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THE LOST ASSETS: PROTECTING SEWER CREEK CROSSINGS AND THE ENVIRONMENT THE CREEK PROTECTION PROJECT, SACRAMENTO AREA SEWER DISTRICT SACRAMENTO, CALIFORNIA

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ABSTRACT: Creek crossings are inherently weak points of any collection system due to limited access and environmental issues that complicate maintenance and repairs, and floodwaters that can damage pipelines and manholes. Also, sanitary sewer overflows (SSOs) into open channels pose a risk to public health and safety and have significant environmental impacts.

SASD owns and maintains approximately 3,000 miles of sanitary sewers, of which 638 sewers cross open-channel waterways. SASD has implemented a Creek Protection Program to reduce the risk of, and improve the response to SSOs that occur at creek crossings. The Creek Protection Project has two objectives: 1) to evaluate and design improvements for the 41 priority creek crossings, and 2) to develop Creek Protection Plans (Emergency Response Plans) for waterways most at risk of experiencing an SSO.

This paper discusses the project as a whole from inception to completion and provides an open discussion of the development of techniques used in the field investigations, categorization of individual sewer crossings, risk assessment of waterways, and creation of Creek Protection Plans. The challenges of preparing rehabilitation designs that consider existing pipe materials, but still allow construction in and around creeks, are also discussed.

INTRODUCTION

The Sacramento Area Sewer District (SASD, District) owns and maintains approximately 3,000 miles of sanitary sewers. These sewers cross creeks and other waterways at over 600 locations. The sewer crossings of waterways can have an additional risk, beyond that of other portions of the collection system, because the consequence of a sanitary sewer overflow (SSO) is higher since SSOs are more difficult to address because of limited access to the sewer pipe in the waterway. The District is developing and implementing a Creek Protection Project to reduce the risk of and improve the District's response to SSOs that occur in creeks and other waterways.

District Collection System Description

The SASD is the largest of four contributors to Sacramento Regional County Sanitation District (SRCSD). The District's collection system serves over 1 million customers, has 2,700 miles of pipe ranging in size from 4 to 75-inches in diameter, and a total of 672 waterway crossings. The District's service area boundaries are delineated in Figure 1.

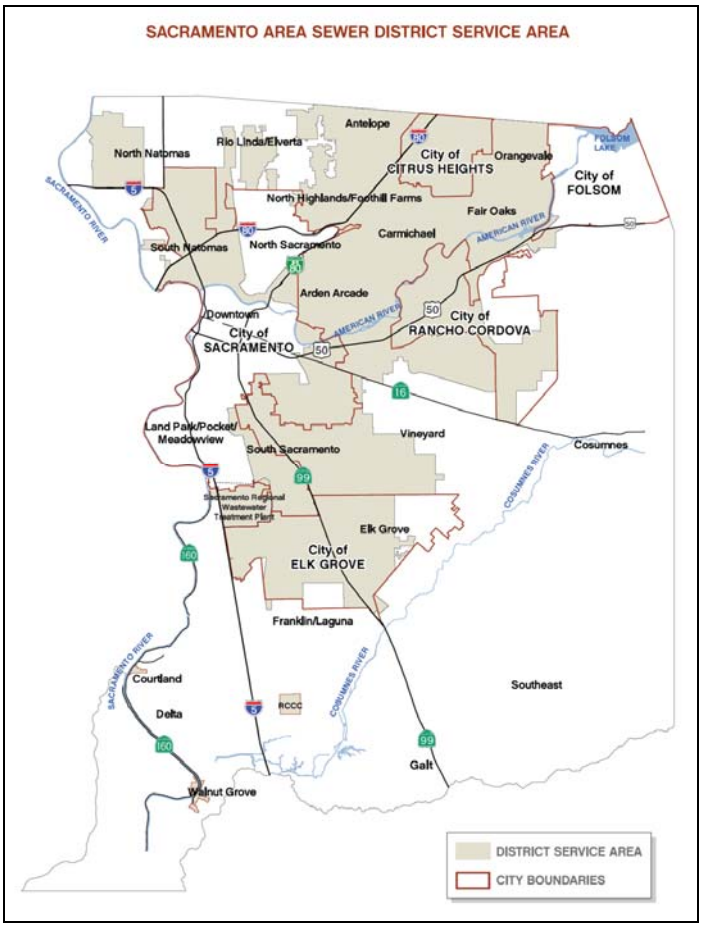

Figure 1 - SASD Service Area Boundaries

Project Drivers

The CPP was initiated after the District had two SSOs at creek crossings within their distribution system. The first break occurred in March 2007 at an Arcade Creek crossing. The second was also at an Arcade Creek crossing, in February 2008. The District immediately initiated inspection of all 672 creek crossing sites and selected Brown and Caldwell to support them in the characterization and implementation components of the CPP.

Creek Protection Project Description

The District elected to follow a phased approach including the following:

- Site Evaluation – As an initial step, the critical crossings identified during the District's initial field effort were further evaluated and prioritized. Based on each site's priority level, repair alternatives were then proposed and designs prepared.
- Creek Protection Plans – This phase of the project included planning for all 672 crossings. Due to the large number of crossings throughout the District's system, a prioritization model was developed to allow the District to select the highest priority creeks. Creek protection plans were then developed for the first round of high priority creeks.
- Permitting Assistance – In parallel with the other tasks on this project, a review of permitting needs and opportunities was prepared for the District.

The discussion presented in this paper is primarily focused on the first two items in the list above.
Site Evaluation

A comprehensive field investigation program was conducted for the 41 crossings identified during the District's initial fieldwork to have significant problems. Based on this investigation, the crossings were categorized as "Monitor", "Preliminary Design", or "Phase 2" based on the recommended action required for the individual crossing. Using the results and recommendations from the field investigation, the District now has detailed documentation and a better understanding of their highest priority crossings.

Creek Protection Plans

Preparation of Creek Protection Plans is the portion of the CPP that specifically addresses the District's response to SSOs which occur in open-channel waterways. Because of the quantity of creek crossings in the SASD system, the preparation of detailed Creek Protection Plans was divided into phases. The Creek Protection Plan recently completed is the first phase, which addresses waterways with the highest risk, as determined by a waterway risk assessment model. Detailed Creek Protection Plans for medium and low risk waterways may be developed in subsequent phases.

SITE EVALUATION AND REPAIR

This section will review the first phase of work in the CPP which included evaluation, prioritization, and preliminary design for the District's 41 critical creek crossing sites. A summary of the fieldwork performed by District staff is provided, followed by a detailed summary of the condition assessment performed on the 41 critical creek crossing sites. Finally, a brief summary of each of the deliverables prepared as part of this effort is provided.

District Fieldwork

The District performed the first step of the CPP by field visiting each crossing and collecting site information regarding the condition of its 672 creek crossings. District staff collected information such as pipe material type, crossing type, and erosion conditions and entered this information into an Access database.

Based on these site visits, the District prioritized 41 sites as "critical" which included sites that were most compromised and could potentially cause discharge of sewage into a waterway. The term "crossing" is defined as a location where the sanitary sewer pipeline comes within close proximity to the waterway. This includes situations where the pipeline crosses a waterway or, in some cases, the pipeline may parallel the waterway.

Photo 1 – Site 13 consists of a cast iron pipe that was originally buried and was exposed as the creek incised over time.

Condition Assessment

Each of the 41 critical sites identified by the District was assessed based on information provided by the District, as well as by visiting each site. This information was evaluated so that each site could be prioritized for future repairs. The following section provides more detailed information regarding the field investigation performed, as well as the documentation prepared to support detailed repair designs.

Field Investigation

The goal during the field investigation was to perform one field visit at each site. Prior to initiating field visits, the District provided information such as closed circuit television (CCTV) videos, as-builts, and photos for each of the 41 critical sites. By anticipating data needs and using a consistent form for all site visits, the majority of the necessary information was collected during the initial site visit.

The initial fieldwork team consisted of a registered civil engineer, geotechnical engineer, and geomorphologist. In addition, District staff accompanied this fieldwork team to provide access when needed, confirm as-built/abandonment conditions, and confirm completed repairs.

Photo 2 – Rapid geomorphic assessment was used to characterize the overall geomorphology at each of the creek crossing sites.

Photo 3 – A structural engineer performed field visits to sites where potential structural deficiencies were identified during the initial field visit.

Fieldwork Results

After the fieldwork was completed, each of the critical sites was categorized as “Monitor”, “Preliminary Design”, or “Phase 2”, as defined below:

Monitor. During the field investigation, nine sites were determined to be in good condition and do not need repair at this time. However, since all crossings have the potential to degrade over time, these sites were designated as requiring periodic inspection and monitoring to determine when the sites may need repair work in the future.

Preliminary Design. Pre-design sites included those crossings where repairs are straight-forward and/or consist of repairing existing erosion control measures. Permitting for pre-design sites is anticipated to be minimal because the work required is considered to be maintenance. Sixteen sites were characterized as pre-design sites.

Phase 2. Phase 2 sites require extensive repair work associated with the pipeline crossing, streambed and bank erosion repair and mitigation, or replacement or removal of the pipeline. This work will include extensive research, design, and permit and agreement acquisition which will require more time and effort than for the sites identified for preliminary design. Approximately half of the sites were categorized as Phase 2.

Deliverables

After each of the 41 critical sites identified by the District was evaluated, a Critical Sites Condition Assessment Technical Memorandum (Condition Assessment TM) was prepared. This document included a summary of existing information, a description of the fieldwork performed by each discipline, and a summary of field observations and preliminary repair recommendations for each critical site. It also contained photos taken at each site, detailed field notes regarding the condition of the crossing, as well as geomorphology assessment data sheets documenting the creek characteristics observed.

Subsequent to the Condition Assessment TM, a technical memorandum was prepared to further define the basic repairs required for each of the sites categorized as “preliminary design” (pre-design). The goal of Crossing Repairs TM was to provide enough information to prepare a preliminary design report for the sites categorized as pre-design.

The Crossing Repairs TM included a description of each of the monitor, Phase 2, and pre-design sites including a summary of the crossing condition and monitoring/repair recommendations. Ten percent preliminary design plans (“A” plans) for the proposed basic repairs at pre-design sites were included as an appendix. Each pre-design site discussion also included a characterization of the waterway and permitting requirements associated with the proposed repair. Additional detail regarding preliminary hydraulic modeling performed for the pre-design sites where erosion control measures were recommended was also provided. Finally, the next steps were outlined including action items and the proposed implementation schedule.

Based on the recommendations presented in the Condition Assessment TM and Crossing Repairs TM, the District compiled its list of 2010/2011 Project Sites. The 2010/2011 Project Sites presented in the PDR included nine (9) pre-design sites and five (5) Phase 2 sites, for a total of 14 Project Sites.

The purpose of the PDR was to build on the recommendations of the Condition Assessment TM and Crossing Repairs TM by preparing the preliminary design for each of the fourteen (14) Project Sites. Potential design and construction issues were described, as well as project phasing and scheduling constraints. The PDR contains a description of each of the 14 Project Sites including repair recommendations, a characterization of the waterway, and permitting requirements associated with the proposed repair. A preliminary engineer’s opinion of probable construction cost and a proposed construction schedule was also provided for each site. The anticipated list of stakeholders, owners,

utilities, and agencies was also included for each of the sites.

PRIORITY SITE DESIGN

After the PDR was completed, the District selected five sites as priority sites for repair and rehabilitation. This section will review each of these sites and the repairs proposed for each one.

At each of the priority sites, the existing sewer mains have been in place for a minimum of 25 years and have been shown to be at an increased risk of failure due to age, exposure to the elements, and the general public. The existing sewer mains vary in size from 6-inch to 8- inch in diameter and are primarily constructed of ductile iron (DIP), cast iron (CIP), or concrete mortar- coated steel pipe materials. At one site, a structural support has failed and is completely washed out, resulting in a long stretch of unsupported pipe within the creek.

The sewer main replacement alternatives were selected based on specific site constraints, risk reduction potential, and the ability to reroute sewer mains to existing facilities. The alternatives selected at each of the five sites are summarized in Table 1 below.

Table 1. Alternatives Selected at Each of the Five Sites

Site	Repair Description
7	New creek crossing
13	Sewer main realignment
22	New creek crossing
23	Sewer main realignment
27	Creek undercrossing and sewer lift station

Site 7

Site 7 consists of a 6-inch diameter DIP gravity pipeline located in Cripple Creek at the end of Zeeland Drive. The crossing was installed in 1985 and is comprised of two sections: an aerial crossing situated approximately 4.5 feet above the creek bed and a portion of the pipeline with minimal cover between the left bank and upstream manhole. One pipe joint is unsupported in the middle of the aerial crossing. As-built drawings indicate that the original design called for three supports. Based on field measurements it appears that the third support is now buried in the left bank.

The following repairs will be performed at Site 7:

- Replace the existing 6-inch ductile iron pipe (DIP) with approximately 60 linear feet (LF) of 8-inch DIP contained within approximately 55 LF of 18-inch steel casing.
- Replacement of the two existing structural supports with new drilled piers to accommodate the new casing and carrier pipe loads.
- Provide concrete embedment between the left bank and the upstream manhole to protect the sewer main with minimal soil cover.

This repair alternative was selected for this site because there was no option to economically re-route the sewer line. Due the vertical location of the crossing within the waterway, a casing will be installed to provide additional carrier pipe protection during heavy storm events.

Site 13

Site 13 consists of a 6-inch diameter CIP gravity pipeline located in Arcade Creek. As-built drawings indicate the sewer line was originally buried with essentially no cover at the creek flow line. The crossing is now completely exposed and unsupported for 23 linear feet. The pipeline is three feet above the creek bed with two exposed joints.

Due to the significant erosion occurring, exposed pipeline, and unsupported joints, the following repairs will be performed at Site 13:

- Installation of approximately 715-ft of new pipeline re-routed away from the creek.
- Removal of the existing aerial creek crossing.

This repair alternative was selected for this site because re-routing was an economical option that allowed the District to remove a sewer crossing from a waterway.

Site 22

Site 22 consists of an 8-inch diameter CIP gravity pipeline crossing Arcade Creek near Crosswoods Circle. The pipeline is shown partially buried in the creek bed in the as-built drawings dated 1971; however, site visits in September 2008 indicate the pipeline is now approximately three inches above the creek bed.

Due to the erosion occurring and the creation of an unsupported crossing, the following repair options are provided for consideration:

- Replace the existing 8-inch CIP with approximately 56 LF of 8-inch steel pipe installed 10-ft into each creek bank.
- Installation of two drilled piers to accommodate the new steel pipe loads.
- Installation of approximately 5-cy of stone cobble apron upstream and downstream of the pipe crossing.

This repair alternative was selected for Site 22 because there was no economical re-route option at this location. In addition, the crossing is situated very near the creekbed and the new pipeline connections will be embedded further into the creek banks to limit the potential for future joint failure.

Site 23

Site 23 consists of a 6-inch diameter CIP gravity pipeline crossing an unnamed creek which is a tributary to Arcade Creek. As-builts dated 1986 indicate that the pipeline was originally installed approximately 1.5 feet below the creek bed. The pipeline is now exposed and is situated approximately 6 inches above the creek bed. In addition, a 16-foot stick of CIP was installed, of which 12 feet is now exposed. Therefore, the joints at which the CIP transitions VCP within each bank are within 1 to 2 feet of the creek bank.

Due to the creation of an unsupported crossing and the close proximity of the pipe material transitions to the creek bank, the following repairs will be performed:

- Installation of approximately 890-ft of new pipeline re-routed away from the creek.
- Removal of the existing aerial creek crossing.
- Abandonment of the existing buried pipeline.

This repair alternative was selected for this site because re-routing was an economical option that allowed the District to remove a sewer crossing from a waterway.

Site 27

Site 27 consists of an 8-inch diameter mortar-coated steel pipeline. It is an aerial crossing over Arcade Creek, near Arcade Creek Park and Garfield Avenue. The pipeline is deflecting in both the horizontal and vertical direction. The mortar coating is no longer present on a 4-foot portion of the pipeline exposing one of the joints. The exposed joint bell is bent and is in poor condition. An offset joint was noted at the transition from pipe material to VCP, which occurs near the left creek bank.

Undated as-builts for the site indicate the crossing was originally supported by two concrete support structures. During field visits, only one support structure was observed at the site. Concrete remnants, assumed to be the failed pier, were located in the creek bed in the vicinity of the crossing. The remaining

support has only six inches of embedment into the existing creek bed and appears to have differential settlement.

Due to the significant erosion occurring and the creation of an unsupported crossing, the following repairs will be performed:

- Installation of 8-in (nominal inside diameter) HDPE piping under the creek bed using pilot tube microtunneling technology.
- Installation of a new 250-gpm sewer lift station.
- Remove the existing aerial creek crossings at sites 27 and 25 (a separate nearby crossing).

While installation of a new lift station and sewer crossing under the creek is more expensive than replacing the crossing at its current location, the District selected this option because it completely removes two sewer crossings from the creek and thereby removes the risk of an SSO in the creek at this location.

CREEK PROTECTION PLAN

In this portion of the CPP, Creek Protection Plans (Plans) were developed to specifically address the District's response to SSOs which occur in open-channel waterways. Because of the quantity of creek crossings in the SASD system, the preparation of detailed Creek Protection Plans was prioritized into phases by a waterway risk assessment model. The Plans include standard information that applies to all waterways within the plan area followed by detailed mapping for each waterway.

The waterway risk assessment model was used to determine the risk of SSOs within waterway segments using the concepts of risk analysis – consequence of failure and likelihood of failure. Using hydrologic GIS maps, the waterways were grouped and/or divided by common channel characteristics, such as channel geometry and erosion control measures. The waterways were divided into a total of 100 segments for analysis in the model.

In addition to SSOs that occur in any part of the collection system, an SSO at a creek crossing can also be caused by washout of the pipeline. Creek crossings are susceptible to being damaged by flows in the waterway or changes in the waterway channel over time. High velocities in the waterway can carry debris including boulders, tree limbs, and trash, which can damage the pipeline or its supports, causing an SSO. Scour and erosion of the channel bottom and banks can also undermine the pipeline, pipeline support structures, and manhole structures.

If an SSO occurs directly in the waterway, the Plans provide the following information to supplement the District's SSO Emergency Response Procedures Manual:

1. Forcemain creek crossing details.
2. Spill containment and recovery locations.
3. Sizing procedures for emergency bypass pumping equipment.
4. Equipment rental supplier contact information.
5. Contractors for emergency construction.

The Creek Protection Plan is divided into Plan Areas, which are shown in Figure 4. Each Plan Area includes detailed Emergency Response Maps, which show available features such as sewer facilities, storm drainage facilities, streets, public facilities, and equipment and pedestrian access points. These maps are based on County and District Graphic Information System (GIS) records and other information described in the following sections. For consistency with other District mapping and response plans, the Emergency Response Maps are based on the District's existing Facility Map grid system. Facility Map numbers are provided on each map, along with the adjacent maps located along the waterway.

The Emergency Response Maps identify sites along the waterways used from 2005 through 2009 for spill containment and recovery. District notes were provided and reference was made to the past SSO event for which photographs are provided.

Creek Crossing Information:

Type	USMH			DSMH			Flow Rate (gpm)			Plug Time (hr:min)	Low MH
	USMH No.	Rim El.	Invert El.	DSMH No.	Rim El.	Invert El.	Avg Day	Dry Peak	Wet Peak	min - max	No.
Gravity	**364-200-1042**	164.62	138.49	**366-200-1021**	149.29	138.09	1	2	3	10:44 - 38:14	364-200-1042
Gravity	**366-200-1004**	152.35	137.07	**366-200-1006**	146.67	136.29	5	11	12	3:44 - 8:60	366-200-1003
Gravity	**366-200-1018**	148.99	137.07	**366-200-1006**	146.67	136.29	298	439	1,170	0:16 - 1:01	366-200-1018
Gravity	**366-200-1034**	139.23	130.19	**366-200-1039**	140.69	128.27	421	618	1,357	0:14 - 0:46	366-200-1048
Gravity	**366-200-1044**	142.00	131.73	**366-200-1034**	139.23	130.19	91	170	248	0:24 - 1:05	366-200-1044

Spill Containment Site Reference SSO and Notes

Site 9	2007 - Madison Ave	Dam upstream of San Juan on Ranch Ave. Very easy site.
Site 10	2008 - 5641 Southgrove	Essentially the same as Site 2, just on the other side of San Juan.

Parks and Public Facilities Contact Information

SUNRISE RECREATION/PARK DISTRICT (916) 725-1585

FACILITY MAP 366-200 / PAGE NO. LA-3	Lower Arcade Creek (LA) MAP 3 OF 25	SACRAMENTO AREA SEWER DISTRICT CREEK PROTECTION PLAN	BROWN AND CALDWELL PROJECT NO. 136116

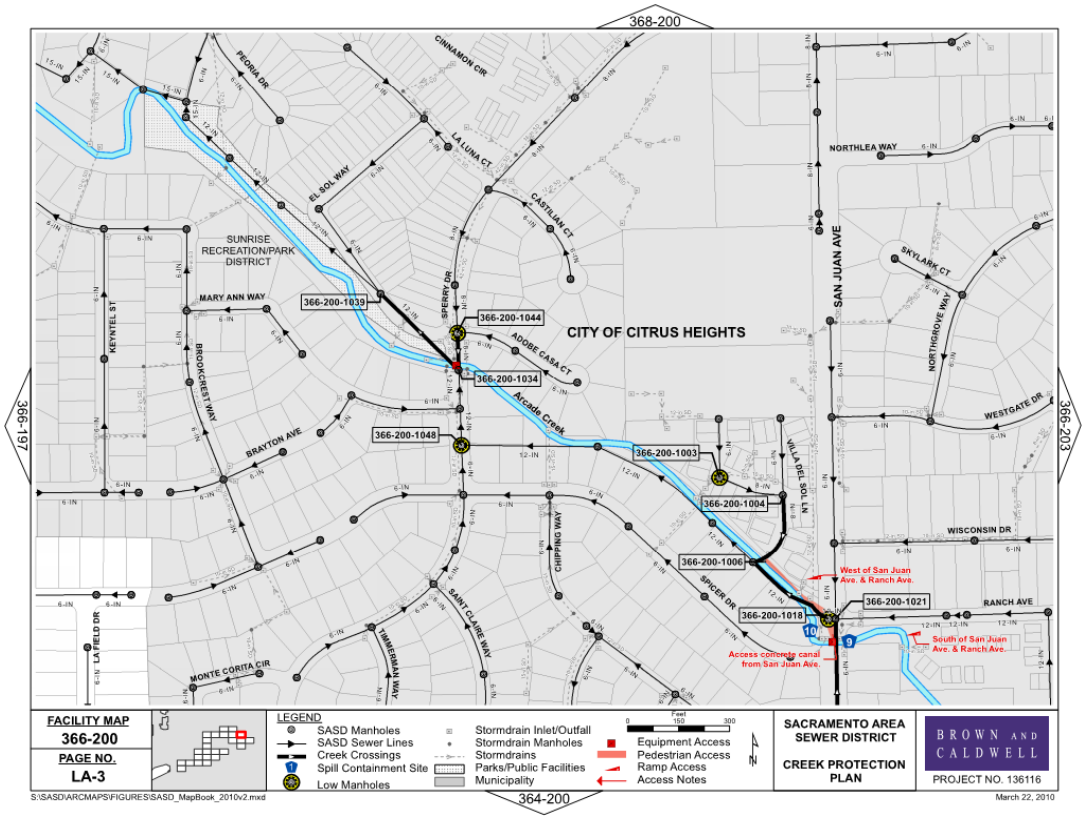

Figure 4 - Detailed Emergency Response Maps

SUMMARY

The primary goal of the CPP is to protect public health and safety and to protect stream health by reducing the risk of SSOs at waterway crossings. The project objectives were separated into two parts: evaluate and prepare designs for crossings deemed "most at risk of loss of structural support" by the District, and to prioritize the waterways for the development of protection plans.

The District has already completed minor repairs to six locations and is currently designing additional repairs to five sites, those that are most in need of repair. The remaining site repairs will be addressed in subsequent phases. The first phase of Creek Protection Plans has also recently been completed and the District is incorporating field versions of the Plans into their SSO manuals for immediate use by their field staff.

While many agencies are not addressing their vulnerable crossings, the District has taken a proactive approach to evaluating, prioritizing, and repairing its creek crossing sites. Additional efforts are planned in the near future to complete the repairs at the remaining priority sites, as well as to prepare creek protection plans for medium and low risk creeks.

The District is paving the way for future agencies to learn from and implement the approach adopted for this project. This project continues to be successful because the District and consultants operate as a true project team, sharing ideas and working together to find the best overall solution.

LESSONS LEARNED

As with any project, there are always lessons learned. We offer the following for others that need to implement their own creek protection project.

- Understand both dry and wet weather characteristics at your creek crossings. The field visits and inspections were performed during dry weather conditions. However, wet weather observations gathered after hydraulic modeling had been performed allowed the design team to confirm modeling assumptions and validate its conclusions on which the final designs were based.
- Involve all internal stakeholders (including engineering, asset management, and operations and maintenance staff) from the beginning, and keep them involved throughout the emergency response planning process. Emergency response plans involve all facets of a collection system agency; keeping each stakeholder engaged in the development of the plan will ensure that competing interests can be met and one single document can meet the needs of everyone.

ACKNOWLEDGMENTS

We would like to acknowledge the support of our client, the Sacramento Area Sewer District, and specifically the following individuals: Sonny Lunde, Linda Peters, Ryan Shewry, and Michael Grinstead. Without their ideas, input, and support, this project could not continue to be a success.

REFERENCES

Brown and Caldwell, Critical Sites Condition Assessment Technical Memorandum, December 23, 2008

Brown and Caldwell, Crossing Repairs Technical Memorandum, January 19, 2009

Brown and Caldwell, Creek Protection Project Preliminary Design Report, May 29, 2009

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Brown and Caldwell, Creek Protection Plans, March 31, 2010