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Green Stormwater Infrastructure (GSI) Hydrologic Modeling: Albion Riverside Park Project in Los Angeles, California

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ABSTRACT

The Albion Riverside Park (Project) was constructed to prevent stormwater pollution runoff in the city of Los Angeles (City) rivers, lakes, and beaches. The stormwater facilities is owned and operated by LA Sanitation and Environment (LASAN) residing in a new park owned and maintained by City Department of Recreation and Parks (RAP). The 272-acre drainage area is predominantly residential and commercial land uses that drain to the site, and total project budget cost is $39.9 million including land acquisition and site remediation/clean up. Hydrologic modeling for this green stormwater infrastructure (GSI) project compares results from field data for water quality/quantity. This project improves the water quality of stormwater and dry-weather runoff entering the LA River to help meet city's total maximum daily load (TMDL). TMDLs provide a useful framework for stormwater quality management and modeling in urban settings, as shown in this work. Treated pollutants of concern include: bacteria, heavy metals, trash, oil and grease, volatile organic compounds, zinc, and copper. The project components are as follows: flows up to 28 cfs peak flow for 0.9 inch (85th percentile) design storm; two hydrodynamic separator units; underground infiltration galleries [capacity equal to 1.7 million gallons (MG)]; potential annual volume 31 MG/Year (95 AFY) infiltrated; bioswale area (12,000 sq. ft.); parking lot permeable paving area (7,500 sq. ft.). Details of water quality and water supply, water quality monitoring, flow meters, and infiltration volumes will be reviewed. The GSI hydrologic modeling methods are demonstrated in Los Angeles, California.

INTRODUCTION

Urban runoff or stormwater is a major source of water-quality degradation in rivers, lakes, seas, swamplands, and aquifers, all of which serve natural and socioeconomic functions. The decline of water quality in water bodies receiving stormwater is persistent in metropolitan areas through the United States and in many places around the world (Tam et al., 2014; Loáiciga et al., 2015; Sadeghi et al., 2019). Stormwater exhibits harmful physical-chemical-biological characteristics, large biochemical-oxygen demand (BOD), oil and grease, water-borne pathogens, suspended and total dissolved solids, trash, heavy metals, pesticide and nutrient content that damage the quality of receiving waters. One threat posed by stormwater is that of urban flooding and protection planning commonly recommends the deployment of Green

Stormwater Infrastructure (GSI) that captures some of the stormwater at development sites to the extent that soil permeability and other physical constraints permit it. The contamination of stormwater is the sum of a number of natural and anthropogenic processes: rainfall affected by changing precipitation patterns amidst pronounced seasonal and inter-annual variability of storm intensity; changing and expanding population and land use within urban areas; vulnerable receiving water bodies that become contaminated with degraded stormwater that hinders their hydrologic, ecologic, and socioeconomic functions.

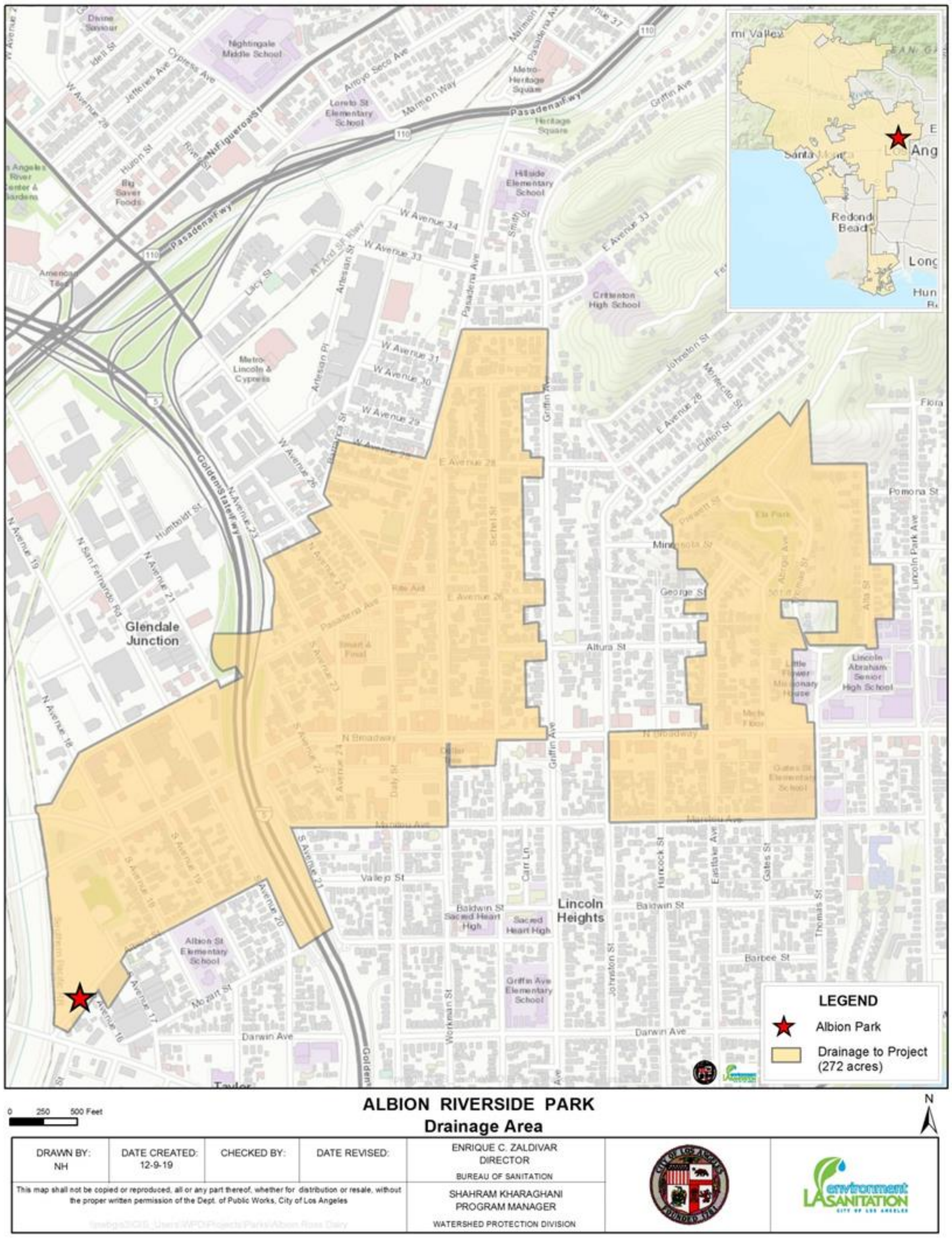


Figure 1. Map of Albion Riverside Park Project-City of Los Angeles (LA Sanitation & Environment).

Due to the harmful impact that contaminated stormwater has on receiving waters, State and Federal guidelines in the United States have been enacted to protect stormwater quality. One such tool is the allowable Total Maximum Daily Loads (TMDLs) of pollutants to natural waters from urban storm runoff. The body of technical publications in the arena of stormwater quantity, stormwater quality management, impaired water quality, GSIs, TMDLs, and is voluminous (City of Los Angeles 2009A, 2009B, and 2009C; Tam et al., 2014; Sebti et al., 2016; City of Los Angeles 2016; Sadeghi et al., 2017 and 2019; National Association of City Transportation Officials 2017; Clary and Piza, 2017; City of Los Angeles, 2018). One regulatory mechanism is through the setting of TMDLs, which, in turn, has given rise to a multi-billion-dollar industry of GSIs (Currier et al., 2005; Houle et al., 2013; Kurkalova 2015). Figure 1 shows a map of the City of Los Angeles (City) boundaries and the Albion Riverside Park Project (Project). The City has an area of 473 squared miles (1,225 km2), and 17,400 miles of streets (28,000 km), with a population of about 4 million people. Los Angeles' storm drain system consists of 1,500 miles of pipes (2,414 km), 100 miles of open channel (161 km). The GSIs in Los Angeles includes about 38,000 screened catch basins and thousands of others. Its average daily dry weather and wet weather runoffs are about 50 million gallons (189,250 m^3) and 10 billion gallons (38 million m^3), respectively [LA Sanitation & Environment (LASAN) - City of Los Angeles data from 2019].

A peculiar phenomenon observed in the GSI study area that adversely impacts stormwater quality is the "first flush" stormwater contamination (Stenstrom and Kayhanian, 2005). This is the generation of large amounts of stormwater pollutants during the first few storms over urban areas following a dry period during the summer season (Larsen et al., 1998). One way to treat first flush stormwater contamination is by deploying GSIs that retain stormwater and its pollutants at the point of origin or through their paths through urban areas (Strecker et al., 2001; City of Los Angeles 2016).

The City has established a three-pronged methodology to improve water quality and meet regulatory requirements:

- Enforcement of laws, codes, and ordinances to prevent/penalize polluting activities
- Implementation of structural measures (GSIs) such as the Project to remove pollutants from urban runoff
- Education and outreach to the public on stormwater issues

As a result, this Project is one of several measures that through the capture of multiple pollutants, will contribute towards the following:

- Preserving the aquatic marine habitat
- Reducing the potential risks to human health and safety
- Improve water quality by reducing pollutant loads to the impaired waters
- Increase the water supply and improving flood management
- Creating or enhancing open space, habitat, and recreation benefits
- Enhancing the beneficial uses of receiving waters

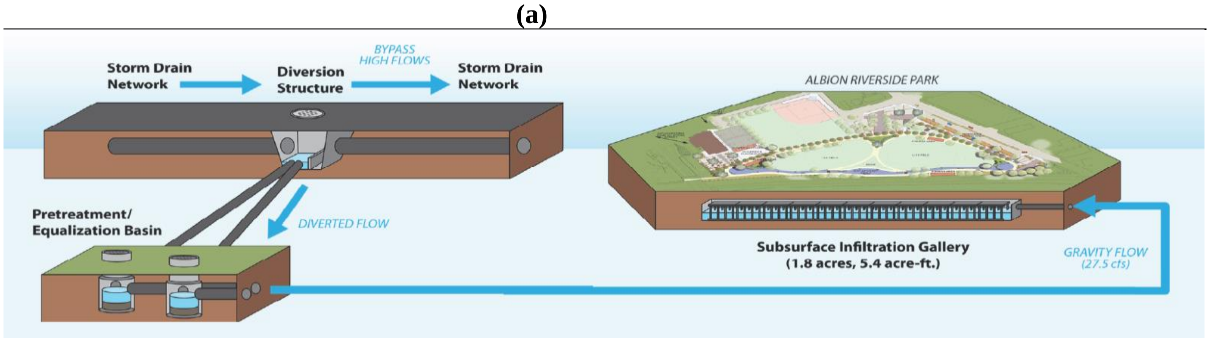
RESULTS AND DISCUSSION

Project Objective

The Project is located in the Los Angeles River Watershed and objective was to capture and infiltrate the stormwater from the storm drain of the Albion Ave. next to the Albion Riverside Park. Albion Riverside Park is a 6.0-acre park serving the Lincoln Heights (Council District 1-Gil Cedillo) community of the City. The park is operated and maintained by the City of Los

Angeles Department of Recreation and Parks (RAP) and the stormwater facilities is owned and operated by LA Sanitation & Environment (LASAN) residing in the new park. The Albion Riverside Park is adjacent to Los Angeles River and Downey Recreation Center, previously occupied by Ross Swiss Dairy and prior to that other Industrial user. The Project is designated as severely disadvantaged community by the California State Parks Community Fact Finder (Figure 1).

(a)



(b)

Figure 2. Map of (a) Albion Riverside Park Location and (b) Treatment Units Underground (Source: LA Sanitation & Environment).

Runoff from the Albion Riverside Park neighborhood discharges to the Los Angeles River. The Lincoln Heights is on the Clean Water Act Section 303(d) list as an impaired water body for coliform bacteria and trash, while the Los Angeles River is listed for trash, nutrients, metals, and bacteria. The City aims to meet the TMDL standards for the Los Angeles River by resorting to a system of structural GSI to capture, treat, and infiltrate the runoff in this project. The GSIs and water supply system consists of the following elements:

1. Diversion structure in an existing 52-inch-diameter storm drain
2. Two hydrodynamic separation pretreatment system (flows up to 28 cfs peak)
3. Five infiltration basin galleries (1.7 million gallons)
4. Porous pavers in the parking lots (7,500 sq. ft.)

5. Bioswale and bioretention basins (12,000 sq. ft.)
6. Potential stormwater annual volume 31 MG/Year (95 AFY) infiltrated

Total project budget is $39.9 million including land acquisition and clean up (contaminated soil). The funding sources are: City Funding [Water quality components ($32.1M) from Prop O Clean Water Bond Program; Recreational (non-water quality) components are Prop K ($700K), RAP ($1.5M), Site & Facility ($200K), CDBG ($250K), and Quimby ($150K)] and State Funding [Recreational (non-water quality) component is Prop 84 ($5M)]. Construction cost of $18.4M started in March 2017 and was completed in March 2019. Water quality monitoring was conducted on November 20, 2019.

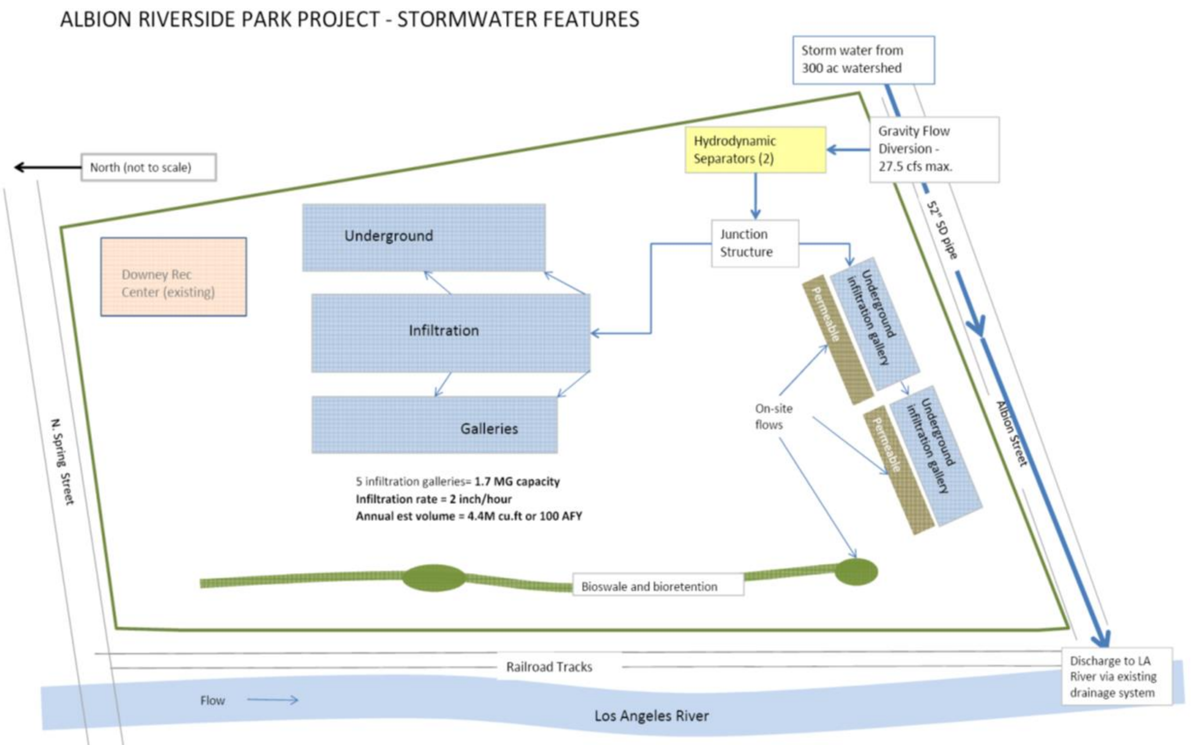
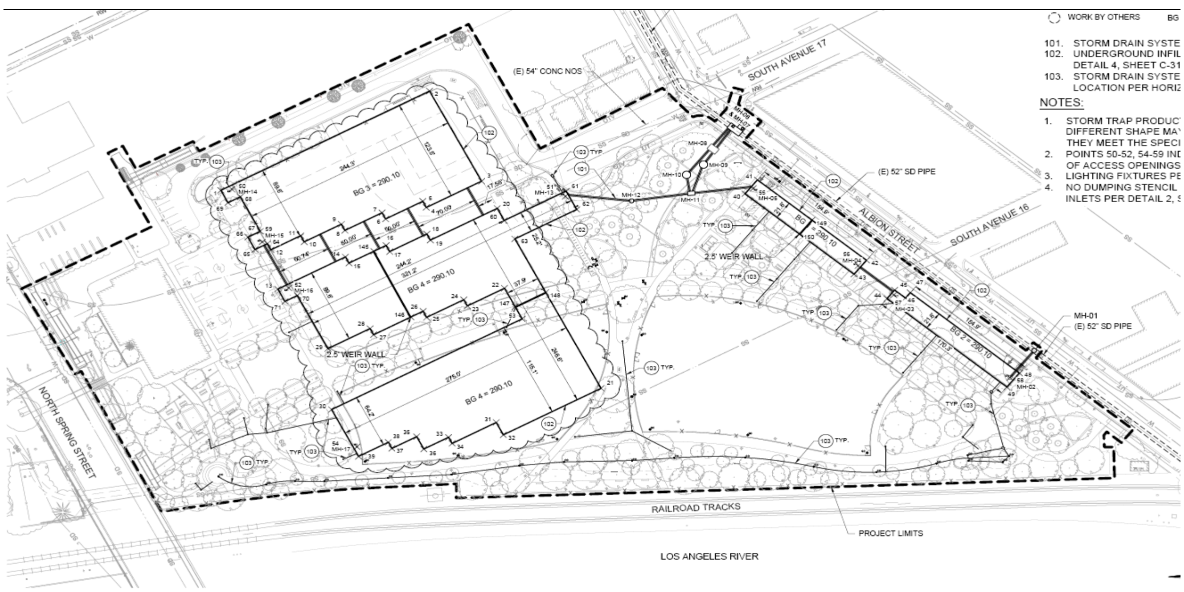


Figure 3. Albion Riverside Park Map of the Stormwater Features (Source: LA Sanitation & Environment).

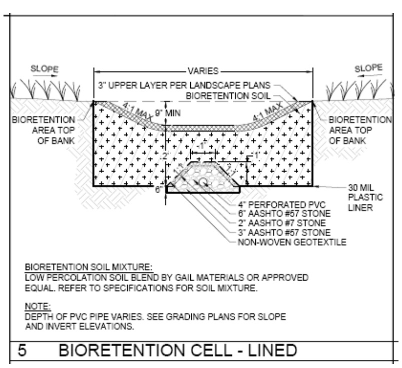
Storm drain flow that is captured in the infiltration basin galleries is removed through the storm drain system. The diversion, treatment, and infiltration of dry- and wet-weather runoff, prevent water carrying pollutants of concern [(which include fecal bacteria (E. coli), suspended solids, trash, oil & grease, volatile organic compounds, and metals (lead, zinc, copper and nickel)] from discharging to the Los Angeles River. Thus, water quality in the receiving waters is improved as a result of the implementation of the Project. Figure 2 shows the map of Albion park location and treatment units. Figure 3 shows Albion park map of the stormwater features. Figure 4 shows the infiltration gallery, bioretention cell lined, and bioretention cell unlined at Albion park.

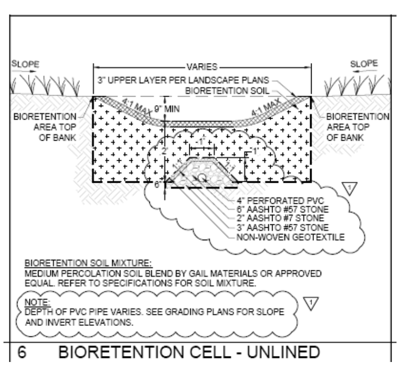
PROJECT DESCRIPTION

The Project abates stormwater pollution from a 272-acre drainage area (see Figure 1). The Project was constructed underground at Albion Riverside Park. Runoff is first diverted with an existing 52-inch-diameter storm drain pipe that traverses the northeastern corner of Albion Riverside Park. The runoff is diverted via an inline drop maintenance hole structure on the south side of the park, immediately south of Albion Avenue. The diverted water flows by gravity to two hydrodynamic separators for removal of heavy sediments, oil and grease, and floatable wastes. Each of the two hydrodynamic separator is a Continuous Deflective Separation (CDS®) unit by Contech (Model No. 5653-D with sump modification) with a minimum treatment flow capacity of 14.0 cfs and trash/debris sump capacity of 235 cubic feet. With the total flow of 28.0 cfs. The runoff then flows to five underground infiltration galleries with a total area of ~1.7 acres containing 5.1 acre feet (1.7 Million Gallons) of volume (based on 3-ft depth) constructed with StormTrap® Chambers with HS-20 loading, using baffle walls to screen additional floatables and increase the infiltration time. Three area-velocity meter/flow sensor are installed to monitor the flows into the park. In addition, several pressure transducer/level sensors are located in all the five infiltration galleries.



(a)





(b) (c)

Figure 4. GSIs at Albion Riverside Park (a) Infiltration Gallery, (b) Bioretention Cell Lined and (c) Bioretention Cell Nulined at (Source: LA Sanitation & Environment).

The Project complies with the California Environmental Quality Act (CEQA) and was found to be categorically exempt pursuant to City CEQA Guidelines Article III, Section 1, Class 3(4), which states that “installation of new equipment and/or industrial facilities involving negligible or no expansion of use is exempt from the requirements of CEQA if required for safety, health, the public convenience, or environmental control.” The Notice of Exemption document was filed with the Los Angeles County Clerk.

MONITORING DATA RESULTS AND POLLUTION LOADS REDUCTION

Stormwater flows were diverted from the storm drains for infiltration instead of discharging into the Los Angeles River. With the treatment of dry and wet-weather runoff, water carrying pollutants of concern such as bacteria (total coliforms, E. coli and Enterococcus), suspended solids, and metals (lead, zinc, copper, and cadmium) were prevented from discharging into the Los Angeles River Watershed. Thus, water quality in the receiving waters is improved as a result of the implementation of the Albion Riverside Park Project. One storm event was sampled during the post-construction phase of monitoring on November 20, 2019. The November 20th storm event produced 0.61 inches of accumulated rainfall for its duration total rain amount for 48 hours. All the rainfall data were taken from the LA County precipitation map (http://dpw.lacounty.gov/wrd/precip/).

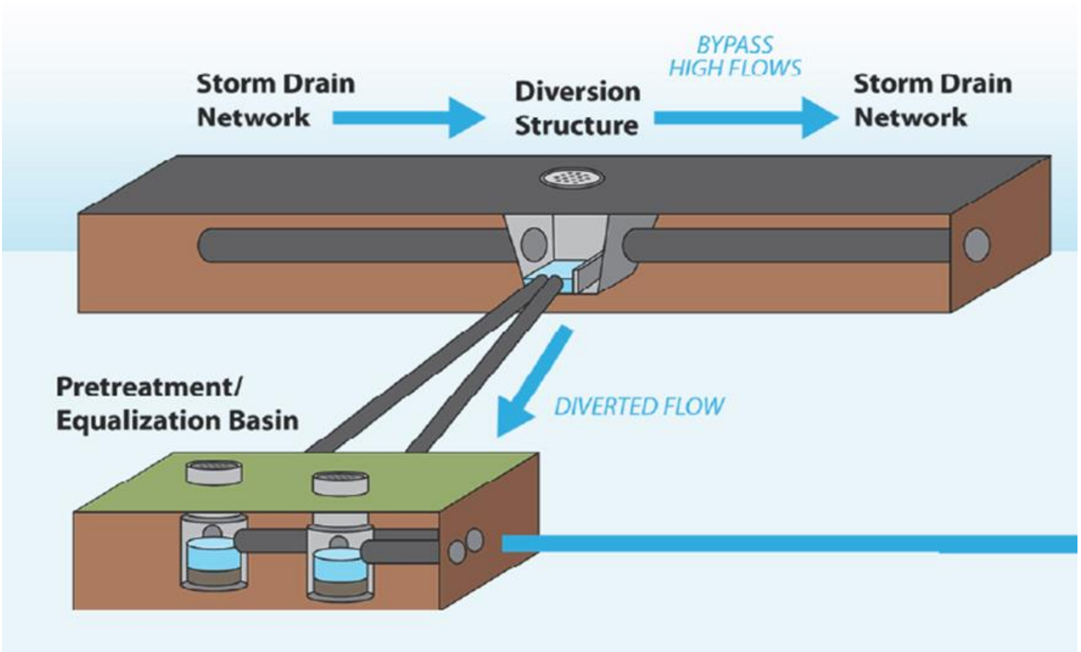


Figure 5. Albion Riverside Park Project, showing approximate locations of post-construction monitoring sites (a) at Diversion Structure and (b) after the CDS Units (Source: LA Sanitation & Environment).

Visual observations were made that noted major accumulation of debris and trash in the two CDS units for the sites. The rain water sampling was done by City staff (LASAN) at the Albion Park. These two rain water sampling locations which are from the Diversion Structure (before the CDS units) and after the CDS units are shown in Figure 5. We collected the samples after it had been treated in CDS units (outside ring). This way we can find how much pollutants are coming to the infiltration gallery and how much the CDS is removing the pollutants. The monitoring of the flows was also done. Collected samples were transported to the laboratory located at LASAN’s Hyperion Water Reclamation Plant. Analyses of those samples were conducted by LASAN's Environmental Monitoring Division (EMD) staff. EMD's laboratory at Hyperion is an EPA-Certified laboratory. In the field reading before CDS units: Temp = 16.17 C, Turbidity = 71.74 NTU, pH = 7.4, Specific Conductively = 335.6 uS/cm, Dissolved Oxygen = 9.60 mg/L and after the CDS units: Temp = 15.95 C, Turbidity = 61.75 NTU, pH = 7.32, Specific Conductively = 333.4 uS/cm, Dissolved Oxygen = 9.73 mg/L.

The results of the water quality monitoring analyses of the wet weather samples are summarized in Table 1. Figure 5 shows the map of the project of the monitoring samples locations at the project location. The total stormwater captured during this rain event on November 20, 2019 which produced 0.61 inches rain was about 534,000 gallons (Flow Junction FT-9 reading for the Project site at Diversion Structure). The metal samples for the sampling event are not available at the time of submitting this paper. Visual observations was noted the presence or absence of trash, debris, and fecal material; water color, odor, clarity; weather conditions; time; and any maintenance issues along with photos of the inlet taken at the time of sampling.

At a minimum, maintenance of the CDS units is recommended to be administered twice a year, once at the beginning of the wet season (October) to prepare the system for rain events and ensure it will function properly, and once at the end of the wet season (May) to remove accumulated trash and debris, and to ensure the system will function properly during the dry season. The CDS and infiltration gallery should also be observed periodically to assess the performance and optimize the system as part of maintenance activities. In general, accumulated debris & sediment is removed with established maintenance practices.

Table 1. Pollution Concentration for the Albion Riverside Park Project (Sampled Post-Construction Phase of Monitoring on November 20, 2019).

Pollutant	Concentration Units	Sample at Diversion Structure	Sample After CDS Units
E. Coli	MPN/100mL	31,000	55,000
Total Suspended Solids	mg/l	100	144
Oil and Grease	mg/l	6	<3

Figures 6 to 12 are pictures for the Project from before construction, during construction, after construction, and during the wet weather sampling from the GSIs.

BEFORE CONSTRUCTION

Figure 6. Albion Riverside Park Project Picture Showing Before Construction (Source: LA Sanitation & Environment).

DURING CONSTRUCTION

(a) (b) (c) (d) (e) (f) (g) (h) (i)

Figure 7. Albion Riverside Park Project photos taken During Construction (a) to (i) (Source: LA Sanitation & Environment).

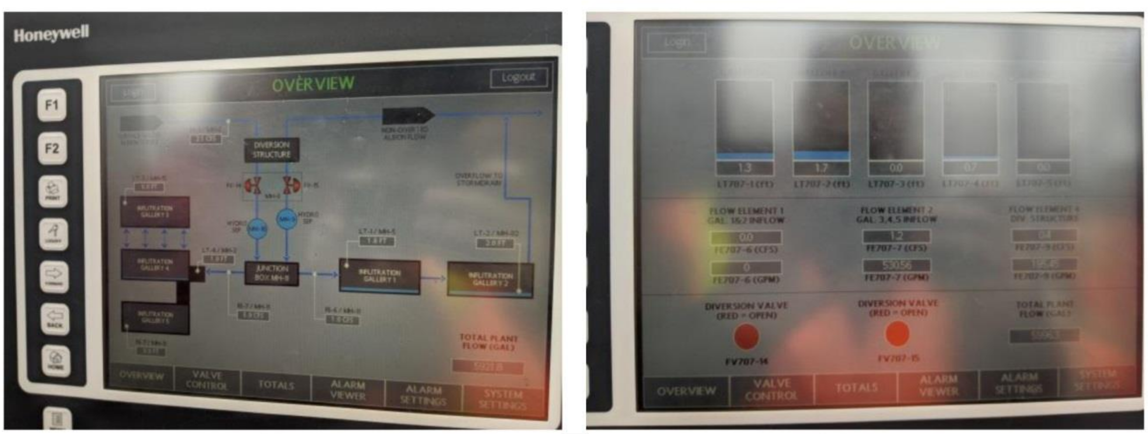
AFTER CONSTRUCTION

(a)

(b)

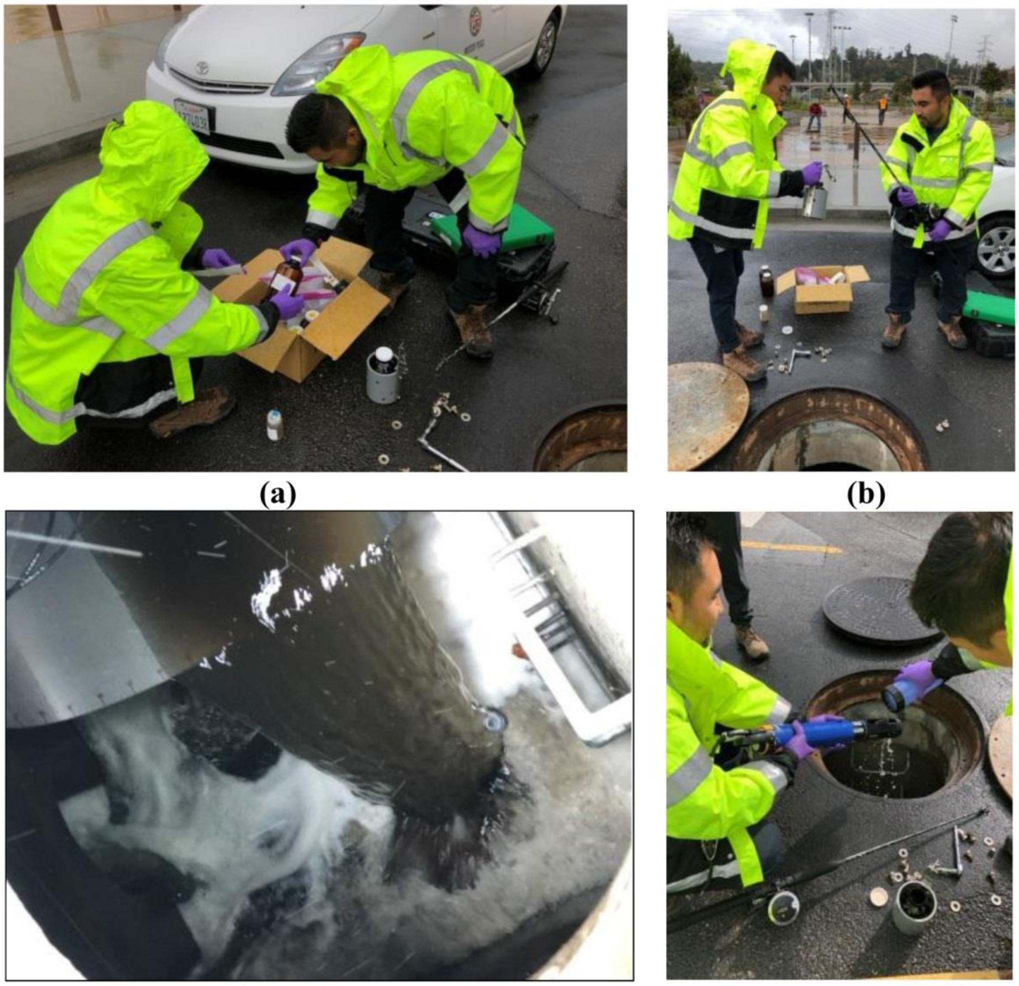
Figure 8. Albion Riverside Park Project Pictures Showing After Construction (a) and (b) (Source: LA Sanitation & Environment).

WET WEATHER MONITORING



(a) (b)

Figure 9. Albion Riverside Park Project Picture Showing the Instrumentation of the Flows and Infiltration Gallery Stormwater Depths (a) and (b) During Storm Event on November 20, 2019 (Source: LA Sanitation & Environment).



(a) (b) (c) (d)

Figure 10. Albion Riverside Park Project Picture Pictures Showing Sampling at Diversion Structure on November 20, 2019 (a) to (d) (Source: LA Sanitation & Environment).

(a) (b)

Figure 11. Albion Riverside Park Project Pictures Showing Sampling after the CDS Units on November 20, 2019 (a) to (d) (Source: LA Sanitation & Environment).

(a) (b)

Figure 12. Albion Riverside Park Project Picture of (a)Trash Capture Inside the CDS Unit and (b) Filter of Stormwater to Remove the Settable Solids in the Field on November 20, 2019 (Source: LA Sanitation & Environment).

GSI HYDROLOGIC MODELING

Albion Park encompasses 272 acres that drain through a 52-inch storm drain with a 0.37% slope to the Los Angeles River. The 85-th percentile 24-hour design storm produces 0.9 inches over the Albion Park 8.56 acre study site and the 272-acre tributary area. Tetra Tech (2015) applied the HydroCalc rainfall runoff model to generate the hydrograph associated with the design storm. The GSIs installed with this project (five infiltration basin galleries (1.7 million gallon), 7,500 sq. ft. porous pavers, and 12,000 sq. ft. bioswale and bioretention basins regulate and infiltrate runoff and diminish pollutants loads in stormwater. The hydraulic/water quality functioning of the GSIs has been described in Loáiciga et al. (2015), and those were applied to calculate the retention and pollutant-loads reductions at Albion Park.

CONCLUSION

Stormwater from the 272 Acres of targeted neighborhood discharges to Los Angeles River. These waterbodies are in Clean Water Act Section 303(d) list as impaired for trash, nutrients, metals, and bacteria. In order to assist the City in meeting TMDL standards for these watersheds, the Project constructed a number of rain gardens to capture and infiltrate the runoff. These GSIs provide the following benefits with respect to Los Angeles River TMDL requirements: Metals Reduction – Meet standards for dry and wet weather runoff; Bacteria Reduction – Result in effluent that meets the concentration limits or result in fewer exceedance days for upstream sub-watershed.; Trash reduction – Achieve one hundred (100%) capture of trash from the upstream watershed. The conclusions and lessons learned from the implementation of the Project are noted as follows. The Project was implemented in a design and built approach and it demonstrated that this project delivery approach is very applicable to these types of projects. The Project provided LASAN staff with valuable experience in implementing this type of project. Through the implementation of the project delivery approach, LASAN staffs were fully engaged through-out the design, construction, and monitoring phase of the Project. The Project demonstrated the complexity of achieving measurable waste load discharges by targeting relatively large drainage areas & the expected high cost of reaching TMDL compliance.

Overall the project was a success on terms of successful implementation and for demonstrating the use of GSIs along the City's watersheds. The relative success of the Project in achieving its objectives may provide a basis for future broader-scale regional programs in implementing similar types of GSIs, particularly as part of TMDL Implementation Plans. Furthermore, the information obtained from this monitoring program demonstrates how this GSIs project performs under varying conditions.

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