Tijuana River Valley Needs and Opportunities Assessment – Sediment Technical Memorandum

San Diego, California

March 13, 2020

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1 Introduction

1.1 Background

The Tijuana River Valley has a long history of water quality issues related to transboundary flows originating in Mexico. These issues include sewage and industrial waste, and trash and sediment transported across the border during both dry- and wet-weather conditions. Recent upgrades in the area of wastewater treatment have resulted in some improvement to water quality on both sides of the border, especially during dry-weather flows. However, wet-weather flows, or stormwater, continue to convey significant quantities of sediment, trash, and other contaminants into the Tijuana River Valley from sources in both the United States (U.S.) and Mexico. The transport of sewage, sediment, and trash causes water quality impairments, threatens life and property from flooding, degrades valuable riparian and estuarine habitats, and affects recreational opportunities for residents, workers, and visitors in the area.

The Tijuana River Watershed is a large, binational watershed in southern California and northern Baja California. Three quarters of the watershed lies in Mexico and includes the cities of Tijuana and Tecate. On the U.S. side, the watershed extends into the County of San Diego and City of San Diego. The Tijuana River flows from Mexico into the U.S. and discharges to the Pacific Ocean through the Tijuana River Estuary.

The flow of the river, at any given time, may consist of stormwater, effluent discharged from wastewater treatment plants in Mexico, sewage spills, industrial/agricultural discharges, groundwater, and other unidentified sources from Mexico. The river and estuary, combined, are listed as having 37 impairments on the Clean Water Act 303(d) list of impaired waters. River flows laden with raw sewage, trash, and contaminants reaching the Pacific Ocean in the U.S. pose health and safety risks and environmental concerns.

There is an agreement between the U.S. and Mexico to divert water from the Tijuana River in Mexico prior to crossing the border to the U.S. The U.S. and Mexico Sections of the International Boundary and Water Commission (IBWC) are responsible for mitigating sewage problems and the associated water quality issues in the Tijuana River Watershed. IBWC's efforts have led to the construction and operation of infrastructure on both sides of the border to capture, treat, and discharge the transboundary sewage flows from Mexico. The infrastructure includes the following, as shown on Figure 1:

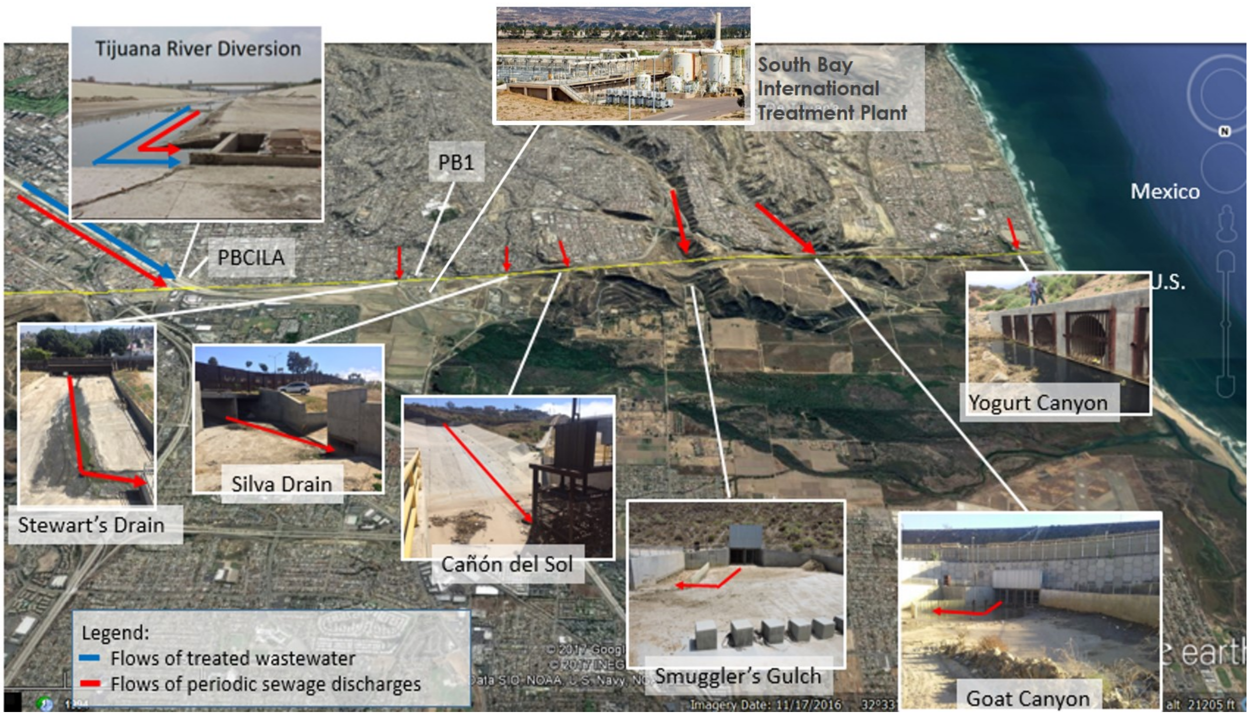
- The River Diversion Structure and Pump Station CILA (PBCILA) divert flows from the Tijuana River at a point just south of the international border to a Pacific Ocean shoreline discharge point approximately 5.6 miles south of the U.S.-Mexico border.
- A combination of pump stations and wastewater treatment plants in Mexico diverts and treats sewage discharges.
- Concrete channels and basins form canyon collector systems designed to capture transboundary flows from Mexico in canyons and ravines draining north across the border to the Tijuana River. The five canyon collector systems are the Smuggler's

Gulch Diversion Structure, Goat Canyon Diversion Structure, Cañon del Sol Collector, Stewart's Drain Canyon Collector, and Silva Drain Canyon Collector.

- The South Bay International Wastewater Treatment Plant treats sewage from Mexico and flows collected by the canyon collectors.

These facilities are designed to handle dry-weather river flows up to 23 million gallons per day (mgd). Flows in excess of 23 mgd enter the river channel and cross into the U.S. These facilities are shut down during storm events and system malfunctions, and the water is allowed to flow through the canyons and the main river channel, leading to uncontrolled transboundary flows that ultimately reach the Tijuana River Estuary and Pacific Ocean south of Imperial Beach. Flow in the Tijuana River during storm events can reach over 1 billion gallons per day. It may take several months for the river channel flow to fall below 23 mgd after a storm event, and for the existing infrastructure to start diverting flow to the treatment facilities or to the Mexican outfall.

Figure 1. Dry-weather Flow Infrastructure in the Tijuana River



In 2012, the Tijuana River Valley Recovery Team set forth a Recovery Strategy that identified actions to clean up and restore the Tijuana River Valley's beneficial uses. The Recovery Strategy focused on actions to address water quality issues, sediment, and trash that currently degrade the river's beneficial uses, exacerbate flooding, affect habitat, and affect recreation. As part of this program, the County of San Diego identified the need for an additional study that objectively and comprehensively identifies possible solutions north of the border to address transboundary sewage flows (point and nonpoint sources), trash, and sediment in four priority watersheds: Tijuana River, Smuggler's Gulch (Cañon de los Mataderos), Goat Canyon (Cañón de los Laureles), and Yogurt Canyon (Cañon Los Sauces).

The Tijuana River Valley Needs and Opportunities Assessment is intended to identify the critical issues within each of the four priority watersheds and to identify and prioritize projects to address the impacts of transboundary flows on the Tijuana River Valley.

1.2 Purpose

This technical memorandum (TM) identifies projects that are viable and feasible to be implemented on the U.S. side of the border to improve sediment management in the Tijuana River Valley. The main focus of this phase is on two tributaries of the Tijuana River (Smuggler's Gulch and Yogurt Canyon), in addition to the operation of existing Goat Canyon sediment basins and the ongoing efforts of USIBWC to evaluate other sediment controls in the Tijuana River. The final goal is to reduce health and safety impacts and limitations on recreational use of the Tijuana River Estuary and coastal beaches in San Diego.

Section 2 of this TM identifies the existing information and ongoing projects that are designed to address sedimentation issues in each of the priority watersheds. Section 3 identifies the remaining unaddressed priority issues related to sedimentation in each of the priority watersheds. Section 4 identifies potential projects to address the remaining issues in priority watersheds. A planning-level cost estimate is included for the project implementation, and for ongoing costs. Section 5 is intended to discuss potential emergency measures to deal with the transboundary stormwater flows until permanent infrastructure—and other projects, policies, and procedures—can be implemented. Finally, Section 6 summarizes the potential projects to be considered for additional study.

2 Review of Existing Projects and Information

The information gathered during Step 1 of this assessment was reviewed, and newly gathered data, to identify specific project-related information that would help in developing the sediment control alternative concepts. The following sections describe the information and projects that were reviewed and applied as appropriate.

2.1 Tijuana River

- Hydrologic, hydraulic, and sediment transport information for the Tijuana River Watershed – U.S. Army Corps of Engineers (USACE) Los Angeles District, 2018, *Phase I Hydrology, Floodplain and Sediment Transport Report Final – Tijuana River United States-Mexico International Border to the Pacific Ocean San Diego, California*
- Hydraulic and floodplain information for the Tijuana River Watershed – URS, 2012, *The Hydraulic and Floodplain Study of the Tijuana River*, Task Order IBM10T0048, contract IBM09D0008
- Tijuana River sediment transport and sediment characterization – Chang Consultants, 2007, *Hydraulic and Sedimentation Study for Wetland Restoration in the Tijuana River Floodplain*, prepared for Dudek Engineering & Environmental
- Tijuana River Pilot Channel, Goat Canyon, and Smuggler's Gulch historical sediment cleanup volumes and sediment management – AECOM, 2016, *Nelson Sloan*

Management and Operations Plan and Cost Analysis, prepared for County of San Diego, Department of Parks and Recreation

- Tijuana Estuary sediment management plan – AMEC Earth and Environmental, 2008, *Tijuana Estuary Sediment Study*, prepared for California State Parks Division of Boating and Waterways
- Tijuana River sediment basins – Stantec Consulting Services, 2019, *60% Report Feasibility Study for Sediment Basins Tijuana River International Border to Dairy Mart Road*, prepared for USIBWC
- Tijuana River bacterial source identification study – WESTON Solutions, 2012, *Tijuana River Bacterial Source Identification Study – Final Report*, prepared for the City of Imperial Beach, Public Works Department
- Topographic information for the Tijuana River Valley and tributaries – U.S. Geological Survey 2011 and USACE 2015 LiDAR data (Tijuana River National Estuary Marine Reserve)

2.2 Smuggler's Gulch

- Hydrologic information for the Smuggler's Gulch Watershed – University of California, Irvine, 2017, *Brown Fill Removal Alternatives: Hydrologic and Hydraulic Analysis*, in support of NSF/UCI FloodRISE Project
- Smuggler's Gulch sediment characterization – URS, 2009, *Smugglers Gulch Channel Excavation Soils Sediment Characterization Report*
- Tijuana River Pilot Channel, Smuggler's Gulch and Goat Canyon sediment characterization – HDR, 2013, *Tijuana River Sediment Loading Assessment – Smuggler's Gulch and Tijuana River Pilot Channel*, Task Order #59, URS Contract #H084440

2.3 Goat Canyon

- Hydraulic and sediment information for Goat Canyon – Rick Engineering, 2003, *Hydraulic and Sedimentation Study of Goat Canyon Creek for the Goat Canyon Enhancement Plan*
- Goat Canyon sediment characterization – AMEC Earth & Environmental, 2005, *Final Tijuana Estuary Restoration Feasibility Study – Sediment Characterization*, prepared for Tierra Environmental Services; and Nautilus Environmental, 2008, *Goat Canyon Retention Basins Phase II and III Source Material Soil Characterization Report*
- Goat Canyon sediment yields – San Diego State University, 2015, *Sediment and Erosion in Tijuana: Socioeconomic Interactions with Sediment Budgets under Rapid Urbanization*, Project Number W-08-15
- Sand beach nourishment projects – Moffatt & Nichol, 2006, *Final Sand Compatibility and Opportunistic Use Program Plan*, prepared for SANDAG and California Coastal Sediments Management Workgroup

2.4 Yogurt Canyon

No pertinent information regarding sediment yield or existing projects was identified for Yogurt Canyon. The sediment information used in this study was derived through correlation with other tributary watersheds (Smuggler's Gulch and Goat Canyon).

3 Priority Issues

Sediment and trash are degrading the Tijuana River Valley and estuary and threatening public health and safety throughout the Tijuana River Watershed. Stormwater flows transport sediment and trash from urban areas downstream into the Tijuana River Valley. The urban population in the City of Tijuana continues to grow rapidly as jobseekers from throughout Latin America seek opportunity near the international border. Infrastructure improvements, such as paved roadways and waste management services, have been unable to keep pace with growth. Often this situation can lead to problems such as accelerated erosion and illicit disposal of trash and other waste materials in canyons and neighborhoods both in incorporated and unincorporated areas of the city. In addition, basic development practices in many areas of the watershed have resulted in disturbance of natural drainage patterns and vegetation removal from slopes, making them unstable and prone to erosion. Storm flows mobilize and then transport the sediment and trash downstream, threatening the health of riparian and estuarine habitats in both the U.S. and Mexico and reducing the flow capacity of the river and tributary channels (Tijuana River Valley Recovery Team 2012).

The main Tijuana River channel is where the majority of the stormwater, sediment, and trash enters the U.S. Historically, much of the sediment has been carried downstream into the Tijuana River Valley. Over time, the downstream areas have served as a sink for accumulated sediment, resulting in an increase in vegetation. This causes storm flows to flood and deposit additional sediment and trash. In 2012, USIBWC allocated funds in its budget to remove sediment and trash from the upper part of the Tijuana River Valley Flood Control Project area adjacent to the border (Tijuana River Valley Recovery Team 2012).

In Smuggler's Gulch, excessive sediment loads reduce the capacity of natural channels to carry storm flows, which exacerbates flooding that adversely affects residential, agricultural and recreational property in the Tijuana River Valley. In the early 1990s, the City excavated an earthen channel (known as the Pilot Channel) to direct larger storm flows away from the northern portion of the Tijuana River Valley, where flooding has resulted in significant damage to public and private property. When resources are available, the County of San Diego and City of San Diego clear sediment from Smuggler's Gulch to maintain its capacity to carry storm flows and minimize the effects of flooding. The County removes approximately 15,000 cubic yards (CY) of trash, waste tires, and accumulated sediment each time it clears the channel from Smuggler's Gulch south of Monument Road. The City has frequently cleared the Pilot Channel and Smuggler's Gulch channel north of Monument Road to reduce the flood risk. Each channel clearing results in the removal of approximately 30,000 to 60,000 CY of sediment, trash, and waste tires. Despite this costly ongoing maintenance of the channel, flooding continues to negatively impact residents and infrastructure. Sedimentation is also rapidly changing the topography, which negatively impacts the ecology of the Tijuana River Valley.

Sediment discharged from Goat Canyon directly affects salt marsh habitat, which has been steadily degraded. To control degradation, California State Parks constructed two sediment basins just downstream of the international border in 2006. The basins were designed to provide maximum sediment storage capacity in the space available for construction. In most wet seasons, the basins intercept a majority of the sediment. In very wet seasons, however, the basins can fill with sediment resulting in the downstream salt marsh being smothered by several feet of sediment in a single storm event.

3.1 Sediment Characteristics

3.1.1 Tijuana River

The main stem of the Tijuana River does not have a sediment gage to identify the inflow sediment loads at the upstream end of the study reach near the U.S.-Mexico border. Therefore, the Tijuana River inflow sediment load was estimated by USACE in the Phase I sediment model (2018) based on the assumption of a quasi-equilibrium condition, in which the inflow sediment load is based on the full capacity of the flow to transport sediment from the supply reach. The amount of sediment crossing the border for a range of flows was calculated by USACE, as shown in Table 1.

Table 1. Tijuana River Sediment Inflow Load

Storm Run-off (cfs)	All Grains (tons/day)	Class 6, VFS (tons/day)	Class 7, FS (tons/day)	Class 8, MS (tons/day)	Class 9, CS (tons/day)	Class 10, VCS (tons/day)	Class 11, VFG (tons/day)	Class 12, FG (tons/day)
167	330	106	60	96	49	18	0	1
1,006	4,849	1,626	886	1,392	681	243	1	12
6,709	56,350	20,615	10,585	15,620	7,075	2,337	6	53
10,000	94,300	35,250	17,825	25,870	11,495	3,727	8	70
23,482	428,500	175,250	82,500	111,200	45,605	13,665	17	154
32,069	750,000	304,943	144,492	195,621	80,438	24,167	25	233
40,659	1,259,000	509,500	242,600	329,600	135,900	40,890	38	346
49,245	1,432,000	576,300	275,900	376,600	155,800	47,000	39	357
57,833	1,624,000	651,500	312,900	428,000	177,300	53,530	40	370
67,100	1,821,000	728,200	350,900	481,100	199,600	60,340	41	382

Source: Excerpted from USACE (2018)

The total annual sediment yield crossing the border in the Tijuana River Watershed was first estimated by USACE (1977) as 271,000 CY, or approximately 311,000 tons (for a bulk sediment density of 85 pounds per cubic foot). URS (2012b) updated the total annual sediment yield at the entrance of the estuary on the order of 492,000 tons (428,500 CY) based on the Dendy-Bolton methodology. The majority of the sediment in the lower Tijuana River Estuary was found to consist of clay, silt, sand, and gravel, with the dominant bed material being fine to medium sand (median particle size D_{50} is on the order of 0.4 millimeters [mm]).

3.1.2 Smuggler's Gulch

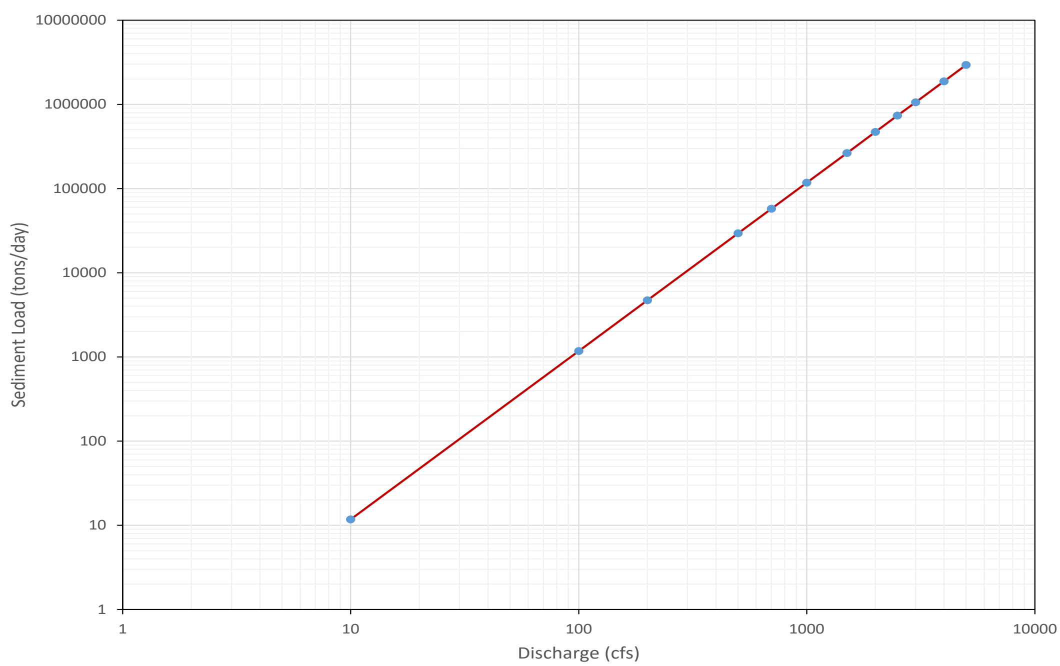
For this study, it was estimated the Smuggler's Gulch sediment load crossing the border based on the assumed average annual sediment yield of 18,000 tons (~16,000 CY), to limit the sediment concentrations in the 5-year flow (corresponding to channel forming discharge) to about 100,000 parts per million (ppm) by weight (10 percent by weight). This conservatively high sediment concentration was observed in many steep, sand bed arroyos similar to Smuggler's Gulch (see discussion on arroyo sediment concentrations in Resource Consultants and Engineers, 1994). A sediment rating curve was constructed for this preliminary sedimentation analysis, as shown on Figure 2 (this curve was developed by distributing the assumed average annual sediment load within the probability averaged annual flow volume in Smuggler's Gulch). It results in an estimated 100-year sediment load of 114,000 tons, which closely matches the amount predicted by Rick Engineering (2003) for the similarly sized Goat Canyon watershed (115,000 tons). The sediment size gradation for Smuggler's Gulch was adopted from previous reports (URS 2009), indicating a representative median grain size of 0.26 mm (Table 2).

Table 2. Smuggler's Gulch Representative Grain Size Distribution

Percentage Cobbles	Percentage Gravel	Percentage Sand	Percentage Fines	Median Grain Size (mm)
14	22	56	8	0.26

Source: URS (2009)
Note: mm = millimeter

Figure 2. Smuggler's Gulch Sediment Load Rating Curve[a]



[an] estimated sediment load carried by discharges across the border

3.1.3 Yogurt Canyon

In the absence of specific sediment characterization in Yogurt Canyon, it was preliminarily assumed that the sediment inflow load rating curve and bed sediment grain size distribution for this tributary are the same as those for Smuggler's Gulch. This would result in an estimated average annual sediment yield of 2,000 tons and a 100-year sediment load of 13,000 tons, based on the reduced watershed area of Yogurt Canyon (see Section 4.4).

3.2 Contaminants

The Goat Canyon Dredged Sediment Special Study conducted in 2010 (Weston 2012) determined that the dredged material removed and stockpiled from the Goat Canyon sediment basins is a reservoir for indicator bacteria for both fecal coliforms and enterococci, which can contribute to elevated bacterial concentrations in the Tijuana River. In 2008, 600 CY of contaminated sediment was removed and stockpiled from Smuggler's Gulch. In 2009, URS characterized sediment in Smugglers Gulch that had been stockpiled. The analyses determined the presence of Title 22 metals, such as total petroleum hydrocarbons, semi-volatile organic compounds (including polynuclear aromatic hydrocarbons), organochlorine pesticides, and polychlorinated biphenyls. These substances pose a considerable risk to human and ecological health.

3.3 Residual Sediments

After each flood in the upper watershed, a portion of the sediment load carried downstream by stormwater, in excess of its transport capacity, is accumulated on the channel bed and/or floodplain, creating sediment deposition landforms termed residual sediments.

The approach to residual sediment management varies by drainage into the Tijuana River Valley and estuary. Most of the stormwater, sediment, and trash enters the U.S. from the main Tijuana River channel. Over time, the downstream areas have served as a sink for accumulated sediment, resulting in increased vegetation. This causes storm flows to flood and deposit additional sediment and trash. Sediment capture alternatives include on-site detention basins, regional basins designed to treat at the sub-watershed level, and large end-of-drainage area basins in the Tijuana River Valley. Trash capture alternatives include mechanized removal of trash and litter from urban areas, improvements to urban drainage conveyance systems to reduce sediment and trash transport, and trash capture nets located within drainage conveyances (Stantec 2018).

The major challenge of capturing sediment and trash material in basins and managed natural channels is budgeting and funding the annual operation and maintenance (O&M) activities that include excavation of sediment, sorting trash and tires from sediment, and disposal of sediment. While source reduction measures throughout the watershed reduce the volume and frequency of this work, O&M of new sediment and trash capture infrastructure must be considered as a long-term, ongoing need. In an effort to stabilize and reduce costs, the following alternative options for the beneficial use of the sediment should be considered (Stantec 2018):

- **Local integrated sediment and trash processing site** – Establish a joint sediment and trash management location for the sediment captured from the proposed basins, the Goat Canyon sediment basins, and other excavation activities in the Tijuana River Valley. This would result in a centralized, cost-efficient processing of excavated material.
- **Nearshore sediment reuse/beach replenishment project** – Continue placing sediment on the beach adjacent to Border Field State Park and Tijuana River National Estuarine Research Reserve. Sediment may also be placed in the nearshore environment through an agreement with the City of Imperial Beach and in accordance with the Sand Compatibility and Opportunistic Use Program Plan (Moffatt & Nichol 2006). This would result in cost-efficient reuse and environmentally beneficial placement of captured sediment for beach replenishment.
- **Nelson and Sloan Quarry Reclamation** – Implement the Reclamation Plan for the Nelson and Sloan property (also known as the Border Highlands Borrow Pit) using sediment excavated from all the proposed basins (AECOM 2016). This would result in beneficial reuse of captured sediment to reclaim the sand and gravel mine in conformance to the original conditional use permit and reclamation plan, the cost-efficient placement of sediment excavated from the Tijuana River Valley's sources, and the improvement of habitat through revegetation of severely eroded slopes.

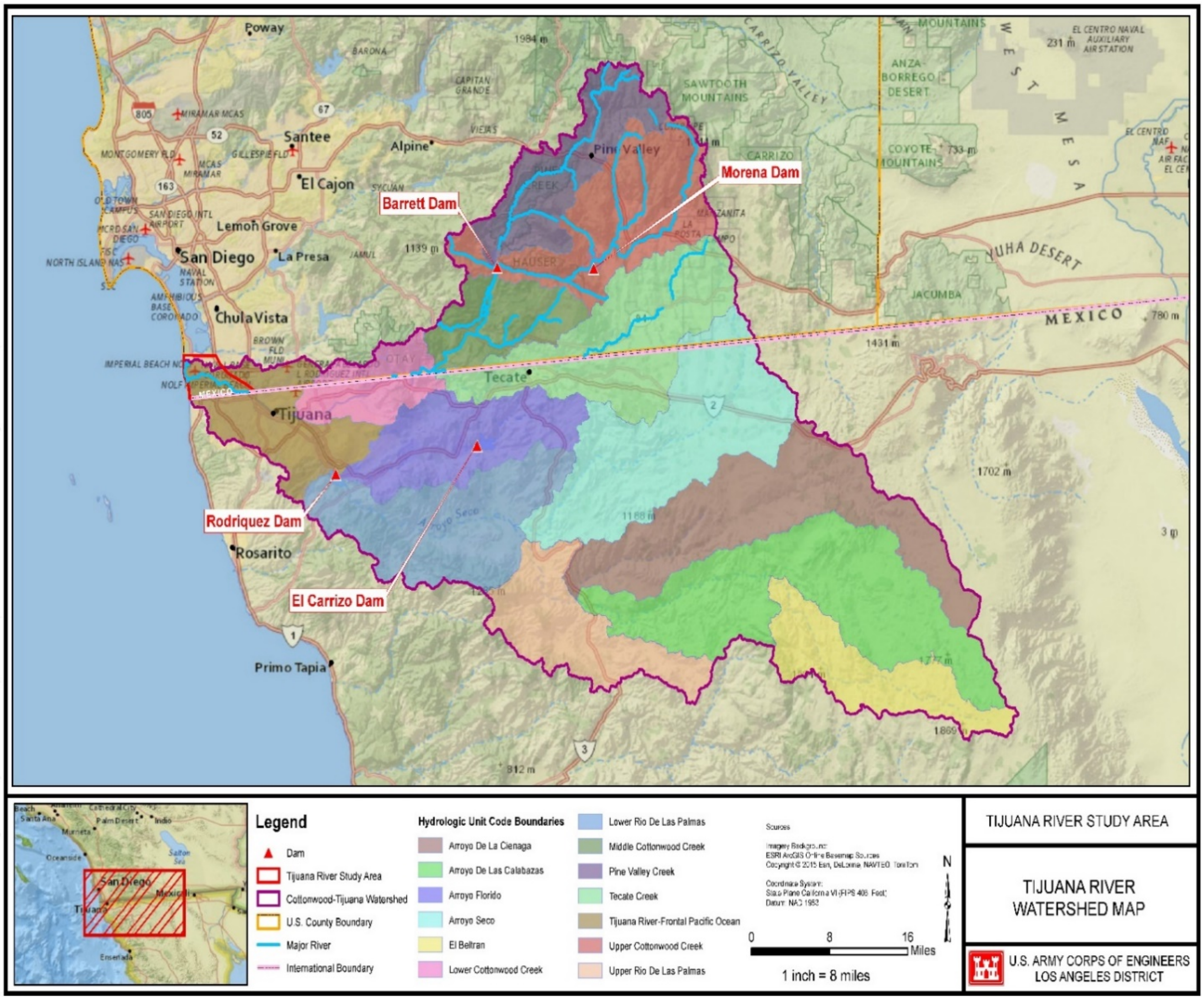
4 Development of Potential Projects

This section summarizes existing projects that have been implemented or those being proposed to reduce the impacts of sedimentation within watershed bodies. Sediment management projects are also discussed.

4.1 Tijuana River

The lower Tijuana River, which starts at the U.S.-Mexico border and ends at the Pacific Ocean, serves as the outlet to the Tijuana River Watershed. The lower river and estuary have been affected by excessive sedimentation and flooding. The suspected source of the sediment is erosion caused by rapid urbanization within the watershed where persistent soil exposure on steep slopes generates large volumes of sediment. The sediment is then routed through the stream network into the estuary and finally to the Pacific Ocean (URS 2012a). The lower part of the Tijuana River formed a broad mud flat estuary that is susceptible to flooding in years of heavy rains. During large storm runoff events, significant amounts of sediment load cross the U.S.-Mexico border into the Tijuana River (URS 2012a). This reach is 1,750 square miles in size, 73 percent of which, or 1,278 square miles, is located in Baja California in Mexico, and 27 percent, or 473 square miles, is located in the county of San Diego in the United States (URS 2012a; Chang Consultants 2007). The Tijuana River Watershed is shown on Figure 3.

Figure 3. Tijuana River Watershed



Source: Excerpted from USACE (2018)

The USACE Los Angeles District (2018) prepared sediment transport models and floodplain maps for the Tijuana River reach from the U.S.-Mexico border to the Pacific Ocean (Phase 1 H&H Study). The intent was to estimate the amount of sediment deposition along the river, calculate the sediment discharge to the ocean, and delineate the existing floodplain for multiple storm frequencies (2- to 500-year). The sedimentation and hydraulic analysis included documentation of methods, assumptions, and results from the modeling efforts. The sediment transport analysis used a one-dimensional (1D) HEC-RAS 5.0.5 model to resolve aggradation and degradation response by the river. The floodplain analysis used a composite 1D and two-dimensional (2D) model of the channelized floodplain and downstream estuary areas.

The USACE study results show that the amount of sediment released to the Pacific Ocean is relatively independent of the watershed sediment yield, because the river lacks enough transport capacity to deliver a significant amount of sediment to the ocean. The amount of sediment released to the ocean was found to mostly depend on the flow capacity to erode the downstream portion of the river reach. Although scour occurs along the streambed of the river, a significant deposition is predicted in the floodplain area.

Overall, considering the entire modeled reach, the analysis shows that as much as 73 percent of the incoming sediment is trapped within the Tijuana River overbank for the 100-year flood event (total annual sediment load in the Tijuana River was discussed in Section 3.1).

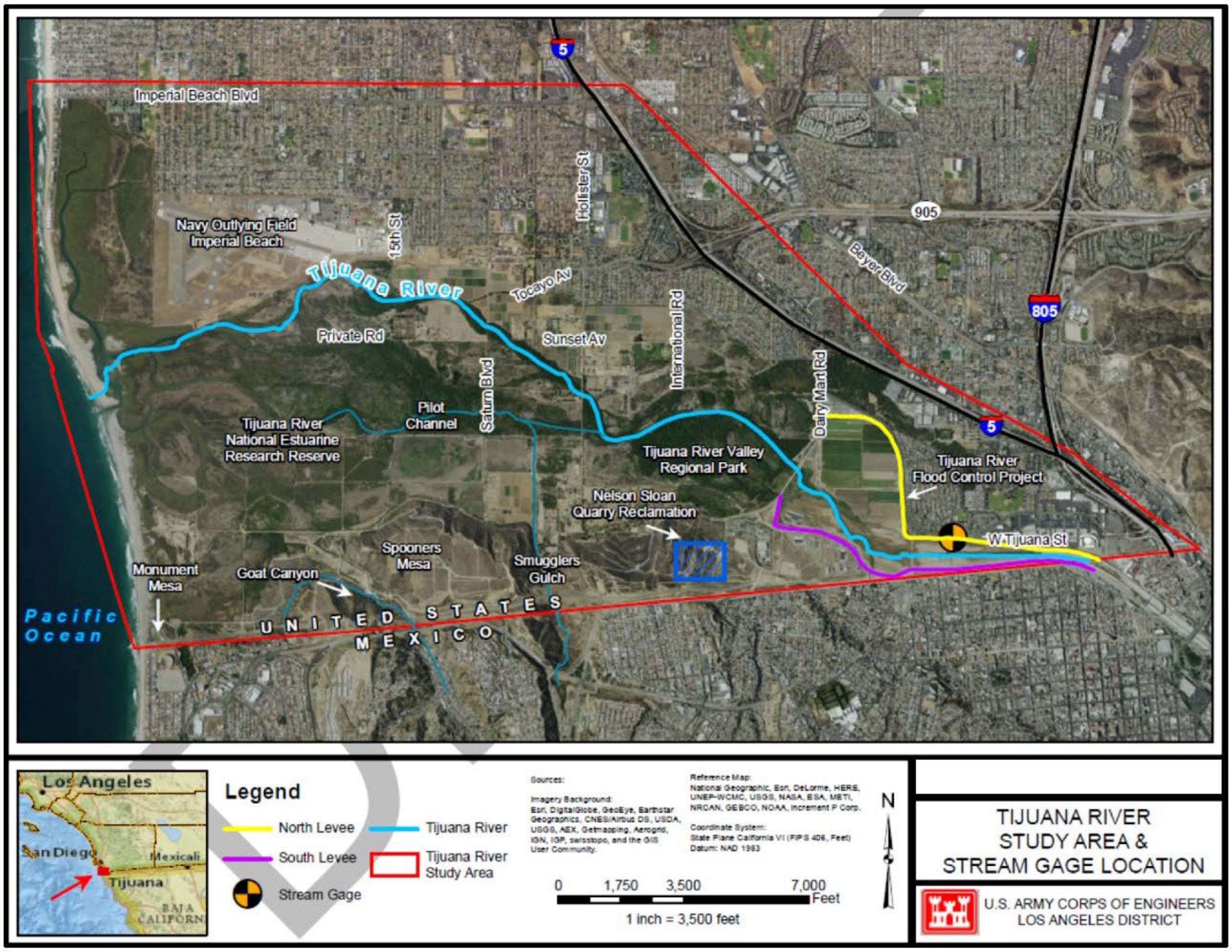
Many factors cause a high sediment deposition. First, the ground surface gradients in the Tijuana Estuary are less than 0.01 percent. Second, the floodplain width in the Tijuana River changes along the study reach at the U.S.-Mexico border to the Pacific Ocean. It starts with an approximately 300-foot-wide channel at the border, which gradually increases in the downstream direction. The channel reaches its maximum width of roughly 15,000 feet just upstream of its outlet. Third, the vegetation is very dense in the study reach. The density of vegetation keeps increasing between the Dairy Mart Road bridge and the Pacific Ocean, specifically in the estuary area.

4.1.1 Projects

Tijuana River sediment basins were studied by Stantec on behalf of USIBWC. To date, Stantec (2019) completed the 60 percent feasibility study to establish the preferred location and size of a sediment basin (or basins) within the main channel of the Tijuana River. The sediment basin was designed to also capture trash and debris. The sediment, trash, debris, and flow management strategies were intended to improve water quality and reduce adverse health risks to people and the environment. This study developed three alternative concepts for the basin, recommended a preferred alternative, and presented a conceptual design for the preferred alternative.

The study included considerations for developing and evaluating civil design components such as specific design criteria, aerial topography, existing utilities research, security, constructability, levee impacts, bridge scour potential, right-of-way, and easements, including hydrologic, hydraulic, and sediment transport modeling. The HEC-RAS hydraulic and sediment transport modeling was used to size the sediment basins and their respective components to support the potential for large volumes of earthwork. A limited geotechnical investigation and evaluation program were included in the scope because large volumes of earthwork were required as part of any sediment basin alternative. The area available for the basin is bound on the upstream side by the international border, the Dairy Mart Road Bridge downstream, and on the north and south sides by flood control levees (Figure 4).

Figure 4. Tijuana River Study Area



Source: Excerpted from Stantec (2018)

All sedimentation alternatives examined include the following elements and constraints:

- Channel/floodplain alterations must not reduce the freeboard on the river's levees to less than regulatory limits during the 100-year flood event.
- Excavation of accumulated sediment and trash in the river will be required to bring the cross section back to its original design or to an alternative cross section. Up to 6 to 8 feet of sediment is believed to have accumulated alongside the central river channel.
- No large fixed dams may be added to the Tijuana River, both for regulatory reasons and to permit passage of the design flood event without violating the mandated freeboard on the North Levee (South Levee is higher and generally not a constraint).
- Standing water must be released within 96 hours.
- Inflatable "dams" may be considered to allow greater flexibility in sediment basin design consistent with allowing high flows to pass within freeboard limits.
- The sediment basin design flow and associated hydrograph will be determined through an iterative approach using the USACE (2018) hydrographs. The design flow

hydrograph may be selected from the 2-, 5-, or 10-year recurrence intervals. Based on Stantec's study (2018), functioning during larger storm events may not be feasible with regard to required flow velocities, basin configurations, and impacts on the levee system and/or Dairy Mart Road Bridge.

Three alternatives were proposed for the sediment basins:

- Alternative A – In-channel Sedimentation Basins
- Alternative B – Off-channel Sedimentation Basins
- Alternative C – Combination of in-channel and off-channel Sedimentation Basins

Alternative A proposes in-channel basins (Figure 5), with appropriately located trash booms, such that an upstream basin cascades into a downstream one. The system of basins would be conceptually designed to capture river sediment, trash, and debris before flows continue past the Dairy Mart Road Bridge. This multibasin cascading concept is similar to the existing sediment basin configuration found at Goat Canyon.

Figure 5. Alternative A – In-channel Sedimentation Basins

Source: Excerpted from Stantec (2018)

The design of the basins will focus on removing existing sediment and widening and flattening the channel in the Tijuana River study area. The assumption will be made (pending hydraulic modelling results) that a series of low-profile grade-control structures will be employed, corresponding generally to the existing structures in the channel, approximately 3 to 5 feet high, to create a sediment basin behind each grade control structure. Since low-flow events must not result in long-term standing water, each of the grade control structures will be fitted with a low-flow relief opening at the low-flow flowline to allow water to slowly drain.

Alternative B proposes a basin in the approximately 98 acres of land currently being used for agricultural use on the north side of the main river channel and east of the Dairy Mart Road Bridge (Figure 6; darker blue line). This concept would divert high-frequency river flows (yet to be determined) into the basin to retain river sediment, trash, and debris, and allow “cleaner” stormwater to slowly meter out of the basin back into the main river channel. Under low-frequency flood events with large peaks, a portion of the flows would be captured by the off-channel basin, and the remainder would bypass the basin and continue west past the Dairy Mart Road bridge.

Figure 6. Alternative B – Off-channel Sedimentation Basin

Source: Excerpted from Stantec (2018)

Alternative C (Figure 7; blue shaded areas are maximum basin footprints) is a combination of Alternatives A and B. It proposes the maximum use of the available footprint for placement, configuration, and operation of a sediment basin/management system featuring both an in-channel and off-channel basin system. The operational concept for the in-channel basin portion is similar to Alternative A. Low flows would flow through the in-channel basin, which would be configured to deposit out the selected sediment particle size. The off-channel basin would be located in similar fashion to Alternative B and would operate during periods of higher discharge in the Tijuana River. The connection between the low-flow in-channel basin and the high-flow off-channel basin could be designed with staged overflow weirs and/or culverts with one-way flap gates to direct flow into the off-channel basin (or something similar). The advantage of Alternative C is the opportunity to capture a larger fraction of the sediment entrained in the Tijuana River. The complexity of the hydraulics required to achieve the design flow split, however, is greater than for Alternatives A and B.

Figure 7. Alternative C – Combination of In-channel and Off-channel Sedimentation Basins

Source: Excerpted from Stantec (2018)

4.1.2 Cost

USIBWC is currently analyzing these project alternatives. At this point in the feasibility study, the estimated implementation cost is between $50 million and $100 million, while the estimated ongoing annual cost is up to $5 million.

4.2 Smuggler’s Gulch

Smuggler’s Gulch (Cañon de los Mataderos) is a side canyon and unregulated tributary drainage to the Tijuana River (Figure 8). The size of the watershed is approximately 3,762 acres (5.88 square miles). The canyon is located primarily in Tijuana, Mexico, and confluences with the Tijuana River in the U.S. Its tributary watershed is highly urbanized, characterized by illegal dumping of trash and waste tires and erosion of sediments from steep canyon walls and unpaved roads (URS 2010).

Smuggler’s Gulch peak discharges (Table 3) and hydrographs (Figure 9) at the mouth of the gulch were determined for various return intervals in the FloodRISE project led by the University of California, Irvine (2017). These flows were developed by a HEC-HMS model consisting of 11 subbasins and six conveyance reaches in the Smuggler’s Gulch Watershed, together with a flood frequency analysis of the Tijuana River streamflow gage.

Figure 8. Tijuana River Tributary Canyons

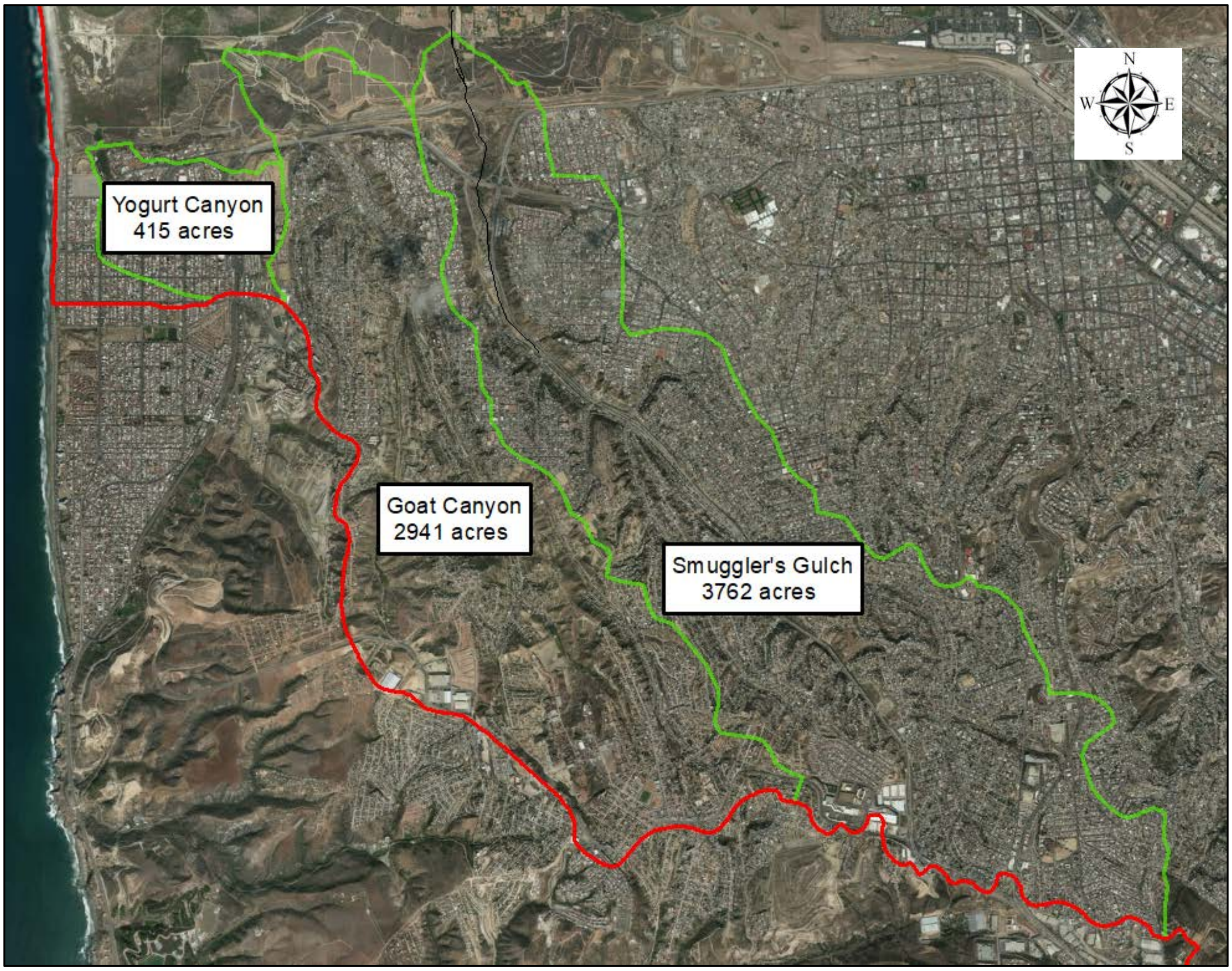
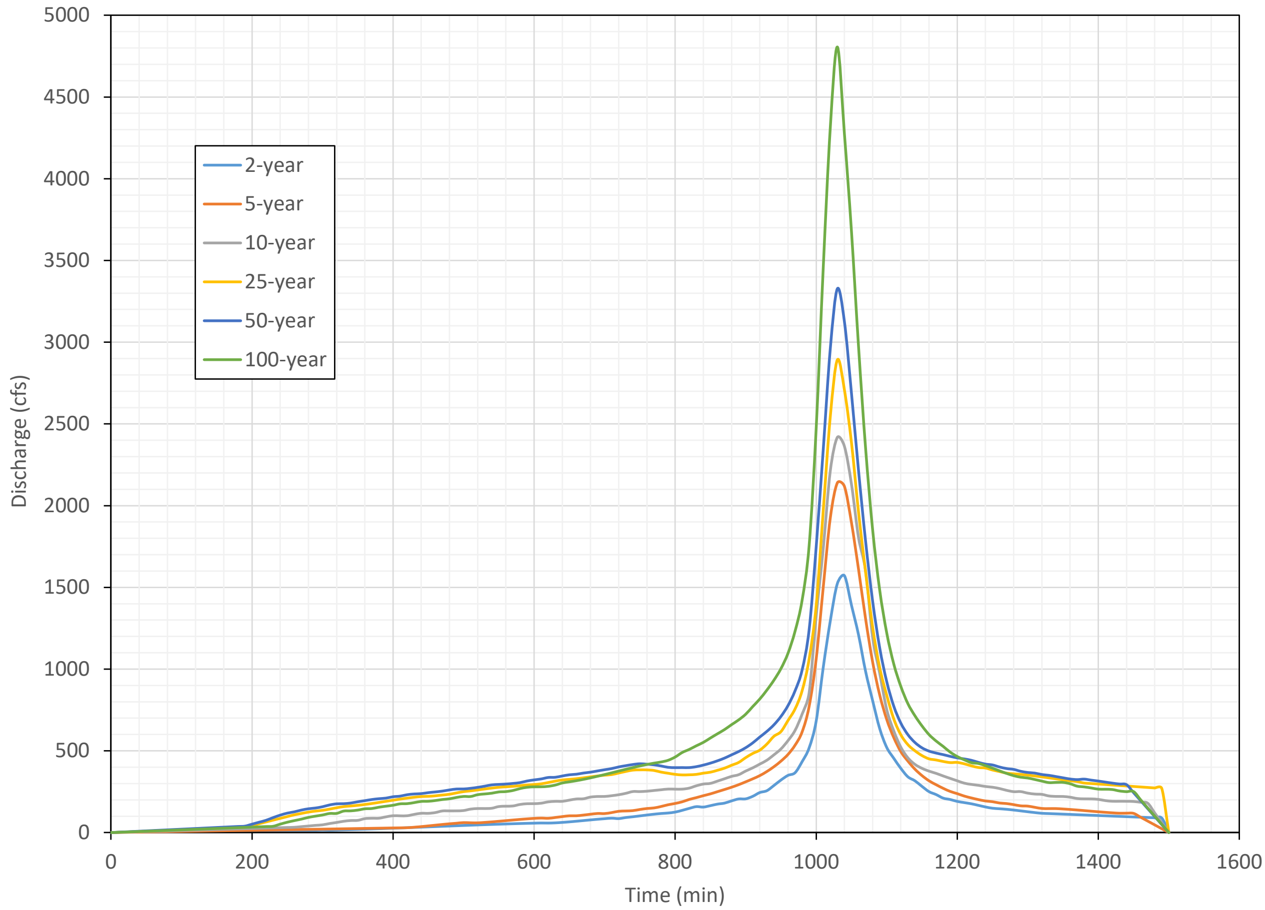


Table 3. Smuggler's Gulch Peak Discharges

Return interval	Peak discharge (cubic feet per second)
2-year	1,572
5-year	2,140
10-year	2,418
25-year	2,892
50-year	3,327
100-year	4,806

Source: University of California, Irvine (2017)

Figure 9. Smuggler's Gulch Hydrographs



Source: University of California, Irvine (2017)

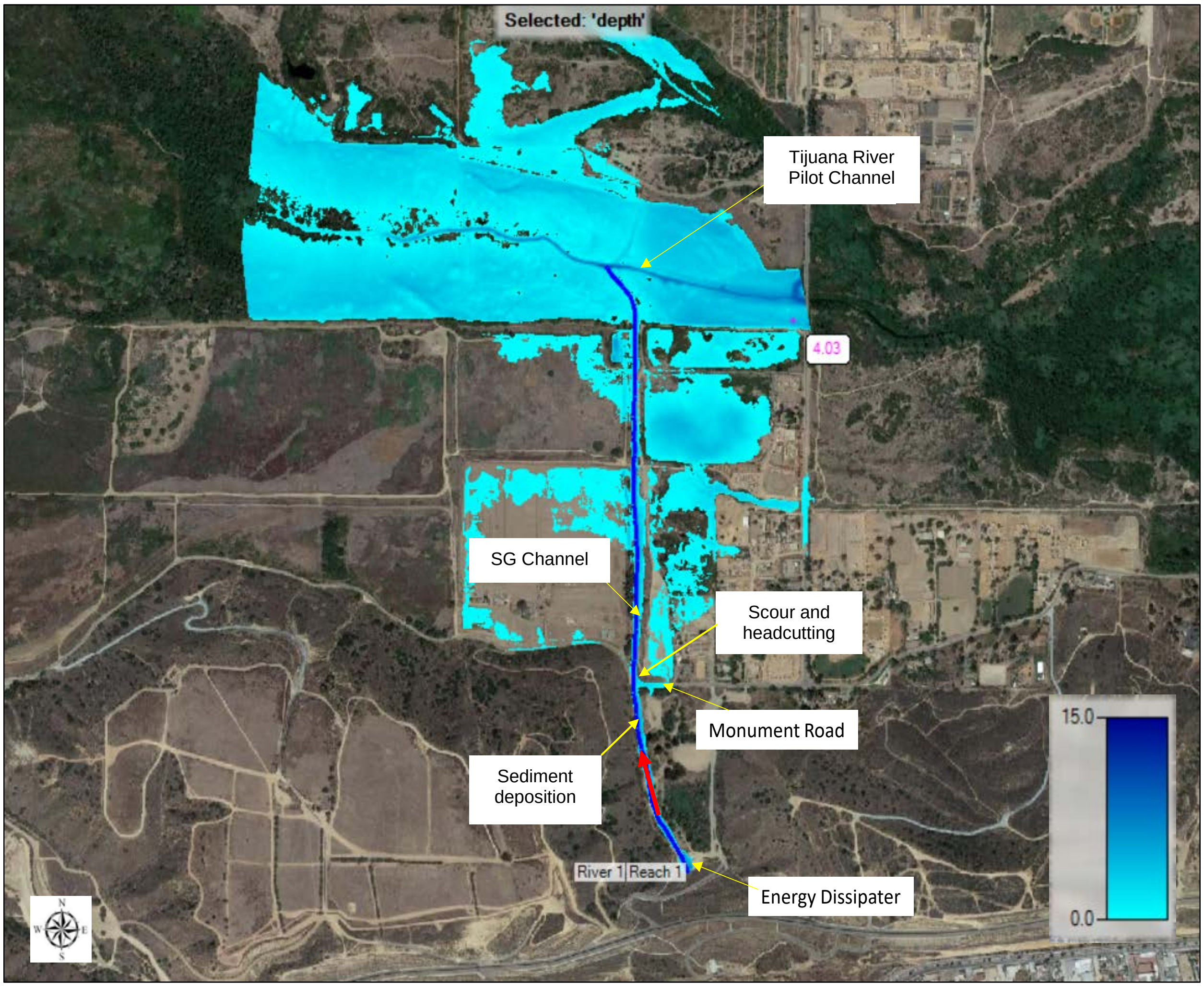
Flows are generally confined within the Smuggler's Gulch canyon north of the U.S.-Mexico border (Figure 10). Shortly after passing Monument Road and culvert, flows reach the historic alluvial plain of the Tijuana River Valley and are able to spread out to some extent. The low flow of Smuggler's Gulch in this area is carried by an excavated ditch (Figure 10, Smuggler's Gulch Channel), running from north of Monument Road to the confluence with the south fork of the Tijuana River. The gulch is prone to heavy sedimentation from eroded dirt roads and steep slopes in the upper watershed, and excessive trash deposition. As part of this study, a field reconnaissance of the area was conducted in January 2019. The representative photos from the field visit are shown on Figure 10 to illustrate existing channel conditions and sedimentation/erosion issues. The City of San Diego maintains the Smuggler's Gulch Channel and Tijuana River Pilot Channel (Figure 10), while the County of San Diego maintains the reach south of Monument Road.

Figure 10. Smuggler's Gulch Field Photos

Downstream of the entrance gate and culvert under the border (Figure 10, images a and b), localized sediment deposition occurs that is attributable to a sudden flow expansion in the concrete-lined energy dissipater and diversion structure (location of energy dissipater is shown in Figure 10, image b) and a scour hole formed downstream at the end sill (concrete slab at the end of the dissipater). Localized bank erosion was also observed in this area. Continuous sediment accumulation (up to approximately 10 feet) occurs in the County reach south of Monument Road (Figure 10, image c, and Figure 11). North of the road (Figure 10, image d, and Figure 11), a scour hole with approximately 7 feet of headcutting is present directly downstream of the road crossing. At the time of the field visit, the existing 52-inch corrugated metal pipe (CMP) under Monument Road was completely filled with sediment, therefore, future storm flows will overtop the road until the pipe is cleaned.

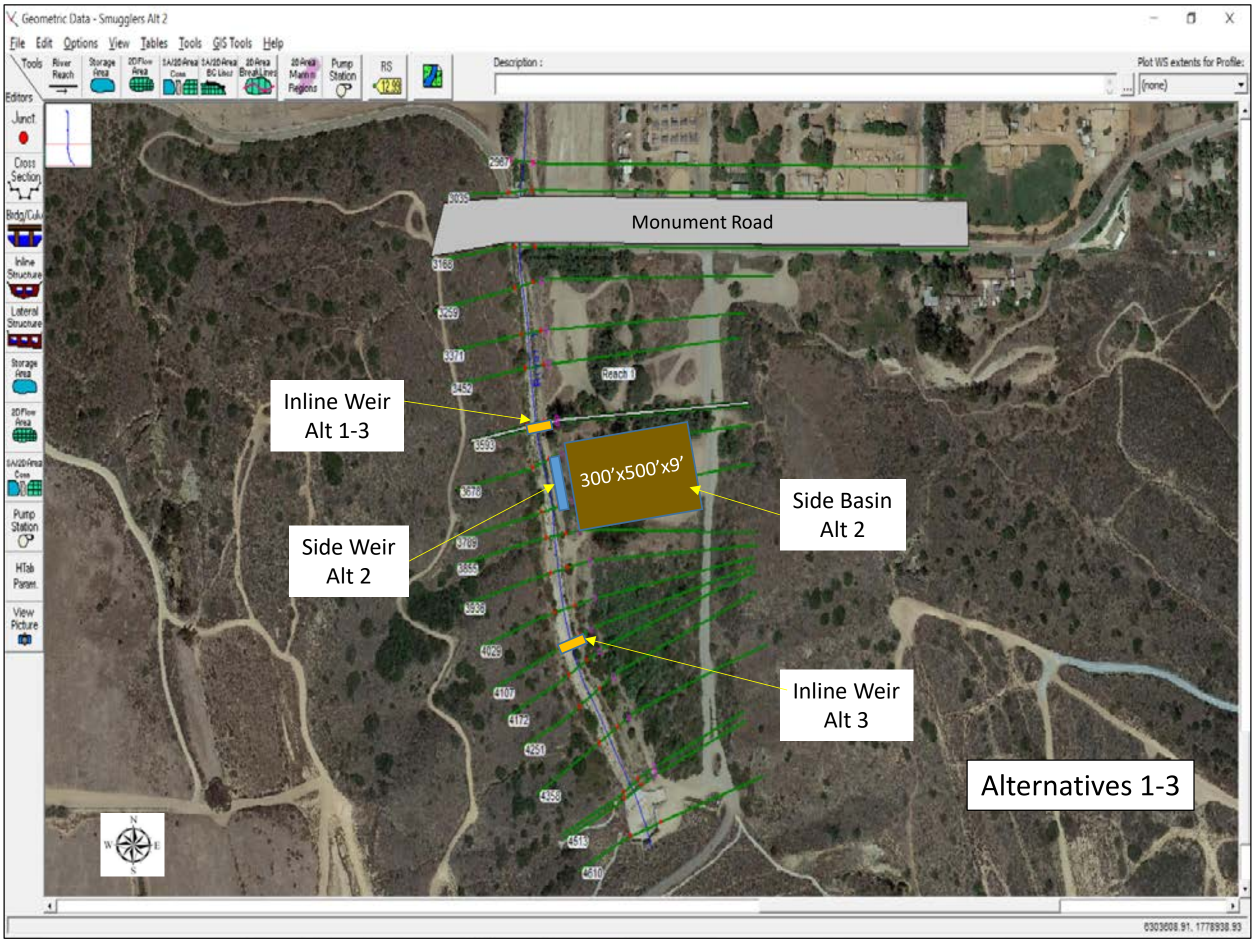
To support the assessment of sediment and trash strategies for Smuggler's Gulch, a preliminary 2D hydraulic model (HEC-RAS 5.0.6) was developed based on the USACE 2015 LiDAR data. The 5-year floodplain, which represents the relatively frequent flows that dominate sediment transport is shown in Figure 11 (it does not include the Tijuana River inflow). The model shows that the flow is contained within the main channel south of Monument Road. It overtops the road and splits into three branches (east overbank, west overbank, and north pilot channel) that eventually merge with the Tijuana River. It is desirable to keep the flow and sediments/trash contained within the main channel (up to at least 5-year flood frequency), which would require increasing the capacity of the existing CMP and elevating the road across the gulch.

Figure 11. Smuggler's Gulch 5-year Floodplain



To analyze conceptual sediment retention alternatives in Smuggler's Gulch, a preliminary 1D hydraulic and sediment transport model (HEC-RAS 5.0.6) was developed from the border to about 500 feet downstream of Monument Road (Figure 12). The grain size gradation was adopted from previous reports (URS 2009), indicating a representative median grain size of 0.26 mm (Table 2). The inflowing sediment load rating curve for Smuggler's Gulch (Figure 2) was developed, as discussed in Section 3.1. The selected sediment transport function was Engelund-Hansen, as recommended by previous sedimentation studies in the region (Chang Consultants 2007).

Figure 12. Smuggler's Gulch HEC-RAS Model Schematic



4.2.1 Projects

Three sediment basin alternatives and Monument Road improvements were considered in this preliminary phase. Alternative 1 consists of a 10-foot-high inline weir (similar to a check dam) located about 400 feet upstream of Monument Road (Figure 12). The weir would retain sediment by creating backwater effects (i.e. a detention pond) while allowing dry-weather flows through a bottom outlet. Large flows would overtop the weir; therefore, the channel bottom and banks would need to be protected from scour/erosion for some distance downstream of the weir. Alternative 1 also incorporates two 8-foot-diameter reinforced concrete pipes under Monument Road, which would require raising the road by 3 feet to provide adequate cover. This alternative would require raising the road by at least 6 feet to prevent road overtopping for the 2-year flood frequency. Downstream of Monument Road, the scour hole observed in the field would need to be stabilized and headcutting prevented by a hard revetment and/or cutoff wall.

Alternative 2 builds on Alternative 1 by proposing the addition of a 100-foot-long side weir (through a notched section in the right overbank berm) upstream of the Alternative 1 inline weir to divert additional flows and sediments into an offline basin (Figure 12). The offline basin would capture primarily fine sediments (finer than medium sand, which binds most of the contaminants) and would additionally reduce potential Monument Road overtopping and uncontrolled sediment deposition on the Smuggler's Gulch floodplain downstream of the road. The basin would be approximately 300 feet long and 500 feet wide, surrounded by a 9-foot-high embankment to store the diverted flow with fine sediments. Alternative 2 considers a 16-foot by 8-foot Conspan Arch bridge for Monument Road (to replace the existing 52-inch CMP) along with raising the road by 3 feet. The Conspan Arch in this alternative would have the capacity to convey the 2-year flow without overtopping the road and provides the least flow overtopping among all three proposed alternatives (for all flood events).

Alternative 3 is a modification of Alternative 1. It proposes to replace the 10-foot-high inline weir from Alternative 1 with two 6-foot-high inline weirs that are 500 feet apart (Figure 12; first inline weir is at the same location as in Alternatives 1 and 2, while the second one is 500 feet upstream). Alternative 3 essentially creates two sediment basins in sequence, with less backwater surcharge (over the weirs) compared with Alternative 1. However, this configuration would not allow for additional flow/sediment diversion into an offline basin since the maximum water surface profile in Alternative 3 is lower than the side weir elevation. In all the alternatives, trash would be collected by trash booms (floating debris barrier systems) located upstream of the weirs.

The computed hydraulic profiles for all the alternatives (for the 2- and 100-year flood events) are shown in Appendix A. The sediment transport results were developed for a range of flood frequencies and are summarized in Table 4.

Table 4. Smuggler's Gulch Sediment Transport Results

5-year flood event								
Alternative	**Sediment Load (tons)**	**Sediment Retained (tons)(1)**	**Sand Diverted (tons)(2)**	**Flow Volume Diverted (yd^3)(2)**	**Sediment Retained+Diverted (yd^3)(1)(2)**	**Trap Efficiency (%)(1)**	**Downstream Scour (ft)(3)**	**Maximum Overtopping Depth (ft)(4)**
Existing	25728	7991	0	0	6961	31	3.5	3.0
Existing Dredged	25728	12542	0	0	10924	49	6.1	4.2
Alternative 1	25728	15575	0	0	13566	61	7.3	1.8
Alternative 2	25728	15254	801	31122	13984	62	6.9	0.7
Alternative 3	25728	14312	0	0	12466	56	6.5	1.4

25-year flood event								
Alternative	**Sediment Load (tons)**	**Sediment Retained (tons)(1)**	**Sand Diverted (tons)(2)**	**Flow Volume Diverted (yd^3)(2)**	**Sediment Retained+Diverted (yd^3)(1)(2)**	**Trap Efficiency (%)(1)**	**Downstream Scour (ft)(3)**	**Maximum Overtopping Depth (ft)(4)**
Existing	48313	16935	0	0	14750	35	5.6	4.0
Existing Dredged	48313	23033	0	0	20062	48	7.9	5.1
Alternative 1	48313	28083	0	0	24461	58	8.7	2.9
Alternative 2	48313	27885	2062	52580	26085	62	8.6	1.5
Alternative 3	48313	24689	0	0	21504	51	8.2	2.5

100-year flood event								
Alternative	**Sediment Load (tons)**	**Sediment Retained (tons)(1)**	**Sand Diverted (tons)(2)**	**Flow Volume Diverted (yd^3)(2)**	**Sediment Retained+Diverted (yd^3)(1)(2)**	**Trap Efficiency (%)(1)**	**Downstream Scour (ft)(3)**	**Maximum Overtopping Depth (ft)(4)**
Existing	114311	47788	0	0	41623	42	6.3	6.1
Existing Dredged	114311	50717	0	0	44174	44	9.1	7.0
Alternative 1	114311	59057	0	0	51438	52	9.5	5.1
Alternative 2	114311	57829	7356	119689	56776	57	9.4	3.4
Alternative 3	114311	54236	0	0	47240	47	9.2	4.8

(1) south of Monument Road at RS 3168 based on bulked density of 85 pounds per cubic foot
(2) diverted over side weir at LS 3700
(3) north of Monument Road at RS 2632
(4) Monument Road at RS 3168; existing road elevation is 40 feet; proposed road elevation is 43 feet (Alternatives 1–3)

The analyses also included the existing channel configuration (with plugged CMP under Monument Road) and existing dredged conditions (when the gulch is dredged about 10 feet below the existing invert upstream of Monument Road). All the proposed alternatives are based on the dredged conditions. Simulated bed elevations (thalweg profiles) with the 5-year hydrograph are shown in Appendix B.

Based on the sediment transport results in Table 4, Alternative 1 would retain about 60 percent of the incoming sediment load (mostly coarser bed load), which is almost twice the amount captured in existing (undredged) conditions. Alternative 2 would trap between 3 and 10 percent more sediment than Alternative 1 (see Sediment Retained + Diverted in Table 4), particularly retaining finer (suspended) sand in the offline basin (800 to 7,000 tons between the 5- and 100-year flood events, respectively). Furthermore, Alternative 2 lowers the Monument Road overtopping by a foot (compared with Alternative 1), additionally reducing potentially contaminated sediment deposition on the Smuggler's Gulch floodplain north of the road. Alternative 3 has the lowest sediment trapping efficiency. All the alternatives exhibit a similar scouring trend immediately downstream of Monument Road, slightly increased with respect to existing dredged conditions. This area will need to be properly protected from the observed (and simulated) upstream headcutting and bank erosion.

Table 4 indicates that the total amount of trapped sediments under both existing channel conditions ranges from 7,000 to 11,000 CY (see Sediment Retained + Diverted in Table 4) for the 5-year storm event (which is representative of mean annual sediment transport). These results are well within the range of Smuggler's Gulch dredging amounts south of Monument Road, as reported by the County of San Diego in Table 5 (2,500 to 11,500 CY/year). Note that the 5-year trapped amounts for Alternatives 1 through 3 (12,500 to 14,000 CY) are lower than the Goat Canyon sediment basin cleanouts (15,000 to 60,000 CY/year in Table 5) reported by California State Parks since the proposed Smuggler's Gulch basin footprints are proportionally smaller than those on Goat Canyon.

In the early 1990s, the City of San Diego excavated an earthen channel, known as the Tijuana River Pilot Channel (Figure 4), to direct larger storm flows away from the northern portion of the valley, where flooding has resulted in significant damage to public and private property. Since then, the City frequently clears the Tijuana River Pilot Channel and Smuggler's Gulch Channel north of Monument Road to reduce flood risk. Each channel clearing results in the removal of 200 to 30,000 CY of sediment, trash, and waste tires (see Table 5).

Table 5. Historical Sediment Excavation

Stakeholder	Project Name/Location	Year(s)	Sediment Excavated (cy)	Total Excavation (cy)	Scope of Work	Disposition	Approximate Cost
City of San Diego	Pilot Channel and Smuggler's Gulch (North of Monument Road) Maintenance	1999	27,000	158,256			
		2000	193				
		2001	15,900				
		2002	1,000				
		2003	8,700				
		2005	30,000				
		2008	600				
		2009-2010	30,000		Excavate, place in stockpile,	Miramar Class III Landfill	$3,000,000
		2013-2014	19,863		Excavate, place in stockpile	Miramar Class III Landfill	$2,000,000
		2015	25,000		Excavate, place in stockpile,		
California State Parks	Goat Canyon Sediment Basin Cleanout	Winter 2005	55,000	406,000	Excavate, transport and dispose	Class III Landfill	$1,100,000
		Fall 2005	35,000		Excavate and transport to pad.	None	$37,500
		2006	25,000		Excavate and transport to pad.	None	$54,000
		2007	25,000		Excavate and transport to pad.	None	$67,500
		2008	40,000		Excavate and transport to pad.	60,000 cy for beach	$1,000,000
		2009	60,000		Excavate and tranport to pad.	Off site	$2,500,000
		2010	55,000		Excavate and transport to pad.	None, off site	$239,500
		2011	51,000		Excavate and transport to pad	None	$380,000
		2012	45,000		Excavate and transport to pad.	None	$800,000
		2013	15,000		Excavate and transport to pad	Off site	$310,000
		2014	35,000		Transport 40,000 cy off-site.	Off site	$860,000
		2015	20,000		Excavate and transport to pad	Off site construction porject in	$900,000
County of San Diego	Smuggler's Gulch South of Monument Road	2002	5,000	83,550	Excavate due to 2003 floods.	Gravel used as aggregate.	$25,000
		2004	12,000		2005 FEMA floods. Dredged	Gravel used as aggregate.	$67,200
		2005-06	23,450		Excavate from Monument Road	Gravel used as aggregate.	$182,000
		2009-2010	16,100		Excavate from Monument Road	Gravel used as aggregate.	$80,000
		2010-2011	12,000		Excavate from Monument Road	Gravel used as aggregate.	$123,000
		2011-2012	7,000			Gravel used as aggregate.	$76,000
		2012-2013	0				$0
		2013-2014	0		Excavate pilot channel 1/4 mile		$0
		2015-2016	8000		Excavate from Monument Road		$170,000

Source: Excerpted from AECOM (2016)

The Tijuana River Pilot Channel and the Smuggler's Gulch Channel north of Monument Road are designed to work in tandem. In order for the Smuggler's Gulch Channel to effectively outlet into the Tijuana River Pilot Channel and consequently the Tijuana River Valley, both channels need to be maintained simultaneously. If only the Smuggler's Gulch Channel is maintained, and not the Tijuana River Pilot Channel, conveyance through the Smuggler's Gulch Channel would be reduced, causing sediment to accumulate in the channel, negating the original maintenance. The sedimentation basins south of Monument Road would decrease the amount of deposition in the downstream Smuggler's Gulch Channel and improve its hydraulic performance, with a less frequent need for Tijuana River Pilot Channel maintenance.

4.2.2 Cost

A planning estimate with a rough approximation of cost for each proposed alternative south of Monument Road is included in Table 6.

Table 6. Smuggler's Gulch Proposed Alternative Cost Estimates

Alternative	Implementation cost	Ongoing cost
Alternative 1	$2.0 million	$1 million
Alternative 2	$4.8 million	$1 million
Alternative 3	$2.6 million	$1 million

Alternative 2 has the highest construction cost, but it provides the best flood control and sediment trapping efficiency, preventing the Monument Road overtopping (up to a 5-year flood level) and uncontrolled sediment/contaminant release into the Tijuana River Valley. Alternative 3 provides less benefit for a greater cost than Alternative 1, so would not be considered as a preferred alternative.

The City of San Diego reported the annual maintenance costs for the Tijuana River Pilot Channel and Smuggler's Gulch Channel north of Monument Road as being between $2 million and $3 million, with sediments being transported to a local landfill (AECOM 2016).

4.3 Goat Canyon

Goat Canyon (Cañón de los Laureles) is a tributary that begins in Tijuana and ends just north of the U.S.-Mexico border, with a watershed area of 2,941 acres (4.59 square miles). The canyon is formed by Goat Canyon Creek, which receives water and other runoff from areas south of the border (Figure 8). The majority of the canyon and its watershed is located in Baja California, Mexico. Two sedimentation basins were constructed at the mouth of the canyon in 2005 to address significant amounts of material originating from south of the border that ended up in the Tijuana River Estuary, leading to considerable loss of habitat (AMEC 2008).

Rick Engineering (2003) performed hydraulic modeling for proposed sedimentation basins and evaluated sedimentation impacts through numerical simulations. This work was prepared for the Southwest Wetland Interpretive Association. Hydraulics for the proposed inline sedimentation basins at the mouth of Goat Canyon were assessed using HEC-2 for water surfaces within the basins and using HEC-RAS for the hydraulic jumps downstream of proposed weir structures. The sedimentation model FLUVIAL-12 (Chang 1998) was used to estimate sediment volumes and trapping efficiency of the basins. Watershed-wide annual sediment yield estimates were not developed or reported in the study, but the report describes the inflowing sediment load for the 100-year flood event as 115,000 tons, or 85,185 CY (using a bulk density of 100 pounds per cubic foot). For a 4.6-square-mile drainage basin, the estimated sediment load is 25,000 tons/square mile. This report also presents the findings of the Danish Hydraulic Institute (DHI), which conducted an independent MIKE-11 hydrodynamic modeling of the 100-year sediment transport capacity and trapping efficiency of the basins to compare with the FLUVIAL-12 results. The DHI used a sediment transport equation developed by Philip Williams and Associates in 2001 as the sediment input boundary condition. The DHI's MIKE-11 results corroborated the FLUVIAL-12 results.

Following construction of the Goat Canyon sedimentation basins, at least two sediment studies were conducted to characterize the deposited material in the basins (AMEC 2007; Nautilus 2008). The results of the two studies on Goat Canyon sediments are summarized in Table 7. The term "fines" in the table represents silt and clay particles, generally smaller in diameter than 0.0625 mm.

Table 7. Grain Size Distribution – Goat Canyon Studies

Study	Soil Sampling Area	Number of Samples	Percentage Sand	Percentage Fines	Average Median Grain Size (mm)
AMEC 2007	Upper basin	5	53.7	46.3	0.079
	Lower basin	3	60.2	39.8	0.092
Nautilus 2008	Upper basin	4	53.8	39.5	0.092
	Lower basin	4	50.5	49.5	0.090

Note: mm = millimeter

4.3.1 Projects

The final design and engineering plans were prepared for the existing Goat Canyon Enhancement Project in 2001. In 2005, California State Parks constructed a concrete bottom inline diversion structure (Figure 13) that transitions into a flow-through sedimentation basin system (upper and lower basins). The sediment basins contain two trash booms intended to capture solid waste during storm events.

The designed sediment basins allow flow to spread out in a wider area and, in conjunction with the backwater effects of the basin weirs, reduce velocities for flows up to and including the design 100-year event. Numerical sediment transport modeling reported by Rick Engineering (2003) indicated a combined 97 percent trapping efficiency for the Goat Canyon basins.

The two basins combined are approximately 19 acres in size and can hold approximately 50,000 to 80,000 CY of material. In over a decade, California State Parks has excavated a total of 514,000 CY of sediment—enough to cover 80 percent of the estuary's salt marsh habitat (318 acres) with a 1-foot sediment layer. Overall, the trash booms have stopped approximately 2 million pounds of debris from entering the Tijuana River Estuary (Tijuana River National Estuarine Research Reserve 2005).

Although this is an existing project, the ongoing management of the captured sediment and trash is still a major problem. Development and implementation of a sediment and trash management plan is needed and is discussed further in Section 4.5.1.

Figure 13. Goat Canyon Sedimentation Basins

4.3.2 Cost

The implementation cost of the Goat Canyon Enhancement Project was estimated at $5 million in 2001. California State Parks maintains the sedimentation basins, with a reported annual maintenance cost on the order of $1 million (maximum $2.5 million) depending on the sediment disposal option (AECOM 2016).

4.4 Yogurt Canyon

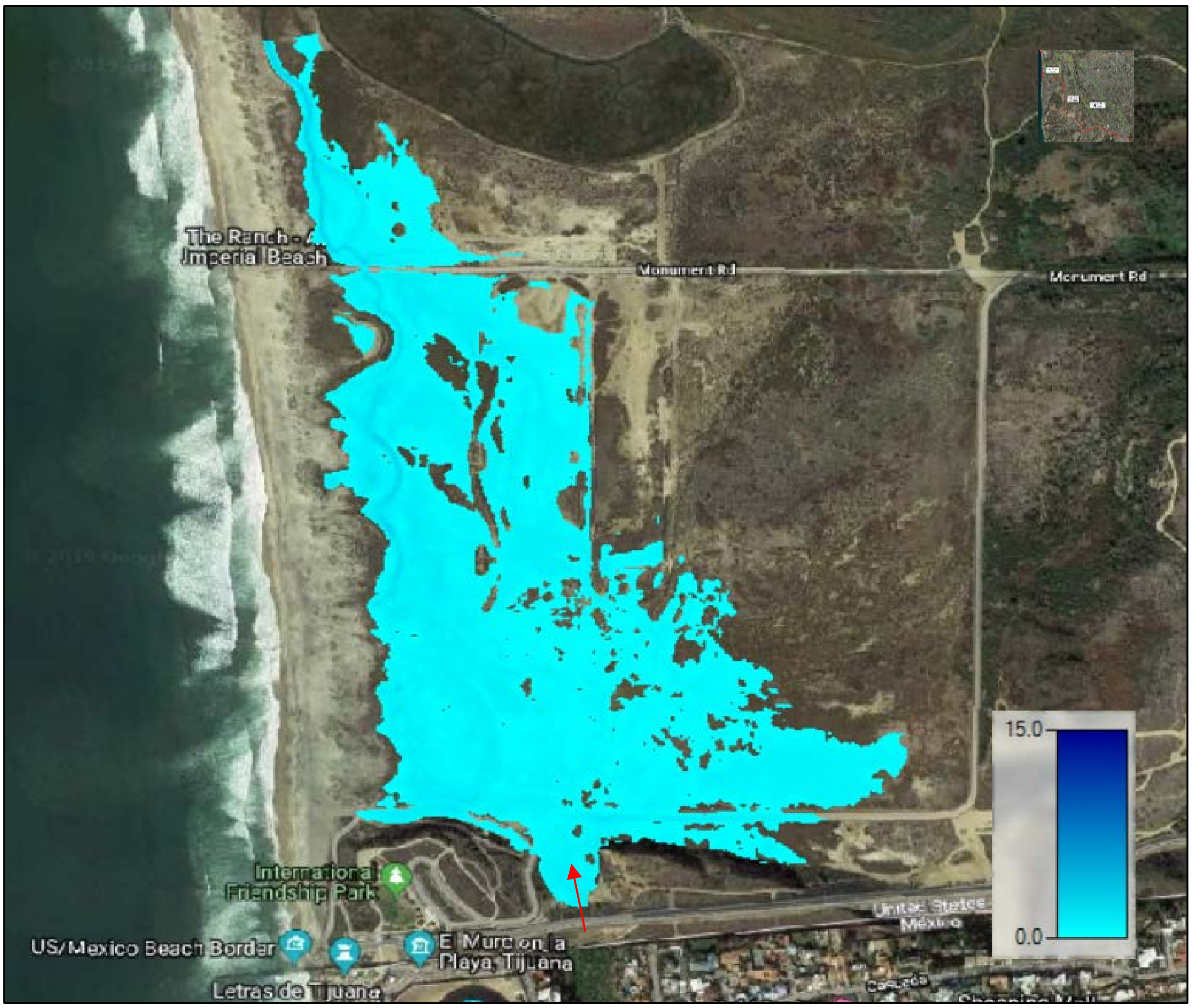
Yogurt Canyon (Cañon Los Sauces) is the smallest of the three tributary canyons, with a watershed area of 415 acres that discharges directly to the estuary (Figure 8). The peak flows (Table 8) and hydrographs for Yogurt Canyon were scaled down from the Smuggler's Gulch values in proportion to their watershed areas.

A preliminary 2D hydraulic model (HEC-RAS 5.0.6) of Yogurt Canyon was developed based on the USACE 2015 LiDAR data. The 5-year floodplain is shown in Figure 14 (it does not include the Tijuana River inflow). The sheet flow and carried sediments regularly impact access on Monument Road and can potentially spread out over the entire floodplain, all the way to the estuary, with maximum flow depths generally below 1 foot. There is a need to ensure that sediment and flood flows can be conveyed unimpeded into the estuary where they can interact with the tidal flushing. Sediment basin alternatives were not considered for this tributary given the relatively small size of its contributing watershed (see Figure 8), which does not generate large sediment load. This was confirmed during the field visit, where no signs of significant sediment deposition were observed.

Table 8. Yogurt Canyon Peak Discharges

Return interval	Peak discharge (cubic feet per second)
2-year	173
5-year	236
10-year	266
25-year	318
50-year	366
100-year	529

Figure 14. Yogurt Canyon 5-year Floodplain



4.4.1 Projects

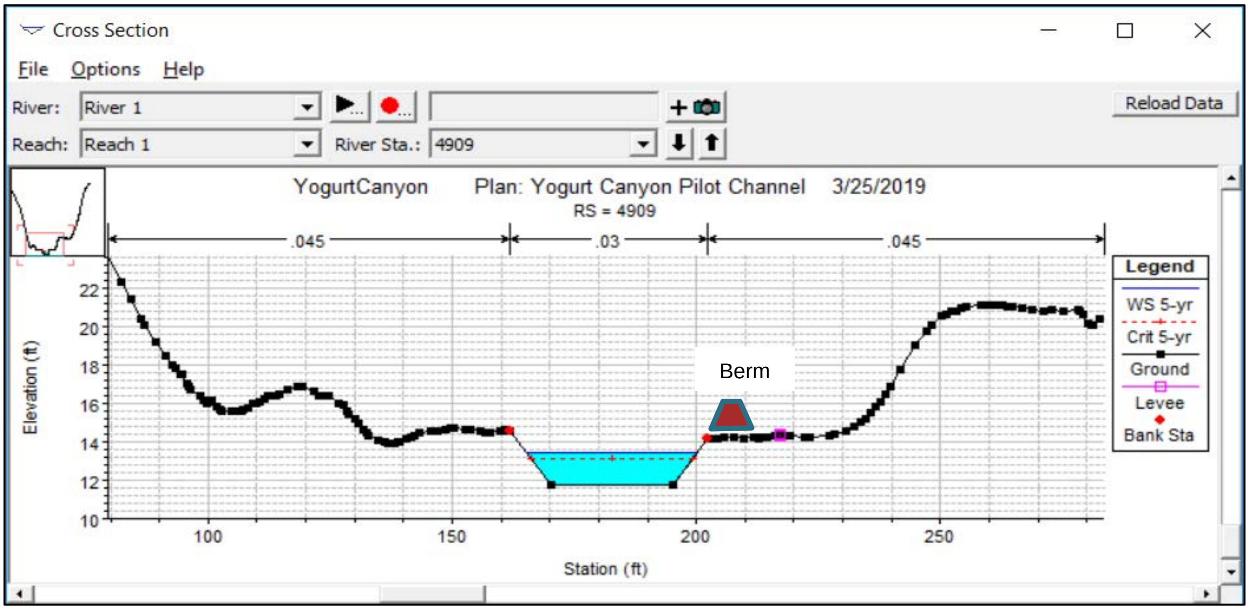
A 25-foot wide pilot channel (shown in Figure 15) was considered to convey Yogurt Canyon flows and sediments up to a 5-year flood frequency. The channel would cross Monument Road 350 feet north of the border and turn northwest toward the beach. The crossing would be a clear span bridge with a capacity to convey the 5-year flood with sediments.

Figure 15. Yogurt Canyon HEC-RAS Model Schematic

The 5-year flow would be completely contained in the pilot channel south of Monument Road. The flow has the potential to break out of the channel north of the road and would need to be confined by a 900-foot long, 3-foot high berm on the right (eastern) side (see Figures 15 and 16).

A preliminary sediment transport model of the pilot channel was developed using the same sediment load curve and sediment gradation data as those of Smuggler's Gulch (assuming conservatively high sediment concentrations and similar sediment composition originating from eroded steep slopes and unpaved roads in the upper watershed). It shows that the channel is capable of transporting both the 5- and 100-year sediment loads without much accumulation or scour. The hydraulic profiles of Yogurt Canyon are shown in Appendix A. Simulated bed elevations (thalweg profiles) with the 5-year hydrograph are shown in Appendix B.

Figure 16. Yogurt Canyon Pilot Channel



4.4.2 Cost

A planning estimate with a rough approximation of cost for the proposed alternative is included in Table 9. This estimate does not include costs for environmental review and permitting.

Table 9. Yogurt Canyon Proposed Alternative Cost Estimate

Alternative	Implementation cost	Ongoing cost
Pilot Channel	$5,000,000	$5,000

4.5 Sediment Management Projects

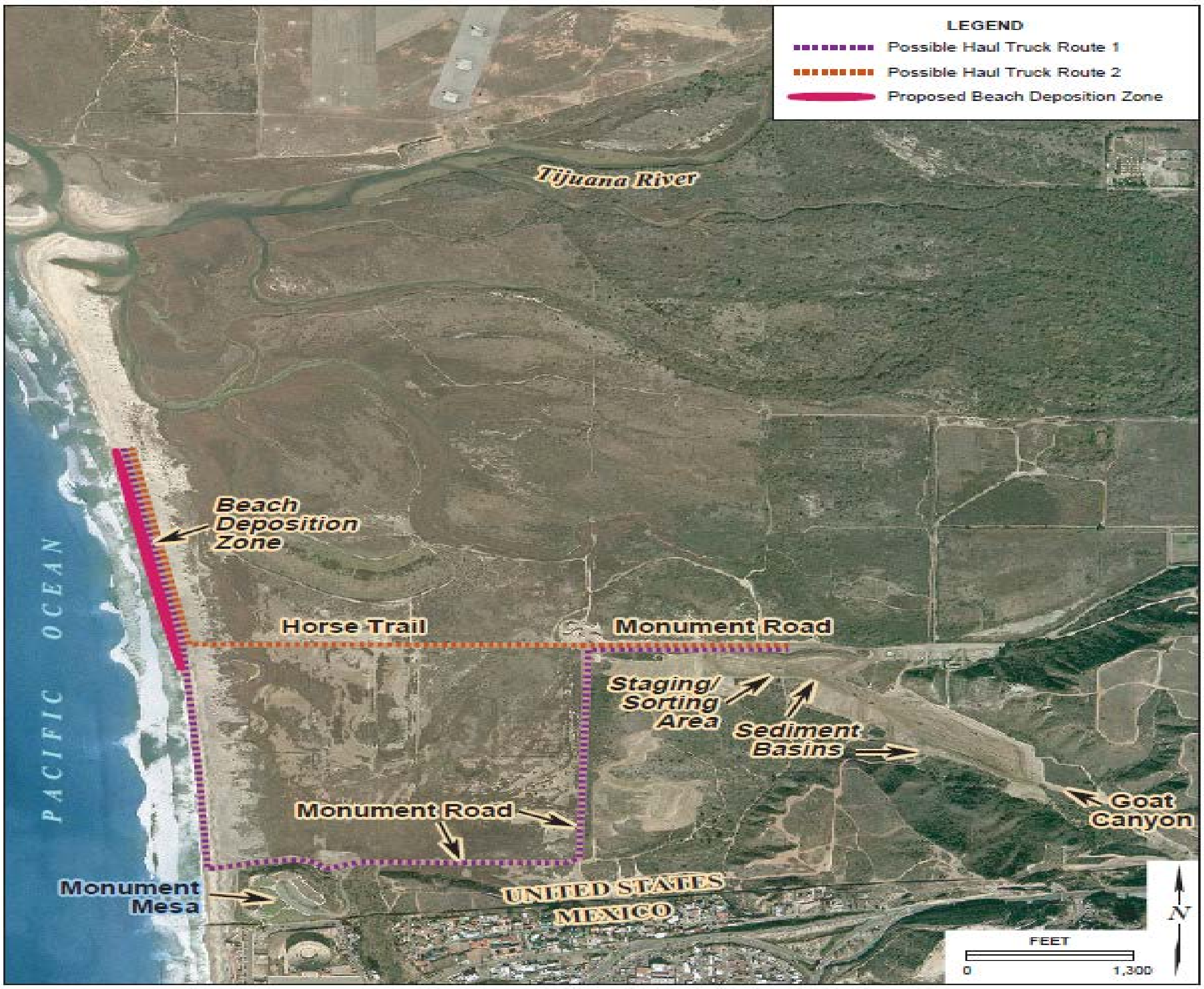
The proposed and already constructed sediment basins in the Tijuana River, Goat Canyon, and Smuggler's Gulch are designed to intercept high volumes of contaminated sediments and trash, inevitably interrupting the natural process of sand transport, which historically has brought sand to the beachfront of Imperial Beach. Therefore, concerns have been raised about the adequacy of sand capture basins with respect to beneficial sediment management in the Tijuana River Valley. These concerns can be addressed by appropriate sediment management techniques as discussed in the following sections.

4.5.1 Goat Canyon Sediment Management Project

The California Department of Parks and Recreation, in partnership with the California State Coastal Conservancy, the California Coastal Sediment Management Workgroup, the Tijuana River National Estuarine Research Reserve, and the Southwest Wetlands Interpretive Association, has proposed implementing a Sediment Fate and Transport Study (Science Study) primarily within Border Field State Park at the Tijuana River

National Estuarine Research Reserve (AMEC 2008). The proposed project would use sorted sediment obtained from the constructed Goat Canyon sediment basins and would include transportation and deposition of this sediment to designated areas on the beach south of the Tijuana River mouth (Figure 17). Sediment would be sorted at an existing staging area and transported from the sediment basins in Goat Canyon to the beach approximately 0.5 mile south of the Tijuana River mouth via haul truck along Monument Road and/or a dirt road that serves as a horse trail (horse trail road). Dispersion of the placed materials in the oceanic environment would then be monitored by the U.S. Geological Survey to determine whether any adverse impacts would arise from the use of the sorted sediments.

Figure 17. Goat Canyon Sediment Management Plan



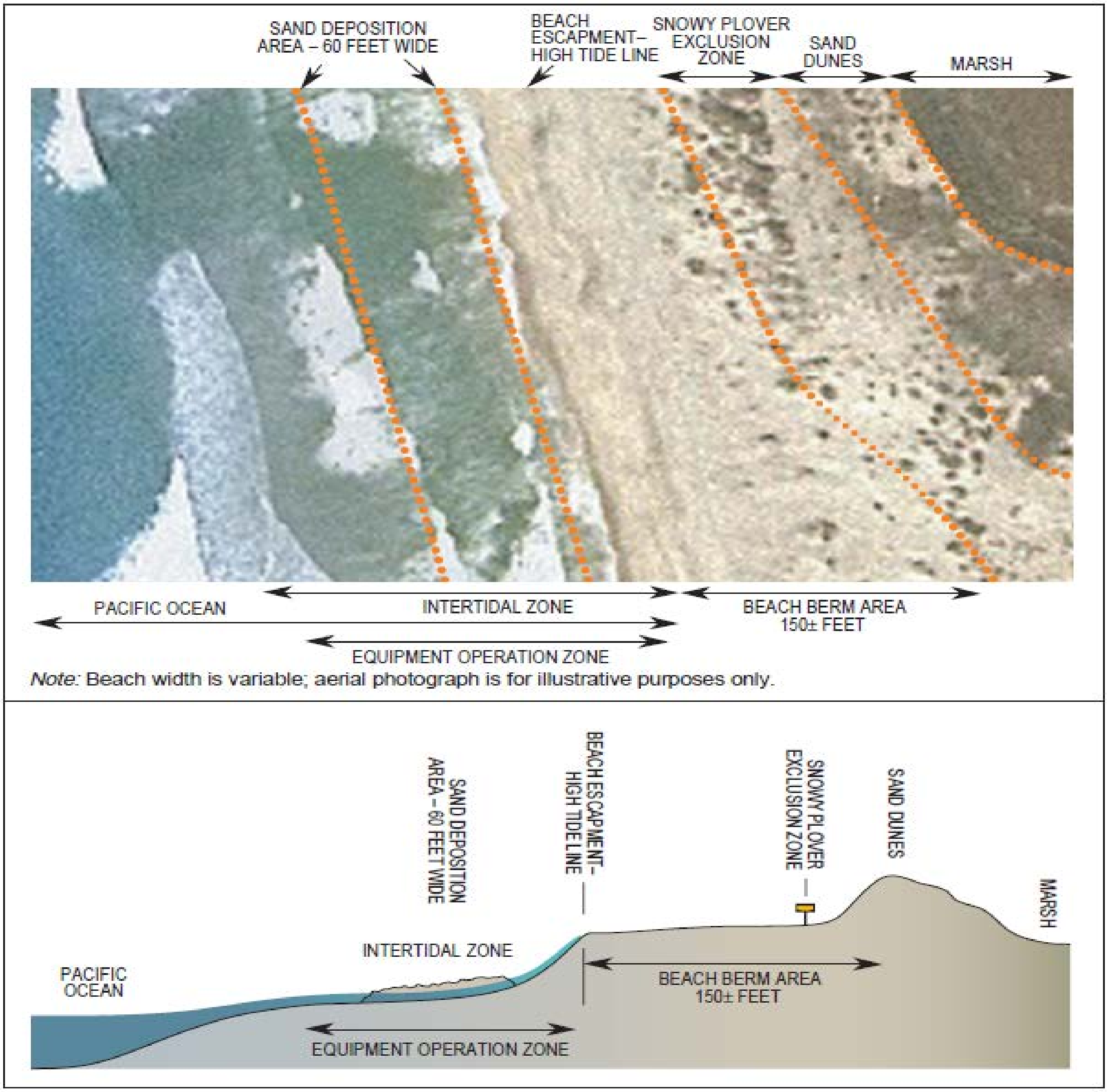
Source: Excerpted from AMEC (2008)

The proposed sediment management project would include the transportation and deposition of approximately 60,000 CY of sorted sediment from the Goat Canyon basins along a 2,600-foot long segment of beach located approximately 3,000 feet north of the international border and approximately 2,600 feet south of the Tijuana River mouth (Figure 17). Sediment was projected to contain a grain size distribution of approximately

60 percent sand and 40 percent fines, based on initial sediment analysis (AMEC 2007). Sediment transportation and deposition would occur in three separate phases, which were proposed to require approximately 3 to 4 consecutive months (October through February). Phases 1 and 2 would each transport and deposit approximately 10,000 CY of sediment; Phase 3 would transport and deposit approximately 40,000 CY of sediment. The lower volumes of sediment proposed for Phases 1 and 2 would allow for establishment and verification of coastal processes and pathways prior to the larger volume of sediment placement proposed for Phase 3. Trash (for example, plastics) and other unwanted materials (for example, cobbles) would be removed from the sediment at the staging/sorting area. Once the sediment has been fully prepared for beach deposition, it would be loaded into trucks or scrapers and transported directly from the staging area to the beach deposition area. The project would also include testing of sediment for grain size and to ensure, through screening, that sediment does not contain contaminants such as fecal coliform bacteria, heavy metals, petroleum distillates, or other hazardous substances and debris.

The proposed project would use sediment that is already excavated from the Goat Canyon basins and sorted at the existing staging/sorting area under existing permits. Once excavated from the sediment basins and transported to the staging area, the sediment would be prepared for transportation to the beach through a sorting and aerating process. Once the aeration process is complete, the sediment would be ready for transportation and deposition on the beach. The sediment was proposed to be deposited below the beach berm, below the high-water mark, generally below the beach escarpment that marks the maximum height reached by a rising tide (Figure 18). Haul trucks were anticipated to “rear dump” to deposit sediment. The sediment would then be bulldozed into a mound on the exposed lower beach and carried by front-end loader toward the water during times of extreme low tide, if needed. The sediment would be placed in a low-lying linear mound, positioned below the mean high tide line stretching along the beach with a height of approximately 1 to 2 yards. Placement below the mean high tide line allows the waves to reach it and immediately start working on distributing the sediment along the nearshore profile with the rising tide. The following day, the mound would be reduced from the wave action and additional sediment could be added to the same area and/or further along the beach. The maximum working beach area length would be approximately 2,600 feet, which allows for sufficient area to construct a deposition mound over a series of days, while protecting the nearby sensitive biological beach habitats.

Figure 18. Proposed Deposited Sand Beach Work Zone



Source: Excerpted from AMEC (2008)

Similar sediment management concepts can be developed for the proposed Smuggler's Gulch basins to replenish beach sand and restore the intercepted flow of sediment that could protect coastal homes. The following options proposed by Stantec (2019) should also be considered:

- **Local integrated sediment and trash processing site** – Establish a joint sediment and trash management location for the sediment captured from the proposed basins and from the Goat Canyon sediment basins, and other excavation activities elsewhere in the Tijuana River Valley. This would result in a centralized cost-efficient processing of excavated material.

- **Nearshore sediment reuse/beach replenishment project** – Continue placing sediment on the beach adjacent to Border Field State Park and the Tijuana River National Estuarine Research Reserve. Sediment may also be placed in the nearshore environment through an agreement with the City of Imperial Beach and in accordance with the Sand Compatibility and Opportunistic Use Program Plan (Moffatt & Nichol 2006). This would result in cost-efficient reuse and environmentally beneficial placement of captured sediment for beach replenishment.

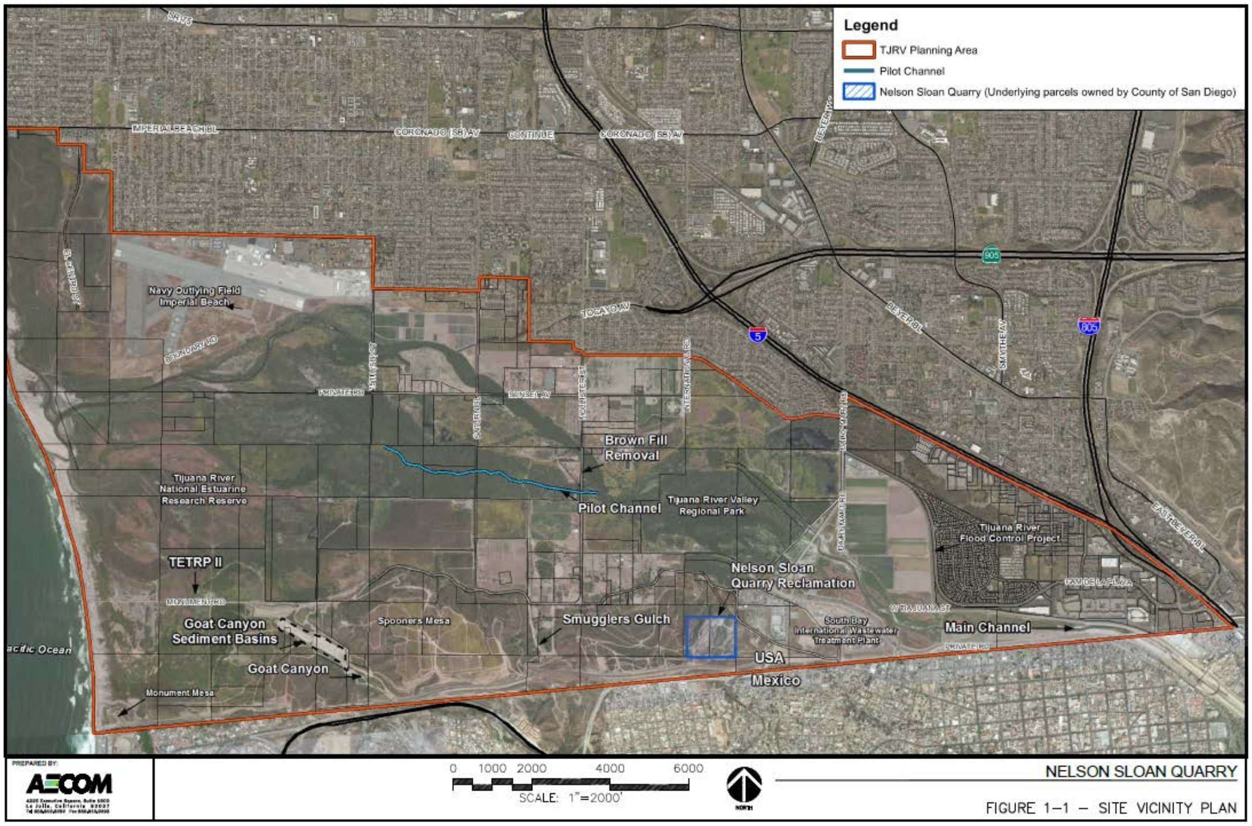
Specific costs would need to be developed for the options discussed above. For the purpose of this TM, based on information from existing operations in the Tijuana River Valley (as well as other similar facilities), it is assumed that the costs would be less than $5M annually to operate these facilities.

4.5.2 Nelson Sloan Management and Operations Plan

The purpose of this plan is to provide stakeholders with sediment management responsibilities in the Tijuana River Valley; it includes a description of how the Nelson Sloan Quarry might be managed and operated as a location for the placement of sediments excavated from the Tijuana River Valley. This plan considers four alternatives: placement of 100,000 CY of sediment with a passive restoration plan, and placement of 100,000, 1 million, and 2.3 million CY of sediment with a robust mitigation and monitoring plan for its restoration. The plan considers alternatives that take into account material import sources, material stockpiling, material sorting, material export, fill plan, restoration plan, project boundaries, operations and management structure, and estimated costs. The plan describes the steps for carrying out each respective alternative, including what must be identified for an environmental document consistent with the California Environmental Quality Act. Preliminary costs to implement each of the filling alternatives are included in the plan. These estimated costs are compared with the cost of disposing of the sediment at the Miramar Class III landfill, the City's current method for disposing of these materials. Disposal at the Otay Class III landfill has also been considered.

The Nelson Sloan Quarry site (Figure 19) is currently undeveloped, aside from the previous quarrying operations and remaining dirt access roads at the top of the mesa and base of the slope that are used by U.S. Customs and Border Protection to patrol the area along the border fence. The quarry encompasses 146.4 acres, of which approximately 46 acres were actively mined. The entire project area is within the Coastal Overlay Zone, and it is completely outside the Tijuana River 100-year floodway as designated by the Federal Emergency Management Agency. After mining ceased in 2002, the quarry site was bisected by a steep cut slope, with the eastern half being flat and the western half containing two naturally steep canyons draining to the north. The project site has an approximate top elevation of 438 feet above mean sea level near the southwestern corner of the site along the border fence. It has a low point near the northeastern portion of the site, on the property of the South Bay Water Reclamation Plant, of approximately 34 feet above mean sea level.

Figure 19. Nelson Sloan Quarry Location



Source: Excerpted from AECOM (2016)

The plan considers two options for processing the excavated sediment in the quarry: on site or off site.

The on-site option calls for establishing a temporary sediment processing station on the project site. The temporary processing area would likely need to be placed on a base rock-lined or other hard substrate-covered area that would allow earthmoving and other processing equipment to be safely operated. Unprocessed excavated sediment could then be transported to the processing area, and rock, cobbles, tires, trash, and other debris could be screened and removed. The processed fill materials could then be placed in appropriate piles/areas for quarry reclamation or be exported for possible reuse. Under this scenario, a portion of the site could serve as a sand and gravel "bank" where material could be sampled (for analytical chemical analyses), held for a period of time, and then blended as needed to optimize its beneficial reuse as a product or commodity with monetary value that could be sold and exported from the site to be used within the Tijuana River Valley or elsewhere. These operations could be conducted on site concurrently with other reclamation activities. This option has the advantage of limiting the environmental issues of sediment processing in one place rather than each of the stakeholders having to go through the process of gaining environmental clearances associated with sediment processing at each of their sites. This would likely save time and reduce costs.

The off-site option includes sorting the material at its source prior to hauling to the quarry reclamation site. This option has the advantage of using less of the quarry project area, in lieu of operating a sediment processing station on site, which would minimize the area subject to environmental mitigation. This difference would likely be minimal. On the other hand, this would shift more environmental burden onto each of the stakeholders. Each stakeholder would have to deal with the environmental issues specific to sediment processing on their own sites. The advantage to the stakeholders would be not having to haul the excavated material twice if it is determined to be unsuitable for the quarry or is deemed suitable for a reuse elsewhere.

To provide the stakeholders with a useful metric to determine whether they would benefit from using the quarry reclamation site for disposal of excavated sediment, the plan describes the anticipated cost the stakeholder would incur under each option and compares it with the cost of disposing the sediment in a landfill.

The cost of landfill disposal is derived from two components: (1) the fee for disposal at the landfill, and (2) the cost of hauling the material to the landfill. In the case of the Miramar Landfill, the cost for disposing of sediment was estimated at $53/ton or $40.80/CY (it was assumed that there are 1.3 CY per ton). The cost of hauling the sediment to the site over a 50-mile round trip was estimated at $16.10/CY. The total cost of the Miramar Landfill disposal would then be $56.90/CY. The unit cost of each of the quarry reclamation options was derived by dividing the total operation cost, including sediment transport to site, by the number of cubic yards of fill it would receive. The unit costs for the quarry reclamation options compared with the landfill disposal options (Miramar Landfill and Otay Landfill) are compared in Table 10. The unit cost for use of the quarry for sediment placement and restoration becomes considerably more favorable than landfill disposal as the placement volumes at the quarry increase. It should also be noted that there could be some cost savings for the disposal of sediment at the Otay Class II Landfill, since it is closer to the Tijuana River Valley.

Table 10. Unit Cost of Nelson Sloan Quarry Operation

Disposal option	Cost per CY
100,000 CY – basic restoration	$11.64
100,000 CY	$40.23
1,000,000 CY	$23.09
2,300,000 CY	$19.74
Miramar Landfill	$56.87
Otay Landfill	$31.32

Source: AECOM (2016)
Note: CY = cubic yard

4.5.3 Tijuana River Watershed Hydraulics and Hydrology Studies – Phase 2

Phase 2 of H&H study will integrate data provided by Mexican agencies so that the assessment reflects conditions in Mexico as well. Ultimately, the H&H study findings may inform a sediment management plan for the Tijuana River Valley, which is a priority project in the Recovery Team's Five-Year Action Plan. A sediment management plan will inform regulatory requirements (waivers, waste discharge requirements, etc.) for the Tijuana River Valley.

5 Emergency Action Plan

Despite existing and anticipated infrastructure, there are times when the volume of flows carrying large amounts of sediment is too high and sediment overflows occur. In these instances, emergency action plans are needed to identify protocols to address water quality, flooding, sediment, and trash.

6 Summary of Project Recommendations

This section summarizes the recommended projects for reducing the sedimentation volumes of a 2- to 5-year storm event. The planning-level costs were developed based on the following assumptions:

- Planning-level (Class 5) cost estimates range in accuracy from 20 to 50 percent below to 30 to 100 percent above actual cost.
- O&M costs are calculated based on experience of typical O&M costs and comparison with already implemented projects.

Coordination with stakeholders will continue to be a key element in the Needs and Opportunity Assessment process. The Tijuana River Valley Recovery Team members were instrumental in the data collection effort and have been identified as a key stakeholder group to continue through the Needs and Opportunity Assessment. Specifically, participation by the implementing agencies within the Tijuana River Valley Recovery Team (USIBWC, U.S. Environmental Protection Agency, California State Parks, U.S. Customs and Border Protection, City of San Diego, and County of San Diego) will be critical to the success of the project implementation. It is anticipated that a series of meetings, workshops, and other outreach opportunities will be effective in continuing the dialogue and advancing project development in the next phase.

Table 11 describes the projects and implementation costs for each project per the watershed.

Table 11. Proposed Implementation Projects

Project #	Project title	Project description	Estimated project cost	Example
2	Tijuana River Sedimentation Basins	Construct sedimentation basins either within or adjacent to the Tijuana River, upstream of Dairy Mart Rd. The basins would capture flows and allow sediment to settle into the basins to reduce sewage and sediment inflow into the downstream portions of the Tijuana River. This project would result in the retention of polluted runoff for a period of time. The basins could also incorporate green technology to remove contaminants from the water. These facilities would require frequent maintenance. This project is currently being analyzed by IBWC through a feasibility study, as well as a conceptual study by Surfrider.	• Estimated implementation cost: $12 million* • Estimated ongoing cost: TBD* * per IBWC 60% Sediment Feasibility Study	

Table 11. Proposed Implementation Projects

Project #	Project title	Project description	Estimated project cost	Example
11	Smuggler's Gulch Sedimentation Basin	Construct a sedimentation basin(s) within Smuggler's Gulch. The basins would capture flows and allow sediment to settle into the basins to reduce sediment inflow into Smuggler's Gulch. This project would reduce the need for ongoing dredging of the channel downstream of Monument, as well. a. Construct an in-line basin south of Monument Road, increase capacity of the road culvert, and elevate the road to 5-yr flood level. b. Add an off-line basin to Alternative 1 to capture fine sediments and reduce overbank flooding north of the road. c. Modification of Alternative 1 with two sequential in-line basins. This project is currently being assessed by the SB 507 NOA.	• Estimated implementation cost: a. $2.0 million b. $4.8 million c. $2.6 million • Estimated ongoing cost: $1 million/year	 

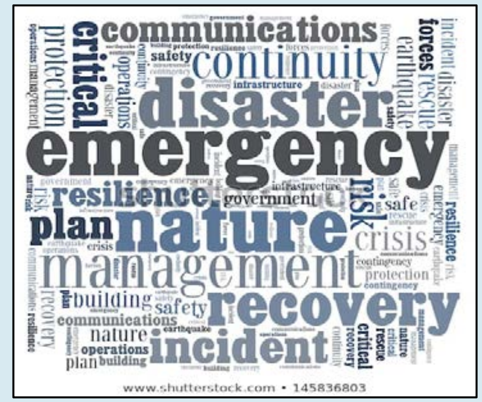
Table 11. Proposed Implementation Projects

Project #	Project title	Project description	Estimated project cost	Example
16	Sedimentation and Trash Management in Goat Canyon	There are two existing sedimentation basins and trash booms in Goat Canyon that are operated by California State Parks. Funding for long-term operation and maintenance of these facilities is necessary to keep trash and sediment from flowing into the Tijuana River and Estuary. This project is currently being assessed by the SB 507 NOA.	• Estimated ongoing cost: <$5 million/year	
18	Yogurt Canyon Pilot Channel	A pilot channel is considered to convey Yogurt Canyon flows and sediment. The pilot channel would cross Monument Road under a pre-fabricated creek crossing structure. The pilot channel would be integrated north of the road with restored salt marsh habitat. This project is currently being considered by SB507 NOA.	• Estimated implementation cost: $5M • Estimated ongoing cost: $5K/year	

Table 11. Proposed Implementation Projects

Project #	Project title	Project description	Estimated project cost	Example
20	Nelson Sloan Quarry Restoration	Beneficially reuse sediment from existing Goat Canyon sedimentation basins to restore a former mine site. The project considers alternatives that take into account material import sources, material stockpiling, material sorting, material export, fill plan, restoration plan, project boundaries, operations and management structure, and estimated costs. This project is identified as a Tier 1 Project in the Tijuana River Valley Recovery Strategy and is currently undergoing design and environmental review by the California State Parks in coordination with the County.	• Estimated implementation cost: $1 million • Estimated ongoing cost: $3 million/year	 
23	Soil Sampling	Data about soil and sediment quality downstream of Dairy Mart Road, as well as in the tributaries, would be needed to determine the potential water quality impacts in the lower river reaches should the soil be disturbed during flood events or river enhancement.	• Estimated initial cost: <$100,000 • Estimated ongoing cost: <$1 million/year	

Table 11. Proposed Implementation Projects

Project #	Project title	Project description	Estimated project cost	Example
		Other Nonstructural Alternatives		
26	Development of Emergency Action Plans	Despite existing and anticipated infrastructure, there are times when the volume of flows carrying sediment is too high and sediment overflows occur. In these instances, emergency action plans are needed to identify protocols to address water quality, flooding, sediment, and trash.	• Estimated soft cost: $250,000 to $500,000 • Estimated ongoing cost: <$1 million/year	

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Appendix A. Hydraulic Results

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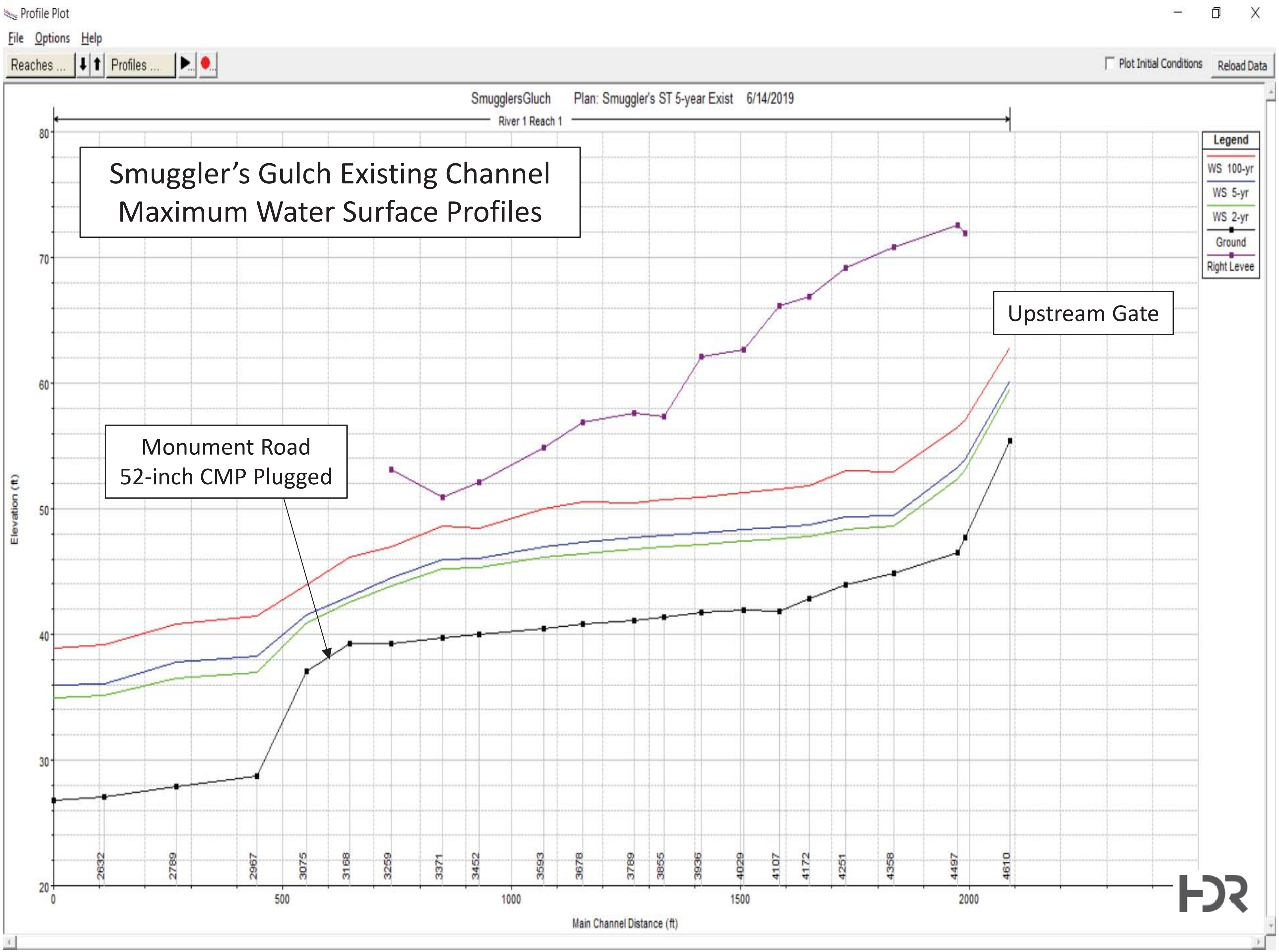

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Legend
WS 100-yr
WS 5-yr
WS 2-yr
Ground
Right Levee
Upstream Gate
Monument Road 52-inch CMP Plugged
Elevation (ft)
2632
2789
2967
3075
3168
3259
3371
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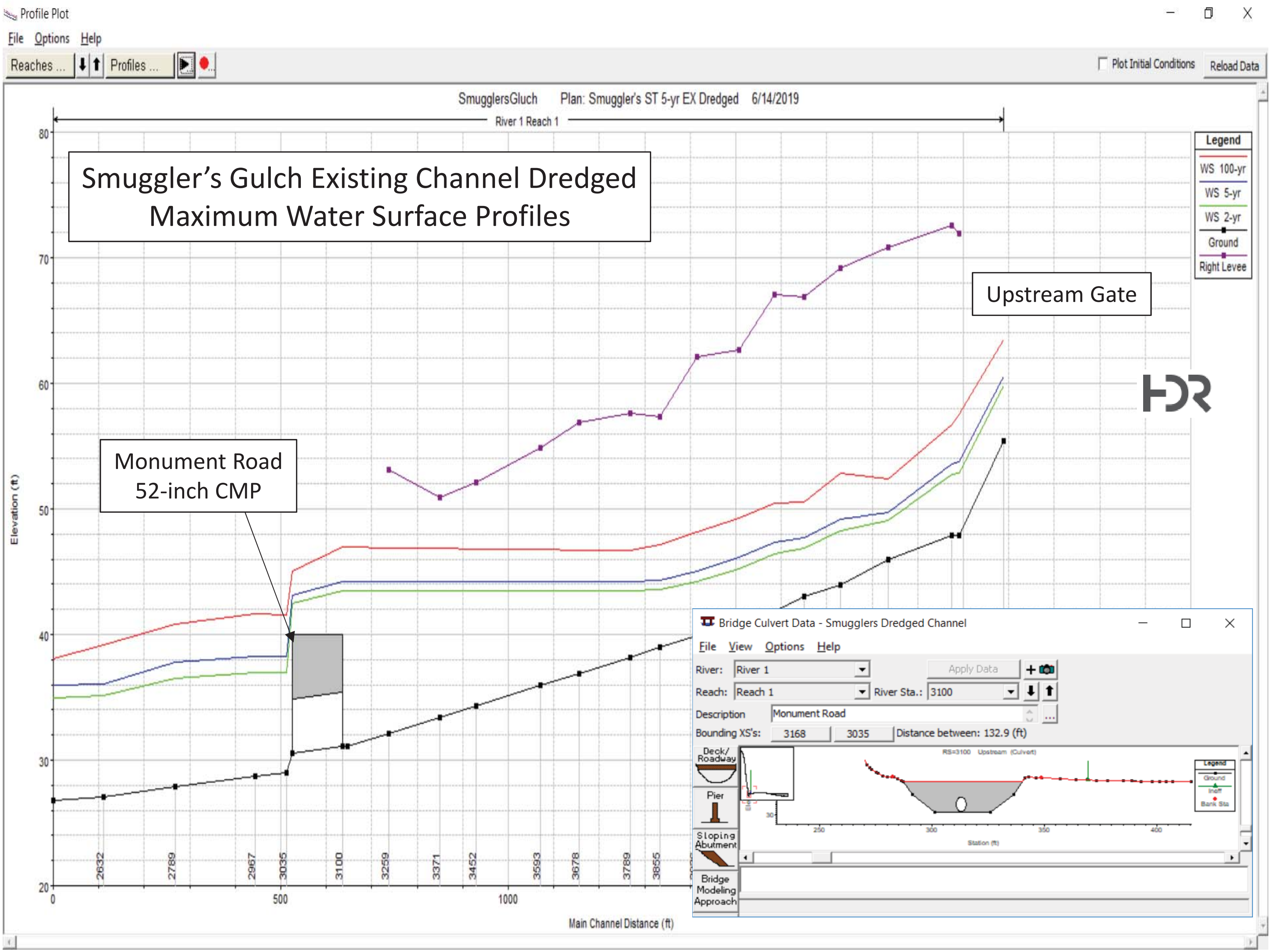
Main Channel Distance (ft)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Maximum Water Surface Profiles
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Monument Road
52-inch CMP
Legend
WS 100-yr
WS 5-yr
WS 2-yr
Ground
Right Levee
Elevation (ft)
Main Channel Distance (ft)
80
70
60
50
40
30
20
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500
1000
2632
2789
2967
3035
3100
3259
3371
3452
3593
3678
3789
3855
Bridge Culvert Data - Smugglers Dredged Channel
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Apply Data
Reach: Reach 1
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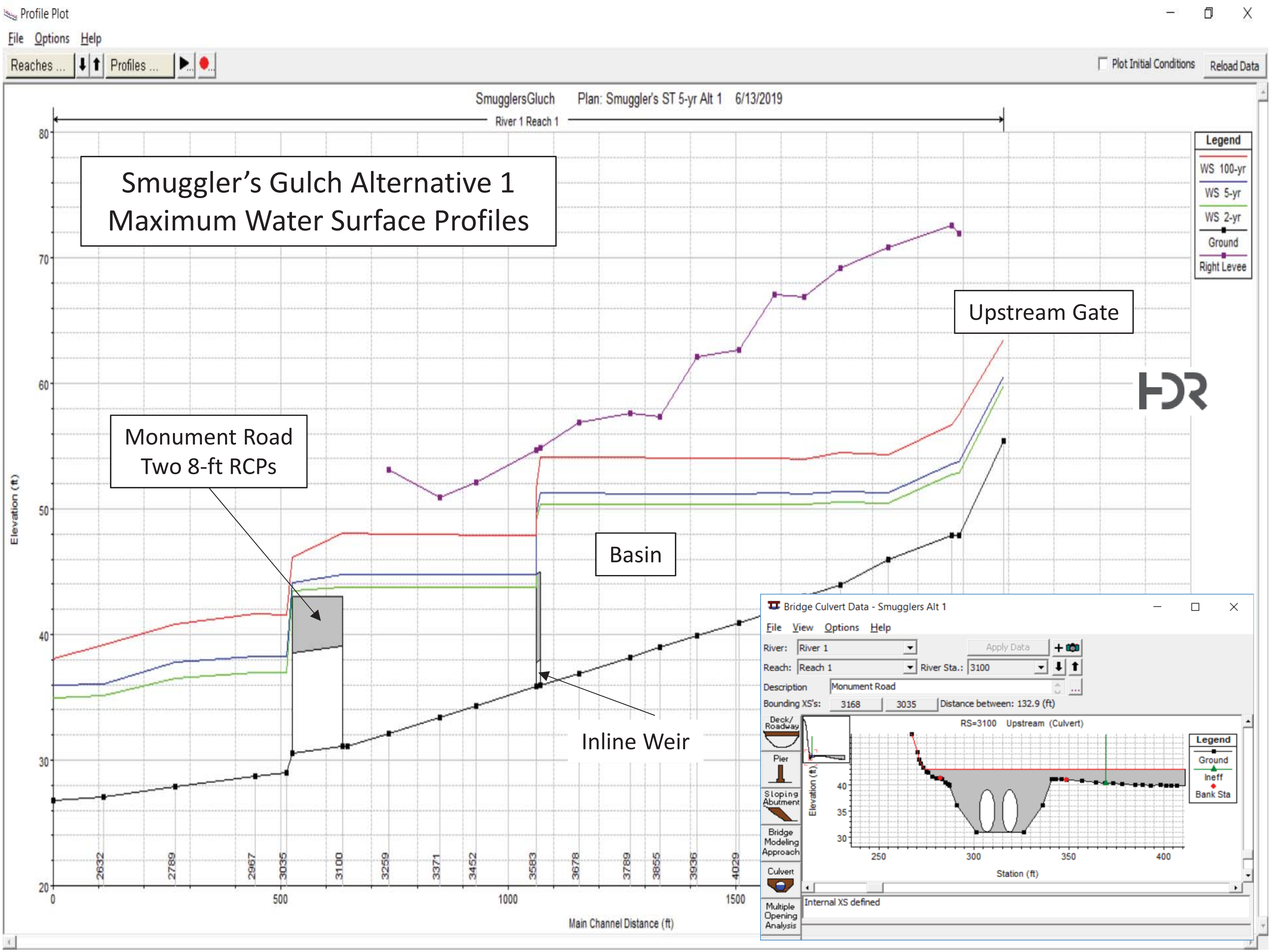
Deck/ Roadway
Pier
Sloping Abutment
Bridge Modeling Approach



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Maximum Water Surface Profiles
Legend
WS 100-yr
WS 5-yr
WS 2-yr
Ground
Right Levee
Upstream Gate
Monument Road
Two 8-ft RCPs
Basin
Inline Weir
Elevation (ft)
Main Channel Distance (ft)
Bridge Culvert Data - Smugglers Alt 1
File View Options Help
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Reach: Reach 1 River Sta.: 3100
Apply Data
Description Monument Road
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Deck/ Roadway
Pier
Sloping Abutment
Bridge Modeling Approach
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Multiple Opening Analysis
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Legend
Ground
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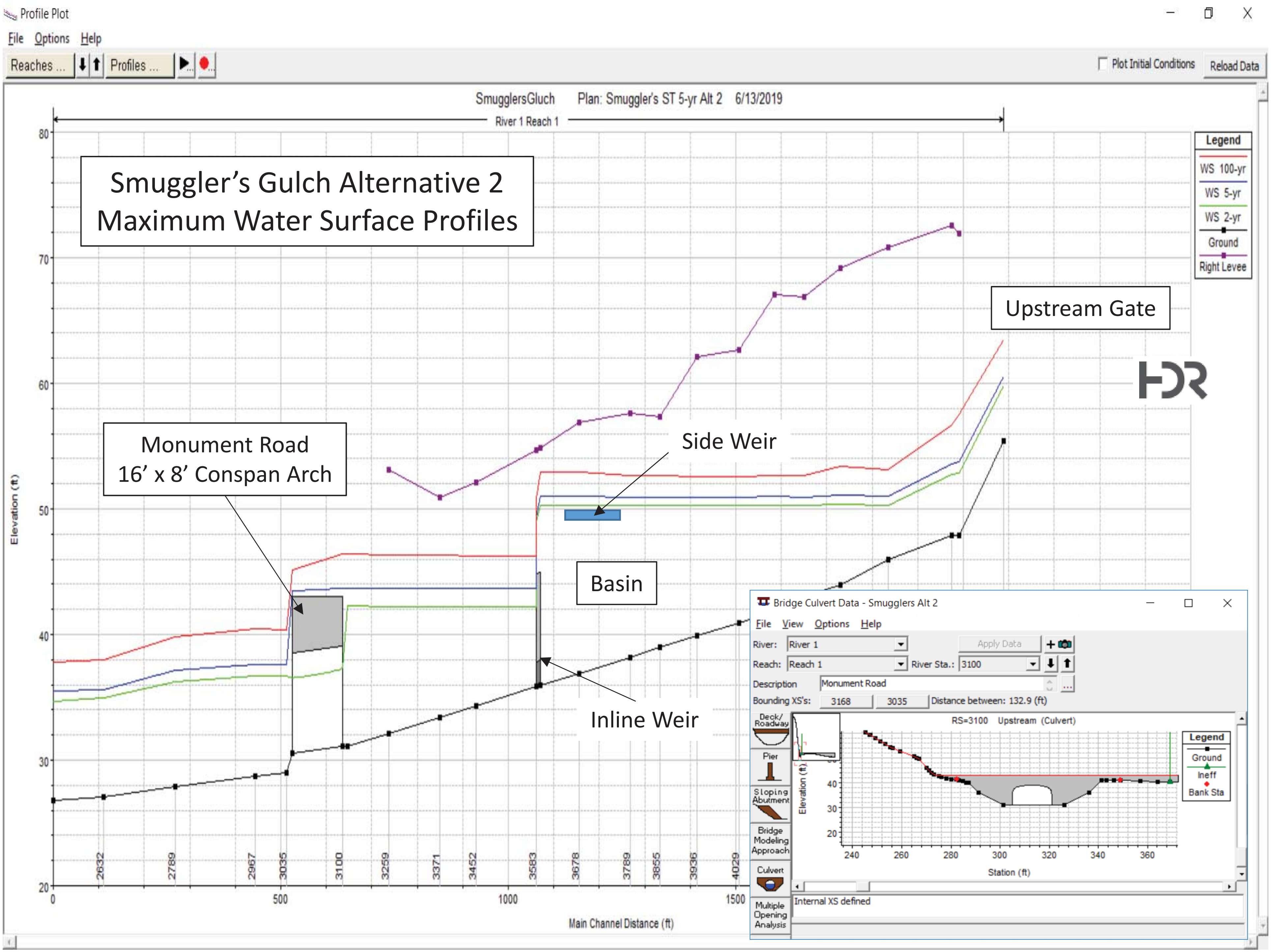
Bank Sta
Station (ft)
Internal XS defined



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Maximum Water Surface Profiles
Legend
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WS 5-yr
WS 2-yr
Ground
Right Levee
Upstream Gate
Monument Road
16' x 8' Conspan Arch
Side Weir
Basin
Inline Weir
Elevation (ft)
Main Channel Distance (ft)
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2789
2967
3035
3100
3259
3371
3452
3583
3678
3789
3855
3936
4029
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File View Options Help
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Reach: Reach 1
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Deck/Roadway
Pier
Sloping Abutment
Bridge Modeling Approach
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Bank Sta
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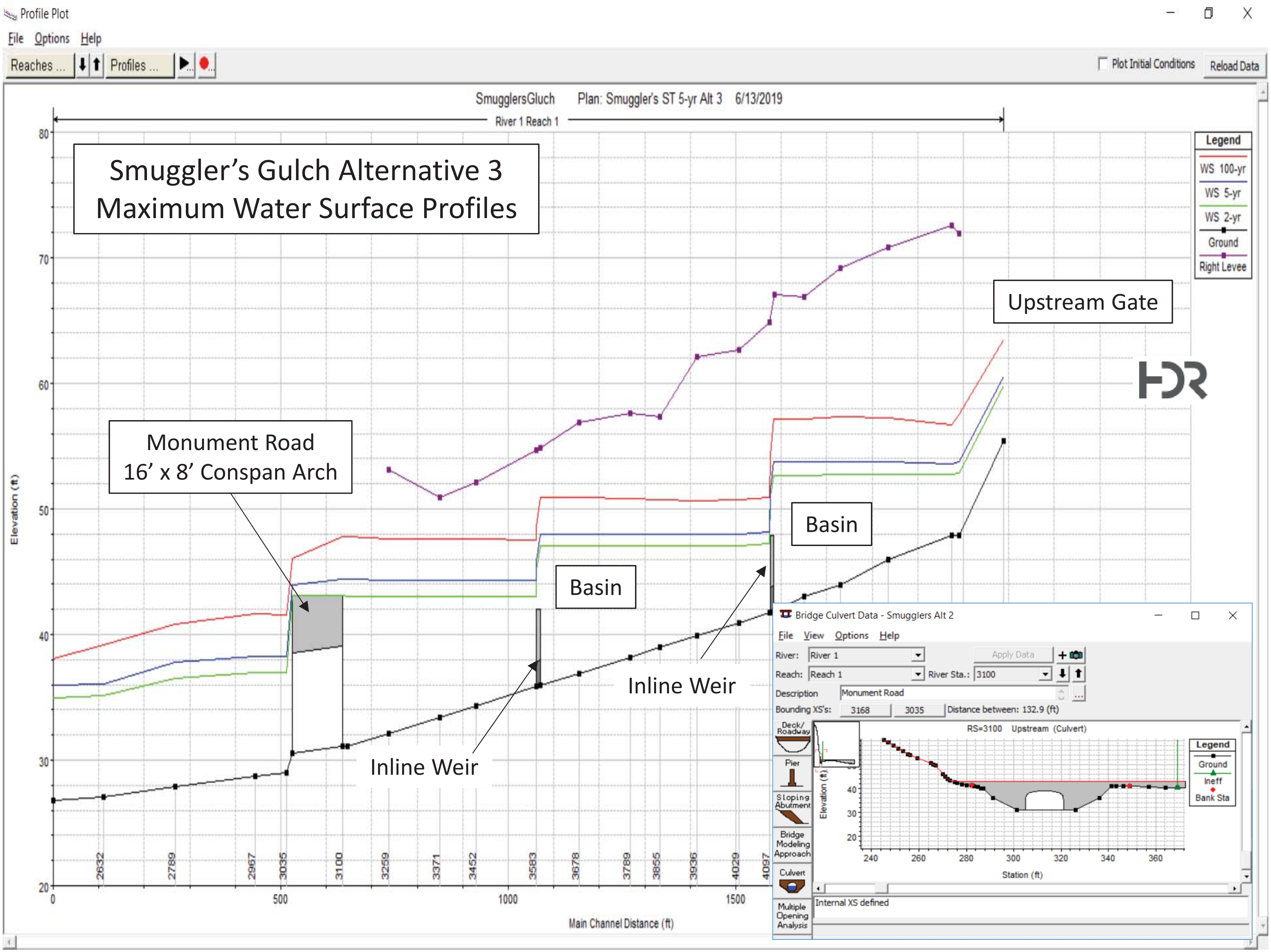
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WS 5-yr
WS 2-yr
Ground
Right Levee
Upstream Gate
Monument Road
16' x 8' Conspan Arch
Basin
Basin
Inline Weir
Inline Weir
Elevation (ft)
Main Channel Distance (ft)
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2789
2967
3035
3100
3259
3371
3452
3583
3678
3789
3855
3936
4029
4097
Bridge Culvert Data - Smugglers Alt 2
File View Options Help
River: River 1
Reach: Reach 1
River Sta.: 3100
Apply Data
Description Monument Road
Bounding XS's: 3168 3035 Distance between: 132.9 (ft)
Deck/ Roadway
Pier
Sloping Abutment
Bridge Modeling Approach
Culvert
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Bank Sta
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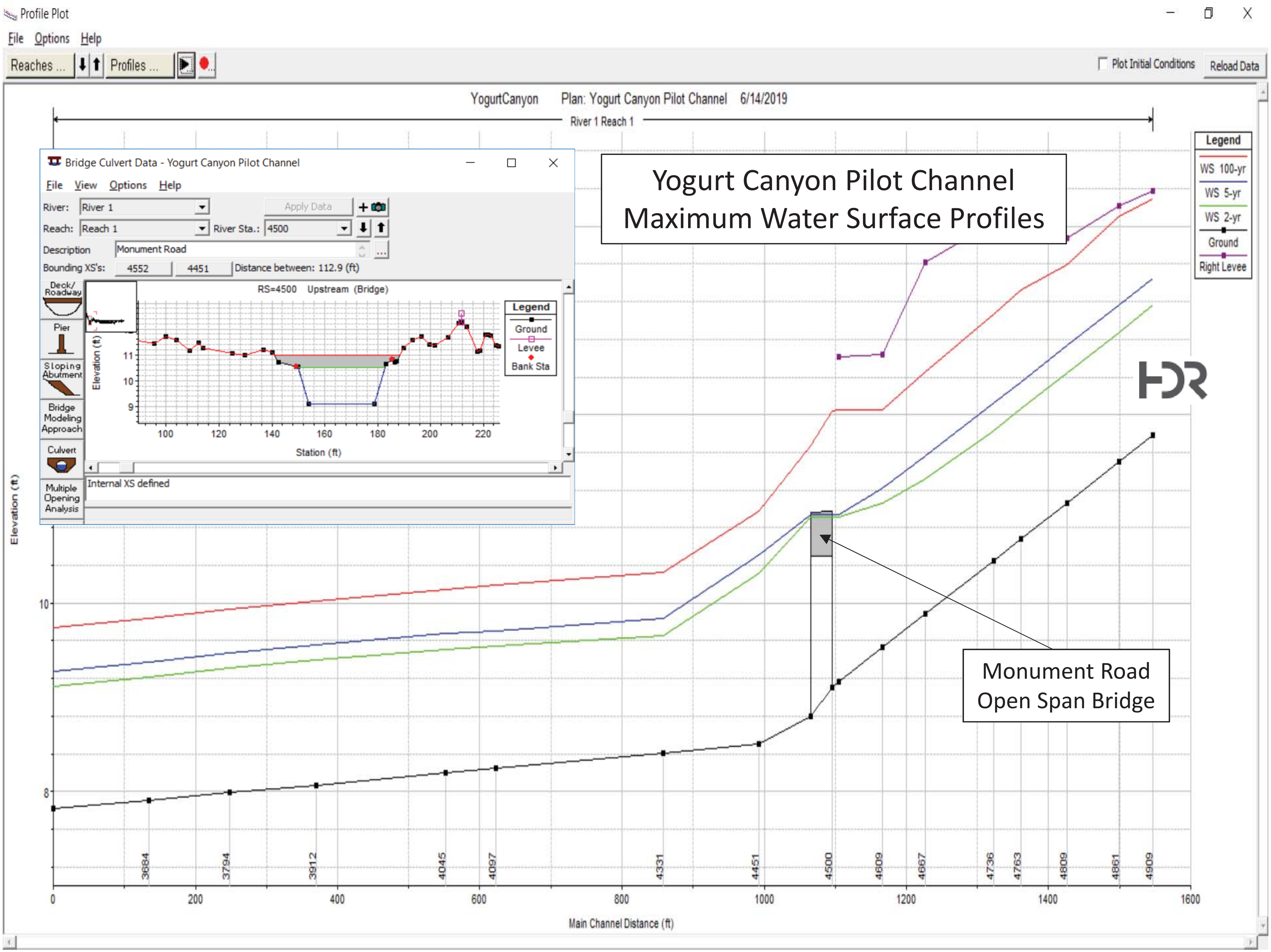
Station (ft)
Internal XS defined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River 1 Reach 1
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Maximum Water Surface Profiles
Legend
WS 100-yr
WS 5-yr
WS 2-yr
Ground
Right Levee
Bridge Culvert Data - Yogurt Canyon Pilot Channel
File View Options Help
River: River 1
Apply Data
Reach: Reach 1
River Sta.: 4500
Description Monument Road
Bounding XS's: 4552 4451 Distance between: 112.9 (ft)
Deck/ Roadway
Pier
Sloping Abutment
Bridge Modeling Approach
Culvert
Multiple Opening Analysis
RS=4500 Upstream (Bridge)
Legend
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
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Open Span Bridge
Elevation (ft)
Main Channel Distance (ft)
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Appendix B. Sediment Transport Results

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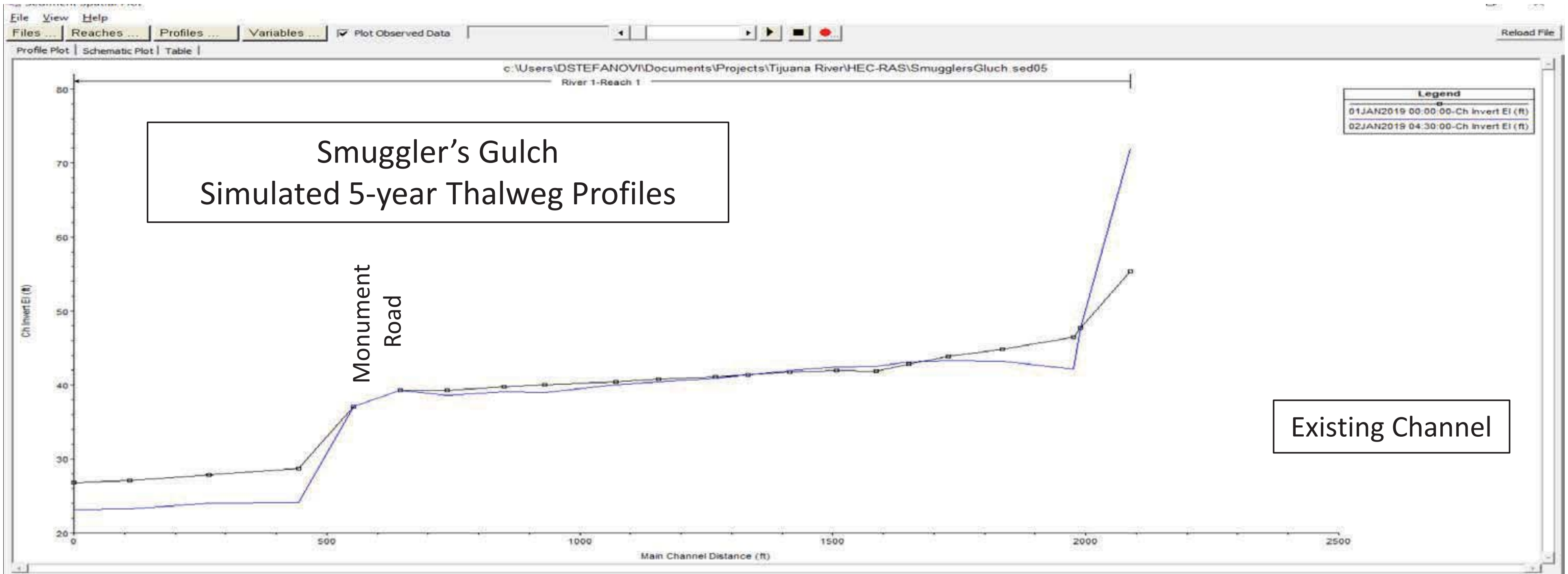
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Smuggler's Gulch
Simulated 5-year Thalweg Profiles
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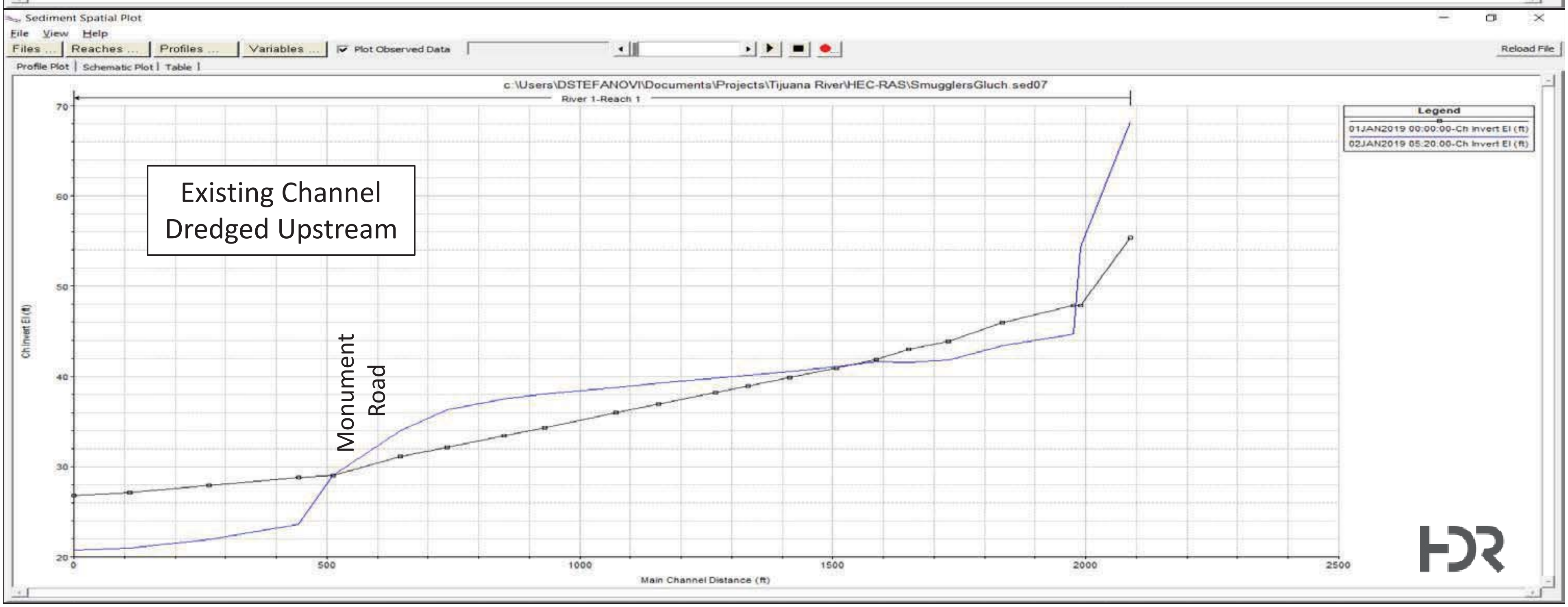
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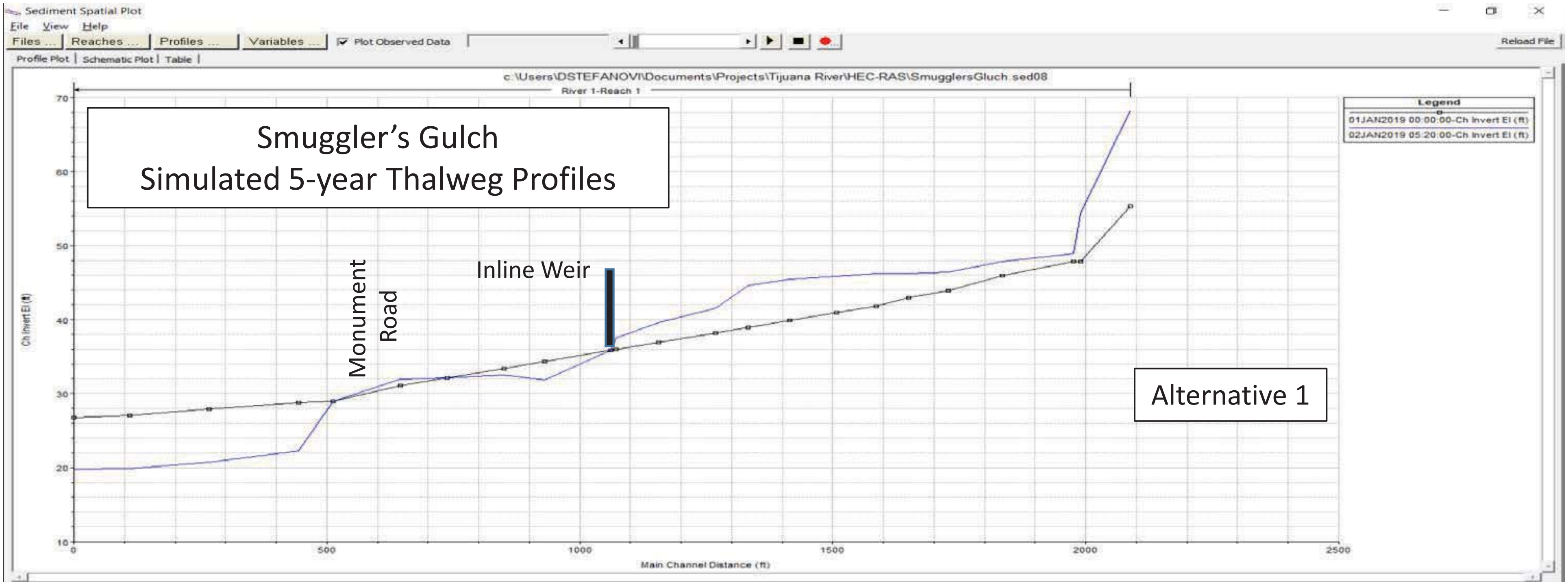
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Smuggler's Gulch
Simulated 5-year Thalweg Profiles
Legend
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02JAN2019 05:20:00-Ch Invert El (ft)
Inline Weir
Monument Road
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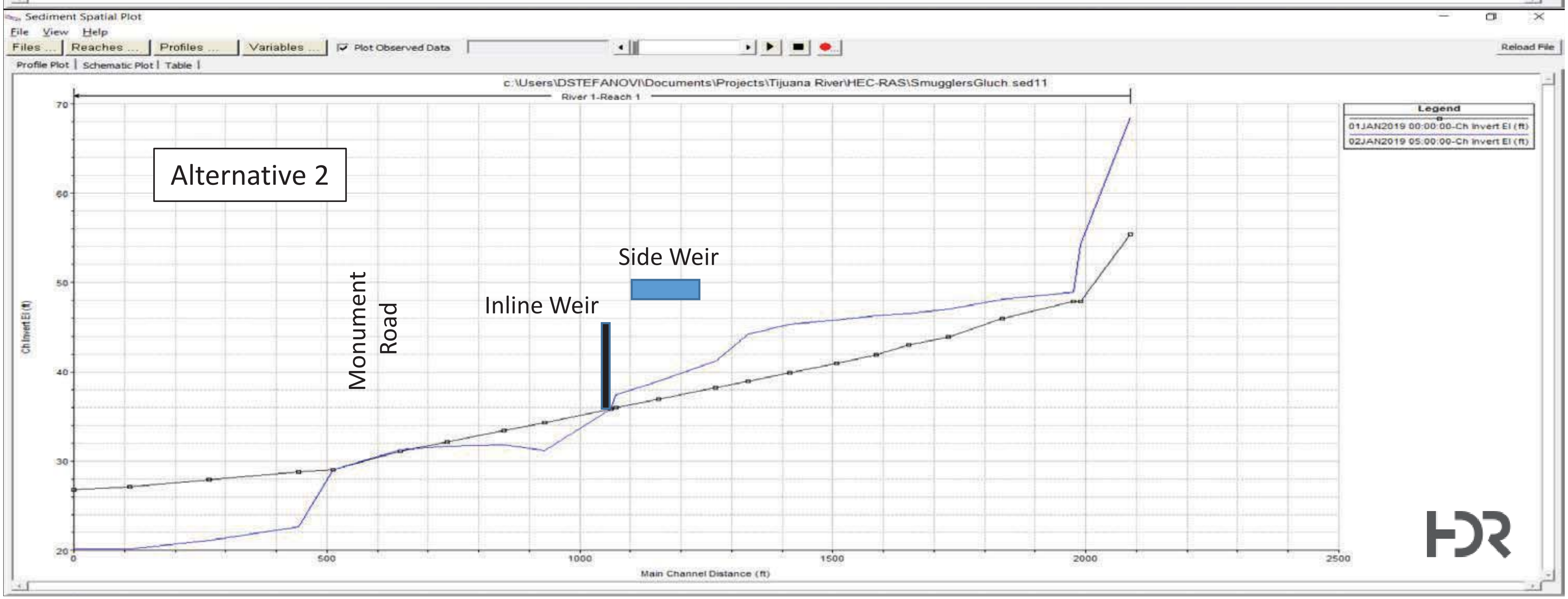
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02JAN2019 05:00:00-Ch Invert El (ft)
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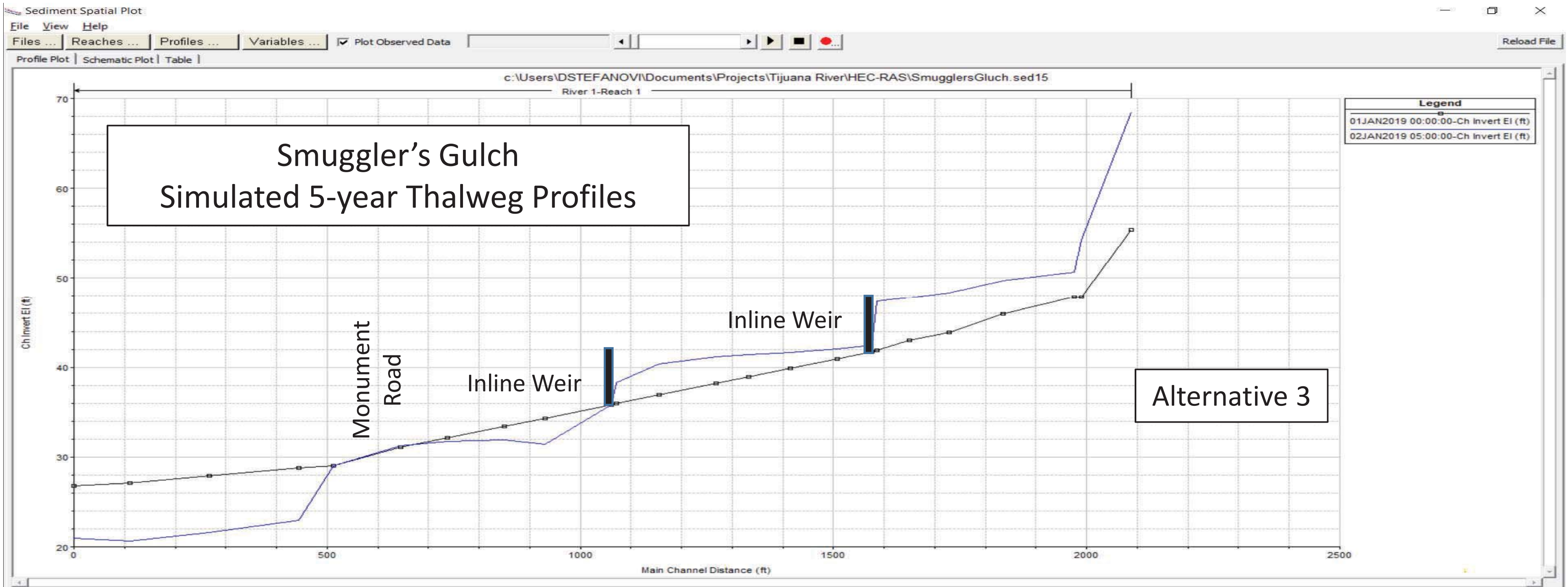
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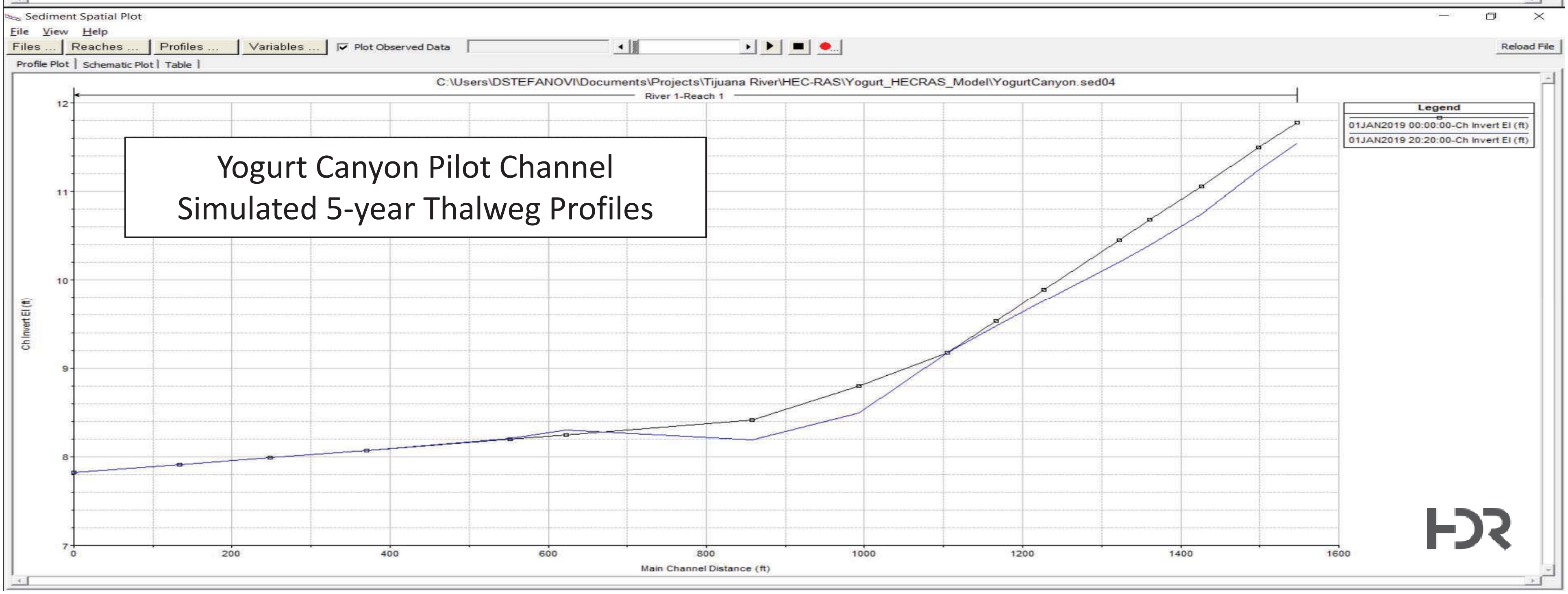
Reload File
Profile Plot | Schematic Plot | Table
c:\Users\DSTEFANOVI\Documents\Projects\Tijuana River\HEC-RAS\SmugglersGluch.sed15
River 1-Reach 1
Smuggler's Gulch
Simulated 5-year Thalweg Profiles
Monument Road
Inline Weir
Inline Weir
Alternative 3
Legend
01JAN2019 00:00:00-Ch Invert El (ft)
02JAN2019 05:00:00-Ch Invert El (ft)
Ch Invert El (ft)
Main Channel Distance (ft)


Sediment Spatial Plot
File View Help
Files ... Reaches ... Profiles ... Variables ... Plot Observed Data
Reload File
Profile Plot | Schematic Plot | Table
C:\Users\DSTEFANOVI\Documents\Projects\Tijuana River\HEC-RAS\Yogurt_HECRAS_Model\YogurtCanyon.sed04
River 1-Reach 1
Yogurt Canyon Pilot Channel
Simulated 5-year Thalweg Profiles
Legend
01JAN2019 00:00:00-Ch Invert El (ft)
01JAN2019 20:20:00-Ch Invert El (ft)
Ch Invert El (ft)
Main Channel Distance (ft)