Preliminary Water Quality Management Plan (WQMP)

Project Name:

24551 Raymond Way
Lake Forest, CA

Prepared for:

National CORE

9421 Haven Avenue

Rancho Cucamonga, CA 91730

(909) 204-3444

Prepared by:

RRM Design Group

Engineer: Apryl Weidl Registration No. 87601

10 E. Figueroa Street, Suite 200

Santa Barbara, CA 93101

(805) 963-8283

May 12, 2020

Section will be completed during final design.

Project Owner's Certification			
Permit/Application No.		Grading Permit No.	
Tract/Parcel Map No.		Building Permit No.	
CUP, SUP, and/or APN (Specify Lot Numbers if Portions of Tract)			APN 617-441-02

This Water Quality Management Plan (WQMP) has been prepared for Owner/Developer Name by Consulting/Engineering Firm Name. The WQMP is intended to comply with the requirements of the local NPDES Stormwater Program requiring the preparation of the plan.

The undersigned, while it owns the subject property, is responsible for the implementation of the provisions of this plan and will ensure that this plan is amended as appropriate to reflect up-to- date conditions on the site consistent with the current Orange County Drainage Area Management Plan (DAMP) and the intent of the non-point source NPDES Permit for Waste Discharge Requirements for the County of Orange, Orange County Flood Control District and the incorporated Cities of Orange County within the Santa Ana Region. Once the undersigned transfers its interest in the property, its successors-in-interest shall bear the aforementioned responsibility to implement and amend the WQMP. An appropriate number of approved and signed copies of this document shall be available on the subject site in perpetuity.

Owner: National CORE Representative:			
Title			
Company	National CORE		
Address	9421 Haven Avenue, Rancho Cucamonga, CA 91730		
Email			
Telephone #	(909) 204-3444		
Signature		Date	

Contents

Attachments

*** Attachments A and D will be provided with the Final WQMP and are not included in this Preliminary WQMP**

Section I Discretionary Permit(s) and Water Quality Conditions

Provide discretionary permit and water quality information. *Refer to Section 2.1 in the Technical Guidance Document (TGD) available from the Orange County Stormwater Program (ocwatersheds.com).*

Section will be completed during final design.

Project Information			
Permit/Application No.		Tract/Parcel Map No.	
Additional Information/ Comments:			
Water Quality Conditions			
Water Quality Conditions (list verbatim)			
Watershed-Based Plan Conditions			
Provide applicable conditions from watershed - based plans including WIHMPs and TMDLS.			

Section II Project Description

II.1 Project Description

Include attributes relevant to determining applicable source controls. *Refer to Section 2.2 in the TGD for information that must be included in the project description.*

Description of Proposed Project				
Development Category (Verbatim from WQMP):	**Significant Redevelopment:** All significant redevelopment projects, where significant redevelopment is defined as the addition or replacement of 5,000 or more square feet of impervious surface on an already developed site. Redevelopment does not include routine maintenance activities that are conducted to maintain original line and grade, hydraulic capacity, original purpose of the facility, or emergency redevelopment activity required to protect public health and safety.			
Project Area (ft2): 85,556	Number of Dwelling Units: 71		SIC Code: N/A	
Narrative Project Description:	The proposed affordable housing project is located at 24551 Raymond Way in Lake Forest, California on a 3.76 acre site which has been previously developed. Currently the site contains two existing commercial buildings and a surface parking lot. The proposed project includes a lot split dividing the parcel into two separate parcels. The proposed development will occur on Parcel 1. No development is proposed on Parcel 2. The proposed development on Parcel 1 includes the demolition of the existing commercial building and the construction of a single building varying from three to four stories in height. The building will contain 71 residential units and a community center. A playground, teen center, and barbeque area are proposed outside of the building. The existing parking lot will be reconfigured for the change in use of the site.			
Project Area	Pervious		Impervious	
	Area (acres or sq ft)	Percentage	Area (acres or sq ft)	Percentage
Pre-Project Conditions	1.07 ac	24.5%	2.70 ac	71.7%%
Post-Project Conditions	0.94 ac	20.2%	2.82 ac	74.9%%
Drainage Patterns/Connections	The site is currently occupied by a commercial building and an asphalt parking lot. Drainage sheet flows from the parking lot in a northwesterly direction toward Packer Place. Drainage flows out of the existing driveway into the curb and gutter on Packer Place. Eventually, runoff enters the municipal storm drain system through a curb inlet at the end of Bendricon Lane. Some runoff from the building flows overland in a westerly direction toward Raymond Way where it enters the municipal storm drain system through an inlet near the easterly corner of the Raymond Way and Packer Place intersection.			

	Runoff from the parking lot on Parcel 2 flows overland through Parcel 1 to Packer Place. The remainder of runoff from Parcel 2 flows to El Toro Road. Ultimately, runoff flows from the municipal storm drain system to the Canada Cannel, San Diego Creek, Newport Bay, and the Pacific Ocean Proposed Development drainage conditions are described in Section II.4.

II.2 Potential Stormwater Pollutants

Determine and list expected stormwater pollutants based on land uses and site activities. *Refer to Section 2.2.2 and Table 2.1 in the TGD for guidance.*

Pollutants of Concern			
Pollutant	Circle One: E=Expected to be of concern N=Not Expected to be of concern		Additional Information and Comments
Suspended-Solid/ Sediment	(E) circled	N	
Nutrients	(E) circled	N	
Heavy Metals	E	(N) circled	
Pathogens (Bacteria/Virus)	(E) circled	N	
Pesticides	(E) circled	N	
Oil and Grease	(E) circled	N	Uncovered Parking Areas
Toxic Organic Compounds	E	(N) circled	
Trash and Debris	(E) circled	N	

II.3 Hydrologic Conditions of Concern

Determine if streams located downstream from the project area are determined to be potentially susceptible to hydromodification impacts. *Refer to Section 2.2.3.1 in the TGD for* NOC *or Section 2.2.3.2 for* SOC*.*

☐ No - Show map

☒ Yes - Describe applicable hydrologic conditions of concern below. *Refer to Section 2.2.3 in the TGD.*

The project is upstream of an earthen channel that is susceptible to erosion per the Susceptibility Analysis Map for the Newport Bay Watershed (Attachment B).

However, the post-development peak runoff will not exceed the pre-development peak runoff for the 10-yr, 25-yr, and 100-yr storm events. See Attachment E for calculations. A summary is provided below.

Peak Flows to Raymond Way

Storm Event	Existing Q (cfs)	Proposed Q (cfs)
10-Year	1.95	1.68
25-Year	2.33	2.01
100-Year	3.00	2.58

Peak Flows to Packer Place

Storm Event	Existing Q (cfs)	Proposed Q (cfs)
10-Year	7.62	7.09
25-Year	9.10	8.46
100-Year	11.67	10.84

Peak Flows to El Toro Road

Storm Event	Existing Q (cfs)	Proposed Q (cfs)
10-Year	1.58	1.58
25-Year	1.89	1.89
100-Year	2.44	2.44

In addition, the time of concentration for the post-development condition is greater than the pre-development condition. See Attachment E for calculations.

Therefore, according the TGD, an HCOC does not exist and hydromodification does not need to be considered further.

II.4 Post Development Drainage Characteristics

Describe post development drainage characteristics. *Refer to Section 2.2.4 in the TGD.*

The proposed development will maintain existing drainage patterns and discharge locations. To address stormwater quality and retention, dry well BMPs have been chosen for the site due to limited flat permeable areas at the site that would allow other infiltration BMPs. Storage chambers are proposed to operate in-line with the dry wells and provide additional storage to meet the required retention volume. The total volume of chambers and drywells combined is equal to the design capture volume. Dry wells are sized to infiltrate the full design capture volume within 72 hours. Sizing calculations are further discussed in section IV.3.2.

The project site has been divided into two (3) drainage areas: A, B and X3.

- Runoff from drainage area ‘A’ will be collected by the on-site storm drain system and directed to a dry well and storage chamber system near the southern corner of the site. Runoff will be captured and retained in the chambers and infiltrated through the dry well. Overflow from the dry well will flow out through the curb and enter the municipal storm drain system through inlets located near the eastern corner of the Raymond Way/Packer Place intersection.
- Runoff from drainage area ‘B’ will flow overland through the parking lot and be collected by the on-site storm drain system which will outlet into a dry well and storage chamber system near the driveway entry to the site. Runoff will be captured in the chambers and infiltrated through three dry wells. Overflow from the dry wells will outlet through the curb face on Packer Place. Runoff will enter the municipal storm drain system through an inlet at the end of the Bendricon Lane cul-de-sac.
- Runoff from drainage area ‘X3’ will flow to the southeast and be captured in a proposed dry well and chamber system. Overflow will continue to flow toward El Toro Road as it has historically.

Ultimately, runoff flows from the municipal storm drain system to the Canada Cannel, San Diego Creek, Newport Bay, and the Pacific Ocean.

II.5 Property Ownership/Management

Describe property ownership/management. *Refer to Section 2.2.5 in the TGD.*

National CORE will own and manage Parcel 1. The Owner will be responsible for the long-term maintenance of the project’s stormwater facilities and conformance with this WQMP after construction is complete.

A Notice of Transfer of Responsibility is provided in Attachment D which should be executed as part of any ownership transfer that might occur.

Section III Site Description

III.1 Physical Setting

Refer to Section 2.3.1 in the TGD.

Planning Area/ Community Name	N/A
Location/Address	24551 Raymond Way (Parcel 1) 23591 El Toro Road (Parcel 2)
	Lake Forest, CA
Land Use	Existing: PA-Profession and Administrative Proposed: Residential
Zoning	Existing: PA-Profession and Administrative Proposed: Residential
Acreage	3.76 Total (Parcel 1: 1.96, Parcel 2: 1.80)
Predominant Soil Type	Hydrologic Soil Group D (see Soils Map, Attachment B)

III.2 Site Characteristics

Refer to Section 2.3.2 in the TGD.

Precipitation Zone	85th percentile Rainfall = 0.85" (See Map, Attachment B)
Topography	The site slopes at 2-3% to the west. There is a roughly 20% slope from the building down to the street level along Raymond Way and Packer Place.
Drainage Patterns/Connections	Runoff from the site enters the municipal storm drain system through inlets at the northwestern end of Bendricon Lane, near the eastern corner of the Raymond Way and Packer Place intersection, and on El Toro Road. Ultimately, runoff flows from the municipal storm drain system to the Canada Cannel, San Diego Creek, Newport Bay, and the Pacific Ocean
Soil Type, Geology, and Infiltration Properties	Per the Orange County Infiltration Study Map (Attachment B), soils at the site are within the NRCS Hydrologic Soils Group D, which gives low infiltration potential and high runoff rates. Site specific infiltration testing was performed by Albus-Keefe & Associates, Inc. showing average infiltration rates of 3.0 inches per hour. See attachment F.

Site Characteristics (continued)	
Hydrogeologic (Groundwater) Conditions	Per the page 4 of the project Soils Report (Attachment F) "Groundwater was encountered during this firm's subsurface exploration at the depth of 41 feet. Based on a review of the referenced CDMG Special Report, the site is mapped with a historical groundwater depth between 10 and 20 feet. Research of groundwater data from the State Water Resources Control Board GeoTracker database, indicates groundwater levels as shallow as 20 feet."
Geotechnical Conditions (relevant to infiltration)	There are no known geotechnical conditions at the site that would prevent or complicate stormwater infiltration at the project site. Refer to Geotechnical Report, Attachment F. The GeoTracker website shows no past or present soil or groundwater contamination sites within a 250' radius of the project site.
Off-Site Drainage	The proposed development will maintain existing drainage patterns which includes conveying runoff from the existing parking lot on Parcel 2through the proposed parking lot on the Parcel 1, see Exhibits B1 and B2 Proposed Hydrology Map in Attachment C. Off-site runoff will flow overland through the proposed parking lot and into the curb and gutter on Packer Place. It is assumed that the proposed dry well system will only capture on-site flows and any additional off-site flows will continue overland as they have historically.
Utility and Infrastructure Information	A sewer lateral from the Parcel 2 runs through both parcels and is shown on the Proposed Hydrology Map in Attachment C.

III.3 Watershed Description

Refer to Section 2.3.3 in the TGD.

Receiving Waters	San Diego Creek Reach 2, San Diego Creek Reach 1, Newport Bay (Upper), Newport Bay (Lower),
303(d) Listed Impairments	San Diego Creek Reach 2: None San Diego Creek Reach 1: Bacteria/Pathogens Newport Bay (Upper): Toxicity, Organics Newport Bay (Lower): Toxicity, Organics
Applicable TMDLs	Metals, Nutrients, Pesticides, Turbidity/Siltation
Pollutants of Concern for the Project	Sediment, Nutrients, Pathogens, Pesticides
Environmentally Sensitive and Special Biological Significant Areas	There are no environmentally sensitive or special biological significant areas within or adjacent to the project, and the project does not discharge directly to an ESA.

Section IV Best Management Practices (BMPs)

IV. 1 Project Performance Criteria

Describe project performance criteria. Several steps must be followed in order to determine what performance criteria will apply to a project. These steps include:

- If the project has an approved WIHMP or equivalent, then any watershed specific criteria must be used and the project can evaluate participation in the approved regional or sub-regional opportunities. The local Permittee planning or NPDES staff should be consulted regarding the existence of an approved WIHMP or equivalent.
- Determine applicable hydromodification control performance criteria. *Refer to Section 7.II-2.4.2.2 of the Model WQMP.*
- Determine applicable LID performance criteria. *Refer to Section 7.II-2.4.3 of the Model WQMP.*
- Determine applicable treatment control BMP performance criteria. *Refer to Section 7.II-*3.2.2 *of the Model WQMP.*
- Calculate the LID design storm capture volume for the project. *Refer to Section 7.II-2.4.3 of the Model WQMP.*

(NOC Permit Area only) Is there an approved WIHMP or equivalent for the project area that includes more stringent LID feasibility criteria or if there are opportunities identified for implementing LID on regional or sub-regional basis?	YES☐	NO x
If yes, describe WIHMP feasibility criteria or regional/sub-regional LID opportunities.		

Project Performance Criteria (continued)	
If HCOC exists, list applicable hydromodification control performance criteria (Section 7.II-2.4.2.2 in MWQMP)	No HCOC exists, refer to Section II.3.
List applicable LID performance criteria (Section 7.II-2.4.3 from MWQMP)	Priority Projects must infiltrate, harvest and use, evapotranspire, or biotreat/biofilter, the 85th percentile, 24-hour storm event (Design Capture Volume). A properly designed biotreatment system may only be considered if infiltration, harvest and use, and evapotranspiration (ET) cannot be feasibly implemented for the full design capture volume. In this case, infiltration, harvest and use, and ET practices must be implemented to the greatest extent feasible and biotreatment may be provided for the remaining design capture volume.
List applicable treatment control BMP performance criteria (Section 7.II-3.2.2 from MWQMP)	Not Applicable-LID performance criteria is met through retention provided on-site.
Calculate LID design storm capture volume for Project.	Refer to Worksheets B in Attachment B for DCV calculations.

IV.2. SITE DESIGN AND DRAINAGE PLAN

Describe site design and drainage plan including

- A narrative of site design practices utilized or rationale for not using practices;
- A narrative of how site is designed to allow BMPs to be incorporated to the MEP
- A table of DMA characteristics and list of LID BMPs proposed in each DMA.
- Reference to the WQMP plot plan.
- Calculation of Design Capture Volume (DCV) for each drainage area.
- A listing of GIS coordinates for LID and Treatment Control BMPs (unless not required by local jurisdiction). Committee

Refer to Section 2.4.2 in the TGD.

Dry well BMPs have been chosen for the site due to limited flat permeable areas at the site that would allow other infiltration BMPs. Runoff from each drainage area will be collected by storm drains and outlet into storage chambers and dry well system that will provide retention and infiltration of the DCV. Per calculations in Section IV.3.2, specifically step 2, the maximum volume of runoff that a single dry well can infiltrate in 48 hours (the maximum draw down time) is 2,065 CF. Because the DCV for Drainage Area B and X3 is greater than 2,065 CF, three dry wells are required to ensure that the full DCV is infiltrated in 48 hours. In each drainage area, the dry wells and storage chambers are interconnected with a level storm drain (0% slope) to allow chambers and dry wells to function as a single system, filling and emptying simultaneously.

The project site has been divided into three drainage management areas (DMAs). The DMAs and associated BMPS are shown on the Proposed Hydrology Exhibit (Exhibit B1) in Attachment C along with project Grading and Drainage Plans. Calculations of Design Capture Volumes for each DMA are provided in Attachment B.

The following treatment BMPs are proposed:

- DMA A is treated by a chamber and dry well system near the southern corner of the site.
    - Dry Well Center Coordinates: 33°37'18.62"N 117°42'5.10"W
- DMA B is treated by a chamber and dry well system near the northern corner of the site.
    - Dry Well 1 Center Coordinates: 33°37'21.06"N 117°42'4.52"W
    - Dry Well 2 Center Coordinates: 33°37'22.02"N 117°42'4.22"W
    - Dry Well 3 Center Coordinates: 33°37'21.37"N 117°42'3.09"W
- DMA X3 is treated by a chamber and dry well system near the southern corner of the site.
    - Dry Well 1 Center Coordinates: 33°37'17.21"N 117°41'59.36"W

DMA	Total Area (SF)	Roof (SF)	Hardscape (SF)	Landscape (SF)	Total Impervious (SF)	Total Pervious (SF)
A	30,525	18,051	1,974	10,500	20,025	10,500
B	110,868	18,542	75,634	16,692	94,176	16,692
X3	22,467	8,077	522	13,868	8,599	13,868
Total	**163,860**	**44,670**	**78,130**	**41,060**	**122,800**	**41,060**

DMA	Percent Impervious	C	DCV
A	65.5%	0.64	1,382
B	84.9%	0.79	6,184
X3	38.3%	0.44	706
Total	79.8%	0.75	8,272

IV.3 LID BMP SELECTION AND PROJECT CONFORMANCE ANALYSIS

Each sub-section below documents that the proposed design features conform to the applicable project performance criteria via check boxes, tables, calculations, narratives, and/or references to worksheets. *Refer to Section 2.4.2.3 in the TGD for selecting LID BMPs and Section 2.4.3 in the TGD for conducting conformance analysis with project performance criteria.*

IV.3.1 Hydrologic Source Controls

Retention criteria for the project is met through infiltration BMPs listed in section IV.3.2. HSCs are not required.

IV.3.2 Infiltration BMPs

Identify infiltration BMPs to be used in project. If design volume cannot be met, state why.

Name	Included?
Bioretention without underdrains	
Rain gardens	
Porous landscaping	
Infiltration planters	
Retention swales	
Infiltration trenches	
Infiltration basins	
Drywells	X
Subsurface infiltration galleries	
French drains	
Permeable asphalt	
Permeable concrete	
Permeable concrete pavers	
Other:	

Show calculations below to demonstrate if the LID Design Strom Capture Volume can be met with infiltration BMPs. If not, document how much can be met with infiltration and document why it is not feasible to meet the full volume with infiltration BMPs

Drainage Area A-Dry Well and Storage Chambers

Step 1: Determine Infiltration Dry Well DCV
(see DCV Calculation Worksheet-Attachment B)
DCV= 1,382 cu-ft.

Step 2: Determine Volume of Infiltration in 48 hours
Design Flow Rate
$Q_{measured}$=0.018cfs (Preliminary Percolation Study, Page 6-Attachment F)
Safety Factor, SF=2.25 (Worksheet H, Attachment B)
Q_{design} =$Q_{measured}$/SF=0.018cfs/2.25=0.008cfs

Total Time for Infiltration= T= Storm Duration + Drawdown Time = 24 hours + 48 hours
T=72 hours
Time to empty chamber=8.5 hours (Preliminary Percolation Study, Page 7-Attachment F)

Volume Infiltrated in first 63.5 hours, $V = Q_{design} \times T$

$$V_{63.5} = 0.008\frac{ft^3}{s} \times 63.5hrs \times \frac{3600\ s}{1\ hr} = 1{,}829\ ft^3$$

Volume Infiltrated in last 8.5 hours=Volume of Dry Well
Given dimensions from Preliminary Percolation Study, Page 7(Attachment F)
V_{DW}=236 CF

Total Volume Infiltrated in 48 Hours
V_T=$V_{39.5}$+V_{DW}=1,829+236=2,065 CF

2,065 cf > 1,382 cf …**OK**

Step 3: Determine Storage Volume of Dry Well
Given dimensions from Preliminary Percolation Study, Page 7(Attachment F)
V_{DW}=236 CF

Step 4: Determine additional Storage Volume in Chambers
Chamber Volume = DCV-V_{DW} = 1,382-236 = **1,146 CF**

Drainage Area B-Dry Wells and Storage Chambers

Step 1: Determine Infiltration Dry Well DCV
(see DCV Calculation Worksheet-Attachment B)
DCV= 6,184 cu-ft.
Step 2: Determine Volume of Infiltration in 48 hours
Design Flow Rate
$Q_{measured}$=0.018cfs (Preliminary Percolation Study, Page 6-Attachment F)
Safety Factor, SF=2.25 (Worksheet H, Attachment B)
Q_{design} =$Q_{measured}$/SF=0.018cfs/2.25=0.008cfs

Total Time for Infiltration= T= Storm Duration + Drawdown Time = 24 hours + 48 hours
T=72 hours
Time to empty chamber=8.5 hours (Preliminary Percolation Study, Page 7-Attachment F)

Volume Infiltrated in first 63.5 hours, $V = Q_{design} \times T$

$$V_{63.5} = 0.008 \frac{ft^3}{s} \times 63.5hrs \times \frac{3600\ s}{1\ hr} = 1{,}829\ ft^3$$

Volume Infiltrated in last 8.5 hours=Volume of Dry Well
Given dimensions from Preliminary Percolation Study, Page 7(Attachment F)
V_{DW}=236 CF

Total Volume Infiltrated in 48 Hours
V_T=$V_{39.5}$+V_{DW}=1,829+236=2,065 CF
Since V_T< DCV… **Three dry wells are required**
V_{T2} = 6,195 CF

6,195 cf > 6,184 cf …**OK**

Step 3: Determine Storage Volume of Dry Wells
Given dimensions from Preliminary Percolation Study, Page 7(Attachment F)
V_{DW}=236 CF*3=708 CF

Step 4: Determine additional Storage Volume in Chambers
Chamber Volume = DCV-V_{DW} = 6,184-708 = **5,476 CF**

Drainage Area X3-Dry Well and Storage Chambers

Step 1: Determine Infiltration Dry Well DCV
(see DCV Calculation Worksheet-Attachment B)
DCV= 706 cu-ft.

Step 2: Determine Volume of Infiltration in 48 hours
Design Flow Rate
$Q_{measured}$=0.018cfs (Preliminary Percolation Study, Page 6-Attachment F)
Safety Factor, SF=2.25 (Worksheet H, Attachment B)
Q_{design} =$Q_{measured}$/SF=0.018cfs/2.25=0.008cfs

Total Time for Infiltration= T= Storm Duration + Drawdown Time = 24 hours + 48 hours
T=72 hours
Time to empty chamber=8.5 hours (Preliminary Percolation Study, Page 7-Attachment F)

Volume Infiltrated in first 63.5 hours, $V = Q_{design} \times T$

$$V_{63.5} = 0.008\frac{ft^3}{s} \times 63.5hrs \times \frac{3600\ s}{1\ hr} = 1{,}829\ ft^3$$

Volume Infiltrated in last 8.5 hours=Volume of Dry Well
Given dimensions from Preliminary Percolation Study, Page 7(Attachment F)
V_{DW}=236 CF

Total Volume Infiltrated in 48 Hours
V_T=$V_{39.5}$+V_{DW}=1,829+236=2,065 CF

2,065 cf > 706cf …**OK**

Step 3: Determine Storage Volume of Dry Well
Given dimensions from Preliminary Percolation Study, Page 7(Attachment F)
V_{DW}=236 CF

Step 4: Determine additional Storage Volume in Chambers
Chamber Volume = DCV-V_{DW} = 706-236 = **470 CF**

IV.3.3 Evapotranspiration, Rainwater Harvesting BMPs

The full Design Storm Capture Volume is met with infiltration BMPs, therefore no evapotranspiration and/or rainwater harvesting BMPs are included.

IV.3.4 Biotreatment BMPs

The full Design Storm Capture Volume is met with infiltration BMPs, no biotreatment BMPs are included.

IV.3.5 Hydromodification Control BMPs

Hydromodification Control BMPs are not necessary because the proposed project decreases the runoff volume and increases the time of concentration.

IV.3.6 Regional/Sub-Regional LID BMPs

The project will not participate in any regional/sub-regional LID BMPs.

IV.3.7 Treatment Control BMPs

Treatment control BMPs are not required because the full design capture volume is retained with LID BMPs.

IV.3.8 Non-structural Source Control BMPs

Fill out non-structural source control check box forms or provide a brief narrative explaining if non-structural source controls were not used.

Non-Structural Source Control BMPs				
Identifier	**Name**	**Check One**		**If not applicable, state brief reason**
		Included	**Not Applicable**	
N1	Education for Property Owners, Tenants and Occupants	☒	☐	
N2	Activity Restrictions	☒	☐	
N3	Common Area Landscape Management	☒	☐	
N4	BMP Maintenance	☒	☐	
N5	Title 22 CCR Compliance (How development will comply)	☐	☒	No Hazardous Waste
N6	Local Industrial Permit Compliance	☐	☒	Residential Development
N7	Spill Contingency Plan	☐	☒	No Hazardous Materials
N8	Underground Storage Tank Compliance	☐	☒	No underground storage tanks
N9	Hazardous Materials Disclosure Compliance	☐	☒	No Hazardous Waste
N10	Uniform Fire Code Implementation	☒	☐	
N11	Common Area Litter Control	☒	☐	
N12	Employee Training	☒	☐	
N13	Housekeeping of Loading Docks	☐	☒	No loading docks
N14	Common Area Catch Basin Inspection	☒	☐	
N15	Street Sweeping Private Streets and Parking Lots	☒	☐	

IV.3.9 Structural Source Control BMPs

Fill out structural source control check box forms or provide a brief narrative explaining if Structural source controls were not used.

Structural Source Control BMPs				
Identifier	**Name**	**Check One**		**If not applicable, state brief reason**
		Included	**Not Applicable**	
S1	Provide storm drain system stenciling and signage	☒	☐	
S2	Design and construct outdoor material storage areas to reduce pollution introduction	☐	☒	No Hazardous Material storage
S3	Design and construct trash and waste storage areas to reduce pollution introduction	☒	☐	
S4	Use efficient irrigation systems & landscape design, water conservation, smart controllers, and source control	☒	☐	
S5	Protect slopes and channels and provide energy dissipation	☐	☒	No slopes or channels on-site
	Incorporate requirements applicable to individual priority project categories (from SDRWQCB NPDES Permit)	☐	☒	Site is within SARWQCB jurisdiction
S6	Dock areas	☐	☒	Not a part of site design
S7	Maintenance bays	☐	☒	Not a part of site design
S8	Vehicle wash areas	☐	☒	Not a part of site design
S9	Outdoor processing areas	☐	☒	Not a part of site design
S10	Equipment wash areas	☐	☒	Not a part of site design
S11	Fueling areas	☐	☒	Not a part of site design
S12	Hillside landscaping	☐	☒	Not a part of site design
S13	Wash water control for food preparation areas	☐	☒	Not a part of site design
S14	Community car wash racks	☐	☒	Not a part of site design

IV.4 ALTERNATIVE COMPLIANCE PLAN (IF APPLICABLE)

IV.4.1 Water Quality Credits

<table>
<tr><th colspan="6">Description of Proposed Project</th></tr>
<tr><td colspan="6">Project Types that Qualify for Water Quality Credits (Select all that apply):</td></tr>
<tr><td>☐Redevelopment projects that reduce the overall impervious footprint of the project site.</td><td colspan="3">☐Brownfield redevelopment, meaning redevelopment, expansion, or reuse of real property which may be complicated by the presence or potential presence of hazardous substances, pollutants or contaminants, and which have the potential to contribute to adverse ground or surface WQ if not redeveloped.</td><td colspan="2">☒ Higher density development projects which include two distinct categories (credits can only be taken for one category): those with more than seven units per acre of development (lower credit allowance); vertical density developments, for example, those with a Floor to Area Ratio (FAR) of 2 or those having more than 18 units per acre (greater credit allowance).</td></tr>
<tr><td colspan="2">☐ Mixed use development, such as a combination of residential, commercial, industrial, office, institutional, or other land uses which incorporate design principles that can demonstrate environmental benefits that would not be realized through single use projects (e.g. reduced vehicle trip traffic with the potential to reduce sources of water or air pollution).</td><td colspan="3">☐ Transit-oriented developments, such as a mixed use residential or commercial area designed to maximize access to public transportation; similar to above criterion, but where the development center is within one half mile of a mass transit center (e.g. bus, rail, light rail or commuter train station). Such projects would not be able to take credit for both categories, but may have greater credit assigned</td><td>☐ Redevelopment projects in an established historic district, historic preservation area, or similar significant city area including core City Center areas (to be defined through mapping).</td></tr>
<tr><td>☐Developments with dedication of undeveloped portions to parks, preservation areas and other pervious uses.</td><td>☐ Developments in a city center area.</td><td>☐ Developments in historic districts or historic preservation areas.</td><td colspan="2">☐ Live-work developments, a variety of developments designed to support residential and vocational needs together – similar to criteria to mixed use development; would not be able to take credit for both categories.</td><td>☐In-fill projects, the conversion of empty lots and other underused spaces into more beneficially used spaces, such as residential or commercial areas.</td></tr>
<tr><td>Calculation of Water Quality Credits
(if applicable)</td><td colspan="5">N/A- Not used for this project</td></tr>
</table>

IV.4.2 Alternative Compliance Plan Information

Not applicable to this project.

Section V Inspection/Maintenance Responsibility for BMPs

Section will be completed during Final Design.

Fill out information in table below. Prepare and attach an Operation and Maintenance Plan. Identify the mechanism through which BMPs will be maintained. Inspection and maintenance records must be kept for a minimum of five years for inspection by the regulatory agencies. *Refer to Section 7.II 4.0 in the Model WQMP.*

BMP Inspection/Maintenance			
BMP	**Responsible Party(s)**	**Inspection/ Maintenance Activities Required**	**Minimum Frequency of Activities**
Chamber and Drywell System	Owner		

Section VI Site Plan and Drainage Plan

VI.1 SITE PLAN AND DRAINAGE PLAN

Include a site plan and drainage plan sheet set containing the following minimum information:

- Project location
- Site boundary
- Land uses and land covers, as applicable
- Suitability/feasibility constraints
- Structural BMP locations
- Drainage delineations and flow information
- Drainage connections
- BMP details

See Exhibits B1 and B2-Proposed Hydrology Exhibit and Preliminary Grading and Utility Plan in Attachment C .

Section VII Educational Materials

Refer to the Orange County Stormwater Program (ocwatersheds.com) for a library of materials available. For the copy submitted to the Permittee, only attach the educational materials specifically applicable to the project. Other materials specific to the project may be included as well and must be attached.

Education Materials			
Residential Material (http://www.ocwatersheds.com)	**Check If Applicable**	**Business Material (http://www.ocwatersheds.com)**	**Check If Applicable**
The Ocean Begins at Your Front Door	☒	Tips for the Automotive Industry	☐
Tips for Car Wash Fund-raisers	☐	Tips for Using Concrete and Mortar	☐
Tips for the Home Mechanic	☐	Tips for the Food Service Industry	☐
Homeowners Guide for Sustainable Water Use	☐	Proper Maintenance Practices for Your Business	☐
Household Tips	☐	**Other Material**	**Check If Attached**
Proper Disposal of Household Hazardous Waste	☒		
Recycle at Your Local Used Oil Collection Center (North County)	☐		☐
Recycle at Your Local Used Oil Collection Center (Central County)	☐		☐
Recycle at Your Local Used Oil Collection Center (South County)	☐		☐
Tips for Maintaining a Septic Tank System	☐		☐
Responsible Pest Control	☐		☐
Sewer Spill	☐		☐
Tips for the Home Improvement Projects	☐		☐
Tips for Horse Care	☐		☐
Tips for Landscaping and Gardening	☐		☐
Tips for Pet Care	☒		☐
Tips for Pool Maintenance	☐		☐
Tips for Residential Pool, Landscape and Hardscape Drains	☐		☐
Tips for Projects Using Paint	☐		☐

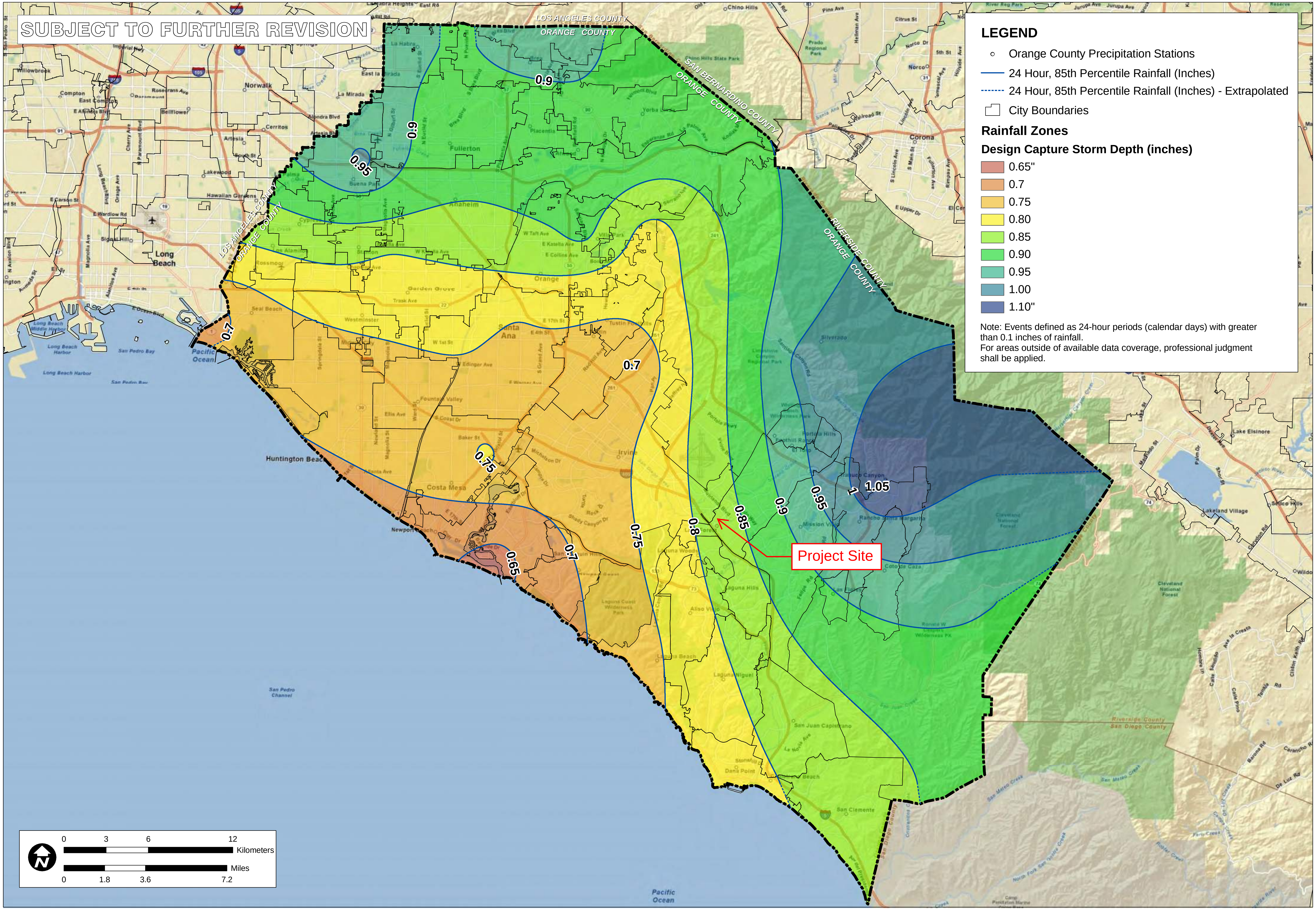
Attachment A

Educational Materials

To be included in Final WQMP, not included in this Preliminary WQMP

Attachment B

TGD Worksheets & Figures



TITLE

RAINFALL ZONES

JOB

ORANGE COUNTY TECHNICAL GUIDANCE DOCUMENT

ORANGE CO. CA

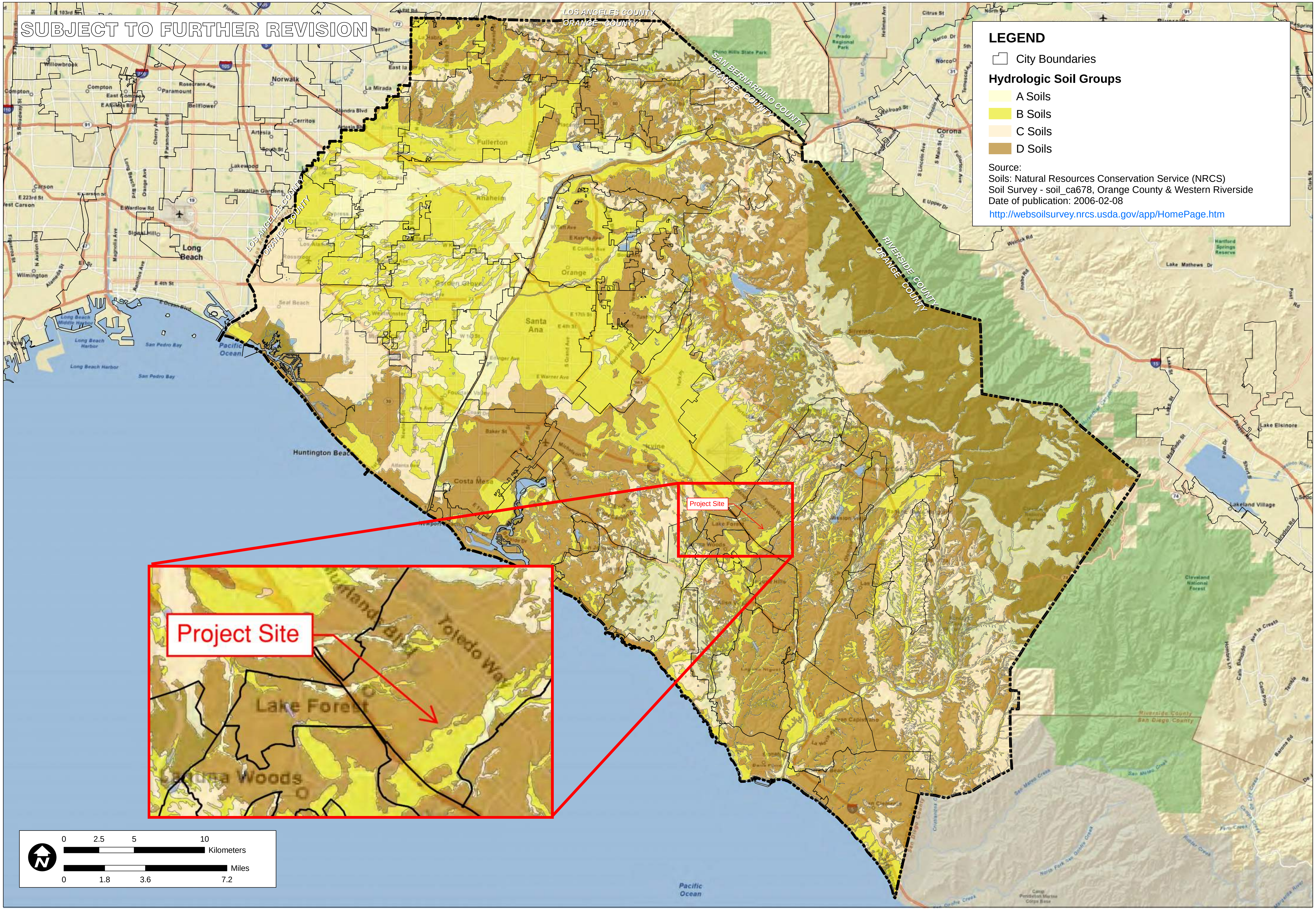
SCALE	1" = 1.8 miles
DESIGNED	TH
DRAWING	TH
CHECKED	BMP
DATE	04/22/10
JOB NO.	9526-E

PACE Advanced Water Engineering

FIGURE

XVI-1

P:\9526E\6-GIS\Mxds\Reports\InfiltrationFeasability_20110215\9526E_FigureXVI-1_RainfallZones_20110215.mxd



P:\9526E\6-GIS\Mxds\Reports\InfiltrationFeasability_20110215\9526E_FigureXVI-2a_HydroSoils_20110215.mxd

TITLE
NRCS HYDROLOGIC SOILS GROUPS

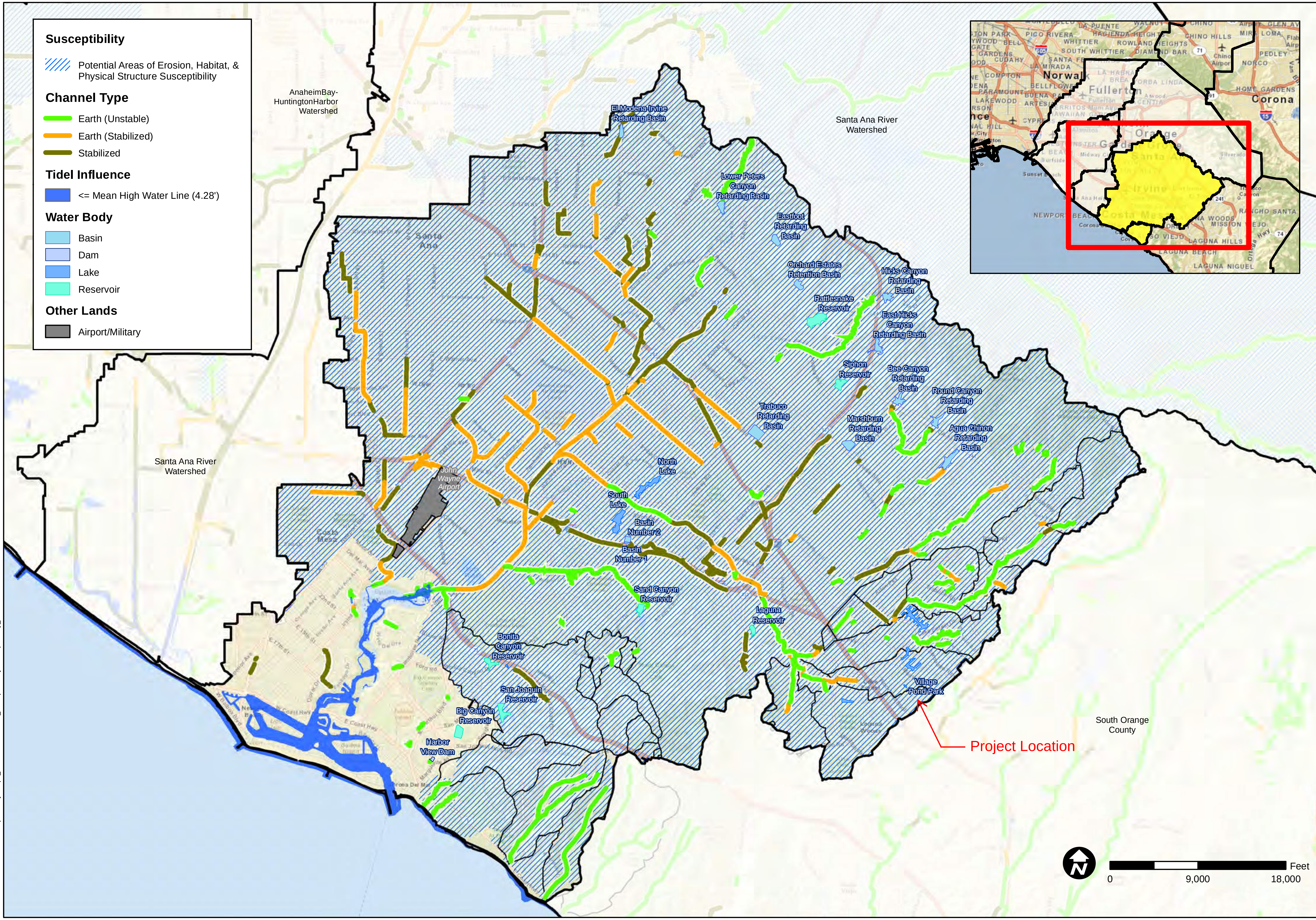
JOB
ORANGE COUNTY INFILTRATION STUDY
ORANGE CO. CA

SCALE	1" = 1.8 miles
DESIGNED	TH
DRAWING	TH
CHECKED	BMP
DATE	02/09/11
JOB NO.	9526-E

PACE
Advanced Water Engineering

FIGURE
XVI-2a

SUSCEPTIBILITY MAP UPATE (FEB 2013)



TITLE

SUSCEPTIBILITY ANALYIS
NEWPORT BAY-
NEWPORT COASTAL STREAMS

JOB

ORANGE COUNTY
WATERSHED
MASTER PLANNING

ORANGE CO. CA

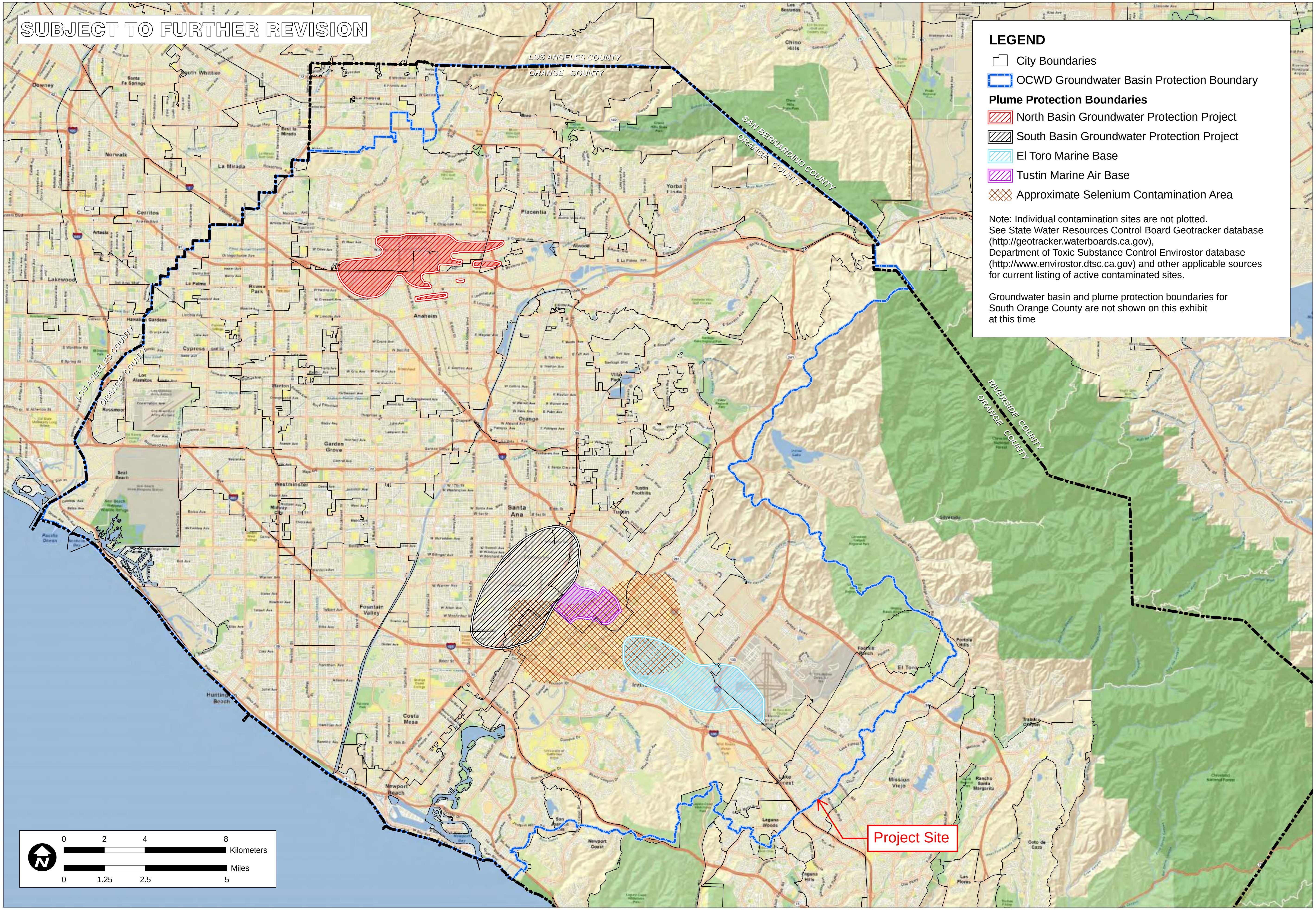
SCALE	DESIGNED	DRAWING	CHECKED	DATE	JOB NO.
1" = 12000'	TH	TH	BMP	04/30/10	9526-E

PACE
Advanced Water Engineering

FIGURE

4

P:\9526E\6-GIS\Mxds\SuceptabilityMaps_20100505\9526E_NewportBaySusceptibility_20100430.mxd



TITLE: NORTH ORANGE COUNTY GROUNDWATER PROTECTION AREAS

JOB: ORANGE COUNTY INFILTRATION STUDY

ORANGE CO. CA

SCALE	1" = 1.25 miles
DESIGNED	TH
DRAWING	TH
CHECKED	BMP
DATE	04/22/10
JOB NO.	9526-E

PACE Advanced Water Engineering

FIGURE XVI-2f

P:\9526E\6-GIS\Mxds\Reports\InfiltrationFeasability_20110215\9526E_FigureXVI-2f_NorthOCGroundwaterProtectionAreasStreetMap_20110215.mxd

Worksheet B: Simple Design Capture Volume Sizing Method Drainage Area A

Step 1: Determine the design capture storm depth used for calculating volume				
1	Enter design capture storm depth from Figure III.1, *d* (inches)	d=	0.85	inches
2	Enter the effect of provided HSCs, d_{HSC} (inches) (Worksheet A)	d_{HSC}=	0	inches
3	Calculate the remainder of the design capture storm depth, $d_{remainder}$ (inches) (Line 1 – Line 2)	$d_{remainder}$=	0.85	inches
Step 2: Calculate the DCV				
1	Enter Project area tributary to BMP (s), *A* (acres)	A=	0.70	acres
2	Enter Project Imperviousness, *imp* (unitless)	imp=	0.66	
3	Calculate runoff coefficient, $C = (0.75 \times imp) + 0.15$	C=	0.64	
4	Calculate runoff volume, $V_{design} = (C \times d_{remainder} \times A \times 43560 \times (1/12))$	V_{design}=	1,382	cu-ft
Step 3: Design BMPs to ensure full retention of the DCV				
Step 3a: Determine design infiltration rate				
1	Enter measured infiltration rate, $K_{observed}$[1] (in/hr) (**Appendix VII**)	$K_{observed}$=	3.0	In/hr
2	Enter combined safety factor from Worksheet H, S_{total} (unitless)	S_{total}=	2.25	
3	Calculate design infiltration rate, $K_{design} = K_{observed} / S_{total}$	K_{design}=	1.33	In/hr
Step 3b: Determine minimum BMP footprint				
4	Enter drawdown time, *T* (max 48 hours)	T=	48	Hours
5	Calculate max retention depth that can be drawn down within the drawdown time (feet), $D_{max} = K_{design} \times T \times (1/12)$	D_{max}=	5.32	feet
6	Calculate minimum area required for BMP (sq-ft), $A_{min} = V_{design} / d_{max}$	A_{min}=	259.8	sq-ft

[1]$K_{observed}$ is the vertical infiltration measured in the field, before applying a factor of safety. If field testing measures a rate that is different than the vertical infiltration rate (for example, three-dimensional borehole percolation rate), then this rate must be adjusted by an acceptable method (for example, Porchet method) to yield the field estimate of vertical infiltration rate, $K_{observed}$. See Appendix VII.

Worksheet B: Simple Design Capture Volume Sizing Method

Drainage Area B

Step 1: Determine the design capture storm depth used for calculating volume				
1	Enter design capture storm depth from Figure III.1, *d* (inches)	d=	0.85	inches
2	Enter the effect of provided HSCs, d_{HSC} (inches) (Worksheet A)	d_{HSC}=	0	inches
3	Calculate the remainder of the design capture storm depth, $d_{remainder}$ (inches) (Line 1 – Line 2)	$d_{remainder}$=	0.85	inches
Step 2: Calculate the DCV				
1	Enter Project area tributary to BMP (s), *A* (acres)	A=	2.55	acres
2	Enter Project Imperviousness, *imp* (unitless)	imp=	0.85	
3	Calculate runoff coefficient, $C = (0.75 \times imp) + 0.15$	C=	0.79	
4	Calculate runoff volume, $V_{design} = (C \times d_{remainder} \times A \times 43560 \times (1/12))$	V_{design}=	6,184	cu-ft
Step 3: Design BMPs to ensure full retention of the DCV				
Step 3a: Determine design infiltration rate				
1	Enter measured infiltration rate, $K_{observed}$[1] (in/hr) (**Appendix VII**)	$K_{observed}$=	3.0	In/hr
2	Enter combined safety factor from Worksheet H, S_{total} (unitless)	S_{total}=	2.25	
3	Calculate design infiltration rate, $K_{design} = K_{observed} / S_{total}$	K_{design}=	1.33	In/hr
Step 3b: Determine minimum BMP footprint				
4	Enter drawdown time, *T* (max 48 hours)	T=	48	Hours
5	Calculate max retention depth that can be drawn down within the drawdown time (feet), $D_{max} = K_{design} \times T \times (1/12)$	D_{max}=	5.32	feet
6	Calculate minimum area required for BMP (sq-ft), $A_{min} = V_{design} / d_{max}$	A_{min}=	1162.4	sq-ft

[1]$K_{observed}$ is the vertical infiltration measured in the field, before applying a factor of safety. If field testing measures a rate that is different than the vertical infiltration rate (for example, three-dimensional borehole percolation rate), then this rate must be adjusted by an acceptable method (for example, Porchet method) to yield the field estimate of vertical infiltration rate, $K_{observed}$. See Appendix VII.

Worksheet B: Simple Design Capture Volume Sizing Method Drainage Area X3

Step 1: Determine the design capture storm depth used for calculating volume				
1	Enter design capture storm depth from Figure III.1, *d* (inches)	d=	0.85	inches
2	Enter the effect of provided HSCs, d_{HSC} (inches) (Worksheet A)	d_{HSC}=	0	inches
3	Calculate the remainder of the design capture storm depth, $d_{remainder}$ (inches) (Line 1 – Line 2)	$d_{remainder}$=	0.85	inches
Step 2: Calculate the DCV				
1	Enter Project area tributary to BMP (s), *A* (acres)	A=	0.52	acres
2	Enter Project Imperviousness, *imp* (unitless)	imp=	0.38	
3	Calculate runoff coefficient, $C= (0.75 \times imp) + 0.15$	C=	0.44	
4	Calculate runoff volume, $V_{design}= (C \times d_{remainder} \times A \times 43560 \times (1/12))$	V_{design}=	706	cu-ft
Step 3: Design BMPs to ensure full retention of the DCV				
Step 3a: Determine design infiltration rate				
1	Enter measured infiltration rate, $K_{observed}$[1] (in/hr) (**Appendix VII**)	$K_{observed}$=	3.0	In/hr
2	Enter combined safety factor from Worksheet H, S_{total} (unitless)	S_{total}=	2.25	
3	Calculate design infiltration rate, $K_{design} = K_{observed} / S_{total}$	K_{design}=	1.33	In/hr
Step 3b: Determine minimum BMP footprint				
4	Enter drawdown time, *T* (max 48 hours)	T=	48	Hours
5	Calculate max retention depth that can be drawn down within the drawdown time (feet), $D_{max} = K_{design} \times T \times (1/12)$	D_{max}=	5.32	feet
6	Calculate minimum area required for BMP (sq-ft), $A_{min} = V_{design} / d_{max}$	A_{min}=	132.7	sq-ft

[1]$K_{observed}$ is the vertical infiltration measured in the field, before applying a factor of safety. If field testing measures a rate that is different than the vertical infiltration rate (for example, three-dimensional borehole percolation rate), then this rate must be adjusted by an acceptable method (for example, Porchet method) to yield the field estimate of vertical infiltration rate, $K_{observed}$. See Appendix VII.

Worksheet H: Factor of Safety and Design Infiltration Rate and Worksheet

Factor Category		Factor Description	Assigned Weight (w)	Factor Value (v)	Product (p) $p = w \times v$
A	Suitability Assessment	Soil assessment methods	0.25	1	0.25
		Predominant soil texture	0.25	1	0.25
		Site soil variability	0.25	1	0.25
		Depth to groundwater / impervious layer	0.25	3	0.75
		Suitability Assessment Safety Factor, $S_A = \Sigma p$			1.50
B	Design	Tributary area size	0.25	1	0.25
		Level of pretreatment/ expected sediment loads	0.25	1	0.25
		Redundancy	0.25	2	0.50
		Compaction during construction	0.25	2	0.50
		Design Safety Factor, $S_B = \Sigma p$			1.50
Combined Safety Factor, $S_{Total} = S_A \times S_B$					2.25
Observed Infiltration Rate, inch/hr, $K_{observed}$ (corrected for test-specific bias)					3.0 in/hr
Design Infiltration Rate, in/hr, $K_{DESIGN} = K_{Observed} / S_{Total}$					1.33 in/hr
Supporting Data					
Briefly describe infiltration test and provide reference to test forms: Percolation testing was performed in accordance with constant head test procedures outlined in the Well Permeameter Method (USBR 7300-89). See Soils Report, Attachment F.					

Note: The minimum combined adjustment factor shall not be less than 2.0 and the maximum combined adjustment factor shall not exceed 9.0.

Worksheet I: Summary of Groundwater-related Feasibility Criteria

1	Is project large or small? (as defined by **Table VIII.2**) circle one	(Large) circled		Small
2	What is the tributary area to the BMP?	A	varies	acres
3	What type of BMP is proposed?	Dry Well		
4	What is the infiltrating surface area of the proposed BMP?	A_{BMP}	varies	sq-ft
5	What land use activities are present in the tributary area (list all) Multi-family residential			
6	What land use-based risk category is applicable?	(L) circled	M	H
7	If M or H, what pretreatment and source isolation BMPs have been considered and are proposed (describe all): N/A			
8	What minimum separation to mounded seasonally high groundwater applies to the proposed BMP? See Section **VIII.2** (circle one)	5 ft		(10 ft) circled
9	Provide rationale for selection of applicable minimum separation to seasonally high mounded groundwater: Dry Wells are listed under 10' minimum separation			
10	What is separation from the infiltrating surface to seasonally high groundwater?	SHGWT	N/A	ft
11	What is separation from the infiltrating surface to mounded seasonally high groundwater?	Mounded SHGWT	N/A	ft
12	Describe assumptions and methods used for mounding analysis: Groundwater was encountered during geotechinical analysis at 41 feet, per soils report.			
13	Is the site within a plume protection boundary (See **Figure**	Y	(N) circled	N/A

Worksheet I: Summary of Groundwater-related Feasibility Criteria

	VIII.2)?	
14	Is the site within a selenium source area or other natural plume area (See Figure VIII.2)?	Y (N) N/A
15	Is the site within 250 feet of a contaminated site?	Y (N) N/A
16	If site-specific study has been prepared, provide citation and briefly summarize relevant findings: N/A	
17	Is the site within 100 feet of a water supply well, spring, septic system?	Y (N) N/A
18	Is infiltration feasible on the site relative to groundwater-related criteria?	(Y) N

Provide rationale for feasibility determination:

Based on the high distance to groundwater and location of the site, infiltration BMPs are considered feasible based on groundwater related criteria.

Note: if a single criterion or group of criteria would render infiltration infeasible, it is not necessary to evaluate every question in this worksheet.

Table 2.7: Infiltration BMP Feasibility Worksheet

	Infeasibility Criteria	*Yes*	*No*
1	**Would Infiltration BMPs pose significant risk for groundwater related concerns?** Refer to Appendix VIII (Worksheet I) for guidance on groundwater-related infiltration feasibility criteria.		X
Provide basis: Based on the high distance to groundwater and location of the site infiltration BMPs are considered feasible based on groundwater related criteria. Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			
2	Would Infiltration BMPs **pose significant risk of increasing risk of geotechnical hazards that cannot be mitigated to an acceptable level**? (Yes if the answer to any of the following questions is yes, as established by a geotechnical expert): • The BMP can only be located less than 50 feet away from slopes steeper than 15 percent • The BMP can only be located less than eight feet from building foundations or an alternative setback. • A study prepared by a geotechnical professional or an available watershed study substantiates that stormwater infiltration would potentially result in significantly increased risks of geotechnical hazards that cannot be mitigated to an acceptable level.		X
Provide basis: None of the above criteria apply. Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			
3	Would infiltration of the DCV from drainage area **violate downstream water rights**?		X
Provide basis: Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			

Table 2.7: Infiltration BMP Feasibility Worksheet (continued)

	Partial Infeasibility Criteria	***Yes***	***No***
4	Is proposed infiltration facility **located on HSG D soils** or the site geotechnical investigation identifies presence of soil characteristics which support categorization as D soils?	X	
Provide basis: See Soils Map in Attachment B Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			
5	Is **measured infiltration rate below proposed facility less than 0.3 inches per hour**? This calculation shall be based on the methods described in **Appendix VII**.		X
Provide basis: See Soils Report, Attachment F Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			
6	Would **reduction of over predeveloped conditions cause impairments to downstream beneficial uses, such as change of seasonality of ephemeral washes or increased discharge of contaminated groundwater to surface waters?**		X
Provide citation to applicable study and summarize findings relative to the amount of infiltration that is permissible: Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			
7	Would **an increase in infiltration over predeveloped conditions cause impairments to downstream beneficial uses, such as change of seasonality of ephemeral washes or increased discharge of contaminated groundwater to surface waters?**		X
Provide citation to applicable study and summarize findings relative to the amount of infiltration that is permissible: Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.			

Table 2.7: Infiltration BMP Feasibility Worksheet (continued)

Infiltration Screening Results (check box corresponding to result):		
8	Is there substantial evidence that infiltration from the project would result in a significant increase in I&I to the sanitary sewer that cannot be sufficiently mitigated? (See **Appendix XVII**) Provide narrative discussion and supporting evidence: Summarize findings of studies provide reference to studies, calculations, maps, data sources, etc. Provide narrative discussion of study/data source applicability.	No
9	If any answer from row 1-3 is yes: infiltration of any volume is **not feasible** within the DMA or equivalent. Provide basis: Summarize findings of infeasibility screening	N/A
10	If any answer from row 4-7 is yes, infiltration is **permissible but is not presumed to be feasible for the entire DCV.** Criteria for designing biotreatment BMPs to achieve the maximum feasible infiltration and ET shall apply. Provide basis: Based on the hydrologic soil group and infiltration rate of the soil, infiltration BMPs are feasible but may not account for the entire DCV. Summarize findings of infeasibility screening	Yes
11	If all answers to rows 1 through 11 are no, infiltration of the full DCV is potentially feasible, BMPs must be designed to infiltrate the full DCV to the maximum extent practicable.	N/A

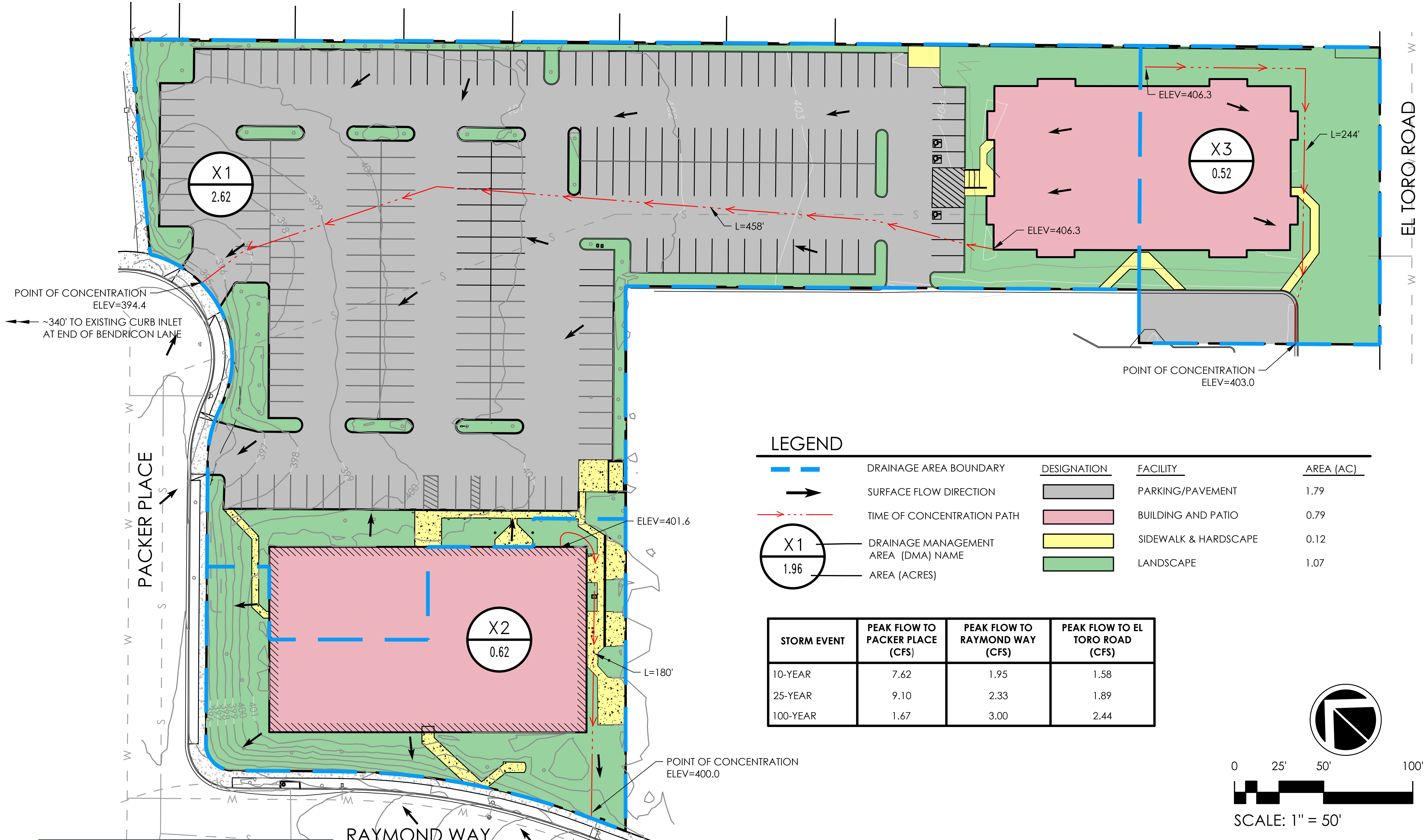
Harvest and Use Infeasibility

Harvest and use infeasibility criteria include:

- If inadequate demand exists for the use of the harvested rainwater. See **Appendix X** for guidance on determining harvested water demand and applicable feasibility thresholds.
- If the use of harvested water for the type of demand on the project violates codes or ordinances most applicable to stormwater harvesting in effect at the time of project application and a waiver of these codes and/or ordinances cannot be obtained. It is noted that codes and ordinances most applicable to stormwater harvesting may change

Attachment C

Exhibits and Grading Plan



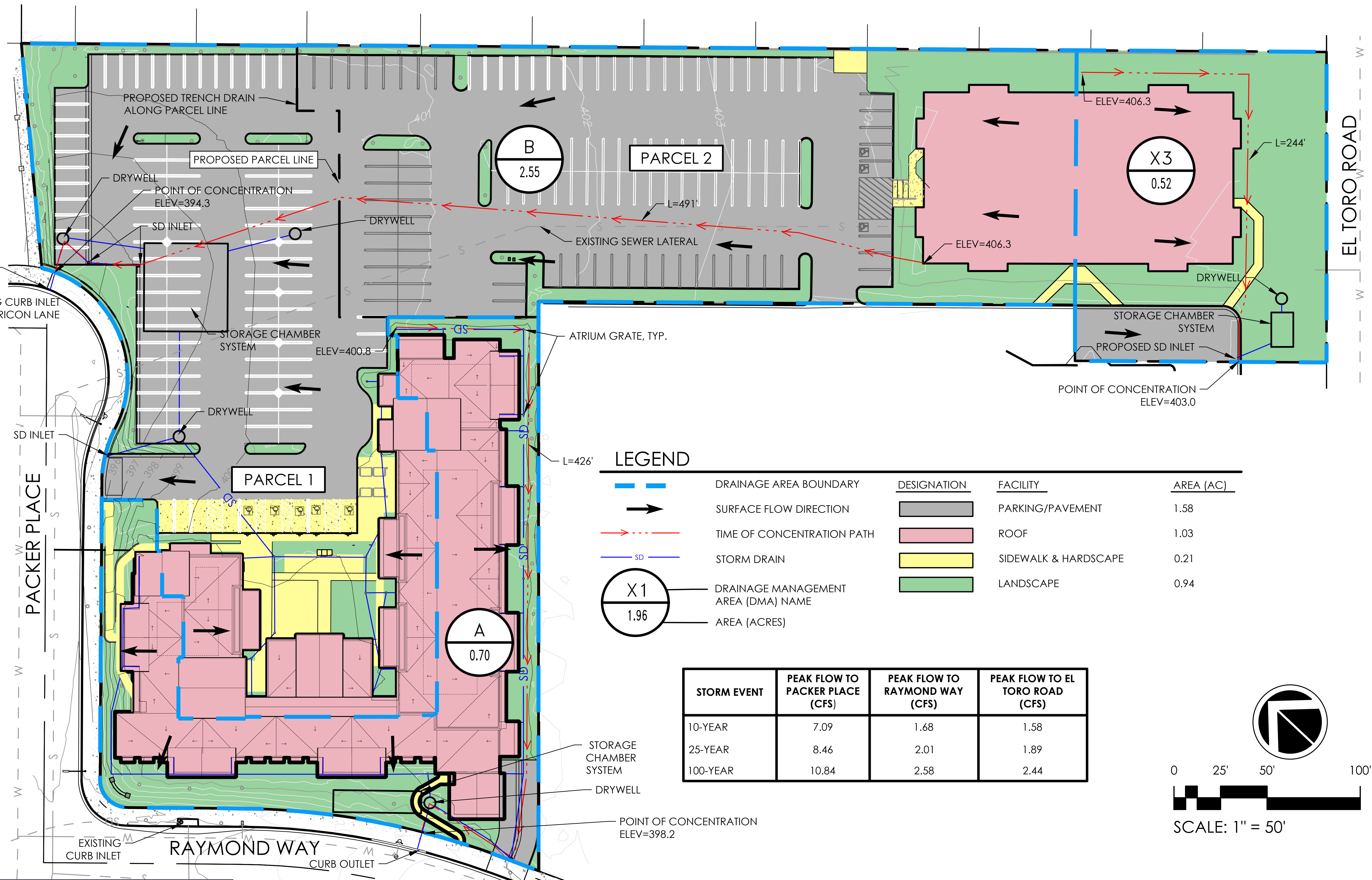
STORM EVENT	PEAK FLOW TO PACKER PLACE (CFS)	PEAK FLOW TO RAYMOND WAY (CFS)	PEAK FLOW TO EL TORO ROAD (CFS)
10-YEAR	7.62	1.95	1.58
25-YEAR	9.10	2.33	1.89
100-YEAR	1.67	3.00	2.44

rrm design group

MAY 7, 2020

EXHIBIT A-EXISTING HYDROLOGY MAP

24551 RAYMOND WAY, LAKE FOREST, CA



LEGEND

		DESIGNATION	FACILITY	AREA (AC)
DRAINAGE AREA BOUNDARY		(gray)	PARKING/PAVEMENT	1.58
SURFACE FLOW DIRECTION		(pink)	ROOF	1.03
TIME OF CONCENTRATION PATH		(yellow)	SIDEWALK & HARDSCAPE	0.21
STORM DRAIN		(green)	LANDSCAPE	0.94
X1 / 1.96	DRAINAGE MANAGEMENT AREA (DMA) NAME; AREA (ACRES)			

STORM EVENT	PEAK FLOW TO PACKER PLACE (CFS)	PEAK FLOW TO RAYMOND WAY (CFS)	PEAK FLOW TO EL TORO ROAD (CFS)
10-YEAR	7.09	1.68	1.58
25-YEAR	8.46	2.01	1.89
100-YEAR	10.84	2.58	2.44

rrm design group

MAY 11, 2020

EXHIBIT B-PROPOSED HYDROLOGY MAP

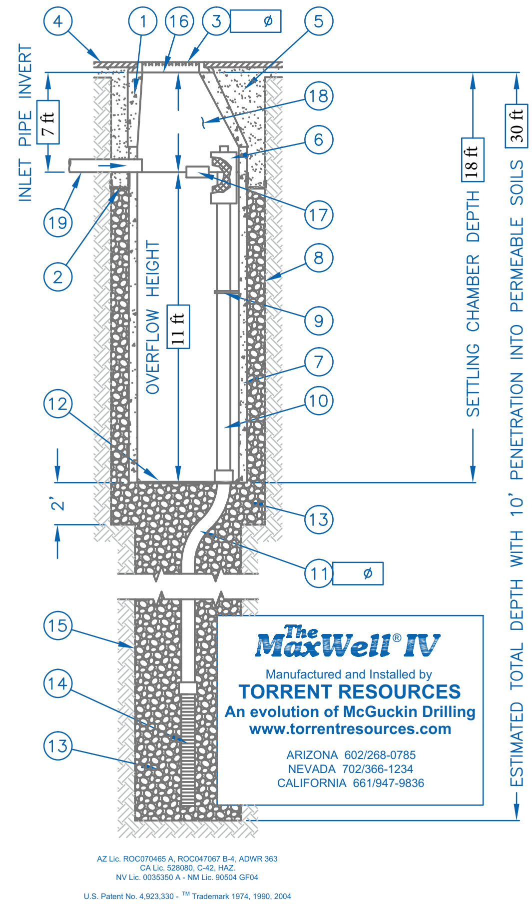
24551 RAYMOND WAY, LAKE FOREST, CA

MAXWELL® IV DRAINAGE SYSTEM DETAIL AND SPECIFICATIONS

ITEM NUMBERS

1. **Manhole Cone** - Modified Flat Bottom.
2. **Moisture Membrane** - 6 Mil. Plastic. Applies only when native material is used for backfill. Place membrane securely against eccentric cone and hole sidewall.
3. **Bolted Ring & Grate** - Diameter as shown. Clean cast iron with wording **"Storm Water Only"** in raised letters. **Bolted in 2 locations** and secured to cone with mortar. Rim elevation ±0.02' of plans.
4. **Graded Basin or Paving** (by Others).
5. **Compacted Base Material** - 1-Sack Slurry except in landscaped installtions with no pipe connections.
6. **PureFlo® Debris Shield** - Rolled 16 ga. steel X 24" length with vented anti-siphon and Internal .265" Max. SWO flattened expanded steel screen X 12" length. **Fusion bonded epoxy coated.**
7. **Pre-cast Liner** - 4000 PSI concrete 48" ID. X 54" OD. **Center in hole** and align sections **to maximize bearing surface.**
8. **Min. 6' Ø Drilled Shaft.**
9. **Support Bracket** - Formed 12 Ga. steel. **Fusion bonded epoxy coated.**
10. **Overflow Pipe** - Sch. 40 PVC mated to drainage pipe at base seal.
11. **Drainage Pipe** - ADS highway grade with TRI-A coupler. **Suspend pipe** during backfill operations to prevent buckling or breakage. Diameter as noted.
12. **Base Seal** - Geotextile or concrete slurry.
13. **Rock** - Washed, sized between 3/8" and 1-1/2" to **best complement soil conditions.**
14. **FloFast® Drainage Screen** - Sch. 40 PVC 0.120" slotted well screen with 32 slots per row/ft.Diameter varies 120" overall length with TRI-B coupler.
15. **Min. 4' Ø Shaft** - Drilled to **maintain permeability** of drainage soils.
16. **Fabric Seal** - U.V. resistant geotextile - **to be removed by customer** at project completion.
17. **Absorbent** – Hydrophobic Petrochemical Sponge. Min. to 128 oz. capacity.
18. **Freeboard Depth** Varies with inlet pipe elevation. Increase settling chamber depth as needed to maintain all inlet pipe elevations above overflow pipe inlet.
19. **Optional Inlet Pipe** (Maximum 4", by Others). Extend moisture membrane and compacted base material or 1 sack slurry backfill below pipe invert.

The referenced drawing and specifications are available on CAD either through our office or web site. This detail is copyrighted (2004) but may be used as is in construction plans without further release. For information on product application, individual project specifications or site evaluation, contact our Design Staff for no-charge assistance in any phase of your planning.



CALCULATING MAXWELL IV REQUIREMENTS

The type of property, soil permeability, rainfall intensity and local drainage ordinances determine the number and design of MaxWell Systems. For general applications draining retained stormwater, use one standard **MaxWell IV** per the instructions below for up to 3 acres of landscaped contributory area, and up to 1 acre of paved surface. For larger paved surfaces, subdivision drainage, nuisance water drainage, connecting pipes larger than 4" Ø from catch basins or underground storage, or other demanding applications, refer to our **MaxWell® Plus** System. For industrial drainage, including gasoline service stations, our **Envibro® System** may be recommended. For additional considerations, please refer to **"Design Suggestions For Retention And Drainage Systems"** or consult our Design Staff.

COMPLETING THE MAXWELL IV DRAWING

To apply the **MaxWell IV** drawing to your specific project, simply fill in the blue boxes per instructions below. For assistance, please consult our Design Staff.

ESTIMATED TOTAL DEPTH

The Estimated Total Depth is the approximate depth required to achieve 10 continuous feet of penetration into permeable soils. Torrent utilizes specialized **"crowd"** equipped drill rigs to penetrate difficult, cemented soils and to reach permeable materials at depths up to **180 feet.** Our extensive database of drilling logs and soils information is available for use as a reference. Please contact our Design Staff for site-specific information on your project.

SETTLING CHAMBER DEPTH

On MaxWell IV Systems of over 30 feet overall depth and up to 0.25cfs design rate, the **standard** Settling Chamber Depth is **18 feet .** For systems exposed to greater contributory area than noted above, extreme service conditions, or that require higher design rates, chamber depths up to 25 feet are recommended.

' OVERFLOW HEIGHT

The Overflow Height and Settling Chamber Depth determine the effectiveness of the settling process. The higher the overflow pipe, the deeper the chamber, the greater the settling capacity. For normal drainage applications, an overflow height of **13 feet** is used with the standard settling chamber depth of **18 feet**. Sites with higher design rates than noted above, heavy debris loading or unusual service conditions require greater settling capacities

"Ø DRAINAGE PIPE

This dimension also applies to the **PureFlo®** Debris Shield, the **FloFast®** Drainage Screen, and fittings. The size selected is based upon system design rates, soil conditions, and the need for adequate venting. Choices are 6", 8", or 12" diameter. Refer to "Design Suggestions for Retention and Drainage Systems" for recommendations on which size best matches your application.

"Ø BOLTED RING & GRATE

Standard models are quality cast iron and available to fit 24" Ø or 30" Ø manhole openings. All units are bolted in two locations with wording "Storm Water Only" in raised letters. For other surface treatments, please refer to "Design Suggestions for Retention and Drainage Systems."

"Ø INLET PIPE INVERT

Pipes up to 4" in diameter from catch basins, underground storage, etc. may be connected into the settling chamber. Inverts deeper than 5 feet will require additional settling chamber depth to maintain effective overflow height.

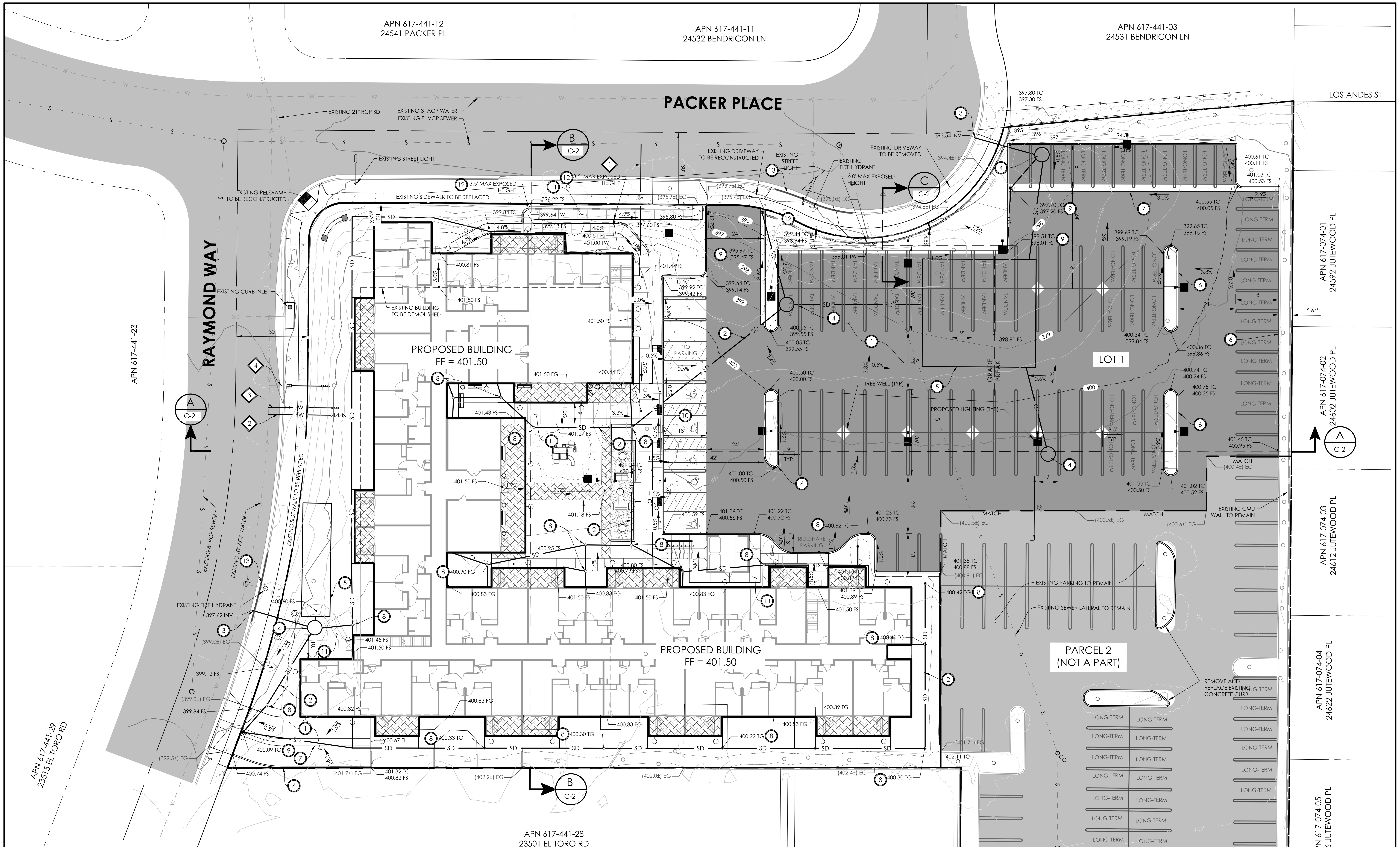
TORRENT RESOURCES INCORPORATED
1509 East Elwood Street, Phoenix Arizona 85040~1391
phone 602~268~0785 fax 602~268~0820
Nevada 702~366~1234
AZ Lic. ROC070465 A, ROC047067 B-4; ADWR 363
CA Lic. 528080 A, C-42, HAZ ~ **NV Lic.** 0035350 A ~ **NM Lic.** 90504 GF04

TORRENT RESOURCES (CA) INCORPORATED
phone 661~947~9836
CA Lic. 886759 A, C-42
www.TorrentResources.com
An evolution of McGuckin Drilling

The watermark for drainage solutions.®

Plate 2

TORRENT RESOURCES



PRELIMINARY EARTH QUANTITIES:

AREA OF DISTURBANCE: 1.97 AC±

RAW CUT: 500 CY
RAW FILL: 1,000 CY
IMPORT/EXPORT: 500 CY FILL

QUANTITY ESTIMATES ON THESE PLANS ARE TO BE USED FOR PERMIT PURPOSES ONLY. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO VERIFY ACTUAL QUANTITIES FOR THE PURPOSE OF CONSTRUCTION.

THE RAW EARTHWORK QUANTITIES SHOWN HEREON REPRESENT THE ESTIMATED VOLUMETRIC DIFFERENCE BETWEEN THE PROPOSED ROUGH GRADE AND THE LIMITED TOPOGRAPHIC EXISTING GRADES. THESE ESTIMATES DO NOT MAKE CONSIDERATIONS FOR LOSSES OR BULKING DUE TO: SHRINKAGE, SOIL AMENDMENTS, STABILIZATION, CONSTRUCTION TECHNIQUE, FOOTING & TRENCHING SPOILS, ETC. THESE, IN ADDITION TO ACTUAL FIELD CONDITIONS, CONSTRUCTION TECHNIQUE AND THE FINAL RECOMMENDATIONS OF THE SOILS ENGINEER MAY SIGNIFICANTLY EFFECT THE FINAL IMPORT/EXPORT QUANTITIES.

NOTE:

FUEL MODIFICATION REQUIREMENTS DO NOT APPLY TO THIS PROJECT.

WET UTILITY NOTES

1. PROPOSED 6" PVC SEWER SERVICE .
2. PROPOSED 4" DOMESTIC WATER SERVICE CONNECTION WITH REDUCED PRESSURE BACKFLOW.
3. PROPOSED 6" FIRE WATER CONNECTION WITH 6" DDC BACKFLOW PREVENTER.
4. EXISTING 2" WATER SERVICE AND METER TO BE USED FOR IRRIGATION PURPOSES.

GRADING/PAVING NOTES

1. PROPOSED ASPHALT CONCRETE PAVING.
2. PROPOSED 12" STORM DRAIN.
3. PROPOSED STORM DRAIN OUTLET THROUGH CURB FACE.
4. PROPOSED STORM WATER DRY WELL (MAXWELL OR APPROVED EQUIVALENT).
5. PROPOSED UNDERGROUND STORM WATER STORAGE CHAMBER (CULTEC 360HD OR APPROVED EQUIVALENT).
6. PROPOSED 6" CONCRETE CURB.
7. PROPOSED 3' WIDE CONCRETE RIBBON GUTTER.
8. PROPOSED 12" ATRIUM GRATE
9. PROPOSED INLET (36" X 36")
10. PROPOSED CONCRETE PAVEMENT FOR ADA STALLS
11. PROPOSED CONCRETE SIDEWALK
12. PROPOSED SPLIT-FACE CMU RETAINING WALL.
13. PROPOSED RED CURB 15' EITHER SIDE OF EXISTING FIRE HYDRANT.

LEGEND

- PROPERTY LINE
- S — EXISTING SEWER LINE
- W — EXISTING WATER LINE
- SD — EXISTING STORM DRAIN
- S — PROPOSED SEWER LINE
- W — PROPOSED WATER LINE
- FW — PROPOSED FIRE WATER LINE
- SD — PROPOSED STORM DRAIN
- PROPOSED STORM INLET (36" X 36")
- PROPOSED 12" ATRIUM GRATE
- EXISTING AC PAVEMENT
- PROPOSED AC PAVEMENT
- EXISTING CONCRETE PAVEMENT
- PROPOSED CONCRETE PAVEMENT
- PROPOSED BIORETENTION
- PROPOSED SPLIT-FACE CMU RETAINING WALL

0 10' 20' 40'
SCALE: 1" = 20'

RRM Design Group
10 E. Figueroa St., Suite 200
Santa Barbara, CA 93101

Tel: 805.963.8283
Fax: 805.963.8184
www.rrmdesign.com

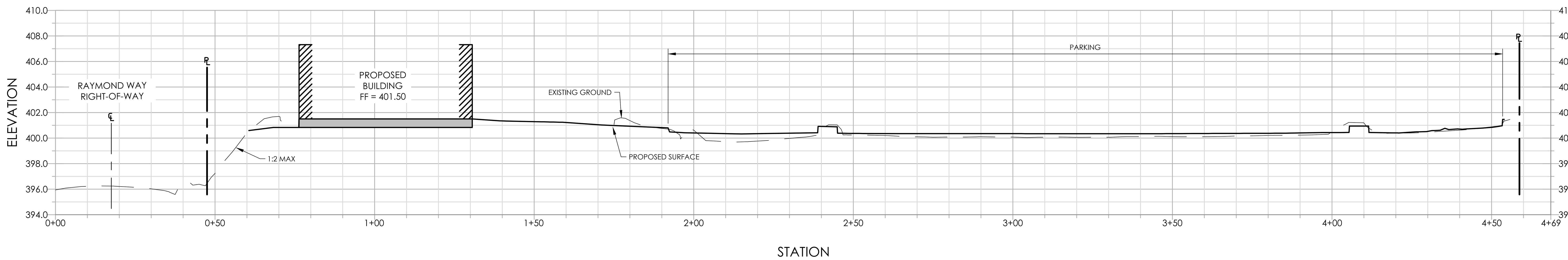
NATIONAL COMMUNITY CORE RENAISSANCE

Mountain View Affordable Housing Community
24551 Raymond Way, Lake Forest, CA 92630

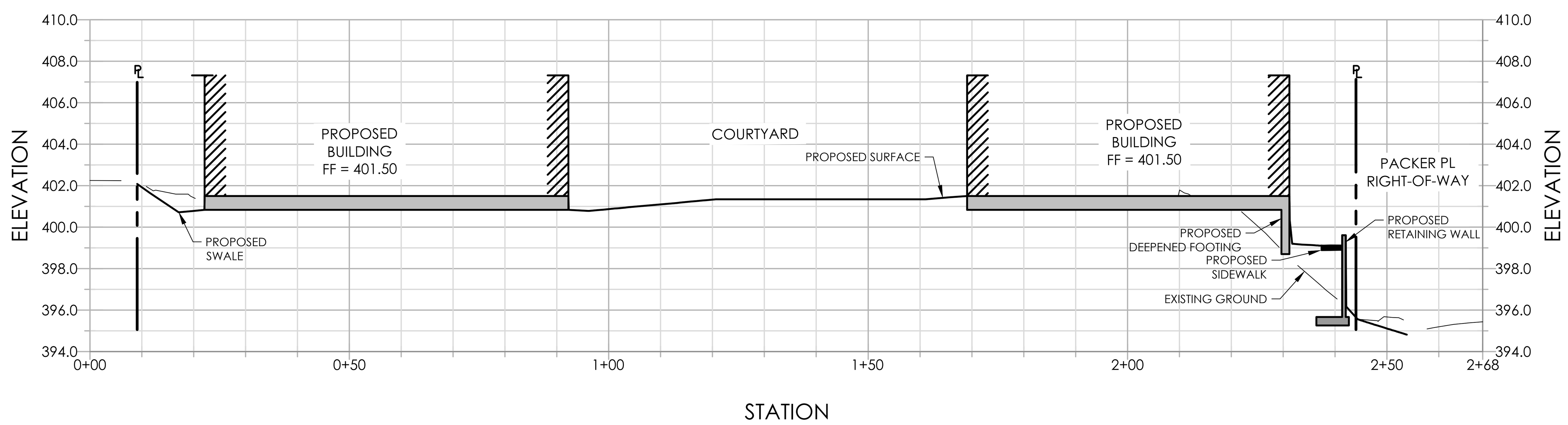
PRELIMINARY GRADING AND UTILITY PLAN

C-1

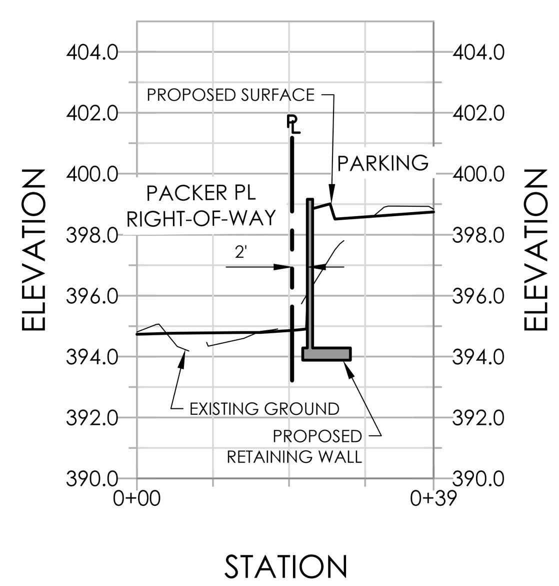
5/12/2020



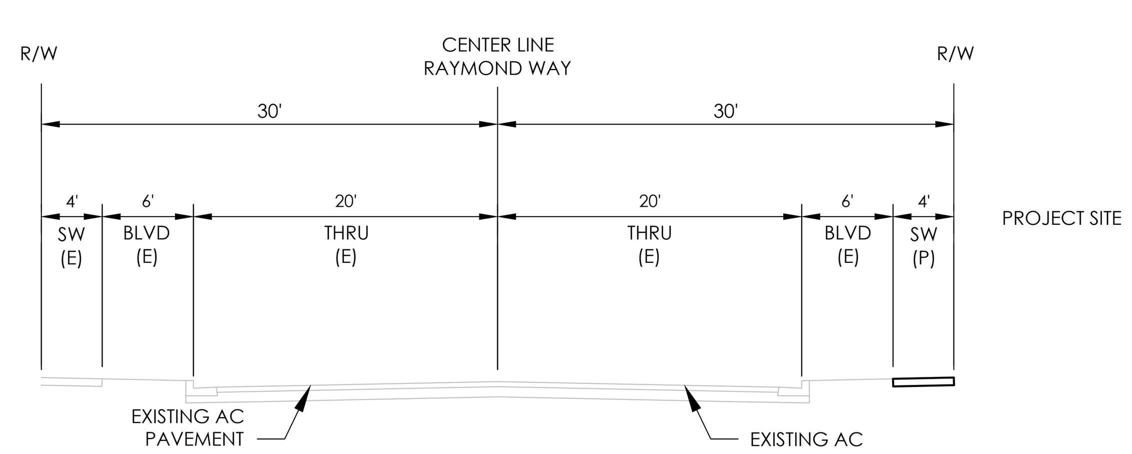
SITE SECTION A-A
SCALE: N.T.S.



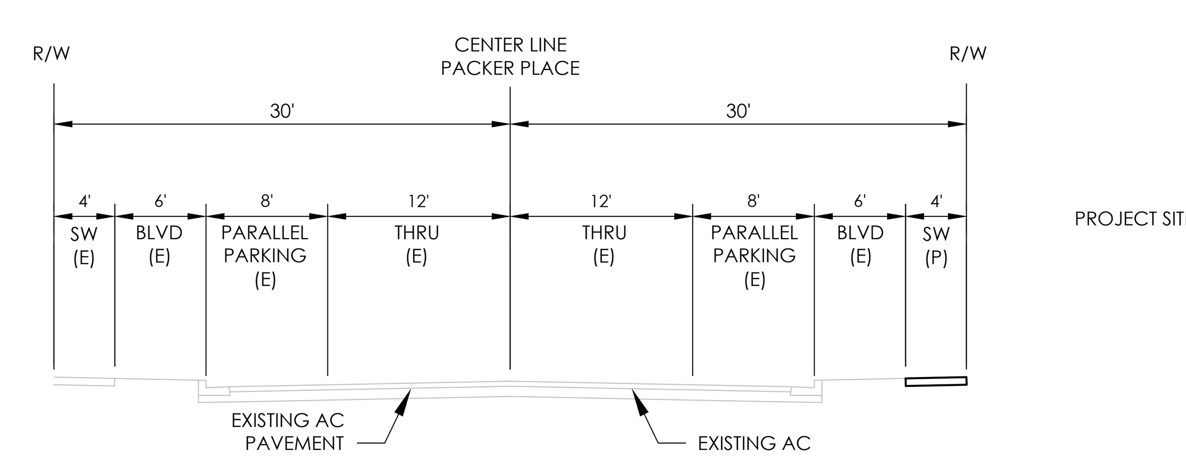
SITE SECTION B-B
SCALE: N.T.S.



SITE SECTION C-C
SCALE: N.T.S.



EXISTING RAYMOND WAY
SCALE: N.T.S.



EXISTING PACKER PLACE
SCALE: N.T.S.

RRM Design Group
10 E. Figueroa St., Suite 200
Santa Barbara, CA 93101
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NATIONAL COMMUNITY CORE RENAISSANCE

Mountain View Affordable Housing Community
24551 Raymond Way, Lake Forest, CA 92630

PRELIMINARY SITE SECTIONS

C-2

05/06/2020

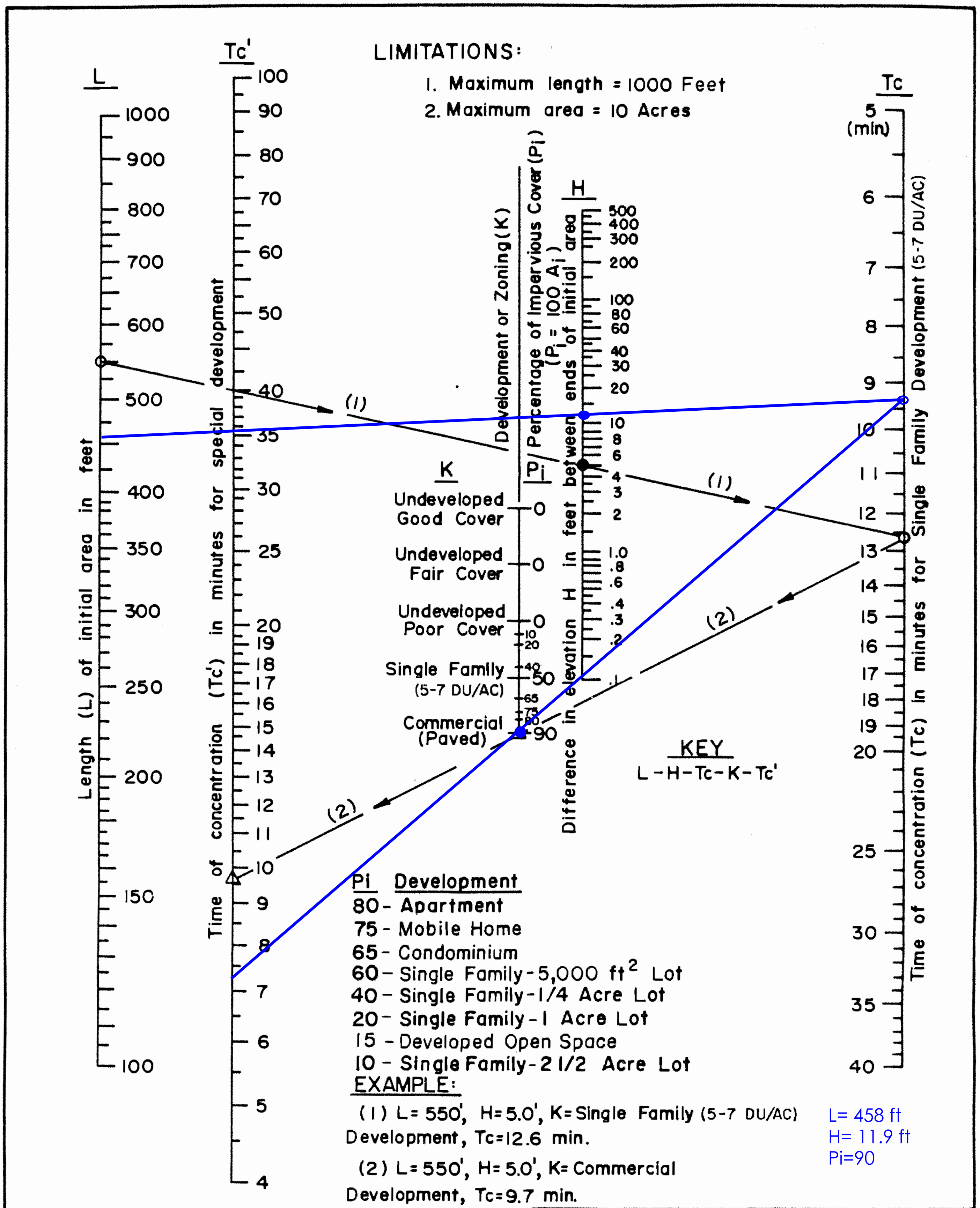
Attachment D

Notice of Transfer

To be included in Final WQMP, not included in this Preliminary WQMP

Attachment E

Hydrology Calculations



Existing Condition
Area X1

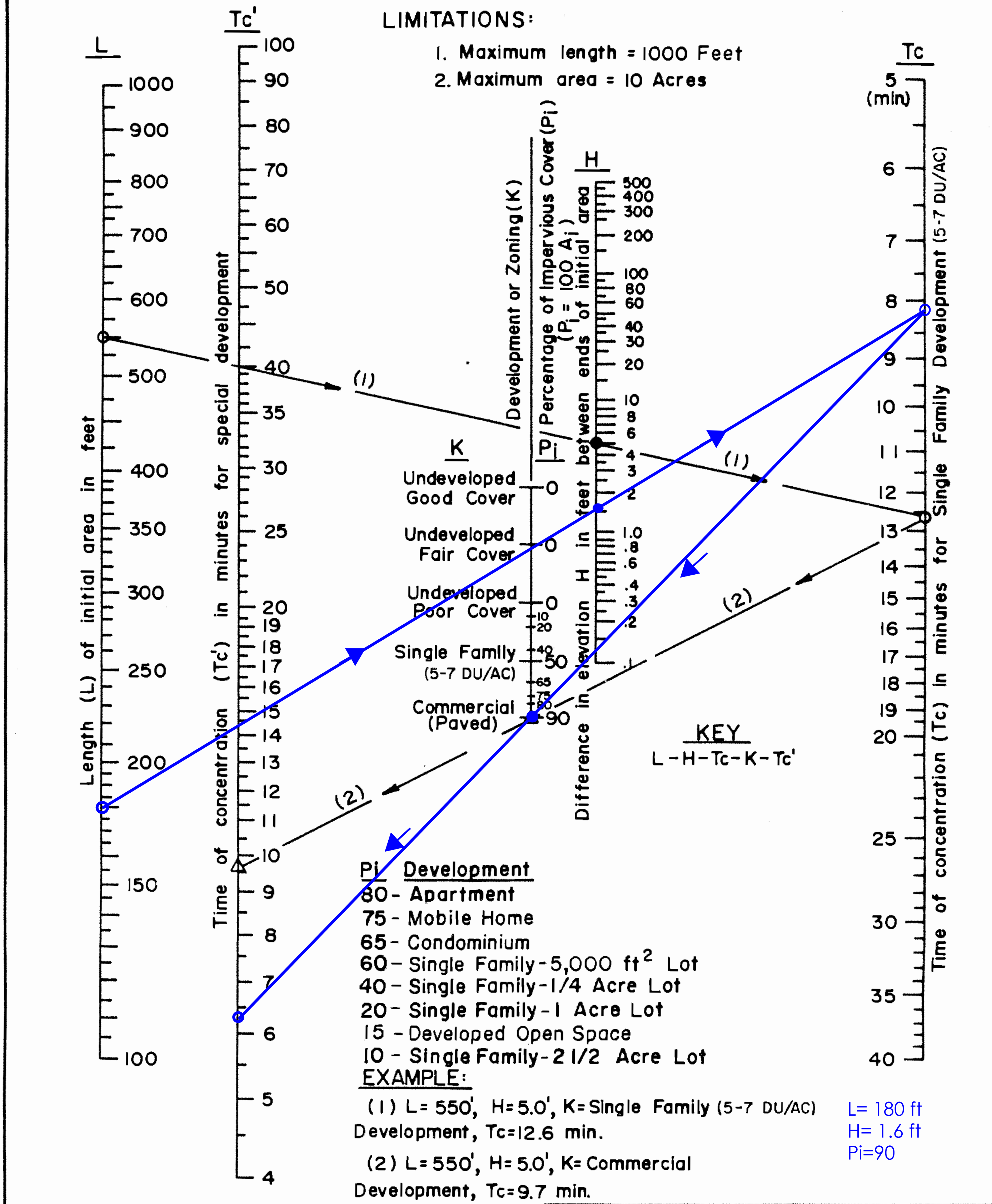
Tc'= 7.3 min

ORANGE COUNTY

HYDROLOGY MANUAL

TIME OF CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA

Figure D-1



Existing Condition
Area X2

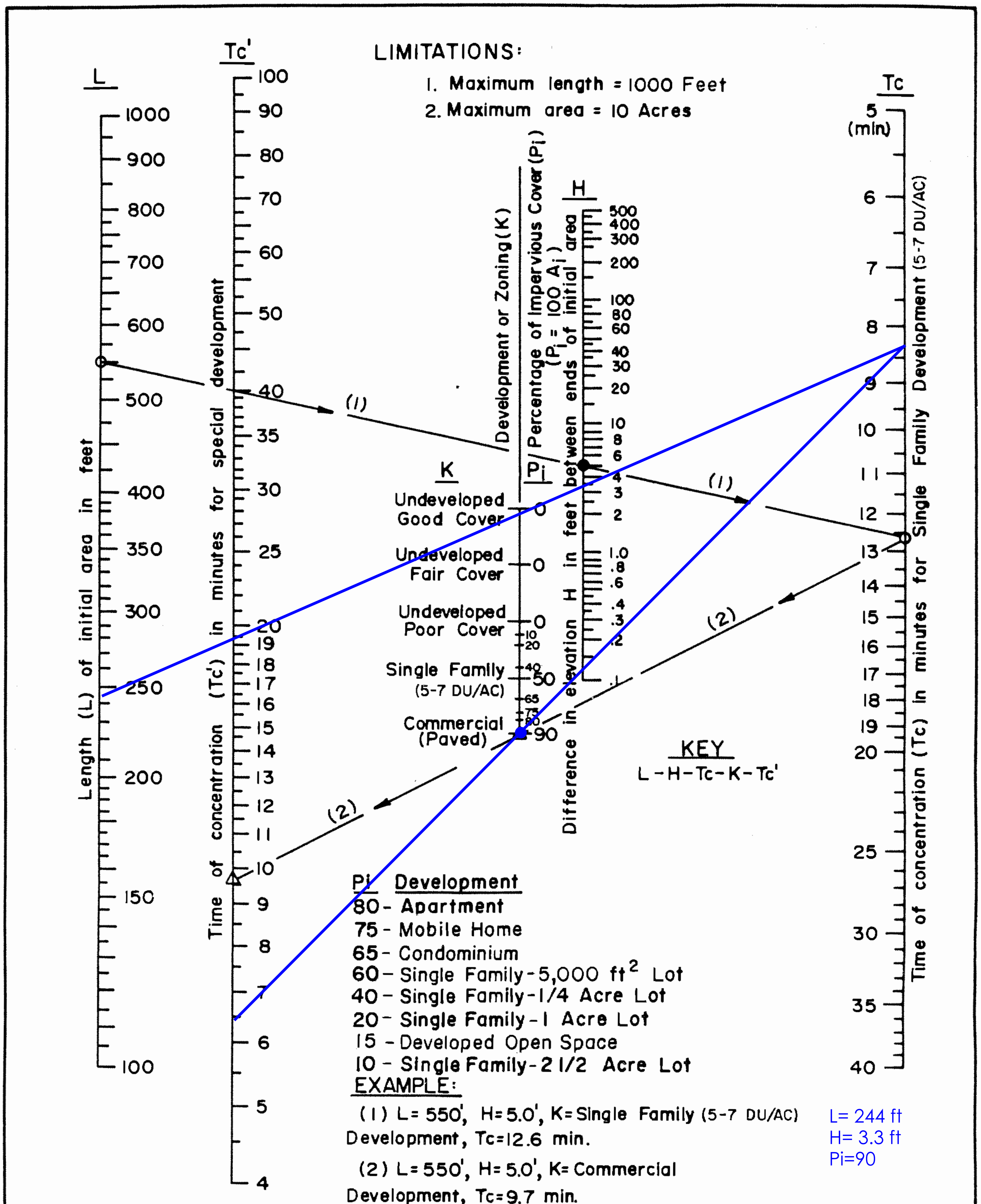
Tc'= 6.3 min

ORANGE COUNTY

HYDROLOGY MANUAL

TIME OF CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA

Figure D-1



Existing and Proposed Condition Area X3

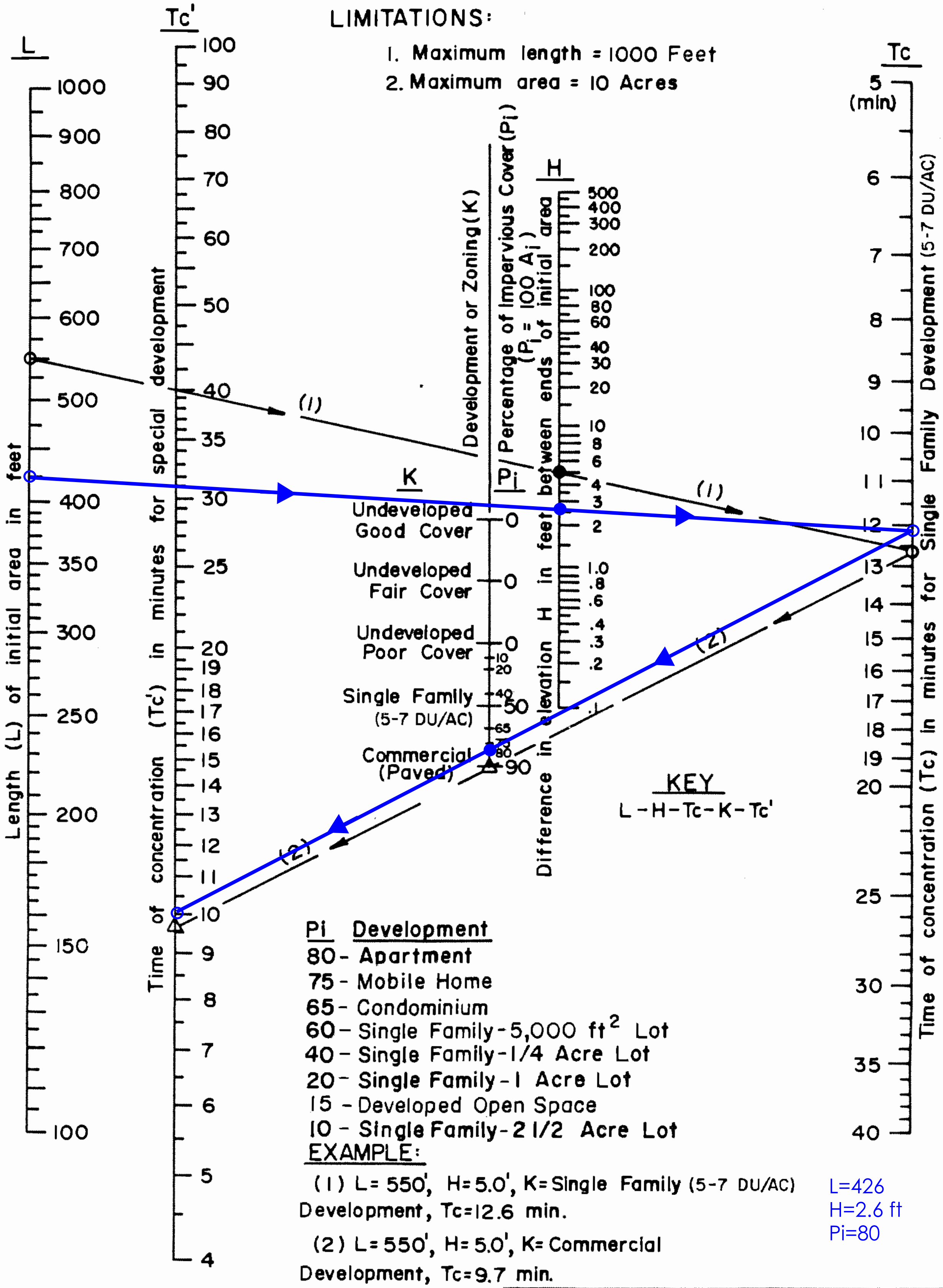
Tc'= 6.4 min

ORANGE COUNTY

HYDROLOGY MANUAL

TIME OF CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA

Figure D-1



ORANGE COUNTY

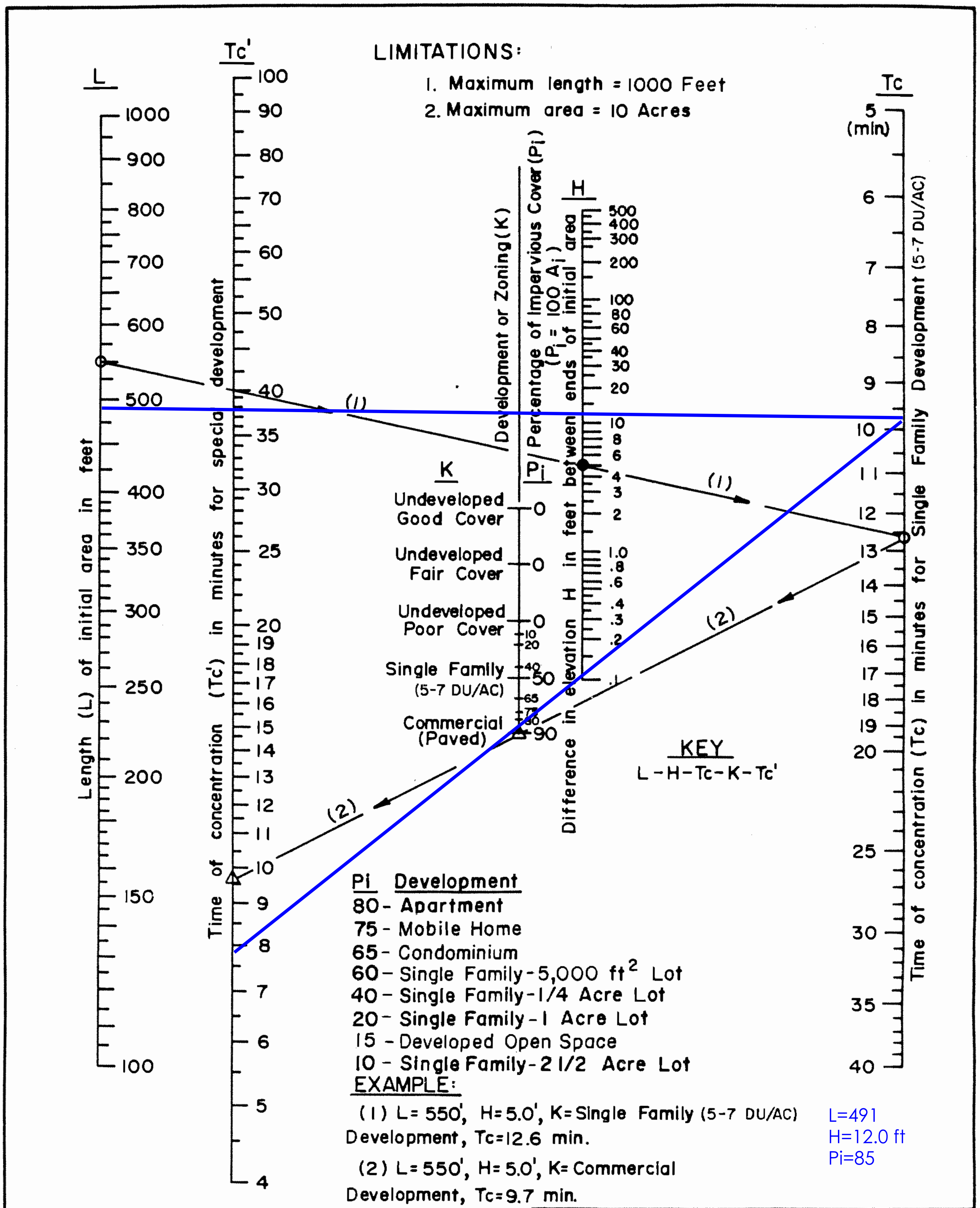
HYDROLOGY MANUAL

Proposed Condition
Area A

Tc'= 10 min

TIME OF CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA

Figure D-1



ORANGE COUNTY

HYDROLOGY MANUAL

Proposed Condition
Area B

Tc'= 7.9 min

TIME OF CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA

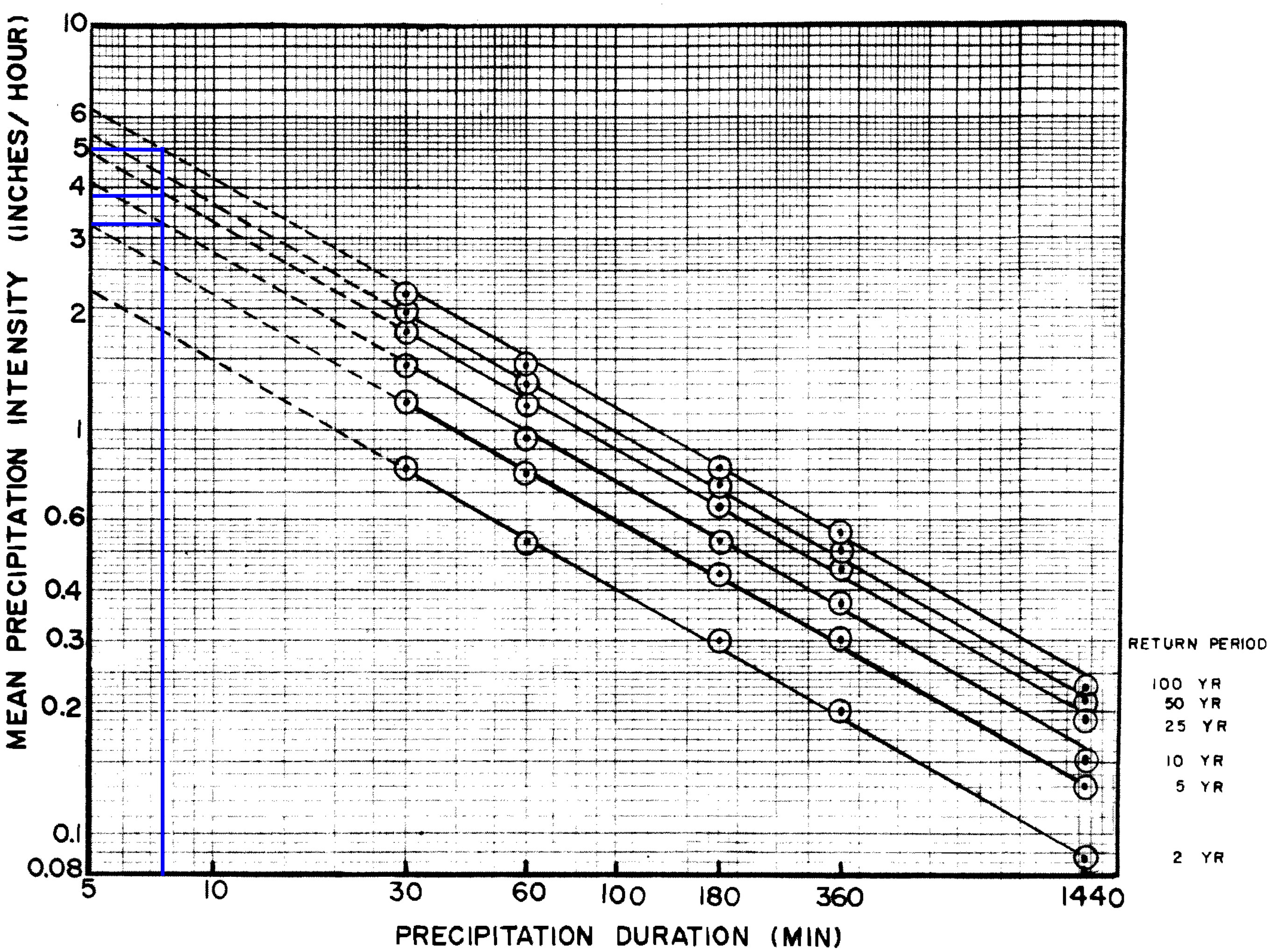
Figure D-1

Regression Equations: $I(t) = at^b$

(I= Intensity in inches/hour, t= duration in minutes)

Return Frequency (years)	a	b
2	5.702	-0.574
5	7.870	-0.562
10	10.209	-0.573
25	11.995	-0.566
50	13.521	-0.566
100	15.560	-0.573

Existing Area X1
For t= 7.3 min
10 yr I= 3.27 in/hr
25 yr I= 3.89 in/hr
100 yr I= 4.98 in/hr



ORANGE COUNTY

HYDROLOGY MANUAL

MEAN PRECIPITATION INTENSITIES FOR NONMOUNTAINOUS AREAS

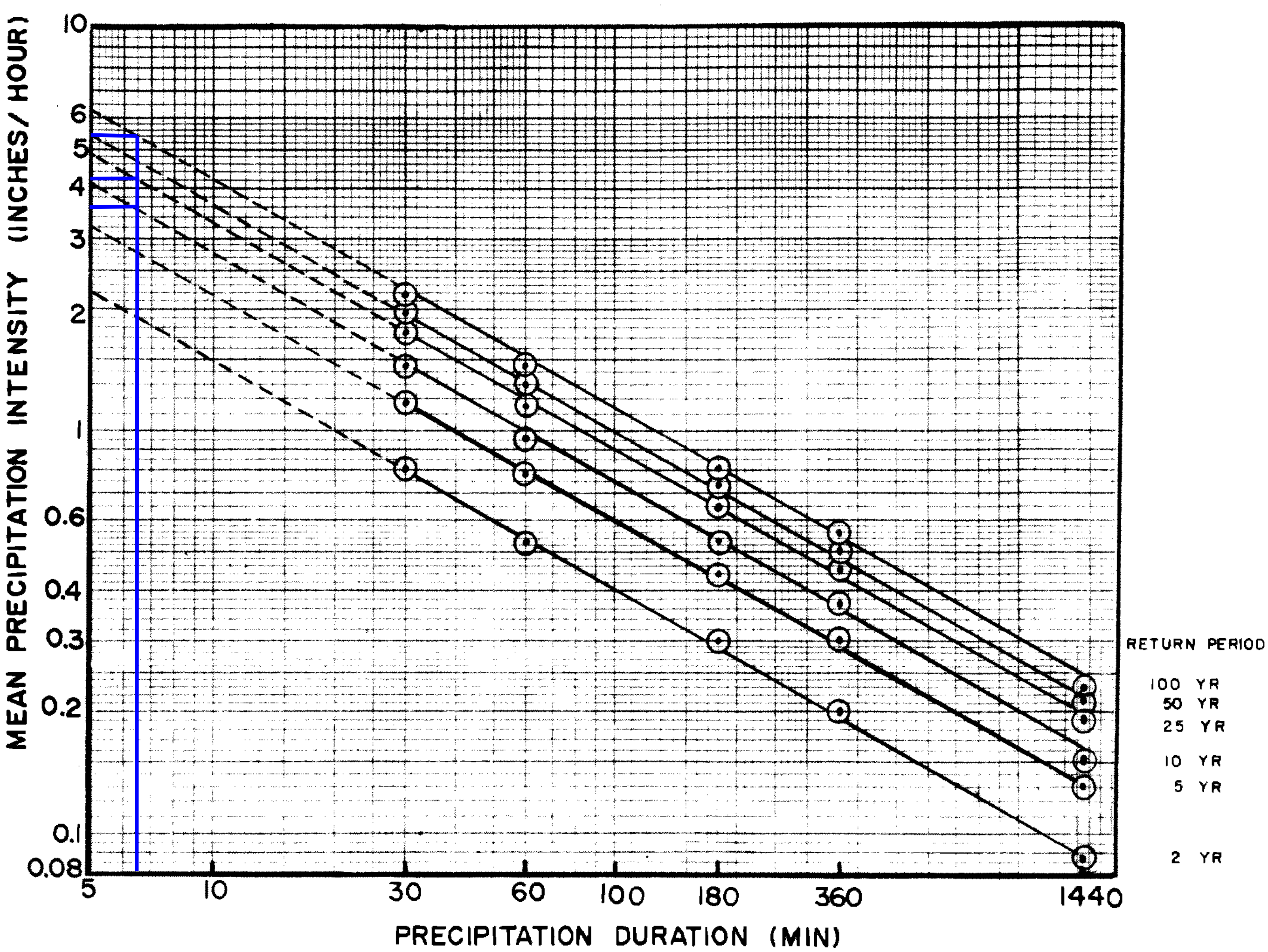
Figure B-3

Regression Equations: $I(t) = at^b$

(I= Intensity in inches/hour, t= duration in minutes)

Return Frequency (years)	a	b
2	5.702	-0.574
5	7.870	-0.562
10	10.209	-0.573
25	11.995	-0.566
50	13.521	-0.566
100	15.560	-0.573

Existing Area X2
For t= 6.3 min
10 yr I=3.56 in/hr
25 yr I=4.23 in/hr
100 yr I=5.42 in/hr



ORANGE COUNTY

HYDROLOGY MANUAL

MEAN PRECIPITATION INTENSITIES FOR NONMOUNTAINOUS AREAS

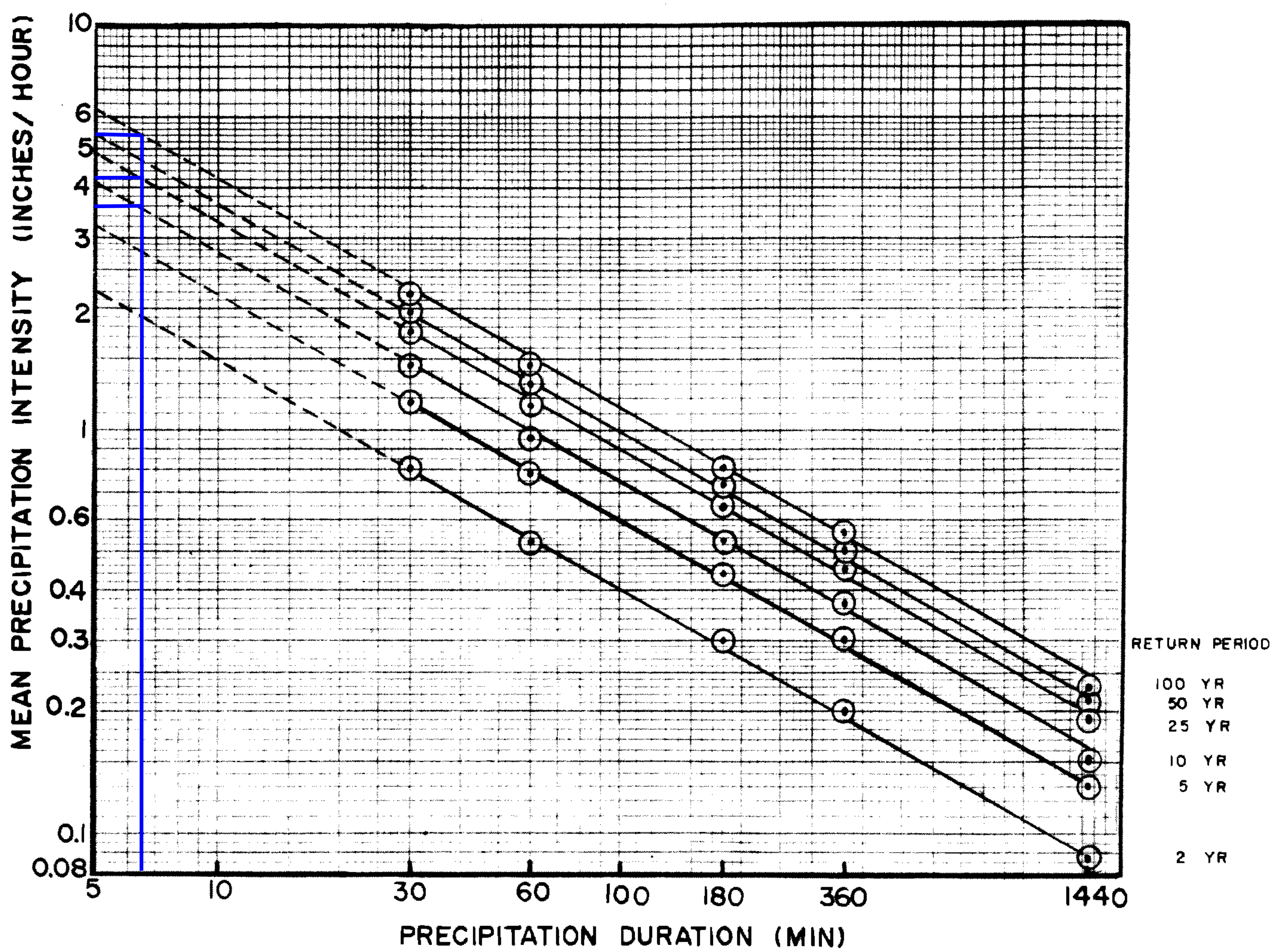
Figure B-3

Regression Equations: $I(t) = at^b$

(I= Intensity in inches/hour, t= duration in minutes)

Return Frequency (years)	a	b
2	5.702	-0.574
5	7.870	-0.562
10	10.209	-0.573
25	11.995	-0.566
50	13.521	-0.566
100	15.560	-0.573

Existing Area X3
For t= 6.4min
10 yr I=3.52 in/hr
25 yr I=4.19 in/hr
100 yr I=5.37 in/hr



ORANGE COUNTY
HYDROLOGY MANUAL

MEAN PRECIPITATION INTENSITIES FOR NONMOUNTAINOUS AREAS

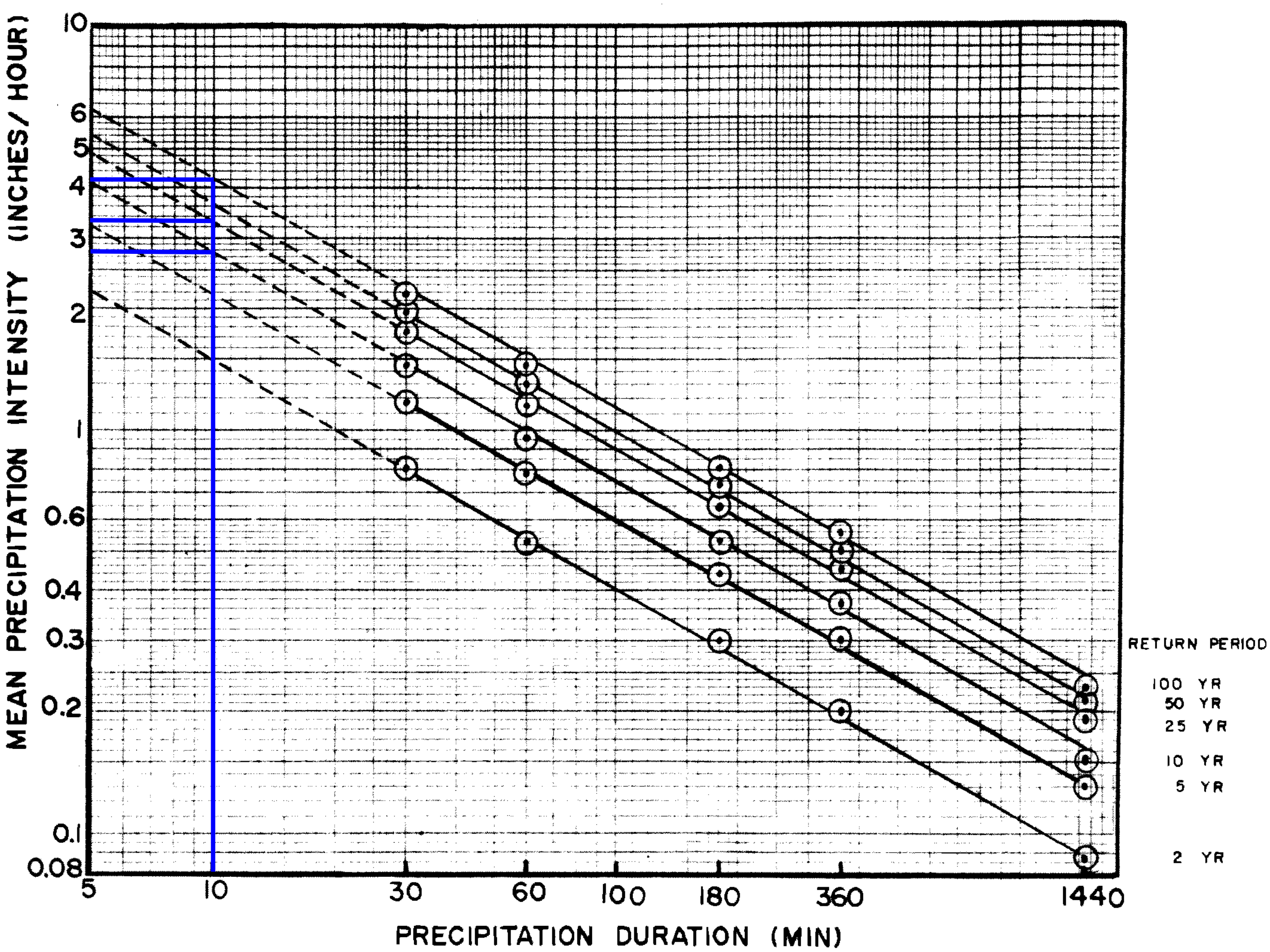
Figure B-3

Regression Equations: $I(t) = at^b$

(I= Intensity in inches/hour, t= duration in minutes)

Return Frequency (years)	a	b
2	5.702	-0.574
5	7.870	-0.562
10	10.209	-0.573
25	11.995	-0.566
50	13.521	-0.566
100	15.560	-0.573

Proposed Area A
For t= 10.0 min
10 yr I=2.73 in/hr
25 yr I=3.26 in/hr
100 yr I=4.16 in/hr



ORANGE COUNTY
HYDROLOGY MANUAL

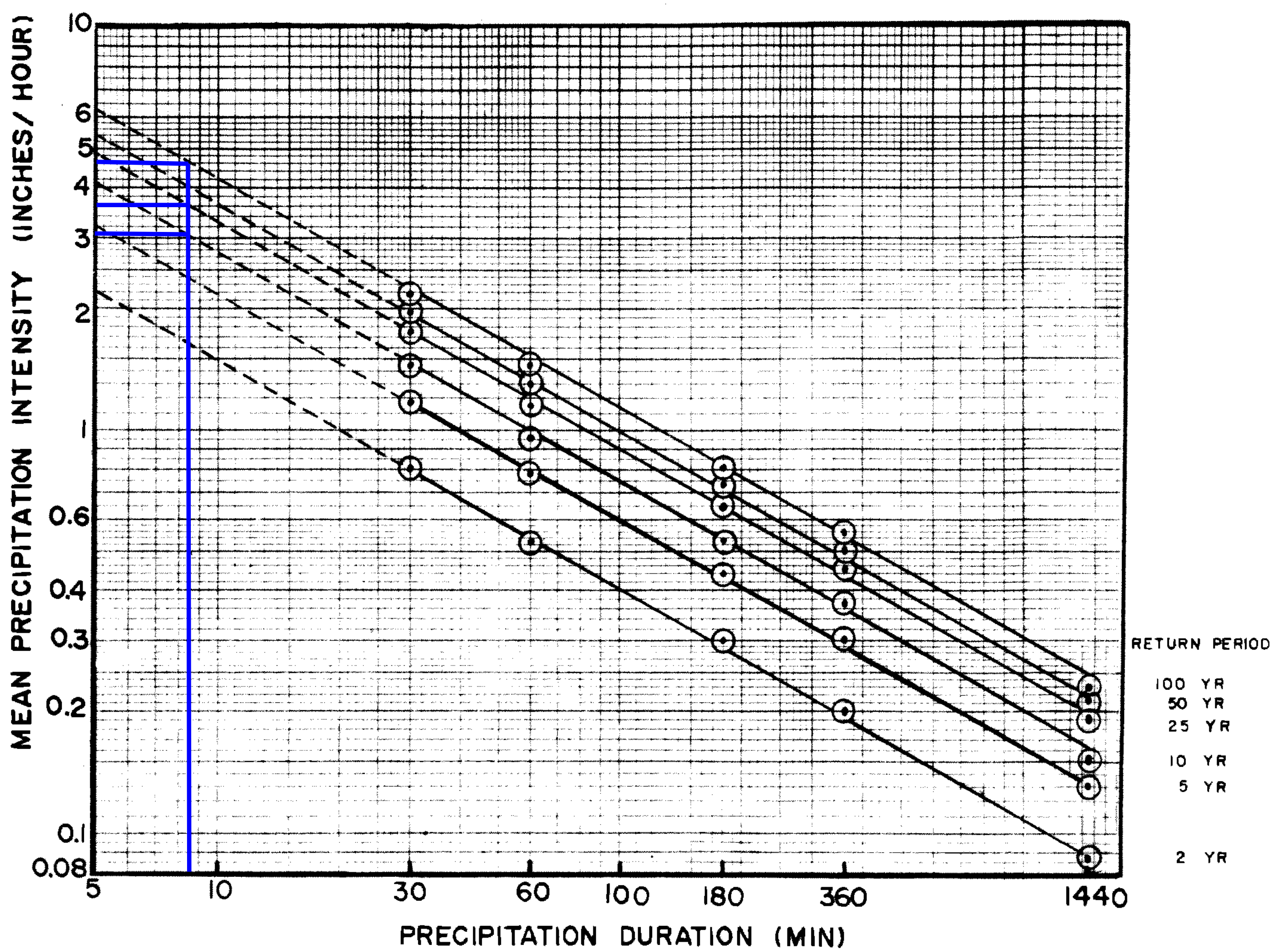
MEAN PRECIPITATION INTENSITIES FOR NONMOUNTAINOUS AREAS

Regression Equations: $I(t) = at^b$

(I= Intensity in inches/hour, t= duration in minutes)

Return Frequency (years)	a	b
2	5.702	-0.574
5	7.870	-0.562
10	10.209	-0.573
25	11.995	-0.566
50	13.521	-0.566
100	15.560	-0.573

Proposed Area B
For t= 7.9 min
10 yr I=3.12 in/hr
25 yr I=3.72 in/hr
100 yr I=4.76 in/hr



ORANGE COUNTY
HYDROLOGY MANUAL

MEAN PRECIPITATION INTENSITIES FOR NONMOUNTAINOUS AREAS

Figure B-3

RATIONAL METHOD STUDY FORM

ORANGE COUNTY HYDROLOGY MANUAL

STUDY NAME: El Toro Road Multifamily Existing Condition

10 –YEAR STORM RATIONAL METHOD STUDY

Calculated by ADW Date 5/6/20
Checked by MCH Date 5/6/20
Page 1 of 1

Concentration Point	Area (Acres) Subarea	Area (Acres) Total	Soil Type	Dev. Type	T_t min.	T_c min.	I in/hr	Fm* in/hr	Fm avg.	Q** Total	Flow Path Length ft.	Slope ft./ft.	V ft./sec.	Hydraulics and Notes
Packer Place (X1)	2.62	2.62	D	COM	-	7.3	3.27	0.0374	0.0374	7.62	458	0.03		Only Subarea
Raymond Way (X2)	0.62	0.62	D	COM		6.3	3.56	0.0823	0.0823	1.95	180	0.009		Only Subarea
El Toro Road (X3)	0.52	0.52	D	COM		6.4	3.52	0.1235	0.1235	1.58	244	0.01		Only Subarea

Equations

*$F_m = a_p F_p$ (Equation C.7 - OC Hydrology Manual)

a_p = pervious area fraction

F_p = 0.20 in/hr (Table C.2 - OC Hydrology Manual)

X1: F_m = (0.187)(0.20) = 0.0374

X2: Fm = (0.412)(0.20) = 0.0823

X3: Fm = (0.617)(0.20) = 0.1235

** $Q = 0.9\,(I-F_m)A$

TABLE C.2.

MAXIMUM EFFECTIVE PERVIOUS AREA LOSS RATES (inch/hour), F_p

SOIL GROUP:	A	B	C	D
F_p:	0.40	0.30	0.25	0.20

RATIONAL METHOD STUDY FORM

ORANGE COUNTY HYDROLOGY MANUAL

STUDY NAME: El Toro Road Multifamily Existing Condition

25 -YEAR STORM RATIONAL METHOD STUDY

Calculated by ADW Date 5/6/20
Checked by MCH Date 5/6/20
Page 1 of 1

Concentration Point	Area (Acres) Subarea	Total	Soil Type	Dev. Type	T_t min.	T_c min.	I in/hr	Fm* in/hr	Fm avg.	Q** Total	Flow Path Length ft.	Slope ft./ft.	V ft./sec.	Hydraulics and Notes
Packer Place (X1)	2.62	2.62	D	COM	-	7.3	3.89	0.0374	0.0374	9.10	458	0.03		Only Subarea
Raymond Way (X2)	0.62	0.62	D	COM		6.3	4.23	0.0823	0.0823	2.33	180	0.009		Only Subarea
El Toro Road (X3)	0.52	0.52	D	COM		6.4	4.19	0.1235	0.1235	1.89	244	0.01		Only Subarea

Equations

*$F_m = a_p F_p$ (Equation C.7 - OC Hydrology Manual)

a_p = pervious area fraction

F_p = 0.20 in/hr (Table C.2 - OC Hydrology Manual)

X1: $F_m = (0.187)(0.20) = 0.0374$

X2: $Fm = (0.412)(0.20) = 0.0823$

X3: $Fm = (0.617)(0.20) = 0.1235$

** $Q = 0.9 (I-F_m)A$

TABLE C.2.

MAXIMUM EFFECTIVE PERVIOUS AREA LOSS RATES (inch/hour), F_p

SOIL GROUP:	A	B	C	D
F_p:	0.40	0.30	0.25	0.20

RATIONAL METHOD STUDY FORM

ORANGE COUNTY HYDROLOGY MANUAL	STUDY NAME: El Toro Road Multifamily Existing Condition 100-YEAR STORM RATIONAL METHOD STUDY	Calculated by ADW Date 5/6/20 Checked by MCH Date 5/6/20 Page 1 of 1

Concentration Point	Area (Acres) Subarea	Total	Soil Type	Dev. Type	T_t min.	T_c min.	I in/hr	Fm* in/hr	Fm avg.	Q** Total	Flow Path Length ft.	Slope ft./ft.	V ft./sec.	Hydraulics and Notes
Packer Place (X1)	2.62	2.62	D	COM	-	7.3	4.98	0.0374	0.0374	11.62	458	0.03		Only Subarea
Raymond Way (X2)	0.62	0.62	D	COM		6.3	5.42	0.0823	0.0823	3.00	180	0.009		Only Subarea
El Toro Road (X3)	0.52	0.52	D	COM		6.4	5.37	0.1235	0.1235	2.44	244	0.01		Only Subarea

Equations

*$F_m = a_p F_p$ (Equation C.7 - OC Hydrology Manual)

a_p = pervious area fraction

F_p = 0.20 in/hr (Table C.2 - OC Hydrology Manual)

X1: F_m = (0.187)(0.20) = 0.0374

X2: Fm = (0.412)(0.20) = 0.0823

X3: Fm = (0.617)(0.20) = 0.1235

** $Q = 0.9 (I - F_m) A$

TABLE C.2.

MAXIMUM EFFECTIVE PERVIOUS AREA LOSS RATES (inch/hour), F_p

SOIL GROUP:	A	B	C	D
F_p:	0.40	0.30	0.25	0.20

RATIONAL METHOD STUDY FORM

ORANGE COUNTY HYDROLOGY MANUAL	STUDY NAME: El Toro Road Multifamily Proposed Condition 10 -YEAR STORM RATIONAL METHOD STUDY	Calculated by ADW Date 5/6/20 Checked by MCH Date 5/6/20 Page 1 of 1

Concentration Point	Area (Acres) Subarea	Total	Soil Type	Dev. Type	T_t min.	T_c min.	I in/hr	Fm* in/hr	Fm avg.	Q** Total	Flow Path Length ft.	Slope ft./ft.	V ft./sec.	Hydraulics and Notes
Raymond Way (A)	0.70	0.70	D	MFR	-	10	2.73	0.0688	0.0688	1.68	426	0.0061		Only Subarea
Packer Place (B)	2.55	2.55	D	MFR	-	7.9	3.12	0.0301	0.0301	7.09	491	0.024		Only Subarea
El Toro Road (X3)	0.52	0.52	D	COM		6.4	3.52	0.1235	0.1235	2.44	244	0.01		Only Subarea

Equations

*$F_m = a_p F_p$ (Equation C.7 - OC Hydrology Manual)

a_p = pervious area fraction

F_p = 0.20 in/hr (Table C.2 - OC Hydrology Manual)

Area A: F_m = (0.344)(0.20) = 0.0688

Area B: Fm = (0.151)(0.20) = 0.0301

Area X1: Fm = (0.617)(0.20) = 0.1235

** $Q = 0.9 (I-F_m)A$

TABLE C.2.

MAXIMUM EFFECTIVE PERVIOUS AREA LOSS RATES (inch/hour), F_p

SOIL GROUP:	A	B	C	D
F_p:	0.40	0.30	0.25	0.20

RATIONAL METHOD STUDY FORM

ORANGE COUNTY HYDROLOGY MANUAL

STUDY NAME: El Toro Road Multifamily Proposed Condition

10 -YEAR STORM RATIONAL METHOD STUDY

Calculated by ADW Date 5/6/20
Checked by MCH Date 5/6/20
Page 1 of 1

Concentration Point	Area (Acres) Subarea	Total	Soil Type	Dev. Type	T_t min.	T_c min.	I in/hr	Fm* in/hr	Fm avg.	Q** Total	Flow Path Length ft.	Slope ft./ft.	V ft./sec.	Hydraulics and Notes
Raymond Way (A)	0.70	0.70	D	MFR	-	10	3.26	0.0688	0.0688	2.01	426	0.0061		Only Subarea
Packer Place (B)	2.55	2.55	D	MFR	-	7.9	3.72	0.0301	0.0301	8.46	491	0.024		Only Subarea
El Toro Road (X3)	0.52	0.52	D	COM		6.4	4.19	0.1235	0.1235	1.89	244	0.01		Only Subarea

Equations

*$F_m = a_p F_p$ (Equation C.7 - OC Hydrology Manual)

a_p = pervious area fraction

F_p = 0.20 in/hr (Table C.2 - OC Hydrology Manual)

Area A: F_m = (0.344)(0.20) = 0.0688

Area B: Fm = (0.151)(0.20) = 0.0301

Area X1: Fm = (0.617)(0.20) = 0.1235

** Q = 0.9 (I-F_m)A

TABLE C.2.

MAXIMUM EFFECTIVE PERVIOUS AREA LOSS RATES (inch/hour), F_p

SOIL GROUP:	A	B	C	D
F_p:	0.40	0.30	0.25	0.20

RATIONAL METHOD STUDY FORM

ORANGE COUNTY HYDROLOGY MANUAL

STUDY NAME: El Toro Road Multifamily Proposed Condition

100-YEAR STORM RATIONAL METHOD STUDY

Calculated by ADW Date 5/6/20
Checked by MCH Date 5/6/20
Page 1 of 1

Concentration Point	Area (Acres) Subarea	Total	Soil Type	Dev. Type	T_t min.	T_c min.	I in/hr	Fm* in/hr	Fm avg.	Q** Total	Flow Path Length ft.	Slope ft./ft.	V ft./sec.	Hydraulics and Notes
Raymond Way (A)	0.70	0.70	D	MFR	-	10	4.16	0.0688	0.0688	2.58	426	0.0061		Only Subarea
Packer Place (B)	2.55	2.55	D	MFR	-	7.9	4.76	0.0301	0.0301	10.84	491	0.024		Only Subarea
El Toro Road (X3)	0.52	0.52	D	COM		6.4	5.37	0.1235	0.1235	2.44	244	0.01		Only Subarea

Equations

$^*F_m = a_pF_p$ (Equation C.7 - OC Hydrology Manual)

a_p = pervious area fraction

F_p = 0.20 in/hr (Table C.2 - OC Hydrology Manual)

Area A: F_m = (0.344)(0.20) = 0.0688

Area B: Fm = (0.151)(0.20) = 0.0301

Area X1: Fm = (0.617)(0.20) = 0.1235

** $Q = 0.9\,(I-F_m)A$

TABLE C.2.

MAXIMUM EFFECTIVE PERVIOUS AREA LOSS RATES (inch/hour), F_p

SOIL GROUP:	A	B	C	D
F_p:	0.40	0.30	0.25	0.20

Attachment F

Geotechnical Report

October 23, 2019
J.N.: 2841.00

Mr. Chris Killian
National Community Renaissance
9421 Haven Avenue
Rancho Cucamonga, California 91730

Subject: **Preliminary Geotechnical Investigation, Proposed Multi-Family Residential Development, 24551 Raymond Way, Lake Forest, California.**

Dear Mr. Killian,

Pursuant to your request, ***Albus-Keefe & Associates, Inc***. is pleased to present to you our preliminary geotechnical investigation report for the subject development. This report presents the results of our field investigation, laboratory testing, engineering analyses, as well as our preliminary geotechnical recommendations for design and construction of the subject development.

We appreciate this opportunity to be of service to you. If you have any questions regarding the contents of this report, please do not hesitate to call this office.

Sincerely,

ALBUS-KEEFE & ASSOCIATES, INC.

Paul Kim
Associate Engineer

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APPENDICES

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

The purposes of our preliminary geotechnical investigation were to evaluate geotechnical conditions within the project area and to provide conclusions and recommendations relevant to the design and construction of the proposed improvements at the subject site. The scope of this investigation included the following:

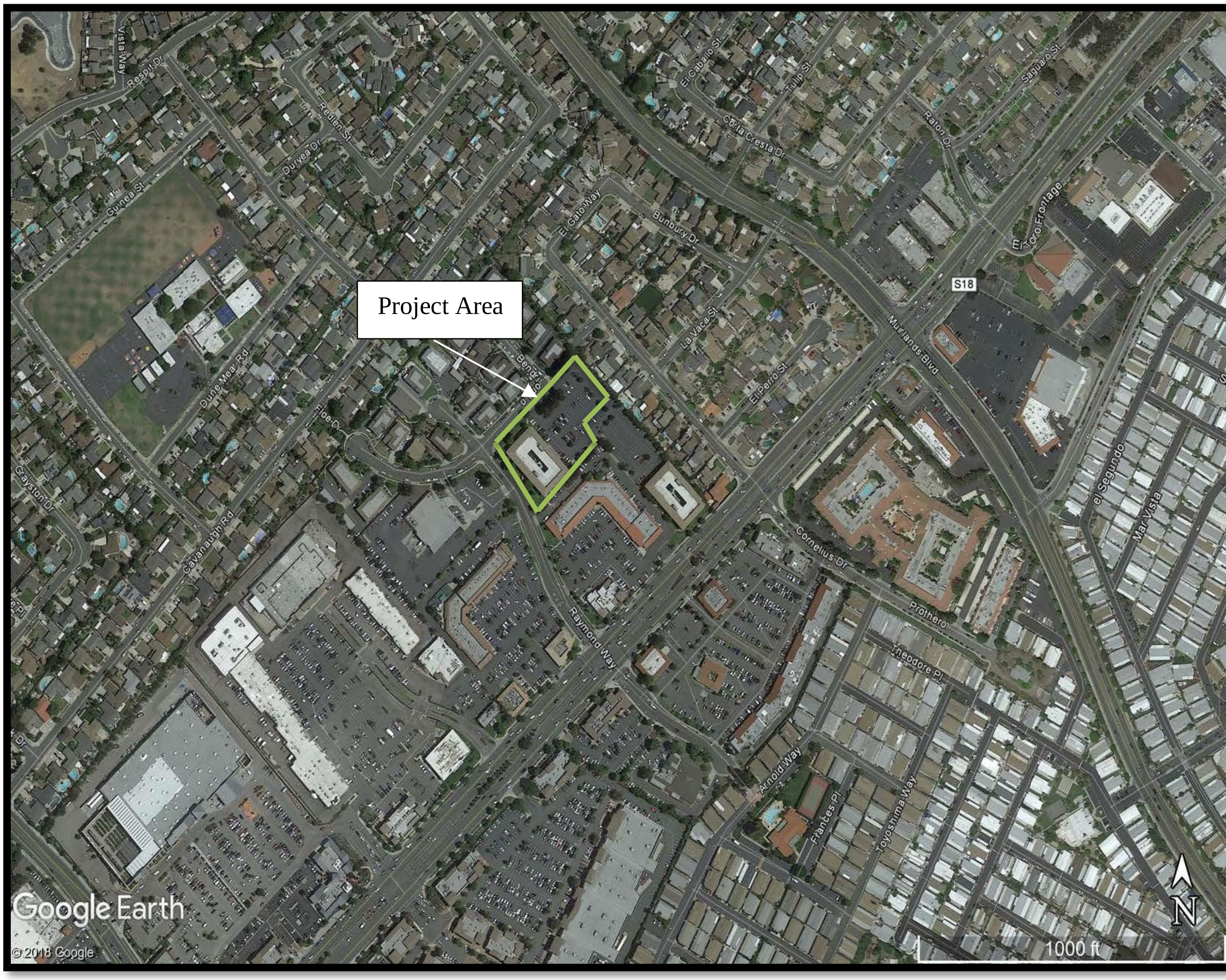
- Review of the referenced conceptual site plan
- Review of published geologic and seismic data for the site and surrounding area
- Review of historical aerial photographs
- Exploratory drilling and soil sampling
- Laboratory testing of selected soil samples
- Engineering analyses of data obtained from our review, exploration, and laboratory testing
- Evaluation of site seismicity, liquefaction, and settlement potential
- Preparation of this report

1.2 SITE LOCATION AND DESCRIPTION

The site is located at 24551 Rayamond Way, within the city of Lake Forest, California. The property is bordered by Raymond Way to the southwest, Packer Place to northwest, single family homes to northeast and northwest, a multi-tenant retail plaza to the southeast and a parking lot to the northeast. The location of the site and its relationship to the surrounding areas is shown on Figure 1, Site Location Map.

The site consists of an irregular-shaped property containing approximately 1.9 acres of land. The site is relatively flat with elevations ranging from EL391 to EL396 above mean sea level (based on Google Earth) descending to the west. Drainage within the site is generally directed as a sheet flow towards Packer Place. The site is currently occupied by 2-story commercial building and asphaltic parking lot.

Vegetation within the site consists of grass cover adjacent to the existing building. Several small trees and bushes are present throughout the site within the islands of the parking lot, adjacent to the existing building, and along the perimeter.



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SITE LOCATION MAP
Lake Forest
Proposed Multi-Family Residential Development
24551 Raymond Way,
Lake Forest, California

NOT TO SCALE
FIGURE 1

1.3 PROPOSED DEVELOPMENT

Based on the architectural site plans by RRM design group, the proposed development for the site will consist of a partial four-story residential building with an interior courtyard and playground area, on-grade parking lot, perimeter site walls, and underground utilities.

No grading or structural plans were available in preparing of this report. However, we anticipate that minor rough grading of the site will be required to achieve future surface configuration. We expect the proposed residential dwellings will be wood-framed structures with concrete slabs on grade yielding relatively light foundation loads.

2.0 INVESTIGATION

2.1 RESEARCH

We have reviewed the referenced geologic publications and maps (see references). Data from these sources were utilized to develop some of the findings and conclusions presented herein.

We have also reviewed available historical aerial photographs. The aerial photos indicate that as early as 1938, the site was vacant land. In the vicinity of the site, some areas of land were used for agricultural purposes. By 1967, the adjacent single-family residential properties to the northeast were developed. By 1980, the property was developed with the present-day commercial building and parking lot. The site has remained unchanged since then.

2.2 SUBSURFACE EXPLORATION

Subsurface exploration for this investigation was conducted on October 2nd, 2019, and consisted of the drilling of five (4) soil borings to depths ranging from approximately 11.5 to 51.5 feet below the existing ground surface (bgs). The borings were drilled using a truck-mounted, continuous flight, hollow-stem-auger drill rig. A representative of Albus-Keefe & Associates, Inc. logged the exploratory borings. Visual and tactile identifications were made of the materials encountered, and their descriptions are presented in the Exploration Logs in Appendix A. The approximate locations of the exploratory excavations completed by this firm are shown on the enclosed Geotechnical Map, Plate 1.

Bulk, relatively undisturbed and Standard Penetration Test (SPT) samples were obtained at selected depths within the exploratory borings for subsequent laboratory testing. Relatively undisturbed samples were obtained using a 3-inch O.D., 2.5-inch I.D., California split-spoon soil sampler lined with brass rings. SPT samples were obtained from the boring using a standard, unlined SPT soil sampler. During each sampling interval, the sampler was driven 18 inches with successive drops of a 140-pound automatic hammer falling 30 inches. The number of blows required to advance the sampler was recorded for each six inches of advancement. The total blow count for the lower 12 inches of advancement per soil sample is recorded on the exploration log. Samples were placed in sealed containers or plastic bags and transported to our laboratory for analyses. The borings were backfilled with auger cuttings upon completion of sampling.

2.3 LABORATORY TESTING

Selected samples of representative earth materials from our borings were tested in our laboratory. Tests consisted of USCS classification, in-situ moisture content and dry density, maximum dry density and optimum moisture content, consolidation/collapse, direct shear strength, grain size analysis, soluble sulfate content, and corrosivity testing (pH, chloride, and resistivity). Descriptions of laboratory testing and the test results are presented in Appendix B and on the Exploration Logs in Appendix A.

3.0 GEOLOGIC CONDITIONS

3.1 SOIL CONDITIONS

Descriptions of the earth materials encountered during our investigation are summarized below and are presented in detail on the Exploration Logs presented in Appendix A.

Soil materials encountered at the subject site consisted of approximately 6 feet of artificial fill over very old alluvial fan deposits. The artificial fill is predominately comprised of grayish brown and light brown silty sand. These fill materials typically were observed to be slightly moist and dense to very dense.

The very old alluvial fan deposits encountered are comprised of reddish-brown clayey sand/sandy clay. A layer of clay and silty sand was observed below a depth of 6 feet. Deeper portions of the very old alluvium fan consist of clayey sand and silty sand with variable some inner layers of clay and silt. The surficial very old alluvial fan materials are typically very dense and hard.

3.2 GROUNDWATER

Groundwater was encountered during this firm's subsurface exploration at the depth of 41 feet. Based on a review of the referenced CDMG Special Report, the site is mapped with a historical groundwater depth between 10 and 20 feet. Research of groundwater data from the State Water Resources Control Board GeoTracker database, indicates groundwater levels as shallow as 20 feet.

3.3 FAULTING

Geologic literature and field exploration do not indicate the presence of active faulting within the site. The site does not lie within an "Earthquake Fault Zone" as defined by the State of California in the Earthquake Fault Zoning Act. Table 3.1 presents a summary of all the known seismically active faults within 10 miles of the site.

TABLE 3.1
Summary of Active Faults

Name	Distance (miles)	Slip Rate (mm/yr.)	Preferred Dip (degrees)	Slip Sense	Rupture Top (km)	Fault Length (km)
San Joaquin Hills	0.18	0.5	23	thrust	2	27
Newport Inglewood Connected alt 1	9.66	1.3	89	strike slip	0	208
Newport Inglewood (Offshore)	9.66	1.5	90	strike slip	0	66
Newport Inglewood Connected alt 2	9.66	1.3	90	strike slip	0	208

4.0 ANALYSES

4.1 SEISMICITY

We have performed probabilistic seismic analyses utilizing the U.S. Seismic Design Maps web application by the U.S. Geological Survey (USGS). From our analyses, we obtain a PGA of 0.598g in accordance with Figure 22-7 of ASCE 7-10. The F_{PGA} factor for site class D with a PGA of 0.598g is 1.0. Therefore, the PGA_M = 1.0 x 0.598 = 0.598g. The mean event associated with a probability of exceedance equal to 2% over 50 years has a moment magnitude of 6.65 with a mean distance to the seismic source of 6.76 miles.

4.2 STATIC SETTLEMENT

Analyses were performed to evaluate potential for static settlement of the underlying very old alluvial fan deposits. Our analyses were based on the results of consolidation tests performed on selected samples from our borings as well as the recorded blow counts during the exploration. Results of our testing indicate the site materials have low compressibility. Based on the data from field exploration and laboratory testing, settlement is estimated to be less than 1.0 inch in the site.

5.0 CONCLUSIONS

5.1 FEASIBILITY OF PROPOSED DEVELOPMENT

From a geotechnical point of view, the proposed site development is considered feasible provided the recommendations presented in this report are incorporated into the design and construction of the project. Furthermore, it is also our opinion that the proposed development will not adversely impact the stability of adjoining properties if the recommendations presented in this report are incorporated into site development. Key issues that could have significant fiscal impacts on the geotechnical aspects of the proposed site development are discussed in the following sections of this report.

5.2 GEOLOGIC HAZARDS

5.2.1 Ground Rupture

No active faults are known to project through the site nor does the site lie within the bounds of an "Earthquake Fault Zone" as defined by the State of California in the Alquis-Priolo Earthquake Fault Zoning Act. As such, the potential for ground rupture due to fault displacement beneath the site is considered very low.

5.2.2 Ground Shaking

The site is located in a seismically active area that has historically been affected by moderate to occasionally high levels of ground motion. The site lies in relatively close proximity to several seismically active faults; therefore, during the life of the proposed development, the property will probably experience moderate to occasionally high ground shaking from these fault zones, as well as some background shaking from other seismically active areas of the southern California region. Design of proposed structures in accordance with the current CBC is anticipated to adequately mitigate concerns with ground shaking.

5.2.3 Landsliding

Geologic hazards associated with landsliding are not anticipated at the site due to not being located within an area identified by the California Geologic Survey (CGS) as having potential for seismic slope instability.

5.2.4 Liquefaction

Engineering research of soil liquefaction potential (Youd, et al., 2001) indicates that generally three basic factors must exist concurrently in order for liquefaction to occur. These factors include:

- A source of ground shaking, such as an earthquake, capable of generating soil mass distortions.
- A relatively loose silty and/or sandy soil.
- A relative shallow groundwater table (within approximately 50 feet below ground surface) or completely saturated soil conditions that will allow positive pore pressure generation.

The liquefaction susceptibility of the onsite soils was evaluated by analyzing the potential of concurrent occurrence of the above-mentioned three basic factors. The liquefaction evaluation for the site was completed under the guidance of Special Publication 117A: Guidelines for Evaluating and Mitigating Seismic Hazards in California (CDMG, 2008).

Based on the fine-grained nature of subsurface materials, the potential for liquefaction at the site is considered to be low. Additionally, the site is underlain by Pleistocene aged deposits, typically not susceptible to liquefaction. Furthermore, the site is not located within a San Diego Seismic Study liquefaction zone.

5.3 STATIC SETTLEMENT

The existing artificial fills consist of variable materials are considered unsuitable for support of the proposed development in its current condition. Therefore, removal and recompaction of the existing surficial soils to provide a uniform compacted blanket will be necessary. Provided grading and construction are performed in accordance with the recommendations provided herein, estimated total and differential settlement of proposed site improvements are anticipated to be less than 1 inch and ½ inch over 30 feet, respectively. These magnitudes of settlement are considered within tolerable limits of proposed site development.

5.4 EARTHWORK AND MATERIAL CHARACTERISTICS

Subsurface soils are anticipated to be relatively easy to excavate with conventional heavy earthmoving equipment. Most of these materials are below optimum moisture content with a few localized layers above optimum moisture content. Blending and the addition of water will be required to achieve proper compaction. Various debris is anticipated within the artificial fill and will likely require of hand picking to remove deleterious materials.

Off-site improvements exist near the property lines. The presence of the existing improvements may limit removals of unsuitable materials adjacent the property lines. Special grading techniques, such as slot cutting, underpinning, or other acceptable criteria may be required when grading adjacent the property lines.

Onsite disposal systems, clarifiers and other underground improvements may be present beneath the site. If encountered during future rough grading, these improvements will require proper abandonment or removal.

5.5 SHRINKAGE AND SUBSIDENCE

Volumetric changes in earth quantities will occur when excavated onsite soil materials are replaced as properly compacted fill. We estimate that the existing artificial fill soils will shrink less than 5 percent to negligible. Subsidence due to reprocessing of removal bottoms is anticipated to be negligible. The estimates of shrinkage and subsidence are intended as an aid for project engineers in determining earthwork quantities. However, these estimates should be used with some caution since they are not absolute values. Contingencies should be made for balancing earthwork quantities based on actual shrinkage and subsidence that occurs during the grading process.

5.6 SOIL EXPANSION

Based on our laboratory test results and USCS visual manual classification, the near-surface soils within the site are generally anticipated to possess a **Low** expansion potential. Additional testing for soil expansion will be required subsequent to rough grading and prior to construction of foundations and other concrete flatwork to confirm these conditions.

6.0 RECOMMENDATIONS

6.1 EARTHWORK

6.1.1 General Earthwork and Grading Specifications

All earthwork and grading should be performed in accordance with all applicable requirements of the grading codes of the City of Lake Forest, California and CAL OSHA, in addition to recommendations presented herein.

6.1.2 Pre-Grade Meeting and Geotechnical Observation

Prior to commencement of earthwork operations and foundation installation, we recommend a meeting be held between the City Inspector, general contractor, civil engineer, and geotechnical consultant to discuss proposed earthwork and logistics.

We also recommend that a geotechnical consultant be retained to provide soil engineering and engineering geologic services during site development. This is to observe compliance with the design specifications and recommendations, and to allow design changes in the event that subsurface conditions differ from those anticipated. If conditions are encountered during construction that appears to be different than those indicated in this report, the project geotechnical consultant should be notified immediately. Design and construction revisions may be required.

6.1.3 Site Clearing

All existing site improvements, including asphaltic concrete paving, structural foundations and underground utilities, should be removed from the areas to be developed prior to any grading activities. Existing underground utility lines within the project area that will be protected in place and that fall within a 1 to 1 (H:V) plane projected down from the edges of footings may be subject to surcharge loads. Under such conditions, this office should be made aware of these conditions for evaluation of potential surcharging. Supplemental recommendations may be required to protect such improvements in place.

The project geotechnical consultant should be notified at the appropriate times to provide observation services during clearing operations to verify compliance with the above recommendations. Voids created by clearing and excavation should be left open for observation by the geotechnical consultant. Should any unusual soil conditions or subsurface structures be encountered during site clearing or grading that are not described or anticipated herein, these conditions should be brought to the immediate attention of the project geotechnical consultant for corrective recommendations as needed.

Temporary construction equipment (office trailers, power poles, etc.) should be positioned to allow adequate room for clearing and recommended ground preparation to be performed for proposed structures, pavements, and hardscapes.

6.1.4 Site Preparation (Removals and Overexcavations)

In general, the upper 5 to 6 feet of earth materials are considered unsuitable for support of proposed engineered fill and site improvements. These materials as well as any additional artificial fill soils, should be removed from proposed building pads and site improvements, and replaced as engineered compacted fill. Within the limits of pavement and free-standing/retaining walls, the existing artificial fill soils should be removed to a minimum depth of 2 foot below subgrade or footing, whichever is deeper. The actual depth of removal should be determined by the geotechnical consultant during grading.

The removals should extend laterally a distance of at least 5 feet beyond the limits of the proposed structures or a 1:1 projection down and away from the bottom of the footings, whichever is greater. Removals for roadways, retaining walls less than 3 feet in height and screen walls may be limited to the edge of the foundations or pavement. Upon review of more detailed site development plans, the depth of removals for roadways, short retaining walls, and screen walls may be lessened from the general removals described above.

Where removals are limited by existing structures, protected trees or property lines, special considerations may be required in the construction of affected improvements. Under such conditions, specific recommendations should be provided by this firm based on review of site-specific development plans.

Following removals/overexcavation, the exposed grade should first be scarified to a depth of 6 inches, brought to at least 110 percent of the optimum moisture content, and then compacted to at least 90 percent of the laboratory standard (ASTM D 1557).

6.1.5 Fill Placement

Materials excavated from the site may be reused as fill provided, they are free of deleterious materials and particles greater than 6 inches in maximum dimension (oversized materials). Asphaltic and concrete debris generated during site demolition or encountered within the existing fill can be incorporated within new fill soils during earthwork operations provided they are reduced to no more than 6 inches in maximum dimension. Such materials should be mixed thoroughly with fill soils to prevent nesting. All fill should be placed in lifts no greater than 8 inches in loose thickness, moisture conditioned to at least 110 percent of the optimum moisture content, then compacted in place to at least 90 percent of the laboratory standard. Each lift should be treated in a similar manner. Subsequent lifts should not be placed until the project geotechnical consultant has approved the preceding lift.

6.1.6 Import Materials

If import materials are required to achieve the proposed finish grades, the proposed import soils should have an Expansion Index (EI, ASTM D 4829) less than 30 and possess negligible soluble sulfate concentrations. Import sources should be indicated to the geotechnical consultant prior to hauling the materials to the site so that appropriate testing and evaluation of the fill materials can be performed in advance.

6.1.7 Temporary Excavations

Temporary construction slopes or trench excavations in site materials may be cut vertically up to a height of 4 feet provided that no surcharging of the excavations is present. Temporary slopes over 4 feet in height should be laid back to 1:1 (H:V) or flatter and evaluated by the geotechnical consultant.

Excavations should not be left open for prolonged periods of time. The project geotechnical consultant should observe all temporary cuts to confirm anticipated conditions and to provide alternate recommendations if conditions dictate. All excavations should conform to the requirements of CAL OSHA.

Where temporary excavations cannot accommodate a 1:1 layback or where surcharging occurs, shoring, slot cutting, underpinning, or other methods should be used. Specific recommendations for other options if considered should be provided by the geotechnical consultant based on review of the final design plans.

6.2 SEISMIC DESIGN PARAMETERS

For design of the project in accordance with Chapter 16 of the 2016 CBC, the table below presents the seismic design factors.

TABLE 6.1
CBC 2016 SEISMIC DESIGN PARAMETERS

Parameter	Value
Site Class	D
Mapped MCE Spectral Response Acceleration, short periods, S_S	1.466
Mapped MCE Spectral Response Acceleration, at 1-sec. period, S_1	0.546
Site Coefficient, Fa	1.0
Site Coefficient, Fv	1.5
Adjusted MCE Spectral Response Acceleration, short periods, S_{MS}	1.466
Adjusted MCE Spectral Response Acceleration, at 1-sec. period, S_{M1}	0.82
Design Spectral Response Acceleration, short periods, S_{DS}	0977
Design Spectral Response Acceleration, at 1-sec. period, S_{D1}	0.546
MCE = Maximum Considered Earthquake	

6.3 FOUNDATION DESIGN

6.3.1 General

The following recommendations are provided for preliminary design purposes. These recommendations have been based on the site materials exposed during our investigation, our understanding of the proposed development, and the assumption that the recommendations presented herein are incorporated into the design and construction of the project. Final recommendations should be provided by the project geotechnical consultant following review of final foundation plans as well as observation and testing of site materials during grading. Depending upon the design plans and actual site conditions, the recommendations provided herein may require modification.

6.3.2 Soil Expansion

The recommendations presented herein are based on soils with a **Low** expansion potential ($EI \leq 40$, $PI \leq 18$). Following site grading, additional testing of site soils should be performed by the project geotechnical consultant to confirm the basis of these recommendations. If site soils with higher expansion potentials are encountered or imported to the site, the recommendations contained herein may require modification.

6.3.3 Settlement

Under normal static conditions, the foundation system should be designed to tolerate a total settlement of 1 inch and a differential settlement of 1/2-inch over 30 feet. These estimated magnitudes of settlement should be considered by the structural engineer in design of the proposed structures at the site.

6.3.4 Allowable Bearing Value

Provided foundations are bearing into engineered fill, a bearing value of 2,700 pounds per square foot (psf) may be used for continuous and pad footings a minimum width of 12 inches and founded at a minimum depth of 12 inches below the lowest adjacent grade. This value may be increased by 200 psf and 500 psf for each additional foot in width and depth, respectively, up to a maximum value of 4,000 psf. Recommended allowable bearing values include both dead and live loads, and may be increased by one-third for wind and seismic forces.

6.3.5 Lateral Resistance

Provided site grading is performed and that foundations are founded in engineered fill, a passive earth pressure of 250 pounds per square foot per foot of depth (psf/ft) up to a maximum value of 2,200 pounds per square foot (psf) may be used to determine lateral bearing for footings. This value may be increased by one-third when designing for wind and seismic forces. A coefficient of friction of 0.37 times the dead load forces may also be used between concrete and the supporting soils to determine lateral sliding resistance. No increase in the coefficient of friction should be used when designing for wind and seismic forces.

The above values are based on footings placed directly against compacted fill or competent native soils. In the case where footing sides are formed, all backfill against the footings should be compacted to at least 90 percent of the laboratory standard.

6.3.6 Conventional Spread Foundations and Slabs on Grade

All exterior and interior continuous footings should have a minimum width of 12 inches and minimum embedment of 12 inches below lowest adjacent grade. All continuous footings for habitable structures should be reinforced with a minimum of one No. 4 bar on top and one No. 4 bar on the bottom.

All spread footings used to support columns should have a minimum width of 18 inches and minimum embedment of 12 inches below lowest adjacent grade. All spread footings in habitable structures should be tied in both directions with a grade beam having a minimum depth and width of 12 inches. The grade beams should be reinforced with a minimum of one No. 4 bar on top and one No. 4 bar on the bottom. Reinforcing of the grade beams should hook into the footings.

Slabs on grade should have a minimum thickness of 4 inches and be reinforced with a minimum of No. 3 bars spaced at 18 inches center to center. Slabs on grade in habitable structures should be hooked to the underlying grade beams on a minimum spacing of 24 inches or poured monolithically with the grade beams.

Interior grade beams as required by the WRI method should be provided in both directions at a maximum spacing of 22 feet. Design of the slab in accordance with the WRI method may use an effective PI of 20. This value already accounts for the factors for ground slope and over-consolidation. All slabs on grade that may have moisture sensitive coverings should be underlain with a minimum of 10-mil moisture vapor retarder conforming to ASTM E 1745, Class A. A minimum of four (4) inches of clean sand having a sand equivalent (SE) of at least 30 should be placed under the membrane. An additional one inch of the sand (SE>30) may be placed over the vapor barrier to aid in the uniform curing of the slab if preferred. This vapor barrier system is anticipated to be suitable for most flooring finishes that can accommodate some vapor emissions. However, this system may emit more than 4 pounds of water per 1000 sq. ft. and therefore, may not be suitable for all flooring finishes. Additional steps should be taken if such vapor emission levels are too high for anticipated flooring finishes.

Prior to placing concrete, the subgrade below all floor slab areas should be moisture-conditioned to achieve a moisture content that is at least 110 percent of the optimum moisture content. This moisture content should be maintained a minimum depth of 12 inches below the bottoms of the slabs.

6.3.7 Post-Tensioned Slab/Mat on grade

Alternatively, a post-tension slab may be utilized. Perimeter edge beams for the post-tensioned slabs should have a minimum effective width of 12 inches and be founded at a minimum depth of 18 inches below the lowest adjacent final ground surface. Interior beams may be founded at a minimum depth of 12 inches below the tops of the finish floor slabs. Where a post-tensioned mat is utilized, the exterior edge of the mat should be embedded at least 8 inches below the lowest adjacent grade. The thickness of the floor slab/mat should be determined by the project structural engineer; however, we recommend a minimum slab thickness of 5.0 inches.

Design of the mat may be based on a modulus of subgrade reaction (Kv1) of 100 pounds per cubic inch (pci). The modulus is based on an effective loading area of 1 foot by 1 foot. The modulus may be adjusted for other effective loading areas using the equation provided below.

$$k_b(pci) = 100\left\{\frac{b+1}{2b}\right\}^2$$

where “b” is the effective width of loading (minimum dimension) in feet.

Concrete floor slabs in areas to receive carpet, tile, or other moisture sensitive coverings should be underlain with a minimum of 10-mil moisture vapor retarder conforming to ASTM E 1745, Class A. The membrane should be properly lapped, sealed, and underlain within a layer of sand at least 4 inches thick. Where a mat is used and has a thickness of at least 8 inches, the sand may be limited to 2 inches. One inch of sand may be placed over the membrane to aid in the curing of the concrete. The sand should have a SE no less than 30. This vapor retarder system is anticipated to be suitable for most flooring finishes that can accommodate some vapor emissions. However, this system may emit more than 4 pounds of water per 1000 sq. ft. and therefore, may not be suitable for all flooring finishes. Additional steps should be taken if such vapor emission levels are too high for anticipated flooring finishes.

Prior to placing concrete, subgrade soils below slab-on-grade/mat areas should be thoroughly moistened to provide moisture contents at least 110 percent of the optimum moisture content to a depth of 12 inches.

Based on the guidelines provided in the "Design of Post-Tensioned Slabs-on-Ground" 3rd Edition by Post-Tensioning Institute, the em and ym values are summarized in Table 6.2.

TABLE 6.2
PTI Design Parameters

Parameter	Value
Edge Lift Moisture Variation Distance, e_m	8.0 feet
Edge Lift, y_m	0.754 inches
Center Lift Moisture Variation Distance, e_m	4.2 feet
Center Lift, y_m	1.182 inches

6.3.8 Foundation Observations

Foundation excavation should be observed by the project geotechnical consultant to verify that they have been excavated into competent bearing soils and to the minimum embedment recommended above. These observations should be performed prior to placement of forms or reinforcement. The excavations should be trimmed neat, level and square. Loose, sloughed or moisture-softened materials and debris should be removed prior to placing concrete.

6.4 RETAINING AND SCREENING WALLS

6.4.1 General

The following preliminary design and construction recommendations are provided for general retaining and screen walls supported by engineered compacted fill or competent native soils. Final wall designs specific to the site development should be provided for review once completed. The structural engineer and architect should provide appropriate recommendations for sealing at all joints and applying moisture-proofing material on the back of the walls.

6.4.2 Allowable Bearing Value and Lateral Resistance

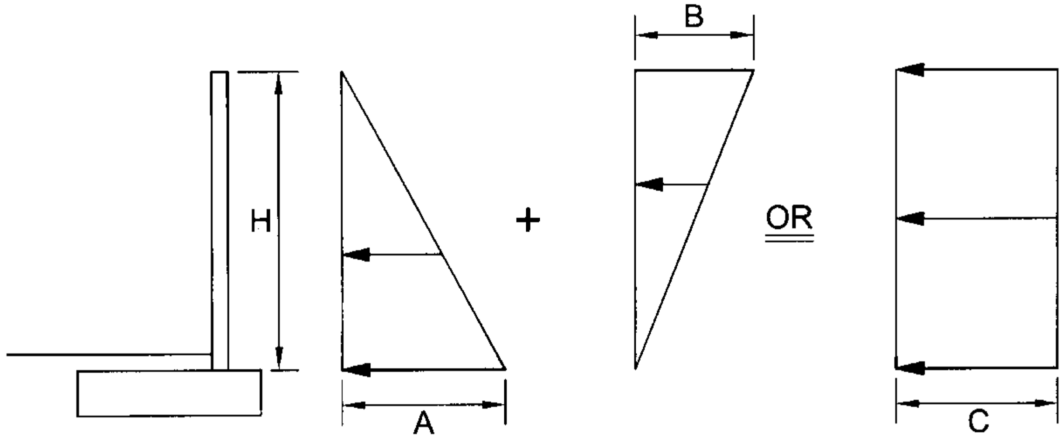
Design of retaining and screen walls may utilize the bearing and lateral resistance values provided in Section 6.3.4 and 6.3.5. Lateral resistance for walls along property lines, where lateral removals are restricted should be reduced by 50%.

6.4.3 Active Earth Pressures

Static and seismic active earth pressures for level backfill and 2:1 (H:V) backfill conditions are provided in Table 6.3. Based on the 2016 CBC, walls that retain less than 6 feet need not be designed for seismic earth pressures. Seismic earth pressures provided herein are based on the method provided by Seed & Whitman (1970) using a peak ground acceleration (PGA) of 0.35 g, for 10% probability of exceedance in 50 years. The values provided in Table 6.4 are based on drained backfill conditions and do not consider hydrostatic pressure. Furthermore, retaining walls should be designed to support adjacent surcharge loads imposed by other nearby footings or traffic loads in addition to the earth pressure.

TABLE 6.3

SEISMIC EARTH PRESSURES
Pressure Diagram



Static Component | Seismic Component | Total Force

Pressure Values
Walls Up To 10 Feet High

Value	**Backfill Condition**	
	Level	**2H:1V Slope**
A	40H	68H
B	11H	11H
C	26H	40H

Note:
H is in feet and resulting pressure is in psf. Design may utilize either the sum of the static component and the seismic component force diagrams or the total force diagram above. SEAOSC has suggested using a load factor of 1.7 for the static component and 1.0 for the seismic component. The actual load factors should be determined by the structural engineer.

6.4.4 Drainage and Moisture-Proofing

Retaining walls should be constructed with a perforated pipe and gravel subdrain to prevent entrapment of water in the backfill. The perforated pipe should consist of 4-inch-diameter, ABS SDR-35 or PVC Schedule 40 with the perforations laid down. The pipe should be embedded in ¾- to 1½-inch open-graded gravel wrapped in filter fabric. The gravel should be at least one foot wide and extend at least one foot up the wall above the footing and drainage outlet. Drainage gravel and piping should not be placed below outlets and weepholes. Filter fabric should consist of Mirafi 140N, or equal. Outlet pipes should be directed to positive drainage devices.

The use of weepholes may be considered in locations where aesthetic issues from potential nuisance water are not a concern. Weepholes should be 2 inches in diameter and provided at least every 6 feet on center. Where weepholes are used, perforated pipe may be omitted from the gravel subdrain.

Retaining walls supporting backfill should also be coated with a moisture-proofing compound or covered with such material to inhibit infiltration of moisture through the walls. Moisture-proofing material should cover any portion of the back of wall that will be in contact with soil and should lap over and onto the top of footing. A drainage panel should be provided between the soil backfill and water proofing. The panel should extend from the top of the backdrain gravel up to within 12 inches of finish grade. The top of footing should be finished smooth with a trowel to inhibit the infiltration of water through the wall. The project structural engineer should provide specific recommendations for moisture-proofing, water stops, and joint details.

6.4.5 Footing Reinforcement and Wall Jointing

All continuous footings should be reinforced with a minimum of two No. 4 bars, one top and one bottom. Walls should be provided with cold joints spaced no more than 40 feet apart. Wall finishes and capping materials should not extend across the cold joint. The structural engineer may require different reinforcement or jointing and should dictate if greater than the recommendations provided herein. Where recommended removals are limited due to space restrictions, greater reinforcement and closer jointing may be recommended. Specific recommendations should be provided by the geotechnical consultant during grading based on as-built conditions exposed in the field.

6.4.6 Footing Observations

Footing excavations should be observed by the project geotechnical consultant to verify that they have been excavated into competent bearing soils and to the minimum embedment recommended herein. These observations should be performed prior to placement of forms or reinforcement. The excavations should be trimmed neat, level and square. Loose, sloughed or moisture-softened materials and debris should be removed prior to placing concrete.

6.4.7 Retaining Wall Backfill

Onsite soils may generally be used for backfill of retaining walls. The project geotechnical consultant should approve all backfill used for retaining walls. Wall backfill should be moisture-conditioned to slightly over the optimum moisture content; placed in lifts no greater than 12 inches in thickness, and then mechanically compacted with appropriate equipment to at least 90 percent of the laboratory standard. Hand-operated compaction equipment should be used to compact the backfill placed immediately adjacent the wall to avoid damage to the wall. Flooding or jetting of backfill material is not recommended.

6.5 EXTERIOR FLATWORK

Exterior flatwork should be a minimum 4 inches thick. Cold joints or saw cuts should be provided at least every 7 feet in each direction. Flatwork having a minimum dimension more than 7 feet should be reinforced with No. 3 bars spaced 18 inches center to center each way or 6-inch by 6-inch, W4 by W4 welded wire mesh. Special jointing detail should be provided in areas of block-outs, notches, or other irregularities to avoid cracking at points of high stress Subgrade soils below flatwork should be thoroughly moistened to at least 110 percent of the optimum moisture content to a depth of 12 inches. Moistening should be accomplished by lightly spraying the area over a period of a few days just prior to pouring concrete. The geotechnical consultant should observe and verify the density and moisture content of subgrade soils prior to pouring concrete to ensure that the required compaction and pre-moistening recommendations have been met.

Drainage from flatwork areas should be directed to local area drains and/or other appropriate collection devices designed to carry runoff water to the street or other approved drainage structures. The concrete flatwork should also be sloped at a minimum gradient of 1 percent away from building foundations and retaining walls.

6.6 CONCRETE MIX DESIGN

Laboratory testing of onsite soil indicates **negligible** soluble sulfate content. Concrete designed to follow the procedures provided in ACI 318, Section 4.3, Table 4.3.1 for **negligible** sulfate exposure are anticipated to be adequate for mitigation of sulfate attack on concrete. Upon completion of rough grading, an evaluation of as-graded conditions and further laboratory testing will be required for the site to confirm or modify the conclusions provided in this section.

6.7 CORROSION

Results of preliminary testing of soils for pH, chloride, and minimum resistivity indicate the site is potentially **Corrosive** to metals that are in contact or close proximity to onsite soils. As such, specific recommendations should be obtained from a corrosion specialist if construction will include metals that will be near or in direct contact with site soils.

6.8 PRELIMINARY PAVEMENT DESIGN

6.8.1 Preliminary Pavement Structural Sections

Based on the soil conditions present at the site and estimated traffic index, preliminary pavement structural sections are recommended in the table below. An assumed “R-value” of 20 utilized for the near-surface soil in this preliminary pavement design. The sections provided in Table 6.4 are for planning purposes only and should be re-evaluated subsequent to site grading. Final pavement sections should be based on actual R-value testing of in-place soils and analysis of anticipated traffic.

6.8.2 Subgrade Preparation

Prior to placement of pavement elements, subgrade soils should be moisture-conditioned to at least 110 percent of the optimum moisture content then compacted to at least 90 percent of the laboratory determined maximum dry density. Areas observed to pump or yield under vehicle traffic should be removed and replaced with firm and unyielding compacted soil or aggregate base materials.

TABLE 6.4
PRELIMINARY PAVEMENT STRUCTURAL SECTIONS

Location	Traffic Index	AC (inches)	PCC (inches)	Concrete Pavers (mm)	AB (inches)
Entry and Main Driveway	5	3.0 4.0 -- --	-- -- 6.5 --	-- -- -- 80.0	8.0 6.0 -- 9.0
Parking Stalls	--	3.0	--	--	5.0

AC - Asphaltic Concrete AB - Aggregate Base

6.8.3 Aggregate Base

Aggregate base should be moisture conditioned to slightly over the optimum moisture content, placed in lifts no greater than 6 inches in thickness, then compacted to at least 95 percent of the laboratory standard (ASTM D 1557). Aggregate base materials should be Class 2 Aggregate Base conforming to Section 26-1 of the latest edition of the Caltrans Standard Specifications, Crushed Aggregate Base conforming to Section 200-2.2 of the latest edition of the Standard Specifications for Public Works Construction (Greenbook) or Crushed Miscellaneous Base conforming to Section 200-2.4 of the Greenbook.

6.8.4 Asphaltic Concrete

Paving asphalt should be PG 64-10. Asphaltic concrete materials should conform to Section 203-6 of the Greenbook and construction should conform to Section 302 of the Greenbook.

6.8.5 Concrete Pavers

Concrete pavers should conform to the requirements of ASTM C 936. Construction of the pavers, including bedding sand, should follow manufacturer's specifications. Typical thickness of bedding sand is about 1 inch. The gradation of bedding sand should meet the requirement in Table 6.5.

Construction of edge restraints should also follow manufacturer's specifications. As a minimum, restraints should be provided along the perimeter of concrete pavers and where there is a change in the paving materials.

TABLE 6.5
Gradation of Bedding for Pavers

Sieve Size	Percent Passing
⅜”	100
No. 4	95 - 100
No. 8	80 - 100
No. 16	50 - 85
No. 30	25 - 60
No. 50	5 - 30
No. 100	0 - 10
No. 200	0 - 1

6.8.6 Portland Cement Concrete

Portland cement concrete used to construct concrete paving should conform to Section 201 of the Greenbook and should have a minimum compressive strength of 3,250 pounds per square inch (psi) at 28 days. Reinforcement and jointing of concrete pavement sections should be designed according to the minimum recommendations provided by the Portland Cement Association (PCA). For rigid pavement, transverse and longitudinal contraction joints should be provided at spacing no greater than 15 feet. Score joints may be constructed by saw cutting to a depth of ¼ of the slab thickness. Expansion/cold joints may be used in lieu of score joints. Such joints should be properly sealed and provided with a key or dowels. Where traffic will traverse over edges of concrete paving (not including joints), the edges should be thickened by 20% of the design thickness toward the edge over a horizontal distance of 5 feet.

Trash pickup areas should be provided with a concrete slab where the bins will be picked up and extend at least 3 feet past the front wheel landing areas. The slab should be at least 8 inches thick and be reinforced with No. 4 bars spaced at 24 inches on centers, both ways. The slabs should be provided transverse and longitudinal joints spacing as specified above. Dowels or a keyway should be provided at all cold joints.

6.9 POST GRADING CONSIDERATIONS

6.9.1 Site Drainage and Irrigation

The ground immediately adjacent to foundations should be provided with positive drainage away from the structures in accordance with 2016 CBC, Section 1804.3. No rain or excess water should be allowed to pond against structures such as walls, foundations, flatwork, etc.

Excessive irrigation water can be detrimental to the performance of the proposed site development. Water applied in excess of the needs of vegetation will tend to percolate into the ground. Such percolation can lead to nuisance seepage and shallow perched groundwater. Seepage can form on slope faces, on the faces of retaining walls, in streets, or other low-lying areas. These conditions could lead to adverse effects such as the formation of stagnant water that breeds insects, distress or damage of trees, surface erosion, slope instability, discoloration and salt buildup on wall faces, and premature failure of pavement. Excessive watering can also lead to elevated vapor emissions within buildings that can damage flooring finishes or lead to mold growth inside the home.

Key factors that can help mitigate the potential for adverse effects of overwatering include the judicious use of water for irrigation, use of irrigation systems that are appropriate for the type of vegetation and geometric configuration of the planted area, the use of soil amendments to enhance moisture retention, use of low-water demand vegetation, regular use of appropriate fertilizers, and seasonal adjustments of irrigation systems to match the water requirements of vegetation. Specific recommendations should be provided by a landscape architect or other knowledgeable professional.

6.9.2 Utility Trenches

Trench excavations should be constructed in accordance with the recommendations contained in Section 6.1.7 of this report. Trench excavations must also conform to the requirements of Cal/OSHA.

Trench backfill materials and compaction criteria should conform to the requirements of the local municipalities. As a minimum, utility trench backfill should be compacted to at least 90 percent of the laboratory standard. Materials placed within the pipe zone (6 inches below and 12 inches above the pipe) should consist of particles no greater than ¾ inches and have a SE of at least 30. The materials within the pipe zone should be moisture-conditioned and compacted by hand-operated compaction equipment. Above the pipe zone (>1 foot above pipe), the backfill may consist of general fill materials. Trench backfill should be moisture-conditioned to slightly over the optimum moisture content, placed in lifts no greater than 12 inches in thickness, and then mechanically compacted with appropriate equipment to at least 90 percent of the laboratory standard. For trenches with sloped walls, backfill material should be placed in lifts no greater than 8 inches in loose thickness, and then compacted by rolling with a sheepsfoot roller or similar equipment. The project geotechnical consultant should perform density testing along with probing to verify that adequate compaction has been achieved.

Within shallow trenches (less than 18 inches deep) where pipes may be damaged by heavy compaction equipment, imported clean sand having a SE of 30 or greater may be utilized. The sand should be placed in the trench, thoroughly watered, and then compacted with a vibratory compactor. For utility trenches located below a 1:1 (H:V) plane projecting downward from the outside edge of the adjacent footing base or crossing footing trenches, concrete or slurry should be used as trench backfill.

6.10 PLAN REVIEW AND CONSTRUCTION SERVICES

We recommend ***Albus-Keefe & Associates, Inc.*** be engaged to review any future development plans, including foundation plans prior to construction. This is to verify that the assumptions of this report are valid and that the preliminary conclusions and recommendations contained in this report have been properly interpreted and are incorporated into the project plans and specifications. If we are not provided the opportunity to review these documents, we take no responsibility for misinterpretation of our preliminary conclusions and recommendations.

We recommend that a geotechnical consultant be retained to provide soil engineering services during construction of the project. These services are to observe compliance with the design, specifications or recommendations, and to allow design changes in the event that subsurface conditions differ from those anticipated prior to the start of construction.

If the project plans change significantly from the assumed development described herein, the project geotechnical consultant should review our preliminary design recommendations and their applicability to the revised construction. If conditions are encountered during construction that appear to be different than those indicated in this report or subsequent design reports, the project geotechnical consultant should be notified immediately. Design and construction revisions may be required.

7.0 LIMITATIONS

This report is based on the proposed development and geotechnical data as described herein. The materials encountered on the project site, described in other literature, and utilized in our laboratory testing for this investigation are believed representative of the total project area, and the conclusions and recommendations contained in this report are presented on that basis. However, soil and bedrock materials can vary in characteristics between points of exploration, both laterally and vertically, and those variations could affect the conclusions and recommendations contained herein. As such, observation and testing by a geotechnical consultant during the grading and construction phases of the project are essential to confirming the basis of this report.

This report has been prepared consistent with that level of care being provided by other professionals providing similar services at the same locale and time period. The contents of this report are professional opinions and as such, are not to be considered a guaranty or warranty. This report should be reviewed and updated after a period of one year or if the site ownership or project concept changes from that described herein.

This report has been prepared for the exclusive use of **National Community Renaissance** and their project consultants in the planning and design of the proposed development. This report has not been prepared for use by parties or projects other than those named or described herein. This report may not contain sufficient information for other parties or other purposes. This report is subject to review by the controlling governmental agency.

Respectfully submitted,

ALBUS-KEEFE & ASSOCIATES, INC

Paul Hyun Jin Kim
Associate Engineer
G.E. 3106

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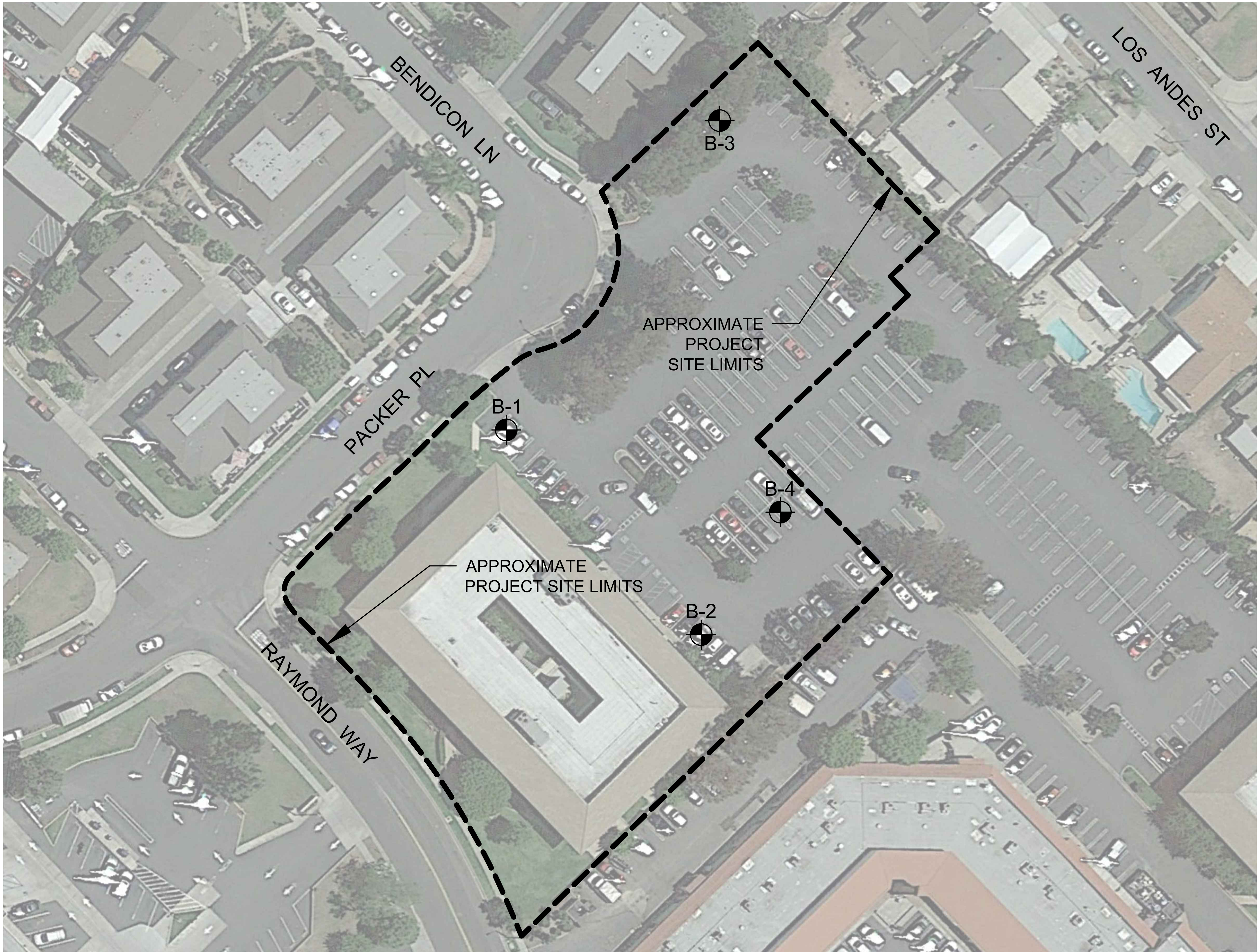


0 20 40 80

APPROX SCALE : 1" = 40'

EXPLANATION
(Locations Approximate)

⊕ - Exploratory Boring

ALBUS-KEEFE & ASSOCIATES, INC.
GEOTECHNICAL CONSULTANTS

GEOTECHNICAL MAP

Job No.: 2841.00 | Date: 10/23/19 | Plate: 1

APPENDIX A

EXPLORATION BORING LOGS

EXPLORATION LOG

Project:		Location:
Address:		Elevation:
Job Number:	Client:	Date:
Drill Method:	Driving Weight:	Logged By:

Depth (feet)	Lith- ology	Material Description	Water	Samples: Blows Per Foot	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
		EXPLANATION							
		Solid lines separate geologic units and/or material types.							
5		Dashed lines indicate unknown depth of geologic unit change or material type change.							
		Solid black rectangle in Core column represents California Split Spoon sampler (2.5in ID, 3in OD).							
		Double triangle in core column represents SPT sampler.							
10		**Vertical Lines** in core column represents Shelby sampler.							
		Solid black rectangle in Bulk column respresents large bag sample.							
15		**Other Laboratory Tests:** Max = Maximum Dry Density/Optimum Moisture Content EI = Expansion Index SO4 = Soluble Sulfate Content DSR = Direct Shear, Remolded DS = Direct Shear, Undisturbed SA = Sieve Analysis (1" through #200 sieve) Hydro = Particle Size Analysis (SA with Hydrometer) 200 = Percent Passing #200 Sieve Consol = Consolidation SE = Sand Equivalent Rval = R-Value ATT = Atterberg Limits							
20									

Albus-Keefe & Associates, Inc.

EXPLORATION LOG

Project: National Community Renaissance, Lake Forest		Location: B-1
Address: 24551 Raymond Way, Lake Forest, CA 92630		Elevation: 395
Job Number: 2841.00	Client: National Community Renaissance	Date: 10/2/2019
Drill Method: Hollow-Stem Auger	Driving Weight: 140 lbs / 30 in	Logged By: SD

Depth (feet)	Lith-ology	Material Description	Water	Samples: Blows Per Foot	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
		Asphalt (AC): Black							SO4 DS pH Resist Ch
		ARTIFICIAL FILL (Af) Silty Sand (SM): Mottled olive brown, reddish brown, and light brown, slightly moist, very dense, fine to medium grained sand, clay nodules, trace pin-hole poros		80/ 10"			11.1	116	
5		@ 4 ft, light gray, increased clay content		76/ 8"			10.2	111.2	Consol
		VERY OLD ALLUVIAL FAN DEPOSITS (Qvof) Sandy Clay (CL): Gray, moist, hard, fine grained sand		72/ 11"			12.8	118.2	
		Clayey Sand (SC): Mottled gray and reddish gray, slightly moist, very dense, fine to medium grained sand, caliche							
10		Clayey Sand/ Sandy Clay (SC/CL): yellowish gray, slightly moist, very dense/ hard, trace coarse grained sand, iron oxide stainings		73/ 8"			11		
		Clayey Sand (SC): Light brown, slightly moist, dense, fine to coarse grained sand, iron oxide stainings							
15		@ 15 ft, reddish brown, moist		29					SA Hydro
		Clayey Sand : Mottled olive brown and gray, moist, very dense, fine to coarse grained sand, increased medium grained sand, some silt inner layers, increased clay							
20				36					SA Hydro

Albus-Keefe & Associates, Inc.

EXPLORATION LOG

Project: National Community Renaissance, Lake Forest		Location: B-1
Address: 24551 Raymond Way, Lake Forest, CA 92630		Elevation: 395
Job Number: 2841.00	Client: National Community Renaissance	Date: 10/2/2019
Drill Method: Hollow-Stem Auger	Driving Weight: 140 lbs / 30 in	Logged By: SD

Depth (feet)	Material Description	Water	Samples: Blows Per Foot	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
	@ 25 ft, caliche		43	■				
30			45	■				SA Hydro
35	@ 35 ft, , moist to very moist		56	■				
	Silty Clay/ Clayey Silt (CL/ ML-CL): Light brown, slightly moist to moist, hard, iron oxide stainings, trace magnesium oxide							
40		▽	31	■				
45			37	■				

Albus-Keefe & Associates, Inc.

Plate A-3

EXPLORATION LOG

Project: National Community Renaissance, Lake Forest		Location: B-1
Address: 24551 Raymond Way, Lake Forest, CA 92630		Elevation: 395
Job Number: 2841.00	Client: National Community Renaissance	Date: 10/2/2019
Drill Method: Hollow-Stem Auger	Driving Weight: 140 lbs / 30 in	Logged By: SD

Depth (feet)	Lith-ology	Material Description	Water	Samples: Blows Per Foot	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
				35					
		End of boring at depth of 51.5 ft. Groundwater encountered at depth of 41 ft. Backfilled with soil cuttings and patched with asphalt.							

EXPLORATION LOG

Project: National Community Renaissance, Lake Forest		Location: B-2
Address: 24551 Raymond Way, Lake Forest, CA 92630		Elevation: 399
Job Number: 2841.00	Client: National Community Renaissance	Date: 10/2/2019
Drill Method: Hollow-Stem Auger	Driving Weight: 140 lbs / 30 in	Logged By: SD

Depth (feet)	Lithology	Material Description	Water	Samples: Blows Per Foot	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
		Asphalt (AC): Black							
		Aggregate Base (AB): Dark brown							
		ARTIFICIAL FILL (Af) Silty Sand (SM): Light brown, moist, dense, fine to medium grained sand, some clay, iron oxide stainings, caliche		35	⧗		12.8	109.1	
5		**VERY OLD ALLUVIAL FAN DEPOSITS (Qvof)** Clay (CL): Reddish brown, slightly moist, hard		79	⧗		11.2	111.3	
		Clayey Sand/ Sandy Clay (SC/CL): Mottled dark brown and reddish brown, slightly moist to moist, very dense/hard, trace silt, caliche		81	⧗		6.4	124.4	
10		Silty Clay with Sand (CL-ML): Reddish brown, moist, hard, fine to medium sand, pin-hole poros, caliche							
		Sandy Silt (ML): Light brown, slightly moist to moist, hard, some clay, caliche, trace fine grained sand		81	⧗		13.5	105.6	
		End of boring at depth of 11.5 ft. No groundwater encountered. Backfilled with soil cuttings and patched with asphalt.							

EXPLORATION LOG

Project: National Community Renaissance, Lake Forest		Location: B-3
Address: 24551 Raymond Way, Lake Forest, CA 92630		Elevation: 394
Job Number: 2841.00	Client: National Community Renaissance	Date: 10/2/2019
Drill Method: Hollow-Stem Auger	Driving Weight: 140 lbs / 30 in	Logged By: SD

Depth (feet)	Lith-ology	Material Description	Water	Samples: Blows Per Foot	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
		Asphalt (AC): Black							
		Aggregate Base (AB): Dark brown							
		VERY OLD ALLUVIAL FAN DEPOSITS (Qvof) Clayey Sand/ Sandy Clay (SC/CL): Mottled brown, dark brown, reddish brown and gray, slightly moist to mosit, very dense/hard, fine to coarse grained sand, caliche		72/ 8"			11.2	119.6	
5				76/ 11"			7	113	
		Silty Sand (SM): Light reddish brown, slightly moist to mosit, very dense, fine to coarse sand, some clay, iron oxide stainings, caliche, rootlets, rock fragments @ 6 ft, dense		57			9.9	120.1	
		Clayey Sand (SC): Gray, slightly moist to moist, very dense, fine to medium grained sand, caliche, rock fragments							
10				75/ 8"			12.1	113.6	
		Sand (SP): Light brown, moist, dense, trace clay, clay nodules							
15				31					
		End of boring at depth of 16.5 ft. No groundwater encountered. Backfilled with soil cuttings and patched with asphalt.							

EXPLORATION LOG

Project: National Community Renaissance, Lake Forest	Location: B-4
Address: 24551 Raymond Way, Lake Forest, CA 92630	Elevation: 401
Job Number: 2841.00 / Client: National Community Renaissance	Date: 10/2/2019
Drill Method: Hollow-Stem Auger / Driving Weight: 140 lbs / 30 in	Logged By: SD

Depth (feet)	Lith-ology	Material Description	Water	Samples: Blows Per Foot	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		Asphalt (AC): Black				■			
		Aggregate Base (AB): Dark brown				■			
2		**VERY OLD ALLUVIAL FAN DEPOSITS (Qvof)** Clayey Sand with Gravel (SC): Dark gray, moist, dense, fine to coarse grained sand		62	■	■	11.9	118.9	
4		Silty Sand (SM): Dark gray, moist, very dense, fine grained sand, some gravel, rootlets, mica present, pin-hole poros		79	■	■	7.8	127.9	Consol
6		@ 6 ft, medium dense		25	■		15.8	114.9	Consol
8		Silty Sand with Clay (SM): Dark gray, moist, medium dense, trace gravel, caliche							
10				36	■		13.8	117	
11		@ 11 ft, light reddish brown, decreased in clay content							
15		@ 15 ft, light brown, no gravel		20	⧗				
20				20	⧗				
21.5		dense, End of boring at depth of 21.5 ft. No groundwater encountered. Backfilled with soil cuttings and patched with asphalt.							

Albus-Keefe & Associates, Inc.

Plate A-7

APPENDIX B

LABORATORY TEST PROGRAM

LABORATORY TESTING PROGRAM

Soil Classification

Soils encountered within the exploratory borings were initially classified in the field in general accordance with the visual-manual procedures of the Unified Soil Classification System (ASTM D2488). The samples were re-examined in the laboratory and classifications reviewed and then revised where appropriate. The assigned group symbols are presented in the Boring Logs provided in Appendix A.

In Situ Moisture and Density

Moisture content and dry density of in-place soil materials were determined in representative strata. Test data are summarized on the Boring Logs provided in Appendix A.

Maximum Dry Density and Optimum Moisture Content

Maximum dry density and optimum moisture content of onsite soils were determined for one selected sample in general accordance with Method A of ASTM D1557. Pertinent test values are given on Table B.

Grain-Size Analyses

Grain size analyses were performed on selected samples of site materials. These tests were performed in accordance with ASTM D 422. Results are graphically presented on Plate B.

Consolidation

Consolidation tests were performed for selected soil samples in general conformance with ASTM D 2435. Axial loads were applied in several increments to a laterally restrained 1-inch-high sample. Loads were applied in geometric progression by doubling the previous load, and the resulting deformations were recorded at selected time intervals. The test samples were inundated at selected loads to evaluate the effects of a sudden increase in moisture content (hydro-consolidation potential). Results of the tests are graphically presented on Plates B-2 to B-5.

Direct Shear

The Coulomb shear strength parameters, angle of internal friction and cohesion, were determined for a bulk sample obtained from one our borings. The tests were performed in general conformance with Test Method ASTM D 3080. The sample was remolded to 90 percent of maximum dry density and at the optimum moisture content. Three specimens were prepared for each test, artificially saturated, and then sheared under varied loads at an appropriate constant rate of strain. Results are graphically presented on Plate B-6.

Expansion Potential

An Expansion Index test was performed on a selected sample in accordance with ASTM D 4829. The test result and expansion potential are presented on Table B.

Corrosion

Select samples were tested for minimum resistivity, chloride, and pH in accordance with California Test Method 643. Results of these tests are provided in Table B.

Soluble Sulfate Content

A chemical analysis was performed on a selected soil sample to determine soluble sulfate content. The test was performed in accordance with California Test Method (CTM) 417. The test result is included in Table B.

Percent Passing No. 200 Sieve

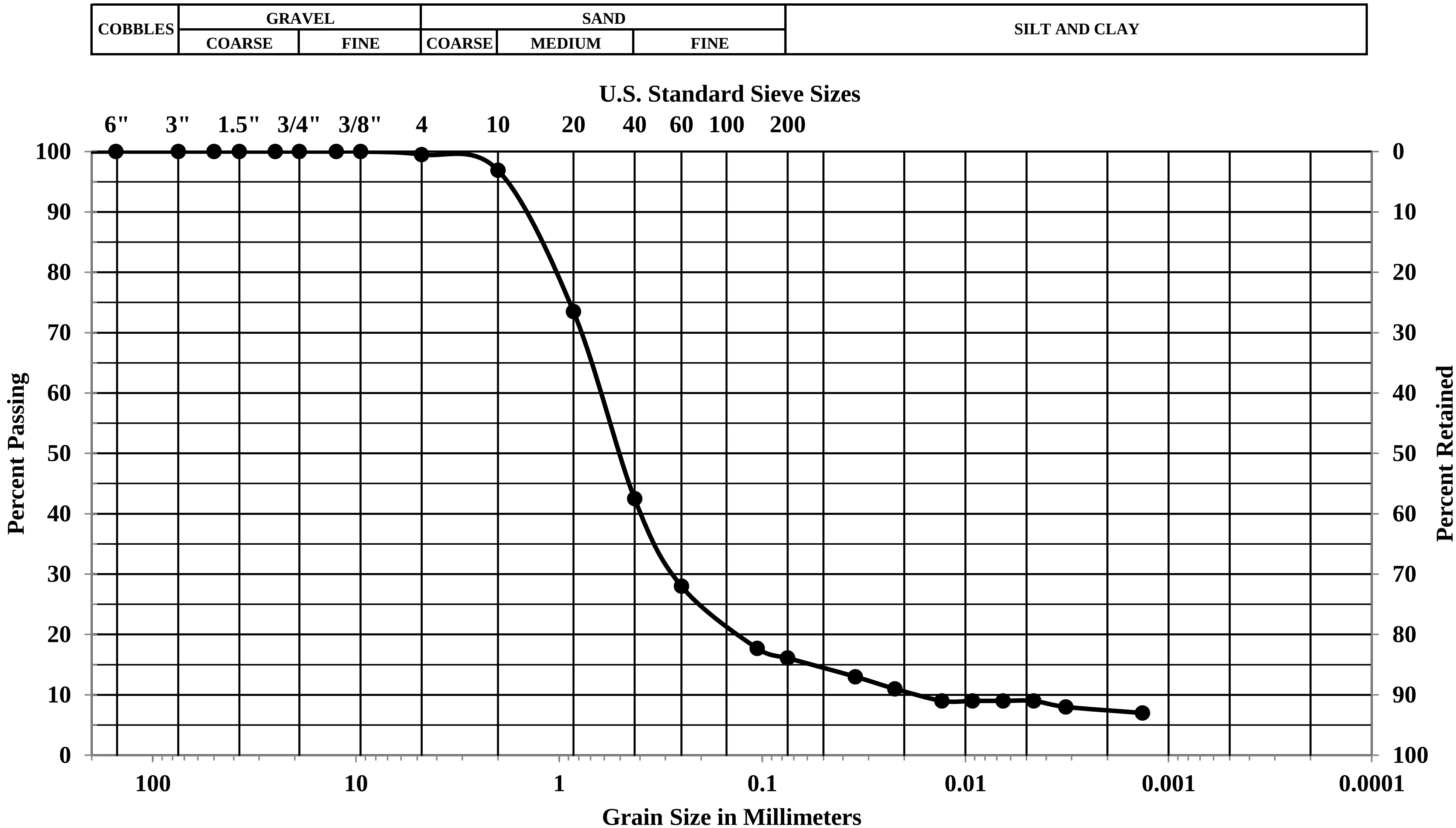
Percent of material passing the No. 200 sieve was determined on selected samples to verify visual classifications performed in the field. These tests were performed in accordance with ASTM D 1140. Test results are presented on Table B.

TABLE B
SUMMARY OF LABORATORY TEST RESULTS

Boring Number	Depth (feet)	Soil Type	Test Results	
B-1	0-5	Silty Sand (SM)	Maximum Dry Density (pcf): Optimum Moisture Content (%): Soluble Sulfate Content (%): Sulfate Exposure: pH: Minimum Resistivity: Chloride: Expansion Index: Expansion Potential:	124.5 11.0 0.000 Negligible 7.22 1700 Ohm-cm 10.0 ppm 30 Low
B-1	15	Clayey Sand (SC)	Percent Passing #200 Sieve:	16.3 %
B-1	20	Clayey Sand (SC)	Percent Passing #200 Sieve:	28.3%
B-1	30	Clayey Sand (SC)	Percent Passing #200 Sieve:	22.2%

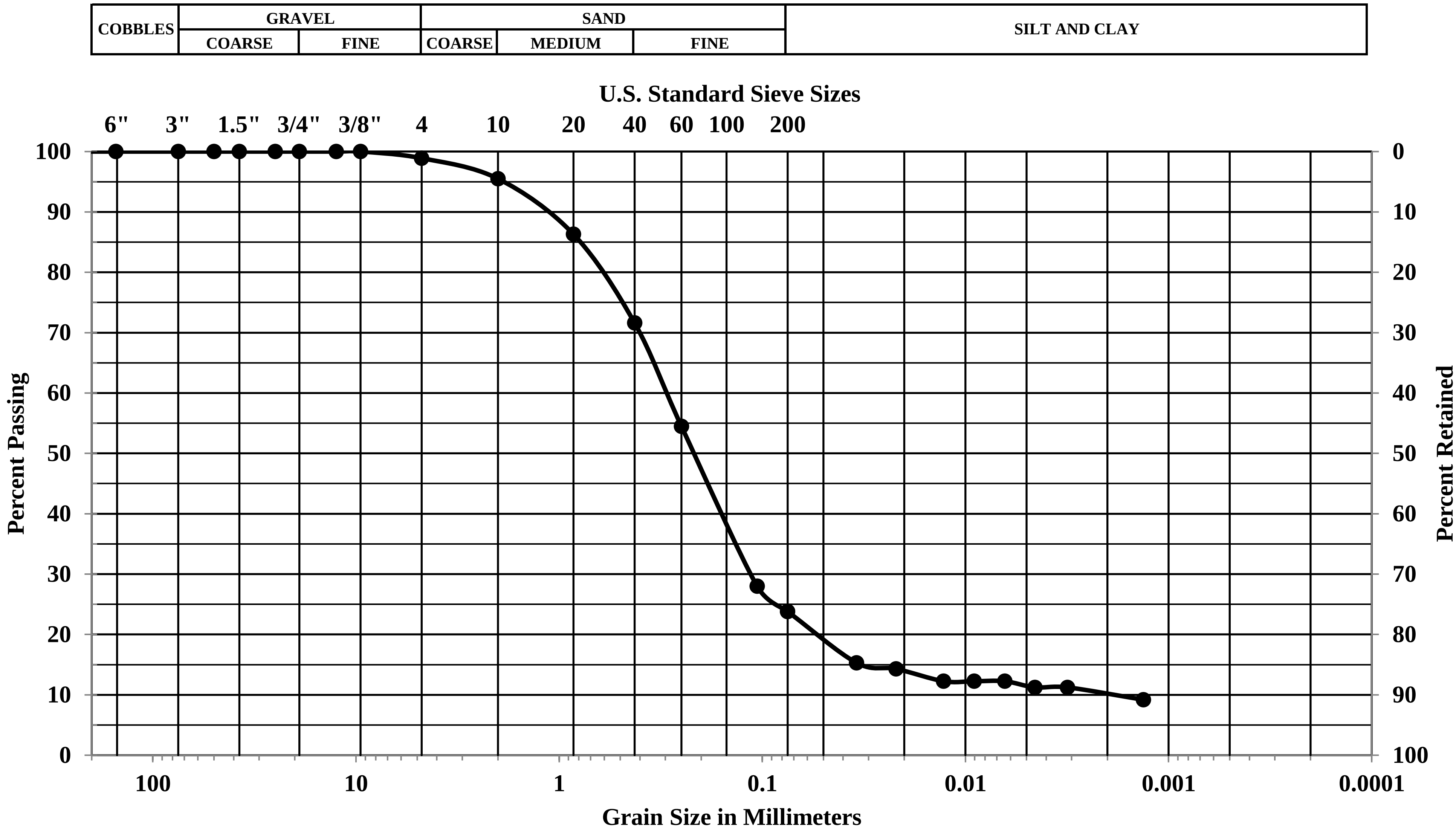
Additional laboratory test results are provided on the boring logs provided in Appendix A and on the Plates that follow.

GRAIN SIZE DISTRIBUTION



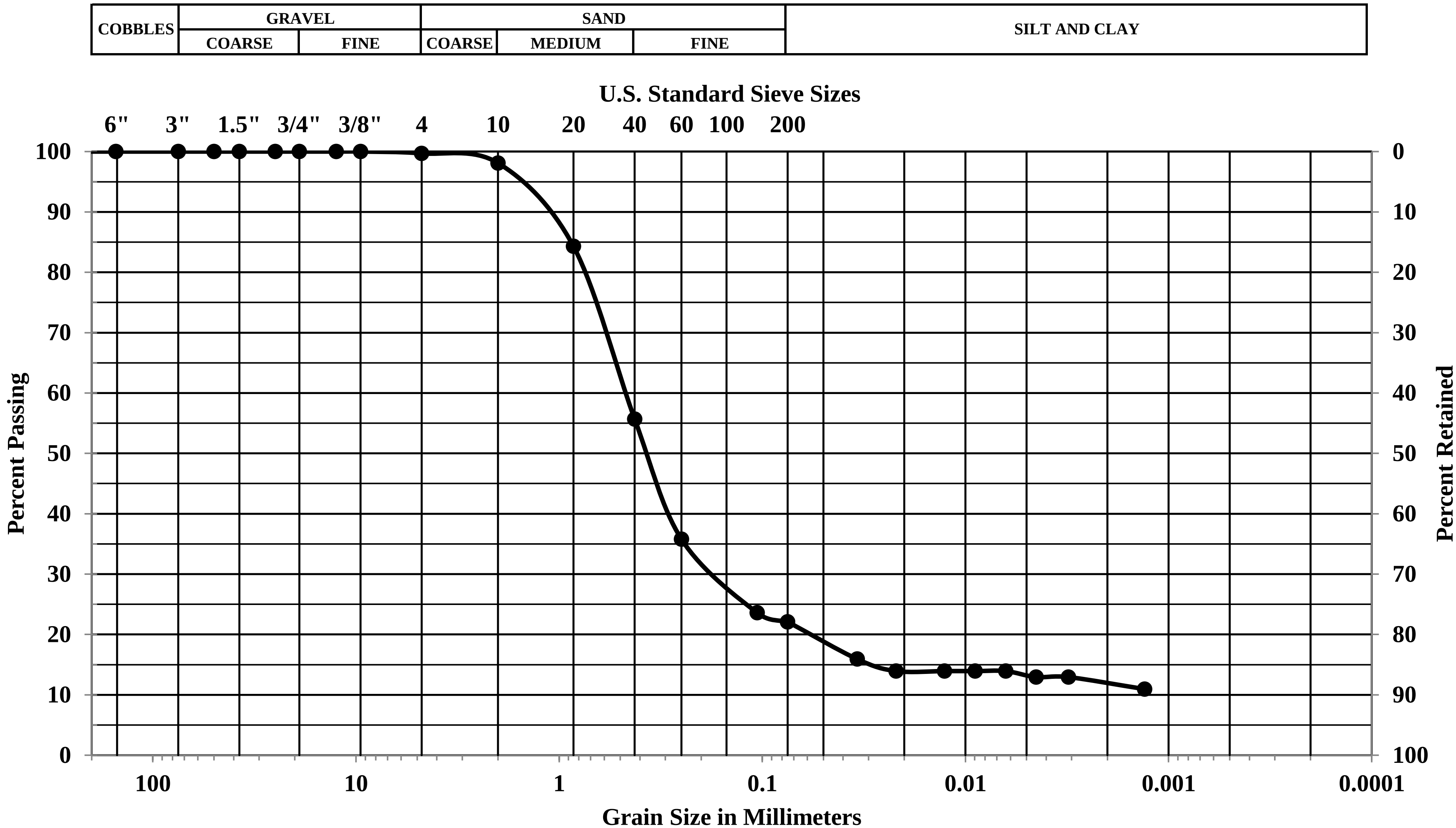
Job Number	Location	Depth	Description
2841.00	B-1	15	Clayey Sand (SC)

GRAIN SIZE DISTRIBUTION



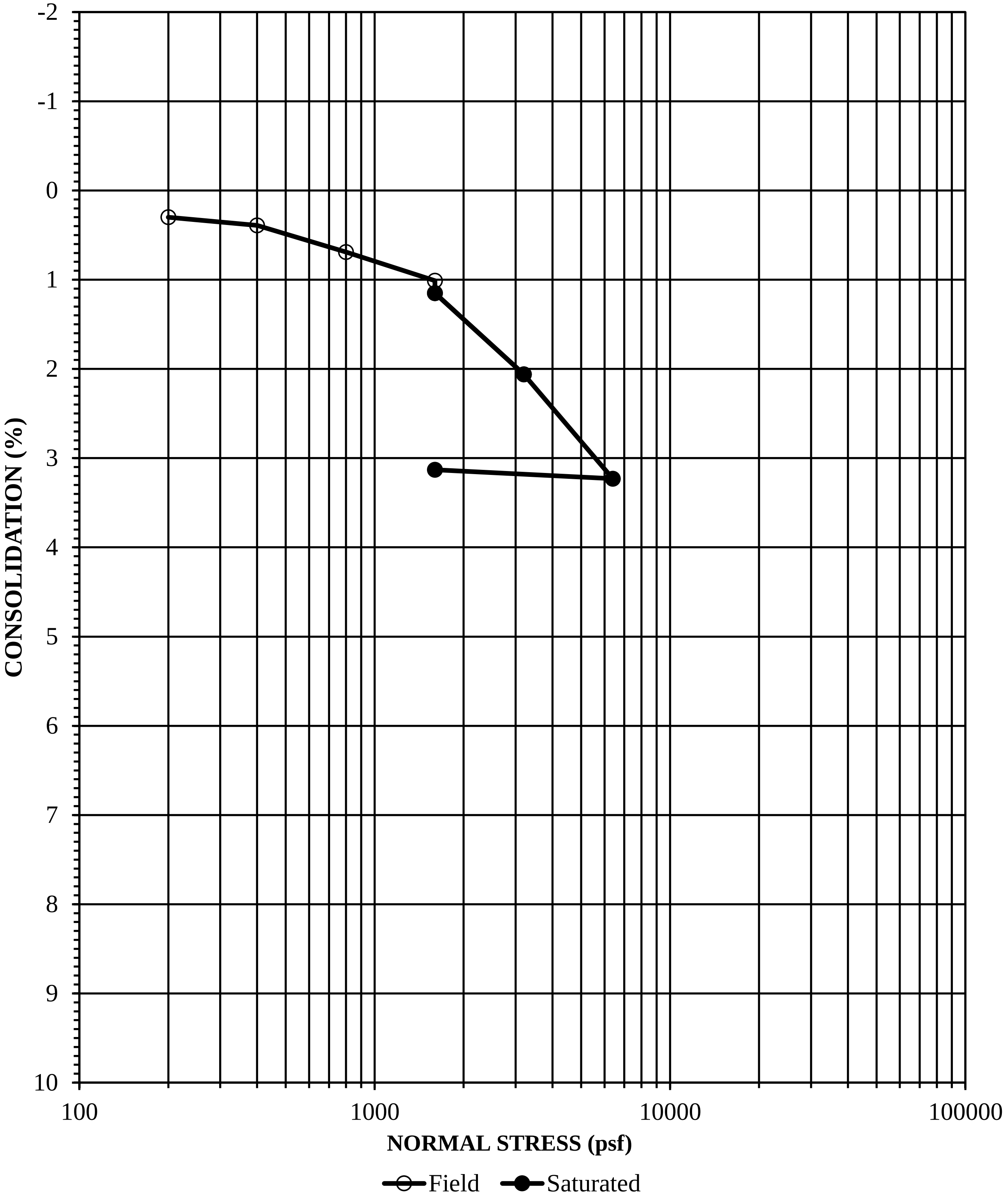
Job Number	Location	Depth	Description
2841.00	B-1	20	Clayey Sand (SC)

GRAIN SIZE DISTRIBUTION



Job Number	Location	Depth	Description
2841.00	B-1	30	Clayey Sand (SC)

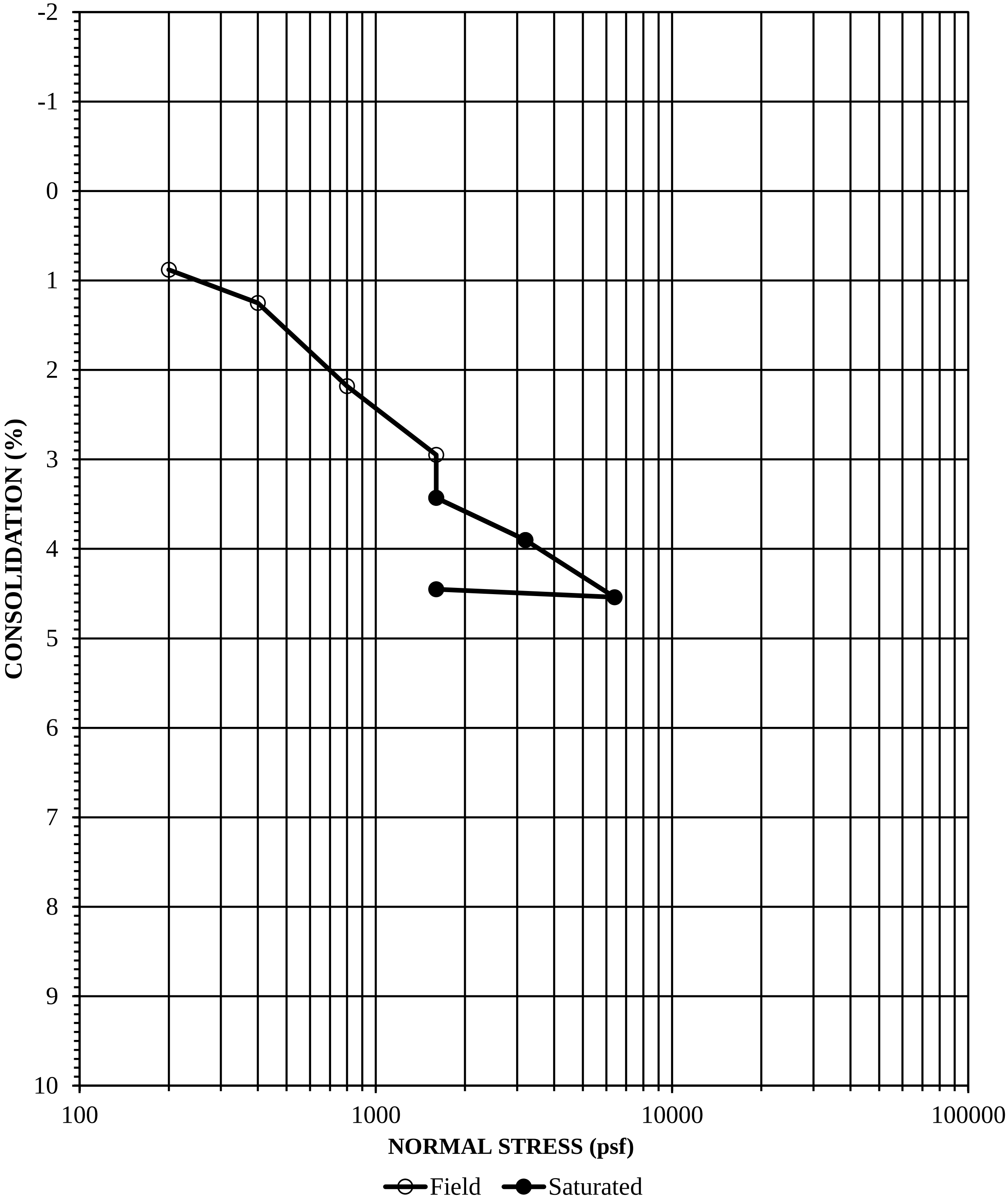
CONSOLIDATION



Job Number	Location	Depth	Description
2841.00	B-1	4	Silty Sand (SM)

Initial Dry Density (pcf)	Initial Moisture Content (%)	Final Moisture Concent (%)
117.9	10.5	12.4

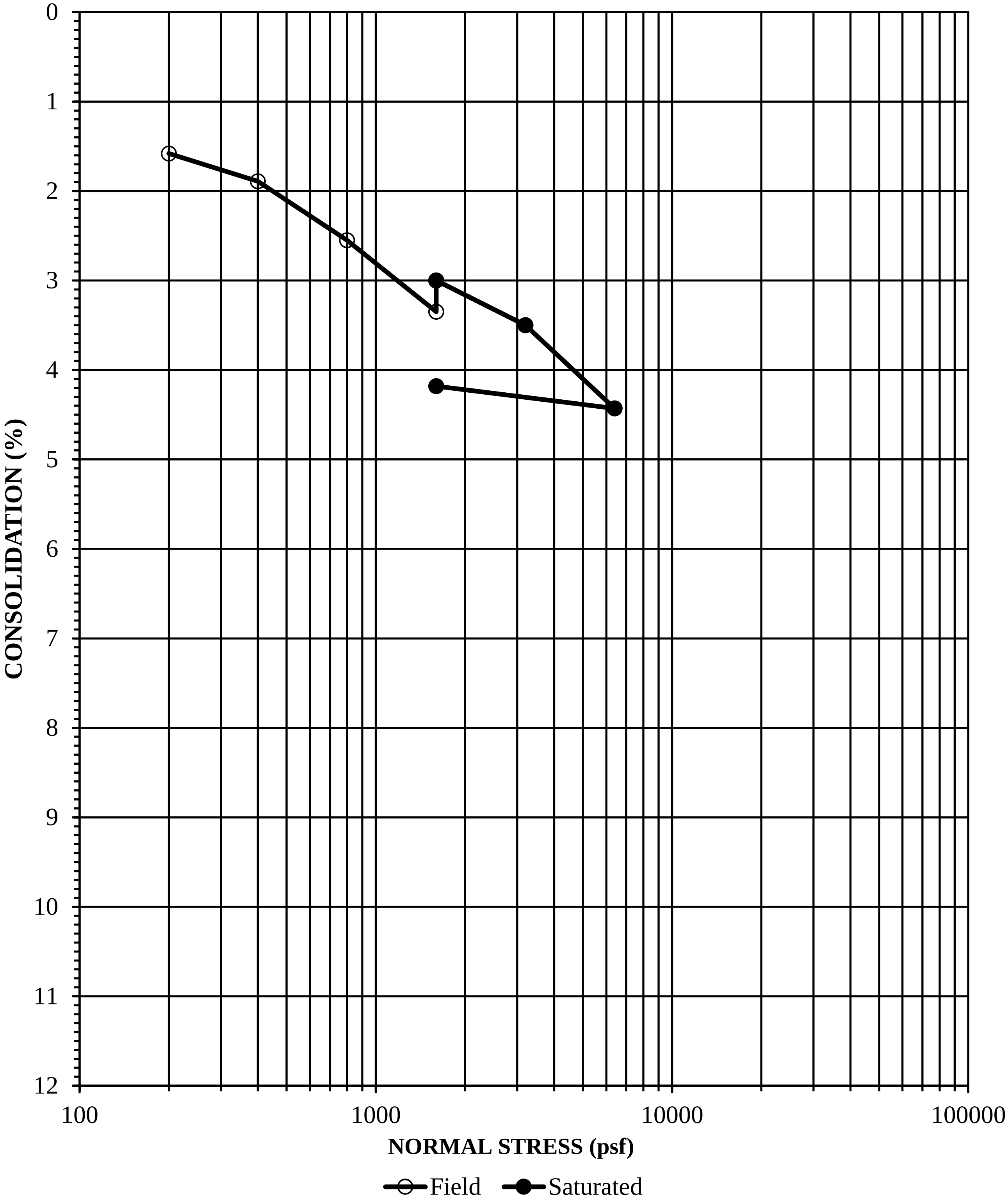
CONSOLIDATION



Job Number	Location	Depth	Description
2841.00	B-4	4	Silty Sand (SM)

Initial Dry Density (pcf)	Initial Moisture Content (%)	Final Moisture Concent (%)
123.8	9.5	9.2

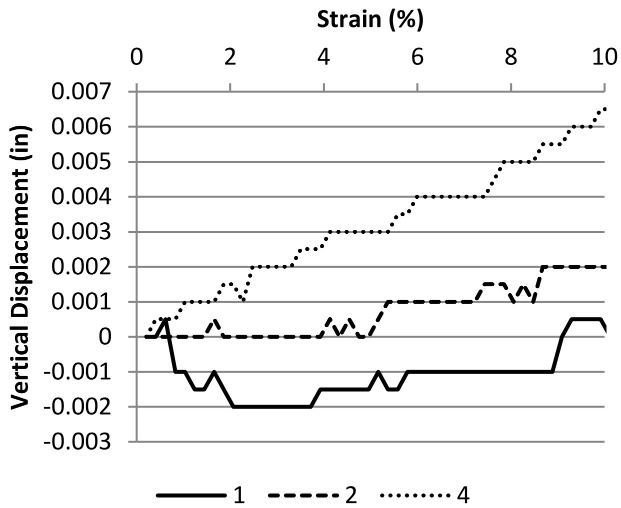
CONSOLIDATION

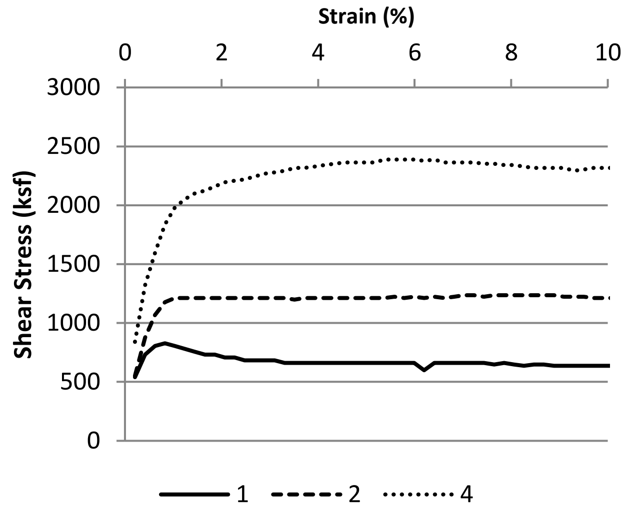


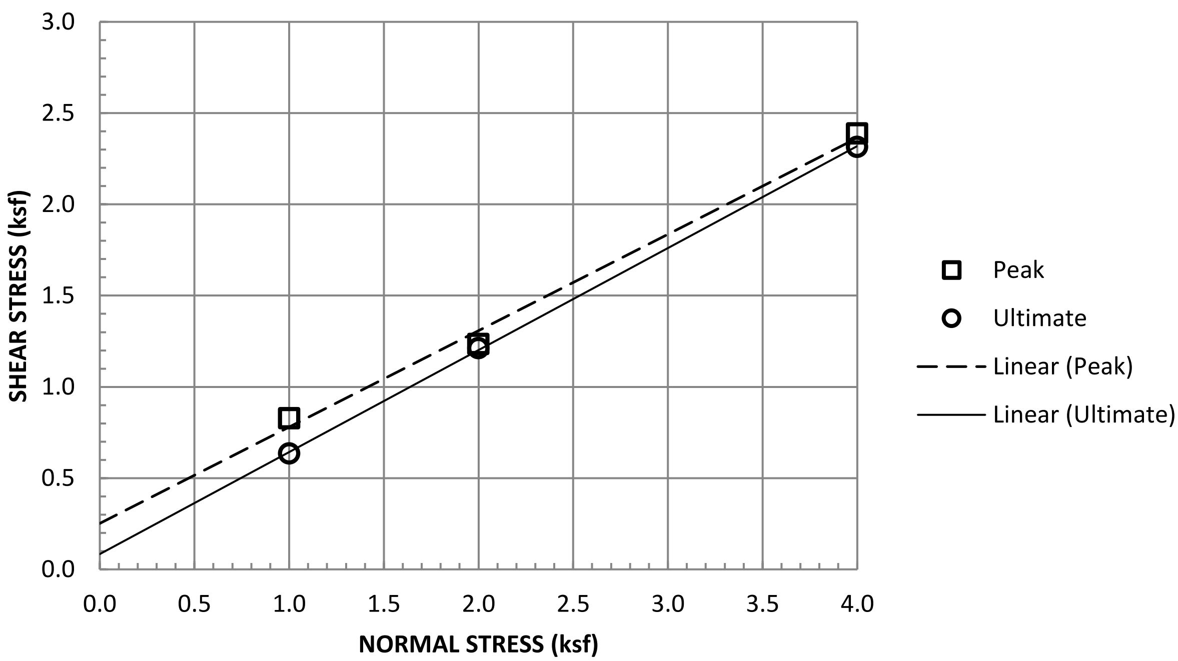
Job Number	Location	Depth	Description
2841.00	B-4	6	Silty Sand with Clay (SM)

Initial Dry Density (pcf)	Initial Moisture Content (%)	Final Moisture Concent (%)
111.2	17.3	17.2

DIRECT SHEAR







Sample Type:	Remolded 90% of 124.5 @ 11%, Saturated		
Normal Stress (ksf)	1	2	4
Peak Shear Stress (ksf)	0.828	1.236	2.388
Peak Displacement (in)	0.002	0.002	0.007
Ultimate Shear Stress (ksf)	0.636	1.212	2.316
Ultimate Displacement (in)	0.25	0.25	0.25
Initial Dry Density (pcf)	112.1	112.1	112.1
Initial Moisture Content (%)	11	11	11
Final Moisture Content (%)	14.8	15.1	15.2
Strain Rate (in/min)	0.01		

Job Number	Location	Depth	Description
2841.00	B-1	0-5	Silty Sand (SM)

December 2, 2019
J.N.: 2841.00

Mr. Chris Killian
National Community Renaissance
9421 Haven Avenue
Rancho Cucamonga, CA 91730

Subject: **Preliminary Percolation Study, Proposed Multi-Family Residential Development, 24551 Raymond Way, Lake Forest, California.**

Dear Mr. Killan,

Albus-Keefe & Associates, Inc. has completed a geotechnical investigation of the site for evaluation of the percolation characteristics of the site soils. The scope of this investigation consisted of the following:

- Exploratory drilling, soil sampling and test well installation
- Field percolation testing
- Laboratory testing of selected soil samples
- Engineering analysis of the data
- Preparation of this report

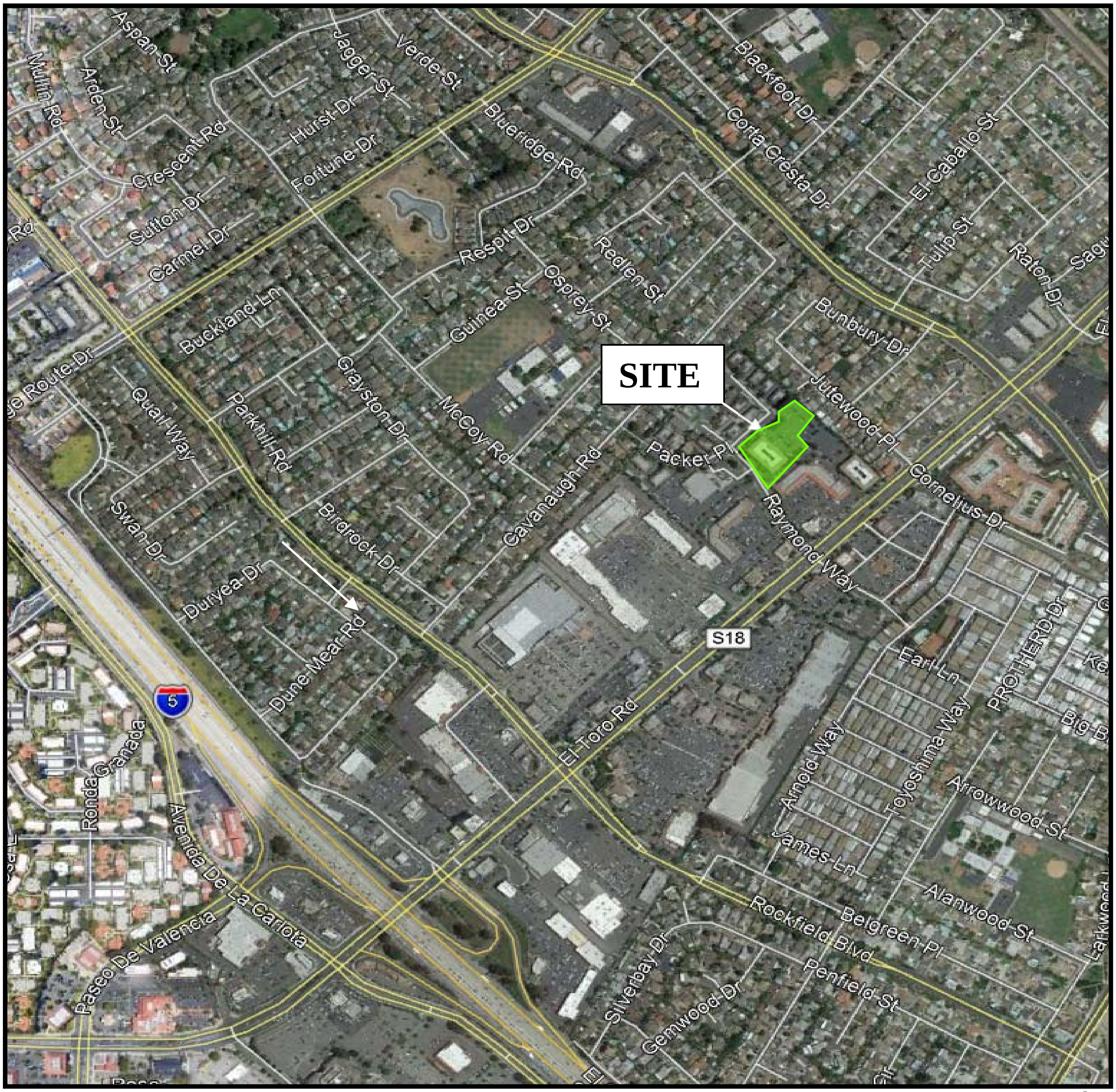
SITE DESCRIPTION AND PROPOSED DEVELOPMENT

Site Location and Description

The site is located at 24551 Raymond Way, within the city of Lake Forest, California. The property is bordered by Raymond Way to the southwest, Packer Place to northwest, single-family homes to northeast and northwest, a multi-tenant retail plaza to the southeast and a parking lot to the northeast. The location of the site and its relationship to the surrounding areas are shown on Figure 1, Site Location Map.

The site consists of an irregular-shaped property comprising approximately 1.9 acres of land. The site is relatively flat with elevations ranging from EL391 to EL396 above mean sea level (based on Google Earth). Drainage within the site is generally directed as a sheet flow towards Packer Place. The site is currently occupied by 2-story commercial building and asphaltic parking lot.

Vegetation within the site consists of grass turf adjacent to the existing building. Several small trees and bushes are present throughout the site within the islands of the parking lot, adjacent to the existing building, and along the perimeter.



N

SITE LOCATION MAP

National Community Renaissance
Proposed Multi-Family Residential Development
24551 Raymond Way
Lake Forest, California

NOT TO SCALE

FIGURE 1

Proposed Development

Based on the architectural site plans by RRM design group, the proposed development for the site will consist of a partial four-story residential building with an interior courtyard and playground area, on-grade parking lot, perimeter site walls, and underground utilities.

No grading or structural plans were available in preparation of this report. However, we anticipate that minor rough grading of the site will be required to achieve future surface configuration. We expect the proposed residential dwellings will be wood-framed structures with concrete slabs on grade yielding relatively light foundation loads.

SUMMARY OF FIELD AND LABORATORY WORK

Subsurface Investigation

Subsurface exploration for this investigation was conducted on October 2, 2019, and consisted of drilling four (4) soil borings to depths ranging from approximately 11.5 to 51.5 feet below the existing ground surface (bgs). The borings were drilled using a truck-mounted, continuous flight, hollow-stem-auger drill rig. A representative of Albus-Keefe & Associates, Inc. logged the exploratory borings. Visual and tactile identifications were made of the materials encountered, and their descriptions are presented in the Exploration Logs in Appendix A. Two additional borings were drilled near boring B-1 for use in percolation testing. These borings were not logged or sampled. Approximately 5 feet of well screening was installed at the bottom of each percolation well with solid pipe extending the reminder of the distance to the ground surface. The annular space of the well screen sections was filled with gravel. At the completion of all work, piping for the test wells were removed and the borings were backfilled with auger cuttings. The approximate locations of the exploratory excavations completed by this firm are shown on the enclosed Geotechnical Map, Plate 1.

Bulk, relatively undisturbed and standard penetration test (SPT) samples were obtained at selected depths within the exploratory borings for subsequent laboratory testing. Relatively undisturbed samples were obtained using a 3-inch O.D., 2.5-inch I.D., California split-spoon soil sampler lined with brass rings. SPT samples were obtained from the boring using a standard, unlined SPT soil sampler. During each sampling interval, the sampler was driven 18 inches with successive drops of a 140-pound automatic hammer falling 30 inches. The number of blows required to advance the sampler was recorded for each six inches of advancement. The total blow count for the lower 12 inches of advancement per soil sample is recorded on the exploration log. Samples were placed in sealed containers or plastic bags and transported to our laboratory for analyses. The borings were backfilled with auger cuttings upon completion of sampling.

Percolation Testing

Percolation testing was performed on October 2, 2019, in general conformance with the constant-head test procedures outlined in the referenced Well Permeameter Method (USBR 7300-89). A water hose attached to a water source on site was connected to an inline flowmeter to measure the water flow. The flowmeter is capable of measuring flow rates up to 10 gallons per minute and as low as 0.06 gallons per minute. A valve was connected in line with the flowmeter to control the flow rate. A filling hose was used to connect the flowmeter and the test wells. Water was introduced by the filling hose near the bottom of the test wells. A water level meter with 1/100-foot divisions was used to measure the depths to water surface from the top of well casings.

Flow to the wells was terminated upon either completion of testing of all the pre-determined water levels or the flow rate exceeded the maximum capacity of the flowmeter. Measurements obtained during the percolation testing are provided in Appendix C on Plates C-1 and C-2.

Laboratory Testing

Selected soil samples of representative earth materials were tested to assist in the formulation of conclusions and recommendations presented in this report. Tests consisted of in-situ moisture contents and dry densities, and sieve analyses. Results of laboratory testing relevant to percolation characteristics are presented in Appendix B and on the Exploration Logs in Appendix A.

ANALYSIS OF DATA

Subsurface Conditions

Descriptions of the earth materials encountered during our investigation are summarized below and are presented in detail on the Exploration Logs presented in Appendix A.

Soil materials encountered at the subject site consisted of approximately 6 feet of artificial fill over very old alluvial fan deposits. The artificial fill is predominately comprised of grayish brown and light brown silty sand. These fill materials typically were observed to be slightly moist and dense to very dense.

The very old alluvial fan deposits encountered are primarily comprised of reddish-brown clayey sand to a depth of approximately 35 feet. Below this depth, the very old alluvium becomes a silty clay/clayey silt that is slightly moist to moist and hard.

Groundwater

Groundwater was encountered during this firm's subsurface exploration at the depth of 41 feet. Based on a review of the referenced CDMG Special Report, the site is mapped with a historical groundwater depth between 10 and 20 feet. Research of groundwater data from the State Water Resources Control Board GeoTracker database, indicates groundwater levels as shallow as 20 feet. The shallower occurrences of ground water in other locations in the vicinity are likely due to localized perched conditions upon finer-grained soil layers within the granular zone. The finer-grained layers are likely lenticular and appear absent from the subject site within the upper 35 feet.

Percolation Data

Analyses were performed to evaluate permeability using the flow rate obtained at the end of the constant-head stage of field percolation testing. These analyses were performed in accordance with the procedures provided in the referenced USBR 7300-89. The procedure essentially uses a closed-form solution to the percolation out of a small-diameter well.

Using the USBR method, we calculated a composite permeability value for the head condition maintained in each well. The results are summarized in Table 1 below and the supporting analyses are included in Appendix C, Plates C-3 and C-4.

TABLE 1
Summary of Back-Calculated Permeability Coefficient

	Total Depth of Well (ft)	Depth to Water in Well (ft)	Height of Water in Well (ft)	Static Flow Rate (gal./min.)	Estimated Permeability, k_s (in/hr.)
P-1	20.0	15.0	5.0	1.5	2.27
P-2	25.0	20.0	5.0	0.75	1.13

Design of Dry Well

The ***infiltration rate*** in a dry well is dependent upon several factors including the soil permeabilities of the various soil layers throughout the soil mass, hydraulic gradient of water pressure head in the soil mass, and depth to groundwater. The infiltration rate is related to the permeability by Darcy's equation:

$V = ki$

Where:

V= water velocity (infiltration rate)
k= permeability
i=hydraulic gradient

The presence of differing soil layers with differing permeabilities, the variable head condition in the well shaft, and presence of ground water are factors that make determining the effective infiltration rate of the dry well somewhat complicated. We have performed the Well Permeameter tests in accordance with the test method. This test provides a means to estimate the ***Permeability Rate*** of the soils influencing the dry well, not the infiltration rate. Therefore, the effective infiltration rate must be determined using the relationship between permeability and infiltration rate as expressed by Darcy's equation. Solution of the Darcy equation essentially requires solving a differential mass balance equation. Due to these complications, the infiltration characteristics of the proposed dry well were modeled using a computer program.

Infiltration in a dry well was modeled using the software Seep/W, version 2007, by Geo-Slope International. The program allows for modeling of both partially-saturated and saturated porous medium using a finite element approach to solve Darcy's Law. The program can evaluate both steady-state and transient flow in planar and axisymmetric cases. Boundaries of the model can be identified with various conditions including fix total head, fix pressure head, fix flow rate, and head as a function of flow. Soil conductivity properties can be modeled with either Fredlund et al (1994), Green and

Corey (1971), Van Genuchten (1980), or Saxton et al. (1986). The parameters suggested by Van Genuchten (1980) were selected for use in our model and were based on test results of particle-size analyses and estimated in-place densities.

A Seep/W model was setup with the bottom of the dry well at a depth of 30 feet below ground surface. The top 20 feet of the dry well assumed a shaft that is 6 feet in diameter and contains a settling chamber having an inside diameter of 4 feet, outside diameter of 4.5 feet, and length of 18 feet. Below 20 feet, the shaft diameter was 4 feet in diameter. The annular space around the chamber between the depths of 0 and 13 feet was assumed to consist of a cement slurry. Below a depth of 13 feet, the annular space around the chamber and below the chamber is assumed to consist of gravel. A more detailed model of the dry well design can be found on Plate 2.

The model consisted of three zones of material to represent the general soil profile. The upper zone (depth 0 to 10 feet) was represented by a set of input parameters to practically make it impermeable due to the fine-grained nature of the material. For the second layer (depth 10 to 35 feet), the saturated conductivity was modeled to represent the clayey sand observed predominantly in this depth range. The properties of this layer were selected based on the coefficient of permeability estimated from percolation tests as well as laboratory gradation test results (Plates B-1 through B-3). The third layer (below depth 35 feet) was estimated from laboratory gradation test results. The soil parameters are summarized in Table 2.

Groundwater was set at a depth of 40 feet using a fix-head boundary which was set on the outside boundary of the problem. Water in the well was assumed to be at a depth of 7 feet below the ground surface so a fix-head boundary was set with a total head elevation of 93 feet around the edge of the well.

TABLE 2
Summary of Characteristic Curve Parameters

Material No.	Material Type	Depth (ft)	Sat. Perm., Ks (in/hr)	Van Genuchten Parameters				
				a (psf)	n	m	Sat. Water Content	Residual Water Content
1	Imperm.	0 – 10	0.001	196	1.21	0.17	0.40	0.010
2	SC/SP	10 – 35	1.0	28	1.17	0.14	0.42	0.010
3	ML/CL	>35	0.05	32	1.32	0.24	0.36	0.025

A steady state analysis was performed to estimate the maximum inflow that the well can accommodate. Using a well as described above, we obtain a static total flow of 0.018 ft^3/sec. A plot depicting the resulting pressure head contours and flow vectors for the model is provided on Plate C-5. The average infiltration rate can be determined by taking the flow rate divided by the wetted surface area. The surface area is equal to 258 square feet which includes the side and bottom area. Based on the above flow rate and surface area, the average “measured” infiltration rate across the wetted surface area is 3.0 in/hr.

To evaluate the time required to empty the well once no more water is introduced, the model was reanalyzed with a variable head condition that was dependent upon the volume of water leaving the well. As water infiltrates into the surrounding soil, the volume of water remaining in the well is reduced as well as the resulting water head. A graph of the well head versus exit volume is provided in Figure 2. The function assumes a void ratio of 0.4 within the zones occupied by gravel. If some other well configuration is used, then the analyses will require updating.

The analysis was performed as a transient case over a total time of 13 hours. The conditions in the model were evaluated in 12 increments of time over the total duration. From our analyses, the water is evacuated from the chamber in approximately 8.5 hours. Plots depicting the resulting pressure head contours and flow vectors at selected times are provided in Appendix C on Plates C-6 through C-10. A plot of time versus water height in the well is shown on Figure 3.

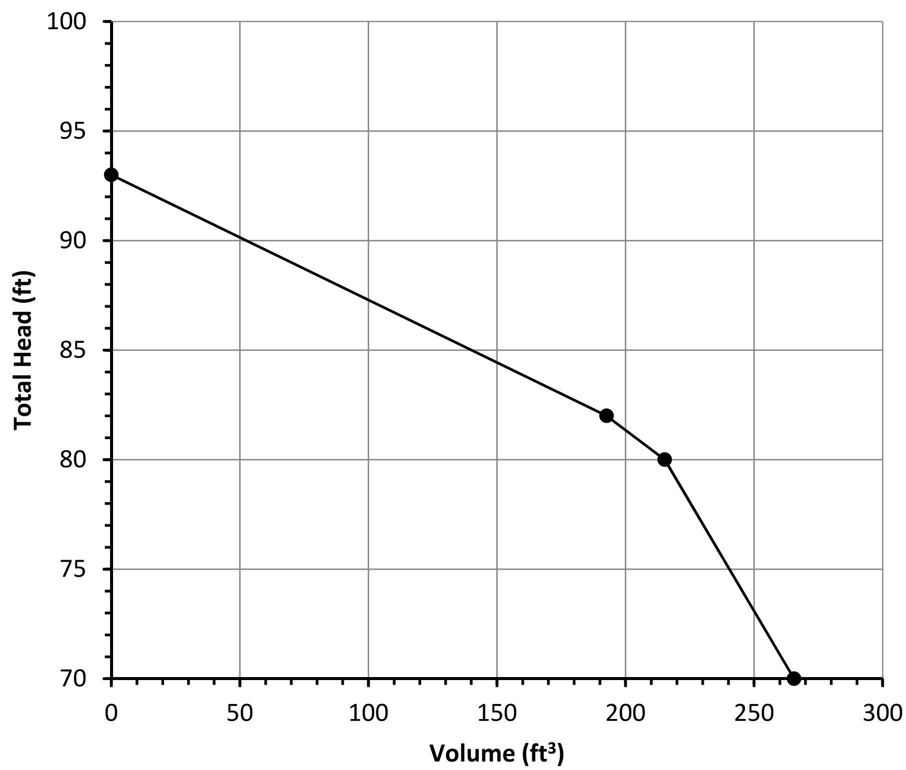


FIGURE 2- Well Head versus Exit Volume

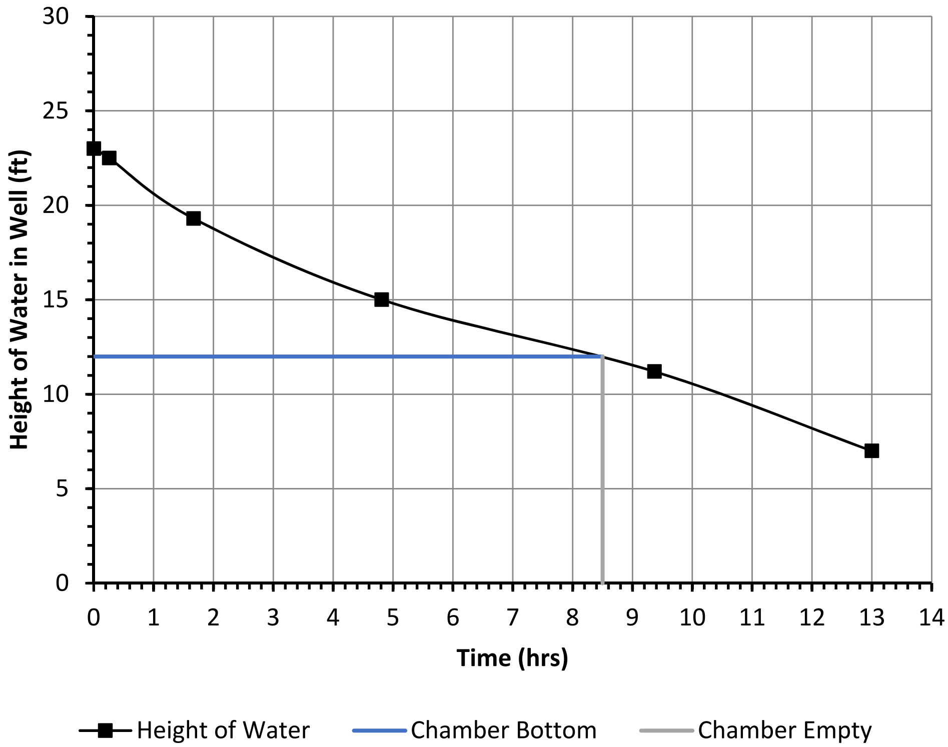


FIGURE 3- Water Head Versus Time

CONCLUSIONS AND RECOMMENDATIONS

Results of our work indicate a storm water disposal system consisting of a dry well is feasible at the site. The use of a dry well is not anticipated to result in worsening any adverse conditions or hazards that may be present for the proposed site development or adjacent properties including subsidence, landsliding, or liquefaction. As discussed above, the groundwater level in this area is approximately 41 feet below ground surface. Therefore, a dry well having a total depth of 30 will maintain a clearance above groundwater greater than the minimum required clearance of 10 feet.

Based on the results of percolation testing and analyses, the well configuration as depicted on Plate 2 may utilize a "measured" peak flow rate of 0.018 ft^3/sec. This flow rate corresponds to an average peak infiltration rate of 3.0 in./hr. This flow rate and infiltration rate only apply to the well configuration evaluated and will differ for other configurations. These values are "measured" values and as such, an appropriate factor of safety should be applied to determine the "design" rates.

The "measured" infiltration rates reported above should be adjusted by applying an appropriate factor of safety. Table 3 includes the details of estimating this factor of safety for Factor Category A per requirements of the Santa Ana Regional Water Quality Control Board. The civil engineer should assign appropriate factor values for Factor Category B to obtain the overall factor of safety.

TABLE 3
Factor Values for Factor Category A

Infiltration Facility Safety Factor Determination Worksheet					
Factor Category		Factor Description	Assigned Weight (w)	Factor Value (v)	Product (p) p = w * v
A	Suitability Assessment	Soil assessment methods	0.25	1	0.25
		Predominant soil texture	0.25	1	0.25
		Site soil variability	0.25	1	0.25
		Depth to groundwater / impervious layer	0.25	3	0.75
		Suitability Assessment Safety Factor, $S_A = \Sigma p$			1.5

Once water flow to the well has ceased, it is estimated to require approximately 8.5 hours to empty the chamber. As such, the time to empty for the dry well should be considered in the overall draw down time of the storm system.

Should you require multiple dry wells across the site, the wells should be spaced at least 120 feet, center to center, to avoid cross influence. The wells should be located at least 10 feet horizontally from any habitable structure or property line.

The actual flow capacity of the dry well could be less or more than the estimated value. As such, provisions should be made to accommodate excess flow quantities in the event the dry well does not infiltrate the anticipated amount. The design also assumes that sediments will be removed from the inflowing water through an upper chamber or other device. Sediments that are allowed to enter the dry well will tend to degrade the flow capacity by plugging up the infiltration surfaces.

In general, the dry well shaft is anticipated to be adequately stable under temporary construction conditions for uncased drilling. However, layers or lenses of granular materials are present and may be prone to sloughing and caving. In the event of caving, casing will be required to install the well. Workers should not enter the shaft unless the excavation is laid back or shored in accordance with OSHA requirements. The placement and compaction of backfill materials, including the gravel and slurry, should be observed by the project geotechnical consultant.

LIMITATIONS

This report is based on the geotechnical data as described herein. The materials encountered in our boring excavations and utilized in our laboratory testing for this investigation are believed representative of the project area, and the conclusions and recommendations contained in this report are presented on that basis. However, soil and bedrock materials can vary in characteristics between points of exploration, both laterally and vertically, and those variations could affect the conclusions and recommendations contained herein. As such, observations by a geotechnical consultant during the construction phase of the storm water infiltration systems are essential to confirming the basis of this report.

This report has been prepared consistent with that level of care being provided by other professionals providing similar services at the same locale and time period. The contents of this report are professional opinions and as such, are not to be considered a guaranty or warranty.

This report should be reviewed and updated after a period of one year or if the site ownership or project concept changes from that described herein.

This report has been prepared for the exclusive use of **National Community Renaissance** to assist the project consultants in the design of the proposed development. This report has not been prepared for use by parties or projects other than those named or described herein. This report may not contain sufficient information for other parties or other purposes.

This report is subject to review by the controlling governmental agency.

We appreciate this opportunity to be of service to you. If you should have any questions regarding the contents of this report, please do not hesitate to call.

Sincerely,

ALBUS-KEEFE & ASSOCIATES, INC.

David E. Albus
Principal Engineer
GE 2455

REGISTERED PROFESSIONAL ENGINEER
DAVID E. ALBUS
No. 2455
Exp. 12/31/20
GEOTECHNICAL
STATE OF CALIFORNIA

Enclosures: Plate 1- Geotechnical Map
Plate 2- Dry Well Diagram
Appendix A - Exploratory Logs
Appendix B – Laboratory Testing
Appendix C - Percolation Testing and Analyses

REFERENCES

Publications and Reports

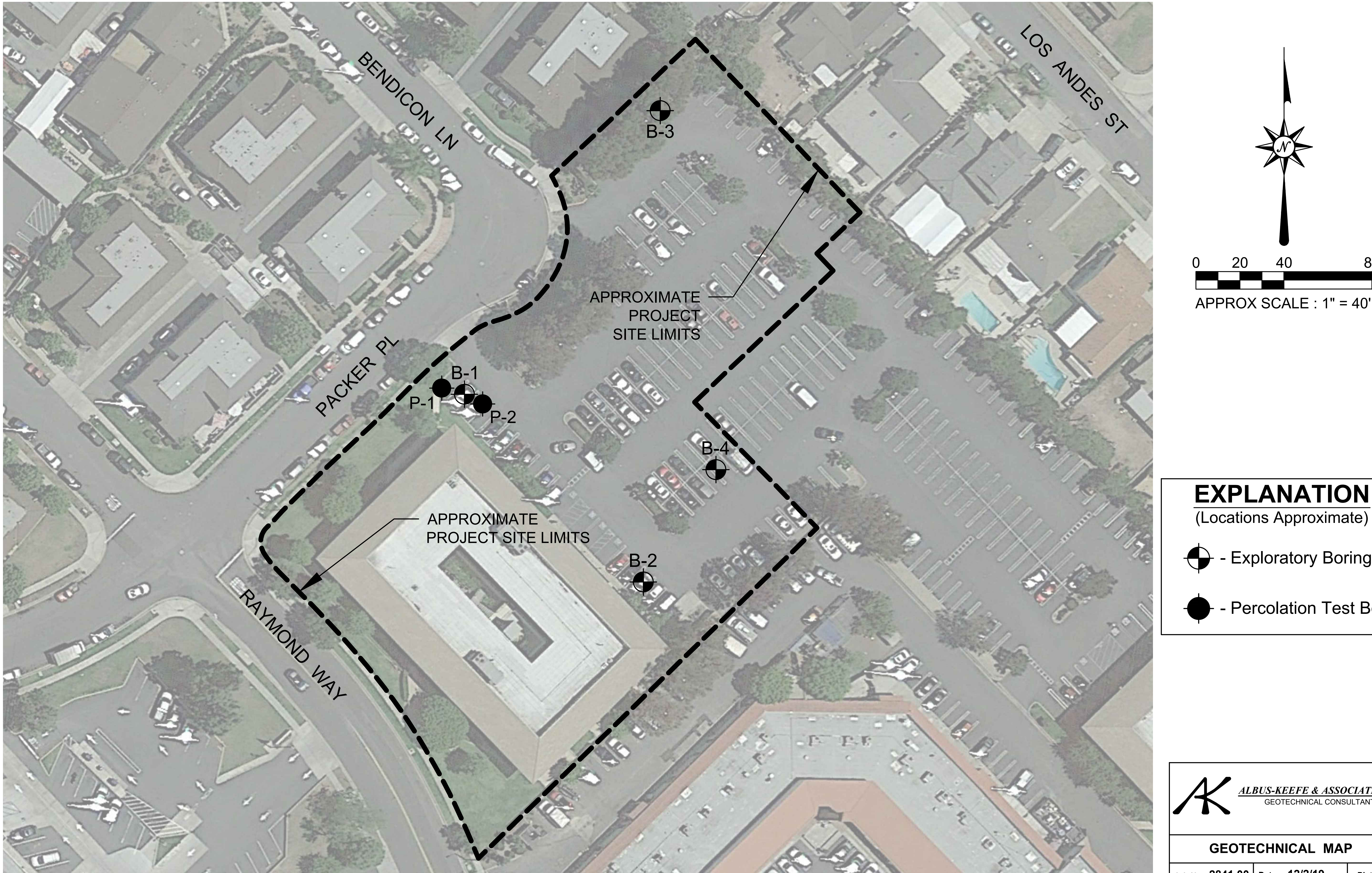
CDMG, "Seismic Hazard Zone Report for the Lake Forest 7.5-Minute Quadrangles, Orange County, California," Seismic Hazard Zone Report 047, 2000.

Californian Department of Water Resources Water Data Library (accessed 2019): http://wdl.water.ca.gov/waterdatalibrary/

Procedure for Performing Field Permeability Testing by the Well Permeameter Method, by United States Department of The Interior, Bureau of Reclamation (USBR 7300-89).

Saxton, K.E., W.J. Rawls, J.S. Romberger, and R.I. Papendick. 1986. Estimating generalized soil-water characteristics from texture. Soil Sci. Soc. Am. J. 50(4):1031-103

Department of The Navy, (1982), *Soil Mechanics, Design Manual 7.1*, Naval Facilities Engineering Command (NAVFAC)



EXPLANATION
(Locations Approximate)

- Exploratory Boring
- Percolation Test Boring

ALBUS-KEEFE & ASSOCIATES, INC.
GEOTECHNICAL CONSULTANTS

GEOTECHNICAL MAP

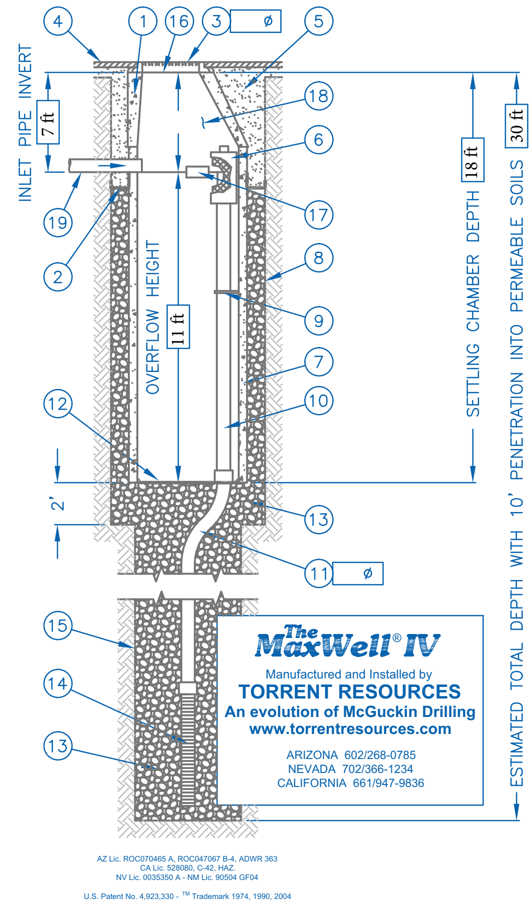
Job No.: 2841.00	Date: 12/2/19	Plate: 1

MAXWELL® IV DRAINAGE SYSTEM DETAIL AND SPECIFICATIONS

ITEM NUMBERS

1. **Manhole Cone** - Modified Flat Bottom.
2. **Moisture Membrane** - 6 Mil. Plastic. Applies only when native material is used for backfill. Place membrane securely against eccentric cone and hole sidewall.
3. **Bolted Ring & Grate** - Diameter as shown. Clean cast iron with wording **"Storm Water Only"** in raised letters. **Bolted in 2 locations** and secured to cone with mortar. Rim elevation ±0.02' of plans.
4. **Graded Basin or Paving** (by Others).
5. **Compacted Base Material** - 1-Sack Slurry except in landscaped installtions with no pipe connections.
6. **PureFlo® Debris Shield** - Rolled 16 ga. steel X 24" length with vented anti-siphon and Internal .265" Max. SWO flattened expanded steel screen X 12" length. **Fusion bonded epoxy coated.**
7. **Pre-cast Liner** - 4000 PSI concrete 48" ID. X 54" OD. **Center in hole** and align sections **to maximize bearing surface.**
8. **Min. 6' Ø Drilled Shaft.**
9. **Support Bracket** - Formed 12 Ga. steel. **Fusion bonded epoxy coated.**
10. **Overflow Pipe** - Sch. 40 PVC mated to drainage pipe at base seal.
11. **Drainage Pipe** - ADS highway grade with TRI-A coupler. **Suspend pipe** during backfill operations to prevent buckling or breakage. Diameter as noted.
12. **Base Seal** - Geotextile or concrete slurry.
13. **Rock** - Washed, sized between 3/8" and 1-1/2" to **best complement soil conditions.**
14. **FloFast® Drainage Screen** - Sch. 40 PVC 0.120" slotted well screen with 32 slots per row/ft.Diameter varies 120" overall length with TRI-B coupler.
15. **Min. 4' Ø Shaft** - Drilled to **maintain permeability** of drainage soils.
16. **Fabric Seal** - U.V. resistant geotextile - **to be removed by customer** at project completion.
17. **Absorbent** – Hydrophobic Petrochemical Sponge. Min. to 128 oz. capacity.
18. **Freeboard Depth** Varies with inlet pipe elevation. Increase settling chamber depth as needed to maintain all inlet pipe elevations above overflow pipe inlet.
19. **Optional Inlet Pipe** (Maximum 4", by Others). Extend moisture membrane and compacted base material or 1 sack slurry backfill below pipe invert.

The referenced drawing and specifications are available on CAD either through our office or web site. This detail is copyrighted (2004) but may be used as is in construction plans without further release. For information on product application, individual project specifications or site evaluation, contact our Design Staff for no-charge assistance in any phase of your planning.



CALCULATING MAXWELL IV REQUIREMENTS

The type of property, soil permeability, rainfall intensity and local drainage ordinances determine the number and design of MaxWell Systems. For general applications draining retained stormwater, use one standard **MaxWell IV** per the instructions below for up to 3 acres of landscaped contributory area, and up to 1 acre of paved surface. For larger paved surfaces, subdivision drainage, nuisance water drainage, connecting pipes larger than 4" Ø from catch basins or underground storage, or other demanding applications, refer to our **MaxWell® Plus** System. For industrial drainage, including gasoline service stations, our **Envibro® System** may be recommended. For additional considerations, please refer to **"Design Suggestions For Retention And Drainage Systems"** or consult our Design Staff.

COMPLETING THE MAXWELL IV DRAWING

To apply the **MaxWell IV** drawing to your specific project, simply fill in the blue boxes per instructions below. For assistance, please consult our Design Staff.

ESTIMATED TOTAL DEPTH

The Estimated Total Depth is the approximate depth required to achieve 10 continuous feet of penetration into permeable soils. Torrent utilizes specialized **"crowd"** equipped drill rigs to penetrate difficult, cemented soils and to reach permeable materials at depths up to **180 feet.** Our extensive database of drilling logs and soils information is available for use as a reference. Please contact our Design Staff for site-specific information on your project.

SETTLING CHAMBER DEPTH

On MaxWell IV Systems of over 30 feet overall depth and up to 0.25cfs design rate, the **standard** Settling Chamber Depth is **18 feet .** For systems exposed to greater contributory area than noted above, extreme service conditions, or that require higher design rates, chamber depths up to 25 feet are recommended.

' OVERFLOW HEIGHT

The Overflow Height and Settling Chamber Depth determine the effectiveness of the settling process. The higher the overflow pipe, the deeper the chamber, the greater the settling capacity. For normal drainage applications, an overflow height of **13 feet** is used with the standard settling chamber depth of **18 feet**. Sites with higher design rates than noted above, heavy debris loading or unusual service conditions require greater settling capacities

"Ø DRAINAGE PIPE

This dimension also applies to the **PureFlo®** Debris Shield, the **FloFast®** Drainage Screen, and fittings. The size selected is based upon system design rates, soil conditions, and the need for adequate venting. Choices are 6", 8", or 12" diameter. Refer to "Design Suggestions for Retention and Drainage Systems" for recommendations on which size best matches your application.

"Ø BOLTED RING & GRATE

Standard models are quality cast iron and available to fit 24" Ø or 30" Ø manhole openings. All units are bolted in two locations with wording "Storm Water Only" in raised letters. For other surface treatments, please refer to "Design Suggestions for Retention and Drainage Systems."

"Ø INLET PIPE INVERT

Pipes up to 4" in diameter from catch basins, underground storage, etc. may be connected into the settling chamber. Inverts deeper than 5 feet will require additional settling chamber depth to maintain effective overflow height.

TORRENT RESOURCES INCORPORATED

1509 East Elwood Street, Phoenix Arizona 85040~1391
phone 602~268~0785 fax 602~268~0820

Nevada 702~366~1234

AZ Lic. ROC070465 A, ROC047067 B-4; ADWR 363
CA Lic. 528080 A, C-42, HAZ ~ **NV Lic.** 0035350 A ~ **NM Lic.** 90504 GF04

1/12

TORRENT RESOURCES (CA) INCORPORATED

phone 661~947~9836

CA Lic. 886759 A, C-42

www.TorrentResources.com

An evolution of McGuckin Drilling

The watermark for drainage solutions.®

Plate 2

TORRENT® RESOURCES

APPENDIX A

EXPLORATORY LOGS

EXPLORATION LOG

Project:		Location:
Address:		Elevation:
Job Number:	Client:	Date:
Drill Method:	Driving Weight:	Logged By:

Depth (feet)	Lith-ology	Material Description	Water	Samples: Blows Per Foot	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
		EXPLANATION							
		Solid lines separate geologic units and/or material types.							
5		Dashed lines indicate unknown depth of geologic unit change or material type change.							
		Solid black rectangle in Core column represents California Split Spoon sampler (2.5in ID, 3in OD).			■				
		Double triangle in core column represents SPT sampler.			⧗				
10		**Vertical Lines** in core column represents Shelby sampler.			▥				
		Solid black rectangle in Bulk column respresents large bag sample.				■			
15		**Other Laboratory Tests:** Max = Maximum Dry Density/Optimum Moisture Content EI = Expansion Index SO4 = Soluble Sulfate Content DSR = Direct Shear, Remolded DS = Direct Shear, Undisturbed SA = Sieve Analysis (1" through #200 sieve) Hydro = Particle Size Analysis (SA with Hydrometer) 200 = Percent Passing #200 Sieve Consol = Consolidation SE = Sand Equivalent Rval = R-Value ATT = Atterberg Limits							
20									

Albus-Keefe & Associates, Inc.

Plate A-1

EXPLORATION LOG

Project: 4-Story Multi-Family Housing Development		Location: B-1
Address: 24551 Raymond Way, Lake Forest, CA 92630		Elevation: 395
Job Number: 2841.00	Client: National Community Renaissance	Date: 10/2/2019
Drill Method: Hollow-Stem Auger	Driving Weight: 140 lbs / 30 in	Logged By: SD

Depth (feet)	Lith-ology	Material Description	Water	Samples: Blows Per Foot	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
		Asphalt (AC): Black							SO4 DS pH Resist Ch
		ARTIFICIAL FILL (Af) Silty Sand (SM): Mottled olive brown, reddish brown, and light brown, slightly moist, very dense, fine to medium grained sand, clay nodules, trace pin-hole poros		80/ 10"			11.1	116	
5		@ 4 ft, light grayincreased clay content		76/ 8"			10.2	111.2	Consol
		VERY OLD ALLUVIAL FAN DEPOSITS (Qvof) Sandy Clay (CL): Gray, moist, hard, fine grained sand		72/ 11"			12.8	118.2	
		Clayey Sand (SC): Mottled gray and reddish gray, slightly moist, very dense, fine to medium grained sand, caliche							
10		Clayey Sand/ Sandy Clay (SC/CL): yellowish gray, slightly moist, very dense/ hard, trace coarse grained sand, iron oxide stainings		73/ 8"			11		
		Clayey Sand (SC): Light brown, slightly moist, dense, fine to coarse grained sand, iron oxide stainings							
15		@ 15 ft, reddish brown, moist		29					SA Hydro
		Clayey Sand : Mottled olive brown and gray, moist, very dense, fine to coarse grained sand, increased medium grained sand, some silt inner layers, increased clay							
20				36					SA Hydro

EXPLORATION LOG

Project: 4-Story Multi-Family Housing Development		Location: B-1
Address: 24551 Raymond Way, Lake Forest, CA 92630		Elevation: 395
Job Number: 2841.00	Client: National Community Renaissance	Date: 10/2/2019
Drill Method: Hollow-Stem Auger	Driving Weight: 140 lbs / 30 in	Logged By: SD

Depth (feet)	Lith-ology	Material Description	Water	Samples: Blows Per Foot	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
		@ 25 ft, caliche		43					
30				45					SA Hydro
35		@ 35 ft, , moist to very moist <u>Silty Clay/ Clayey Silt (CL/ ML-CL):</u> Light brown, slightly moist to moist, hard, iron oxide stainings, trace magnesium oxide		56					
40			▽	31					
45				37					

EXPLORATION LOG

Project: 4-Story Multi-Family Housing Development		Location: B-1
Address: 24551 Raymond Way, Lake Forest, CA 92630		Elevation: 395
Job Number: 2841.00	Client: National Community Renaissance	Date: 10/2/2019
Drill Method: Hollow-Stem Auger	Driving Weight: 140 lbs / 30 in	Logged By: SD

Depth (feet)	Lith-ology	Material Description	Water	Samples			Laboratory Tests		
				Blows Per Foot	Core	Bulk	Moisture Content (%)	Dry Density (pcf)	Other Lab Tests
				35					
		End of boring at depth of 51.5 ft. Groundwater encountered at depth of 41 ft. Backfilled with soil cuttings and patched with asphalt.							

EXPLORATION LOG

Project: 4-Story Multi-Family Housing Development		Location: B-2
Address: 24551 Raymond Way, Lake Forest, CA 92630		Elevation: 399
Job Number: 2841.00	Client: National Community Renaissance	Date: 10/2/2019
Drill Method: Hollow-Stem Auger	Driving Weight: 140 lbs / 30 in	Logged By: SD

Depth (feet)	Lith-ology	Material Description	Water	Samples: Blows Per Foot	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
		<u>Asphalt (AC):</u> Black							
		<u>Gravel wth Silt and Sand (CAB):</u> Dark brown							
		ARTIFICIAL FILL (Af) <u>Silty Sand (SM):</u> Light brown, moist, dense, fine to medium grained sand, some clay, iron oxide stainings, caliche		35 79	⧗ ⧗		12.8 11.2	109.1 111.3	
5		**Very Old Alluvium fan Deposits (Qovf)** <u>Clay (CL):</u> Reddish brown, slightly moist, hard		81	⧗		6.4	124.4	
		<u>Clayey Sand/ Sandy Clay (SC/CL):</u> Mottled dark brown and reddish brown, slightly moist to moist, very dense/hard, trace silt, caliche							
10		<u>Silty Clay with Sand (CL-ML):</u> Reddish brown, moist, hard, fine to medium sand, pin-hole poros, caliche		81	⧗		13.5	105.6	
		<u>Sandy Silt (ML):</u> Light brown, slightly moist to moist, hard, some clay, caliche, trace fine grained sand							
		End of boring at depth of 11.5 ft. No groundwater encountered. Backfilled with soil cuttings.							

EXPLORATION LOG

Project: 4-Story Multi-Family Housing Development		Location: B-3
Address: 24551 Raymond Way, Lake Forest, CA 92630		Elevation: 394
Job Number: 2841.00	Client: National Community Renaissance	Date: 10/2/2019
Drill Method: Hollow-Stem Auger	Driving Weight: 140 lbs / 30 in	Logged By: SD

Depth (feet)	Lith-ology	Material Description	Water	Samples: Blows Per Foot	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
		Asphalt (AC): Black							
		Gravel with Silt and Sand (CAB): Dark brown							
		Very Old Alluvium fan Deposits (Qovf) Clayey Sand/ Sandy Clay (SC/CL): mottled brown, dark brown, reddish brown and gray, slightly moist to mosit, very dense/hard, fine to coarse grained sand, caliche, brick		72/ 8"			11.2	119.6	
5				76/ 11"			7	113	
		Silty Sand (SM): Light reddish brown, slightly moist to mosit, very dense, fine to coarse sand, some clay, iron oxide stainings, caliche, rootlets, rock fragments @ 6 ft, dense		57			9.9	120.1	
		Clayey Sand (SC): Gray, slightly moist to mosi, very dense, fine to medium sand, caliche, rock fragments							
10				75/ 8"			12.1	113.6	
		Sand (SP): Light brown, moist, dense, trace clay, clay nodules							
15				31					
		End of boring at depth of 16.5 ft. No groundwater encountered. Backfilled with soil cuttings.							

EXPLORATION LOG

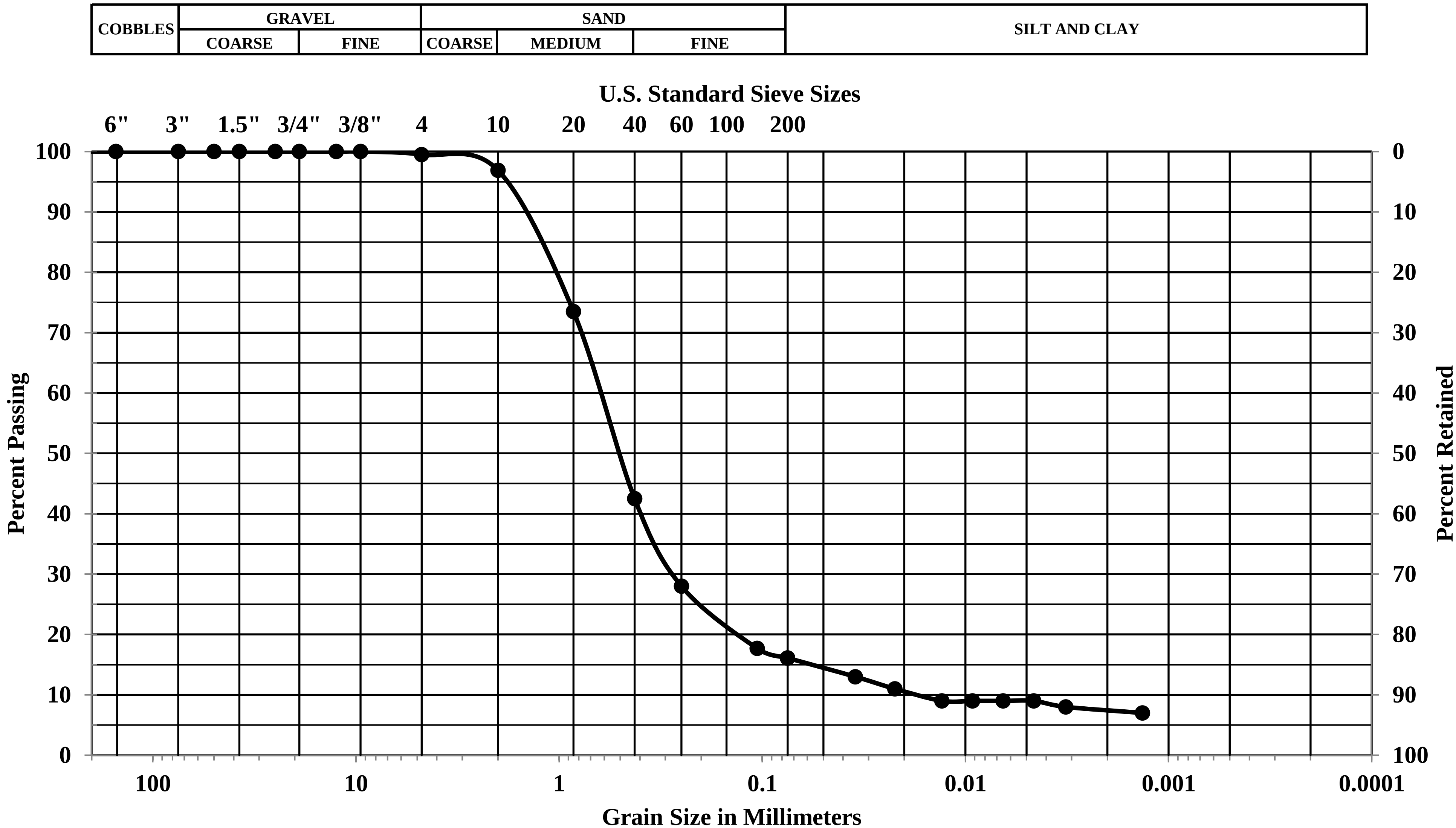
Project: 4-Story Multi-Family Housing Development	Location: B-4
Address: 24551 Raymond Way, Lake Forest, CA 92630	Elevation: 401
Job Number: 2841.00 / Client: National Community Renaissance	Date: 10/2/2019
Drill Method: Hollow-Stem Auger / Driving Weight: 140 lbs / 30 in	Logged By: SD

Depth (feet)	Material Description	Water	Blows Per Foot	Core	Bulk	Moisture Content (%)	Dry Density (pcf)	Other Lab Tests
0	Asphalt (AC): Black				X			
	Gravel with Silt and Sand (CAB): Dark brown				X			
2	**Very Old Alluvium fan Deposits (Qovf)** Clayey Sand with Gravel (SC): Dark gray, moist, dense, fine to coarse grained sand		62	X	X	11.9	118.9	
4	Silty Sand (SM): Dark gray, moist, very dense, fine grained sand, some gravel, rootlets, mica present, pin-hole poros		79	X	X	7.8	127.9	Consol
6	@ 6 ft, medium dense		25	X		15.8	114.9	Consol
8	Silty Sand with Clay (SM): Dark gray, moist, medium dense, trace gravel, caliche							
10			36	X		13.8	117	
11	@ 11 ft, Light reddish browndecreased in clay content							
15	@ 15 ft, Light brownno gravel		20	X				
20			20	X				
21.5	End of boring at depth of 21.5 ft. No groundwater encountered. Backfilled with soil cuttings.							

APPENDIX B

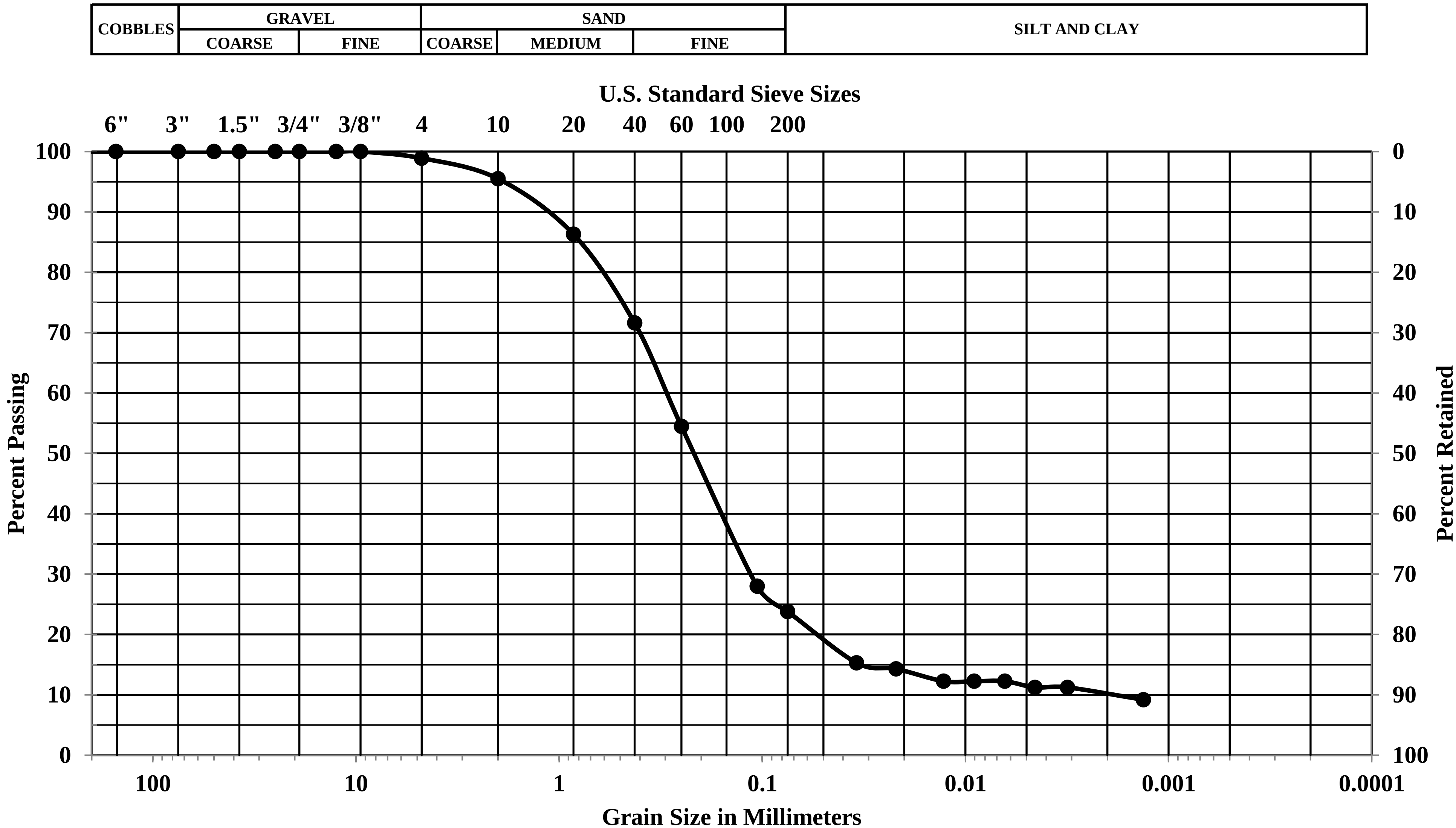
LABORATORY TEST PROGRAM

GRAIN SIZE DISTRIBUTION



Job Number	Location	Depth	Description
2841.00	B-1	15	Clayey Sand (SC)

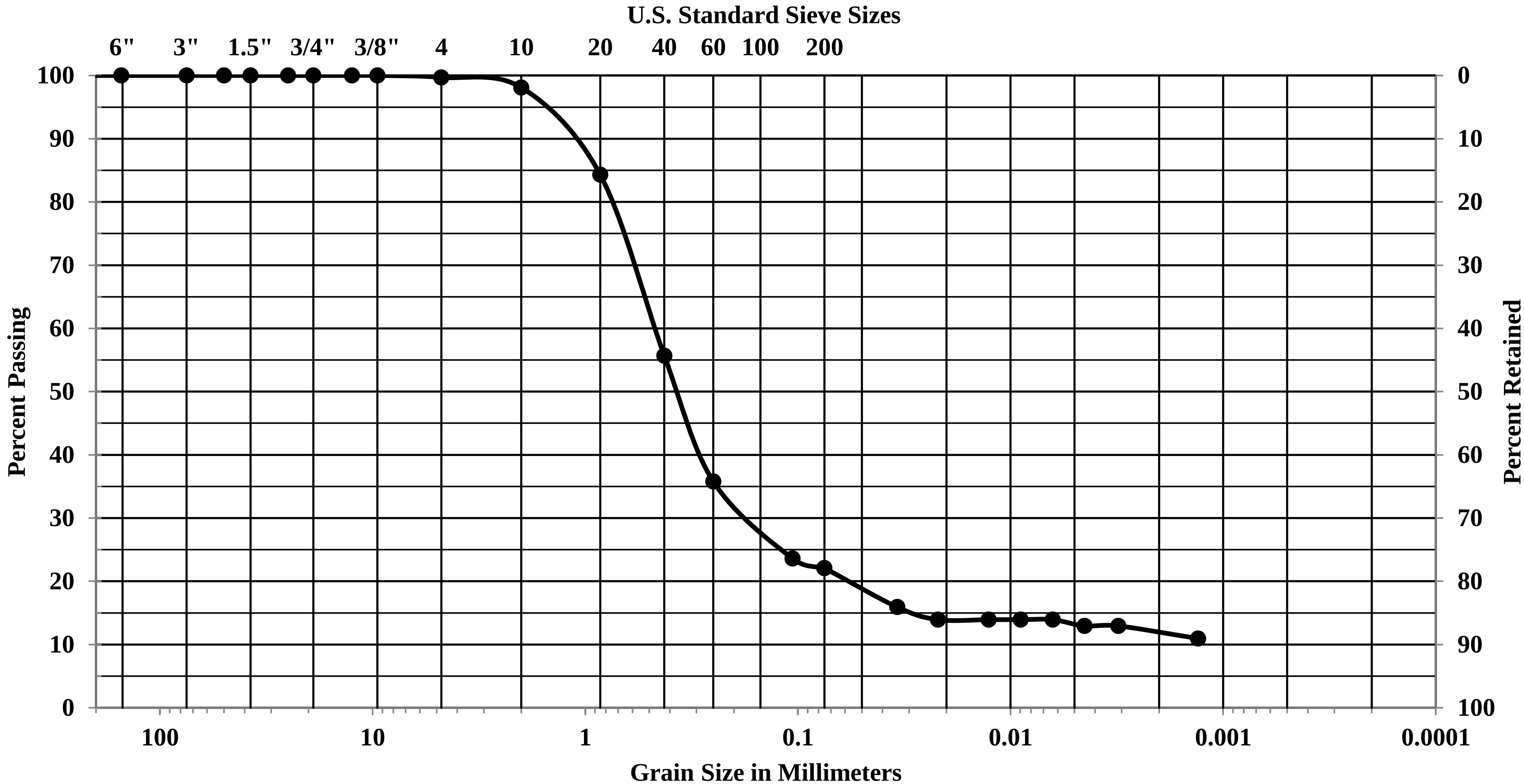
GRAIN SIZE DISTRIBUTION



Job Number	Location	Depth	Description
2841.00	B-1	20	Clayey Sand (SC)

GRAIN SIZE DISTRIBUTION

COBBLES	GRAVEL		SAND			SILT AND CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Job Number	Location	Depth	Description
2841.00	B-1	30	Clayey Sand (SC)

APPENDIX C

PERCOLATION TESTING AND ANALYSES

Field Percolation Testing - Constant Head

Client: National Core

Job. No.: 2841.00

Date Tested: 10/2/2019

Test by: SD

Location: P-1

Top of Casing to Bottom of Well (ft): 20.3

Elev. of Ground Surface (ft):

Diam. of Test Hole (in): 8

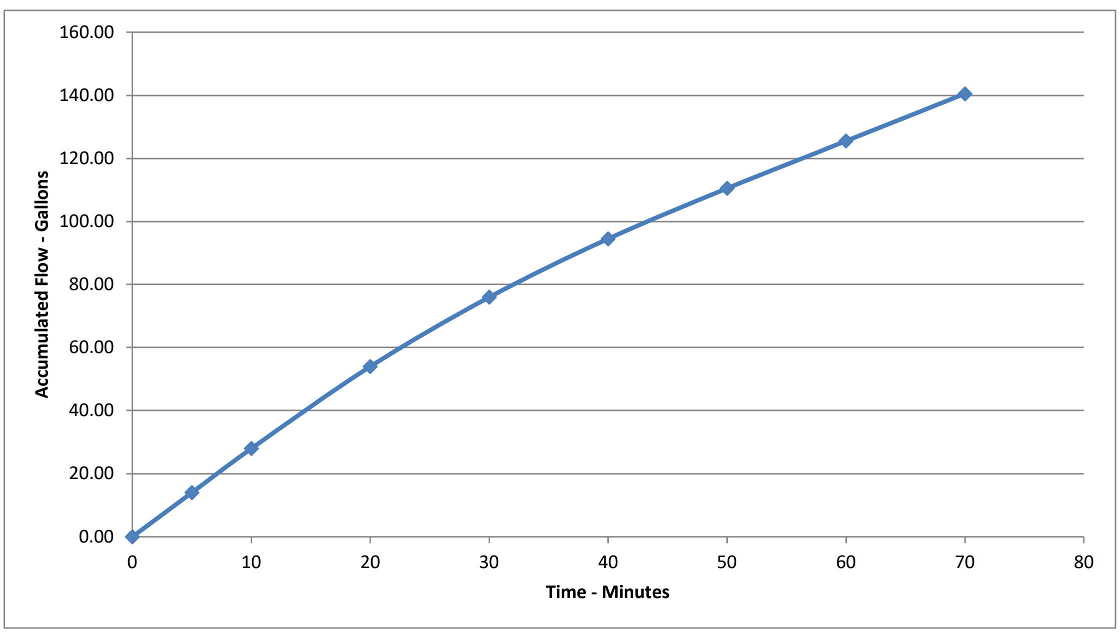
Diam. of Casing (in): 3

Ht. to Top of Casing (ft): 0.3

Water Tempurature (C°): 20

Constant Head

Elapsed Time (minutes)	Time	Depth to H2O (ft)	Flow Rate (gal./min.)	Total H_2O used (gal)
0	14:40	15.3		0.00
5	14:45	15.3	2.80	14.00
10	14:50	15.3	2.40	28.00
20	15:00	15.3	2.00	54.00
30	15:10	15.3	1.70	76.00
40	15:20	15.3	1.50	94.50
50	15:30	15.3	1.50	110.50
60	15:40	15.3	1.50	125.50
70	15:50	15.3	1.50	140.50



Field Percolation Testing - Constant Head

Client: National Core

Job. No.: 2841.00

Date Tested: 10/2/2019

Test by: SD

Location: P-2

Top of Casing to Bottom of Well (ft): 25.4

Elev. of Ground Surface (ft):

Diam. of Test Hole (in): 8

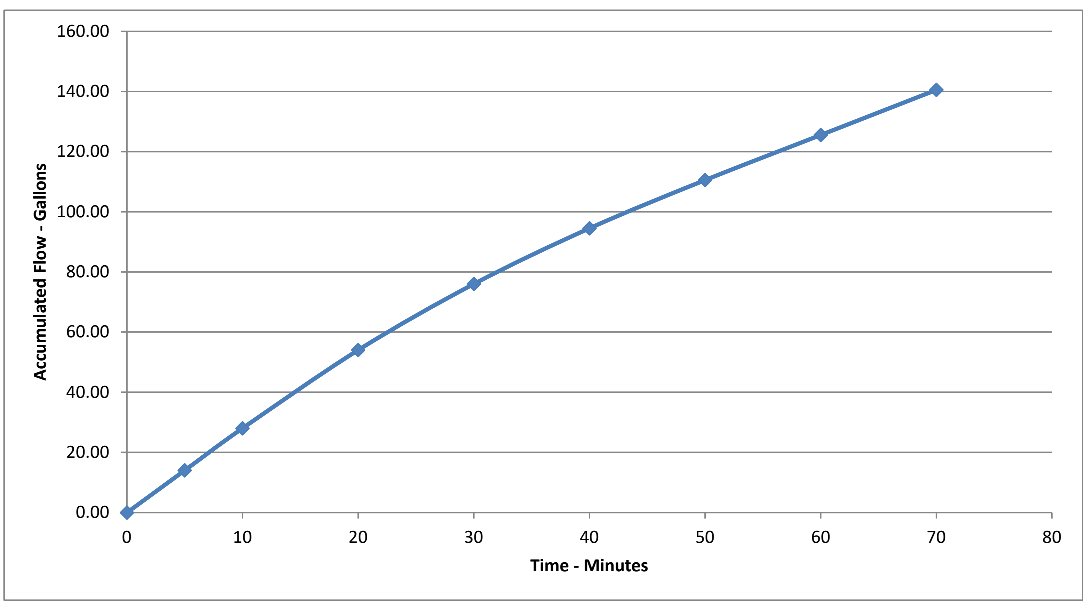
Diam. of Casing (in): 3

Ht. to Top of Casing (ft): 0.4

Water Tempurature (C°): 20

Constant Head

Elapsed Time (minutes)	Time	Depth to H2O (ft)	Flow Rate (gal./min.)	Total H_2O used (gal)
0	16:00	20.4		0.00
5	16:05	20.4	2.40	12.00
10	16:10	20.4	1.80	24.00
20	16:20	20.4	1.40	45.00
30	16:30	20.4	1.10	61.00
40	16:40	20.4	0.90	73.50
50	16:50	20.4	0.75	83.50
60	17:00	20.4	0.75	91.75
70	17:10	20.4	0.75	99.25
80	17:20	20.4	0.75	106.75



INFILTRATION WELL DESIGN

Constant Head

USBR 7300-89 Method

J.N.: 2841.00

Client: National Core

Well No.: P-1

Low Water Table	Condition 1	
High Water Table & Water Below Bottom of Well	Condition 2	
High water Table with Water Above the Well Bottom	Condition 3	
		Units:
Enter Condition (1, 2 or 3):	1	
Ground Surface to Bottom of Well (**h_1**):	20	feet
Depth to Water (**h_2**):	15	feet
Height of Water in the Well (h_1-h_2=**h**):	5	feet
Radius of Well (**r**):	4.0	Inches
Minimum Volume Required:	1473.4	Gal.
Discharge Rate of Water Into Well for Steady-State Condition (**q**):	1.5	Gal/min.
Temperature (**T**):	20	Celsius
(Viscosity of Water @ Temp. T) / (Viscosity of water @ 20° C) (**V**):	0.9889	ft^3/min.
Unsaturated Distance Between the Water Surface in the Well and the Water table (**T_u**):		Ignore T_u
Factor of Safety:	1	
Coefficient of Permeability @ 20° C (**k_{20}**):	3.15E-03	ft/min.
Design k_{20}:	2.27	in./hr.

The presence or absence of a water table or impervious soil layer within a distance of less than three times that of the water depth in the well (measured from the water surface) will enable the water table to be classified as **Condition I**, **Condition II**, **Condtion III**.

Low Water Table-When the distance from the water surface in the test well to the ground water table, or to an impervious soil layer which is considered for test puposes to be equivalent to a water table, is greater than three times the depth of water in the well, classify as **Condition I**.

High Water Table-When the distance from the water surface in the test well to the ground water table or to an impervious layer is less than three times the depth of water in the well, a high water table condition exists. Use **Condition II** when the water table or impervious layer is below the well bottom. Use **Condition III** when the water table or impervious layer is above the well bottom.

INFILTRATION WELL DESIGN

Constant Head

USBR 7300-89 Method

J.N.: 2841.00

Client: National Core

Well No.: P-2

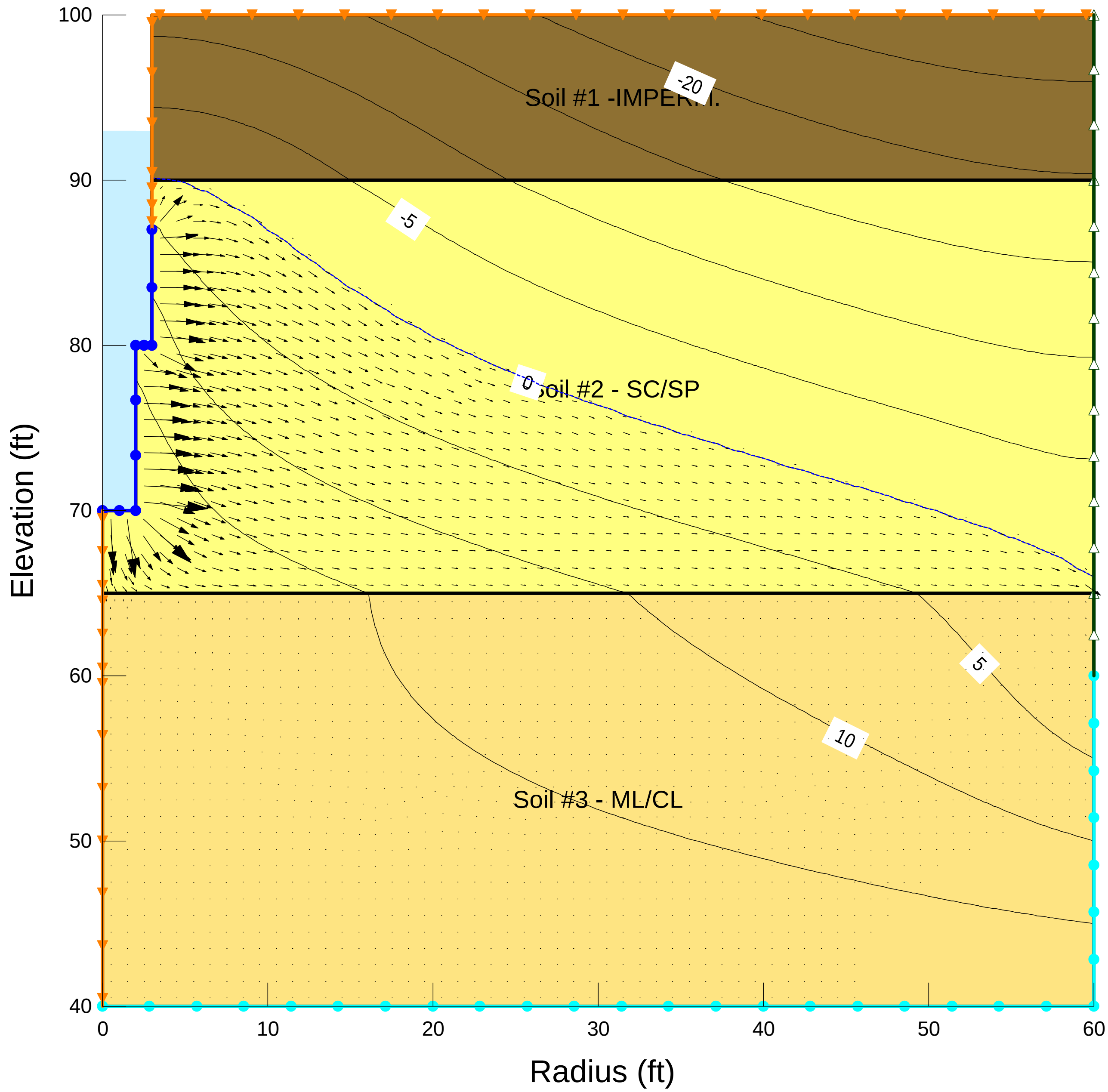
Low Water Table	Condition 1	
High Water Table & Water Below Bottom of Well	Condition 2	
High water Table with Water Above the Well Bottom	Condition 3	
		Units:
Enter Condition (1, 2 or 3):	1	
Ground Surface to Bottom of Well (**h_1**):	25	feet
Depth to Water (**h_2**):	20	feet
Height of Water in the Well (h_1-h_2=**h**):	5	feet
Radius of Well (**r**):	4.0	Inches
Minimum Volume Required:	1473.4	Gal.
Discharge Rate of Water Into Well for Steady-State Condition (**q**):	0.75	Gal/min.
Temperature (**T**):	20	Celsius
(Viscosity of Water @ Temp. T) / (Viscosity of water @ 20° C) (**V**):	0.9889	ft^3/min.
Unsaturated Distance Between the Water Surface in the Well and the Water table (**T_u**):		Ignore T_u
Factor of Safety:	1	
Coefficient of Permeability @ 20° C (**k_{20}**):	1.57E-03	ft/min.
Design k_{20}:	1.13	in./hr.

The presence or absence of a water table or impervious soil layer within a distance of less than three times that of the water depth in the well (measured from the water surface) will enable the water table to be classified as **Condition I**, **Condition II**, **Condtion III**.

Low Water Table-When the distance from the water surface in the test well to the ground water table, or to an impervious soil layer which is considered for test puposes to be equivalent to a water table, is greater than three times the depth of water in the well, classify as **Condition I**.

High Water Table-When the distance from the water surface in the test well to the ground water table or to an impervious layer is less than three times the depth of water in the well, a high water table condition exists. Use **Condition II** when the water table or impervious layer is below the well bottom. Use **Condition III** when the water table or impervious layer is above the well bottom.

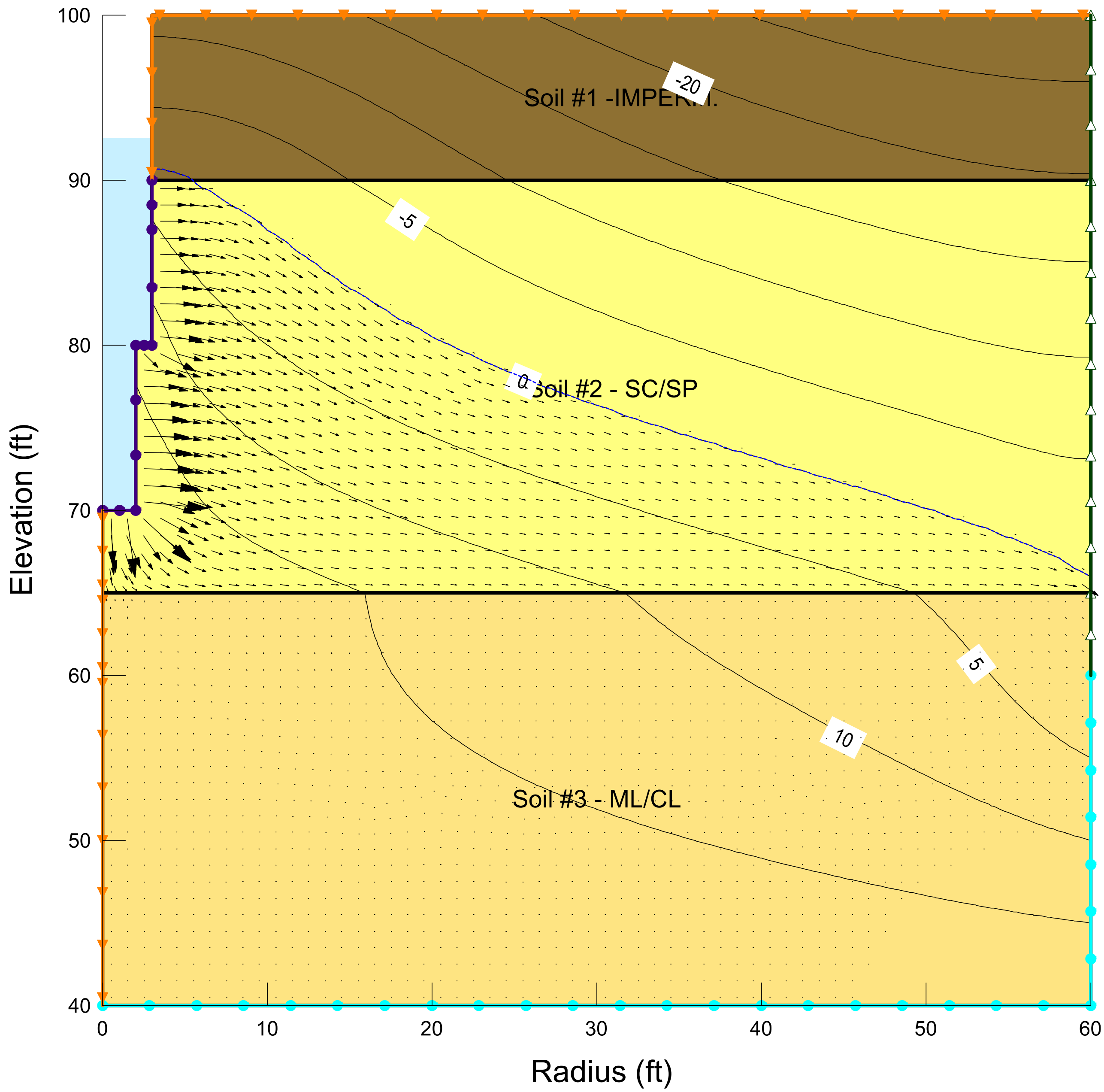
STEADY STATE CASE



Contours are Pressure Head in Feet.

Arrows indicate direction of flow and relative magnitude of velocity.

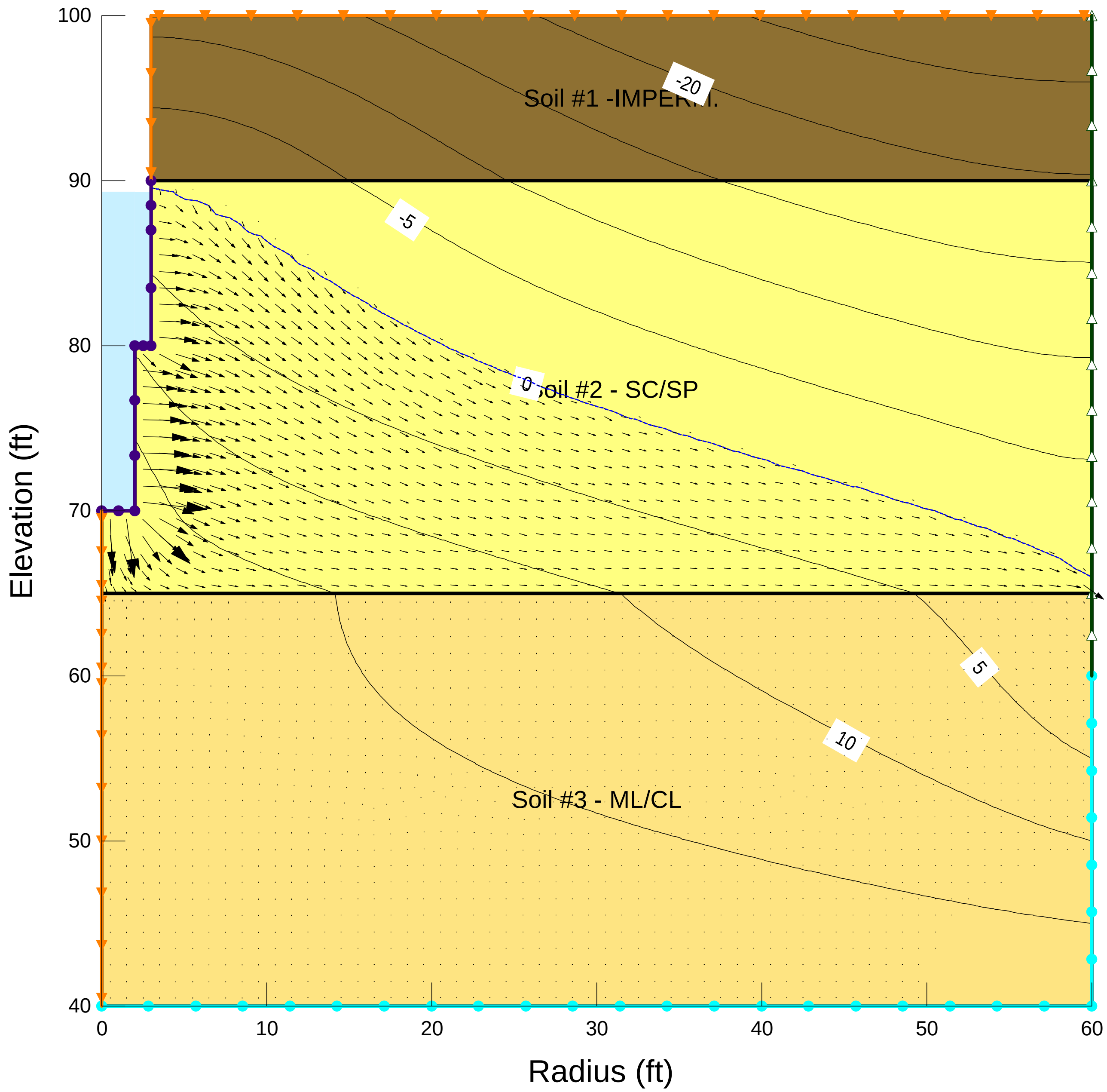
TRANSIENT CASE- TIME=0.26 HR



Contours are Pressure Head in Feet.

Arrows indicate direction of flow and relative magnitude of velocity.

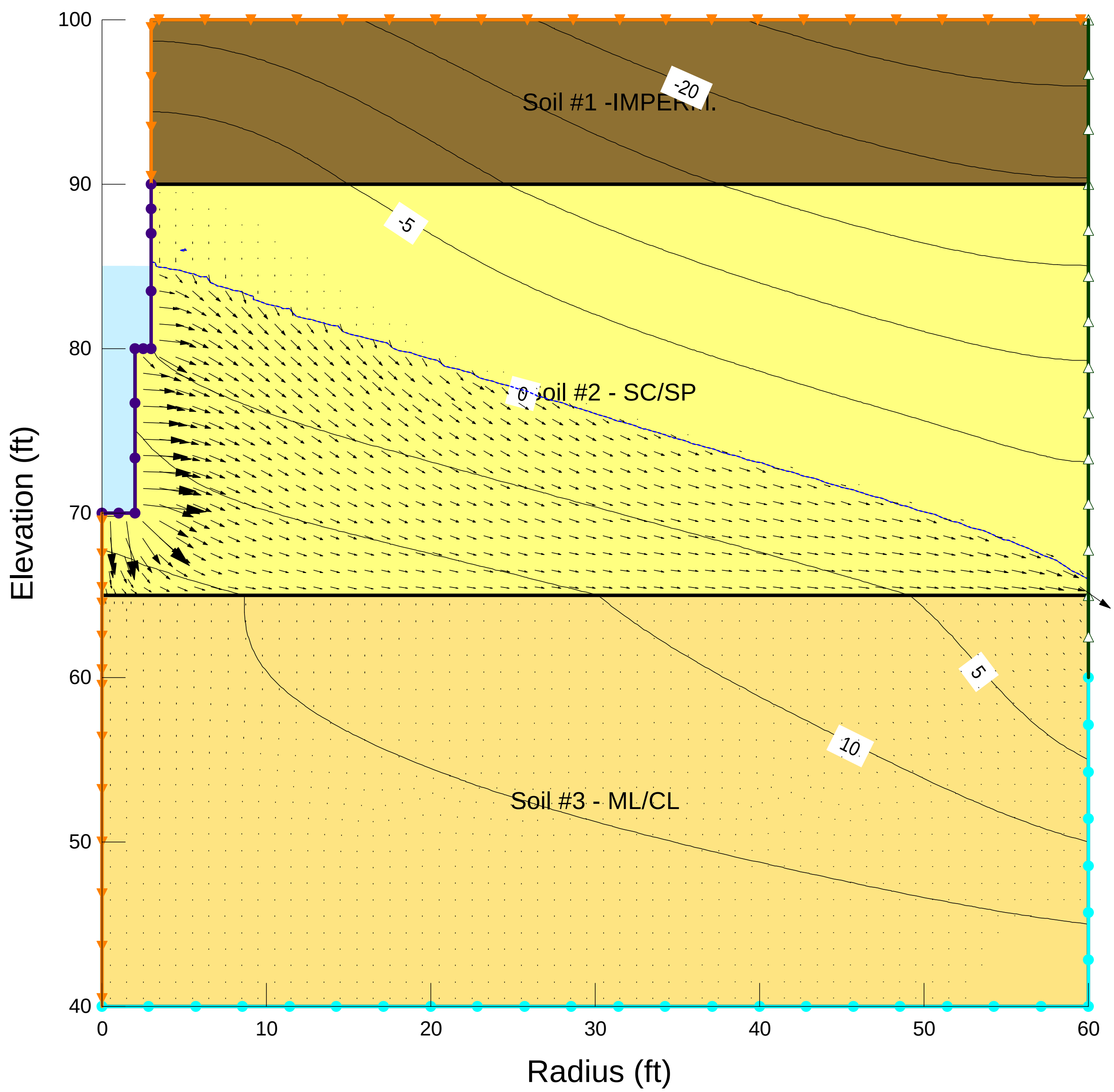
TRANSIENT CASE T=1.7 HR.



Contours are Pressure Head in Feet.

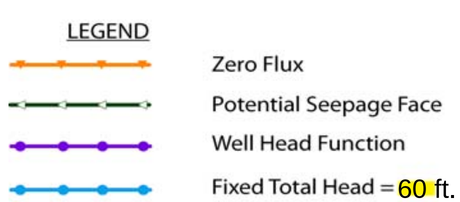
Arrows indicate direction of flow and relative magnitude of velocity.

TRANSIENT CASE T=4.8 HR.

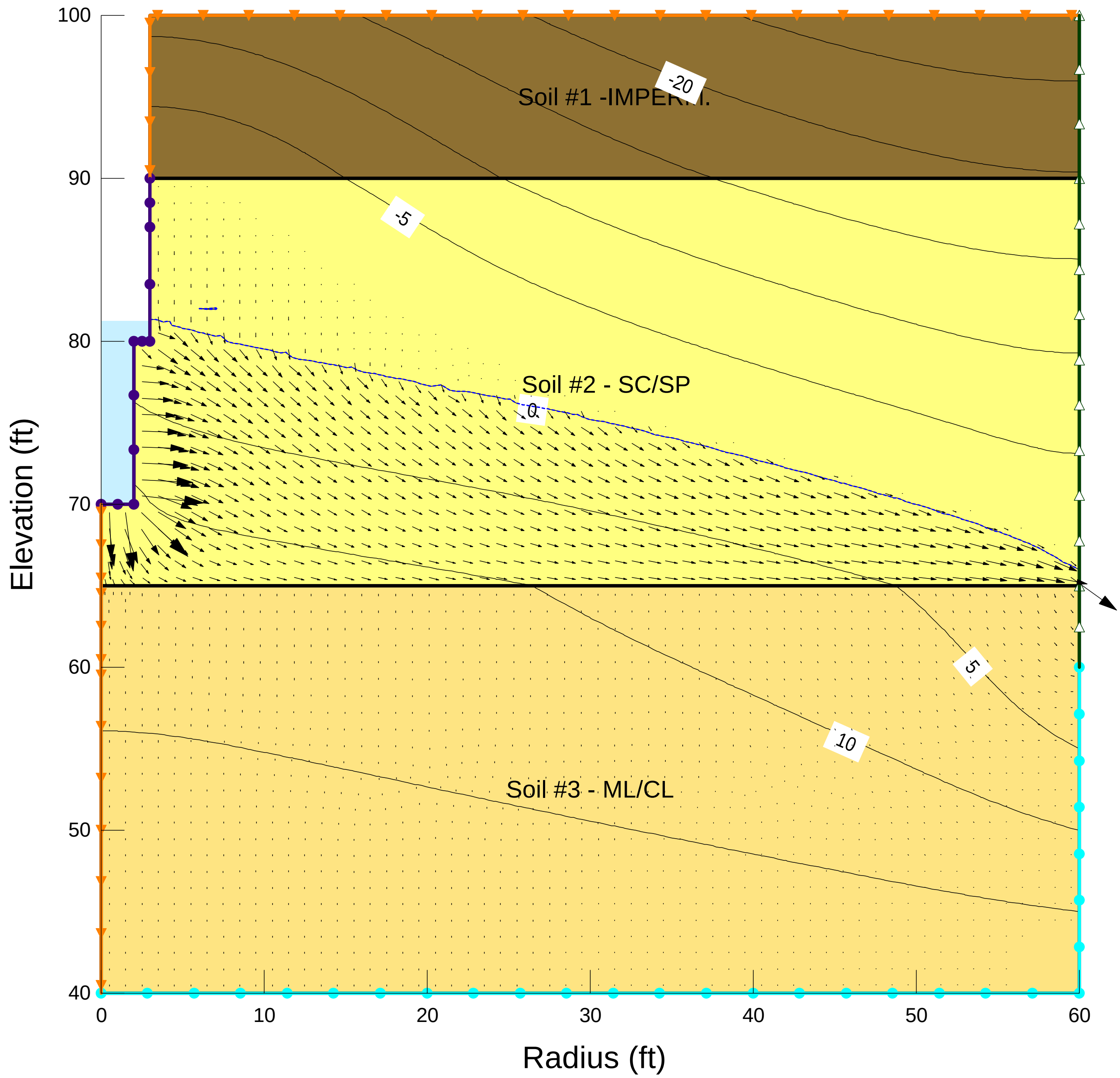


Contours are Pressure Head in Feet.

Arrows indicate direction of flow and relative magnitude of velocity.



TRANSIENT CASE T=9.4 HR.



Contours are Pressure Head in Feet.

Arrows indicate direction of flow and relative magnitude of velocity.

LEGEND

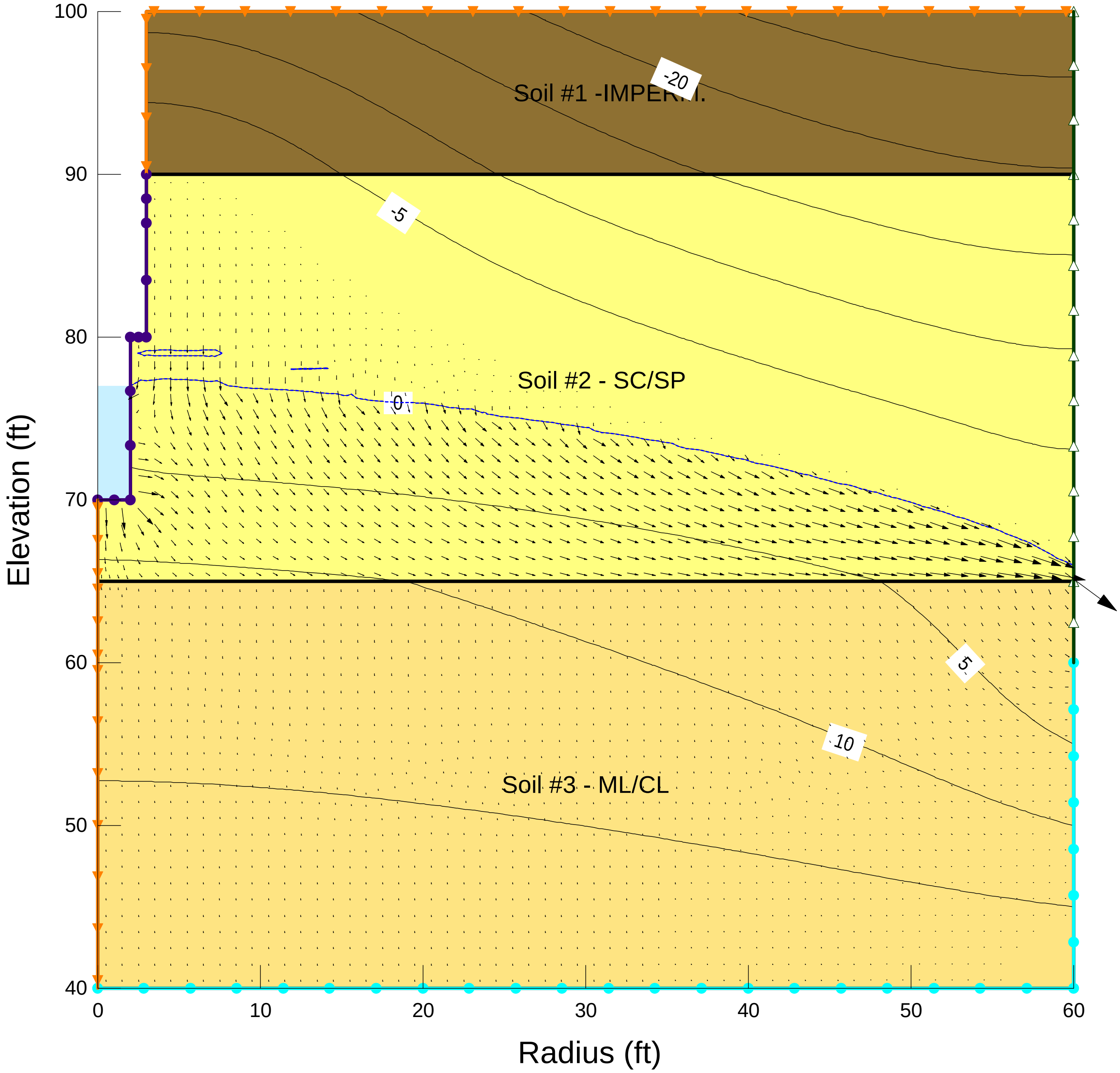
Zero Flux

Potential Seepage Face

Well Head Function

Fixed Total Head = 60 ft.

TRANSIENT CASE T=13.0 HR.



Contours are Pressure Head in Feet.

Arrows indicate direction of flow and relative magnitude of velocity.