614 Magnolia Avenue
Ocean Springs, Mississippi 39564
228.818.9626

ANCHOR QEA

Memorandum

October 5, 2017

To: Gary Miller, U.S. Environmental Protection Agency

From: David Keith, John Laplante, Matt Henderson, and Fanghui Chen

Re: San Jacinto Superfund Site – Hurricane Harvey Simulation

Introduction

A Time-Critical Removal Action (TCRA) was implemented at the northern impoundments of the San Jacinto River Superfund Site (Site). This TCRA involved construction of an Armored Cap over 15.7 acres of the original former waste impoundments, and it was completed in 2011. The Armored Cap, as defined by the U.S. Environmental Protection Agency (USEPA), is a temporary cap that isolates underlying waste until the final remedy is implemented. The Armored Cap was designed to protect the underlying materials from erosion for events up to, and including, a 100-year flow event.

On August 25, 2017, Hurricane Harvey (Harvey) made landfall between Port Aransas and Port O'Connor, Texas. At that time, the storm was a Category 4 hurricane with winds of 130 miles per hour (mph). In the Houston area, while wind speeds were not nearly as high as they were at landfall, rainfall was intense. Harvey produced rainfall amounts of more than 50 inches over several days in some areas. As a result, there was flooding along the San Jacinto River, including the Site, due to a combination of storm surge and rainfall runoff. Harvey is considered to be greater than a 500-year return interval event in the San Jacinto River. There were high flows in the San Jacinto River, resulting in high velocities over the Armored Cap. Post storm inspections—including visual, hydrographic, and topographic surveys as well as probing to measure armor rock thickness—indicated that although there was some minor displacement of cap materials on the berms of the impoundment and in submerged areas, there was no release of the underlying materials as a result of Harvey and the Armored Cap is stable. The combined surface area of the Armored Cap requiring maintenance was approximately 1 percent (of the total surface area of the entire Armored Cap.

Anchor QEA had previously simulated the hypothetical extreme storm event for Alternative 3aN (proposed by the USEPA) and showed that it would be stable in the event of the hypothetical extreme storm event with a factor of safety of 2 to 7. The hypothetical "extreme" storm event, consisted of the hypothetical synoptic occurrence of increased stage height during Hurricane Ike (due to a storm surge) and increased flow during the October 1994 flood.[1] The Armored Cap stone size is based on the hydrodynamic modeling performed for a full range of extreme events and was computed using USEPA and USACE guidance and recommended safety factors as described in detail

[1] This work was performed under Task 2 of the USACE report (USACE 2016).

in Appendix I – Hydrodynamic Modeling of the Removal Action Work Plan (RAWP) (Anchor QEA 2010) and Appendix B – Hydrodynamic Cap Modeling of the Draft FS (Anchor QEA 2014). By using armor stone with a median stone of 15 inches for Alternative 3aN, the safety factor would be increased to a minimum of two to more than seven depending on location.

As described below, Anchor QEA performed a hindcast simulation of Harvey using a hydrodynamic model to estimate the velocities that acted over the existing Armored Cap during the event. The results of this evaluation can be used to inform the design of a permanent cap (such as that proposed in Alternative 3aN) with respect to its long-term stability and permanence under future storm conditions.

Model Development

The hydrodynamic model used for this study was the Environmental Fluid Dynamics Code (EFDC), which is a well-tested model supported by USEPA. EFDC is a three-dimensional hydrodynamic model capable of simulating time-variable flow in rivers, lakes, reservoirs, estuaries, and coastal areas (Hamrick 1992). For this study, the model was run in the two-dimensional, vertically-averaged mode because density-driven circulation due to salinity stratification is minimal within the estuary. Hydrodynamic flows, particularly during high-flow events, can result in elevated water velocities and correspondingly elevated bed shear stresses. For the Harvey simulation, the hydrodynamic model developed as part of the TCRA design was used. The model framework, boundary conditions, development, and calibration are described in detail in Appendix I of the Removal Action Work Plan (Anchor QEA 2010).

The Armored Cap elevations used in the model were based on the January 2017 Quarterly Inspection survey (Anchor QEA 2017). The model has three boundary conditions that need to be specified: 1) upstream inflow; 2) downstream water level (tidal elevation) for the confluence between the San Jacinto River and the Houston Ship Channel; and 3) wind. Flow rate data at Lake Houston Dam during Harvey were obtained from the Coastal Water Authority. For comparison, the flow rates from Harvey in the San Jacinto River were also estimated at the US-90 bridge (based on U.S. Geological Survey [USGS] gage station 0872050 at the US-90 bridge near Sheldon, Texas[2]). The water surface elevations at the downstream boundary were obtained from National Oceanic and Atmospheric Administration gage station 8770613 near Morgans Point, Texas.[3] Wind data were also obtained from this station.

A time series of water surface elevations from the model simulations were compared with water surface elevations measured at a temporary gage installed by USGS at the Interstate 10 (I-10) bridge

[2] Available from: https://waterdata.usgs.gov/tx/nwis/inventory/?site_no=08072050&agency_cd=USGS
[3] Available from: https://tidesandcurrents.noaa.gov/stationhome.html?id=8770613

near the Site.[4] Figure 1 shows a comparison of the measured water surface elevations at the I-10 bridge with the simulation results using the following: 1) the upstream flow based on Lake Houston Dam, and 2) the upstream flow estimated at the US-90 bridge. The results show good agreement with the Lake Houston Dam flow rate during the event and a slight overprediction of the flood elevation using the US-90 estimated discharge. Based on these results, the model is able to reproduce the flood elevations at the Site.

Results

The results of the modeling were evaluated over the entire range of the Harvey simulation, including periods before and after the peak flow of the storm. The maximum predicted depth-averaged current velocity over the Armored Cap is 6.9 feet per second (ft/s), with average maximum current velocities on the order of 5 to 6 ft/s. The maximum predicted current velocities within each grid cell over the Armored Cap are shown in Figures 2a and 2b. Figure 2a shows the results for the simulation using the upstream flow based on the USGS gage data at US-90. Figure 2b show the results using the upstream flow based on the Lake Houston Dam data. Results from this simulation are consistent and comparable to the velocities used in the TCRA design. The maximum predicted depth-averaged current velocity over the Armored Cap used in the TCRA design was 8.5 ft/s, with average maximum current velocities on the order of 7 to 8 ft/s.

Summary

Results of the evaluation confirm that Harvey was an extreme flood event with high velocities acting over the Armored Cap. Based on the modeling performed, it does not appear that Harvey produced higher forces on the Armored Cap than the large range of storm conditions simulated as part of both the TCRA (Anchor QEA 2010) and Draft Feasibility Study (Anchor QEA 2014). Therefore, the previous conclusions that covering the Armored Cap with a 2-foot thick layer of armor stone with a D_{50} of 15 inches (as proposed by the USEPA in Alternative 3aN) will provide a factor of safety of 2 to 7 for the Armored Cap under conceivable storm conditions would still apply.

[4] Available from: https://waterdata.usgs.gov/tx/nwis/uv?site_no=294733095034100

References

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Hamrick, J.M., 1992. *A Three-Dimensional Environmental Fluid Dynamics Code: Theoretical and Computational Aspects*. Special Report 317. College of William and Mary, Virginia Institute of Marine Sciences.

USACE (U.S. Army Corps of Engineers), 2016. *Evaluation of the San Jacinto Waste Pits Feasibility Study Remediation Alternatives*. August 2016.

Figures

Figures

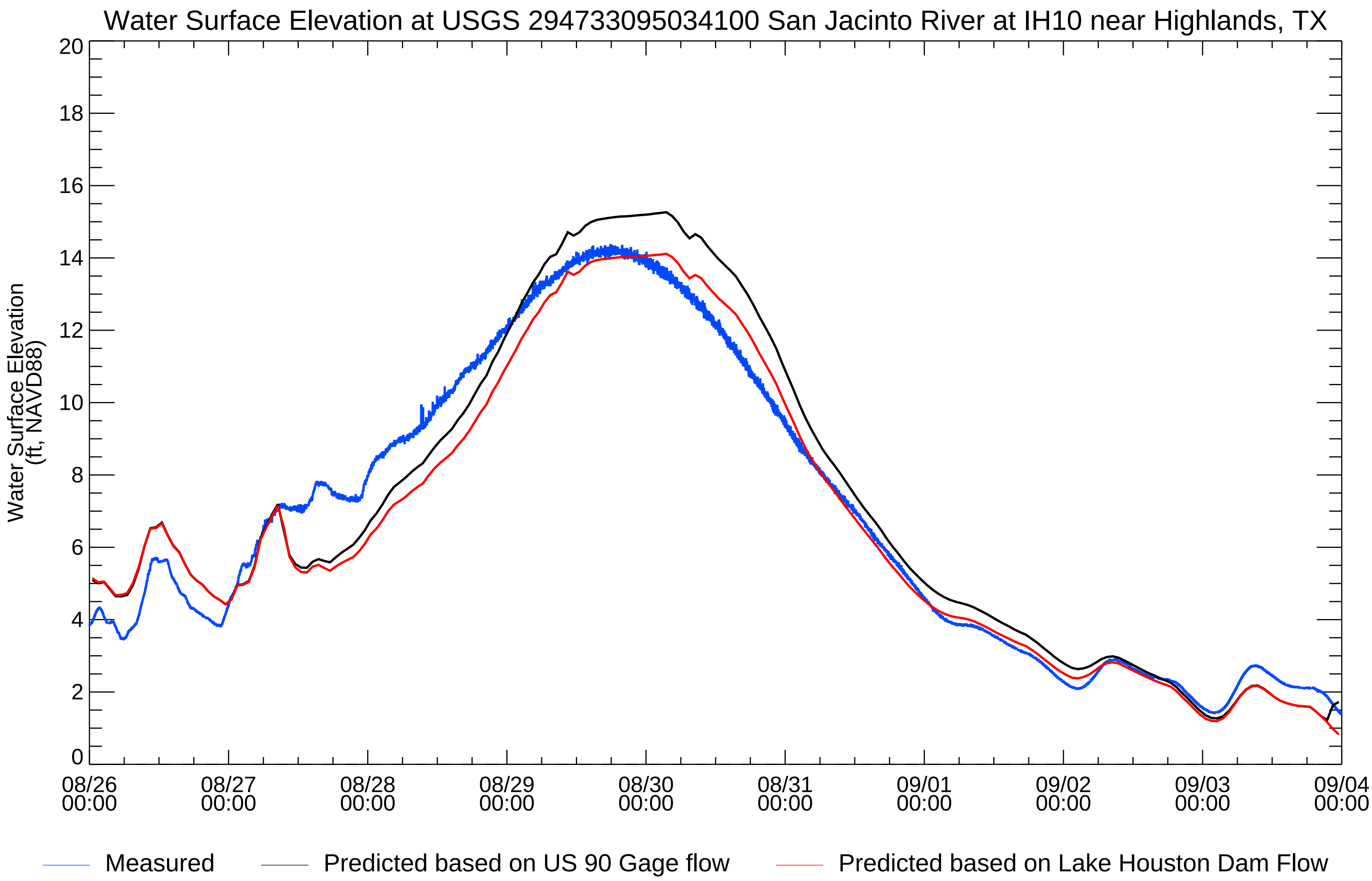

Figure 1

Model-to-Data Comparison of Water Surface Elevations at
USGS 294733095034100 San Jacinto River at IH-10 near Highlands, TX during August 26 through September 3, 2017

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Run ID: calib_1709-05_wind and calib_1709-06_wind.
Bathymetry was based on Jan 2017 bathy survey data.
Rating-curve based flow was used to specify upstream inflow, and it was based on USGS data collected at HW-90 bridge, USGS08072050, San Jacinto River near Sheldon, TX

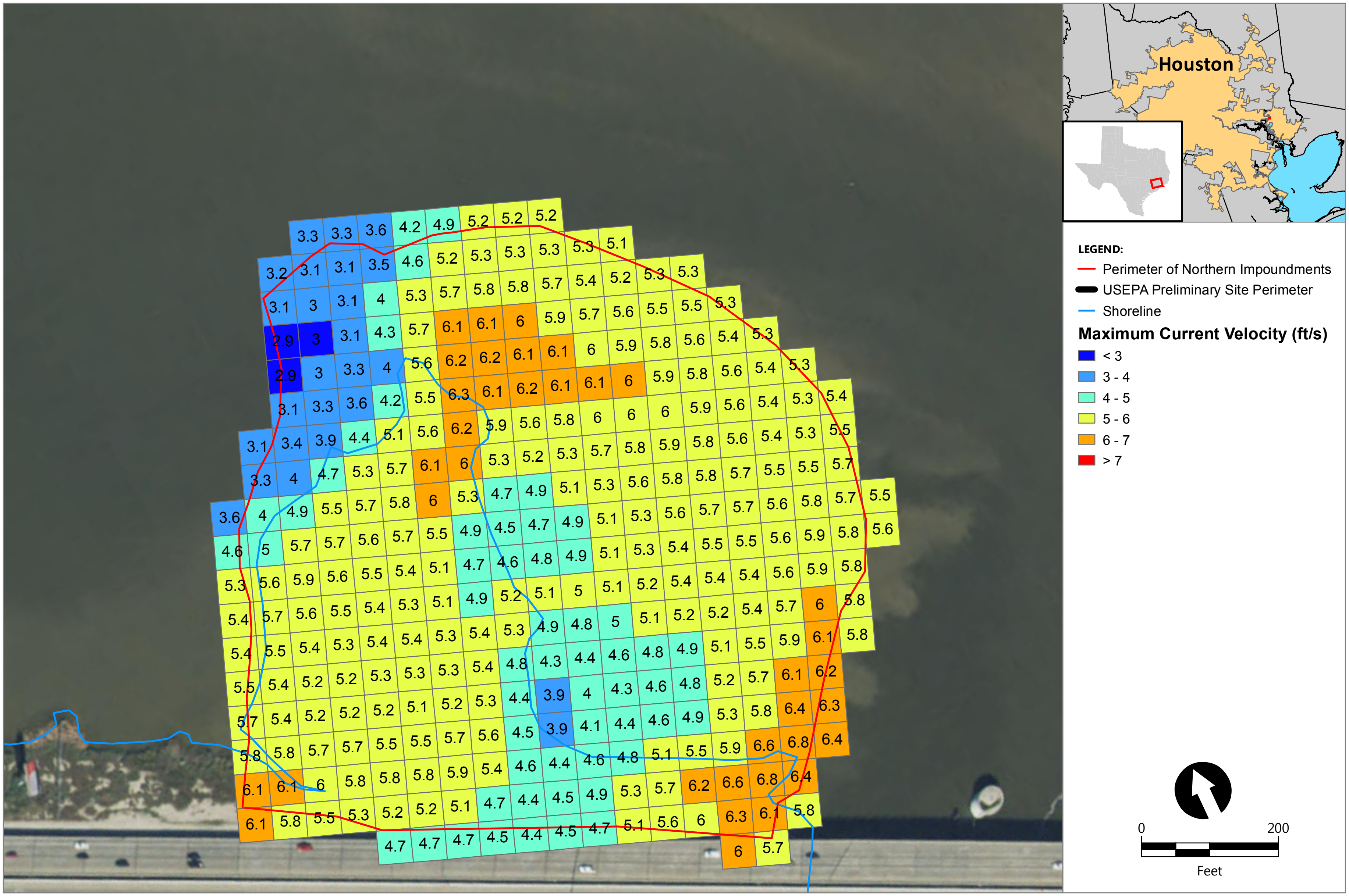

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Figure 2a

Predicted Maximum Current Velocity Based on Upstream Flow from the USGS Gage Data at US-90
Hurricane Harvey Hindcast during August 16 through September 4, 2017
San Jacinto River Waste Pits Superfund Site

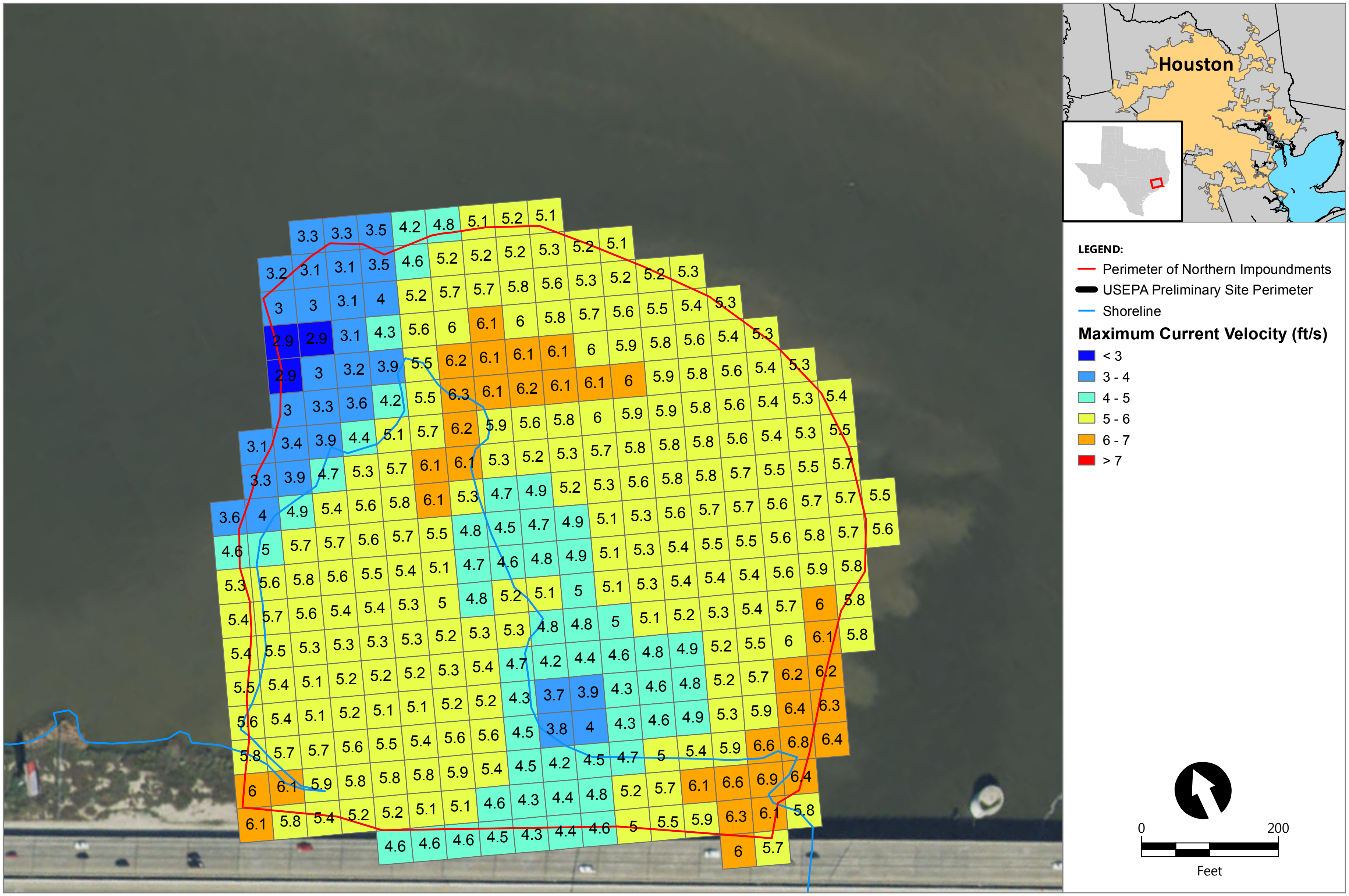

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Figure 2b
Predicted Maximum Current Velocity Based on Upstream Flow from the Lake Houston Dam Data
Hurricane Harvey Hindcast during August 16 through September 4, 2017
San Jacintio River Waste Pits Superfund Site