Tijuana River Valley Needs and Opportunities Assessment – Flood Technical Memorandum

San Diego, California

March 6, 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, industrial waste, 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, trash, and sediment 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 in Mexico. 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 sewage, trash, and contaminants reaching the Pacific Ocean in the U.S. pose health and safety risks and environmental concerns.

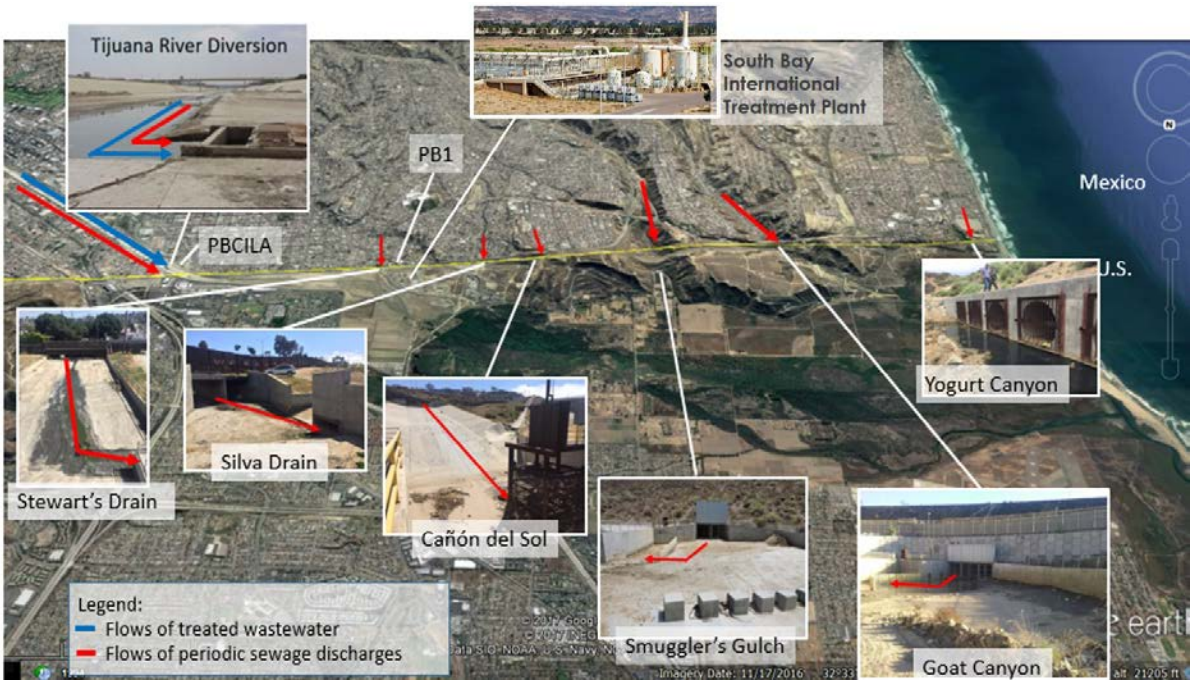
There is an agreement between the U.S. and Mexico to divert water from the Tijuana River in Mexico prior to crossing the border to the U.S. The U.S. and Mexico sections of the International Boundary and Water Commission (IBWC) are responsible for mitigating sewage problems and the associated water quality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

PBCILA is 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. The facilities are shut down during storm events exceeding this flow level and system malfunctions. During these closures, water flows 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 one billion gallons per day. It may take several months for the river channel flow to fall below 23 mgd after a storm event. Flows below this 23 mgd limit are necessary for 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, trash, and sediment 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 projects that could be implemented to address the impacts of transboundary flows on the Tijuana River Valley.

1.2 Purpose

Although existing flooding is not considered a priority issue of concern for this assessment, there is the potential that projects proposed to address the other key issues of concern (sewage, trash, and sediment) may have an impact (positive or negative) on the existing flooding conditions. Flood risk reduction measures will be considered as an additional benefit to any projects proposed to address the other issues of concern. Several projects proposed to address sediment management include a flood reduction benefit and are discussed in greater detail in the *Tijuana River Valley Needs and Opportunities Assessment – Sediment* Technical Memorandum (TM).

Section 2 of this TM identifies the existing key infrastructure and other ongoing projects that are designed to address flood control issues in each of the four priority watersheds. Section 3 identifies the remaining priority issues related to flood control in each of the priority watersheds. Section 4 identifies potential projects to address the priority issues in each of the watersheds. A planning-level cost estimate is also included for the project implementation, as well as for ongoing costs. Section 5 discusses potential emergency measures to deal with the flood issues until permanent infrastructure, as well as other projects, policies, and procedures, can be implemented. Section 6 summarizes the potential projects to be considered for additional study. Finally, Section 7 provides a list of references used in this report.

2 Review of Existing Projects and Information

Information gathered during Step 1 of this assessment was reviewed to determine specific project-related information that would directly benefit the development of the flood control alternative concepts. The following information and documents were reviewed and applied as appropriate:

- Hydrologic, hydraulic, and sediment transport information for the Tijuana River Watershed – US 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*
- 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
- 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
- Hydraulic and sediment information for Goat Canyon – Rick Engineering, 2003, *Hydraulic and Sedimentation Study of Goat Canyon Creek for the Goat Canyon Enhancement Plan*

The following sections describe the major flood control elements within the Tijuana River Valley that are considered for each of the priority watersheds in the Needs and Opportunities Assessment.

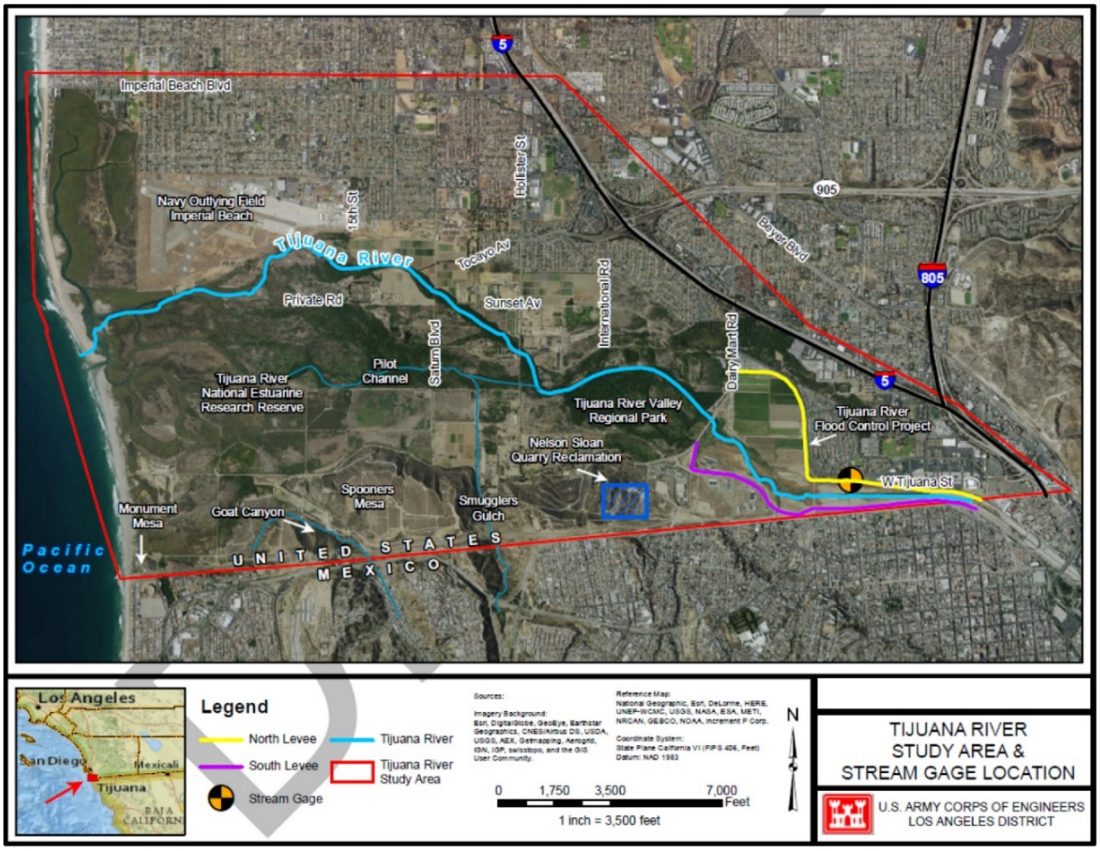
2.1 Tijuana River

The U.S. Section of the International Boundary and Water Commission (USIBWC) operates and maintains the Tijuana River Flood Control Project. The flood control project consists of a concrete-lined channel for the Tijuana River in Mexico extending from the boundary upstream 2.7 miles and a concrete- and rock-lined channel in the U.S. extending from the boundary downstream 0.9 mile (see Figure 2). The downstream portion of the channel in the U.S. is a flared section to reduce the velocity of flows before discharging into the natural channel below the project. The channel and bordering levees were constructed pursuant to binationally-approved design criteria which included the ability to contain an approximate 500-year storm event (135,000 cubic feet per second). The levees in the U.S. tie into high ground on the north to protect the community of San Ysidro, and on the south to protect the South Bay International Wastewater Treatment Plant and the City of Tijuana. The U.S. levee on the north bank of the river is 2.0 miles in length, and the south bank of the river is 1.9 miles in length. Flows in the Tijuana River from Mexico that bypass the diversion structures, canyon collectors, and pump station are conveyed through this levee system.

The USIBWC is currently studying the existing the levees with the intent to provide a levee design that fully meets 44 CFR section 65.01(b) and the rehabilitated levee to meet and/or exceed all requirements of the Engineering Manual. Improvements include efforts to contain flows onto the USIBWC/Sod farm property, rehabilitate burrows caused by squirrels and other animals, and install sluice gates to prevent backflow during flood events. This study was initiated in 2017, however is being delayed in order to take advantage of the USACE Phase 2 hydrology modeling efforts. A 60% Design Documentation Report was completed in May 2019.

Downstream of the Tijuana River Flood Control Project, the river opens into a broad valley over 1 mile wide. Major bridge crossings at Dairy Mart Road and Hollister Road confine flows during smaller storm events and are overtopped in major events (approximate 5-year storm event or greater). The City of San Diego maintains a 1-mile-long earthen pilot channel downstream of Hollister Road to help direct flows away from a northern channel that formed during a storm event in 1993.

Figure 2. Tijuana River Study Area



Source: Excerpted from Stantec (2018)

2.2 Smuggler's Gulch

Smuggler's Gulch is one of five canyon collectors in the region that are concrete channels and basins designed to capture transboundary dry-weather flows from Mexico in canyons and ravines draining north across the border to the Tijuana River. The contributing watershed area is approximately 3762 acres. The other canyon collector systems are: Goat Canyon Diversion Structure, Cañon del Sol Collector, Stewart's Drain Canyon Collector, and Silva Drain Canyon Collector. Yogurt Canyon is the only tributary that does not have a canyon collector and diversion structure to control dry-weather flows and spills.

The Smuggler's Gulch canyon collector system includes a detention basin designed to capture dry-weather flows, a screened drain/inlet, and a pump conveyance to the South Bay International Wastewater Treatment Plant (SBIWTP) (Figure 3). When flows do not exceed the maximum design capacity of the collector system, and the system is properly operated and maintained, dry-weather flows are captured and diverted to the treatment plant for treatment and disposal through the South Bay Ocean Outfall (SBOO).

Any quantity of flow in the canyon exceeding the maximum design capacity of the collector system bypasses the structure and continues flowing north, discharging to the Tijuana River and ultimately the Pacific Ocean through the Tijuana River Estuary. The

pump diversion is turned off during storm events and therefore, does not provide significant flood control benefits.

The existing channel downstream (north) of the collector system provides flood flow conveyance. The existing channel is an engineered earthen channel that is dredged by the County of San Diego on a regular basis to maintain the conveyance capacity. The existing culvert at Monument Road, however, is severely undersized, which results in frequent overtopping and flooding of Monument Road. The earthen channel downstream of Monument Road is dredged by the City of San Diego to maintain the conveyance capacity; however, flow overtopping Monument Road can travel overland before reentering the channel, which results in flooding of existing structures east of the channel, north of Monument Road (see Section 4.2 for additional details).

Figure 3. Smuggler's Gulch Diversion Structure

2.3 Goat Canyon

Goat Canyon is formed by Goat Canyon Creek, which receives water and other runoff from areas south of the border. The size of the drainage area is approximately 2941 acres. The majority of the canyon and its watershed is located in Baja California, Mexico. Similar to Smuggler's Gulch, Goat Canyon includes a dry-weather collector and diversion system (see Figure 4) that is nonoperational during storm events and does not provide significant flood control benefits. Unlike Smuggler's Gulch, however, Goat Canyon includes a sedimentation basin downstream (north) of the collector system that does provide some flood control benefit.

The Goat Canyon Sediment Basin complex, which was constructed in 2005, is managed by California State Parks. The sediment and debris retention facility captures large volumes of sediment and debris directly affecting estuarine and ocean habitats (AMEC 2008).

The Goat Canyon Sediment Basin complex includes two sediment basins that consist of a concrete bottom in a canyon diversion structure that transitions into a flow-through

sedimentation basin system (Figures 5 to 7). The sediment basins contain two floating trash booms intended to capture solid waste during storms.

Although the purpose of the sediment basins is not to provide direct flood control benefits, there are indirect benefits of the project. The removal of sediment and debris helps maintain the flow conveyance capacity of Goat Canyon, which would reduce flooding at Monument Road and at the lower reaches of the Tijuana River and Estuary.

Figure 4. Goat Canyon Diversion Structure

Figure 5. Goat Canyon Sediment Basin

Figure 6. Goat Canyon Sediment Basin and Trash Boom

Figure 7. Goat Canyon Sediment Basin with Border in Background

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2.4 Yogurt Canyon

Yogurt Canyon is the smallest of the three tributary canyons, with a watershed area of 415 acres. The storm flows crossing the border are conveyed north toward the Tijuana River National Estuarine Research Reserve by way of a natural channel. Any measurable rainfall in the Yogurt Canyon watershed is likely to produce enough runoff to flood Monument Road, which restricts access to Border Field State Park and Friendship Park. In addition to sewage and sediment impacts, the flow of stormwater into the Reserve affects salt marsh habitat in the reserve by diluting fresh water.

3 Priority Issues

Flooding in the Tijuana River Valley is greatly influenced by transport of sediment across the border. The inclusion of sediment management (which is considered a priority issue of concern in the NOA Report) would likely reduce the rate of sediment accumulation that could affect flooding of existing and future infrastructure. In addition, there is the potential that projects proposed to address the other key issues of concern (sewage, trash, and sediment), may have an impact (positive or negative) on the existing flooding conditions. Proposed improvements will be evaluated to identify potential flood risk impacts. Flood risk reduction measures will be considered as an additional benefit to any projects proposed to address the other priority issues of concern (see related TMs for additional discussion).

The following sections summarize the key flood-related issues in each of the watersheds.

3.1 Tijuana River

As discussed in Section 2.1, the main channel of the Tijuana River experiences frequent flooding across the approximate 1-mile-wide floodplain. Major bridge crossings at Dairy Mart Road and Hollister Road are overtopped during significant rain events. The valley is flooded frequently, which can restrict vehicular access; inundate homes, farms, ranches, and other structures; and affect border protection operations. Infill of vegetation and sediment have choked the mainstream channels, contributing significantly to flooding problems.

3.2 Smuggler’s Gulch

The flooding adjacent to the Smuggler’s Gulch channel immediately upstream and downstream from Monument Road is a major disruption to traffic and has resulted in damage to public and private property. It has also affected border protection operations.

3.3 Goat Canyon

Other than the need to address the long-term operation and maintenance of the existing trash booms and sediment basins associated with the Goat Canyon Sediment Basin complex, there are no issues related to storm flow or flooding identified in Goat Canyon.

3.4 Yogurt Canyon

Similar to Smuggler's Gulch, the major flood-related issues associated with Yogurt Canyon are impacts to flooding on Monument Road. Monument Road, which is the only public access to Border Field State Park and Friendship Park, closes during most storm events (often throughout the entire winter and spring) because of inundation of the dirt access road. Border protection operations, as well as trails and other access to the beach, are also affected. In addition, the direct inflow of fresh water into the estuary can negatively affect the salt-marsh habitat.

4 Development of Potential Projects

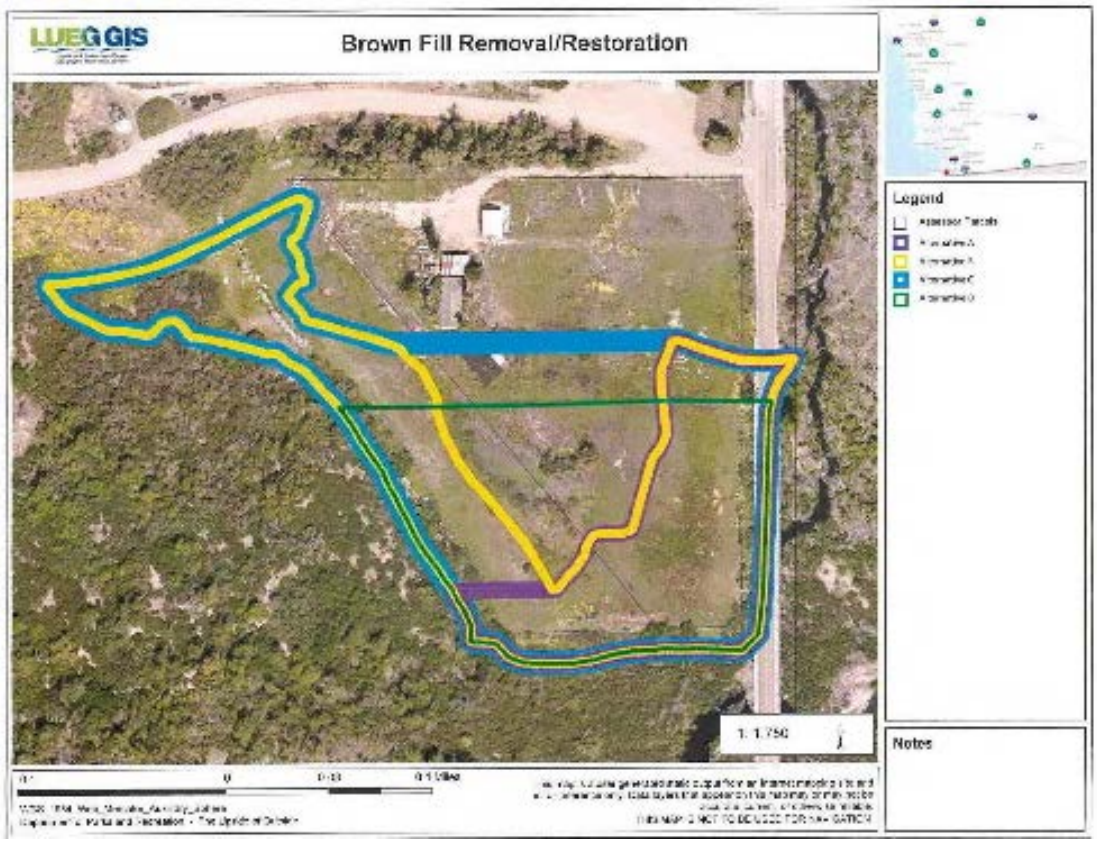
As discussed in Section 1.2, flooding is not considered a priority issue of concern and, as such, no specific flood risk reduction projects are being considered for the Needs and Opportunities Assessment. There are, however, projects being considered that have a secondary impact on flooding. This section summarizes those projects for reference.

4.1 Tijuana River

Brown Property Restoration

Restoration of the Brown Property was included in the Tijuana River Valley Recovery Team Five-year Action Plan. The Brown Property, owned by the County of San Diego Department of Parks and Recreation, is located on Hollister Street and was the site of historical unauthorized fill. This fill is believed to have occurred in the early 1980s and includes inert and nonhazardous waste. Removal of the fill was proposed to restore the natural hydrology and improve flood flows in the Tijuana River. Subsequent to the Tijuana River Valley Recovery Team Action Plan, the County of San Diego Department of Parks and Recreation hired Chang Consultants to evaluate four fill removal and channel restoration alternatives (Figure 8). Chang Consultants prepared a report entitled *Hydraulic and Sediment Transport Analyses for the Brown Property Fill Removal* (February 6, 2019). The report concluded that removing the fill will not significantly lower the water surface elevations or provide flood inundation benefits.

Figure 8. Brown Property Fill Removal Alternatives



Source: Excerpted from Chang Consultants (2019)
Note: Lines represent the following: black – Assessor parcels, purple – Alternative A, yellow – Alternative B, blue – Alternative C, and green – Alternative D.

Invasive Plant Removal

Invasive plant species have increased in abundance in the Tijuana River Valley, which is also facing infestation from an invasive beetle (shot-hole borer). The invasive plants have choked out the historic flow paths within the river and have contributed to the flooding problems. Although the direct benefits have yet to be quantified, the removal of these plants would help in restoring the natural hydrology and reduce flooding impacts. The County of San Diego Department of Parks and Recreation has historically removed invasive species in targeted areas and is currently considering plans to expand these areas and restore native habitat.

Other Projects

The USIBWC is currently developing a feasibility study to establish the preferred location and size of a sediment basin (or basins) within the main channel of the Tijuana River (Stantec 2019). The sediment basin could be designed to also capture trash, debris, and transboundary flows. The sediment, trash, and debris strategies are intended to improve water quality and reduce adverse health risks to people and the environment. This study will develop three alternative concepts for the basin, recommend a preferred alternative, and present a conceptual design for the preferred alternative. Although there is no direct

flood control benefit anticipated, indirect benefits could result from the capture and removal of sediment and trash (i.e. increased hydraulic capacity). Figure 9 illustrates one of the basin alternatives. At the time of this technical memorandum, the feasibility study was still in progress. Further discussion of this project alternative can be found in the *Tijuana River Valley Needs and Opportunities Assessment – Sediment* TM.

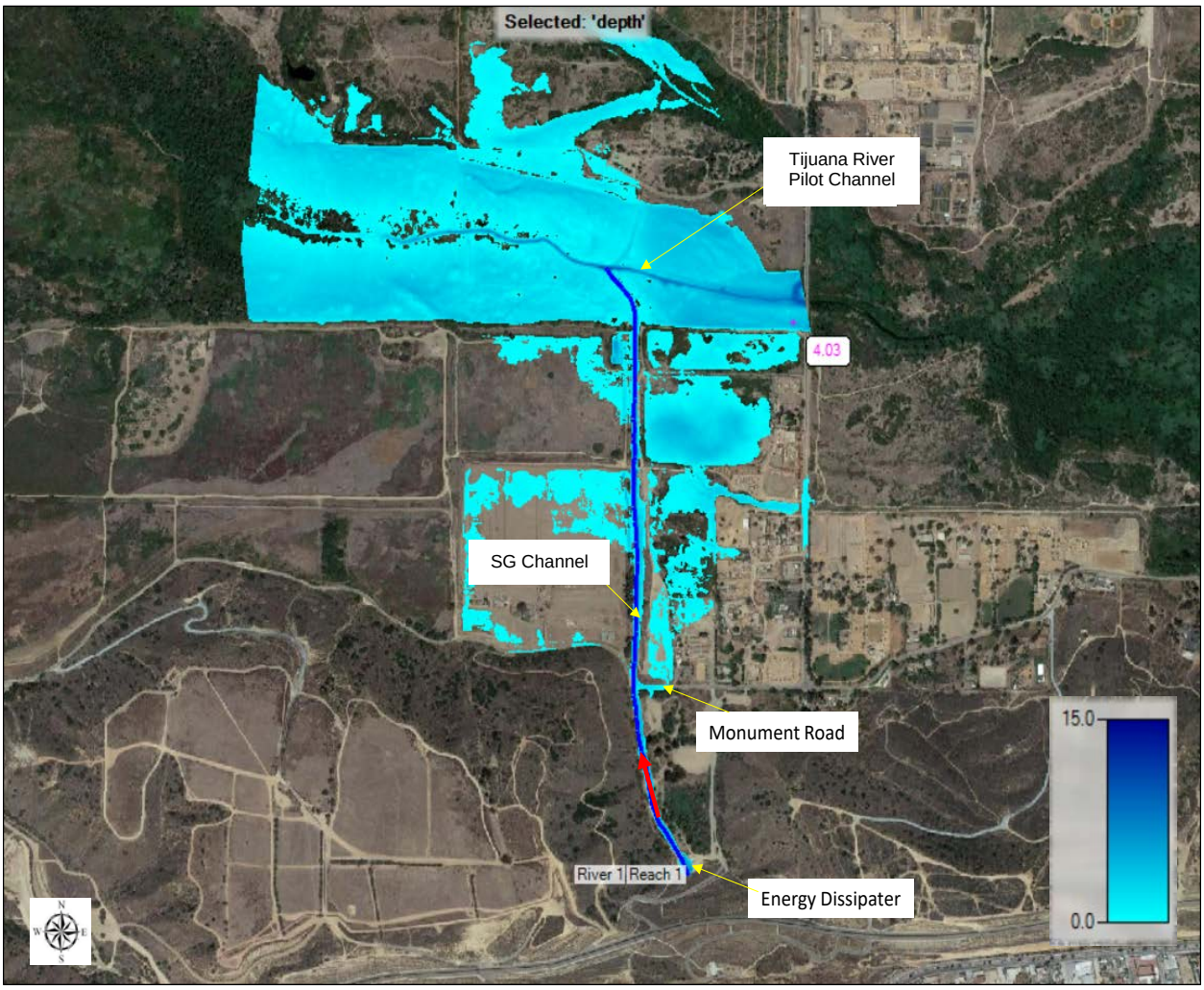
Figure 9. Alternative A – Sedimentation Basins

Source: Excerpted from Stantec (2018)

4.2 Smuggler's Gulch

As part of the evaluation of sediment issues within Tijuana River Valley, a preliminary two-dimensional (2D) hydraulic model (HEC-RAS 5.0.6) of Smuggler's Gulch was developed based on the USACE 2015 LiDAR data. The 5-year floodplain (excluding Tijuana River inflow) is shown on Figure 10. The flow is contained within the main channel upstream 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 sediment/trash contained within the main channel, which would require increasing the capacity of the existing corrugated metal pipe and elevating the road across the gulch.

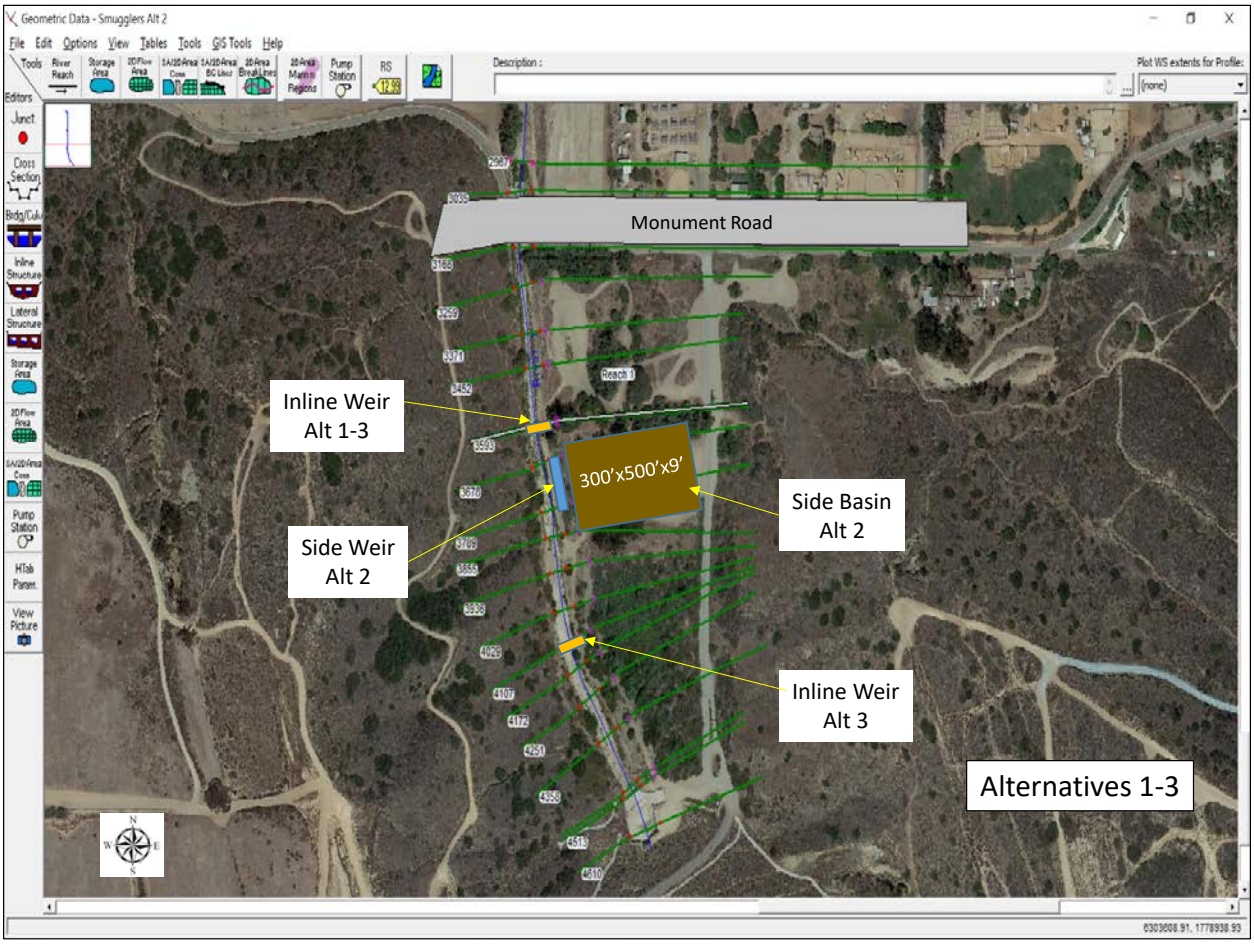
Figure 10. Smuggler's Gulch 5-year Floodplain



To analyze conceptual sediment alternatives in Smuggler's Gulch (see *Tijuana River Valley Needs and Opportunities Assessment – Sediment* TM), a preliminary hydraulic and sediment transport model (HEC-RAS 5.0.6) was developed from the border to about 500 feet downstream of Monument Road (Figure 11).

Three sediment basin alternatives were considered in the *Tijuana River Valley Needs and Opportunities Assessment – Sediment* TM. All three alternatives included improvements to the existing culvert and roadway profile for Monument Road. The computed hydraulic profiles for all the alternatives (for the 5- and 100-year flood events) were evaluated and are discussed further in the Sediment TM. Although the alternative hydraulic models showed an increase in the hydraulic profiles upstream of the proposed inline weirs, the 100-year profile was still contained within the channel banks upstream of the weir. Although not primarily designed to provide flood benefits, the proposed replacement of the existing culvert under Monument Road would improve the flood protection for the road and, therefore, could potentially reduce roadway closures attributable to flooding. Further discussion of this project alternative can be found in the Sediment TM.

Figure 11. Smuggler's Gulch HEC-RAS Model Schematic



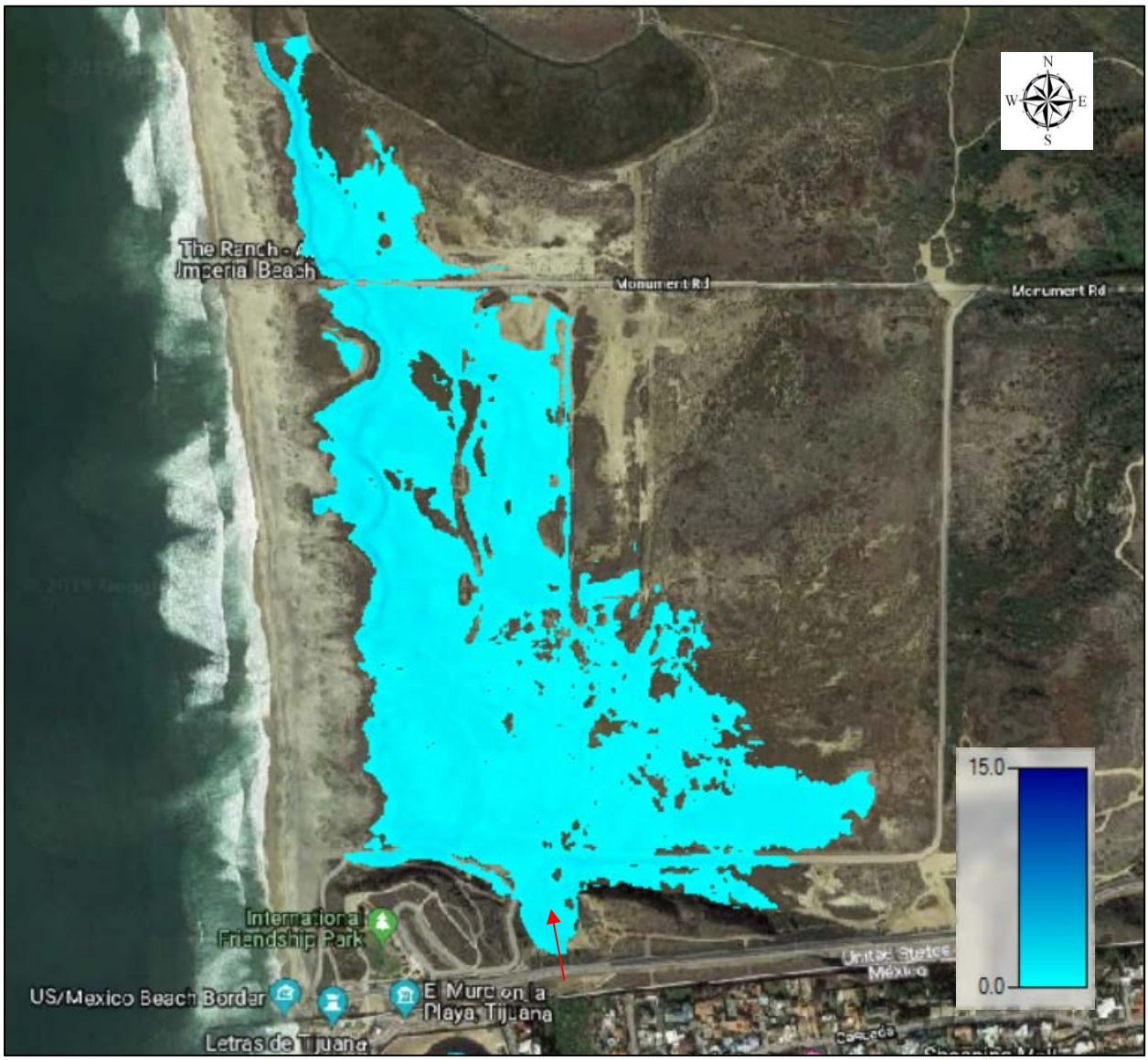
4.3 Goat Canyon

No projects are being considered as part of the Needs and Opportunities Assessment that are expected to have any impact (positive or negative) on the flood risk associated with Goat Canyon. Ongoing maintenance of the existing channel and sediment basins would be required to maintain the design conveyance capacity.

4.4 Yogurt Canyon

Similar to Smuggler's Gulch, a preliminary 2D hydraulic model (HEC-RAS 5.0.6) of Yogurt Canyon was developed, based on the USACE 2015 LiDAR data, as part of the NOA study. The 5-year floodplain (excluding Tijuana River inflow) is shown on Figure 12. The sheet flow and sediment potentially spread over the floodplain and to the estuary, with maximum depths generally below 1 foot. It is preferable to keep the flow and sediment/trash contained within a narrower conveyance (up to 5-year flood frequency) to help convey the material downstream. This would require a pilot channel which would cross Monument Road under a prefabricated creek crossing structure. The pilot channel would be integrated north of the road with restored salt marsh habitat.

Figure 12. Yogurt Canyon 5-year Floodplain



A potential project being considered is a 25-foot-wide pilot channel to convey Yogurt Canyon flows and sediments up to a 5-year flood frequency to the ocean (see Figure 13). The channel would cross Monument Road 350 feet north of the border and turn northwest toward the beach. The proposed crossing would be a clear span bridge with a capacity to convey the 5-year flood with sediment. The proposed bridge would also help alleviate flooding (depth and duration) of Monument Road for floods greater than 5-year events, as well.

Figure 13. 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 (Figure 13). Further discussion of this project alternative can be found in the *Tijuana River Valley Needs and Opportunities Assessment – Sediment* TM.

5 Emergency Action Plan

Despite existing and anticipated infrastructure, there are times when the volume of flows is too high, resulting in flooding impacts to the area. In these instances, emergency action plans are needed to identify protocols to address the flooding risks. Road closures (for example, Monument Road) are frequent and homes may be threatened or damaged by the Tijuana River and/or the collector channels. The USIBWC, City of San Diego, County of San Diego, California State Parks, and other affected agencies/stakeholders should establish coordinated emergency action protocols (channel maintenance, road closures, evacuations, etc.) to be carried out in advance of significant storm forecasts. Predictive models could be developed and used to inform decision makers and emergency responders. A community flood alert system is a common example of this type of approach and would be recommended for consideration in the Tijuana River Valley.

6 Summary of Project Recommendations

This section describes potential projects that may have a secondary benefits of flood risk reduction, as well as potential new projects being considered by others (independent of the Needs and Opportunities Assessment). The projects are included here for reference. Additional details can be found in the other Needs and Opportunities Assessment TMs or reference documents.

Table 1 describes the projects and implementation costs for each project for the watersheds.

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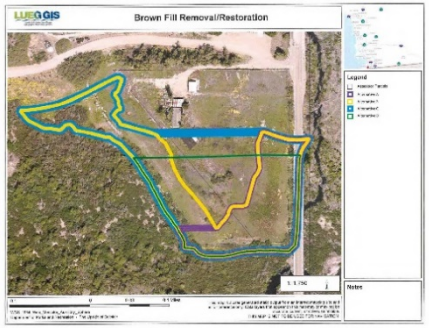
Table 1. Proposed Implementation Projects

Project #	Project Title	Project Description	Funding Needs	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 million b. $4.8 million c. $2.6 million • Estimated ongoing cost: $1 million/year	

Table 1. Proposed Implementation Projects

Project #	Project Title	Project Description	Funding Needs	Example
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 prefabricated creek crossing structure. The pilot channel would be integrated north of the road with restored salt marsh habitat. This project is currently being assessed by the Senate Bill 507 Needs and Opportunities Assessment.	• Estimated implementation cost: <$5 million • Estimated ongoing cost: <$5,000/year	
19	Brown Property Restoration	Remove or adjust fill materials within a specific property to reestablish previous hydrologic flow conditions in this portion of the Tijuana River. This project is currently undergoing design and environmental review by the County.	• Estimated implementation cost: <$3.5 million • Estimated ongoing cost: $100,000 to $250,000/year	
21	Invasive Species Removal and Restoration	Invasive plant species have increased in abundance in the Tijuana River Valley, which is facing infestation from an invasive beetle (shot-hole borer). There are plans to remove these invasive species and restore native habitat. The County of San Diego has identified multiple sites for restoration.	• Estimated implementation cost: $5 million to $10 million • Estimated ongoing cost: $100,000 to $250,000/year	

7 References

AECOM. 2016. *Nelson Sloan Management and Operations Plan and Cost Analysis*. Prepared for County of San Diego Department of Parks and Recreation.

AMEC Earth and Environmental. 2007. *Goat Canyon Retention Basin Soil Particle Size Distribution Study*.

———. 2008. *Tijuana Estuary Sediment Study*. Prepared for California Division of Boating and Waterways.

Benham, L. 2019. *Elimination of Sand Capture Basins and the Restoration of the Tijuana River, in support of Citizens for Coastal Conservancy*.

Chang Consultants. 2007. *Hydraulic and Sedimentation Study for Wetland Restoration in the Tijuana River Floodplain*. Prepared for Dudek Engineering & Environmental.

———. 2019. *Hydraulic and Sediment Transport Analyses for the Brown Property Fill Removal*. Prepared for San Diego County Department of Parks and Recreation.

Chang, H. 1998. *FLUVIAL-12 Mathematical Model for Erodible Channels, User's Manual*.

Minute 320. 2017. *Report of Transboundary Bypass Flows into the Tijuana River*. Minute 320 Binational Technical Team, Water Quality Work Group.

Moffatt & Nichol. 2006. *Final Sand Compatibility and Opportunistic Use Program Plan*. Prepared for SANDAG and California Coastal Sediments Management Workgroup.

Nautilus Environmental. 2008. *Goat Canyon Retention Basins Phase II and III Source Material Soil Characterization Report*.

Resource Consultants and Engineers. 1994. *Sediment and Erosion Design Guide*. Prepared for Albuquerque Metropolitan Arroyo Flood Control Authority AMAFCA.

Rick Engineering. 2003. *Hydraulic and Sedimentation Study of Goat Canyon Creek for the Goat Canyon Enhancement Plan*.

Stantec Consulting Services. 2018. *30% Report Feasibility Study for Sediment Basins Tijuana River International Border to Dairy Mart Road*. Prepared for International Boundary and Water Commission.

Stantec Consulting Services. 2019. *60% Report Feasibility Study for Sediment Basins Tijuana River International Border to Dairy Mart Road*. Prepared for International Boundary and Water Commission.

Tijuana River National Estuarine Research Reserve. 2005. *Goat Canyon Sediment Basins – An Effective Model for Marine Debris Capture in the Tijuana River Watershed*.

University of California, Irvine. 2017. *Brown Fill Removal Alternatives: Hydrologic and Hydraulic Analysis*. In support of NSF/UCI FloodRISE Project.

URS. 2009. *Smugglers Gulch Channel Excavation Soils Sediment Characterization Report*.

US Army Corps of Engineers (USACE) Los Angeles District. 1977. *Basis for Design Memorandum – Tijuana River Project, San Diego, California*.

US 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*.

US Army Corps of Engineers (USACE) Los Angeles District. 2019. *Tijuana River Levee Rehabilitation Project, 60% Design Documentation Report.*

———. 2010. *Report of Trash, Waste Tire and Sediment Characterization – Tijuana River Valley, San Diego, California*.

———. 2012. *The Hydraulic and Floodplain Study of the Tijuana River*. Task Order IBM10T0048, contract IBM09D0008.