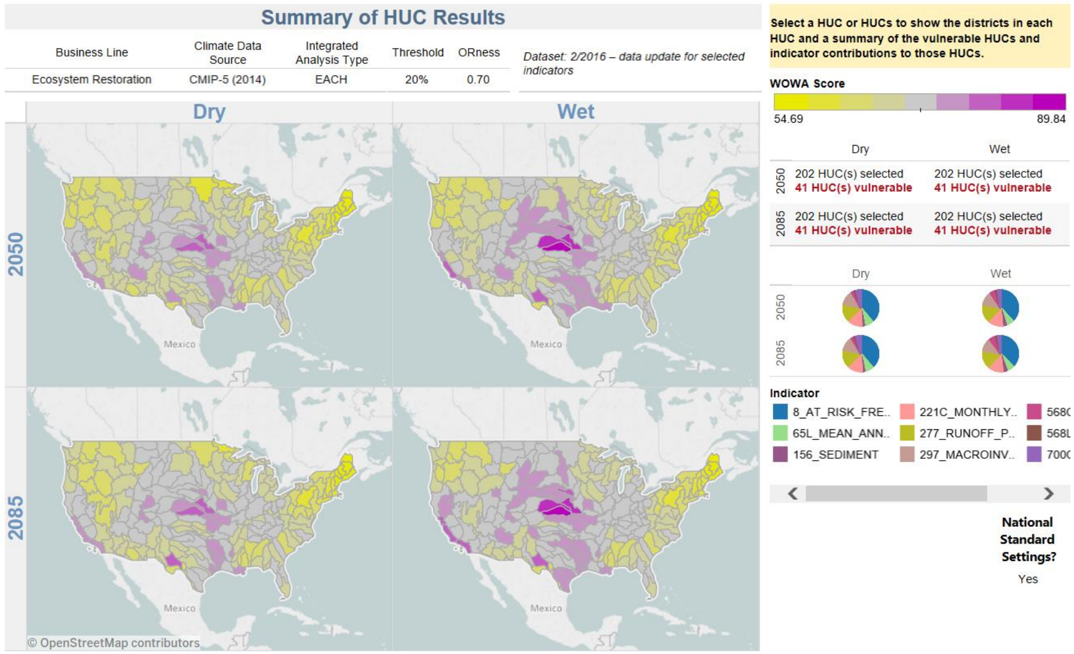

Figure 33 : Nationwide HUC Comparison

The vulnerability WOWA score was also evaluated over time, from the period 2050 to 2085. During a both dry and wet hypothetical future scenario, the WOWA score can be expected to decrease approximately .17%.

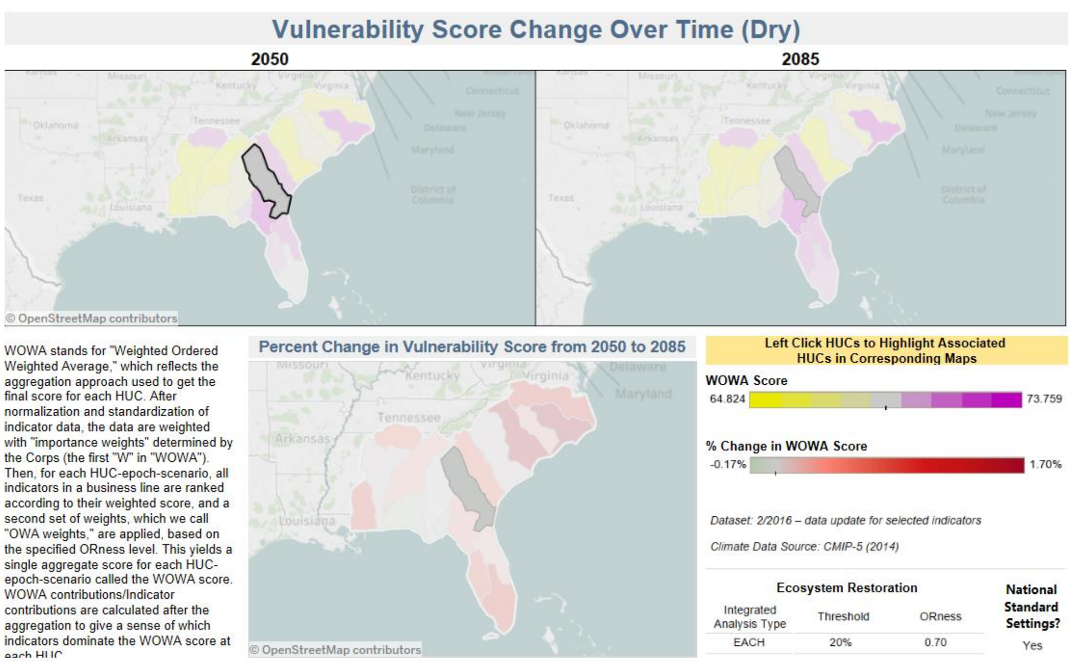

Figure 34 : HUC Vulnerability over time

6.6 Morphological History

The project area is a dynamic system and continually evolving toward and equilibrium. In the past decade, there has been enough human influence to the area such that the natural equilibrium has not yet been achieved. Figure 35 shows a portion of a county map drawn based on survey data collected between 1981-1917. Prior to all manmade cuts, the system appears very simple with headwaters to the west with a steady gradient toward the ocean.

Figure 35 : Map of area ~1900

Since the year 1900, multiple cuts have been introduced to the system without any real concern for long term impacts. Below is an approximate timeline of man-made changes, each of which have a butterfly-effect on the natural long term morphological response. The system in the current state is shown in Figure 36.

Early Timeline

- 1900: No manmade cuts in system
- 1910: Noyes Cut dug by local interest
- 1915: Dover and Umbrella cuts dug by USACE
- 1939: Federal Alternate AIWW Cut
- 1971: Wing dam built on Umbrella Creek, failed.

Recent natural morphological changes can be evaluated via google earth aerial imagery dating back to 1988. The most apparent change is ORR visibly closing from ~140’ wide to ~25’ wide.

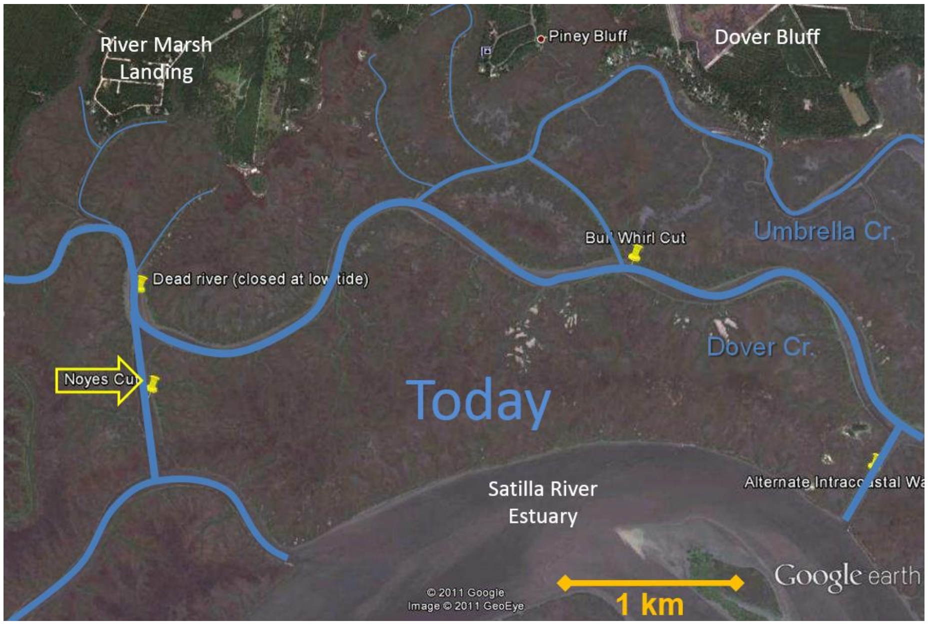

Figure 36 : Map of area ~2013

APPENDIX C

COORDINATION AND PERMITS

Appendix C

Table of Contents

Agencies to receive letters from USACE during Public Comment Period:

GADNR
Satilla Riverkeeper
Georgia EPD-DWR
Georgia EPD-CRD
Georgia SHPO
USFWS
EPA
NMFS

The following Native American Tribes will be consulted:

- Absentee-Shawnee Tribe of Oklahoma
- Alabama-Quassarte Tribal Town
- Catawba Indian Nation
- Cherokee Nation
- Coushatta Tribe of Louisiana
- Eastern Band of Cherokee Indians
- Eastern Shawnee Tribe of Oklahoma
- Kialegee Tribal Town
- Muscogee (Creek) Nation
- Poarch Band of Creek Indians
- Seminole Nation of Oklahoma
- Thlopthlocco Tribal Town
- United Keetoowah Band of Cherokee Indians

GEORGIA
DEPARTMENT OF NATURAL RESOURCES

HISTORIC PRESERVATION DIVISION

MARK WILLIAMS
COMMISSIONER

DR. DAVID CRASS
DIVISION DIRECTOR

May 18, 2017

William G. Bailey, PE
Chief, Planning Division
Savannah District, Corps of Engineers
100 West Oglethorpe Avenue
Savannah, Georgia 31401-3604
Attn: Julie Morgan, Archaeologist

RE: **Ecosystem Restoration Study, Satilla River, Noyes Cut, St Andrews Sound**
Camden County, Georgia
HP-170501-021

Dear Mr. Bailey:

The Historic Preservation Division (HPD) has received initial information concerning the above referenced project. Our comments are offered to assist the US Army Corps of Engineers (USACE) in complying with the provisions of Section 106 of the National Historic Preservation Act of 1966, as amended (NHPA).

Thank you for notifying us of this proposed project. HPD looks forward to receiving Section 106 compliance documentation, including the restoration study, when it becomes available and working with you as this project progresses. In regards to identifying the area of potential effect (APE) for the proposed project, HPD recommends completing background research, such as the Georgia Archaeological Site Files and Georgia's Natural, Archaeological, and Historic Resources GIS, for the entire study area in order to guide the selection of alternatives to consider. As the type of closure method is refined, the APE should include not only the area of direct impact, but any nearby properties that could have visual or other indirect effects. HPD concurs that field investigations may be needed due to dated, inaccurate, or incomplete existing information in order to fully assess effects to historic properties within the APE.

Please refer to project number **HP-170501-021** in future correspondence regarding this project. If we may be of further assistance, please do not hesitate to contact me at Jennifer.dixon@dnr.ga.gov or (770) 389-7851.

Sincerely,

Jennifer Dixon, MHP, LEED Green Associate
Program Manager
Environmental Review & Preservation Planning

JEWETT CENTER FOR HISTORIC PRESERVATION
2610 GA HWY 155, SW | STOCKBRIDGE, GA 30281
770.389.7844 | FAX 770.389.7878 | WWW.GEORGIASHPO.ORG

From: Theodore Isham
To: Morgan-Ryan, Julie A CIV USARMY CESAS (US)
Subject: [Non-DoD Source] SNO Response to USACE Project of Satilla River Estuary
Date: Monday, June 5, 2017 3:21:08 PM

This ***Opinion*** is being provided by Seminole Nation of Oklahoma's Cultural Advisor, pursuant to authority vested by the Seminole Nation of Oklahoma General Council. The Seminole Nation of Oklahoma is an independently Federally-Recognized Indian Nation headquartered in Wewoka, OK.

In keeping with the National Environmental Policy Act (NEPA)d, and Section 106 of the National Historic Preservation Act (NHPA), 36 CFR Part 800, this letter is to acknowledge that the Seminole Nation of Oklahoma has received notice of the proposed project at the above mentioned location.

Based on the information provided and because the potential for buried cultural resources, the proposed project has an extreme probability of affecting archaeological resources, some of which may be eligible for listing in the National Register of Historic Places (NRHP).

We recommend that an intensive literature/phaseI survey of the nearby archaeological sites from the states master site files be completed and other CRS surveys. Also, we request that a listing of the flora in the affected area be provided.

We do request that if cultural or archeological resource materials are encountered at all activity cease and the Seminole Nation of Oklahoma and other appropriate agencies be contacted immediately.

Furthermore, due to the historic presence of our people in the project area, inadvertent discoveries of human remains and related NAGPRA items may occur, even in areas of existing or prior development. Should this occur we request all work cease and the Seminole Nation of Oklahoma and other appropriate agencies be immediately notified.

Theodore Isham

Seminole Nation of Oklahoma
Historic Preservation Officer
PO Box 1498
Wewoka, Ok 74884
Phone: 405-234-5218
e-mail: isham.t@sno-nsn.gov

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Office of the Chief

Bill John Baker
Principal Chief
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S. Joe Crittenden
Deputy Principal Chief
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June 5, 2017

Marvin L. Griffin
Army Corps of Engineers
Savannah District
100 W Oglethorpe Avenue
Savannah, GA 31401-3604

Re: Satilla River Ecosystem Restoration Project

Colonel Marvin L. Griffin:

The Cherokee Nation (CN) is in receipt of your correspondence about **Satilla River Ecosystem Restoration Project**, and appreciates the opportunity to provide comment upon this project. The CN maintains databases and records of cultural, historic, and pre-historic resources in this area. Our Historic Preservation Office reviewed this project, cross referenced the project's legal description against our information, and found no instances where this project intersects or adjoins such resources. Thus, the CN does not foresee this project imparting impacts to Cherokee cultural resources at this time. However, the CN requests that the Army Corps of Engineers halt all project activities immediately and re-contact our Offices for further consultation if items of cultural significance are discovered during the course of this project.

Additionally, we would request Army Corps of Engineers conduct appropriate inquiries with other pertinent Tribal and Historic Preservation Offices regarding historic and prehistoric resources not included in the CN databases or records. If you require additional information or have any questions, please contact me at your convenience.

Thank you for your time and attention to this matter.

Wado,

Elizabeth Toombs

Elizabeth Toombs, Special Projects Officer
Cherokee Nation Tribal Historic Preservation Office
elizabeth-toombs@cherokee.org
918.453.5389

CC: Ms. Julie Morgan

APPENDIX D

FISH AND WILDLIFE COORDINATION ACT REPORT

August 17, 2017

Colonel Marvin L. Griffin
U. S. Army Corps of Engineers
Regulatory Division
100 West Oglethorpe Avenue
Savannah, Georgia 31401-3640

Dear Colonel Griffin:

The Fish and Wildlife Service (Service) has completed an evaluation of the proposed Noyes Cut Section 1135 Satilla River estuary restoration project, Camden County, Georgia. This letter report contains the Service's analysis of, and position on, the proposed project; it also constitutes the report of the Secretary of the Interior as required by Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

INTRODUCTION

Section 1135 of the Water Resources Development Act of 1986 authorizes the modification of completed Corps of Engineers (Corps) projects for the purpose of improving environmental quality. The Corps Savannah District has proposed a project under that authority for improving water quality in Noyes Cut by restoring the estuarine conditions critical to maintaining healthy ecosystems in the Satilla River estuary in the vicinity of Noyes Cut.

The proposed project would be located in the Satilla River estuary in the vicinity of Noyes Cut. Noyes Cut was excavated in 1910 by citizens of Camden County to provide small boats a safe inland route from Satilla River to Brunswick and transporting barges loaded with timber to coastal sawmills. The U.S. Army Corps of Engineers (USACE) completed construction of Noyes Cut in 1932 as an Atlantic Intracoastal Waterway auxiliary channel to provide small boats a safe inland route from the Satilla River to Brunswick, Georgia and avoid the open waters of St. Andrews Sound.

With authorized dimensions of 50 feet wide by 5 feet deep, Noyes Cut has since grown in size and is now 300-500 feet wide by 7-10 feet deep. The expanded cut has altered flows in the Satilla River watershed and surrounding tidal creeks, most notably Dover Creek and Umbrella Creek. In Dover Creek, decreased tidal flows have increased shoaling blocking access for migratory fish, crabs and shrimp to the creek's former reaches. Portions of the creek that were once 100 yards wide have now narrowed to ten (10) yards, and the inland reaches of Dover Creek and adjacent Umbrella Creek go dry at low tide. The siltation has also blocked creek access to commercial fisherman whose livelihood depends on harvesting seafood from these waters. The impacts of Noyes Cut are compounded by land use changes in the larger Satilla River watershed that have resulted in chronic low flows and with naturally low oxygen levels in the river. These conditions have driven migratory fish from the river's main stream, making restoration of the river's tidal creeks all the more important for a healthy fishery in the river's estuary which expands across 10,000 acres of Georgia's coast.

FISH AND WILDLIFE RESOURCES OF STUDY AREA

Intertidal Habitat:

It is estimated that between 60 and 80 % of the commercially important fish and shellfish species in the southeast have some life stage associated with salt marsh habitats (DeVoe and Baughman 1986; Crowder 1999). The extensive salt marshes surrounding the Satilla are generally dominated by salt marsh cord grass, (*Spartina alterniflora)* at lower elevations. Areas that are infrequently flooded are dominated with black needle rush, (*Juncus roemerianus)*. Brackish marshes are dominated by big cordgrass (*S. cynosuroides)* and salt marsh cord grass *(S. alterniflora)* along levees, with monospecific stands of black needle rush (*J. roemerianus)* throughout the mid-marsh. Freshwater marshes typically contain a greater diversity of species, including wild rices, (*Zizania aquatic)* and (*Zizaniopsis miliacae)* (Alber et al. 2003).

Many species of crabs live in the marsh including brown squareback crab (*Sesarma cinereum*), purple squareback crab (*S. reticulatum*) and mud crab (*Eurytium limosum*). Two fiddler crab species are the mud fiddler (*Uca pugnax*), the sand fiddler (*U. pugilator*) and the red-jointed fiddler (*U. minax*). Snails commonly found within the salt marshes include three species: the marsh periwinkle (*Littorina irrorata*), the mud snail (*Ilynassa obsoleta*), and the air-breathing coffeebean snail (*Melampus bidentatus*). More than 100 insect species have been identified in Georgia's salt marshes, with the most dominant species the salt marsh grasshopper (*Orchelimum fidicinium*) and the planthopper (*Prokelisia marginata*).

Reptiles inhabiting the salt marsh include the diamondback terrapin (*Malaclemys terrapin*) and alligators (*Alligator mississippiensis*) occasionally feed in the marsh. Three bird species nest in the marsh—the clapper rail (*Rallus longirostris*); seaside sparrow (*Ammodramus maritimus*); and long-billed marsh wren (*Telmatodytes palustris*). Great blue herons (*Ardea herodias*), common and snowy egrets (*Egretta* spp.), and other wading birds commonly forage in the marsh at low tide. Several mammal species also feed in the salt marsh: raccoons (Procyon lotor), marsh rabbits (*Sylvilagus palustris),* mink (Mustela vison), otter (*Lontra canadensis*), and rice rat (Oryzomys palustris). (Seabrook, 2017).

Marine Habitat:

These species have been commercially harvested from the Satilla River since 1972: catfish, black drum, red drum, flounders, whiting mullet, spotted sea trout, sheepshead, sturgeon, crab, whelk, oysters, american eel, american shad, hickory shad, white and brown shrimp (Alber et. Al. 2003). The Atlantic waterways off the coast of Georgia provide habitat for the North Atlantic Right Whale *(Eubalaena glacialis)*, West Indian Manatee *(Trichechus manatus)*, Green Sea Turtle *(Chelonia mydas),* Leatherback Sea Turtle *(Dermochelys coriacea),* Loggerhead Sea Turtle *(Caretta caretta),* Hawksbill Sea Turtle *(Eretmochelys imbricate),* Kemp's Ridley Sea Turtle *(Lepidochelys kempii),* Bottlenose Dolphin (Tursiops truncatus), Common Dolphin (Delphinus delphis), along with numerous fish species including the popular sportfish striped bass *(Morone saxatilis).*

Federally listed threatened (T) , endangered (E) and candidate (C) species known to occur in

Camden County, Georgia include the North Atlantic Right Whale *(Eubalaena glacialis)* (E), West Indian Manatee *(Trichechus manatus)*, (T), Piping Plover *(Charadrius melodus)* (T), Red Knot *(Calidris canutus rufa)* (T), Red-cockaded Woodpecker *(Picoides borealis)* (E), Wood Stork *(Mycteria Americana)* (T), Eastern Indigo Snake *(Drymarchon corais couperi)* (T), Gopher Tortoise *(Gopherus Polyphemus)* (C) , Green Sea Turtle *(Chelonia mydas)* (T), Leatherback Sea Turtle *(Dermochelys coriacea)* (E), Loggerhead Sea Turtle *(Caretta caretta)* (T), Striped Newt *(Notophthalmus perstriatus)* (C), Atlantic Sturgeon *(Acipenser oxyrinchus oxyrinchus)* (E) and Shortnose Sturgeon *(Acipenser brevirostrum)* (E). The Service does not anticipate that project implementation would adversely impact those species.

DESCRIPTION OF PROPOSED PROJECT

The Corps proposes to alter the hydrodynamic environment by closing a combination of one or more man-made cuts (e.g., Noyes; Old River Run (ORR) (near Bull Whirl Cut); and Dynamite Cut) to alter tidal exchange in Dover and Umbrella Creeks. By closing these man-made cuts, it will restore salinity gradients, reduce local sedimentation issues, and increase connectivity for local biota and it is also anticipated to restore historic conditions of salinity regimes along with increasing connectivity for local fauna.

In its current state, the salinity gradients are changed by a large amount of Satilla River water entering through the pathway of Noyes Cut. This volume of estuarine water overwhelms the freshwater that enters the headwater area, which causes the salinity to be constant throughout Dover Creek. Tidal flows through multiple creeks and cuts also causes a tidal node where sediment deposition clogs channels. A reduction in tidal exchange through man-made cuts is anticipated to restore water depths in Dover and Umbrella Creeks, which have silted in as a result of changes in circulation. The sedimentation restricts access to portions of the rivers by migratory fish, shellfish and shrimp.

PROJECT IMPACTS ON FISH AND WILDLIFE RESOURCES

Salt marshes provide feeding areas for wading birds, including the federally threatened wood stork (*Mycteria americana*), the federally threatened piping plover (*Charadrius melodus*), and the federally threatened red knot (*Calidris canutus rufa*). The project area is within the thirteen mile core foraging area for four nearby wood stork nesting colonies as well as within five miles of three bald eagle (*Haliaeetus leucocephalus*) nests and likely provides some forage habitat. The Service removed the bald eagle as threatened under the ESA in August 2007, and published in May 2007, National Bald Eagle Management Guidelines to assist in understanding protections afforded to and prohibitions related to the bald eagle under the BGEPA.

The natural tidal exchange distribution in unaltered tidal creeks is upstream and the proposed project aims to restore this process which will enhance the overall water quality in the Satilla River estuary. Eventually this distribution should redistribute the sediments, create a sandier, deeper creek bottom, and restore gradual salinity gradients from headwaters to mouth. Salinity gradients serve as important cues for orienting migratory fauna and are also key in maintaining tidal exchange processes (e.g., sediment, nutrients, carbon).

The estuarine species historically found in Dover and Umbrella Creeks include shrimp (white and brown), river herring, American shad, blue crabs, eastern oyster, and striped bass. All of these species may benefit from the restoration of tidal exchange, water depths, and salinity gradients in the area. Shad, herring, and striped bass require freshwater for spawning, while blue crabs, oysters, and shrimp require brackish water for successful reproduction. Potential indirect long-term benefits of restoring depths and flows in the study area may include increased dissolved oxygen (DO) levels, decreased Total Suspended Solids (TSS), and improved nutrient exchange between the Satilla River, St. Andrews Sound, and the Atlantic Ocean. In addition to the intended ecosystem benefits, ancillary benefits would include the return of commercial fishing and crabbing and sport fishing in Dover and Umbrella Creeks for the aforementioned species. Residential deep water access would also be restored to residential developments adjacent to the estuary that currently have access only at high tide.

SERVICE POSITION AND RECOMMENDATIONS

The proposed Noyes Cut Section 1135 Project should be designed to provide the greatest incremental increase in fisheries and related aquatic habitat values.

Based on our evaluation, the Service would not object to implementation of the proposed Noyes Cut project, provided that the following recommendations are incorporated into the project:

1) Construction does not occur from March 1 to November 30 to avoid impacts to manatees.

2) The inclusion of the "Standard Manatee Conditions and Procedures for Aquatic Construction" as special conditions of any permit that would be issued by USACE.

We appreciate the cooperation of your staff during our involvement in this planning effort. Please have your staff contact Gail Martinez of this office at 912/312-8739 (Extension 7), if they have any questions regarding our recommendations.

Sincerely,

Donald W [signature]

Donald Imm, PhD
Field Supervisor

LITERATURE CITED

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