City of Rolling Hills INCORPORATED JANUARY 24, 1957

NO. 2 PORTUGUESE BEND ROAD
ROLLING HILLS, CA 90274
(310) 377-1521
FAX (310) 377-7288

Agenda Item No: 9-B
Mtg. Date: 01/14/2019

TO: HONORABLE MAYOR AND MEMBERS OF THE CITY COUNCIL

FROM: ELAINE JENG, P.E., CITY MANAGER

SUBJECT: RECEIVE AND FILE AN UPDATE ON THE TORRANCE AIRPORT STORM WATER INFILTRATION PROJECT

DATE: JANUARY 14, 2019

ATTACHMENTS:

1. **TORRANCE AIRPORT INFILTRATION PROJECT DRAFT PRELIMINARY DESIGN REPORT**

BACKGROUND

Portions of the Stormwater discharge from the City of Rolling Hills drain to Machado Lake. The MS4 permit requires the City, and others that also discharge to Machado Lake to reduce the Nutrient pollutants in Machado Lake by September 2018 and Pesticides and PCBs pollutants by September 2019. One definite way to comply with such pollutant limitations is to eliminate certain volume (specified design storm runoff volume by the Regional Water Quality Control Board) of storm water discharge and the associated pollutants from draining into Machado Lake. In response to the 2018 Nutrient compliance deadline for Machado Lake, on June 13, 2018 Rolling Hills submitted a joint request with the other Peninsula Cities and LA County unincorporated for a time schedule order to the Regional Board requesting more time to demonstrate compliance. One of the proposed compliance activities in the request for time schedule order is to participate in a regional project.

Faced with the same MS4 permit requirements for Machado Lake, the City of Torrance contemplated constructing an infiltration basin at the Torrance Airport to divert storm water flow from entering Machado Lake. The cities of Rolling Hills (RH), Rolling Hills

Estates (RHE), Rancho Palos Verdes (RPV) and Palos Verdes Estates (PVE) and County Unincorporated decided to partner with Torrance on the project. In June 2018, a Memorandum of Understanding for the preliminary design of the project was executed between the Peninsula cities (RH, RHE, RPV, and PVE) and Torrance with Torrance as the lead agency. Torrance engaged the services of Carollo Engineers and in August 2018, Carollo Engineers provided the group with a draft Preliminary Design Report (PDR).

Carollo Engineers' scope of work included the calculation of the volume of water for the collective group to be in compliance, determining the footprint of the infiltration basin to meet the compliance volume, siting the infiltration basin(s) at the airport, and provide high level construction cost estimates for the project. Per the MOU between the Peninsula Cities and Torrance, Torrance was required to keep the group updated on preliminary design progress.

Carollo Engineer's draft PDR dated August 2018 recommended three project phases to meet compliance volume. The first two phases will construct infiltration basins that will only be able to accept stormwater discharges from the City of Torrance. The report goes on to outline a phase three dedicated to accept the stormwater discharges from the Peninsula Cities. Phase three has two options. The first option is to pump the discharged storm water to Walteria Lake; the second option is to pump the discharged storm water to an underground storage unit under the parking lot at the airport and then discharged to a series of dry wells placed along Skypark Drive and Madison Avenue (the north and northeast boundaries of the airport). High level cost estimates for the construction of three phases of the project is as follows:

Phase 1:	$5,720,000
Phase 2:	$10,380,000
Phase 3:	Option 1 - $20,550,000 (divert to Walteria Lake)
	Option 2 - $36,070,000 (divert to a series of dry wells)

Collectively, the Peninsula Cities provided extensive review comments to the draft August 2018 PDR and are waiting for the City of Torrance to respond to review comments and questions.

DISCUSSION

Partnership in the Torrance Airport Storm Water Infiltration Project is significant in that it served as a compliance activity for all agencies involved to meet Machado Lake pollutant limitations in the MS4 permit requirements. When the draft report was released, it was the first time the Peninsula Cities were informed that the geotechnical investigation found no clay confining layer between the contaminant plume in the shallow groundwater and the lower drinking water aquifer and thus limiting the storm water storage/infiltration footprint. At the time of report release was also the first time the Peninsula Cities saw the contemplated phasing of the project and the chosen points of storm water diversions. Specifically on the select points of diversion, it appears the diversion points of phase 1 and 2 were selected to only include storm water discharges from the City of Torrance. In either footprint for phase 1 and or 2, the diversion points could have been moved to include comingled flow from the Peninsula Cities and Torrance to demonstrate that the preliminary design effort would result in a comprehensive joint project.

The Walteria Lake is a man-made flood control basin located in the City of Torrance. The Lake was built and is operated by the Los Angeles County Flood Control District (District). The District was not consulted on phase 3 of the project and since the release of the draft PDR in August 2018, the District has expressed that for technical reasons, no storm water discharges can be diverted to Walteria Lake. This eliminated phase 3 option 1. Furthermore, since the release of the report, the City of Torrance has expressed that modeling of the groundwater movement from the infiltration activities of phase 3 option 2 would likely impact and move the underground plume of containments (TCE plume) after a 20 year period. While the draft PDR suggested that the recommended drywells for phase 3 option 2 be moved further north (away from the plume) to avoid impacts to the TCE plume, the draft PDR does not provide details on this front to determine exact locations where these dry wells should be relocated. In October/November 2018 timeframe, the City of Torrance, out of concern for the TCE plume, noted to the Peninsula Cities that as an alternative to phase 3 option 2, diverting storm water discharges to a sanitary sewer main would be a better solution. In effect, the entire draft PDR did not provide the Peninsula Cities including Rolling Hills with a viable project to comply with MS4 requirements for Machado Lake.

The Peninsula Cities are pursuing changes to the draft PDR so that the document reads that all participants that contributed monies to fund the effort be reflected as partners of the project. In other words, all project phases should be a group effort and not be specifically assigned to any one agency. The City of Torrance has been receptive to the Peninsula Cities' request. This pursuit continues to be a work in progress.

Due to the TCE plume and the lack of a confining soil layer, infiltration basin footprints are constrained at the Torrance airport. Phase one and two of the Torrance Airport Storm Water Infiltration Project will not be able to meet the compliance volume. As such, the group is also investigating supplemental projects to divert additional volume of storm water from Machado Lake.

<u>TCE Plume</u>

In December 2018, during discussions with Torrance staff, it was revealed to the Peninsula Cities that the City of Torrance has been named as one of the Responsible Party (PR) – a contributor to creating the TCE plume - by the Regional Board. Torrance is seeking Regional Board's permission to concentrate efforts on mitigating the underground-contaminated plume before taking on any storm water projects at the

Torrance airport. This approach, as noted by Torrance, could result in shrinking the plume so that the infiltration basin footprints at the airport can be increased. The City of Torrance is seeking to delay the storm water regional project for 10 years. The Peninsula Cities are waiting to hear the Regional Board's feedback on Torrance's proposal. If successful, potentially the Peninsula Cities stand to delay completing a storm water infiltration for 10 years.

FISCAL IMPACT

The City's share of the PDR was $42,210. City staff is working with the City of Torrance to ensure that the RH's contribution to the PDR results in identifying a viable infiltration project to comply or partially comply with MS4 permit requirements for Machado Lake.

It is unknown at this time what RH's share in the construction of a storm water infiltration project would be. With the passage of Measure W, the safe and clean water parcel tax, RH can apply for regional Measure W funds for such a project if partnered with other agencies.

RECOMMENDATION

It is recommended that the City Council receive and file this report.

City of Torrance
Torrance Airport Storm Water Infiltration Project, I-174

PRELIMINARY DESIGN REPORT

DRAFT | August 2018

City of Torrance
Torrance Airport Storm Water Infiltration Project, I-174

PRELIMINARY DESIGN REPORT

DRAFT | August 2018

Inge Wiersema,
August 27, 2018
California 66123

Contents

Appendices

Tables

Figures

Abbreviations

1,1-DCE	1,1-Dichloroethene
ac	acre
BMP	best management practices
bgs	below ground surface
Blvd	Crenshaw Boulevard
CA MCLs	California maximum contaminant levels
Carollo	Carollo Engineers, Inc.
cfs	cubic feet per second
COC	constituents of concern
DWR	Department of Water Resources
EEC	EEC Environmental
ft	feet
H&SP	Health and Safety Plan
HSA	hollow stem auger
JS	junction structure
LID	low impact development
MW	monitoring well
MWDSC	Metropolitan Water District of Southern California
µg/L	micrograms per liter
MS4	Municipal Separate Storm Sewer System
N	Nitrogen
ND	non-detected
NOI	Notice of Intent
NOT	Notice of Termination
NPDES	National Pollutant Discharge Elimination System
PAHs	Polycyclic aromatic hydrocarbons
PCE	Tetrachloroethene
PenCities	Peninsula Cities
Project	Torrance Airport Stormwater Infiltration Project
Prop 1	Proposition 1
RCP	reinforced concrete pipe
Regional Board	Los Angeles Regional Water Quality Control Board
RSA	runway safety area
RSL	Regional Screening Levels
RWTA	regional water table aquifer
SB	soil boring

SD	Storm Drain
SMARTS	Stormwater Multi-Application Reporting and Tracking System
Sonic	Roto-Sonic Drilling
State Board	State Water Resources Control Board
SD	Storm Drain
SUSMP	Standard Urban Stormwater Mitigation Plan
SWGP	Storm Water Grant Program
SWMM	Storm Water Management Model
SWPPP	Storm Water Pollution Prevention Plan
TASWIP	Torrance Airport Storm Water Infiltration Project
TCE	Trichloroethene
TMDLs	total maximum daily loads
TOA	Torrance Municipal Airport
TN	Total Nitrogen
Torrance	City of Torrance
THECD	Torrance Health and Environmental Control Department
TP	Total Phosphorus
TSS	Total Suspended Solids
USA	Underground Service Alert
USDW	underground source of drinking water
USEPA	United States Environmental Protection Agency
UIC	underground injection control
USGS	United States Geological Survey
VOCs	volatile organic compounds
WCBBP	West Coast Basin Barrier Project

Section 1
INTRODUCTION AND BACKGROUND

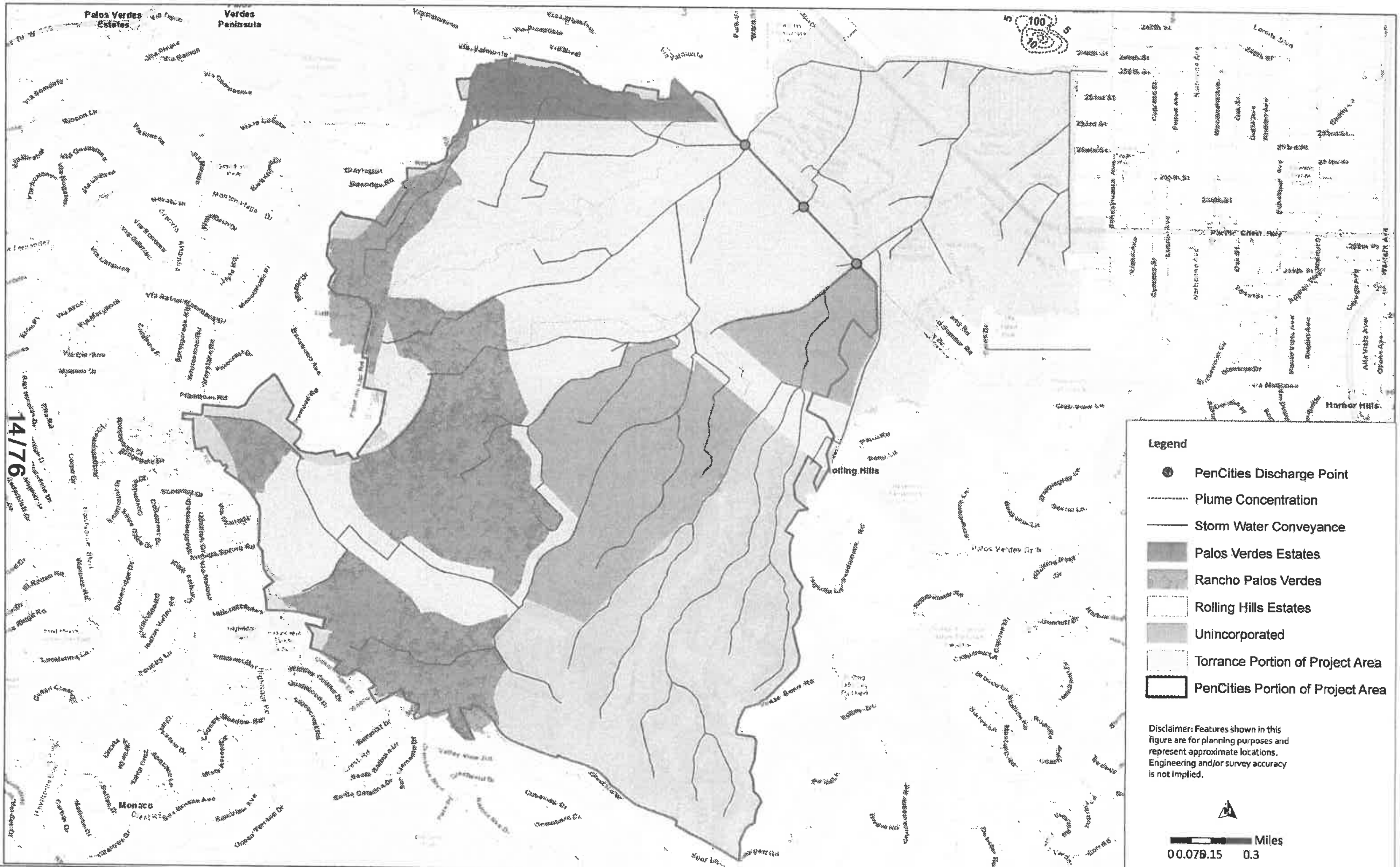
1.1 Project Background

The City of Torrance (Torrance) in response to the Los Angeles Regional Water Quality Control Board's (Regional Board's) National Pollutant Discharge Elimination System (NPDES) for Municipal Separate Storm Sewer System (MS4) Permit requirements is evaluating the Torrance Airport Storm Water Infiltration Project (TASWIP, or Project) in partnership with the Peninsula Cities (PenCities) to improve water quality and the ecological health of Machado Lake and address the Machado Lake Total Maximum Daily Loads (TMDLs). The PenCities consist of the Cities of Rancho Palos Verdes, Rolling Hills Estates, Palos Verdes Estates, Rolling Hills, and Los Angeles County Unincorporated.

Torrance Municipal Airport

The PenCities drainage areas do not drain directly into Machado Lake. Drainage from the PenCities areas exit the Peninsula in an easterly or northeasterly direction where it is comingled with drainage with Torrance and the City of Lomita prior to flowing into three of the four major drainage systems entering Machado Lake. The drainage from the PenCities crosses Torrance Airport warranting a coordinated approach in an effort to implement this regional storm water infiltration best management practice (BMP). The project site and participating jurisdictions are shown on Figure 1.1.

Torrance applied for and received Proposition 1 (Prop 1) Storm Water Grant Program (SWGP) Planning Grant from the California State Water Resources Control Board (State Board). The PenCities requested Torrance to expand the preliminary design to include PenCities storm water and approved a Memorandum of Agreement to share the costs of this Preliminary Design Report. Using resources from the water bond along with significant contributions from project partners, the preliminary design for the Project was initiated.



Carollo

Figure 1.1 Project Vicinity Map

The Project will utilize the open areas at the Torrance Municipal Airport (TOA) and is designed to bypass contaminated shallow groundwater aquifers and use treated storm water to replenish the deeper, isolated groundwater aquifer through ground infiltration using deep drywells. The Project will provide artificial recharge. Thus, treated storm water will be discharged through 285 feet (ft) deep drywells, by-passing the shallow contaminated aquifer to the Gage Aquifer thereby minimizing transport of contaminants in the shallow aquifer.

The portion of the watershed which drains to the project site or storm water treatment areas consists of approximately 3,481 acres (ac), which is approximately 22 percent of the Machado Lake watershed. The drainage areas of Torrance and the PenCities are respectively 640 ac and 2,841 ac. This drainage flows in an easterly or northeasterly direction, contributing flow to three of the four major drainage systems entering Machado Lake (i.e., Wilmington Drain, Project 77 and Project 510) as shown on Figure 1.2.

The Project site is approximately 80 ft above mean sea level. Topography in the vicinity of the site slopes towards the northeast. The subwatersheds surrounding the project site is mostly urbanized and commercial with very little open space.

1.1.1 Project Benefits

This project would protect the beneficial and recreational uses of Machado Lake, reduce storm water runoff, reduce potential risks for human safety and health due to flooding, preserve aquatic habitats, and increase groundwater supplies by infiltrating runoff from the upstream drainage areas.

Underground infiltration systems can be ideal for use under recreation parks and complexes, athletic fields, parking lots, sidewalks and areas adjacent to roads, and other commercial, industrial, and residential paved areas. Project benefits include:

- Reduction of storm water runoff flow.
- Extended storage to facilitate measured release of collected storm water runoff.
- Favorable for high density or urban areas with limited available space or other site constraints.
- Rapid installation using modular systems and components.
- Durability and long life (20 to 50 years plus depending on materials and components).
- Increased level of airport safety by not having open basins and other surface BMPs.

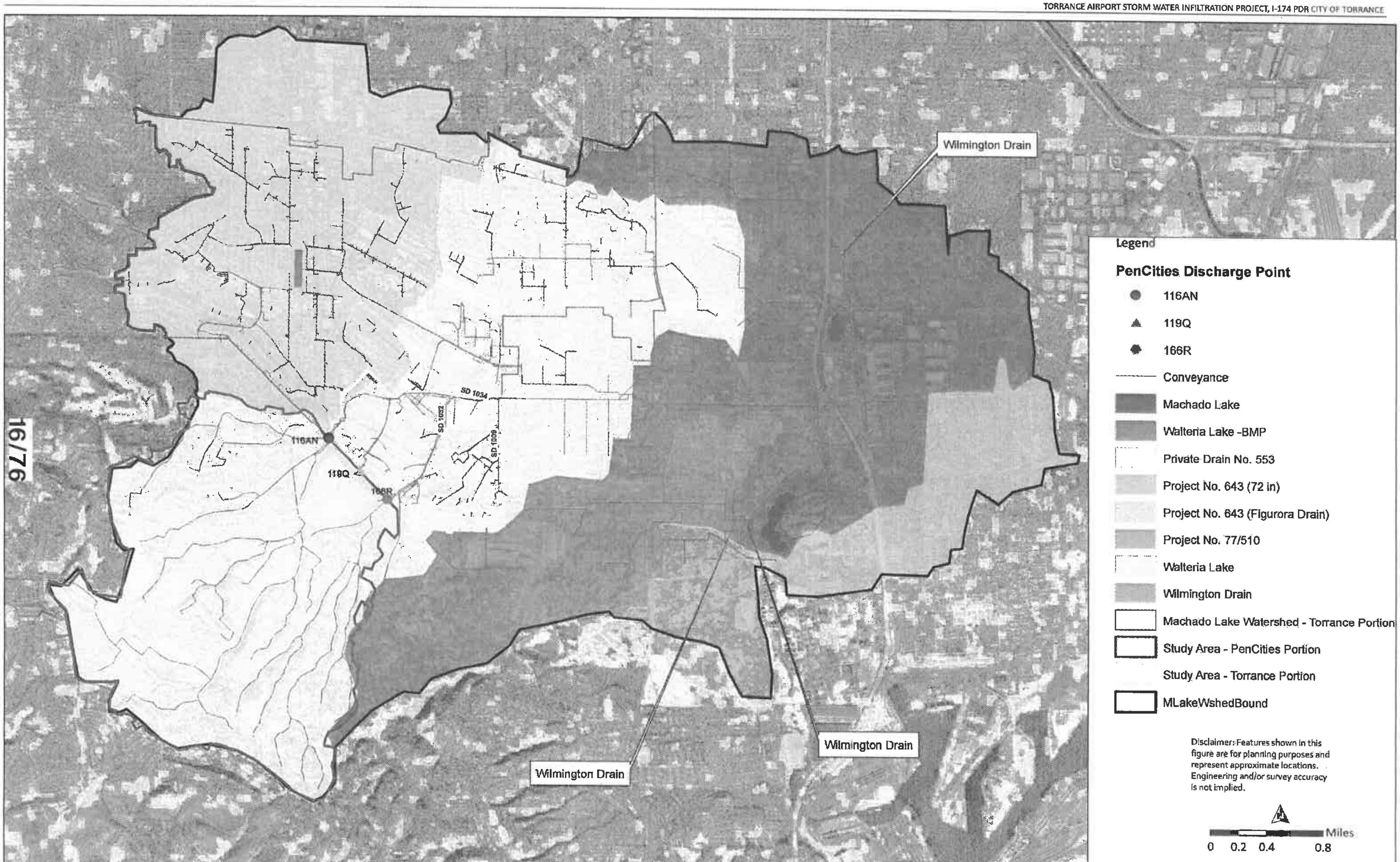
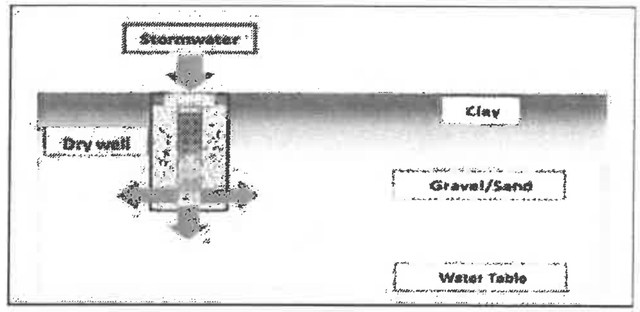


Figure 1.2 Machado Lake Watershed Subbasins

1.1.2 Dry Well Use in California

A dry well is an underground infiltration device that disposes of unwanted water, most commonly surface runoff and storm water. It is a covered, porous-walled chamber that allows water to slowly soak into the ground (that is, percolate), dissipating into the groundwater. Dry wells can be used in conjunction with low impact development (LID) practices to reduce the adverse effects of hydromodification on surface water quality and aquatic habitat while providing additional benefits such as localized flood reduction and groundwater recharge.



Storm water infiltration via a dry well

Historically, dry wells were used infrequently in California and with caution due to the concern that they provide a conduit for contaminants to enter the groundwater. As a consequence, storm water/LID guidelines often do not include dry wells. However, scientific reports show a lack of correlation between the use of dry wells and groundwater contamination (Jurgens 2008, Los Angeles 2005).

The Regional Boards' Standard Urban Stormwater Mitigation Plans (SUSMP) also differ in technical specifications for dry well construction. The California Department of Water Resources' (DWR) well water regulations are interpreted by some to have applicability to storm water infiltration through dry wells. Due to the desire to maintain high groundwater quality and the lack of clarity about various technical considerations, many are reluctant to incorporate dry wells into storm water management projects. To alleviate these concerns, this project includes specific elements to treat storm water runoff prior to discharge via dry wells.

1.2 Project Objective

The overall objective of TASWIP is to comply with the MS4 Permit requirements by capturing and infiltrating the volume of water from the 24-hour 85th percentile storm runoff generated from the area of influence (tributary area) and increase groundwater pumping rights for Torrance. Due to contamination at the Project Site related to historical activities, storm water infiltration through dry wells are designed to bypass the contaminated soil layer.

In particular, the TASWIP aims to control discharge of nutrients, copper, lead, toxics, and bacteria into the existing storm drains discharging into the Machado Lake from the drainage area tributary to the Project Site. This objective may in general be met by implementing one of the several storm water BMPs or a combination of selected multiple BMPs as part of a treatment train.

The Project through subsurface infiltration facilities aims to decrease runoff volume through groundwater recharge via dry wells and improve water quality through filtration and sorption. Thus, TASWIP will protect Machado Lake by capturing the pollutants transported in urban storm water such as Total Nitrogen (TN), Total Phosphorus (TP), Total Suspended Solids (TSS), bacteria, toxics, heavy metals, and petroleum products, among others.

1.3 Project Description

The TASWIP site, located at TOA, comprises three storm water treatment areas separated by the TOA main runway. The storm water treatment areas are illustrated on Figure 1.3. Each storm water treatment area has ample open space to provide access for maintenance. Considering current usage, ample space would also be available for construction activities at each selected site, but with constraints due to TOA operations.

A storage-dry well system was chosen to meet the project objectives. The conceptual configuration of the storage-dry well system, shown on Figure 1.4, consists of a treatment train of four main features:

1. A pretreatment hydrodynamic separator unit that will filter sediment and debris out of storm water runoff prior to discharge into the underground storage-dry well system.
2. Underground storage galleries that will store and release runoff at controlled rate to a post treatment unit.
3. Post treatment unit (JellyFish) will treat runoff through filtration prior to discharge through the dry wells.
4. Dry wells will by-pass the contaminated soil layers to convey post treated storm water runoff below restricting clay and contaminated layers.

Flow rates and total volume of runoff infiltrated were quantified. Fate and transport modeling was also performed using MODFLOW 2000 (Harbaugh et al. 2000), a finite- difference numerical model developed by the United States Geological Survey (USGS), to evaluate the long term potential for contaminants to reach the water table and predict the travel time of selected pollutant and assess the movement of the contaminated plume in the project area.

Additionally, two groundwater monitoring wells (MW) were installed northeast of the main runway to monitor the contamination in the area northeast of the airport property.

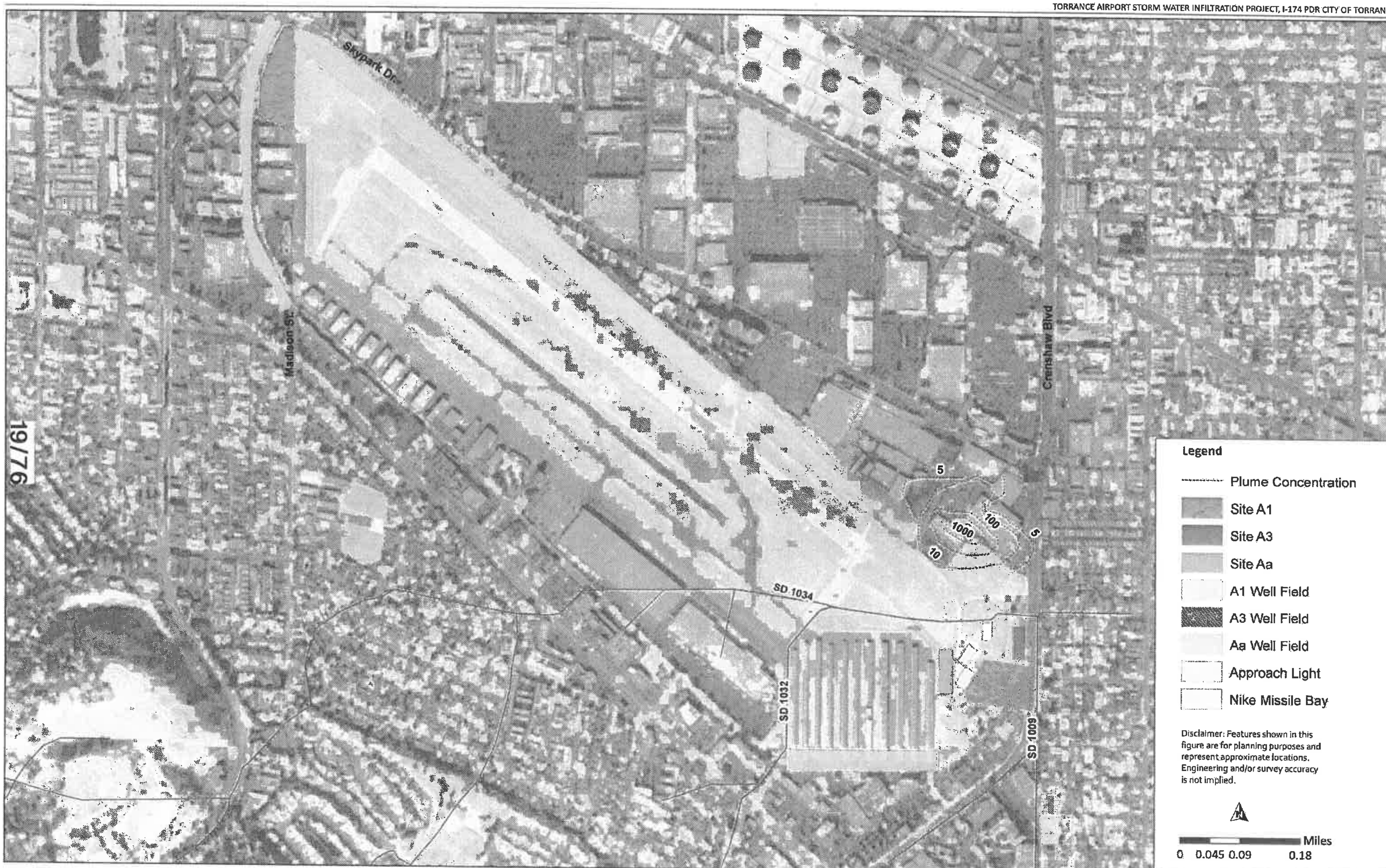
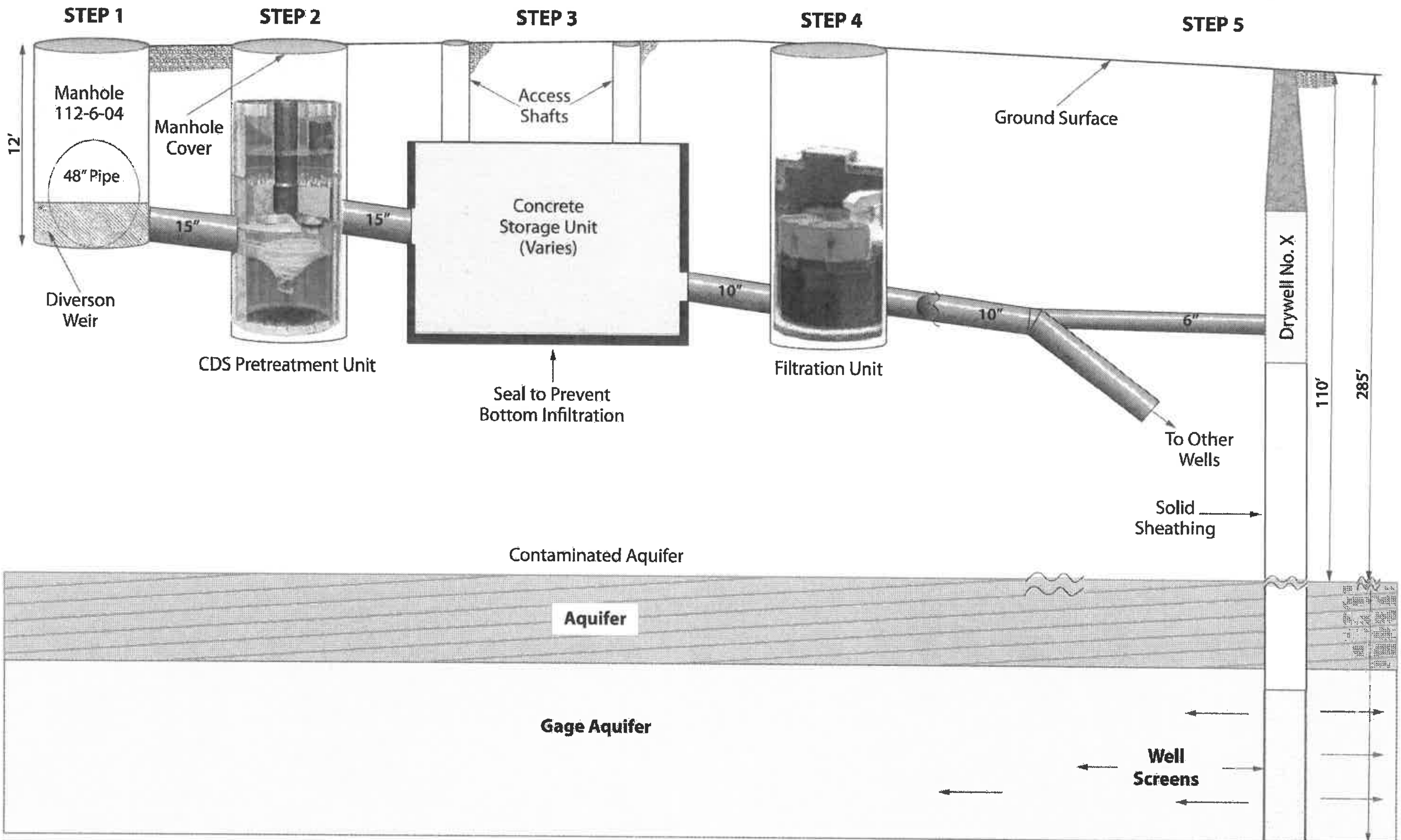


Figure 1.3 Project Treatment Sites and Well Fields



STEP 1: Diversion of flow up to the 24-hr 85th Percentile storm runoff (7.7 cfs) from the existing 48" pipe along Crenshaw Blvd. to CDS pretreatment unit through a 15" diameter pipe.

STEP 2: Sediment and trash removal from diverted flow using CDS unit installed in a 8-ft diameter manhole.

STEP 3: Temporary storage (up to 3 days) of pretreated flow in a 4.5 ac-ft (11.33' deep) concrete storage unit installed 20' below ground surface. Bottom of concrete storage unit sealed to prevent infiltration.

STEP 4: Post treatment of flow from storage unit using filtration system.

STEP 5: Discharge of treated flow into gage aquifer through two 285' deep dry wells.

Not to Scale

Figure 1.4
Dry Well System Layout

1.4 Project Site and Watershed

1.4.1 Project Site

The Project Site which situated at TOA is located within the Machado Lake watershed. The site was identified as a potential project site in the Enhanced Watershed Management Program for the Machado Lake Watershed (2016). The Airport is a city-owned public airport three miles (5 km) southwest of downtown Torrance, in Los Angeles County, California, United States. The Airport is a regional airport covers 506 acs that consists of two asphalt and concrete runways: and an asphalt helipad.

The Project Site comprises three storm water treatment areas separated by the TOA main runway as depicted on Figure 1.3. Table 1.1 provides pertinent information about the storm water treatment areas.

Table 1.1 Project Site Characteristics

Storm Water Treatment Area	Location	Tributary Area (ac)	Available Space for Storage (ac)
A3	Located east of TOA and near Crenshaw Blvd. and 250th Street	239	8.5
Aa	Located east of TOA and 0.2 miles west of Crenshaw Blvd and along Airport Dr.	401	8.0
A1	Located at parking lot west of TOA and near Madison St./Airport Dr.	2,841	4.0

1.4.2 Project Watershed

The Machado Lake watershed is situated within the Dominguez Channel Watershed Management Area. Machado Lake is separate from Dominguez Channel and discharges, under storm conditions, to Wilmington Drain and the Los Angeles Harbor. Machado Lake is considered a freshwater reservoir or lake approximately 40 ac in size located adjacent to Vermont Avenue south of its intersection with Pacific Coast Highway (USEPA, 2014b). The Regional Board's Basin Plan has identified the existing beneficial uses as WARM, WILD, RARE, WET, REC-1, and REC-2. The responsible parties located within the Machado Lake Watershed include the Cities of Los Angeles, Torrance, Carson, Lomita, Rolling Hills, Rolling Hills Estates, Rancho Palos Verdes, Redondo Beach, and Palos Verdes Estates, and unincorporated Los Angeles County.

The portions of the PenCities and Torrance within Machado Lake, were delineated into four subwatersheds. The drainage areas of the Torrance and PenCities tributary to the Project Site are respectively 640 ac and 2,841 ac; totaling 3,481 ac. The drainage area tributary to the Project Site by collaborating agencies is provided in Table 1.2.

Table 1.2 Drainage Area Break Down by Jurisdictional Agency

City/Agency	Total Area (ac)	Percent of Group	Imperviousness (%)
Rancho Palos Verdes	569.42	16.36	32.34
Rolling Hills Estates	1,034.41	29.71	48.23
Palos Verdes Estates	83.37	2.39	16.89
Rolling Hills	718.78	20.65	18.01
LA County Unincorporated	435.22	12.50	26.13
Torrance	640.00	18.38	59.00
Total	**3,481.10**	**100**	**NA**

The contributing drainage area imperviousness ranges from approximately 16 percent to approximately 59 percent. Of all the agencies, Torrance is the most developed. The average imperviousness is approximately 33 percent. According to the Los Angeles County Hydrology Manual (2006), soil types around the project site range from clay to fine sand. The characteristics of the native subsoil and underlying geology encountered during geotechnical investigations suggested good to medium levels of permeability.

Figure 1.5 provides delineation of the four subwatersheds of the agencies participating in the implementation of this regional BMP. For storm water capture and infiltration purposes, the subwatersheds were delineated based on proximity to storm water treatment area, flow volume that could be diverted, and more importantly maintenance responsibilities. The four subwatersheds are:

1. Crenshaw subwatershed, 239 ac - drains to storm water treatment area A3 which is located just east of Crenshaw Blvd. and 250th Street. The subwatershed generates runoff from Torrance only.
2. Airport Drive Subwatershed, 401 ac – drains to treatment area Aa located just east of TOA runway and about 0.2 miles west of site A3. This subwater drains Torrance only.
3. Madison 116 AN Subwatershed, 2,056 ac – drains to storm water treatment area A1, just south of Skypark Dr. and Madison Street.
4. Madison 166R Subwatershed, 785 ac – generates runoff from portion PenCities drainage area which will be conveyed to storm water treatment area A1.

Table 1.3 provides a summary of the drainage characteristics of each subwatershed.

Table 1.3 Subwatershed Drainage Summary

Subwatershed	Responsible Agency	Drainage Area (ac)	24-hr 85th Percentile Runoff	
			Volume (ac-ft)	Peak Runoff (cfs)
Crenshaw	Torrance	239	5.7	14
Airport Dr.	Torrance	401	16.8	25
Madison 116AN	PenCities	2056	60.9	157
Madison 166R	PenCities	785	16.3	40

Notes:
Abbreviations: Cubic feet per second (cfs).

This report includes the following additional sections to describe the TASWIP:

- Section 2 – Field Investigations.
- Section 3 – Design Criteria and Permitting Requirements.
- Section 4 – Site Layouts and Design Alternatives.
- Section 5 – Underground Storage, Conveyance and Dry Well Sizing.
- Section 6 – SWMM and Groundwater (MODFLOW) Modeling.
- Section 7 – Construction Cost Estimates.
- Section 8 – Conclusions and Recommendations.
- Section 9 – References.

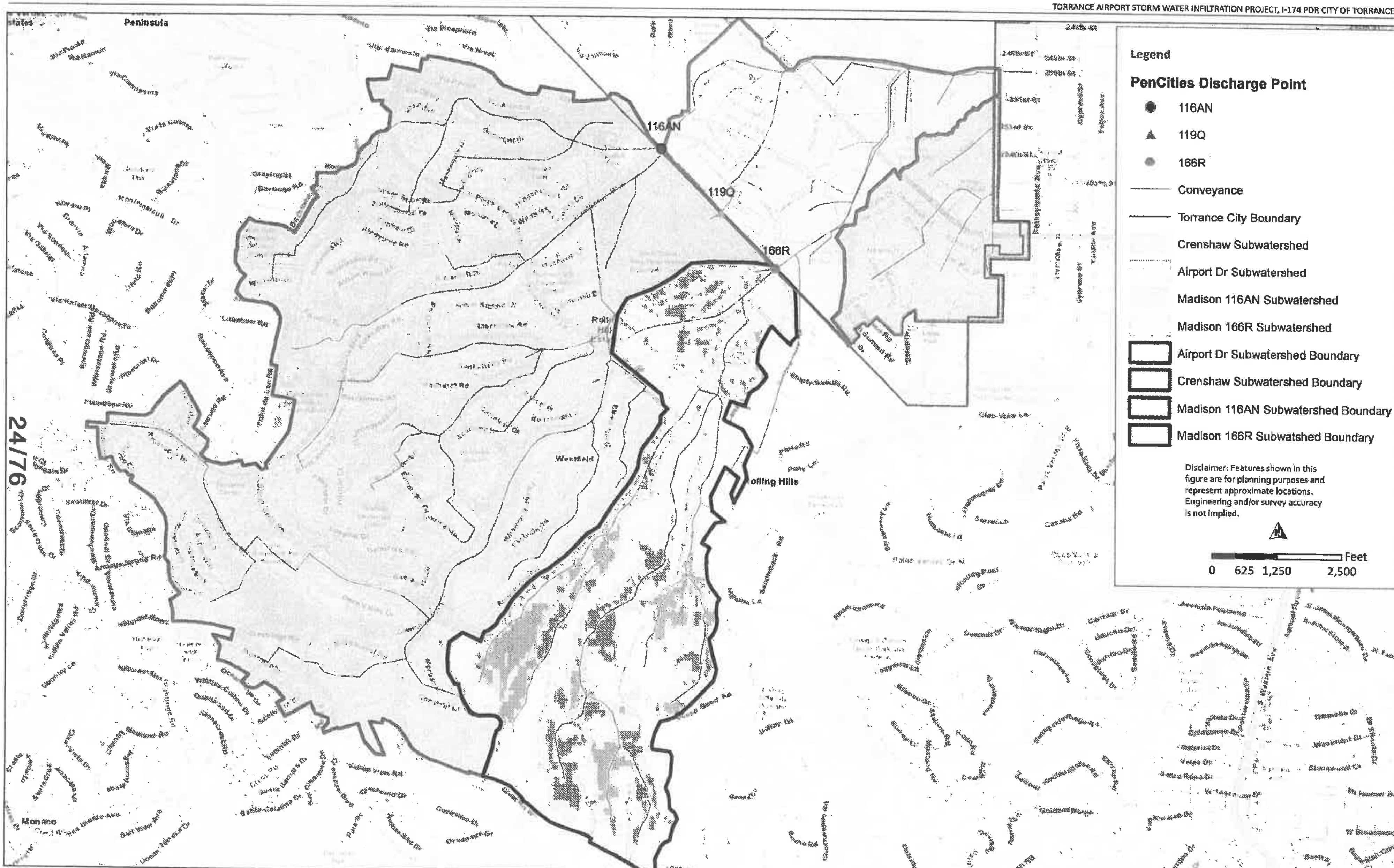


Figure 1.5 Delineated Subwatersheds

Section 2

FIELD INVESTIGATIONS

Although some soil borings have been previously drilled and documented in the Torrance Airport area, none of these previous borings were drilled to bedrock. In assessing the feasibility of storm water injection, test locations were drilled at the Torrance Airport as shown on Figure 2.1. These locations were selected to confirm the depth to bedrock and the presence of water bearing sand/gravel layers overlying the bedrock. Core samples from each location were analyzed and logged for future reference. The following sections summarize the field investigation conducted as part of the TASWIP.

2.1 Field Investigation

In assessing the feasibility of groundwater recharge two monitoring wells (MWs) and two soil boring (SB, or borings) were drilled in the TOA area shown on Figure 2.1 through Figure 2.7. The MWs and borehole were used to delineate the lateral and vertical extent of contamination in groundwater at the project site. The two borings were extended to map the bedrock surface and to describe the geology at the Project Site.

The field investigation was conducted in June 2018 and provided important data such as potentiometric surfaces, groundwater chemistry, detailed lithostratigraphy, and matrix properties. The MWs were drilled using hollow stem auger (HSA), to approximately 110 ft below ground surface (bgs). These wells will provide for future monitoring along the northeast portion of the airport of contaminants of concern. The borings were drilled using Roto-Sonic Drilling (Sonic) to approximately 285 ft bgs. The MWs and borings confirmed the presence of water bearing sand/gravel layers overlying the bedrock. Soil samples from each location were collected from the continuous coreat approximately 10-foot intervals and analyzed by a State certified laboratory. Discrete groundwater samples were collected from the borings at the saturated zone for analysis. Samples were collected from the MWs following well development. A summary of the field investigations is included as Appendix A.

2.1.1 Pre-Field Activities

Prior to field work, a number of tasks were completed in preparation for the drilling borings, MWs installation and sampling of the MWs and borings. These tasks included attending a kickoff meeting, preparing a site specific health and safety plan, obtaining copies of the approved City of Torrance well installation and encroachment permits, and completing utility clearances. All work was completed by EEC Environmental (EEC).

2.1.2 Health and Safety Plan

Prior to commencement of field work, EEC prepared a Health and Safety Plan (H&SP) for the work to be conducted as part of the Project. The H&SP addressed the protocols to be followed during performance of fieldwork to protect site workers and the public. Other safety activities completed prior to or during field work included an inspection of the drill rig and its safety features (documented on a drill rig safety checklist), completing underground utility clearance by notifying Underground Service Alert (USA) and completing air-knife clearance (documented on the underground utility clearance checklist), and monitoring ambient air for VOCs and fixed gases (documented on appropriate field forms). All field equipment was calibrated in accordance with the manufacture suggested time frame. Documentation of these activities is presented on the appropriate forms provided in Appendix A.

2.1.3 Permits

Encroachment permits were obtained from the City of Torrance and well construction permits were obtained from the City of Torrance Health and Environmental Control Department (THECD). The City of Torrance notified the Federal Aviation Administration that drilling activities will be located near Torrance Airport main runway. Based on this information, EEC negotiated an Access Agreement with the property owner, TOA. Copies of the approved permits are included in Appendix A.

2.1.4 Utility Clearance

EEC marked the location of the MWs and borings. Each borehole and well location was cleared of underground utilities. Underground utility clearance was completed on June 15, 2018. Activities were documented on underground utility clearance checklist forms and are also included in Appendix A.

2.2 Borehole Drilling and Well Installation

Borehole and well drilling, installation, development, and sampling activities were conducted between June 18, 2018 through June 28, 2018. Prior to drilling, each location was hand augered to 5 ft bgs to confirm the absence of underground utilities. At each well location, one borehole was drilled for the installation of three nested well casings. During drilling activities, EEC logged the soil cuttings at each borehole and to identify water bearing zones and lithological conditions. Soil samples from these water bearing zones were periodically collected for physical analyses.

2.3 Summary of Analyses and Results

Soil and water samples were collected and transferred to a California State Certified laboratory for analysis. The following is a summary of the analytical results for soil and ground water samples collected.

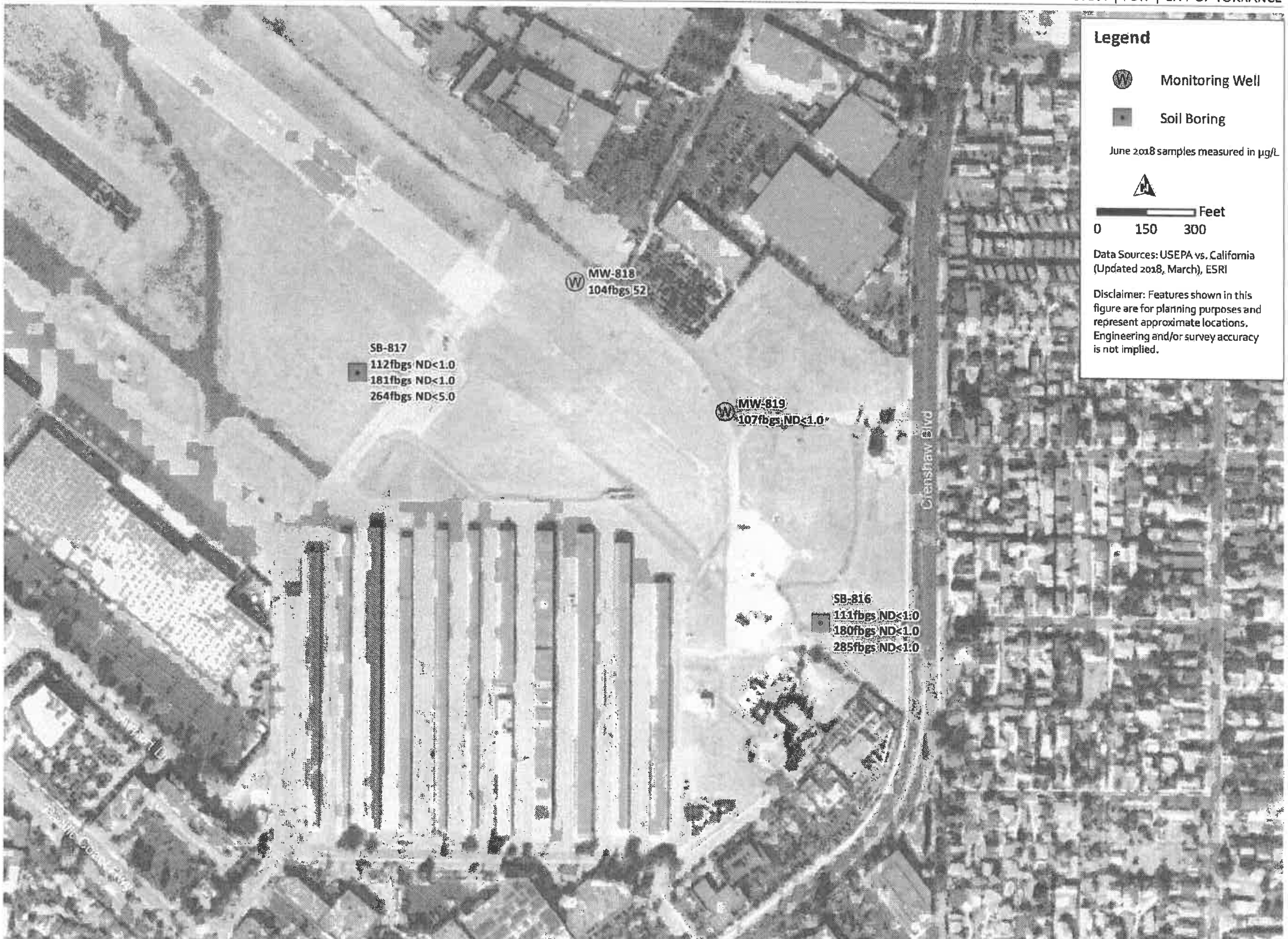
Soil

- Tetrachloroethene (PCE), Trichloroethene (TCE), Benzene and Toluene concentrations detected in soils borings (SB) at MW-818 were below the United States Environmental Protection Agency (USEPA) commercial/industrial Regional Screening Levels (RSL) (USEPA, 2018).
- 1,1,2-trichloroethane was detected in one sample at a concentration of 1.1 µg/kg in the soil sample collected from MW-818 at 60 ft bgs. All other VOCs were non-detected (ND).
- Nitrate (as Nitrogen (N)) detections are below the USEPA Region 9 commercial/industrial RSL.
- Naphthalene was detected in soil sample SB-816 at 100 ft bgs. Polycyclic aromatic hydrocarbons (PAHs) were ND in the soil samples collected except for.

Existing GroundwaterWater Quality

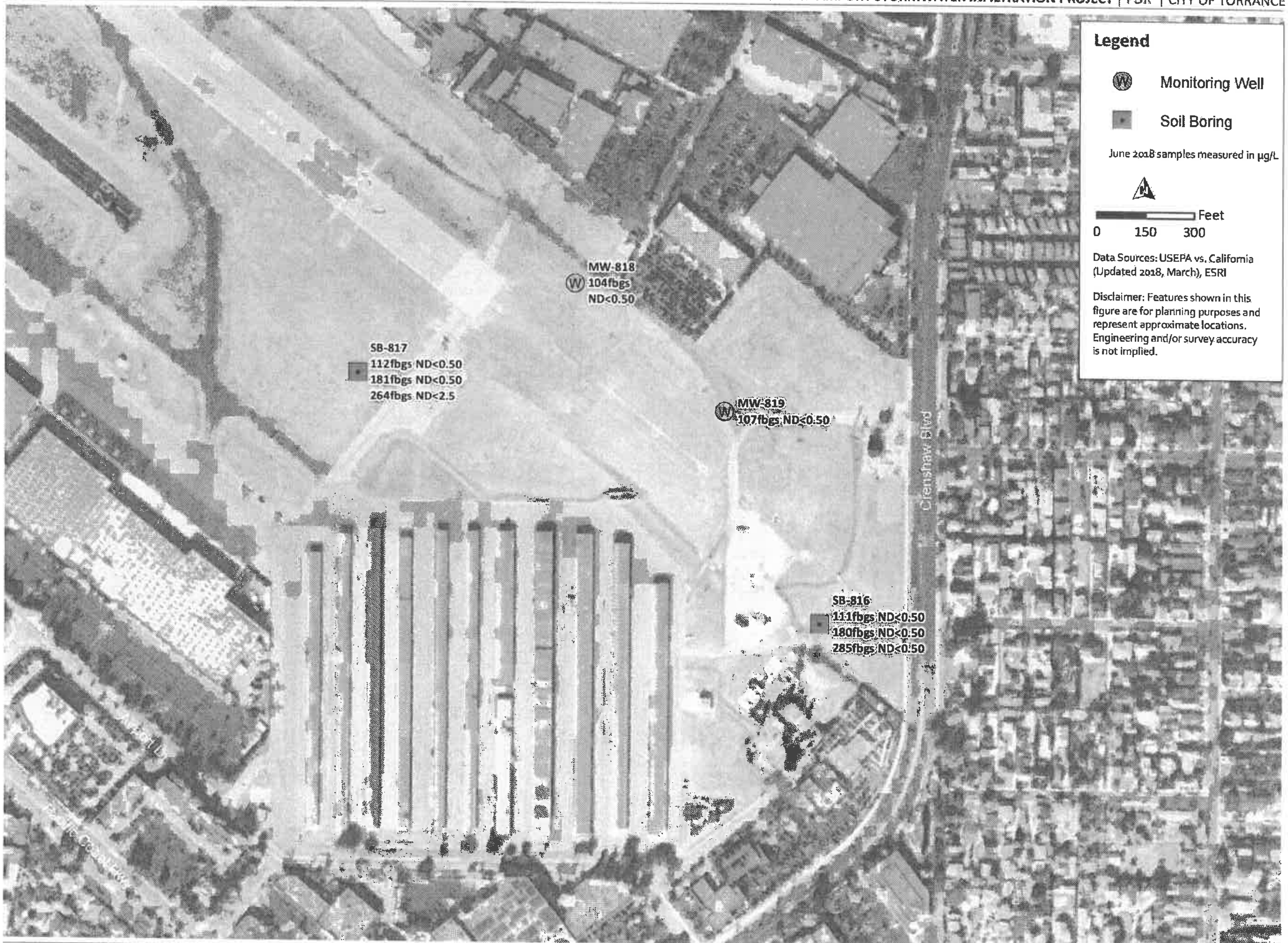
- PCE, TCE, 1,1-dichloroethene (1,1-DCE) were detected in groundwater samples from MW-818 at concentrations above the California maximum contaminant levels (CA MCLs) (USEPA vs. CA, 2018).
- Toluene, nitrate (as N), and other volatile organic compounds (VOCs) concentrations were detected in groundwater samples collected from MW-818 and MW-819 are below the CA MCLs.
- PAHs were ND for groundwater samples collected.

Figures 2.1 through 2.7 show the variation of selected pollutants with depth. Detailed laboratory reports are presented in Appendix A.



Carollo
Last Revised: July 30, 2018 pw:\\IO-PW-INT.Carollo.local:Carollo\Documents\Client\CA\Torrance\11014A00\Data\GIS\SamplingLocation.mxd

Figure 2.1 Site Plan and PCE Sampling Location Map



Carollo
Last Revised: July 30, 2018 pw:\\IO-PW-INT.Carollo.local.Carollo\Documents\Client\CA\Torrance\11014A00\Data\GIS\SamplingLocation.mxd

Figure 2.2 Site Plan and Benzene Sampling Location Map

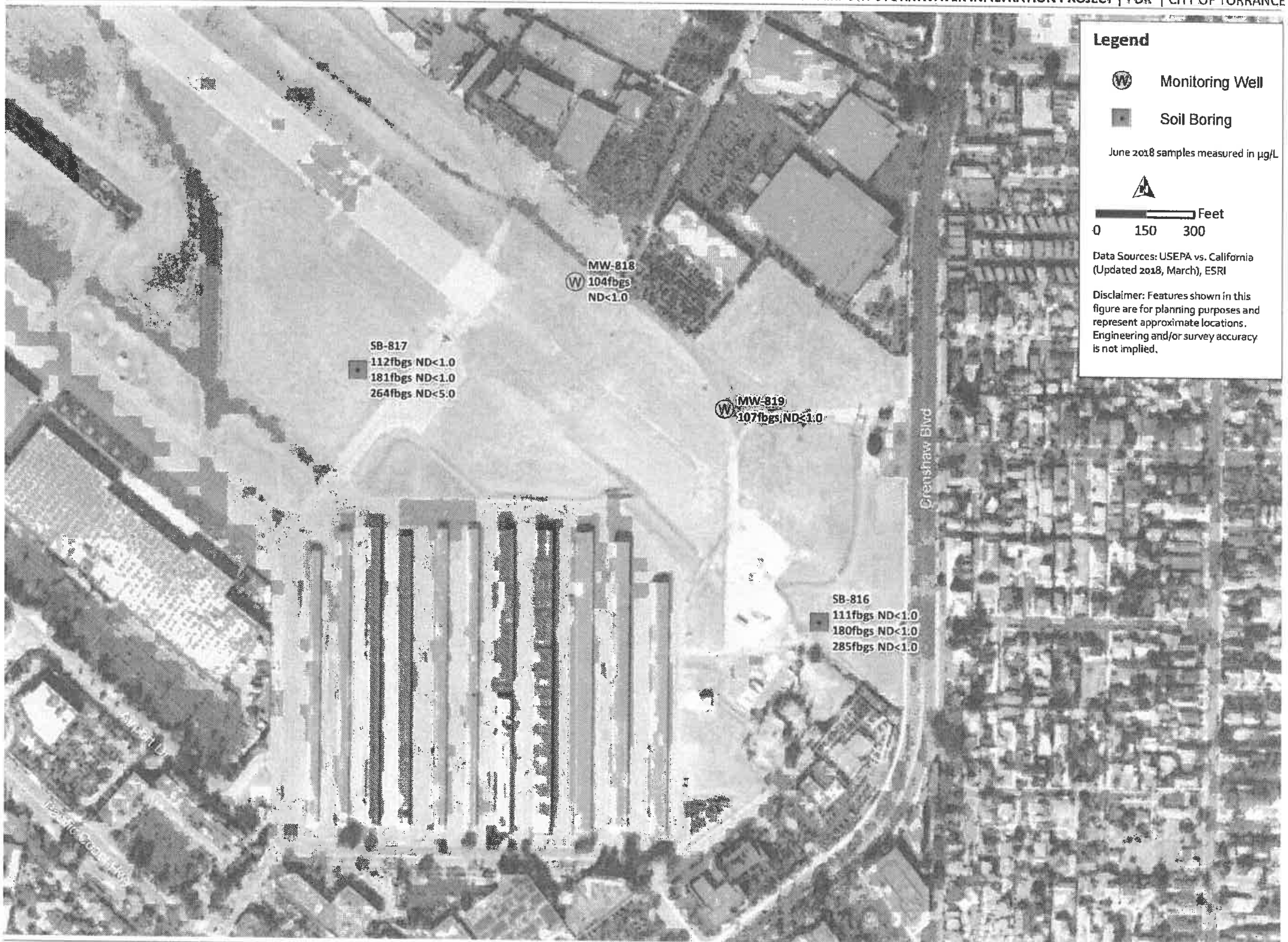
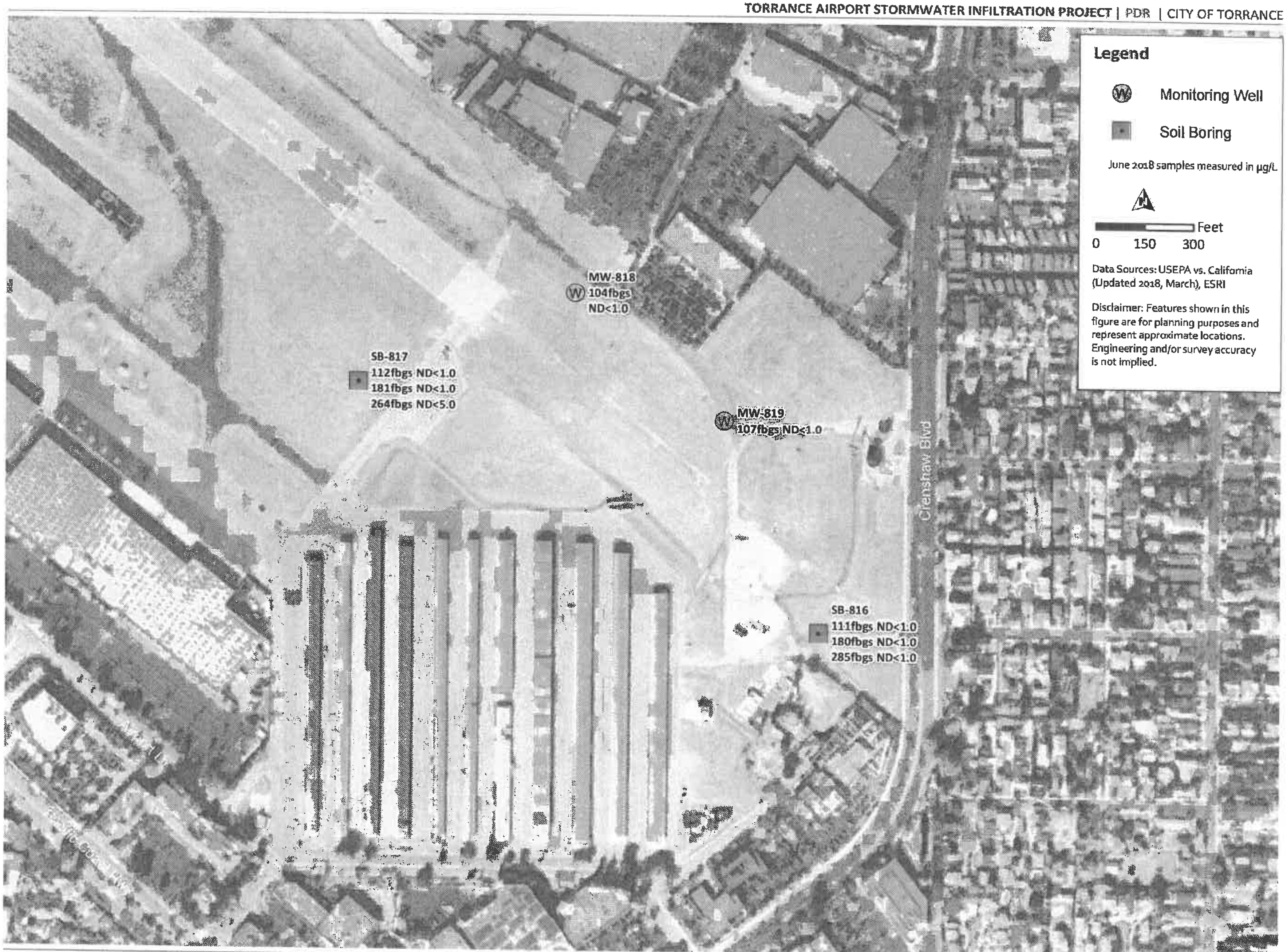


Figure 2.3 Site Plan and Ethylbenzene Sampling Location Map

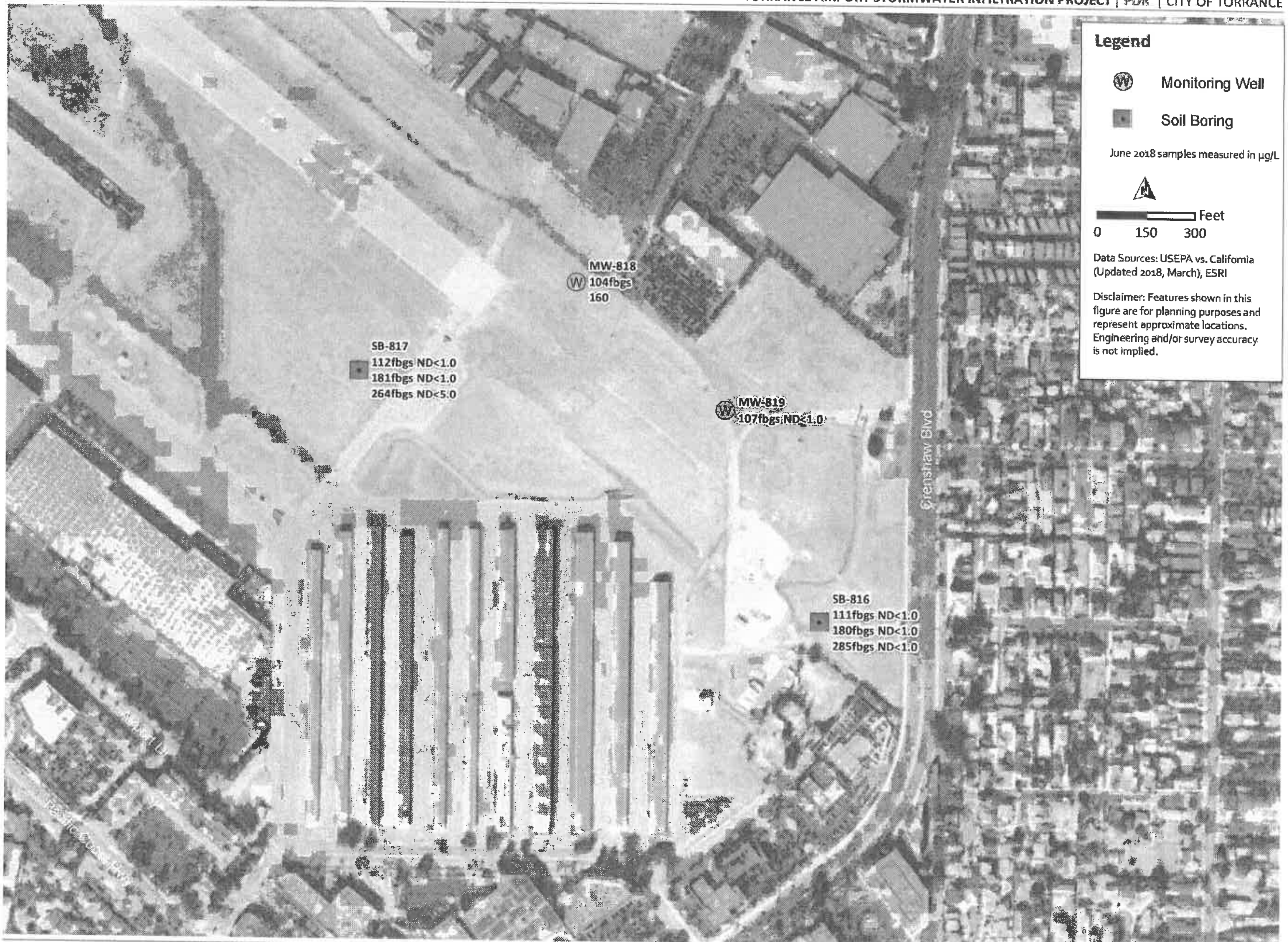
Last Revised: July 30, 2018 pw:\\IO-PW-INT.Carollo.local.Carollo\Documents\Client\CA\Torrance\11014A00\Data\GIS\SamplingLocation.mxd



Carollo

Last Revised: July 30, 2018 pw:\\IO-PW-INT.Carollo.local:Carollo\Documents\Client\CA\Torrance\11011A00\Data\GIS\SamplingLocation.mxd

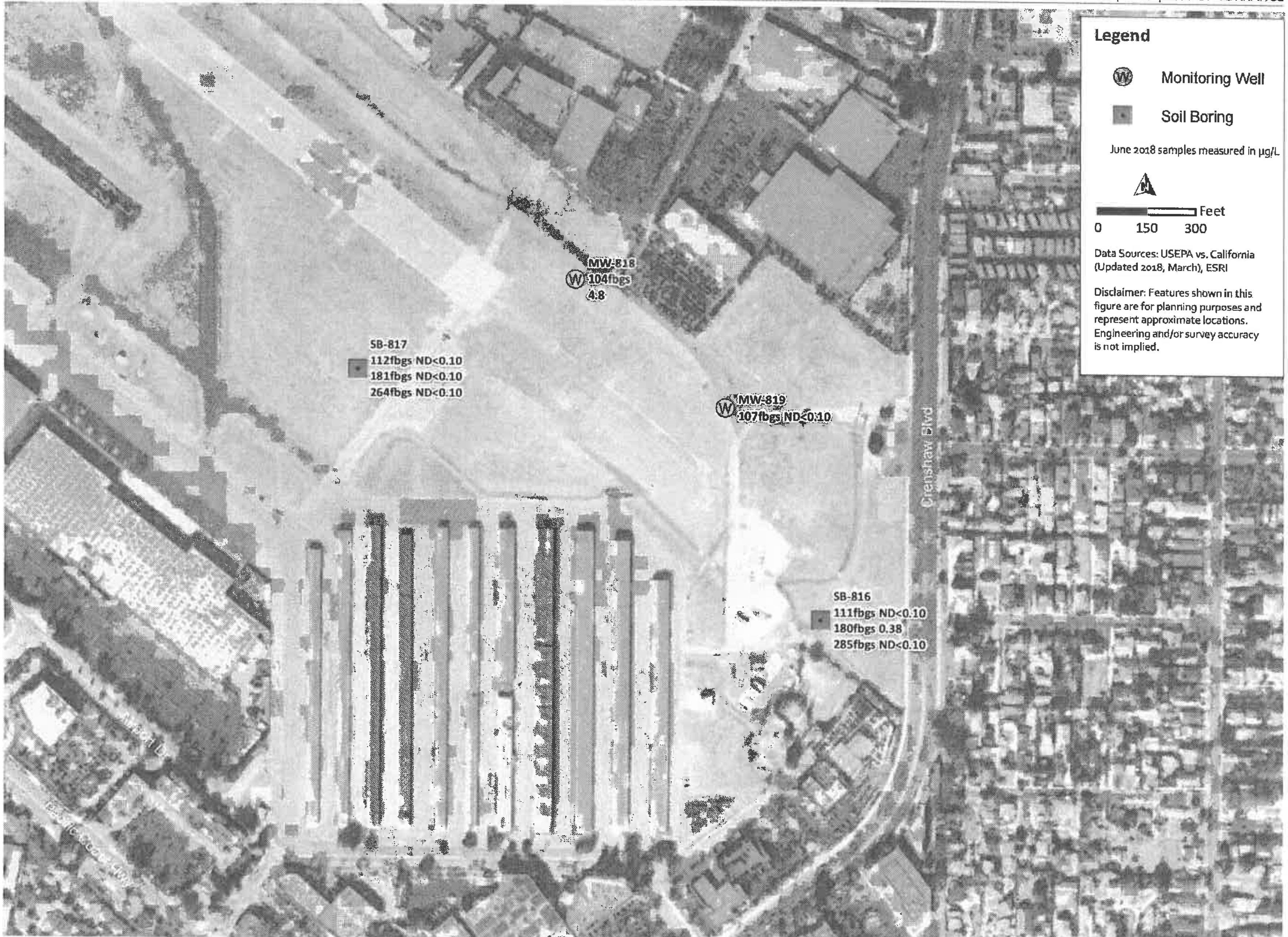
Figure 2.4 Site Plan and cis-1,2-DCE Sampling Location Map



Carollo

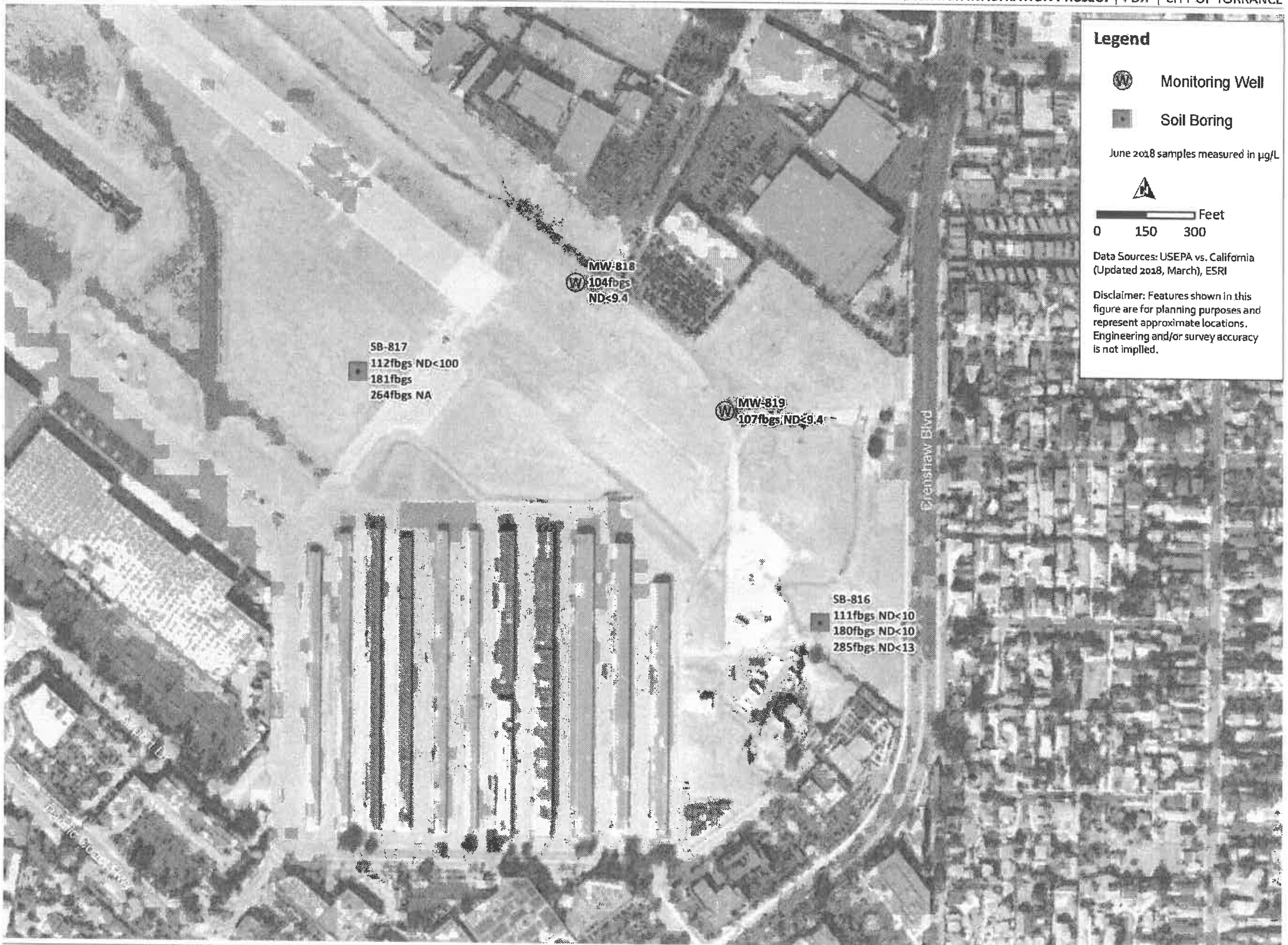
Last Revised: July 30, 2018 pw:\\IO-PW-INT.Carollo.local:Carollo\Documents\Client\CA\Torrance\11014\Aeo\Data\GIS\SamplingLocation.mxd

Figure 2.5 Site Plan and 1,1-DCE Sampling Location Map



Carollo
Last Revised: July 30, 2018 pw:\\IO-PW-INT.Carollo.local.Carollo\Documents\Client\CA\Torrance\12014A00\Data\GIS\SamplingLocation.mxd

Figure 2.6 Site Plan and Nitrate (as N) Sampling Location Map



Carollo
Last Revised: July 30, 2018 pw:\\IO-PW-INT.Carollo.local:Carollo\Documents\Client\CA\Torrance\11014A00\Data\GIS\SamplingLocation.mxd

Figure 2.7 Site Plan and PAHs Sampling Location Map

Section 3

DESIGN CRITERIA AND PERMITTING REQUIREMENTS

The design criteria guiding the TASWIP project is discussed under the following:

- Site selection criteria.
- Dry well design criteria.
- Underground storage design criteria.

3.1 Site Selection

Torrance worked with members of the project team to make field visits to potential sites and conducted related research representing the best combination of features for the Project. Public ownership was a key factor in making the determination for the storm water treatment areas, along with access and safety. Initially the project proposed five treatment areas; however, due to exiting contamination, and other logistical constraints with the proposed, two areas north of the main runway were not included.

Criteria considered during the storm water treatment area selection consisted of:

- 150 foot setback from any domestic wells.
- 500 foot setback from any public supply well.
- 5 foot setback from utility lines.
- Parcel large enough to accommodate the dry well and pretreatment facility with MW network.
- Adequate watershed size and flow volume to produce sufficient surface water volumes to perform monitoring.
- Site access to conduct construction and monitoring.

Each site was evaluated during the preliminary investigation stage to ensure that the final determination of the treatment areas selected would meet the projects goals and objectives for construction/implementation and monitoring/performance. Prior to recommending the Project Site, a utility search was conducted. Known utilities companies contacted for utility information regarding the project area include:

- Sempra – Gas utility.
- Southern California Edison – Electric utility.
- Metropolitan Water District of Southern California (MWDSC).

Utility information was obtained from the companies in an effort to avoid potential conflicts with the proposed projects. The final site selection determined that A1, Aa and A3 storm water treatment areas shown on Figure 1.3 would be sufficient sites for this project.

3.1.1 Geologic and Hydrogeologic Data Review

Geologic and hydrogeologic data related to groundwater conditions at, and surrounding, the Project Site was collected. Specifically, this included gathering information such as existing designs of the facilities at the site, associated hydrogeologic information, such as lithologic logs, well completions records, infiltration tests, and groundwater quality data. In addition, available groundwater elevation data was compiled of the surrounding areas of the Project Site and reviewed to delineate the vadose zone and uppermost aquifer units, estimate aquifer properties, and determine the direction and velocity of groundwater flow at each site.

3.1.2 Hydrologic Data Review

Available information was collected to help with the design of hydrologic and surface water monitoring facilities and dry well installation. Specifically, this included gathering information such as existing designs for the facilities at the Project Site, and associated hydrologic information, such as precipitation records, impervious cover data, watershed boundary data, drainage designs, and water quality data.

3.1.3 Utility Research and Results

3.2 Storage-Dry Well System Design Criteria

A storage-dry well system is a subsurface storm water discharge facility that receives and temporarily stores storm water runoff. Discharge of runoff from a storage-dry well system occurs through infiltration into the surrounding soils. The system can be used to indirectly enhance water quality by reducing the amount of storm water quality design storm runoff volume to be treated by the other, downstream storm water management facilities. The system can also be used to meet the groundwater recharge requirements of the Water Replenishment District (WRD) Storm Water Management Rules.

A storage-dry well system is a type of storm water management measure and must therefore fully drain within 72 hours of the most recent rainfall. Standing water in excess of 72 hours is a sign of failure. The design drain time should be closely monitored to ensure that potential failure is recognized early.

Storage-dry well system can detain, infiltrate, and recharge storm water runoff; however, these are not designed to treat storm water runoff for water quality; therefore, no TSS removal is assigned to this system. Water quality requirements must therefore be met through pre- and post-treatment facilities. The basic design parameters for a storage-dry well system are its storage volume and the permeability rate of the subgrade soils. A storage-dry well system must have sufficient storage volume to contain the design runoff volume, while the subgrade soils' permeability rate must be sufficient to drain the stored runoff within 72 hours. Details of these and other design parameters are presented below.

3.2.1 Storage Volume, Depth, and Duration

A storage-dry well system must be designed to treat the total runoff volume generated by the system's maximum design storm. The design runoff volume for the Project is the runoff volume generated by the 24-hr 85th Percentile storm. This is storm water quality design storm to meet the TMDLs and MS4 permit requirements. The system must fully drain the 24-hour 85th Percentile runoff volume within 72 hours. Runoff storage for greater times can render the system ineffective and may result in anaerobic conditions, odor, and water quality and mosquito breeding problems. Thus, the system is sized to fully drain in 72 hours.

3.2.2 Permeability Rates

The minimum design permeability rate of the subgrade soils below a dry well depends upon the dry well's location, groundwater level, and maximum design storm. The use of dry wells for storm water quality or quantity control is feasible only where the soils are sufficiently permeable to allow for a reasonable rate of infiltration. Therefore, dry wells designed for storms greater than the groundwater recharge storm can be constructed only in areas with Hydrologic Soil Group A and B soils or as in the case of TASWIP provide a temporary storage system. Soils are classified by the Natural Resource Conservation Service into four Hydrologic Soil Groups based on the soil's runoff potential. The four Hydrologic Soils Groups are A, B, C and D. Where Group A generally has the smallest runoff potential or highest infiltration rate and Group D the greatest runoff potential (or least infiltration rate).

In addition, the design permeability rate of the subgrade soils must be sufficient to fully drain the dry wells maximum design storm runoff volume within 72 hours. The design permeability rate for this project was estimated from field investigation results. Since the actual permeability rate may vary from test or estimated results and may also decrease over time due to soil bed consolidation or the accumulation of sediments removed from the treated storm water, a factor of safety of 1.5 was applied to the estimated permeability rate of 0.5 cfs to determine the design permeability rate of 0.33 cfs. This design rate was then used to size the dry wells' and storage units' maximum design storm drain time.

3.2.3 Groundwater Contamination

The groundwater north of the project site is contaminated as the site is near the Hi-Shear facility located at 2600 Skypark Drive. One of TASWIP's main goals is to discharge treated storm water to the Gage Aquifer without moving the contaminated plume near the Hi-Shear facility. The dry wells will therefore be constructed to a depth of 285 ft bgs, and the bottom and sides of the underground storage system will be sealed to prevent infiltration through the sides and bottom of the system. The dry wells will have solid walls down to 150 ft bgs to prevent any impact to contaminated soil and conversely, to the Gage Aquifer.

3.2.3.1 Site Contamination Background

Hi-Shear Corporation manufactures fasteners for the aerospace industry. The Hi-Shear site is an approximately 12.25 ac property located on the northwestern portion of the Skypark Property. The Regional Board has designated the Site as Site Cleanup Program Case No. 218, Site ID NO. 2042300.

Assessment and groundwater monitoring has been on-going at the Hi-Shear site since 1991. Currently the groundwater at TOA is sampled triannually from 31 onsite and offsite groundwater MWs. The majority of the wells are screened in the upper portion of the regional water table aquifer (RWTA) with total well depths approximately 101 to 119 ft bgs.

The primary constituents of concern (COC) in groundwater at the site are TCE and PCE. In addition, other COCs detected previously at the site include chlorinated VOCs, VOCs, hexavalent chromium, 1,4-dioxane, and perchlorate.

An elliptical groundwater VOC plume (predominantly TCE), with the long axis of the plume oriented east-west in the direction of groundwater flow, is present and extends offsite to the east. The dissolved-phase TCE plume extends offsite to the east beyond Crenshaw Boulevard (Blvd) and has been migrating farther downgradient over the years. The interpreted extent and isoconcentration contours of TCE in the RWTA, based on the most recent triannual groundwater sampling event (November 2017), are included on Figure 3.1. The highest TCE concentration during the November 2017 event was 19,000 micrograms per liter (µg/L).

Based on the results for groundwater MWs, the bulk of the VOC-impacted groundwater within the RWTA occurs in the uppermost shallow portion of the RWTA. TCE concentrations in wells screened at intermediate or deep depths in the RWTA are significantly below concentrations observed near the top of the RWTA. The chlorinated solvents are primarily migrating horizontally in the aquifer rather than vertically.

The stated goal of the Hi-Shear groundwater remediation is to reduce the size and concentration of the VOC-impacted groundwater plume both on and offsite, and to improve groundwater quality thereby protecting public health or the threat to public health by remediating the core of the VOC plume (Alta, 2017). Ongoing remediation of the site includes an SVE system to reduce the VOC source in the vadose zone and enhanced in-situ bioremediation to treat the core of the chlorinated VOC groundwater offsite plume. SVE has been effective at removing VOCs from vadose zone soils, and declining concentrations of TCE in groundwater at some wells indicate that enhanced in-situ bioremediation efforts are effectively remediating the plume in the treated areas. According to Hi-Shear, assessment activities on downgradient property revealed significant offsite VOC releases and at least one potentially still active PCE source. Releases from this property are contributing to the regional RWTA VOC plume extending offsite to the east of Hi-Shear property forming a commingled plume (Alta, 2017).

According to soil boring results from SB-816, at a depth of 180 ft bgs nitrate (as N) is present at the Nike Missile sites.

3.3 Underground Storage

The underground storm water storage provided as a component of TASWIP will minimally provide storm water quality benefits, but can be a successful segment to the overall storm water management plan as it is coupled in-line with the pre-treatment hydrodynamic separators and post treatment JellyFish Filter units. The addition of pretreatment features at the system's inlet will facilitate improvements to water quality by removing floatables, skimming of oils and grease and trap some level of sediments through deposition. Pretreatment is most important since the temporary stored water will infiltrate into the soil through dry wells, otherwise rapid clogging of the system will occur.

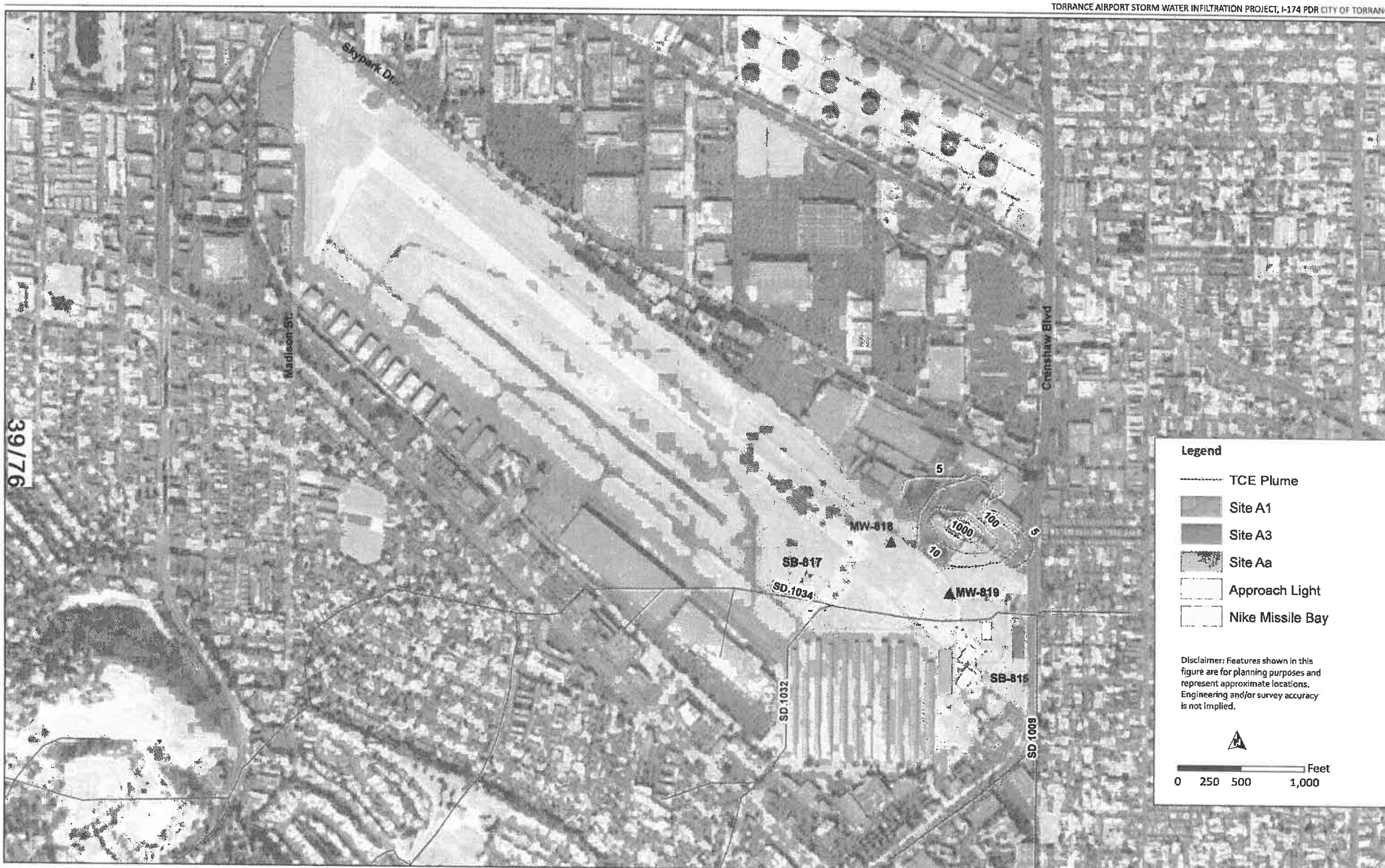
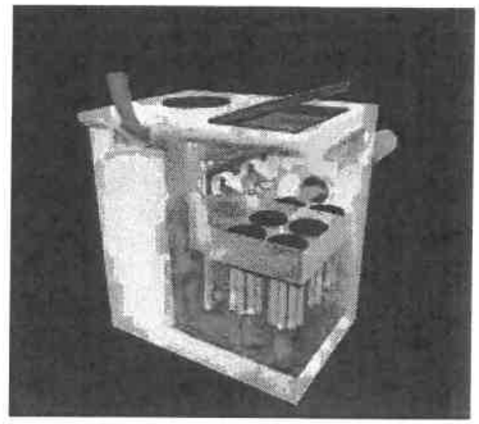


Figure 3.1 Isoconcentrations of TCE

The underground storage unit relies on construction of water storage structures made of concrete (vaults). A number of pre-built, modular systems are commercially available. Generally, storage structures, inlet and outlet pipes and maintenance access (man holes) are fitted and attached in a predetermined excavated area and then the entire area is back-filled to surrounding landscape surface height with gravel and subsequently surfaced. Because TASWIP will be implemented at the airport, the construction method employed must avoid big excavations for more than one day.

Concrete subsurface storm water detention and infiltration system

Post treatment unit, JellyFish Filter is placed downstream of the underground storage unit for further treatment. The Jellyfish Filter is a storm water quality treatment technology featuring high surface area, high flow rate membrane filtration, at low driving head. By incorporating pretreatment with light-weight membrane filtration, the Jellyfish Filter removes a high level and a wide variety of storm water pollutants. The high surface area membrane cartridges, combined with up flow hydraulics, frequent backwashing, and rinseable/reusable cartridges ensures long-lasting performance. Table 3.1 provides published removal rates of selected pollutants. The table shows that the initial concentrations of these pollutants will be significantly reduced by the percentages listed in the table prior to discharge into the aquifer.



CONTECH JellyFish Filter

Table 3.1 Reported JellyFish Filter Performance Testing Results

Pollutant of Concern	% Removal
Total Trash	99
Total Suspended Solids	89
Total Phosphorous	59
Total Nitrogen	51
Total Copper	>50
Total Zinc	>50
Turbidity	<15

3.4 Permitting Requirements

Under the minimum federal requirements, storm water drainage wells or dry wells are "authorized by rule" (40 CFR 144). This means that storm water drainage wells do not require a permit if they do not endanger the underground source of drinking water (USDW) and comply with federal underground injection control (UIC) program requirements. The prohibition on endangerment means the introduction of any storm water contaminant must not result in a violation of drinking water standards or otherwise endanger human health. Federal program requirements include:

- Submitting basic inventory information about the storm water dry wells to the state or EPA.
- Constructing, operating, and closing the drainage well in a manner that does not endanger USDWs.
- Meeting any additional prohibitions or requirements (including permitting or closure requirements) specified by a primacy state or USEPA region.

Given below are some permits that will be required as part of implementing the project:

- Construction General Permit for Storm Water Discharges Associated with Disturbance Activities [Order No. 2012-0006-DWQ NPDES Permit No. CAS000002]:
  - The Construction General Permit is applicable to projects that disturb 1 or more acs of soil or whose projects disturb less than 1 ac but are part of a larger common plan of development that in total disturbs 1 or more acs. Projects are required to obtain coverage under the General Permit for Discharges of Storm Water Associated with Construction Activity. Construction activities subject to this permit includes clearing, grading, and disturbances to the ground such as stockpiling, or excavation.
  - The permit requires the development and implementation of a site specific Storm Water Pollution Prevention Plan (SWPPP). The SWPPP should contain a site map(s) which shows the construction site perimeter, existing and proposed buildings, lots, roadways, storm water collection, and discharge points, general topography both before and after construction, and drainage patterns across the project. The SWPPP must list BMPs that the discharger will implement to protect storm water runoff and the placement of those BMPs. Additionally, the SWPPP must contain a visual monitoring program; a chemical monitoring program for "non-visible" pollutants to be implemented if there is a failure of BMPs; and a sediment monitoring plan if the site discharges directly to a water body listed on the 303(d) list for sediment. Section A of the Construction General Permit describes the elements that must be contained in a SWPPP.
  - The project owner will be required to submit the permit registration documents (i.e., SWPPP, Notice of Intent (NOI), Risk Assessments, site map, and annual fees.) using the State Board's Stormwater Multi-Application Reporting and Tracking System (SMARTS).
- Authorization/Approval from Los Angeles County Water Quality Regional Board:
  - As the first of its kind BMP/groundwater storage project, approval will be needed from both Regional Board storm water and ground water divisions.

- Permit for Construction Groundwater Dewatering & Discharge:
  - Dewatering may be required during project construction involving excavation or other activities where groundwater will be encountered. Permit application will include application of NOI with a time schedule on the start date and end date of the discharge, representative groundwater quality data via SMARTS and estimated quantity of both treated and untreated groundwater to be discharged. Upon completion of the dewatering activity, a Notice of Termination (NOT) for close-out should be submitted.
- Encroachment Permit from the City of Torrance:
  - Encroachment permit will be required from the City of Torrance if temporary storage of construction materials is anticipated on the street right-of-way or other reasons including use of sidewalks or other public spaces.
- Grading Permit:
  - Grading permit will be required to control excavation, grading, and earthwork construction, including fills and embankments. This permit is administered by the City of Torrance.
  - Torrance is partnering with the PenCities to pursue the implementation of a regional storm water BMP at an open space near TOA. This proposed project would not involve any changes to the declared distances on the airport runways or other changes such as relocation or closure of existing service road or any other existing airport operations. Hence, this project will be in compliance with the requirements of the Transportation, Treasury, Housing and Urban Development, the Judiciary, the District of Columbia, and Independent Agencies Appropriations Act, 2006 (Public Law [P.L.] 109-115) and would not need any improvements within the runway safety area (RSA).
- Federal Aviation Authority Permit (Permit). The Project site is within Torrance Airport which regulated by FAA. A permit is required from FAA for any activities in the Airport.

3.4.1.1 Approval from West Basin Water Authority (WBWA) and WRD

The West Basin Water Association is a non-profit whose members include cities, industries, and private entities with water pumping rights or general interest in the West Coast Basin. The WBWA was formed in 1946 to develop a firm water supply where many years of gross overpumping caused a disastrous situation. Approval will be needed from this group prior to project implementation.

Water Replenishment District manages groundwater and aquifers in Southern Los Angeles County. Their approval will be required for this project.

Section 4

SITE LAYOUTS AND DESIGN ALTERNATIVES

4.1 Site Layouts

The feasibility of selecting underground storage and dry well systems for storm water management at the project site depends on existing site drainage conditions and the regional geology and hydrogeology. The most factor is construction at TOA that keeps the airport open at all times. These factors were reviewed to help develop feasible site layouts and design alternatives.

4.1.1 Existing Drainage Condition Summary

There is an existing conveyance system within the project site to capture and convey storm water runoff. There are four main storm drains that receive runoff from the tributary subbasins. These are Storm Drain (SD) 1032, SD 1034, SD 351 and SD 1009 as shown on Figure 4.1. SD 1032 is an 84-inch diameter reinforced concrete pipe (RCP) that receives runoff from Torrance and the PenCities. The PenCities discharge into SD 1032 at discharge point 166R shown on Figure 4.1. During a 24-hr 85th Percentile storm event, the peak flow conveyed in SD 1032 is about 55 cfs of which 40 cfs is generated from the PenCities drainage areas, which is Madison 166R subwatershed. SD 1032 discharges into SD 1034 at a junction structure (JS) shown on Figure 4.1.

The largest conveyance structure at the project site is SD 1034, which is a double 8 ft 9 in W x 10 ft 1 in H RCB. SD 1034 also receives runoff from both Torrance and PenCities. The PenCities runoff discharges into SD 1034 at discharge point 116AN which receives runoff from Madison 116AN subwatershed. During a 24-hr 85th Percentile storm event, more than 95 percent of the peak flow conveyed in SD 1034 is generated from the PenCities, and is estimated at 157 cfs. At Cricklewood Street, SD 1034 receives flow from SD 351, which is a 66-inch diameter RCP. SD 351 also conveys runoff from both Torrance and the PenCities. The PenCities discharges runoff into SD 351 at discharge point 119Q as shown on Figure 4.1.

The Crenshaw subwatershed which drains only Torrance discharges into SD 1009 through a 48-inch RCP along Blvd. The total drainage area of Crenshaw subwatershed discharging runoff into SD 1009 is about 239 ac. During the 24-hr 85th Percentile storm event, the peak flow conveyed in SD 1009 is approximately 14 cfs.

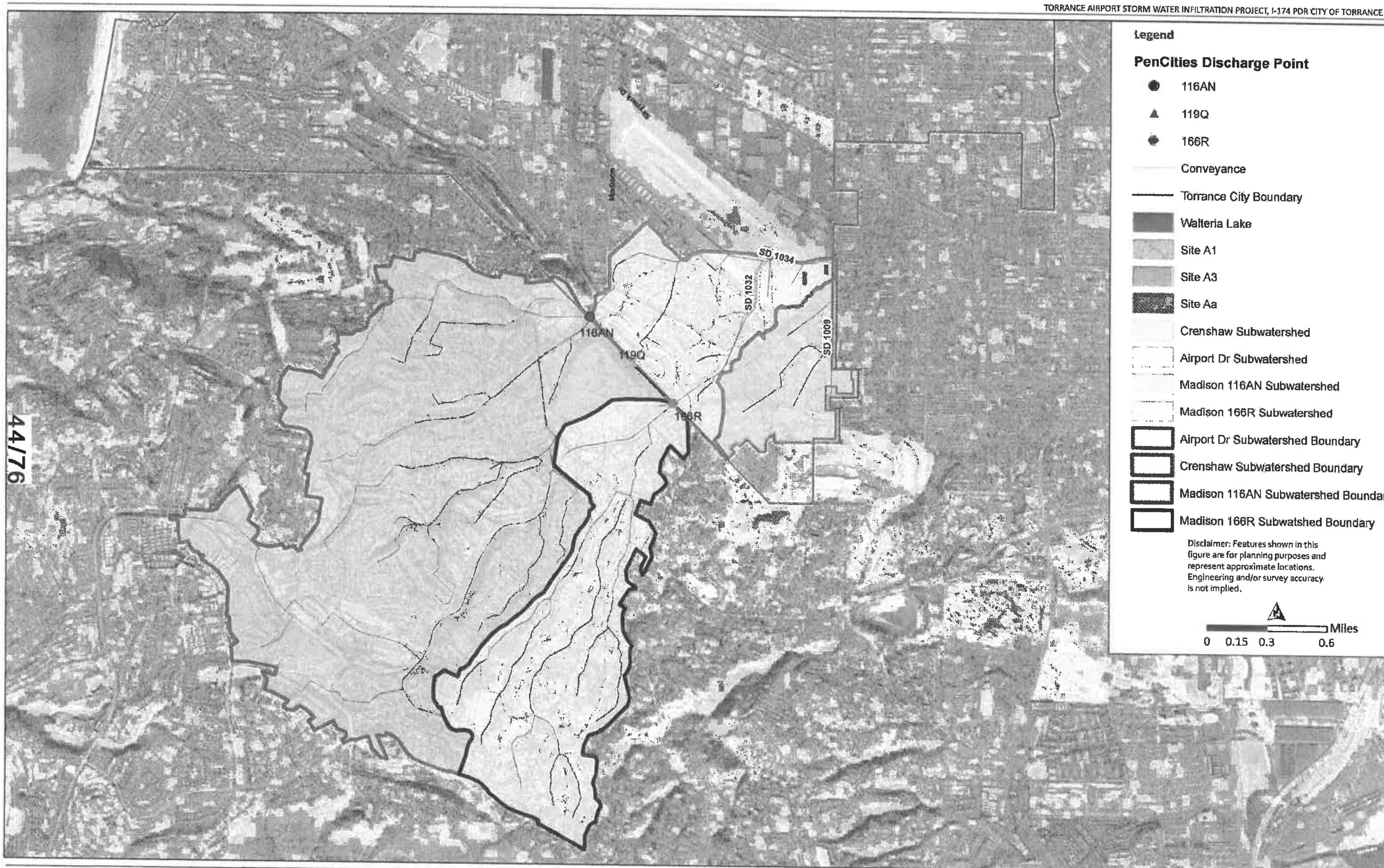


Figure 4.1 Project Site Design Layout

4.1.2 Regional Geology and Hydrogeology

The TOA is located on the Torrance Plain within the West Coast Groundwater Basin, a sub-basin of the Los Angeles Basin. The stratigraphy underlying the Torrance Plain, from the surface down, consists of upper Pleistocene aged Older Dune Sand, the upper Pleistocene aged Lakewood Formation, the lower Pleistocene aged San Pedro Formation, and the Pliocene aged Pico Formation. Based on investigations of the local area associated with the Hi-Shear site just north of the airport, the geologic formations of interest include the Older Dune Sand, Lakewood Formation, San Pedro Formation, and the Pico Formation (Alta, 2016).

The Older Dune Sand Formation is about 50 ft thick and is composed of fine to medium grained sand with silt and gravel lenses. The Lakewood Formation is about 225 ft thick and comprises marine and continental gravel, sand, sandy silt, silt and clay with shale pebbles. The San Pedro Formation, about 700 ft thick, is composed of unconsolidated marine and continental gravel, sand, sandy silt, silt and clay. The Pico Formation, composed of semi-consolidated marine sand, silt and clay interbedded with gravel, extends beyond 1,500 ft bgs where the base of fresh water is thought to occur (DWR, 1961).

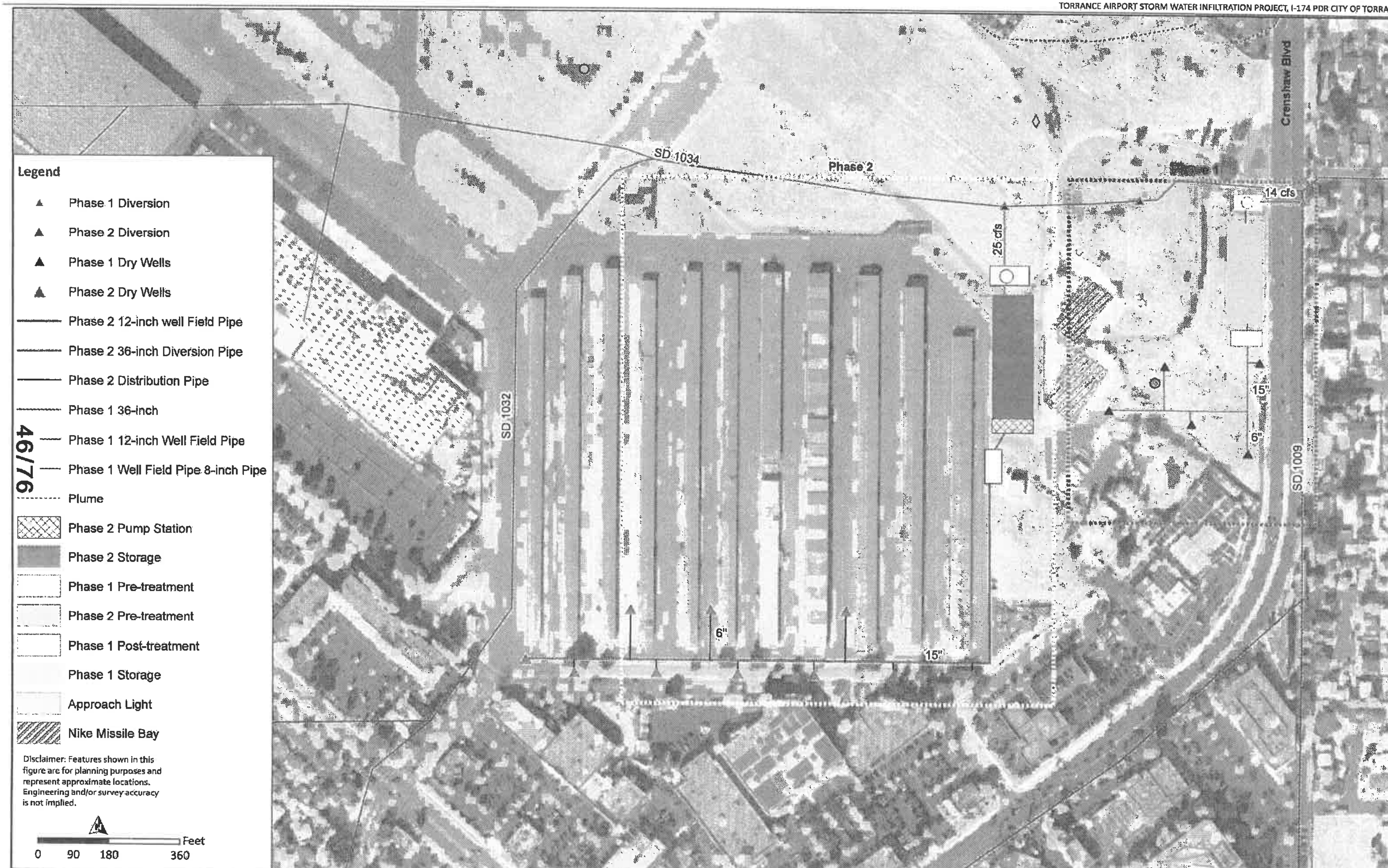
The Lakewood Formation includes the Gage Aquifer, the uppermost regional aquifer in the vicinity of the airport. The Gage Aquifer is composed chiefly of sand with minor amounts of gravel and thin beds of silt and clay and is unconfined in this area. Based on local drilling at the airport and at the Hi-Shear site, the base on the uppermost aquifer occurs at a depth of about 285 fbgs with a saturated thickness of up to 190 ft. Recent drilling at the airport encountered the water table at depths ranging from 97 to 111 ft bgs.

Regional groundwater flow is to the east and the flow pattern is maintained by the combination of groundwater injection along the West Coast Basin Barrier Project (WCBBP) to the west and groundwater withdrawals to the east. The WCBBP, completed in 1969, consists of a series of injection wells that extend approximately nine miles in a north-south orientation; the closest barrier wells are located approximately 2.75 miles west-northwest of the airport.

The injection well barrier has injected water into the Gage, Silverado, and the Lower San Pedro Aquifers since the early to mid-1960s to minimize the intrusion of salt water into the fresh water aquifers, although some saline water is present east of the barrier wells (CDM, 1989). Based on recent groundwater monitoring at the Hi-Shear site, the direction of horizontal groundwater flow is generally towards the east-southeast with a calculated horizontal gradient of approximately 0.002 to 0.003 ft/ft. This horizontal flow direction has remained consistent since 1991 when groundwater level monitoring began at the Hi-Shear site (Geosyntec, 2018).

4.2 Design Alternatives

Based on the site layout, several design alternatives were developed and reviewed with the project partners. Only the selected alternatives are discussed in the following sections. The alternatives are grouped into three phases based on subbasin delineations, jurisdictional agency, and maintenance considerations. The layout of the project phases are depicted on Figure 4.2 through Figure 4.4 and summarized in Table 4.1.



Carollo

Conceptual Layout of Phase 1 and Phase 2 Projects

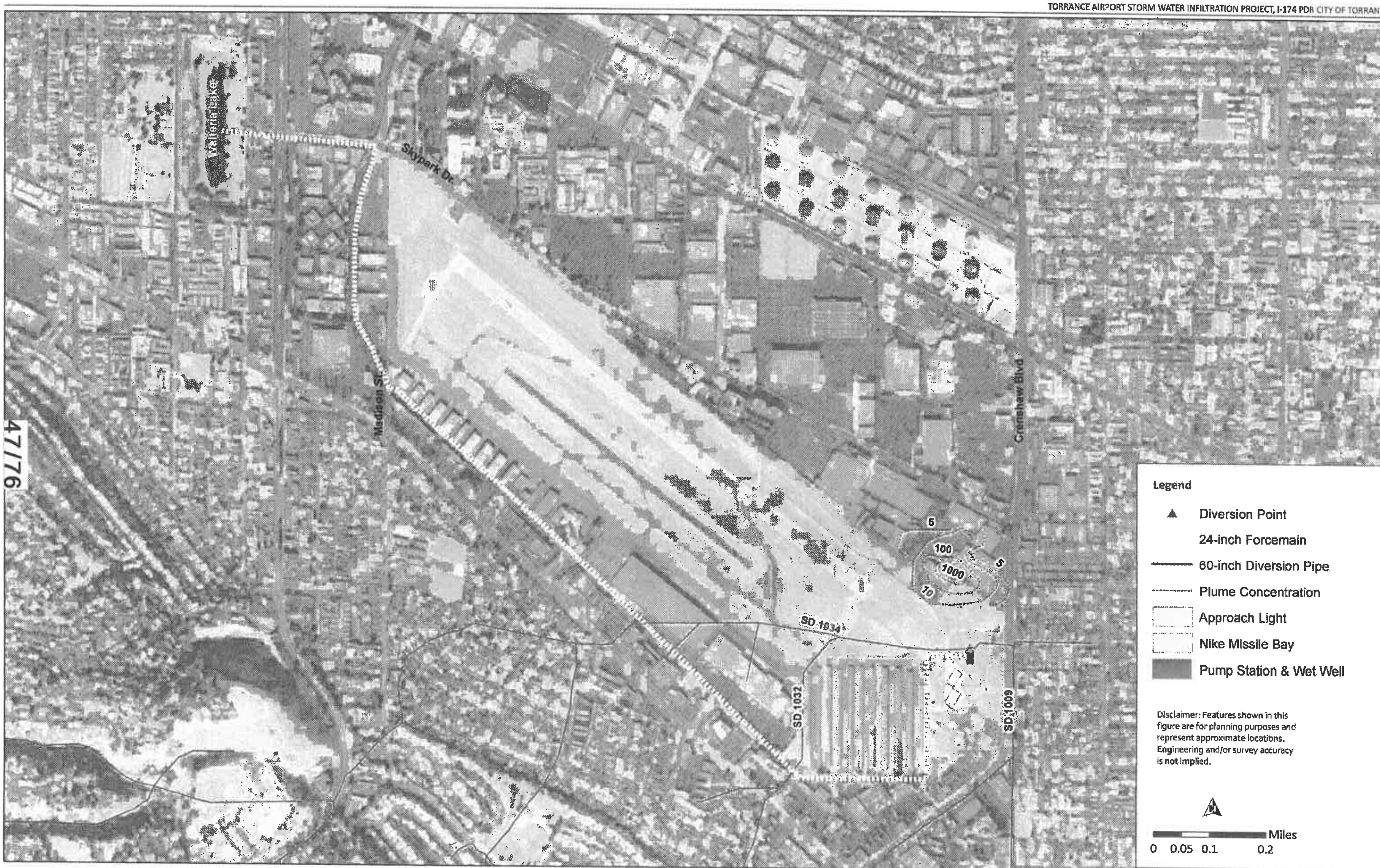


Figure 4.3 Conceptual Layout of Phase 3 Project - Lake Option

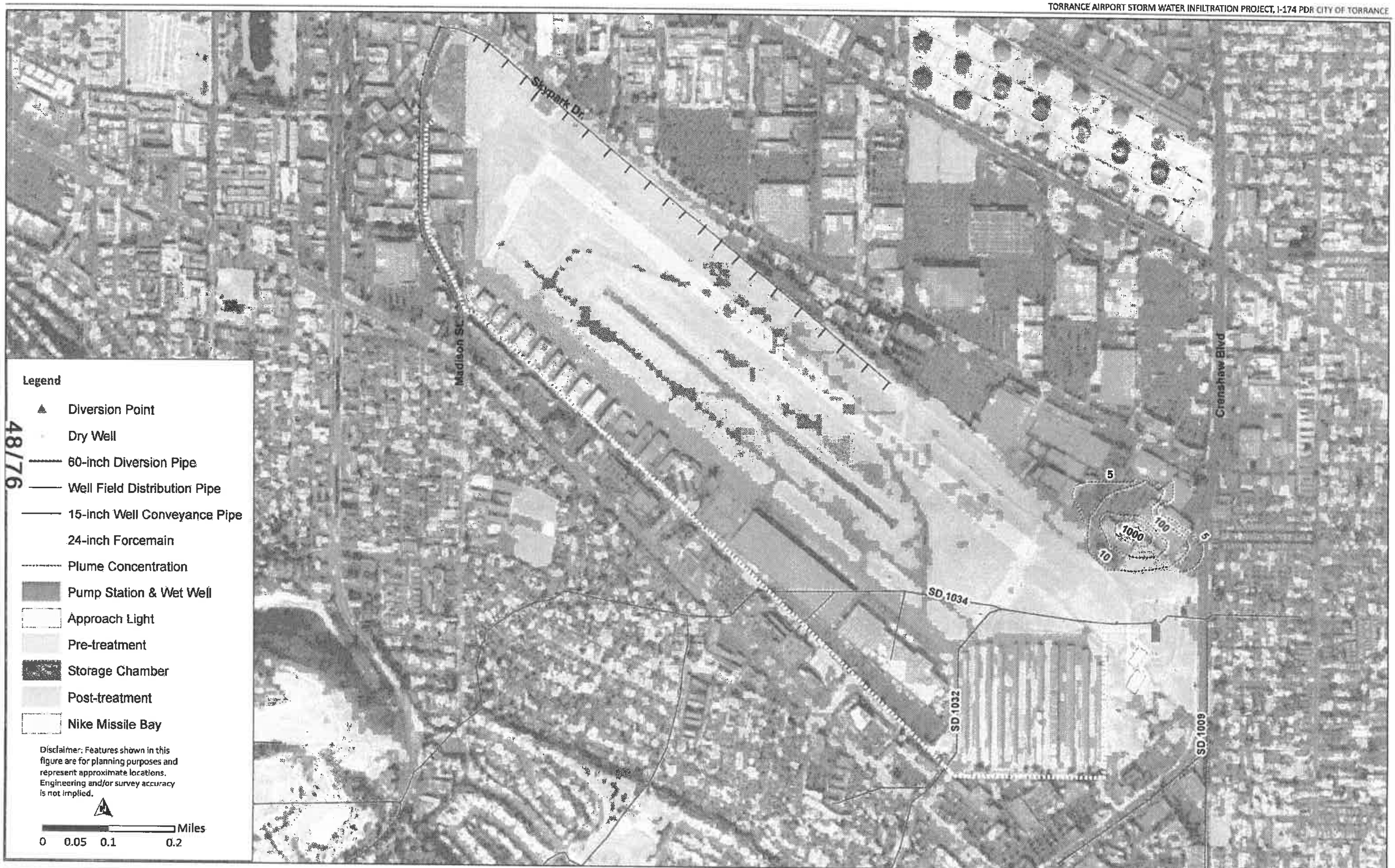


Figure 4.4 Conceptual Layout of Phase 3 Project - Dry Well Option

4.2.1 Phase 1 Conceptual Layout– Crenshaw Blvd

The City of Torrance is the responsible agency for the Phase 1 portion of the Project. It is anticipated that Torrance will assume all future responsibilities regarding maintenance activities related to this Phase 1 project. All of the 24-hr 85th Percentile runoff volume generated from a tributary area of 239 ac will be diverted from SD 1009 to storm water treatment area A3 which is located west of Crenshaw Blvd. and 250th Street. The tributary area to A3 is completely located within the city of Torrance boundary. Both pre and post storm water treatment units respectively located upstream and downstream of the underground storage are components of Phase 1. The dry wells are located along Crenshaw Blvd as shown on Figure 4.2. A pump station may be needed after the storage unit and must be explored during final design.

The Phase 1 Project is recommended to be completed as a Pilot Project to confirm and validate the design before the implementation of Phase 2 and Phase 3.

Table 4.1 Summary of Project Phases

Project Phase	Responsible Agency	Storm Water Treatment Area	Dry Well	Pre-Treatment	Post-Treatment	Underground Storage	Pump Station
Phase 1	Torrance	A3	√	√	√	√	?
Phase 2	Torrance	Aa	√	√	√	√	√
Phase 3							
Lake Option	PenCities	Walteria Lake		√			√
Dry Well Option		A1	√	√	√	√	√

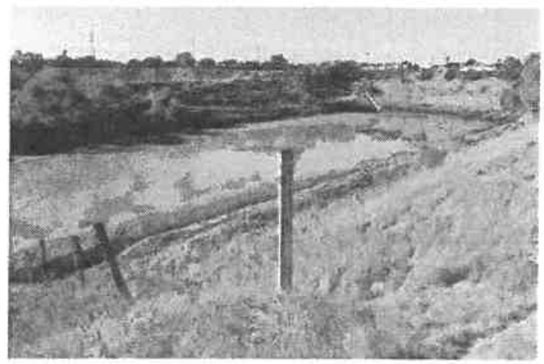
4.2.2 Phase 2 Conceptual Layout

The city of Torrance is the responsible agency for the Phase 2 portion of the project. It is also assumed that Torrance will take responsibilities regarding future maintenance activities. All of the 24-hr 85th Percentile runoff volume generated from the Airport Drive subwatershed will be diverted from SD 1034 to storm water treatment area Aa which is located near Airport Drive. The tributary area to Aa is completely located within the city of Torrance boundary. Both pre and post storm water treatment units respectively located upstream and downstream of the underground storage are components of Phase 2. The dry wells are located south of the Airport Hangars as shown on Figure 4.2 to minimize impacts on TOA. A pump station is a significant component of this project to reduce the manhole depth of the dry wells and to allow efficient management of the system.

4.2.3 Phase 3 Conceptual Layout

The PenCities will be responsible for the Phase 3 portion of the project. Thus, it is anticipated that the PenCities will manage this storm water treatment area regarding all future maintenance activities. Two design options have been identified. These include the Lake Option and Dry Well Option. The Lake Option and Dry Well Option are shown on Figure 4.3 and Figure 4.4, respectively. The Lake Option includes flow diversion from SD 1034 to a wet well and lift station located near Airport Drive. Storm water will be conveyed from the wet well through a 24-inch diameter forcemain to Walteria Lake.

The Walteria Flood Control Basin (Walteria Basin or Lake) is a man-made basin located in the City of Torrance. The Lake was built in 1962 by the Los Angeles County Flood Control District (LACFCD). Walteria Lake has a perimeter of approximately one mile and extends to an approximate depth of 100 feet. Walteria Lake's watershed is approximately 2,287 acres.



By jurisdictional area, Walteria Lake's watershed is 92.61 percent Torrance, 7.35 percent Palos Verdes Estates, and 0.04 percent Redondo Beach. The primary function of Walteria Lake is to provide flood protection. During storm and dry weather conditions Walteria Lake receives runoff from the surrounding sub watersheds. The water in the Lake is discharged during the dry season to pump out accumulated dry weather flows and after storm events to maintain flood protection for the adjacent communities. The discharge is pumped through the Project No. 584 storm drain and flows through the drainage network where it eventually discharges to Wilmington Drain. The Wilmington Drain is a soft-bottom open channel maintained by LACFCD. Surface water in Wilmington Drain can flow via gravity or an unmanned pump station into Machado Lake. To ensure the downstream capacity is available for other storm flows, Walteria Lake is only pumped down after runoff in the watershed subsides

The existing capacity of Walteria Lake is about 1,005 acre-feet. Preliminary analysis shows that Walteria Lake has enough capacity to accommodate the 24-hr 85th Percentile runoff from the PenCities. Using the total drainage area of Walteria Lake watershed of 2,287 ac, average imperiousness of 50 percent, the 24-hr runoff volumes for several design storms were calculated and compared with the total capacity of Walteria Lake in Figure 4.5. The figure does not take into account the used volume or the initial volume of Walteria Lake at the onset of a storm event. Assuming that 40 percent of Walteria Lake is unavailable at the onset of a storm event, then only 603 ac-ft of Walteria Lake is available to the PenCities. The volume of Walteria Lake available to PenCities for several storms are summarized in Table 4.2. The table shows storms larger than 24-hr 50 years storm, may not be able to accommodate the 24-hr 85th Percentile runoff volume from the PenCities. During such storm events, runoff from the PenCities can be stored in a storage unit and gradually pumped into the Walteria Lake after the storm. Additional storm water flows to Walteria Lake would likely increase downstream gradient of the groundwater table. Further analysis including surface water and groundwater is required.

Table 4.2 Walteria Lake Capacity Evaluation

24-hr Storm Event	Storm Depth (in)	WL Watershed Runoff Volume (ac-ft)	WL Watershed and PenCities Runoff Volume (ac-ft)	Excess Volume (ac-ft)
2-yr	2.3	219	296	307
5-yr	3.5	334	411	192
10-yr	4.3	410	487	116
25-yr	5.3	505	582	21
50-yr	6.0	572	649	-46
100-yr	6.7	638	715	-112

In the Dry Well Option, all the 24-hr 85th Percentile runoff volume will diverted from SD 1034 to pump station to a 24-inch force main along Airport Drive to a pre-treatment unit at a parking lot located along Madison Street. The pre-treated runoff will then discharge into an underground storage unit under the parking lot. The post-treatment unit will discharge into dry wells along Skypark Drive and Madison Ave.

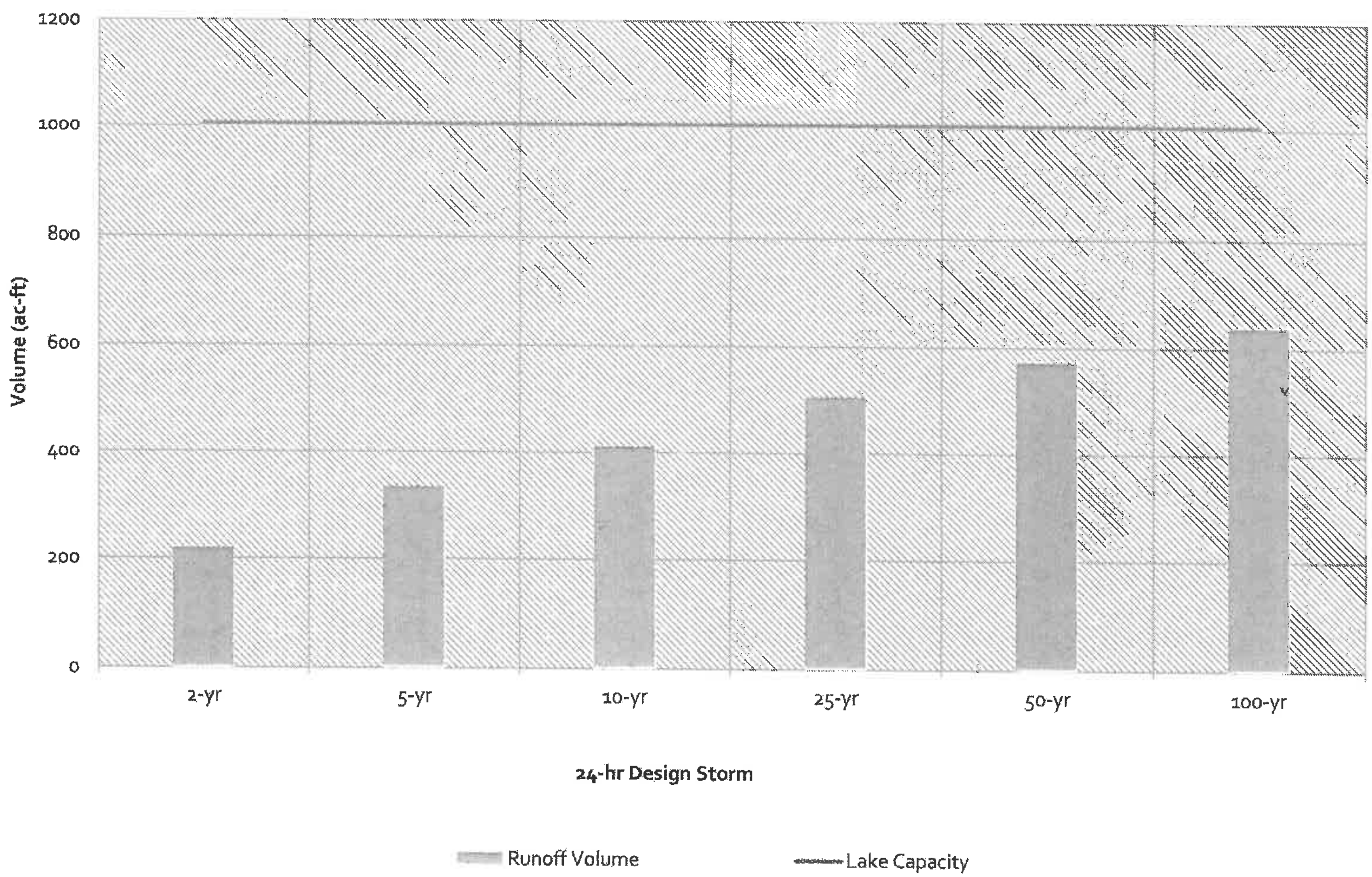


Figure 4.5 Walteria Lake Watershed Runoff Volumes vs Walteria Lake Capacity

Section 5
UNDERGROUND STORAGE, CONVEYANCE AND DRY WELL SIZING

Many factors influence the sizing of underground storage, conveyance, and dry well facilities, which can have a strong impact on the economic feasibility of storm water capture and recharge projects. Determining the appropriate sizes for these elements for a storm water infiltration and recharge system is an iterative process. Thus, the sizes of these TASWIP project elements were first determined using simplified tools, and then optimized through USEPA Storm Water Management Model (SWMM) Version 5.0 (SWMM) and MODFLOW modeling efforts.

5.1 Underground Storage System

The initial sizes of the underground system for all project phases were set based on the estimated runoff volume from the tributary areas using the 24-hr 85th Percentile storm. The values were then refined through optimization process in SWMM and MODFLOW. The initial underground storage volumes for project Phase 1 and Phase 2 of the Project were calculated according to the following equation:

$$V = \frac{P}{12} \times C \times A \tag{1}$$

V = Estimated runoff volume of 24-hr 85th Percentile storm in ac-ft.
P = 24-hr 85th Percentile rainfall depth in inches – 0.85 in
A= Tributary area in acres
C = Runoff coefficient – 0.59

The 24-hour 85th Percentile is defined as the measured precipitation depth accumulated over a 24-hour period for the period of record that ranks as the 85th Percentile rainfall based on the range of all daily event occurrences during this period. The 24-hour 85th Percentile storm depth was estimated from the County of Los Angeles Department of Public Works online Hydrology Map to be 0.85 inches for Crenshaw and Airport Drive subwatersheds (Torrance). The 24-hr 85th Percentile runoff volumes to be captured by each phase of the project are summarized in Table 5.1. The Phase 3 24-hr 85th Percentile runoff volume was obtained from the PenCities.

The underground system volume was determined iteratively using SWMM. Section 6 of this report discusses in detail the methodology used to determine the size of the underground storage required to meet the desired 24-hr 85th Percentile runoff volume objective. The underground storage volume determined for each phase of the project is summarized in Table 5.1. The storage volume depends on the number of dry wells that can be installed at the project site without moving the contaminated plume.

Table 5.1 24-hr 85th Percentile Runoff Volume to be Captured per Project Phase

Project Phase	Drainage Area (ac)	Volume (ac-ft)	
		24-hr 85th Percentile	Design Volume
Phase 1	239.0	9.98	5.5
Phase 2	401.0	16.76	9.5
Phase 3	2,944.6	77.23	42.8

The storage system consists of prefabricated concreted units. Each unit will be 15 feet deep and 8.4 feet wide. The use of 15 feet deep units is cost effective as less foot print is required. However, this will increase the depth of downstream manholes and inlet to the dry wells, and may require pump station for maintenance purposes and to effectively manage the dry wells. The required pumping needs for each phase are discussed later in this chapter. Some of the physical attributes of storage units for each project phase are summarized in Table 5.2.

It is a challenge to construct these large units at an airport and therefore construction methods that will not close TOA runways and also not create safety hazard should be employed. These units will be installed by excavation and cranes should not be involved in the installation activities.

Table 5.2 Physical Characteristics Attributes of Storage Units

Phase	Elevation (ft)		Depth Below Ground Surface (ft)	Soil Cover Thickness (ft)
	Ground Surface	Storage Invert		
1	91	63	28	13
2	98	69	29	14
3	75	57	19	4

5.2 System Piping

The piping for each project phase was determined using Manning's Equation and confirmed through SWMM modeling. The piping for each phase is summarized in Table 5.3. The peak flows used in the analysis corresponds to 24-hr 85th Percentile storm.

Table 5.3 Piping Requirement Summary

Project Phase	Peak Flow (cfs)	Pipe Sizes (inches)		Length (ft)				
		Diversion (1)	Main Conveyance(2)	6-inch	15-inch	36-inch	60-inch	Forcemain (24-inch)
Phase 1	13.9	36	15	300	530	150		
Phase 2	24.9	36	15	600	1,650	180		
Phase 3a(3)	199.3	60	18				50	11,750
Phase 3b(4)				2,400	6,900		50	9,730

Notes:
(1) Pipe from diversion to underground storage.
(2) Pipe from underground storage to dry wells.
(3) Phase 3 – Lake Option
(4) Phase 3 – Dry well Option
All distribution pipes are 6 inches.

5.3 Dry Well

For Phase 1, a total of five dry wells are planned. These are shown schematically on Figure 4.2. Storm water flows from the Crenshaw Storage unit will be conveyed through a 15-inch diameter transmission pipeline to the individual injection drywells via smaller branch pipelines, about 6-inches in diameter. Figure 5.1 illustrates a section view of a typical dry well and shows the various components associated with the borehole and completed dry well and also the drainage and screen pipes. The length of overflow and drainage pipes will be determined from field lithographic sampling. The design criteria for a typical dry well and drainage pipe are listed in Table 5.4.

Table 5.4 Design Criteria for Drywell and Drainage Pipe

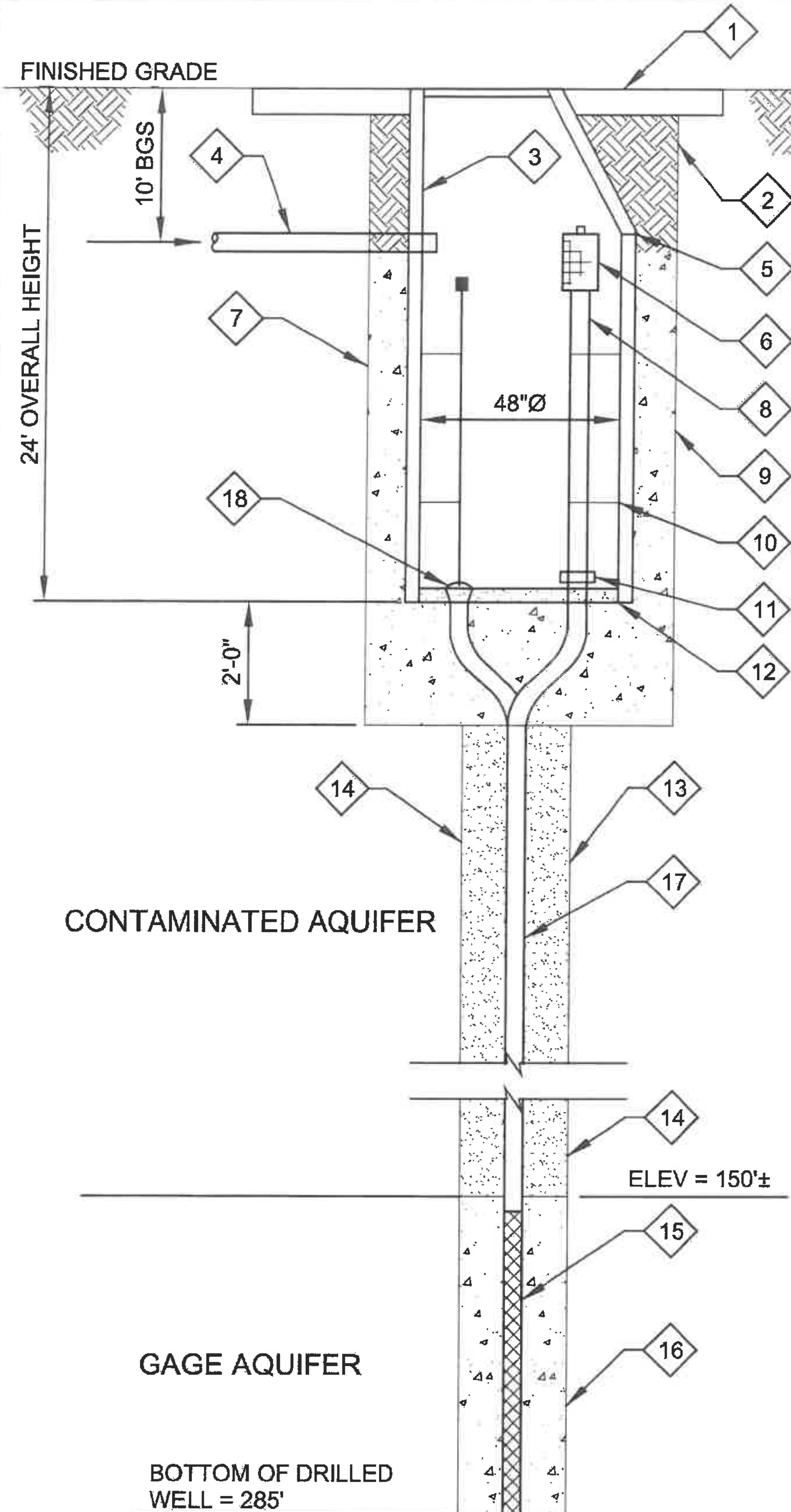
Component	Dimension	Height/Length	Material
Water Storage Chamber	48-inch diameter	≤ 10 ft	Precast Concrete
Influent Pipe	12-inch diameter	Varies	HDPE
Overflow Inlet Screen	12-inch opening	12" x 18"	306 SST
Overflow Pipe	12-inch diameter	25 ft	HDPE
Drainage Pipe	12-inch diameter	200 ft	HDPE
Drainage Screen Pipe	12-inch diameter	100 ft	314 SST
Filter Pack	6-inch thick	100 ft	Granular media

5.4 Pump Station

Pump stations are proposed for Phase 2 and Phase 3 downstream of the storage units to lift pretreated storm water to downstream discharge facilities effectively. Phase 1 may require a pump station but more evaluations are needed to determine if such a need is warranted. A very important consideration of this Project is to select a pumping system and sizes compatible with the needs of each specific Project Site and phase: too large of a pump wastes energy and ultimately leads to a shorter life of equipment due to over-cycling; and too small of a pump fails to adequately address the duration and frequency of storage units overflow.

Since the Project Site is at TOA, the pump station for Phase 2 is small enough to be built inside a manhole using a phased, two-pump design to comply with airport safety requirements. The Phase 3 pump station is too large to be built inside a manhole and therefore above ground structures that comply with airport safety requirements should be used. To achieve maximum efficiency during light rainfall (events less than the 24-hr 85th Percentile storm) without sacrificing maximum performance during design conditions, float controls can be used to activate one or more pumps based on the level of water collecting inside the wet well –with both pumps operating simultaneously at maximum capacity during periods of design events.

The pumps are selected to have a combined pumping rate capable of pumping the runoff from the design event, meaning they are capable of displacing the amount of runoff associated with a 24-hr, 85th Percentile storm. For Phase 1 and Phase 2, each of the pumps will be equipped with a 10-hp electric motor capable of pumping 1,000 gal/min at 30 feet of total dynamic head.



KEY NOTES:

1. CONCRETE COLLAR - 6'Ø
2. 1-SACK CEMENT SLURRY
3. TAPERED OR FLAT TOP CONE
4. INLET PIPE - 10"Ø
5. 48"Ø CONCRETE RISERS
6. OVERFLOW INLET
7. ABC BACKFILL
8. DRAIN PIPE - SOLID
9. 6'Ø DRILLED BORE HOLE
10. SST STRAPS
11. THREADED COUPLING
12. 6" GROUT BOTTOM
13. 12" BORE HOLE
14. GROUT BACKFILL
15. 10" SLOTTED DRAIN PIPE
16. FILTER PACK MATERIAL
17. 10" SOLID DRAIN PIPE
18. 10" MUD VALVE W/EXTENSION OPERATOR

Figure 5.1

INJECTION DRYWELL

TORRANCE AIRPORT STORM WATER INFILTRATION PROJECT

carollo

User: KJackson Plot Date: 21-AUG-2018 2:41:31 PM File: IP_PWP:d0557941\11014A10FIG005-1.dgn

The design storm peak flow for Phase 3 is approximately 200 cfs. Wet well storage will be provided to reduce the peak flow from 200 cfs to 150 cfs. Because of the complex relationship between the variables of pumping rates, storage, and pump on-off settings, a trial and error approach was used through SWMM modeling to estimate the pumping rates and storage required for a balanced design. A wide range of combinations will produce an adequate design flow. However, the goal of this task is to develop an economic balance between volume and pumping capacity. Table 5.5 lists the pumping requirements for each phase of the project.

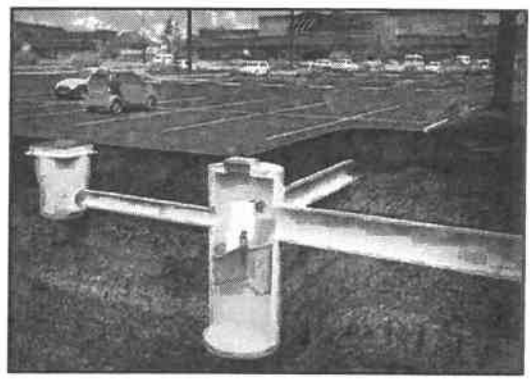
Table 5.5 Pumping Requirements by Project Phase

Phase	Design Flow (gpm)	Pump Capacity (gpm)	Total Dynamic Head (ft)	No. of Pumps
1	741	1,000	30	2
2	1,481	1,000	30	3
3	67,325	10,000	30	7

5.5 Pre- and Post-Treatment Units

5.5.1 Pretreatment

Pretreatment is a required part of infiltration and filtration practices covered under the California Construction Stormwater General Permit. Sediment, trash, debris, and organic materials found in storm water runoff can clog and significantly affect the functionality of structural storm water best management practices (BMPs). Reducing these burdens prior to entering structural storm water BMP(s) will preserve their long-term functionality, particularly for filtration and infiltration BMPs. Pretreatment reduces maintenance and prolongs the lifespan of structural storm water BMPs by removing trash, debris, organic materials, coarse sediments, and associated pollutants prior to entering structural storm water BMPs.



Proprietary pretreatment unit

Manufactured Treatment Devices (MTDs) or proprietary devices are proposed for the Project. Hydrodynamic separator is a required component of all phases of the Project. They are installed immediately preceding storage units and are designed with consideration of the flow network and the downstream structural storm water facility characteristics. Table 5.6 summarizes the characteristics of pretreatment units proposed for this Project.

Table 5.6 Pretreatment Configuration Summary

Phase	Peak Flow (cfs)	Manhole (MH)		Minimum MH Depth (ft)	Inlet Pipe Depth to MH Bottom (ft)
		Size (ft)	No. Needed		
1	14	10	1	11	14
2	25	10	1	13	16
3	199	12	4	16	19

Based on storm water sampling results gathered to data for the project site, total suspended sediment (TSS) concentration varies between 14 and 1,800 mg/L. Hydrodynamic separators are reported to have TSS removal efficiency of about 85 percent. Thus, TSS concentration entering the storage units will have concentrations between 2.1 and 270 mg/L.

5.5.2 Post Treatment

Proprietary storm water post treatment device is proposed downstream of the storage units. The Jellyfish Filter is a storm water quality treatment technology featuring high surface area, high flow rate membrane filtration, at low driving head. By incorporating pretreatment with light-weight membrane filtration, the Jellyfish Filter removes a high level and a wide variety of storm water pollutants. The high surface area membrane cartridges, combined with up flow hydraulics, frequent backwashing, and rinseable or reusable cartridges ensures long-lasting performance. The membrane filters provide a very large surface area to effectively remove fine sand and silt-sized particles, and a high percentage of particulate-bound pollutants such as nitrogen, phosphorus, metals, and hydrocarbons while ensuring long-lasting treatment. Table 5.7 summarizes the characteristics of post treatment units proposed for this Project.

Table 5.7 Post Treatment Configuration Summary

Phase	Peak Flow (cfs)	Manhole (MH)		No. of Cartridges	Inlet Pipe Depth to MH Bottom (ft)
		Size (ft)	No. Needed		
1	1.65	8	1	16	15
2	3.33	10	1	21	17
3	13.20	12	3	28	20

Based on the reported pollutant removal efficiencies for Jellyfish Filter the quality of storm water that will be discharged through the dry wells after both pre- and post-treatment are summarized in Table 5.8. As indicated in the table, the storm water quality that will be discharged meets the WRD standards summarized in the Basin Plan.

Table 5.8 Expected Storm Water Quality After Pre- and Post Treatment

Pollutant	Min. and Max Concentration (mg/L)	Concentration After Treatment (mg/L)	
		Pre Treatment	Post Treatment
TSS	14 – 1,800	2.1 - 270	0.23 – 29.7
Total Organic carbon	8 – 61.0		
Turbidity	19.9 - 943		16.9 - 802
Total Nitrogen	0.71 – 10.5		0.65 – 4.9
Total Phosphorus	0.19 – 10.0		0.08 – 4.1

5.6 Diversion Structure

The design concept of the Project is construct diversion structures to divert flows from storm drains SD 1009, SD 1032 and SD 1034 to pretreatment units. The bottom of the structure will be connected reinforced concrete pipes discussed earlier in this section. The diversion pipes will be restricted to convey only flows equivalent to the 24-hr 85th Percentile runoff during peak flow conditions. The diversion pipes will be limited by orifice plates downstream of the diversion structure sized for the 85th Percentile runoff.

Section 6

SWMM AND GROUNDWATER (MODFLOW) MODELING

The Storm Water Management Model (SWMM) and MODFLOW were performed to optimize the sizes of the project elements. In addition, the modeling efforts were also used to evaluate the system performance under specific storm conditions. The detail modeling efforts for both the surface water and groundwater modeling are provided in Appendix D. The following sections provide a summary of the modeling efforts.

6.1 Modeling Methodology

6.1.1 SWMM Modeling

SWMM is a hydrologic and hydraulic model used to analyze watersheds and conveyance facilities. The existing USEPA SWMM 5.0 model used by Torrance to complete the Machado Lake EWMP was used for this modeling effort. The SWMM model was updated to include the project elements of each project phase. The initial project elements sizes determined in Section 5 were used in the modeling efforts.

The PenCities provided the flow volumes and hydrographs corresponding to the 24-hr 85th Percentile storm from their drainage areas. Figures 6.1 through 6.3 present the 24-hr 85th Percentile hydrographs for the three locations, 116AN, 119Q and 166R where the PenCities runoff discharges into the Torrance storm water collection system.

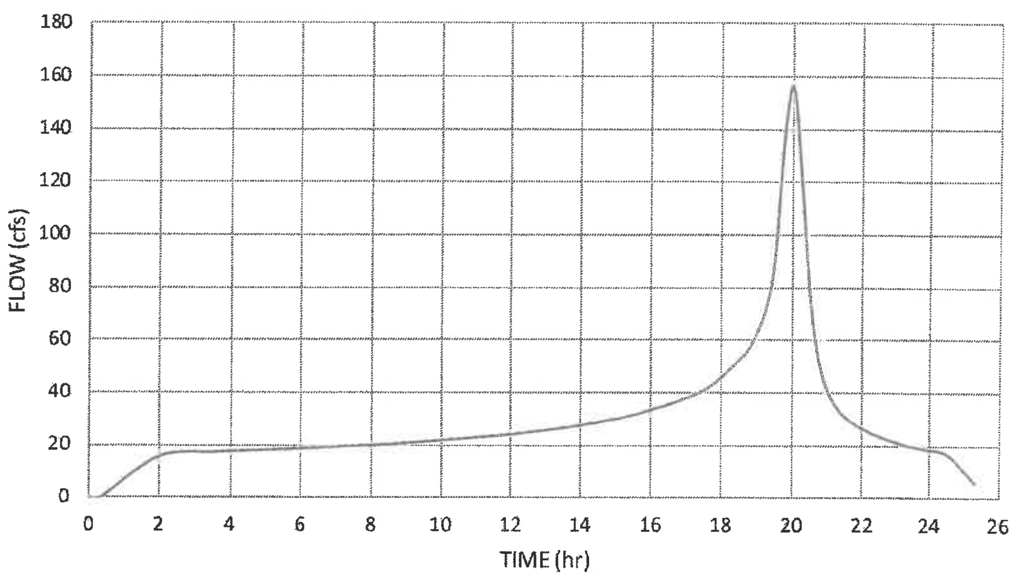


Figure 6.1 24-hr 85th Percentile Runoff Hydrograph at Discharge Point 116AN

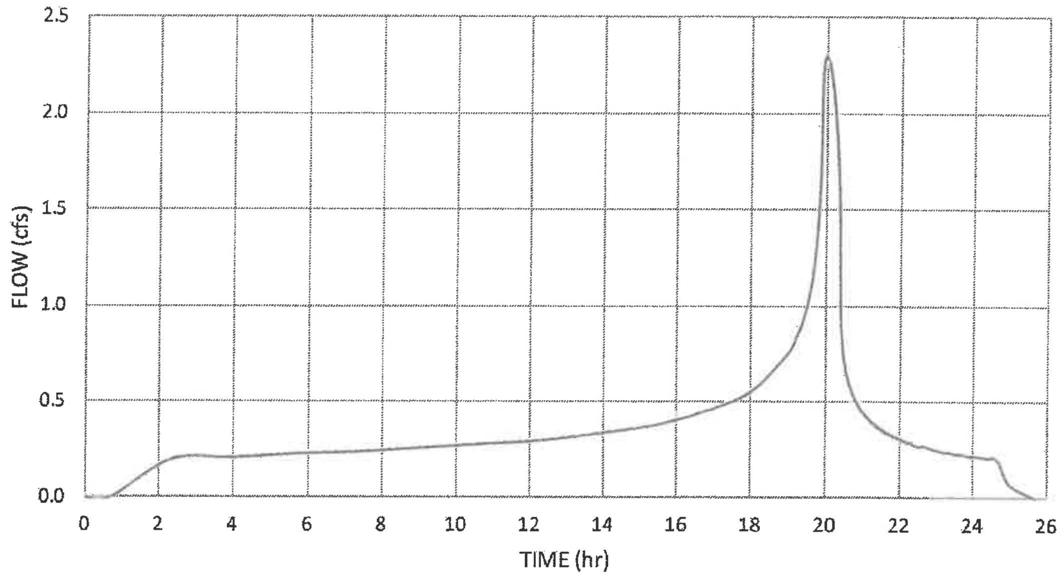


Figure 6.2 24-hr 85th Percentile Runoff Hydrograph at Discharge Point 119Q

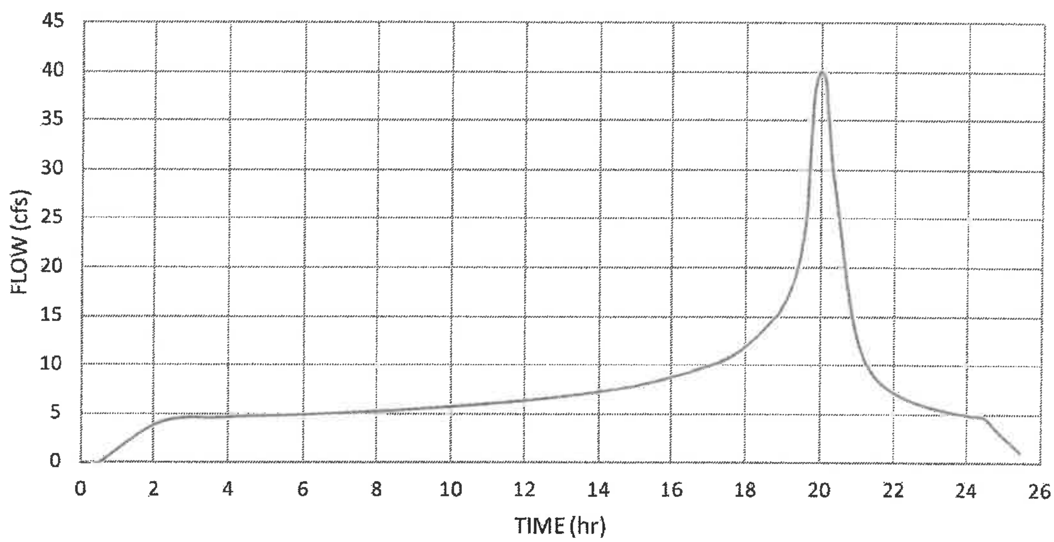


Figure 6.3 24-hr 85th Percentile Runoff Hydrograph at Discharge Point 166R

Through an iterative process using SWMM the capacity of the project elements were estimated. Each dry well capacity was set 0.33 cfs. Based on the geotechnical information and analysis done previously by others, the capacity of each well was estimated to be 0.5 cfs. However, since the capacity may decrease with time and other uncertainties a factor of safety of 1.5 was applied. Thus, the estimated capacity of 0.5 cfs was divided by 1.5 to arrive at 0.33 cfs.

Table 6.1 shows a summary of the final storage sizes and number of wells needed for each storm water treatment area. Through SWMM modeling the times for storage units to drain after an 85th Percentile storm event were determined and summarized in Table 6.2. One of the main design objective of this Project is to size the project elements such that the storage units drain in less than 72 hours after an 85th Percentile event. The table shows that for all phases of the Project, the storage units drain completely in 65 hours or less, thereby meeting a key design objective. The table also shows that the storage units utilizes at least 93 percent of the available storage volume during this event.

Table 6.1 Maximum Storage Volume per Each Storm Water Treatment Area

Project Phase	Location	24-hr 85th Percentile Storm		Underground Storage Volume (ac-ft)	No. of Dry Wells
		Volume	Peak Runoff		
Phase 1	A3	9.98	13.9	5.5	5
Phase 2	Aa	16.76	16.8	9.5	10
Phase 3[(1)]	A1	77.23	199.3	41.3	40

Notes:
(1) Reported volume does not include wet well volume of 1.5 ac-ft.

Table 6.2 Storage Units Maximum Drain Times After an 85th Percentile Storm Event

Project Phase	Location	Underground Storage Volume (ac-ft)	Maximum Drain Time (hr)	Maximum Depth Attained (ft)	Percent Utilization
Phase 1	A3	5.5	62	14.1	94
Phase 2	Aa	9.5	65	13.9	93
Phase 3	A1	41.3	65	14.4	96

6.1.2 Groundwater Modeling

The objective of the groundwater modeling is to investigate the potential impacts of the storm water infiltration project on the local groundwater system, including an evaluation of the potential to affect movement of the contaminated groundwater plume underlying properties on the north side of the airport.

Carollo developed a three-dimensional groundwater flow model using MODFLOW to simulate the local saturated groundwater flow system representing the Gage Aquifer to a depth of 285 ft bgs. Hydraulic parameters and groundwater information for the model were primarily derived from data and information collected as part of the investigation and remediation efforts associated with the Hi-Shear site. This information was supplemented with additional data collected through recent drilling on the airport property by EEC. Because of the proximity of the Hi-Shear site to the infiltration project area on the airport, the Hi-Shear site provides excellent data for use in building the model. The model is coupled with a particle tracking and/or solute transport modeling analysis to demonstrate potential impacts, or the lack thereof, on the contaminant plume.

The model evaluation consisted of the following steps:

- Construct a steady state flow model of the airport vicinity using available data from the storm water infiltration project and the Hi-Shear site.
- Develop a set of representative infiltration scenarios using various recharge flow rates and screened well depths. These scenarios will be transient simulations designed to represent the effects of long-term infiltration operations on the groundwater flow system.
- Utilize particle tracking and/or solute transport modeling to estimate the radius of influence of the infiltration wells. Alternatively, these analyses can be used to examine movement of the outer plume boundary for the baseline (no infiltration) and infiltration project scenarios.

The model utilizes a rectangular grid encompassing an area approximately 3 miles long by 2 miles wide oriented east to west along the prevailing regional groundwater flow direction. Grid cell dimensions are variable with grid cells of about 20-ft on a side being used in the central portion of the grid overlying the project area. Vertically, the model includes the saturated thickness of the Gage Aquifer to a depth of 285 ft bgs. An appropriate number of model layers are used to allow for analysis of infiltration at various depths. The results of the groundwater modeling analyses will help to inform decisions regarding the most appropriate depth and length of screened interval for the infiltration wells.

6.1.3 Fate and Transport Scenarios

To allow comprehensive analysis of the impact of the dry well discharge on the fate and transport of pollutants, three scenarios have been developed. The scenarios are:

1. Steady state baseline – applies constant flows in the aquifer and no storm water discharge considered. This scenario helps to establish a baseline of plume movement for comparison with the storm water discharge scenarios.
2. Short term dry well operation – This scenario is transient with discharge occurring during the 24-hr 85th Percentile storm event. This scenario is intermittent as storm water is captured during this runoff event and then discharged over a period of three days afterward.
3. Long term dry well operation - In a groundwater context, the long term aquifer impact as a result of dry well operation is a concern. This scenario therefore simulates long-term operations of the dry wells over a period of 30 years.

Under each scenario, three options (scenario option) to establish the appropriate depth to discharge the storm water have been developed. The three depth ranges are:

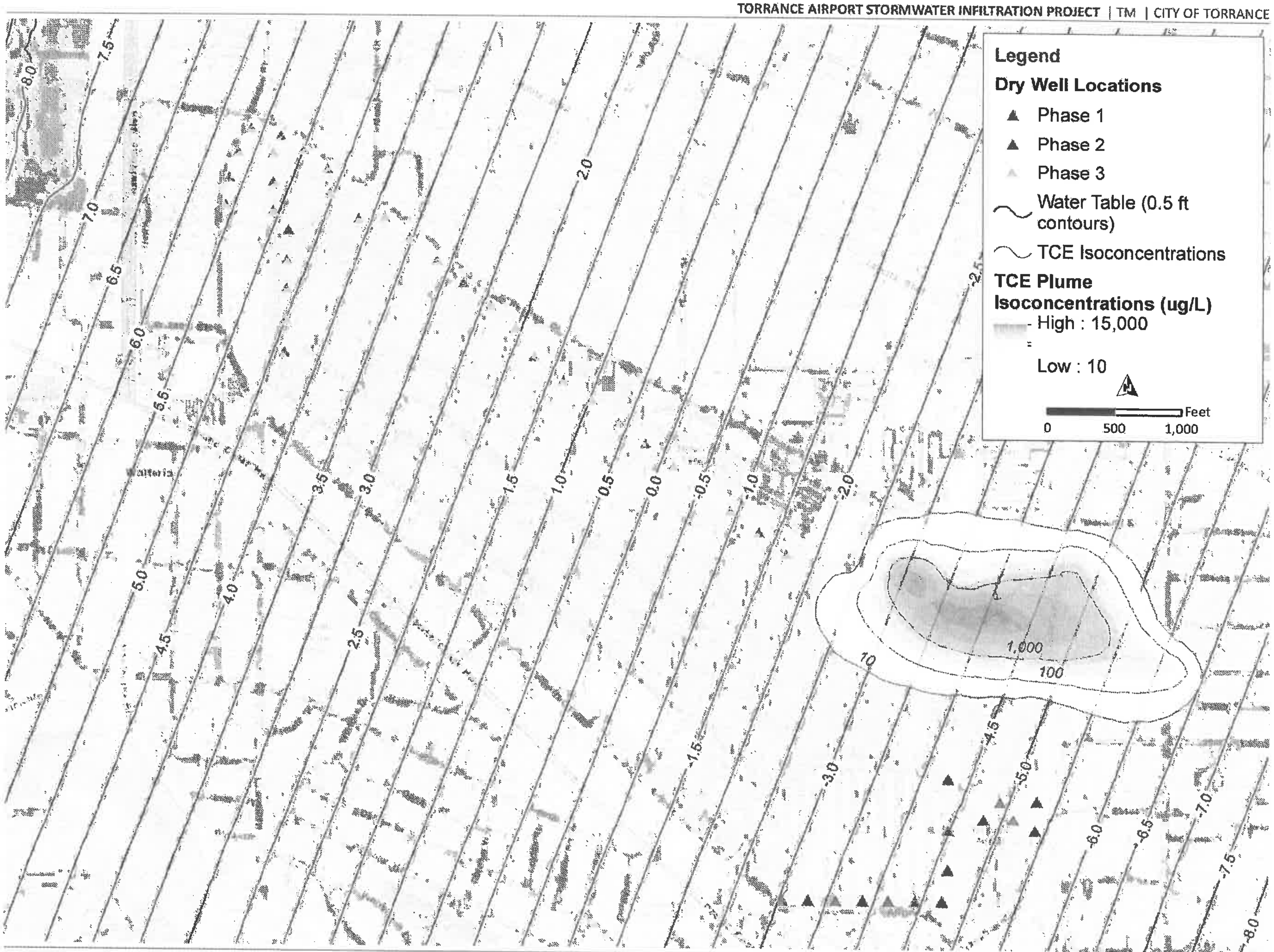
1. 50 - 80 fbgs – The reported pollutants are located mostly in the shallow aquifer. Therefore this scenario option is to observe the fate and transport of the pollutants.
2. 100 – 120 fbgs – The scenario option is used to observe the fate and transport of the plume as storm water is discharge just below the plume.
3. 250 – 285 fbgs - The scenario option is used to observe the fate and transport of the plume as storm water is discharge at a significant distance below the plume.

6.2 Modeling Results

Based on the preliminary analysis using the estimated injection flow rate of 0.33 cfs per well, the storm water infiltration project is not expected to affect the contaminated groundwater plume to the north of the project area. The results of the long-term simulation (20 yrs) which has the greatest impact in terms of plume movement is presented below. The results of the remaining scenarios are presented in details in Appendix D.

6.2.1 Long-term Simulation Results

The initial water table and TCE concentrations for the simulations are shown in Figure 6.4. Groundwater flows under a uniform hydraulic gradient to the east-southeast. TCE concentrations are shown on a logarithmic scale with contours showing values of 10, 100, and 1,000 µg/L based on November 2017 monitoring data.



Carollo
Last Revised: August 24, 2013 pw:\\IO-PW-INT.Carollo.local:Carollo\Documents\Client\CA\Torrance\11014A00\Data\GIS\Figure 3.1.mxd

Figure 6.4 Initial Water Table and TCE Concentrations

The effects of 20-years of continuous injection (worst case scenario) through the upper zone of wells in Phases 1 and 2 are shown in Figure 6.5. The water table is locally elevated around the dry wells as a result of the infiltrated water, and water levels have increased by about 1 ft in the area of the TCE plume. Injection pathlines originating at the wells indicate the approximate zone of hydraulic influence of the wells after 10 years. Because of the regional hydraulic gradient of the aquifer, the simulated particles move downgradient, and no particles enter the area of the aquifer within the TCE plume.

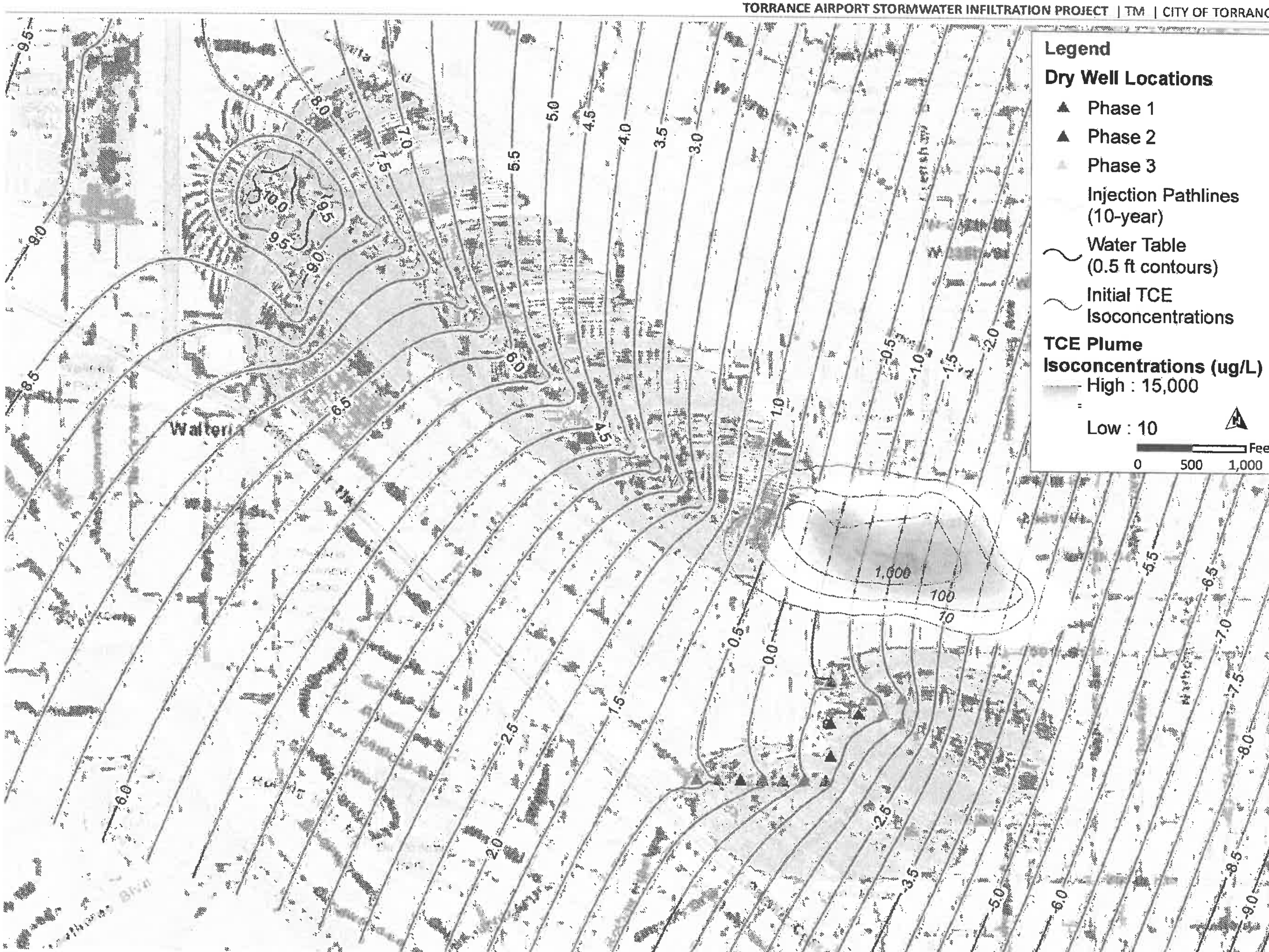
The TCE plume in Figure 6.5 is represented by gray contour lines showing the initial position of the plume and color-filled contours showing the position and extent of the plume after 20 years of simulated transport. The results of this scenario show that the centroid of the plume migrates about 243 ft downgradient compared to a distance of 240 ft for the baseline (no injection) scenario. After 20 years of continuous infiltration at the dry wells, the plume is migrating about 0.25 ft/year faster than in the baseline scenario. The spread of the plume increases less than 1 percent after 20 years compared to the baseline scenario. Similar results are obtained for the simulations of infiltration into the middle and lower zones of the aquifer. This worst scenario demonstrates that implementation of Phase 1 and Phase 2 projects

The effects of 20-years of continuous injection through the upper zone of wells in Phases 1, 2, and 3 are shown in Figure 6.6. The water table is locally elevated around the dry wells as a result of the infiltrated water, and water levels have increased by about 3 ft in the area of the TCE plume. Injection pathlines originating at the wells indicate the approximate zone of hydraulic influence of the wells after 10 years. Because of the regional hydraulic gradient of the aquifer, the simulated particles move downgradient, and particles originating at some of the Phase 3 wells upgradient of the TCE plume are shown to enter the area of the aquifer within the TCE plume.

The TCE plume in Figure 6.6 is represented by gray contour lines showing the initial position of the plume and color-filled contours showing the position and extent of the plume after 20 years of simulated transport. The results of this scenario show that the centroid of the plume migrates about 350 ft downgradient compared to a distance of 240 ft for the baseline (no injection) scenario. After 20 years of continuous infiltration at the dry wells, the plume is migrating about 5.5 ft/year faster than in the baseline scenario. The spread of the plume is about the same after 20 years compared to the baseline scenario. Similar results are obtained for the simulations of infiltration into the middle and lower zones of the aquifer.

Figure 6.5 Water Table and TCE Concentrations after 20 Years, Phase 2 Upper Zone Scenario

Carollo
Last Revised: August 24, 2018 pw:\\IO-PW-INT.Carollo.local:Carollo\Documents\Client\CA\Torrance\11014A00\Data\GIS\Figure 3.1.mxd



Carollo

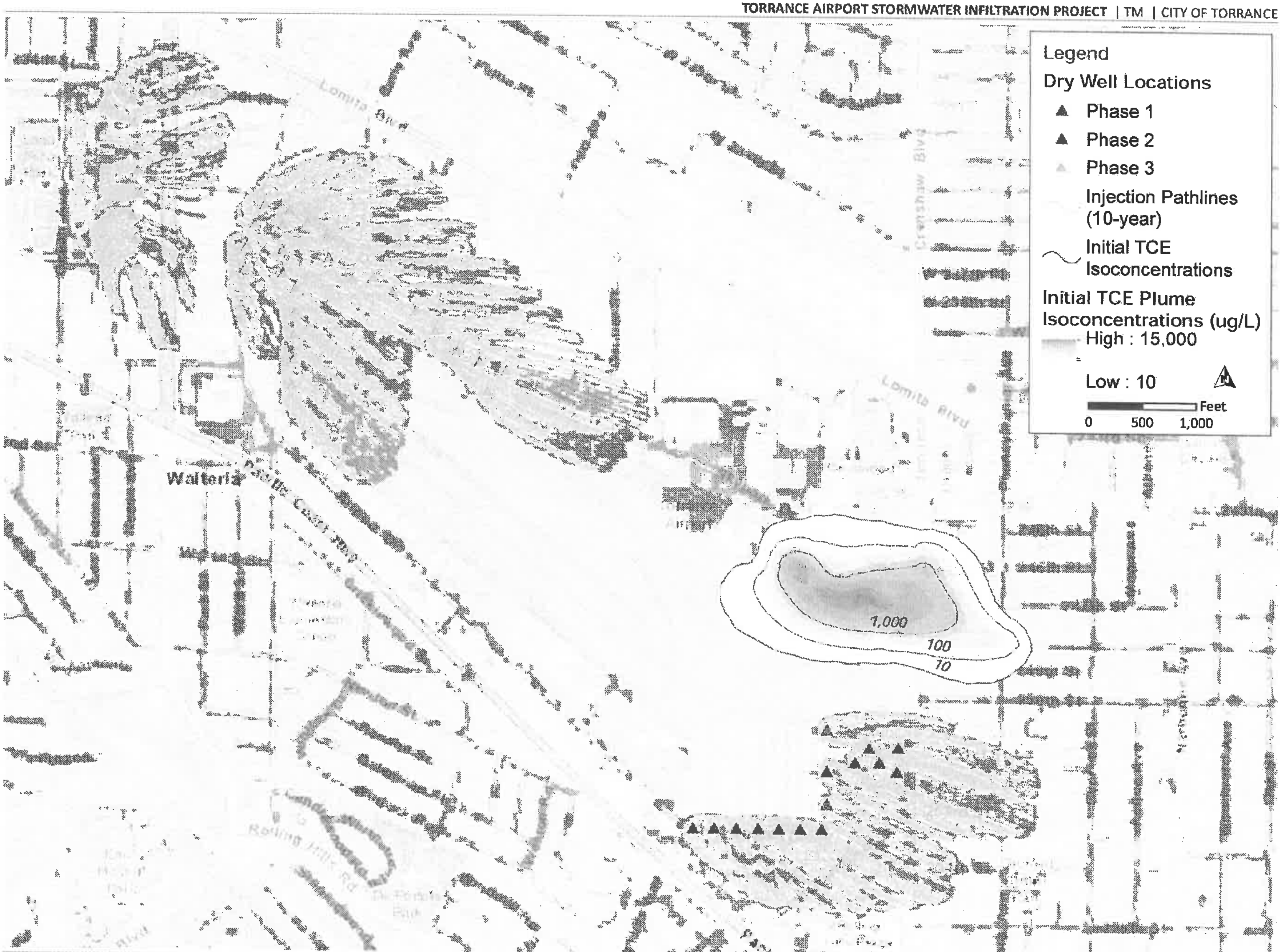
Figure 6.6 Water Table and TCE Concentrations after 20 Years, Phase 3 Upper Zone Scenario

Last Revised: August 24, 2018 pw:\\IO-PW-INT.Carollo.local:Carollo\Documents\Client\CA\Torrance\11014A00\Data\GIS\Figure 3.1.mxd

Because the particle tracking and transport analysis of the proposed Phase 3 dry wells indicated the potential for infiltration to affect movement of the TCE plume, an alternate Phase 3 scenario was developed. In this alternate scenario, herein referred to as Phase 3b, the eight easternmost Phase 3 dry wells were relocated to an upgradient location along the eastern edge of the Walteria Sump. These wells were relocated in order to increase the distance from the nearest point of infiltration to the TCE plume; the nearest Phase 3 well is approximately 2,800 ft upgradient of the TCE plume in this scenario. For the preliminary analysis presented here, only the results of the short-term monthly simulation model are available; no TCE transport analysis was conducted for this alternate scenario. The TCE plume in Figure 6.7 is represented by gray contour lines and color-filled contours showing only the initial position of the plume.

The effects of 10-years of injection following a variable monthly pattern through the upper zone of wells in Phases 1, 2, and 3 are shown in Figure 6.7. Injection pathlines originating at the wells indicate the approximate zone of hydraulic influence of the wells after 10 years. Because of the regional hydraulic gradient of the aquifer, the simulated particles move downgradient, but no particles enter the area of the aquifer within the TCE plume. The distance from the nearest particle to the TCE plume is more than 1,500 ft after ten years of infiltration. Based on these preliminary results, the potential for Phase 3 to affect the TCE plume can be greatly reduced by increasing the distance from the dry wells to the edge of the TCE plume.

The results of the long-term scenarios of continuous injection indicate Phases 1 and 2 of the storm water infiltration project are expected to have negligible impact on the TCE plume in the upper zone of the aquifer. Infiltration through the Phase 3 wells as initially located poses the potential to affect movement of the TCE plume by increasing downgradient movement of the plume on the order of about 100 ft after 20 years, or increasing the rate of migration by about 5.5 ft/year. Preliminary results of an alternate layout for Phase 3 indicate that increasing the distance from the nearest upgradient dry well to the TCE plume can significantly reduce the potential for increased plume movement. These preliminary results should be confirmed through additional long-term modeling of solute transport.



Carollo

Figure 6.7 Monthly Injection Pathlines after 10 Years, Phase 3 Lower Zone Scenario

Last Revised: August 24, 2013 pw:\\IO-PW-INT.Carollo.local:Carollo\Documents\Client\CA\Torrance\11014A00\Data\GIS\Figure 3.1.mxd

Section 7
CONSTRUCTION COST ESTIMATES

The cost for each phase of the TASWIP is a combination of construction costs and project costs. Construction costs account for the budget required for a contractor to install the proposed infrastructure. Project costs account for project contingencies, construction management, engineering, planning, and legal fees.

7.1 Level of Accuracy

The level of accuracy for cost estimates varies depending on the level of detail to which the project has been defined. Feasibility studies and master plans represent the lowest level of accuracy, while pre-bid estimates represent a much higher level of accuracy. The American Association of Cost Engineers has developed guidelines, which are shown in Table 7.1, for developing project cost estimates.

Table 7.1 Project Estimates Guidelines[1]

Type of Estimate	Anticipated Accuracy
Order-of-Magnitude (Master Plans)	+50% to -30%
Budget Estimate (Pre-design Report)	+30% to -15%
Budget Estimate (Design Report)	+15% to -5%

Notes:
(1) Developed by the American Association of Cost engineers.

The cost opinions in this report should be considered budget estimate (pre-design report) estimates, with an anticipated accuracy level of +30 to -15 percent.

7.2 Budget Estimate (Pre-Design Report)

The total construction cost estimate for three project phases are summarized in Table 7.2 and the detailed cost break are depicted in Tables 7.3 through 7.6.

Table 7.2 Project Phases Construction Cost Estimate Summary

Project Phase	Cost ($)
Phase 1	5,720,000
Phase 2	10,380,000
Phase 3	
Lake Option	20,550,000
Dry Well Option	36,070,000

Table 7.3 Torrance Airport Storm Water Infiltration Project - Phase 1

Water Quality Benefits Construction Cost Estimate				
Description	Unit	Quantity	Unit Cost	Cost ($)
Diversion structure	EA	1	80,000	80,000
Underground prefabricated concrete infiltration unit (5.5 ac-ft); 15' deep	EA	1	1,578,366	1,578,366
Installation of 150 ft of 36-inch diversion pipe	LF	150	860	129,000
Installation of 530 ft of 15-inch diversion pipe	LF	530	470	249,100
Installation of 300 ft of 6-inch diversion pipe	LF	300	50	15,000
Power/Electrical cabinets	LS	0	200,000	0
Pre-treatment hydrodynamic separator unit in 12 ft diameter manhole	EA	1	180,000	180,000
Pre-treatment unit installation cost (25% - 35% Material)	EA	30%		54,000
Filtration unit in a 12 ft diameter manhole	EA	1	210,000	210,000
Filtration unit installation cost (25% - 35% Material)	EA	30%		63,000
Installation of five 285 feet dry wells	EA	5	165,000	825,000
Subtotal (1)				3,383,466
Mobilization - 0% to 7% of Subtotal (1)		5%		169,173
Permits - 2% to 5% of Subtotal (1)		3%		101,504
Subtotal (2)				3,654,143
Estimating contingency - 10% to 25% of Subtotal (2)		15%		548,121
Subtotal (3)				4,202,265
Escalation - 5% to 10% per year of Subtotal (3)		3%		126,068
Subtotal (4)				4,328,333
Construction contingency - 10% to 20% of Subtotal (3)		10%		432,833
Total Estimated Project Construction Cost				4,761,166

TASWIP - Crenshaw Blvd Project Cost Estimate			
Budget Category	Water Quality Benefits Cost	Other Project Benefits Cost	Total Cost
Construction cost (including estimating contingency, etc.)	$4,761,166	$0	$4,761,166
Land Purchase/Right-of-way acquisition	$0	$0	$0
Final Design (8% of construction cost) and Administrative Costs	$380,893.28	$100,000	$480,893
Construction and Post-Construction Management (10% of Cons. cost)	$476,117	$0	$476,117
Grand Total - Sum (a) through (d)	$5,618,176	$100,000	$5,718,176

Notes:
* Includes installation.

Table 7.4 Torrance Airport Storm Water Infiltration Project - Phase 2

Water Quality Benefits Construction Cost Estimate				
Description	Unit	Quantity	Unit Cost	Cost ($)
Diversion structure	EA	1	80,000	80,000
Underground concrete infiltration unit (9.5 ac-ft); 15' deep	EA	1	2,722,670	2,722,670
Installation of 180 ft of 36-inch diversion pipe	LF	180	860	154,800
Installation of 1,650 ft of 15-inch diversion pipe	LF	1650	470	775,500
Installation of 600 ft of 6-inch diversion pipe	LF	600	50.00	30,000
Installation of 3 No. 10 HP 1000 gpm pumps	EA	3	15,000	45,000
Power/Electrical cabinets	LS	0	200,000	200,000
Pre-treatment hydrodynamic separator unit in 12 ft diameter manhole	EA	1	200,000	200,000
Pre-treatment unit installation cost (25% - 35% Material)	EA	30%		60,000
Filtration unit in a 12 ft diameter manhole	EA	1	210,000	210,000
Filtration unit installation cost (25% - 35% Material)	EA	30%		63,000
Installation of ten 285 feet dry wells	EA	10	165,000	1,650,000
Subtotal (1)				6,190,970
Mobilization - 0% to 7% of Subtotal (1)		5%		309,549
Permits - 2% to 5% of Subtotal (1)		3%		185,729
Subtotal (2)				6,686,248
Estimating contingency - 10% to 25% of Subtotal (2)		15%		1,002,937
Subtotal (3)				7,689,185
Escalation - 5% to 10% per year of Subtotal (3)		3%		230,676
Subtotal (4)				7,919,860
Construction contingency - 10% to 20% of Subtotal (3)		10%		791,986
Total Estimated Project Construction Cost				8,711,846

TASWIP - Crenshaw Blvd Project Cost Estimates			
Budget Category	Water Quality Benefits Cost	Other Project Benefits Cost	Total Cost
Construction cost (including estimating contingency, etc.)	$8,711,846	$0	$8,711,846
Land Purchase/Right-of-way acquisition	$0	$0	$0
Final Design (8% of construction cost) and Administrative Costs	$696,947.70	$100,000	$796,948
Construction and Post-Construction Management (10% of Cons. cost)	$871,185	$0	$871,185
Grand Total - Sum (a) through (d)	$10,279,979	$100,000	$10,379,979

Notes:
* Includes installation.

Table 7.5 Torrance Airport Storm Water Infiltration Project - Phase 3; Lake Option

Water Quality Benefits Construction Cost Estimate				
Description	Unit	Quantity	Unit Cost	Cost ($)
Diversion structure	EA	1	80,000	80,000
Underground prefabricated concrete storage unit (44 ac-ft); 15' deep	EA	0	10,163,636	0
Power/Electrical cabinets	LS	0	200,000	200,000
Pre-treatment hydrodynamic separator unit in 8 ft diameter manhole	EA	1	210000	210,000
Pre-treatment unit installation cost (25% - 35% Material)	EA	30%		63,000
Filtration unit in a 12 ft diameter manhole	EA	0	230000	0
Filtration unit installation cost (25% - 35% Material)	EA	30%		0
Installation of forty 285 feet dry wells	EA	0	165,000	0
Install new storm water 156 mg lift station (975 hp) + wet well	EA	1	3,500,000	3,500,000
Install 30 ft 60-inch diameter pipe	LF	30	1,200	36,000
Install 11700 linear foot of 24 inch forcemain	LF	11,750	700	8,225,000
Subtotal (1)				12,314,000
Mobilization - 0% to 7% of Subtotal (1)		5%		615,700
Permits - 2% to 5% of Subtotal (1)		3%		369,420
Subtotal (2)				13,299,120
Estimating contingency - 10% to 25% of Subtotal (2)		15%		1,994,868
Subtotal (3)				15,293,988
Escalation - 5% to 10% per year of Subtotal (3)		3%		458,820
Subtotal (4)				15,752,808
Construction contingency - 10% to 20% of Subtotal (3)		10%		1,575,281
Total Estimated Project Construction Cost			3,500,000	17,328,088

TASWIP - Crenshaw Blvd Project Cost Estimate			
Budget Category	Water Quality Benefits Cost	Other Project Benefits Cost	Total Cost
Construction cost (including estimating contingency, etc.)	$17,328,088	$0	$17,328,088
Land Purchase/Right-of-way acquisition	$0	$0	$0
Final Design (8% of construction cost) and Administrative Costs	$1,386,247.07	$100,000	$1,486,247
Construction and Post-Construction Management (10% of Cons. cost)	$1,732,809	$0	$1,732,809
Grand Total - Sum (a) through (d)	$20,447,144	$100,000	$20,547,144

Notes:
* Includes installation.

Table 7.6 Torrance Airport Storm Water Infiltration Project - Phase 3; Dry Well Option

Water Quality Benefits Construction Cost Estimate				
Description	Unit	Quantity	Unit Cost	Cost ($)
Diversion structure	EA	1	80,000	80,000
Underground prefabricated concrete storage infiltration unit 44 ac-ft); 15' deep	EA	0	10,163,636	0
Power/Electrical cabinets	LS	0	200,000	200,000
Pre-treatment hydrodynamic separator unit in 8 ft diameter manhole	EA	1	210000	210,000
Pre-treatment unit installation cost (25% - 35% Material)	EA	30%		63,000
Filtration unit in a 12 ft diameter manhole	EA	1	230000	230,000
Filtration unit installation cost (25% - 35% Material)	EA	30%		69,000
Installation of forty 285 feet dry wells	EA	40	165,000	6,600,000
Install new storm water 156 mg lift station (975 hp) + wet well	EA	1	4,000,000	4,000,000
Install 30 ft 60-inch diameter pipe	LF	30	1,200	36,000
Install 6,900 ft 15-inch diameter pipe	LF	6900	470	3,243,000
Install 2,400 ft 6-inch diameter pipe	LF	2400	50	120,000
Install 9,730 linear foot of 24 inch forcemain	LF	9,730	700	6,811,000
Subtotal (1)				21,662,000
Mobilization - 0% to 7% of Subtotal (1)		5%		1,083,100
Permits - 2% to 5% of Subtotal (1)		3%		649,860
Subtotal (2)				23,394,960
Estimating contingency - 10% to 25% of Subtotal (2)		15%		3,509,244
Subtotal (3)				26,904,204
Escalation - 5% to 10% per year of Subtotal (3)		3%		807,126
Subtotal (4)				27,711,330
Construction contingency - 10% to 20% of Subtotal (3)		10%		2,771,133
Total Estimated Project Construction Cost				30,482,463

TASWIP - Crenshaw Blvd Project Cost Estimate			
Budget Category	Water Quality Benefits Cost	Other Project Benefits Cost	Total Cost
Construction cost (including estimating contingency, etc.)	$30,482,463	$0	$30,482,463
Land Purchase/Right-of-way acquisition	$0	$0	$0
Final Design (8% of construction cost) and Administrative Costs	$2,438,597.05	$100,000	$2,538,597
Construction and Post-Construction Management (10% of Cons.cost)	$3,048,246	$0	$3,048,246
Grand Total - Sum (a) through (d)	$35,969,306	$100,000	$36,069,306

Notes:
* Includes installation.

Section 8

CONCLUSIONS AND RECOMMENDATIONS

Concentrations of contaminants detected in the soil samples collected during the investigation were below the USEPA Region 9 commercial/industrial RSLs for soil. PCE, TCE, and 1,1-DCE were detected at concentrations above the CA MCLs in groundwater samples collected from MW-818.

The review of the hydrogeologic data, EPA SWMM 5 and MODFLOW groundwater modeling results indicate that the TASWIP can be implemented without impacting the environment negatively. Initial groundwater modeling results indicate that the contaminated plume will not be affected by discharging the treated storm water to the Gage Aquifer in all the three storm water treatment areas. This will continue to be evaluated as the modeling is completed.

In Phase and Phase 2 (no Phase 3), the modeling results indicate that no particles from the Project Site will enter the contaminated Hi-Shear site. On the average rainfall simulation scenario for 20 years, the rate of movement of the plume as a result of Phases 1 and 2 projects will not change. However, under the worst case scenario where constant injection rate per year is employed, the plume migration rate changes by about 0.3 ft/year. No molecule enters the plume area from the Project Site under this scenario also as indicated by particle tracking analysis.

In Phase 3, under the Dry well Option, molecules from the Project Site enter the contaminated site. If at least 10 of the dry wells are removed from Skypark Dr. and installed along Madison St., no molecules will enter the contaminated area.

Further evaluations are needed for the Lake Option under Phase 3 to assess the impacts on the plume.

To ensure the safety and operations at the airport are not impacted, the recommended construction method for construction of the underground storage area by bore tunnel where feasible. Almost all the Project elements were identified to be installed at distances from the runways in order to limit closures at the airport during construction activities.

The risks associated with the use of dry wells are primarily linked to the potential to introduce pollutants into the aquifer. Data collected at the two project sites in Elk Grove combined with modeling results did not provide evidence that groundwater quality would be degraded by the use of dry wells. Practices in other states and conclusions reached by US EPA suggest that with proper dry well siting, design, and maintenance, dry wells can be used safely. Results from this project are consistent with these conclusions.

All goals for the project were met and the City will continue to monitor and maintain the Strawberry Creek water quality basin dry well system for at least 20 years.