HENNEPIN MARSH HABITAT RESTORATION HYDRAULIC MODELING AND ANALYSIS SUMMARY

Introduction

The proposed Hennepin Marsh habitat restoration project is located in the upper section of the Trenton channel, adjacent to the northwest part of Grosse Ile Township (Figure 1). The proposed project includes construction of new shoals approximately 4,000 ft upstream of the Grosse Ile Toll Bridge (North Shoals) and modifications to the existing shoals located just downstream of the Grosse Ile Toll Bridge (South Shoals). A hydraulic analysis was performed to determine the potential impacts of the proposed shoal designs on the distribution of flow rate, depth, and velocity in the vicinity of the Grosse Ile Toll Bridge and within the main navigation channel, near-shoal areas, and marshes adjacent to Grosse Ile. This summary describes the results of the hydraulic analysis.

Methodology

A hydraulic model was developed using the U.S. Army of Corps of Engineers Hydrologic Engineering Center's River Analysis System (HEC-RAS 5.0.6) software. The one-dimensional model was developed using existing condition cross-sections. Cross-sections were obtained from a combination of bathymetry, existing NOAA 3D model for Huron-Erie corridor, and USGS's digital elevation models. Further interpolations of additional cross-sections were made at or near proposed shoal locations (Figure 1) to properly capture shoal dimensions and potential effects. The existing condition model was calibrated using the Federal Emergency Management Agency (FEMA) 100-year flood elevation. Once calibrated, cross-sections were modified to represent the new shoal designs in the north and modified shoal designs in the south. Three alternative designs for the North Shoals with equal total lengths were originally simulated. The difference between the three alternative shoal designs was in the number of openings between shoal sections, having one, two or three openings for alternatives 1, 2 and 3, respectively (Figure 2). A fourth alternative was later proposed with three openings, longer shoals and new shoal locations (Figure 2) to avoid potential effects on existing wells in the Hennepin Marsh area. Three flow conditions were simulated using the existing and proposed condition geometries: Two flow values measured by ECT (see details of measurement methodology in Appendix D) in October of 2018 (Q1 = 50,600 cfs) and July of 2019 (Q2 = 53,070 cfs) and estimated FEMA 100-year flow (Q3 = 63,000 cfs). Cross-sections were divided into three sections representing the marsh area (section 1), near-shoal area (section 2) and main navigation channel

(section 3) to separately assess changes in different parts of the channel cross-sections (Figure 3). Flow, depth, and velocity distributions were compared for the 4 alternative designs to evaluate changes in existing versus proposed conditions. Results were reported in terms of absolute and percent changes.

Results and Conclusion

The results of the hydraulic modeling indicate that the proposed improvements will not have a significant impact on flow depths, velocities, nor flow rate distributions.

North Shoals

The simulation results of the four alternative configurations for the North Shoals indicated that the alternatives with two or three openings (versus a single opening) minimized depth, and velocity changes. There was no appreciable difference between alternatives with two and three openings; therefore, the alternative layout which has three openings and was proposed to avoid potential erosions around wells in the marsh area (Alternative #4) was selected as the final layout of the North shoals to increase habitat value of the shoals and protected backwater while minimizing disturbances around existing wells in the marsh area.

Figure 4a depicts the predicted changes in depths and velocities at the cross-sections adjacent to the proposed North Shoals for the alternative #4 design configuration in the 100-year flow scenario. Figure 4a indicates that the model predicted a 0.38% (0.007 ft/s) or less increase in velocities within the main navigation channel; 0.88% (0.011 ft/s) or less decrease in velocities in the near-shoal area; and a 2.70% (0.017 ft/s) or less decrease in velocities within the marsh areas adjacent to Grosse Ile. Figure 4a also shows that the model predicted a 0.00% (0.000 ft) change in depths within the main navigation channel and near-shoal area and a 0.73% (0.050 ft) or less decrease in depths along the marsh areas. Changes within the navigation channel were relatively small or negligible because the changes in the near-shoal area were spread out across a much larger cross-sectional area in the navigation channel, as shown in Figure 3. The predicted changes associated with the October 2018 and July 2019 smaller flow events were less than those depicted in Figure 4a for the 100-year design event. Details of results are provided in Appendices A, B and C.

South Shoals

Figure 4b depicts the modeling results for the South Shoals, which indicate that the proposed improvements will have no effect on the depths and velocities based on the largest flow event analyzed (100-year flow). This is in line with the fact that the shoals are located within an area where the bridge casts a large downstream hydraulic shadow and that the proposed shoals are only improvements for existing shoals.

List of Figures

The following figures that were referenced in the technical memorandum are attached.

- Figure 1: Locations of project sites and layouts of the North and South Shoals
- Figure 2: Four North Shoal alternative configurations that were analyzed
- Figure 3: Typical cross-section with shoal and different sections of the cross-section
- Figure 4a: Percentage changes in flow depth and velocity of select cross-sections near the proposed (Alternative #4) North Shoals for the 100-year flow
- Figure 4b: Percent changes in flow depth and velocity of select cross-sections around the Grosse Ile Toll Bridge and South Shoals for the 100-year flow

List of Appendices

The following attached appendices contain detailed hydraulic model output that serves as supporting documentation for the results and conclusions described above. Note that the following appendices contain average values from multiple cross-sections, whereas the values listed in Figures 3a and 3b contain values from individual cross-sections, so the values reported in the figures and appendices are not intended to match.

- Appendix A
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Figure 1: Locations of project sites and layouts of the North and South Shoals

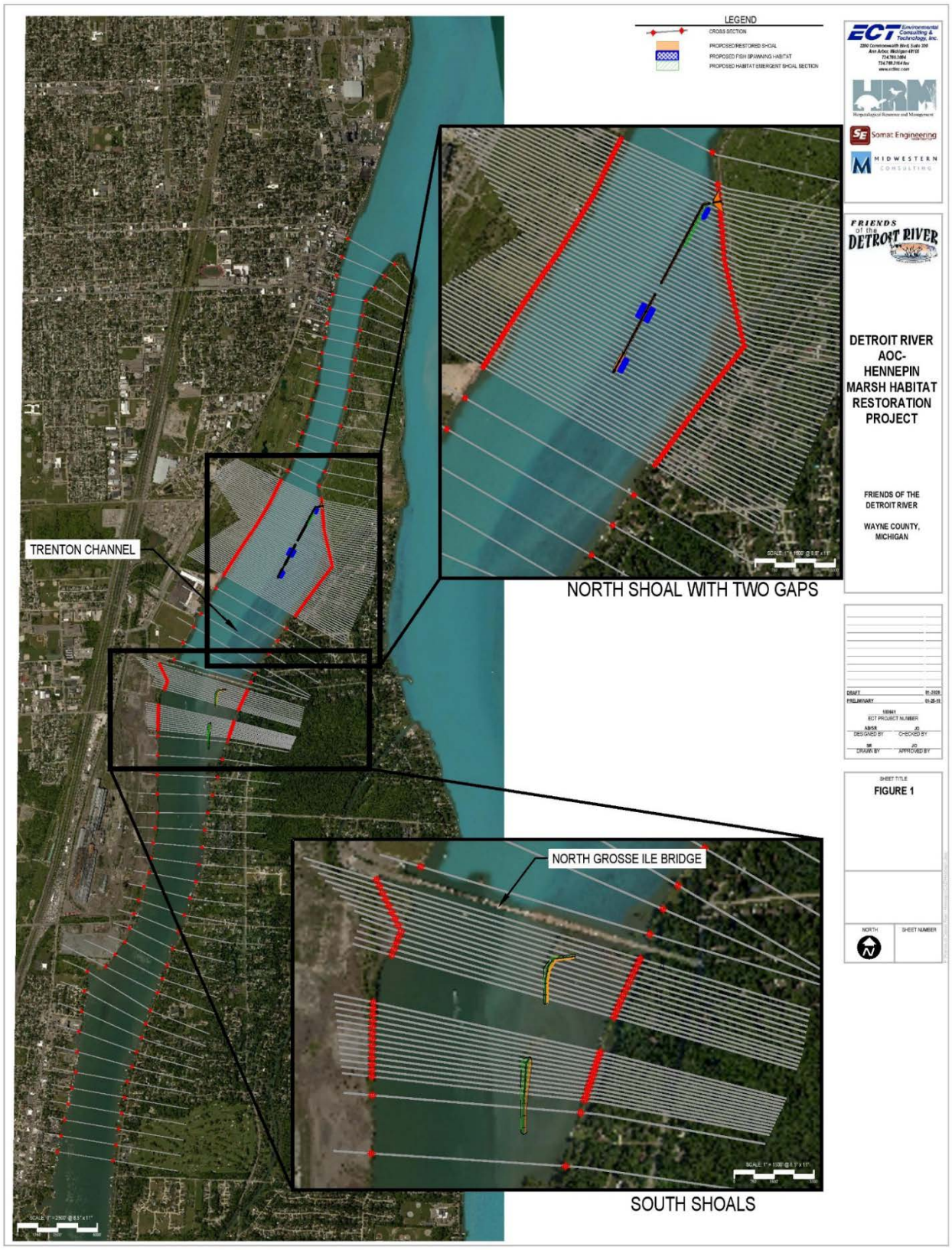


Figure 2: Four North Shoal alternative configurations that were analyzed

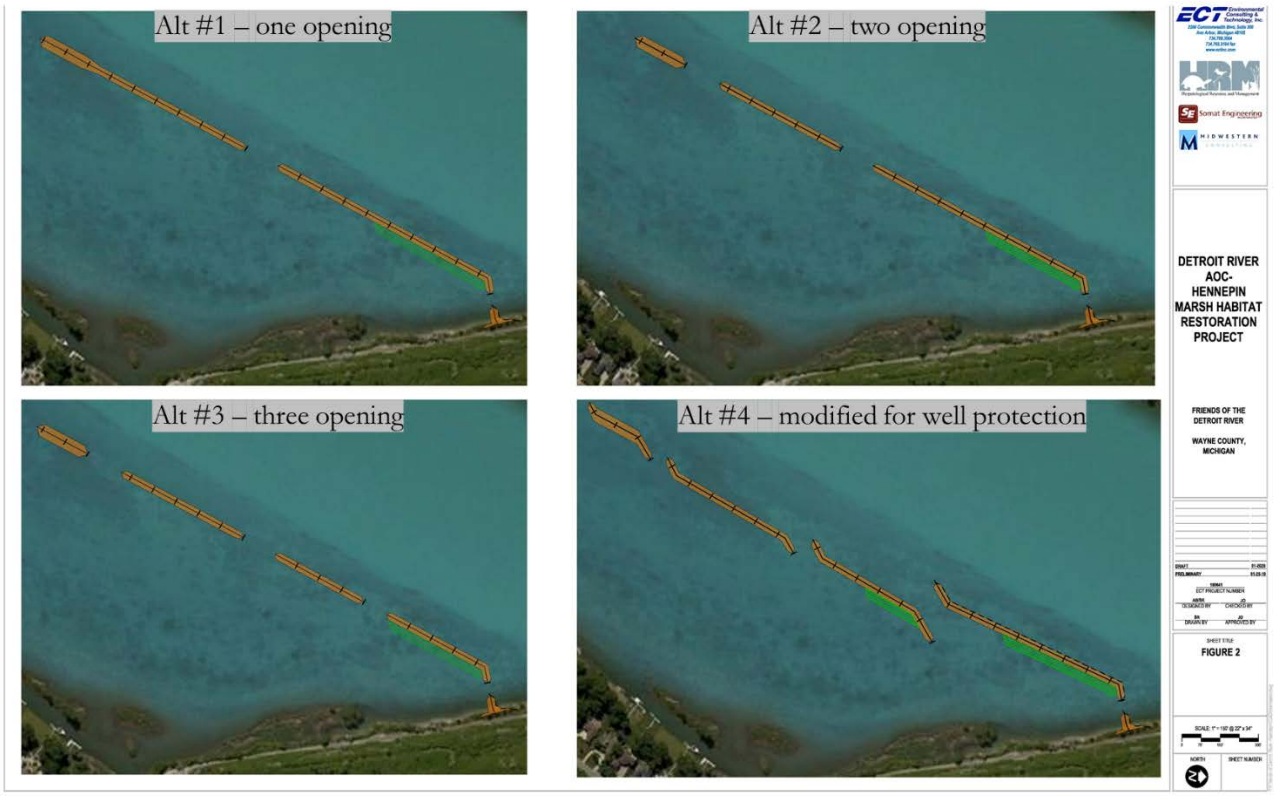


Figure 3: Typical cross-section with shoal and different sections of the cross-section

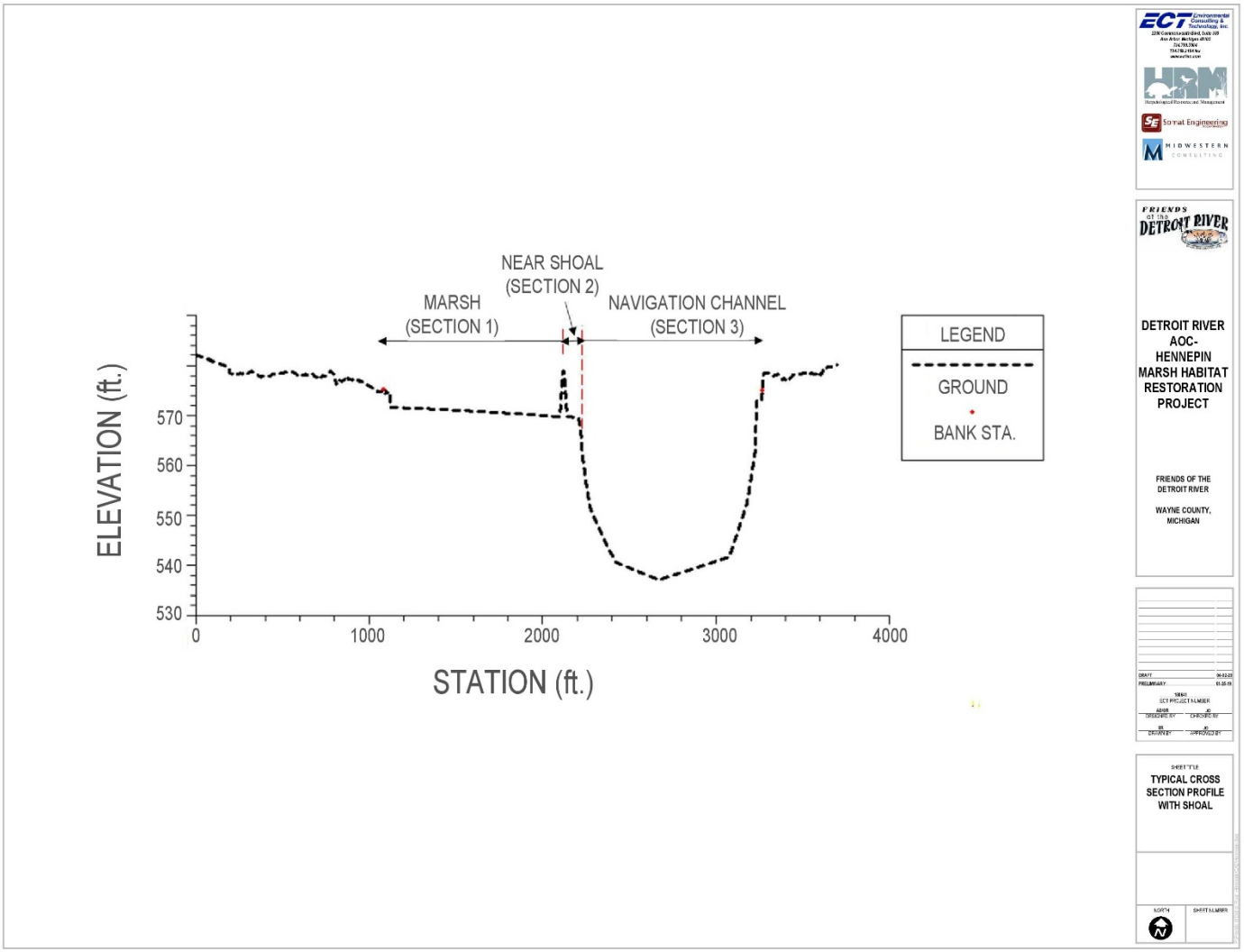


Figure 4a: Changes in flow depth (ft) and velocity (ft/s) of select cross-sections near the proposed (Alternative #4) North Shoals for the 100-year flow

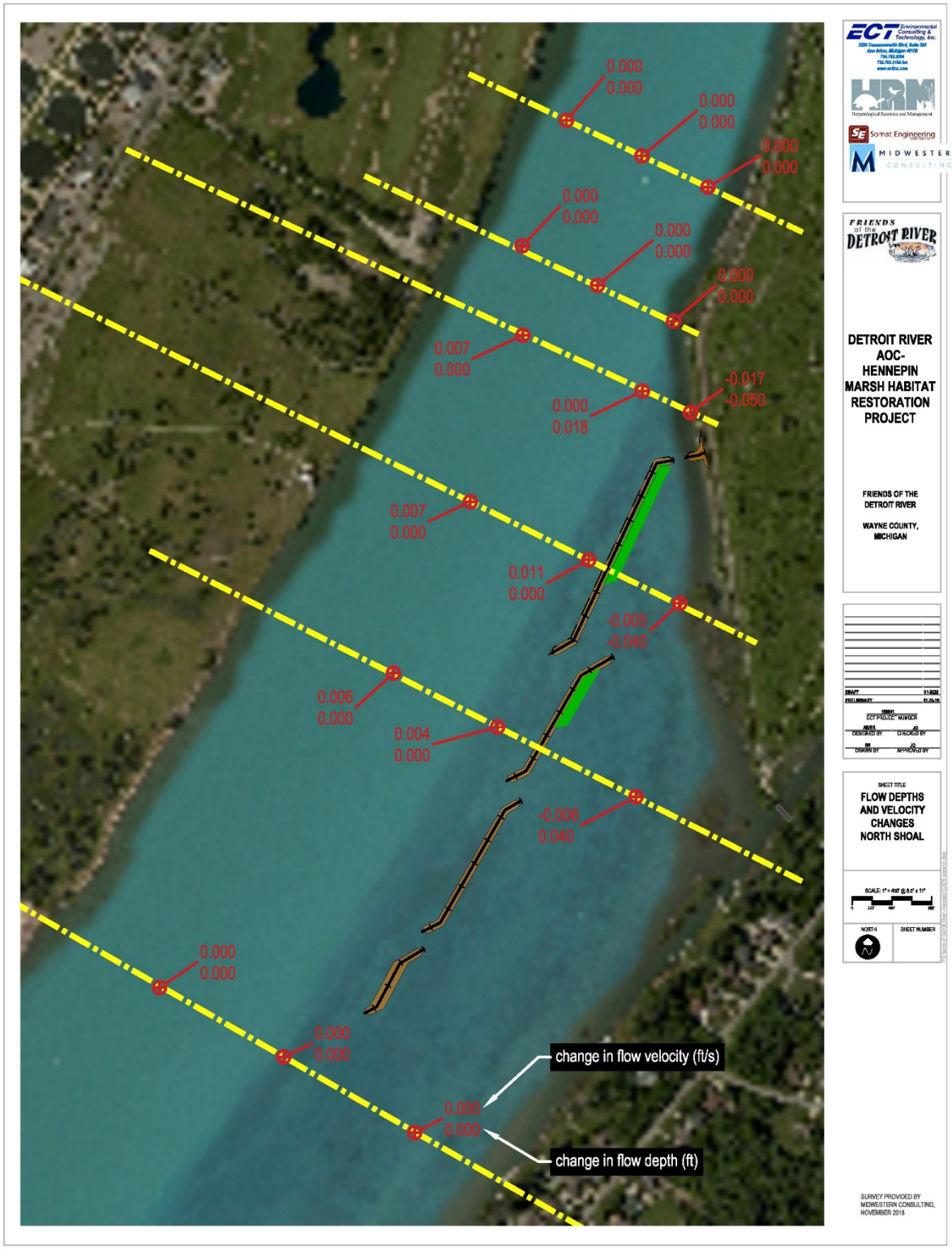
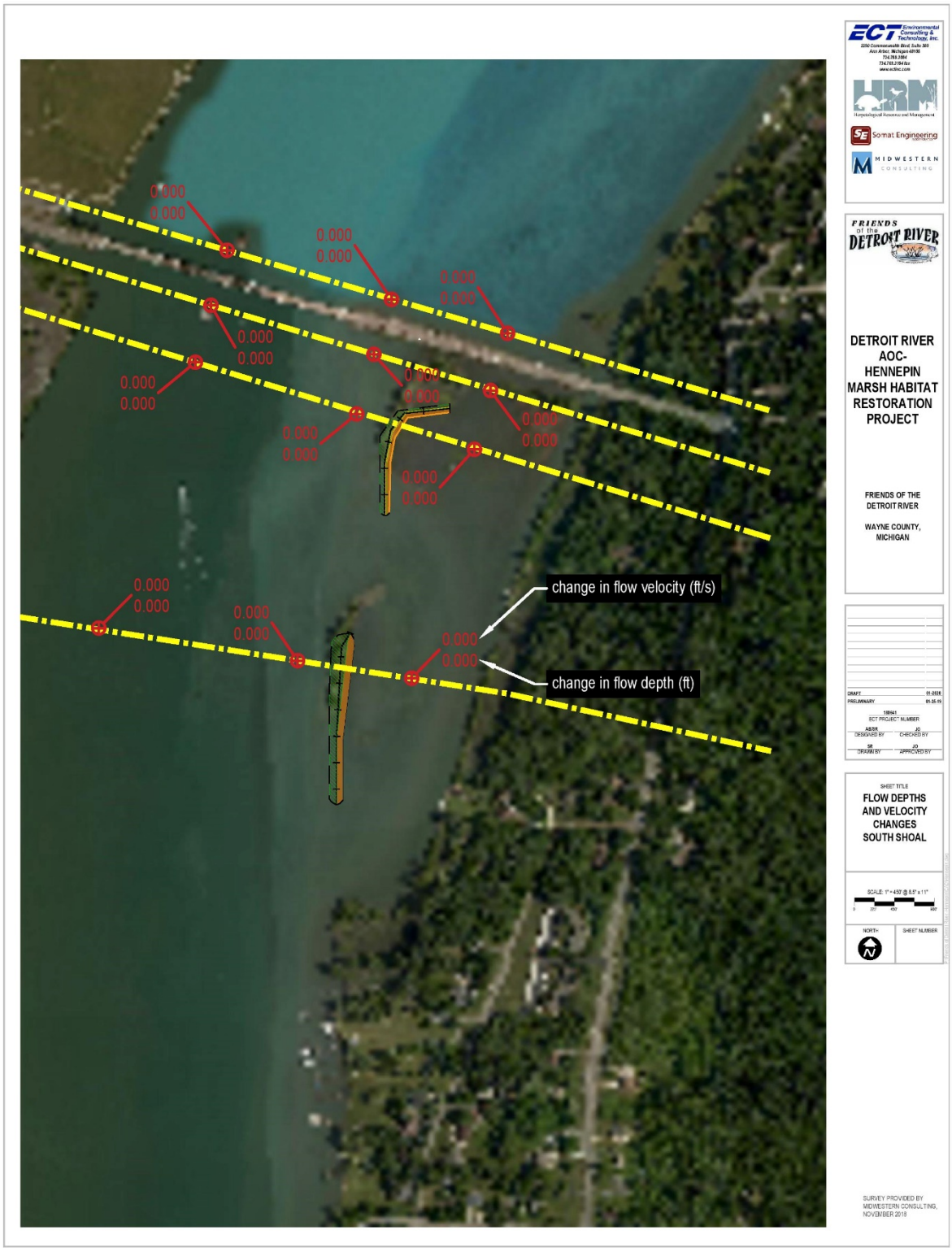


Figure 4b: Changes in flow depth (ft) and velocity (ft/s) of select cross-sections around the Grosse Ile Toll Bridge and South Shoals for the 100-year flow



APPENDIX A

Table A-1: Percent change in flow conditions by design alternative (average values from all three flow events, A1=Alternative #1, A2=Alternative #2, A3=Alternative #3, A4=Alternative #4)

	Location	Section1 (Marsh area)				Section2 (Near shoal area)				Section3 (Navigation channel)			
		A1	A2	A3	A4	A1	A2	A3	A4	A1	A2	A3	A4
Change in flow (%)	*Upstream of North shoals*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At North shoals	-19.025	-12.472	-11.149	-10.435	-1.687	-0.888	-0.615	-0.730	0.356	0.227	0.222	0.221
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000
Change in velocity (%)	*Upstream of North shoals*	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	At North shoals	-3.289	-2.140	-2.043	-1.745	0.606	0.509	0.434	0.911	0.410	0.228	0.224	0.226
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000
Change in depth (%)	*Upstream of North shoals*	-0.001	-0.001	-0.001	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
	At North shoals	-1.658	-1.080	-0.954	-0.261	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.002
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table A-2: Absolute change in flow conditions by design alternative (average values from all three flow events, A1=Alternative #1, A2=Alternative #2, A3=Alternative #3, A4=Alternative #4)

	Location	Section1 (Marsh area)				Section2 (Near shoal area)				Section3 (Navigation channel)			
		A1	A2	A3	A4	A1	A2	A3	A4	A1	A2	A3	A4
Change in flow (cfs)	**Upstream of North shoals**	-0.013	-0.013	-0.015	-0.020	0.028	0.017	0.012	0.023	-0.001	-0.005	0.000	0.003
	At North shoals	-157.150	-103.241	-106.442	-95.457	-32.582	-17.472	-12.538	-22.881	190.165	121.461	119.633	119.098
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.002	0.003	0.003	0.000	0.007	0.007	0.007	0.000	-0.016	-0.012	-0.012	0.000
Change in velocity (ft/s)	**Upstream of North shoals**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
	At North shoals	-0.015	-0.010	-0.009	-0.008	0.006	0.005	0.004	0.010	0.007	0.004	0.004	0.004
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Change in depth (ft)	**Upstream of North shoals**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At North shoals	-0.077	-0.050	-0.044	-0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

APPENDIX B

Table B-1: Percent change in flow rate distribution by flow event and design alternative (A1=Alternative #1, A2=Alternative #2, A3=Alternative #3, A4=Alternative #4)

Event Date	Location	% Change in flow											
		Section1 (Marsh area)				Section2 (Near shoal area)				Section3 (Navigation channel)			
		A1	A2	A3	A4	A1	A2	A3	A4	A1	A2	A3	A4
Oct-18	*Upstream of North shoals*	0.000	0.000	0.000	-0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
	At North shoals	-22.295	-13.199	-11.879	-11.088	-1.118	-0.648	-0.455	-0.488	0.236	0.139	0.136	0.135
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.001	0.001	0.001	0.000	0.002	0.002	0.002	0.000	0.000	0.000	0.000	0.000
Jul-19	*Upstream of North shoals*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At North shoals	-16.834	-12.664	-11.323	-10.613	-1.836	-0.787	-0.550	-0.618	0.269	0.183	0.178	0.178
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
100-yr	*Upstream of North shoals*	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At North shoals	-17.947	-11.553	-10.244	-9.605	-2.107	-1.229	-0.840	-1.084	0.562	0.359	0.353	0.351
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table B-2: Percent change in flow velocity distribution by flow event and design alternative (A1=Alternative #1, A2=Alternative #2, A3=Alternative #3, A4=Alternative #4)

Event Date	Location	% Change in Velocity											
		Section1 (Marsh area)				Section2 (Near shoal area)				Section3 (Navigation channel)			
		A1	A2	A3	A4	A1	A2	A3	A4	A1	A2	A3	A4
Oct-18	*Upstream of North shoals*	0.002	0.002	0.002	0.004	0.002	0.002	0.002	0.004	0.002	0.002	0.002	0.004
	At North shoals	-3.471	-2.258	-2.202	-1.890	0.841	0.579	0.466	0.882	0.206	0.141	0.137	0.141
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.000	0.000	0.000	0.000	0.002	0.002	0.002	0.000	0.000	0.000	0.000	0.000
Jul-19	*Upstream of North shoals*	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	At North shoals	-3.320	-2.160	-2.068	-1.787	0.560	0.551	0.455	0.922	0.419	0.184	0.180	0.182
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
100-yr	*Upstream of North shoals*	-0.001	-0.001	-0.001	-0.002	-0.001	-0.001	-0.001	-0.003	-0.001	-0.001	-0.001	-0.002
	At North shoals	-3.077	-2.002	-1.858	-1.558	0.417	0.397	0.381	0.928	0.606	0.360	0.354	0.355
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table B-3: Percent change in flow depth distribution by flow event and design alternative (A1=Alternative #1, A2=Alternative #2, A3=Alternative #3, A4=Alternative #4)

		% Change in Depth											
Event Date	Location	Section1 (Marsh area)				Section2 (Near shoal area)				Section3 (Navigation channel)			
		A1	A2	A3	A4	A1	A2	A3	A4	A1	A2	A3	A4
Oct-18	*Upstream of North shoals*	0.000	0.000	0.000	-0.001	0.000	0.000	0.000	-0.003	-0.002	-0.002	-0.002	-0.002
	At North shoals	-2.247	-1.393	-1.194	-0.366	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.007
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jul-19	*Upstream of North shoals*	-0.003	-0.003	-0.003	0.000	-0.002	-0.002	-0.002	0.000	-0.001	-0.001	-0.001	-0.001
	At North shoals	-1.646	-1.148	-1.038	-0.238	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
100-yr	*Upstream of North shoals*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At North shoals	-1.080	-0.699	-0.631	-0.179	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

APPENDIX C

Table C-1: Absolute change in flow rate distribution by flow event and design alternative (A1=Alternative #1, A2=Alternative #2, A3=Alternative #3, A4=Alternative #4)

Event Date	Location	Change in Flow (cfs)											
		Section1 (Marsh area)				Section2 (Near shoal area)				Section3 (Navigation channel)			
		A1	A2	A3	A4	A1	A2	A3	A4	A1	A2	A3	A4
Oct-18	*Upstream of North shoals*	-0.050	-0.045	-0.045	-0.110	0.120	0.080	0.060	0.140	0.004	0.000	0.005	0.000
	At North shoals	-96.582	-57.180	-58.425	-52.910	-15.609	-9.043	-6.387	-12.000	112.214	66.200	65.090	64.900
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.006	0.005	0.005	0.000	0.020	0.015	0.015	0.000	-0.030	-0.025	-0.025	0.000
Jul-19	*Upstream of North shoals*	-0.040	-0.035	-0.035	-0.030	0.030	0.025	0.025	0.025	-0.026	-0.020	-0.020	-0.010
	At North shoals	-103.380	-77.773	-79.825	-71.910	-29.365	-12.590	-8.850	-16.647	133.225	90.360	88.682	88.567
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
100-yr	*Upstream of North shoals*	0.050	0.040	0.035	0.080	-0.065	-0.055	-0.050	-0.095	0.020	0.005	0.015	0.020
	At North shoals	-271.488	-174.770	-181.075	-161.550	-52.771	-30.783	-22.378	-39.997	325.056	207.823	205.128	203.827
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.000	0.005	0.005	0.000	0.000	0.005	0.005	0.000	-0.019	-0.010	-0.010	0.000

Table C-2: Absolute change in flow velocity distribution by flow event and design alternative (A1=Alternative #1, A2=Alternative #2, A3=Alternative #3, A4=Alternative #4)

Event Date	Location	Change in Velocity (ft/s)											
		Section1 (Marsh area)				Section2 (Near shoal area)				Section3 (Navigation channel)			
		A1	A2	A3	A4	A1	A2	A3	A4	A1	A2	A3	A4
Oct-18	*Upstream of North shoals*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000
	At North shoals	-0.013	-0.008	-0.008	-0.007	0.008	0.006	0.004	0.009	0.004	0.002	0.002	0.002
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jul-19	*Upstream of North shoals*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At North shoals	-0.014	-0.009	-0.009	-0.007	0.006	0.006	0.004	0.010	0.007	0.003	0.003	0.003
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
100-yr	*Upstream of North shoals*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At North shoals	-0.019	-0.013	-0.011	-0.009	0.005	0.005	0.004	0.011	0.011	0.007	0.007	0.007
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table C-3: Absolute change in flow depth distribution by flow event and design alternative (A1=Alternative #1, A2=Alternative #2, A3=Alternative #3, A4=Alternative #4)

		Change in Depth (ft)											
Event Date	Location	Section1 (Marsh area)				Section2 (Near shoal area)				Section3 (Navigation channel)			
		A1	A2	A3	A4	A1	A2	A3	A4	A1	A2	A3	A4
Oct-18	*Upstream of North shoals*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	-0.001	-0.001	-0.001	-0.001
	At North shoals	-0.081	-0.050	-0.043	-0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jul-19	*Upstream of North shoals*	-0.001	-0.001	-0.001	0.000	-0.001	-0.001	-0.001	0.000	0.000	0.000	0.000	0.000
	At North shoals	-0.072	-0.050	-0.045	-0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
100-yr	*Upstream of North shoals*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At North shoals	-0.077	-0.050	-0.045	-0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At Bridge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	At South shoals	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

APPENDIX D

HENNEPIN MARSH HABITAT RESTORATION
FLOW MONITORING SUMMARY

Introduction

To help guide design and construction of habitat shoals at the Hennepin Island restoration project, Environmental Consulting & Technology, Inc. (ECT) conducted numerous flow monitoring events using an acoustic doppler current profiler (ADCP). The purpose of the monitoring was to characterize the flow of the Detroit River under a variety of weather and flow conditions to better characterize potential interactions between river flow and the proposed shoals. This summary presents a discussion of the flow monitoring that has occurred between the fall of 2018 and the fall of 2019. It outlines the methods used to complete the monitoring and provides a brief discussion of the results.

Methods

An ADCP was used to collect flow data at select transects at three locations within the project site as well as around the Grosse Ile toll bridge. Sampling occurred on five separate dates, twice in 2018 and three times in 2019. Three locations were sampled, two located north of the Grosse Ile Toll bridge and one south of the bridge. However, on October 28, 2019, data were collected on the north and south sections directly adjacent to the bridge. This was to determine the flow characteristics through the bridge itself.

Transects were collected in quadruplicate, when possible, with a minimum of three transects per site. At each sampling site, a transect started on either shoreline as close as possible to the shore (given depth limitations of the ADCP). In a straight line, the boat was motored slowly across the river, maintaining a speed between 1 and 2 meters/second. Once a transect was completed, the process was repeated until four total transects were collected at each site. If conditions did not allow completion of four acceptable transects, sampling was conducted until three acceptable transects were recorded. Quality assurance of the ADCP data was determined in real-time, noting the number of bad ensembles or any gaps in collection data. If a transect contained more than 10% bad ensembles or large gaps occurred in the data collection, that transect was redone. Bad ensembles and data gaps can occur for a variety of reasons (e.g., loss of connectivity between the unit and the Bluetooth receiver, vegetation, boat speed, loss of GPS signal, boat path, etc.). Many sites, especially in shallow areas during the summer months, contained heavy submerged vegetation growth. This can negatively affect results as the sound signal does not penetrate through thick vegetation and can scatter the signal.

Results

For further discussions on the flow data collected, please refer to the hydraulic analysis report. In general, flows appeared to remain fairly consistent at each sampling section across all five sampling times (Table 1). Water elevations did not differ greatly (range of approximately 2 feet in elevation). Weather patterns did not seem to have a large effect on the flow conditions at each sampling site.

Table D-1: Flow Data from Acoustic Doppler Current Profiler (ADCP) Sampling at the Hennepin Marsh Restoration Project. Selected Weather Data and Detroit River Water Elevations are Included for Reference.

Date	Average flow rate (cfs)					Average flow velocity (ft/s)					Water Elevation (ft)	Wind speed (mph)	Wind Direction
	North	Middle	South	Bridge North	Bridge South	North	Middle	South	Bridge North	Bridge South			
10/31/2018	49076	51891	50811	-	-	1.75	1.71	1.62	-	-	574.20	9	NNW
11/8/2018	52188	52928	51666	-	-	1.75	1.58	1.48	-	-	574.38	4	NNW
6/16/2019	53113	53013	52199	-	-	1.72	1.38	1.38	-	-	576.08	11	W
7/11/2019	53721	52845	52604	-	-	1.79	1.47	1.49	-	-	576.11	12	WNW
10/28/2019	53146	54968	57425	55755	56878	1.78	1.65	1.72	2.10	1.98	574.96	10	SSW
Range	4646	3077	6613	-	-	0.075	0.328	0.344	-	-	1.91	8.0	-
St. Dev.	1857	1121	2595	-	-	0.029	0.134	0.134	-	-	0.91	3.6	-

Flow was similar between sites during each sampling period. However, there some differences in flow rate and velocity values between sampling sites for a given date. The middle and south sites were more similar in their flow velocities than the north site. This may be a result of the river being wider in those sections than at the north sampling site and flow turbulence. Additionally, the middle and south sampling sites had more protected areas away from the navigation channel. These areas have shallow and slow-moving water and the bed is filled with vegetation which resulted in error gaps and introduced uncertainties in the measured flows. These two factors are the more likely reasons for the differences seen between the sampling sites.