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**Supplemental Comments on U.S. Environmental Protection  
Agency Region 6 Proposed Remedial Action Plan for the  
San Jacinto Waste Pits Superfund Site  
Considering Hurricane Harvey**

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# 1 Introduction

## 1.1 Background

I have been a member of the technical team supporting Respondents International Paper Company and McGinnes Industrial Maintenance Corporation on the San Jacinto Site since 2012. I prepared a report detailing my comments on the U.S. Environmental Protection Agency (EPA) Region 6 Proposed Remedial Action Plan (PRAP) for the Site which was submitted as Appendix A to the Comments of International Paper Company and McGinnes Industrial Maintenance Corporation on U.S. EPA Region 6 PRAP (Palermo 2017a).

The Hurricane Harvey event has presented an opportunity to provide supplemental comments on the EPA Region 6 PRAP alternatives with respect to potential impacts of an extreme flow event. Due to time constraints, I prepared a letter, transmitted by Certified Mail on September 28, 2017, providing my supplemental comments related to the Hurricane Harvey event in summary form in order to enter those comments into the record for consideration prior to a decision on a final remedy (Palermo 2017b). I mentioned in that letter my intention to develop a detailed report on my supplemental comments, to be submitted within two weeks. This report presents my supplemental comments with additional technical discussion and supporting data.

My supplemental comments on the PRAP were informed by a review of results from the surveys and sampling conducted at the Site following the Hurricane Harvey event and a Site visit conducted on September 21, 2017.

## 1.2 Summary of Additional Comments Related to Hurricane Harvey Event

My comments in summary form are as follows:

- The Hurricane Harvey event and its resulting impacts do not cause me to change any of my earlier comments on the PRAP. In fact, Hurricane Harvey has confirmed the validity of many of my comments. Most importantly, it confirmed that Remedial Alternative 3aN (an enhanced cap) will be effective and provide long-term stability against an ultra-extreme event.
- Hurricane Harvey was certainly an “ultra-extreme” event, and should be considered a defining ultra-extreme event.
- The Time Critical Removal Action (TCRA) cap withstood the forces of Harvey, with only small areas of the TCRA armor being affected. These areas, as with previous maintenance activities, were largely on the raised berms in the upland portion of the Site which do not overlie any waste material. It should be emphasized that the armor in place when Hurricane Harvey occurred was the TCRA cap designed to withstand a 100-year

flood with stone sizes of 3 to 10 inches in mean diameter. Yet, the TCRA cap remained intact and effective in the face of the more extreme Hurricane Harvey event.

- EPA had earlier voiced concern about uncertainties of modeling the ability of an enhanced cap to provide long-term stability. Modeling uncertainty is now a moot point. Hurricane Harvey was a definitive ultra-extreme event, and the TCRA cap, with 3 to 10-inch in mean diameter stone, remained in place and the waste was effectively contained. This fact clearly demonstrates, with a very high degree of certainty, that the Alternative 3aN enhanced cap, with 15-inch in mean diameter stone, will be effective and provide long-term stability against any such ultra-extreme event.
- Samples collected by EPA and others did not indicate a release of waste from the Site, demonstrating that the TCRA cap remained as an effective containment, even in the face of the Hurricane Harvey event. Both containment effectiveness and physical stability would be enhanced with a more robust cap as provided by Alternative 3aN.
- From a technical point of view, the Hurricane Harvey event results nullify the EPA argument that the Site should be considered a Principal Threat Waste (PTW) site. The basis of EPA's PTW argument was that the waste cannot be contained in the face of an ultra-extreme event. The fact that the present TCRA cap remained intact against the forces generated by Hurricane Harvey clearly demonstrates that the waste can in fact be contained with the much more robust 3aN enhanced cap. The same argument would apply to EPA's attempt to justify excavation of buried waste material in the area on the peninsula located south of Interstate 10 referred to as the "Southern Impoundment."
- Scour was observed in non-armored areas immediately adjacent to the TCRA cap. Even in the face of such erosive forces, the TCRA cap area itself was not eroded and no undermining was evident. This mechanism of potential erosion in non-armored areas adjacent to the cap indicated that appropriate control measures should be included in the design for a permanent cap to prevent undermining. Such measures should include flattening of the present cap slopes and incorporation of a toe berm and/or similar component to prevent potential undermining.
- The minor movements of stone on the TCRA cap were predominantly along the perimeter berm that formed a raised geometry encouraging localized higher flow velocities. Consideration should be given in a final permanent cap design to eliminate the raised geometry of the perimeter berm, resulting in a more streamlined geometry for the cap.
- With respect to Alternative 6N (EPA's preferred removal alternative), Hurricane Harvey has highlighted the serious disadvantages of any removal alternative with respect to short-term effectiveness. If EPA had begun implementation of Alternative 6N this past year, even with the control measures as proposed in the PRAP, portions of the Site would have been open to the flood waters of Hurricane Harvey and a significant release of waste would likely have occurred.

Each of these comments is discussed in more detail in the following sections of this report.

## **2 Hurricane Harvey and Its Implications on Remedy Selection**

### **2.1 Hurricane Harvey Event Validates Earlier Comments on the PRAP**

**The Hurricane Harvey event and its resulting impacts do not cause me to change any of my earlier comments on the PRAP. In fact, Hurricane Harvey has confirmed the validity of many of my comments. Most importantly, it confirmed that Remedial Alternative 3aN (an enhanced cap) will be effective and provide long-term stability against an ultra-extreme event.**

EPA's PRAP included a range of remedy alternatives for the Site, but Alternatives 3aN and 6N represented the two principal approaches for remediation of the impoundments located north of Interstate 10, and a remedy decision comes down to a choice between some version of these two. Alternative 3aN is the containment alternative with features designed to resist the most extreme event. In addition, protections would be added to guard against barge groundings. The armored cap for this alternative would be composed of median stone size of 15 inches (mean diameter) placed in a layer thickness of at least 24 inches over the entire surface of the cap. Alternative 6N is a full removal alternative.

My earlier PRAP comments addressed the Final Interim Feasibility Study (FS; USEPA 2016) and PRAP prepared by EPA, and the report prepared by the USACE's Engineer Research and Development Center (EDRC) that provided specific technical information and modeling analysis (EPA 2017a and 2017b). I structured my earlier PRAP comments in a way that compares the details of Alternatives 3aN (enhanced cap) and 6N (removal by dredging and excavation) (Palermo 2017a). Many, but not all, of my comments pertain to issues that are informed by the Hurricane Harvey event and subsequent data collected at the Site post-Hurricane Harvey. Comments from my earlier report with discussion of how the Hurricane Harvey event validated those comments are included in the following sections of this report.

### **2.2 Hurricane Harvey was a Defining Ultra-Extreme Event**

**Hurricane Harvey was certainly an “ultra-extreme” event, and should be considered a defining ultra-extreme event.**

Hurricane Harvey made landfall near Houston on August 25, 2017. Winds from Harvey were not the main problem in the Houston area. The rainfall from Hurricane Harvey was intense and the storm essentially stalled over the Houston area for several days with a reported cumulative rainfall of over 50 inches. The flooding on the San Jacinto River from storm surge and runoff was unprecedented. Dr. Doug Shields and I visited the Site on September 21, 2017.

The true return interval of the Hurricane Harvey event is difficult to define, but some sources have indicated the event exceeds a 500-year return interval (Shields 2017). By any measure, Hurricane Harvey was an ultra-extreme event. Terms such as “extreme” or “ultra-extreme” do

not have a single definition. For example, the EPA technical guidance on cap design recommends that armor design be based on a 100-year return interval, but states that longer return interval events could be considered (Palermo et al 1996a and EPA 2005) and the same 100-year criterion is also recommended for design of dredged material caps (Palermo et al 1996b).

Regardless of the measurement or characterization approach one could apply, Hurricane Harvey was certainly a defining “ultra-extreme” event, one which defines the most severe event that could be reasonably assumed to occur at that Site. Such an event has occurred. We do not need to conceive of a more energetic event for purposes of design.

### **3 Cap Physical Stability and Containment Effectiveness Validated by Hurricane Harvey**

#### **3.1 Cap Physical Stability was Proven by Hurricane Harvey**

**The TCRA cap withstood the forces of Harvey, with only small areas of TCRA armor affected. These areas, as with previous maintenance activities, were largely on the raised berms in the upland portion of the Site, which do not overlie any waste material. It should be emphasized that the armor in place when Hurricane Harvey occurred was the TCRA cap designed to withstand a 100-year flood with stone sizes of 3 to 10 inches in mean diameter. Yet, the TCRA cap remained intact and effective in the face of the more extreme Hurricane Harvey event.**

Immediately following Hurricane Harvey, a series of inspections and surveys were conducted by the Respondents and by EPA. These included visual inspections, analysis of satellite imagery, hydrographic and topographic surveys, probing surveys to measure armor rock thickness, and samples of surface water and sediments over the TCRA cap to evaluate the condition of the armored cap post-Hurricane Harvey.

Figure 1 is a collage of photos showing areas of the TCRA cap where armor stone movement occurred as a result of the Hurricane Harvey event. These photos, taken on the Western Cell, show armor stones were moved, primarily in limited areas on the raised geometry of the perimeter berm surrounding the Western Cell. The photos also clearly show that the underlying 3-layer geotextile/geomembrane that covers the waste within the Western Cell remained intact in these areas even in instances in which the surface geotextile was exposed or moved. A key result of the post-Hurricane Harvey surveys is that areas of armor stone movement were very limited in extent.

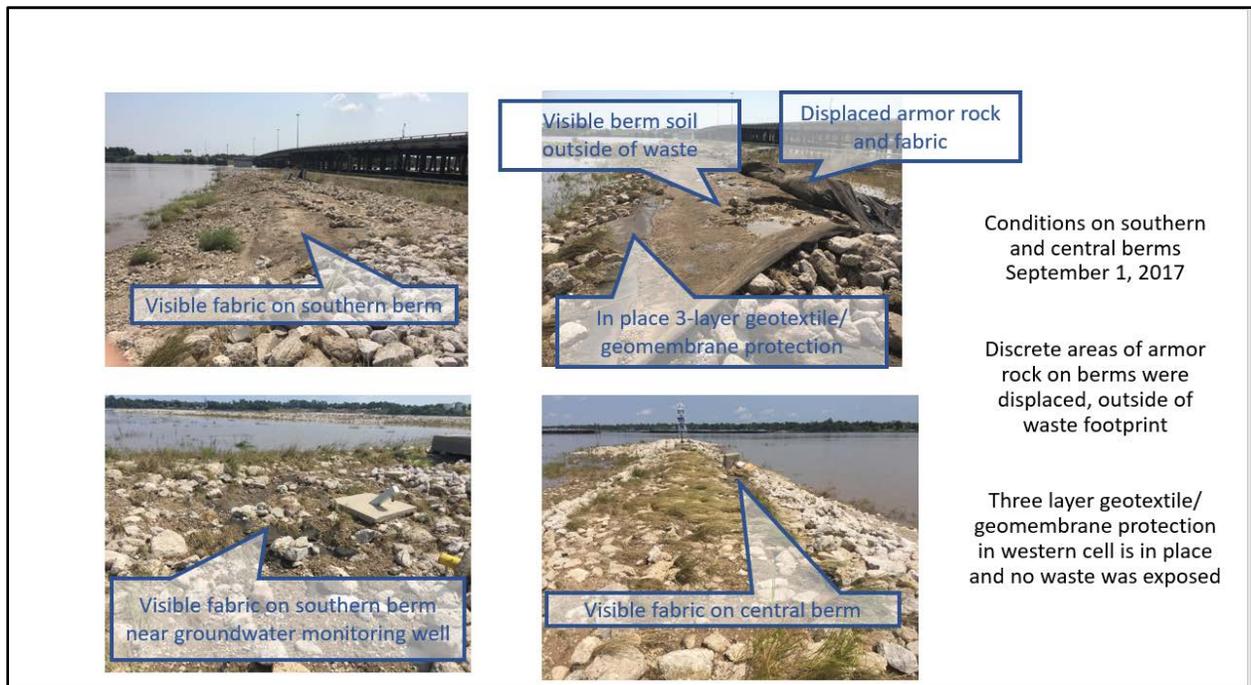


Figure 1. Photos of localized displacement of armor stones following Hurricane Harvey event.

Figure 2 is a map showing the results of the visual and probing surveys taken by Anchor QEA post-Hurricane Harvey to determine cap armor stone thickness. The green dots show stations where the design cap thickness was confirmed. The map of the TCRA cap area is practically all green. The “areas of interest” are shown as blue dots and are labeled. The blue dots are widely scattered specks over the TCRA cap area, but there is a concentration of areas of interest on the northwestern perimeter of the cap. All these areas of interest were found to have armor stone still in place, but at thickness potentially less than the design thickness. The combined surface area of all the areas of interest was approximately 195 square feet, or less than 0.03 percent of the surface area of the TCRA cap. There was no evidence of a release of waste from any of these areas. (Anchor QEA 2017a). Within days following the Hurricane Harvey event, maintenance was performed in all areas of interest with armor stone thickness that could not be confirmed to be at the design thickness, using 10-inch mean diameter stone.

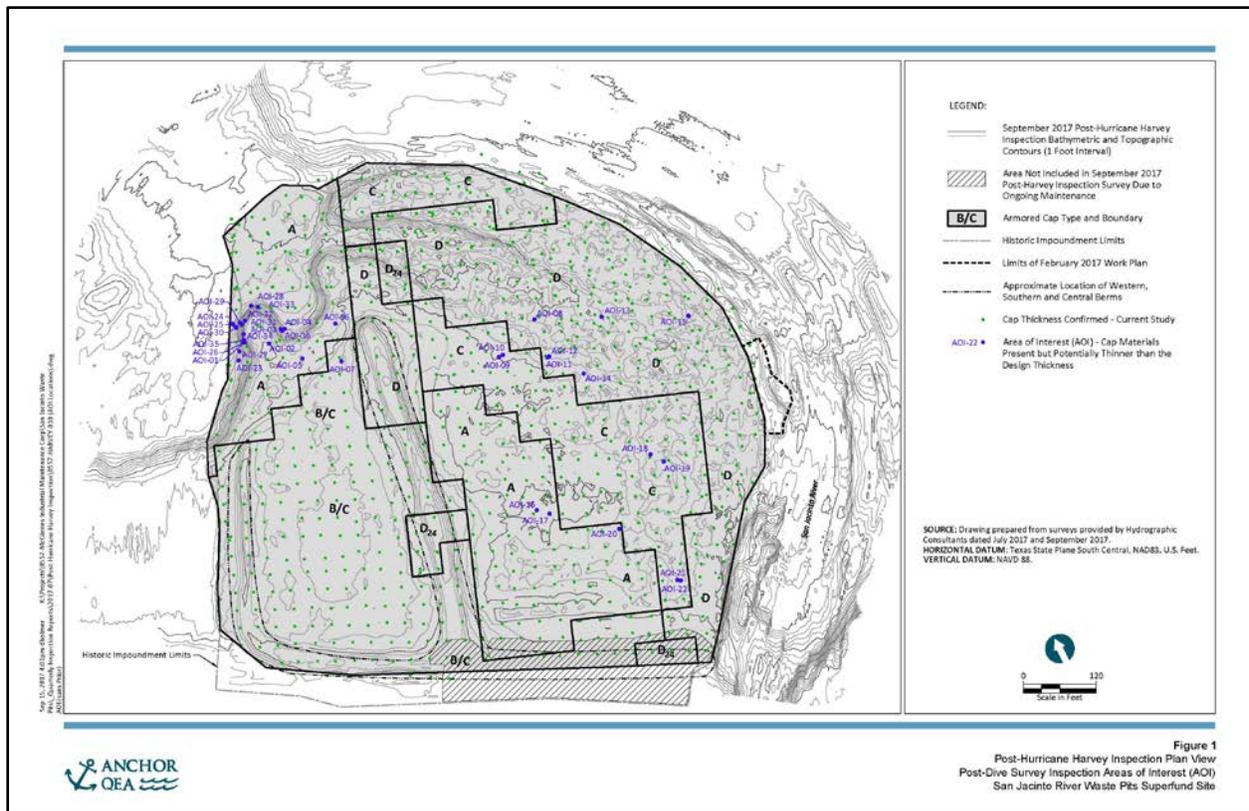


Figure 2. Post-Dive Survey Inspection Areas of Interest (AOI) (from Anchor QEA 2017a).

These survey results are indicative of the margin of safety in the design process for cap armor. The TCRA cap armor, intended as a temporary measure, was designed to protect against a 100-year event, with 3 to 10-inch mean diameter stone sizes. The basis of an armor design is to select a stone size to resist stresses that would merely induce movement of the stone, not wash the stone armor layer away. Hurricane Harvey, characterized as a 500-year event, was much stronger than the 100-year design event and did in fact move armor stones in limited areas. Yet, the TCRA cap remained intact, providing stability against the forces generated by Hurricane Harvey.

### 3.2 Ground Truth from Hurricane Harvey Makes Modeling Uncertainty a Moot Point

**EPA had earlier voiced concern about uncertainties of modeling the ability of an enhanced cap to provide long-term stability. Modeling uncertainty is now a moot point. Hurricane Harvey was a definitive ultra-extreme event, and the TCRA cap, with 3 to 10-inch mean diameter stone, remained in place and the waste was effectively contained. This fact clearly demonstrates, with a very high degree of certainty, that the Alternative 3aN enhanced cap, with 15-inch mean diameter stone, will be effective and provide long-term stability against any such ultra-extreme event.**

EPA states in the PRAP that the modeling supporting design of an enhanced cap has a high degree of uncertainty. But predictive modeling uncertainty for purposes of design is now a moot point. The defining ultra-extreme event has occurred at the Site. There is not a more energetic event that could be reasonably assumed to occur at this Site. The TCRA cap, with 3 to 10-inch mean diameter stone, remained stable in the face of the Hurricane Harvey event.

Anchor QEA has performed a hindcast analysis to estimate the flow velocities acting over the Site during the Hurricane Harvey event. Anchor QEA 2017c. That effort indicated flow velocities of approximately 7 feet per second. At these velocities, Alternative 3aN, with a stone size of 15-inches in mean diameter across the entire Site footprint, would be stable with a factor of safety between 2 and 7.

The combined evidence of the survey results for the TCRA cap post-Hurricane Harvey and the hindcast modeling demonstrate that, with very high degree of certainty, Alternative 3aN would remain stable against any ultra-extreme event that can reasonably be assumed to occur at the Site.

### **3.3 Containment Effectiveness was Confirmed by Post-Hurricane Harvey Sampling**

**Samples collected by EPA and others did not indicate a release of waste from the Site, demonstrating that the TCRA cap provided effective containment, even in the face of the Hurricane Harvey event. Both containment effectiveness and physical stability would be enhanced with a more robust cap as provided by Alternative 3aN.**

Based on the results of the probing surveys, the EPA dive team sampled the sediments accumulated on the cap surrounding and downslope from the concentration of the areas of interest with cap armor that could not be confirmed to be at design thickness. Locations of the EPA dive team samples are shown in Figure 3. These locations were selected based on “areas of interest” identified by the probing surveys described above. These samples were analyzed for toxicity equivalent quotient constituents. Of all samples taken, only one sample (at location AOI-30) had concentrations above the 200 ng/kg benchmark. Based on the data that we have now, the one sampling point with a hit is small and localized, with no other exceedances in surrounding areas. These results do not indicate any breach or release from beneath the armored cap. The EPA sampling results demonstrate that the TCRA cap was effective in containing the waste in addition to providing physical stability.



can be reliably contained over the long term (Appendix A). Therefore, the dioxin/furan waste at the San Jacinto River Waste Pits Superfund Site is considered a Principal threat waste based on high toxicity or potential mobility.” (Final Interim FS, p. ES-4).

I had earlier commented that the USACE report prepared by the EDRC clearly supports the position that a containment cap can in fact be designed to provide physical stability even against the ultra-extreme event proposed by EPA. Hurricane Harvey was that ultra-extreme event, and the fact that the TCRA cap remained stable and the containment remained effective validates both the USACE report’s finding and my earlier comments. The defining ultra-extreme nature of the Hurricane Harvey event and the subsequently observed stability and effectiveness of the TCRA cap effectively nullify the PTW argument on a technical basis.

## **4 Alternative 3aN Design Should be Further Enhanced**

### **4.1 Hurricane Harvey Defines Specific Design Considerations to Prevent Undermining**

**Scour was observed in non-armored areas immediately adjacent to the TCRA cap. Even in the face of such erosive forces, the TCRA cap area itself was not eroded and no undermining was evident. This mechanism of potential erosion in non-armored areas adjacent to the cap indicated that appropriate control measures should be included in the design for a permanent cap to prevent undermining. Such measures should include flattening of the present cap slopes and incorporation of a toe berm and/or similar component to prevent potential undermining.**

Anchor QEA conducted a topographic and bathymetric survey of the Site and surrounding area and compared the results with pre-Hurricane Harvey results. Results of these surveys are mapped in Figure 4. The blue and white shading indicates areas with increases in surface elevation or no change in elevation. The yellow and orange shading indicates areas with reductions in elevation, indicative of scour due to Hurricane Harvey. With the exception of very small areas, the entire surface of the TCRA cap shows no decrease in elevation, demonstrating that the TCRA cap remained stable.

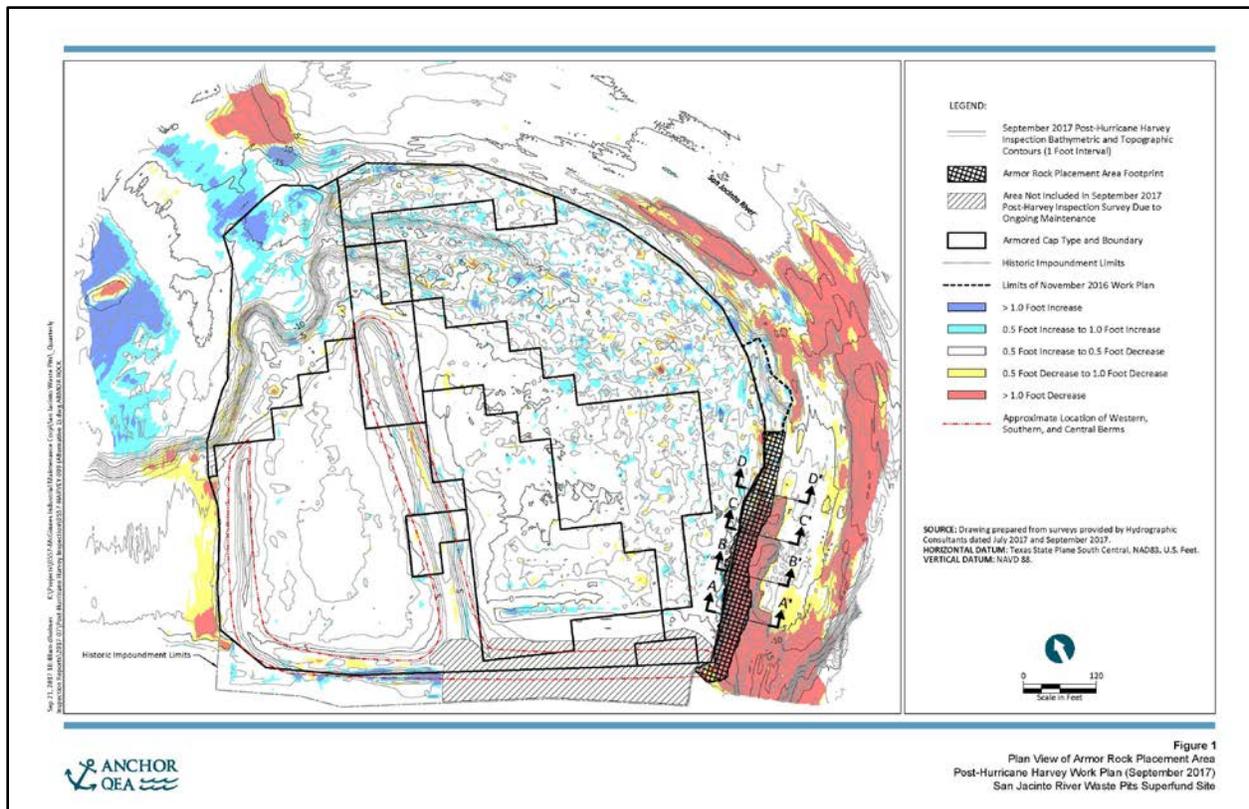


Figure 4. Map showing elevation changes at the TCRA Site resulting from Hurricane Harvey (from Anchor QEA 2017b).

Areas outside of and around the periphery of the TCRA cap are not armored. The cross sections accompanying the map show areas immediately adjacent to the TCRA cap with significant elevation decreases indicating scour had occurred. Areas of particular concern include the area immediately adjacent to the eastern edge of the TCRA cap and the area at the prominent feature at the northwest edge of the cap (this is the same area with multiple small “areas of interest” with reduced cap thickness that the EPA dive team focused its sediment sampling effort).

This observed scouring does not indicate a potential issue with the stability of either the TCRA cap itself or of the Alternative 3aN enhanced cap. The caps themselves are armored. But clearly, these results in non-armored areas indicate the need to address the areas adjacent to the cap boundary to avoid potential undermining of the armored cap. Such an enhancement of the Alternative 3aN enhanced cap was mentioned in both the USACE report and in my earlier comments on the PRAP. This can be accomplished by flattening the cap slopes to extend the armor stone protection beyond the present limits of the TCRA cap. Anchor QEA has prepared conceptual drawings showing the flattened slopes as shown in Figure 5. Additional protection could be provided by including an armor stone toe berm at the edge of the cap. These enhancements to the design of the Alternative 3aN cap would avoid potential undermining of the cap.

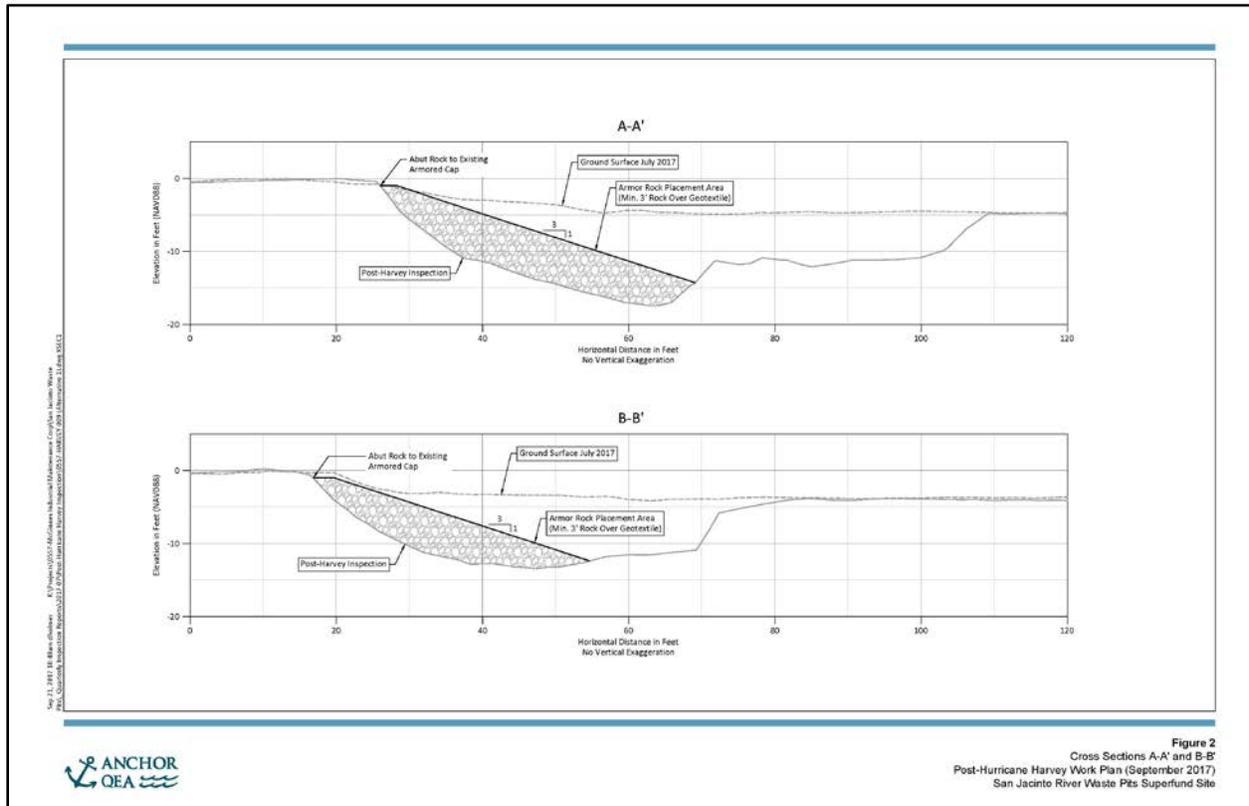


Figure 5. Flattened berm slopes as proposed by Anchor QEA (from Anchor QEA 2017b).

## 4.2 Final Cap Design Should Consider Streamlining the Geometry of Western Berm

The minor movements of stone on the TCRA cap on the Western Cell were predominantly along the perimeter berm that formed a raised geometry encouraging localized higher flow velocities. Consideration should be given in a final permanent cap design to eliminate the raised geometry of the perimeter berm, resulting in a more streamlined geometry for the cap.

As mentioned above, the geotextile was exposed by movement of armor stones in several areas along the perimeter berm on the Western Cell. The crest of the perimeter berm is several feet higher than the interior of the TCRA Site. If the entire new cap surface for the Western Cell was at uniform elevation, the Site would become more streamlined, and areas resulting in localized higher flow velocities would be eliminated.

## 5 Alternative 6N Presents High Risk with a Hurricane Harvey-Like Event

**With respect to Alternative 6N (EPA’s preferred removal alternative), Hurricane Harvey has highlighted the serious disadvantages of any removal alternative with respect to short-term effectiveness. If EPA had begun implementation of Alternative 6N this past year, even with the control measures as proposed in the PRAP, portions of the TCRA cap and the Southern Impoundment would likely have been open to the flood waters of Hurricane Harvey and a significant release of waste would likely have occurred.**

EPA described measures in the PRAP for Alternative 6N to protect against flood flows during active removal operations. The proposed design of these measures called for protection from 25 to 50-year return interval events. My earlier comments on the PRAP pointed out the double standard exercised by EPA in evaluating containment versus removal, with 50-year events set as the protection goal for Alternative 6N, and 500-year events set as the protection goal for Alternative 3aN.

Hurricane Harvey has demonstrated that Alternative 6N at this Site, where significant sub-areas of waste would be exposed during implementation, presents a high risk for significant release of waste as compared to Alternative 3aN, where the entire area would remain armored while the enhanced armor is constructed. The same comment would apply to any excavation taking place in the Southern Impoundment during a storm event.

## 6 Conclusions and Recommendations

My recommendation on remedy selection as stated in my earlier report and as summarized in my letter remains unchanged.

EPA identified Alternative 6N as the proposed remedy in the PRAP based on concerns that the Alternative 3aN enhanced cap could not reliably remain stable and effective in the face of an ultra-extreme flow event. Hurricane Harvey was such an event. Yet, the TCRA cap, designed as a temporary measure, remained stable and effective. Alternative 3aN would be much more robust than the existing TCRA cap. These facts demonstrate, with a very high degree of certainty, that Alternative 3aN will be stable and effective in the face of any such ultra-extreme event.

Based on my earlier comments on the PRAP and these supplemental comments, I recommend that EPA select Alternative 3aN for permanent containment with additional enhancements in adjacent areas to prevent potential undermining during ultra-extreme events.

## 7 References

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Anchor QEA, 2017b Letter to USEPA Gary Miller from David Keith and John Verduin, Re: Plan for Armor Rock Placement Adjacent to the Time Critical Removal Action Armored Cap San Jacinto River Waste Pits Superfund Site, Channelview, Texas, dated October 5, 2017.

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USEPA 2016b. Proposed Plan, San Jacinto River Waste Pits Site, Harris County, Texas. September 2016.