APPENDIX 1-D. PRELIMINARY ENHANCED STORMWATER CAPTURE AND INFILTRATION ASSESSMENT OF 2 WATERSHED GROUP 4 PROJECTS

1.0 INTRODUCTION

As part of the Phase 1B Hydrogeologic Evaluation for the Central Coast Blue Project, GEOSCIENCE Support Services, Inc. (GEOSCIENCE) was tasked with building and calibrating a groundwater flow model covering the Northern Cities Management Area (NCMA), Nipomo Mesa Management Area (NMMA), and portion of the Santa Maria Valley Management Area (SMVMA) in the northwestern Santa Maria Groundwater Basin. The main purpose of this model, referred to as the Phase 1B Model, was to evaluate injection and extraction scenarios with flows from the South San Luis Obispo County Sanitation District (SSLOCSD) and City of Pismo Beach Wastewater Treatment Plants (WWTPs).

The City of Arroyo Grande and its Zone 3 partner agencies are considering adopting a stormwater capture and infiltration program in the community of Oceano to improve drainage, reduce flooding, and enhance groundwater recharge. In order to evaluate potential impacts and the feasibility of recharging captured stormwater, the Phase 1B Model was used to run stormwater infiltration scenarios. This technical memorandum (TM) summarizes the quantification of runoff and the results of a model scenario runs with and without stormwater recharge in infiltration ponds near Arroyo Grande Creek.

2.0 PROJECT LOCATION

The infiltration pond location evaluated in this study corresponds to the detention basin proposed in the Oceano Drainage Improvement Project (Cannon, 2016). It is located in the community of Oceano, just north of the Arroyo Grande Creek (Figure 1). The stormwater spreading program would capture runoff from areas covered by the Oceano Drainage Improvement Project, which includes parts of the Oceano Low Impact Development (LID) Plan (Cannon, 2019) and the Oceano Drainage and Flood Control Study (RMC, 2004). The combined drainage area tributary to the proposed stormwater infiltration pond is approximately 229.3 acres (0.4 square miles; highlighted in yellow on Figure 1).

3.0 ESTIMATION OF AVAILABLE RUNOFF

The first step in evaluating potential stormwater spreading involves determining the amount of available runoff from the surrounding tributary area. Stormwater runoff was calculated using the U.S. Department of Agriculture (USDA) Soil Conservation Service (SCS) Curve Number technique (USDA, 1986). Using this method, the SCS runoff equation is:

$$\boldsymbol{Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}}$$

Where

Q = runoff (in.),

P = precipitation (in.), and

S = potential maximum retention after runoff begins (in.), where

$$S = \frac{1000}{CN} - 10$$

And

CN = curve number.

3.1 Curve Number

Curve number ranges from 0 to 100 and is dependent on multiple factors, including the hydrologic soil type, land cover, connectivity to drainage network, and antecedent runoff condition. The weighted curve numbers developed for each drainage area in the drainage and improvement study (Cannon, 2016) were used for the runoff calculations. The parameters used to calculate runoff for each of the drainage areas highlighted on Figure 1 are summarized in the following table.

Table 3-1. Drainage Area Properties

Drainage ID	Area [acres]	Curve Number
D and G	190	77
2	0.4	98
3	1.5	77
4	1	77
5	2.2	77
6	0.8	93.6
7	5.86	84.4
8	4	80.8
9	4.9	81.6
10	12.2	80.6
11	0.2	98
12A	1.05	91.7
12B	1.83	91.7
15	3.35	89

3.2 Precipitation

Precipitation data were available from a nearby County of San Luis Obispo Department of Public Works rainfall gage (Oceano 795; see Figure 1). Any data gaps were filled in using a statistical correlation with neighboring gaging stations which had more complete records. Monthly data was used to calculate runoff from the SCS equation. Annual precipitation from this gage, which averages 13.8 inches per year from 1977 through 2016, is summarized below.

Table 3-2. Annual Precipitation – Oceano Gage (795)

Year	Precipitation [in.]	Year	Precipitation [in.]	Year	Precipitation [in.]
1977	10.6	1991	17.0	2005	14.6
1978	25.8	1992	14.4	2006	20.7
1979	13.9	1993	16.7	2007	6.9
1980	14.0	1994	13.1	2008	11.9
1981	15.6	1995	25.0	2009	8.0
1982	17.4	1996	18.5	2010	26.6
1983	26.7	1997	12.1	2011	12.9
1984	8.3	1998	28.2	2012	10.9
1985	8.6	1999	12.1	2013	2.6
1986	14.5	2000	13.6	2014	7.9
1987	12.5	2001	19.7	2015	5.6
1988	11.9	2002	8.8	2016	15.1
1989	4.3	2003	9.0		
1990	6.9	2004	10.2		
				Average Annual Precipitation	**13.8**

3.3 Runoff

Monthly potential runoff for stormwater infiltration was calculated using the SCS runoff equation. The annual estimated runoff is summarized in the following table. As shown, available stormwater runoff averaged 108.7 acre-ft/yr for the hydrologic period from 1977 through 2016.

Table 3-3. Annual Runoff

Year	Runoff [acre-ft]	Year	Runoff [acre-ft]	Year	Runoff [acre-ft]
1977	74.5	1991	169.1	2005	76.6
1978	252.6	1992	114.6	2006	168.4
1979	97.1	1993	135.8	2007	38.9
1980	111.0	1994	65.5	2008	106.9
1981	118.6	1995	278.8	2009	49.9
1982	112.8	1996	139.3	2010	284.0
1983	243.8	1997	98.3	2011	74.7
1984	44.7	1998	280.0	2012	66.7
1985	42.5	1999	93.4	2013	20.0
1986	99.8	2000	126.4	2014	55.5
1987	72.9	2001	176.1	2015	25.0
1988	76.0	2002	63.3	2016	122.4
1989	12.4	2003	48.7		
1990	28.3	2004	80.9		
				Average Annual Runoff	**108.7**

4.0 STORMWATER INFILTRATION SCENARIOS

4.1 Scenario Assumptions

Two scenario runs were made using the calibrated Phase 1B Model to evaluate the effects from stormwater capture and recharge at the proposed stormwater infiltration pond (refer to GEOSCIENCE, 2018 for model information). These scenarios consist of:

- Baseline Scenario (i.e., no stormwater infiltration), and
- Stormwater Infiltration Scenario.

Both model runs were simulated using monthly stress periods for 40 years (representing the hydrologic period from 1977 through 2016). Model fluxes related to hydrology (e.g., areal infiltration of precipitation, streambed percolation, etc.) were repeated from the historical hydrology. Model fluxes related to human activities (e.g., groundwater pumping, artificial recharge, return flow, etc.) were assumed to be the average of the last 5 years (i.e., 2012 – 2016).

For the stormwater infiltration scenario, the runoff estimated for the drainage areas tributary to the stormwater infiltration pond was evaluated to determine how much of the runoff could become infiltration, based on the capacity of the proposed pond and the assumed infiltration rate. The infiltration pond parameters used for this study are summarized in the following table. Runoff in excess of the infiltration pond capacity and/or the infiltration rate was assumed to discharge to Arroyo Grande Creek.

Table 4-1. Proposed Infiltration Pond Parameters

Basin Depth [ft]	4
Width [ft]	50
Length [ft]	515
Area [acres]	0.59
Capacity [acre-ft]	2.36
Infiltration Rate [ft/day]	2.00
Maximum Daily Infiltration [acre-ft]	1.18

The annual amount of stormwater recharged at the proposed infiltration pond averaged 81.4 acre-ft/yr, as shown in Table 4-2 below.

Table 4-2. Annual Stormwater Infiltration

Year	Infiltration [acre-ft]	Year	Infiltration [acre-ft]	Year	Infiltration [acre-ft]
1977	73.0	1991	83.4	2005	76.6
1978	141.9	1992	87.4	2006	139.6
1979	97.1	1993	114.6	2007	38.9
1980	87.1	1994	65.5	2008	76.0
1981	96.1	1995	94.9	2009	49.9
1982	101.7	1996	88.9	2010	146.8
1983	157.1	1997	93.4	2011	69.5
1984	44.7	1998	153.4	2012	66.7
1985	42.5	1999	71.0	2013	20.0
1986	86.6	2000	77.0	2014	55.5
1987	72.9	2001	140.3	2015	25.0
1988	76.0	2002	60.5	2016	120.1
1989	12.4	2003	48.7		
1990	28.3	2004	74.5		
				Average Annual Infiltration	**81.4**

4.2 Scenario Results

Groundwater elevation contours after 40 years are shown on Figures 2 and 3 for the baseline and stormwater infiltration scenarios, respectively. The difference in groundwater elevations between the two scenarios, representing the effect of stormwater infiltration, is presented on Figure 4. As shown, the recharge of stormwater at the proposed infiltration pond causes groundwater to mound in the vicinity of the pond. Water elevation directly under the infiltration pond rise approximately 5 ft over the 40-year simulation period, as compared to the baseline scenario.

Hydrographs of groundwater level elevation and groundwater elevation change at the infiltration pond are shown in Figures 4-1 and 4-2, respectively, below.

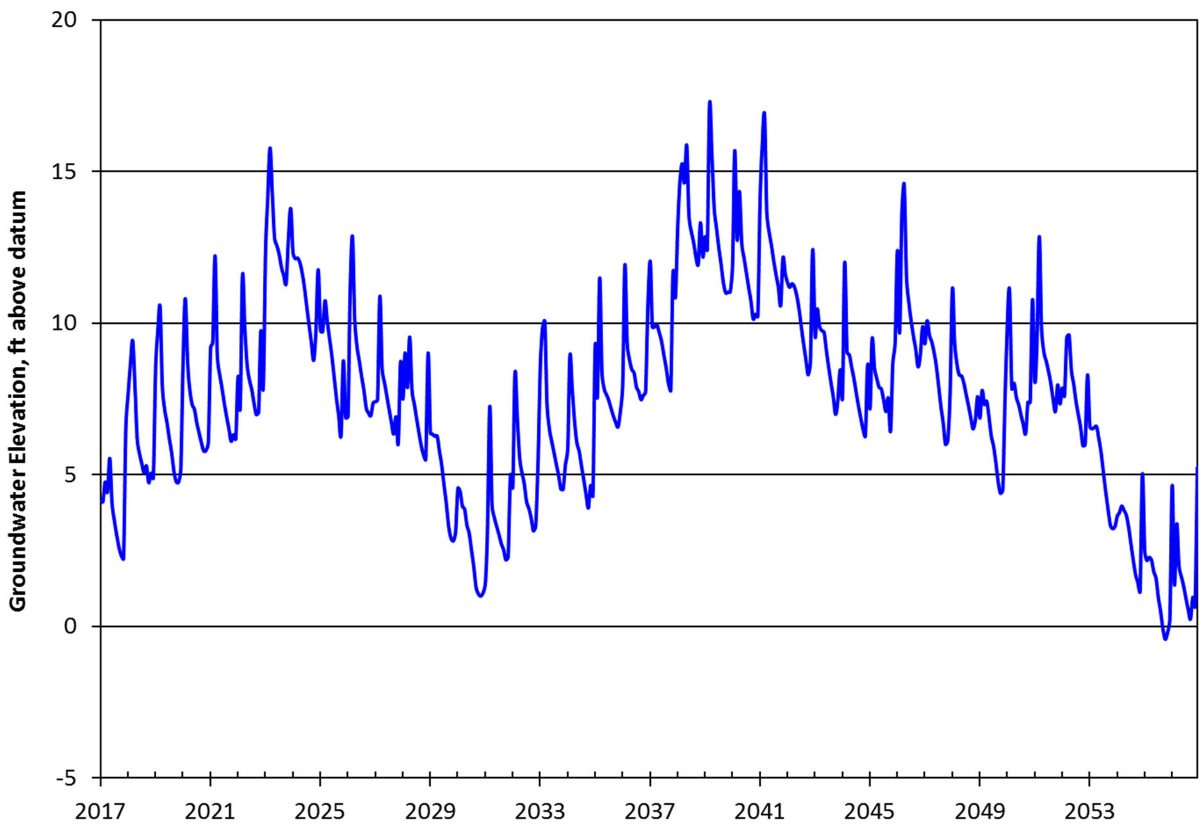


Figure 4-1. Groundwater Elevation at Proposed Infiltration Pond with Stormwater Recharge (Hydrologic Period from 1977 through 2016)

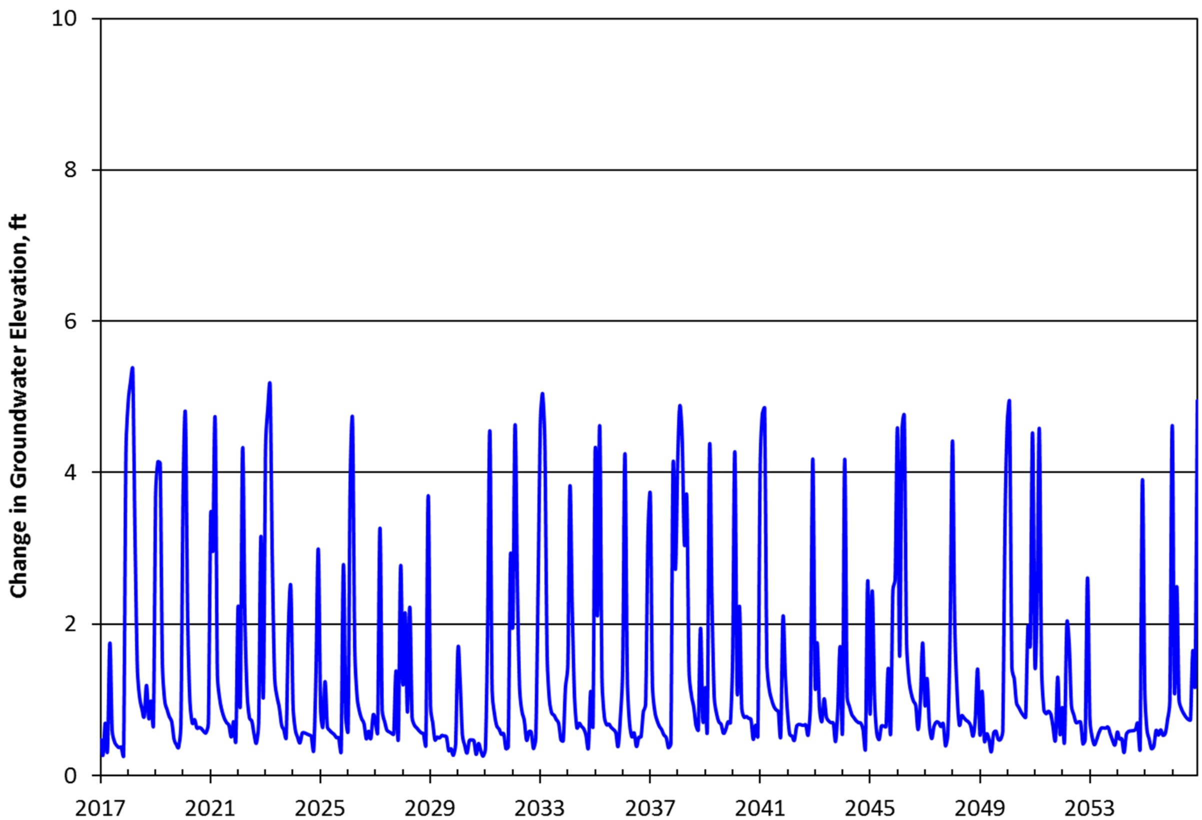


Figure 4-2. Change in Groundwater Elevation at Proposed Infiltration Pond with Stormwater Recharge (Hydrologic Period from 1977 through 2016)

Ground surface elevation at the location of the proposed infiltration pond is approximately 15 ft NAVD88. When groundwater elevation rises above this level, the recharge water is lost to the Arroyo Grande Creek. Therefore, both the groundwater elevation and change in groundwater elevation hydrographs at the pond suggest that over the 40-year simulation period, daylighting of recharged water can occur under extremely wet conditions. This is due in part to the fact that the pond has a relatively small footprint and also that groundwater in this area is quite shallow. In field investigations, groundwater was encountered 13 ft to 15 ft below ground surface (bgs; Cannon, 2016), but can be higher depending on the season and the rainfall. In addition, the greatest amount of runoff tends to occur during the wet season when the groundwater is usually already high. Designing a bigger basin or distributing the runoff over multiple basins (i.e., alternative locations proposed by the drainage improvement plan) would help mitigate excessive mounding and daylighting of stormwater recharge.

The model-simulated groundwater mound primarily affects the shallow aquifer and has negligible to no impact on deeper layers (e.g., Paso Robles Aquifer). This is due to the fact that confinement in this area between the shallow and the deeper Paso Robles aquifers effectively isolate both layers. Even when mounding is at its highest, the change in water level elevation drops to 0 ft or less within three to four miles from the pond.

5.0 SUMMARY AND CONCLUSIONS

Using the tributary area outlined in the Oceano Drainage Improvement Project, which includes parts of the Oceano LID Plan and the Oceano Drainage and Flood Control Study, there is approximately 109 acre-ft/yr of stormwater runoff available for capture. Of this, 81 acre-ft/yr can be recharged at the proposed infiltration pond. Recharging this captured stormwater is predicted to cause groundwater mounding in the vicinity of the pond, with water elevation directly under the infiltration pond rising approximately 5 ft after 40 years, as compared to the baseline scenario. However, due to shallow groundwater elevations at this location, some recharge will be lost to surface discharge during extremely wet conditions, depending on the depth to groundwater.

This initial estimate of stormwater recharge impacts relies on generalized assumptions and therefore has limitations and uncertainty associated with it. In absence of a proposed infiltration pond location and design in the drainage studies used for this preliminary assessment, an infiltration pond was assumed to match the size and location of the detention basin outlined in the Oceano Drainage Improvement Project (Cannon, 2016). A new infiltration basin design intended specifically for infiltration could help optimize stormwater capture and recharge. In addition, simulating infiltration on a daily basis, rather than relying on a monthly infiltration estimate, may yield more accurate results and help determine when mounding from stormwater recharge may be lost to surface flow.

6.0 REFERENCES

Cannon, 2016. Hydrologic and Hydraulic Drainage Report for Oceano Drainage Improvement Project. Prepared for San Luis Obispo County, dated October.

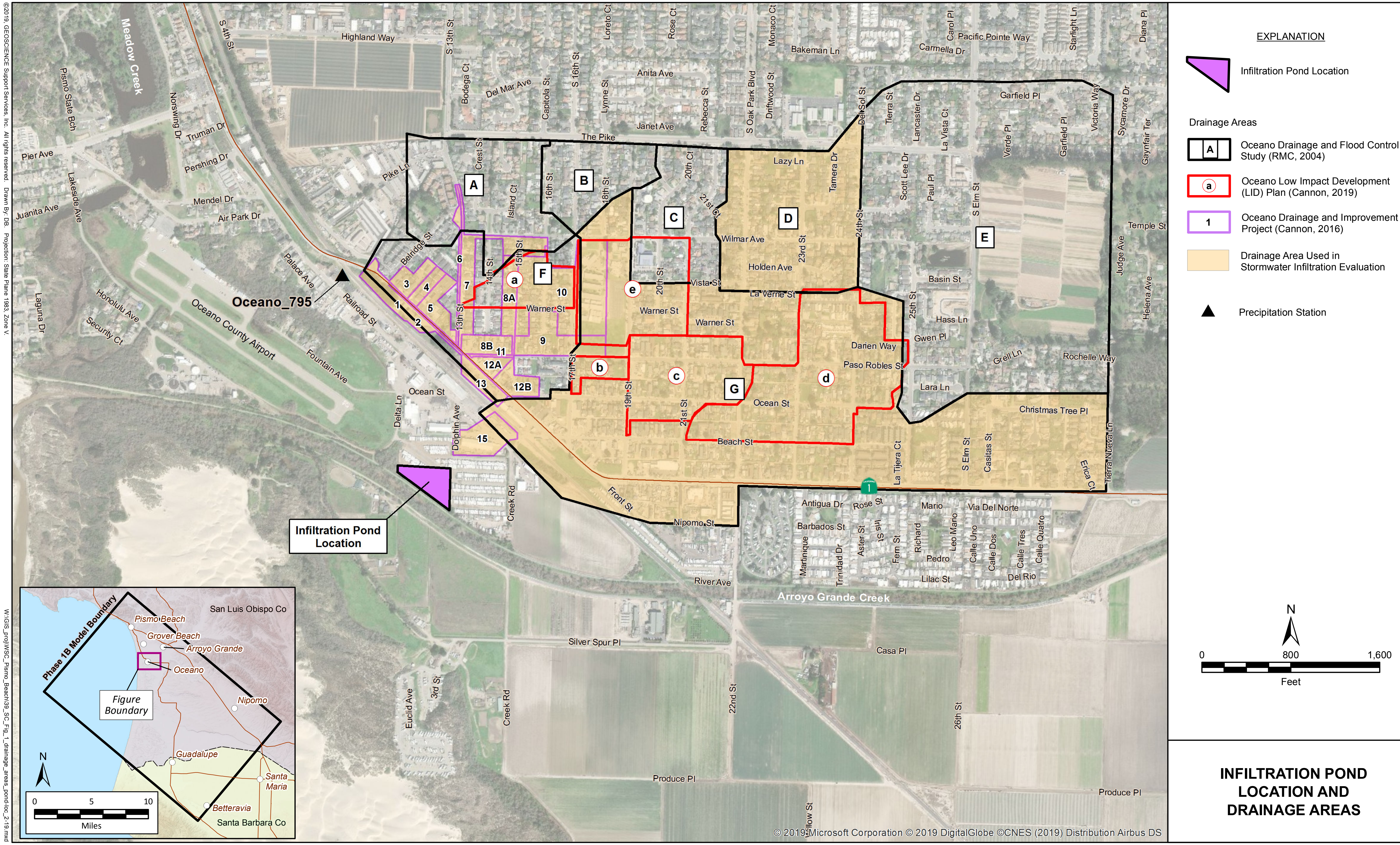
Cannon, 2019. Oceano Low Impact Development Plan Feasibility Study. Prepared for Oceano Community Services District, dated January 17.

GEOSCIENCE (GEOSCIENCE Support Services, Inc.), 2018. City of Pismo Beach and South San Luis Obispo County Sanitation District Regional Groundwater Sustainability Project Phase 1B Hydrogeologic Evaluation – Technical Memorandum No. 3: Model Calibration, Draft. Prepared for Water Systems Consulting, Inc., dated August 17.

RMC, 2004. Oceano Drainage and Flood Control Study, Final Report. Prepared for San Luis Obispo County Flood Control and Water Conservation District, dated February.

USDA (U.S. Department of Agriculture), 1986. Urban Hydrology for Small Watersheds. Technical Release 55 (TR-55), dated June.

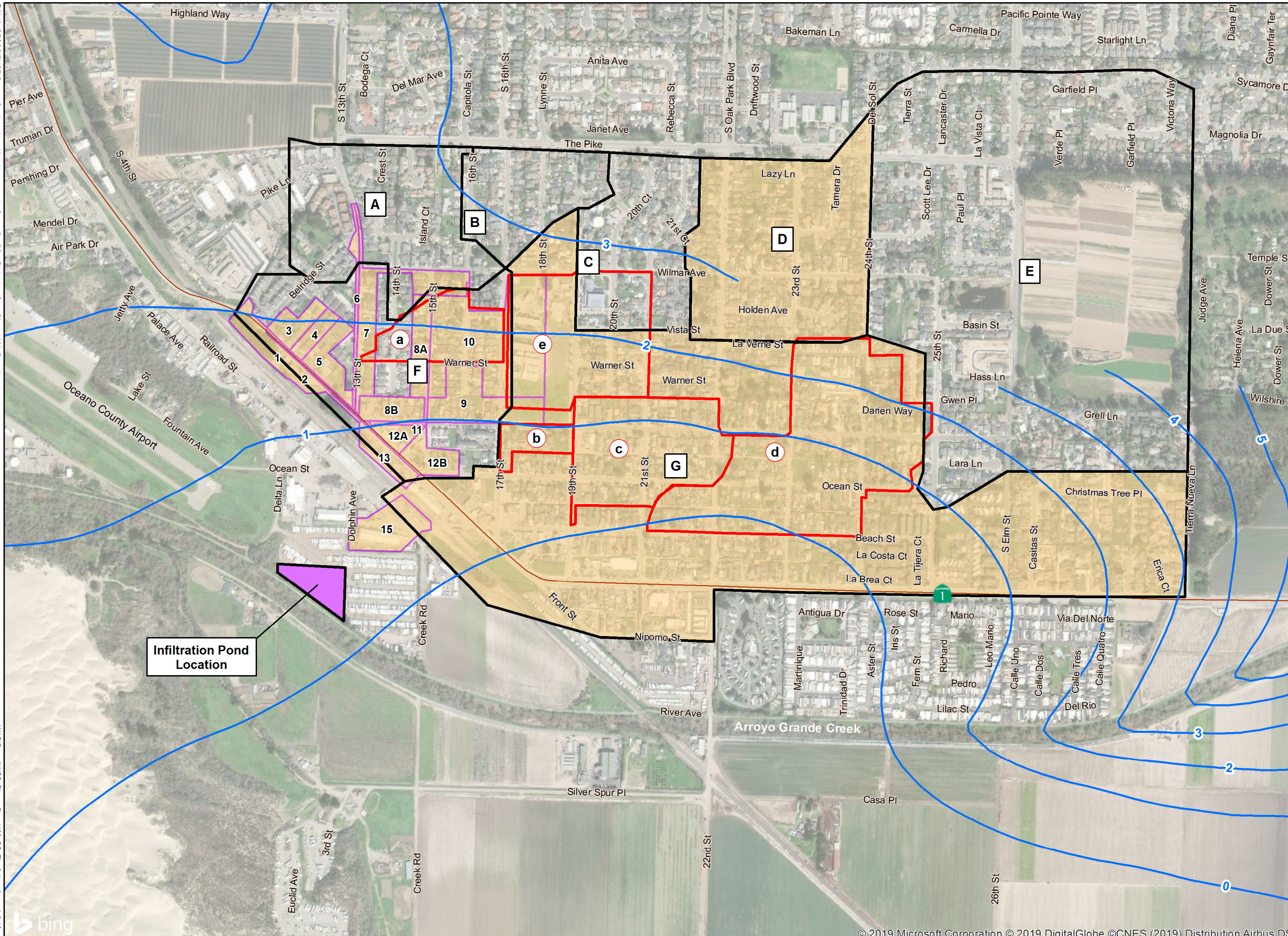
FIGURES



INFILTRATION POND LOCATION AND DRAINAGE AREAS

28-Feb-19

FIGURE 1



EXPLANATION

Infiltration Pond Location

Groundwater Elevation (ft NAVD88)

Drainage Areas

- A — Oceano Drainage and Flood Control Study (RMC, 2004)
- a — Oceano Low Impact Development (LID) Plan (Cannon, 2019)
- 1 — Oceano Drainage and Improvement Project (Cannon, 2016)
- Drainage Area Used in Stormwater Infiltration Evaluation

N

0 700 1,400
Feet

GROUNDWATER ELEVATION AFTER 40 YEARS BASELINE SCENARIO

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FIGURE 2

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APPENDIX 1-D. PRELIMINARY ENHANCED STORMWATER CAPTURE AND INFILTRATION ASSESSMENT OF 2 WATERSHED GROUP 4 PROJECTS

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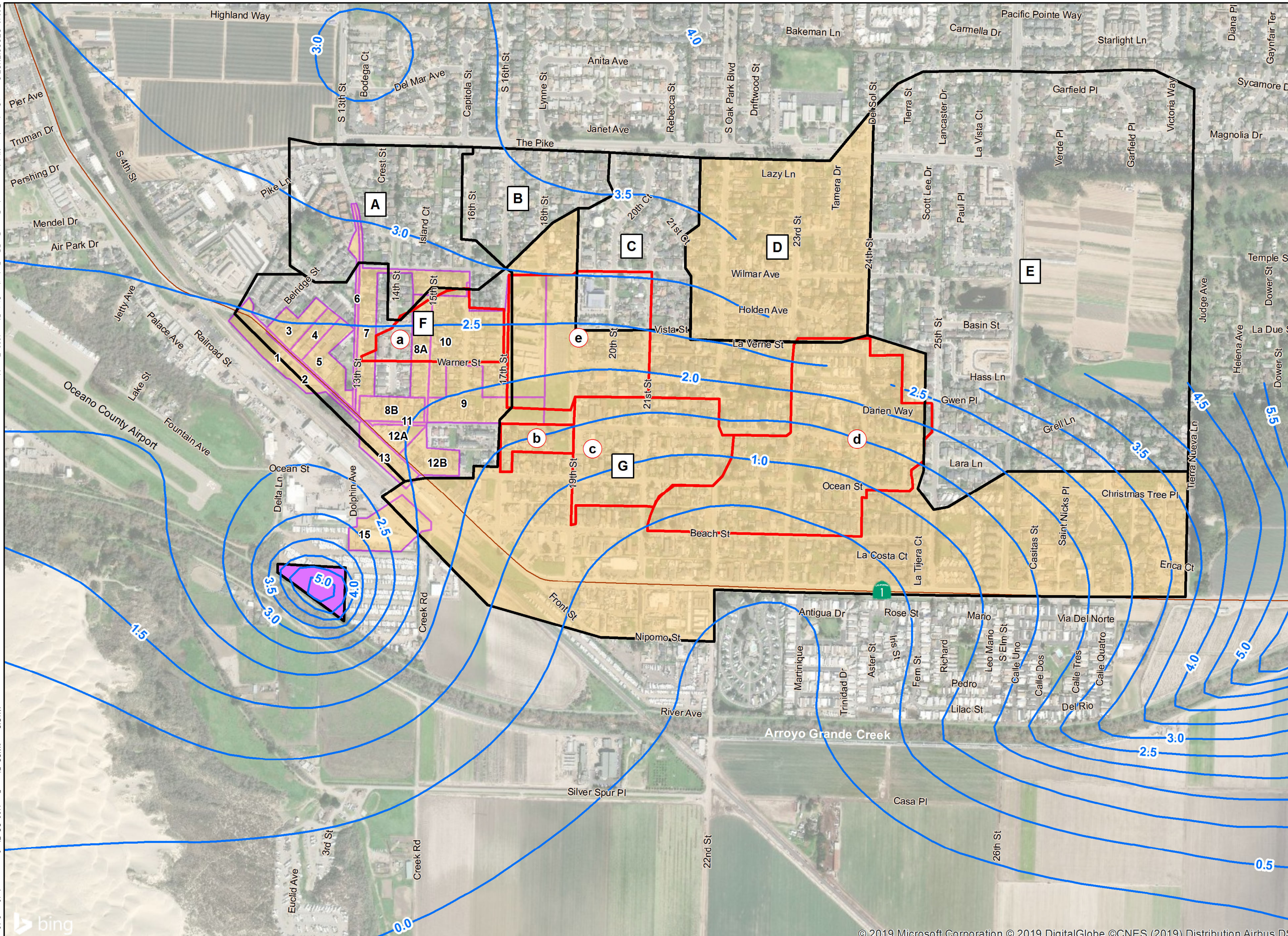

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EXPLANATION

Infiltration Pond Location

5 Groundwater Elevation (ft NAVD88)

Drainage Areas

A Oceano Drainage and Flood Control Study (RMC, 2004)

a Oceano Low Impact Development (LID) Plan (Cannon, 2019)

1 Oceano Drainage and Improvement Project (Cannon, 2016)

Drainage Area Used in Stormwater Infiltration Evaluation

N

0 700 1,400

Feet

GROUNDWATER ELEVATION AFTER 40 YEARS STORMWATER INFILTRATION SCENARIO

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WATER SYSTEMS CONSULTING, INC.

APPENDIX 1-D. PRELIMINARY ENHANCED STORMWATER CAPTURE AND INFILTRATION ASSESSMENT OF 2 WATERSHED GROUP 4 PROJECTS

FIGURE 3

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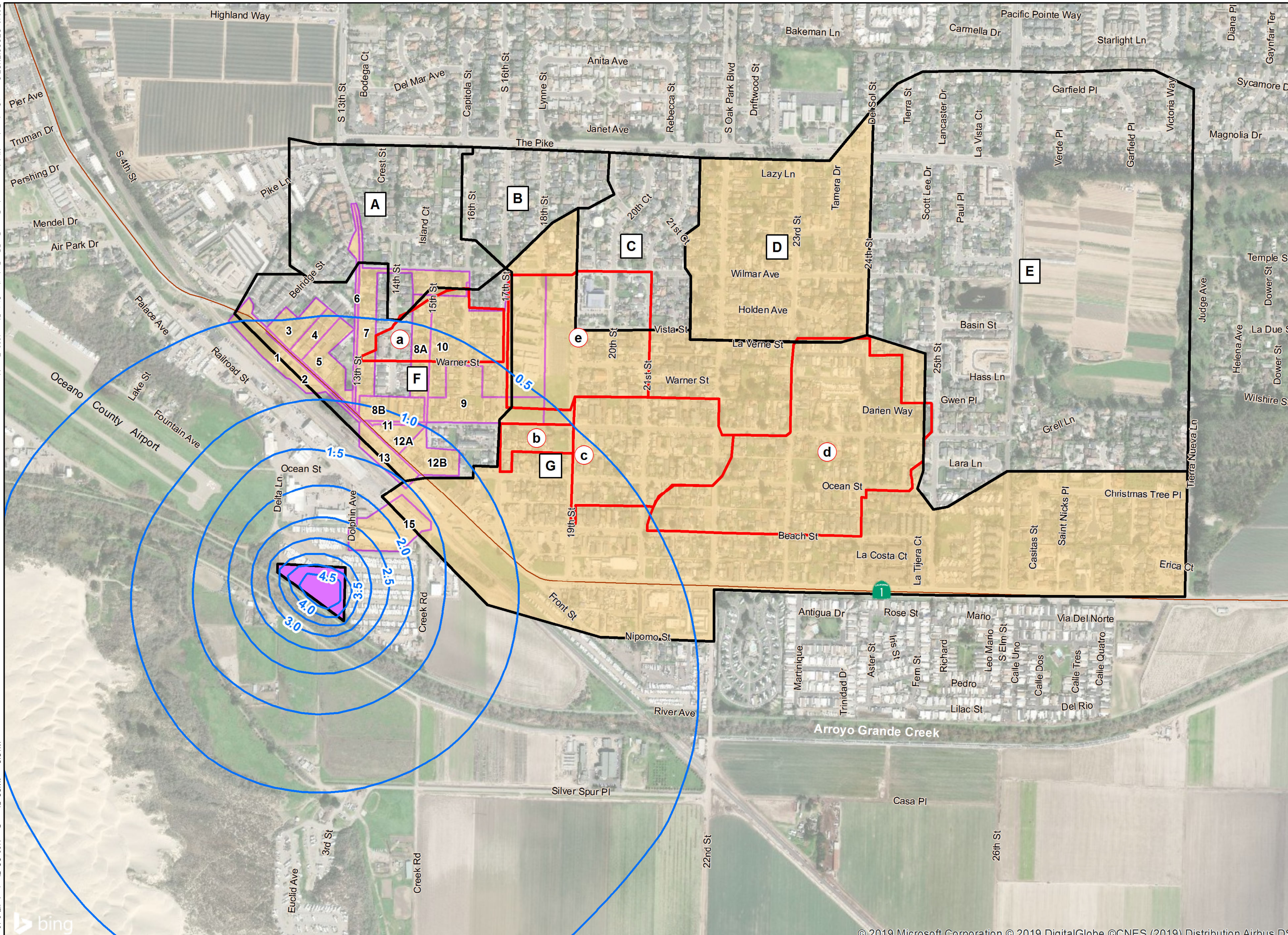

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EXPLANATION

Infiltration Pond Location

5 Groundwater Elevation Difference With Stormwater Infiltration, Compared to Baseline (ft)

Drainage Areas

A Oceano Drainage and Flood Control Study (RMC, 2004)

a Oceano Low Impact Development (LID) Plan (Cannon, 2019)

1 Oceano Drainage and Improvement Project (Cannon, 2016)

Drainage Area Used in Stormwater Infiltration Evaluation

N

0 700 1,400 Feet

GROUNDWATER ELEVATION DIFFERENCE WITH STORMWATER INFILTRATION

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FIGURE 4

GEOSCIENCE