

EXHIBIT C

Flow-Control BMP Monitoring Site
Selection Technical Memorandum



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memorandum

date June 26, 2015 (updated December 4, 2015)
to San Diego HMP Monitoring Subworkgroup and Municipal Stormwater Copermittees
from Brian Haines and Damien Kunz
subject BMP monitoring site selection and instrumentation (Contract 550238, Task Order 7, Task 2)

Executive Summary

The San Diego Hydromodification Management Plan (HMP) developed as part of the 2007 MS4 Permit requires the Municipal Stormwater Copermittees (Copermittees hereafter) to develop a monitoring program to assess the effectiveness of the HMP. Chapter 8 of the HMP detailed the Monitoring Plan and outlined three primary questions regarding program effectiveness, the second of which was, “Are mitigation facilities (or BMPs) of priority development projects adequately meeting flow duration criteria as outlined in the HMP?” In response, the HMP Monitoring Subworkgroup (Subworkgroup hereafter) and their consultant team screened a total of 15 BMP locations offered by the Copermittees for monitoring potential. Five of the BMP locations were deemed appropriate for further consideration and site visits were conducted in March and October of 2015 to confirm as-built site conditions, to assess appropriate locations for monitoring the BMPs, and to select the most appropriate instrumentation options. Due to construction schedules, and programmatic budget and operational constraints, the number of BMP monitoring locations was narrowed to one. An array of monitoring equipment was purchased for the select location, and the three BMPs were instrumented in April 2015. Continuous monitoring and event-based validation monitoring will continue at the location until June of 2016 when the monitoring equipment will be removed, and the monitoring data analyzed. Results and findings of the BMP monitoring effort will be included as a key component in the Final Project Report which will be submitted to the San Diego Regional Water Quality Control Board by December 2016.

Introduction to Effectiveness Assessment Monitoring

As required by the Board Order R9-2007-001, the County of San Diego and Copermittees initiated a long-term monitoring project to assess the effectiveness of their HMP (Brown and Caldwell, 2011). The Copermittees defined an effective plan as one which ensures compliance with HMP design criteria, and results in no significant stream degradation due to increased erosive force caused by runoff from new development. Chapter 8 of the HMP, which was updated in 2013, details the monitoring approach and presents three questions to assess program effectiveness:

1. Do field observations confirm that the HMP appropriately defines the flow rate (expressed as a function of the 2-year runoff event) that initiates movement of channel bed or bank materials?
2. Are mitigation facilities (or BMPs) adequately meeting flow duration design criteria outlined in the HMP?
3. What is the effect of development on receiving channel cross section stability?

Monitoring activities are focused on field-based sediment transport studies to evaluate the low flow threshold of receiving channels (question 1), continuous flow monitoring and hydrologic modeling to assess BMP flow control criteria (question 2), and field-based geomorphic assessments and channel surveys to assess the effect of BMP performance on channel stability (question 3). Together these monitoring activities will collect the necessary data to assess the effectiveness of the HMP.

The Need for ‘Decoupled’ Monitoring of BMPs

The original approach outlined in the Monitoring Plan was to monitor water flow and sediment load in the receiving channels downstream of three future development projects that were designed with flow control BMPs built to existing HMP standards (termed “Development Sites”). In-channel flow sediment transport monitoring would be *coupled* with continuous monitoring of the flow control BMPs and annual channel surveys to assess BMP performance (Figure 1). Receiving channels of already developed watersheds (Urban Sites) and relatively undeveloped watersheds (Reference Sites) would also be monitored to bracket the range of expected channel conditions for the San Diego Region. For example, we’d expect urban sites to have receiving channels that are enlarged (deeper and wider) relative to receiving channels in undeveloped reference watersheds. We’d expect channel dimensions from recently development sites to be somewhere between the two. Unfortunately, construction schedules have stalled and BMPs have not been completed at the three development sites, effectively eliminating the potential for BMP monitoring and coupling with receiving channel monitoring data within the term of the monitoring project.

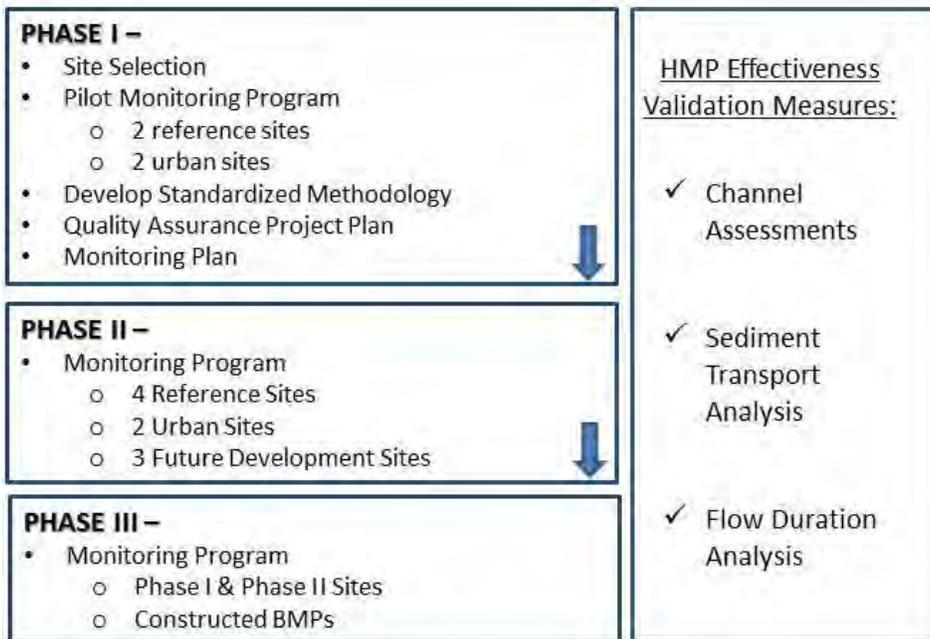


Figure 1. Phased approach for the HMP monitoring project. Source: Weston, 2014

The Copermittees reviewed and updated the Monitoring Plan in 2013 based on opportunities and constraints encountered during the first three years of monitoring project implementation. Following a key recommendation of the update, Copermittees have pursued monitoring at BMP locations *decoupled* from the nine receiving channels currently being monitoring as part of the HMP. Monitoring of decoupled BMPs will allow the Copermittees to assess BMP performance and existing design criteria within the project term.

BMP Monitoring Site Selection

The Copermittees began searching for potential BMP monitoring sites in March of 2014 based on site selection criteria outlined in Attachment A. A total of 15 BMP locations were offered by the Copermittees and subsequently screened by ESA and the Subworkgroup (Table 1, Figure 2). The names of BMP locations were kept anonymous at the request of the Subworkgroup and Copermittees. As such, site IDs are used throughout the remainder of this document.

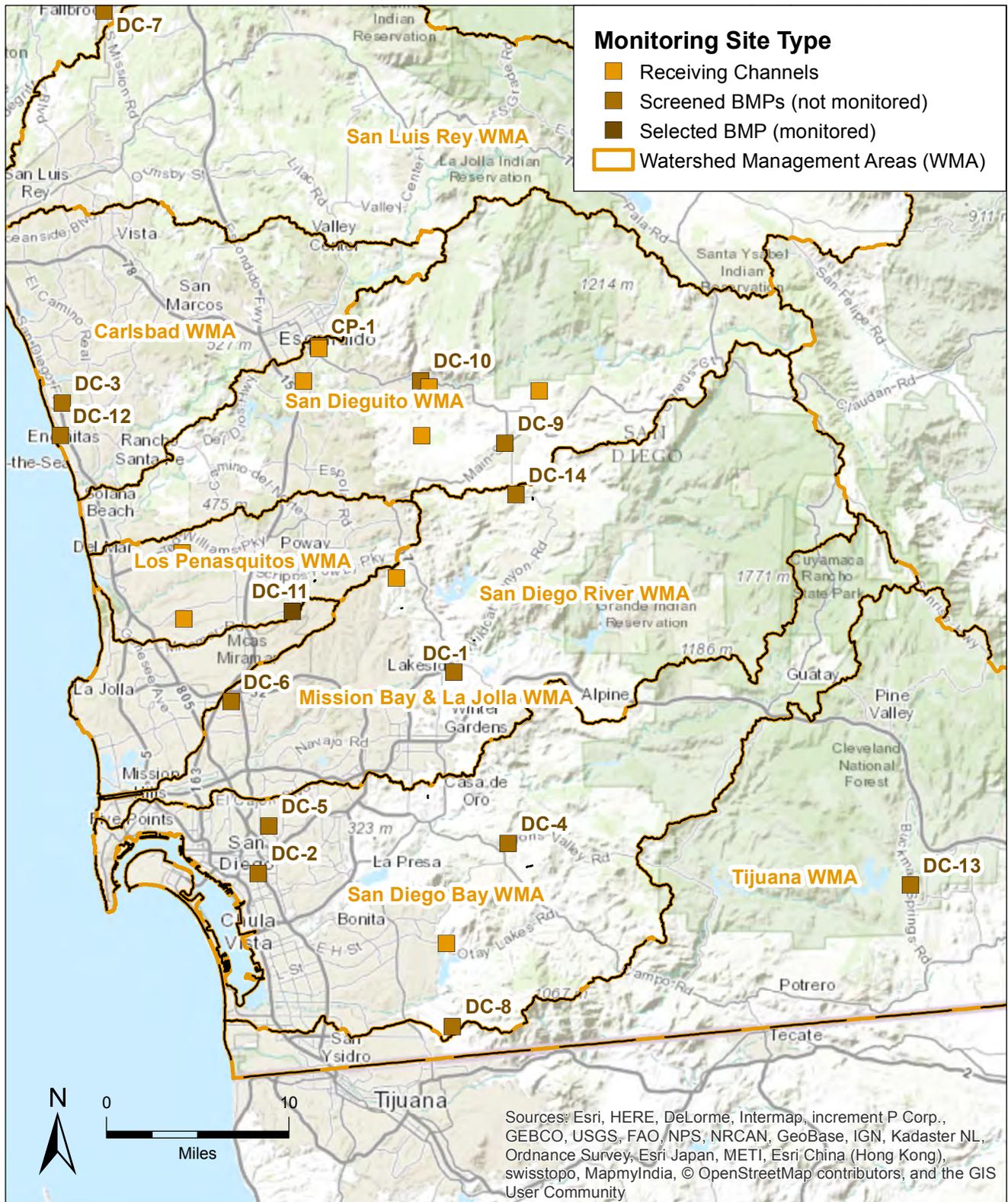
Table 1. BMP monitoring locations screened since March 2014. Site DC-11 was selected for monitoring.

Site ID	Nearby Placename	Type of BMP(s)	Screening Period	Site Visit Conducted	Reason Not Selected
DC-1	Lakeside	Underground vault	Mar, 2014	3/18/2014	Pre-HMP design
DC-2	San Diego	Bioretention, filtration	Jul, 2014	-	Pre-HMP design
DC-3	Encinitas	Bioretention	Nov, 2014	3/6/2015	Access not granted
DC-4	Jamul	Catch basin insert, gross solids removal device (pre-HMP)	Nov, 2014	-	Pre-HMP design
DC-5	San Diego	Bioretention, bioswale, vegetated swale	Nov, 2014	-	Difficult to isolate stormwater inputs without site modification
DC-6	Kearny Mesa	Bioswales, filtration, porous pavement	Nov, 2014	-	Pre-HMP design
DC-7	Fallbrook	Bioswale	Nov, 2014	-	Pre-HMP design
DC-8	East Otay Mesa	Detention basin, bioswale	Nov, 2014	-	Access not granted
DC-9	Ramona	Detention basin, bioswale	Nov, 2014	-	Pre-HMP design
DC-10	San Pasqual Valley	Bioretention, bioswale	Nov, 2014	-	Pre-HMP design
DC-11	Scripps Ranch	Bioretention, bioswale	Feb, 2015	3/6/2015	Selected
DC-12	Encinitas	Flow-through planters, infiltration basin (no flow control)	Feb, 2015	3/6/2015	Pre-HMP design
DC-13	Moreno Village	Bioretention	Sep, 2015	10/6/2015	Construction complete, but revisions required
CP-1*	Escondido	Bioretention	Sep, 2015	10/7/2015	Under construction
DC-14	Ramona	Bioretention	Sep, 2015	-	Under construction

* This BMP location is coupled with the Bear Valley receiving channel monitoring site (Site ID: DH-2).

Screening of the BMPs included a focused review of Water Quality Technical Reports, Storm Drain Plans, and other associated documents and exhibits supplied by the Copermittees. Potential monitoring sites were screened as information was provided. Several of the sites were quickly removed from further consideration because they were designed prior to HMP design criteria (e.g. the use of orifices and risers to control flow from the BMP).

Site visits were conducted to BMP locations that passed the initial screening process and appeared appropriate for instrumentation. The purpose of the site visits was to confirm as-built site conditions and to select the most appropriate BMP instrumentation options. The County of San Diego and ESA conducted sites visits to three BMP monitoring locations: DC-3, DC-11, and DC-12 in March of 2015. DC-3 was designed to HMP standards and used bioretention, an underdrain, and flow control; however, the developer was not amenable to allowing long-term access for monitoring. DC-12 was originally considered for monitoring since it used flow through planters,



SOURCE: Adapted from Weston, 2014

NOTES: Receiving channel monitoring site locations shown for reference.
Only BMP monitoring sites are labeled. See Table 1 for more information.

San Diego HMP Monitoring . 211485.08

Figure 2

Screened BMP Monitoring Locations

but later dropped because the BMP designs predated the HMP design criteria. DC-11 was built to HMP standards and selected for instrumentation and monitoring. County of San Diego and ESA conducted site visits to DC-13 and CP-1 in October of 2015. Construction at DC-13 was recently completed, but site inspections showed that several modifications of the site would be required. Several BMPs were constructed at CP-1, but the on-site engineer informed us that the project would be completed in time for monitoring.

All but one (DC-11) of the BMP locations were removed from the site selection process due to incomplete documentation, the use of pre-HMP design criteria, ongoing construction, or complications with land ownership and access agreements.

BMP Instrumentation

Site instrumentation and monitoring plans were developed for the three screened monitoring sites prior to initial site visits: DC-3, DC-11, and DC-12 (Attachment B). The purpose of the plans was to orient the land manager and/or relevant agency officials attending the site visit to the general monitoring approach and specific site access requirements. Each plan discussed site drainage patterns, treatment and flow control BMPs, and proposed monitoring locations and instrumentation options. Various instrumentation options (e.g. flume, area-velocity flow module, or flow logger) were available for each monitoring location and the most appropriate option was selected based on the perceived quality of data collection, ease of instrumentation, and combined equipment cost. Initial instrumentation options were discussed during the November 19, 2014 Subworkgroup meetings, and selected options were included in the site-specific instrumentation and monitoring plans after the March 6, 2015 site visits. Most of the monitoring equipment for DC-11 was installed on April 7, 2015, but a backordered flume was installed on October 1, 2015.

Monitoring Activities

BMP performance at DC-11 will be assessed through automated continuous monitoring of flow control facility inflow and outflow locations. Area velocity modules will calculate discharge through culverts and storm drains using direct area-velocity measurements. Flow loggers will estimate discharge in select drainage pipes, using slope and surface roughness coefficients (i.e. Manning's n values). Leve loggers will measure water surface elevations in the bioretention basin and bioswale flume. Tipping-bucket style rain gauges will collect and record rainfall depths in 0.01-inch intervals. Monitoring equipment will be inspected and monitoring data will be downloaded every 1-2 months or after a major storm event. The monitoring data will be validated during select storm events through field measurements and photo documentation. Cross-section flow measurements will be collected as-needed. Calibration of monitoring equipment may also occur if needed. The BMP validation monitoring will also serve as an additional opportunity to identify faulty equipment and suggest recommendations for improved monitoring techniques.

Analytical Methods

Ideally, BMP monitoring data should be collected over a long period of time (30 years or more) in order to fully evaluate the flow frequency and flow duration estimates developed from rainfall-runoff models for post-development conditions. The term of the existing HMP monitoring project is limited to five years, two of which were recommended for the pre-development condition. As discussed above, construction schedules have stalled at the three development sites that are coupled with receiving channel monitoring sites and as a result, flow control BMPs are not complete at this time. This does not allow for any post-development monitoring of BMPs. Further, decoupled monitoring at one BMP location was recently established (April 2015). Thus, the term of BMP monitoring will be effectively limited to just over one year in duration.

Inferences on BMP performance will be limited by the short-term monitoring record. For instance, it will be impossible to estimate the 10-year peak flow from the BMP in the post-development condition using one year of monitoring data. Similarly, it will be impossible to generate a flow duration curve spanning a portion of the 2-year peak flow event up to the 10-year peak flow event.

Such limitations were considered and discussed in the 2013 revision of the Monitoring Plan, which shifts emphasis from the original flow frequency and duration approach to assessing the accuracy of continuous simulation models in representing rainfall-runoff relationships using field measurements from monitoring sites. This assessment can be done for the decoupled BMP location (DC-11) and more urbanized receiving channel locations. Continuous simulation rainfall-runoff models such as the San Diego Hydrology Model (SDHM) and Storm Water Management Model (SWMM) can be used for this task. Further details of the continuous simulation modeling task will be discussed in the Final Data Analysis Report, scheduled for completion in August of 2016.

Summary and Conclusions

The BMP site selection process was required in order to screen, select, and monitor BMPs; and to assess the effectiveness of the flow control BMP design criteria required by the HMP. Several challenges were faced during the site selection process including designs that pre-date HMP criteria, delayed or active site construction, and denied site access agreements. Though only one decoupled BMP location (DC-11) is currently being monitored, the location has three BMP features that can be evaluated – two bioswales and one bioretention basin. The range in magnitude and duration of rainfall-runoff events that will be measured at DC-11 is dependent on the active El Nino condition. A larger range of rainfall-runoff events will improve the assessment. Modeling of the rainfall-runoff events with SDHM or SWMM should allow the Copermittees to better evaluate the accuracy of models used to design flow control BMPs, and meet the requirements outlined in the Monitoring Plan.

ATTACHMENT A

BMP Site Selection Criteria

ATTACHMENT A

BMP SITE SELECTION CRITERIA:

- The BMP is one of 5 LID treatment types outlined in the HMP (e.g. bioretention basins, infiltration facilities)
- The BMP was built to current HMP design standards (flow duration control) and the design is well documented and readily available
 - Pre and post project hydrology is discussed (magnitude and duration)
 - Design methodology is outlined (continuous simulation model or BMP sizing factors)
 - A receiving channel was assessed and a channel susceptibility rating of HIGH or MEDIUM was assigned
- The BMP has a outfall that is or can be instrumented to monitor discharge
- The BMP outfall empties into a well-defined, non-exempt, receiving channel (e.g. small creek of native material)
- The BMP and receiving channel is located on public property
- The property manager is open to long-term site access for monitoring

ATTACHMENT B

Instrumentation and Monitoring Plan for “DC-11”



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memorandum

date March 12, 2015

to Stuart Kuhn, County of San Diego, Watershed Protection Program
Jim Nabong, City of San Diego, Stormwater Division
Garth Engelhorn, Weston Solutions

from Brian Haines, Project Manager
Damien Kunz, Field Services Manager

subject BMP Instrumentation and Monitoring Plan for “DC-11” located near Scripps Ranch, California

This memorandum serves as the draft Instrumentation and Monitoring Plan for BMPs at Monitoring DC-11 located near Scripps Ranch, California. Monitoring of BMPs at DC-11 will help the County of San Diego and Municipal Copermittees to assess the effectiveness of the design criteria set forth in the San Diego Hydromodification Management Plan in protecting stormwater receiving channels. DC-11 is being considered for effectiveness assessment monitoring due to the type of BMPs outlined in the Water Quality Technical Report and associated exhibits, and the ease of access to the site from municipal roads. The purpose of this memorandum is to orient relevant parties to the initial site instrumentation plan as well as long-term monitoring activities and access requirements.

- **Verification of BMP Design**

There are three BMP locations to be monitored at DC-11: the detention basin in the northwest corner of the lot and two bioswales leading into the detention basin along the northern and southern perimeter of the open space area (**please see Figure 1 for an overview of BMP locations**).

The project team made two site visits during February and March of 2015 to verify site conditions as described in the 2005 Proposed Conditions Analysis, and 2012 Water Quality Technical Report and Storm Drain Plans. The WQTR shows two Drainage Management Areas (DMA) with DMA #1 draining 0.7 acres to the northeast, and DMA #2 draining 7 acres to the west and south of the property.

Drainage from DMA #1 enters an 18” reinforced concrete storm drain then discharges into the northern bioswale. The storm drain is accessible through a manhole on the road to the east. Drainage from the bioswale enters a modified Type F catch basin then enters another 18” reinforced concrete pipe before discharging into the bioretention basin from the north. The F type catch basin is accessible from a manhole on top of the basin.

Drainage from DMA #2 sheet flows across the streets from the north and east and enters a modified curb inlet towards the middle of the property. Two other unidentified drainage sources enter the curb inlet

structure from the west and east, before discharging through a 4' x 1.75' concrete ditch to the southern bioswale. Drainage from the bioswale enters the bioretention basin from the south via a riprap energy dissipating structure. The dimensions of the concrete ditch differ from those shown in the Storm Drain Plans dated June 29, 2012. It is unclear what drains to the curb inlet from the west and south.

Drainage from the bioswales to the bioretention basin is allowed to infiltrate through layers of sand and gravel media and into underlying native soil, while a 4" perforated pipe underdrain provides additional drainage as soils become saturated. Flow from the underdrain enters a G Type catch basin to the north. Large runoff events are retained in the bioretention basin and enter the catch basin through a 1" low flow orifice towards the bottom of the catch basin and a 12" orifice near the top. Emergency flood drainage is provided by a removable grated inlet on top of the catch basin. Flow exits the catch basin through a 24" reinforced concrete storm drain to the northwest of the property. The storm drain is accessible through a manhole near the northwest corner of the property.

Additional data requests: Pipe/culvert slopes based on as-built construction documentation.

- **Instrumentation Options**

In order to effectively monitor BMP locations, an accurate measurement of inflow vs outflow needs to be quantified and then compared to the expected design assumptions. The inputs and outputs of the BMP structures at DC-11 will be instrumented based first on data accuracy and then installation feasibility. In addition, precipitation data will be collected on site to assess actual rainfall-runoff response.

Based on planning efforts thus far, the following instruments were identified as monitoring options for each BMP location at DC-11 (**please see Table 1 for photos of selected instrumentation options**).

- *Northern Bioswale Input:* ISCO Area-Velocity-Flow Modules installed in manhole with sensor mounted in 18" RCP
- *Northern Bioswale Output:* ISCO Area-Velocity-Flow Modules installed in Type F catch basin with sensor mounted in 18" RCP
- *Southern Bioswale Input:* Custom Weir or H-Flume with Onset HOBO Water Level Logger (to be determined)
- *Detention Basin Output:* Global Water FL16 Water Flow Logger, and Onset HOBO Water Level Logger (for water level redundancy)
- *Site-specific Precipitation:* Onset HOBO RG3 Data Logging Rain Gauge

All of the instruments proposed will require regular download and maintenance in order to maximize functionality and ensure quality of data. The current plan calls for the maintenance and downloads to be carried out by City of San Diego staff, with the ESA consultant team to provide contingency.

- **Monitoring Plan and Access Requirements**

The current plan is to instrument BMP locations at DC-11 in March of 2015 and collect continuous rainfall and runoff data through June of 2016. An extension may be requested to achieve the goals of the HMP monitoring plan and requirements put forth by the San Diego Regional Water Quality Control Board.

After instrument installation, maintenance and data download site visits will need to occur at a minimum of once every two (2) months and/or within one week of every major storm event in order to ensure that minimal loss of data occurs in the event of malfunction or vandalism. Each of these site visits will require a computer with the necessary software installations, instrument download cables, and all necessary

safety equipment. DC-11 access will also be required at the end of the monitoring project to uninstall monitoring equipment, and to conduct a site walk through with the site manager.

All field operations undertaken by ESA staff or subconsultants will operate under the following clause:

“There are risks associated with field data collection, especially in the marine environment. ESA maintains insurance for instruments, and therefore takes the risk of damage to the hardware or loss. ESA also applies quality control procedures to reduce the possibility of malfunction. However, ESA cannot guarantee that data collection will be complete. ESA will endeavor to complete the scope of work within the estimated fee and schedule with the data actually collected. ESA’s policy is to notify clients if a problem arises and results in the need for added effort or schedule revision, so that the appropriate remedy can be identified and implemented. ESA reserves the right to not re-deploy instruments if the risk of damage or loss, especially due to theft or vandalism, appears high.

A long-term DC-11 access agreement for ESA and any other monitoring staff will be developed by the County of San Diego or other responsible Municipal Copermittee (City of San Diego).

Figure 1. DC-11 Monitoring Locations and Reconnaissance Areas

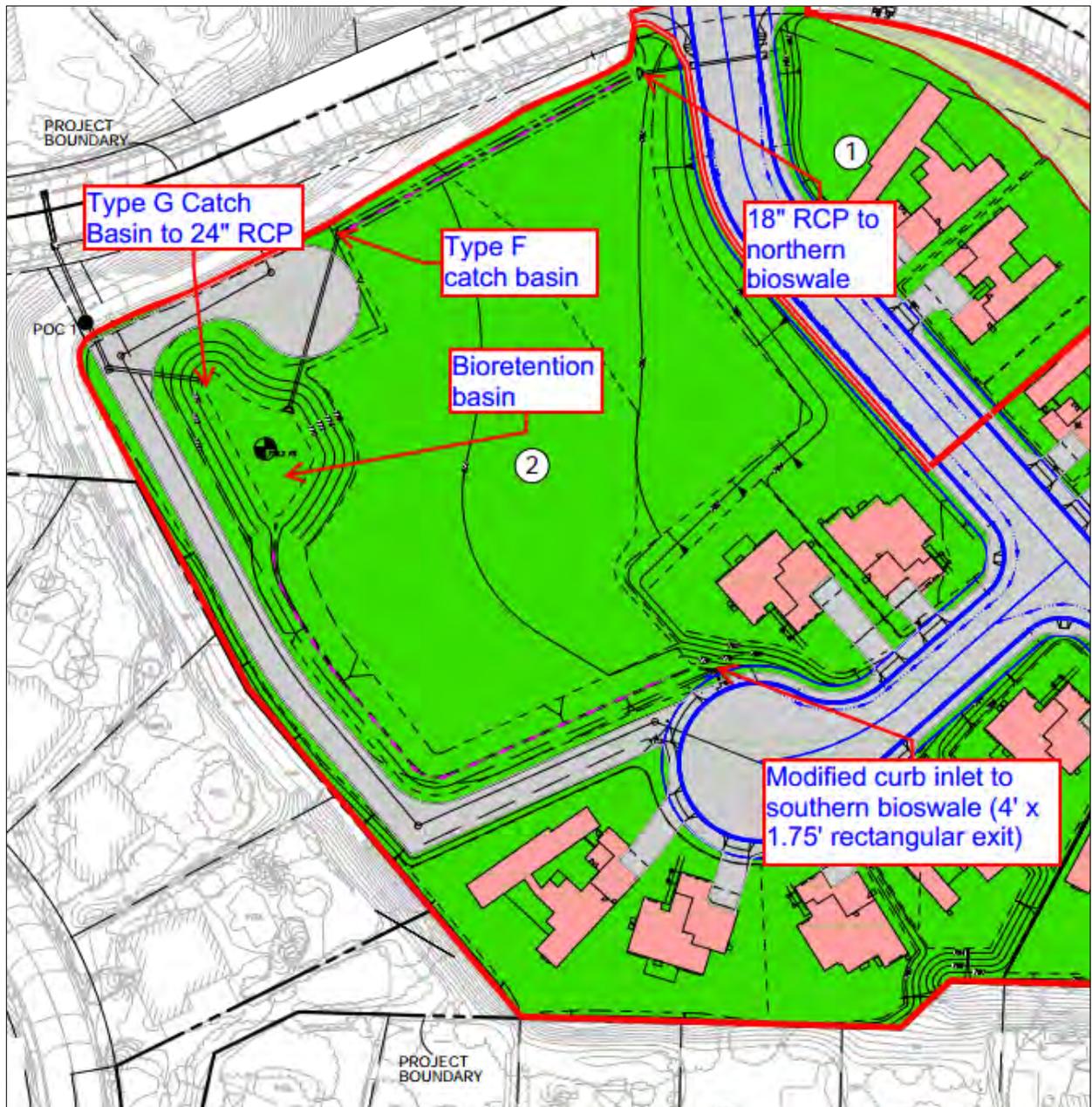


Table 1. Monitoring Equipment Options

<p>ISCO 2150 Area-Velocity-Flow Module</p>	 A blue rectangular electronic device with a black cable and a black probe. The device has a label that reads "Area Velocity Flow Module".
<p>Global Water FL-16 Water Flow Logger</p>	 A silver cylindrical probe with a yellow cable coiled next to it.
<p>Custom Weir with Onset HOBO Water Level Logger (in well behind flume)</p>	 A black and white photograph of a weir structure in a stream. A white cylindrical water level logger is mounted in a well behind the weir. A white ruler is placed vertically next to the logger for scale. The water level is visible in the stream.

<p>H-Flume</p>	
<p>Onset HOBO Water Level Logger</p>	

Onset HOBO RG3 Data
Logging Rain Gauge
(shown with high-rise
mount and waist height
data logger port)

