Final Report

Groundwater Basins Master Plan

ch2m

In association with

RMC Water and Environment

Prepared for

WRD

Water Replenishment District of Southern California

September 2016

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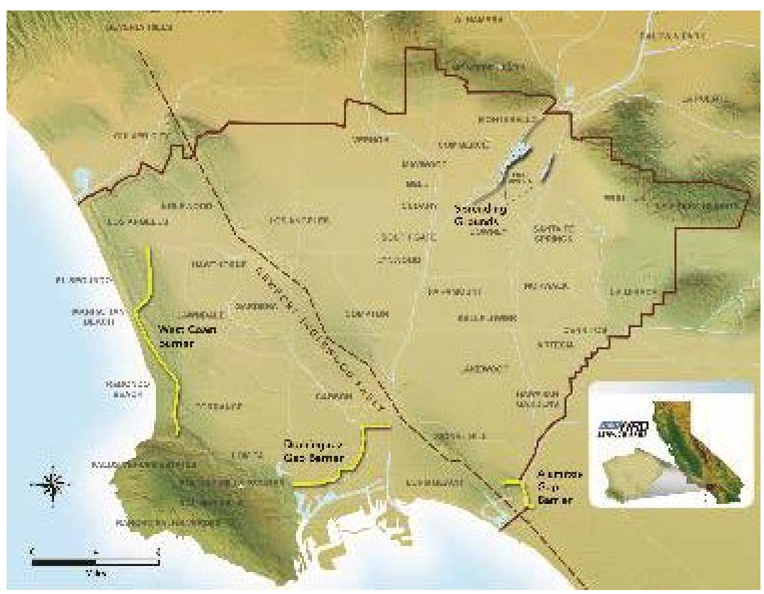

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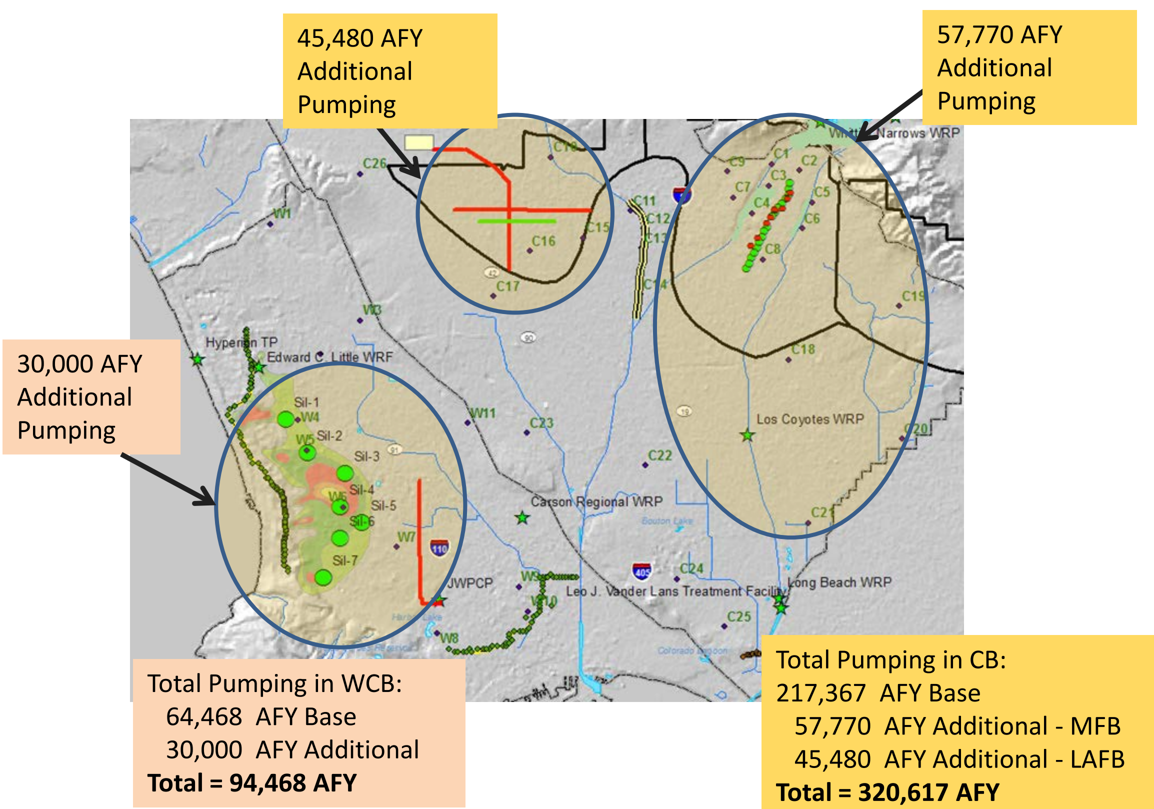
Executive Summary

The Water Replenishment District of Southern California (WRD), in coordination with other basin stakeholders, has developed this Draft Groundwater Basins Master Plan (GBMP). The intent of this plan is to provide a single reference document for parties operating within and maintaining the West Coast and Central groundwater basins. This plan is intended to help guide the stakeholders develop and assess initial concepts for additional recharge and pumping from these basins to utilize the basins fully and reduce dependence on imported water. This GBMP complements the efforts of WRD's Water Independence Now (WIN) program by identifying projects and programs to enhance basin replenishment, increase the reliability of groundwater resources, improve and protect groundwater quality, and ensure that the groundwater supplies are suitable for beneficial uses.

This GBMP identifies opportunities to develop supplemental replenishment water supplies to further utilize the West Coast and Central Basins. The key objective for creating additional replenishment water supply is to significantly reduce imported water use by providing for increased pumping from these basins. This GBMP focuses on developing concepts to generate additional water supply of as much as (1) 30,000 acre-feet per year (AFY) above the current water rights in the West Coast Basin for a total annual pumping quantity of 94,468 AFY, and (2) 103,250 AFY above the current Central Basin Allowed Pumping Allocation (APA), or a total annual pumping quantity of 320,617 AFY (Figure ES-1). Note that the current pumping is below the adjudicated limit (i.e., water rights) in the West Coast Basin and allowable limits (i.e., APA) in the Central Basin.



Notes:
CB = Central Basin
MFB = Montebello Forebay
LAFB = Los Angeles Forebay
WCB = West Coast Basin

Figure ES-1. Conceptualization of Water Supplies for Pumping with Increased Utilization of the West Coast and Central Basins

The increases in water supplies for basin replenishment and subsequent pumping were considered as a stepwise process, first assuming the pumping matches the adjudicated and allowable limits and then adding supplies in order to allow increased pumping above the adjudicated and allowable limits in both basins. The stepwise increase in water supplies approach considered the use of low-cost water supplies first, and then the use of more costly water supplies to further increase replenishment, thus allowing increased pumping from both basins. Provided below is a detailed conceptual approach used for the development of scenarios for additional recharge and pumping from these basins and alternatives, developed in coordination with basin stakeholders). The testing of scenarios was conducted using an updated WRD/U.S. Geological Survey (USGS) MODFLOW groundwater flow model to understand the effect of recharge on groundwater levels and basin storage in the West Coast and Central Basins.

A phased approach was used for the development of the GBMP. Phase 1 of the study began with the focus on the West Coast Basin in March 2010 and Central Basin in November 2010. Stakeholder workshops were held with the West Coast Basin and Central Basin stakeholders and pumpers to discuss the baseline operating conditions, increased utilization of the groundwater basins, and proposed management alternatives to develop initial concepts for additional recharge and pumping in the basins. The initial concepts were further refined based on stakeholder feedback. With the concepts established, Phase 2 detailed analyses of the West Coast Basin and Central Basin alternatives of various recharge and pumping conditions commenced, including groundwater modeling and cost evaluations. The basin stakeholders that have been engaged in this process include water purveyors and pumpers with water rights (including local refineries), water wholesalers (Metropolitan Water District of Southern California member agencies), and recycled water providers.

To meet the overall goal of the GBMP, Concepts A and B were defined as described below:

Concept A: This concept was based on increased pumping from the current pumping levels up to the total adjudicated limit of 64,468.25 AFY in in the West Coast Basin and APA of 217,367 AFY in the Central Basin (Figure ES-2).

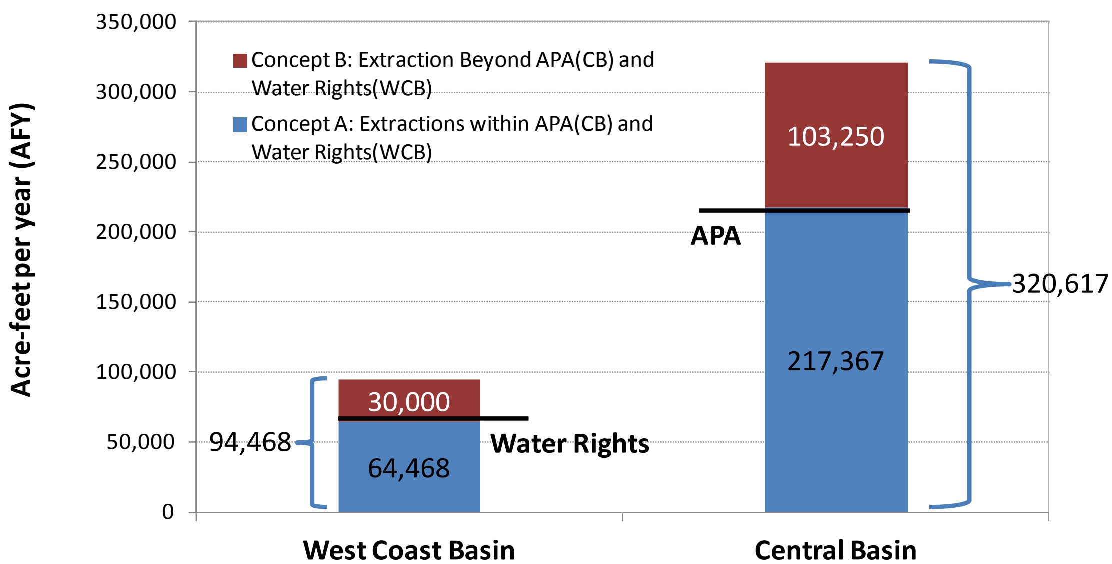


Figure ES-2. Conceptualization of Concepts A and B in the West Coast and Central Basins

Concept B: This concept, as shown in Figure ES-2, is based on increased pumping for up to 30,000 AFY above the current West Coast Basin water rights, or 94,468 AFY. Under this concept, pumping in the Central Basin is increased up to 103,250 AFY above the current APA, or a total supply of 320,617 AFY to offset nearly the entire imported water use in this basin.

Additional stormwater and recycled water could be used for additional recharge. Presented below are descriptions and conceptualizations of the various combinations of supplies that can be generated in both basins. Figures ES-3 through ES-5 provide schematic representations of how the West Coast and Central Basins could be further developed to increase use of local supplies and offset the use of imported water. The following three potential additional recharge schemes depicted in these figures are detailed further below:

1. **Expansion of replenishment in the West Coast Basin:** Opportunities were considered to use available recycled water supplies from the City of Los Angeles' Hyperion Water Reclamation Plant (HWRP) and Los Angeles County Sanitation Districts' (LACSD) Joint Water Pollution Control Plant (JWPCP). Expansion of West Basin Municipal Water District's (WBMWD) Edward C. Little Water Reclamation Facility (ECLWRF) for injection into the West Coast Basin Barrier Project (WCBBP) as also considered.
2. **Additional recharge near the Montebello Forebay area:** Figure ES-4 depicts the concept of utilizing additional stormwater and recycled water that could be developed in the Central Basin by (1) using recycled water from nearby water reclamation plants (WRPs), (2) increased pumping near the Montebello Forebay Spreading Grounds (MFSG) allowing for an increase of stormwater capture and recharge from the San Gabriel River, and (3) stormwater that could be captured from the Los Angeles River through an Aquifer Recharge and Recovery Project (ARRF). Ultimately 57,770 AFY of additional groundwater production could be developed from these supplies which can be pumped to offset imported water demands.
3. **Potential development of replenishment in the Los Angeles Forebay:** Figure ES-5 depicts the concept of utilizing sewer flows from the HWRP that could be treated by a newly constructed satellite advanced water treatment facility (AWTF) and subsequently injecting this water in the Los Angeles Forebay for replenishment and extracting water for delivery to the City of Los Angeles and other pumpers in the area. (This concept was identified in the City of Los Angeles' Recycled Water Master Planning documents.)

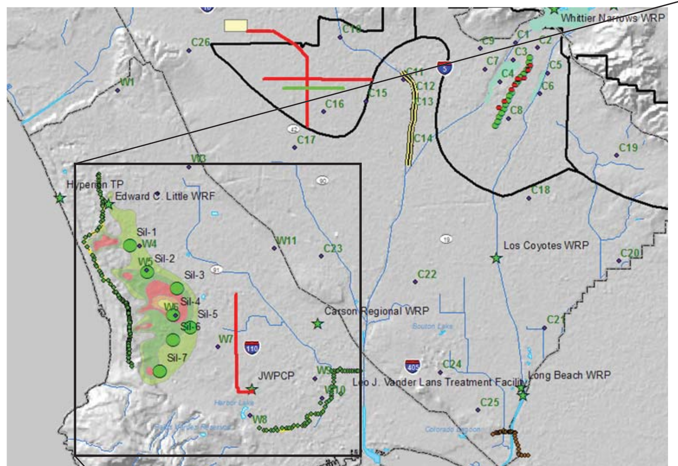
Figure ES-3 shows the conceptualization of opportunities to use available recycled water supplies from nearby wastewater treatment and reclamation plants. Recycled water from the City of Los Angeles' HWRP as well as LACSD's JWPCP. Expansion of WBMWD's ECLWRF could meet the injection requirements into the WCBBP. These supplies are sufficient to replenish the West Coast Basin through injection, as necessary, to allow for pumping up to the basin water rights of 64,468 AFY, and beyond by as much as 30,000 AFY for a total of 94,468 AFY. The existing injection barriers have sufficient capacity to meet replenishment needs up to the basin's water rights; however, additional injection capacity will likely be needed to allow pumping beyond water rights levels. Figure ES-3 shows a new line of inland injection wells to provide a total of 15,000 AFY from the JWPCP. In addition, up to seven desalters could be constructed to contain/remove saline to brackish groundwater in the Silverado Aquifer in order to restore groundwater quality of this principal aquifer used for municipal and industrial supplies. As a part of this overall water resource plan, oil refineries would reduce their use of groundwater substantially, and transfer this use to municipalities such as the City of Los Angeles, by replacing their groundwater supplies with recycled water supplies.

Figure ES-4 shows the conceptualization of potential new water supplies for supplemental recharge in the Central Basin. The additional water supply sources include recycled water from theLACSD's San Jose Creek Water Reclamation Plant (SJCWRP) and Los Coyotes WRP (LCWRP). WRD is currently constructing the Groundwater Reliability Improvement Project (GRIP), which will replace 21,000 AFY of imported water at the MFSG with recycled water from the SJCWRP (10,000 AFY of advanced treated water and 10,000 AFY of tertiary-treated water). WRD also recently expanded the Leo J. Vander Lans Water Treatment Facility to 8,000 AFY, which currently treats recycled water produced by LACSD's Long Beach WRP for injection into the Alamitos Barrier Project. Full utilization of SJCWRP, Whittier Narrows WRP, Pomona WRP, and LCWRP flows could provide up to an additional 67,800 AFY of recycled water for replenishment (which includes GRIP) through surface spreading and injection in the Montebello Forebay. However, as this increased recharge causes mounding of groundwater, which limits recharge, it is necessary to increase groundwater extraction to limit the rise of groundwater levels from this increased recharge. The Groundwater Basin Optimization Pipeline (GBOP) project is proposed to deliver additional 25,000 AFY of extracted water to participating pumpers as far south as Long Beach, which will allow for the increased stormwater capture.

In addition, approximately 5,000 AFY of stormwater could be captured from the Los Angeles River through an ARRF Project, which is a unique facility to capture stormwater, provide for soil aquifer treatment (SAT) and injection into the Central Basin aquifers for recovery by participating pumpers.

In summary, up to 22,000 AFY of stormwater (i.e., 17,000 AFY from the San Gabriel River and 5,000 AFY from the Los Angeles River) could potentially be developed as part of various alternatives presented in this GBMP.

Figure ES-5 shows the conceptualization of potential development of replenishment in the Los Angeles Forebay. Opportunities were considered to intercept sewer flows to HWRP and a new satellite AWTF could be constructed to produce high quality recycled water for injection into the Los Angeles Forebay using 50 new injection wells. Approximately 21 extraction wells would extract 29,000 AFY for delivery to the City of Los Angeles' potable water distribution system and participating pumpers would extract an additional 16,480 AFY within their service areas. This 45,480 AFY of additional replenishment and pumping, combined with the water resources development in the Montebello Forebay described above, could largely offset imported water use in the Central Basin.



In the West Coast Basin, recycled water supplies are available from the City of Los Angeles' Hyperion Water Reclamation Plant and the Los Angeles County Sanitation Districts' Joint Water Pollution Control Plant. These supplies can be used for injection to first meet replenishment requirements for pumping water rights (WR), then expanded to provide up to 30,000 AFY of pumping above water rights of 64,468 AFY as follows:

Potential New Supplies

23,000	AFY	HWRP/ECLWRF
17,000	AFY	JWPCP
40,000	AFY	
-10,000	AFY	
30,000	AFY	

Replenishment Required to Meet WR

17,000 AFY	HWRP/ECLWRF
13,000 AFY	TIWRP
10,000 AFY	
40,000 AFY	

30,000 AFY	Additional Pumping Yield Above Water Rights
15,000 AFY	Desalters targeted to remove salts
15,000 AFY	Increased extraction to participating pumpers

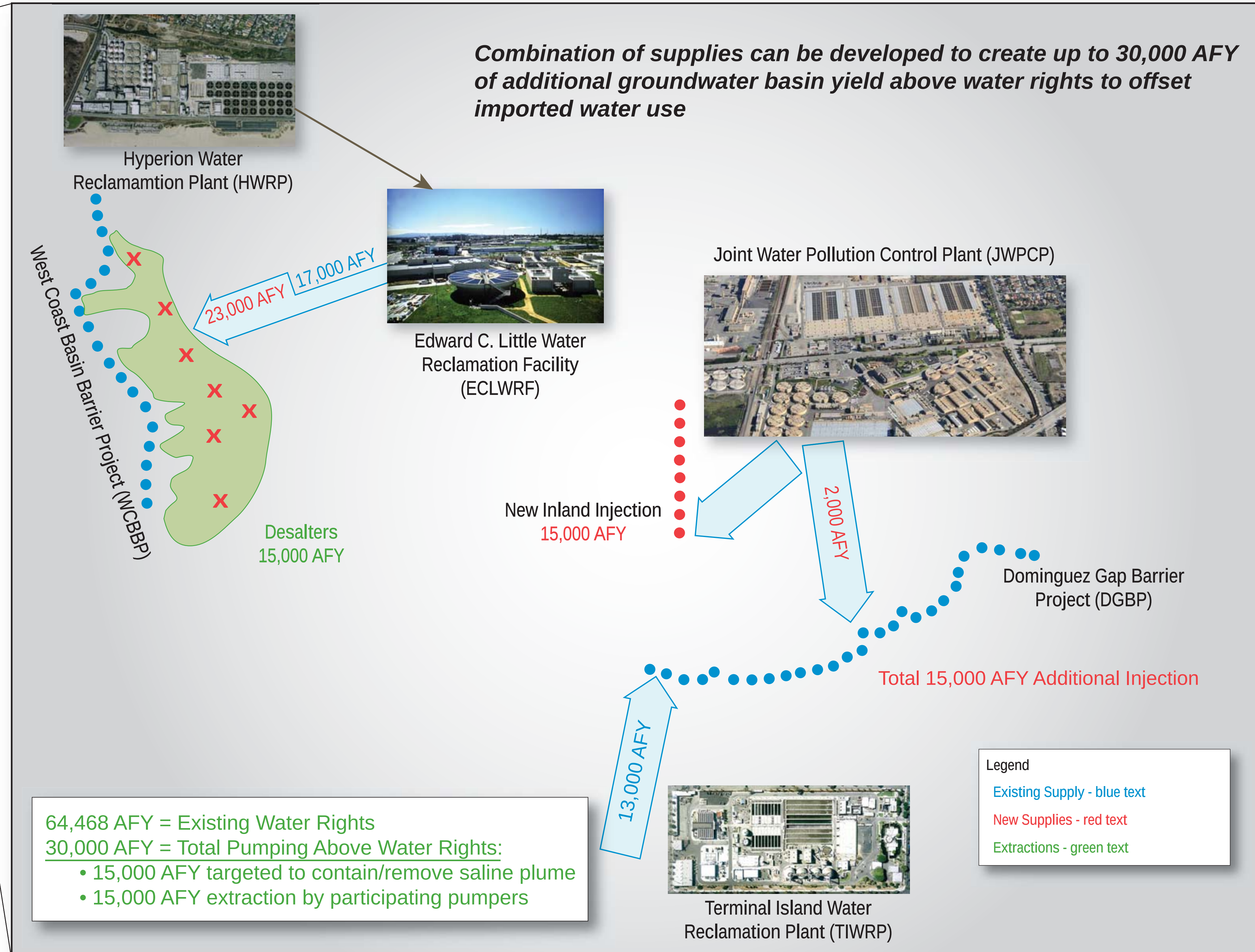


FIGURE ES-3
Potential Development of West Coast Basin
Groundwater Basins Master Plan

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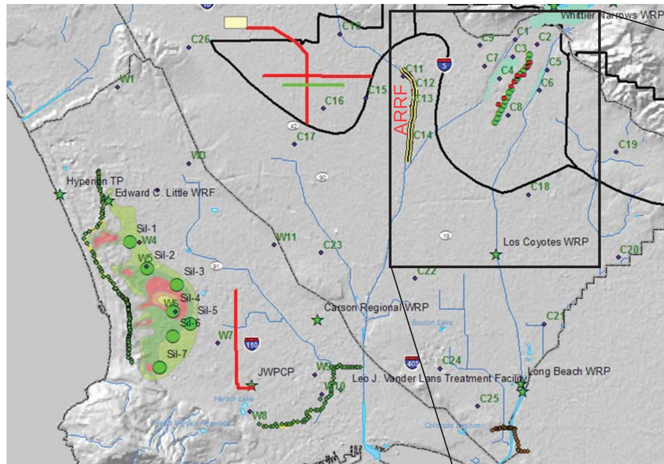

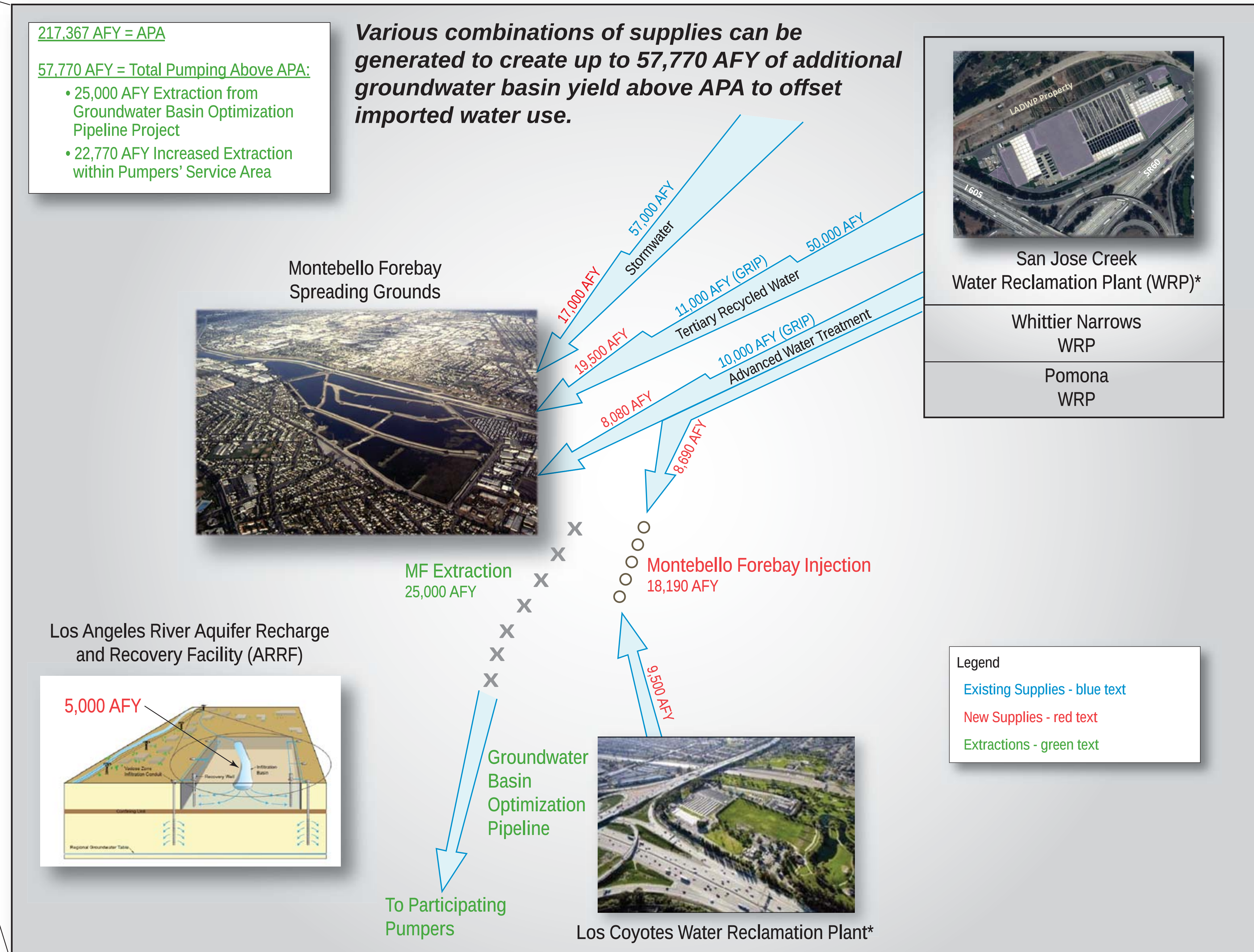

Alternative combinations of available stormwater, tertiary recycled water and advanced treated recycled water supplies are described in this GBMP. Ultimately 57,770 AFY of additional groundwater production could be developed from these supplies which can be pumped to offset imported water demands.

Potential New Supplies
17,000 AFY stormwater
19,500 AFY tertiary
16,770 AFY (8,690 + 8,080) advanced
9,500 AFY advanced
5,000 AFY ARRF
67,770 AFY
-10,000 AFY
57,770 AFY

Supplemental Replenishment to provide for 217,367 AFY of APA pumping
57,000 AFY surface water
50,000 AFY tertiary
11,000 AFY GRIP tertiary
10,000 AFY GRIP advanced
10,000 AFY
138,000 AFY

57,770 AFY Additional Pumping yield to offset imported water demand
25,000 AFY Groundwater Basin Optimization Pipeline Project Pumping to prevent mounding at spreading grounds
22,770 AFY Increased extraction within pumpers' service areas

* Photos courtesy of LACSD: www.lacsd.org/wastewater/wwfacilities/joint_outfall_system_wrp/

FIGURE ES-4
Potential Development of Montebello Forebay.
Groundwater Basins Master Plan

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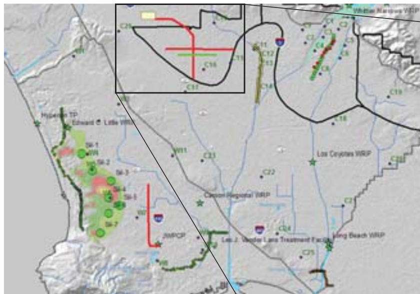

Sewer flows going to the City of Los Angeles' Hyperion Water Reclamation Plant could be intercepted and treated by a newly constructed advanced water treatment facility (AWTF). This high quality recycled water could be injected in the Los Angeles' Forebay for replenishment of the Central Basin. 50 new injection wells could be constructed to inject the recycled water. 21 new extraction wells could extract 29,000 AFY for delivery to the City of Los Angeles and participating pumpers could extract the remaining 16,480 AFY to offset imported water demands.

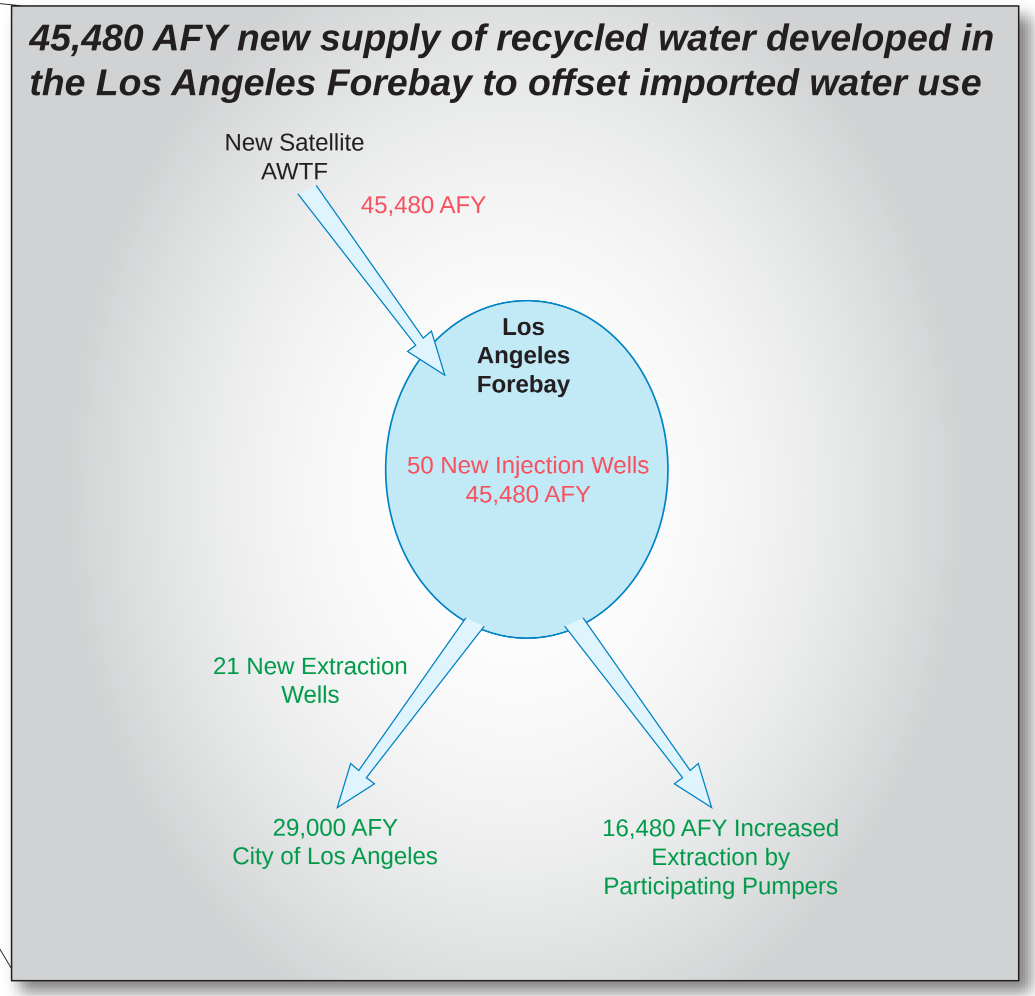

FIGURE ES-5
Potential Development of Los Angeles Forebay Area
Groundwater Basins Master Plan

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Conceptualization of Scenarios using Concepts A and B in the West Coast and Central Basins

Consistent with Concepts A and B, GBMP planning scenarios, which represent a range of basin operating conditions (extraction/replenishment), were developed for each basin. Presented above was the conceptualization of maximum replenishment and pumping from both basins for ultimate utilization of basin. A series of scenarios were designed under Concepts A and B to utilize low-cost water supplies first, and then the use more costly water supplies to further increase replenishment, thus allowing increased pumping from both basins. This stepwise process included conceptualization of scenarios which was based on a supply mix for basin replenishment and pumping schemes (such as pumping locations and changes to current pumping patterns for some of the purveyors) for each basin. Presented below is a summary of the approach, goals, supply sources and extractions and replenishment conditions for both basins.

West Coast Basin:

- **Approach:** The Concept A and B scenarios for the West Coast Basin were formulated such that the extraction expands beyond the adjudicated water rights, in accordance with the requirements of the recently approved Judgment amendments. Shifted oil companies' non-potable demands from groundwater use to recycled water and shifted groundwater pumping to municipal purveyors. Increased water supply in increments starting from the current groundwater replenishment level up to the water rights, and finally to create up to 30,000 AFY of additional groundwater basin yield above water rights to offset imported water use. The approach assumed 100 percent recycled water contribution to injection barriers and increased injection required for extraction of 94,468 AFY from the basin.
- **Overall Goal:** Contained/removed the saline plume. Scenarios were developed with increased injection into the Silverado aquifer, and decreasing or eliminating injection into the San Pedro aquifer while increasing extractions from Silverado aquifer to pump up to the adjudicated water rights. Scenarios that were found to increase seawater intrusion significantly into the Lower San Pedro aquifer, and even somewhat into the Silverado aquifer, were deemed too risky and/or ineffective and thus, were not considered for further consideration and modeling and analysis.
- **Water Supply Sources for Replenishment:** Additional sources of groundwater replenishment supply considered were recycled water supplied by HWRP with advanced treatment provided either at HWRP or at WBMWD's ECLWRF, expansion of the TIWRP, and advanced treatment of effluent from LACSD's JWPCP. Because the West Coast Basin aquifers are largely confined, stormwater infiltration is not a viable source of basin replenishment. (Seawater desalination projects, such as those currently being considered by WBMWD and others in the region, would be delivered directly into the potable water distribution system rather than serve as a groundwater replenishment supply. As such, seawater desalination is not a supply component of the GBMP alternatives.)
- **Extraction and Replenishment Conditions:** Groundwater injection using the existing barriers (WCBBP and Dominguez Gap Barrier Project [DGBP]), as well as new inland injection wells, are utilized for the West Coast Basin scenarios. Table ES-1 describes scenarios considered and evaluated under Concept A. Table ES-2 describes the pumping and injection conditions evaluated in the Concept A and B planning scenarios for the West Coast Basin.

Table ES-1. Locations of Extraction and Injection under West Coast Basin – Concept A Scenarios

Concept A Scenarios	Silverado Aquifer		Lower San Pedro Aquifer	
	Injection[a]	Silverado Extraction	Injection	Extraction
Scenario WCB-A1 (A1a, A1b, A1c)	Increased beyond current plans	Increased to adjudicated rights; pump from saline plume	No change to current level of protection	None
Scenario WCB-A2	Same as in Scenario WCB-A1	Same as in Scenario WCB-A1, and also moved Lower San Pedro pumping to this aquifer	Eliminated injection and shift pumping to Silverado	None
Scenario WCB-A3	Same as in Scenario WCB-A1	Same as in Scenario WCB-A1	Eliminated injection unless surplus imported water is available	None
Scenario WCB-A4	Same as in Scenario WCB-A1	Same as in Scenario WCB-A1	Eliminated injection	Considered extraction and treatment of brackish groundwater

[a] Injection considered at existing barriers only

Table ES-2. Injection and Extraction Conditions under West Coast Basin Planning Scenarios (Concepts A and B)

West Coast Basin Scenarios	Recharge	Pumping
Concept A Scenarios (Pumping within water rights): WCB-A1 (A1a, A1b, A1c), WCB-A2, WCB-A3, WCB-A4	Assumed recharge at the two existing injection barriers with 100 percent recycled water contribution at each barrier, sufficient to meet the adjudicated water rights.	It was assumed that all pumpers pumped their full water rights and that oil companies shifted their non-potable demands from groundwater to recycled water, and that these water rights are pumped by municipal purveyors; For Scenario WCB-A1c, three pumpers (that is, California Water Service Company (CWSC)–Hawthorne, City of Torrance, and City of Los Angeles) would use a total 15,000 AFY of desalinated groundwater. Thus, extraction for these three pumpers was shifted from their current well locations to seven new desalters (shown in Figure ES-3) in the Silverado aquifer.
Concept B Scenarios (Pumping above water rights): WCB-B1	In addition to increased recharge at the two existing injection barriers, replenishment included the use of a new, inland injection well system (shown in Figure ES-5).	Pumping of additional 30,000 AFY above water rights assumes that pumping was distributed to CWSC-Hawthorne, City of Torrance, and City of Los Angeles; otherwise all other pumping was the same as Scenario WCB-A1c.

Central Basin:

- **Approach**: Increased water supply in increments starting from the current groundwater replenishment level up to the APA, followed by an increase of 57,770 AFY in the Montebello Forebay and finally, an increase of 45,480 AFY in the Los Angeles Forebay.

- **Overall Goal:** Offset nearly all imported water supplies, including direct deliveries.
- **Water Supply Source for Replenishment:** Additional sources of groundwater replenishment in the Central Basin considered were stormwater and recycled water from LACSD's SJCWRP and LCWRP, as well as potentially from the City of Los Angeles. New advanced purification facilities would be constructed to treat wastewater and provide high quality water for replenishment. Stormwater from the San Gabriel River and Rio Hondo that currently bypasses the spreading grounds following large storm events could be used for recharge in the Montebello Forebay. Increased recharge capacity at the MFSG is provided by depressing nearby groundwater levels through shifting of pumping in the Montebello Forebay with the GBOP project. Storm flows from the Los Angeles River that are wasted to the ocean can be captured and used as a potential source for groundwater basin recharge. The Los Angeles River ARRF project (shown in Figure ES-4) is considered as a system that would first treat stormwater and then recover (pump) the treated water for subsequent injection through a vadose zone infiltration conduit into the groundwater basin for replenishment in the Los Angles Forebay.
- **Extraction and Replenishment Conditions:** Recharge of the basin would occur by increased spreading at the MFSG) and injection using the existing barrier (Alamito Barrier Project), as well as using a new inland injection wellfield to match the pumping. The additional available stormwater that could be diverted into the spreading basins and the spreading basin recharge capacity were evaluated based on historical operations. Table ES-3 provides a description of recharge and pumping conditions evaluated in the Concept A and B planning scenarios for the Central Basin.

Table ES-3. Extraction and Injection Conditions under CB – Concepts A and B Scenarios

Central Basin Scenarios	Recharge	Pumping
Concept A Scenarios (Pumping within APA):		
CB-A1	Increases extraction by water rights holders up to the APA basin by replenishing the basin through the spreading of an additional 10,000 AFY of recycled water from the SJCWRP at the MFSG.	Pump full APA by distributing additional pumping similarly to recent 10 years of extraction and allocate unused water rights to pumpers with imported water usage.
CB-A2	Modifies Scenario CB-A1 by using recycled water from both the SJCWRP as well as the LCWRP.	Same as in Scenario CB-A1.
CB-A3	Modifies Scenario CB-A2 by injecting recycled water from the LCWRP.	Same as in Scenario CB-A1.
CB-A4	Modifies Scenario CB-A1 by increasing the amount of stormwater that can be captured from the Los Angeles River and recharged in the Los Angeles Forebay.	Same as in Scenario CB-A1.
Concept B Scenarios (Pumping above APA):		
CB-B1	Maximizing use of stormwater capture from the Rio Hondo and San Gabriel and Los Angeles Rivers (22,000 AFY) and available recycled water from SJCWRP and LCWRP (66,800 AFY) in the Montebello Forebay.	Extraction is increased beyond the APA by an additional 57,770 AFY in the Montebello Forebay.
CB-B2:	Injection of 45,480 AFY of -full advanced treated effluent from new satellite AWTF at new line of extraction wells in the Los Angeles Forebay, in conjunction with maximizing stormwater capture and recycled water use (per Scenario CB-B1).	Extraction is increased in the Montebello and Los Angeles Forebays to a total of 103,250 AFY above the APA.

The scenarios developed for each basin were combined for the purposes of groundwater modeling, conducted simultaneously for both basins. Several modeling combinations were generated by combining select West Coast Basin and Central Basin scenarios to evaluate basinwide groundwater conditions. Only feasible combinations of scenarios were used for conducting model simulations.

The WRD/USGS MODFLOW groundwater flow model of the West Coast and Central Basins, developed for the period of 1971 through 2000, was updated to include hydrologic data and basin operations from the 2000 through 2010 period into the existing model. The model was extended through water year 2050 by repeating the hydrology from 1971 through 2010 and refined to provide for monthly stress periods in order to better assess fluctuations in groundwater levels and storage. Groundwater modeling of various basin operational conditions was conducted to assess the overall water balance in the West Coast and Central Basins, considering hydrologic variations over a long-term (40-year) period. Pumping and replenishment were balanced so that groundwater storage levels ended at the same levels as they began over the simulation period. Scenarios that were simulated with the model included the following:

1. Pumping at APA levels in the Central Basin (Concept A) and at water rights levels in the West Coast Basin (Concept A), with sufficient replenishment to support these pumping conditions
2. Pumping above APA levels in the Central Basin (Concept B) and at water rights levels in the West Coast Basin (Concept A), with sufficient replenishment to support these pumping conditions
3. Pumping at APA levels in the Central Basin (Concept A) and above water rights levels in the West Coast Basin (Concept B), with sufficient replenishment to support these pumping conditions
4. Pumping above APA levels in the Central Basin (Concept B) and above water rights levels in the West Coast Basin (Concept B), with sufficient replenishment to support these pumping conditions

The modeling results were used to assess groundwater level fluctuations, identify trends in groundwater storage, and identify groundwater flow between adjacent groundwater basins and subareas within basins. Table ES-4 provides a summary of modeling combinations, including the GBMP planning scenarios that make up each combination, the replenishment and pumping quantities used for each model run, and modeling results.

Table ES-4. Summary of Modeling Conditions and Results

Modeling Scenarios	Modeling Combinations (GBMP Planning Scenarios[a])	Pumping (AFY)	Total Replenishment (AFY)	Modeling Results
WCB: Pumping within water rights CB: Pumping within APA	*Combination 1* (WCB-A1a and CB-A1) *Combination 2* (WCB-A1c and CB-A1)	64,468 (WCB) +217,367 (CB) =281,835	186,001	Groundwater level hydrographs show an overall water balance in both the basins. The changes in the basinwide groundwater balance are within acceptable limits. Under Scenario WCB-A1a, the flow path lines show eastward advancement of the saline plume. Under Scenario WCB-A1c, modeling results indicate improvements in water quality.
WCB: Pumping within water rights CB: Pumping above APA	*Combination 3* (WCB-A1a and CB-B1)	64,468 (WCB) +275,137 (CB) =339,605	243,423	Hydrographs in the Montebello Forebay show groundwater levels in wells near the Rio Hondo spreading grounds rise to and slightly above land surface during high-rate recharge events in wet years. Basins are balanced over the simulation period.
	Combination 4 (WCB-A1a and CB-B2)	64,468 (WCB) +320,617 (CB) =385,085	288,903	Groundwater levels in this model run were similar to Combination 3 results. Water budget indicated that the basins end with a significant surplus at the end of the simulation period. This surplus is largely contained in the Los Angeles Forebay, which indicates that replenishment is not equally balanced with pumping in this area.
WCB: Pumping above water rights CB: Pumping within APA	*Combination 5* (WCB-B1 and CB-A1)	94,468 (WCB) + 217,367 (CB) = 311,835	318,890	Hydrographs are similar to Combination 1. Cumulative storage indicated that the basins are balanced over the simulation period. There is not a surplus or deficit in storage at the end of the period.
WCB: Pumping above water rights CB: Pumping above APA	*Combination 6* (WCB-B1 and CB-B1)	94,468 (WCB) +275,137 (CB) =369,605	250,223	Same as Combination 5.

[a] Per Tables ES-1 and ES-2

Based on the planning concepts and viable scenarios for the West Coast and Central Basins, GBMP alternatives were developed for the purpose of comparative assessment. GBMP alternatives comprise specific projects consisting of supply, recharge, and extraction components to meet target supply yields corresponding to the basin planning scenarios. Formulating alternatives with consistent supply yields allowed for comparison of the alternatives with respect to the GBMP evaluation criteria, including costs. The costs for each of the alternatives were prepared by combining the individual project costs.

Table ES-5 shows the total extraction and recharge schemes for each of the West Coast Basin alternatives, and the amount of imported water shifted to groundwater for these alternatives is shown in Table ES-6.

Table ES-5. Total Extractions and Additional Recharge Beyond Current Levels Considered for West Coast Basin Alternatives

			Additional Recharge Needed to Meet Total Extraction			
			Recycled Water (Injection)			
Concept	**Alternatives**	**Total Extraction (AFY)**	**WCBBP (AFY)**	**DGBP (AFY)**	**WCB-NEW (AFY)**	**Total (AFY)**
A	WCB-A1	64,468	15,500	2,500[a]	N/A	18,000
B	WCB-B1	94,468	23,000	10,000	15,000	48,000

[a] Expands recycled water production capacity to fully replace current imported water replenishment for 100 percent recycled water contribution (RWC).

Notes:

N/A = not applicable
WCB-NEW = New inland injection well system in the West Coast Basin

Table ES-6. Imported Water Replacement and Pumping Shifts Under West Coast Basin Alternatives

Concept	Alternatives	Total Extraction (AFY)	Quantity of Imported Water Shifted to Groundwater (AFY)	Number of Purveyors
A	WCB-A1	64,468	See footnote[a]	See footnote[b]
B	WCB-B1	94,468	30,000	8

[a] The difference between adjudicated rights and pumping over recent 10–year period (water years 2000/2001-2009/2010) averaged 22,500 AFY, indicating the amount of imported water use that would be replaced with groundwater pumping.
[b] Adjusted existing pumpers to reach their respective water rights

For the Central Basin alternatives, the total extraction and recharge schemes are shown in Table ES-7. The amount of imported water use replaced with groundwater pumping and the associated pumping shifts are shown in Table ES-8.

A summary of the major facilities included in the GBMP alternatives is provided on Figure ES-6.

Table ES-7. Total Extractions and Additional Recharge Beyond Current Levels Considered for Central Basin Alternatives

Concept	Alternatives	Total Extraction (AFY)	Additional Recharge Needed to Meet Total Extraction: Stormwater (AFY) SGR	Stormwater (AFY) LAR	AWT Injection (AFY) MFB	AWT Injection (AFY) LAFB	Spreading (AFY) Tertiary	Spreading (AFY) AWT	Total (AFY)
A	Pumpers extract full APA	217,367					10,000		10,000
	CB-A1a-f							10,000	10,000
	CB-A2a						5,000	5,000	10,000
	CB-A2b							10,000	10,000
	CB-A3a						5,000	5,000	10,000
	CB-A3b							10,000	10,000
	CB-A4a			5,000			5,000		10,000
	CB-A4b			5,000				5,000	10,000
B	Pumpers extract above full APA	275,137 - 320,617							
	CB-B1a	275,137 [a, b]	17,000	5,000	18,190		27,580		67,770
	CB-B1b	275,137 [a, b]	17,000	5,000	18,190			27,580	67,770
	CB-B2a	320,617 [c]	17,000	5,000	18,190	45,480		27,580	113,250
	CB-B2b	320,617 [c]	17,000	5,000	18,190	45,480	27,580		113,250

[a] Includes 25,000 AFY of extraction associated with the GBOP project in the Montebello Forebay

[b] Includes 57,770 AFY of extraction associated with the GBOP project in the Montebello Forebay

[c] Includes 29,000 AFY of extraction in the Los Angeles Forebay to serve the City of Los Angeles and 25,000 AFY of extraction associated with the GBOP project in the Montebello Forebay

Notes:

LAR = Los Angeles River
SGR = San Gabriel River

Table ES-8. Imported Water Replacement and Pumping Shifts Under Central Basin Alternatives

Concept	Alternatives	Total Extraction (AFY)	Revised Pumping[a] MFB (AFY)	Revised Pumping[a] LAFB (AFY)
A	Pumpers extract full APA	217,367		
	CB-A1a-f		[b]	[b]
	CB-A2a		[b]	[b]
	CB-A2b		[b]	[b]
	CB-A3a		[b]	[b]
	CB-A3b		[b]	[b]
	CB-A4a		[b]	[b]
	CB-A4b		[b]	[b]
B	Pumpers extract above full APA	275,137		
	CB-B1a		57,770[c]	N/A
	CB-B1b		57,770[c]	N/A
	Pumpers extract above full APA	320,617		
	CB-B2a		57,770[c]	45,480[d]
	CB-B2b		57,770[c]	45,480[d]

[a] Some pumping occurs outside the forebay limits.

[b] The difference between adjudicated rights and pumping over recent 10-year period (water years 2000/2001-2009/2010) averaged 22,000 AFY, indicating the amount of imported water that would be replaced by groundwater pumping.

[c] Shifted pumping of 25,000 AFY for four pumpers for the GBOP project

[d] Pumping includes 29,000 AFY for City of Los Angeles

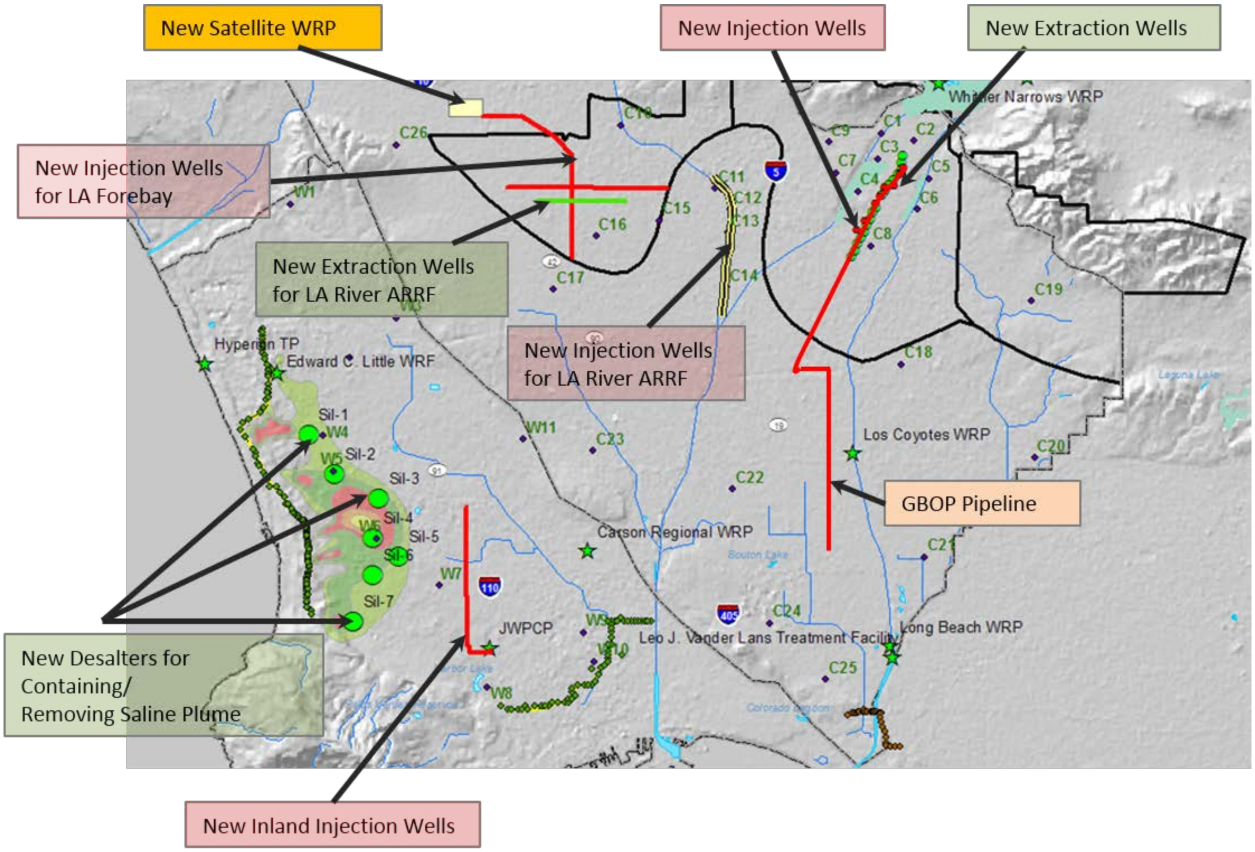

Figure ES-6. Location of Major Facilities in the GBMP Alternatives for the West Coast and Central Basins

Figures ES-7 and ES-8 present annual yield and present value unit cost (dollars per acre-foot [$/AF]) for the West Coast and Central Basin alternatives, respectively. An analysis of the GBMP alternatives provides an assessment of the performance of the alternatives relative to evaluation criteria that can guide stakeholder decision making.

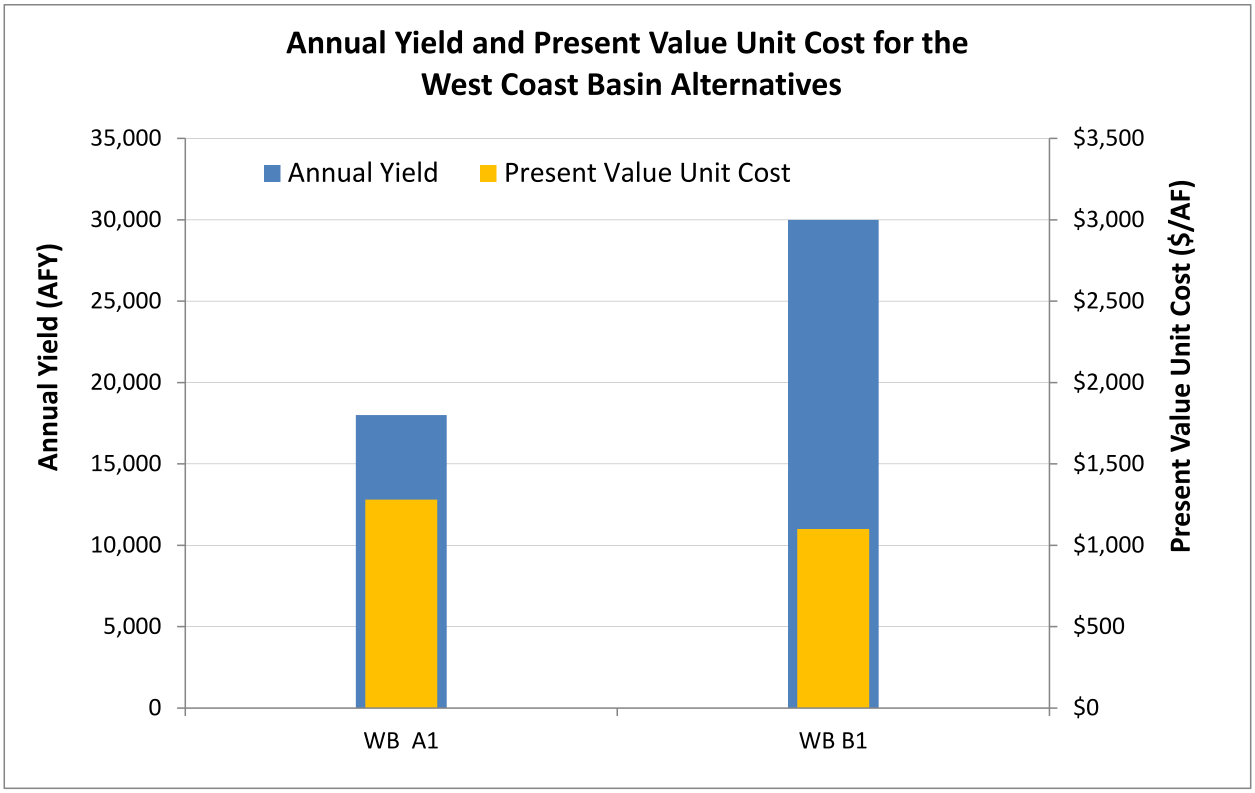

Figure ES-7. Annual Yield and Present Value Unit Cost for the West Coast Basin Alternatives

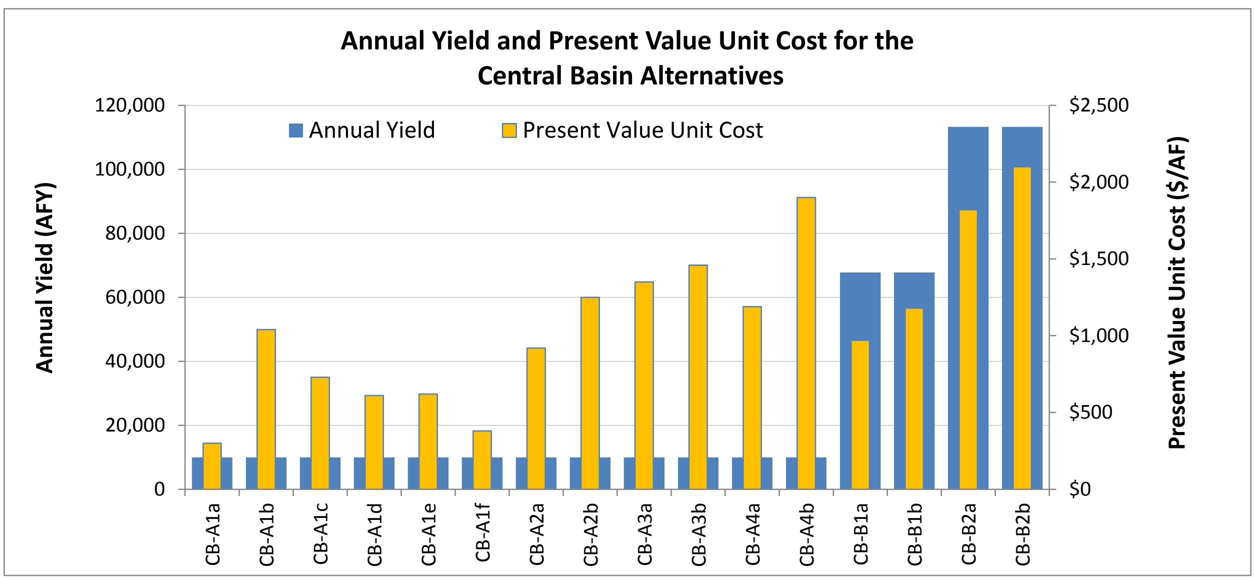

Figure ES-8. Annual Yield and Present Value Unit Cost for the Central Basin Alternatives

In addition to cost, the following criteria were also evaluated for each alternative: (1) water supply availability and reliability, (2) energy/greenhouse gas emissions, (3) environmental impacts, and (4) total dissolved solids (TDS) loading. These were compared against the No Project Alternative, in which imported water was used to provide additional replenishment to match basin pumping.

Key findings from the evaluation are:

- Lifecycle costs for alternatives using recycled water with full advanced treatment are more than twice the costs for tertiary alternatives.
- The lifecycle costs for tertiary alternatives could be even lower if the purchase price for tertiary effluent is reduced. These estimates assume a price of $300 per acre-foot ($/AF) for tertiary projects and a price of $100/AF for projects utilizing advanced water treatment processes.
- Energy demands and carbon dioxide (CO_2) emissions are significantly higher for the No Project Alternative due to pumping required for the conveyance of imported water.
- CO_2 emissions for full advanced treatment alternatives are approximately 60 percent less than the No Project Alternative.
- CO_2 emissions for tertiary alternatives are significantly lower than the No Project Alternative.
- Full advanced treatment alternatives result in a TDS loading that is significantly lower than the No Project Alternative.

This GBMP identifies a range of projects and opportunities to not only ensure that additional replenishment water will be supplied to meet the pumpers' use of groundwater for which they have rights, but also identifies opportunities to further reduce reliance on imported water through enhanced use of the vast groundwater storage of these basins. The projects have been defined sufficiently to estimate their broad cost implications and allow for comparison of the value of pursuing development of these various water sources. The implementation of projects and alternatives would require stakeholder coordination, regulatory and legal considerations, confirmation of availability of supplies for replenishment, validation of spreading ground capacity, and development/enhancement of the modeling framework to evaluate the impacts of changes to the water quantity and quality as an effect of these alternatives.

This GBMP is not a capital improvement program, nor does it encourage or commit any party to a particular project or program. It does not address institutional issues, which are significant and critical to advancing any of the elements identified herein. While estimated planning-level costs are provided for specific projects and alternatives as a basis for comparison, no attempt has been made to analyze future Replenishment Assessment impacts, or to allocate potential benefits that may be realized from these projects or alternatives.

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Abbreviations

$/af	dollar(s) per acre-foot
$M	million dollars
AB	Assembly Bill
ABP	Alamitos Barrier Project
AF	acre-feet
AFM	acre-feet per month
AFY	acre-feet per year
AOP	advanced oxidation process
APA	Allowed Pumping Allocation
ARRF	Aquifer Recharge Recovery Facility
ASR	aquifer storage and recovery
AWT	advanced water treatment
AWTF	advanced water treatment facility
BAC	biological activated carbon
CDPH	California Department of Public Health
cfs	cubic foot (feet) per second
CO_2	carbon dioxide
CRWRF	Juanita Millender-McDonald Carson Regional Water Reclamation Facility
CWSC	California Water Services Company
DDW	Division of Drinking Water of State Water Resources Control Board
DGB	Dominguez Gap Barrier
DGBP	Dominguez Gap Barrier Project
DWR	California Department of Water Resources
ECLWRF	Edward C. Little Water Reclamation Facility
EIR	environmental impact report
EIS	environmental impact statement
ft	feet; foot
GAC	granular activate carbon
GBMP	Groundwater Basins Master Plan
GBOP	Groundwater Basin Optimization Pipeline
GHG	greenhouse gas
GRIP	Groundwater Reliability Improvement Project
GRRP	Groundwater Replenishment Reuse Project

GWR	groundwater recharge
GWV	Groundwater Vistas
hp	horsepower
HWRP	Hyperion Water Reclamation Plant
ID	identification number
IRP	Integrated Resources Plan
JOS	Joint Outfall System
JWPCP	Joint Water Pollution Control Plant
kWh	kilowatt-hour
LACDPW	Los Angeles County Department of Public Works
LACSD	Los Angeles County Sanitation Districts
LADWP	Los Angeles Department of Water and Power
LBWRP	Long Beach Water Reclamation Plant
LCWRP	Los Coyotes Water Reclamation Plant
LVLWTF	Leo J. Vander Lans Water Treatment Facility
MBR	membrane bioreactor
MF	microfiltration
MFSG	Montebello Forebay Spreading Grounds
mg/L	milligram(s) per liter
mgd	million gallon(s) per day
MWD	Metropolitan Water District of Southern California
N/A	not applicable
NDMA	N-nitrosodimethylamine
NF	nanofiltration
NPR	non-potable reuse
O&M	operations and maintenance
OCWD	Orange County Water District
PEIR	Programmatic Environmental Impact Report
RA	replenishment assessment
Reclamation	Bureau of Reclamation
RO	reverse osmosis
RW	recycled water
RWC	recycled water contribution
RWQCB	Regional Water Quality Control Board
SAT	soil aquifer treatment

SJCWRP	San Jose Creek Water Reclamation Plant
SNMP	Salt and Nutrient Management Plan
SWRCB	State Water Resources Control Board
TDS	total dissolved solids
TIWRP	Terminal Island Water Reclamation Plant
TOC	total organic carbon
USGS	U.S. Geological Survey
UV	ultraviolet
WaterSMART	Sustain and Manage America's Resources for Tomorrow
WBMWD	West Basin Municipal Water District
WCBBP	West Coast Basin Barrier Project
WIN	Water Independence Now
WIN BIGGR	Water Independence Now By Increasing Groundwater Recharge and Recovery
WRD	Water Replenishment District of Southern California
WRP	water reclamation plant
WWTP	wastewater treatment plant

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SECTION 1

Introduction

1.1 Introduction

The Water Replenishment District of Southern California (WRD), in coordination with other basin stakeholders, has developed this Draft Groundwater Basins Master Plan (GBMP). The intent of this plan is to provide a single reference document for parties operating within and maintaining the West Coast and Central groundwater basins. This GBMP presents a number of options for meeting replenishment requirements of the West Coast and Central Basins and options for expanding use of the basins' storage to increase reliability of area water supplies. While this GBMP provides opportunities for increased use of these groundwater basins, realization of these opportunities will come from future actions of pumpers, the holders of water rights for these basins, and other basin stakeholders. WRD can, and is willing to facilitate additional activities and partnerships to continue to move those options, or other similar options that might be identified, forward to improve reliability of local water supplies and continue protection of these important groundwater basins.

The water supply planning environment has changed dramatically in recent years—locally dry conditions have reduced local water supplies; reductions in Colorado River supplies due to hydrologic conditions have occurred; and significant reductions in State Water Project water supplies have occurred due to hydrologic and regulatory conditions. In addition, there has been much recent work on climate change and its impacts, including El Niño Southern Oscillation, Pacific Decadal Oscillation, and long-term climate changes, such as reduced snowpack in California and along the Colorado River Basin. Climate change impacts may include reduced inflows into reservoirs throughout the spring and summer; increase the frequency of short, high-intensity storms with high sediment loads that cannot be easily diverted into off-stream storage; and cause sea level rise that could affect State Water Project diversion facilities and saltwater intrusion into coastal aquifers. The vulnerability of Southern California to potential impacts of catastrophic events, such as earthquakes and Bay-Delta levee failures, has also prompted increased emphasis on reducing the region's dependence on imported water supplies and increasing the use of local water resources.

As a result of the uncertainties in imported water supplies and significant increases in the cost of imported water, local pumpers are revisiting their business plans to assess their alternatives to develop more local water. In recent years, nearly one-third of the adjudicated water rights in the West Coast Basin (approximately 20,000 acre-feet per year [AFY]), and a comparable amount (although only about 10 percent of the Allowed Pumping Allocation [APA]) in the Central Basin have not been pumped. This is principally because of the need to install relatively expensive wellhead treatment systems to address localized water quality issues. Groundwater production, including pumping, wellhead treatment, and replenishment, was not historically as cost effective as relying on imported water. However, given the rising costs of imported water, groundwater may become a much more competitive supply as long as the cost of replenishment water is affordable. Recycled water may prove to be the most affordable and reliable supply of replenishment and water augmentation.

To enhance and protect local water resources and facilities, WRD has partnered with pumpers and other local agencies such as the Los Angeles County Department of Public Works (LACDPW) who operates the existing seawater intrusion injection barriers and spreading grounds; oil companies who pump large quantities of water for oil refining; and suppliers of recycled water, including the West Basin Municipal Water District (WBMWD), the Los Angeles County Sanitation Districts (LACSD), and the City of Los Angeles. For example, programs are in place to reduce the use of potable groundwater and imported water for non-potable uses and switch those non-potable uses to recycled water supplies (for instance, oil refineries are switching some water demands to recycled water). In addition, several studies have been completed to assess the condition of the injection barrier facilities and wells, enhance the capacities of the existing spreading basins, and move to the use of recycled water for replenishment to reduce reliance on imported water.

Overlying agencies in the West Coast and Central Basins have initiated efforts to improve water supply reliability and protect local water resources, including the following:

- WRD's Water Independence Now (WIN) initiative
  - The WIN program is a network of local facilities and education efforts that could help the quality of life and economy of southern Los Angeles County if the imported water we depend upon becomes unavailable. WIN includes support of increased conservation, increased use of recycled water, storage of water in groundwater basins to protect against drought and emergency water supply interruptions, and protection of local groundwater resources.
- WBMWD Water Reliability 2020 program
  - The Water Reliability 2020 program is designed to reduce imported water use from 66 to 33 percent by the year 2020 by more than doubling efforts to recycle water, doubling conservation efforts, increasing educational programs about conservation, and developing an ocean water desalination program.
- WRD's ongoing assessments of the West Coast Basin saline plume and development of a Saline Plume Policy. The saline plume is a mass of brackish groundwater in the Torrance area created by seawater intrusion that was trapped inland of the West Coast Basin Barrier after the barrier was put into operation in the 1950s and 1960s.
- WRD's and WBMWD's development of recycled water supplies
- Water purveyors' expansion of recycled water uses within their service areas
- City of Los Angeles' development of their Water Integrated Resources Plan (IRP), subsequent Recycled Water Master Planning documents, and current One Water LA Plan
- Cooperative efforts by WRD and LACDPW to assess the condition of the existing injection barriers and enhance the capacity of the Montebello Forebay Spreading Basins
- LACDPW's extension of the Dominguez Gap Barrier
- Cooperative efforts between stakeholders to shift industrial water uses from groundwater and imported water to recycled water

Lastly, recent amendments to the West Coast and Central Basin Judgments allow for more flexibility in the use of these basins' storage capacity, including conjunctive use of the groundwater basins. These Judgment amendments .allow for increased optimization of the West Coast and Central Basin operations and provide for a more reliable and cost-effective water supply for the region.

This GBMP is intended to be a starting point for basin-wide planning that will serve as the basis for a programmatic environmental review process. Complementing stakeholder outreach conducted during the preparation of the GBMP, WRD intends to use the environmental impact report (EIR) process to formally vet the GBMP alternatives and further open dialogue about these potential opportunities. The determination of the relative value of these opportunities will stem from such dialogue. WRD's intent is to facilitate these discussions with the preparation of this GBMP. The GBMP is not intended to be a capital improvement program, nor does it address any of the institutional, financial, regulatory, or legal issues that might be associated with implementation of any of the identified projects or alternatives. Rather, the GBMP provides technical analysis of what might be possible to enhance utilization of the West Coast and Central groundwater basins for local and regional benefits.

1.1.1 Background

The content of this GBMP should be considered in light of the densely urban and geologically complex area of study, the historical use of the subject groundwater basins, and the role of WRD in both managing these basins and providing this analysis of potential long-term replenishment alternatives.

1.1.2 Description of Study Area

The GBMP Study Area is located in the southern portion of Los Angeles County, in the WRD service area, shown in Figure 1-1, which overlays the West Coast and Central groundwater basins. Home to over 4 million people, the water supply reliability in this area is critical to the economic sustainability of water resources both locally and statewide through the Study Area's connection to imported water sources.

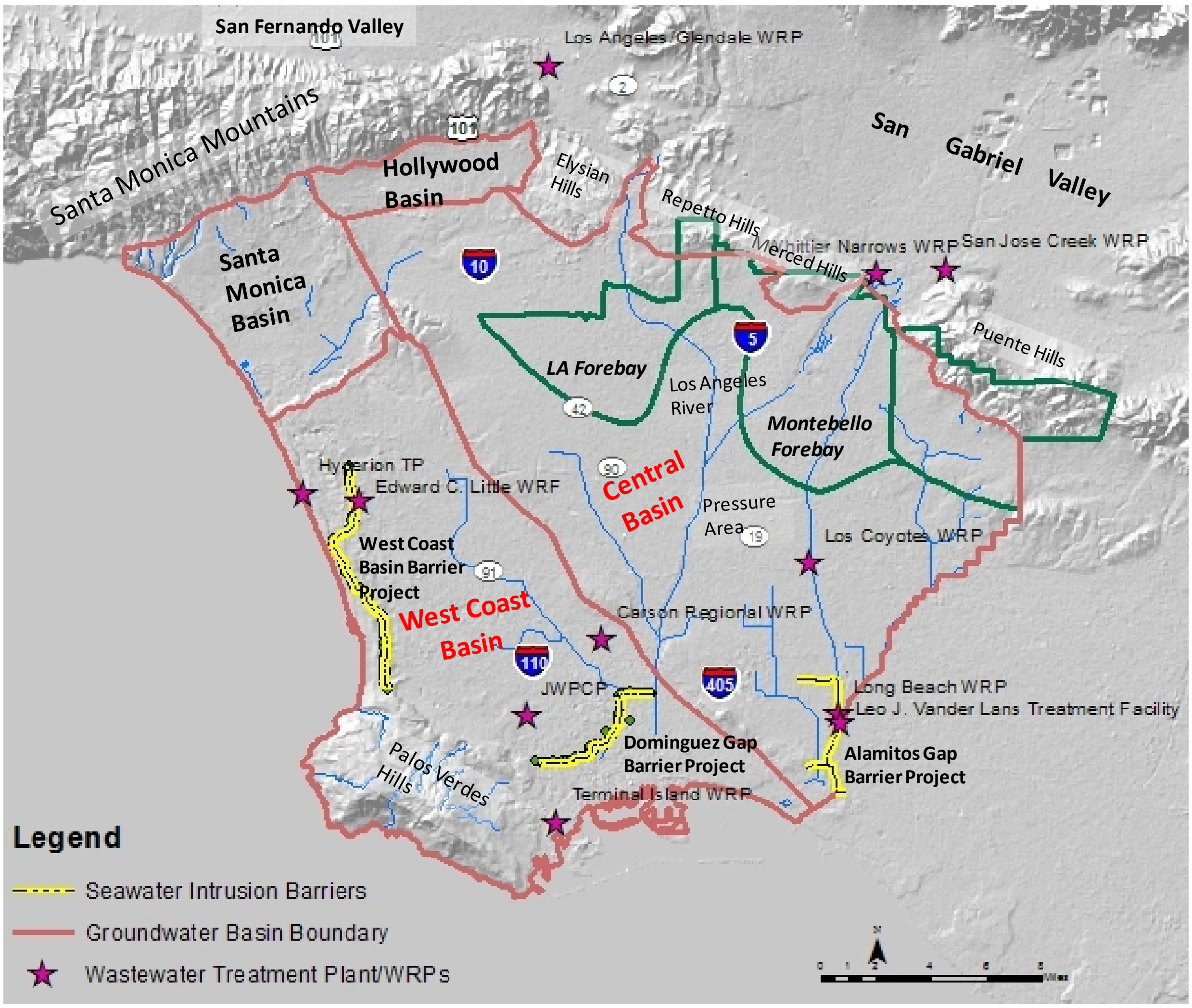


Figure 1-1. Water Replenishment District of Southern California Service Area

The Study Area is located in the Los Angeles Coastal Plain and is highly urbanized. The major land forms of the Coastal Plain consist of bordering highlands and foothills, older plains and hills, younger alluvial plains, rivers that drain the area, and offshore topography.

The Central Basin covers approximately 270 square miles and is bounded on the north by the Hollywood Basin and the Elysian, Repetto, Merced, and Puente Hills; to the east by the Los Angeles County/Orange County line; and to the south and west by the Newport-Inglewood Uplift, a series of discontinuous faults and folds that form a prominent line of northwest-trending hills including the Baldwin Hills, Dominguez Hills, and Signal Hill.

The West Coast Basin covers approximately 140 square miles and is bounded on the north by the Baldwin Hills and the Ballona Escarpment (a bluff just south of Ballona Creek), on the east by the Newport-Inglewood Uplift, to the south by San Pedro Bay and the Palos Verdes Hills, and to the west by Santa Monica Bay.

The Central Basin is divided into four sections—the Los Angeles Forebay, the Montebello Forebay, the Whittier Area, and the Pressure Area (California Department of Water Resources [DWR], 1961). The two forebays represent areas of unconfined (water table) aquifers that allow percolation of surface water down into the deeper production aquifers to replenish the rest of the basin. The Whittier Area and Pressure Area are confined aquifer systems that receive relatively minimal recharge from surface water, but are replenished from the upgradient forebay areas or other groundwater basins.

In the West Coast Basin, aquifers are generally confined and receive the majority of their natural replenishment from adjacent groundwater basins or from the Pacific Ocean (seawater intrusion). Both the Newport-Inglewood Uplift and the Charnock Fault (in the West Coast Basin) are partial barriers to groundwater flow, causing differences in water levels on opposite sides of each fault system. Groundwater flows between the West Coast and Central Basins based on the groundwater elevations on either side of the Newport-Inglewood Uplift. Most of the groundwater in the West Coast and Central Basins remains at an elevation below sea level due to historic overpumping, so maintaining the seawater barrier wells to keep out the intruding saltwater is of vital importance. (WRD, 2011a).

1.1.3 Groundwater Basins History

Prior to the adjudication of groundwater rights in the early 1960s, annual production (pumping) reached levels as high as 292,000 acre-feet (AF) in the Central Basin and 94,000 AF in the West Coast Basin. This was more than double the 173,400 AF of natural safe yield of the basins determined by DWR in 1962. The “natural safe yield” is the amount that can be withdrawn from the aquifer without adverse effect (DWR, 2009), assuming natural replenishment of the aquifer generally from runoff and precipitation. Due to this serious overdraft, water levels declined, groundwater was lost from storage, and seawater intruded into the coastal aquifers. To remedy this problem, the courts adjudicated the two basins to limit pumping. The West Coast Basin adjudication was set at 64,468.25 AFY. The Central Basin adjudication was set at 267,900 AFY, although the Judgment set a lower APA of 217,367 AFY to impose stricter control. Therefore, the current amount allowed to be pumped from both basins in total is 281,835 AFY (WRD, 2011b).

Prior to the recent Judgment amendments, the Judgments did not allow for use of currently unused storage space in the basins, estimated at a total of 450,000 AF in both basins (120,000 AF in the West Coast Basin and 330,000 AF in the Central Basin). In 2009, motions were filed in court to amend both Judgments to allow parties to the Judgments to store water for later extraction. The amendments also included provisions for the interbasin transfer of storage rights between the West Coast and Central Basins, also not previously allowed. Most significantly, the implementation of water augmentation projects, wherein recharge and extraction volumes are matched, now allows pumping beyond adjudicated rights, without using the allotted storage space described in the storage provisions. After several challenges to these motions, final decisions on the amendments were rendered on December 23, 2013 (Central Basin) and December 5, 2014 (West Coast Basin) (see Appendix A for more details regarding the approved Judgment amendments).

1.1.4 Role of the Water Replenishment District of Southern California

WRD was formed by a vote of the people in 1959 for the purpose of protecting the groundwater resources of the West Coast and Central groundwater basins. WRD manages groundwater for nearly 4 million residents in 43 cities of southern Los Angeles County over a 420-square-mile service area, shown in Figure 1-1. WRD protects the basins through groundwater replenishment, deterrence of seawater intrusion, and groundwater quality monitoring of contamination through an assessment on water pumped from the WRD service area. WRD ensures that a reliable supply of high-quality groundwater is available through its clean water projects, water supply programs, and effective management principles.

The adjudicated pumping amounts described in Appendix A are greater than the natural replenishment of the groundwater basins, creating an annual deficit or annual overdraft. WRD is enabled under the California Water Code to purchase and recharge additional water to make up the overdraft, which is known as artificial replenishment or managed aquifer recharge. WRD has the authority to levy a replenishment assessment on all pumping within the District to raise the monies necessary to purchase the artificial replenishment water and to fund projects and programs necessary for replenishment and groundwater quality activities (WRD, 2011b).

WRD initiated the preparation of this GBMP to facilitate long-term planning with basin stakeholders and identify sustainable, reliable sources of replenishment water to cost-effectively meet projected groundwater production demands.

1.2 Groundwater Basins Master Plan Objectives

As an element of WRD's WIN program, the GBMP establishes a framework in which projects recommended for further evaluation can be examined and considered within an open, transparent process. By considering regional, basin-wide needs and opportunities, the GBMP offers stakeholders options that can satisfy individual water systems' interests and priorities while also providing broader basin benefits. Under the WIN program, WRD has been implementing projects and programs that enhance basin replenishment, increase the reliability of groundwater resources, improve and protect groundwater quality, and ensure that the groundwater supplies are suitable for beneficial uses. Offering a wide range of alternatives for the basin stakeholders to consider in advancing the WIN program goals is the primary objective of the GBMP.

Ultimately, implementation of any of these projects or programs beyond meeting replenishment obligations of WRD would result solely from the impetus of the basin stakeholders to invest in the development of additional replenishment water to more fully use the basins, and "WIN BIGGR" (**W**ater **I**ndependence **N**ow **B**y **I**ncreasing **G**roundwater **R**echarge and **R**ecovery). These are complex projects, some with lengthy implementation timeframes and numerous institutional challenges. This GBMP makes no attempt to resolve these challenges; rather, it is intended to identify possibilities that may hold sufficient interest and support of the basin stakeholders to warrant further exploration.

This GBMP is supported by the U.S. Department of the Interior's WaterSMART (**S**ustain and **M**anage **A**merica's **R**esources for **T**omorrow) program. WaterSMART provides funding for the bureaus of the Department, including the Bureau of Reclamation (Reclamation), to work with local government agencies such as WRD to pursue a sustainable water supply. Reclamation's WaterSMART System Optimization Review grant was awarded for this study and is intended to provide an analysis of system-wide efficiency that focuses on improving the effectiveness and operations of a delivery system, district, or watershed (Reclamation, 2012).

The following GBMP objectives thus address not only the interests of WRD and regional stakeholders, but national interests as well:

- Meet adjudicated pumping rights in each basin
- Provide sufficient supply to meet replenishment for adjudicated rights, and then to offset surface water deliveries of imported water via increased pumping beyond the adjudications (pending approval of the proposed Judgment amendments)
- Reduce reliance on imported water through increased usage of stormwater and recycled water

- Increase local supply production
- Remove contamination from key portions of the groundwater basins
- Maintain protections against seawater intrusion
- Protect existing water quality
- Identify opportunities for a coordinated energy strategy for new water supply projects in the Study Area, including the use of renewable energy where feasible and minimizing energy footprints
- Minimize the cost to the agencies and other stakeholders that use groundwater
- Expand use of supplies, developing lower costs supplies first, then progressively us more costly supplies
- Minimize impacts on the environment by progressive development
- Engage stakeholders in the planning and decision-making process

Development of this GBMP was initiated by WRD to provide the basin stakeholders with a roadmap for collaborative and strategic development of potential future projects and programs that will more effectively use the groundwater basins to increase water supply reliability. Applying a long-term planning perspective, this GBMP identifies a range of projects and opportunities to not only ensure that additional replenishment water will be supplied to meet the pumpers use of groundwater for which they have rights, but also identifies opportunities to further reduce reliance on imported water through enhanced use of the vast groundwater storage of these basins. The projects have been defined sufficiently to estimate their broad cost implications and allow for comparison of the value of pursuing development of these various water sources.

1.3 Groundwater Basins Master Plan Content

This GBMP is organized to first present the GBMP planning process followed by development of conceptual options (Concepts A and B) in both basins. Based on these concepts, planning scenarios were developed for each basin to represent a range of basin operating (extraction/replenishment) conditions. Scenarios for each basin were combined for the purposes of groundwater modeling, which was conducted simultaneously for both basins.

Based on the concepts and scenarios in the West Coast and Central Basins, GBMP alternatives were developed. Specific projects were identified which can be selected under the GBMP alternatives to meet target supply yields corresponding to the basin planning scenarios. Formulating alternatives with consistent supply yields allowed for comparison of the alternatives with respect to evaluation criteria, including costs. Figure 1-2 shows the organization of this planning process in specific sections of this report.

Following this section, which includes the Introduction and GBMP objectives, the GBMP consists of the following sections:

- **Section 2.0: GBMP Planning Process** – This section describes the approach employed to define and develop conceptual options, scenarios, modeling combinations and alternatives for potential groundwater replenishment options for the West Coast and Central Basins.
- **Section 3.0: Groundwater Basin Extraction/Replenishment Planning Scenarios** – This section describes the broad planning scenarios for each groundwater basin that served as the basis for developing the GBMP alternatives. The planning scenarios were based on the Concept A (pumping within the adjudicated rights) and Concept B (pumping above the adjudicated rights) conceptual

options for the West Coast and Central Basins. Concept A and Concept B scenarios were developed separately for both basins.

- **Section 4.0: Groundwater Modeling Assessments of Basin Operating Condition**s – This section summarizes groundwater modeling simulations conducted to evaluate the impacts of the GBMP planning scenarios. The West Coast and Central Basin scenarios developed in Section 3.0 were combined to generate groundwater basin-wide conditions. Various "Combinations" were generated by combining the West Coast Basin and Central Basin scenarios. Only feasible combinations of scenarios were used for conducting model simulations.
- **Section 5.0: Formulation and Evaluation of Alternatives** – This section identifies specific projects consisting of supply, recharge, and extraction components, which are ultimately combined into GBMP alternatives to satisfy the GBMP planning scenarios presented in Section 3.0 and evaluated in Section 4.0. The identified basin-specific projects were used to satisfy the groundwater yield needed for each of the scenarios identified in Section 3.0. The costs for each of the alternatives were prepared by combining the individual project costs. An analysis of the GBMP alternatives provides an assessment of the performance of the alternatives relative to evaluation criteria that can guide stakeholder decision making.
- **Section 6.0: Implementation Plan** – This section outlines the key considerations that must be addressed to advance the GBMP alternatives as well as next immediate steps for GBMP implementation. These issues include regulatory and legal issues, implementation of related projects and planning activities currently underway, the availability of replenishment water sources, spreading ground capacity, model development/enhancement, and consideration of project cost impacts on the groundwater replenishment assessment (RA).

As noted previously, the GBMP is not a capital improvement program, nor does it encourage or commit any party to a particular project or program. It does not address institutional issues, which are significant and critical to advancing any of the elements identified herein. While estimated planning-level costs are provided for specific projects and alternatives as a basis for comparison, no attempt has been made to analyze future RA impacts, or to allocate potential benefits that may be realized from these projects or alternatives.

The implementation plan included in Section 6.0 provides recommendations for further stakeholder consideration, and potential next steps to explore the identified projects more fully. It does not, however, lay out a specific plan, as that would require site-specific environmental review, further policy development, and resolution of institutional issues.

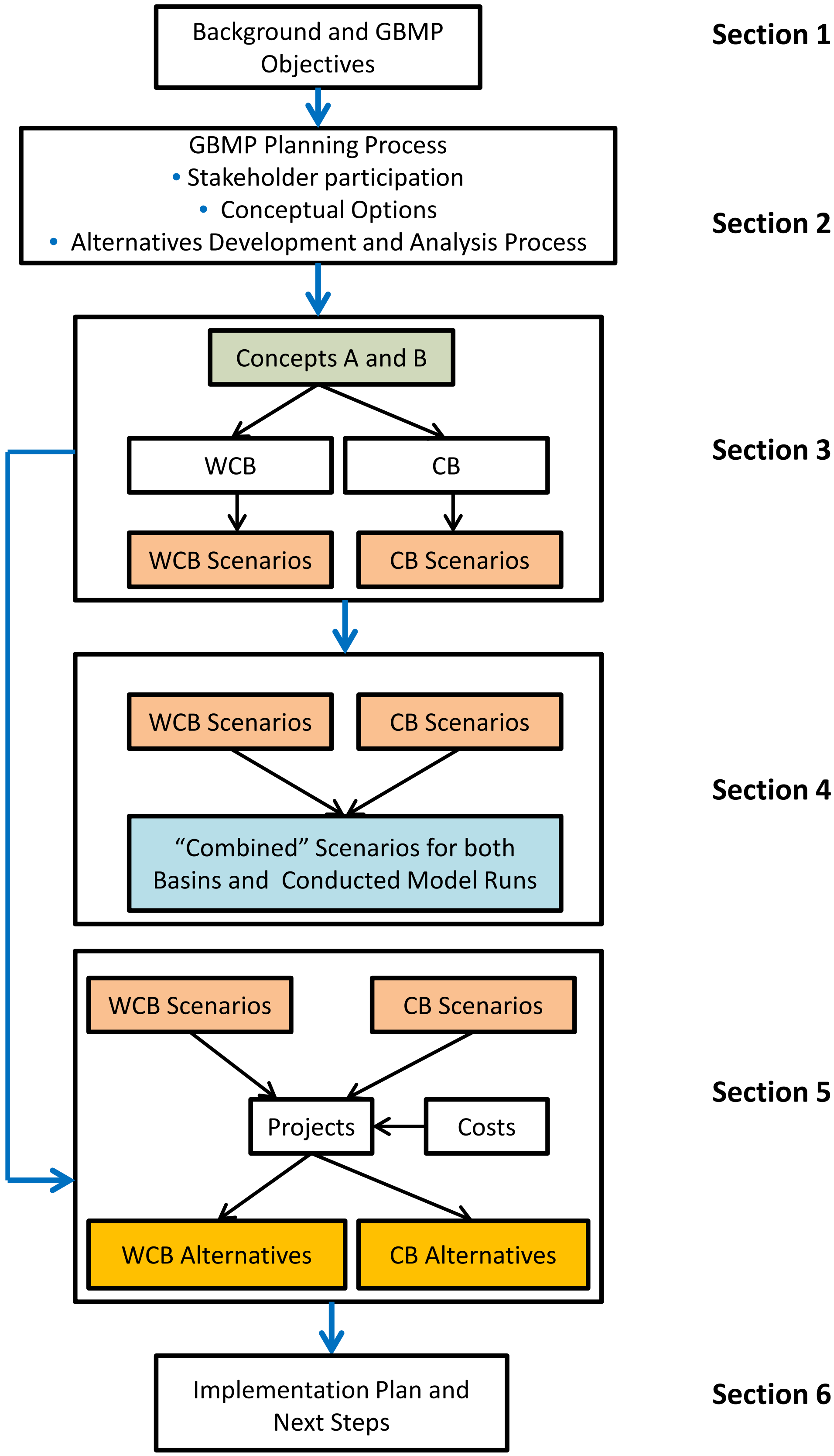


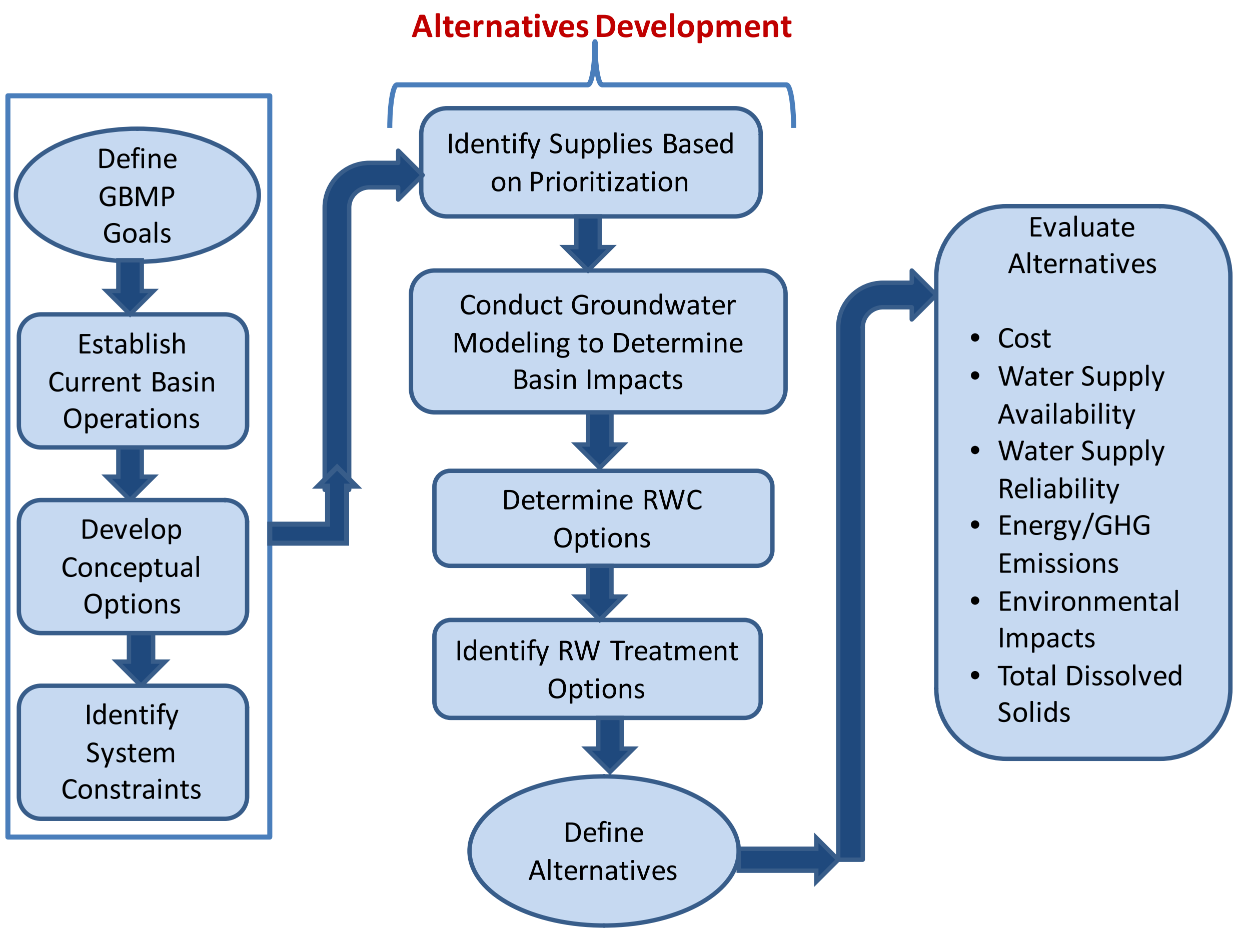
Figure 1-2. Organization of Planning Process Elements

SECTION 2

Groundwater Basins Master Plan Planning Process

2.1 Planning Process

The process employed to develop alternatives for this GBMP is described in this section and summarized in Figure 2-1.



Notes:

GHG = greenhouse gas
RW = recycled water
RWC = recycled water contribution

Figure 2-1. GBMP Planning Process

2.1.1 Overview

Planning for each of the two groundwater basins was conducted in two phases. Phase 1 consisted of study scoping and alternatives development, and Phase 2 consisted of detailed alternatives analysis, including groundwater modeling and economic comparisons. Basin stakeholders, primarily wholesale water agencies, water purveyors, pumpers, and recycled water providers were engaged throughout the process.

The GBMP was developed with a “bottoms-up” perspective, both with respect to the groundwater basin operations and impacts, as well as with consideration—first and foremost—for the interests and drivers of the water rights holders. Programs and projects that can provide synergistic opportunities and benefits to basin stakeholders will naturally find support and be carried through to implementation. The relative costs and benefits of the alternatives evaluated, when measured against alternate water supply options such as the purchase of imported water for either direct use or for replenishment, will drive implementation decisions by the stakeholders.

With the approval of the recent basin Judgment amendments (described in Appendix A) to allow for enhanced use of basin storage, extraction beyond the current adjudication limits by water rights holders can be considered through the development of water augmentation replenishment projects. Examples of such projects and their associated costs were developed for this report. Implementation of such projects would be a complex and protracted process, requiring extensive coordination across multiple institutions and potentially vast geographical expanse. The GBMP provides a groundwater-focused framework within which to begin exploring such possibilities.

2.1.2 Stakeholder Participation

This GBMP is being developed as a tool for the basin stakeholders to use as they plan for increased utilization of the groundwater basins. The basin stakeholders that have been engaged in the GBMP development process include water purveyors and pumpers with water rights (including local refineries), water wholesalers (member agencies of Metropolitan Water District of Southern California, [MWD]), and recycled water providers.

As the study began with the focus on the West Coast Basin on March 2, 2010, West Coast Basin stakeholders were introduced to the initiation of the plan development process at the monthly meeting of the West Basin Water Association. Meeting participants were asked to identify points of contact within each representative organization with whom WRD could communicate regarding the plan development. Individual meetings followed in which pumper plans for future groundwater use were discussed so that the GBMP could consider how to meet changing future groundwater demand patterns. In early September 2010, an initial workshop was held with West Coast Basin stakeholders to discuss the baseline operating conditions, and proposed alternative management concepts were initially presented. These initial concepts, described in Section 3.0, were further refined based on stakeholder feedback and discussed in a subsequent workshop in late September 2010. With the initial concepts established, the Phase 2 detailed analyses of the West Coast Basin alternatives commenced, including groundwater modeling and cost evaluations.

In early November 2010, Phase 1 of the Central Basin portion of the study began. Due to the large number of Central Basin pumpers, three introductory workshops were held through early January 2011 to ensure that stakeholders interested in participating had ample opportunity to engage in the process. Follow-up one-on-one meetings with the Central Basin stakeholders were also held in the ensuing months as the Phase 1 concepts and alternatives were developed. In early May 2011, the Phase 1 work was discussed with the Central Basin Water Association and, later that month, a meeting of MWD member agencies from the Central Basin was held to discuss the planning approach and Phase 1 findings. In early August 2011, the projects and alternatives identified during Phase 1 were presented at the Central Basin Water Association seeking feedback, refinements, and consensus on proceeding with the Phase 2 technical and economic analyses.

The findings of the Phase 2 analyses were presented to the West Basin and Central Basin groundwater pumpers in March 2012.

2.2 GBMP Goals, Basin Operations, and Conceptual Options

The specific goals of the GBMP stem from historical and current basin operations. Each year, WRD plans for the replenishment needs of the West Coast and Central Basins for the ensuing year. This is done by estimating anticipated groundwater production demands (based on 3-year historical averages) relative to monitored groundwater levels, and incorporating the effects of averages from a long-term (30-year) hydrologic record. Sources of replenishment water currently include recycled water and imported water, as well as stormwater (primarily in the Central Basin). The cost of replenishing the basins with recycled water and imported water to match anticipated pumping demands is determined by the anticipated mix of water supplies expected to be available.

WRD is responsible for ensuring that the adjudicated water rights within each basin can be satisfied for the pumping community. Without sufficient planning, the development of projects that could potentially provide more reliable, cost-effective water supply sources than are currently available for replenishment may be delayed, and full utilization of these water rights will be contingent on the availability and value of imported water purchase. The objectives of the GBMP thus support the region’s broader goals of increased water supply reliability through the use of local water resources in a cost-effective and environmentally sustainable manner.

2.2.1 Groundwater Basins Master Plan Goals

The primary goals of the GBMP alternatives include the following:

1. Replace the current use of imported water for basin replenishment
2. Enhance utilization of the West Coast and Central Basins

With the uncertain reliability and availability of imported water described previously, discounted, surplus replenishment water has decreased significantly in recent years and is currently not available. Thus, increasing the availability of locally supplied and accessible groundwater, if relatively cost-effective replenishment can be provided, increases the ability of local water purveyors to plan for and control their water supply.

Long-term planning for the replacement of imported water as a source of replenishment water is needed to ensure that adequate treatment and conveyance facilities, in terms of size and treatment level, are in place in time to meet groundwater pumping demands cost-effectively.

This GBMP is intended to be a tool or resource to be used by all basin stakeholders to aid in decision making for future development of groundwater resources in the West Coast and Central Basins. The components of the various GBMP alternatives can be used as building blocks to provide comparative cost estimates of future basin management scenarios. By considering a long-term planning horizon, WRD can work with the basin stakeholders to cultivate those programs and projects that will ultimately provide cost-effective replenishment for adjudicated pumping rights in the basins.

2.2.2 Basin Operations

This section describes existing basin operations and associated facilities that represent the starting point from which GBMP alternatives were crafted.

2.2.2.1 Historical and Projected Groundwater Use

Historical basin operations with respect to pumping volumes and replenishment supplies were evaluated for the GBMP and are summarized in Appendix B. In the West Coast Basin, 42,000 AFY have been pumped, on average, over the 10-year period (2000-2010) considered for this study, which is approximately two-thirds of the adjudicated rights of 64.468.25 AFY.. Similarly, in the Central Basin, 195,500 AFY has been pumped, on average, over the same 10-year period, which is about 90 percent of the Central Basin APA of 217,367 AFY. Discussions with basin stakeholders indicated that they plan to pump more of their groundwater rights in the future as the cost of purchasing imported water for potable use continues to rise.

To pump the full adjudication of the West Coast Basin, an additional 18,000 AFY of artificial replenishment will be needed, and to pump the full APA in the Central Basin, an additional 12,000 AFY will be needed. Of this 30,000 AFY total additional replenishment needed, existing facilities can provide an additional 4,500 AFY (i.e., 1,000 AFY from ECLWRF, 1,500 AFY from TIWRP and 2,000 AFY from LVLWTF); thus WRD would need to secure an estimated total of 25,500 AFY of additional replenishment to meet the long-term future pumping demands in the West Coast and Central Basins.

2.2.2.2 Replenishment Facilities

Managed groundwater replenishment in the West Coast Basin is provided exclusively through injection at two seawater intrusion barrier systems. In the Central Basin, replenishment is provided both by injection at a single barrier system and with spreading. Provided below is a summary of these replenishment facilities.

West Coast Basin

The two injection barriers in the West Coast Basin are located along the west coast of the Los Angeles County Coastal Plain and along the south coast in the Dominguez Gap area. These barriers are used to reduce the amount of seawater intrusion along the coast and are owned, operated, and maintained by LACDPW. Initiated with a test injection well in 1951, the West Coast Basin Barrier Project (WCBBP), shown in Figure 2-3, now consists of over 150 injection wells and extends over 9 miles from Los Angeles International Airport in the north to Palos Verdes in the south. The Dominguez Gap Barrier Project (DGBP), shown in Figure 2-4, has been in operation since 1971 and protects the southern coast of Los Angeles County. The original DGBP consisted of 41 injection wells spaced over 4 miles, in a north/south alignment from F Street to E Street along the Dominguez Channel. In 2002, 17 additional injection wells were added to the DGBP, extending 1.5 miles eastward along Spring Street in Long Beach, from the Dominguez Channel to the Long Beach Freeway. Artificial replenishment of the basin via these injection barriers has historically averaged approximately 28,000 AFY since 1959 (WRD, 2012).

The operating permits for these barrier facilities are discussed in Appendix C.

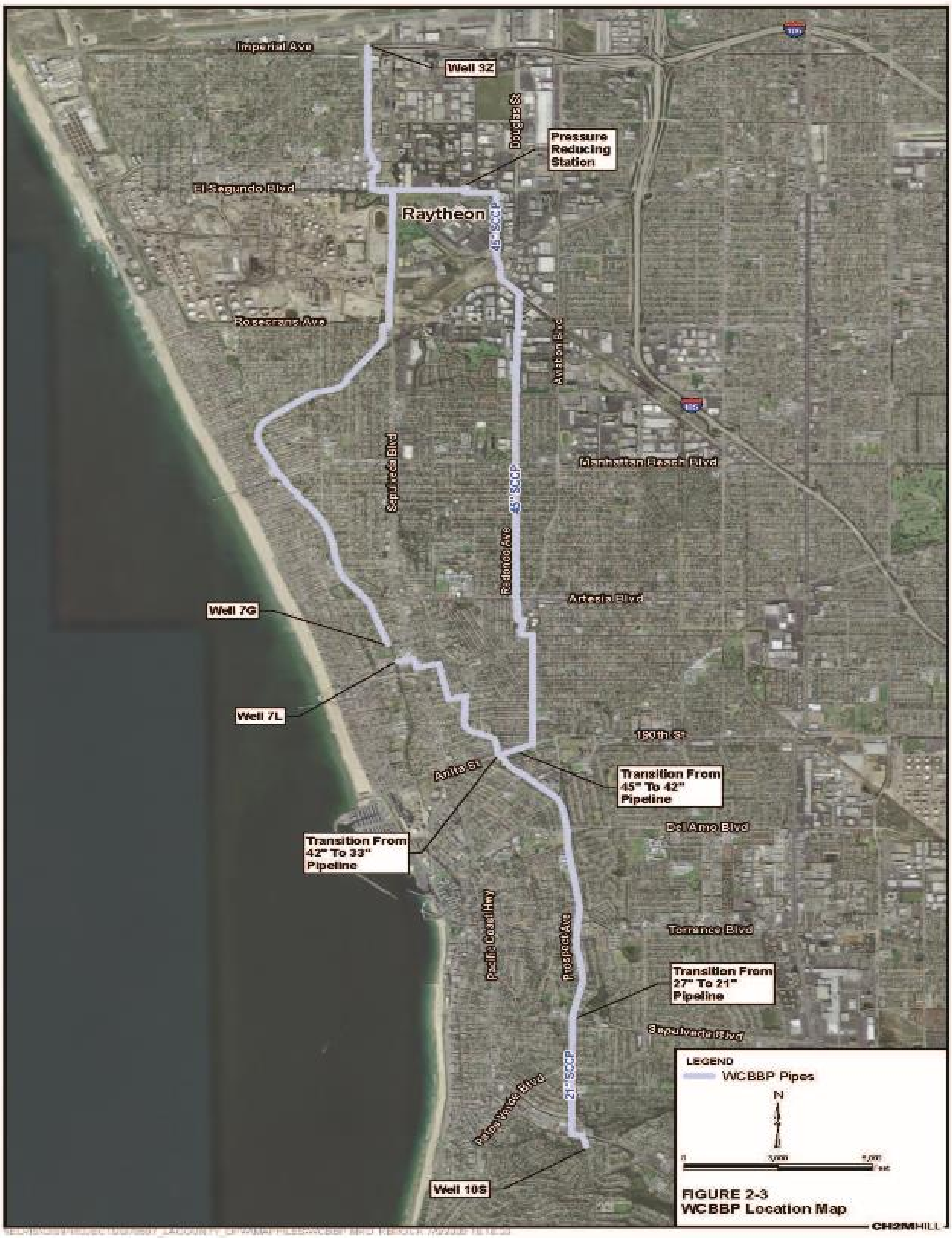


Figure 2-3. West Coast Barrier Project Facilities

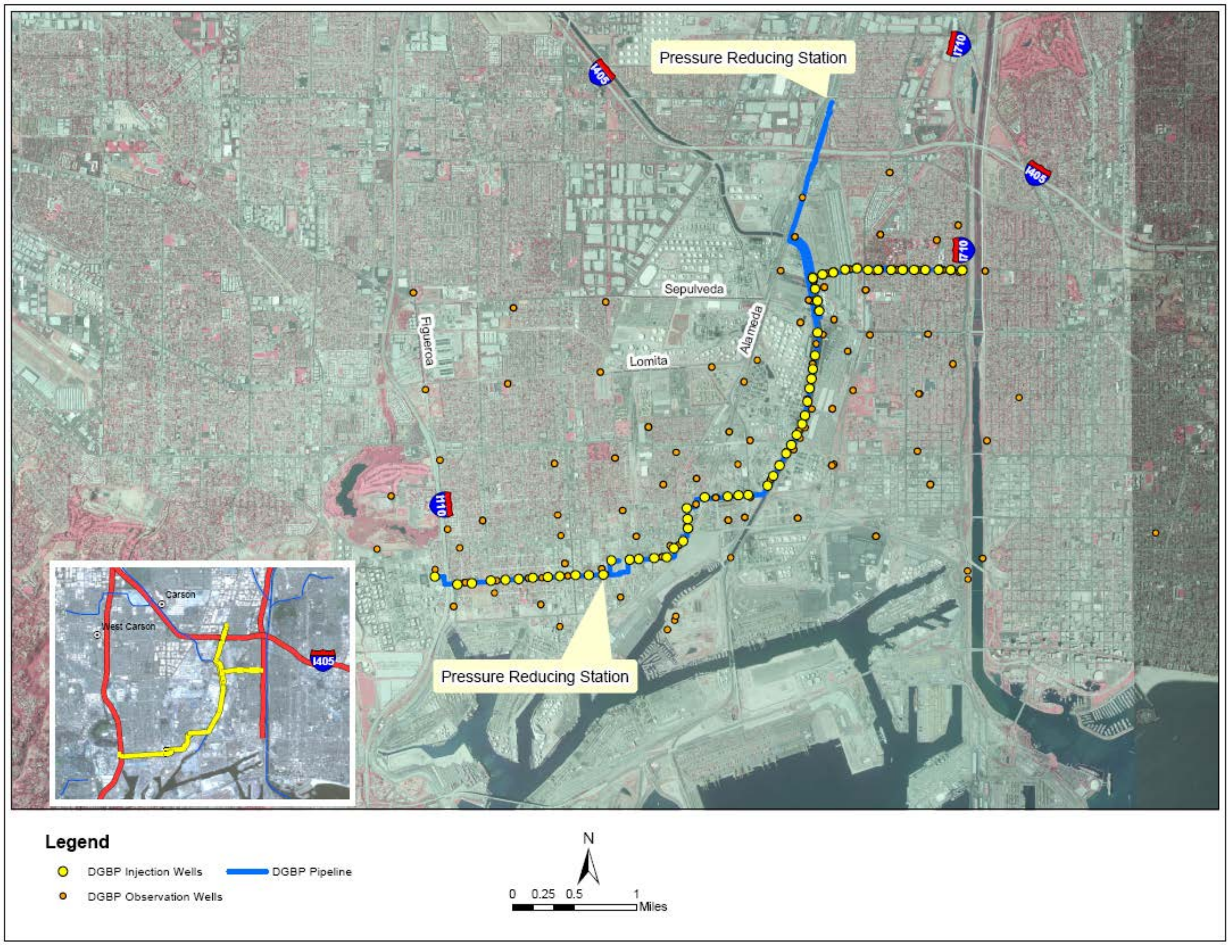


Figure 2-4. Dominguez Gap Barrier Project Facilities

Central Basin

Groundwater in the Central Basin is recharged via surface spreading at the Whittier Narrows Dam, Montebello Forebay Spreading Grounds (MFSG), which consists of the Rio Hondo Spreading Grounds and San Gabriel Coastal Spreading Grounds, infiltration in the unlined portions of the Lower San Gabriel River, and via direct injection at the Alamitos Barrier Project (ABP) (Figure 2-5). The lower San Gabriel River extends from the Whittier Narrows Dam though the Pacific coastal plain ending at Long Beach. Through most of the Montebello Forebay, the San Gabriel River is unlined, allowing spreading by percolation through its unlined bottom. The river is lined from about Firestone Avenue through the remainder of the Central Basin.

Natural recharge to the Central Basin includes surface infiltration of precipitation and applied water (such as landscape irrigation), subsurface inflow from the surrounding mountains (referred to as mountain-front recharge), through the Los Angeles and Whittier Narrows and along the boundary with the Orange County Basin, and through stormwater percolation at the spreading grounds and unlined portions of rivers. Sources of artificial recharge include recycled water, imported water, and stormwater. The volume of recharge varies significantly from year to year based on precipitation and availability of imported water. Artificial replenishment of the basin via the spreading grounds and injection barrier has historically averaged approximately 142,500 AFY since 1959, whereas production has averaged approximately 205,000 AFY (WRD, 2016). Projects recently implemented and currently planned for implementation by WRD are increasing the amount of the artificial recharge from both stormwater and recycled water in the Central Basin.

The ABP is jointly owned by LACDPW and the Orange County Water District (OCWD). As shown in Figure 2-5, the project can be divided into three major segments: (1) the main supply line that runs easterly and then southerly from the pressure reducing station to the T-vault, (2) the west leg that runs westerly to all injection wells west of the T-vault, and (3) the east leg that runs southerly and easterly to all injection wells east of the T-vault. Additionally, the City of Long Beach has four aquifer storage and recovery (ASR) wells that can be used to inject imported water available in wet years into the Central Basin. The combined injection capacity is estimated to exceed 3,250 AFY (MWD, 2007).

Figure 2-5. Alamitos Barrier Project Facilities

2.2.2.3 Saline Plume

Continuous operation of the barriers has effectively curtailed further seawater intrusion into the West Coast Basin. However, the residual saline plume that was trapped inland of the barriers continues to impact the water quality of the basin, thereby increasing the cost of produced water (as salt removal is required before it can be used).

WRD has been tracking the migration of the plume as it advances eastward with groundwater movement. Mapping of the plume has been updated periodically, with the most recent update in 2008. Figure 2-6 shows the plume within the Silverado aquifer, which is most highly impacted relative to the shallower Gage aquifer and the deeper Lower San Pedro aquifer. WRD has estimated that the plume is moving eastward at an average rate of 250 feet per year, or about 1 mile every 20 years. The volume of groundwater affected by the saline plume is approximately 650,000 AF (WRD, 2009). Adjustments to the plume map continue as additional monitoring data becomes available.

Two treatment facilities located in the City of Torrance extract water from the saline plume and treat to potable water standards. The 1-mgd product-water capacity Brewer Desalter is owned, operated, and maintained by WBMWD, and the treated water is provided to the California Water Services Company (CWSC). The Goldsworthy Desalter is owned by WRD and is operated and maintained by the City of Torrance who delivers the treated water to its customers. The treatment (product-water) capacity Goldsworthy Desalter is currently being expanded to 5 mgd. Brine flows from these treatment facilities are discharged to nearby sanitary sewers for treatment at the downstream wastewater treatment plant (i.e., LACSD's Joint Water Pollution Control Plant (JWPCP).

The extent to which additional remediation projects should be considered and developed will be established as part of the Saline Plume Policy that will be addressed after completion of this GBMP.

2.2.3 Conceptual Options

Alternatives for extraction, recharge, and supply were initially formulated based on broad concepts, and subsequently screened and refined for further analysis.

The underpinnings for operation of the West Coast and Central Basins are the provisions of the respective basin Judgments, described in Appendix A. These adjudications limit extraction from the West Coast Basin to 64,468.25 AFY and 217,367 AFY from the Central Basin. It is the responsibility of WRD to ensure that these limits can be extracted by the water rights holders (or their leasees). As such, the first series of conceptual options under "Concept A" provides for variations on the basin extraction and replenishment schemes within the current adjudicated limits.

The recent Judgment amendments enhance the utilization of the groundwater basin storage capacities and may fundamentally change basin operations. "Augmentation" projects involving recharge above replenishment requirements for existing water rights, will allow pumpers to extract a similar volume of groundwater as recharged. The extraction limit is thus tied to the physical basin capacities, which are best approximated as historical maximum production, as well as by supply limitations. Thus "Concept B" options provide for up to 30,000 AFY above the current West Coast Basin adjudication, or 94,468 AFY, which has historically been achieved. The Central Basin "Concept B" options were crafted to ultimately replace the imported water use with groundwater pumping for the service area overlying the basin. The target recharge volume was based on reasonably available local stormwater and recycled water supplies (that is, SJCWRP, LCWRP, and a potential new satellite advanced water treatment plant for the City of Los Angeles) totaling 320,000 AFY, which is approximately 103,000 AFY above the current APA.

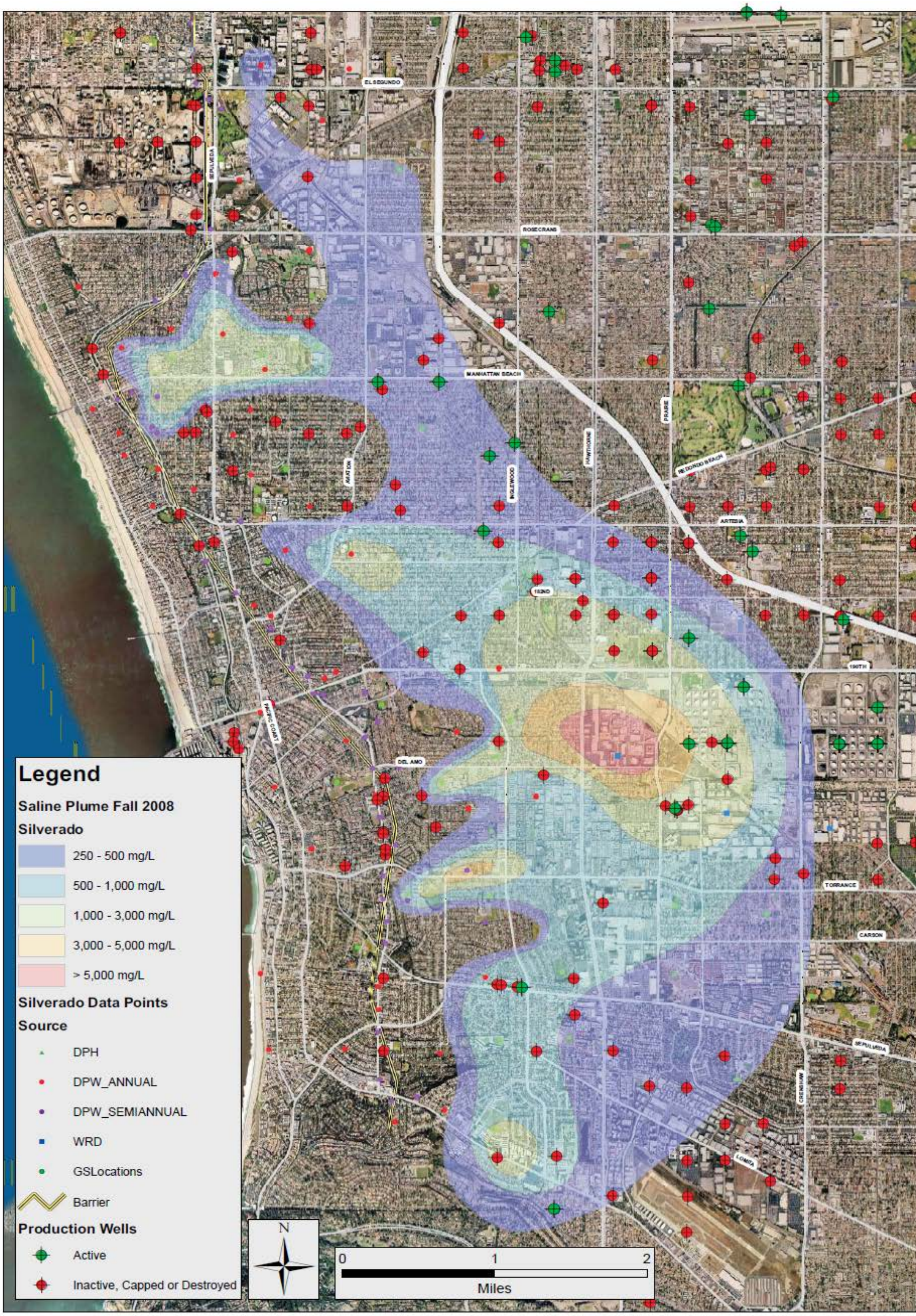


Figure 2-6. West Coast Basin Saline Plume

2.3 Constraints

WRD is responsible for ensuring that pumper demands, up to the water rights in the West Coast Basin and APA in the Central Basin, can be met through sufficient replenishment. The replenishment volumes are limited by several factors, including existing stormwater infiltration capacity, available recycled water and blending supplies to meet the permitted recycled water contribution (RWC) for each recharge facility in each basin, as well as injection barrier system capacities and water quality challenges. These are described later in this section.

With these constraints in mind, planning scenarios for each basin were identified during the scoping phase (Phase 1) of the GBMP process, and are described in Section 3.0. Supply options for each scenario were developed with consideration for the supply limitations from existing sources (based on historical and projected patterns of stormwater and recycled water availability). These scenarios were then developed into distinct alternatives for economic analysis in Phase 2 (discussed in Section 5.0).

Hydrogeological constraints within the groundwater basins are represented in the groundwater flow model discussed in Section 4.0.

2.3.1 Spreading Grounds Capacities

Replenishment of the groundwater basins with stormwater provides water supply as well as dilution credit to meet RWC requirements. The most cost-effective method for capturing and infiltrating large volumes of stormwater from the San Gabriel River and Rio Hondo is limited by the available capacity of the existing MFSG. Recharge is typically highest during the wet season when large volumes of stormwater are available from storm events and from subsequent releases from upstream dams. An analysis of historical, monthly recharge at the MFSG was conducted for the GBMP modeling and is described in Section 4.1.2.

2.3.1.1 Montebello Forebay Spreading Grounds Improvements

WRD is implementing three projects to increase capture of stormwater at the MFSG to offset purchase of imported water for replenishment—Whittier Narrows Conservation Pool, Spreading Grounds Interconnection Pipeline, and rubber dams. Also, WRD is currently implementing GRIP to offset the amount of imported water historically used for replenishment at the MFSG (21,000 AFY) with recycled water. All of these projects are assumed to be completed as part of the baseline conditions for the GBMP and are described below

Spreading Grounds Interconnection Pipeline

The Spreading Grounds Interconnection Pipeline project enhances operational flexibility between the Rio Hondo and San Gabriel spreading grounds (which make up the MFSG), allowing the increase of stormwater capture and RW recharge. Existing operational constraints limit the opportunity to recharge approximately 5,700 AFY of recycled water and 1,300 AFY of stormwater, so the project is expected to allow for increased replenishment of 7,000 AFY. The interconnection pipeline was put into service in March 2011.

San Gabriel River Rubber Dams

The San Gabriel River currently has seven rubber dams along the unlined portion of the river located downstream of Whittier Narrows Dam. The rubber dams create a spreading facility within the river and enhance recharge of water that would otherwise be wasted to the ocean. WRD has plans to construct two rubber dams in the San Gabriel River to allow for the capture of an additional 3,600 AFY of stormwater, which would be released when the spreading grounds have available recharge capacity.

Whittier Narrows Conservation Pool

The Whittier Narrows Dam captures local stormwater flows that would otherwise flow to the ocean. Water behind the dam can be released at a rate equal to the infiltration rate of the MFSG to maximize water replenishment. Operational enhancements to the Whittier Narrows Conservation Pool will allow the maximum conservation pool elevation behind the dam to 205 feet from 201.6 feet, which will increase the volume of stormwater captured and ultimately released for replenishment in the MFSG by approximately 3,000 AFY.

Groundwater Reliability Improvement Project (GRIP)

WRD's GRIP recycled water project consists of recharge of up to an additional 21,000 AFY of recycled water in the Central Basin. Historically, WRD has purchased approximately 21,000 AFY of imported water for recharge, but in recent years, this has become an increasingly unreliable and more expensive source of replenishment water for the basin. GRIP is intended to replace the need for purchasing imported water for Central Basin replenishment. The 21,000 AFY of recycled water from GRIP will consist of 10,000 AFY of advanced treated and 11,000 AFY of tertiary treated effluent from SJCWRP beyond that already permitted for replenishment at the MFSG.

2.3.2 Recycled Water Availability

Use of recycled water for recharge of the West Coast and Central Basins will be limited by existing and planned use of potential supplies, as well as the seasonal and diurnal variations in non-potable reuse demands. Nearby water reclamation plants (WRPs) with potential recycled water supplies considered for this plan include the following:

- SJCWRP
- LCWRP
- Long Beach WRP (LBWRP)
- Hyperion Water Reclamation Plant (HWRP)
- Edward C. Little Water Reclamation Facility (ECLWRF)
- TIWRP
- JWPCP

Each plant, except for the JWPCP and HWRP, produces at least tertiary-treated effluent for non-potable customers and groundwater recharge (GWR) via surface spreading while some of the effluent is further treated with full advanced treatment for injection into the groundwater basin (see Section 2.4.4.2 for a description of the full advanced treatment process train). The various entities that currently purchase effluent from these facilities, including WRD, have potential future reuse plans for some of the unused flows. Also, some entities have purchase agreements for specific volumes of water; however, many of these agreements are expiring in the near future, and much of the effluent reflected in these agreements currently goes unused.

With the exception of recharge of San Jose Creek and Whittier Narrows WRPs effluent at the MFSG, the majority of reuse of effluent from these plants is for non-potable reuse. Most of the non-potable reuse is for irrigation uses, which have severe seasonal variations such that use in the summer is typically more than twice the annual average demand and over four times the winter demand. Therefore, more recycled water is generally available for recharge in the winter than in the summer; however, as discussed in the previous section, the MFSG capacity is limited in the winter due to recharge of stormwater.

The use of effluent from the HWRP or JWPCP (both of which currently discharge secondary-treated effluent to the Pacific Ocean), assumes some addition of advanced treatment. The volume of available effluent (of roughly 150 mgd, each) from these large plants is not considered to be limiting for this plan.

2.3.3 Blending Supplies

In the Central Basin, recycled water has been used successfully as a source for GWR via surface spreading in the Montebello Forebay since 1962. Currently, disinfected tertiary recycled water, in addition to engineered stormwater recharge (local runoff and precipitation) and imported water, is used for replenishment at the spreading grounds. For the purpose of determining the allowable RWC, underflow from the Main San Gabriel Basin is also counted as dilution water. The amount of recycled water recharged at the spreading grounds will vary from year to year depending on the availability of recycled water, stormwater, imported water, and the capacity of the spreading grounds. The current Water Recycling Requirements (WRR) permit (discussed in Appendix C) allows for a 45 percent RWC over a 10-year period. As more recycled water is proposed to be recharged at MFSG, the volume could be limited by the availability of blend water because stormwater and imported water tend to be highly variable from year to year. The ultimate goal of this GBMP is to reduce or eliminate the use of imported blend water at the spreading grounds.

Imported water is currently the blend supply used at each of the seawater intrusion barriers; however, each barrier is expected to have an RWC of 100 percent in the near future, so no blend supply will be needed.

2.3.4 Injection Barrier Capacities

The ability to use the existing barrier systems for injection of additional replenishment water is dependent on both the condition and capacity of the existing systems. LACDPW is actively studying the condition of the barrier facilities, which consist of supply pipelines, injection wells, valves, and other appurtenances. The recommendations of these condition assessments, including valve replacement, telemetry, cathodic protection, and increased monitoring of higher-risk pipe segments, are being considered by LACDPW for implementation.

The current hydraulic capacities of these systems, however, have not been recently assessed, and are important considerations for evaluating the GBMP alternatives. If additional injection capacity is needed for a given alternative, then the associated costs would need to be included. To that end, a cursory analysis was performed as part of the GBMP to identify whether sufficient was capacity available to receive the volumes of replenishment water needed for the GBMP alternatives. The technical memorandum documenting the analysis approach and results is provided in Appendix D.

Based on this analysis, the current capacities estimated for the three existing barrier systems are as follows:

- ABP: 8.0 mgd (8,960 AFY)[1]
- DGBP – Total capacity is the sum of the following:
  - System south of Sepulveda Boulevard (original system): 9.8 mgd (10,976 AFY)
  - System north of Sepulveda Boulevard (extension): 23.5 mgd (26,320 AFY)
  - Total: 33.3 mgd (37,296 AFY)
- WCBBP – Capacity analysis was conducted based on two conditions: a) using well data available during the analysis period, or b) assuming use of the remaining, unused wells, and wells for which no data was available:
  - Based on wells actively in use: 38.4 mgd (43,008 AFY)
  - Based on all wells: 47.4 mgd (53,088 AFY)

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[1] The ABP is in the process of being expanded with an additional 17 injection wells. This additional capacity was not considered for the GBMP analyses.

The GBMP alternatives do not require expansion of the existing barrier systems. However, a comprehensive analysis of barrier capacity is recommended for injection schemes that significantly expand current operations.

2.3.5 Groundwater Remediation

In addition to the saline plume discussed in Section 2.2.2.3, additional water quality challenges within the West Coast Basin have arisen from historical industrial sources and are currently undergoing remediation activities. The Del Amo and Montrose Chemical Superfund sites are located near the center of the West Coast basin. The Del Amo site included industrial dumping between 1943 and 1972. The waste, including benzene, napthelene, ethylbenzene, and phenol, has contaminated the soil and groundwater around the site. The Montrose Chemical Corporation manufactured high-grade dichlorodiphenyltrichloroethane from 1947 to 1982. Groundwater flow from the Montrose and Del Amo sites is to the east-southeast. Groundwater contamination plumes from the Montrose and Del Amo sites have merged. The approximate extent of contamination is shown in Figure 2-7.

Several large oil refineries are located in the West Coast Basin. Most of these refineries are major water rights holders. Oil recovery and basin cleanup efforts by some of these oil companies are ongoing.

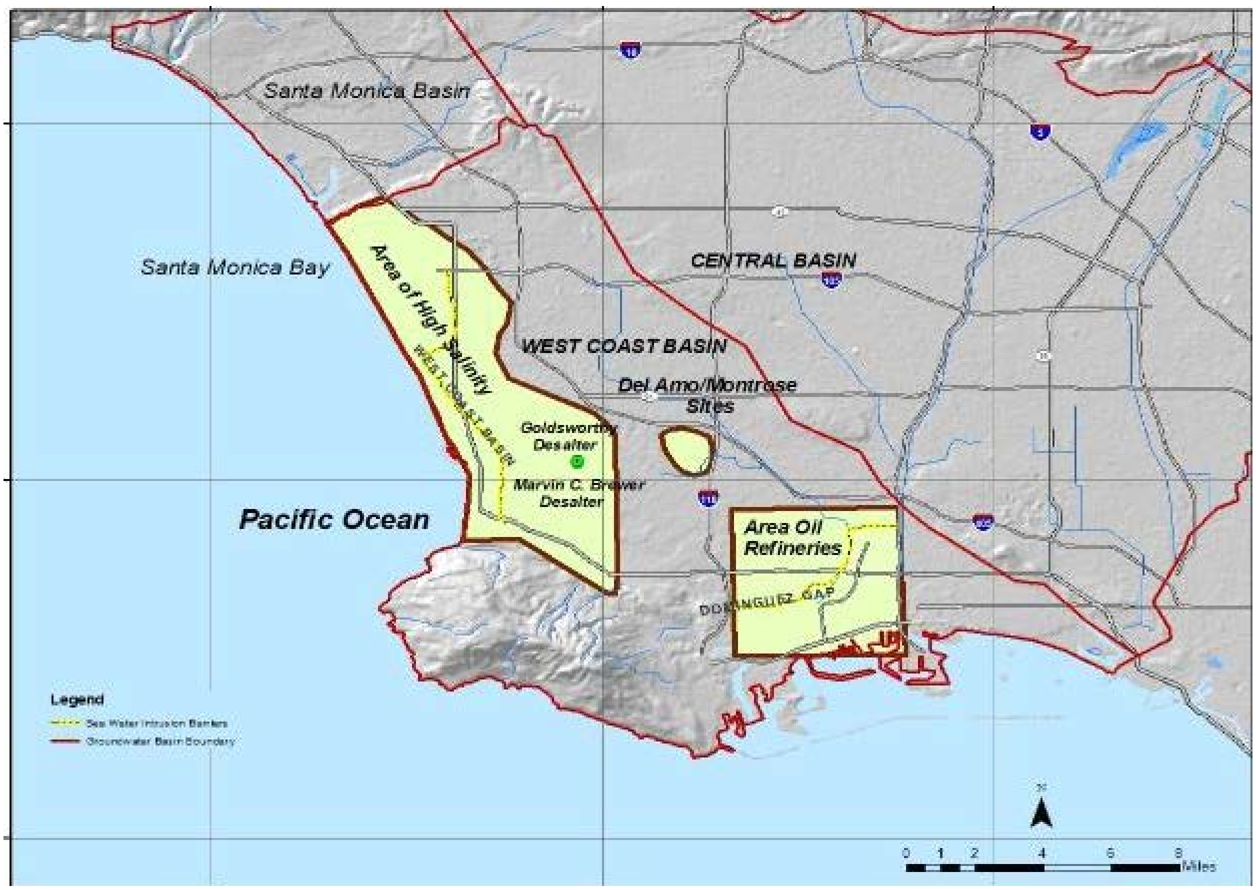


Figure 2-7. Locations of Groundwater Contamination – West Coast Basin

The confined layering in the Central Basin has provided it with a greater degree of natural protection from surface releases of contaminants than the forebay areas. Overall, the groundwater in the Central Basin is of high quality and suitable for potable use without treatment. The primary water quality issues are associated with shallow volatile organic compound plumes, one of which is located southeast of the San Gabriel Spreading Grounds, related to the former Omega Chemical Corporation parcel, as seen in Figure 2-8 and additional contamination migrating through the Whittier Narrows from the Main San

Gabriel Basin. There are some natural occurrences of arsenic at levels above the maximum contaminant level. In addition, some other well sites have been contaminated with perchlorate and other volatile organic compounds, the sources of which have not yet been determined.

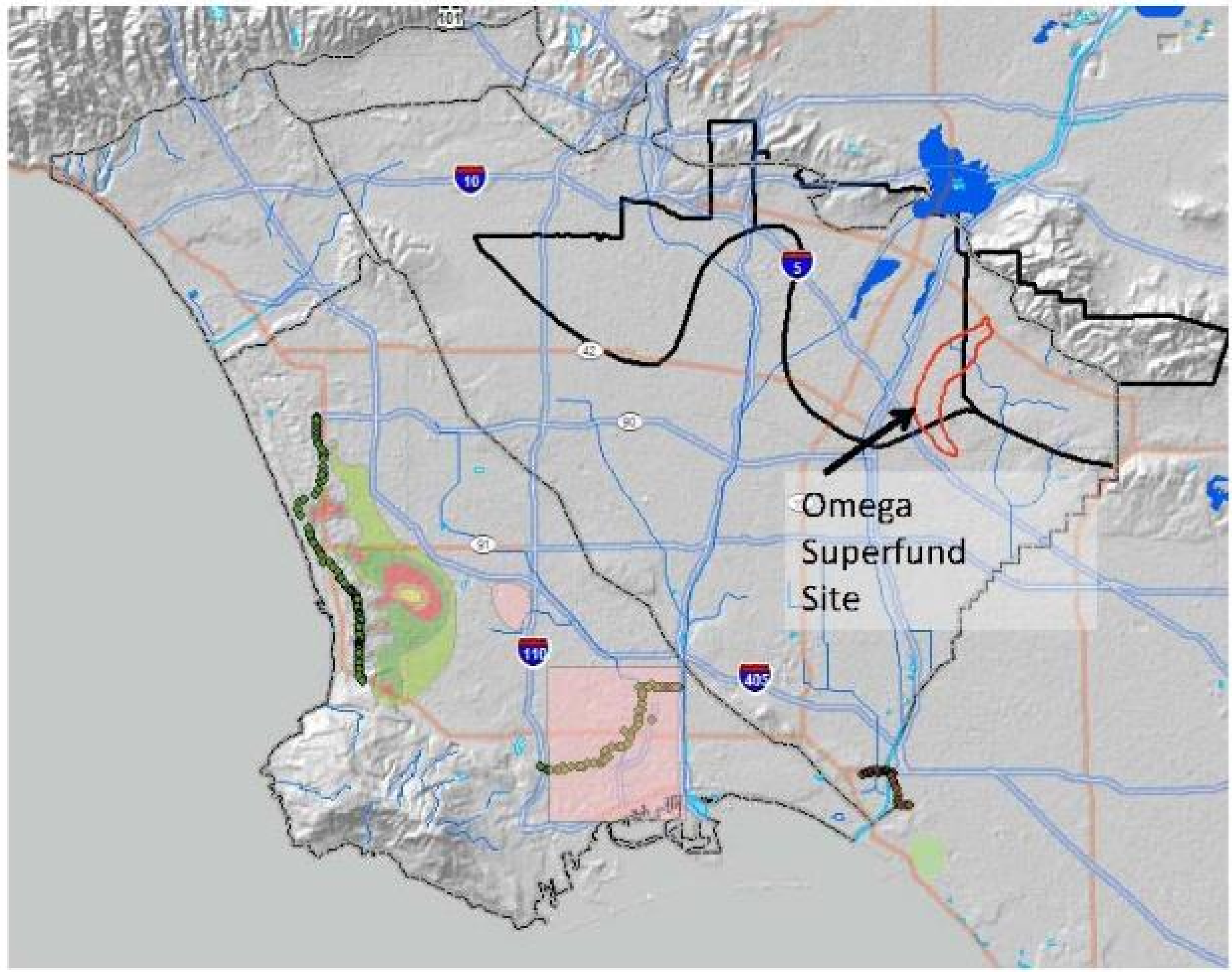


Figure 2-8. Omega Chemical Volatile Organic Compound Contamination

2.4 Alternatives Development and Analysis Process

The process of alternatives development began with the prioritizing of replenishment supplies with respect to available flow, water quality, and relative cost. Then, groundwater modeling was conducted to evaluate the basin impacts of the planning scenarios. The RWC to the basins then had to be considered in light of the recently adopted regulations for groundwater replenishment using recycled Water, (DPH-14-003E, effective on June 18, 2014, described in Appendix E), and in conjunction with the potential treatment options for recycled water. Finally, source water supplies, recharge, and extraction components were combined into GBMP alternatives for analysis and evaluation. These steps to developing the GBMP alternatives, highlighted in Figure 2-9, are described in this section.

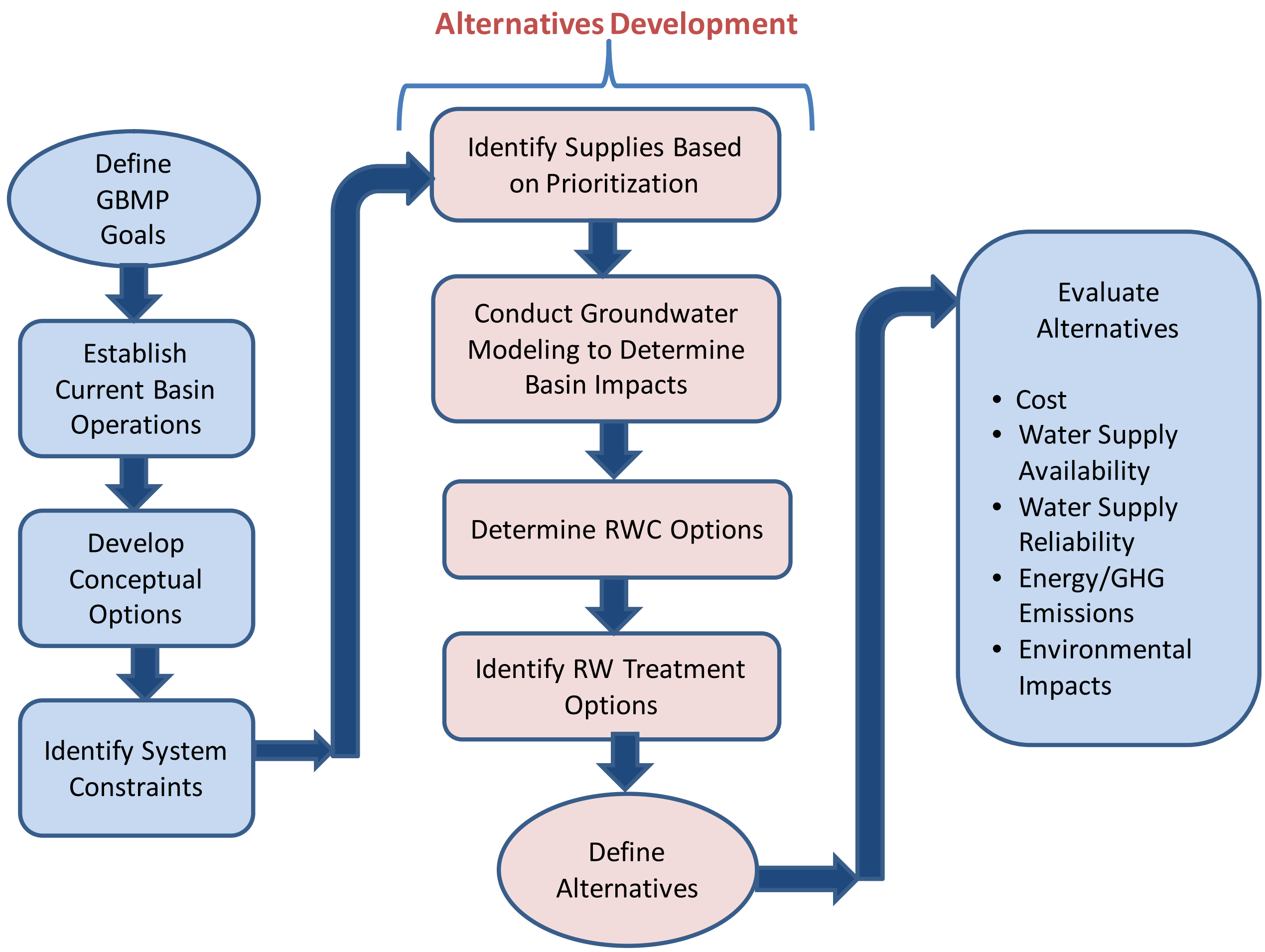


Figure 2-9. Groundwater Basins Master Plan Alternatives Development

Focusing initially on varying the basin operations to meet pumping demands established under Concepts A and B for each basin (described previously in Section 2.2.3), a series of groundwater modeling runs were conducted to analyze the impacts of varying basin operating (injection and extraction) conditions. Future pumping demands were identified based on historical and current pumping patterns, water rights, and feedback received directly from the pumper stakeholders. Required recharge volumes were identified to meet the pumping demands of the GBMP planning scenarios, described in Section 3.0.

Recharge patterns were modeled at the existing locations (MFSG, existing injection barriers), as well as at proposed locations (Los Angeles Forebay, inland injection). The pumping effects on the basin, in combination with assumed recharge patterns (via spreading basins or injection), but independent of specific supply sources, were analyzed using the WRD/U.S. Geological Survey (USGS) MODFLOW model under varying operating conditions. The basin modeling approach and results are described in detail in Section 4.0.

Specific sources of potential replenishment supplies were identified to meet the pumping demands for each of the planning scenarios, and a range of treatment options for recycled water were considered.

Combinations of supply options with recharge and extraction patterns were defined with specific, major cost components for cost estimating (that is, treatment, conveyance, extraction, injection, brine discharge, recycled water purchase, pumping). Alternatives were developed independently for the West Coast and the Central basins. Alternatives that met the range of pumping demands (that is, up to the adjudicated limits or beyond) were formulated from combinations of the costing components for the purposes of analysis and comparison.

2.4.1 Prioritized Replenishment Supplies

Specific sources of replenishment water were identified for replacement of imported water. In formulating alternatives for the GBMP, discounted, surplus imported water was assumed to be unavailable, as had been the case for the past 5 years. For the purposes of this study, only recycled water and stormwater were considered as potential replenishment supplies.

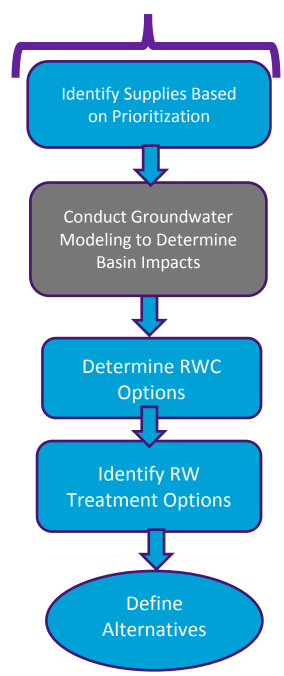
The priority given to delivering recharge water from these supplies was based on their relative availability with respect to (1) *flow* (quantity and frequency); (2) *quality*, with respect to water quality objectives for constituents such as total dissolved solids (TDS) and chloride, as well as other constituents regulated or monitored in the current permits or groundwater replenishment regulation); and (3) *cost*. Cost considerations for formulating the alternatives were initially qualitative and related to distance and elevation change from water supply to replenishment location (spreading grounds or injection wells), type of source water, and level of recycled water treatment.

Sources of recycled water nearest to the MFSG and with higher-quality effluent are recognized as highest priority options, because their proximity and water quality minimizes conveyance and treatment costs. However, competing demands for the plant effluent may limit its availability for groundwater replenishment, particularly during the dry season when the spreading grounds are less likely to be filled with stormwater. Maximizing the use of existing facilities, such as the MFSG, will be a critical factor in minimizing recharge costs in the Central Basin.

Although stormwater is “free” in the sense that there is no charge directly related to the volume of stormwater used for replenishment, there are costs associated with constructing new facilities for storing and infiltrating the stormwater. No additional treatment of stormwater is assumed to be required beyond that achieved through the infiltration process via soil aquifer treatment (SAT).

2.4.2 Groundwater Basin Assessments

Alternatives Development

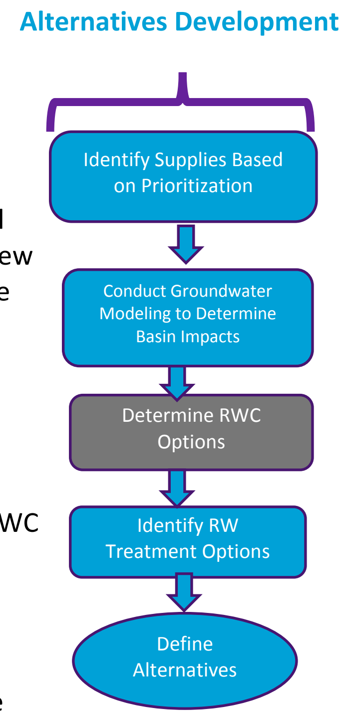


The WRD/USGS MODFLOW groundwater flow model of the West Coast and Central Basins was updated and refined for use in simulating groundwater conditions through water-year 2050. Groundwater modeling of various basin operational conditions was conducted to assess the overall water balance in the West Coast and Central Basins, considering hydrologic variations over a long-term (40-year) period. Pumping and replenishment were balanced so that groundwater level fluctuations are maintained within historical limits of fluctuations. Scenarios that were simulated with the model include the following:

- Pumping at APA levels in the Central Basin and at Water Rights levels in the West Coast Basin, with sufficient replenishment to support these pumping conditions
- Pumping above APA levels in the Central Basin and at Water Rights levels in the West Coast Basin, with sufficient replenishment to support these pumping conditions
- Pumping at APA levels in the Central Basin and above Water Rights levels in the West Coast Basin, with sufficient replenishment to support these pumping conditions
- Pumping above APA levels in the Central Basin and above Water Rights levels in the West Coast Basin, with sufficient replenishment to support these pumping conditions

The modeling results are used to assess groundwater level fluctuations, identify trends in groundwater storage, and identify groundwater flow between adjacent groundwater basins and subareas within basins. The GBMP modeling scenarios and results are discussed in Section 4.0.

2.4.3 Recycled Water Contribution Options

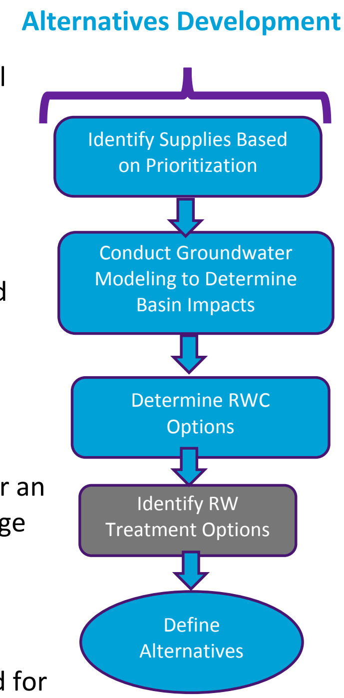


GWR regulations promulgated by the California Division of Drinking Water (DDW) limits the RWC of recharge projects based on the level of recycled water treatment and method of recharge. For example, the permit for the Montebello Forebay GWR project (discussed in Appendix C) allows for a maximum RWC of 45 percent using a 120-month running average for the total recharge in the MFSG. Also, the regulations usually limit the initial RWC of a new recharge project and allow for increased RWC if certain water quality goals are met after operation of a Groundwater Replenishment Reuse Project (GRRP[2]) begins. For example, each of the three injection barriers in the basins was previously limited to 50 percent RWC, but has received approval or is in the process of receiving approval to increase the RWC to 100 percent.

In general, higher levels of treatment result in a higher RWC. For this plan, recharge with full advanced treated product water was assumed to have an RWC of 100 percent, because the technology is proven and several thorough DDW approval steps will likely occur prior to a project starting. Other than surface spreading at the MFSG and Los Angeles Forebay, the only feasible recharge method available across the basins is injection. Full advanced treated product water was assumed for all of the potential injection projects considered in the GBMP.

[2] A GRRP is a means a project involving the planned use of recycled municipal wastewater that is operated for the purpose of replenishing a groundwater basin designated in the Water Quality Control Plan [as defined in Water Code section 13050(j)] for use as a source of municipal and domestic water supply. (DDW, 2014)

2.4.4 Recycled Water Treatment Options



The available sources for recycled water in the Study Area include several municipal wastewater treatment plants that treat primarily domestic sewage. These plants produce various levels of treated effluent depending on their permitted discharge locations. The local treatment plants that discharge to the ocean provide undisinfected, oxidized wastewater using conventional biological, secondary treatment, which focuses on the removal of biodegradable organic material and suspended solids.

Wastewater treatment plants that provide disinfected, tertiary-treated recycled water, with filtration and disinfection to meet Title 22 requirements for recycled water are typically referred to as WRPs. The WRPs in the Study Area discharge their unused effluent to inland rivers or an enclosed bay. All of the reclamation plants in the Study Area that discharge to rivers have been upgraded in recent years to reduce nitrogen levels in their effluent.

Advanced treatment facilities in the Study Area are characterized as such because they provide the most extensive treatment commonly employed for municipal wastewater. The effluent from the advanced treatment facilities within the Study Area is currently injected at three groundwater intrusion barrier injection well systems in the two groundwater basins.

The specific wastewater treatment plants considered for the GBMP alternatives are described in Section 5.0.

To develop discrete alternatives that can be compared for the GBMP analysis, a range of treatment options were considered. These included tertiary, full advanced treated, a blend of tertiary and full advanced treated, and alternative advanced treatment processes that may be considered as alternatives to, or in conjunction with, tertiary or full advanced treatment. This broad range of treatment options provides WRD and the basin stakeholders with an indication of the degree to which regulatory flexibility offered in the recent Draft Recharge Regulation may be worth exploring.

2.4.4.1 Disinfected Tertiary Recycled Water

WRD has been recharging the Central Basin with tertiary-treated recycled water at the MFSG for 50 years. For the purposes of this study, it is assumed that this is the minimum level of treatment that would continue to be viable for groundwater replenishment via spreading. As defined in the Title 22 regulations governing recycled water in California, "disinfected tertiary recycled water" means a filtered and subsequently disinfected wastewater that meets specific criteria regarding pathogen inactivation/ removal and coliform limits.

Ultimately, the selection of the appropriate treatment levels will be determined by DDW, in conjunction with the Regional Water Quality Control Board (RWQCB), with due consideration for effluent quality and quantity, spreading area operations, soil characteristics, hydrogeology, residence time, and distance to withdrawal for drinking water.

2.4.4.2 Full Advanced Treatment

Recycled water used for injection requires full advanced treatment of the entire recycled water stream prior to subsurface application. The groundwater replenishment regulation defines full advanced treatment as treatment of an oxidized wastewater (that is, secondary-treated), using reverse osmosis

(RO) and advanced oxidation processes (AOPs) that meet specific performance criteria that generally refer to the ability to achieve specific removal limits of indicator constituents.

2.4.4.3 50/50 Blend of Tertiary/Full-Advanced Treatment

The extent to which tertiary recycled water must be treated with full advanced treatment will depend on a variety of factors, including the source water quality, method of application (spreading/injection), and basin operations. The Draft Recharge Regulation allows alternatives to the specified requirements for spreading and injection with adequate demonstration that they achieve comparable levels of public health protection. Given the significant cost implications and potential technical viability of such alternatives, an example 50/50 blend of tertiary and full advanced treated recycled water was considered for the GBMP analyses. Project-specific blend percentages would need to be evaluated on a case-by-case basis, factoring in basin-wide water quality impacts of similar projects and activities.

2.4.4.4 Alternative Advanced Treatment Processes

In addition to RO and AOP, there is growing interest and research in alternative technologies that could be suitably applied for groundwater recharge projects with potentially lower costs and environmental impacts. The GBMP considered two such alternatives—nanofiltration (NF) and treatment with ozone/biological activated carbon (BAC)/granular activated carbon (GAC).

The intent of the proposed NF or ozone-BAC schemes is to reduce the TOC concentration to allow a higher RWC. Therefore, achieving DDW approval with this approach is not likely to be difficult as long as providing an increased RWC continues to comply with other water quality requirements (such as total nitrogen).

However, the alternative subsurface application (microfiltration [MF]-ozone-BAC-GAC-ultraviolet [UV]) described as follows would require extensive discussion with DDW, including involvement by an independent scientific advisory panel and possibly extensive demonstration-scale testing and public hearings. In addition, approval from DDW may be questionable due to the historical commitment made in RO-based approaches in Southern California, and full-scale implementation would likely take many years. However, consideration to an alternative approach may be warranted because of the significant cost and environmental benefits it offers.

Nanofiltration

Brine management from any advanced treatment process is potentially a significant cost component of such projects. Reducing the volume of the RO or NF waste stream can reduce the overall project costs. While such brine minimization strategies are not evaluated as part of the GBMP alternatives, the costs for brine disposal to the sewer system are included and are directly proportional to the volume discharged. Such strategies are best considered on a project-specific basis. For example, a secondary RO system will be constructed as part of the WRD Leo J. Vander Lans Water Treatment Facility (LVLWTF) to treat brine from the primary RO system, thereby reducing the volume of waste stream discharged to the sewer. For the GRIP project, LACSD has developed and tested an integrated NF/RO system in which a secondary RO system treats the NF concentrate stream, then the NF and RO product water is blended prior to application.

Like RO, NF membrane systems typically consist of spiral-wound membrane operated under pressure. The feed pressures tend to be significantly lower than those required for RO treatment, thus reducing the energy requirements and associated costs and environmental impacts. NF membranes, however, have lower degrees of rejection of constituents of concern for groundwater recharge. Alternatives considered in the GBMP included full stream treatment with NF as well as a 50/50 blend of NF-treated and tertiary-treated effluents prior to application.

Ozone/Activated Carbon

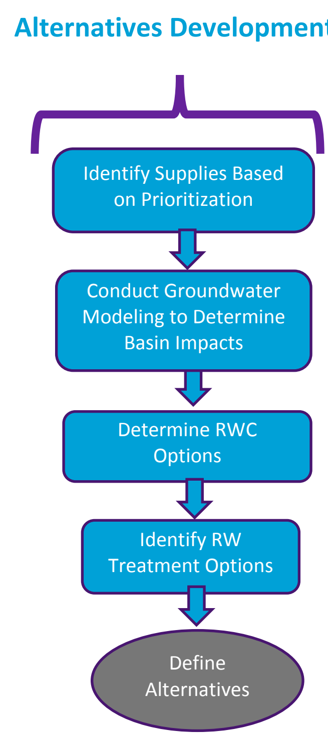
Ozone is a powerful oxidant that breaks down organic material, which can then be biodegraded using BAC or adsorbed onto GAC. The ozone also provides pathogen inactivation but does not provide photolysis like UV does (photolysis is needed for N-nitrosodimethylamine [NDMA] removal). Liquid waste from this process is minimal, but brominated disinfection byproducts might be formed.

Following are two examples of ozone/activated carbon treatment options for surface and subsurface applications:

- **Surface Application** – Incorporating ozone-BAC into the tertiary treatment process will reduce TOC concentration and potentially allow more recycled water to be recharged (that is, increasing RWC).
- **Subsurface Application** – Use of MF-ozone-BAC-GAC-UV treatment process for direct injection of recycled water in lieu of the standard MF-RO-UV AOP will eliminate production of RO concentrate and the need for its disposal, which can be both environmentally challenging and costly. Although not practiced in California, non-RO based potable reuse treatment schemes have been implemented in other parts of the U.S. and the world because of the difficulty and cost of concentrate disposal for inland locations. For example, in northern Virginia, a GAC-based treatment process has successfully been used to augment inflows to a potable water reservoir for more than 30 years. More recent potable reuse projects have also implemented a non-RO based approach, such as the UF-ozone-BAC-ozone process used in Gwinnett County, Georgia, which was implemented as part of a facility expansion in 2005.

The selection of the appropriate treatment technology, or combination of technologies, while reliably protecting the groundwater basins, requires consideration of many factors. As such, treatment options need to be evaluated on a project-specific basis.

2.4.5 Formulation and Analysis of Alternatives



For the West Coast Basin, planned extraction to meet the 64,468 AFY of adjudicated water rights under Concept A requires a total of 40,000 AFY of replenishment water provided via injection at the two existing barriers (that is, 32,500 AFY at the WCBBP and 7,500 AFY at the DGBP). Based on historical operation of the basin, the West Coast Basin is capable of delivering an additional 30,000 AFY of production. Thus the GBMP alternatives that reflect extraction conditions for Concept B options (that is, beyond adjudicated water rights) assume an additional injection of 30,000 AFY at a combination of both of the existing barriers, as well as with a new inland injection system (that is, a total of 40,000 AFY at the WCBBP, 15,000 AFY at the DGBP, and 15,000 AFY at the new inland system). These are within the estimated hydraulic capacities of the existing barrier systems. These GBMP extraction and artificial replenishment volumes for the West Coast Basin are summarized in Table 2-1.

For the Central Basin, planned extraction to meet the APA of 217,367 AFY under Concept A requires a total of 146,000 AFY of replenishment. This consists of:

- 8,000 AFY (assuming the expansion of the LVLWTF to 8 mgd) from the ABP
- 57,000 AFY from current average stormwater infiltration
- 50,000 AFY of currently permitted tertiary recycled water
- 21,000 AFY of currently recharged imported water replaced by GRIP

- 10,000 AFY of additional replenishment water needed

The GBMP alternatives consider various sources of recycled water and stormwater to provide this additional 10,000 AFY of replenishment water. These GBMP extraction and artificial replenishment volumes for the Central Basin are summarized in Table 2-2.

Table 2-1. Summary of Extraction and Replenishment for Concepts A and B – West Coast Basin

	Concept A	Concept B
Extraction (AFY)	64,468	94,468
Artificial Replenishment (AFY)		
Total	40,000	70,000
WCBBP	32,500	40,000
DGBP	7,500	15,000
New Inland Injection	N/A	15,000

Note:

N/A = not applicable

Table 2-2. Summary of Extraction and Artificial Replenishment for Concepts A and B – Central Basin

	Concept A	Concept B
Extraction (AFY)	217,367	275,137-320,617
Artificial Replenishment (AFY)		
Total	146,000	203,410-248,890
MFSG – Stormwater[a]	57,000	57,000
MFSG – Tertiary Recycled Water	50,000	50,000
LVLWTF/ABP	8,000	8,000
GRIP	21,000	21,000
Additional Replenishment Needed (various sources)	10,000	67,770-113,250

[a] Based on historical spreading at the MFSG.

The GBMP alternatives that meet the Concept B conditions in the Central Basin include additional potential extraction of 57,770 AFY in the Montebello Forebay, assuming the maximum potential use of recycled water from SJCWRP and LCWRP beyond current non-potable reuse demands and enhanced capture of stormwater from the Rio Hondo, San Gabriel River, and Los Angeles River. Additionally, 45,480 AFY could be extracted from the Los Angeles Forebay assuming replenishment of the same volume from a potential new, satellite advanced water treatment plant. Several combinations of recycled water and stormwater sources are considered in the GBMP alternatives for the additional replenishment in the Montebello Forebay, allowing for a total of 320,000 AFY of potential extraction.

The formulation and evaluation of GBMP alternatives that satisfy these planning scenarios is described in Section 5.0. The GBMP alternatives were evaluated with respect to water supply availability, water supply reliability, basin utilization, energy (greenhouse gas) emissions, and broad environmental impacts. A more-detailed environmental analysis is conducted in the accompanying programmatic environmental impact report (PEIR).

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Groundwater Basin Extraction/ Replenishment Planning Scenarios

3.1 Groundwater Basins Master Plan Planning Scenarios

GBMP planning scenarios that reflect extraction and replenishment conditions were developed during the scoping phase (Phase 1) for each groundwater basin. These scenarios were based on the conceptual options defined by the current and proposed amendments to the basin Judgments (as described in Section 2.2.3). Those include:

- Concept A scenarios are limited to extraction patterns within the West Coast Basin Water Rights and Central Basin APA.
- Concept B scenarios expand extraction beyond the water rights and APA, assuming approval of the Judgment amendments as currently proposed.

Figure 3-1 shows the target extraction flows for Concepts A and B for the West Coast and Central Basins. Using these concepts, various scenarios were developed for each basin.

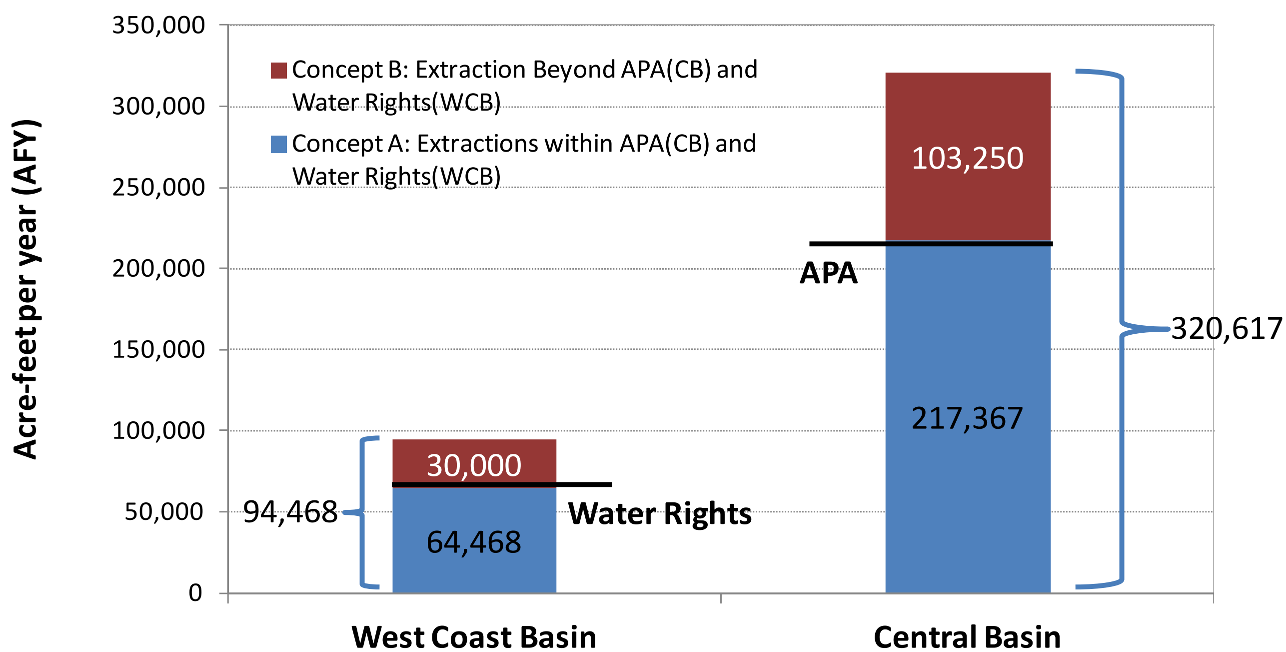


Figure 3-1. Concept A and Concept B Target Extractions for the West Coast and Central

The overall goals for developing the planning scenarios for these concepts were to:

- Assure that the scenarios meet replenishment obligations up to the water rights in the West Coast Basin and APA in the Central Basin.
- Evaluate operational conditions assuming pumping to water rights in West Coast Basin and APA in Central Basin with respect to replenishment locations and pumping distribution.
- Maintain at or near water balance over 40-year period.

- Develop projects that can be combined into alternatives that satisfy the Concept A and Concept B scenarios.
- Prioritize development of alternatives using anticipated low-cost water supplies, then add more costly water supplies to increase replenishment, thus allowing increased pumping.

A description of the key components that serve as the building blocks for developing the GBMP planning scenarios is provided below. Following the description, an approach for each scenario is discussed based on the goals of the study. After the screening of the scenarios, only the viable scenarios were considered for modeling (described in Section 4.0) and further analysis.

3.2 West Coast Basin Scenarios

This section summarizes the formulation of GBMP planning scenarios for the West Coast Basin during Phase 1. The supply, recharge, and pumping components used to define these scenarios are described below, along with the potential sources of replenishment water. Finally, the specific West Coast Basin planning scenarios were defined and evaluated, and viable scenarios were identified to serve as the basis for the GBMP alternatives evaluated in the Phase 2 analysis (as discussed in Section 5.0).

3.2.1 Components Used for Developing West Coast Basin Scenarios

The GBMP planning scenarios comprise three fundamental components: water supply sources, groundwater recharge mechanisms, and pumping patterns. For the West Coast Basin, these components consisted of the following elements, as illustrated in Figure 3-2:

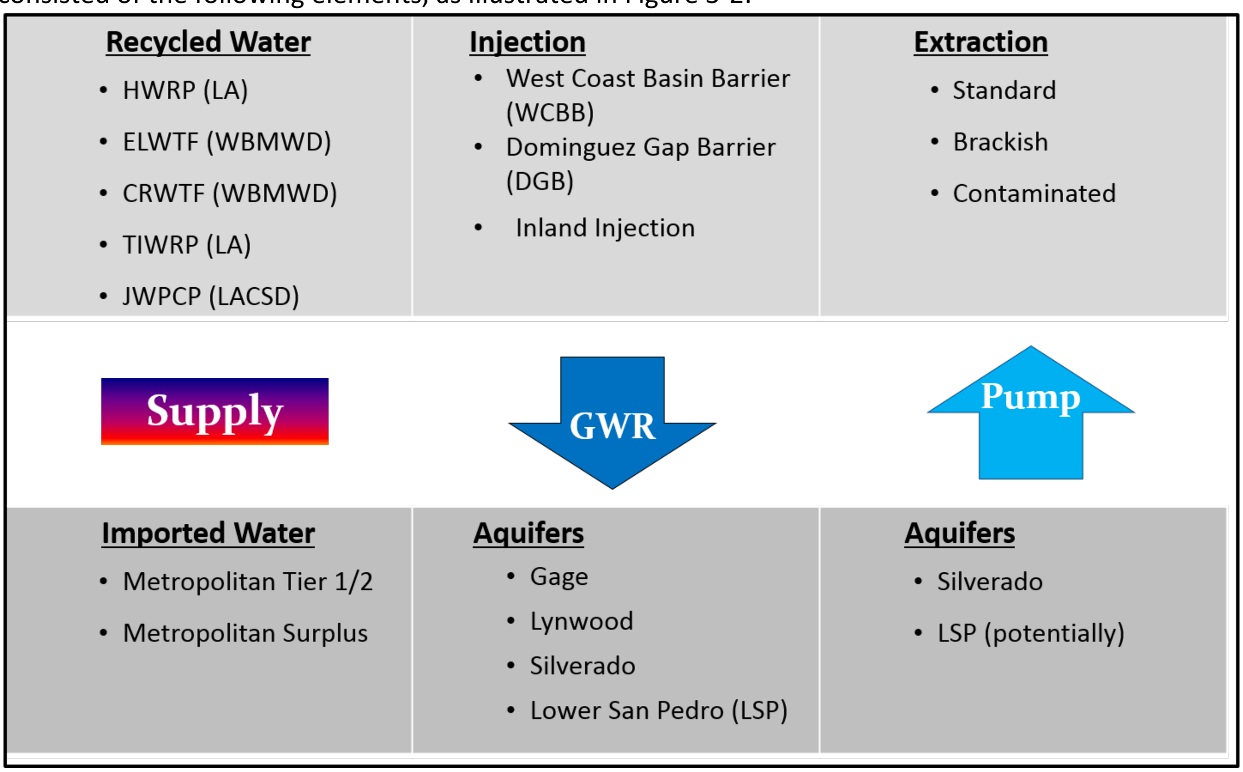


Figure 3-2. Components of Planning Scenarios in the West Coast Basin

- Water supply sources for injection into the basin – Recycled water and imported water
- Injection locations and aquifer targets – Existing barriers (WCBBP and DGBP), as well as new inland injection systems; target aquifers are those currently injected (that is, Gage, Lynwood, Silverado, and Lower San Pedro). Consider practice of in-lieu use of imported water to replace groundwater pumping. (Note that in-lieu recharge will occur as in the past; that is, this would be an opportunistic

activity that will occur if discounted imported water is available at a rate that is of a lower cost than use of other supplies. Given the uncertain nature of imported water supplies, in-lieu operations have not been specifically analyzed; however, given the offsetting effects of pumping and recharge, limited in-lieu operations are not expected to significantly change the analysis presented herein.)

- Pumping-extraction quality and aquifer target – Extraction quality dictates wellhead treatment requirements; pumping based on current operational schemes (predominantly from the Silverado aquifer, with some existing and potential pumping from the Lower San Pedro aquifer) and varied according to specific planning considerations, discussed below.

The following goals were considered in the development of the West Coast Basin scenarios:

- Provide replenishment necessary to support pumping at water rights of 64,468 AFY.
- Increase replenishment at existing barriers using recycled water to allow for pumping to water rights.
- Shift oil refineries to recycled water and then shift this groundwater pumping to municipal purveyors.
- Adjust pumping pattern to maximize containment and removal of saline plumes.
- Assess potential to stop injection into the Lower San Pedro aquifer.
- Assess potential to extract instead of inject into the Lower San Pedro aquifer.
- Continue to protect the Lower San Pedro aquifer for overall preservation of groundwater basin.
- Increase injection to allow for extraction above the water rights.

Table 3-1 summarizes the key extraction and replenishment operational considerations that provided the basis for formulating the planning scenarios for the West Coast Basin. The supply sources needed to support these extraction/replenishment operations are discussed below.

Table 3-1. Key Operational Considerations for the West Coast Basin Scenario Formulation

Operational Factors	Considerations for Concept A Scenarios	Considerations for Concept B Scenarios
Basin Pumping	Up to adjudicated rights (up to 64,468 AFY)	Beyond adjudicated rights (greater than 64,468 AFY)
West Coast Basin Barrier	100 percent recycled water (17,000 AFY existing[3] supply capacity) Additional injection needed	Same as in Concept A, but more injection may be needed
Dominguez Gap Barrier	100 percent recycled water (5,000 AFY existing[4] supply capacity) Additional injection needed	Same as in Concept A, but more injection may be needed
Inland Injection	Not considered	Included in some concepts
Lower San Pedro Aquifer	Adjust injection/extraction strategy	Same as in Concept A
Saline Plume	Pump/treat saline plume as additional water source	Same as in Concept A

Several scenarios were developed for the West Coast Basin based on (1) the components provided in Figure 3-2; (2) the planning goals for basin identified above; (3) the considerations summarized in Table 3-1; and (4) the potential sources of replenishment water identified below. These specific scenarios for Concepts A and B are described below.

[3] Based on the Phase V expansion of the ECLWRF.

[4] Based on the current capacity of the TIWRP AWTF.

3.2.2 Potential Sources of Replenishment Water

Potential sources of groundwater replenishment supply for the West Coast Basin considered for the GBMP were imported water and recycled water. Because the West Coast Basin aquifers are largely confined, stormwater infiltration is not a viable source of basin replenishment. Desalination projects, such as those currently being considered by WBMWD and others in the region, would be delivered directly into the potable water distribution system rather than serve as a groundwater replenishment supply. Thus, the two viable options for West Coast Basin replenishment are imported water and recycled water, consistent with current practice. These water sources are discussed below.

3.2.2.1 Imported Water

While imported water has been used historically to replenish the West Coast Basin at the two seawater intrusion barriers (WCBBP and DGBP), they ultimately will be replenished with 100 percent RWC, thereby eliminating the need for imported water used for blending. Because this GBMP seeks to replace the use of imported water, it is not included in the GBMP alternatives as a future supply source for the West Coast Basin.

Early in the GBMP planning process, the use of such surplus imported water was considered for just one of the West Coast Basin planning scenarios, described in Section 3.2.3.6. Ultimately, the alternatives developed in this GBMP assume that no surplus discounted water is available so that they can be compared against the availability, reliability, and costs of imported water. The actual use of discounted "Level 2" imported water for replenishment would continue to be considered by WRD on an annual basis as the opportunities for its purchase and use for replenishment in the West Coast Basin arise.

3.2.2.2 Recycled Water

Recycled water is the largest source of untapped, local supply across Los Angeles County, and two of the largest wastewater treatment plants in California are located within the West Coast Basin. WRD and other local agencies reuse some of this supply, but much remains unused. As a result, recycled water is a key component considered for basin replenishment supplies.

The locations of wastewater treatment plants and water reclamation plants in the vicinity of the West Coast and Central Basins are shown in Figure 3-3. Those in closest proximity to the potential recharge locations were considered for the GBMP and are discussed further below.

Hyperion Water Reclamation Plant

The Hyperion Water Reclamation Plant (HWRP), located south of the Los Angeles International Airport, is the largest wastewater treatment plant owned and operated by the City of Los Angeles and has a permitted average dry weather capacity of 450 mgd. All wastewater is treated to a secondary level, and the majority is discharged through a 5-mile ocean outfall.

The Los Angeles Department of Water and Power (LADWP), in conjunction with the City's Department of Public Works, completed preparation of a series of Recycled Water Planning Documents in 2012. This summary of available supply reflects the understanding and analysis as described in these documents.

Based on the LA RWMP Long-Term Concepts Report (RMC, 2012a), HWRP can produce 160 mgd of full advanced treated recycled water occurring in four distinct implementation phases based on long-term plans. However, simultaneous construction of any of the phases could potentially be accomplished. These phases in combination provide a production capacity of 128 mgd within the HWRP site (Phase 1 through 3) and an additional 32 mgd of production capacity using nearby offsite areas (Phase 4). A phased approach is recommended so that the recycled water production capacity can match incremental increases in recycled water demands.

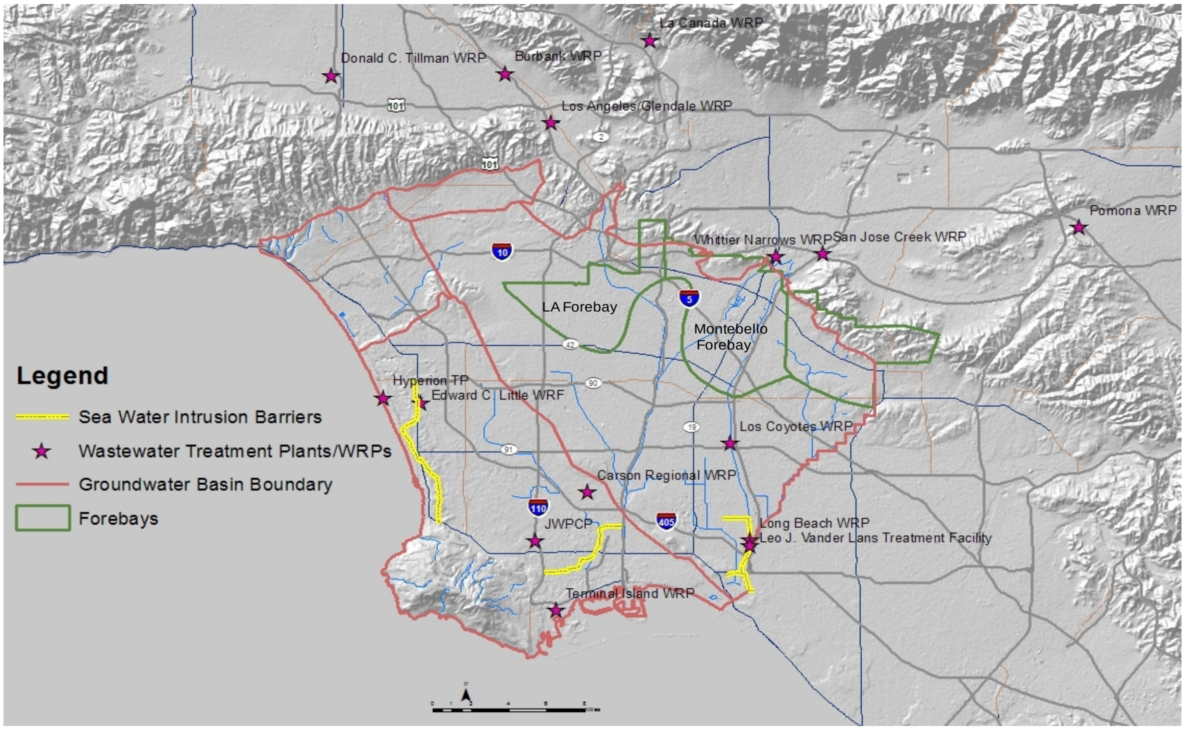


Figure 3-3. Locations of Wastewater Treatment Plants and Water Reclamation Plants

Terminal Island Water Reclamation Plant

Also owned and operated by the City of Los Angeles, the Terminal Island Water Reclamation Plant (TIWRP) is located on a 22-acre site on Terminal Island in the port area of San Pedro near the entrance to the Los Angeles Harbor. TIWRP has a permitted treatment capacity of 30 mgd and is currently operating at an average influent flow rate of 15.4 mgd. The treatment plant discharges undisinfected tertiary effluent on a continuous basis through its permitted harbor outfall into the Los Angeles Harbor, which is hydraulically connected by the harbor entrance to the Pacific Ocean. TIWRP also has a 5-mgd capacity advanced water treatment facility (AWTF), which consists of MF, RO, and disinfection with sodium hypochlorite. Advanced treated disinfected recycled water from TIWRP is sent to the DGBP as well as to non-potable customers, while RO concentrate waste and other residuals from the advanced treatment process are dechlorinated and discharged through the Harbor Outfall to San Pedro Bay. The TIWRP AWTF is planned to be expanded to 12 mgd.

Edward C. Little Water Reclamation Facility

WBMWD currently serves an estimated 32,000 AFY of recycled water to over 220 customer sites from the ECLWRF in El Segundo. The ECLWRF treats secondary effluent from HWRP to produce four different qualities of recycled water onsite and feeds other downstream treatment plants. The product water is conveyed through a network of nearly 100 miles of distribution pipelines. One of the treatment streams is produced at an AWTF onsite for delivery to the WCBBP. WBMWD estimated that the AWTF could be expanded onsite by 10 mgd beyond its current capacity of 17 mgd; expansion beyond 10 mgd could be accomplished in the vicinity of ECLWRF, but land would need to be acquired.

Juanita Millender-McDonald Carson Regional Water Reclamation Facility

Also owned and operated by WBMWD is the Juanita Millender-McDonald Carson Regional Water Reclamation Facility (CRWRF). The CRWRF treats tertiary-treated water conveyed from ECLWRF with nitrification and advanced treatment for industrial use. Expansion of the nitrification plant capacity by a minimum of 12 mgd, and possibly up to 17 mgd, is currently being planned for the City of Los Angeles to serve industrial customers in the Los Angeles Harbor area. The existing site is very constrained and the current product water is fully committed to end users; thus there is limited opportunity to expand or tap this plant for additional replenishment of the West Coast Basin.

Joint Water Pollution Control Plant

The LACSD wastewater treatment facilities in the Los Angeles Basin area are part of an interconnected network of sewers, pump stations, and treatment plants called the Joint Outfall System (JOS). The JOS collects and treats sewage in Los Angeles County that is not otherwise managed by the City of Los Angeles. There are six water reclamation plants in the JOS that return their solids to the sewer system for conveyance and treatment at the JWPCP. Brine waste from upstream dischargers, including WBMWD's CRWRF, are also conveyed to the JWPCP.

The JWPCP has a permitted capacity of 400 mgd and currently treats an estimated 300 mgd of influent sewage. Secondary-treated effluent is discharged from the plant through two tunnels for approximately 6 miles to the outfall structure off the Palos Verdes Peninsula, which then extends approximately 2 miles offshore.

Water recycling at the JWPCP is currently limited to in-plant uses. MWD is currently exploring a potential regional recycled water supply program in partnership with LACSD that would treat the JWPCP's secondary effluent for replenishment of several local groundwater basins, including the West Coast and Central Basins. Considering the flow reductions due to conservation and regulatory compliance issues associated with the brine discharge, LACSD has estimated that up to 150 mgd of JWPCP effluent would be available for purification and reuse (MWD, 2015).

Consideration of these potential sources of additional replenishment is important to the formulation of GBMP scenarios. Sufficient available replenishment water needs to be identified to satisfy the planning scenarios. The specific assumptions regarding which plant delivers to which replenishment locations in the basin are addressed in the alternatives developed for each planning scenario. The alternatives are discussed in Section 5.0.

3.2.3 Concept A Scenarios – West Coast Basin

The Concept A scenarios for the West Coast Basin were formulated so that the extraction patterns are limited to the West Coast Basin adjudicated water rights. Four scenarios under Concept A were identified for the West Coast Basin. They differ with respect to the operation of the Lower San Pedro aquifer, which receives replenishment water to protect it from seawater intrusion, but has limited extraction. The possibility of reducing or eliminating replenishment to this aquifer was explored through these four scenarios. All Concept A scenarios assume recharge at the two existing injection barriers in the West Coast Basin with 100 percent RWC at each barrier, sufficient to meet the adjudicated water rights of 64,468 AFY of extraction.

The specific, assumed, pumping distributions for these scenarios are provided in Table 3-2. Note that these extraction assumptions were purely for basin analysis purposes, and, although shared with the stakeholders during the GBMP development, do not represent extraction agreements.

Each of these Concept A scenarios assumes the following:

- Shifting of oil companies' non-potable demands from groundwater to recycled water and shifting of this groundwater pumping to municipal purveyors
- Increasing recycled water contribution to injection barriers
- Increasing injection required for extraction of 64,468 AFY

Initial screening of these scenarios was conducted using WBMWD's groundwater flow and solute transport model. Subsequent modeling of West Coast Basin operations in conjunction with Central Basin operations (defined as "modeling combinations") for the various GBMP alternatives was conducted with the WRD/USGS groundwater model, as described in Section 4.0. A description of the Concept A scenarios for the West Coast Basin is provided below.

3.2.3.1 Scenario WCB-A1

Scenario A1 for the West Coast Basin (Scenario WCB-A1) assumes increased extraction by the water rights holders up to the adjudicated limit with three distinct pumping patterns, described below in three scenarios (Scenario WCB-A1a, Scenario WCB-A1b, and Scenario WCB-A1c).

Recent pumping in the West Coast Basin averaged about 42,000 AFY (over the past 10 years). Thus, to enable the full adjudicated water rights of 64,468 AFY to be pumped under this scenario, additional replenishment of approximately 22,500 AFY would be needed. This can be delivered through the existing barrier systems.

To match the pumping under this scenario, a total of 32,500 AFY was assumed to be injected at the WCBBP, which is 15,500 AFY more than planned with the current expansion of the ECLWRF AWTF; and 7,500 AFY was injected at the DGBP, which is 2,500 AFY more than the current capacity of the TIWRP's AWTF. This injection distribution between the two barriers was based on the pumping concentration in the more northern part of the basin as well as to avoid overpressuring the DGBP where the depth to the aquifers is much shallower than near the WCBBP.

Table 3-2. Assumed Groundwater Pumping Distribution[a] (in AFY) under Scenarios WCB-A1a, WCB-A1b, and WCB-A1c

Purveyor/ Pumpers	Water Right	Current (based on last 3 yrs)	Scenario WCB-A1a		Scenario WCB-A1b		Scenario WCB-A1c	
			Distribute to Major WR Holders & LA	Differential from Current Pumping	Distribute to Major WR holders & LA	Differential from Current Pumping	Regional Partnership (Remediate Saline Plume)	Differential from Current Pumping
Golden State Water Co.	7,502	13,500	14,000	500	13,000	(500)	14,000	500
CWSC (Hermosa-Redondo)	4,070	1,000	2,000	1,000	2,000	1,000	2,000	1,000
CWSC (Dominguez)	10,417	7,000	16,000	9,000	14,000	7,000	16,000	9,000
CWSC (Hawthorne)	1,882	40	2,500	2,460	2,500	2,460	2,500[b]	2,460
City of Torrance	5,639	2,400	11,000	8,600	9,000	6,600	11,000[b]	8,600
City of El Segundo	953	0	1,500	1,500	1,500	1,500	1,500	1,500
City of Inglewood	4,450	3,700	6,000	2,300	5,000	1,300	6,000	2,300
City of Lomita[c]	1,352	5	2,465	2,460	2,468	2,463	2,465	2,460
City of Manhattan Beach	1,131	1,500	2,000	500	2,000	500	2,000	500
City of Los Angeles	1,503	0	1,503	1,503	7,500	7,500	1,503[b]	1,503
Oil Companies[d]	23,128	10,600	4,000	(6,600)	4,000	(6,600)	4,000	(6,600)
Minor Water Rights Holders	2,440	1,300	1,500	200	1,500	200	1,500	200
TOTAL	64,468	41,045	64,468	23,423	64,468	23,423	64,468	8,420

[a] For **planning purposes only** to assess the range in potential distribution of pumping that could develop in the future. Actual distribution will be determined (outside of this study) by pumper needs, lease market, and economics.

[b] Extraction by CWSC (Hawthorne), City of Torrance and City of Los Angeles eliminated from existing well locations and replaced with pumping from saline plume. Volumes pumped may or may not use water rights depending on the total dissolved solids of the extracted groundwater.

[c] Groundwater usage designated for City of Lomita used to bring TOTAL basin pumping to 64,468 AFY.

[d] Assumes reduction of refinery use of groundwater through conversion to recycled water, assuming favorable economic and lease agreements are developed to support conversion.

3.2.3.2 Scenario WCB-A1a

Scenario WCB-A1a assumes additional extraction by large water rights holders (except oil companies); it also assumes that the City of Los Angeles extracts its 1,500 AFY of adjudicated rights (which it has not been doing for the past 30 years). Figure 3-4 is a schematic illustrating how this scenario could be implemented by potential expansion of existing wells to provide additional pumping capacity by pumper.

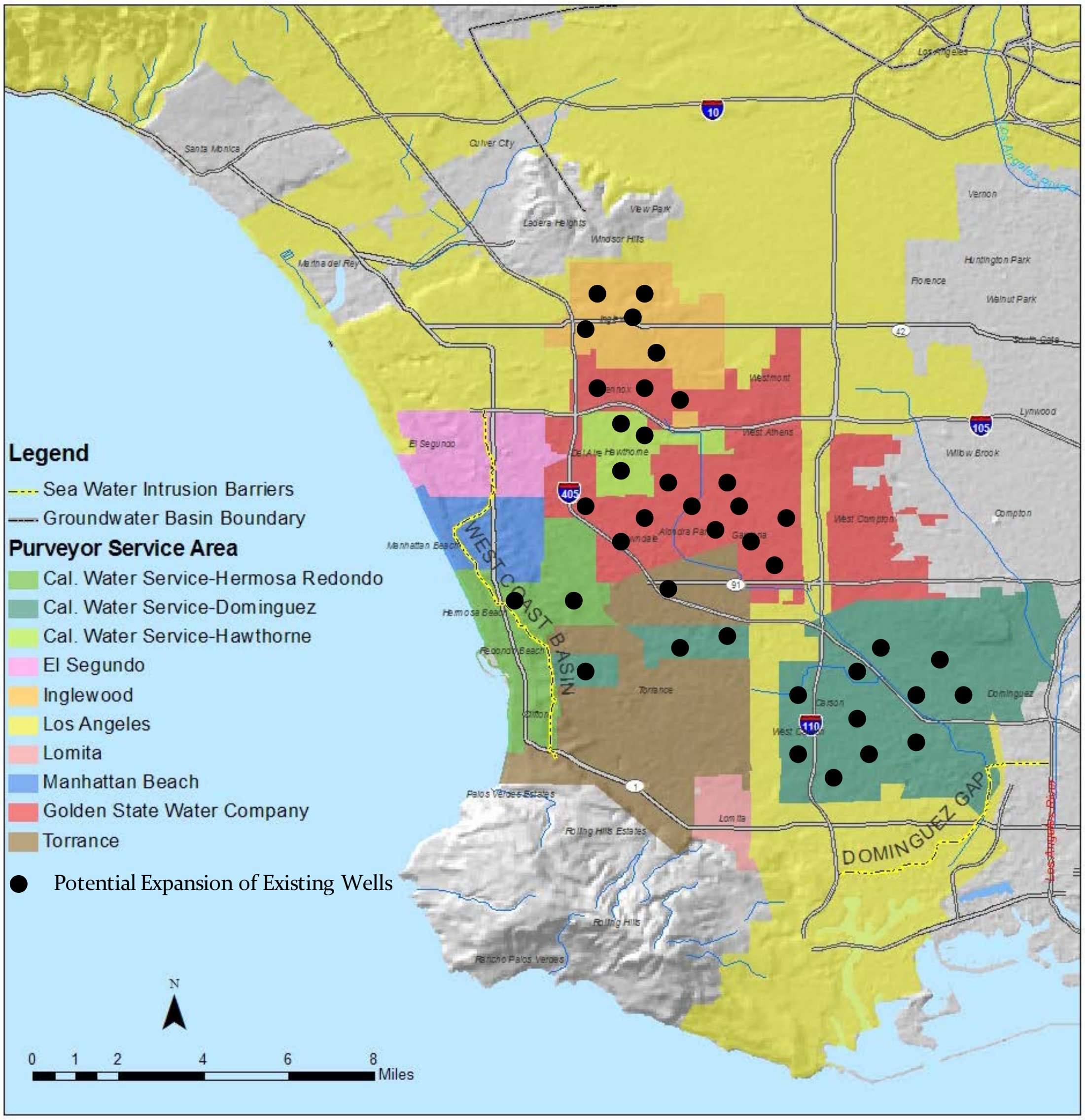


Figure 3-4. Schematic of Potential Expansion of Existing Wells for Major Water Rights Holders under Scenario WCB-A1a

3.2.3.3 Scenario WCB-A1b

Scenario WCB-A1b assumes additional extraction by large water rights holders (except oil companies) as well as by the City of Los Angeles in excess of its adjudicated rights (that is, to 7,500 AFY). Figure 3-5 is a schematic illustrating how this scenario could be implemented by some of the pumpers (see Table 3-2).

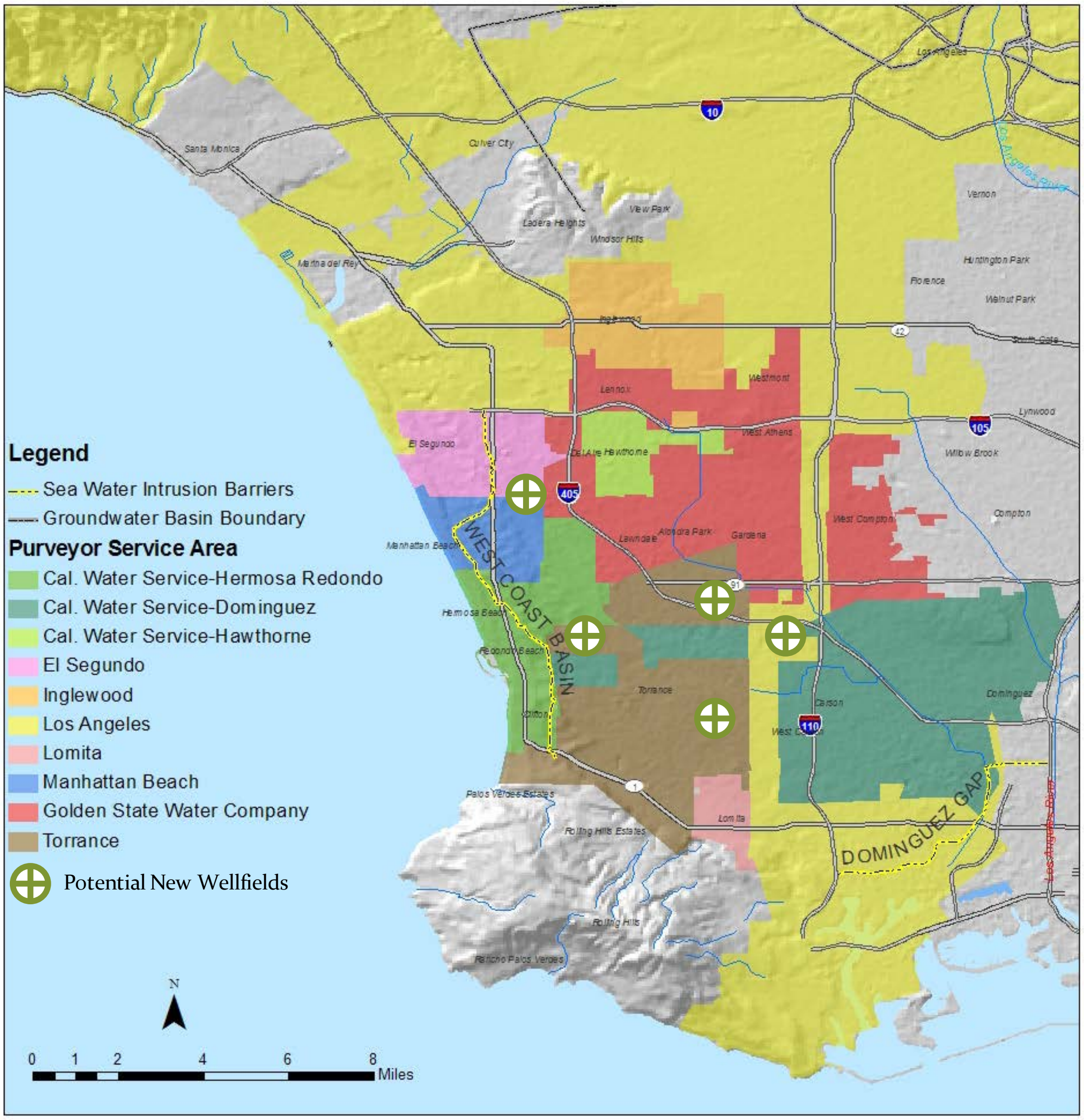


Figure 3-5. Schematic of Expansion of Potential Wellfields for Increased Extraction under Scenario WCB-A1b

3.2.3.4 Scenario WCB-A1c

Under Scenario WCB-A1c, pumping is redistributed with the goal to contain and remove the saline plume in the Silverado aquifer. It was assumed that three pumpers (CWSC – Hawthorne, City of Torrance, and City of Los Angeles) would use the total 15,000 AFY of desalinated water. Thus extraction for these three pumpers was shifted from their current well locations to seven new desalters in the Silverado aquifer. The assumed locations of these wells/desalters are shown in Figure 3-6. The locations of these desalters are based on, (1) being on the leading edge of the saline plume in order to contain the plume from further migration, (2) generally located downgradient of parts of the plume containing higher concentrations of salts, (3) potential availability of land to site a demineralization facility, and (4) within or near the service areas of the pumpers.

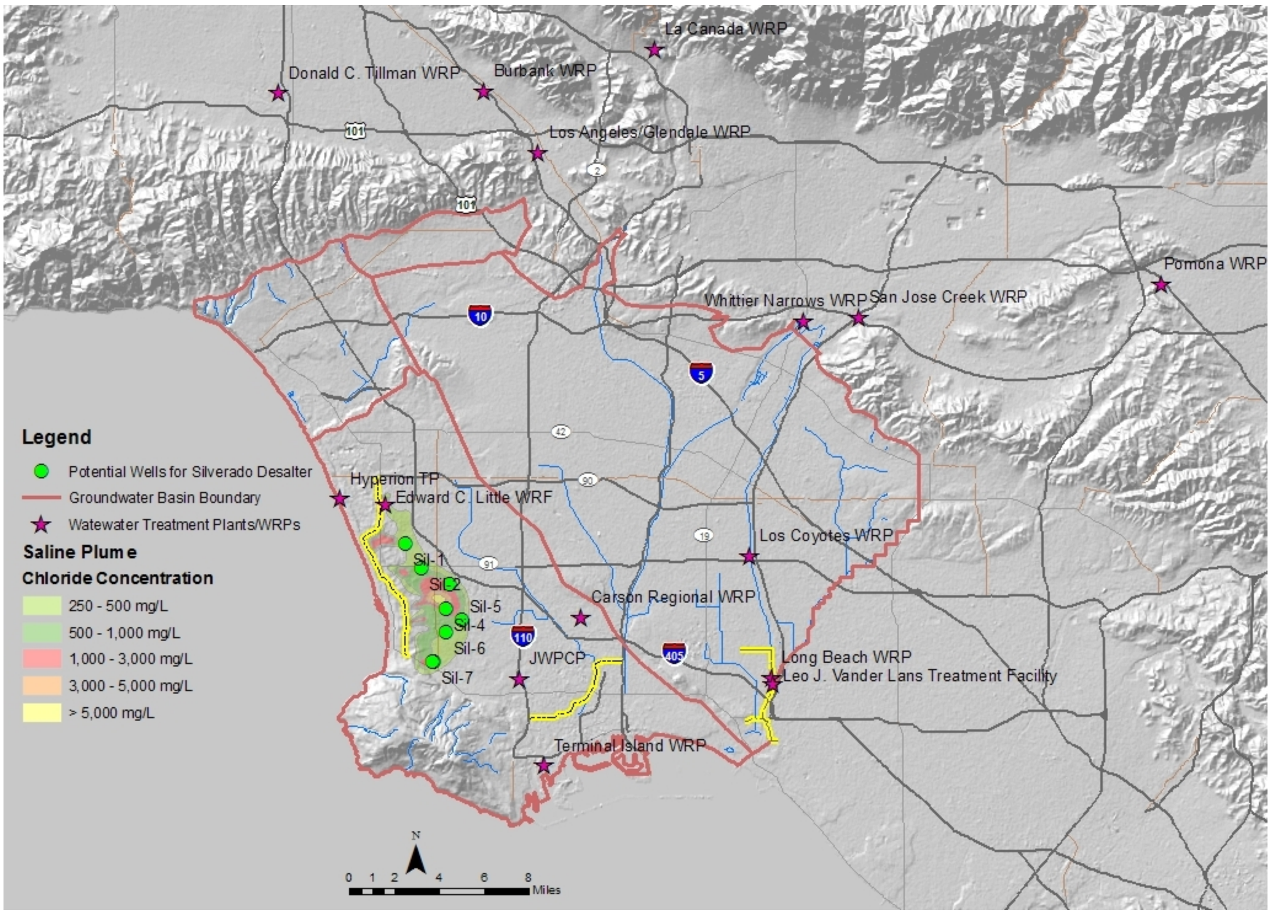
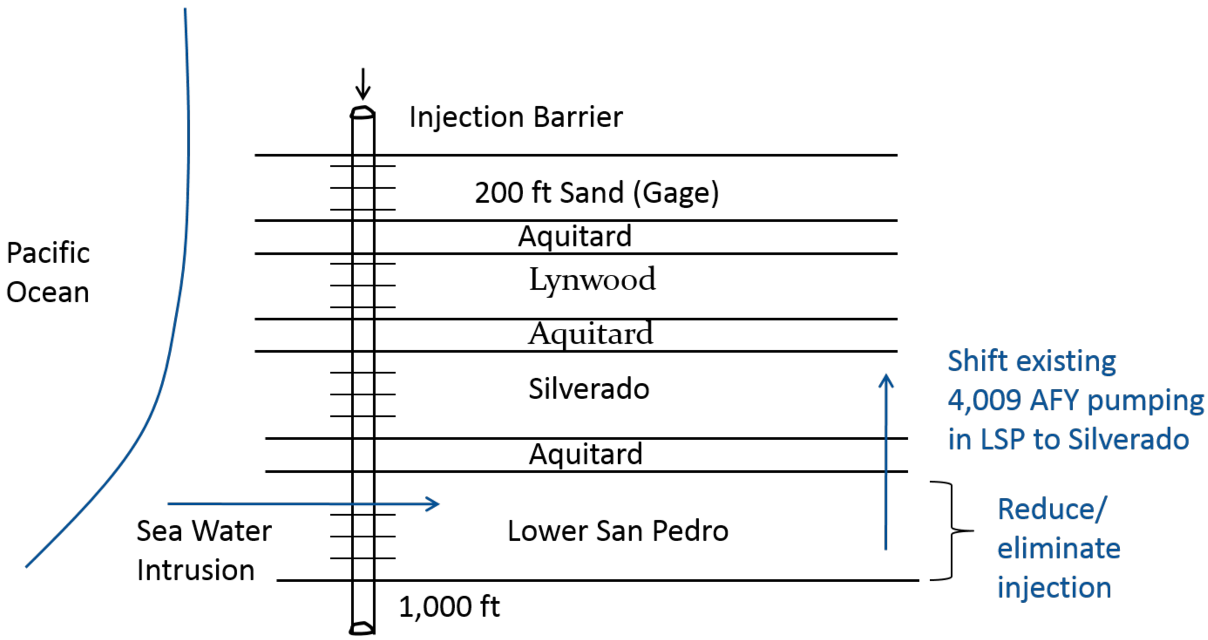


Figure 3-6. Potential New Wellfields in the Saline Plume Area under Scenario WCB-A1c

3.2.3.5 Scenario WCB-A2

Scenario WCB-A2 modified Scenario WCB-A1 by reducing or eliminating injection and extraction from the Lower San Pedro aquifer, while providing protection from seawater intrusion by balancing pumping in the Silverado aquifer. Figure 3-7 provides a conceptualization of this scenario. The purpose of exploring this scenario was to determine whether the amount of replenishment water that needed to be purchased to support full extraction of the adjudicated basin rights could be reduced by this modified basin operation.



Note:

ft = feet

Figure 3-7. Conceptualization of Scenario WCB-A2

The extraction pattern for Scenario WCB-A2 was identical to that of Scenario WCB-A1a with respect to the geographic well locations and pumped flows. However, the extraction zones were changed by shifting approximately 4,900 AFY of pumping and 10,390 AFY injection from the Lower San Pedro aquifer to the Silverado aquifer. The 4,900 AFY pumping is largely associated with wells screened across the Silverado Aquifer and Lower San Pedro Aquifer and this represents the portion estimated to come from the Lower San Pedro Aquifer. Most of this pumping is in the Torrance area.

3.2.3.6 Scenario WCB-A3

Scenario WCB-A3 limited injection to the Lower San Pedro aquifer to be based on the availability of discounted, surplus (or “Level 2”) imported water, assumed to be available 2 out of 10 years. The purpose of exploring this scenario was to ultimately develop a cost/benefit analysis of injecting and storing surplus water in the Lower San Pedro aquifer for subsequent extraction. A variation on this was suggested by one of the stakeholders—that is, to consider injection near the points of extraction from the Lower San Pedro aquifer rather than at the existing barrier wells.

The extraction pattern for Scenario WCB-A3 is assumed to be identical to that of Scenario WCB-A2. Figure 3-8 provides a conceptualization of this scenario.

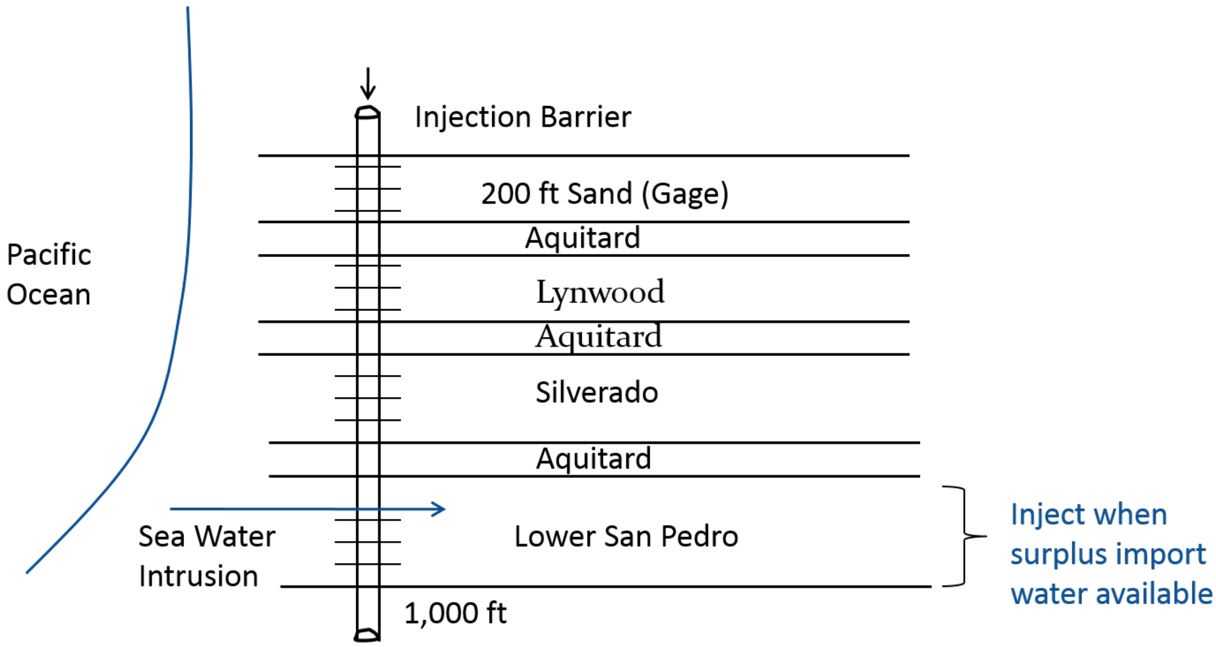


Figure 3-8. Conceptualization of Scenario WCB-A3

3.2.3.7 Scenario WCB-A4

Scenario WCB-A4 eliminates injection of highly treated barrier water to the Lower San Pedro aquifer. Rather than prevent seawater intrusion into this formation, extraction of brackish groundwater from this aquifer was assumed to be treated at the wellhead.

The extraction pattern for Scenario WCB-A4 is assumed identical to that of Scenario WCB-A1a with the exception of the added extraction from the Lower San Pedro. Figure 3-9 provides a conceptualization of this scenario.

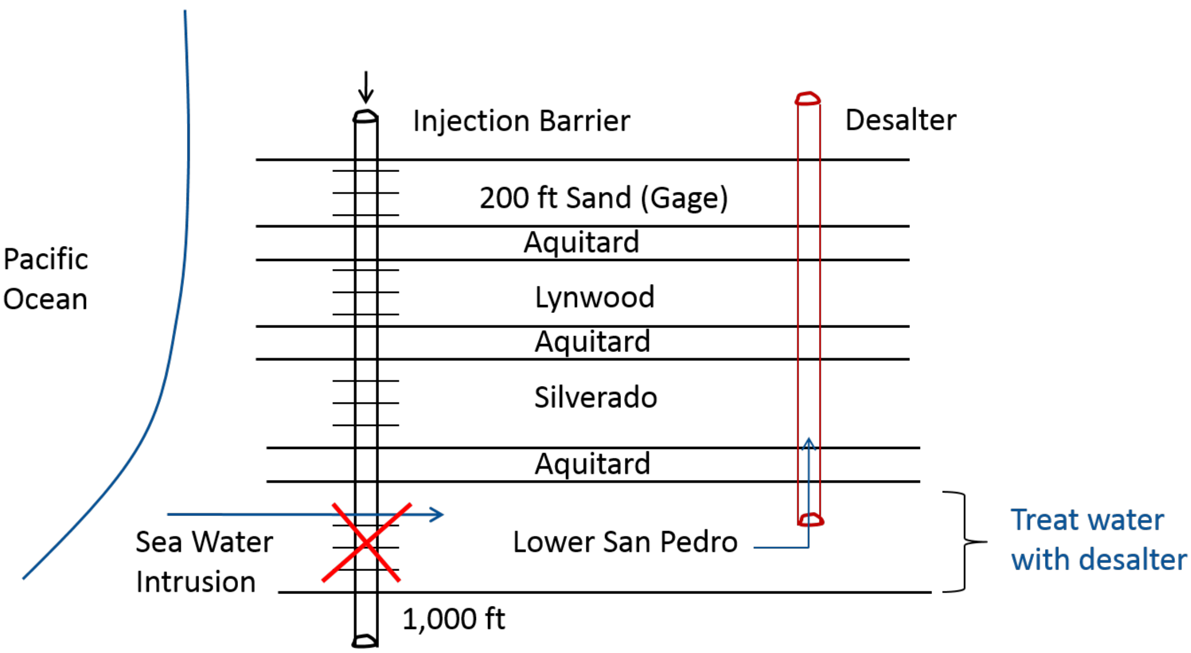


Figure 3-9. Conceptualization of Scenario WCB-A4

3.2.3.8 Summary of Injection and Extraction Options in WCB-Concept A Scenarios

As discussed above, various options for injection and extraction were considered in the Concept A scenarios for the West Coast Basin. These included increased injection into the Silverado aquifer, and potentially decreased or eliminated injection into the San Pedro aquifer while increasing current extractions from Silverado aquifer to pump up to the adjudicated water rights. Table 3-3 summarizes the primary differences in these scenarios.

3.2.3.9 Screening of WCB-Concept A Scenarios

WBMWD's groundwater flow and solute transport model was used to evaluate the WCB-Concept A scenarios. Based on the model results, only the Scenario WCB-A1 series was found to be viable for further analysis.

Shifting pumping and injection from the Lower San Pedro aquifer to the Silverado aquifer in Scenario WCB-A2 was found to increase seawater intrusion significantly into the Lower San Pedro, and even somewhat into the Silverado. Thus Scenario A2 was deemed too risky to for further consideration. And, since Scenario WCB-A2 was ineffective, Scenario WCB-A3, an even riskier operation, was thus not considered for modeling and analysis. The model results for Scenarios WCB-A1 and WCB-A2 are compared in Figure 3-10, demonstrating the effect of seawater intrusion in the West Coast Basin.

Table 3-3. Location of Extraction and Injection under WCB – Concept A Scenarios

Concept A Scenarios	Silverado Aquifer		Lower San Pedro Aquifer	
	Injection*	**Silverado Extraction**	**Injection**	**Extraction**
Scenario A1 (A1a, A1b, A1c)	Increase beyond current plans	Increase to adjudicated rights; pump from saline plume	No change to current level of protection	None
Scenario A2	Same as in Scenario A1	Same as in Scenario A1, plus move Lower San Pedro pumping to this aquifer	Eliminate injection and shift pumping to Silverado	None
Scenario A3	Same as in Scenario A1	Same as in Scenario A1	Eliminate injection unless surplus water available	None
Scenario A4	Same as in Scenario A1	Same as in Scenario A1	Eliminate injection	Consider extraction and treatment of brackish groundwater

*Injection occurs at existing barriers only.

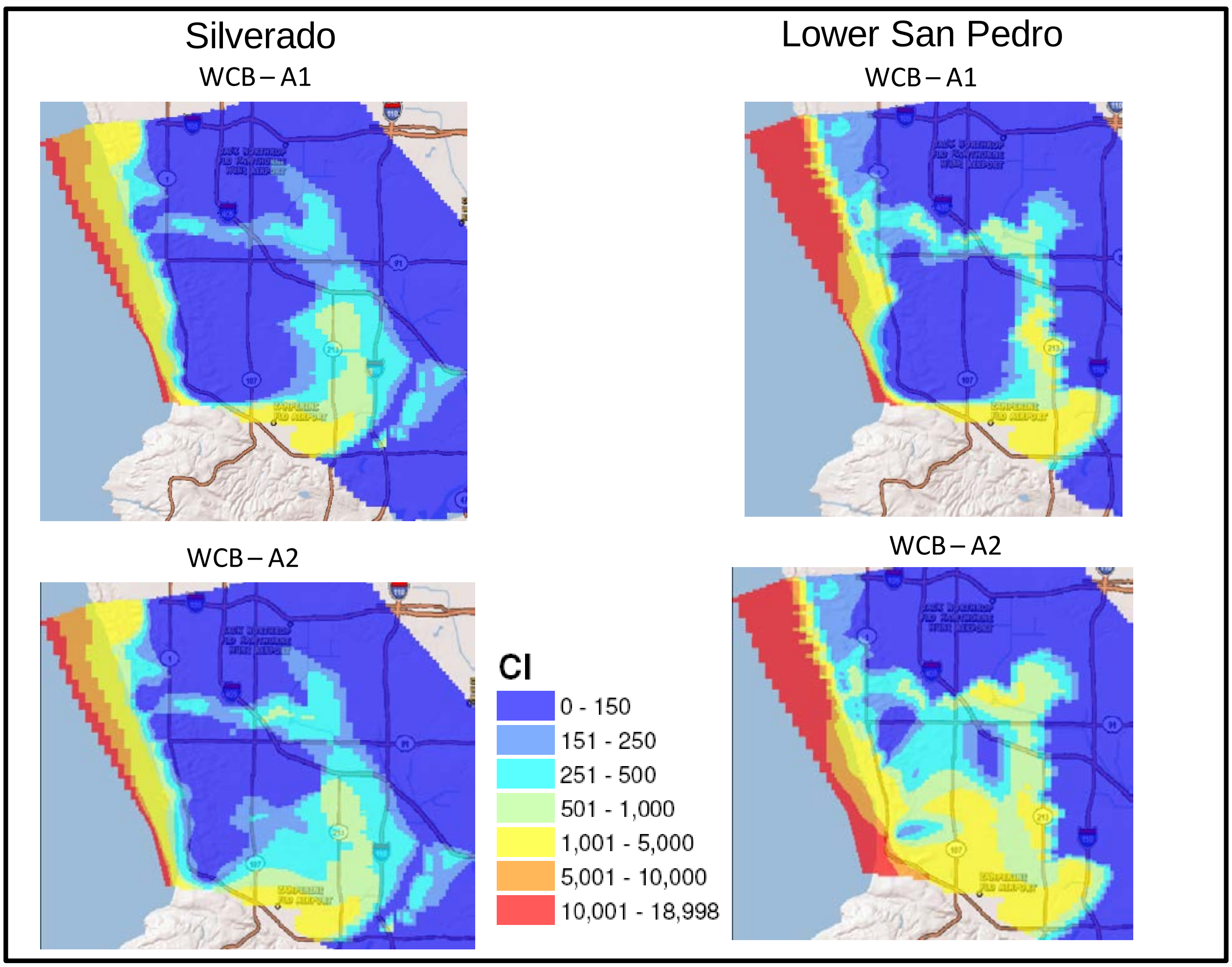


Figure 3-10. Comparison of Model Results for Chloride Concentrations in mg/L for Scenarios WCB-A1 and WCB-A2 for Year 2040

Scenario WCB-A4 eliminated injection in the Lower San Pedro aquifer, but extraction (with assumed wellhead treatment for desalination of the brackish groundwater) was introduced as a means to manage seawater intrusion. The effects on the basin were significant as seawater intrusion occurs around the extraction wells of the Lower San Pedro aquifer and brackish water moves into the Silverado aquifer. If extraction were stopped for any reason, the intruded seawater would be trapped inland, degrading overall basin water quality, which is an unacceptable operational scheme. Thus, Scenario WCB-A4 was also eliminated from further consideration. The model results for Scenarios WCB-A1 and WCB-A4 are compared in Figure 3-11, demonstrating the extent of the seawater intrusion in the Silverado and Lower San Pedro aquifers of the West Coast Basin.

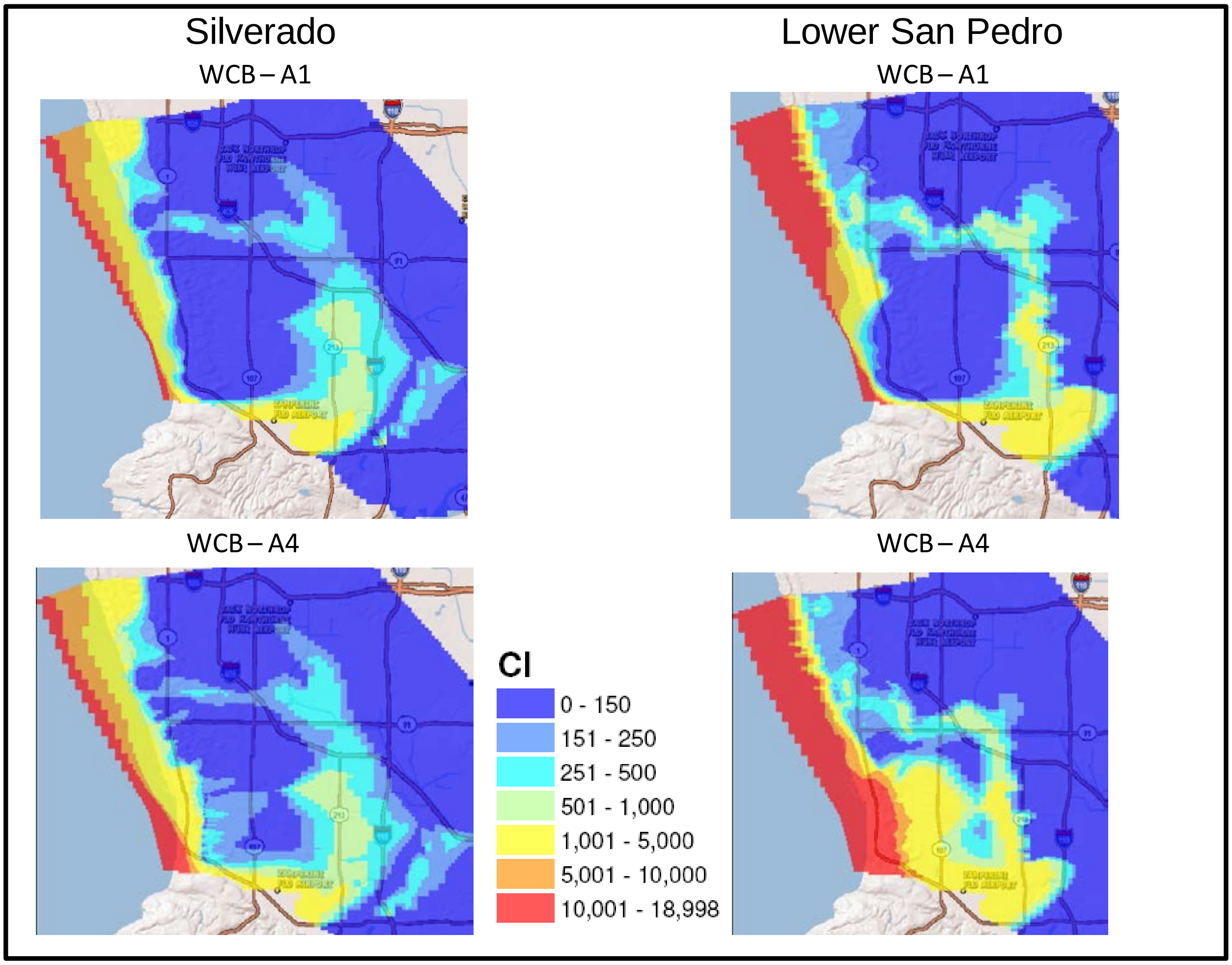


Figure 3-11. Comparison of Model Results for Chloride Concentrations in mg/L for Scenarios WCB-A1 and WCB-A4 for Year 2040

3.2.4 Concept B Scenario – West Coast Basin

The Concept B scenario for the West Coast Basin was formulated such that the extraction expands beyond the adjudicated water rights, in accordance with the requirements of the recently approved Judgment amendments. For the West Coast Basin, extraction beyond the water rights was evaluated with one extraction/replenishment scenario. Extraction up to an additional 30,000 AFY was assumed, because this approximates historical production from the basin. Replenishment for this scenario included the use of a new, inland injection well system, as well as increased injection at the existing barriers.

As with the Concept A scenarios, the Concept B scenario for the West Coast Basin assumes the following:

- Shifting of oil companies' non-potable demands from groundwater to recycled water and shifting of this groundwater pumping to municipal purveyors
- 100% recycled water contribution to injection barriers
- Increasing injection required for extraction of 94,468 AFY

3.2.4.1 Scenario WCB-B1

Scenario B1 for the West Coast Basin (Scenario WCB-B1) increases extraction by water rights holders to 30,000 AFY beyond the adjudicated limit by assuming additional pumping by the following water purveyors from wells at or near their existing wells to offset their imported water demands:

- CWSC: 15,000 AFY
- City of Torrance: 5,000 AFY
- City of Los Angeles: 10,000 AFY

Pumping for all other purveyors will be the same as in Scenario WCB-A1a. Extraction under this scenario also included use of the new Silverado Desalters to mitigate the saline plume, thus applying the pumping locations as described for Scenario WCB-A1c.

This additional *30,000 AFY* of extraction would require a comparable level of additional replenishment. For Scenario WCB-B1, replenishment was assumed to occur as follows:

- **WCBBP:** Current WCBBP injection of 17,000 AFY is expanded by 15,500 AFY to meet the pumping up to the adjudicated limit of Concept A (see Section 3.2.3.1). *Additional injection of 7,500 AFY* **i**s assumed under the Concept B scenario to provide a total of 40,000 AFY of artificial replenishment to the WCBBP to pump beyond the adjudicated limit.
- **DGBP:** Current DGBP injection of 7,500 AFY is *expanded by 7,500 AFY* in the Concept B scenario to provide a total of 15,000 AFY of artificial replenishment to the DGBP to allow additional pumping beyond the adjudicated limit..
- **New injection wells:** Injection of *15,000 AFY* into 14 new injection wells in the southeastern area of basin (assumed along Normandie Street, west of the 110 freeway).

The locations of the facilities associated with this replenishment scheme are shown in Figure 3-12.

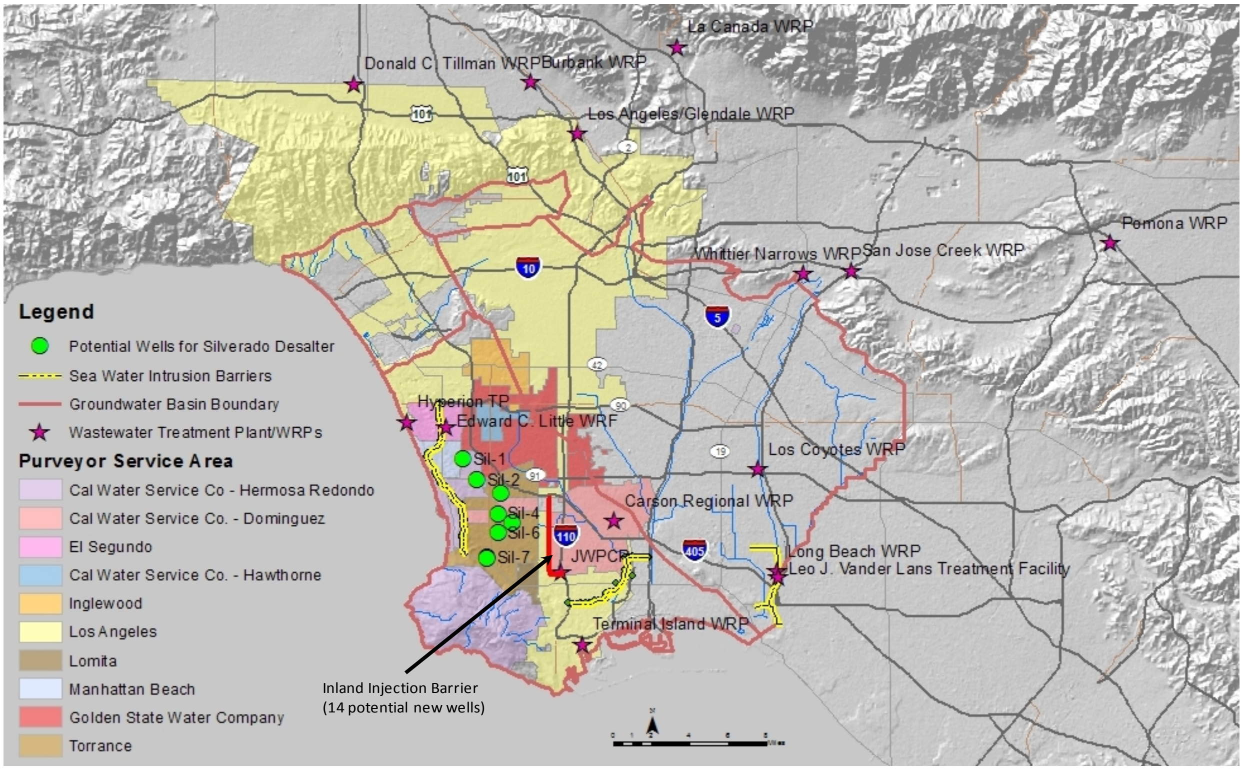


Figure 3-12. Conceptualization of Scenario WCB-B1

3.3 Central Basin Scenarios

This section summarizes the formulation of GBMP planning scenarios for the Central Basin during Phase 1. The supply, recharge, and pumping components used to define these scenarios are described below, along with the potential sources of replenishment water. Finally, the specific Central Basin planning scenarios were defined and evaluated, and viable scenarios were identified to serve as the basis for the GBMP alternatives evaluated in the Phase 2 analysis.

3.3.1 Components Used for Developing Central Basin Scenarios

For the Central Basin, the components of the GBMP planning scenarios (water supply sources, groundwater recharge mechanisms, and pumping patterns) consisted of the following elements, as illustrated in Figure 3-13:

- Water supply sources for injection and spreading in the basin – Recycled water and imported water for injection; stormwater, and recycled water for spreading.
- Injection and spreading locations – Existing barrier (ABP) as well as new inland injection system; consider practice of in-lieu use of imported water to replace groundwater pumping. (As noted for the West Coast Basin, assume that in-lieu recharge will occur as in the past; that is, this would be an opportunistic activity that will occur if discounted imported water is available at a rate that is of a lower cost than use of other supplies. Given the uncertain nature of imported water supplies, in-lieu operations have not been specifically analyzed; however, given the offsetting effects of pumping and recharge, limited in-lieu operations are not expected to significantly change the analysis presented herein.)
- Pumping locations – Extraction is expected to be expanded by pumpers in their service areas; however, large increases in extraction are assumed to be focused near areas of recharge (such as

forebay areas) to minimize large fluctuations in groundwater levels. However, extraction patterns could be optimized in subsequent implementation phases to consider containment or cleanup of selected areas of groundwater contamination.

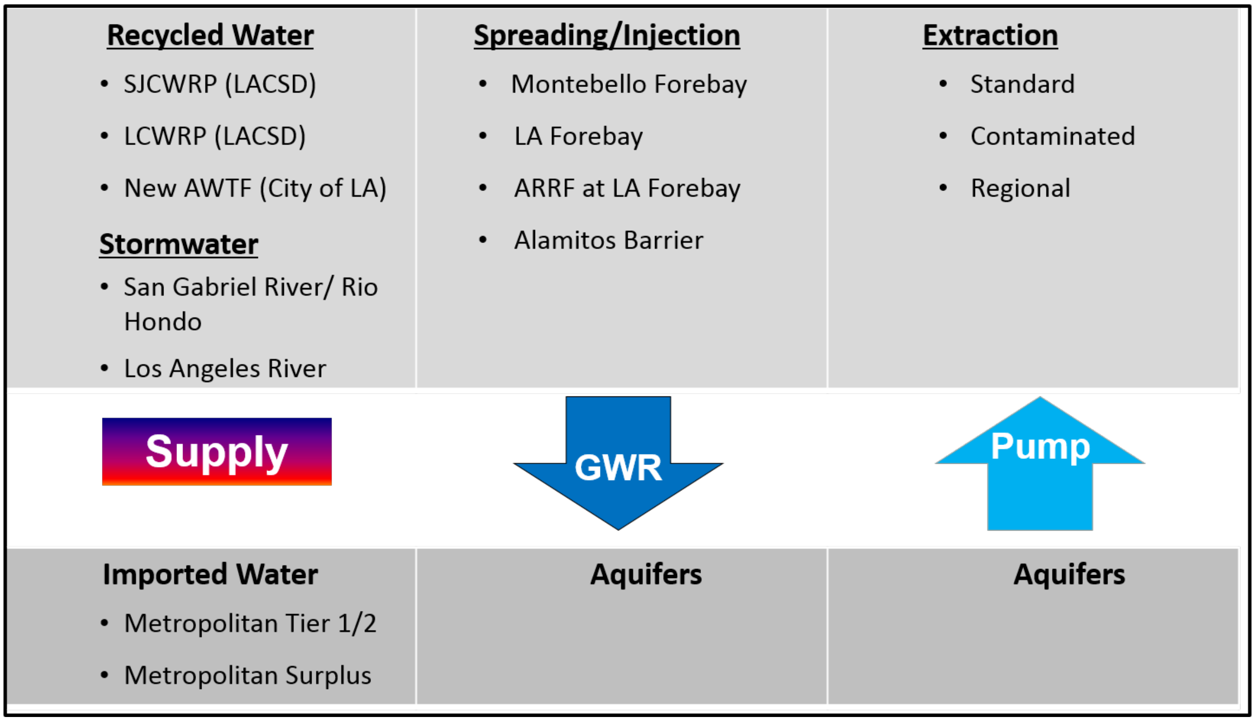


Figure 3-13. Elements for Developing Scenarios in the Central Basin

The overall goals for developing the Central Basin scenarios are as follows:

- Replenish Central Basin within current APA of 217,367 AFY (Concept A scenarios) and above APA (Concept B scenarios).
- Further develop sources of local water, principally stormwater and recycled water (excluding imported water).
- Maximize use of supplies and spreading grounds in Montebello Forebay.
- Provide for increased pumping to offset imported water demands consistent with increased replenishment.
- Maintain an overall water balance in the basin.
- Use groundwater basin storage space as required to meet the objectives.

In the Central Basin, Concept A and B GBMP planning scenarios were varied according to extraction and recharge patterns related to enhancing the potential for stormwater recharge and increased injection and spreading of recycled water at both the existing spreading grounds and new injection wells.

Several scenarios were developed based on (1) the components identified in Figure 3-13; (2) the planning goals for the basin identified above; and (3) the potential sources of replenishment water described below. These specific scenarios for Concepts A and B are described below.

3.3.2 Potential Sources of Replenishment Water

Potential sources of groundwater replenishment water for the Central Basin include:

- Imported water
- Recycled water
- Stormwater

3.3.2.1 Imported Water

While imported water has been used historically to replenish the Central Basin, the existing ABP seawater intrusion barrier will ultimately be replenished with 100 percent RWC with the expansion of the LVLWTF. And the imported water that has been used in recent years to replenish the basin at the MFSG will be replaced by the GRIP Recycled Water Project.

The alternatives developed in this GBMP assume that no surplus, discounted imported water is available so that they can be compared against the availability, reliability, and costs of imported water. The actual use of discounted surplus imported water for replenishment would continue to be considered by WRD on an annual basis as the opportunities for its purchase and use for replenishment in the Central Basin arise, particularly for the MFSG. Therefore, use of imported water will be considered on an opportunistic basis to provide for replenishment via in-lieu operations. The occasional implementation of in-lieu operations is not expected to significantly alter the analysis presented herein.

3.3.2.2 Recycled Water

As noted in Section 3.2.2.2 and shown in Figure 3-3, there are several potential sources of recycled water in the Study Area. This section discusses the WRPs considered for sources of replenishment water in the Central Basin.

San Jose Creek Water Reclamation Plant

The SJCWRP provides primary, secondary, and tertiary treatment for up to 100 mgd. The plant serves a large residential population of approximately one million people. Approximately 35 mgd of the tertiary-treated water was reused at 17 different reuse sites in 2010, including groundwater recharge and irrigation of parks, schools, and greenbelts (LACSD, 2011[5]). The remainder is discharged to the San Gabriel River.

NPR demand totaled approximately 4,500 AFY in fiscal year 2009/2010[6] and is projected to increase to 10,500 AFY by 2030 as a result of planned increases in use by each existing customer. In addition, WRD is currently implementing the GRIP Recycled Water Project which increases recharge at the MFSG with recharge of SJCWRP effluent by 21,000 AFY (i.e., from 40,000 AFY to 61,000 AFY) and it replaces imported water supply. Existing SJCWRP production is approximately 70 mgd (78,400 AFY), and current expectations are for increased flows due to economic and population growth to be offset by increased implementation of conservation measures. Therefore, an average of 70 mgd is conservatively assumed to be the future SJCWRP effluent production. Based on these projections, nearly all SJCWRP effluent is projected to be reused during the summer. Recycled water production and projected reuse by month is shown in Figure 3-14.

[5] The analysis conducted for the GBMP was based on recycled water availability at the time that the draft report was prepared in 2012. The use of recycled water from SJCWRP, as well as other WRPs, will be subject to availability at the time that a new project is considered. In recent years, drought conditions have resulted in decreasing wastewater flows due to conservation measures, and demand for recycled water has been increasing. In fiscal year 2013-14, more than 45 mgd of SJCWRP recycled water was reused at 166 sites. (LACSD, 2015).

[6] Reuse by CBMWD is supplied by both SJCWRP and LCWRP, but the split between each source is not measured. SJCWRP and LCWRP non-potable reuse estimates assume that approximately two-thirds of CBMWD total reuse (3,750 AFY) is supplied from SJCWRP and the other one-third is supplied by LCWRP.

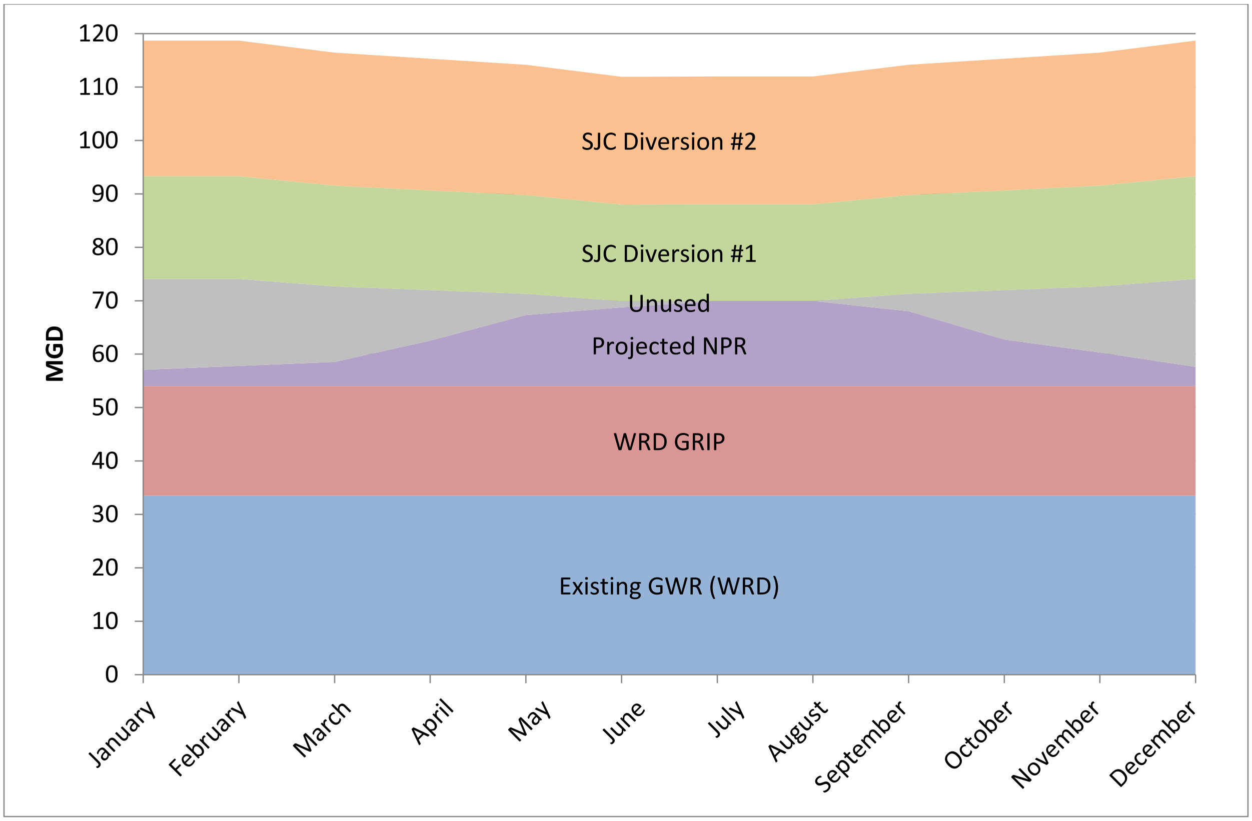


Figure 3-14. SJCWRP Monthly Supplies

As indicated in Figure 3-14, sewer diversions and plant modifications are necessary to increase influent flows to the SJCWRP, which will increase effluent flows to help supply potential GBMP projects. Based on an LACSD technical memorandum (2010[7]), a series of projects referred to as "Diversion No.1" could increase SJCWRP influent by 20,900 AFY at a cost of $1.6 million.

Another project, referred to as "Diversion No.2" could increase tributary flow to the SJCWRP by 27,600 AFY by diverting available flows from the Whittier Narrows WRP drainage area at an estimated by cost of $76 million.

Los Coyotes Water Reclamation Plant

The LCWRP provides primary, secondary, and tertiary treatment for up to 37 mgd. The plant serves a population of approximately 370,000 people. Over 5 mgd of the tertiary-treated water is reused at over 200 sites. Reuse includes landscape irrigation of schools, golf courses, parks, nurseries, and greenbelts; and industrial use at local companies for carpet dying and concrete mixing (LACSD, 2011[8]). The remainder of the effluent is discharged to the San Gabriel River.

Existing LCWRP production is approximately 26 mgd, and current expectations are for increased flows due to economic and population growth to be offset by increased implementation of conservation measures. Therefore, an average of 26 mgd is conservatively assumed to be the future LCWRP effluent

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[7] Although much has changed since this 2010 analysis on which these diversions were based, the assumption that the need for sewage diversions to meet the flow requirements of the projects identified for SJCWRP in this final 2016 GBMP report was maintained. While the specific flow diversion projects may differ from those identified in 2010, the use of those projects and their respective flows and costs captures this likely requirement but the values and projects would need to be revised as specific recharge projects are implemented.

[8] In fiscal year 2013-14, more than 6 mgd of LCWRP recycled water was reused at 278 sites. (LACSD, 2015).

production. Based on these projections, an annual average of approximately 12 mgd was projected to be available. Recycled water production and projected reuse by month is shown in Figure 3-15.

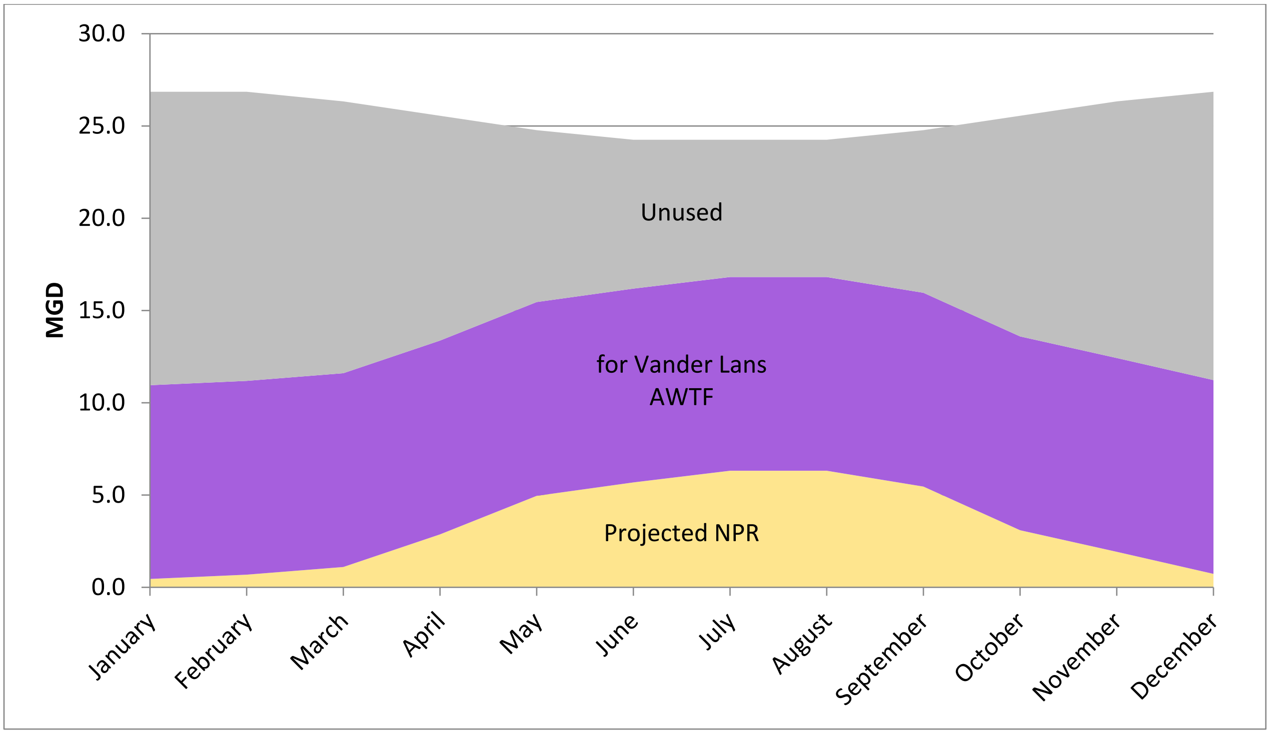


Figure 3-15. LCWRP Monthly Supplies

Long Beach Water Reclamation Plant

The LBWRP as capacity to provide primary, secondary, and tertiary treatment for up to 25 mgd. The City of Long Beach owns the rights to recycled water produced at LBWRP in exchange for the land it sits on. They also operate and maintain the LVLWTF. In fiscal year 2009/2010, 5.8 mgd (6,550 AFY) of the effluent produced at the plant was reused beneficially at 56 individual sites. NPR demand totaled approximately 4,272 AFY in fiscal year 2009/2010, delivered by the Long Beach Water Department for landscape irrigation of schools, golf courses, parks, and greenbelts. An additional 2,278 AFY was delivered to the LVLWTF for replenishment at the ABP. The majority of the effluent is discharged to the lined portion of Coyote Creek, which then joins the San Gabriel River and flows to the Pacific Ocean. (LACSD, 2011[9]) Existing LBWRP production is approximately 18 mgd, and current expectations are for increased flows due to economic and population growth to be offset by increased implementation of conservation measures. Therefore, an average of 18 mgd is conservatively assumed to be the future LBWRP effluent production.

WRD recently expanded the current production capacity of the LVLWTF from 3 MGD to 8 MGD. The expansion enables WRD to increase its RWC to the Alamitos Barrier from 50 percent to 100 percent. The expansion demands of LVLWTF are assumed to be met after the other customer demands are met.

In their *2010 Recycled Water Master Plan* (MWH, 2010), the City of Long Beach identified at least 2,505 AFY of additional recycled water demand from potential NPR customers, and acknowledges additional potable water demands that could be served with recycled water that could reach more than 4,510 AFY. Due to the high projected demand for LBWRP recycled water, it is not considered as a viable potential supply source of additional replenishment water for the GBMP alternatives.

[9] In fiscal year 2013-14, more than 5 mgd of LBWRP recycled water was reused at 66 sites. (LACSD, 2015).

3.3.2.3 Stormwater

Stormwater from the San Gabriel River, Rio Hondo, and Los Angeles River can be captured and used for recharge. The potential to capture more stormwater for recharge requires that (1) the capacity to recharge additional stormwater exists and, (2) additional stormwater is available to divert into the spreading basins. Provided below is a description of the amount of water available from the San Gabriel River and Rio Hondo and the Los Angeles River, which can be captured and used for recharge, instead of it discharging to the ocean.

San Gabriel River and Rio Hondo

As described in Section 2.2.2.2, the Montebello Forebay recharge facilities consist of two off-stream spreading facilities operated by LACDPW, including the Rio Hondo Spreading Grounds and San Gabriel Coastal Spreading Grounds (collectively referred to as the MFSG), as well as several in-stream facilities in the San Gabriel River for replenishment of recycled water, direct precipitation, local runoff, and imported water. LACDPW monitors the source of water supplies and locations of recharge of these waters at the MFSG. The recharge waters at the spreading grounds have averaged approximately 128,000 AFY, composed of about 57,000 AFY of local runoff, 21,000 AFY of imported water, and about 50,000 AFY of recycled water. The use of imported water for replenishment at the MFSG is being replaced with either increased capture of stormwater or recycled water, given that the WIN program goal is to replace the use of imported water.

In 2000, WRD completed the Montebello Forebay Recharge Optimization Study (MFROS). This study concluded that on average, approximately 17,000 AFY additional stormwater could be captured and recharged at the MFSG if there was approximately 25,000 AFY of additional pumping in the forebay area to reduce groundwater levels, so that recharge would not be reduced due to rising groundwater levels during high-rate recharge events. A project to provide this combination of pumping and enhanced stormwater recharge is included in this GBMP, and referred to as the Groundwater Basin Optimization Pipeline (GBOP) project.

Large volumes of San Gabriel River and Rio Hondo flows bypass the spreading grounds following large storm events and are wasted to the ocean. In fact, approximately 55,000 AFY was bypassed on average during the period of record shown in Figure 3-16 (October 1996-May 2011). LACDPW maintains records of stormwater captured at the MFSG and reports approximate volumes of water "wasted to the ocean" when they could not capture all of the stormwater in a given storm event. Although these records are not complete for all years between water years 1971 to 2010, Figure 3-16 shows the historical volumes of water wasted to the ocean where these data are available, i.e., beginning in 1996. Typically, the volumes of stormwater are very large and much greater than can reasonably be captured and recharged; therefore, only a fraction of these flows can be diverted and captured for additional recharge. For this study, future projections assume stormwater will be available in the same quantities in the future as it was in the past. This means that any non-captured stormwater in years past when stormwater was wasted to the ocean is now assumed to be excess stormwater available for capture and recharge.

Figure 3-17 shows the monthly volume of water recharged at the MFSG, for all water supplies, including releases from the upstream Whittier Narrows Dam, for water years 1971 through 2010. The maximum monthly quantity of water recharged exceeds 60,000 AF once, 40,000 AF in a few months, and 30,000 AF in many months over this period. Figure 3-18 shows the monthly volumes of stormwater captured and spread at the MFSG.

Based on a review of these historical spreading data, the short-term, back-to-back, maximum monthly recharge rate is assumed to be a no more than 45,000 acre-feet per month (AFM), limited to no more than 3 months, and the average "typical" operating recharge rate is set at a maximum of 15,000 AFM, to allow for routine drying and maintenance activities.

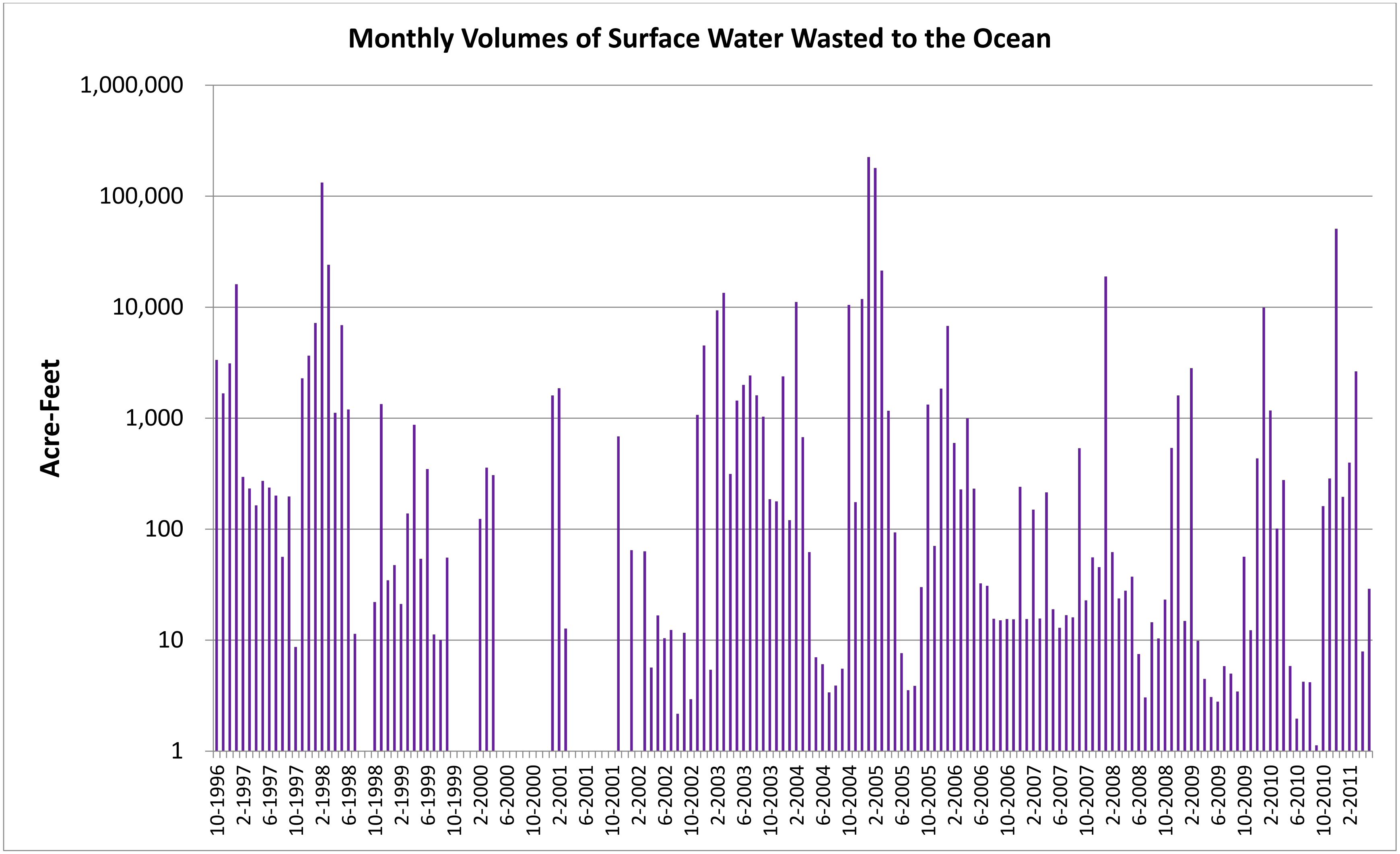


Figure 3-16. Historical Monthly Volumes of Stormwater Wasted to the Ocean

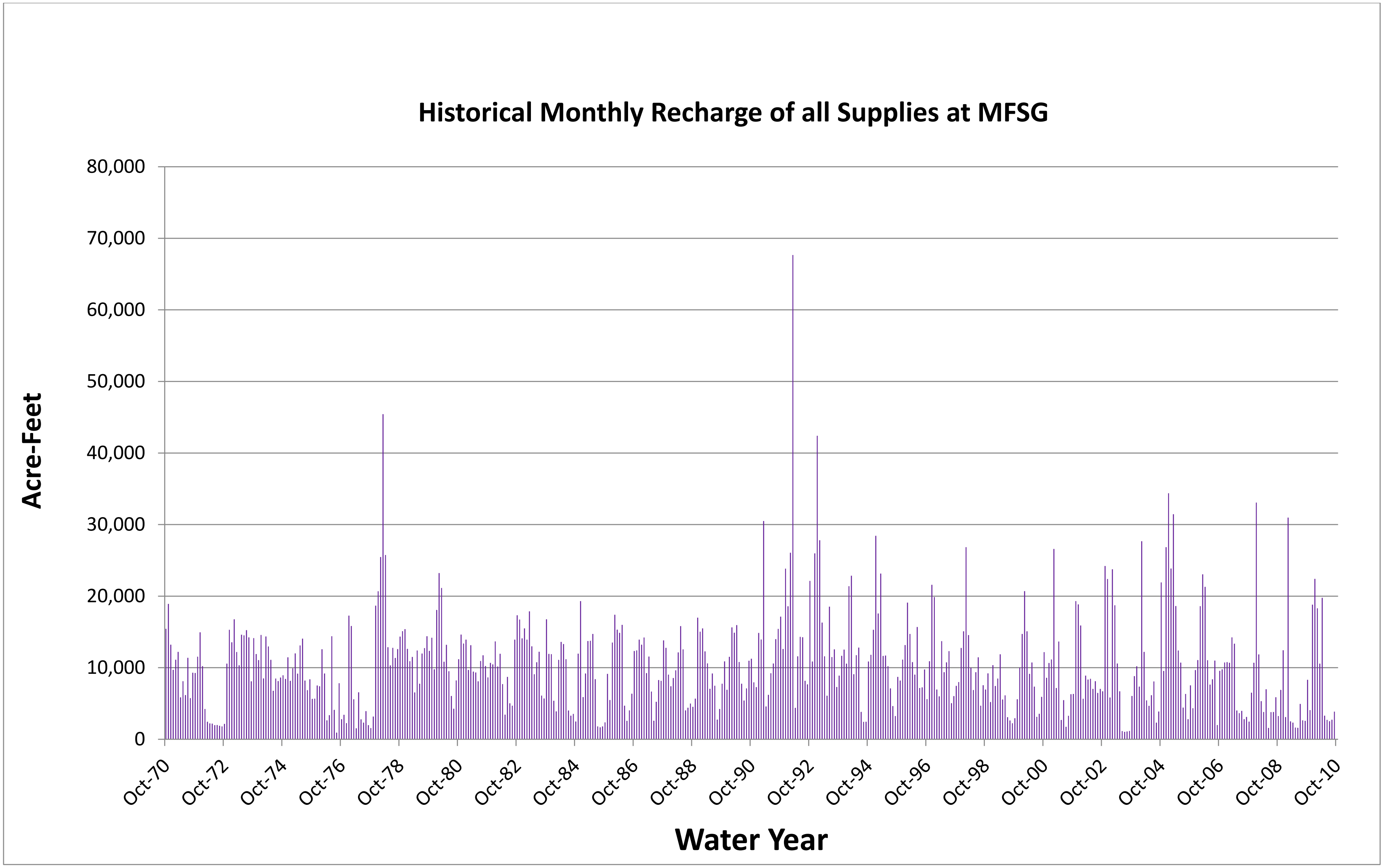


Figure 3-17. Historical Monthly Recharge for All Supplies Combined at Montebello Forebay Spreading Basins

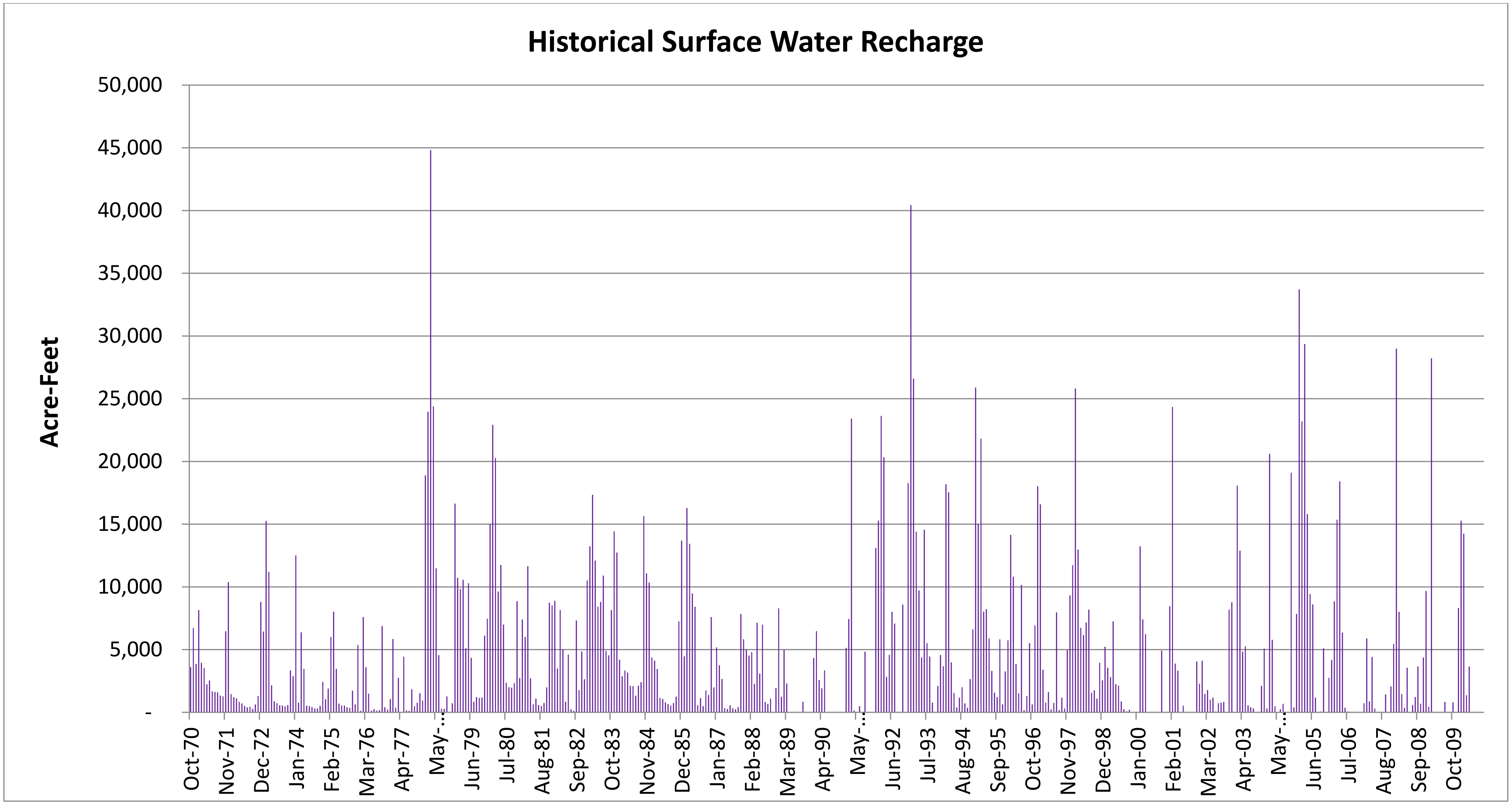


Figure 3-18. Historical Monthly Recharge of Stormwater at Montebello Forebay Spreading Basins

Los Angeles River

The City of Los Angeles has conducted a Recycled Water Master Planning effort, which outlines potential strategies for reusing some of the recycled water for upstream beneficial uses, while acknowledging the role that recycled water plays in the Los Angeles River as well. The GBMP analysis takes a conservative approach and excludes dry-weather flows in the Los Angeles River from consideration as a source of recharge water to the underlying basin. The GBMP only considers wet-weather stormwater flows as a potential supply.

The Los Angeles River drains a highly urbanized basin, with storm flows originating from local mountains and canyons, urban runoff, and tertiary recycled water from three WRPs: the Tillman WRP, owned wholly by the City of Los Angeles, the Los Angeles-Glendale WRP, jointly owned by the cities of Glendale and Los Angeles, and the Burbank WRP, owned and operated by the City of Burbank. During dry weather, a majority of the flow in the Los Angeles River is composed of tertiary-treated disinfected effluent from these WRPs. During a snapshot monitoring event by the Southern California Coastal Water Research Project in 2000, it was reported that 72 percent of the flow discharged into the Los Angeles River was WRP effluent (Ackerman et al., 2003). During wet weather, WRPs account for less than 1 percent of the total flow in the river (CREST, 2009).

The storm flows in the Los Angeles River typically occur during the months of October through March. The Los Angeles River is lined through most of the Central Basin and the area along the river is developed, so there is very limited potential to capture stormwater even though there is significant stormwater runoff. However, there is a possibility to divert the stormwater runoff from the river to a recharge facility, such as an Aquifer Recharge Recovery Facility (ARRF), discussed below, to utilize the storm flows for groundwater recharge. The Los Angeles River flow data collected by LACDPW at two monitoring stations (*Los Angeles River above Arroyo Seco* and *Los Angeles River below Firestone Boulevard*) were analyzed to determine the availability and amount of storm flow runoff available for spreading in the Los Angeles Forebay, reducing downstream flows during storm periods.

The flow data for these stations represented the period from 1971 through 2010. In the summer months (April through September), the baseflows currently average about 150 cfs. As shown in Table 3-4, the baseflow during this period has increased from 50 cfs to 150 cfs. This increase in flows is due to increases in discharges from three WRPs noted above.

The storm flows above the baseflows were calculated during this time period to estimate the amount of water available for recharge. Appendix F contains the details of the analysis conducted for flow data available from the *Los Angeles River above Arroyo Seco* and *Los Angeles River below Firestone Blvd.* gaging stations. Based on this analysis, at least 5,000 AFY of stormwater is considered to be available above baseflow conditions for capture and recharge of the Central Basin.

Table 3-4. Average Baseflow at the Los Angeles River Stations (F34D-R and F57C-R)

Period	Average Baseflow (cfs)
1971-1980	50
1981-1990	50
1992-2000	100
2001-2010	150

Note:

Locations of these Los Angeles River Stations can be found in Appendix F.

Los Angeles River Aquifer Recharge Recovery Facility Description

The Los Angeles River ARRF project consists of a system that would inject naturally treated stormwater from the Los Angeles River. As shown in Figure 3-19, storm flows would be diverted to an easement along the Interstate 710 freeway into an infiltration basin where it would percolate into the upper, shallow aquifer above the confining aquitard. This would serve as a natural filtration process that removes nitrate, pathogens, and micro-pollutants and provides a physical separation from the source of supply (that is, the Los Angeles River). Then, the treated water would be recovered (pumped) for subsequent injection through a vadose zone infiltration conduit into the groundwater basin as a source of supplemental replenishment supply.

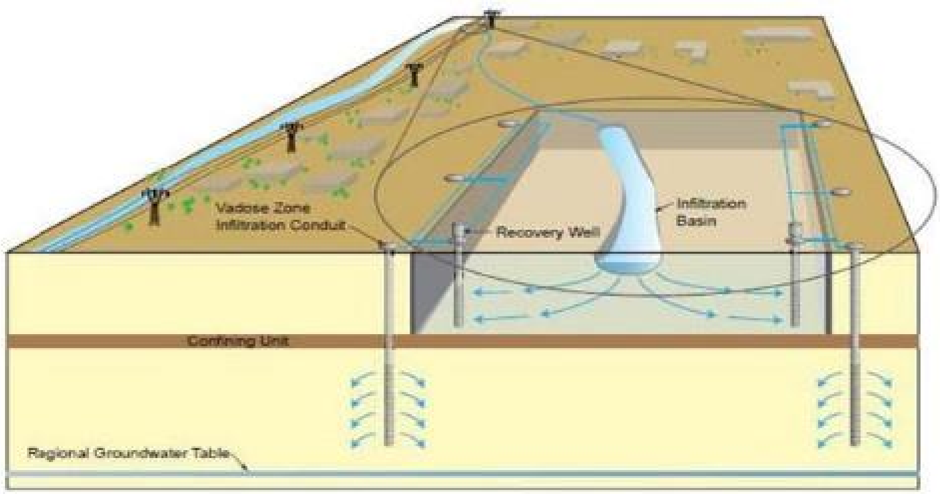


Figure 3-19. Los Angeles River Aquifer Recharge and Recovery Facility (ARRF)

3.3.3 Concept A Scenarios – Central Basin

Concept A scenarios for the Central Basin were formulated so that the extraction patterns are limited to the Central Basin APA. Three scenarios under Concept A were identified for the Central Basin. They differed with respect to the specific source water used for replenishment, and whether the recycled water was applied using surface spreading alone or in combination with injection.

All Concept A scenarios for the Central Basin assume that the recharge occurs at the ABP and MFSG. The ABP planned recharge of 8,000 AFY of full advanced treated recycled water from the LVLWTF is assumed as a baseline operating condition. The GBMP scenarios reflect replenishment of recycled water and stormwater needed to meet the full APA of 217,367 AFY of extraction.

Each of these Concept A scenarios assumes the following:

- Increasing replenishment to allow pumping up to the APA
- Pumping patterns will be similar to those of recent years (2000-2010), but unused water rights are leased by imported water users

Modeling of Central Basin operations represented in these scenarios, in conjunction with West Coast Basin operations for the various GBMP alternatives, was conducted with the WRD/USGS updated and refined groundwater model, as described in Section 4.0. A description of the Concept A scenarios for the Central Basin is provided below.

3.3.3.1 Scenario CB–A1

As shown in Figure 3-20, Scenario A1 for the Central Basin (Scenario CB-A1) increases extraction by water rights holders up to the APA by replenishing the basin by spreading an additional 10,000 AFY[10] of recycled water from the SJCWRP at the MFSG.

Table 3-5 provides the assumed distribution of annual pumping for Scenario CB-A1. It is assumed that pumpers will (1) increase capacity of existing wells, (2) bring on standby wells, (3) activate wells that have been inactivated, (4) replace existing wells with new wells, (5) drill new wells generally in the area of existing wells, and/or, (6) collaborate with adjacent pumpers to use common wells to meet demands jointly. This pattern of pumping is not expected to result in a significant shift in the general geographic distribution of pumping in the basin. Other pumping patterns are possible as pumpers determine their actual pumping plan; however, these alternative pumping distributions are not likely to significantly change the modeling results unless there is substantially different geographical redistribution of pumping than assumed herein.

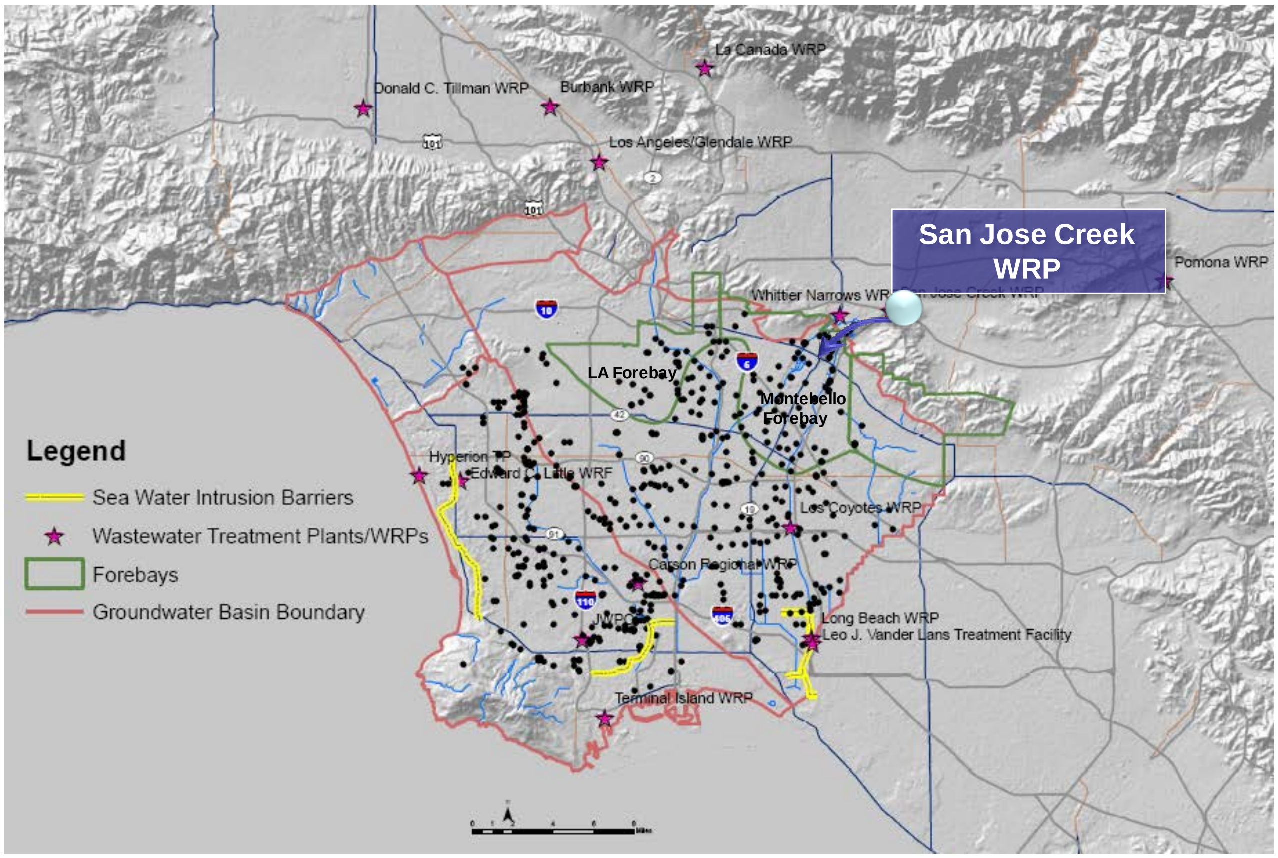


Figure 3-20. Conceptualization of Scenario CB-A1

[10] 10,000 AFY of additional replenishment was estimated from the revised and refined WRD/USGS model to be the average replenishment required to balance the water budget in the Central Basin over the 40-year period, based on hydrological conditions represented by 1970 through 2010 and pumping distribution based on 2000 through 2010 and increased to the full APA.

Table 3-5. Assumed Distribution of Pumping in the Central Basin for Concept A Scenarios

Pumper	APA (AFY)	Assigned Pumping (AFY)
City of Long Beach	32,692	32,692
Golden State Water Company	16,439	20,504
City of Downey	16,554	17,325
City of South Gate	11,183	10,363
City of Cerritos	4,680	10,617
City of Lakewood	9,432	9,432
City of Vernon	8,039	8,527
City of Compton	5,780	6,511
California Water Service Company	11,774	11,774
City of Lynwood	5,337	5,302
City of Los Angeles	15,000	15,000
City of Pico Rivera	5,579	4,479
City of Paramount	5,883	5,883
Bellflower Somerset Mutual Water Company	4,313	4,398
Montebello Land and Water Company	1,624	3,662
Pico Water District	3,624	3,702
City of Huntington Park	3,853	4,000
City of Santa Fe Springs	4,036	4,700
California Water Service Company (Dominguez)	6,480	6,480
California American Water Company	2,067	2,311
La Habra Heights County Water District	2,596	3,846
Park Water Co.	2	1,674
San Gabriel Valley Water Company	2,565	2,565
Suburban Water Systems	3,721	1,751
City of Commerce	5,081	1,976
South Montebello Irrigation District	1,268	1,880
Tract Number One Hundred & Eighty Water Company	2,137	1,700
Maywood Mutual Water Company No. 3	1,407	3,012
City of Signal Hill	2,022	2,022
Walnut Park Mutual Water Company	996	1,026
City of Whittier	895	879
All Other*		7,372
Total	217,367	217,367

* Pumping to other water rights holders distributed to their existing wells using the average of their last 10 years of pumping.

3.3.3.2 Scenario CB–A2

Scenario A2 for the Central Basin (Scenario CB-A2) modifies Scenario CB-A1 by spreading recycled water from both the SJCWRP (5,000 AFY tertiary) as well as the LCWRP (5,000 AFY AWT) at the MFSG, as shown in Figure 3-21. The extraction pattern is identical to Scenario CB-A1.

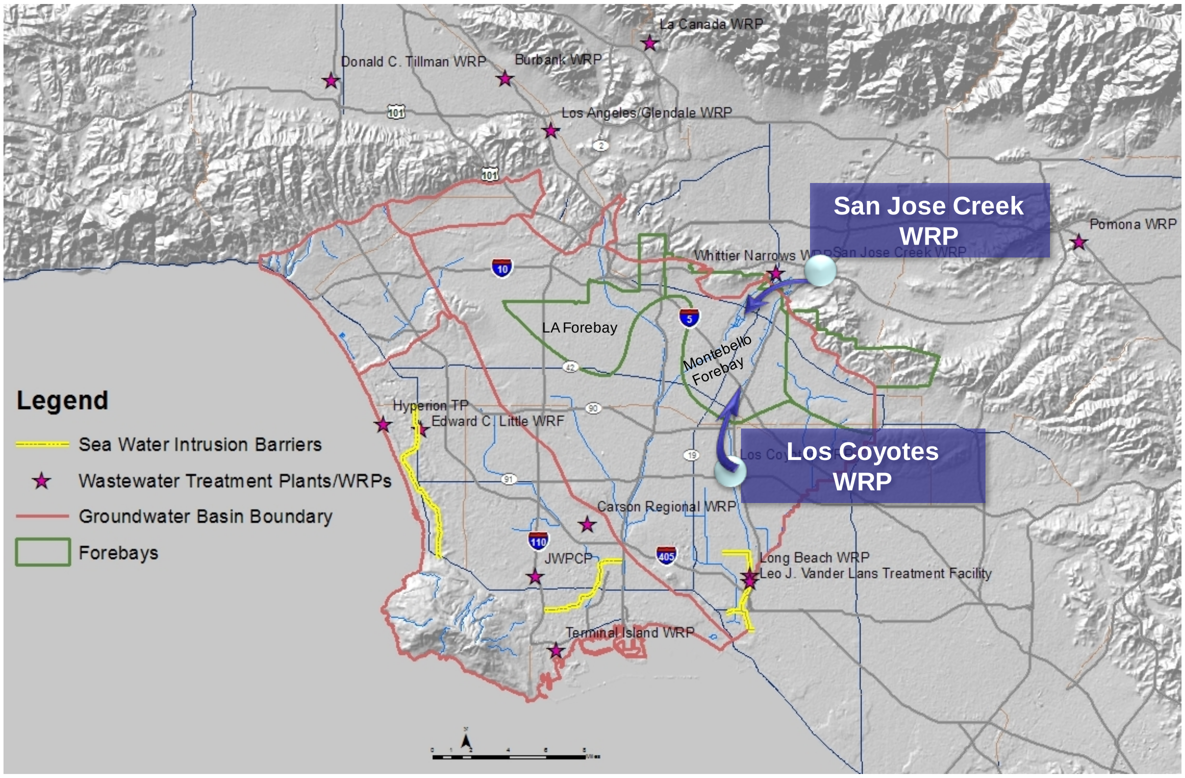


Figure 3-21. Conceptualization of Scenario CB-A2

Additional Recycled Water from Both SJCWRP and LCWRP is Spread at the Rio Hondo and San Gabriel Coastal Spreading Grounds.

3.3.3.3 Scenario CB–A3

Scenario A3 for the Central Basin (Scenario CB-A3) modifies Scenario CB-A2 by injecting 5,000 AFY of AWT recycled water from the LCWRP, and spreading 5,000 AFY of tertiary recycled water at the MFSG, as shown in Figure 3-22. The extraction pattern is identical to Scenario CB-A1 and Scenario CB-A2.

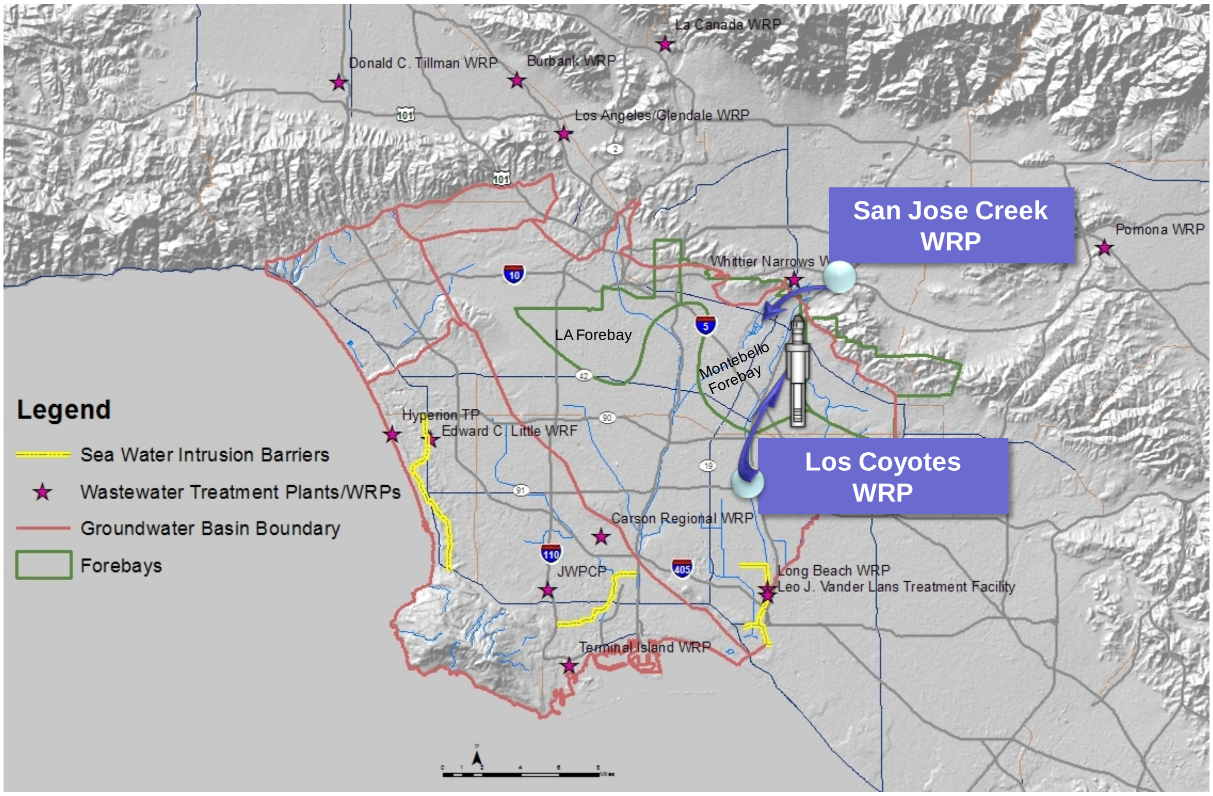


Figure 3-22. Conceptualization of Scenario CB-A3

Additional Recycled Water from SJCWRP is Replenished at the MFSG and Recycled Water from LCWRP is Injected at the MFSG.

3.3.3.4 Scenario CB–A4

Scenario A4 for the Central Basin (Scenario CB-A4) modifies Scenario CB-A1 by increasing the amount of stormwater that can be captured from the Los Angeles River and recharged in the MFSG, as shown in Figure 3-23. As described in Section 3.3.2.3, 5,000 AFY of stormwater from the Los Angeles River can be recharged in a Los Angeles River ARRF. The location of the ARRF facility is shown in Figure 3-19. To meet the 10,000 AFY total recharge volume, 5,000 AFY of tertiary recycled water from SJCWRP is assumed.

The specific extraction patterns for this scenario were identical to those in Scenario CB–A1.

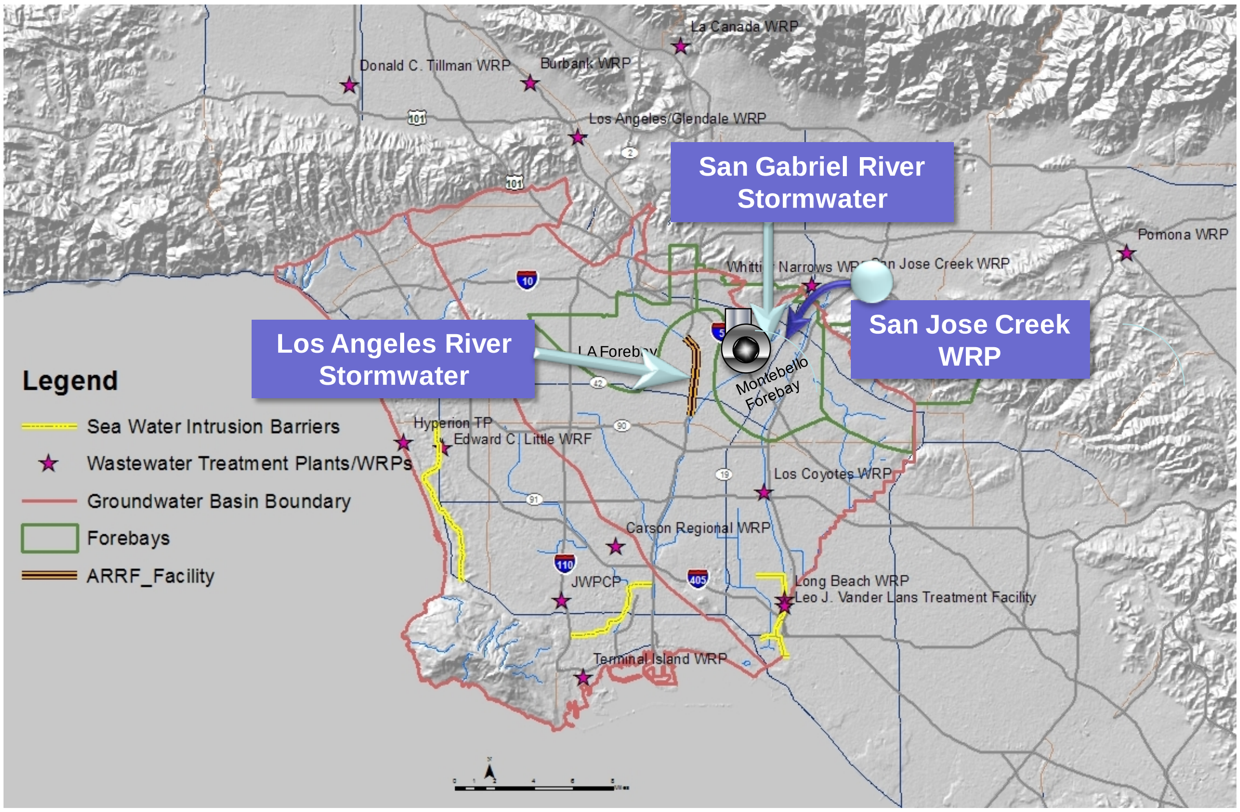


Figure 3-23. Conceptualization of Scenario CB-A4

Additional Replenishment includes Spreading at MFSG with 5,000 AFY of Recycled Water from the SJCWRP and 5,000 AFY of Stormwater from the LA River ARRF Project.

3.3.4 Concept B Scenarios – Central Basin

The Concept B scenarios for the Central Basin were formulated so that the extraction is increased beyond the APA. Two scenarios under Concept B were identified for the Central Basin. They differed with respect to the total amounts and locations of recharge and extraction as follows:

- Scenario CB-B1 – Increased recharge and pumping in both the Montebello and Los Angeles Forebays
- Scenario CB-B2 – Implementation of a new AWTF as well as increased recharge and pumping per Scenario CB-B1

Each of these Concept B scenarios assumes the following:

- Replenishment supply will be increased to allow pumping beyond the APA based on implementation of assumed recharge options.
- Pumping patterns will be similar to those of the 2000-2010 water years, and additional pumping is allocated to imported water users to ultimately replace nearly all imported water demand in the basin.

Modeling of Central Basin operations represented in these scenarios, in conjunction with West Coast Basin operations for the various GBMP alternatives, was conducted with the WRD/USGS updated and refined groundwater flow model, as described in Section 4.0. A description of the Concept B scenarios for the Central Basin is provided below.

3.3.4.1 Scenario CB-B1

As shown in Figure 3-24, Scenario B1 for the Central Basin (Scenario CB-B1) increases extraction by additional extraction above the APA from the Montebello Forebay.

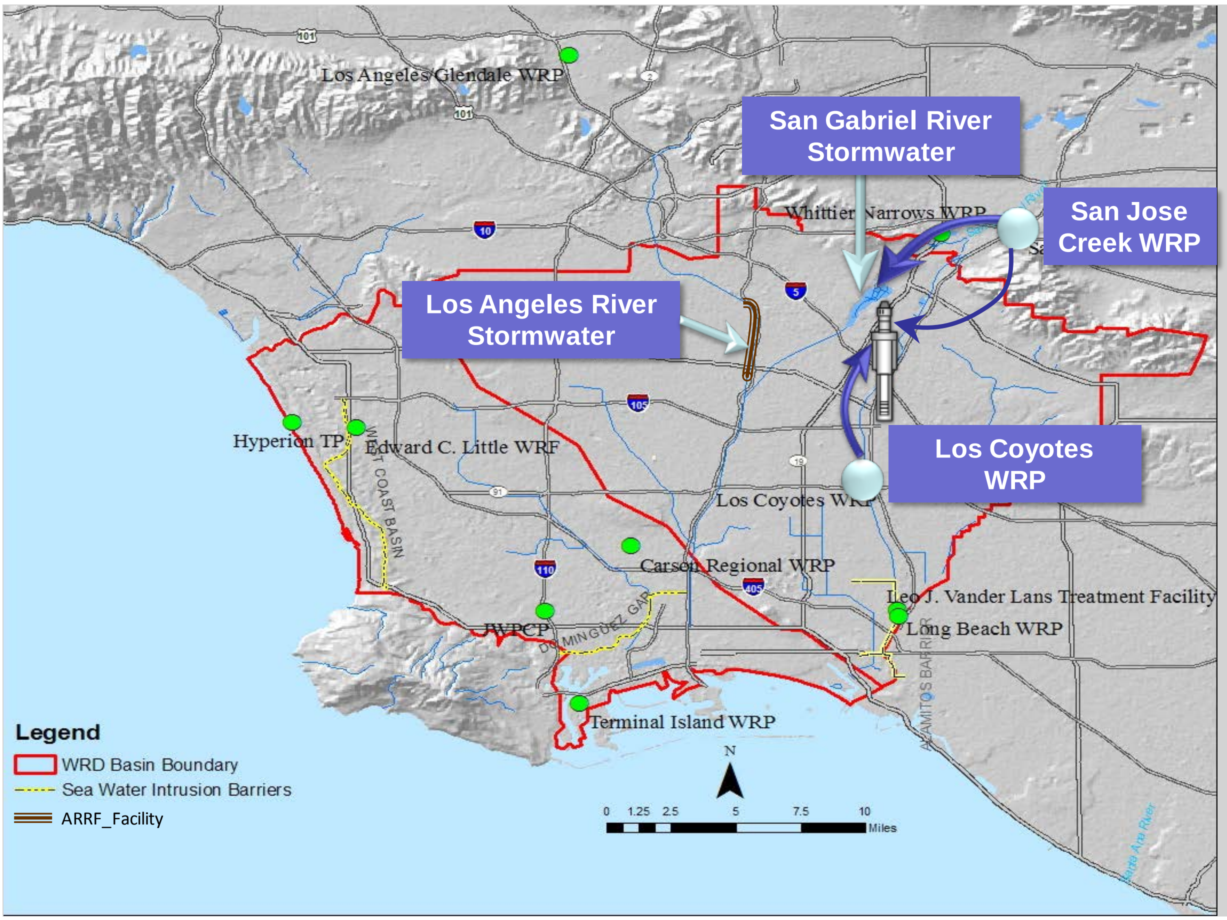


Figure 3-24. Conceptualization of Scenario CB-B1

Maximizes Replenishment from San Gabriel River and Los Angeles River Stormwater and Spreading and Injection of Recycled Water from the SJCWRP and LCWRP to Provide Pumping of 57,770 AFY above the APA. The replenishment water to satisfy this increased pumping demand is provided by a combination of capture and recharge of 5,000 AFY of stormwater from the Los Angeles River with the ARRF project and by increasing the amount of stormwater that can be captured from the San Gabriel River and recharged in the MFSG via the GBOP. By increasing the pumping in the vicinity of the spreading grounds, groundwater levels are kept from rising to ground surface, thereby allowing additional stormwater replenishment. As mentioned in Section 3.3.2.3, the MFROS has estimated that on average, approximately 17,000 AFY additional stormwater could be recharged with 25,000 AFY of additional pumping.

In conjunction with replenishment of the maximum available recycled water from the SJCWRP and LCWRP (estimated at 89,550 AFY through a combination of spreading and injection), up to 57,770 above the APA (or a total of 57,770+217,367=275,137 AFY) would be available for pumping from the Central Basin.

This additional assumed pumping for analysis purposes was allocated as shown in Table 3-6.

Table 3-6. Redistribution of Pumping for Maximizing Replenishment in the Montebello Forebay Area

Pumpers	Pumping from Montebello Forebay Extraction Wellfield (AFY)
Golden State Water Company	6,770
Park Water Company	9,000
City of Santa Fe Springs	3,300
City of Paramount	2,000
Cal Water Service Company	4,700
City of Long Beach	30,000
City of Compton	2,000
Total	57,770

3.3.4.2 Scenario CB-B2

As shown in Figure 3-25, Scenario B2 for the Central Basin (Scenario CB-B2) builds off of Scenario CB-B1 with additional injection and extraction in the Los Angeles Forebay. Under this scenario, additional replenishment supply would come from a new AWTF, identified in the City of Los Angeles' Recycled Water Master Planning documents, that would skim wastewater from a major sewer trunk line otherwise destined for the HWRP. The assumed capacity of this new AWTF is 40.6 mgd, or 45,480 AFY. Thus, Scenario CB-B2 provides for a total of 45,480+57,770 = 103,250 AFY of additional pumping beyond the APA, or a total basin pumping of 103,250+217,367=320,617 AFY, as shown in Figure 3-26. Such utilization of the groundwater basin can offset nearly all of the area's imported water demands above the Central Basin.

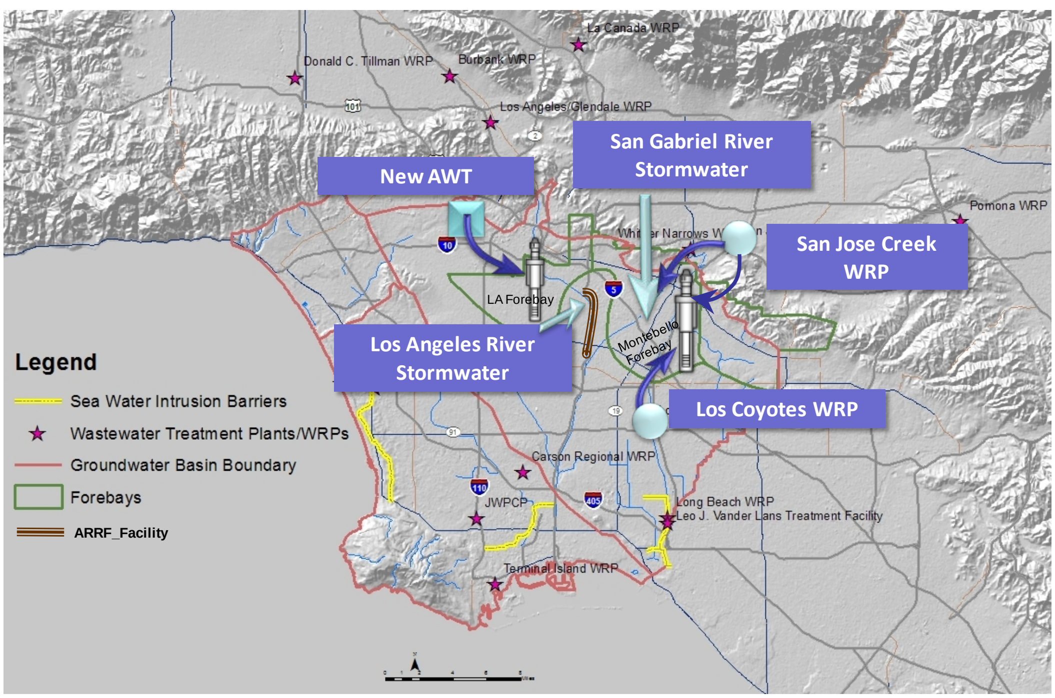
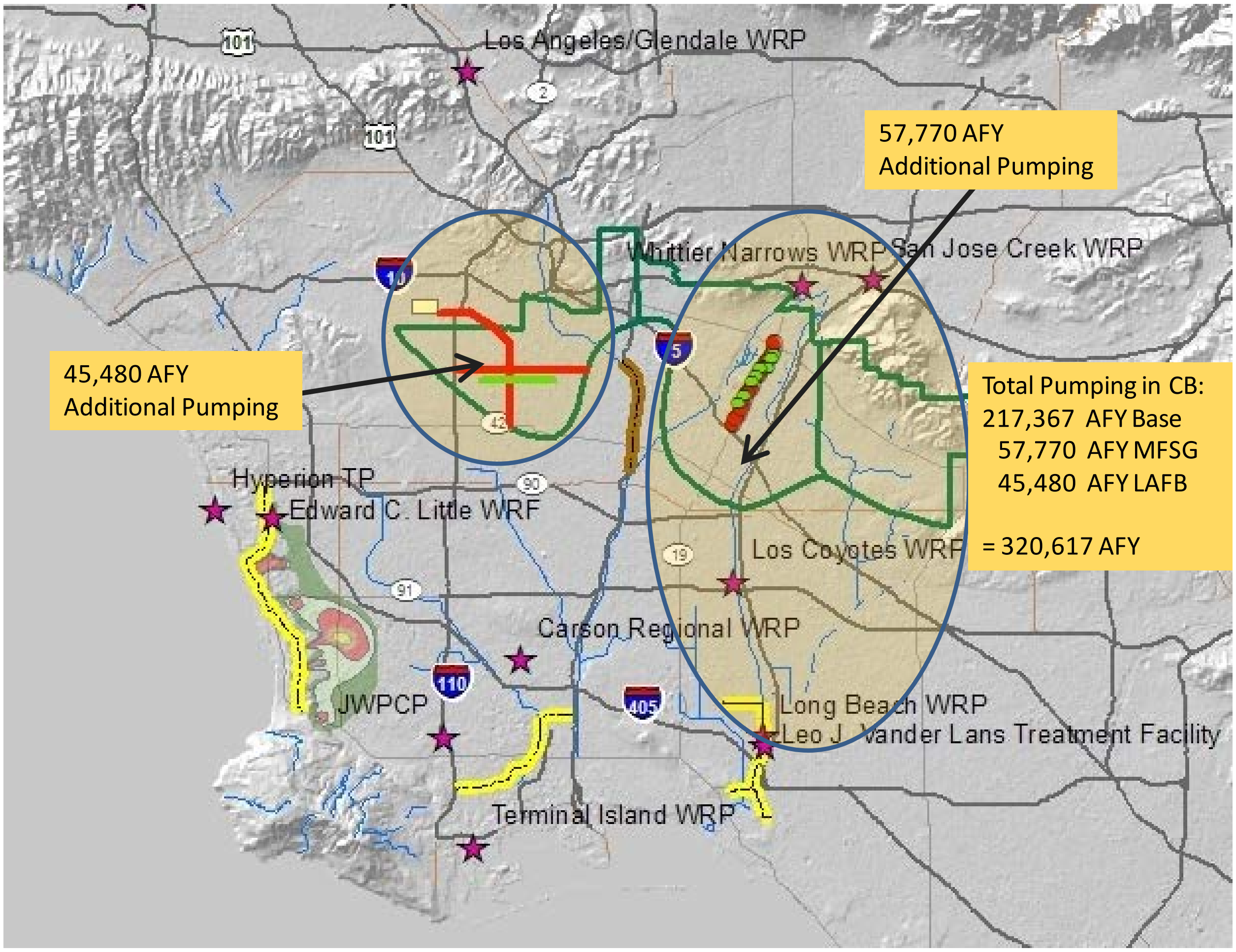


Figure 3-25. Conceptualization of Scenario B2 in the Central Basin

Addition of 45,480 AFY Recycled Water Recharge in LA Forebay in Combination with Montebello Forebay Facilities Allows for Increased Pumping to 103,250 AFY above the APA.

This additional assumed pumping for analysis purposes was allocated as shown in Table 3-7. As noted, most of this additional pumping is assumed to take place within the individual pumpers' service areas, with the exception of the City of Los Angeles, which would pump from a new wellfield in the Los Angeles Forebay.



Note: LAFB = Los Angeles Forebay

Figure 3-26. Total Pumping under Scenario CB-B2

Pumpers Increase Pumping in their Service Areas, plus 25,000 AFY of Pumping in Montebello Forebay and 29,000 AFY of Pumping in New Wellfield in Los Angeles Forebay Provides for 320,617 AFY of Total Pumping.

Table 3-7. Redistribution of Pumping to Pumpers in the Central Basin for Maximizing Replenishment in the Montebello Forebay and Los Angeles Forebay Areas

			Other	
Pumper	**Total New Extraction (AFY)**	**Pumping from Montebello Forebay Extraction Wellfield (AFY)**	**Assigned Additional Pumping (AFY)**	**Geographic Location**
Golden State Water Company	6,770	6,770	0	
Park Water Company	9,000	9,000	0	
City of Santa Fe Springs	3,300	3,300	0	
City of Paramount	2,000	2,000	0	
Cal Water Service Company	12,500	4,700	7,800	Within pumper’s service area
City of Long Beach	30,000	30,000	0	
City of Compton	2,200	2,000	200	Within pumper’s service area
City of Los Angeles	29,000		29,000	From the LA Forebay
City of Cerritos	300		300	Within pumper’s service area
City of Vernon	1,150		1,150	Within pumper’s service area
Bellflower Somerset Mutual Water Company	2,000		2,000	Within pumper’s service area
City of Huntington Park	1,400		1,400	Within pumper’s service area
La Habra Heights County Water District	800		800	Within pumper’s service area
Suburban Water Systems	330		330	Within pumper’s service area
City of Signal Hill	100		100	Within pumper’s service area
City of Bell Gardens	500		500	Within pumper’s service area
City of Norwalk	800		800	Within pumper’s service area
City of Montebello	1,100		1,100	Within pumper’s service area
Total	103,250	57,770	45,480	

3.4 Summary of the West Coast and Central Basin Scenarios

The GBMP planning scenarios established the hydraulic boundaries for basin utilization that were subsequently evaluated with the WRD/USGS updated and refined groundwater flow model. These scenarios were structured according to the initial conceptual options defined early in the planning process—Concept A (pump up to water rights in the West Coast Basin and up to the APA in the Central Basin) and Concept B (pump above the water rights and APA).

Scenarios were formulated for each basin to satisfy these conceptual options. Each scenario was constructed using combinations of supply, recharge and pumping components. Consideration of supply options (that is, recycled water sources in the West Coast Basin and combinations of recycled water and stormwater in the Central Basin) informed the range of scenarios that would be evaluated hydraulically to assess groundwater basin impacts.

Table 3-8 summarizes the GBMP planning scenarios presented in this section for both the basins. Combinations of the Central Basin and West Coast Basin Concept A and B scenarios were used for groundwater modeling of the interconnected basins, as described in Section 4.0. Viable scenarios were then further defined as distinct alternatives with specific supply sources and associated treatment, conveyance, recharge, and extraction for economic evaluation, described in Section 5.0.

Table 3-8. Summary of GBMP Planning Scenarios for the West Coast and Central Basins

Basin	Concept	Scenario	Description (Pumping/Replenishment)
West Coast Basin	A (Meet Water Rights)	Scenario WCB-A1	Pump full water rights by assumed distribution of additional pumping per three scenarios: WCB-A1a, WCB-A1b, WCB-A1c; Shift oil companies' non-potable demands from groundwater to recycled water and shift this groundwater pumping to municipal purveyors; Assume 100 percent RWC at injection barriers (WCBBP and DGBP)
		Scenario WCB-A1a	Distribute to Major Water Rights Holders (Torrance, CWSC, Golden State Water Company, Manhattan Beach, El Segundo, Inglewood, and Lomita) and City of Los Angeles Extracts their Adjudicated Rights
		Scenario WCB-A1b	Distribute to Major Water Rights Holders and to the City of Los Angeles
		Scenario WCB- A1c	Regional Partnership – Includes **remediation of saline plume** and minimizing impacts to barriers
		Scenario WCB-A2	Reduce or eliminate injection in Lower San Pedro aquifer by balancing pumping in Silverado aquifer
		Scenario WCB-A3	Inject surplus imported water only when available (assumed 2 out of 10 years) and reduce or eliminate injection into Lower San Pedro aquifer during the remaining (8) years
		Scenario WCB-A4	Pump and treat from Lower San Pedro aquifer
	B (Above Water Rights)	Scenario WCB-B1	Pump additional **30,000 AFY above water rights** by assumed distribution to CWSC, City of Torrance, and City of Los Angeles Increase injection at DGBP, WCBBP, and using new inland injection wells (assuming 100 percent RWC); Includes remediation of saline plume and pumping pattern Scenario WCB-A1c
Central Basin	A (Meet APA)	Scenario CB-A1	Pump full APA by distributing additional pumping similarly to recent 10 years of extraction and allocate unused water rights to pumpers with high imported water usage; Assume 100 percent RWC at injection barrier (ABP); *Increase replenishment by 10,000 AFY using **SJCWRP** tertiary effluent for **spreading** at the MFSG*
		Scenario CB-A2	Pump full APA by distributing additional pumping similarly to recent 10 years of extraction and allocate unused water rights to pumpers with high imported water usage; Assume 100 percent RWC at injection barrier (ABP); *Increase replenishment by 10,000 AFY using tertiary **SJCWRP and LCWRP** AWT effluent for **spreading** at MFSG*
		Scenario CB-A3	Pump full APA by distributing additional pumping similarly to recent 10 years of extraction and allocate unused water rights to pumpers with high imported water usage; Assume 100 percent RWC at injection barrier (ABP); *Increase replenishment by 10,000 AFY using **SJCWRP** AWT effluent for **spreading** at MFSG and **LCWRP** AWT treated effluent for **injection** in Montebello Forebay.*

Table 3-8. Summary of GBMP Planning Scenarios for the West Coast and Central Basins

Basin	Concept	Scenario	Description (Pumping/Replenishment)
		Scenario CB-A4	Pump full APA by distributing additional pumping similarly to recent 10 years of extraction and allocate unused water rights to pumpers with high imported water usage; Assume 100 percent RWC at injection barrier (ABP); *Increase replenishment by a total of 10,000 AFY using tertiary **SJCWRP** effluent for **spreading** 5,000 AFY at MFSG and **stormwater capture of 5,000 AFY in LAF***
	B (Above APA)	Scenario CB-B1	Maximizing use of stormwater capture from S**an Gabriel and Los Angeles Rivers** (22,000 AFY) and available recycled water from **SJCWRP and LCWRP** (66,770 AFY) in the Montebello Forebay allows for increased pumping of **57,770 AFY above the APA**
		Scenario CB-B2	Injection of 45,480 AFY of effluent from **new satellite AWTF** at new line of extraction wells in Los Angeles Forebay, in conjunction with maximizing stormwater capture and recycled water use (per Scenario CB-B1) allows for increased pumping in the Montebello and Los Angeles Forebays to a total of **103,270 AFY above the APA**

Groundwater Modeling Assessments of Basin Operating Conditions

This section presents an update of the WRD/USGS groundwater flow model of the West Coast and Central Basins and application of this model to assess the various GBMP planning scenarios described in Section 3.0. WRD/USGS developed a groundwater simulation model of the Los Angeles Coastal Basin, including the West Coast and Central Basins, to serve as a tool to evaluate alternative groundwater management strategies. The model, which uses the USGS MODFLOW program (McDonald and Harbaugh, 1988; Harbaugh and McDonald, 1996), is described in detail by the USGS (2003). Following is a brief summary of the features of the model:

- The extents of the model are shown in Figure 4-1, which covers the entire Los Angeles County portion of the Los Angeles Coastal Basin, including offshore extensions of the basins' aquifers.
- The grid consists of a uniform finite-difference grid (three-dimensional grid blocks), with each cell 0.5 miles by 0.5 miles on a side. The grid and boundaries of the model are shown in Figure 4-1.
- The hydrogeology, including variations in hydrogeologic properties (such as storage and transmissivity) of the West Coast and Central Basins are represented by four layers (from top to bottom), including the following aquifers as identified by the California Department of Water Resources (1961):
  - **Layer 1** – Semiperched and Gaspur aquifers
  - **Layer 2** – Ballona, Exposition, Artesia, and Gardena, Gage, and 200-Foot Sand aquifers
  - **Layer 3** – Hollydale, Jefferson, Lynwood, 400-Foot Gravel, and Silverado aquifers, which are the principal aquifers tapped by production wells in the West Coast and Central Basins
  - **Layer 4** – Sunnyside and Lower San Pedro aquifers
- Faults throughout the basin, such as the Newport-Inglewood Fault zone, are represented using the hydraulic flow barrier package, which acts to impede movement of groundwater flow across these faults.
- Boundary conditions include the following:
  - Constant heads, or constant groundwater levels, are used to represent inflow from the San Fernando Valley Basin through the Los Angeles Narrows, inflow from the Main San Gabriel Basin through Whittier Narrows and movement of water between the Orange County Groundwater Basin and Central Basin. Values of heads are constant for the Los Angeles and Whittier Narrows, but vary based on actual observed historical groundwater levels along the boundary with Orange County.
  - General head boundaries where aquifers are in contact with the Pacific Ocean, which also accounts for the density differences in freshwater and heavier ocean water.
  - Mountain Front (groundwater entering from the surrounding hills and mountains) and interior recharge (areal recharge over the surface of the basins) from precipitation and applied water, which varies based on precipitation at the Downey precipitation station (USGS, 2003).

- Recharge and discharge stresses including stormwater, recycled water, and imported water diverted to the spreading grounds in the MFSG, injection of imported water and advanced treated recycled water at the three injection barriers (ABP, WCBBP, and DGBP), and pumping by basin pumpers.
- Simulation period covers water years 1971 (October 1, 1970, through September 30, 1971) through 2000. The stress periods are for a full year (meaning all water budget terms are averaged over an entire year) resulting in 30 stress periods.

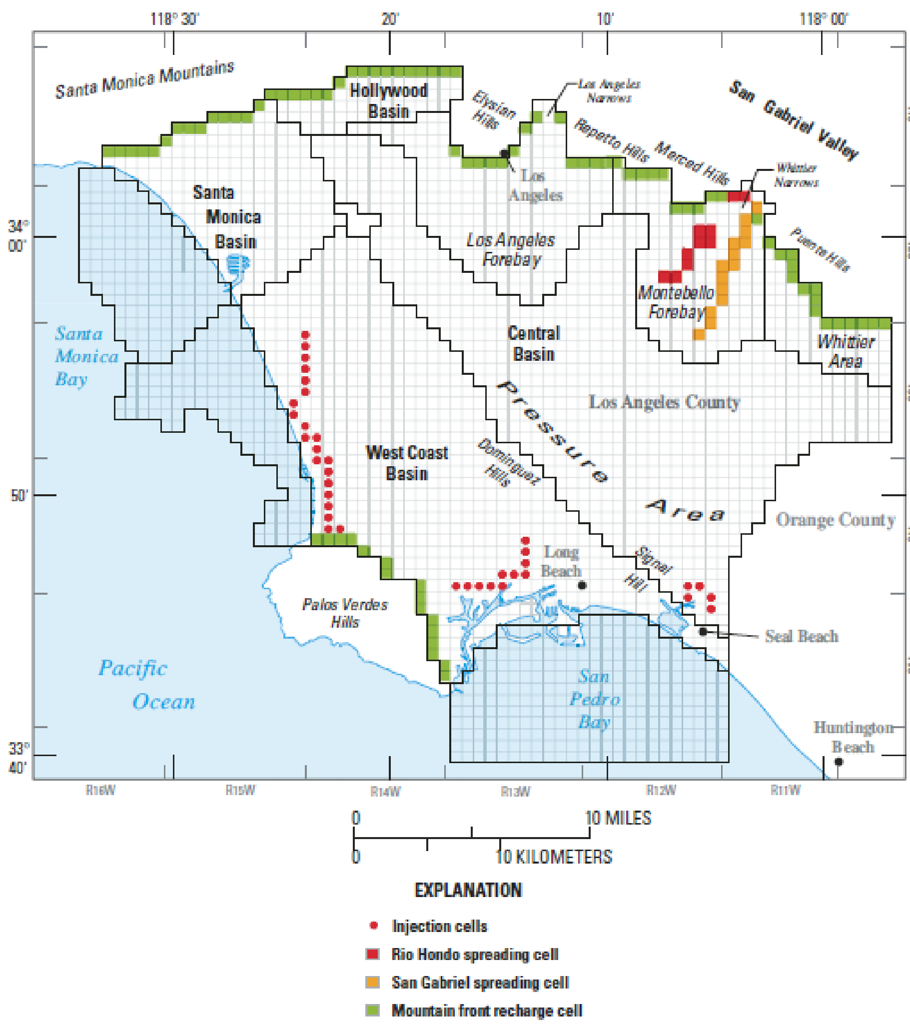


Figure 4-1. WRD/USGS Groundwater Flow Model – Grid and Boundary Conditions (USGS, 2003)

The WRD/USGS groundwater flow model was updated through water year 2010 as a part of this study, then used to project groundwater levels and storage conditions for various operating conditions in the West Coast and Central Basins over a 40-year period of water years 2011 through 2050, as described below.

4.1 Update of WRD/USGS Groundwater Flow Model (through Water Year 2010)

The WRD/USGS groundwater flow model was updated as a part of this study in order to use it to assess alternative operating conditions in the West Coast and Central Basins. The MODFLOW data sets were imported into Groundwater Vistas (GWV) offered by Environmental Simulations Inc. (www.groundwatermodels.com). GWV is a groundwater modeling environment that couples a model design system with graphical analysis tools. Model inputs and results can be exported for use in other programs, such as Microsoft Excel or ESRI, Inc., Geographical Information System (GIS) software. GWV was used, along with standard database tools, to update the WRD/USGS groundwater flow model through water year 2010.

The model update includes extending four principal stresses (recharge and discharge) and one boundary condition (refer to Figure 4-1 for locations of these stresses):

- Mountain front and interior recharge
- Recharge of stormwater, imported water, and recycled water at the MFSG
- Injection of imported water and advanced treated recycled water into the three injection barriers
- Inclusion of additional production wells installed since 2000 and pumping
- Constant heads along the Orange County boundary

Each of these stresses was updated for water years 2001 through 2010, which was the extent of available data for most of these data sets. The updated WRD/USGS groundwater flow model was run to create groundwater-level conditions at the end of water year 2010, which were used as the initial condition for subsequent modeling simulations.

4.1.1 Mountain Front and Interior Recharge

The USGS uses simple formulae to compute mountain front and interior recharge. The model area was broken into zones, and recharge values were estimated for each zone during calibration of a steady-state model. The transient recharge was estimated by multiplying the steady-state recharge values by a normalized precipitation value for a given year. LACDPW precipitation station 107D, located in Downey, was used as an indicator station of precipitation over the model area (USGS, 2003).

Precipitation data for the period 2000 through 2010 were obtained for station 107D from LACDPW to update mountain front and interior recharge over the modeled area using the approach described by USGS (2003). Table 4-1 shows the estimated mountain front and interior recharge applied to the model for the entire period of simulation for water years 1971 through 2010, which includes the updates for the last 10 years. This recharge was applied according to the zonal distribution as described by the USGS (2003).

4.1.2 Recharge of Stormwater, Imported Water, and Recycled Water at the MFSG

LACDPW monitors the source of water supplies and locations of recharge at the MFSG. Sources of supplies include stormwater, imported water from MWD, and recycled water. Recycled water includes wastewater of tertiary quality from the Whittier Narrows WRP, Pomona WRP, and SJCWRP, all owned and operated by LACSD. Managed aquifer recharge occurs at the Whittier Narrows Dam, Rio Hondo Spreading Basins, and San Gabriel Coastal Spreading Basins, which includes unlined sections of the San Gabriel River. These data are reported to WRD. The San Gabriel River Watermaster also reports water conserved at the MFSG. The USGS (2003) used those data reported by the San Gabriel River Watermaster in their groundwater model simulations. Subsequent to the USGS (2003) published report, WRD reviewed those data reported by LACDPW and determined that these data should be used as the recharge quantities in this study.

Table 4-1 provides the reported quantities of water recharged at the MFSG, including an update through water year 2010 and a comparison of the 1971 through 2000 quantities as used in the original WRD/USGS groundwater flow model. On average, the updated recharge values are approximately 5,000 AFY more than those values used in the original WRD/USGS groundwater model. These recharge quantities were applied to the appropriate spreading basin as represented in the groundwater flow model.

Table 4-1. Annual Precipitation at LACDPW Downey Station 107D, Mountain Front and Interior Recharge, and MFSG Spreading

Water Year	Precipitation (inches)	Normalized Precipitation	WRD/USGS Model Mountain Front and Interior Recharge (AFY)	Updated Mountain Front and Interior Recharge (AFY)	WRD/USGS Model Spreading Data (AFY)	Updated Spreading (AFY)
1971	11.46	1	64,400	64,345	121,700	127,272
1972	6.4	0.56	36,100	35,192	62,900	64,734
1973	18.63	1.63	83,700	83,236	147,100	147,621
1974	14.55	1.27	81,800	80,985	123,900	130,697
1975	15.01	1.31	83,700	83,236	105,700	118,761
1976	9.58	0.84	54,100	53,460	81,900	81,350
1977	11.24	0.98	63,100	62,562	69,900	66,352
1978	33.86	2.95	83,700	83,236	170,700	200,672
1979	18.69	1.63	83,700	83,236	151,800	145,772
1980	28.29	2.47	83,700	83,236	137,100	150,869
1981	8.74	0.76	48,900	48,638	128,400	135,792
1982	13.41	1.17	75,300	74,356	110,100	109,113
1983	30.32	2.65	83,700	83,236	165,200	152,365
1984	11.99	1.05	67,600	67,048	114,500	109,956
1985	12.45	1.09	70,200	69,530	110,200	104,743
1986	19.47	1.7	83,700	83,236	117,400	111,801
1987	6.49	0.57	36,700	35,501	101,000	117,934
1988	11.47	1	64,400	64,365	100,300	115,230
1989	7.82	0.68	43,800	43,810	123,900	111,404
1990	7.87	0.69	44,400	44,030	132,700	125,683
1991	12.22	1.07	68,900	67,618	138,700	145,876
1992	16.07	1.4	83,700	83,236	152,800	226,369
1993	26.56	2.23	83,700	83,236	174,500	213,127
1994	9.26	0.81	52,200	51,210	113,600	130,299
1995	26.17	2.28	83,700	83,236	151,700	155,720
1996	10.68	0.93	59,900	59,870	130,500	134,754

Table 4-1. Annual Precipitation at LACDPW Downey Station 107D, Mountain Front and Interior Recharge, and MFSG Spreading

Water Year	Precipitation (inches)	Normalized Precipitation	WRD/USGS Model Mountain Front and Interior Recharge (AFY)	Updated Mountain Front and Interior Recharge (AFY)	WRD/USGS Model Spreading Data (AFY)	Updated Spreading (AFY)
1997	13.95	1.22	78,600	78,400	128,300	128,224
1998	32.45	2.83	83,700	83,236	133,200	134,692
1999	7.29	0.64	41,200	39,986	80,400	79,219
2000	9.21	0.8	51,500	51,001	108,900	108,922
2001	15.6	1.36		83,236		109,520
2002	2.8	0.24		14,486		120,480
2003	16.93	1.48		83,236		123,369
2004	9.37	0.82		51,560		102,926
2005	24.86	2.17		83,236		203,335
2006	11.36	0.99		62,803		135,637
2007	2.85	0.25		16,180		96,753
2008	17.11	1.49		83,236		95,800
2009	9.49	0.83	-	53,132	-	74,967
2010	13.02	1.14	-	72,225	-	117,424

4.1.3 Injection Barrier Operations

Two steps were required to update injection barrier operations since 2000. The first step was to assign injection to model layers corresponding to injection well screened intervals, and the second step was to update injection quantities through water year 2010. The original WRD/USGS model files contain the combined injection rates for all injection wells in a given model grid cell; and not for the individual injection well. To determine the grid and layer(s) for each injection well, the locations of each injection well were overlain on the model grid. The layer assignment was determined by comparing the screened interval of the injection well with the top and bottom layer elevations of the model layers at the location of the injection well. Flow from an injection well was partitioned to each layer penetrated by the screen interval based on a transmissivity-weighted value as was done for the original WRD/USGS model. So, a percentage of a given injection well flow was assigned to each model layer based on this transmissivity-weighted flow value.

WRD and LACDPW provided data on injection by well for all three seawater intrusion barriers. Table 4-2 shows the annual injection quantities to each barrier simulated for the period water years 2000 through 2010.

Table 4-2. Injection Values for Seawater Intrusion Barriers

Water Year	Dominguez Gap (AFY)	West Coast Basin (AFY)	Alamitos Barrier (AFY)	Total Injection (AFY)
1971				36,200
1972				41,000
1973				41,800
1974				42,700
1975				36,900
1976				44,800
1977				49,300
1978				40,200
1979				34,500
1980				37,200
1981				34,400
1982				34,300
1983				45,200
1984				39,500
1985				37,500
1986				31,700
1987				39,400
1988				37,500
1989				33,500
1990				32,100
1991				29,700
1992				34,800
1993				31,300
1994				25,100
1995				23,200
1996				23,300
1997				29,300
1998				25,400
1999				27,300
2000				30,400
2001	3,923	20,826	5,674	30,423
2002	5,459	20,000	6,193	31,652
2003	8,056	16,611	4,642	29,309

Table 4-2. Injection Values for Seawater Intrusion Barriers

Water Year	Dominguez Gap (AFY)	West Coast Basin (AFY)	Alamitos Barrier (AFY)	Total Injection (AFY)
2004	6,089	12,973	5,968	25,030
2005	8,557	8,468	4,555	21,580
2006	8,709	10,246	2,547	21,502
2007	7,243	15,333	2,495	25,071
2008	6,920	14,616	6,509	28,045
2009	6,964	13,612	7,473	28,049
2010	7,532	17,281	5,500	30,313

4.1.4 Groundwater Production

WRD maintains information on wells and groundwater production records for the West Coast and Central Basins. These data were obtained to update the groundwater flow model through water year 2010. Sixty-six new wells were installed in the basins since 2000, as shown in Figure 4-2. Grid and proportional assignment of flow rates to each layer of the model was done using the same procedure used for the injection wells. Groundwater production by basin is shown in Table 4-3.

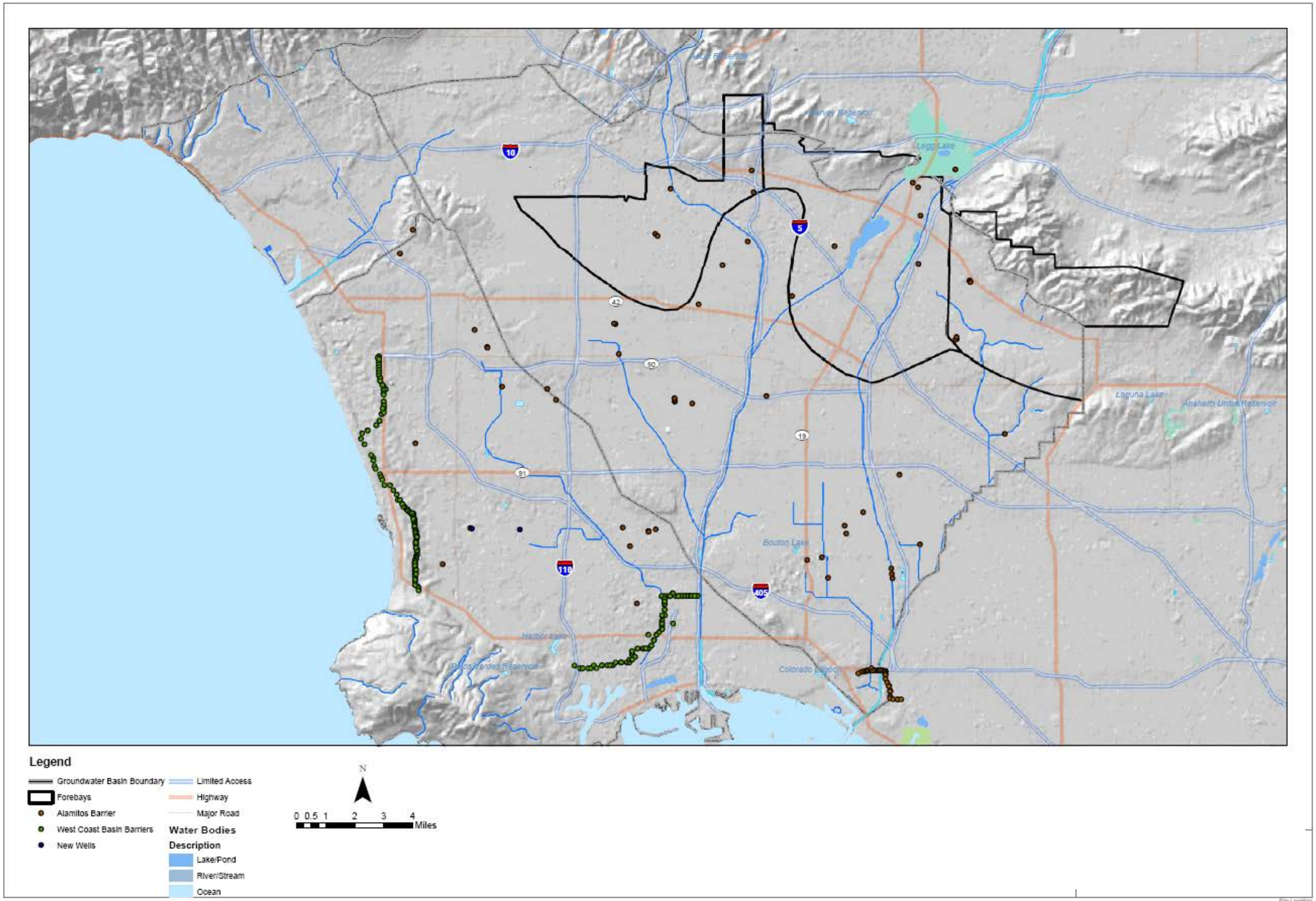


Figure 4-2. Location of New Extraction Wells Installed Since 2000

Table 4-3. Pumping for the West Coast and Central Basins

Water Year	West Coast Basin (AFY)	Central Basin (AFY)	Total Pumping (AFY)
1971*			278,300
1972*			289,300
1973*			272,300
1974*			274,000
1975*			278,500
1976*			283,200
1977*			279,000
1978*			259,600
1979*			270,700
1980*			272,300
1981*			275,800
1982*			276,500
1983*			261,400
1984*			258,300
1985*			256,900
1986*			264,600
1987*			254,000
1988*			254,300
1989*			252,100
1990*			245,200
1991*			247,900
1992*			260,500
1993*			226,800
1994*			181,100
1995*			235,300
1996*			238,800
1997*			243,800
1998*			244,500
1999*			259,700
2000*			254,200
2001	53,870	195,361	249,231
2002	50,063	200,168	250,231
2003	51,946	190,268	242,214

Table 4-3. Pumping for the West Coast and Central Basins

Water Year	West Coast Basin (AFY)	Central Basin (AFY)	Total Pumping (AFY)
2004	48,013	200,365	248,378
2005	41,297	188,783	230,079
2006	36,808	191,123	227,931
2007	37,659	198,249	235,908
2008	38,472	206,296	244,768
2009	45,538	197,163	242,701
2010	44,013	197,386	241,398

* Data Source – USGS

4.1.5 Boundary with Orange County Groundwater Basin

The modeled groundwater flow boundary with the Orange County Groundwater Basin is simulated as a constant head boundary, using fixed groundwater levels based on observed historical groundwater levels as contoured from observation wells along this boundary. OCWD compiles groundwater levels throughout the Orange County Groundwater Basin and prepares groundwater level contour maps for each of the principal aquifers in the basin. These annual contour maps (2000 through 2010) were obtained from OCWD and used to assign groundwater levels to constant head grid cells of the three layers simulated along the boundary (see Figure 4-1 for location of constant head boundary grid cells). Appendix G contains the maps provided by OCWD.

4.1.6 Simulation Update Results Through Water Year 2010

Figure 4-3 shows simulated groundwater levels at the end of water year 2010 for all four layers represented in the model. Figure 4-4 shows hydrographs for selected locations in the West Coast and Central Basins for the historical period of water years 1971 through 2010. Additional groundwater level contour maps and hydrographs for more locations are provided in Appendix H. Generally, groundwater levels in the Central Basin were relatively stable from 2000 through 2004, rose somewhat in response to wetter than normal conditions in 2005, then declined in response to drier than normal conditions through the end of the simulation. Groundwater levels in the West Coast Basin are generally steady to slightly rising over the simulation period.

Figure 4-5 shows a summary of average groundwater fluxes by zone throughout the modeled area over the period of simulation (water years 1971 through 2010). These fluxes show flow between 10 zones that were used in the original WRD/USGS groundwater flow model discussed below.

The groundwater levels in each layer at the end of water year 2010 were used as the starting groundwater levels for each of the simulations of the alternative basin operational conditions.

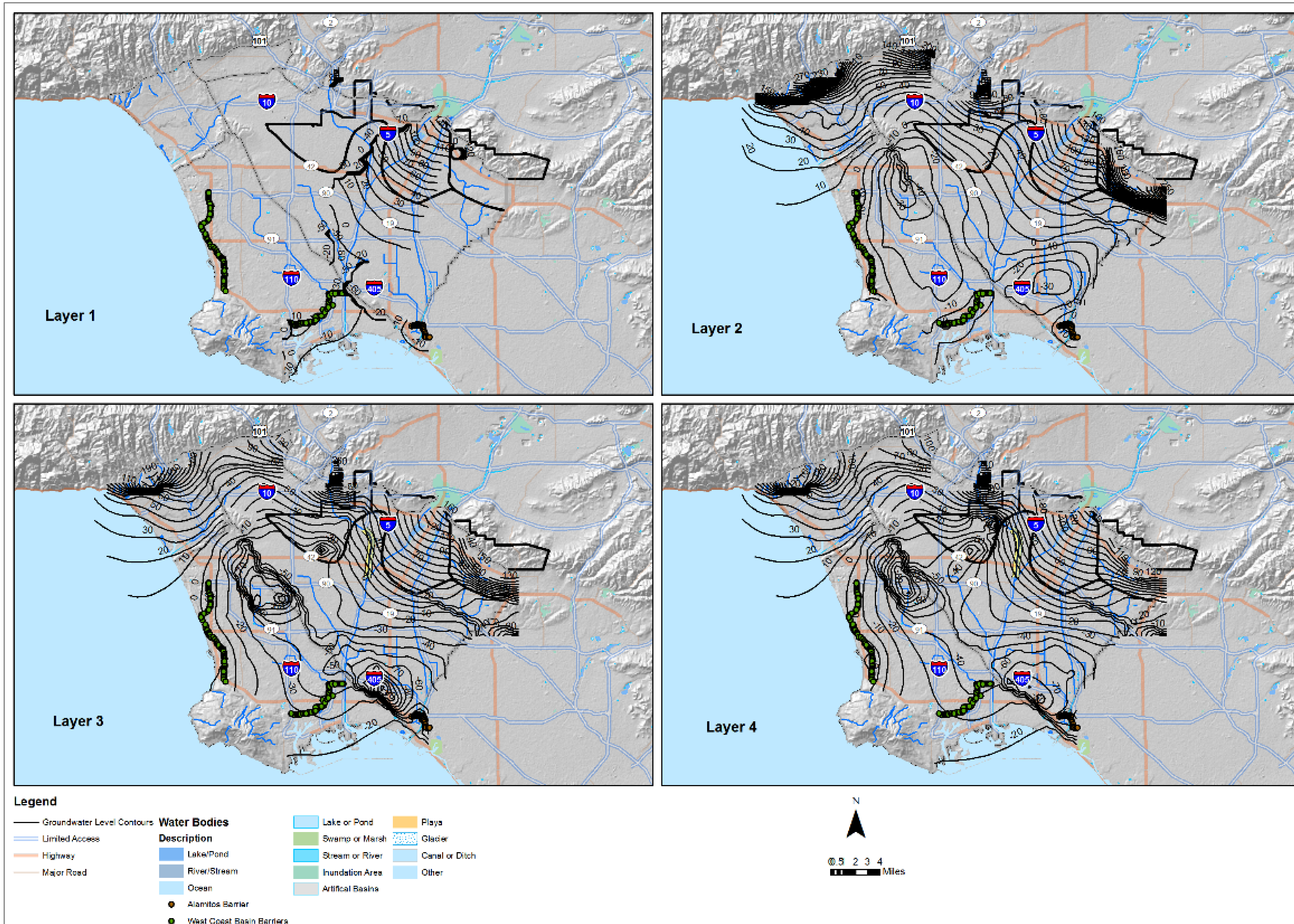


Figure 4-3. Groundwater Level Contours for Historical Conditions at the end of the Simulation Period (September 30, 2010)

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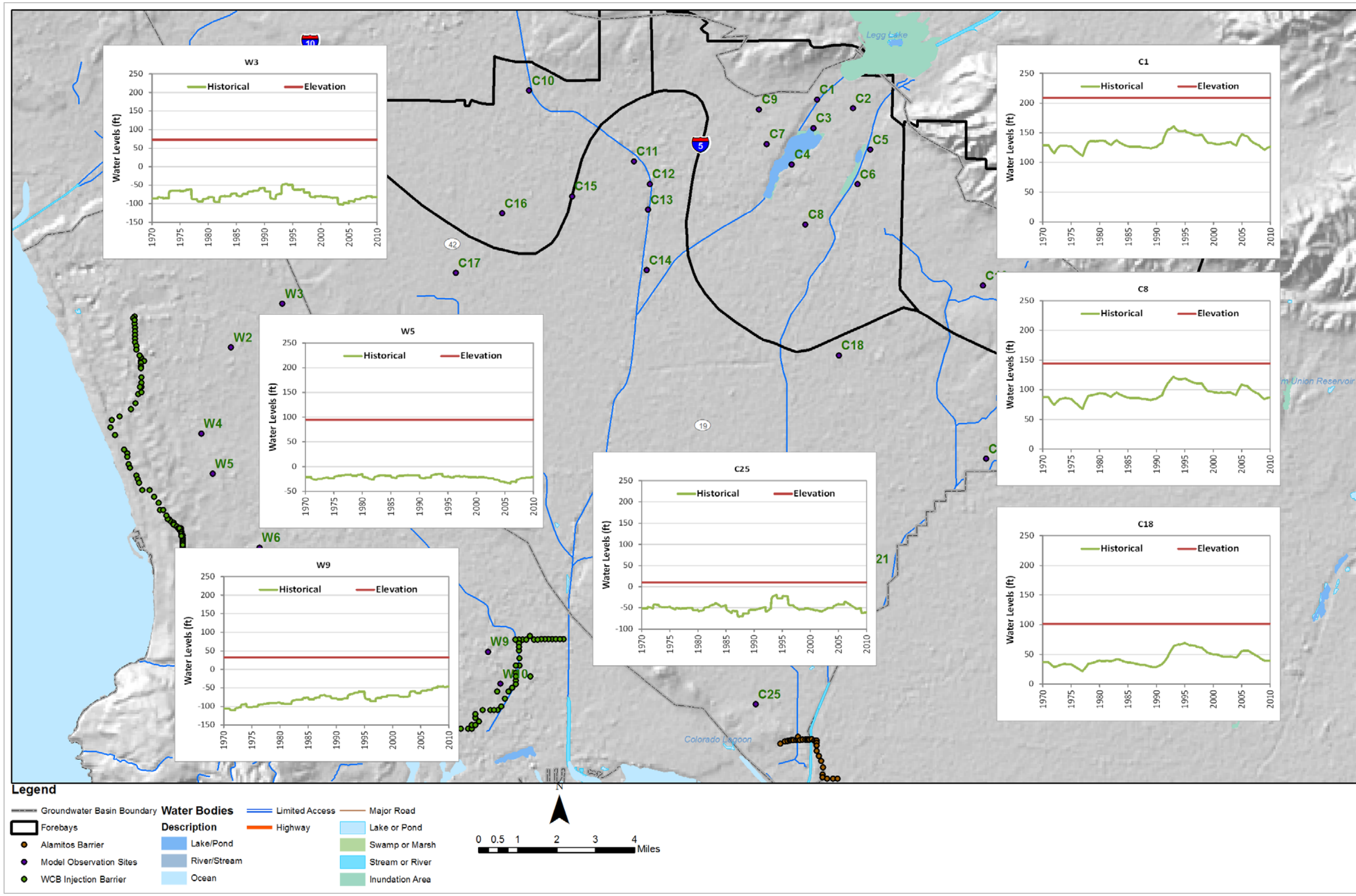

Figure 4-4. Selected Hydrographs Showing Simulated Historical Groundwater Levels

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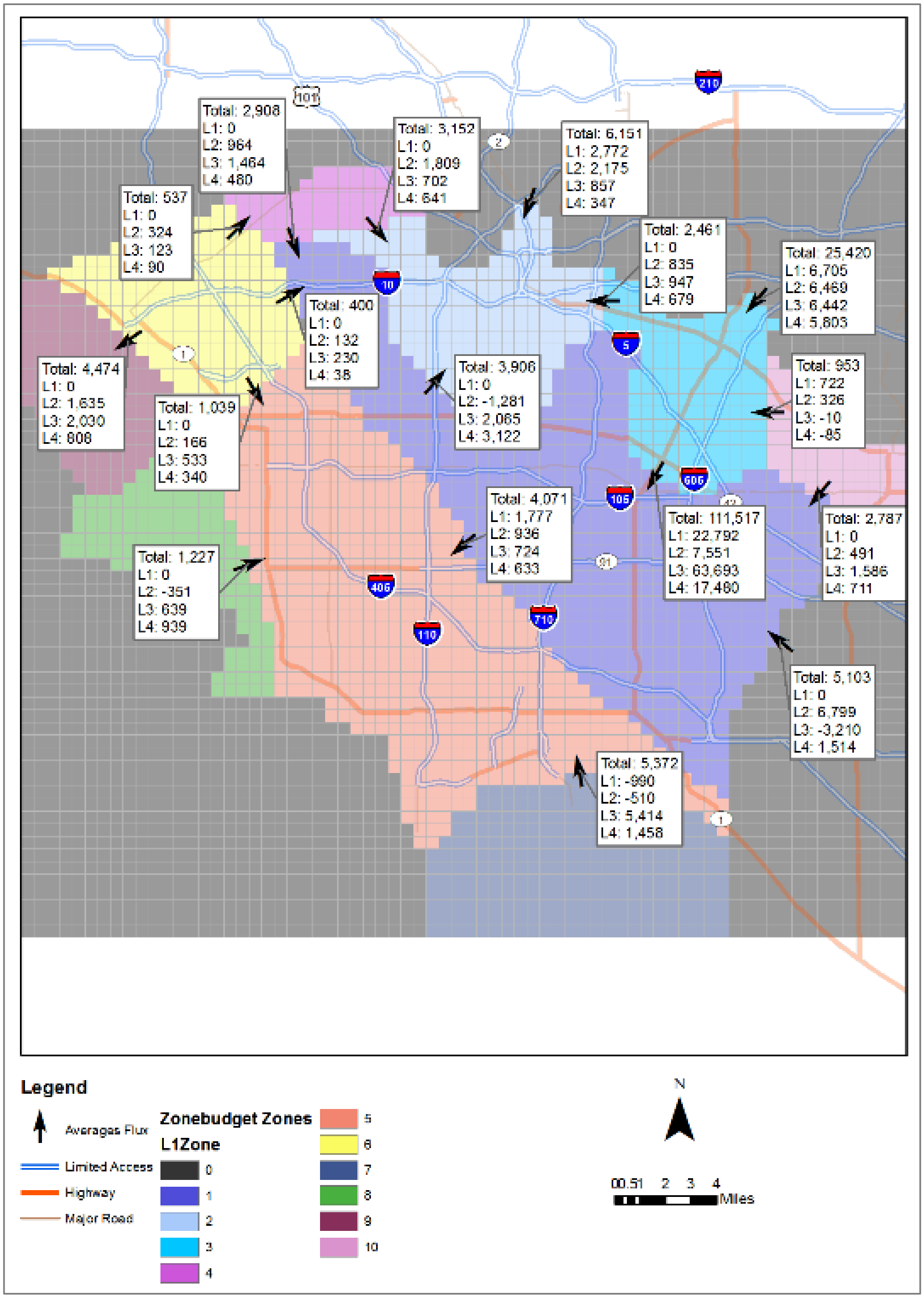

Figure 4-5. Zonebudget Summary for 10 Zones for Simulation Period (Water Years 1971 through 2010)

4.2 Simulation of Groundwater Basins Master Plan Planning Scenarios

The updated WRD/USGS groundwater flow model was used to evaluate a number of alternative basin operating conditions represented by the GBMP planning scenarios for both the West Coast and Central Basins presented in Section 3.0. These alternative operating conditions included scenarios in which the basins are pumped within the APA of the Central Basin and adjudicated water rights of the West Coast Basin (Concept A scenarios) and scenarios where the Central Basin is pumped above the APA and West Coast Basin is pumped above water rights (Concept B scenarios), with variations in sources of replenishment supplies. These scenarios can provide insights into how the groundwater basins would respond to management actions that might be implemented under various recharge programs.

The forecast period for modeled scenarios was 2011 through 2050. The model was used to simulate groundwater levels and cumulative groundwater storage in the groundwater basins in response to changes in water replenishment and pumping conditions. The simulation conditions included combinations of operating conditions wherein one basin is pumped within or above its APA/water rights, while the other basin is being pumped within or above its APA/water rights.

4.2.1 GBMP Modeling Combinations

Provided below is a summary of the combinations developed under each of the operating conditions in both the basins that were used for the GBMP model simulations. The operating conditions for each of the scenarios used for developing the modeling combinations are discussed in Section 3.0.[11]

4.2.1.1 APA-Central Basin and Water Rights-West Coast Basin

The following combinations were modeled with pumping at APA levels in the Central Basin and at water rights levels in the West Coast Basin, with sufficient replenishment to support these pumping conditions.

- **Combination 1:** This is a baseline model run using the updated model for a 40-year forecast period using the APA of 217,367 AFY in the Central Basin and water rights of 64,468 AFY in the West Coast Basin. This represents a combination of GBMP Scenarios WCB–A1a and CB–A1 for the two basins. The conditions used in this combination serve as the baseline condition that was used as a starting point for subsequent model run combinations. Generally, pumping is assigned to each pumper according to their adjudicated rights (see Table 3-5). Replenishment to support this pumping is provided at the existing seawater intrusion barriers and spreading grounds.
- **Combination 2:** In this combination, the APA of 217,367 AFY is pumped in the Central Basin and water rights of 64,468 AFY are pumped in the West Coast Basin. This represents a combination of GBMP Scenarios WCB-A1c and CB–A1. For this combination, pumping in the West Coast Basin is redistributed with the goal of containing/removing saline plume in Silverado aquifer. 15,000 AFY is extracted from the Silverado aquifer for desalting. Pumping for three pumpers (CWSC, City of Torrance, and City of Los Angeles) is shifted from their current well locations to the saline plume. Recharge for the West Coast Basin is the same as in Combination 1. Pumping and recharge for the Central Basin are also the same as in Combination 1.

[11] In addition, a separate analysis was conducted to assess the impact of additional recharge at the MFSG relative to historical conditions, without additional corresponding extraction. The results are provided in Appendix K.

4.2.1.2 Above APA-Central Basin and Water Rights-West Coast Basin

The following combinations were conducted with pumping above APA levels in the Central Basin and at water rights levels in the West Coast Basin, with sufficient replenishment to support these pumping conditions:

- **Combination 3:** In this combination, pumping is above the APA to 275,137 AFY in the Central Basin and at the water rights of 64,468 AFY in the West Coast Basin. This represents a combination of GBMP Scenarios WCB-A1a and CB–B1. Under this combination, pumping and replenishment are the same as in Combination 1 in the West Coast Basin. In the Central Basin, an additional 57,770 AFY is pumped by major imported water users from the MFSG, and additional recharge is provided in both the MFSG and the Los Angeles Forebay. Additional replenishment is provided through spreading and injection of recycled water and enhanced stormwater capture.
- **Combination 4:** In this combination, pumping is above the APA to 320,617 AFY in the Central Basin and at the water rights of 64,468 AFY in the West Coast Basin. This represents a combination of GBMP Scenarios WCB-A1a and CB–B2. Under this combination, pumping and replenishment are the same as in Combination 1 in the West Coast Basin. In the Central Basin, additional extraction occurs in the Los Angeles Forebay and MFSG. To support pumping for this combination, additional recharge of stormwater and recycled water to the MFSG and Los Angeles Forebay is assumed.

4.2.1.3 APA-Central Basin and Above Water Rights-West Coast Basin

The following combination was conducted with pumping at APA levels in the Central Basin and above water rights levels in the West Coast Basin, with sufficient replenishment to support these pumping conditions:

- **Combination 5:** In this combination, pumping is at the APA of 217,367 AFY in the Central Basin and above the water rights at 94,468 AFY in the West Coast Basin. This represents a combination of GBMP Scenarios WCB-B1 and CB–A1. Under this combination, pumping in the West Coast Basin is redistributed with the goal of containing or removing the saline plume in Silverado aquifer. Extraction of an additional 30,000 AFY beyond the water rights for the West Coast Basin was allocated to three pumpers: CWSC, City of Torrance, and City of Los Angeles. To balance the pumping, additional water replenishment in the West Coast basin occurs at the existing barriers and a new line of inland injection wells.

4.2.1.4 Above APA-Central Basin and Above Water Rights-West Coast Basin

The following combination was conducted with pumping above APA levels in the Central Basin and above water rights levels in the West Coast Basin, with sufficient replenishment to support these pumping conditions:

- **Combination 6:** In this combination, pumping is above the APA to 275,137 AFY in the Central Basin and above the water rights to 94,468 AFY in the West Coast Basin. This represents a combination of GBMP Scenarios WCB-B1 and CB–B1. Pumping and replenishment for the West Coast Basin is the same as in Combination 6. Pumping and replenishment for the Central Basin is the same as in Combination 4.

Table 4-4 summarizes the basin operating conditions in each basin used for the modeling combinations described above.

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Table 4-4. Basin Operating Conditions for Modeling Assessments

										Artificial Replenishment									
				Pumping						Subsurface Injection					Surface Spreading				TOTAL - Both Basins
Basin Operating Conditions (Model Run)[a]	Basin	Description	GBMP Planning Scenario (see Table 3-9)	WCB	CB	Additional Pumping by Pumpers	New Extraction Wells	TOTAL - per Basin	TOTAL - Both Basins	WCBBP	DGBP	ABP	New Injection Wells	TOTAL per Basin	Storm-water	Incidental RW Recharge[b]	RW	TOTAL - per Basin	
Combination 1 (Base Case Model Run)	WCB	Pumping within water rights	WCB-A1a	64,468				64,468	281,835	32,500	7,500			40,000					186,001
	CB	Pumping within APA	CB-A1		217,367			217,367				8,000		8,000	57,032	9,047	71,922	138,001	
Combination 2	WCB	Pumping within water rights	WCB-A1c	49,468			15,000	64,468	281,835	32,500	7,500			40,000					186,001
	CB	Pumping within APA	CB-A1		217,367			217,367				8,000		8,000	57,032	9,047	71,922	138,001	
Combination 3	WCB	Pumping within water rights	WCB-A1a	64,468				64,468	339,605	32,500	7,500			40,000					243,423
	CB	Pumping above APA	CB-B1		217,367		57,770	275,137				8,000	23,200	31,200	73,983	8,690	89,550	172,223	
Combination 4	WCB	Pumping within water rights	WCB-A1a	64,468				64,468	385,085	32,500	7,500			40,000					288,903
	CB	Pumping above APA	CB-B2		217,367	16,480	86,770	320,617				8,000	68,680	76,680	73,983	8,690	89,550	172,223	
Combination 5	WCB	Pumping above water rights	WCB- B1	49,468			45,000	94,468	311,835	40,000	15,000		15,000	70,000					318,890
	CB	Pumping within APA	CB-A1		217,367			217,367				8,000		8,000	57,032	9,047	71,922	138,001	
Combination 6	WCB	Pumping above water rights	WCB- B1	49,468			45,000	94,468	369,605	35,000	10,000		25,000	70,000					250,223
	CB	Pumping above APA	CB-B1		217,367		57,770	275,137				8,000		8,000	73,983	8,690	89,550	172,223	

[a] Indicates the model run number used in simulations for a specific model Combination. Some figures in this section reference model run numbers.

[b] Incidental RW recharge occurs from discharge of RW by Whittier Narrows WRP to the Rio Hondo and Pomona WRPs to San Jose Creek, a tributary of the San Gabriel River.

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4.3 Combination 1 (Baseline Operating Conditions)

WRD is required to meet the replenishment needs of the West Coast and Central Basins so that pumpers can extract groundwater up to the APA in the Central Basin and up to their water rights in the West Coast Basin. The APA in the Central Basin is 217,367 AFY, and water rights in the West Coast Basin are 64,468 AFY. Given the drivers described in Section 1.0, it is anticipated that pumping will increase up to the APA and water rights as water purveyors look to meet their water demands in the most reliable and economic manner. Therefore, WRD desires to develop the GBMP assuming pumping at the APA in the Central Basin and water rights in the West Coast Basin as the baseline operational condition.

4.3.1 Combination 1 – Assumptions and Model Input

To assess the potential replenishment requirements for Combination 1, the updated WRD/USGS groundwater flow model was extended through water year 2050, for a 40-year simulation period by repeating the hydrology from 1971 through 2010. This period (1971 through 2010) is a reasonably good period to use for planning purposes as it (1) is a relatively long period, (2) includes severe wet and dry periods, (3) includes variations in pumping, (4) covers the period of the WRD/USGS groundwater flow model simulations, and (5) contains a relatively complete data set. Following are the assumptions used for this planning period from water year 2011 through 2050:

- The historical hydrology of water years 1971 through 2010 are repeated into the future, beginning with water year 2011. This assumption also implies that the mountain front and interior recharge are repeated as in the updated groundwater flow model.
- Stormwater will be available in the same quantities in the future as it was in the past for each equivalent water year into the future. So, stormwater runoff in 1971 available for capture and recharge is the same in the equivalent water year 2012, and for 2013 it is the same as 1972, and so on. This also means that any non-captured stormwater in years when stormwater was wasted to the ocean (Figure 3-18), that this excess stormwater is available for capture and use for recharge. This is case for both the Rio Hondo/San Gabriel River and Los Angeles River. Table 4-5 provides a summary of stormwater captured and recharged at the Whittier Narrows Dam, Rio Hondo and San Gabriel River Coastal Spreading Grounds for water years 2011 through 2050.
- Use of imported water for replenishment at the MFSG is replaced with either increased capture of stormwater or recycled water given that the WIN program goal is to replace the use of imported water. It is important to note that the groundwater flow model does not distinguish between sources of water, so any distinction between water sources is tracked separately outside of the model. Table 4-5 shows the supplemental replenishment water recharged at the Whittier Narrows Dam, Rio Hondo and San Gabriel River Coastal Spreading Grounds for water years 2011 through 2050.
- Groundwater production is increased to the APA in the Central Basin and water rights in the West Coast Basin. It is assumed that pumpers who also use imported water will likely lease or acquire water rights to increase pumping to the levels assumed herein. This distribution of pumping is not certain, but it is assumed for purposes of analysis. In addition, each pumper’s monthly pumping is varied based on their average monthly pumping over water years 2000 through 2010 to account for seasonal variations in water demands. Tables 3-2 and Table 3-5 provide the distribution of annual pumping by pumper in the West Coast and Central Basins, respectively. Other pumping patterns are possible as pumpers determine their actual pumping plan; however, these alternative pumping distributions are not likely to significantly change the modeling results unless there is substantially different geographical redistribution of pumping than assumed herein.

- Injection into the seawater intrusion barriers is increased to 32,500 AFY for the WCBBP, 7,500 AFY for the DGBP, and 8,000 AFY for the ABP. WRD is in the final design stage of expanding the LVLWTF to provide 8,000 AFY of advanced treated wastewater for injection to the ABP.
- In addition, the groundwater flow model stress periods are reduced from annual to monthly durations over the 40-year simulation period. This finer stress period resolution allows for simulation of more representative groundwater levels in response to recharge events, especially high-rate recharge of stormwater events at the MFSG. This allows for an assessment of whether groundwater levels could potentially rise to (or above) land surface during these high-rate recharge events. Also, this finer stress period allows for assessment of groundwater fluctuations due to seasonal pumping patterns.

Table 4-5. Summary of Surface Water and Supplemental Replenishment Water at MFSG

Water Year	Base Stormwater (AFY)	Supplemental Recycled Water (AFY)	Total (AFY)
2011	40,833	93,983	134,816
2012	25,064	92,071	117,135
2013	49,009	78,408	127,417
2014	32,003	89,805	121,808
2015	25,924	94,737	120,661
2016	28,099	95,095	123,194
2017	17,713	97,512	115,225
2018	133,186	58,172	191,358
2019	71,467	69,762	141,229
2020	107,667	59,040	166,707
2021	45,261	85,437	130,698
2022	57,917	84,117	142,034
2023	100,010	61,309	161,319
2024	58,963	79,783	138,746
2025	53,979	79,246	133,225
2026	78,210	65,213	143,423
2027	24,670	96,106	120,776
2028	50,068	94,292	144,360
2029	19,587	95,114	114,701
2030	18,680	96,941	115,621
2031	41,481	87,169	128,650
2032	94,881	61,875	156,756
2033	147,699	48,502	196,201
2034	55,896	80,612	136,508
2035	100,578	65,965	166,543

Table 4-5. Summary of Surface Water and Supplemental Replenishment Water at MFSG

Water Year	Base Stormwater (AFY)	Supplemental Recycled Water (AFY)	Total (AFY)
2036	62,920	79,674	142,594
2037	58,262	77,665	135,927
2038	96,706	67,924	164,630
2039	32,013	96,688	128,701
2040	27,104	87,690	114,794
2041	45,470	85,937	131,407
2042	18,279	98,297	116,576
2043	59,337	75,450	134,787
2044	35,317	88,909	124,226
2045	148,674	47,265	195,939
2046	61,398	77,564	138,962
2047	13,693	97,520	111,213
2048	55,343	86,039	141,382
2049	44,251	84,764	129,015
2050	43,658	77,086	120,744

4.3.2 Combination 1 – Model Simulation Results

The groundwater flow model was used to determine the supplemental replenishment requirements at the MFSG and injection barriers to maintain an overall water balance in the West Coast and Central Basins. That is, over the simulation period, the goal is that the cumulative change in storage is near zero at the end of the simulation period, so that all inflows and outflows are relatively balanced over the simulation period. This balancing approach also results in groundwater levels that fluctuate, but in general end at levels that are comparable to their beginning levels. Given the large storage capacity of these basins and the fact that WRD would review actual replenishment requirements annually, the ending cumulative storage goal of the model simulations are considered satisfactory if they are within about 1 to 2 percent of the annual pumping cumulative over the simulation period, which is about 3,000 to 6,000 AFY or about 120,000 to 240,000 AF over the 40-year simulation period.

A trial and error approach was used to determine the supplemental replenishment water required at the MFSG to result in a balanced model over the 40-year simulation period. The total recharge required, including supplemental replenishment water, is approximately an average of 138,000 AFY. The historical quantity of stormwater conserved over this period is approximately 57,000 AFY, which leaves a requirement of 81,000 AFY of supplemental replenishment water to meet APA pumping requirements in the Central Basin.

Figure 4-6 shows a few selected hydrographs at locations throughout the West Coast and Central Basins. The hydrographs for locations in the Montebello Forebay show groundwater-level fluctuations in Layer 1 (to capture groundwater responses in the shallowest layer). The remainder of the hydrographs are for Layer 3 (which represents the layer with the most pumping) of the model. Simulated historical groundwater levels (water years 1971 through 2010 by adding 40 years to the date) are plotted, as well as the projected groundwater levels under this baseline modeling combination for comparison purposes. This comparison shows groundwater level responses to identical hydrological conditions in the basins, with the addition of supplemental replenishment in the MFSG, increased injection into the injection barriers, and pumping at APA and water rights. Additional hydrographs are provided in Appendix I.

These hydrographs show an overall near water balance in these basins. Groundwater level fluctuations in the Montebello Forebay area are slightly muted compared to historical fluctuations. This is a result of a projected more consistent replenishment of recycled water compared to historical imported water, which was recharged based on the availability of low-cost surplus supplies. Figure 4-7 shows groundwater level contours for each model layer at the end of water year 2050.

Figure 4-8 shows the baseline Combination 1 cumulative groundwater storage for the modeled area. Groundwater in storage fluctuates in response to local hydrological conditions, with storage increasing during wet years and decreasing during dry years. The ending balance is about -50,000 AF, which is about 1,250 AFY of deficit inflow compared to outflow—less than 0.5 percent of the annual pumping in these basins.

Figure 4-9 shows a summary of the average annual fluxes between zones over the simulation period. Comparison of these fluxes to the historical period (1971 through 2010) shows a significant reduction of inflow from the Orange County Groundwater Basin: 5,100 AFY on average compared to 2,540 AFY on average for Combination 1. This reduction in inflow is twice the 1,250 AFY imbalance of overall storage. In addition, the inflows from the San Gabriel Basin are reduced approximately 2,000 AFY in Combination 1 compared to the historical period. This demonstrates the need for continuous monitoring and evaluation of actual recharge and pumping (location and quantity of pumping) to ensure the long-term water balance of the basins.

Pumping in the West Coast Basin is distributed to pumpers assuming that they would acquire pumping rights (through leases or purchase) and pump this water from their wells or wells in or near their service areas (see Table 3-2, Scenario A1a). Therefore, under this operating condition, there is no plan to address the large saline plumes; these plumes of salty water would continue to migrate unabated, in response to injection and pumping as described for this operating condition. Figure 4-10 shows a plot of path lines in the Silverado aquifer (model Layer 3) from the western extent of the saline plume (as characterized by WRD) over the 40-year simulation period. These path lines show the eastward advancement that the saline water would make under the injection and pumping pattern assumed for this baseline operating condition.

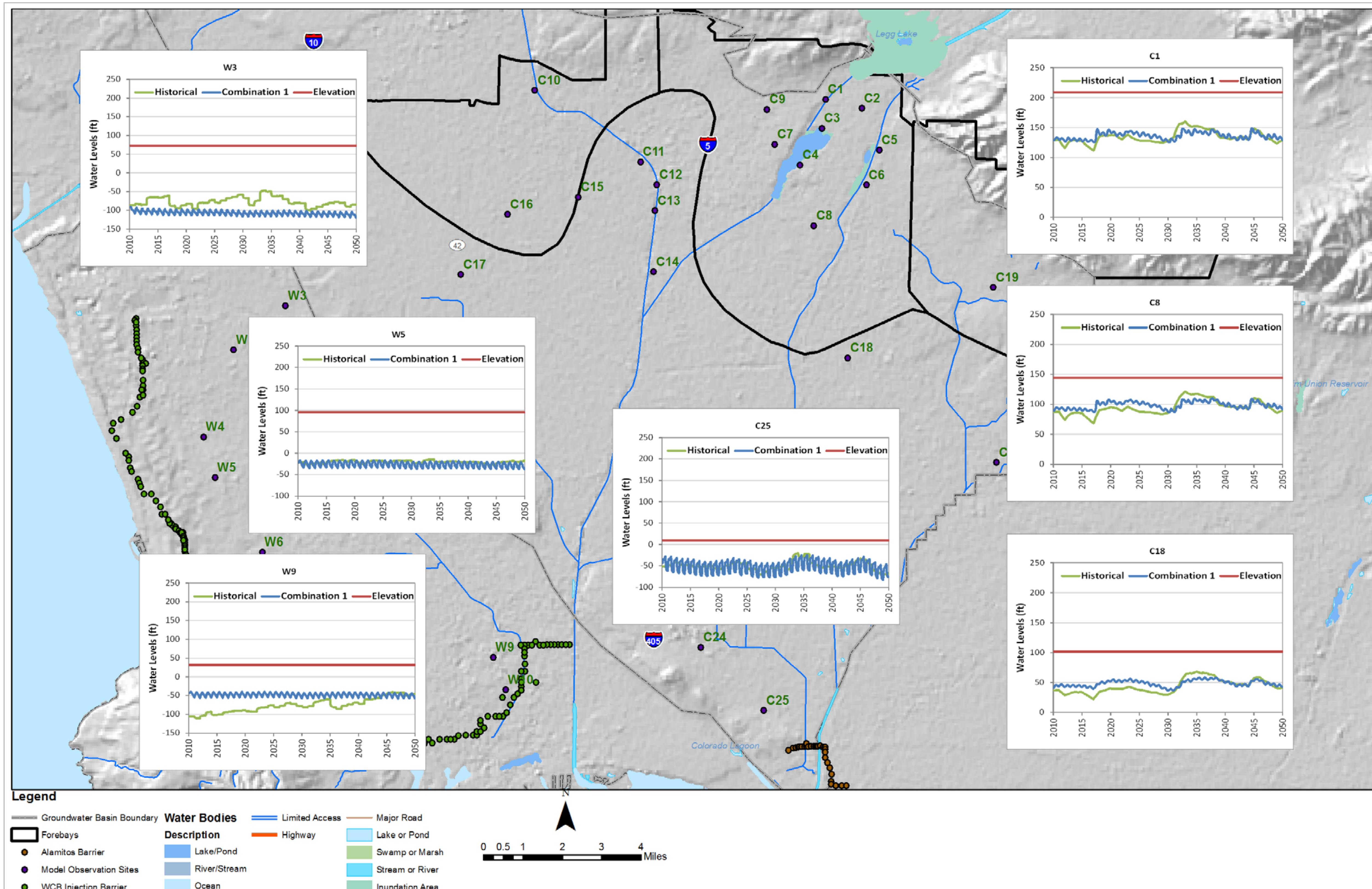

Figure 4-6. Selected Hydrographs Showing Simulated Baseline Groundwater Levels under Combination 1

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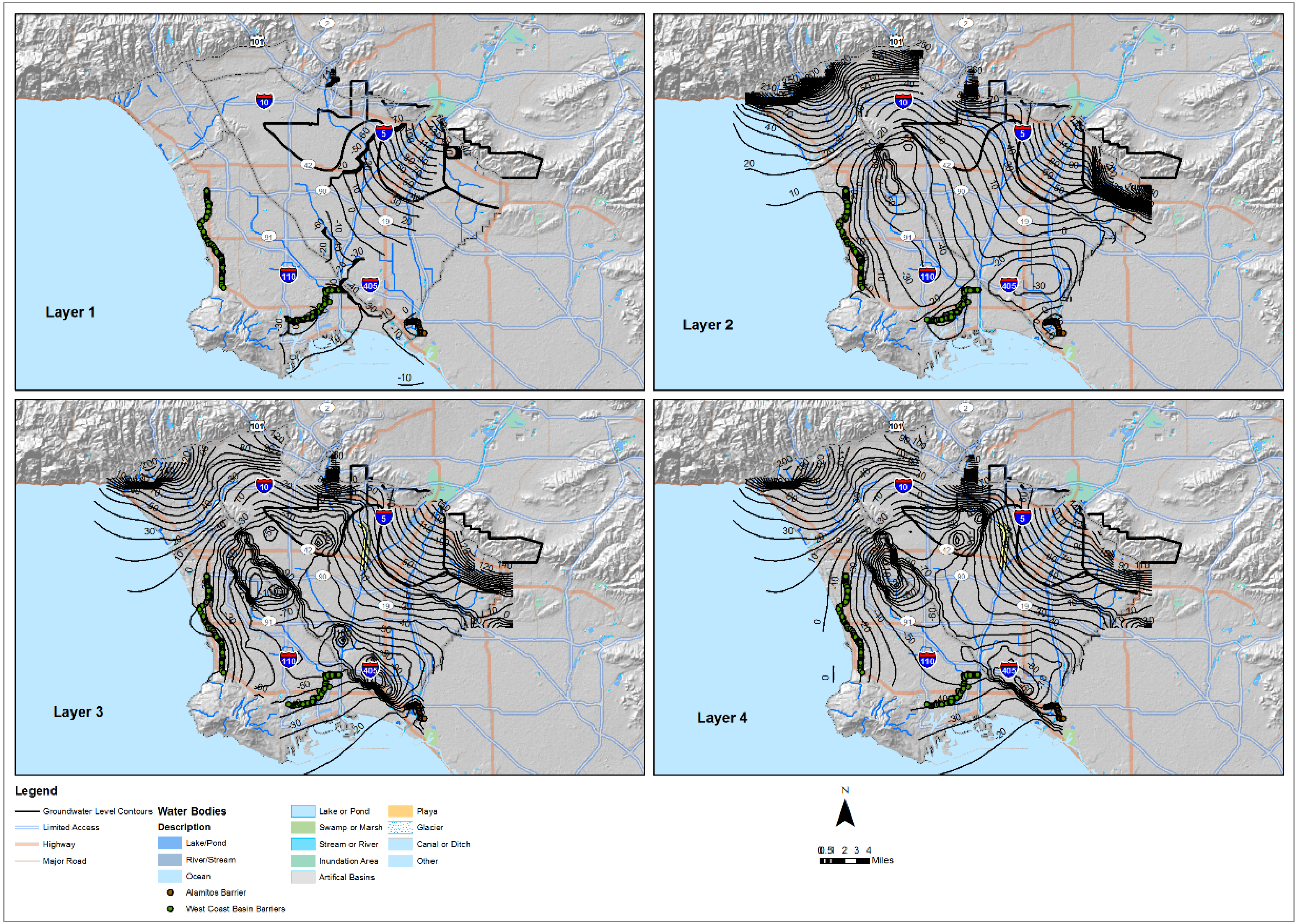

Figure 4-7. Groundwater Level Contours at the End of the Simulation Period (September 30, 2050) under Combination 1

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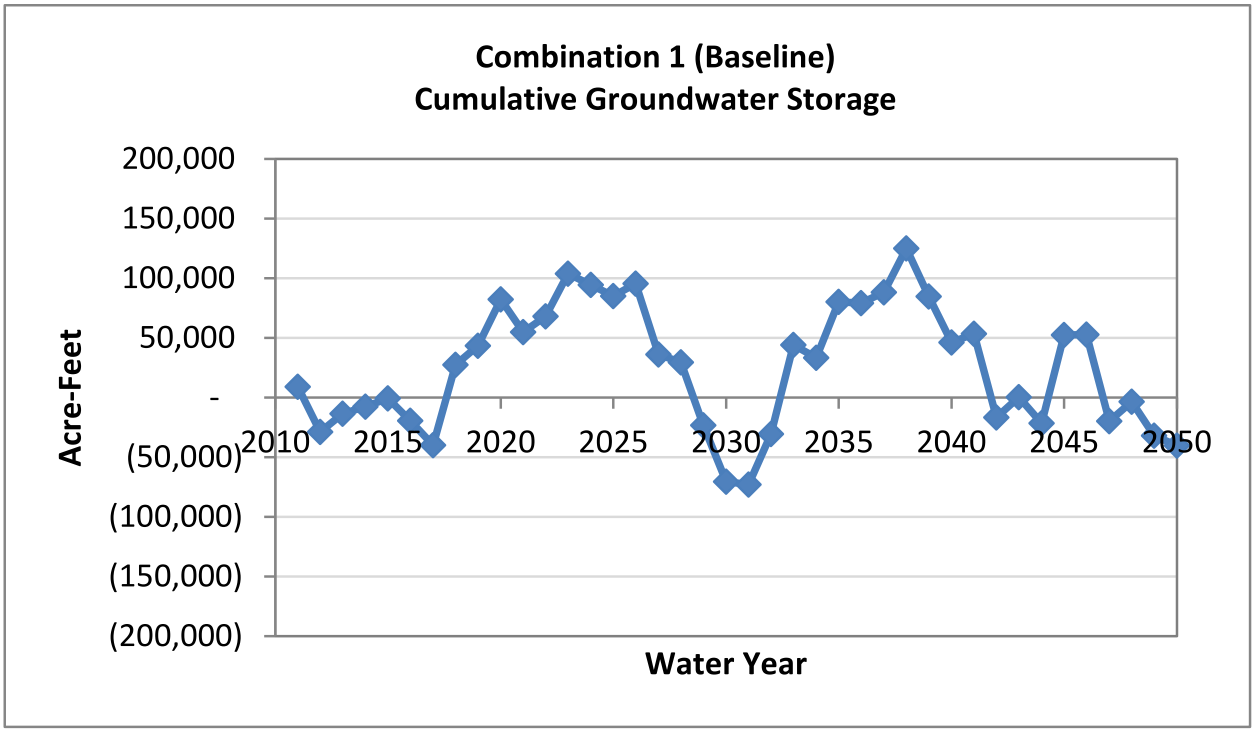

Figure 4-8. Cumulative Groundwater in Storage for the West Coast and Central Basins under Combination 1

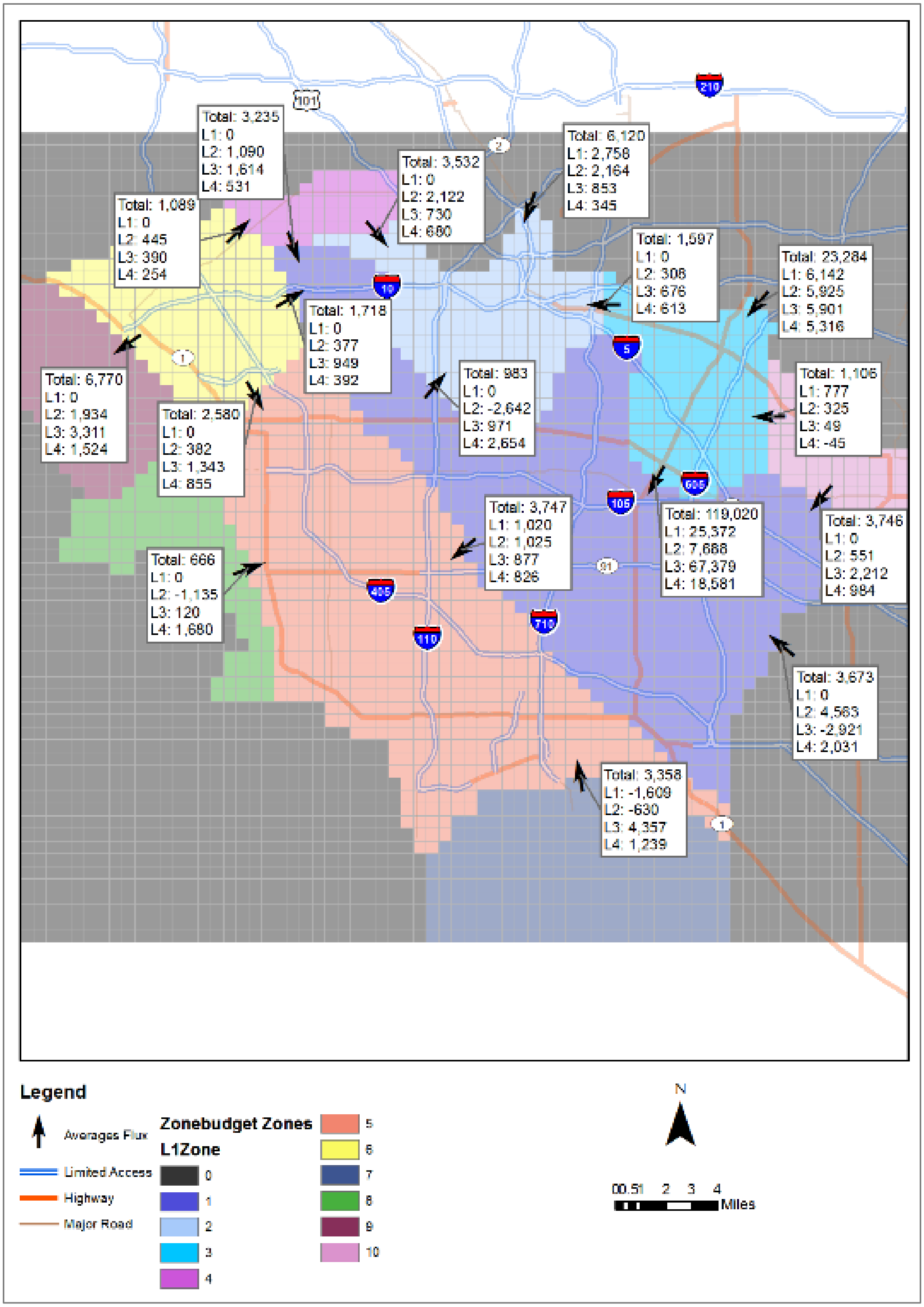

Figure 4-9. Zonebudget Summary of 10 Zones for Simulation Period (Water Years 2010 through 2050) under Combination 1

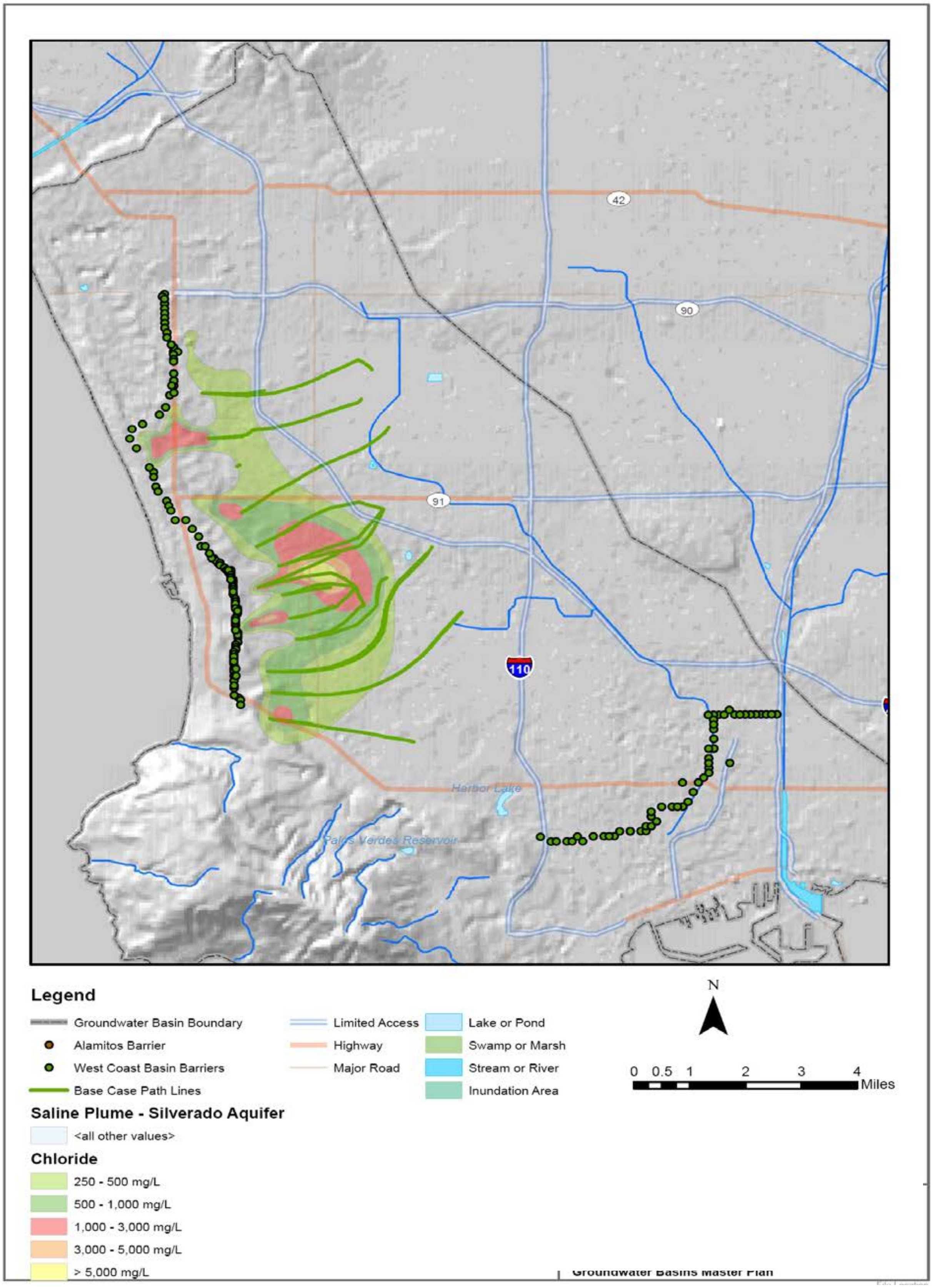

Figure 4-10. Baseline (Combination 1) – Groundwater Path Lines Through Saline Plume in Silverado Aquifer

4.4 Combination 2

Combination 3 is the operating condition for the West Coast Basin simulated with the updated WRD/USGS groundwater flow model. It reflects a strategic redistribution of pumping to contain/remove salty groundwater from the saline plume. In this modeling combination, pumping by selected pumpers is reduced so that 15,000 AFY of water rights water is moved to wells that will intercept and extract brackish/saline groundwater in the Silverado aquifer. This extracted water would be delivered to and treated by desalination facilities, then delivered to water purveyors for distribution in their potable water delivery systems.

4.4.1 Combination 2 – Assumptions and Model Input

The recharge conditions under this combination are the same as in Combinations 1 and 2. However, the pumping distribution is changed. Table 3-2 shows the redistribution of pumping to pumpers in the West Coast Basin under this combination (that is, for GBMP planning Scenario WCB-A1c) to contain/remediate saline plume. This redistribution of pumping is the only change made to the updated WRD/USGS groundwater flow model used for the baseline simulation described under Combination 1.

4.4.2 Combination 2 – Model Simulation Results

Figure 4-11 shows groundwater flow paths through the saline plume for this extraction condition. Groundwater path lines are terminated by some of the saline plume extraction wells and other path lines are shortened or deflected from their flow paths compared to the baseline, Combination 1 extraction condition. This change in flow path indicates that more mass of salts will likely be removed compared to the Combination 1 condition.

Appendix I contains groundwater level contour maps and hydrographs for the model simulation observation sites distributed throughout the basins. Groundwater levels and storage are not significantly different for this operating condition compared to the baseline Combination 1 condition.

Use of the West Coast Basin groundwater flow and solute transport model maintained by WBMWD is recommended to simulate this operating condition. WBMWD and WRD are in the process of having this groundwater flow and solute transport model calibrated for simulations of the saline plume. As described above, preliminary simulations of saline plume containment/removal were conducted with the current WBMWD groundwater flow and solute transport model. These preliminary simulations indicated significant improvement in basin water quality. Once the groundwater flow and solute transport model is recalibrated for the saline plume, these simulations should be repeated to refine this operating condition.

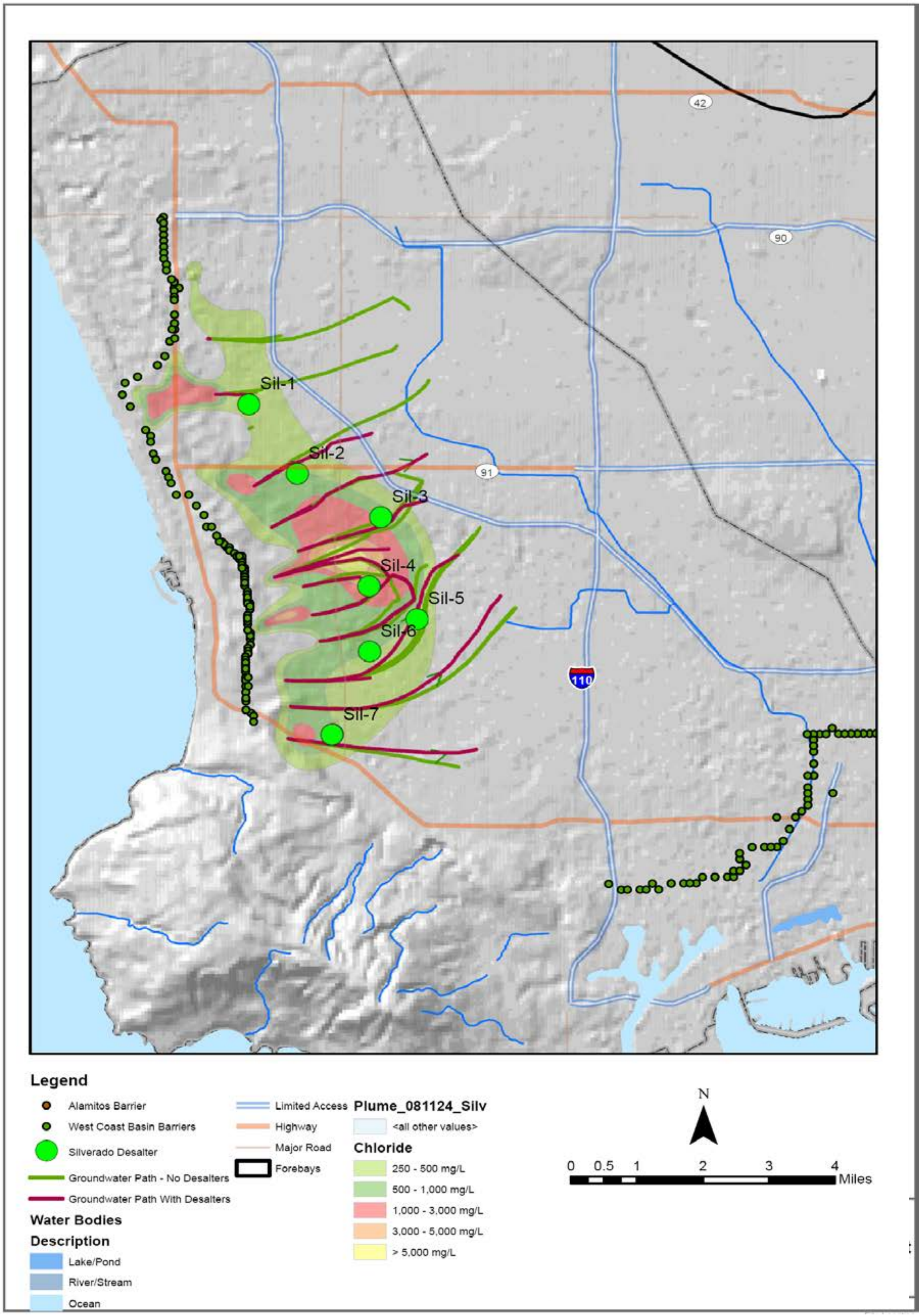

Figure 4-11. Comparison of Travel Paths Through Silverado Saline Plume With and Without Desalters

4.5 Combination 3

Combination 4 assumes additional recycled water and stormwater are recharged in the MFSG, allowing for extraction of up to 57,700 AFY above the APA. The West Coast Basin was operated at water rights, as in the baseline, Combination 1, operating condition.

4.5.1 Combination 3 – Assumptions and Model Input

This operating scenario is based on the assumption that additional stormwater is available for capture and recharge at the MFSG. In addition, Los Angeles River stormwater is available for recharge along the Los Angeles River. Stormwater capture and available recycled water use was maximized in the Montebello Forebay to increase replenishment under this modeling combination in order to increase pumping above APA in the Central Basin. It is assumed that enhanced stormwater capture can be accomplished as described in Section 3.3.2.3, so that approximately 22,000 AFY of additional stormwater would be captured (from the San Gabriel and Los Angeles Rivers) compared to historical capture and recharge of stormwater. It is assumed that improvements would be made at the SJCWRP (for example, Diversions 1 and 2) to allow for increased availability of recycled water. This would allow for an annual average of approximately 108,200 AFY of recycled water (which includes 8,690 AFY of incidental recharge of tertiary recycled water from the Whittier Narrows WRP and Pomona WRP) to be spread at the MFSG or injected into injection wells in the Montebello Forebay area. It is assumed that 9,500 AFY will be available from the LCWRP for injection into wells in the Montebello Forebay. In addition to the MFSG recharge, 5,000 AFY are recharged via an ARRF along the Los Angeles River as described in Section 3.3.2.3. An ARRF is proposed to capture stormwater for recharge along the Los Angeles River between Atlantic Boulevard and Firestone Boulevard.

Tertiary and advanced treated recycled water will be replenished at the MFSG. To maximize the use of available recycled water from the SJCWRP, full advanced treated recycled water will be injected into new injection wells located between the Rio Hondo and San Gabriel Coastal Spreading Grounds. In addition, full advanced treated recycled water from the LCWRP will be injected into these injection wells. Figure 4-12 shows the locations of these injection wells. Figure 4-13 shows the projected monthly spreading and injection of stormwater, tertiary recycled water, and advanced treated recycled water from SJCWRP (including Whittier Narrows and Pomona Water Reclamation Plants) and LCWRP in the Montebello Forebay area.

The replenishment that results from maximizing stormwater from the Rio Hondo/San Gabriel River and Los Angeles River, and recycled water from the SJCWRP and LCWRP is sufficient to provide for 57,770 AFY of additional pumping above the APA in the Central Basin. This pumping is assumed to take place from new extraction wells in the Montebello Forebay, as shown in Figure 4-12. These wells would be connected to the GBOP pipeline as described in Sections 3 and 5 and delivered to purveyors in the Central Basin to offset their imported water demands. Table 3-7 shows the distribution of the pumping that would be conveyed to these pumpers via the GBOP pipeline in the Central Basin. This distribution is based on feedback from pumpers during workshops; however, as described previously, this distribution is for planning purposes only and should not be considered a definitive plan.

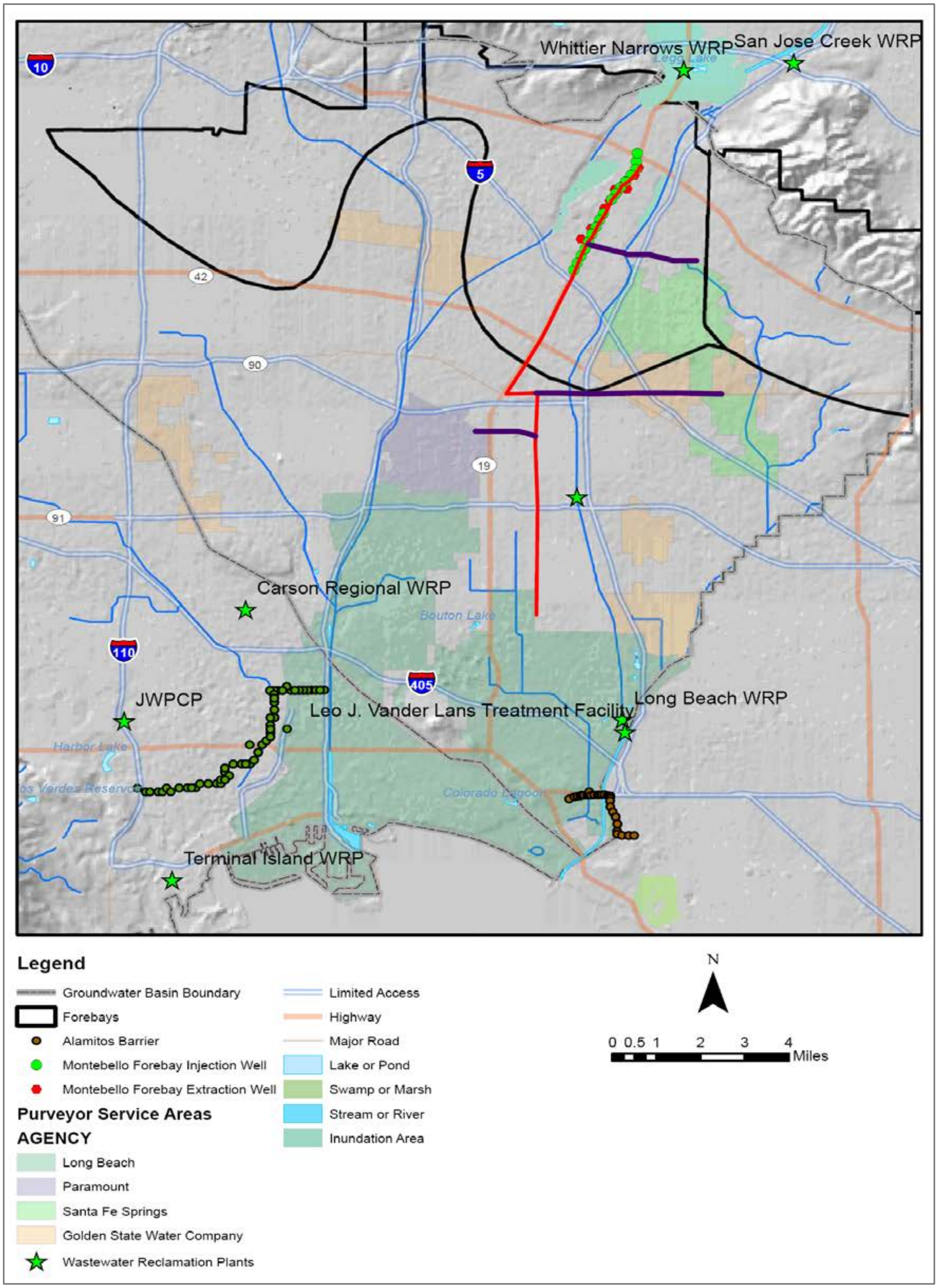

Figure 4-12. Location of Injection and Extraction Wells – Montebello Forebay Area for Additional Pumping Considered under Combination 3

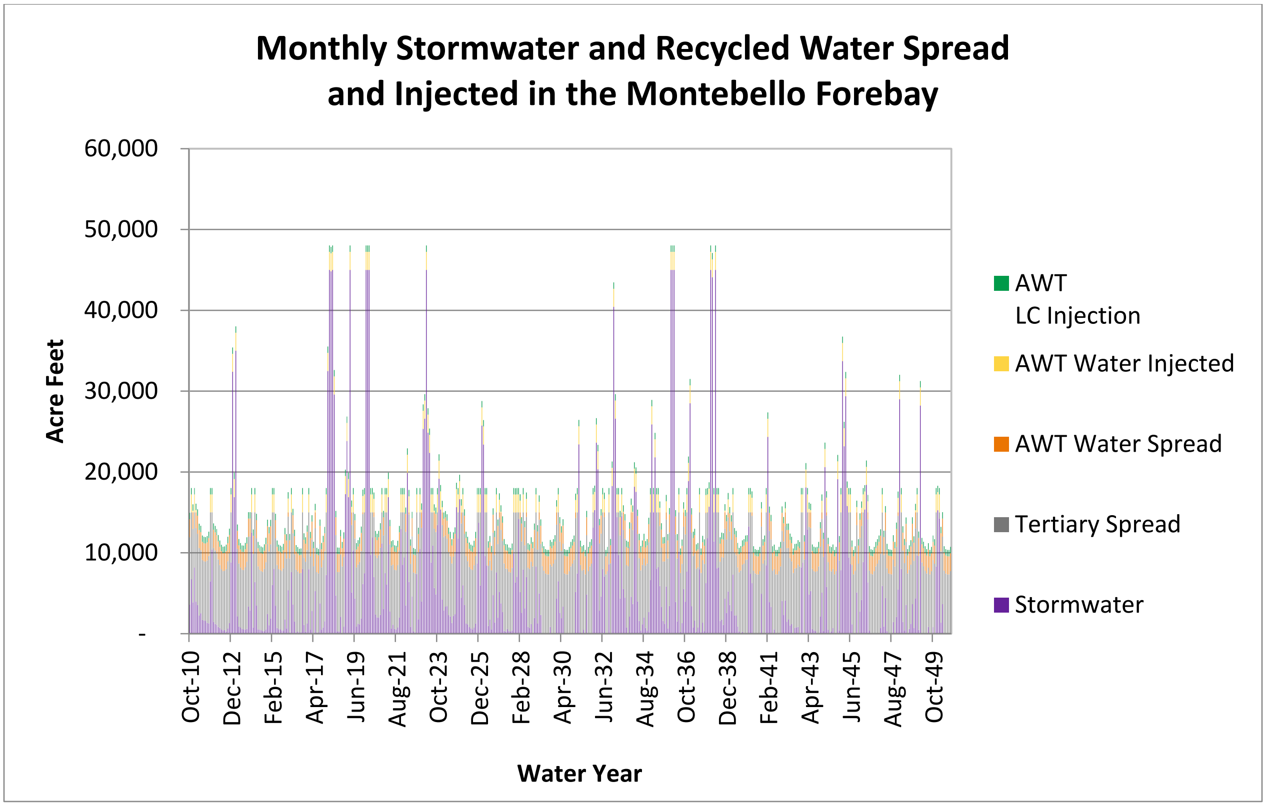

Figure 4-13. Projected Monthly Spreading and Injection in the Montebello Forebay Area – Scenario to Maximize Stormwater and Recycled Water Spread and Injected In the Montebello Forebay

4.5.2 Combination 3 – Model Simulation Results

Figure 4-14 shows selected hydrographs for model simulated groundwater levels in the Central Basin. Figure 4-15 shows groundwater-level contours for each of the four model layers. Hydrographs in the Montebello Forebay show groundwater levels in wells near the Rio Hondo spreading grounds rise to and slightly above land surface during high-rate recharge events in wet years. To reduce the rise of groundwater levels above ground surface, additional pumping would be required above the pumping assumed in this modeling combination. This additional pumping potentially could be accomplished by individual pumpers increasing pumping in the Montebello Forebay area, or increasing pumping from the Montebello Forebay extraction wells.

Figure 4-16 shows the cumulative change in storage in the West Coast and Central Basins under this combination. Figure 4-17 shows the Zonebudget summary for flow between the 10 zones of the West Coast and Central Basins. Figure 4-16 shows there is a slight storage deficit over the simulation period similar to the other simulations, but within acceptable limits. This is also indicated by the groundwater level hydrographs, which end relatively close to the levels from which they started. Again, the storage deficit is less than the reduction in inflow from adjacent basins.

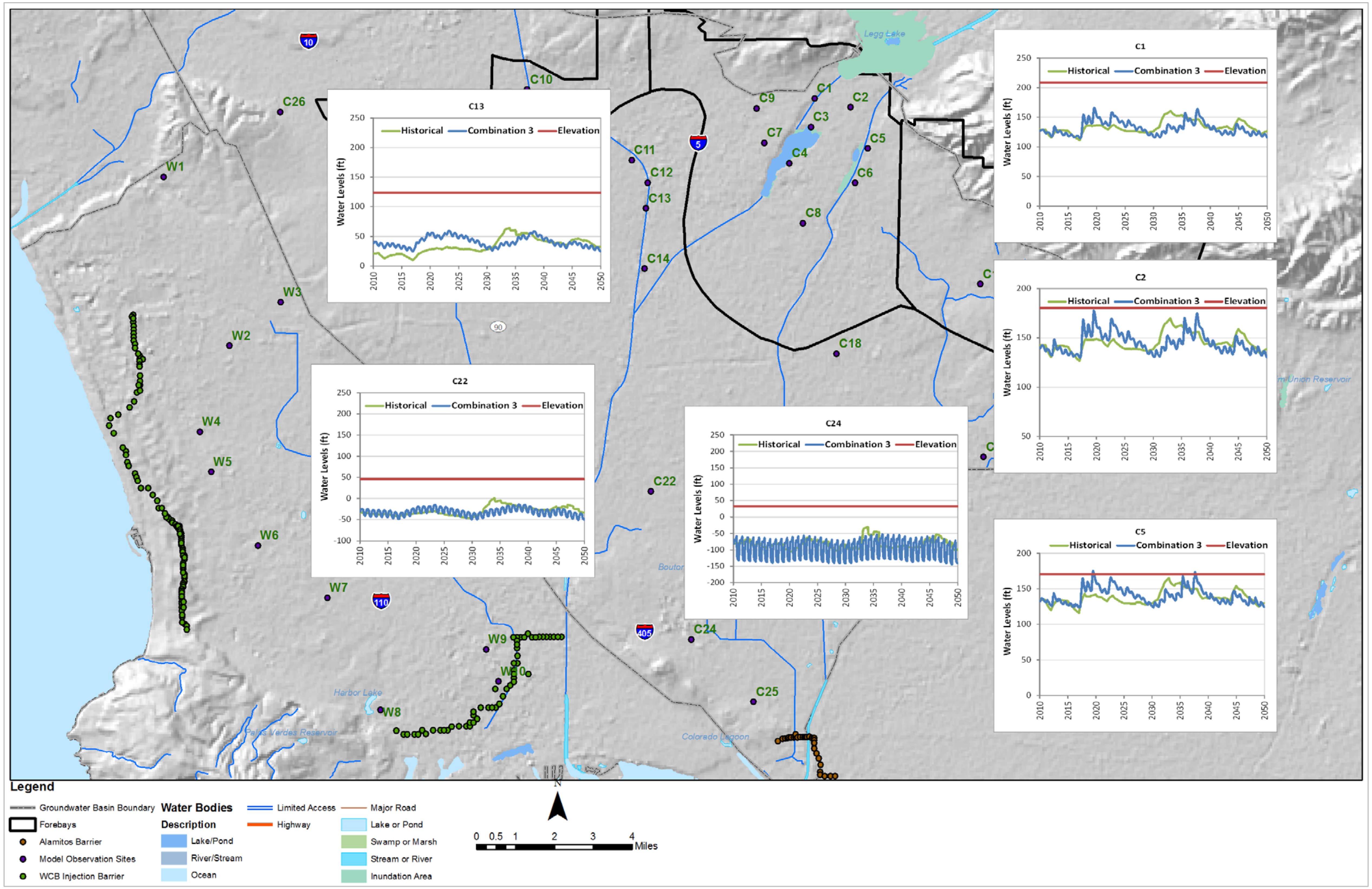

Figure 4-14. Selected Hydrographs Showing Simulated Groundwater Levels for Combination 3 Operating Conditions

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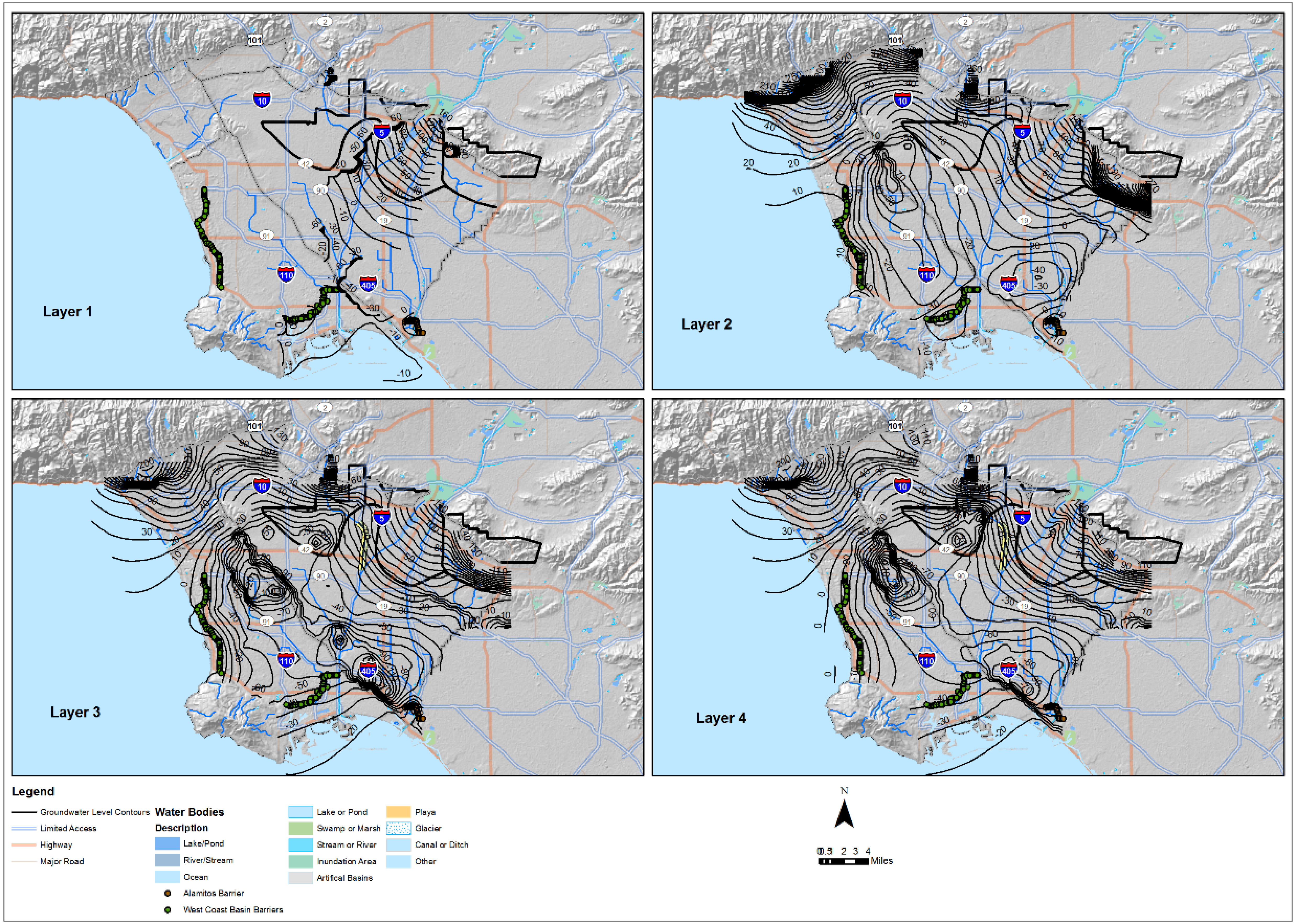

Figure 4-15. Groundwater Level Contours at the End of the Simulation Period (September 30, 2050) under Combination 3

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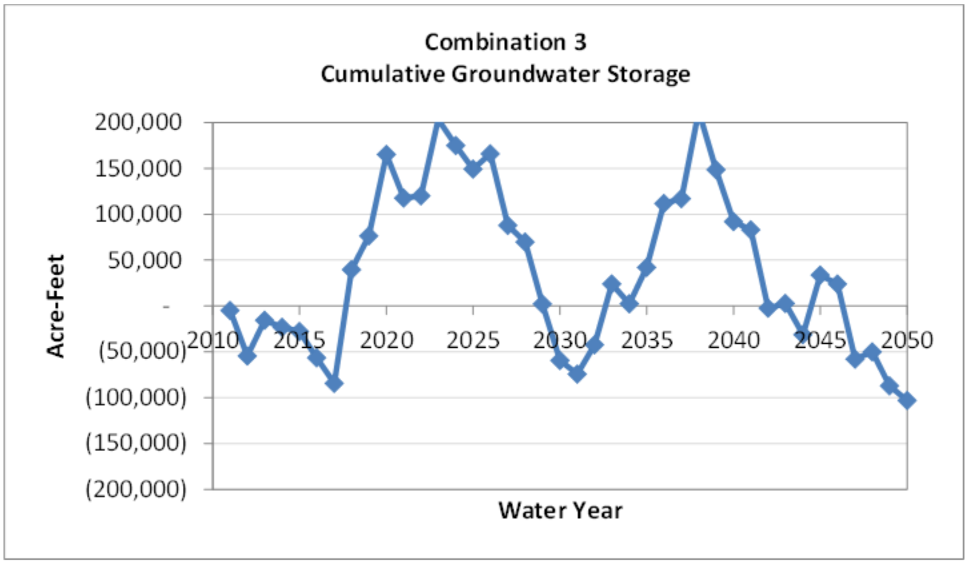

Figure 4-16. Cumulative Groundwater in Storage for the West Coast and Central Basins under Combination 3

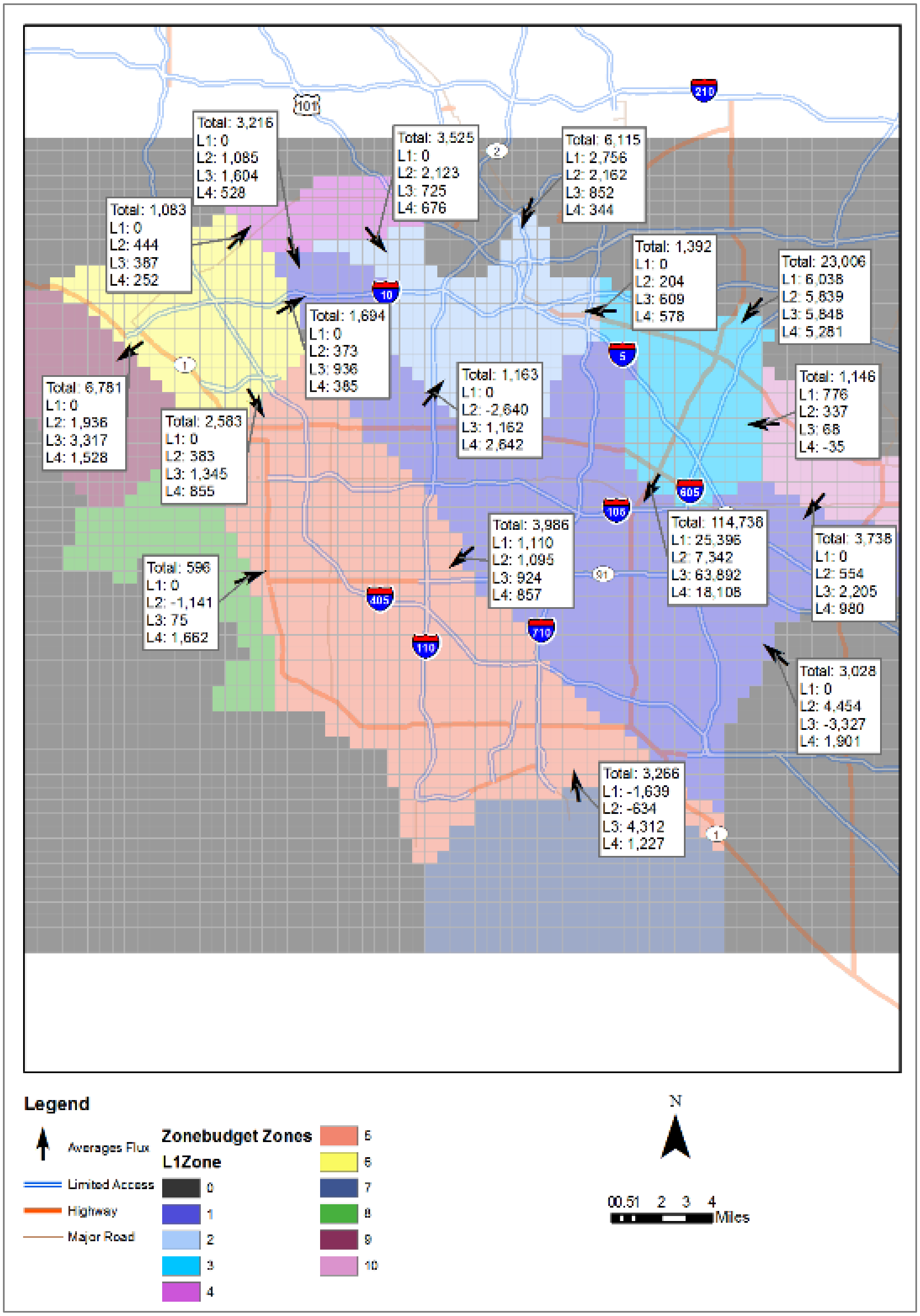

Figure 4-17. Zonebudget Summary of 10 Zones for Simulation Period (Water Years 2010 through 2050) under Combination 3

4.6 Combination 4

Combination 5 modified Combination 4 by simulating even more recharge and extraction in the Los Angeles Forebay. This effectively provided sufficient groundwater extraction to replace nearly all of the imported water use in the Central Basin. The West Coast Basin was operated at water rights, as in the baseline Combination 1 operating condition.

4.6.1 Combination 4 – Assumptions and Model Input

This operating condition builds on Combination 3. Additional replenishment in the Los Angeles Forebay is sufficient to provide for an additional 45,480 AFY of pumping, for a total of 103,250 AFY of pumping above the Central Basin APA. This modeling combination assumes development of a satellite treatment facility in the Los Angeles Forebay that will intercept sewer flows to City of Los Angeles's HWRP. A line of 50 injection wells would distribute 45,480 AFY of full advanced treated recycled water for recharge into the Los Angeles Forebay as shown in Figure 4-18.

A line of extraction wells would be developed in Los Angeles Forebay to extract 29,000 AFY for delivery to City of Los Angeles Manhattan and 99th Street wellfields, where water would be distributed to City of Los Angeles water system. The remaining quantity of recharged water not used by City of Los Angeles (16,480 AFY) would be redistributed to Central Basin pumpers. Table 3-7 shows the distribution of pumping to pumpers assumed under this operating condition. This distribution is made to offset imported water, so that nearly all imported water use in the Central Basin is eliminated under this modeling combination. All other recharge and extraction would be same as in the previous operating condition as described above in Combination 4.

4.6.2 Combination 4 – Model Simulation Results

Figure 4-19 shows selected hydrographs for model simulated groundwater levels in the Central Basin. Figure 4-20 shows groundwater level contours for each of the four model layers. Hydrographs in the Montebello Forebay show groundwater levels in wells near the Rio Hondo spreading grounds rise close to land surface during high-rate recharge events in wet years.

Figure 4-21 shows the cumulative change in storage in the West Coast and Central Basins under this modeling combination. Figure 4-22 shows the Zonebudget summary for flow between the 10 zones of the West Coast and Central Basins. Figure 4-21 shows the basins end with a significant surplus at the end of the simulation period. This surplus is largely contained in the Los Angeles Forebay, which indicates that replenishment is not equally balanced with pumping in this area. Figure 4-21 indicates that there is additional inflow from the basin boundaries, so that the pumping assigned to pumpers is not "pulling" water from the replenishment in the Los Angeles Forebay, but from adjacent areas to the Central Basin. This is also indicated by the groundwater level hydrographs.

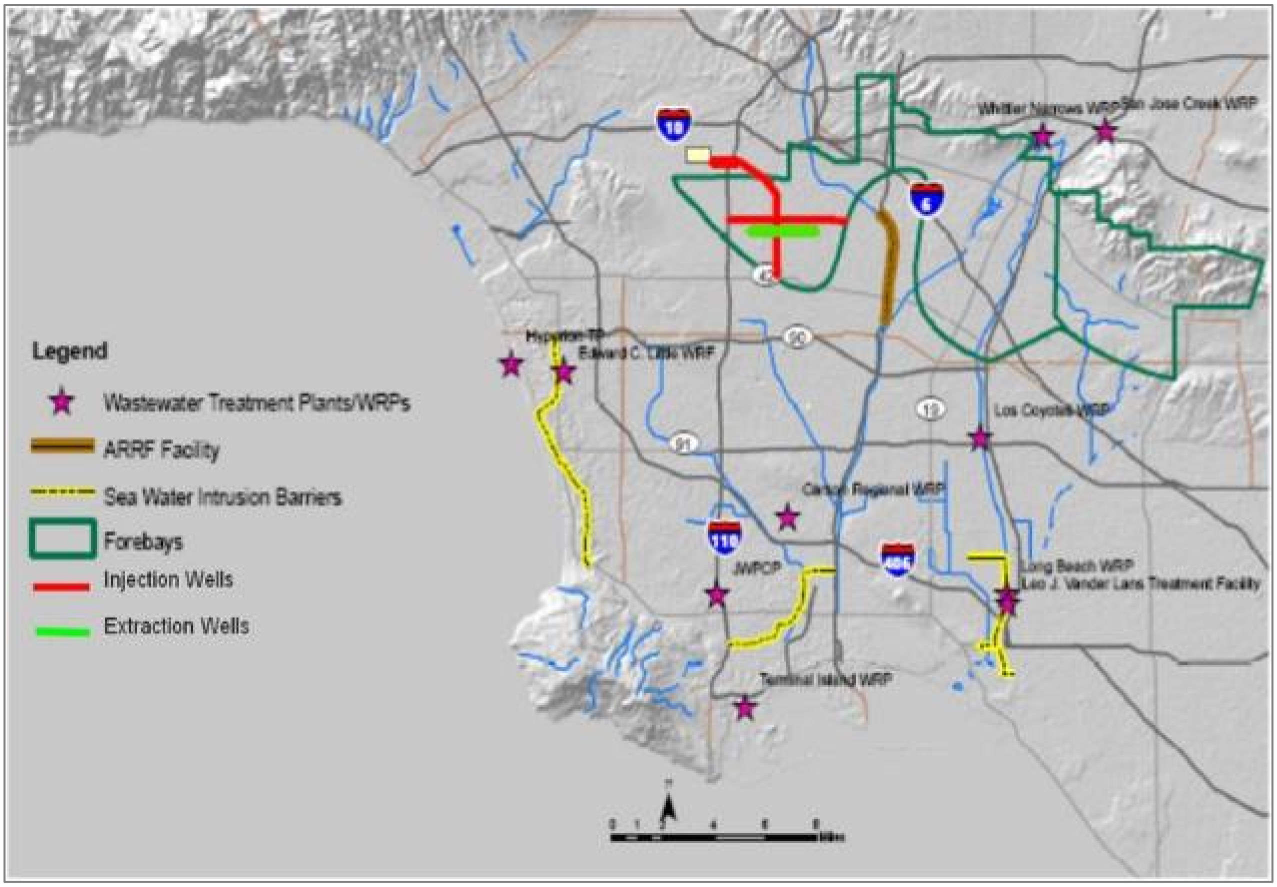

Figure 4-18. Location of Injection and Extraction Facilities in the Los Angeles Forebay Area

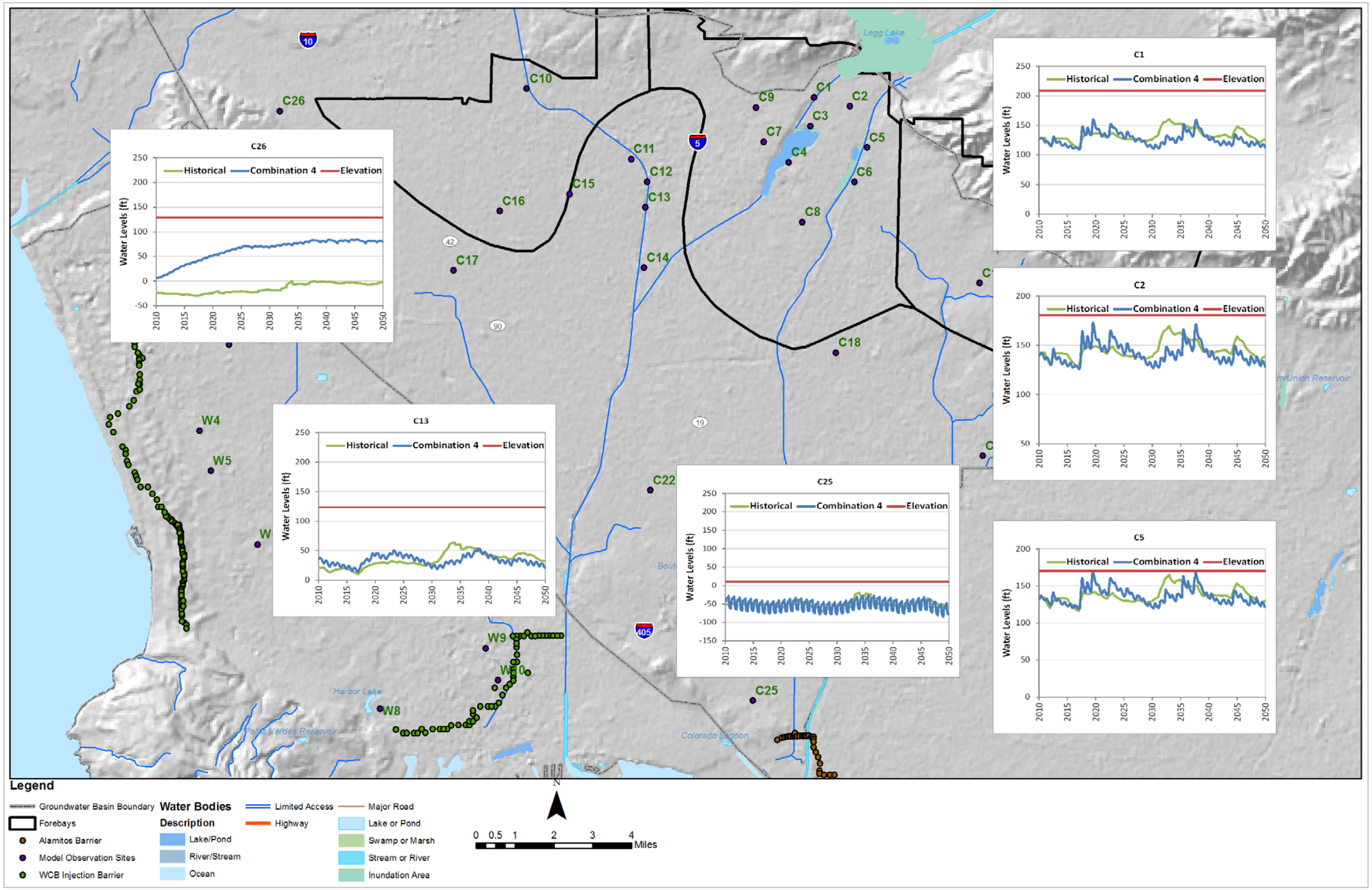

Figure 4-19. Selected Hydrographs Showing Simulated Groundwater Levels for Combination 4 Operating Conditions

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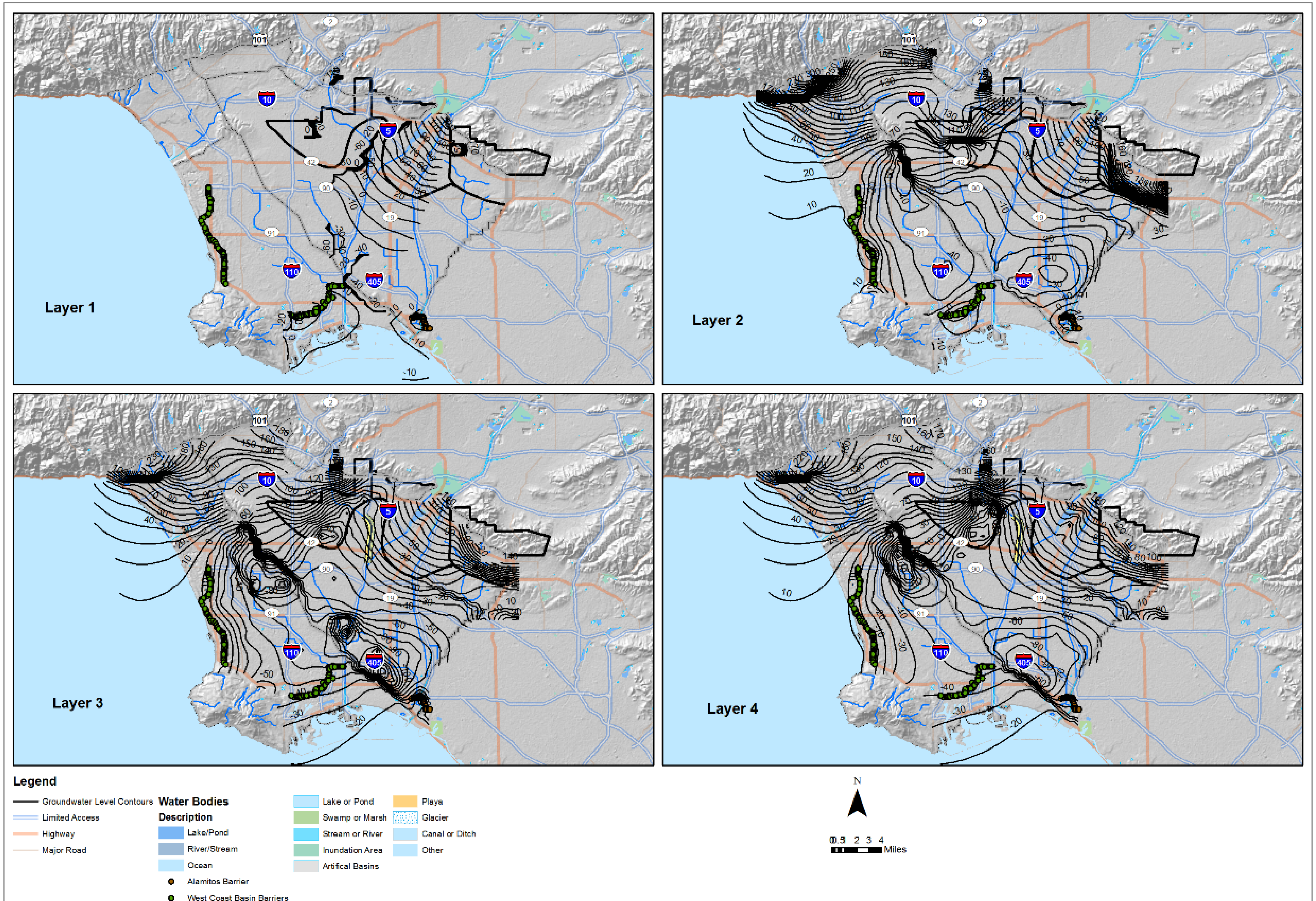

Figure 4-20. Groundwater Level Contours at the End of the Simulation Period (September 30, 2050) under Combination 4

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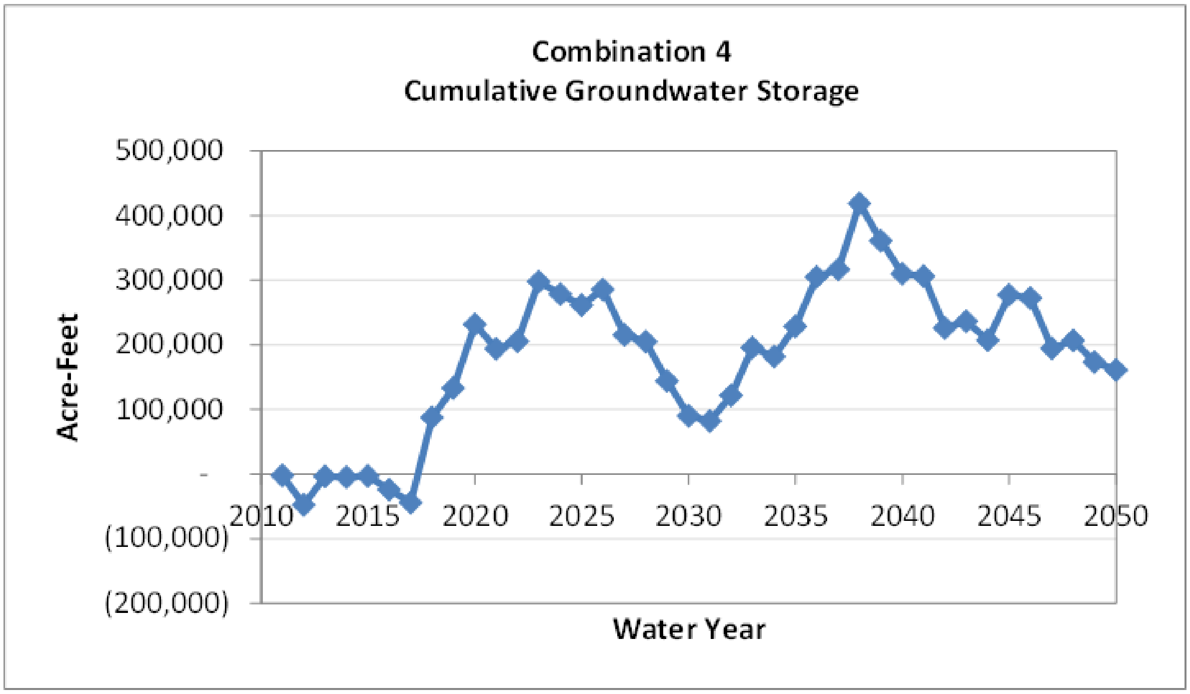

Figure 4-21. Cumulative Groundwater in Storage for the West Coast and Central Basins under Combination 4

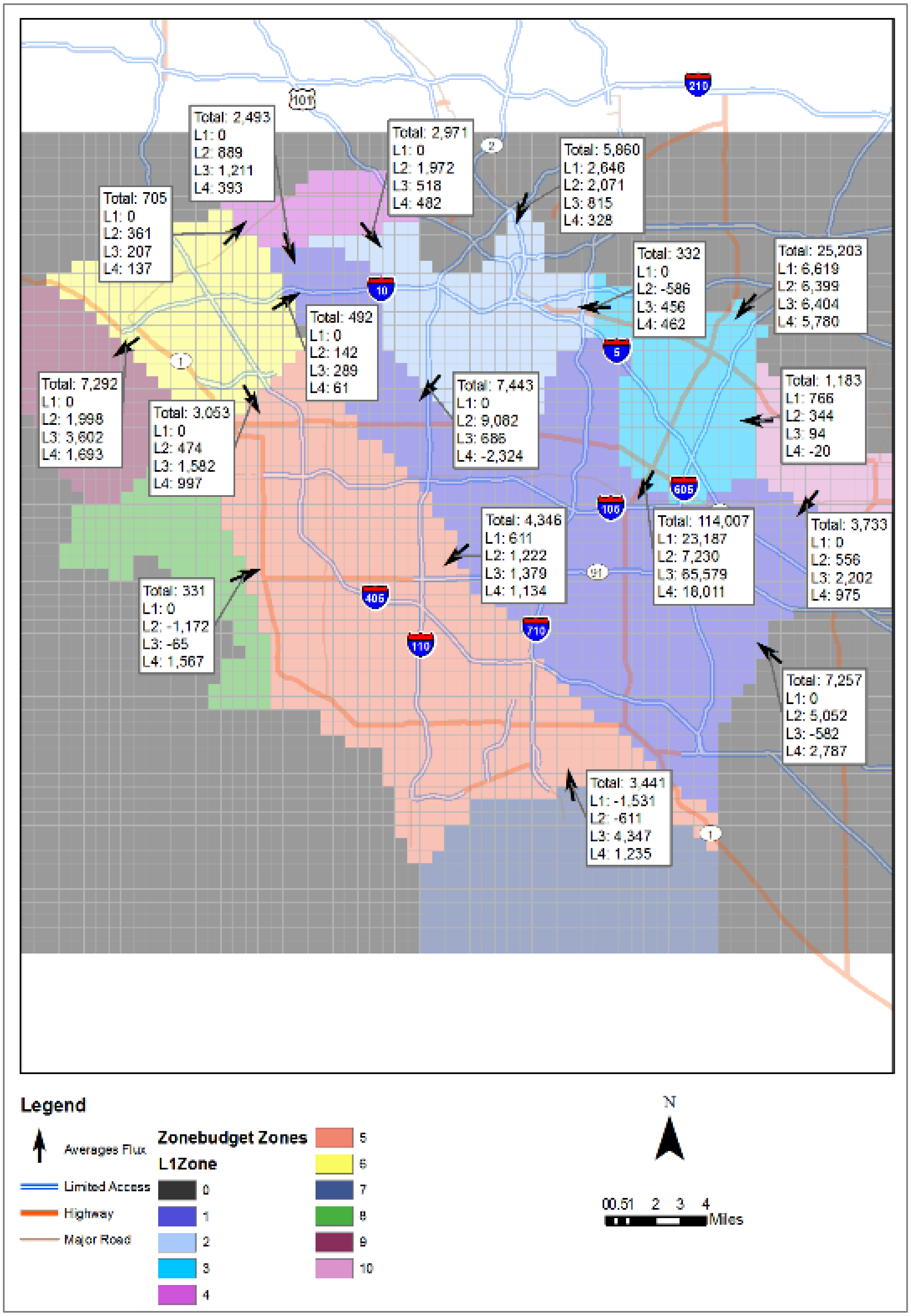

Figure 4-22. Zonebudget Summary of 10 Zones for Simulation Period (Water Years 2010 through 2050) under Combination 4

4.7 Combination 5

Combination 5 is the second operating condition simulated with the updated WRD/USGS groundwater flow model for the West Coast Basin. It assumes additional extraction of an additional 30,000 AFY above the West Coast Basin water rights. Replenishment is provided with additional recycled water injected at the existing sweater intrusion barriers, as well as a new line of inland injection wells. The Central Basin was operated at the APA, as in the baseline, Combination 1, operating condition.

4.7.1 Combination 5 – Assumptions and Model Input

In the Carson/Torrance area along Normandie Boulevard there is a potential capacity to inject between 15,000 to 25,000 AFY of recycled water. Under this modeling combination, 15,000 AFY of recycled water was considered for injection in this area using a series of new inland injection wells. In addition, injection to the WCBBP would be increased by 7,500 AFY and injection to the DGBP would be increased by 6,500 to 7,500 AFY, so that the overall additional replenishment would be increased by 30,000 AFY over the West Coast Basin water rights (that is, up to 94,468 AFY). The source of this replenishment supply would likely be a new AWTF at the LACSD JWPCP in Carson. Section 5.0 (Figure 5-2) shows the line of 14 injection wells that would be installed under this operating condition. As mentioned in Section 3.2.4 (Scenario WCB-B1), it is assumed that City of Torrance, CWSC, and the City of Los Angeles would pump a total of 30,000 AFY from wells at or near their existing wells to offset their imported water demands. All other pumping is the same as in the baseline Combination 1 operating condition, including the saline plume containment/removal pumping for the West Coast Basin.

4.7.2 Combination 5 – Model Simulation Results

Figure 4-23 shows selected hydrographs for model simulated groundwater levels in the Central Basin. Figure 4-24 shows groundwater level contours for each of the four model layers. Hydrographs show that groundwater levels are very similar to groundwater levels in the baseline Combination 1 operating condition.

Figure 4-25 shows the cumulative change in storage in the West Coast and Central Basins under this modeling combination. Figure 4-26 shows the Zonebudget summary for flow between the 10 zones of the West Coast and Central Basins. Figure 4-25 shows a slight storage deficit in the basins over the simulation period similar to the other combinations This is also indicated by the groundwater level hydrographs, which end relatively close to the levels from which they started.

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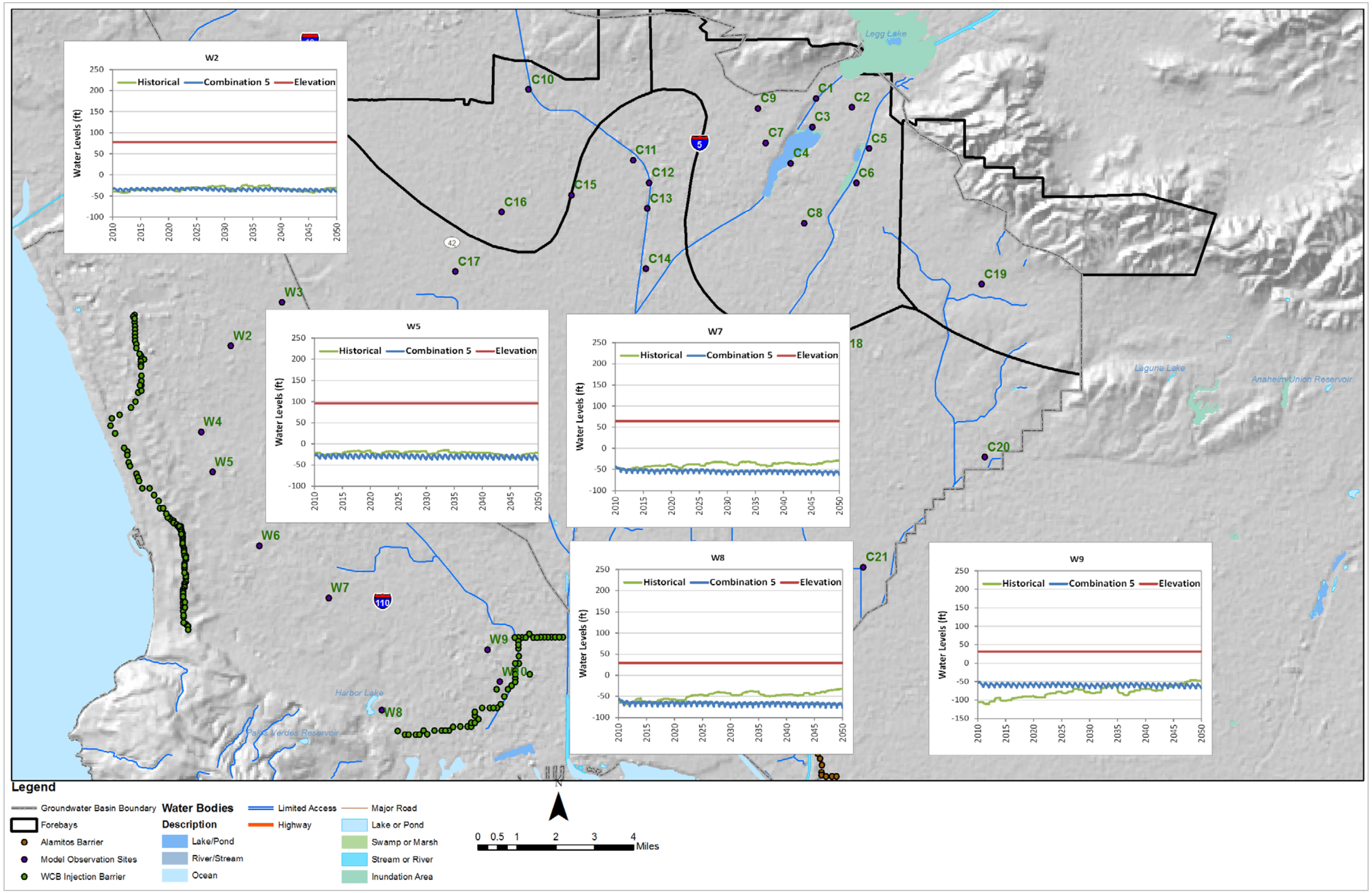

Figure 4-23. Selected Hydrographs Showing Simulated Groundwater Levels for Combination 5 Operating Conditions

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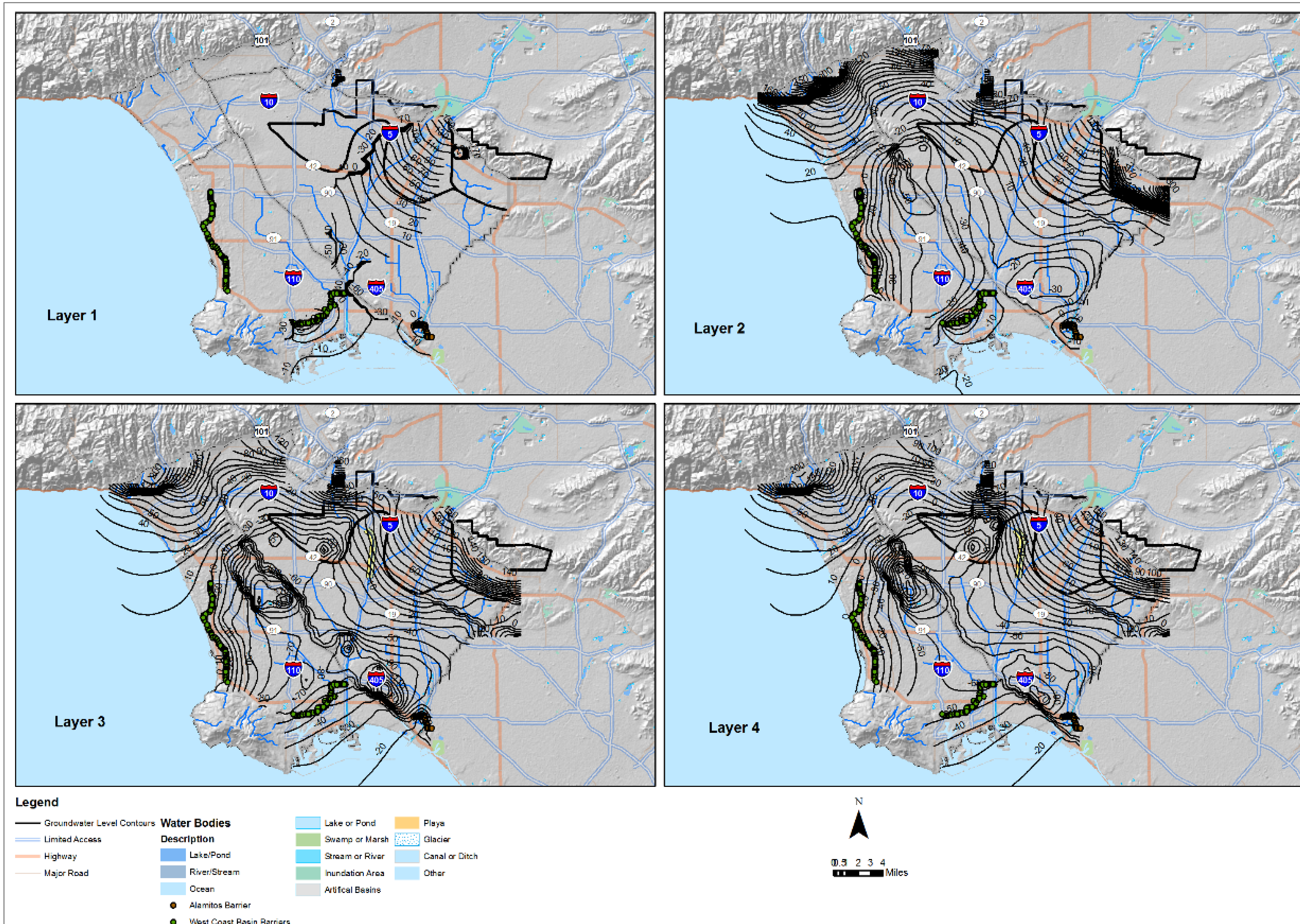

Figure 4-24. Groundwater Level Contours at the End of the Simulation Period (September 30, 2050) under Combination 5

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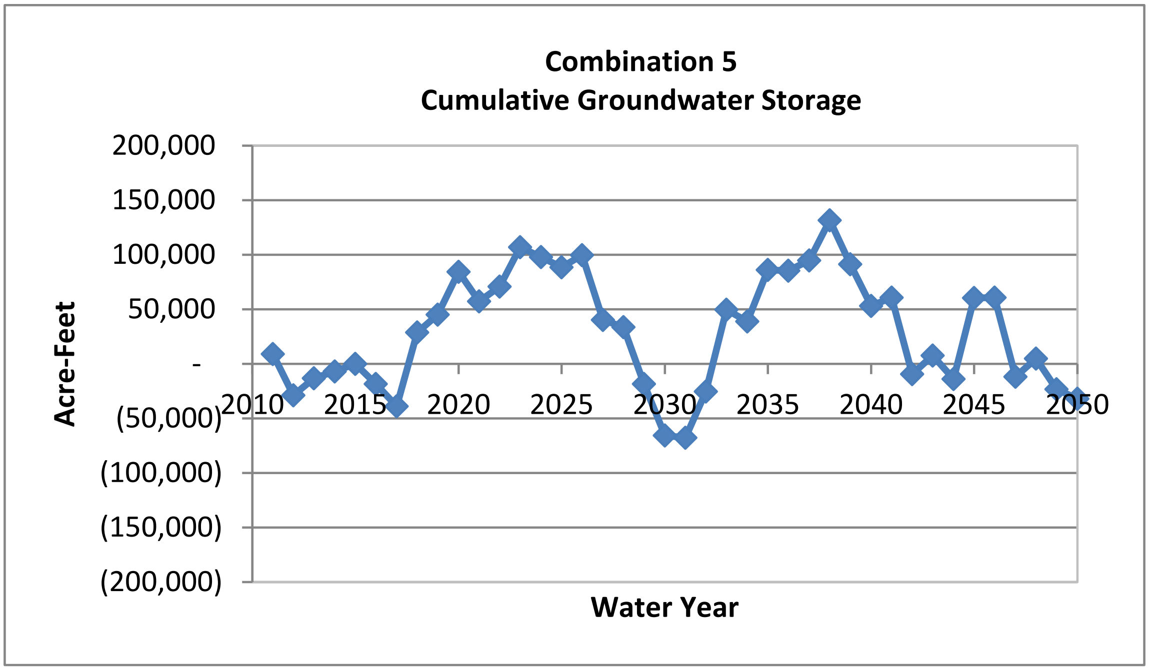

Figure 4-25. Cumulative Groundwater in Storage for the West Coast and Central Basins under Combination 5

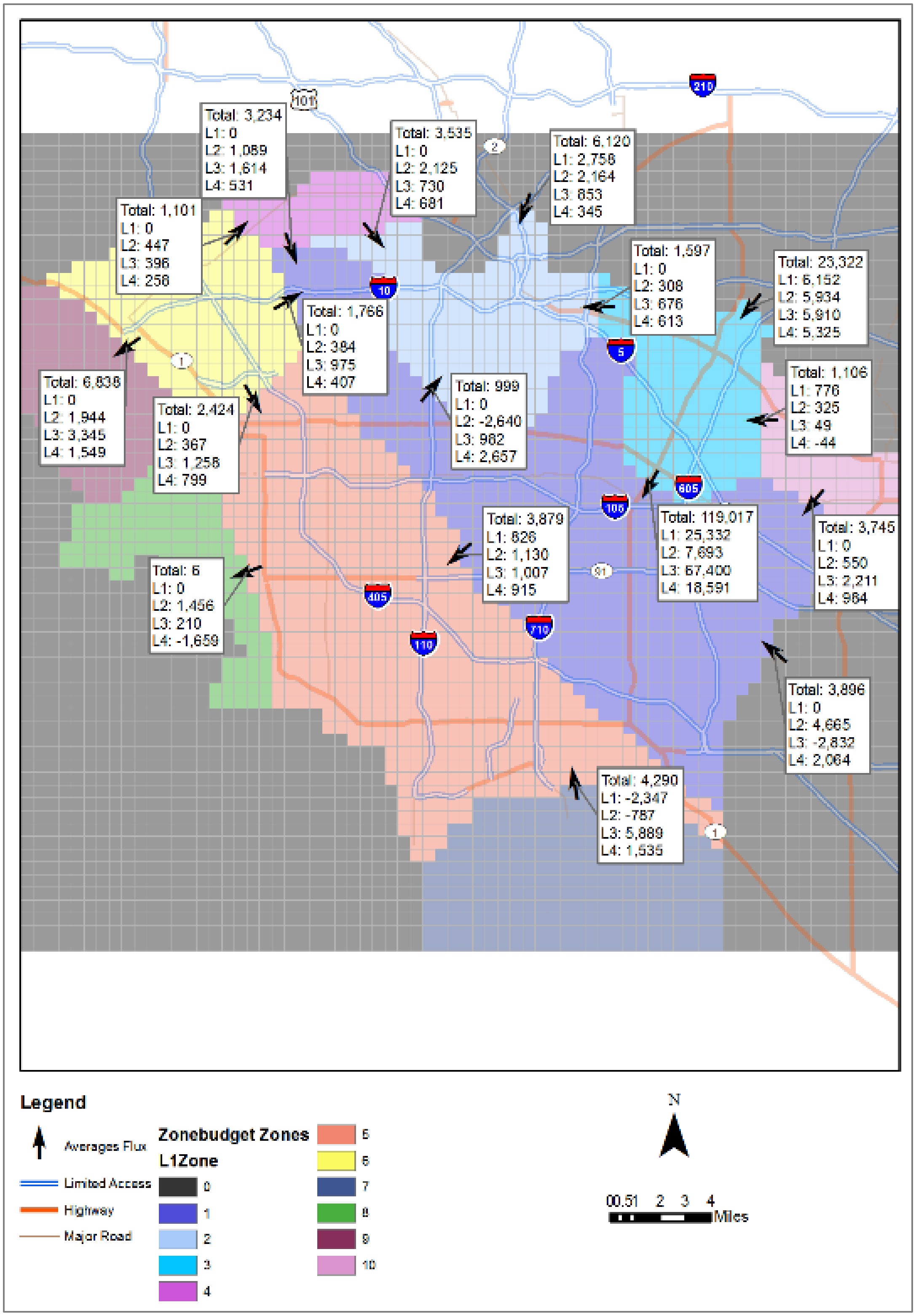

Figure 4-26. Zonebudget Summary of 10 Zones for Simulation Period (Water Years 2010 through 2050) under Combination 5

4.8 Combination 6

Combination 6 is for an operating condition in which both the West Coast and Central Basins are pumped at levels above the water rights and APA, respectively.

4.8.1 Combination 6 – Assumptions and Model Input

This operating condition was a combination of pumping 57,700 AFY over APA in the Central Basin (which is the same as the conditions used in Combination 4) and 30,000 AFY over water rights in the West Coast Basin. Replenishment of West Coast Basin is accomplished in a similar manner as described in Combination 6 (under Scenario WCB-B1), but varied by increasing the amount of water replenished at the new inland injection wells to a total of 25,000 AFY, while injecting 35,000 AFY into the WCBBP and 10,000 AFY into the DGBP. Replenishment for the Central Basin is accomplished in the same manner as described Combination 4 (Scenario CB-B1).

4.8.2 Combination 6 – Model Simulation Results

Figure 4-27 shows selected hydrographs for model simulated groundwater levels in the Central Basin. Figure 4-28 shows groundwater level contours for each of the four model layers at the end of the simulation. Hydrographs show that groundwater levels are very similar to groundwater levels in for the two Central Basin and West Coast Basin operating conditions on which this modeling combination is based.

Figure 4-29 shows the cumulative change in storage in the West Coast and Central Basins under this modeling combination. Figure 4-30 shows the Zonebudget summary for flow between the 10 zones of the West Coast and Central Basins. Figure 4-29 shows the basins in a slight storage deficit are balanced over the simulation period similar to most of the other combinations. This is also indicated by the groundwater level hydrographs, which end relatively close to the levels from which they started.

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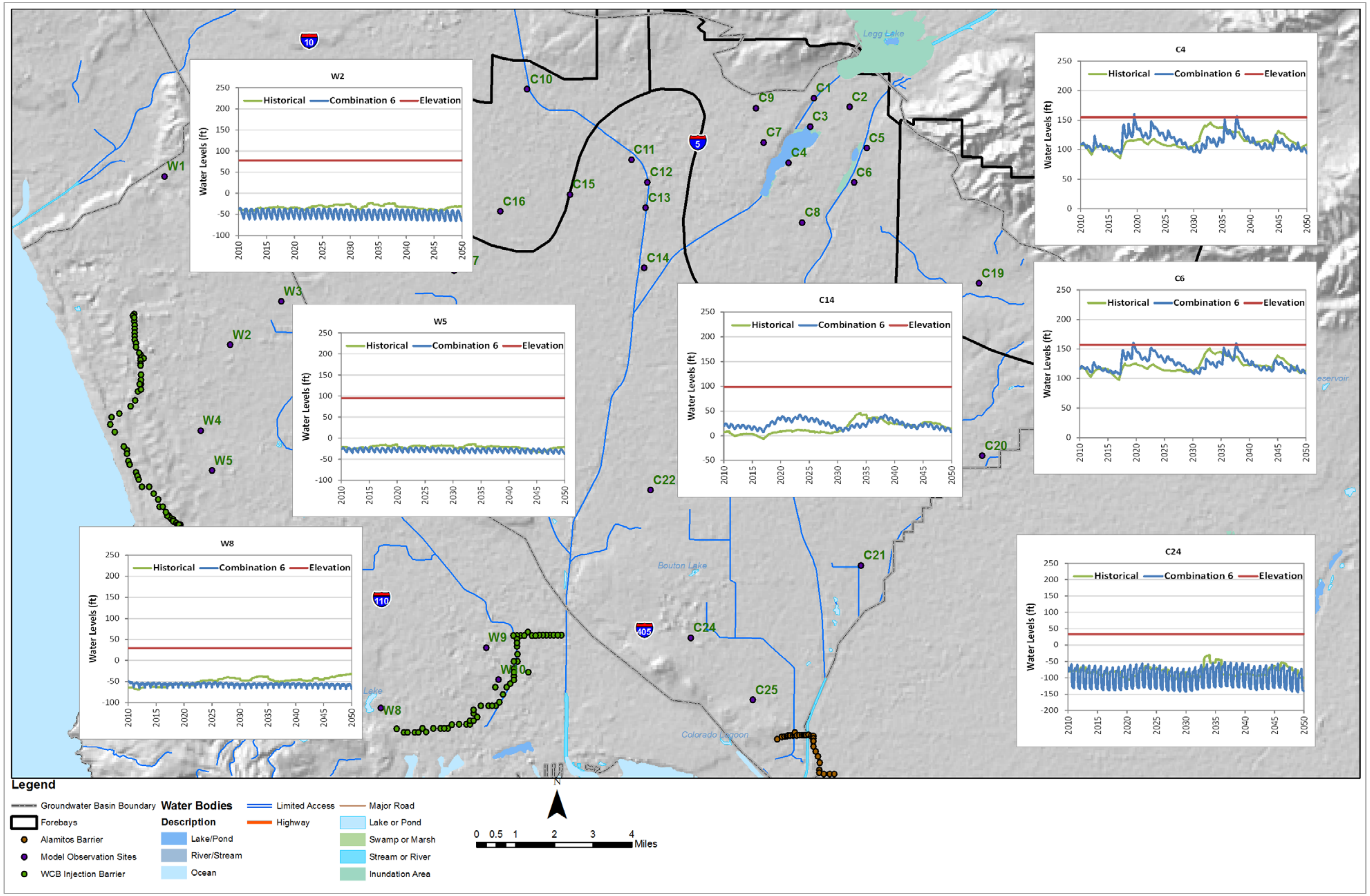

Figure 4-27. Selected Hydrographs Showing Simulated Groundwater Levels for Combination 6 Operating Conditions

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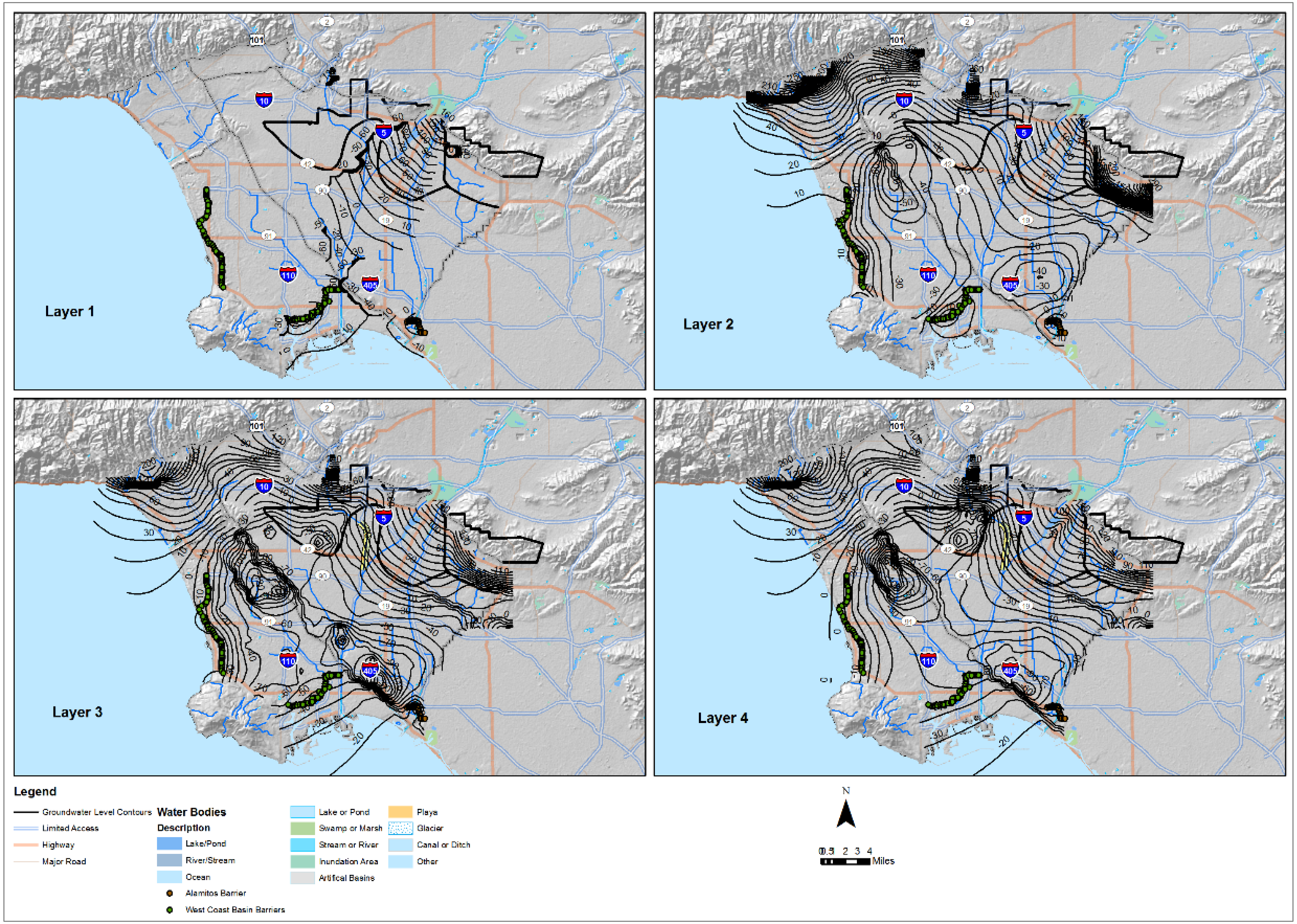

Figure 4-28. Groundwater Level Contours at the End of the Simulation Period (September 30, 2050) under Combination 6

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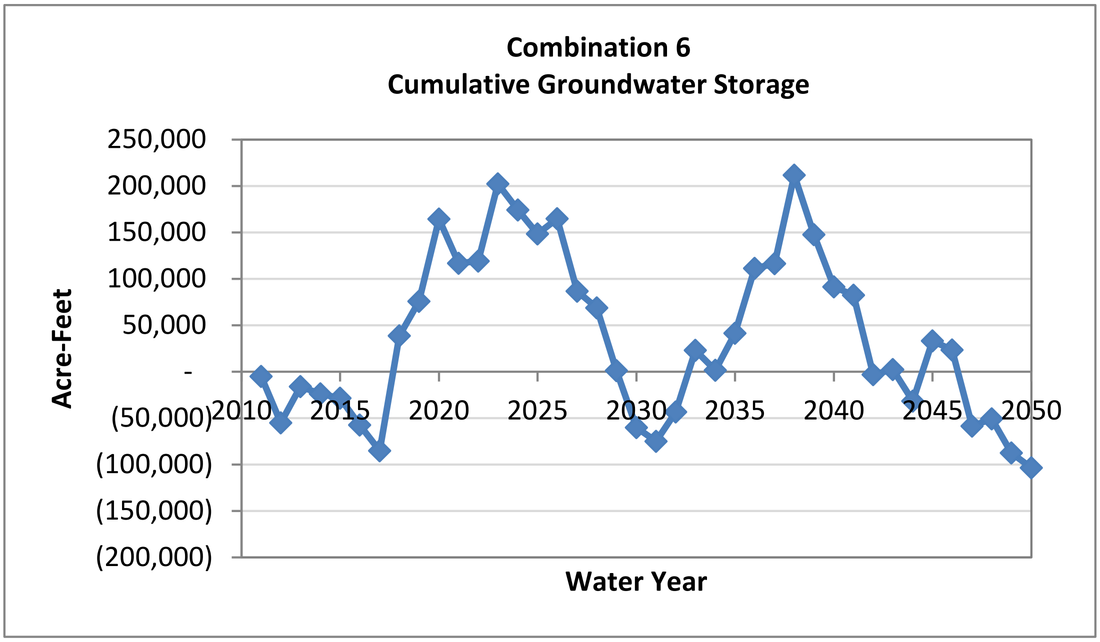

Figure 4-29. Cumulative Groundwater in Storage for the West Coast and Central Basins under Combination 6

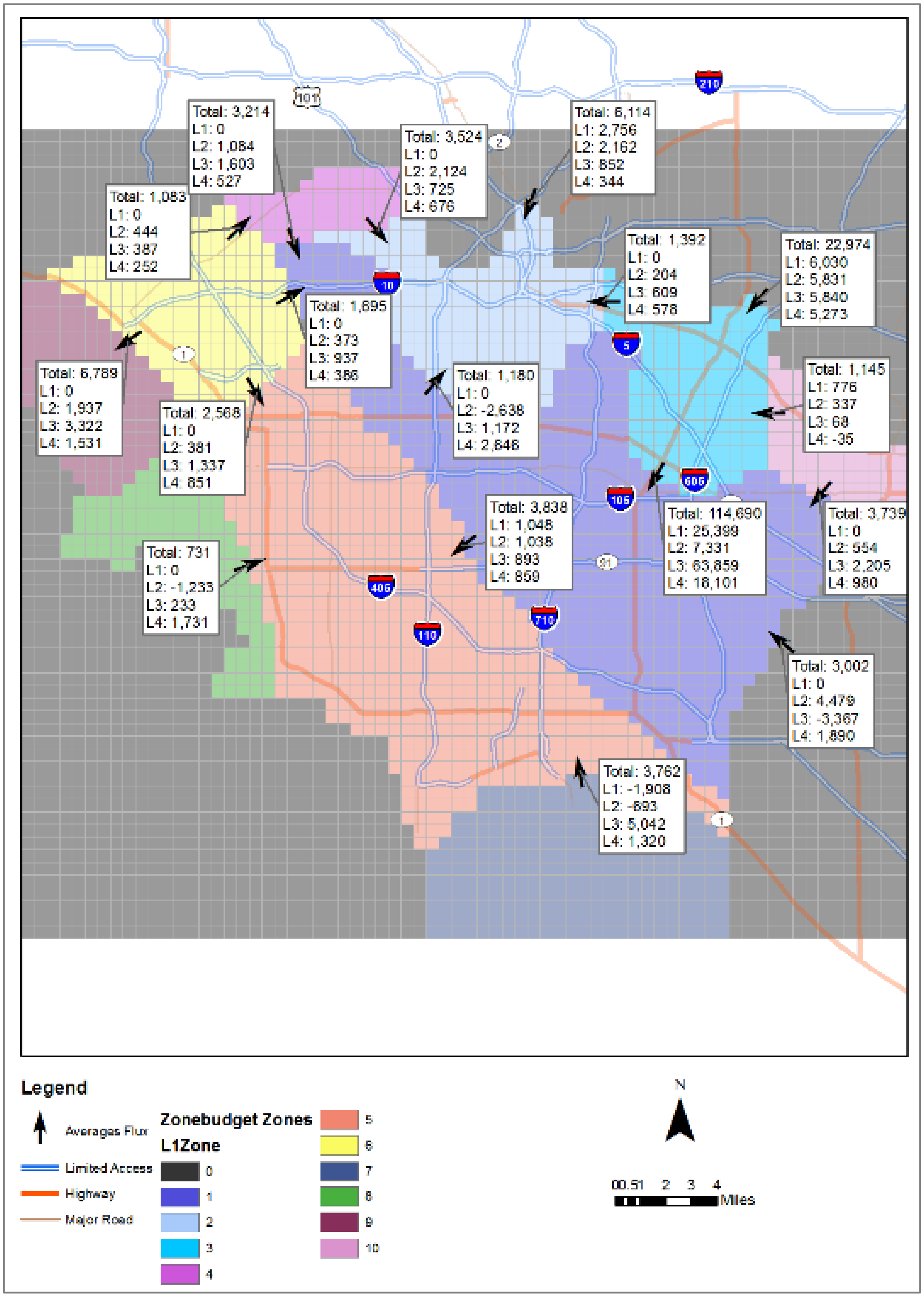

Figure 4-30. Zonebudget Summary of 10 Zones for Simulation Period (Water Years 2010 through 2050) under Combination 6

SECTION 5

Formulation and Evaluation of Alternatives

5.1 Groundwater Basins Master Plan Components

GBMP alternatives were developed by combining GBMP projects to provide sufficient replenishment to meet the water rights in the West Coast Basin and the APA in the Central Basin (Concept A), or exceed these adjudications, consistent with the recent Judgment amendments (Concept B). The projects are combined into GBMP alternatives, which are crafted to satisfy the target supply yields for the planning scenarios described in Section 3.0. Thus the alternatives with common supply yields can be directly compared against one another. Table 5-1 indicates the relationships between the GBMP Concepts, Scenarios and Alternatives.

Projects consist of facility components, such as treatment, conveyance (pump stations and pipelines), brine disposal, extraction wells and production wells. Each project includes a unique supply and recharge method and location. The recycled water and stormwater supplies considered, which were discussed in Section 3.0, include:

- SJCWRP
- LCWRP
- LBWRP
- TIWRP
- ECLWRF
- JWPCP
- San Gabriel River/Rio Hondo
- Los Angeles River

Recharge methods include surface spreading and injection. The potential locations, which were discussed in Section 3.0, include:

- MFSG
- ABP
- WCBBP
- DGBP
- New injection wells in both basins

Table 5-1. GBMP Concepts, Scenarios and Alternatives

Basin	Concept	Scenario (based on Pumping Conditions)	Alternative (based on Replenishment Supplies)	Description
West Coast Basin	A (Meet Water Rights)	Scenario WCB-A1		Pump full water rights per 3 scenarios: WCB-A1a, WCB-A1b, WCB-A1c; Shift oil companies' non-potable demands from groundwater to recycled water, and shift this groundwater pumping to municipal purveyors Assume 100% RWC at injection barriers (WCBBP and DGBP).
		Scenario WCB-A1a		Distribute pumping to major water rights holders (Torrance, CWSC, Golden State Water Company, Manhattan Beach, El Segundo, Inglewood, and Lomita) and City of Los Angeles extracts their adjudicated rights.
		Scenario WCB-A1b		Distribute to major water rights holders and to the City of Los Angeles.
		Scenario WCB-A1c		Regional Partnership – Includes **containment/remediation of saline plume**. Assumed pumping of 15,000 AFY of desalinated water by CWSC-Hawthorne, City of Torrance and City of Los Angeles.
			Alt. WCB-A1	Expansion of existing barrier recycled water supplies by 18,000 AFY (to a total of 40,000 AFY) to meet pumping at total water rights of 64,468 AFY. Additional replenishment includes injection of an additional 15,500 AFY beyond current recycled water supply capacity of ECLWRF to WCBBP and replacement of imported blend water at DGBP.
		Scenario WCB-A2		Reduce or eliminate injection in Lower San Pedro aquifer by balancing pumping in Silverado aquifer.
		Scenario WCB-A3		Inject surplus imported water only when available (assume 2 out of 10 years) and reduce or eliminate injection into Lower San Pedro aquifer during the remaining (8) years.
		Scenario WCB-A4		Pump and treat from Lower San Pedro aquifer.
	B (Above Water Rights)	Scenario WCB-B1		Pump additional **30,000 AFY above water rights** – Assume this additional pumping is distributed to CWSC, City of Torrance, and City of Los Angeles; otherwise all other pumping is the same as Scenario WCB-A1c. Increase injection at DGBP, WCBBP and using new inland injection wells (assuming 100% RWC); Includes containment/remediation of saline plume.
			Alt. WCB-B1	Expansion of up to 48,000 AFY of additional replenishment supply (18,000 AFY to meet existing water rights and 30,000 AFY for expanded pumping), including use of 17,000 AFY of JWPCP effluent to new inland injection wells (15,000 AFY) and to the DGBP (2,000 AFY), along with 13,000 AFY to the DGBP from the TIWRP AWTF

Table 5-1. GBMP Concepts, Scenarios and Alternatives

Basin	Concept	Scenario (based on Pumping Conditions)	Alternative (based on Replenishment Supplies)	Description
Central Basin	A (Meet APA)	Scenario CB-A1		Pump full APA by distributing additional pumping similarly to recent 10 years of extraction and allocate unused water rights to pumpers with imported water usage. Assume 100% RWC at injection barrier (ABP). *Increase replenishment by 10,000 AFY using **SJCWRP** effluent for **spreading** at the MFSG.*
			Alt. CB-A1a	SJCWRP-100% tertiary (10,000 AFY)
			Alt. CB-A1b	SJCWRP-100% full advanced treated (10,000 AFY)
			Alt. CB-A1c	SJCWRP-50% full advanced treated (5,000 AFY) / 50% tertiary (5,000 AFY)
			Alt. CB-A1d	SJCWRP-100% NF/UV/AOP (10,000 AFY)
			Alt. CB-A1e	SJCWRP-50% NF/UV/AOP (5,000 AFY) / 50% tertiary (5,000 AFY)
			Alt. CB-A1f	SJCWRP-ozone/BAC/GAC/UV (10,000 AFY)
		Scenario CB-A2		Pump full APA by distributing additional pumping similarly to recent 10 years of extraction and allocate unused water rights to pumpers with imported water usage. Assume 100% RWC at injection barrier (ABP). *Increase replenishment by 10,000 AFY using **SJCWRP and LCWRP** effluent for **spreading** at MFSG.*
			CB-A2a	SJCWRP-100% tertiary (5,000 AFY) / LCWRP-100% full advanced treated (5,000 AFY)
			CB-A2b	SJCWRP (5,000 AFY) and LCWRP (5,000 AFY) - 100% full advanced treated
		Scenario CB-A3		Pump full APA by distributing additional pumping similarly to recent 10 years of extraction and allocate unused water rights to pumpers with imported water usage. Assume 100% RWC at injection barrier (ABP). *Increase replenishment by 10,000 AFY using **SJCWRP** effluent for **spreading** at MFSG and **LCWRP** full advanced treated effluent for **injection** in Montebello Forebay.*
			CB-A3a	SJCWRP-100% tertiary (5,000 AFY) / LCWRP-100% full advanced treated (5,000 AFY)
			CB-A3b	SJCWRP (5,000 AFY) & LCWRP (5,000 AFY) - 100% full advanced treated

Table 5-1. GBMP Concepts, Scenarios and Alternatives

Basin	Concept	Scenario (based on Pumping Conditions)	Alternative (based on Replenishment Supplies)	Description
		Scenario CB-A4		Pump full APA by distributing additional pumping similarly to recent 10 years of extraction and allocate unused water rights to pumpers with imported water usage. Assume 100% RWC at injection barrier (ABP). *Increase replenishment by 10,000 AFY using **SJCWRP** effluent for **spreading** at MFSG and **stormwater capture in Los Angeles Forebay using ARRF project.***
			CB-A4a	SJCWRP-100% tertiary (10,000 AFY), ARRF project (5,000 AFY)
			CB-A4b	SJCWRP-100% full advanced treated (10,000 AFY), ARRF project (5,000 AFY)
			CB-A4c	SJCWRP-50% full advanced treated (5,000 AFY) / 50% tertiary (5,000 AFY), ARRF project (5,000 AFY)
	B (Above APA)	Scenario CB-B1		Maximize use of stormwater capture from **San Gabriel and Los Angeles Rivers** (22,000 AFY) and recharge of available recycled water from **SJCWRP and LCWRP** (66,800 AFY) in the Montebello Forebay providing for increased pumping of **57,770 AFY above the APA.**
			CB-B1a	SJCWRP-100% tertiary / LCWRP-100% full advanced treated, GBOP project, ARRF project
			CB-B1b	SJCWRP & LCWRP-100% full advanced treated, GBOP project, ARRF project
			CB-B1c	SJCWRP-50% full advanced treated / 50% tertiary / LCWRP-100% full advanced treated, GBOP project, ARRF project
		Scenario CB-B2		Injection of 45,480 AFY of full advanced treated-treated effluent from **new satellite AWTF** at new line of extraction wells in Los Angeles Forebay, in conjunction with maximizing stormwater capture and recycled water use (per Scenario CB-B1) allows for increased pumping in the Montebello and Los Angeles Forebays to a total of **103,270 AFY above the APA.**
			CB-B2a	New AWTF, SJCWRP-100% tertiary / LCWRP-100% full advanced treated, GBOP project, ARRF project
			CB-B2b	New AWTF, SJCWRP and LCWRP-100% full advanced treated, GBOP project, ARRF project

Notes:

% = percent
Gray-shaded, West Coast Basin scenarios are not reflected in GBMP modeling nor carried forward into the formulation of GBMP alternatives.

The GBMP alternatives comprise the projects listed in Table 5-2. The projects identified for each basin are described below.

Table 5-2. List of GBMP Projects

ID	Replenishment Supply	Replenishment Location/Method	Annual Average Replenishment (AFY)
West Coast Basin			
WCB-P1	ECLWRF AWT	WCBBP	15,500 to 23,000
WCB-P2	JWPCP AWT	Mid-basin injection wells	15,000
WCB-P3	JWPCP AWT	DGBP	2,000
Central Basin			
CB-P1	SJCWRP – 100% Tertiary	MFSG	5,000 – 17,600
CB-P2	SJCWRP – 100% AWT	MFSG	5,000 – 17,600
CB-P3	SJCWRP – 50% AWT/50% Tertiary	MFSG	10,000
CB-P4	SJCWRP – 100% NF	MFSG	10,000
CB-P5	SJCWRP – 50% NF/50% Tertiary	MFSG	10,000
CB-P6	SJCWRP – Ozone/BAC/GAC/UV	MFSG	10,000
CB-P7	LCWRP AWT	MFSG	5,000
CB-P8	LCWRP full advanced treated	Injection at Montebello Forebay	5,000 – 9,500
CB-P9	Los Angeles River	ARRF at Los Angeles Forebay	5,000
CB-P10	San Gabriel River/Rio Hondo	MFSG	17,000
CB-P11	SJCWRP – 100% AWT	Injection at Montebello Forebay	8,690
CB-P12	New Satellite AWT (MBR/RO/AOP)	Los Angeles Forebay injection wells	45,480

Note:

ID = Identification number

5.1.1 West Coast Basin

The West Coast Basin projects consist of injection of various recycled water supplies. Four projects are defined in this section:

- WCB-P1: ECLWRF to WCBBP
  - P1a: 15,500 AFY
  - P1b: Additional 7,500 AFY
- WCB-P2: JWPCP to Mid-basin, 15,000 AFY
- WCB-P3: JWPCP to DGBP, 2,000 AFY

5.1.1.1 WCB-P1: ECLWRF to WCBB

Two project sizes are defined for this project. The initial project (**WCB-P1a**) would expand injection at WCBBP by 15,500 AFY from 17,000 AFY to 32,500 AFY with secondary effluent from HWRP conveyed to an expanded AWTF at ECLWRF and new offsite AWTF (Figure 5-1). The AWTF product water would be conveyed to the existing WCBBP connection point. The initial project would be expanded for an additional 7,500 AFY (**WCB-P1b**) to 40,000 AFY and is based on the estimated maximum WCBBP injection capacity using existing injection wells (Appendix D). The initial project size to meet 32,500 AFY of injection is designed to meet projected geographical distribution of pumping in the basin within existing water rights. The expanded project size is based on the maximum potential sustainable injection of 40,000 AFY, again paired with the projected geographical distribution of pumping in the area, beyond existing water rights.

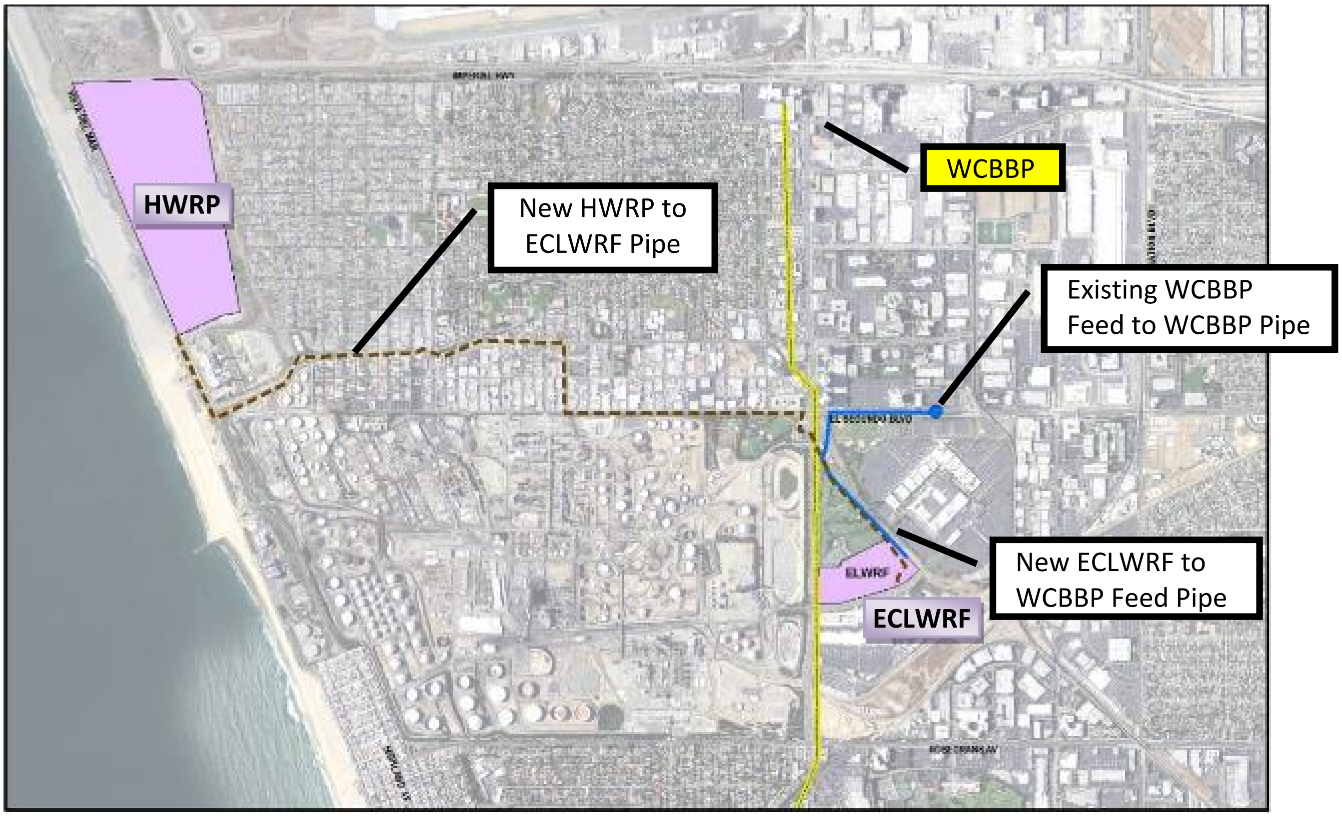

Figure 5-1. WCB-P1: ECLWRF to WCBBP

The initial project of 15,500 AFY includes the following facilities:

- **Supply:** 19,400 AFY of secondary effluent from HWRP to produce 15,500 AFY of ECLWRF AWT product water
- **Treatment:** 10.0-mgd AWT expansion onsite at ECLWRF (estimated maximum site capacity) and new 3.8-mgd AWT offsite adjacent to the ECLWRF
- **Brine disposal:** 2.4-mgd flow increase to HWRP outfall
- **Conveyance:**
  - HWRP to ECLWRF: New pipeline (16,400 feet, 36-inch) and pump station (1,010 horsepower [hp])
  - ECLWRF to WCBBP: New pipeline (4,600 feet, 30-inch) and pump station (630 hp)
- **Recharge Method:** Injection at WCBBP within existing system capacity
- **Production Wells:** Pumpers will activate wells or install new wells, including treatment, as required to meet demands

The expanded project of 7,500 AFY includes the following facilities:

- **Supply:** 9,375 AFY of secondary effluent from HWRP to produce 7,500 AFY of ECLWRF AWT product water
- **Treatment:** 6.7-mgd AWT offsite expansion near ECLWRF
- **Brine disposal:** 1.2-mgd flow increase to HWRP outfall
- **Conveyance:**
  - HWRP to ECLWRF: Upsize WCB-P1 pipeline (16,400 feet) from 36-inch to 42-inch diameter and expand pump station by 490 hp.
  - ECLWRF to WCBBP: Upsize WCB-P1 pipeline (4,600 feet) from 30-inch to 36-inch diameter and expand pump station by 175 hp.
- **Recharge Method:** Injection at WCBBP within existing system capacity
- **Production Wells**: Pumpers will activate wells or install new wells, including treatment, as required to meet demands

5.1.1.2 WCB-P2: JWPCP to Mid-basin (15,000 AFY)

This project would consist of constructing a new AWTF at JWPCP to treat secondary effluent from the JWPCP and new conveyance facilities to new inland injection wells, centrally located within the West Coast Basin (Figure 5-2). This project includes the following facilities:

- **Supply:** 18,750 AFY of secondary effluent from JWPCP to produce 15,000 AFY of JWPCP AWT product water
- **Treatment:** 13.4-mgd AWT at JWPCP
- **Brine disposal:** 2.4 mgd through existing JWPCP outfall
- **Conveyance:** JWPCP AWTF to Mid-basin injection wells: New pipeline (25,600 feet, 30-inch) and pump station (220 hp)
- **Recharge Method:** Injection at 14 new Mid-basin wells
- **Production Wells:** 16 extraction wells, which may include activation of existing wells or installation of new wells, with treatment facilities as required

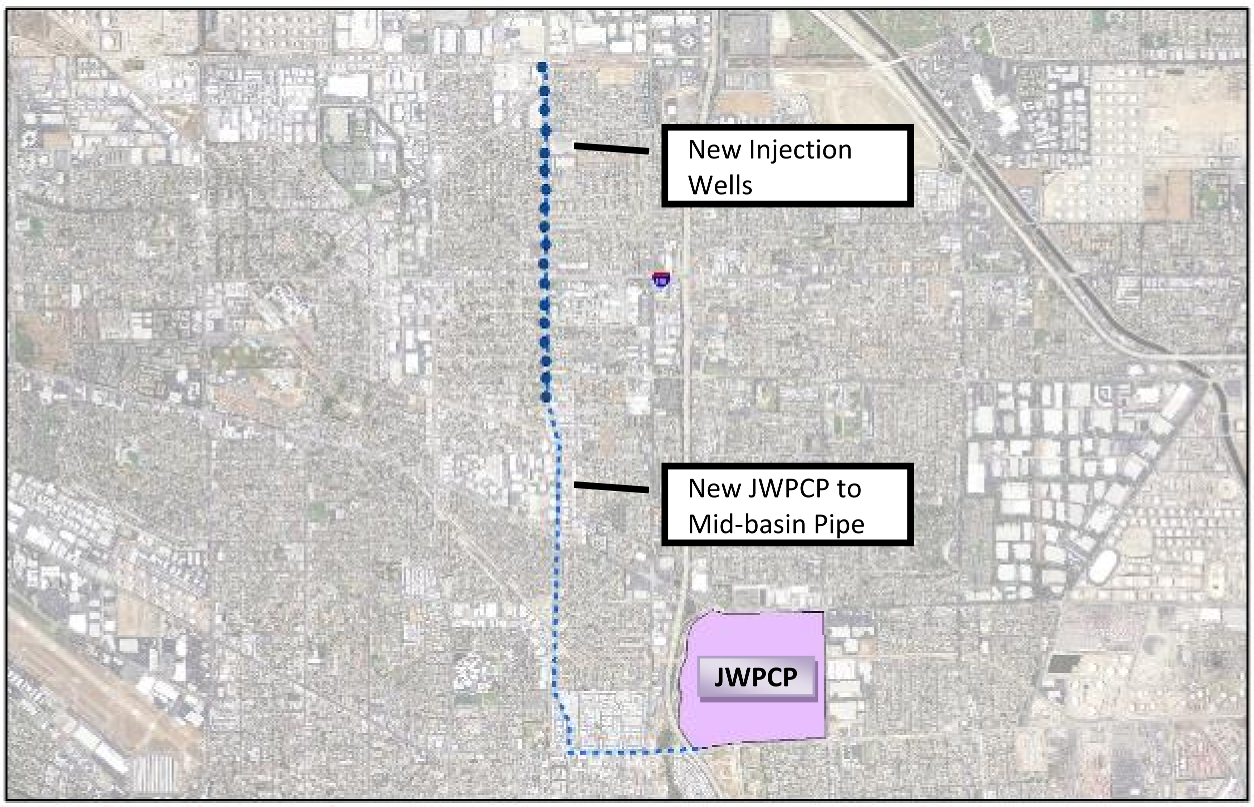

Figure 5-2. WCB-P2: JWPCP to Mid-basin

5.1.1.3 WCB-P3: JWPCP to DGBP (2,000 AFY)

This project would expand WCB-P2 or construct a new AWTF at JWPCP to treat secondary effluent from JWPCP and new conveyance facilities to the DGBP (Figure 5-3). The project size is based on the total replenishment needed to balance overall basin pumping beyond that provided at the WCBBP. This project includes the following facilities:

- **Supply:** 2,500 AFY of secondary effluent from JWPCP to produce 2,000 AFY of JWPCP AWT product water
- **Treatment:** New 1.8-mgd AWT at JWPCP
- **Brine disposal:** 0.35 mgd through existing JWPCP outfall
- **Conveyance:** JWPCP AWTF to DGBP: New pipeline (27,800 feet, 12-inch) and pump station (30 hp)
- **Recharge Method:** Injection at DGBP within existing capacity
- **Production Wells:** Pumpers will activate wells or install new wells, including treatment, as required to meet demands

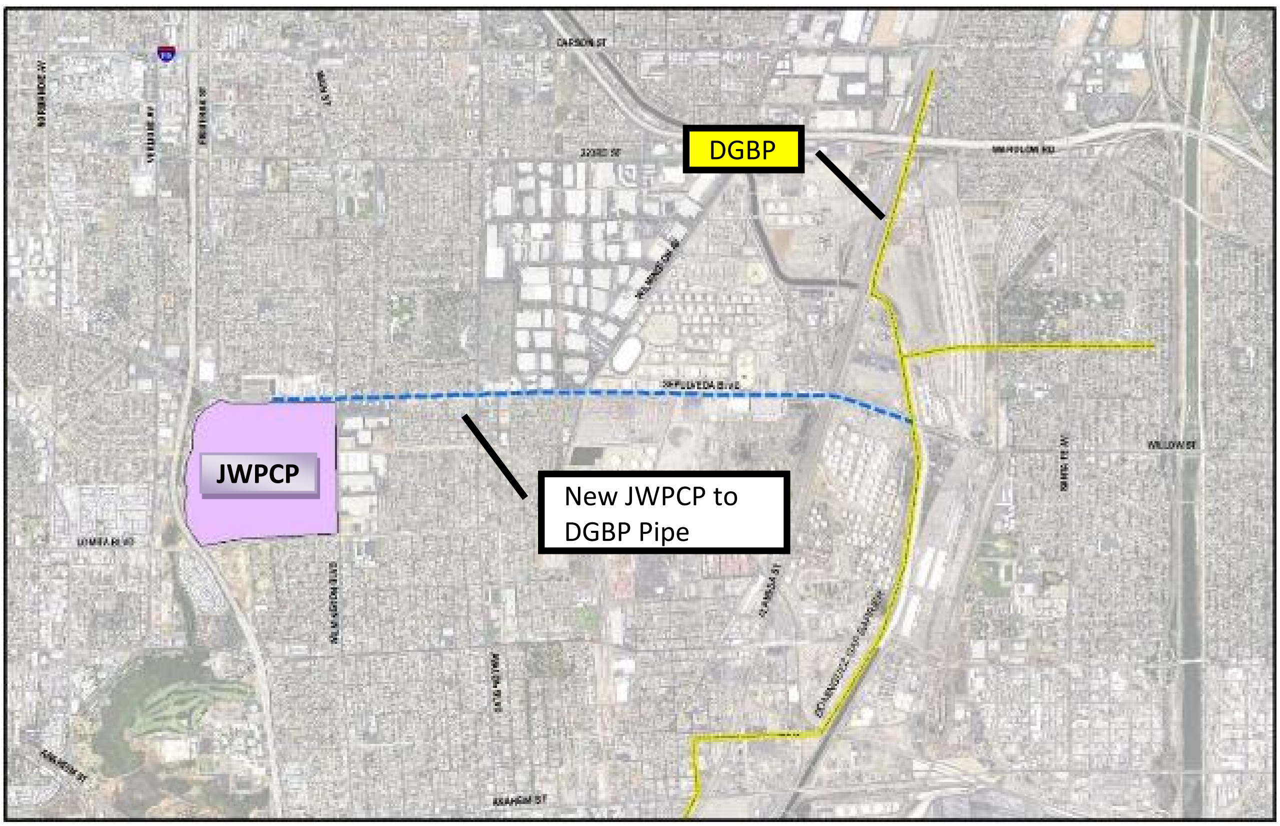

Figure 5-3. WCB-P3: JWPCP to DGBP

5.1.2 Central Basin Projects

The Central Basin projects consist of surface spreading and/or injection of various recycled water and stormwater supplies. Twelve projects are defined in this section:

- CB-P1 to CB-P6: SJCWRP to MFSG (5,000 - 17,600 AFY), with varying levels of treatment
- CB-P7: LCWRP to MFSG – 100 percent AWT (5,000 AFY)
- CB-P8: LCWRP to Montebello Forebay Injection Wells – 100 percent full advanced treated (5,000 - 9,500 AFY)
- CB-P9: ARRF (5,000 AFY)
- CB-P10: GBOP (17,000 AFY)
- CB-P11: Maximum SJCWRP to Montebello Forebay Injection Wells – 100 percent full advanced treated (+8,690 AFY)
- CB-P12: Satellite AWT to Los Angeles Forebay Injection (45,480 AFY)

Note that Projects CB-P1, CB-P2, and CB-P8 contain separate projects under each category (i.e. P1a, P1b and P1c; P2a, P2b and P2c; and P8a and P8b) for different flow rates from the same supply sources to the same recharge locations.

5.1.2.1 CB-P1 to P6: SJCWRP to MFSG (5,000-17,600 AFY)

Ten projects are defined that would expand surface spreading at MFSG by up to 17,600 AFY with SJCWRP tertiary effluent with varying levels of treatment (Figure 5-4):

- CB-P1a: 100 percent tertiary (5,000 AFY)
- CB-P1b: 100 percent tertiary (10,000 AFY)
- CB-P1c: 100 percent tertiary (17,600 AFY)
- CB-P2a: 100 percent AWT (5,000 AFY)
- CB-P2b: 100 percent AWT (10,000 AFY)
- CB-P2c: 100 percent AWT (17,600 AFY)
- CB-P3: 50 percent AWT (5,000 AFY), 50 percent tertiary (5,000 AFY)
- CB-P4: 100 percent NF (10,000 AFY)
- CB-P5: 50 percent NF (5,000 AFY), 50 percent tertiary (5,000 AFY)
- CB-P6: 100 percent ozone/BAC/GAC (10,000 AFY)

Also, at the time of this original analysis in the 2012 Draft GBMP report (i.e., based on 2010 recycled water production and demands) up to 15,500 AFY of effluent was estimated to be available for these projects from SJCWRP. However, with the implementation of the GRIP project underway, all flows assumed for the GBMP include some flow diversions to SJCWRP, described in Section 3.3.2.2, to provide enough tertiary effluent to supply these projects. Each project may require implementation of one or more of the several diversion elements, the number of which varies for each project’s flow needs. As flows have changed significantly since this initial analysis was conducted, diversion requirements to provide influent flows to satisfy the projects identified in the GBMP are likely to differ from those identified in 2012. As such, the costs associated with influent sewage diversion are not included in the GBMP project costs, but such diversions and their associated costs may need to be identified as individual projects are considered for implementation. No new injection or extraction wells are included in these projects.

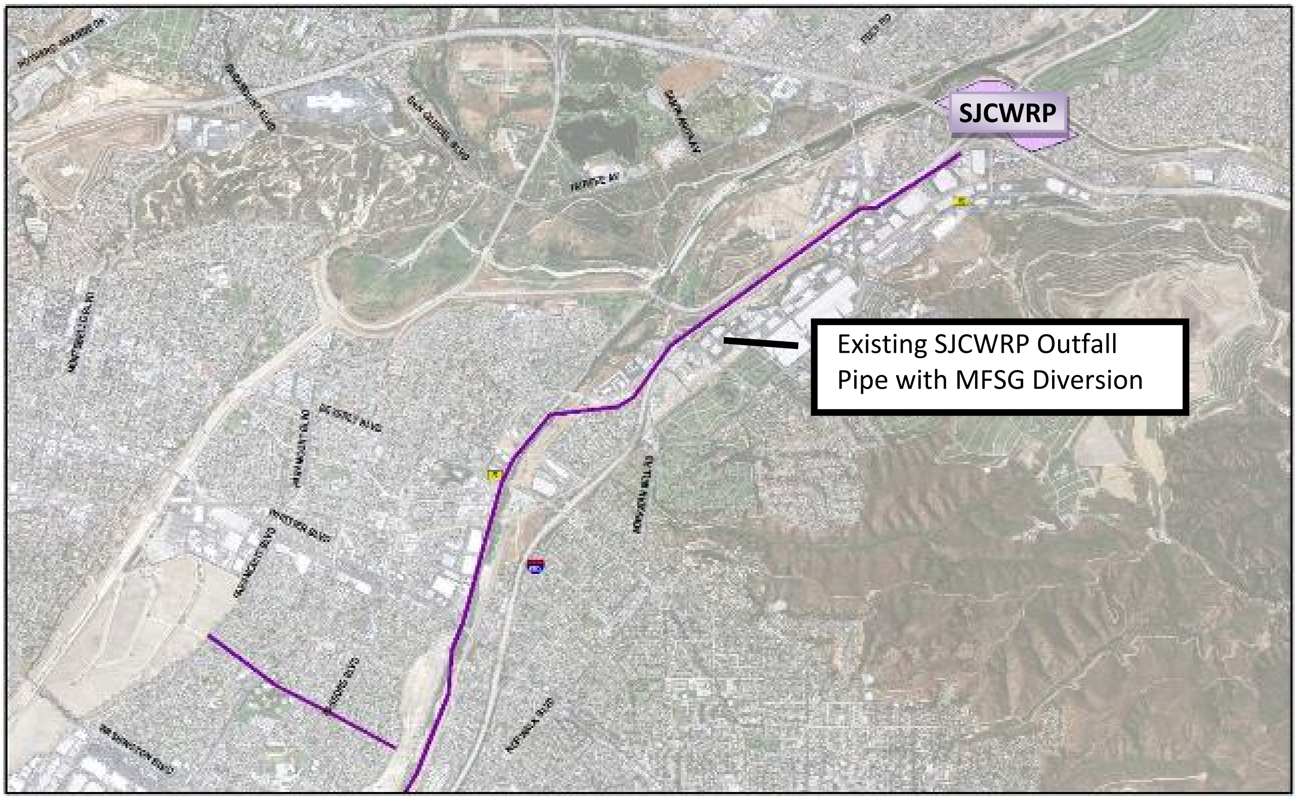

Figure 5-4. CB-P1: SJCWRP to MFSG

CB-P1a: SJCWRP to MFSG – 100 Percent Tertiary (5,000 AFY)

This project includes the following facilities:

- **Supply:** 5,000 AFY of tertiary effluent from SJCWRP
- **Treatment:** No new treatment
- **Brine disposal:** No brine disposal
- **Conveyance:** No new conveyance pipelines

CB-P1b: SJCWRP to MFSG – 100 Percent Tertiary (10,000 AFY)

This project includes the following facilities:

- **Supply:** 10,000 AFY of tertiary effluent from SJCWRP
- **Treatment:** No new treatment
- **Brine disposal:** No brine disposal
- **Conveyance:** No new conveyance pipelines

CB-P1c: Maximum SJCWRP to MFSG (+17,600 AFY), using tertiary effluent

This project is an expansion of project CB-P1a and includes the following facilities:

- **Supply:** 17,600 AFY of tertiary effluent from SJCWRP
- **Treatment:** No new treatment
- **Brine disposal:** No brine disposal
- **Conveyance:** No new conveyance pipelines

CB-P2a: SJCWRP to MFSG – 100 Percent AWT (5,000 AFY)

This project is identical to project CB-P1a but uses advanced treatment of SJCWRP effluent. This could be an expansion of the GRIP facilities located in Pico Rivera. This project includes the following facilities:

- **Supply:** 5,880 AFY of SJCWRP tertiary effluent to produce 5,000 AFY of AWT product water
- **Treatment:** 4.5-mgd AWT
- **Brine disposal:** 0.8 mgd to LACSD's JWPCP collection system

CB-P2b: SJCWRP to MFSG – 100 Percent AWT (10,000 AFY)

This project is an expansion of project CB-P2a and includes the following facilities:

- **Supply:** 11,760 AFY of SJCWRP tertiary effluent to produce 10,000 AFY of AWT product water
- **Treatment:** 8.9-mgd AWT
- **Brine disposal:** 1.6 mgd to LACSD's JWPCP collection system

CB-P2c: Maximum SJCWRP to MFSG (+17,600 AFY), 100 percent AWT

This project is an expansion of project CB-P2b and includes the following facilities:

- **Supply:** 20,710 AFY of SJCWRP tertiary effluent to produce 17,600 AFY of AWT product water
- **Treatment:** 15.7-mgd AWT
- **Brine disposal:** 2.8 mgd to LACSD's JWPCP collection system

CB-P3: SJCWRP to MFSG – 50 Percent AWT/50 Percent Tertiary (10,000 AFY)

This project includes the following facilities:

- **Supply:** 10,880 AFY of SJCWRP tertiary effluent to produce 5,000 AFY of AWT product water and 5,000 AFY of SJCWRP tertiary effluent
- **Treatment**: 5-mgd AWT at SJCWRP
- **Brine disposal:** 0.8 mgd to LACSD's JWPCP collection system

CB-P4: SJCWRP to MFSG – 100 Percent NF (10,000 AFY)

This project includes the following facilities:

- **Supply:** 11,360 AFY from SJCWRP tertiary effluent to produce 10,000 AFY of NF product water
- **Treatment:** 8.9 mgd of NF at SJCWRP
- **Brine disposal:** 1.2 mgd to LACSD's JWPCP collection system

CB-P5: SJCWRP to MFSG – 50 Percent NF/50 Percent Tertiary (10,000 AFY)

This project includes the following facilities:

- **Supply:** 11,560 AFY of SJCWRP tertiary effluent to produce 5,000 AFY of AWT product water and 5,000 AFY of SJCWRP tertiary effluent
- **Treatment:** 4.5-mgd NF at SJCWRP
- **Brine disposal:** 0.6 mgd to LACSD's JWPCP collection system

CB-P6: SJCWRP to MFSG – 100 Percent Ozone/BAC/GAC (10,000 AFY)

This project includes the following facilities:

- **Supply:** 11,765 AFY from SJCWRP with ozone-BAC treatment
- **Treatment:** 8.9 mgd of ozone/BAC/GAC treatment at SJCWRP
- **Brine disposal:** No brine disposal

5.1.2.2 CB-P7: LCWRP to MFSG – 100 Percent AWT (5,000 AFY)

This project would expand surface spreading at MFSG by 5,000 AFY with AWT product water fed by LCWRP tertiary effluent (Figure 5-5). This project includes the following facilities:

- **Supply:** 5,880 AFY of LCWRP tertiary effluent to produce 5,000 AFY of AWT product water
- **Treatment:** 4.5-mgd AWT onsite at LCWRP
- **Brine disposal:** 0.8 mgd to LACSD's JWPCP collection system
- **Conveyance:** LCWRP to MFSG: New pipeline (47,000 feet, 18-inch) and pump station (185 hp)
- **Recharge Method:** Surface spreading at MFSG

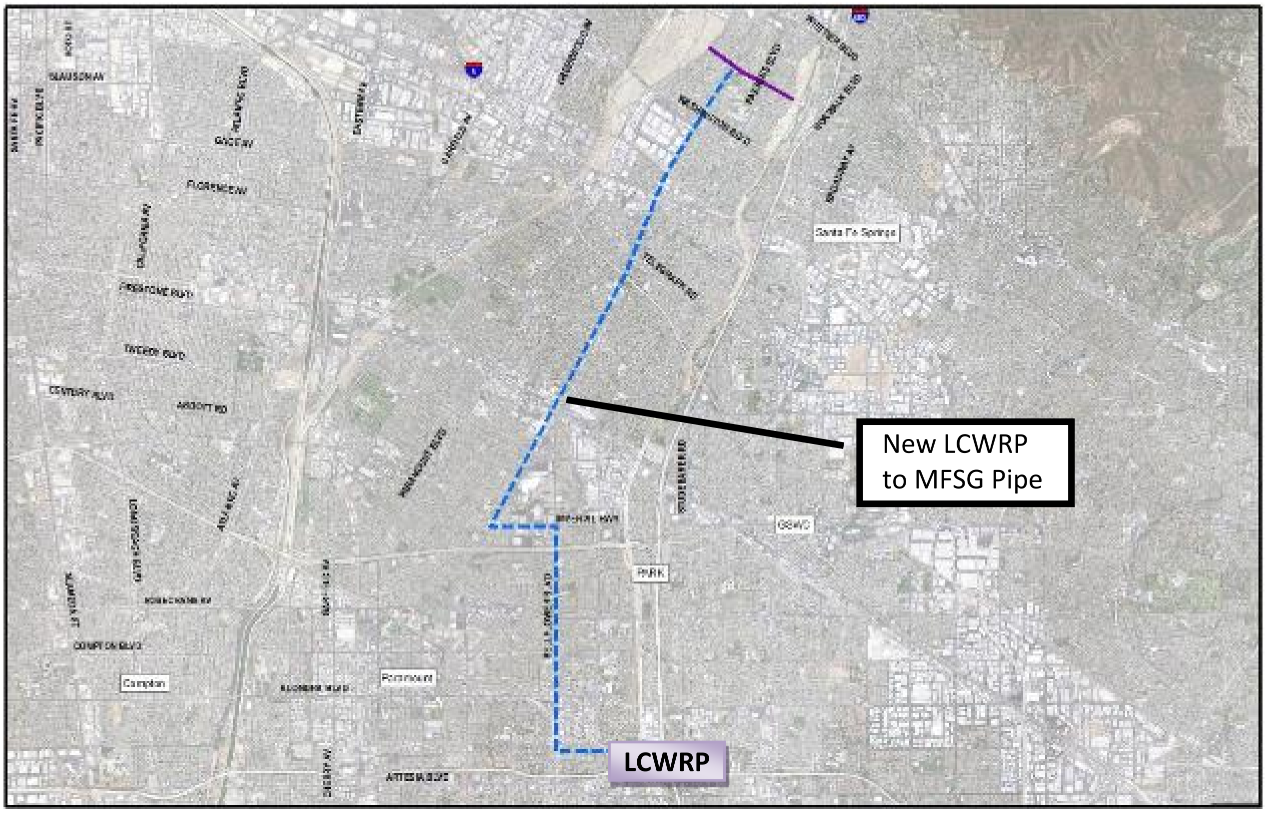

Figure 5-5. CB-P7: LCWRP to MFSG – 100 Percent AWT

5.1.2.3 CB-P8a: LCWRP to Montebello Forebay Injection Wells – 100 Percent Full Advanced Treated (5,000 AFY)

Similar to CB-P7, this project would recharge 5,000 AFY with full advanced treated product water fed by LCWRP tertiary effluent (Figure 5-6); however, this project proposes to use injection wells instead of surface spreading at the MFSG. This project includes the following facilities:

- **Supply:** 5,880 AFY of LCWRP tertiary effluent to produce 5,000 AFY of full advanced treated product water
- **Treatment:** 4.5-mgd AWTF onsite at LCWRP
- **Brine disposal:** 0.8 mgd to LACSD's JWPCP collection system
- **Conveyance:** LCWRP to MFSG: New pipeline (66,500 feet, 16-inch) and pump station (200 hp)
- **Recharge Method:** Injection at 4 new injection wells in the Montebello Forebay

5.1.2.4 CB-P8b: LCWRP to Montebello Forebay Injection Wells – 100 Percent Full Advanced Treated (4,500 AFY)

This project is an expansion of project CB-P8a and includes the following facilities:

- **Supply:** 5,290 AFY of LCWRP tertiary effluent to produce 4,500 AFY of full advanced treated product water
- **Treatment:** 4.0-mgd AWTF onsite at LCWRP
- **Brine disposal:** 1.5 mgd to LACSD's JWPCP collection system
- **Conveyance:** LCWRP to MFSG: New pipeline (66,500 feet, 16-inch) and pump station (175 hp)
- **Recharge Method:** Injection at 4 new injection wells in the Montebello Forebay

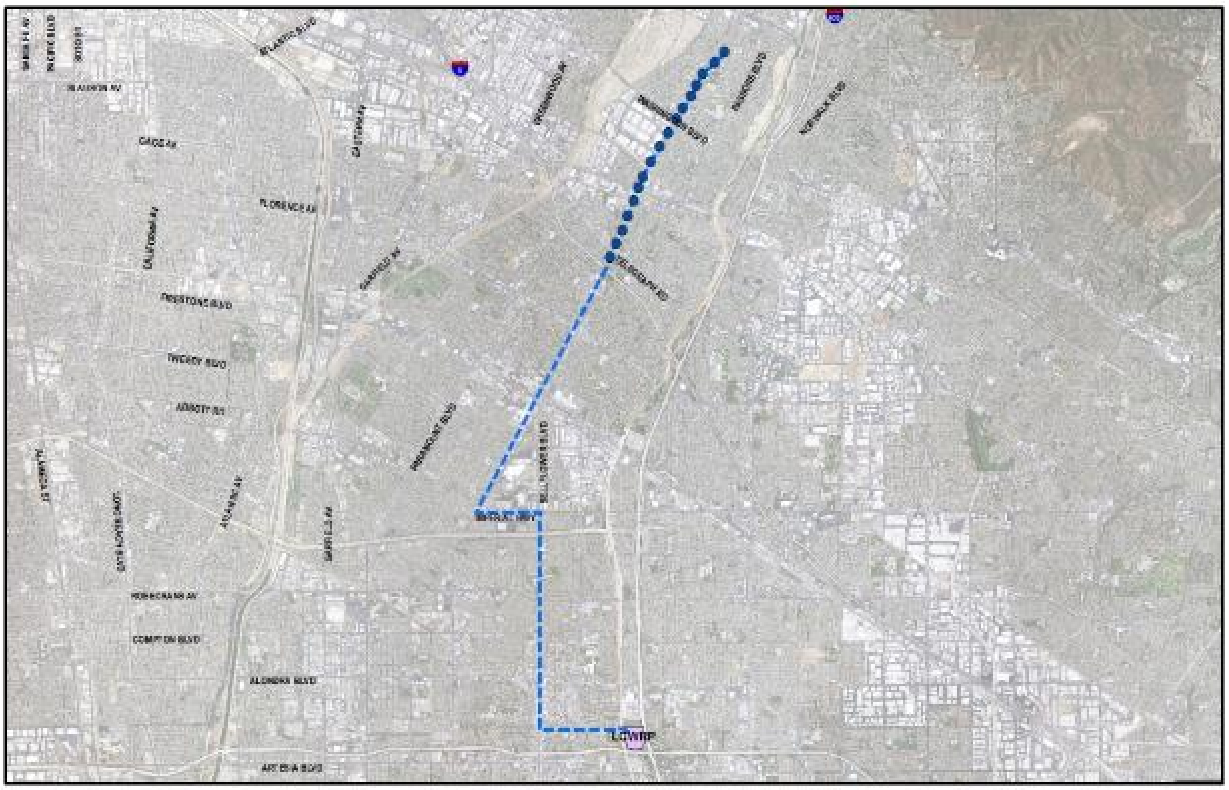

Figure 5-6. CB-P8a and CB-8b: LCWRP to Montebello Forebay Injection Wells – 100 Percent AWT

5.1.2.5 CB-P9: ARRF – Los Angeles River to Los Angeles Forebay (5,000 AFY)

The stormwater conveyed in the Los Angeles River between Atlantic Boulevard and Firestone Boulevard could be captured and diverted to the ARRF, described in Section 3.3.2.3.

This project (Figure 5-7) includes the following facilities:

- **Supply:** 5,000 AFY of storm flows from the Los Angeles River
- **Treatment:** Soil aquifer treatment through ARRF facility as described in Section 3.3.2.3.
- **Brine disposal:** No brine disposal
- **Conveyance:** No new conveyance pipelines
- **Recharge Method:** Surface spreading and injection at Los Angeles Forebay

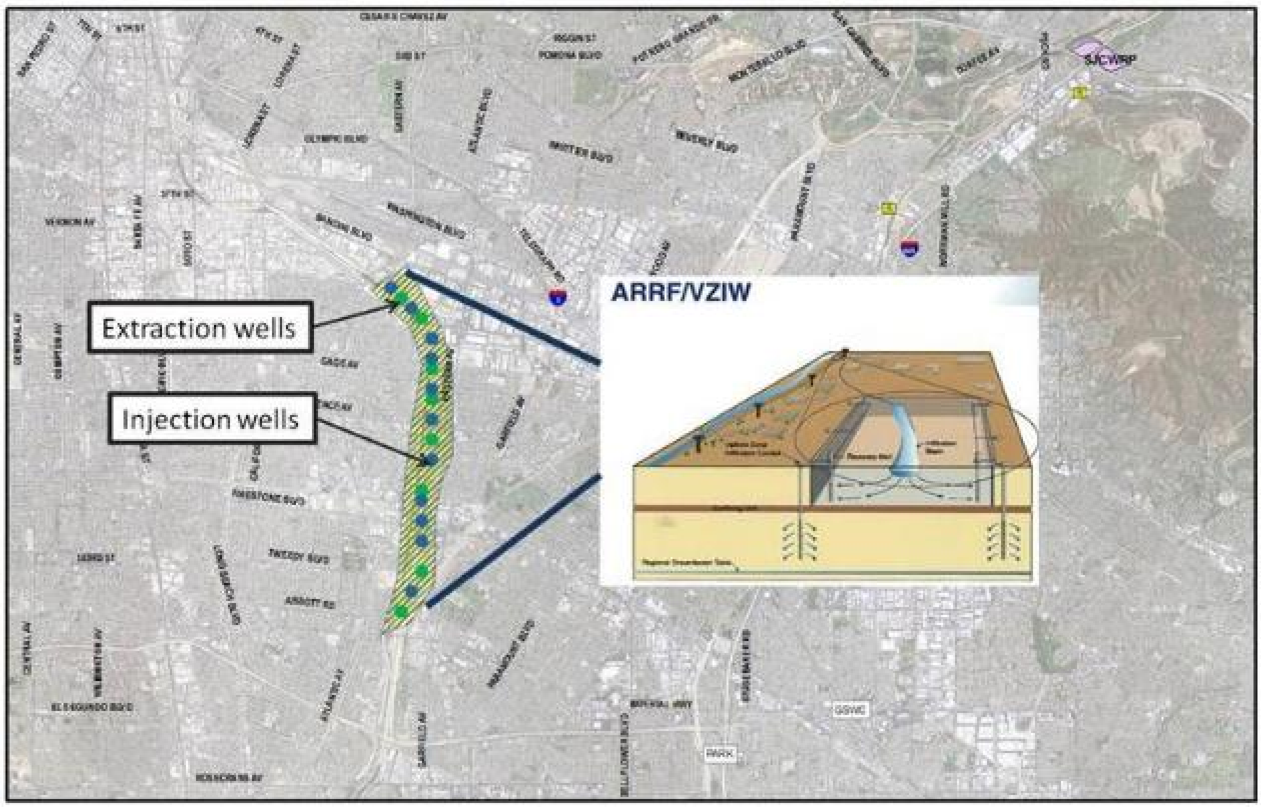

Figure 5-7. CB-P9: ARRF – Los Angeles River to Los Angeles Forebay

5.1.2.6 CB-P10: GBOP – San Gabriel River/Rio Hondo to MFSG (17,000 AFY)

This project would capture an additional 17,000 AFY of stormwater that is currently released to the ocean by increasing pumping in the Montebello Forebay area by 25,000 AFY to reduce elevated groundwater levels that prevent recharge following high recharge periods (Figure 5-8). The assumed distribution of the 25,000 AFY in shifted pumping was described in Section 3.3.4.1. This project includes the following facilities:

- **Supply:** 17,000 AFY of stormwater from San Gabriel River and Rio Hondo
- **Treatment:** No new treatment
- **Brine disposal:** No brine disposal
- **Conveyance:** Pipeline from new Montebello Forebay extraction wells to four retailers: MFSG to Junction 1 (12,300 feet, 36-inch), Junction 1 to Santa Fe Springs (11,000 feet, 14-inch), Junction 1 to Junction 2 (30,750 feet, 36-inch), Junction 2 to Golden State Water Company (15,000 feet, 16-inch), Junction 2 to Junction 3 (12,200 feet, 30-inch), Junction 3 to Paramount (8,500 feet, 16-inch), and Junction 3 to Long Beach (28,100 feet, 30-inch)
- **Recharge Method:** Surface spreading at MFSG
- **Production Wells**: Nine new extraction wells to provide 25,000 AFY of pumping shifted to the Montebello Forebay area from elsewhere in the Central Basin

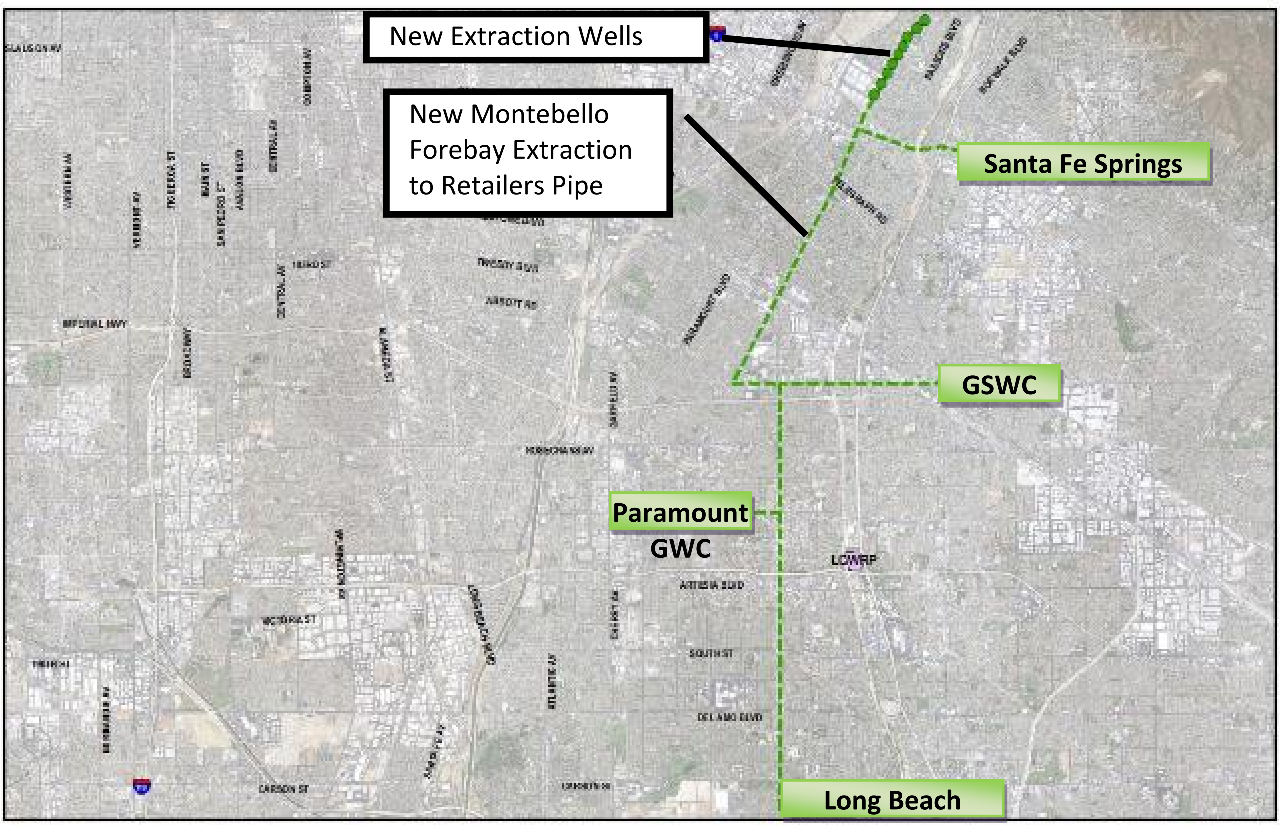

Figure 5-8. CB-P10: GBOP – San Gabriel/Rio Hondo Rivers to MFSG

5.1.2.7 CB-P11: Maximum SJCWRP to Montebello Forebay Injection Wells – 100 percent Full Advanced Treated (+8,690 AFY)

Similar to project CB-P8, this project would recharge AWT produce water via injection at the MFSG. The supply for this project comes from surplus SJCWRP tertiary effluent during periods that the effluent cannot be recharged at the spreading grounds due to stormwater capture and spreading ground capacity limitations. To capture and treat this flow when available, a treatment plant size of 23-mgd was identified. As this plant would not be operated year-round, it would produce only 8,690 AFY of product water for injection.

This project includes the following facilities:

- **Supply:** 10,224 AFY of LCWRP tertiary effluent to produce 8,690 AFY of FAT product water
- **Treatment:** 23.0-mgd AWTF onsite at SJCWRP
- **Brine disposal:** 2.4 mgd to LACSD's JWPCP collection system
- **Conveyance:** LCWRP to MFSG: New pipeline (22,400 feet, 36-inch) and pump station (430 hp)
- **Recharge Method:** Injection at 17 new injection wells in the Montebello Forebay

5.1.2.8 CB-P12: Satellite to Los Angeles Forebay Injection Wells – 100 Percent Full Advanced Treatment (45,480 AFY)

This project would construct a new satellite water reclamation facility with AWT in eastern Los Angeles for injection into the Los Angeles Forebay (Figure 5-9). This project includes the following facilities:

- **Supply:** 45,480 AFY from new satellite AWTF (MBR/RO/AOP) supplied from raw wastewater from City of Los Angeles' HWRP collection system
- **Treatment**: 40.6 mgd new satellite AWTF
- **Brine disposal:** 7.2 mgd to City of Los Angeles' HWRP collection system
- **Conveyance:** Several new conveyance pipelines are needed:
  - AWTF to Los Angeles Forebay Injection Wells: Pipeline (26,900 feet, 48-inch), laterals (42,800 feet, 36-inch), and pump station (720 hp)
  - Extraction wells to LADWP (35,500 feet, 48-inch)
- **Recharge Method:** 50 new injection wells at Los Angeles Forebay
- **Production Wells:** 21 new extraction wells

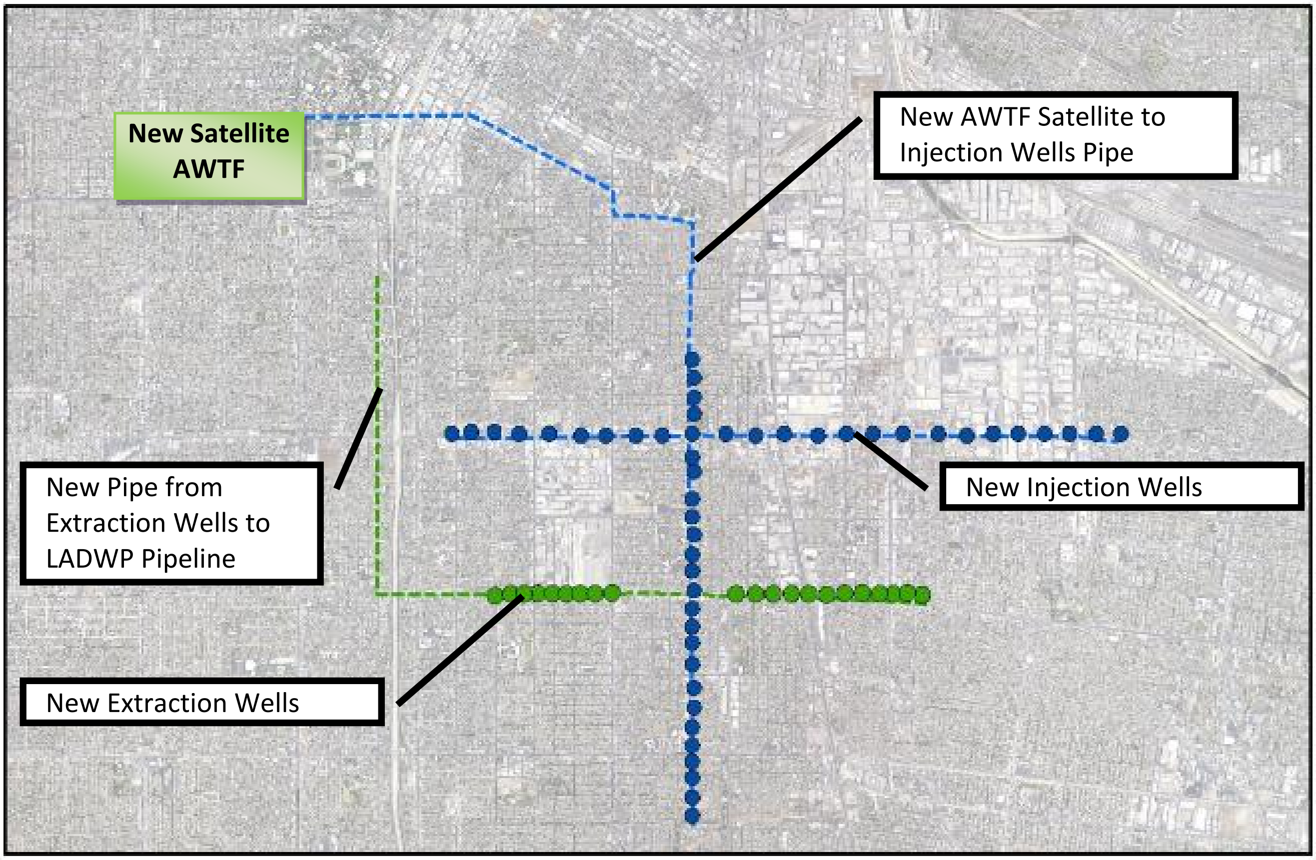

Figure 5-9. CB-P12: Satellite to Los Angeles Forebay Injection Wells – 100 Percent Full Advanced Treatment (45,480 AFY)

5.1.3 Groundwater Basins Master Plan Projects Summary

5.1.3.1 Facilities

Tables 5-3 and 5-4 summarize facilities for each project.

Table 5-3. West Coast Basin Projects – New Facilities

Project ID	Project Description	Annual Yield (AFY)	Treatment (mgd)	Brine (mgd)	Conveyance	Wells
WCB-P1	ECLWRF to WCBBP					
WCB-P1a		15,500	13.8	2.4	30” to 36”, 4.0 miles	--
WCB-P1b		+7,500	6.7	1.2	Upsize by 6”, 4.0 miles	--
WCB-P2	JWPCP to Mid-basin	15,000	13.4	2.4	30”, 4.8 miles	14 injection
WCB-P3	JWPCP to DGBP	2,000	1.8	0.4	12”, 5.3 miles	--

Note:
“ = inch(es)

Table 5-4. Central Basin Projects – New Facilities

Project ID	Project Description	Annual Yield (AFY)	Treatment (mgd)	Brine (mgd)	Conveyance	Wells
CB-P1a	SJCWRP to MFSG (100% Tertiary)	5,000	--	--	--	--
CB-P1b	SJCWRP to MFSG (100% Tertiary)	10,000	--	--	--	--
CB-P1c	SJCWRP to MFSG (100% Tertiary)	17,600	--	--	--	--
CB-P2a	SJCWRP to MFSG (100% AWT)	5,000	4.5	0.8	--	--
CB-P2b	SJCWRP to MFSG (100% AWT)	10,000	8.9	1.6	--	--
CB-P2c	SJCWRP to MFSG (100% AWT)	17,600	15.7	2.8	--	--
CB-P3	SJCWRP to MFSG (50% AWT)	10,000	5.0	0.8	--	--
CB-P4	SJCWRP to MFSG (100% NF)	10,000	8.9	1.2	--	--
CB-P5	SJCWRP to MFSG (50% NF)	10,000	4.5	0.6	--	--
CB-P6	SJCWRP to MFSG (Ozone/BAC/GAC)	10,000	8.9	--	--	--
CB-P7	LCWRP to MFSG (100% AWT)	5,000	4.5	0.8	16”, 8.9 miles, pump station	--
CB-P8a	LCWRP to Montebello Forebay Injection (100% full advanced treated)	5,000	4.5	0.8	16”, 8.9 miles, pump station	4 injection

Project ID	Project Description	Annual Yield (AFY)	Treatment (mgd)	Brine (mgd)	Conveyance	Wells
CB-P8b	LCWRP to Montebello Forebay Injection (100% full advanced treated)	4,500	4.0	0.7	16", 8.9 miles, pump station	4 injection
CB-P9	ARRF	5,000	--	--		64 injection 32 extraction
CB-P10	GBOP	17,000	--	--	14" to 36", 22.3 mi	9 extraction
CB-P11	SJCWRP to Montebello Forebay Injection (100% full advanced treated)	8,690	23.0	1.4	24" to 48", 4.1 miles	17 injection
CB-P12	Satellite to Los Angeles Forebay Injection (100% full advanced treated)	45,480	40.6	10.2	36" to 48", 19.9 mi	50 injection 21 extraction

5.1.3.2 Cost Estimates

Tables 5-5 and 5-6 and Figures 5-10 and 5-11 summarize the capital, O&M, water purchase (as supply or as feed water to advanced treatment process), total present value and present value unit costs (dollars per AF [$/AF]) for each GBMP project as defined above. These costs include supply treatment, conveyance and injection, where applicable and unique to the proposed project. Groundwater extraction and treatment costs are not included as they will vary by purveyor as some redundant pumping capacity may be available in existing systems and some pumpers may choose to reactivate or refurbish existing but currently unused wells. Additionally, some purveyors may opt to collaborate in the installation of larger extraction systems rather than install individual wells for each purveyor independently, potentially realizing cost savings. Thus the cost of installing additional wells to match additional proposed extraction under the GBMP alternatives is omitted from the GBMP project costs and left to the individual purveyor to consider.

Table 5-5. West Coast Basin Projects – Preliminary Cost Estimates

Project ID	Project Description	Annual Yield (AFY)	Total Capital Cost ($M)	Total Annual O&M ($M)	Total Water Purchase ($M)	Total Present Value ($M)	Present Value Unit Cost ($/af)
WCB-P1a	ECLWRF to WCBBP	15,500	$203.1	$9.7	$0.018	$395	$1,290
WCB-P1b	ECLWRF to WCBBP	7,500	$93.8	$4.7	$0.009	$187	$1,260
WCB-P2	JWPCP to Mid-basin	15,000	$275.2	$7.8	$1.765	$479	$1,610
WCB-P3	JWPCP to DGBP	2,000	$34.1	$0.9	$0.235	$59	$1,480

Notes:

$/af = dollar(s) per acre-foot
$M = million dollars
O&M = operations and maintenance

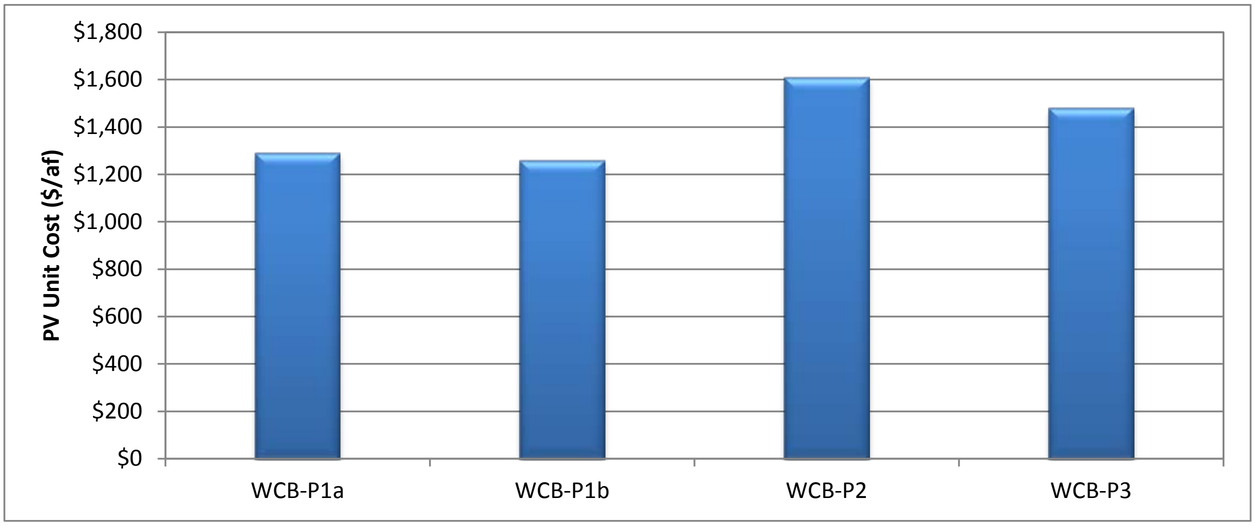

Figure 5-10. West Coast Basin Projects – Present Value Unit Costs

Cost estimating details for the GMBP projects and alternatives are provided in Appendix J. Also provided in Appendix J are cost curves representing a range of wellhead treatment options that might need to be added for individual pumping projects associated with these alternatives as the projects may have site specific requirements for wellhead treatment of various water quality constituents (e.g., iron and manganese, iron, hydrogen sulfide, color/odor, and disinfection). Similarly, an estimate for the seven assumed desalters for the West Coast Basin saline plume remediation is provided in Appendix J, but not included in the GBMP cost estimates. If remediation of the saline plume is conducted as an element of any West Coast Basin alternative, the desalter costs would be added into the total cost of the alternative.

Table 5-6. Central Basin Projects – Preliminary Cost Estimates

Project ID	Project Description	Annual Yield (AFY)	Total Capital Cost ($M)	Total Annual O&M ($M)	Total Water Purchase ($M)	Total Present Value ($M)	Present Value Unit Cost ($/af)
CB-P1a	SJCWRP to MFSG (100% Tertiary)	5,000	$0.0	$0.0	$1.500	$30	$300
CB-P1b	SJCWRP to MFSG (100% Tertiary)	10,000	$0.0	$0.0	$3.000	$59	$300
CB-P1c	SJCWRP to MFSG (100% Tertiary)	17,600	$0.0	$0.0	$5.280	$104	$300
CB-P2a	SJCWRP to MFSG (100% AWT)	5,000	$52.1	$2.6	$0.588	$115	$1,160
CB-P2b	SJCWRP to MFSG (100% AWT)	10,000	$84.8	$5.0	$1.176	$206	$1,040
CB-P2c	SJCWRP to MFSG (100% AWT)	17,600	$134.0	$8.7	$2.071	$346	$990
CB-P3	SJCWRP to MFSG (50% AWT)	10,000	$52.1	$2.6	$2.088	$144	$730
CB-P4	SJCWRP to MFSG (100% NF)	10,000	$59.9	$2.0	$1.136	$121	$610
CB-P5	SJCWRP to MFSG (50% NF)	10,000	$50.2	$2.5	$1.156	$123	$620
CB-P6	SJCWRP to MFSG (Ozone/BAC/GAC)	10,000	$29.8	$1.1	$1.176	$75	$380
CB-P7	LCWRP to MFSG (100% AWT)	5,000	$77.3	$2.8	$0.588	$156	$1,580
CB-P8a	LCWRP to Montebello Forebay Injection (100% AWT)	5,000	$93.8	$2.9	$0.588	$174	$1,760
CB-P8b	LCWRP to Montebello Forebay Injection (100% full advanced treated)	4,500	$98.7	$2.8	$0.529	$164	$1,840
CB-P9	GBOP	5,000	$60.7	$1.0	$0.000	$81	$820
CB-P10	ARRF	17,000	$147.6	$2.3	$0.000	$194	$580
CB-P11	SJCWRP to Montebello Forebay Injection (100% FAT)	8,690	$206.0	$16.9	$1.022	$561	$3,260
CB-P12	Satellite to Los Angeles Forebay Injection (100% full advanced treated)	45,480	$1,511.0	$61.3	$0.000	$4,398	$4,890

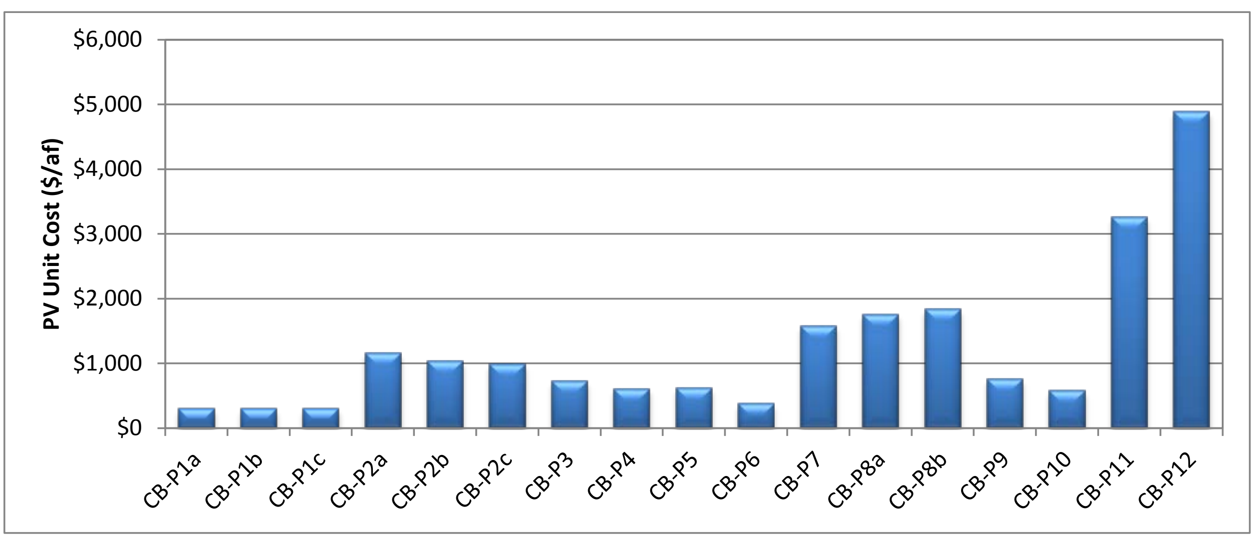

Figure 5-11. Central Basin Projects – Present Value Unit Costs

5.2 Groundwater Basins Master Plan Alternatives

The section combines the projects defined in Section 5.1 into two sets of alternatives. The first set, the "Concept A" alternatives, are designed to meet either the projected pumping within existing rights/allotment, which is an increase of 18,000 AFY in the West Coast Basin and 31,000 AFY in the Central Basin. The second set, the "Concept B" alternatives, define conceptual programs to go beyond the Concept A replenishment goals in line with the proposed Judgment amendments for each basin.

5.2.1 West Coast Basin

West Coast Basin alternatives are summarized in the following tables and further described in the following sections. On average, existing recycled water replenishment supplies for the West Basin consist of 22,000 AFY of full advanced treated recycled water (17,000 AFY at the WCBBP from WBMWD's ECLWRF and 5,000 AFY at the DGBP from the City Los Angeles' TIWRP).

5.2.1.1 Concept A Alternatives (18,000 AFY)

One Concept A alternative was defined in the West Coast Basin:

- **WCB-A1.** WCBBP and DGBP Expansions

The alternative is summarized in Table 5-7.

Table 5-7. List of West Coast Basin Concept A Alternatives

Alt ID	Project ID	Replenishment Supply	Replenishment Location/Method	Annual Average Replenishment (AFY)
WCB-A1: ECLWRF to WCBBP and TIWRP AWT to DGB				**18,000**
	WCB-P1a	ECLWRF AWT	WCBBP	15,500
		TIWRP AWT	DGBP	2,500*

* TIWRP expansion underway; thus a GBMP project ID has not been assigned and impacts not further considered.

5.2.1.2 Concept B Alternatives (+30,000 AFY)

One Concept B alternative was defined in the West Coast Basin, and builds upon WCB-A1:

- **WCB-B1.** Further WCBBP Expansion; JWPCP to DGBP and Mid-basin Injection

The alternatives are summarized in Table 5-8.

Table 5-8. List of West Coast Basin Concept B Alternatives

Alt ID	Project ID	Replenishment Supply	Replenishment Location/Method	Annual Average Replenishment (AFY)
WCB-B1: Alt WCB-A1 and ECLWRF to WCBB, JWPCP to WCB-Inland & DGBP				**+ 30,000**
	WCB-P1b	ECLWRF AWT	WCBBP	+ 7,500
	WCB-P2	JWPCP AWT	Mid-basin	15,000
	WCB-P3	JWPCP AWT	DGBP	2,000

5.2.2 Central Basin

Central Basin alternatives are summarized in the following tables and further described in the following sections. On average, existing replenishment supplies for the Central Basin consist of 57,000 AFY of stormwater and 50,000 AFY of tertiary recycled water. With the implementation of the GRIP project[12], an additional 11,000 AFY of tertiary recycled water and 10,000 AFY of advanced treated water will replace 21,000 AFY of average historical imported water replenishment.

5.2.2.1 Concept A Alternatives (10,000 AFY)

Five core Concept A alternatives were defined for the Central Basin, and each has multiple variations that adjust the level of treatment applied to recycled water prior to replenishment:

- CB-A1. SJCWRP to MFSG
- CB-A2. SJCWRP and LCWRP-Spreading
- CB-A3. SJCWRP-Spreading and LCWRP-Injection
- CB-A4. SJCWRP Spreading and Enhanced Los Angeles Forebay Stormwater Capture

The alternatives are summarized in Table 5-9.

Table 5-9. List of Central Basin Concept A Alternatives

Alt ID	Project ID	Replenishment Supply	Replenishment Location/Method	Annual Average Replenishment (AFY)
CB-A1a: SJCWRP (100% Tertiary) to MFSG				**10,000**
	CB-P1b	SJCWRP	MFSG	10,000
CB-A1b: SJCWRP (100% AWT) to MFSG				**10,000**
	CB-P2b	SJCWRP – 100% AWT	MFSG	10,000
CB-A1c: SJCWRP (50% AWT) to MFSG				**10,000**
	CB-P3	SJCWRP – 50% AWT/50% Tertiary	MFSG	10,000
CB-A1d: SJCWRP (100% NF) to MFSG				**10,000**
	CB-P4	SJCWRP – 100% NF	MFSG	10,000
CB-A1e: SJCWRP (50% NF) to MFSG				**10,000**
	CB-P5	SJCWRP – 50% NF/50% Tertiary	MFSG	10,000
CB-A1f: SJCWRP (Ozone/BAC/GAC) to MFSG				**10,000**
	CB-P6	SJCWRP – Ozone/BAC/GAC	MFSG	10,000
CB-A2a: SJCWRP (100% Tertiary) to MFSG & LCWRP (100% AWT) to MFSG				**10,000**
	CB-P1a	SJCWRP	MFSG	5,000
	CB-P7	LCWRP AWT	MFSG	5,000
CB-A2b: SJCWRP (100% AWT) to MFSG & LCWRP (100% AWT) to MFSG				**10,000**
	CB-P2a	SJCWRP – 100% AWT	MFSG	5,000
	CB-P7	LCWRP AWT	MFSG	5,000

[12] In the 2012 Draft GBMP Report, the GRIP project was evaluated as a component of the GBMP Alternatives. For this 2016 GBMP Final Report, the GRIP project is considered part of the existing system. An analysis of the potential impacts of GRIP on the groundwater basin was conducted as part of this GBMP study, and is included herein as Appendix L.

Table 5-9. List of Central Basin Concept A Alternatives

Alt ID	Project ID	Replenishment Supply	Replenishment Location/Method	Annual Average Replenishment (AFY)
CB-A3a: SJCWRP (100% Tertiary) to MFSG & LCWRP (100% full advanced treated) to Montebello Forebay Injection				**10,000**
	CB-P1a	SJCWRP	MFSG	5,000*
	CB-P8a	LCWRP AWT	Injection at Montebello Forebay	5,000
CB-A3b: SJCWRP (100% AWT) to MFSG & LCWRP (100% full advanced treated) to Montebello Forebay Injection				**10,000**
	CB-P2a	SJCWRP – 100% AWT	MFSG	5,000
	CB-P8a	LCWRP AWT	Injection at Montebello Forebay	5,000
CB-A4a: SJCWRP (100% Tertiary) to MFSG & Los Angeles River to Los Angeles Forebay (via ARRF)				**10,000**
	CB-P1a	SJCWRP	MFSG	5,000
	CB-P9	Los Angeles River	ARRF at Los Angeles Forebay	5,000
CB-A4b: SJCWRP (100% AWT) to MFSG & Los Angeles River to Los Angeles Forebay (via ARRF)				**10,000**
	CB-P2a	SJCWRP – 100% AWT	MFSG	5,000
	CB-P9	Los Angeles River	ARRF at Los Angeles Forebay	5,000

5.2.2.2 Concept B Alternatives

Two Concept B alternatives were defined, and each has two versions that adjust the level of treatment applied to recycled water prior to replenishment:

- **CB-B1.** Maximum Existing RW Sources with Enhanced Stormwater Capture (+ 57,770 AFY)
- **CB-B2.** Maximum Existing and Additional RW Sources with Enhanced Central Basin Stormwater Capture (Alternative CB-B1 + 45,480 AFY)

The alternatives are summarized in Table 5-10.

Table 5-10. List of Central Basin Concept B Alternatives

Alt ID	Project ID	Replenishment Supply	Replenishment Location/Method	Annual Average Replenishment (AFY)
CB-B1a: SJCWRP (100% Tertiary) to MFSG, SJCWRP to Montebello Forebay Injection, LCWRP to Montebello Forebay Injection, SW to MFSG (GBOP), Los Angeles River to Los Angeles Forebay (ARRF)				**67,770**
	CB-P1b+CB-P1c	SJCWRP (100% Tertiary)	MFSG	27,580[a]
	CB-P8a+P8b	LCWRP AWT	Injection at Montebello Forebay	9,500[a]
	CB-P9	Los Angeles River	ARRF at Los Angeles Forebay	5,000
	CB-P10	San Gabriel River/Rio Hondo	MFSG	17,000
	CB-P11	SJCWRP (100% AWT)	Montebello Forebay Injection	8,690
CB-B1b: SJCWRP (100% AWT) to MFSG, SJCWRP to Montebello Forebay Injection, LCWRP to Montebello Forebay Injection, SW to MFSG, Los Angeles River to Los Angeles Forebay				**67,770**
	CB-P2b+CB-P2c	SJCWRP (100% AWT)	MFSG	27,580[a]
	CB-P8a+P8b	LCWRP AWT	Injection at Montebello Forebay	9,500
	CB-P9	Los Angeles River	ARRF at Los Angeles Forebay	5,000
	CB-P10	San Gabriel River/Rio Hondo	MFSG	17,000
	CB-P11	SJCWRP (100% AWT)	Montebello Forebay Injection	8,690
CB-B2a: New Satellite AWT to Los Angeles Forebay w/ CB-B1a				**113,250**
	CB-B1a[a]			67,770
	CB-P12	New Satellite AWT (MBR/RO/AOP)	Los Angeles Forebay Injection Wells	45,480
CB-B2b: New Satellite AWT to Los Angeles Forebay w/ CB-B1b				**113,250**
	CB-B1b[b]			67,770
	CB-P12	New Satellite AWT (MBR/RO/AOP)	Los Angeles Forebay Injection Wells	45,480

[a] Indicates that this alternative includes all projects associated with Alternative CB-B1a, per above.
[b] Indicates that this alternative includes all projects associated with Alternative CB-B1b, per above.

5.2.3 Alternatives Evaluation

This section provides a qualitative and quantitative comparison of the alternatives defined in Section 5.2. The following criteria were defined for each alternative for comparison:

- Cost
- Water supply availability and reliability
- Energy/ GHG emissions
- Environmental impacts
- Total dissolved solids (TDS) loading

5.2.4 Cost Estimates

Tables 5-11 and 5-12 summarize the cost estimates for each West Coast Basin and Central Basin alternative, respectively, composed of the sum of the relevant project costs. The graphs in Figures 5-12 and 5-13 show the present value unit costs ($/af) for each alternative, relative to the total alternative yield.

Table 5-11. West Coast Basin Alternatives – Preliminary Cost Estimates

Alternative ID	Description	Annual Yield (AFY)	Total Capital Cost ($M)	Total Annual O&M ($M)	Total Water Purchase ($M)	Total Present Value ($M)	Present Value Unit Cost ($/af)
WB-A1	WCBB+DGBP	18,000	$213.0	$10.0	$2.268	$456	$1,280
WB-B1	+30k	30,000	$358.0	$12.9	$2.009	$653	$1,100

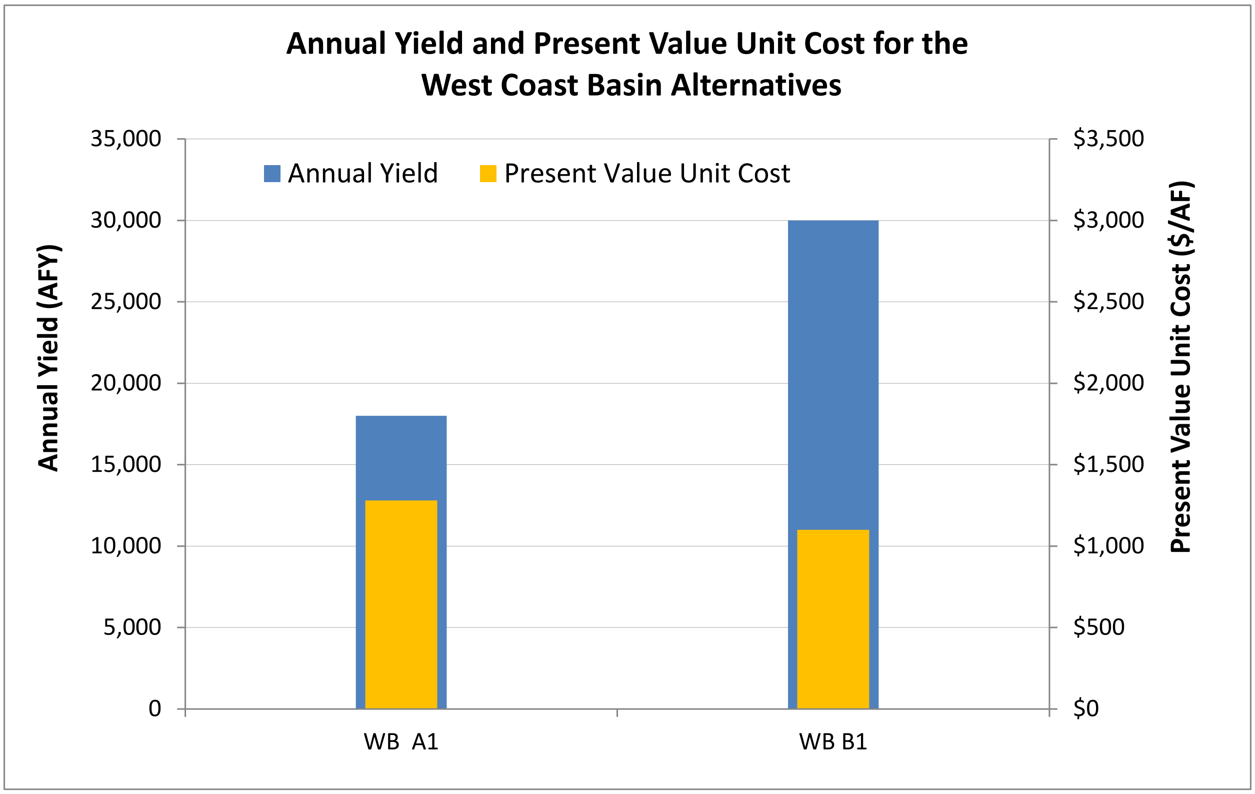

Figure 5-12. West Coast Basin Alternatives – Present Value Unit Costs

Table 5-12. Central Basin Alternatives – Preliminary Cost Estimates

Alternative ID	Description	Annual Yield (AFY)	Total Capital Cost ($M)	Total Annual O&M ($M)	Total Water Purchase ($M)	Total Present Value ($M)	Present Value Unit Cost ($/af)
CB-A1a	SJCWRP (100% Tertiary) to MFSG	10,000	$0.0	$0.0	$3.000	$59	$300
CB-A1b	SJCWRP (100% AWT) to MFSG	10,000	$84.8	$3.9	$1.176	$206	$1,040
CB-A1c	SJCWRP (50% AWT/50% Tertiary) to MFSG	10,000	$52.1	$2.6	$2.088	$144	$730
CB-A1d	SJCWRP (100% NF) to MFSG	10,000	$59.9	$2.0	$1.136	$121	$610
CB-A1e	SJCWRP (50% NF/50% Tertiary) to MFSG	10,000	$50.2	$2.5	$1.156	$123	$620
CB-A1f	SJCWRP (Ozone/BAC/GAC) to MFSG	10,000	$29.8	$1.1	$1.176	$75	$380
CB-A2a	SJCWRP (100% Tertiary) & LCWRP (100% AWT) to MFSG	10,000	$82.3	$3.0	$2.088	$182	$920
CB-A2b	SJCWRP (100% AWT) & LCWRP (100% AWT) to MFSG	10,000	$112.2	$5.6	$1.176	$247	$1,250
CB-A3a	A1a & LCWRP (100% AWT) to Montebello Forebay Injection	10,000	$102.2	$3.1	$5.238	$266	$1,350
CB-A3B	A1b & LCWRP (100% AWT) to Montebello Forebay Injection	10,000	$154.2	$3.1	$1.176	$289	$1,460
CB-A4a	SJCWRP (100% Tertiary) & ARRF	10,000	$60.7	$1.0	$7.800	$235	$1,190
CB-A4b	SJCWRP (100% AWT) & ARRF	10,000	$118.4	$12.4	$0.588	$376	$1,900
CB-B1a	Max SJCWRP (100% Tertiary) to MFSG, SJCWRP & LCWRP to Inject, GBOP, ARRF	67,770	$610.1	$24.5	$10.414	$1,301	$970
CB-B1b	Max SJCWRP (100% AWT) to MFSG, SJCWRP & LCWRP to Inject, GBOP, ARRF	67,770	$809.3	$12.4	$5.385	$1,579	$1,180
CB-B2a	CB-B1a plus Satellite AWTF to Los Angeles Forebay Injection	113,250	$2,189.8	$84.8	$10.414	$4,075	$1,820
CB-B2b	CB-B1b plus Satellite AWTF to Los Angeles Forebay Injection	113,250	$2,665.0	$97.4	$5.385	$4,699	$2,100

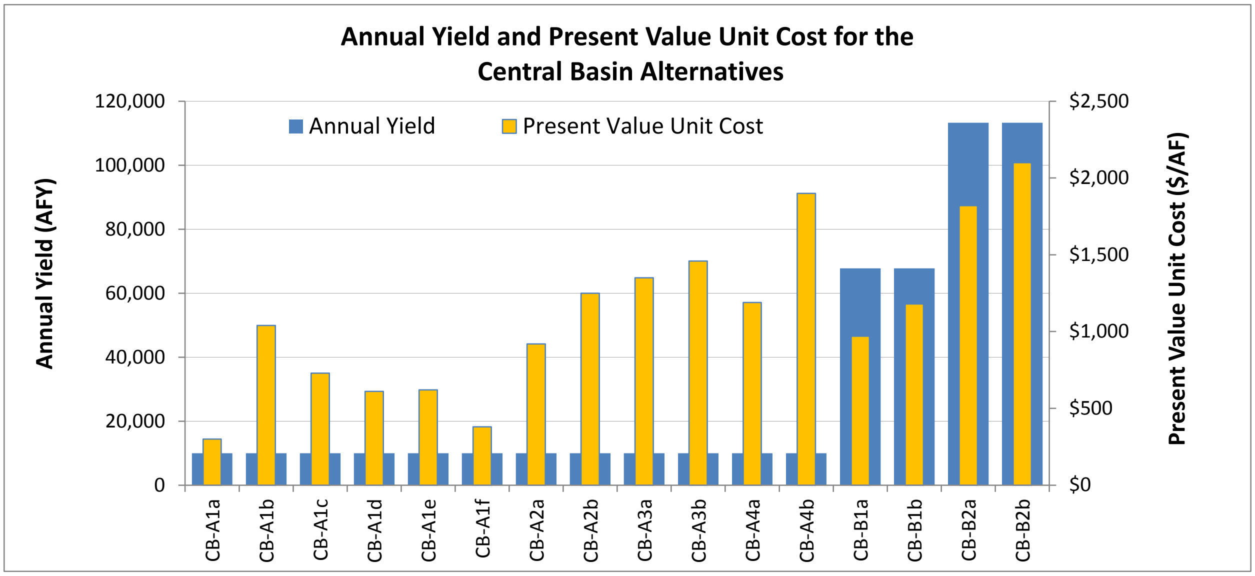

Figure 5-13. Central Basin Alternatives – Present Value Unit Costs

5.2.5 Water Supply Availability and Reliability

The replenishment supplies considered in the GBMP include:

- SJCWRP
- LCWRP
- JWPCP
- TIWRP
- ECLWRF from HWRP
- Satellite AWTF from Los Angeles raw wastewater
- San Gabriel River/Rio Hondo
- Los Angeles River

Of these, JWPCP and HWRP have significant surplus effluent such that its availability for a GBMP project is the most likely. Raw wastewater could possibly be mined from the City of Los Angeles' collection system, but its use would reduce flows to HWRP. The volumes of remaining recycled water supplies included in the GBMP from LACSD's SJCWRP and LCWRP will be subject to availability as there may be alternate plans for these supplies that could supersede GBMP project needs. All of the recycled water supplies are reliable if they are available.

The San Gabriel River/Rio Hondo flows considered in the GBMP are captured during wet-weather conditions when the existing MFSG are at capacity. They would require the same conditions in the future, so their availability and reliability are dependent on future flow conditions. The Los Angeles River flows considered in the GBMP are captured exclusively under wet weather conditions. As these flows are not currently captured, they would have greater potential for availability and reliability.

5.2.6 Energy/Greenhouse Gas Emissions

Energy demand is expressed as total annual kilowatt-hours (kWh) for an alternative. It is calculated from combining the energy requirements for treatment and pumping. The calculations include the energy required for typical operation only and do not include raw material or construction activities. The basis for treatment and conveyance energy calculations is summarized in Table 5-13. The calculations for energy demand are included in Appendix J.

Table 5-13. Treatment and Conveyance Energy Values for GBMP Replenishment Supplies

Supply	kWh/AF	Reference
Recycled Water – tertiary	0	
Recycled Water – full advanced treated	980	CPES
Recycled Water – NF	770	CPES
Recycled Water – ozone/BAC/GAC	390	CPES
Stormwater	0	
Imported Water - MWD Treated	2,500	Wilkinson

Notes:

Conveyance energy intensity for MWD imported water is calculated using the average values for State Project Water and Colorado River Authority water (Wilkinson, 2005).

Energy calculations for conveyance are based on the Hazen-Williams formula, using inputs for flow rate, total dynamic head, a pumping efficiency of 0.75, and a motor efficiency of 0.95. The calculations for conveyance energy are included with the cost estimates in Appendix J.

CPES = CH2M HILL Parametric Estimating System
kWh/AF = kilowatt-hour per acre-foot

Using these assumptions, annual values for energy demands (in kWh) were calculated for each project/alternative (Figures 5-14 and 5-15). In addition to lifecycle energy demands, lifecycle carbon dioxide (CO_2) emissions were also calculated to indicate potential contributions with respect to climate change. The emissions calculated were carbon dioxide, methane, and nitrous oxide, which each converted to metric tons of carbon dioxide equivalents. The metric tons CO_2 equivalents were then divided by the total potable water use offset by recycled water use. The Global Warming Potential Factors were based on the *General Reporting Protocol* (California Climate Action Registry, 2008).

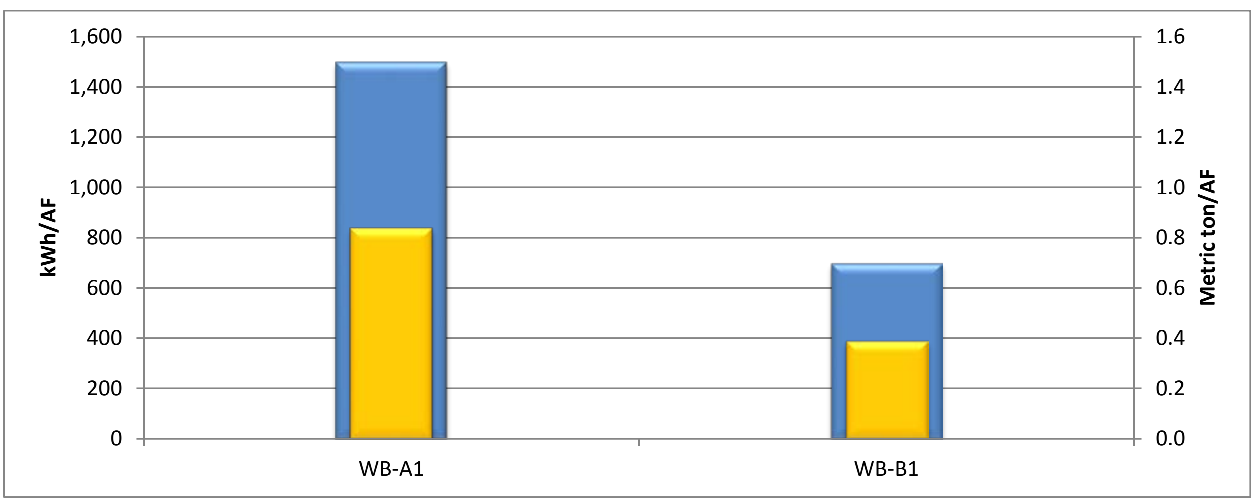

Figure 5-14. West Coast Basin Alternatives – Energy Use/Greenhouse Gas Emissions

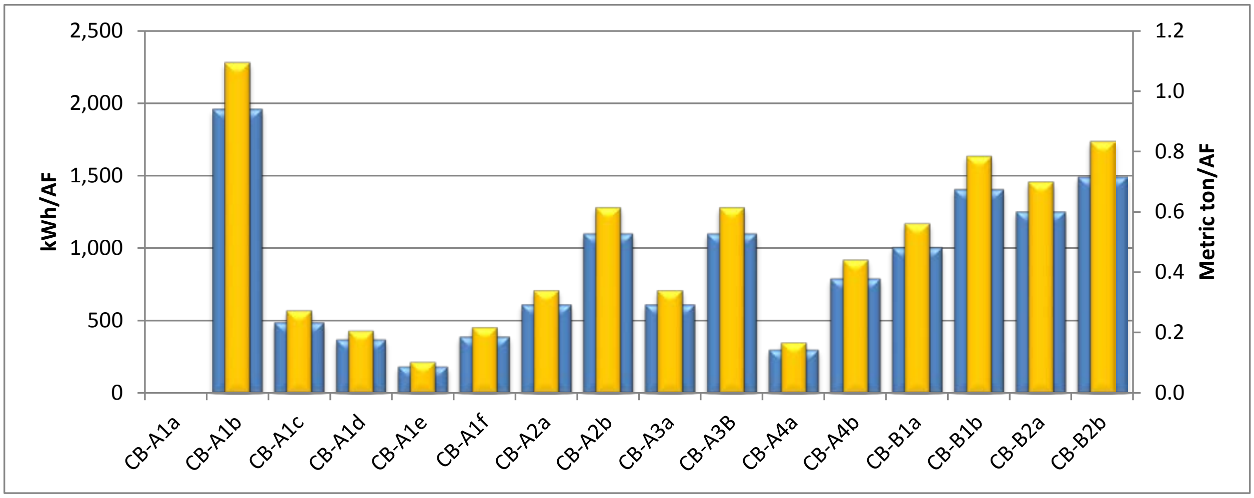

Figure 5-15. Central Basin Alternatives – Energy Use/Greenhouse Gas Emissions

5.2.7 Environmental Impacts and Total Dissolved Solids Loading

The GBMP alternatives vary with respect to the environmental impacts they may have. Generally, the greater the number of new facilities included in an alternative, the greater the potential environmental impact. Evaluations of these alternatives have been conducted at a programmatic level with the preparation of the accompanying Program Environmental Impact Report (PEIR).

A critical operational consideration is the potential impacts, which can be potentially beneficial as well as detrimental, to the groundwater quality. Such issues have been explored more fully in the Salt and Nutrient Plan (SNMP) for the Central and West Coast Basins (WRD, 2015).

The potential changes in TDS due to varying proposed levels of treatment are identified in Table 5-14.

Using these assumptions and the supply graphs, the annual tons of TDS added to the basins were calculated for each alternative, based on the volumes and estimated TDS concentrations of the various supply sources. These are shown on Figures 5-16 and 5-17 for the West Coast Basin and Central Basin alternatives, respectively.

Table 5-14. Total Dissolved Solid Concentration Values for GBMP Replenishment Supplies

Supply	TDS Concentration (mg/L)	Reference
Recycled Water – tertiary (SJCWRP)	567	CH2M HILL, 2012b
Recycled Water – 100% full advanced treated	100	MWH, 2009
Recycled Water – 100% NF	340	CH2M HILL, 2012a
Recycled Water – ozone/BAC/GAC	567	CH2M HILL, 2012a
Stormwater[a]	271	LACDPW, 2010a
Imported Water (No Project)[b]	439	MWD, 2010b

[a] Average value for wet weather months
[b] Average of Colorado River Aqueduct (628 mg/L) and State Water Project (250 mg/L)

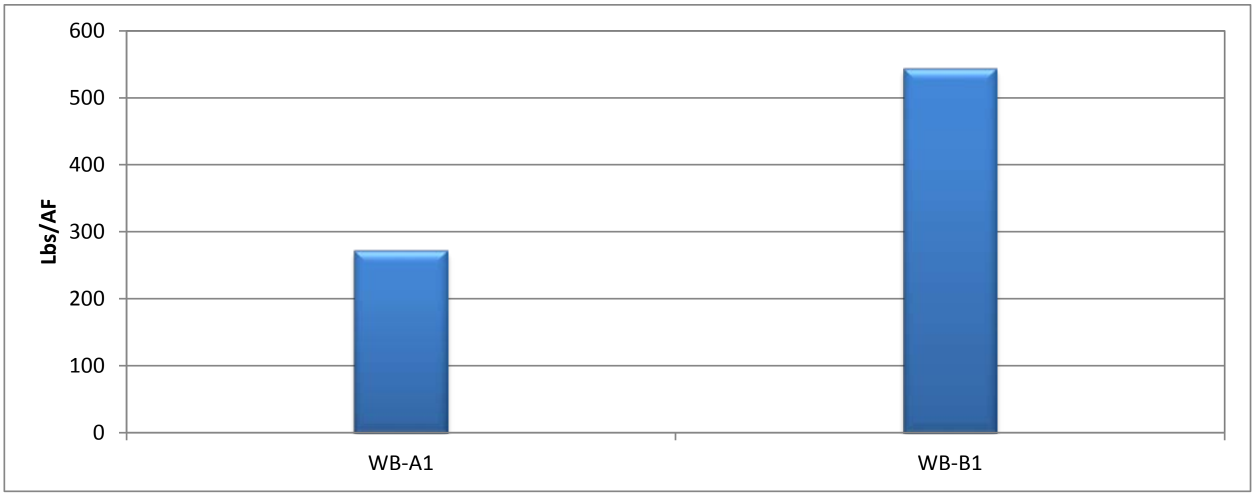

Figure 5-16. West Coast Basin Alternatives – Total Dissolved Solids Loading Rates

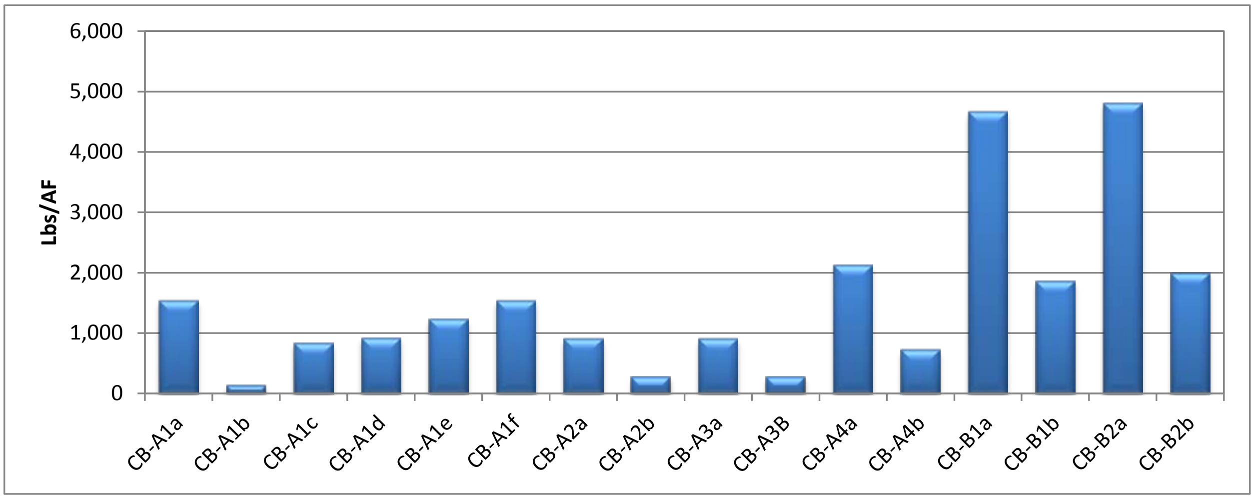

Figure 5-17. Central Basin Alternatives – Total Dissolved Solids Loading Rates

The SNMP has established guidelines for projects within the Central and West Coast Basin that need to be considered as elements of the GBMP alternativ es move forward toward implementation.

5.2.7.1 Summary of Alternatives Evaluation

Key findings of a comparison of the GBMP alternatives against the evaluation criteria described above include:

- AWT alternatives lifecycle costs are more than twice the costs for tertiary alternatives.
- The lifecycle costs for tertiary alternatives could be even lower if the purchase price for tertiary effluent is reduced. These estimates assume a price of $300/AF for tertiary projects and a price of $100/AF for AWT projects.
- Energy demands and CO_2 emissions are significantly higher for the No Project Alternative due to pumping required for the conveyance of imported water.
- CO_2 emissions for AWT alternatives are approximately 60 percent less than the No Project Alternative.
- CO_2 emissions for tertiary alternatives are significantly lower than the No Project Alternative.
- AWT alternatives result in a TDS loading that is significantly lower than the No Project Alternative.
- Tertiary alternatives result in a TDS loading that is approximately 40 percent higher than the No Project Alternative.

SECTION 6

Implementation Plan

WRD initiated the preparation of this GBMP to facilitate long-term planning with basin stakeholders and to identify sustainable, reliable sources of replenishment water to meet projected groundwater production demands cost-effectively.

As an element of WRD's WIN program, the GBMP establishes a framework in which projects recommended for further evaluation can be examined and considered within an open, transparent process. By considering regional, basin-wide needs and opportunities, the GBMP offers stakeholders options that can satisfy individual water systems' interests and priorities while also providing broader basin benefits. Under the WIN program, WRD has been implementing projects and programs that enhance basin replenishment, increase the reliability of groundwater resources, improve and protect groundwater quality, and ensure that the groundwater supplies are suitable for beneficial uses. Offering a wide range of alternatives for the basin stakeholders to consider in advancing the WIN program goals is the primary objective of the GBMP.

WRD is responsible for ensuring that replenishment goals are met with respect to quantity and quality of replenishment water to meet the pumping demands in the West Coast and Central Basins, up to the adjudicated water rights and APA, respectively. Toward that end, WRD would lead the development of such projects that would provide reliable, cost-effective replenishment sources.

The implementation of any projects or programs that would exceed the replenishment obligations of WRD would result solely from the impetus of the basin stakeholders to invest in the development of additional replenishment water to more fully utilize the basins, and "WIN BIGGR."

This section summarizes potential implementation issues associated with the projects that make up the GBMP alternatives and identifies next steps for implementation of the GBMP program. Some of the implementation issues described below vary with respect to whether the project is considered to meet replenishment needs for pumping within the adjudicated rights, or extend beyond these limits to further utilize basin storage, and are discussed in that context.

6.1 Implementation Considerations

Advancement of the GBMP projects or alternatives described above will require consideration of the following:

- Recycled water flow availability
- River storm flow availability
- MFSG capacity
- SNMP implementation measures
- West Coast Basin Flow and Transport Model revisions
- Public and stakeholder participation process
- Replenishment assessment
- Recent Judgment amendments

6.1.1 Recycled Water Flow Availability

Implementing all of the identified GBMP alternatives requires a large supply of recycled water for replenishment. Of the wastewater treatment plants, the JWPCP and HWRP have significant surplus effluent such that its availability for a GBMP project is the most likely. Los Angeles raw wastewater should also be available, but its use would reduce flows to HWRP. The volumes of remaining recycled water supplies included in the GBMP—SJCWRP, LCWRP, and TIWRP—are currently not being reused, but there may be alternate plans for these supplies that could impact their availability for GBMP project needs. GBMP projects represent very high beneficial use of these supplies (that is, groundwater replenishment), so firming up these supplies for GBMP projects should be a high priority. All of the recycled water supplies are reliable if they are secured by a long-term commitment.

6.1.2 Storm Flow Availability

The San Gabriel River/Rio Hondo flows considered in the GBMP are based on historical wet-weather conditions. Thus future hydrological patterns would need to be relatively similar to historical patterns to provide sufficient storm flow for the assumed capture volumes for the enhanced stormwater capture scenarios described in this GBMP. The Los Angeles River flows estimated for capture and use in the GBMP alternatives are also based on historical patterns, but none of these flows are currently captured and used. Therefore, there is a higher chance of availability of these flows. However, countywide programs targeting reduction of storm flows to mitigate downstream water quality impacts along with climate change impacts can affect these patterns in the long term, resulting in potentially less available storm flows than identified for the GBMP alternatives. Further study of storm flow availability is recommended if enhanced stormwater capture is chosen to be advanced forward. Given that enhanced stormwater capture from the San Gabriel River/Rio Hondo could be one of the more economical replenishment projects, with potential additional benefits to pumpers, this project should be considered for early implementation.

6.1.3 Montebello Forebay Spreading Grounds Capacity

Replenishment of the groundwater basins with stormwater provides both water supply as well as dilution credit to meet RWC requirements. The most cost-effective method for capturing and infiltrating large volumes of stormwater from the San Gabriel River and Rio Hondo is limited by the available capacity of the existing MFSG. Recharge is typically highest during the wet season when large volumes of stormwater are available from storm events and from subsequent releases from upstream dams. An analysis of historical, monthly recharge at the MFSG was conducted for the GBMP modeling and is described in Section 4.1.2. Historical records of recharge at the MFSG were used as the basis of assumptions for potential future recharge capacities during short-term high recharge events and for “normal” operations. Further detailed study of the recharge capacity, especially short-term high-rate recharge capacity to capture storm flows, is recommended to confirm that the assumed quantities of short-term high recharge rates are possible, as reductions in these rates will reduce the long-term average stormwater volumes that can be conserved. This study should be conducted as a part of the study of storm flow availability, as the two considerations are linked and critical to the overall supply volume that can be created from enhanced stormwater capture.

6.1.4 Salt and Nutrient Management Plan (SNMP)

The Central and West Coast Basins SNMP, prepared in a partnership led by WRD, was completed in February 2015. The water quality modeling of major recycled water projects conducted for the development of the plan indicated that the constituents of concern (i.e., TDS, chloride and nitrate) will remain below the Basin Plan Objectives in the Central Basin. The SNMP’s planned implementation measures will enable the West Coast Basin to meet the Basin-Specific Basin Plan Objective for TDS by 2035. The major projects included in the SNMP analysis were as follows:

Recycled water projects: injection of 100 percent AWT recycled water at the seawater intrusion barriers; GRIP; and, increased use of tertiary-treated recycled water for irrigation;

Barrier projects: expansion of the existing Goldsworthy Desalter; increased pumping from the existing Brewer Desalter;

Stormwater projects: increasing stormwater capture at the Dominguez Gap Spreading Grounds to increase replenishment in the West Coast Basin; sediment removal at the Rio Hondo Spreading Grounds to restore percolation and storage capacity; MS4 EWMP projects (LID/stormwater BMPs); LA Basin Stormwater Conservation Study projects, Broadway Neighborhood Stormwater Greenway project; improvements to Entradero Storm Drain Channel for stormwater infiltration in the City of Torrance; and Vermont Avenue Stormwater Capture project in the City of Gardena.

The projects identified in this GBMP were acknowledged in the SNMP as conceptual implementation measures, and, as such, were not included in the modeling analysis. As shown in Section 5.2.2.7, the salt loading for each alternative varies based on the replenishment supply mix and the level of treatment applied to recycled water. The alternatives with AWT and/or stormwater have lower salt and nutrient loadings than projects that rely more on tertiary effluent. As each of the GBMP project is considered for implementation, it will need to be evaluated in light of its salt and nutrient water quality impacts to the groundwater basins.

6.1.5 West Coast Basin Flow and Transport Model

WBMWD and WRD are in the process of further calibrating the West Coast Basin groundwater flow and solute transport model for simulations of the saline plume. As described in Section 3.2.3.9, preliminary simulations of saline plume containment/remediation were conducted with the current West Coast Basin groundwater flow and solute transport model. These preliminary simulations indicated significant improvement in basin water quality. Once the groundwater flow and solute transport model is recalibrated for the saline plume, these simulations should be repeated to refine this operating condition. It is recommended that the West Coast Basin groundwater flow and solute transport model maintained by WBMWD be used to simulate this condition.

6.1.6 Public and Stakeholder Participation

As described in Section 2.1.2, many West Coast and Central Basin stakeholders were engaged in the development of the GBMP. Several key opportunities for public and stakeholder participation followed that advanced the planning reflected in the GBMP to replace imported water use and more fully utilize the groundwater basins. These included the following processes led by WRD:

- GBMP PEIR process
- GRIP Recycled Water Project EIR/EIS process
- SNMP stakeholder process

In its role as the Administrative Body of the Watermaster of both the West Coast and Central Basins, WRD will facilitate coordination of groundwater replenishment projects in these basins with the project proponents. (See section 6.1.8 below for a discussion of the Judgment Amendments.) Through such coordination, WRD can help identify where projects that proponents may consider implementing to meet more near-term pumping needs—that is, to satisfy potential extractions up to the current adjudicated limits (i.e., Concept A), could potentially be expanded to meet pumping demands associated with Water Augmentation projects, (i.e., Concept B). For example, the GRIP Recycled Water Project may be expanded in the future, which may or may not require implementation of diversion projects that would provide additional influent flow to the SJCWRP (described in Section 3.3.2.2). However, there may be an augmentation project spearheaded by another water rights holder that might justify the implementation of some of the more expensive diversion projects to maximize the use of the SJCWRP as a producer of replenishment water for the Central Basin. Through such coordination, efficiencies of costs and basin operations can be identified for replenishment and extraction that best serve the basin water rights holders and other regional stakeholders.

6.1.7 Replenishment Assessment

Each year, WRD establishes a replenishment assessment (RA) for the ensuing fiscal year (July 1 through June 30) based on the planned purchase of replenishment water as well as projects and programs related to groundwater replenishment and groundwater quality over the next water year (October 1 through September 30). The cost of replenishment water is the most significant component of the RA.

Although the costs for projects and alternatives developed in this GBMP are not projected as elements of future RAs, any water supply that can minimize the costs of replenishment water will be beneficial to minimizing future RAs. As the GBMP alternatives are intended to replace imported water use, their costs can be measured relative to projected imported water purchase costs, and thus their relative impact on the RA inferred.

Ultimately, specific agreements will be developed for each potential project, and the costs and benefits of implementation will be weighed by the affected parties. The RA impact of a particular project will necessarily become a part of that project's implementation evaluation process.

6.1.8 Recent Judgment Amendments

Amendments to both the Central Basin and West Coast Basin adjudications were approved in December 2013 and December 2014, respectively. The amendments allows storage of water for later recovery in both basins, thereby optimizing the use of available storage space, estimated at 120,000 AFY in the West Coast Basin and 330,000 AFY in the Central Basin. Comprising the available storage ("dewatered") space are the Basin Operating Reserve and Adjudicated Storage Capacity, which are managed by WRD in accordance with the terms of the judgment amendments. Most notably, the amendments allow parties to the Judgments to implement Water Augmentation projects that would allow for extraction of the project's yield in excess of the party's adjudicated rights. Each basin's Watermaster is comprised of the following three entities: (1) the Administrative Body (i.e., WRD), (2) the Water Rights Panel (made of up representatives of the Parties holding adjudicated rights), and (3) the Storage Panel (made of the Water Rights Panel and WRD Board members.) The amendments prescribe the requirements for the Watermaster's review and approval of Storage and Water Augmentation Projects.

6.2 Next Steps

This GBMP is intended to be a starting point for basin-wide planning that serves as the basis for a programmatic environmental review process. Complementing stakeholder outreach conducted during the preparation of the GBMP, WRD intended to use the EIR process to formally vet the GBMP alternatives and further open dialogue about these potential opportunities. The determination of the relative value of these opportunities will stem from such dialogue. WRD's intent is to facilitate these discussions with the preparation of this GBMP.

The GBMP is not intended to be a capital improvement program, nor does it address any of the institutional, financial, regulatory, or legal issues that might be associated with implementation of any of the identified projects or alternatives. Rather, the GBMP provides technical analysis of what might be possible to enhance utilization of the West Coast and Central groundwater basins for local and regional benefits.

Next steps for moving forward with the findings of this GBMP include:

- Ongoing GRIP Recycled Water Project implementation: utilize GRIP project-specific analysis and EIR process to explore near-term and long-term project options, including phasing considerations.
- Recycled Water Flow Availability: Coordinate with LACSD for SJCWRP and LCWRP, with WBMWD for ECLWRF and with the City of LA for HWRP and TIWRP. Define available flows with and without any improvements considering flow and use projections, seasonal and diurnal flow variations, and

improvements necessary to maximize effluent, such as flow equalization or collection system diversions.

- River Flow Availability: Continue to update the WRD/USGS Groundwater Flow Model with stormwater data to maximize its benefit as a predictive tool using historical data. Explore potential long-term climate change impact predictions on future storm flows in the Los Angeles region.
- MFSG Capacity: Coordinate with LACDPW to define the constraints and timing available for recharge via surface spreading of recycled water in the MFSG, as well as facilities necessary to convey the supply considering historic and projected stormwater recharge, historic and projected recycled water recharge, historic and projected spreading basins (including unlined river stretches), capacity/infiltration rates, LACDPW O&M, groundwater mounding, potential spreading grounds improvements, and existing and necessary conveyance facilities.
- West Coast Basin Flow and Transport Model: Once the West Coast Basin flow and transport model is refined by WBMWD and WRD, reassess and refine desalter alternatives for saline plume containment/remediation, as appropriate.
- Public and Stakeholder Outreach: Coordinate among public/stakeholder participation efforts associated with the GBMP, GRIP, SNMP and other key stakeholder forums such as the West Basin Water Association and Central Basin Water Association.

The GBMP is intended to be a tool or resource to be used by all of the basin stakeholders to aid in decision making for future development of groundwater resources in the West Coast and Central Basins. The components of the various GBMP alternatives can be used as building blocks to provide comparative cost estimates of future basin management scenarios. By considering a long-term planning horizon, WRD can work with the basin stakeholders to cultivate those programs and projects that will ultimately provide cost-effective replenishment for adjudicated pumping rights in the basins and ultimately a reliable supply alternative to a portion or all of the imported water use in the basins.

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References

California Climate Action Registry. 2008. *Local Government Operations Protocol For the quantification and reporting of greenhouse gas emissions inventories, Version 1.* September.

California Department of Water Resources (DWR). 1961. *West Coast Basin Judgment*. http://www.water.ca.gov/watermaster/westbasin_judgment/index.cfm.

California Department of Water Resources (DWR). 1965. *Central Basin Judgment*. http://www.water.ca.gov/watermaster/centralbasin_judgment/index.cfm.

California Department of Water Resources (DWR). 2009. *Watermaster Service in the West Coast Basin Los Angeles County*. September.

California Department of Water Resources (DWR). 2010a. *DWR Bulletin 132-08.*

California Department of Water Resources (DWR). 2010b. *Watermaster Service in the Central Basin Los Angeles County*. October.

California Department of Water Resources (DWR). 2010c. Watermaster Service in the Central Basin Annual Reports 2000-01 to 2008-09. http://www.water.ca.gov/watermaster/.

California State Water Resources Control Board, Division of Drinking Water (DDW). 2014. *Groundwater Replenishment Using Recycled Water*. May.

California Water Service Company (CWSC). 2011a. *2010 Urban Water Management Plan- East Los Angeles District*. June.

California Water Service Company (CWSC). 2011b. *2010 Urban Water Management Plan- Dominguez District*. June.

California Water Service Company (CWSC). 2011c. *2010 Urban Water Management Plan- Hawthorne*. June.

California Water Service Company (CWSC). 2011d. *2010 Urban Water Management Plan- Hermosa -Redondo*. June.

Carollo Engineers (Carollo). 2009. *West Basin Municipal Water District Capital Implementation Master Plan for Recycled Water Systems*. June.

Central Basin Municipal Water District (CBMWD). 2011. *Central Basin Municipal Water District 2010 Urban Water Management Plan*. May.

Cerritos, City of. 2011. *2010 Urban Water Management Plan*. June.

CH:CDM, A Joint Venture. 2006. *City of Los Angeles Recycled Water Master Plan.* December.

CH2M HILL. 2012a. *CH2M HILL Cost Parametric Estimating System (CPES).* March.

CH2M HILL. 2012b. *Alternatives Analysis Update Report Groundwater Reliability Improvement Program Recycled Water Project Final Draft.* July.

Cleaner Rivers through Effective Stakeholder-led TMDLs (CREST). 2009. *Draft Los Angeles River Watershed Bacteria TMDL – Technical Report Section 4: Bacteria TMDL Source Assessment.* July. http://www.crestmdl.org/reports/working_documents.html.

Downey, City of. 2012. *2010 Urban Water Management Plan*. January.

El Segundo, City of. 2011. *2010 Urban Water Management Plan*. October.

Environmental Simulations Inc. *Groundwater Vistas*. www.groundwatermodels.com.

Golden State Water Company (GSWC). 2011a. *2010 Urban Water Management Plan- Artesia.* September.

Golden State Water Company (GSWC). 2011b. *2010 Urban Water Management Plan- Bell/Bell Gardens.* September.

Golden State Water Company (GSWC). 2011c. *2010 Urban Water Management Plan- Florence.* September.

Golden State Water Company (GSWC). 2011d. *2010 Urban Water Management Plan- Norwalk.* September.

Harbaugh, A.W., and McDonald, M.G. (1996). "*User's documentation for MODFLOW-96 an update to the U.S. Geological Survey modular finite-difference ground-water flow model*": U.S. Geological Survey Open-File Report 96-485, 56 p.

Inglewood, City of. 2011. *2010 Urban Water Management Plan*. June.

Lakewood, City of. 2011. *2010 Urban Water Management Plan*. May.

Lomita, City of. 2011. *2010 Urban Water Management Plan*. June.

Long Beach Water Department (LBWD). 2011. *LBWD 2010 Urban Water Management Plan*. June.

Los Angeles County Department of Public Works (LACDPW). 2010a. *2009-2010 Stormwater Monitoring Report*.

Los Angeles County Department of Public Works (LACDPW). 2010b. Annual Hydrologic Reports. 1996 to 2008, and recent online data. http://www.lacounty.gov/wrd/publication/.

Los Angeles County Sanitation District (LACSD). 2010. *Recycled Water Supply for GRIP – August 2010 Update Memorandum.* August 23.

Los Angeles County Sanitation District (LACSD). 2011. *Twenty-First Annual Status Report on Recycled Water Fiscal Year 2009-2010.*

Los Angeles Department of Water and Power (LADWP). 2011. *LADWP Urban Water Management Plan*. May.

McDonald, M.G., and Harbaugh, A.W. (1988). "*A modular three-dimensional finite-difference ground-water flow model"*: Techniques of Water-Resources Investigations of the United States Geological Survey, Book 6, Chapter A1, 586 p.

Manhattan Beach, City of. 2011. *2010 Urban Water Management Plan*. June.

Metropolitan Water District of Southern California (MWD). 2007. *Groundwater Assessment Study.* September.

Metropolitan Water District of Southern California (MWD). 2010b. *The Regional Urban Water Management Plan*. November.

Metropolitan Water District of Southern California (MWD). 2010a. *Integrated Water Resources Plan (IRP) 2010 Update*. October.

Metropolitan Water District of Southern California (MWD). 2015. *Board of Directors Water Planning and Stewardship Committee 9/22/2015 Board Meeting Item 9-1.* September 22.

MWH. 2009. *GRIP Technical Memorandum No. 5-Reverse Osmosis Treatment*. April.

MWH. 2010. *Draft Report Recycled Water Master Plan*. August.

RMC Water and Environment (RMC). 2011. *GRIP Alternatives Analysis Final Report*. June.

RMC Water and Environment (RMC). 2012a. *Groundwater Replenishment Master Planning Report and GWR Treatment Pilot Study*. March 2012.

RMC Water and Environment (RMC). 2012c. *Long-Term Concepts Report*. March 2012.

RMC Water and Environment (RMC). 2012d. *Terminal Island Water Reclamation Plant Barrier Supplement and NPR Concepts Report*. March 2012.

RMC Water and Environment (RMC). Water and Environment (RMC). 2012b. *Non-Potable Reuse Master Planning Report*. March 2012.

RMC. 2011. *GRIP Alternatives Analysis Final Report*. June.

RMC. 2012a. *Long-Term Concepts Report*. March.

RMC. 2012b. *Terminal Island Water Reclamation Plant Barrier Supplement and NPR Concepts Report*. March.

South Gate, City of. 2011. *2010 Urban Water Management Plan.* June.

Torrance, City of. 2011. *2010 Urban Water Management Plan*. July.

U.S. Bureau of Reclamation (Reclamation). 2012. http://www.usbr.gov/WaterSMART/grants.html.

United States Geological Survey (USGS). 2003. *Geohydrology, Geochemistry, and Groundwater Simulation/Optimization of the Central and West Coast Basins, Los Angeles County, California Water Resources Investigations Report 03-4065.*

Vernon, City of. 2011. *2010 Urban Water Management Plan.* June.

Water Replenishment District (WRD). 2001. *Montebello Forebay Recharge Optimization Study.*

Ted Johnson, Water Replenishment District (WRD). 2009. *Memorandum to Board of Directors. Report by the Groundwater Quality Committee: Saline Plume Update.* September 24.

Water Replenishment District (WRD). 2011a. Fi*nal Revised Workplan of the Salt/Nutrient Management Plan (SNMP) Central Basin and West Coast Basin (CWCB) Southern Los Angeles County, California*. October.

Water Replenishment District (WRD). 2011b. *Engineering Survey and Report*. March.

Water Replenishment District (WRD). 2012. *Engineering Survey and Report*. March.

Water Replenishment District (WRD). 2015. *Salt and Nutrient Management Plan, Central Basin and West Coast Basin, Southern Los Angeles County, California.* February.

Water Replenishment District (WRD). 2016. *Engineering Survey and Report*. March. Weeks, Jason. Personal communications.

West Basin Municipal Water District (WBMWD). 2011. *WBMWD Urban Water Management Plan 2010*. May.

Wilkinson, Robert C., Fawzi Karajeh, and Julie Mottin, 2005. *Water Sources "Powering" Southern California: Imported Water, Recycled Water, Ground Water, and Desalinated Water: An Analysis of the Energy Intensity of Water Supplies for the West Basin and Central Basin Municipal Water Districts.*

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Appendix A
Basin Adjudications and Judgment Amendments

APPENDIX A

Adjudications and Judgment Amendments

The Central Basin and West Coast Basin Judgments and most recent Judgment amendments are summarized in the sections below.

A.1 West Coast Basin Judgment

Historical extractions far in excess of the natural replenishment resulted in declining groundwater levels and seawater intrusion into the West Coast Basin. In response, the West Coast Basin was adjudicated in 1961 (California Water Service Company et al. v. City of Compton, Case No. 506806), thereby limiting the amount of groundwater each party to the West Coast Basin Judgment can extract annually from the basin. These limits are monitored by a court-appointed Watermaster who administers and enforces the terms of the Judgment and reports annually to the court on significant groundwater-related events that occur in the basin. The court also retained jurisdiction to monitor ongoing management of the basin, including the conjunctive use of basin storage space to assure the basin will be capable of supplying sufficient water to meet local needs, as well as future growth and development needs.

The West Coast Basin has total adjudicated rights of 64,468.25 acre-feet-year (AFY), which is based on historical use and not the safe yield of the basin. Natural replenishment is limited to underflow from the Central Basin (which has been estimated to be between 20,000 to 30,000 AFY). The adjudication is based on a physical solution that includes artificial replenishment by the Water Replenishment District of Southern California (WRD) with a combination of imported and recycled water through two injection barriers, thus allowing pumpers to pump in excess of the natural safe yield of the basin creating an annual overdraft. To recover its replenishment costs, WRD charges pumpers a Replenishment Assessment (RA) base on the volume of water each pumps per year. The RA covers replenishment costs in both the West Coast and Central Basins and is divided among the pumpers in both basins collectively.

The Judgment contains provisions that allow for limited flexibility in the management of the West Coast Basin. The Judgment has the following provisions:

- Carryover: Pumpers that do not exercise their full pumping rights in a particular year are allowed to carry over from one administrative year to the next up to 2 AF or 20 percent of the adjudicated right, whichever is greater.
- Over-Pumping: Pumpers are allowed to pump up to 110 percent of their adjudicated of their adjudicated right provided that any over production is made up by under production in the following. In addition, the judgment allows for up to 10,000 AFY of emergency over-pumping under certain conditions.
- Lease: Pumpers are able to lease their rights. Terms of the leases can vary including whether or not to include carryover.
- Sales: Pumpers are able to sell their rights.
- Exchange Pool: The West Coast Basin Judgment creates an exchange pool through which pumpers who have access to supplemental imported water can make their pumping rights available to pumpers who do not have access to imported water for a price not to exceed the cost of the supplemental imported water. The exchange pool operates on an annual pooled basis, as compared to leasing of rights, which is between specific parties and can be for extended terms.

A.2 Central Basin Judgment

The Central Basin currently operates under an adjudication judgment. The Central Basin Judgment was entered in 1965 (Central and West Basin Water Replenishment District v. Adams, Case No. 786656). The judgment establishes adjudicated rights totaling 267,900 AFY but limits pumping to an Allowable Pumping Allocation (APA) of approximately 80 percent of this amount, which is equivalent to 217,367 AFY. Both amounts exceed the natural yield of the basin, and the judgment recognizes that WRD artificially replenishes the basin to make up the difference. To recover its replenishment costs, WRD charges a RA based on the volume of water pumped per year. The RA covers replenishment costs in both the West Coast and Central Basins and is divided among the pumpers in both basins collectively.

The judgment has the following provisions:

- Carryover: Pumpers are allowed to carryover up to 20 percent of their APA into the following year.
- Over-Pumping: Pumpers are allowed to pump up to 120 percent of their APA (or 20 AF, whichever is greater) provided that any over production is made up by under- production in the following year. Under certain circumstances, parties may over-extract in greater amounts; however, prior approval by the Watermaster must be obtained.
- Lease: Parties are able to lease their rights. Terms of the leases can vary including whether or not to include carryover.
- Sales: Parties are able to sell their rights.
- Exchange Pool: The Central Basin Judgment creates an exchange pool through which pumpers who have access to supplemental imported water can make their pumping rights available to pumpers who do not have access to imported water for a price not to exceed the cost of the supplemental imported water.

Outside of the Central Basin Judgment, WRD adopted a set of Interim Storage Rules that were designed to establish a framework and process through which pumpers could begin to store and extract water from conjunctive use projects. These Interim Storage Rules were developed at the request of a number of pumpers and under the premise held by many that WRD has the authority to develop and implement such rules under its legislative mandate. The Interim Storage Rules have been developed and are supported by many of the pumpers. However, they have not been implemented because of concern about legal challenges.

At this time, the judgment does not recognize the right to store water, nor does it give pumpers the legal mechanism to pump more than their rights with the exception of the Over-Pumping provision described above. The annual Watermaster's Report prepared by DWR tracks the claimed storage amounts but explicitly states that it does so, "without acknowledging their legal standing under the Judgment." In addition, any water pumped from the groundwater basin could currently be subject to the RA even if it could be shown to have been recharged outside the confines of the judgment. In effect, these restrictions preclude pumpers from operating the Basin to generate additional water supply yield. Operating outside of these restrictions could invite legal challenges from other pumpers (DWR, 2010).

A.3 Recent Judgment Amendments

Recent amendments to both the West Coast Basin and Central Basin Judgments provide for enhanced utilization of the basins for groundwater storage and extraction. The effect of these amendments is to utilize the currently unused storage space, estimated at a total of 450,000 AF in both basins, 120,000 AF of which is in the West Coast Basin. The amendments also included provisions for the interbasin transfer of storage rights between the West Coast Basin and the Central Basin. Most significantly, the implementation of water augmentation projects, wherein recharge and extraction volumes are matched within an established timeframe, would allow pumping beyond adjudicated rights. Such additional recharge can be accomplished with surplus imported water, when available, as well as with local recycled water, which has become a much more consistent and reliable source of replenishment water.

The Judgment amendments provide definitive rules for governing storage and recovery. The amendments seek to provide opportunities that were not possible prior to these adjudication Judgments. The amendments contain four principal elements that impact the types of projects that could be pursued. These principal elements are summarized below:

- **New Management Entities:** The court-appointed watermasters for the basins did not administer unused storage space or approve new groundwater recharge projects. The judgment amendments would create a Storage Panel for each basin, made up of a Basin Administrator (WRD) and a Water Rights Panel (five groundwater producers), to review and approve discretionary projects. Discretionary projects would be those that construct new facilities, require California Environmental Quality Act review, and/or use more than 120 percent of a given pumper's APA. New groundwater recharge and recovery projects are considered discretionary.
- **Storage Space:** The prior adjudication decrees did not contain provisions for use of unused storage space in the basins. The amendments would declared that "available dewatered space" exists and divided this space into the allotments shown in Table A-1. The amendments include rules for the use of these allotments by parties and non-parties to the adjudications.

Briefly, each of these categories is defined as follows:

1. **Basin Operating Reserve:** Reserved for use by WRD in order to more effectively achieve its mandate of providing replenishment to meet adjudicated pumping rights. However, it is envisioned that water augmentation projects (described below) would utilize space within this allotment.
2. **Individual Storage Accounts:** Each party to the judgments is assigned storage rights of 40 percent of its adjudicated right (West Coast Basin) or APA (Central Basin) for its exclusive use.
3. **Community Storage Pool:** Once a party "fills" its Individual Storage Account, it may access the Community Storage Pool on a first come, first-served basis. There are provisions that require parties to turn over their storage and provide access to other parties.
4. **Regional Storage Projects:** This category is meant to provide access to or implementation of projects by non-parties to the proposed amendments. Projects would need to be designed to provide various benefits to those that are parties to the amendments (e.g., reducing the RA).
5. **Water Rights Transfers:** The current adjudication decrees do not allow water rights transfers between the basins. The amendments, as proposed, would allow each party to transfer up to 5,000 AFY from the West Coast Basin to the Central Basin to increase groundwater production in the Central Basin. Total transfers less than 20,000 AFY would be considered a non-discretionary project.
6. **Water Augmentation:** The current adjudication decrees establish fixed annual pumping rights for the parties. The amendments, as proposed, would allow parties to increase their production rights by recharging the basins with new water supplies using water augmentation projects. These projects are envisioned to increase yield from the basins by matching recharge and extraction volumes on a regular basis (e.g., every 1 to 3 years). As such, the projects would not be considered storage and thus would not require a party to utilize adjudicated storage space and the restrictions attached to that space. This type of project represents the largest potential for maximizing the reuse of recycled water.

TABLE A-1
Basin Storage Volumes by Category

Storage Categories	West Coast Basin	Central Basin
Individual Storage Allocation	25,800	87,000
Community Pool	35,500	95,000
Regional Storage	9,600	23,000
Basin Operating Reserve	49,100	125,000
TOTAL	**120,000**	**330,000**

On December 18, 2013, the third amendment to the Judgment for the Central Basin was issued by the courts.

The Judgment now permits parties holding water rights to store water in the Central Basin for later recovery. This ability to access available storage space, as well as other provisions for increased flexibility, provide the framework for the optimal utilization of the Central Basin to meet the future water demands of the region.

The Third Amended Judgment also established a new Watermaster, which replaces the Department of Water Resources in that role. The Watermaster now consists of three separate arms with different functions (WRD, 2014).

- The first arm is the Administrative Body, to administer the Watermaster accounting and reporting functions. The Water Replenishment District of Southern California was appointed by the court to fulfill this role.
- The second arm is the Water Rights Panel which enforces issues related to the pumping rights within the adjudication. The Water Rights Panel is made up of seven water rights holders who are selected through election.
- The third arm is the Storage Panel that comprises the Central Basin Water Rights Panel and the WRD Board of Directors, which together approve certain groundwater storage efforts.

On December 5, 2014, a judgment amendment for the West Coast Basin was issued by the Courts with similar provisions as the Central Basin third judgment amendment. WRD is also the Watermaster for the West Coast Basin. The Water Rights Panel consists of five members, three of whom are the president, vice-president and treasurer of the West Basin Water Association and two of whom are selected by the Association's Board of Directors. In addition, at least one member must be a non-water purveyor adjudicated rights holder with at least 1 percent of the Basin's adjudicated rights. The Storage Panel is comprised of the West Coast Basin Water Rights Panel and the WRD Board of Directors.

A.4 References

California Department of Water Resources (DWR). 2010. *Watermaster Service in the Central Basin Annual Reports 2000-01 to 2008-09.* http://www.water.ca.gov/watermaster/.

Water Replenishment District of Southern California (WRD). 2014. *Watermaster Service in the Central Basin – Los Angeles County, July 1, 2014-June 30, 2014, November 2014*.

Appendix B
Groundwater Basin Conditions and Operations

APPENDIX B

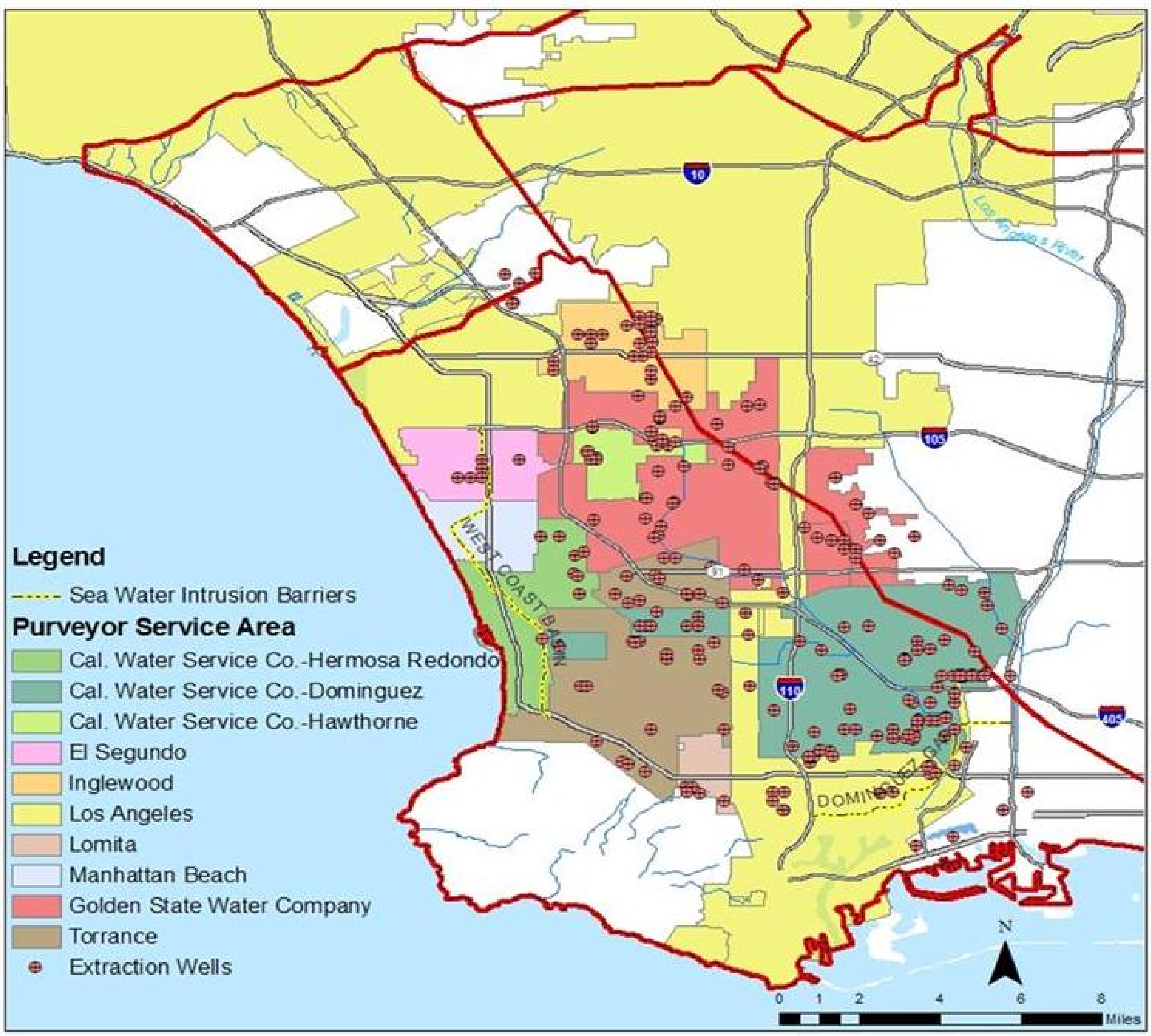
Groundwater Basin Conditions and Operations

This appendix summarizes historical operating conditions in the West Coast Basin and Central Basin, including historical water demands and replenishment facilities.

B.1 West Coast Basin

Groundwater extractions from the West Coast Basin are governed primarily by the legal requirements of the existing West Coast Basin Judgment, water consumption demands, and water supplies from the local water purveyors for the areas overlying the West Coast Basin. These demands include the injection water for the two barrier systems that protect the groundwater from seawater intrusion. Basin operations are also regulated by policies and practices related to other water quality issues that must be managed within the basin such as saline plumes and other sources of groundwater contamination. Figure B-1 shows the service areas for the major water purveyors in the West Coast Basin (i.e., with groundwater rights greater than 1,500 acre-feet (AF) and their respective extraction wells.

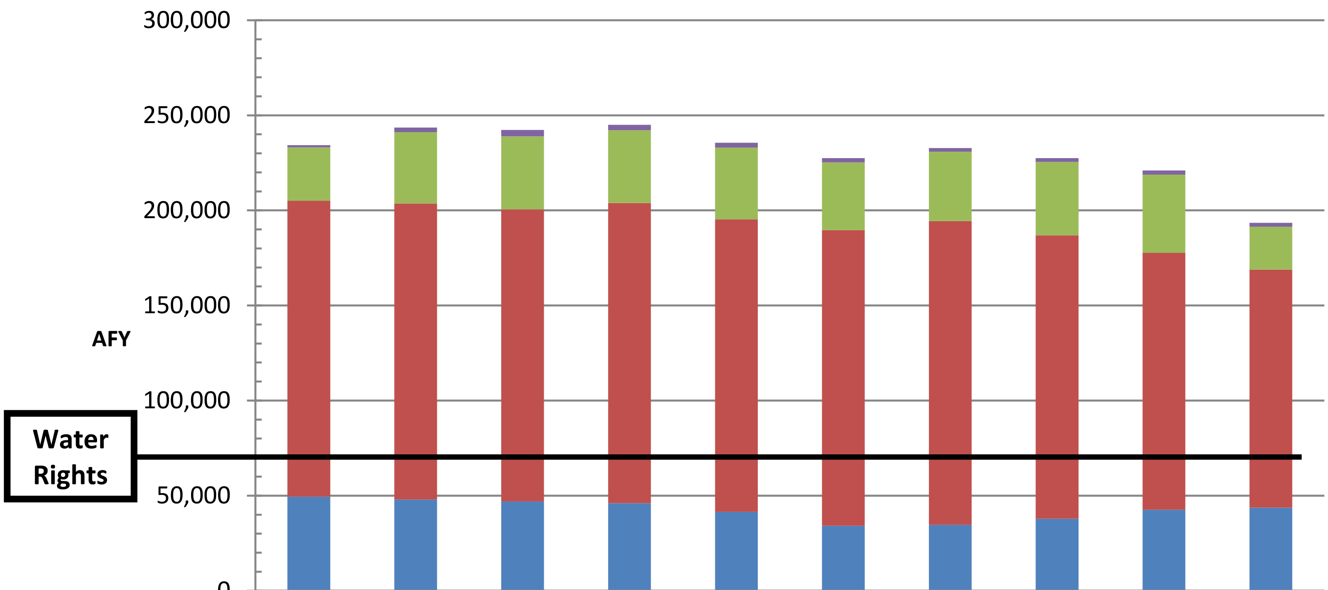
Figure B-1: West Coast Basin – Purveyors and Extraction Wells



B.1.1 Historical Water Demands

As shown in Figure B-2, annual total groundwater extractions in the West Coast Basin averaged approximately 42,000 AF per year (AFY) from water year (WY) 2000/01 to WY 09/10. Nearly two-thirds of the groundwater is extracted by major water rights holders in the basin, approximately one-third is extracted by several refineries, and a small fraction is used by minor water rights holders.[1] Figure B-2, shows that only about 66 percent of the basin's total water right adjudication of 64,468.25 AFY is actually pumped and supplied by rights holders. This is due in part to water quality issues, infrastructure repair and maintenance activities, and reduced demand resulting from conservation and economic conditions in recent years.

Figure B-2: Historical Water Demand and Supplies – West Coast Basin



Water Year	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10
Other	1,131	2,455	3,358	2,919	2,497	2,250	1,945	2,073	2,195	1,999
Recycled Water	28,074	37,458	38,394	38,167	37,713	35,554	36,447	38,560	41,023	22,588
Imported Water	155,619	155,698	153,603	157,934	153,873	155,487	159,712	148,997	135,195	125,201
Groundwater	49,480	47,962	46,950	46,020	41,485	34,168	34,678	37,883	42,566	43,669

Note: "Other" supply consists of brackish groundwater treated by the Goldsworthy and Brewer Desalters.

Over 30,000 AFY of recycled water from West Basin Municipal Water District (WBMWD) is also used to meet demands within the basin area, including both above ground non-potable supplies as well as indirect potable injection water at the WCBBP. Additional recycled water demands have been met by LADWP, including injection at the DGBP, and are expected to increase in future years. The region has also experienced an overall decline in water usage from 2000 to 2009 (seen in Figure B-2) due largely to water conservation measures implemented in response to reductions in available imported water, as well as strained economic conditions.

The water supply for the service areas overlying the West Coast Basin is significantly augmented by imported water provided by WBMWD, LADWP and the City of Torrance, as member agencies of Metropolitan. More than 125,000 AF of water was imported into the West Coast Basin during WY 2009-10, excluding water used for basin replenishment. In previous years, imported water deliveries were well over 150,000 AF, reaching nearly

[1] Water usage in the Palos Verdes area is not included in this analysis of West Coast Basin area water demands because it is not served with groundwater due to its high elevation.

160,000 AF in WY 2006/07. On an average basis, imported water comprises 60 to 65 percent of the water supply for the West Coast Basin region.

Oil companies in this area that are also major water rights holders in the West Coast Basin. More than one-third of their water demand for oil refining and other industrial uses is supplied by imported water (purchased “within basin” from other suppliers). Basin-wide, historical use of imported water has averaged 65 percent, with 18 and 16 percent of demands met by groundwater and recycled water, respectively. In addition to imported supply, oil companies extracted an average of 14,000 AFY of groundwater.

B.1.2 Replenishment Facilities

LACDWP owns, operates, and maintains, two injection barriers that protect the West Coast Basin from seawater intrusion: (1) WCBBP; and (2) DGBP. These are described in Section 2.2.2.2 of the main report.

Since 1995, WBMWD has provided recycled water to the WCBBP. From 2000 to 2009, an average of 15,000 AFY of combined recycled and imported water was injected into the WCBBP. Since 2006, an average of 1,900 AFY of recycled water has been provided by LADWP from the TIWRP for injection into the DGBP. This recycled water is then blended with imported water for a combined average of 6,800 AFY. Prior to the introduction of recycled water to the West Coast Basin, injection of imported water was used exclusively for both barriers.

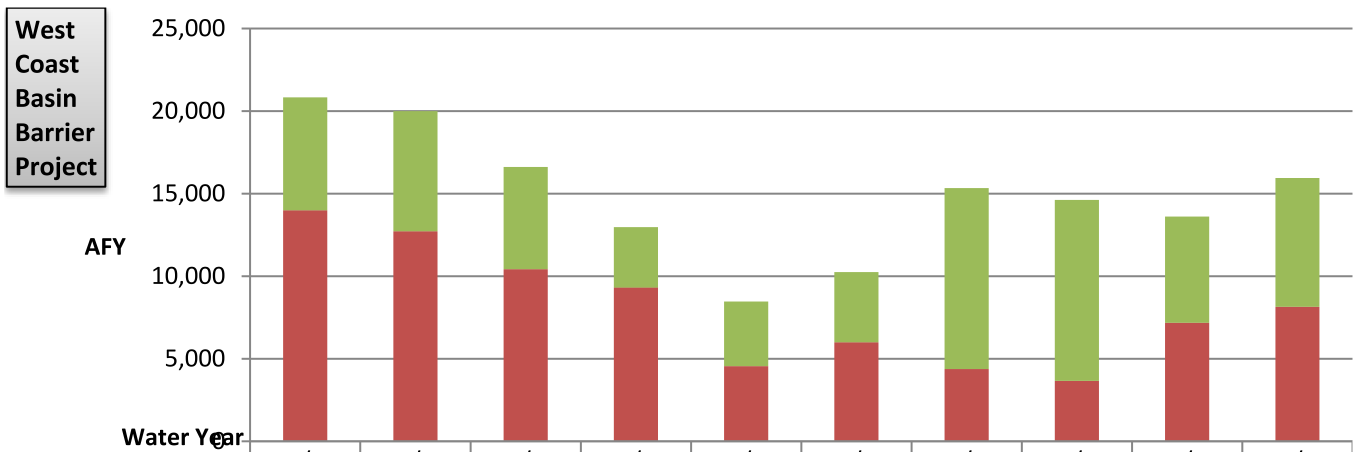
Currently, a blend of approximately 20,000 AFY of imported water and recycled water is injected into the two barriers. In WY 2008/09, injection into the WCBBP consisted of approximately 7,600 AF of recycled water and 6,000 AF of imported water for a 55 percent recycled water contribution (RWC). The WCBBP has been approved by the Los Angeles Regional Water Quality Control Board (RWQCB) for injection of 75 percent RO-treated recycled water with 25 percent imported water. Once the requisite “initial operating period” for the 75 percent RWC and the associated monitoring and reporting is completed, the WCBBP may be approved for 100 percent RWC (RWQCB, 2006). A similar process is underway for the DGB to achieve 100 percent RWC.

Historical injection into each barrier since operations began is shown in Figure B-3. Increased injection in the DGBP due to the barrier extension can be seen in 2003. A dramatic decline is apparent in the WCBBP injection rates trend. This is due to both declining groundwater extractions as well as declining specific capacity of the wells. With the aging of the infrastructure of both barrier projects, which include injection wells, pressure-reducing stations, distribution pipelines and appurtenances, and observation wells, LACDPW has been examining the condition of these facilities to assess rehabilitation and replacement needs to maintain and restore barrier capacities.

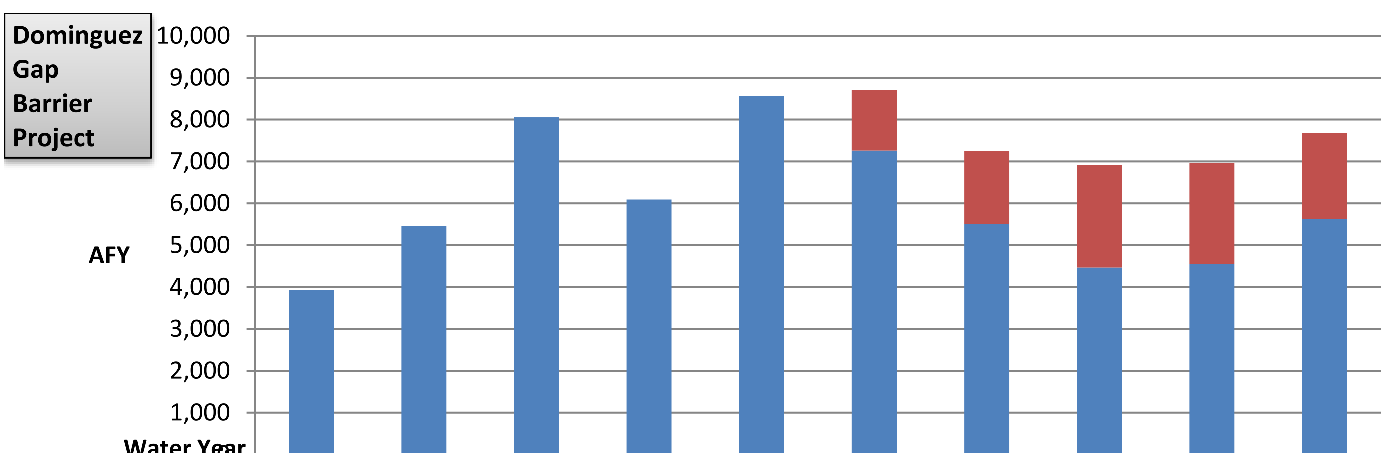
It is expected that the two seawater intrusion barriers will be approved in the future for operation with 100 percent RWC. Injection of replenishment water into the WCBBP is projected to consist of a blend of recycled water and imported water until year 2015, when a total of 17,000 AFY of recycled water (at 100 percent RWC) will be injected.

Replenishment water into the DGBP is initially assumed to be comprised of 3,500 AFY of recycled water and 4,000 AFY of imported water. Injection of recycled water to the DGBP is projected to increase to 7,500 AFY by the year 2020.

Figure B-3: Historical Annual Injection and Supplies at the West Coast Basin and Dominguez Gap Barriers



	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10
Recycled Water	6,838	7,276	6,192	3,669	3,920	4,249	10,960	10,954	6,434	7,797
Imported Water	13,988	12,724	10,419	9,304	4,548	5,997	4,373	3,662	7,178	8,145

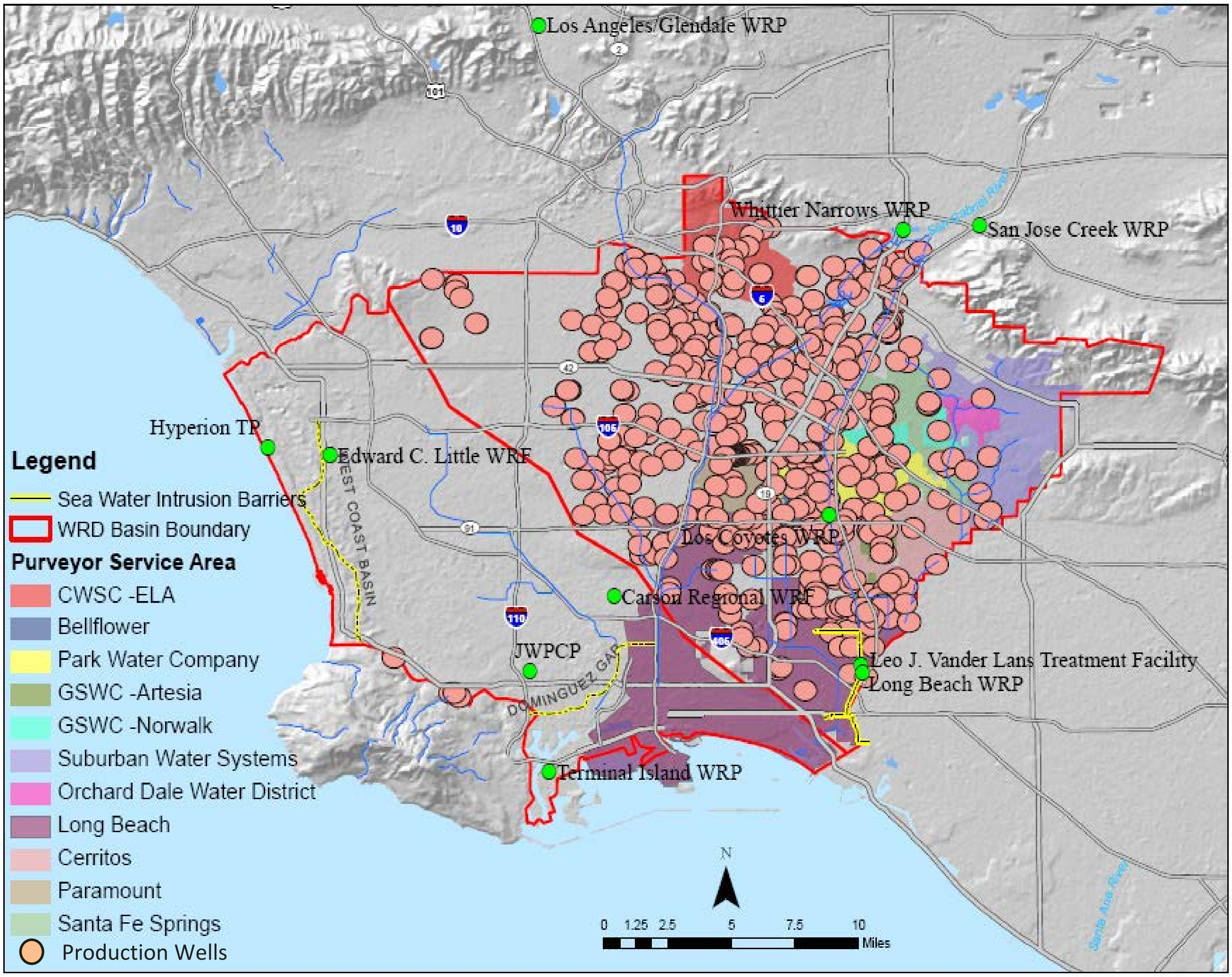


	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10
Recycled Water	0	0	0	0	0	1,450	1,733	2,452	2,414	2,055
Imported Water	3,923	5,459	8,056	6,089	8,557	7,259	5,510	4,468	4,550	5,622

B.2 Central Basin

Groundwater extractions from the Central Basin are governed primarily by the legal requirements of the existing Central Basin Judgment, water consumption demands, and water supplies from the local water purveyors for the areas overlying the Central Basin. These demands consist of groundwater, groundwater imported from the San Gabriel Basin, imported Water, recycled water, and in-lieu supplies. Central Basin demands also include groundwater recharge via surface spreading at the Montebello Forebay Spreading Grounds (MFSG) and direct injection at the Alamitos Barrier Project (ABP). Figure B-4 shows the service areas for the major water purveyors in the Central Basin and their respective extraction wells.

Figure B-4: Central Basin – Purveyors and Extraction Wells



B.2.1 Historical Water Demands

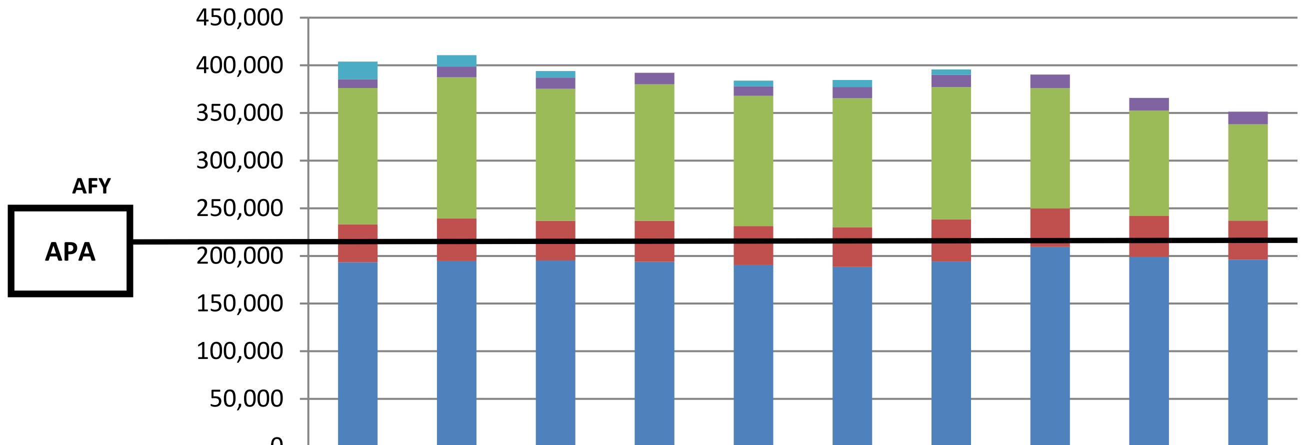
Central Basin water customers have met their water demand from several supplies:

- Groundwater from Central Basin
- Imported Metropolitan water purchased from CBMWD, WBMWD, LADWP, City of Long Beach, and City of Compton
- Imported groundwater from San Gabriel Basin
- Recycled water from four LACSD water reclamation plants

Imported Metropolitan water was used in-lieu of groundwater water in some years as part of WRD's In-Lieu Replenishment Program. To maintain basin levels, this water counts as groundwater production against the customer's APA.

As shown in Figure B-5, total demand for the last ten years (WY 2000/01 to 2009/10) has averaged around 387,000 AFY[2]. To supply these needs, groundwater production from the Central Basin has averaged 195,500 AFY[3] (50 percent of total supplies). Metropolitan imported water deliveries for potable supply have been about 132,000 AFY[4] (34 percent), with imported groundwater at 42,000 AFY (11 percent), in-lieu supplies at 5,600 AFY (1 percent), and recycled water used for non-potable purposes has averaged about 12,000 AFY[5] (3 percent).

Figure B-5: Historical Water Demand and Supplies – Central Basin (WY 2000/01 to 09/10) (AFY)



Water Year	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10
In-Lieu Water	18,364	11,931	6,866	0	6,000	7,475	5,779	0	0	0
Recycled Water	9,339	11,387	11,759	12,072	9,923	11,647	12,649	14,331	13,245	13,162
Imported Water	142,966	148,011	138,563	143,191	136,701	135,404	138,844	126,173	110,653	101,151
San Gabriel Basin Groundwater	39,895	44,593	41,700	43,057	40,778	41,669	44,232	40,343	42,791	40,990
Groundwater	193,328	194,775	195,179	193,855	190,520	188,444	194,174	209,454	199,045	196,044

As shown in Figure B-5, total demand was fairly consistent from WY 2000/01 to 2007/08 but fell to 351,000 AFY in WY 2009/10 due to water use restrictions and conservation instigated by limited availability of imported Metropolitan water. Observed trends for each supply include:

- The in-lieu replenishment program has been inactive after WY 2006/07 due to a limited amount of available imported water.
- Imported Metropolitan water averaged approximately 140,500 AFY from WY 2000/01 to 2006/07 but fell to 101,151 AFY in WY 2009/10 due limited availability.
- Imported groundwater has remained fairly constant over the past ten years with a variation of approximately ±10 percent compared with the average.
- Recycled water use has slowly increased over the past ten years with the exception of WY 2004/05, which was likely due to reduced demand resulting from an abnormally wet year with more than twice the average annual precipitation.

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2 Some Central Basin groundwater is exported by California-American Water Company for use in its service area overlying the West Coast Basin. This volume is included in the total demand estimate since the volume exported was not documented by the Watermaster until WY 2003/04. For reference, an average of 2,511 AFY was exported from WY 2003/04 through 2009/10. This pumping is counted toward the Allowed Pumping Allocation.

3 Groundwater production values exclude pumping by California Department of Transportation and for groundwater clean-up by Boeing Company, Omega Chemical, and Ashland Chemical Company because these volumes are considered temporary, non-consumptive use by the Central Basin Watermaster and, therefore, do not count toward the basin's total Allowed Pumping Allocation.

4 Excludes imported water purchased by Water Replenishment District for delivery to Montebello Forebay Spreading Grounds or Alamitos Barrier Project.

5 Excludes recycled water purchased by Water Replenishment District for delivery to Montebello Forebay Spreading Grounds or Alamitos Barrier Project

The average pumpage for the last ten years, including in-lieu water, has been 93 percent the basin’s total water right adjudication of 217,367 AF, which means approximately 15,700 AFY of groundwater rights were not used. Most of the “major” groundwater pumpers (over 8,000 AFY) at least 90 percent of their APA with the exception of California Water Service Company (CWSC) and Los Angeles which have used approximately 50 percent and 80 percent of their annual allowable extraction, respectively.

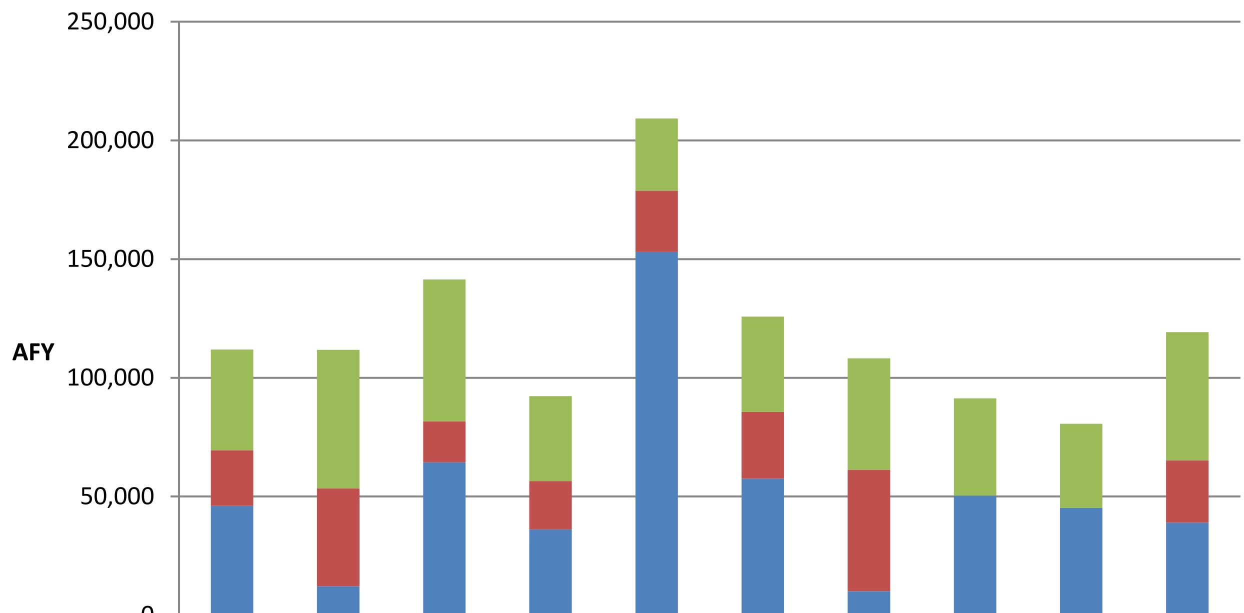
B.2.2 Replenishment Facilities

Groundwater in the Central Basin is recharged via surface spreading at the MFSG, the Lower San Gabriel River, and direct injection at the ABP.

B.2.2.1 Montebello Forebay Spreading Grounds

Natural recharge to the Central Basin occurs largely through surface and subsurface inflow through Whittier Narrows and through stormwater percolation. Sources of artificial recharge include recycled water, imported water, and stormwater. As shown in Figure B-6, the volume of recharge varies significantly from year to year based on precipitation and availability of imported water but has average approximately 130,000 AFY between WY 2000/01 to 2009/10. Projects recently implemented and currently planned for implementation by WRD will increase the use of stormwater and recycled water to offset imported water spreading as discussed in Section 2.3.1.1.

Figure B-6: Historical Montebello Forebay Replenishment Supplies



Water Year	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10
Recycled Water	42,388	58,302	59,727	35,819	30,388	40,149	46,930	40,940	35,442	53,948
Imported Water	23,451	41,268	17,297	20,369	25,833	28,149	51,144	0	0	26,286
Stormwater	46,062	12,229	64,390	36,128	152,991	57,491	10,137	50,389	45,181	38,982

The Montebello Forebay, located just south of Whittier Narrows, is a valuable area for groundwater recharge due to its highly permeable soils, which allow deep percolation of surface waters. The Montebello Forebay consists of two off-stream spreading facilities operated by Los Angeles County Department of Public Works (LACDPW), the Rio Hondo Spreading Grounds and the San Gabriel Coastal Basin Spreading Grounds, and several in-stream facilities in the lower San Gabriel River for replenishment of recycled water, stormwater, and imported water.

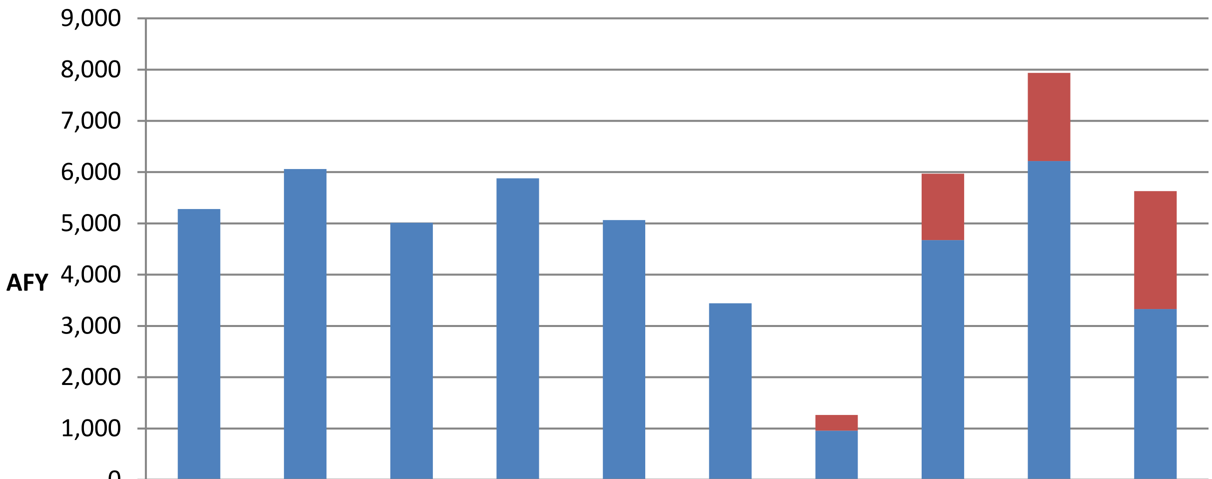
The lower San Gabriel River extends from the Whittier Narrows Dam though the Pacific coastal plain ending at Long Beach. Through most of the Montebello Forebay, the San Gabriel River is unlined, allowing spreading by percolation through its unlined bottom, and is lined through the remainder of the Central Basin.

The volume of recharge varies significantly from year to year based on precipitation and availability of imported water but, as shown in Figure D-6, has averaged about 120,000 AFY over the period of the last 10 years, from about 51,000 AFY of local runoff (43 percent), 23,000 AFY of imported water (20 percent), and 44,000 AFY of recycled water (37 percent) (LACDPW, 2010 and DWR, 2010).

B.2.2.2 Alamitos Barrier Project

The ABP facilities are described in Section 2.2.2.2 of the main report. Figure B-7 shows that the volume of recharge has averaged 5,000 AFY between WY 2000/01 to 2009/10. In the last several years, the RWC has ranged from 20 to 40 percent of the total injected flow with the delivery of recycled water from the LVLWTF that began in 2006. WRD is currently planning to deliver 100 percent RWC to the ABP, with the expansion of the LVLWRF, as discussed in Section 3.3.25 of the main report.

Figure B-7: Historical Alamitos Gap Barrier Supplies



Water Year	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10
Recycled Water	0	0	0	0	0	0	307	1,295	1,719	2,301
Imported Water	5,282	6,062	5,012	5,880	5,066	3,444	958	4,677	6,217	3,329

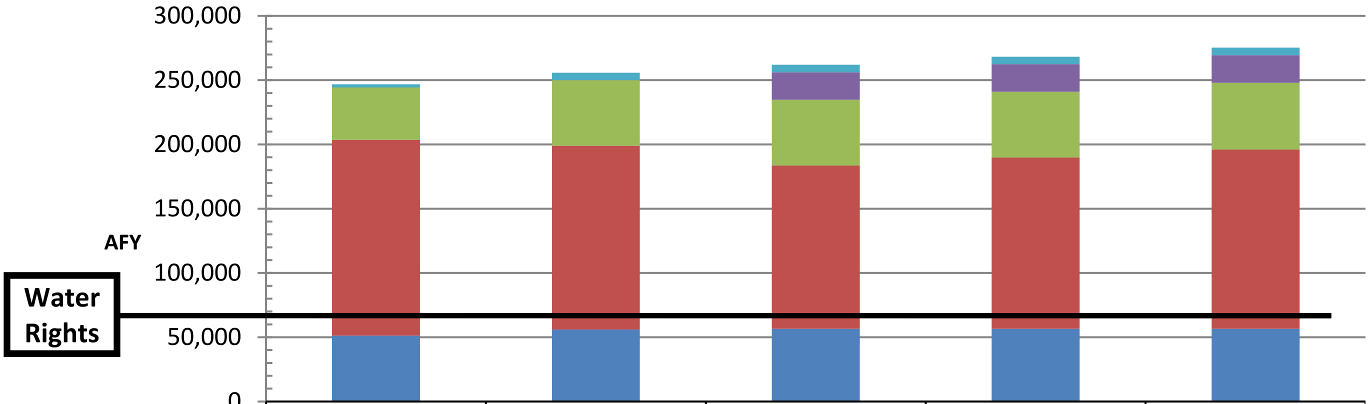
B.3 Projected Water Demands and Supplies

Projected water demands for the West Coast and Central Basins were prepared using Urban Water Management Plans (UWMPs) projections as well as through discussions with the pumpers and purveyors. Values are provided for calendar years rather than water years because the UWMPs report future usage on a calendar year basis.

B.3.1 West Coast Basin

Projected water supplies and demands for the major pumpers are based on information in the respective 2010 UWMPs or the 2005 UWMP if the 2010 UWMP was not available. Figure B-8 depicts the average supply distribution for the entire service area overlying the West Coast Basin over the planning period (from 2010 through 2030). While uses of recycled water, groundwater, and other new water sources, such as desalination, are expected to increase over the planning period, there is still a significant amount of imported water use assumed in the portfolios of water supplies.

Figure B-8: Projected Demand and Supplies – West Coast Basin (2010 to 2030) (AFY)



	2010	2015	2020	2025	2030
Other	2,497	5,800	5,800	5,800	5,800
Desalination	0	0	21,500	21,500	21,500
Recycled Water	40,784	50,961	51,083	51,216	51,949
Imported Water	152,360	143,014	127,018	133,168	139,454
Groundwater	51,203	55,993	56,563	56,563	56,563

"Other" sources of water is brackish groundwater treated at the Brewer Desalter (1,000 AFY) and the expanded Goldsworthy Desalter (4,800 AFY). The WBMWD ocean desalination project is assumed to directly replace imported water use, reducing imported water supplies by 10 percent of the total supply. This corresponds to a decrease in the estimated volume of planned imported water use from 150,000 AFY to 140,000 AFY.

Although the UWMP projections indicate that planned groundwater extractions from the West Coast Basin will be less than the total adjudicated water rights, individual discussions with pumpers indicated that their plans for realizing their full water rights will depend on the cost- of pumping versus the purchase price of imported water. As shown in, the planned extractions for each of the major water rights holders, defined as pumpers with water rights greater than 1,500 AFY of groundwater, meet or exceed (via leasing arrangements) their adjudicated water rights in the West Coast Basin. The oil companies, however, expect an overall reduction of water use corresponding to dwindling oil processing. Assuming their rights are leased or purchased by others, the total basin adjudication will likely be pumped in the future.

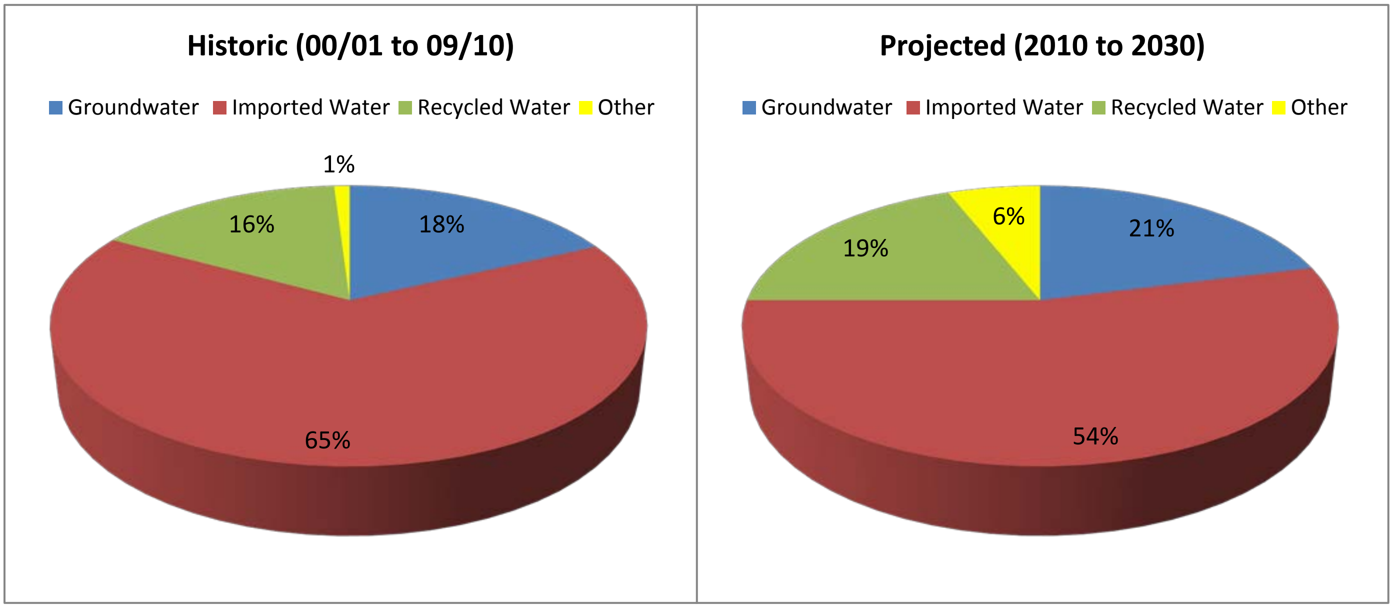
TABLE B-1
Groundwater Pumping by Major Pumpers

Pumper	Adjudicated Water Rights (AFY)	Average Historical Pumping (00/01 to 09/10) (AFY)	Percentage of Water Rights	Average Projected Pumping[a] (AFY)	Percentage of Water Rights
CWSC-Hawthorne District	1,882	315	17 percent	1,882	100 percent
CWSC-Hermosa/Redondo District	4,070	1,776	44 percent	4,070	100 percent
CWSC-Dominguez District	10,417	5,873	56 percent	16,897	162 percent
City of El Segundo	953	0	0 percent	0	100 percent
City of Inglewood	4,450	4,721	106 percent	4,450	100 percent
City of Manhattan Beach	1,131	1,016	90 percent	1,131	100 percent
City of Lomita	1,352	15	1 percent	1,350	100 percent
City of Los Angeles	1,503	0	0 percent	0	0 percent
City of Torrance[b]	5,639	3,406	60 percent	5,640	100 percent
Golden State Water Company	7,502	11,834	158 percent	8,160	109 percent
Oil Companies	23,128	13,770	60 percent	11,307	49 percent
Total[c]	**62,028**	**42,726**	**69 percent**	**54,887**	**88 percent**

Notes:
a. Based on 2005 Urban Water Management Plans
b. Includes brackish groundwater treated by the Goldsworthy Desalter
c. Total does not include minor water rights holders

Basin-wide, planned use of imported water is estimated to be 54 percent, with 21 percent of demands met by groundwater, 19 percent met by recycled water, and 6 percent met by desalinated ocean and brackish groundwater. This distribution, in contrast to the historical distribution described previously, is shown in Figure B-9.

Figure B-9: Average Overall West Coast Basin Water Use

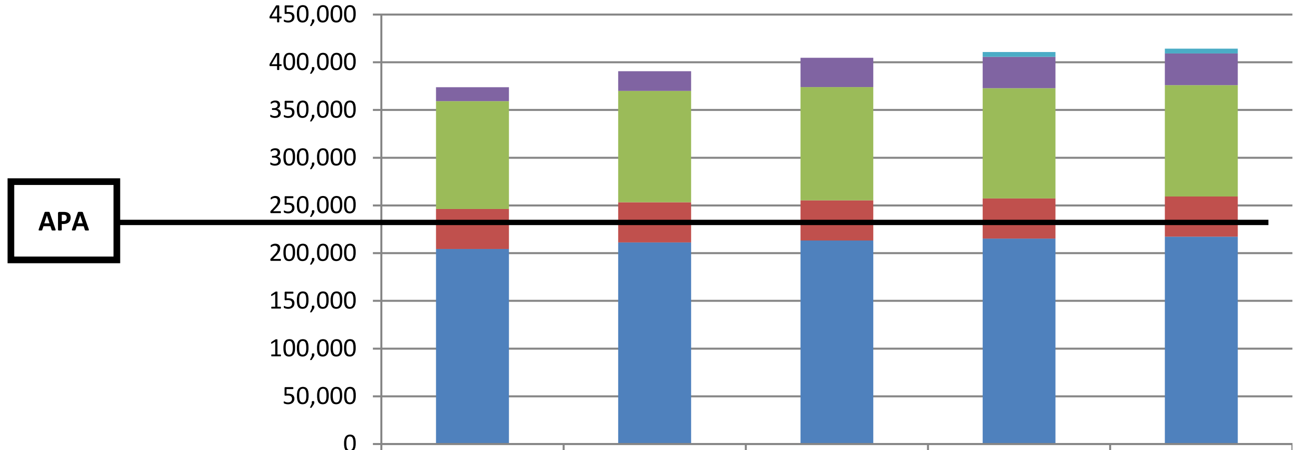


Projected water supplies and demands for the major pumpers are based on information in the respective UWMP and feedback from major pumpers (≥8,000 AFY). Nine major pumpers contribute to over 60 percent of total demand in the basin as well as groundwater production. Projections for retailers other than the major pumpers assumed groundwater rights are maximized by 2030 and the use of imported water, recycled water, and imported groundwater from San Gabriel Basin would remain the same throughout the planning period.

Future annual water supplies for the entire service area overlying the Central Basin are shown in Figure B-10. The projected water supplies for each of the major pumpers are shown in Table B-2. Note that values are provided for in calendar years rather than water years because the UWMPs report future usage on a calendar year basis.

While uses of recycled water, groundwater, and new water sources such as desalination, are expected to increase over the planning period, there is still a significant amount of imported water use (over 115,000 AFY) assumed in the water supply portfolios. As shown in Figure B-10, the projections indicate that planned groundwater extractions from the Central Basin will be approach the APA.

Figure B-10: Projected Demand and Supplies – Central Basin (2010 to 2030) (AFY)



	2010	2015	2020	2025	2030
Desalination	0	0	0	5,000	5,000
Recycled Water	14,556	20,684	30,719	32,859	33,179
Imported Water	112,945	116,707	118,705	115,650	116,713
San Gabriel Basin Groundwater	42,000	42,000	42,000	42,000	42,000
Groundwater	204,351	211,314	213,307	215,301	217,367

TABLE B-2
Groundwater Pumping by Major Pumpers (≥ 8,000 AFY)

Pumper	Adjudicated Water Rights (AFY)	Average Historical Pumping (00/01 to 09/10) (AFY)	Percentage of Water Rights	Average Projected Pumping (AFY)	Percentage of Water Rights
California Water Service Co (ELA)	11,774	5,462	46 percent	11,063	94 percent
California Water Service Co (Dominguez)	6,480	2,233	34 percent	6,480	100 percent
City of Cerritos	4,680	10,560	226 percent	8,770	187 percent
City of Downey	16,554	17,447	105 percent	16,554	100 percent
Golden State Water Co	16,439	20,453	124 percent	16,992	103 percent
City of Lakewood	9,432	9,185	97 percent	9,015	96 percent
Long Beach Water Department	32,692	31,724	97 percent	32,981	101 percent
LADWP	15,000	12,386	83 percent	15,000	100 percent
South Gate	11,183	10,436	93 percent	10,786	101 percent
City of Vernon	8,039	9,155	114 percent	8,039	100 percent
Total[a]	**132,273**	**129,041**	**98 percent**	**135,680**	**108 percent**

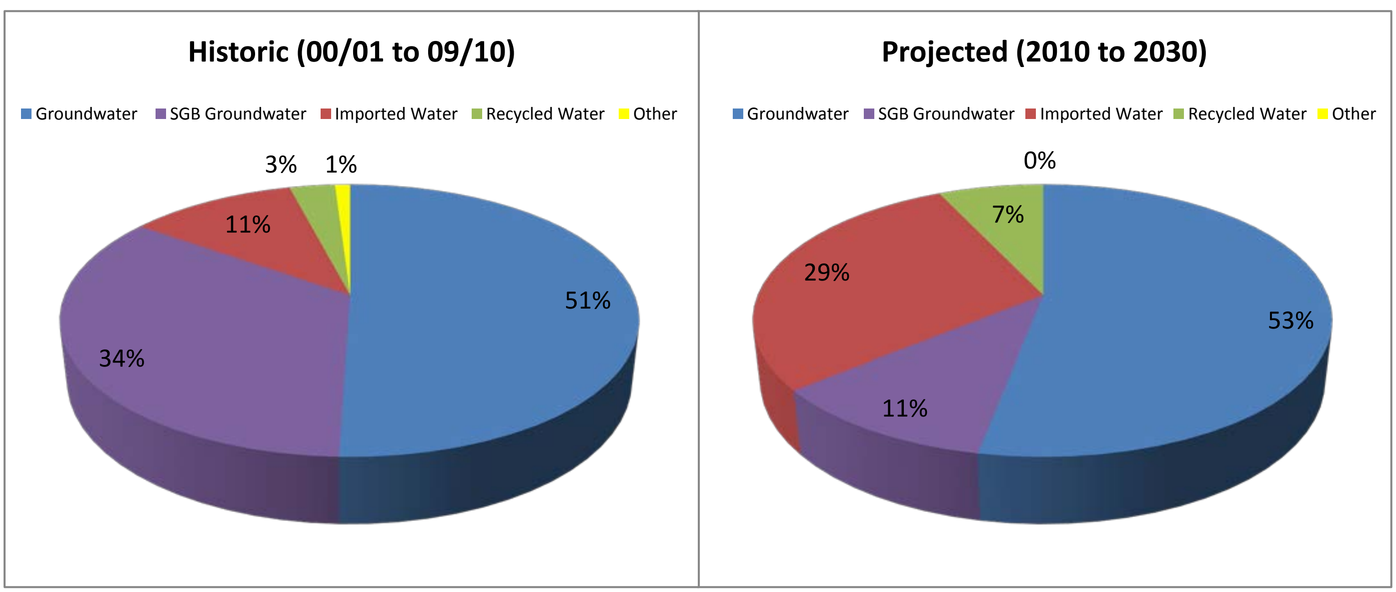
Notes:
a. Total does not include minor water rights holders (<8,000 AFY)

Projections to note for the major pumpers include:

- The City of Cerritos plans to continue to lease groundwater rights to continue to pump approximately 4,000 AFY beyond their APA. The sources of their existing leases include California Water Service Co. (5,000 AF), Long Beach (500 AF), and Paramount (500 AF).
- The City of East Los Angeles, which is part of the CWSC district, plans to construct new wells to maximize groundwater production instead of leasing these groundwater rights.
- The City of Downey is planning on a Groundwater Storage Program to recharge the basin with groundwater imported from adjacent basins to increase their groundwater production beyond their APA by 1,800 AFY initially to 4,400 AFY by 2030.
- The City of Long Beach projections include 5,000 AFY of desalination starting in 2025 to offset imported suppliers.
- Long Beach projects an increase in recycled water use from approximately 6,500 AFY in 2010 to 13,700 AFY in 2030. Roughly half of this demand is for the repowering of an LADWP power plant in Long Beach.
- Los Angeles plans to maximize groundwater rights and is currently installing wells in the LA Forebay.
- The City of Vernon projects an increase in recycled water use from approximately 800 AFY in 2010 to 11,700 AFY in 2030 assuming a new power plant in 2015 and conversion of all potential recycled water customers by 2030.

Basin wide, planned use of imported water is projected to decrease from 54 percent of supplies in 2010 to 51 percent in 2030 while groundwater and imported groundwater (from San Gabriel Basin) are projected to remain approximately the same at 30 percent and 10 percent of supplies, respectively. Conversely, recycled water is projected to increase from 4 percent in 2010 to 8 percent in 2030 and desalinated water is projected to increase from zero to 1 percent. This distribution, in contrast to the historical distribution described previously, is show in Figure B-11.

Figure B-11: Average Overall Central Basin Water Use



B.4 References

California Department of Water Resources (DWR). 2010. *Watermaster Service in the Central Basin Annual Reports 2000-01 to 2008-09.* http://www.water.ca.gov/watermaster/.

California Regional Water Quality Control Board (RWQCB), Los Angeles Region. 2006. Waste Discharge and Water Recycling Requirements for West Coast Basin Barrier Project – Expansion Phase III Project. Order No. R4-2006-0069m Amending Order No. R4-2006-0009. Issued to West Basin Municipal Water District and Los Angeles County Department of Public Works. File No. 93-009. July 10 (Revised September 14).

Los Angeles County Department of Public Works (LACDPW). 2010. *2009-2010 Stormwater Monitoring Report*.

Appendix C
Replenishment Permits

APPENDIX C
Replenishment Permits

C.1 Replenishment Permits

This section provides details on the individual replenishment permits that are relevant for the Groundwater Basins Master Plan (GBMP). The following replenishment permits are discussed below: the Montebello Forebay Groundwater Recharge (GWR) Project, Alamitos Barrier Project (ABP), West Coast Basin Barrier Project (WCBBP), and the Dominguez Gap Basin Barrier Project (DGBBP).

C.1.1 Montebello Forebay GWR Water Recycling Requirements (WRR)

Recycled Water has been successfully used as a source for groundwater recharge via spreading in the Montebello Forebay since 1962. The Montebello Forebay recharge permit was substantively revised in 1987 with amendments in 1991 and 2009. In June 2013, the permit (WDR/WRR, Order No. R4-2009-0048) for the Montebello Forebay GWR project was amended to allow for a 10-year running averaging cycle for meeting the recycled water contribution (RWC) limit. The RWC was then increased from 35 percent to 45 percent in April 2014. The amount of recycled water recharged at the spreading grounds has and will continue to vary from year to year depending on the availability of recycled water, dilution water, and the capacity of the spreading grounds. Historically, an average of 43,000 Acre Feet per Year (AFY) of recycled water was spread between 1999-00 and 2008-09 (RMC, 2011)..

C.1.2 WDR/WRR Permit for ABP

On September 1, 2005, the Los Angeles Regional Water Quality Control Board (RWQCB) adopted Waste Discharge and Water Recycling Requirements (WDR/WRR, Order No. R4-2005-0061 or Permit) for the ABP. The WDR/WRR was issued to WRD and the Los Angeles County Department of Public Works (LACDPW) for the injection of up to 3 MGD of advanced treated recycled water for the ABP for the purpose of groundwater replenishment. In support of the WDR/WRR, a number of reports and other pertinent documents were provided to CDPH and the Los Angeles RWQCB, including a Title 22 Engineering Report (dated August 1999), an Amended Title 22 Engineering Report (dated May 2002), a Groundwater Monitoring Program (dated August 2002), an Expanded Groundwater Monitoring Program (dated March 2004), and other supplemental information and responses. With the expansion of the LVLWTF to 8 MGD, WRD received approval in June 2014 for injection of 100 percent RWC over a 10-year averaging period (per WDR/WRR, Order No. R4-2014-0111).

C.1.3 WDR/WRR Permit for WCBBP

The initial project to use recycled water for barrier injection was authorized under Los Angeles RWQCB Order No. 95-014 that approved the use of 5,600 AFY of advanced treated recycled water and 5,600 AFY of imported water. The permit was jointly issued to WBMWD and LACDPW. In 1997, WBMWD received authorization (RWQCB Order No. 97-069) to expand the project to 8,400 AFY of advanced treated recycled water, which represented 50 percent of the total water injected at that time. In 2006, the project was authorized under WDRs (Order No. R4-2006-0009) to increase the amount of recycled water up to 75 percent of the total blended water injected (or a maximum of 14,000 AFY) over a five-year averaging period. The project is subject to a complex water quality monitoring and compliance program that assesses all of the waters used for replenishment and the groundwater system.

The 2006 WDRs also included provisions that would allow increase of the RWC to 100 percent (or a maximum of 19,600 AFY, which represents 120 percent of current barrier demands), following successful completion of an "initial operating period". During this period, which is currently underway, WBMWD must demonstrate fulfillment of all CDPH requirements and show that the injection of blended water has reached at least one barrier monitoring well for at least one year with an average of at least 60 percent advanced treated recycled water, based on injection at the maximum average of 75 percent. Approval of the increase is also subject to a review by an expert panel and requires a demonstration that the project has not caused levels of endocrine disrupting chemicals, pharmaceuticals, or other constituents of interest to CDPH to increase above the levels in the recycled water.

The WDRs currently require an underground retention time of at least 12 months before the water is extracted for drinking purposes and a minimum horizontal separation of 2,000 feet between the injection site and the nearest drinking water well.

C.1.4 WDR/WRR Permit for DGBP

On October 2, 2003, the RWQCB adopted the injection recharge permit for the DGBP (WDR/WRR Order No. R4-2003-0134). The permit is issued to the City of Los Angeles Department of Public Works and Department of Water and Power, as well as LACDPW and WRD. The permit was amended twice, initially in October 2010 to revise the groundwater monitoring program and remove the tracer monitoring requirements, and subsequently in February 2011 to eliminate the requirement to construct a blending station. Currently, water supply to the barrier wells is split, with recycled water from the TIWRP AWTF injected at the midpoint of the east-west alignment of the barrier and imported water provided by WBMWD injected at the northern end of the barrier. Although the blend ratio of recycled water to diluent, imported water at the DGBP has been well below the permitted 50 percent RWC (over a 60-month running average) due to operational limitations at the AWTF. The City of Los Angeles has addressed the operational challenges and is expanding the AWTF to increase the amount of recycled water that can be injected at the DGBP. Ultimately the permittees intend to pursue 100 RWC for the DGBP, following the same phased approach to obtaining CDPH approval as the other barriers have undertaken.

C.2 References

RMC Water and Environment (RMC). 2011. *GRIP Alternatives Analysis Final Report*. June.

Appendix D
Barrier Capacity Analysis Technical Memorandum

LA County Seawater Barrier Capacity Estimation – FINAL DRAFT

PREPARED FOR: Terry Foreman/THO

PREPARED BY: Kevin Bral / DEN

DATE: 6/8/2011

Introduction

The Los Angeles County Department of Public Works (Department) operates three seawater intrusion barriers: the Alamitos Barrier Project (ABP), the Dominguez Gap Barrier Project (DGBP), and the West Coast Basin Barrier Project (WCBBP). Collectively, the barriers consist of over 229 injection wells that function to protect the West Coast and Central Groundwater Basins from seawater intrusion.

An initial estimate of the ultimate capacity of the existing three barriers was calculated to generally determine the highest injection capacity that the three barriers may sustain. The wells and infrastructure as listed in the 1998 report, "Well Redevelopment Study, Los Angeles Coastal Basin Injection Barriers", CH2M HILL, June 9, 1998 were used as the basis for this estimate. The estimate was not intended to be exhaustive nor did it include obtaining new data from the County. In addition to the wells mentioned above, the 33 new wells installed for the Dominguez Gap Barrier Extension project were included in this analysis.

The basis of well capacity for this estimate was injection well operational data for two full years beginning in January 2001 and ending in December 2002. The data consisted of the status of each well (operational or not operational), the static and operating water level and/or casing pressure in each well, the injection tubing in each well, and the injection rate. This information was supplemented by other well size and depth information from the previous reports for the Well Redevelopment Study.

The basis for delivery pipelines to each well were maps and piping layouts provided by the County in a Request for Proposal entitled, "Seawater Barrier Water Supply Facilities Evaluation", dated April 27, 2000.

Methodology

The general methodology used to estimate the ultimate capacity for each of the Barriers was as follows:

- The delivery piping lengths and sizes to all the wells for each barrier were measured off maps and documents provided by the County.

- The feed pressure and source of the water (Metropolitan Turnouts) was determined from documents obtained from the County.
- Individual well specific capacities were determined using the average specific capacities calculated from the 2001 to 2002 well data. For the Dominguez Barrier north of Sepulveda, the specific capacities were assumed to be those measured after the wells were constructed in 2002.
- Limits on the water levels in each well or the wellhead pressure were developed.
- A hydraulic spreadsheet model was developed for each Barrier system. The ultimate capacity of each system was calculated as limited by well water levels or pressures and the ability of the piping system to deliver water to the wells.
- For the West Coast Barrier, the above was done assuming only operational wells were included, and also assuming that all wells, used or unused, could be included in the Barrier operations.

Dominguez Barrier South of Sepulveda

The Dominguez Barrier south of Sepulveda obtains water for injection from a Metropolitan turnout located on Alameda Street. The water is piped from the turnout, west on Alameda to a pressure reducing station near the Dominguez Channel. The water is further piped south along the west side of the Dominguez channel. The northernmost injection well (well 28C) is located near the Dominguez Channel just south of Sepulveda Avenue. The pressure reducing station on Alameda is set to a downstream pressure of 70 psi.

The wells are spaced about 800 feet apart and run south along the channel to East Grant Street. The wells continue west on E. Grant Street across Alameda, and then southwest to East E street. The wells continue west on E Street to terminate near the Harbor Freeway. There are 30 well sites, with 11 of the well sites completed as dual wells, injecting separately into an upper and lower aquifer. The 2001 to 2002 data indicate average injection rates ranged from 30 gpm to 210 gpm and average specific capacities ranged from about 1 gpm/ft to 48 gpm/ft, however most of the wells have specific capacities below 7 gpm/ft.

Injection flows to the wells are generally limited by the wellhead pressure, which is restricted to prevent damage to the aquifer confining layers. The south portion of the Dominguez Barrier is operated by limiting wellhead pressures at each well to between 5 psi and 35 psi, depending on the aquifer being injected into. If the wells were not restricted by these wellhead pressures and the wells were allowed to operate at the highest pressure the piping system could deliver, the piping and wells system ultimate capacity would more than double, but wellhead pressures over 50 psi would be seen on wells in the northern part of the system. Conversely, if zero wellhead pressures were allowed at the wells, the ultimate capacity would decrease by about 68%. With the wellhead pressure restrictions, the calculated ultimate capacity is 6,780 gpm, (9.8 mgd, 15.1 cfs), compared to the 2001 to 2002 average operating data of 4,370 gpm, (6.3 mgd, 9.7 cfs). These values are also presented in a table at the end of this Technical Memorandum.

The wellhead pressure restrictions are the limiting capacity factor for the south portion of the Dominguez Barrier. The existing piping system is sized to deliver flows that can result in pressures higher than the limiting pressures to the wells. Therefore increases in capacity to the south portion of the Dominguez Barrier system would require additional wells be installed, or increasing the specific capacity of the existing wells through well rehabilitation or other means.

As-Built engineering drawings from the City of Los Angeles Department of Water and Power indicate a 36-inch pipeline has been constructed from Terminal Island to the south portion of the Dominguez Barrier. The drawings indicate the pipeline terminates on E street, close to well 25E. This pipeline could transmit additional water to the Barrier but because the Barrier capacity is limited by the wellhead pressure restrictions, additional water brought in from Terminal Island would not increase the ultimate capacity of the south portion of the Dominguez Barrier.

Dominguez Barrier North of Sepulveda (Extension Project)

The Dominguez Barrier north of Sepulveda obtains water for injection from the same Metropolitan turnout as the south portion of the Dominguez Barrier, located on Alameda Street. The water is piped from the turnout, west on Alameda to a pressure reducing station near the Dominguez channel. The water is further piped south along the east side of the Dominguez channel to the first well, located about half way between Alameda and Sepulveda, west of and aligned with Spring Street to the east. The pressure at the reducing station on Alameda is set to a downstream pressure of 70 psi.

The wells are spaced about 500 feet apart and run south along the southern east side of the Dominguez Channel to Sepulveda and east from the channel to Spring Street, extending along Spring Street to the Los Angeles River. There are 33 wells, with two wells each located on 17 well sites. The exception to this is well 28Z2 which exists by itself on a wellsite. Each well pair injects separately into an upper and lower aquifer. The data obtained when the north portion of the Dominguez Barrier was completed in 2004 indicates average injection rates ranged from 30 gpm to 290 gpm and average specific capacities ranged from about 2 gpm/ft to 47 gpm/ft, with about one-half of the wells having specific capacities above 10 gpm/ft.

Injection flows to the wells are generally limited by the wellhead pressure which is restricted to prevent damage to the aquifer confining layers. The north portion of the Dominguez Barrier is operated by limiting wellhead pressures at each well to between 15 psi and 20 psi, depending on the aquifer being injected into. If the wells were not restricted by these wellhead pressures and the wells were allowed to operate at the highest pressure the piping system could deliver, the piping and wells system ultimate capacity would increase by about 44 percent, but wellhead pressures over 50 psi would be seen on wells in the western part of the system. Conversely, if zero wellhead pressures were allowed at the wells, the ultimate capacity would decrease by about 41%. With the wellhead pressure restrictions, the calculated ultimate capacity is 16,290 gpm, (23.5 mgd, 36.3 cfs), compared to the 2004 startup data of 3,160 gpm, (4.6 mgd, 7.1 cfs). The much lower observed startup capacity relative to the calculated ultimate capacity is a result of the startup operation. During startup, the wells were operated with individual well water levels between 9 feet to 19 feet below ground level. It must be noted that the wells have not been tested at their allowed wellhead pressure limit. These capacity values are also presented in a table at the end of this Technical Memorandum.

The wellhead pressure restrictions are the limiting capacity factor for the north portion of the Dominguez Barrier. The existing piping system is sized to deliver flows that can result in pressures higher than the limiting pressures to the wells. Therefore increases in capacity to the north portion of the Dominguez Barrier system would require additional wells be installed. As the wells were recently constructed, it is probably not likely individual well specific capacity could be increased beyond the values observed after construction.

Alamitos Barrier

The Alamitos Barrier obtains water for injection from a Metropolitan turnout located at the intersection of Wooddruff Avenue and Wardlow Road. The water is piped from the turnout, east on Wardlow to the San Gabriel River, then south along the river to 7th Street, where a 24-inch piping connection feeds the Alamitos Barrier piping.

The Alamitos Barrier runs from the 7th Street connection at the San Gabriel River, southeast to the Los Alamitos Channel, and then south along the channel to Westminster Avenue. The Barrier runs west of the 7th Street connection along 7th Street, then south west on 6th Street to about the end of 6th Street. The pressure at the reducing station is set to a downstream pressure of 70 psi.

The well spacing varies from about 200 feet to 1,000 feet. There are 35 wells, with the wells completed either as a single, dual, or triple configuration on 27 well sites. Each well generally injects separately into an upper, middle, or lower aquifer with three of the wells being completed into multiple aquifer zones. The 2001 to 2002 data indicates average injection rates ranged from 20 gpm to 330 gpm and average specific capacities ranged from about 0.5 gpm/ft to 5 gpm/ft. The specific capacity values are fairly well distributed through this range.

Injection flows to the wells are generally limited by pressure losses in the delivery pipelines. There is no limiting wellhead pressure limit however, at maximum flow to all the wells, the range of delivered wellhead pressures was 34 psi near the 7th Street connection, to 21 psi at well 35G in the south part of the Barrier. Operating wellhead pressures observed in the 2001 to 2002 data indicate pressures ranged from about 0.5 psi to 33 psi.

The calculated ultimate capacity was then calculated at 5,580 gpm, (8.0 mgd, 12.4 cfs), compared to the 2001 to 2002 data of 4,000 gpm, (5.8 mgd, 8.9 cfs).

West Coast Barrier

The West Coast Barrier obtains water for injection from a Metropolitan turnout located on El Segundo Blvd near North Nash Street. The water is piped from the turnout, west and south through a series of pipelines. To the west, the barrier extends past Sepulveda, then north to the Imperial Highway. From that west leg, the barrier also extends south to the middle of Hermosa Beach. A major trunk-line parallels the southern leg and ties back into the interconnecting well pipeline at Anita Street. From the Anita Street connection, a short run of pipe runs north and feeds several wells in the southern part of Hermosa Beach. Another pipe runs south of the Anita Street connection and feeds barrier wells past Hermosa Beach to the south of Torrance, just past the Pacific Coast Highway. The pressure at the reducing station is set to a downstream pressure of 80 psi.

The well spacing varies from about 200 feet to over 1,000 feet. There are 162 wells, with the wells completed either as a single or dual configuration on 121 well sites. Each well generally injects separately into an upper or lower aquifer. The 2001 to 2002 data indicates average injection rates ranged from 4 gpm to 385 gpm with 28 wells reported as either "no data" or "not in use". Average specific capacities ranged from about 0.3 gpm/ft to 74 gpm/ft, but most of the specific capacities are less than 10 gpm/ft. An unusually high specific capacity of 74 gpm/ft is calculated for Well 8V and is likely a result of bad data.

The 2001 to 2002 data indicates there were 35 wells in the West Basin Barrier listed as either "no data", or "well not used". For this reason, the West Basin Barrier ultimate capacity was calculated for two different groups of wells. The first group included only the wells reported in use, and the second group assumed the wells with no data or not used could be brought back into service.

Given the relatively deep static water levels in the West Basin wells, most of the wells operate with injection water levels below the measuring point; anything from a few feet, to 150 feet. The wells that operate with injection water levels above the measuring point only have levels a few feet above the measuring point. Based on that observation, it was assumed that the wells may not be capable of operating with significant injection pressures and the ultimate capacity calculation assumed a maximum injection water level at 10 feet below grade for each well.

Injection flows to the wells are not limited by pressure losses in the delivery pipelines for many of the wells. This includes the wells located north of El Segundo, wells located in the south part of Hermosa Beach, and the wells south of Hermosa Beach to the south or Torrance. However, flows to the wells fed from the pipeline that runs from El Segundo south to the middle of Hermosa Beach, are limited by pressure losses in the north-south pipeline sizes.

The calculated ultimate capacity of the West Coast Barrier for the group of wells reported in use was then calculated at 26,660 gpm, (38.4 mgd, 59.4 cfs), and was 32,890 gpm, (47.4 mgd, 73.3 cfs), if all wells were able to be operated. This is compared to the 2001 to 2002 data of 4,000 gpm, (5.8 mgd, 8.9 cfs).

The ultimate capacity calculations for the group of wells reported in use indicates south of about well 5Y (a short section of 10-inch pipe), pipeline pressures fall below 10 psi if all wells are attempted to be run with a 10 foot depth to injection water level. The three southernmost wells on that pipeline segment then fall to injection rates below 50 gpm, with the southernmost well receiving almost zero flow.

The ultimate capacity calculations for the group of wells that includes all wells, indicates about the same conditions and south of about well 5Y (a short section of 10-inch pipe), pipeline pressures fall below 10 psi if all wells are attempted to be run with a 10 foot depth to injection water level. The three southernmost wells on that pipeline segment then fall to injection rates below 50 gpm, with the southernmost two wells receiving almost zero flow.

If the West Coast Barrier were to be run at its maximum capacity, improvements would be needed to the pipeline that runs south of El Segundo to the middle of Hermosa Beach. These could include paralleling or increasing the size of some of the pipe segments, and interconnecting the pipeline that runs south of El Segundo to the middle of Hermosa Beach with the pipeline that runs north of from the Anita Street connection. Connecting those two pipeline segments would require a short run of piping between wells 7G and 7L.

Ultimate Capacity Flows

The ultimate capacity flows calculated for each barrier as discussed above are listed in the table below.

	Ultimate Capacity			2001 to 2002 Operations		
	(gpm)	(mgd)	(cfs)	(gpm)	(mgd)	(cfs)
Barrier						
South Dominguez	6,779	9.76	15.1	4,370	6.3	9.7
North Dominguez	16,290	23.5	36.3	3,160[a]	4.61[a]	7.1[a]
Alamitos	5,580	8.0	12.4	4,000	5.8	8.9
West Coast (in use wells)	26,660	38.4	59.4	16,190	23.3	36.1
West Coast (all wells)	32,890	47.4	73.3	na	na	na

a – Values for Startup Operations in 2004

na – Not Applicable

Appendix E
Groundwater Replenishment Reuse Regulation

APPENDIX E

Requirements for Groundwater Replenishment Using Recycled Water

Regulations governing the use of recycled water for groundwater replenishment have been in formulation since 1978. In 2010, Senate Bill 918, required that CDPH adopt uniform water recycling criteria for indirect potable reuse (IPR) for groundwater recharge, and the regulations for Groundwater Replenishment Using Recycled Water (Groundwater Recharge Regulations) were promulgated into law in 2014.

A summary of these regulatory requirements are provided in the GBMP Program Environmental Impact Report, Appendix E - Status of Recycled Water Regulations Technical Report (Nellor Environmental Associates, Inc., September 2016).

E.1 References

Nellor Environmental Associates, Inc. 2016. *Technical Memorandum: Status of Recycled Water Regulations Technical Report.* Appendix E to the Groundwater Basins Master Plan Program Environmental Impact Report. September.

Appendix F
Los Angeles River Storm Flow Analysis

Availability of Stormwater from the Los Angeles River for Recharge of the Los Angeles Forebay

The Los Angeles Forebay (LA Forebay) is located in the northern part of the Central Basin. It is generally bounded on the north by the Repetto Hills and Elysian Hills, and on the east, south, and west by the Central Basin Pressure Area. A forebay is an area with a free groundwater surface, meaning that the uppermost aquifer is unconfined and percolating surface waters can reach the aquifer rapidly. Some sections of the Los Angeles River (LA River) pass through the LA Forebay. Those sections are concrete-lined channels with varied cross-sections.

This appendix describes the flow analysis conducted to identify the amount of stormwater runoff that can be captured and diverted from the LA River for groundwater recharge. Specifically, this appendix provides an analysis of the availability of LA River storm flows above dry weather, baseflow conditions for recharging the Central Basin.

One possible way of diverting the LA River flow for recharge is discussed in Section 3 of the report. The plan includes construction of an Aquifer Recharge Recovery Facility (ARRF) to infiltrate storm flows into a shallow aquifer along powerline easement between the LA River and 710 Freeway. The ARRF would provide natural, soil aquifer treatment (SAT) and associated contaminant removal (such as total organic carbon, nitrate, and so forth) from storm flows comparable to spreading basins. The treated stormwater then serves as a high quality source supply for vadose zone infiltration conduits (VZICs). Recovery wells extract infiltrated water and convey to VZICs. VZICs provide additional SAT prior to groundwater recharge.

This appendix includes the following:

- A brief description and background information about the LA River watershed and the sources of water to the river
- An analysis of the flow data collected by the Los Angeles County Department of Public Works (LACDPW) at four locations on the LA River.
- Analysis and results of flow data collected at two stations in the vicinity of the LA Forebay to understand the baseflows and amount of water volume available that can be used for recharge purposes.

Background

The cities in the LA Forebay area include portions of Vernon, Huntington Park, Maywood, South Gate, the City of Los Angeles (South-East Los Angeles, Boyle Heights, Center City, and North Center City neighborhoods), and unincorporated areas of Los Angeles County (communities of Walnut Park and Florence). These neighborhoods, lying southeast of downtown Los Angeles are typically old and highly urbanized. Land use lying along the banks of the LA River is generally industrial. Mixed commercial and residential areas dominate, with increasing commercial zoning toward downtown Los Angeles (WRD, 1997).

There are three Water Reclamation Plants (WRPs) that discharge into the LA River and one of its tributaries, the Burbank Western Wash (Figure F-1). These WRPs include the Donald C. Tillman (Tillman) WRP, Los Angeles-Glendale WRP, and the Burbank WRP. During dry weather, a majority of the flow in the LA River comprises tertiary-treated, disinfected effluent from these WRPs. During a snapshot monitoring event by Southern California Coastal Water Research Project in 2000, it was reported that 72 percent of the flow discharged into the LA River was WRP effluent, while storm drains and tributaries contribute roughly 13 percent of the flow discharged by point sources in the Los Angeles River in dry weather (Ackerman et al., 2003). During dry weather, flows into storm drains consist of residential and commercial runoff from activities such as over-irrigation, car washes, pavement cleaning, and so forth. The remaining flows can be attributed other sources such as industrial and construction stormwater discharges, minor National Pollutant Discharge Elimination System (NPDES) dischargers, and general NPDES discharges. As of November 2008, approximately 1,384 permits had been issued under the Statewide Industrial Activities Storm Water General Permit in the watershed (Cleaner Rivers through Effective

Stakeholder-led Total Maximum Daily Loads [TMDLs] [CREST], 2009a), and 759 permits under the Statewide Construction Activities Storm Water General Permit (Los Angeles Regional Water Quality Control Board [LARWQCB], 2007). The general NPDES permits issued by LARWQCB are for construction dewatering, industrial wastewater, petroleum fuel cleanup sites, volatile organic compound (VOC) cleanup sites, potable water, and hydrostatic test water (LARWQCB, 2010). During wet weather, WRPs account for less than 1 percent of the total flow in the LA River (CREST, 2009a).

The Tillman WRP discharges approximately 53 million gallons per day (mgd) to the LA River. Most of the flow is discharged directly into Reach 4 of the river (Figure F-1). However, a portion of the flow goes into a recreational lake, which then drains into Bull Creek and Hayvenhurst Channel and back into Reach 5 of the river. Another portion of the flow goes into a wildlife lake, which drains into Haskell Channel and ultimately back into Reach 5 of the river (LARWQCB, 2005). Some of the flow is also discharged into the Japanese Garden lake adjacent to the Tillman WRP (CREST, 2009a).

The Los Angeles-Glendale WRP discharges approximately 13 mgd directly into Reach 3 of the LA River in the Glendale Narrows, downstream from Colorado Boulevard. In addition, approximately 4 mgd of the treated wastewater is used for irrigation and industrial uses (LARWQCB, 2010).

The Burbank WRP discharges approximately 4 mgd directly into the Burbank Western Channel. A significant portion of the effluent is reclaimed for irrigation, and treated water is used as cooling water for the Burbank Steam Power Plant (LARWQCB, 2010).

In addition to these three major public dischargers, two major private dischargers are in the region. Table F-1 provides a summary of those major dischargers.

The daily average WRP effluent discharge rates are shown in Figure F-2. In general, the median flows during wet season are higher than dry season flows for all plants.

Municipal stormwater is regulated, per the Clean Water Act, as a point source by the RWQCB. Three NPDES permits cover municipal separate storm sewer system (MS4) discharges within the watershed (Table F-2): Angeles County, City of Long Beach, and the California Department of Transportation (Caltrans).

A large majority of the urban areas of the watershed are covered under the joint MS4 permit for Los Angeles County. The current MS4 permit for Los Angeles County was issued in 2001 by LARWQCB under Order No. 01-182, NPDES No. CAS004001. The total area covered includes approximately 3,100 square miles and serves a population of approximately 10 million (U.S. Census, 2000) within Los Angeles County and 84 incorporated cities including the City of Los Angeles.

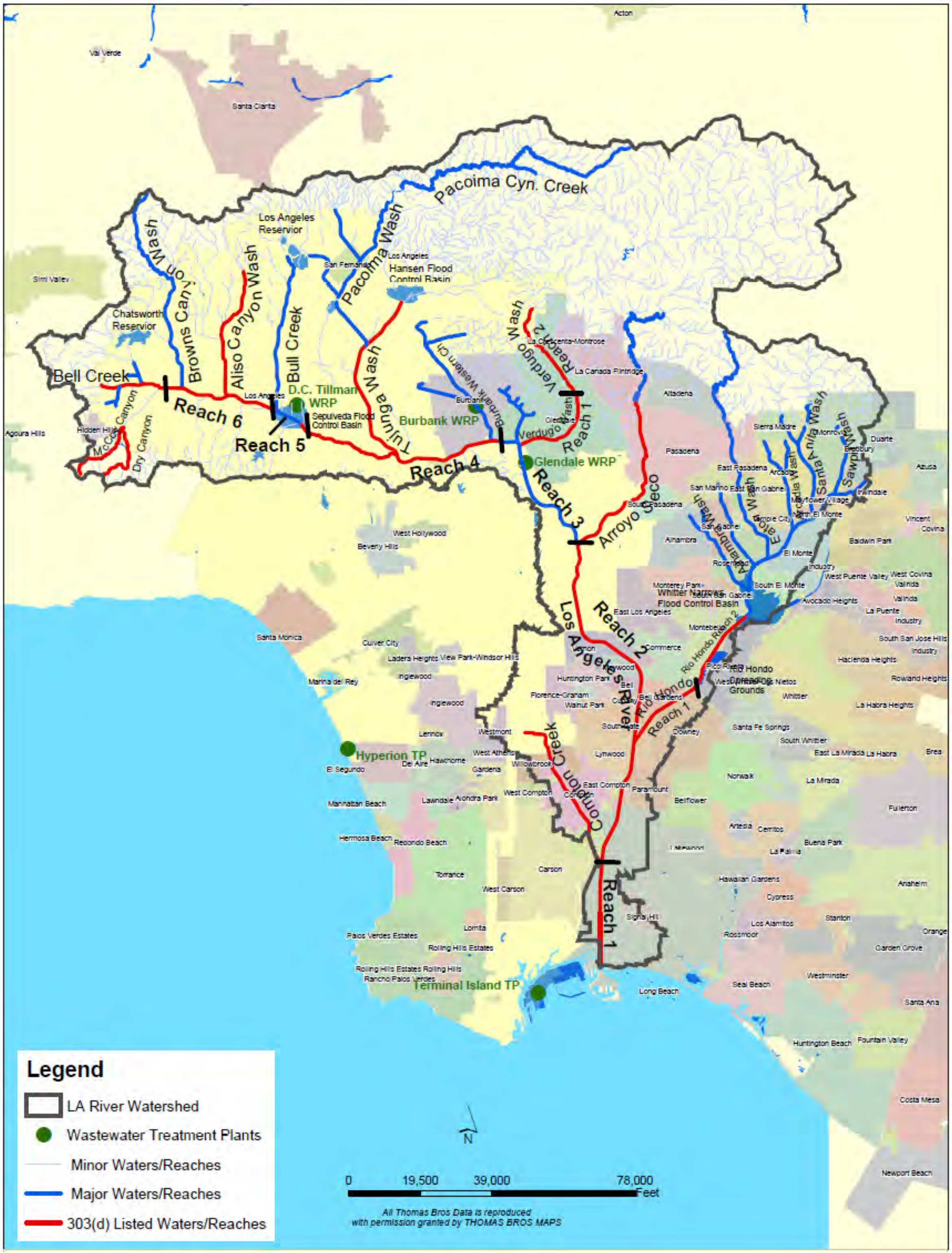
The City of Los Angeles has estimated that there may be more than 1,980 storm drain outfalls that discharge to segments and tributaries of the LA River within the City of Los Angeles, along with as many as 1,735 outfalls outside of the City of Los Angeles that discharge to LA River segments and tributaries (CREST, 2010). Many of these outfalls only flow during wet weather.

Flow Rates in the Los Angeles River

The LA River drains a highly urbanized watershed, where flow in the LA River includes stormwater, runoff from local mountains and canyons, urban runoff, and tertiary recycled water. Rainfall in the watershed is generally limited to the months of October through March, and even during the wet season, storm events are relatively rare. During dry weather, a majority of the flow in the LA River consists of tertiary-treated, disinfected effluent. During storm events, the large impervious area of the watershed leads to rapid increases in flow rates.

Flow data collected by LACDPW at four locations (Figure F-3) on the LA River main channel were analyzed to assess the range of historical flows. Available flow data cover the period from October 1970 to September 2010. Table F-3 presents the minimum, maximum, and median flow rates at these stations. Some of the data contains the estimated values reported by LACDPW. At these locations, minimum flows ranged from 10 to 69 cubic feet per second (cfs) and maximum flows ranged from 15,800 to 44,900 cfs. The median flow increases from upstream to downstream locations of the LA River.

FIGURE F-1
Los Angeles River Watershed



Source: CREST, 2009a

TABLE F-1
Major Dischargers in the Los Angeles River Watershed

Permit Number	Permittee	Design Capacity (mgd)	Facility
CA0056227	City of Los Angeles	80	Donald C. Tillman Water Reclamation
CA0053953	City of Los Angeles	20	Los Angeles-Glendale Water Reclamation Plant
CA0055531	City of Burbank	12.5	Burbank Water Reclamation Plant
CA0001309	The Boeing Company[a]	N/A	Santa Susana Field Lab
CA0052949	Plains West Coast Terminals[b]	N/A	Dominguez Hills Tank Farm

[a]The Boeing Company Santa Susana Field Lab discharges up to 160 mgd of stormwater (based on the 24-hour duration, 10-year return storm event) mixed with industrial wastewater to Bell Creek via two discharge points (LARWQCB, 2005).

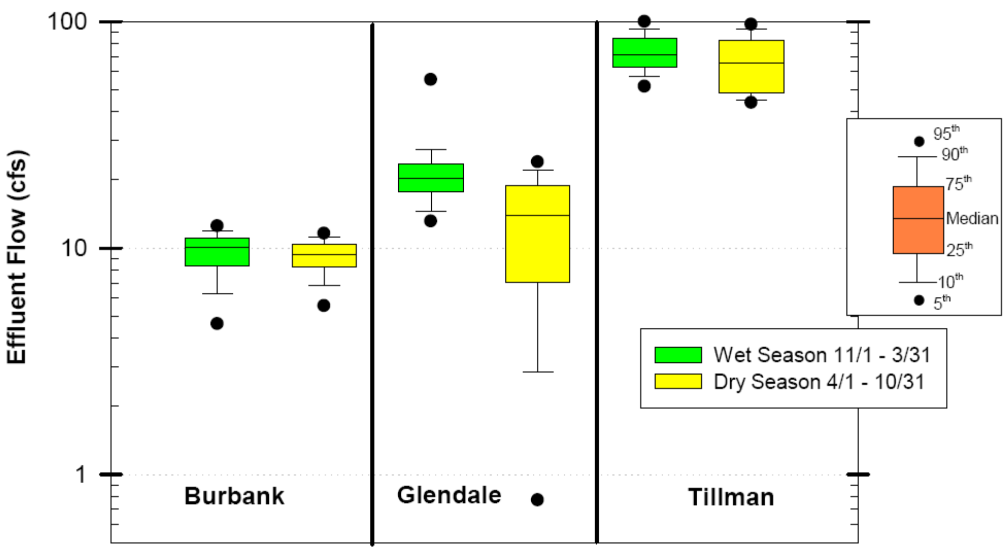
[b]Plains West Coast Terminals, LLC, Dominguez Hills Tank Farm has a permitted discharge of up to 4.32 mgd of hydrostatic test water, fuel equipment wash water, and stormwater runoff to Compton Creek.

Notes:

N/A = not applicable

Source: LARWQCB, 2010

FIGURE F-2
Historical[a] WRP Daily Effluent Flow Rates by Season



[a]Burbank: 1997-2008; Glendale: 1996-2007; Tillman: 1994-2007

Source: CREST, 2009a

TABLE F-2
Summary of Municipal Stormwater NPDES Permits in the LA River Watershed

Permittee	NPDES Permit Number	NPDES Permit Effective Date	Total Area Covered (sq. mi.)	Total Area Covered in Watershed (sq. mi.)	% of LA River Watershed
Los Angeles County (and 84 incorporated cities)	Order No. 01-82 CAS004001.	2001	3,100	801	96%
City of Long Beach	Order No. 99-060 CAS004003	1999	50	22	3%
Caltrans	Order No. 99-06 CAS000003	1999	136	11	1%

Notes:

% = percent
sq. mi. = square miles
Source: CREST, 2009a

FIGURE F-3
LA River Flow Measurement Stations

TABLE F-3
Summary of Flow Rates at the LA River Monitoring Stations from October 1970 through September 2010

Station	Minimum Flow (cfs)	Maximum Flow (cfs)	Median (cfs)
LA River at Tujunga (F300-R)	26	15,800	79
LA River above Arroyo Seco (F57C-R)	31	19,900	120
LA River below Firestone (F34D-R)	10[a]	24,200	132
LA River below Wardlow (F319-R)	69	44,900	138

[a]This value is an estimated value provided by LACDPW. The flow rates are expected to increase from upstream to downstream locations of the LA River. That increasing trend is apparent from median and maximum flow values.

Figure F-4 provides flow duration curves generated for each of these four monitoring stations. These curves are plots of the cumulative frequency distribution of all measured daily average flow rates for the entire period of record. Days with missing flows were excluded from the analysis. The flow duration curves are flat for the dry season, which represents approximately 90 percent of the time. The higher flow rates (with occurrence frequencies of approximately 10 percent) represent the storm-generated flows.

The following two monitoring stations, one upstream and one downstream of the LA Forebay, were considered for further analysis to estimate the availability of flows for recharge purposes: LA River above Arroyo Seco (F57C-R) and LA River below Firestone (F34D-R). Figures F-5, F-6, and F-7 show the daily flow rates, monthly average flows during summer months, and monthly minimum flows during summer months at F57C-R station, respectively. Figures F-8, F-9, and F-10 show similar information for the F34D-R station.

FIGURE F-4
Flow Duration Curves for the LA River at the Flow Monitoring Stations

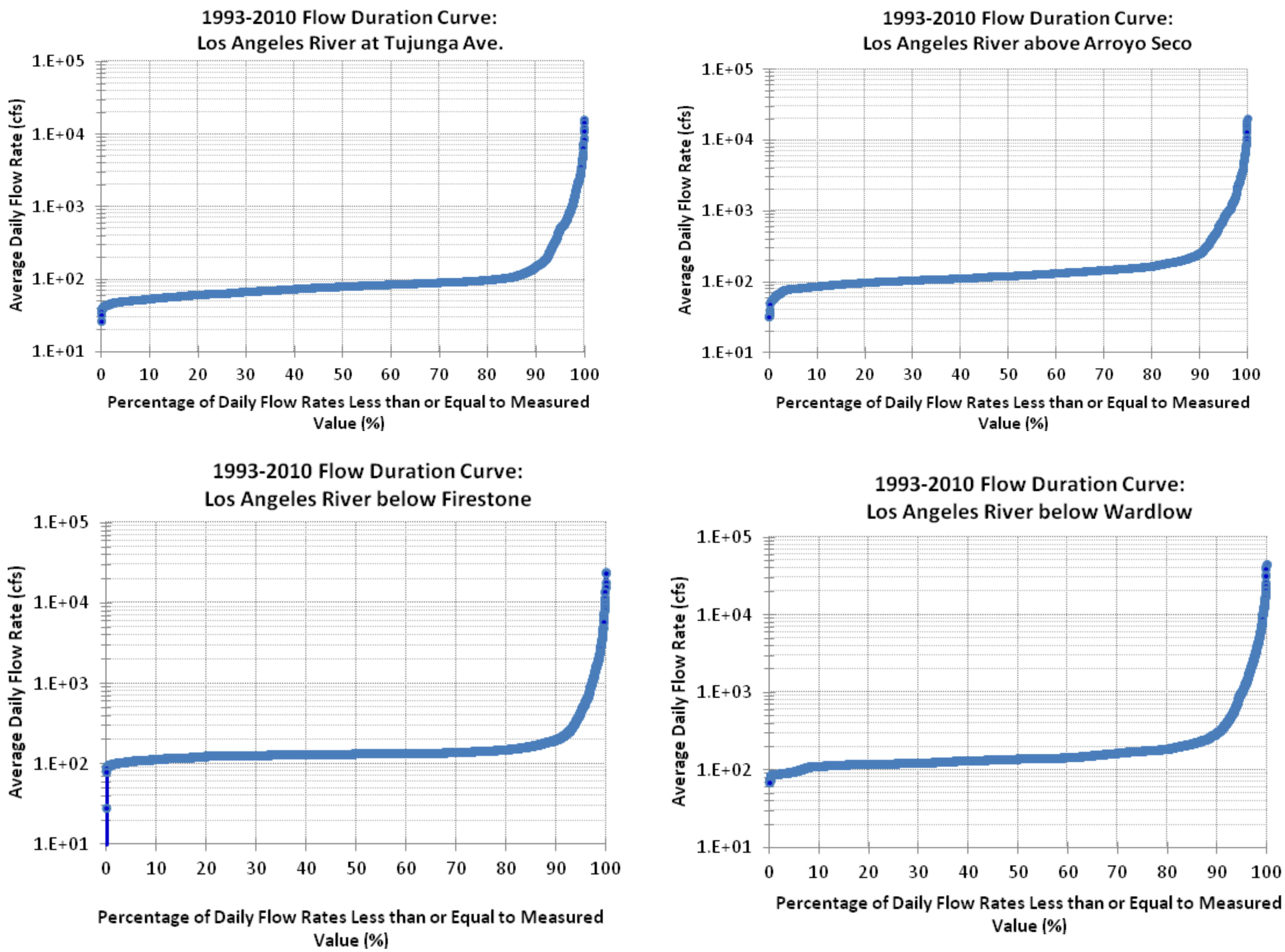


FIGURE F-5
Variations in Flows from Water Year 1970 through 2010 at the F57C-R (LA River above Arroyo Seco) Station

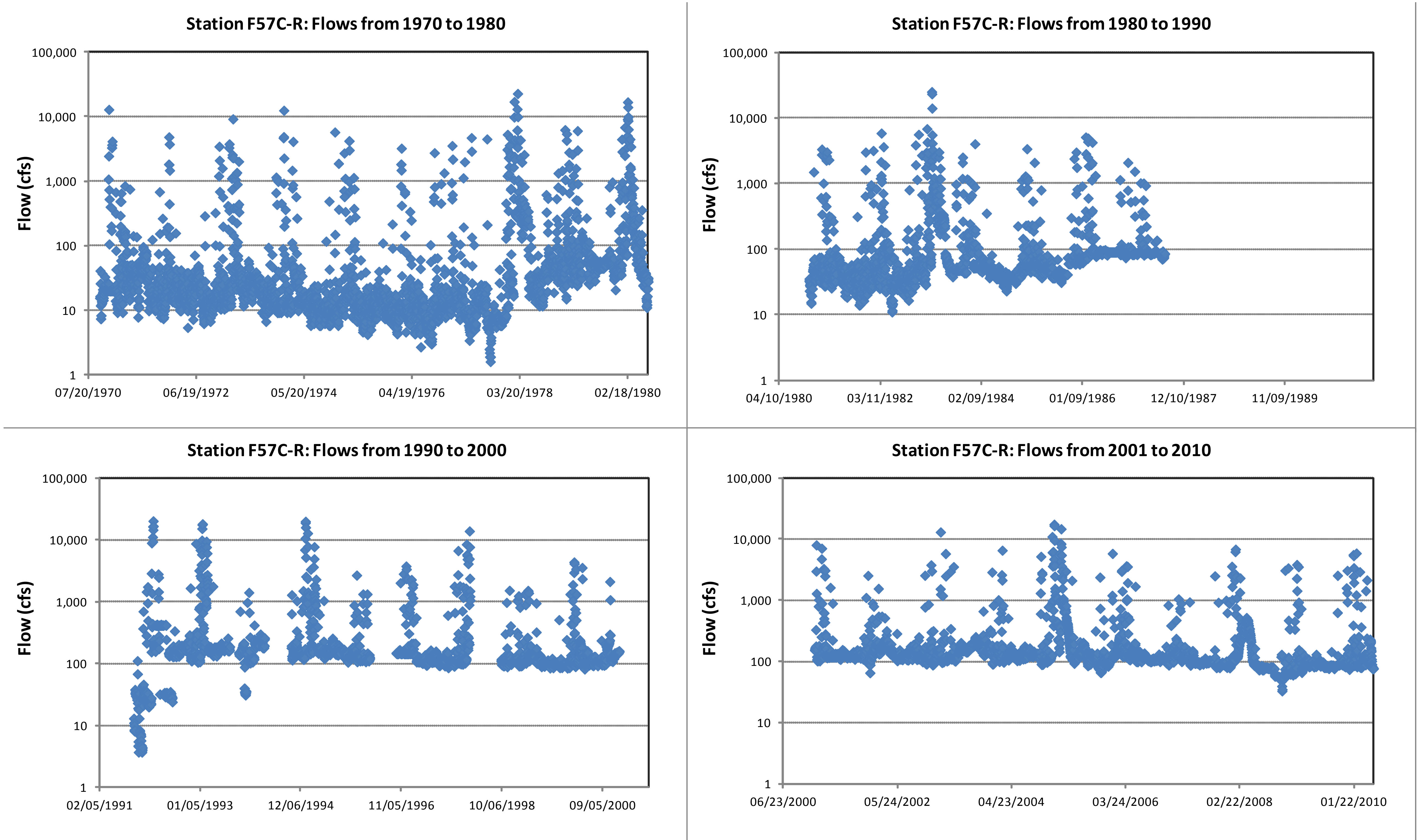


FIGURE F-6
Summer Season Monthly Average Flows from Water Year 1970 through 2010 at the F57C-R (LA River above Arroyo Seco) Station

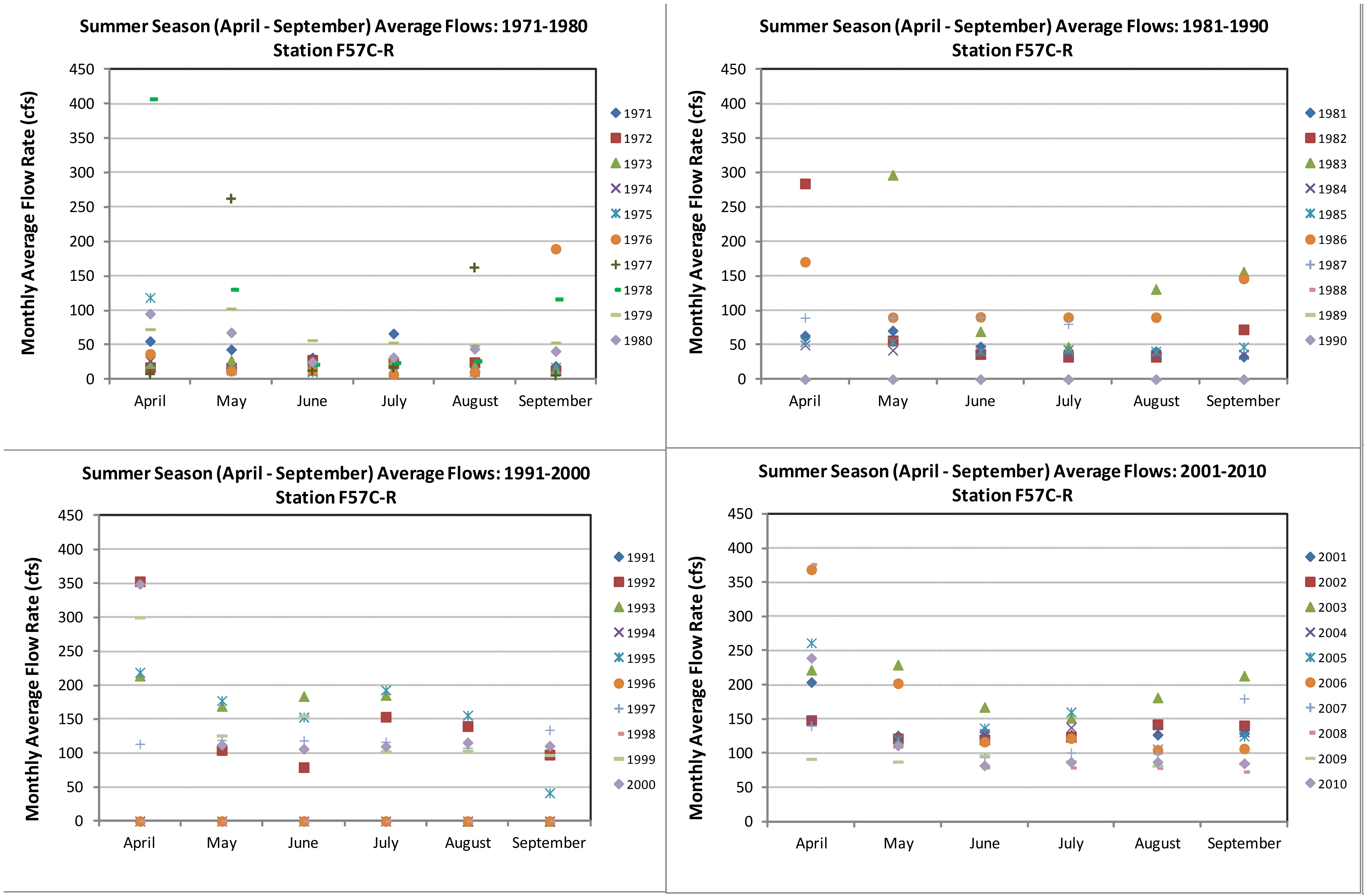
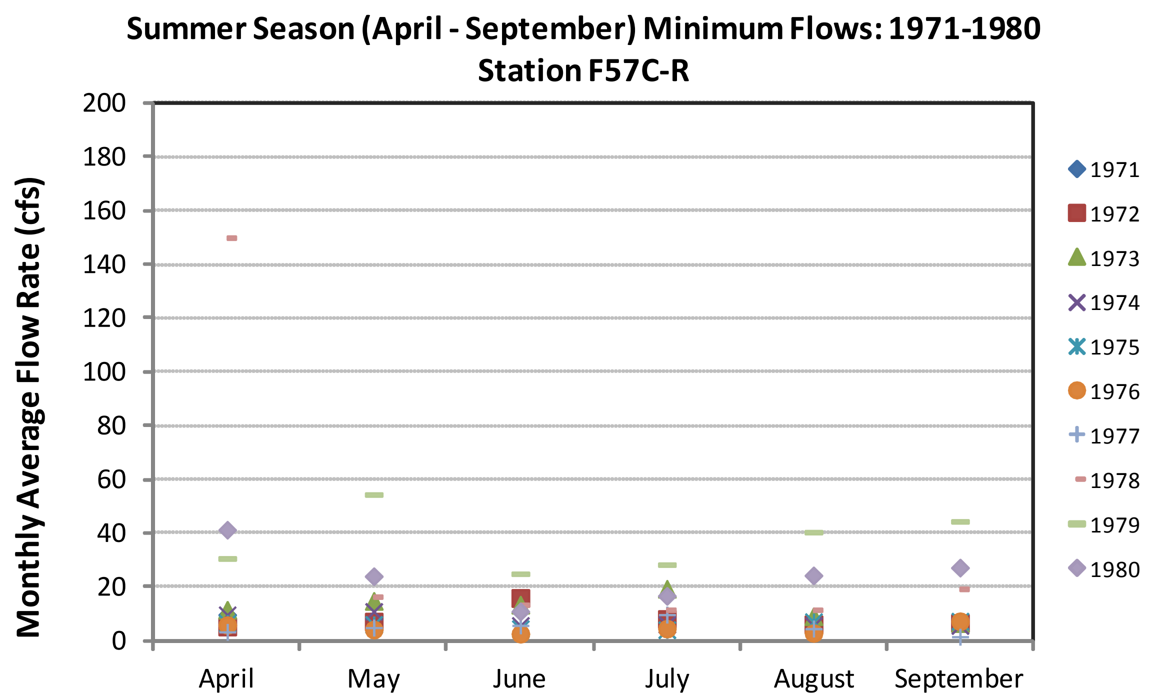
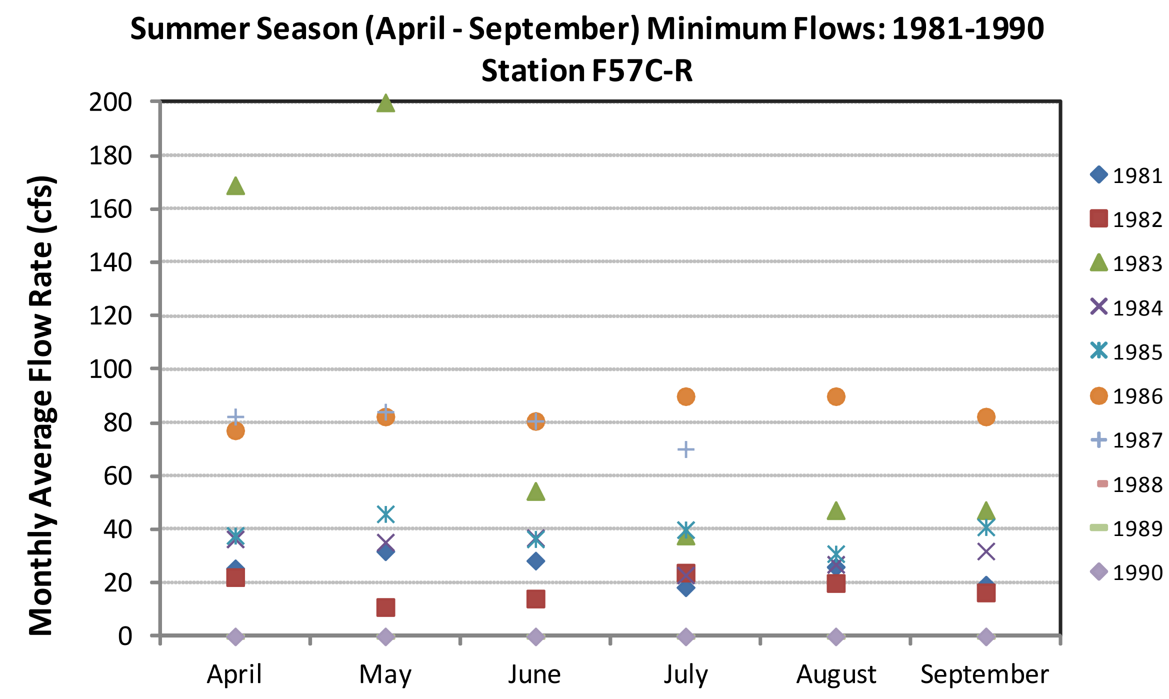
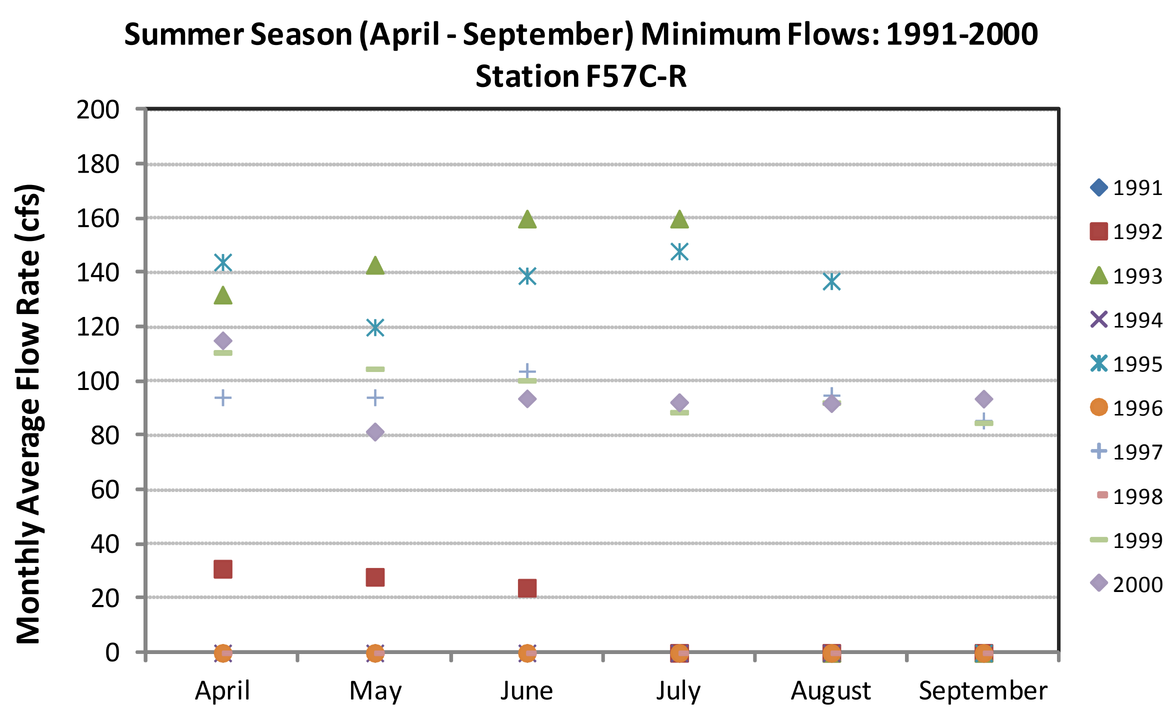


FIGURE F-7
Summer Season Minimum Flows from Water Year 1970 through 2010 at the F57C-R (LA River above Arroyo Seco) Station







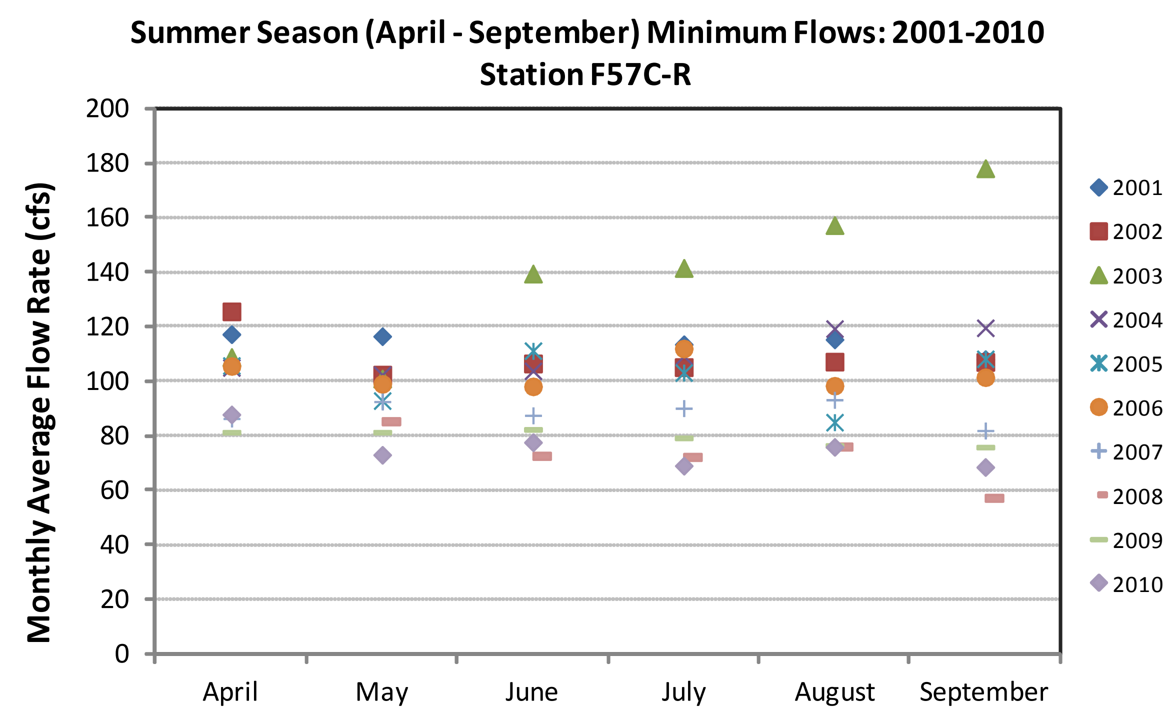
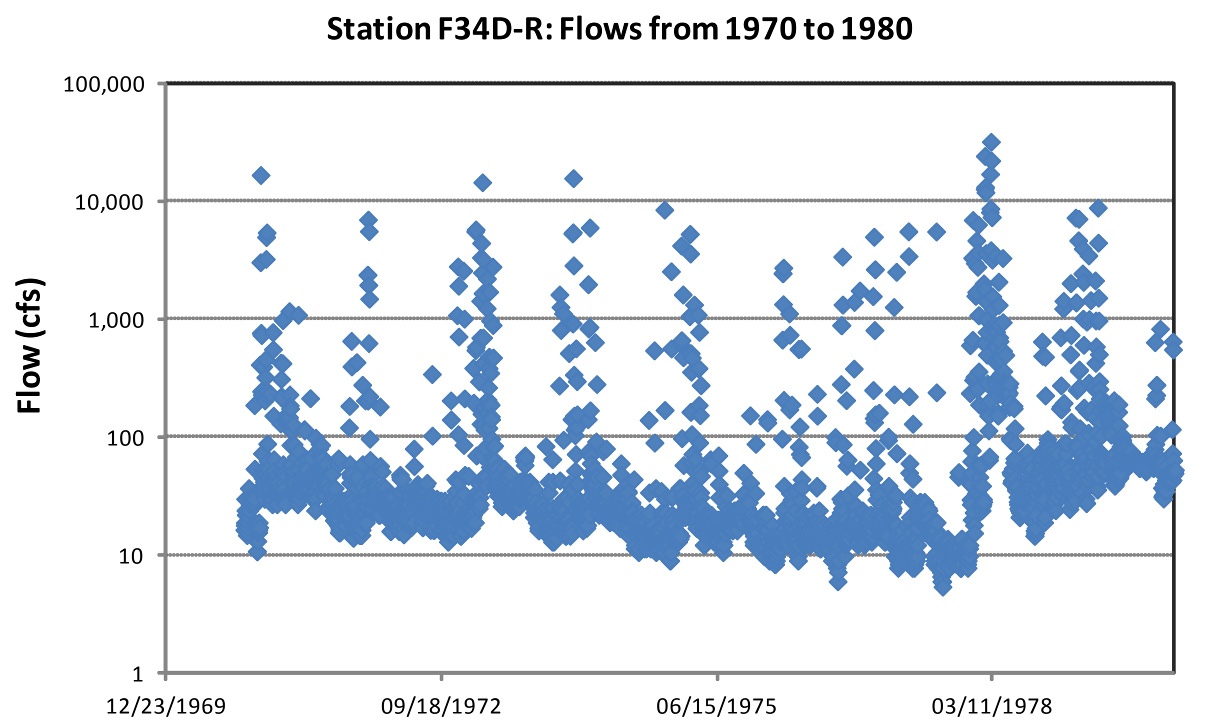
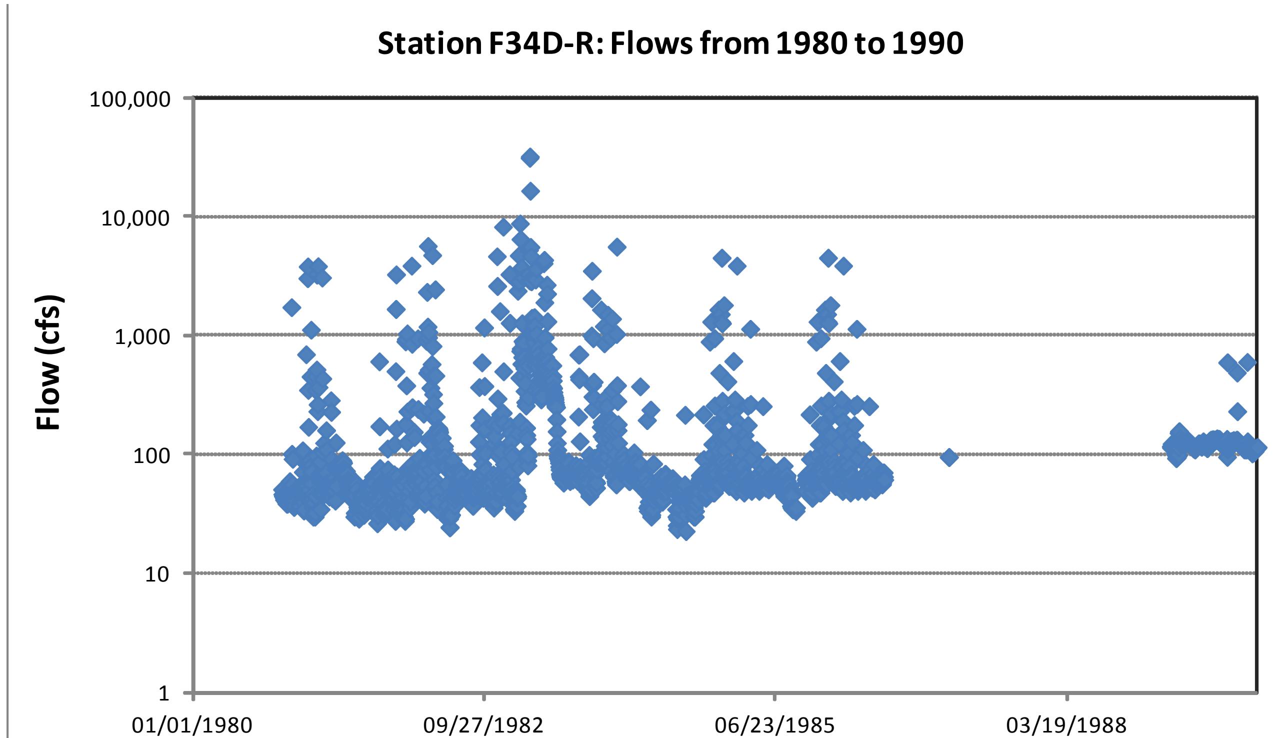
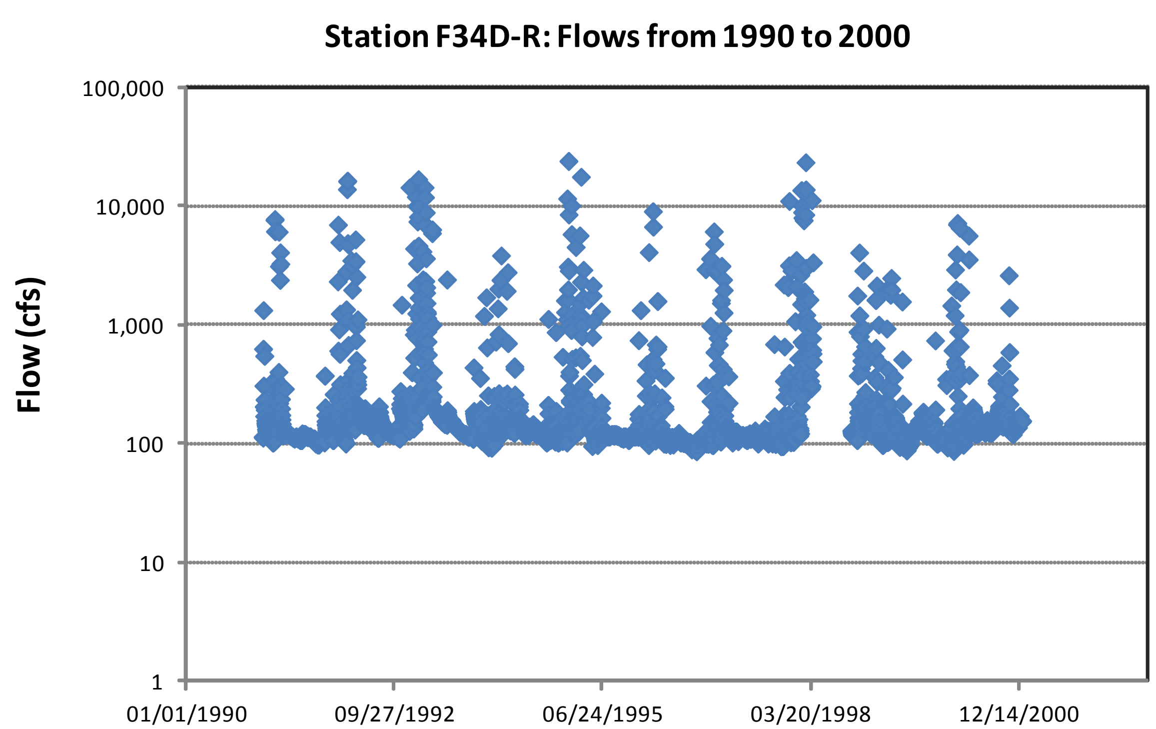


FIGURE F-8
Variations in Flow Rates from Water Year 1970 through 2010 at the F34D-R (LA River below Firestone) Station







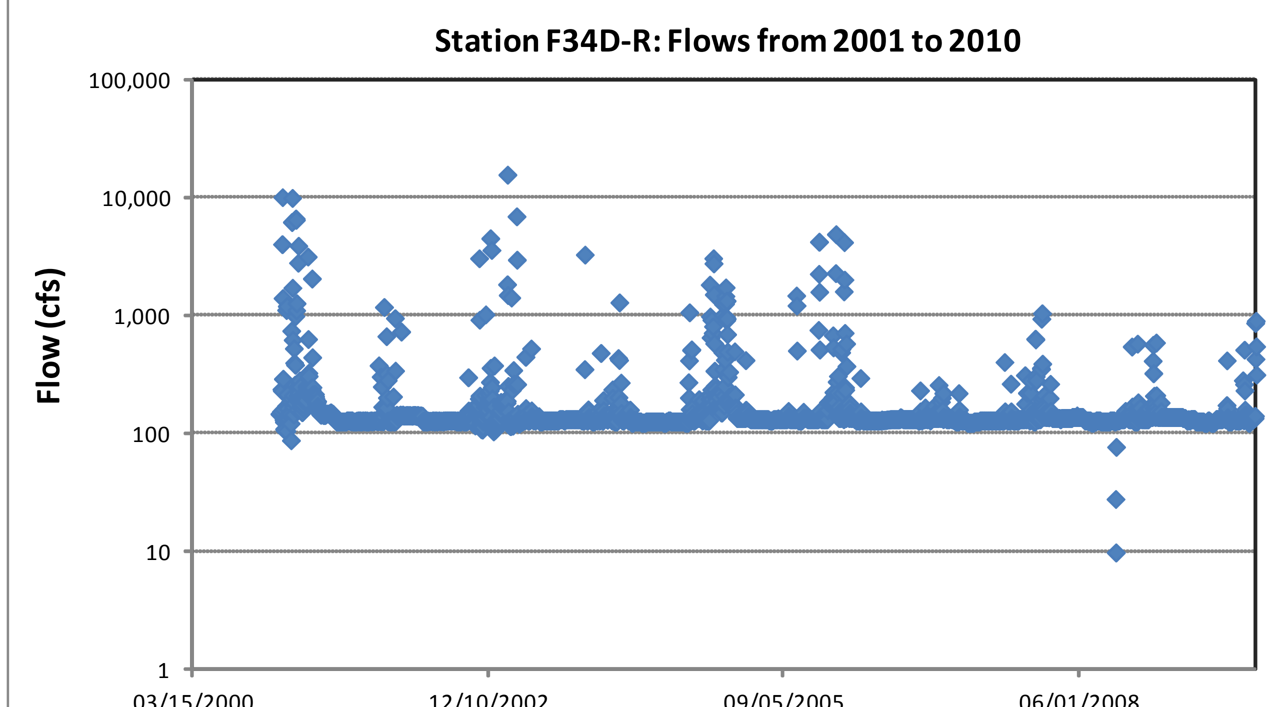


FIGURE F-9
Summer Season Monthly Average Flows from Water Year 1970 through 2010 at the F34D-R (LA River below Firestone) Station

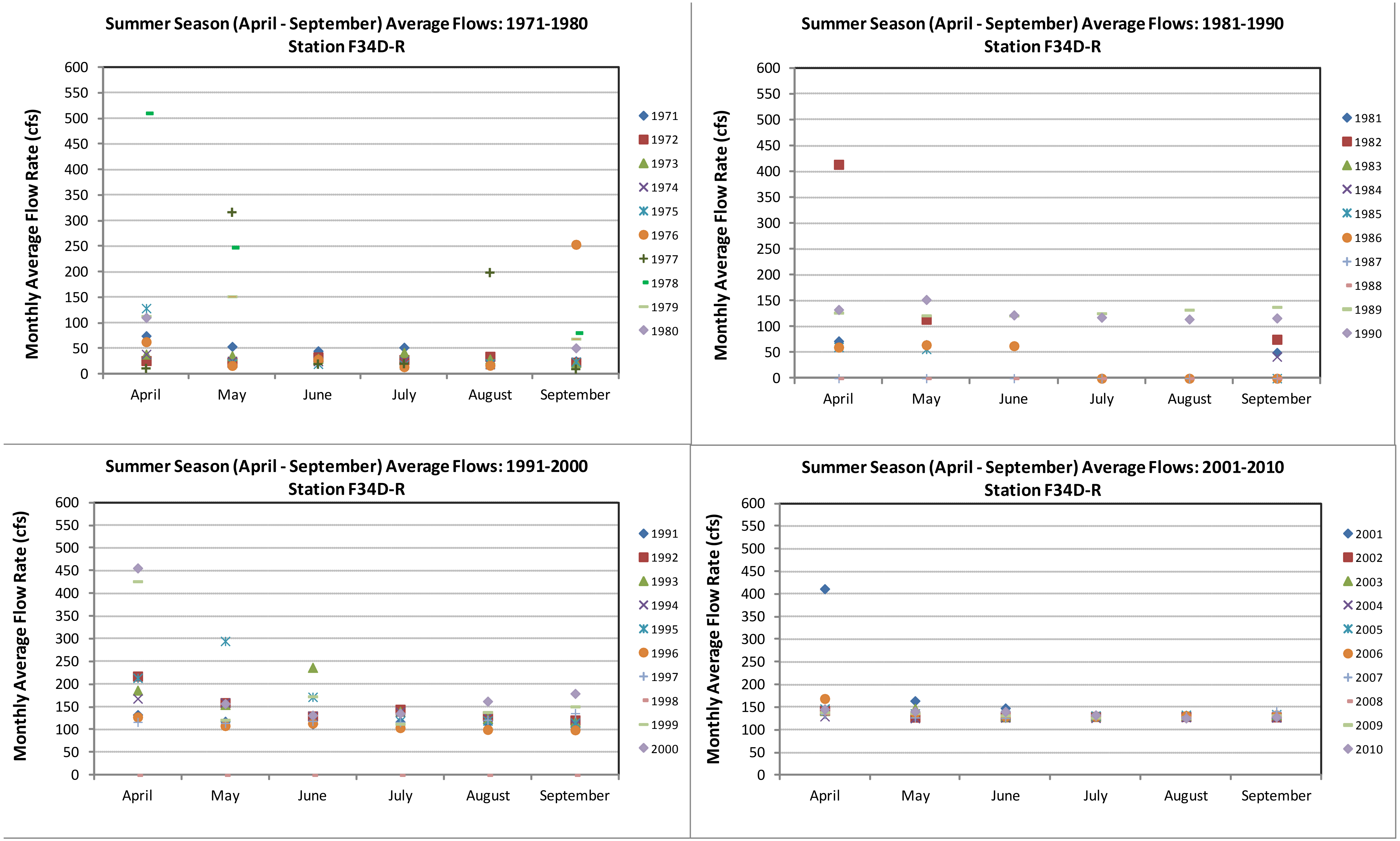
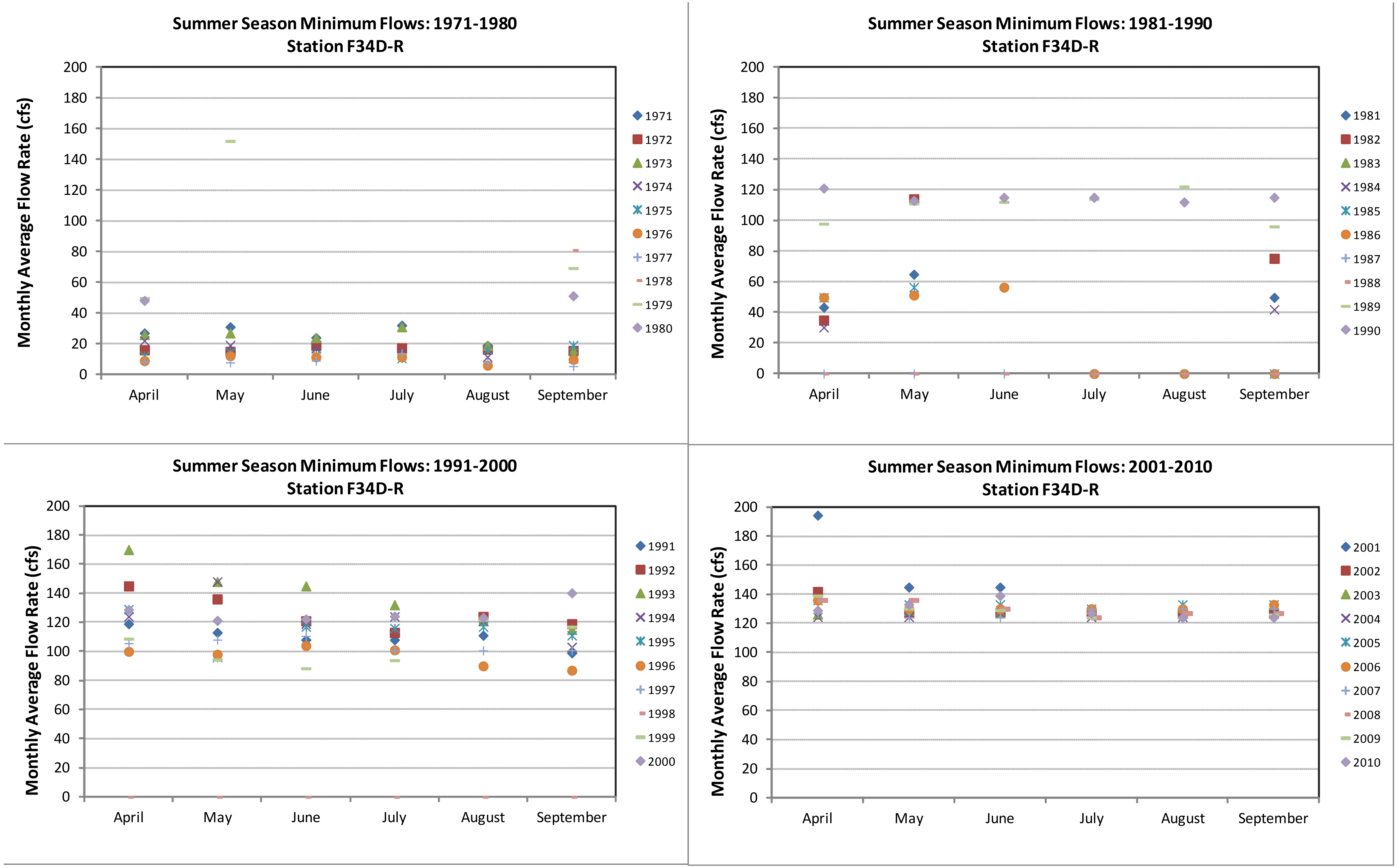


FIGURE F-10
Summer Season Minimum Flows from Water Year 1970 through 2010 at the F34D-R (LA River below Firestone) Station



Comparison of Flows Between Upstream and Downstream Stations

It is anticipated that the downstream station F34D-R will have higher flows compared to the upstream F57C-R station. As shown in Figure F-11, differences in daily flow rates between the downstream station and the upstream station revealed that the flows were not always higher at the downstream station. A few observations can be made:

- The differences in flows close to zero indicate that the flows at the upstream station are nearly the same as the flows at the downstream station. This situation can occur if (1) there was no addition of flows in this section of the river, and (2) if the gain in flows was equal to the loss in flows.
- Positive flow differential values indicate that the flows at the downstream station (F34D-R) are higher than the flows at the upstream station (F57C-R). This is likely due to additional downstream inflows.
- Negative flow differentials indicate that the flows at the downstream station are lower than the flows at the upstream station. This may be attributable to flow losses in this section of the river.

In general, the increase in flows from upstream to downstream locations can be a result of inflow from storm drains, tributaries, and groundwater that exfiltrates into the channel through existing "weep holes" in the concrete liner (CREST, 2009b). Between these two stations, the potential sources of flows include a tributary (Arroyo Seco) and storm drains. It was also suggested by the CREST (2009b) study that due to "concentrated" flows, it is not uncommon for storm peak flow rates in the middle reaches of the LA River (above Reach 2) to exceed those at the Wardlow Road station, even though the storm total volume discharged at Wardlow Road is larger. The Wardlow Road station is further downstream from the Firestone station (F34D-R). It is not apparent that the flows may be lost to groundwater, as most of this section of the river is concrete-lined. However, losses to the groundwater cannot be ruled out. Further investigation is warranted to better understand the relationships between the locations of flow measurement stations, channel characteristics (such as presence or absence of low-flow channel), sources of flows, and losses in flows in this section of the river.

Estimate of Los Angeles River Storm Flows

Over time, primarily as a result of increased WRP discharges, the LA River baseflows have increased during the summer months (April through September), from approximately 10 cfs to 150 cfs, as shown in Tables F-4 and F-5, and Figures F-12 and F-13. The primary factor contributing to these changes in average baseflows was the construction of the Tillman WRP in 1985 and its expansion in 1991. Additionally, the LA-Glendale WRP began continuous operation in 1977.

The baseflows at station F34D-R were higher than the flows at station F57C-R for all time periods except for 1991 to 2000, when the flows appear to be the same at both stations. These flows are similar to the baseflows evaluated by WRD in an earlier study conducted to determine the preliminary feasibility of developing a recharge facility in the LA Forebay for LA River stormwater (WRD, 1997).

The goal of the analysis discussed herein was to determine the amount of stormwater runoff above the baseflows that can be captured for groundwater recharge. For planning purposes, higher average baseflows were applied in this analysis, as shown in Table F-4. The use of higher baseflows for planning purposes ensures that the LA River baseflows are protected, and only the storm flows above these assumed baseflows are used for recharge of the Central Basin.

FIGURE F-11
Difference in Los Angeles River Average Daily Stream Flow at Station F34D-R (LA River Below Firestone) and Station F57C-R (LA River Above Arroyo Seco)

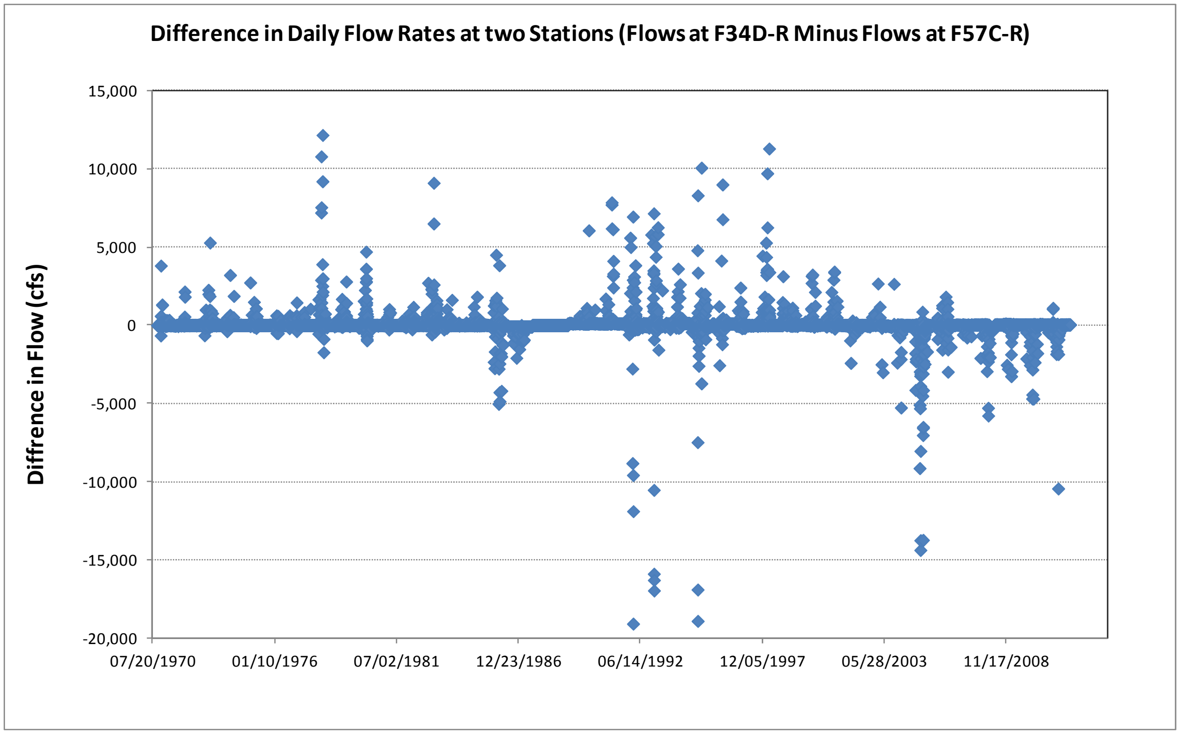


TABLE F-4
Average Baseflow at the Los Angeles River Stations (F34D-R and F57C-R)

Period	Average Baseflow (cfs) Based on 1997 WRD Study Station - F34D-R	Average Baseflow (cfs) Based on Figure F-12: Station F57C-R	Average Baseflow (cfs) Based on Figure F-13: Station - F34D-R*	Assumed Average Baseflow (cfs) for GBMP Analysis
1971-1980	25[a]	10	20	50
1981-1990	60[a]	30	50	50
1991-2000	120[a]	100	100	100
2001-2010	N/A[b]	100[c]	130	150

[a]The 1997 WRD Study data period differs from the data period reflected in Figures F-12 and F-13. The WRD study periods are presented in Table F-5.
[b]The 1997 WRD study spanned from water years 1956-57 to 1995-96.
[c]The average baseflows for the last 3 years appear to be lower than 100 cfs.

Notes:

GBMP = Groundwater Basin Master Plan
N/A = not available

TABLE F-5
Average Baseflow at the Los Angeles River Station (F34D-R Based on 1997 WRD Study

Period	Average Baseflow (cfs)
1957-1966	10
1967-1978	25
1979-1986	60
1987-1996	120

After determining the baseflows for the entire period of record, the analysis was conducted to determine (1) the storm flows above the baseflows that can be used for recharge, and (2) the frequency of those available flows on annual basis.

Data for the period from 1970 through 2011 at monitoring stations F57C-R and F34D-R were used for analysis, excluding years 1987 through 1991 for which data were not available. This analysis was conducted using the following steps:

1. Days when the flows are above the baseflows were flagged. (Note that the baseflows were varied per Table F-4 for every 10-year time interval.)
2. Baseflows were subtracted from the daily storm flows.
3. Captured flows were capped at a maximum of 50 cfs (that is, a maximum diversion of 50 cfs on a daily basis was estimated based on the available area that could be used in developing an ARRF between about Atlantic Boulevard on the north to Firestone on the south). The number of days with storm flows available above the baseflows is highly variable, as shown in Tables F-6 and F-7 for the two monitoring stations. A conservative estimate of 50 days per year is assumed for planning purposes (this allows for 20 percent downtime for drying and maintenance in those periods when storm flow may be available). Thus, diverting 50 cfs (about 100 acre-feet [AF] per day) for 50 days can provide 5,000 acre-feet per year (AFY) for recharge.
4. The number of days in each month that have flows of at least 50 cfs were identified. These are the potential days when the storm flows can be diverted for recharge.
5. On this basis, the annual total water volume available over the course of the year was calculated.
6. The annual maximum recharge volume was limited to 10,000 AFY. It is assumed that this is the maximum volume that can be captured on an annual basis and used for recharge, which allows for downtime and maintenance during longer periods that storm flows would be available.
7. The total annual water volume available for recharge was then calculated and averaged over the analysis period. These results are shown in Table F-8.

FIGURE F-12
Los Angeles River Average Daily Stream Flow: Station F57C-R (LA River Above Arroyo Seco)

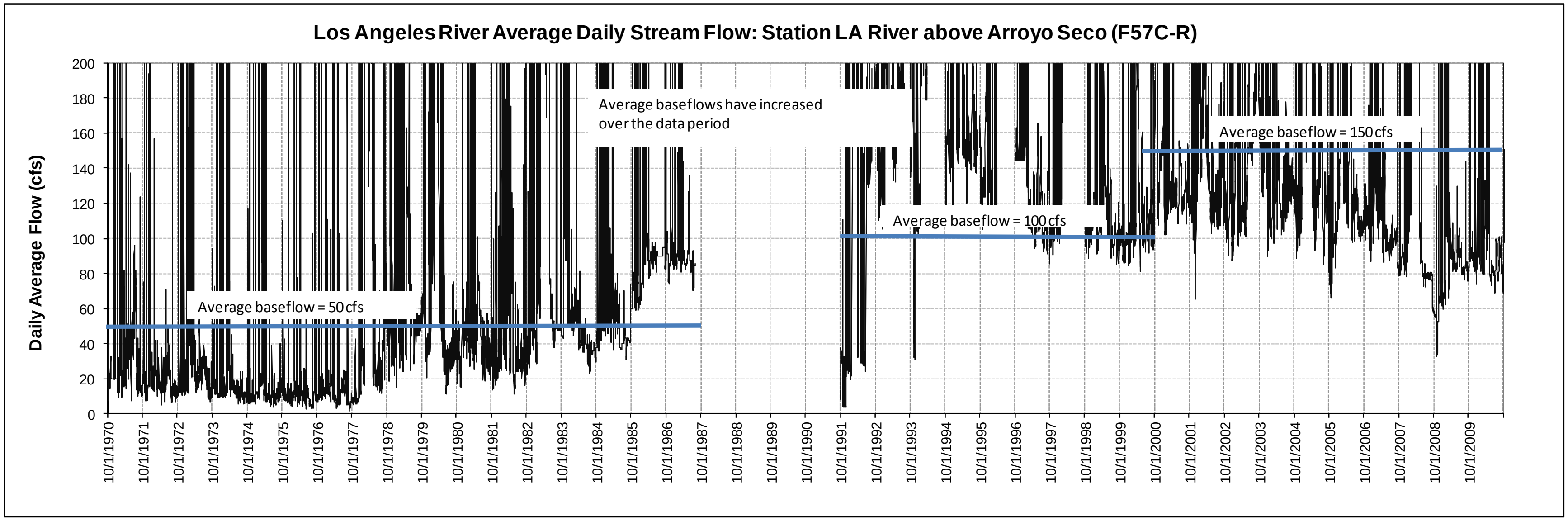


FIGURE F-13
Los Angeles River Average Daily Stream Flow: Station F34D-R (LA River Below Firestone)

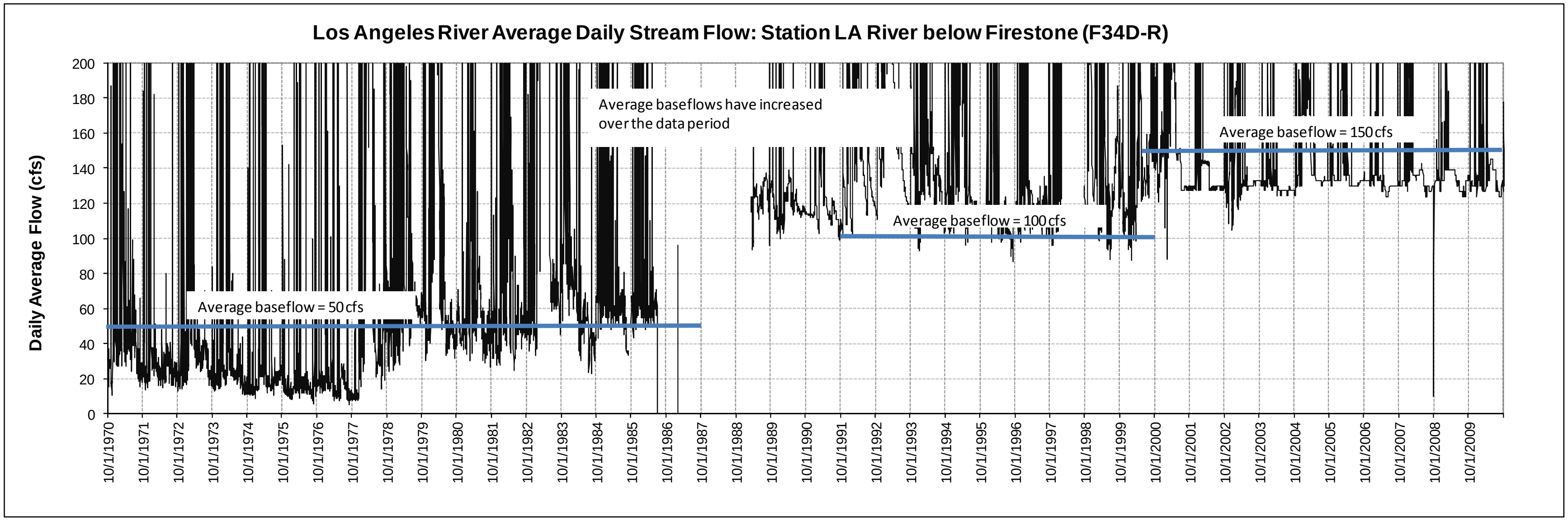


TABLE F-6
Number of Days and Volume of Water Available for Recharge: Station F57C-R (LA River Above Arroyo Seco)

Water Year	Number of Days with Instream Flows Greater Than Baseflows	Total Volume (AF)	Total Volume with 10,000 AF Spreading Cap
1971	27	2,678	2,678
1972	14	1,388	1,388
1973	35	3,471	3,471
1974	20	1,983	1,983
1975	21	2,083	2,083
1976	16	1,587	1,587
1977	16	1,587	1,587
1978	121	12,000	10,000
1979	42	4,165	4,165
1980	76	7,537	7,537
1981	21	2,083	2,083
1982	32	3,174	3,174
1983	134	13,289	10,000
1984	29	2,876	2,876
1985	21	2,083	2,083
1986	40	3,967	3,967
1987	19	1,884	1,884
1988	N/A	N/A	N/A
1989	N/A	N/A	N/A
1990	N/A	N/A	N/A
1991	N/A	N/A	N/A
1992	149	14,777	10,000
1993	233	23,107	10,000
1994	106	10,512	10,000
1995	237	23,504	10,000
1996	37	3,669	3,669
1997	69	6,843	6,843
1998	50	4,959	4,959
1999	30	2,975	2,975
2000	56	5,554	5,554
2001	87	5,599	5,599
2002	125	7,422	7,422

TABLE F-6
Number of Days and Volume of Water Available for Recharge: Station F57C-R (LA River Above Arroyo Seco)

Water Year	Number of Days with Instream Flows Greater Than Baseflows	Total Volume (AF)	Total Volume with 10,000 AF Spreading Cap
2003	156	9,086	9,086
2004	96	4,316	4,316
2005	155	13,105	10,000
2006	85	5,965	5,965
2007	23	1,519	1,519
2008	101	9,493	9,493
2009	16	1,498	1,498
2010	41	3,552	3,552
Total	**2,536**	**225,290**	**184,995**
Average	**70**	**6,258**	**5,139**

TABLE F-7
Number of Days and Volume of Water Available for Recharge: Station F34D-R (LA River Below Firestone)

Water Year	Number of Days Flows Greater Than Baseflows	Total Volume(AF)	Total Volume with 10,000 AF Spreading Cap
1971	36	3,570	3,570
1972	16	1,587	1,587
1973	44	4,364	4,364
1974	23	2,281	2,281
1975	26	2,579	2,579
1976	21	2,083	2,083
1977	19	1,884	1,884
1978	120	11,901	10,000
1979	61	6,050	6,050
1980	80	7,934	7,934
1981	23	2,281	2,281
1982	55	5,455	5,455
1983	150	14,876	10,000
1984	49	4,860	4,860
1985	31	3,074	3,074
1986	31	3,074	3,074
1987	N/A	N/A	N/A

TABLE F-7
Number of Days and Volume of Water Available for Recharge:
Station F34D-R (LA River Below Firestone)

Water Year	Number of Days Flows Greater Than Baseflows	Total Volume(AF)	Total Volume with 10,000 AF Spreading Cap
1988	N/A	N/A	N/A
1989	N/A	N/A	N/A
1990	14	1,388	1,388
1991	46	4,562	4,562
1992	125	12,397	10,000
1993	212	21,025	10,000
1994	89	8,826	8,826
1995	108	10,711	10,000
1996	32	3,174	3,174
1997	45	4,463	4,463
1998[a]	94	9,322	9,322
1999	116	11,504	10,000
2000	122	12,099	10,000
2001	163	10,674	10,000
2002	20	1,409	1,409
2003	77	5,163	5,163
2004	26	1,380	1,380
2005	111	7,167	7,167
2006	68	4,742	4,742
2007	15	827	827
2008	29	2,073	2,073
2009	26	1,319	1,319
2010	33	2,162	2,162
Total	**2,360**	**214,634**	**189,051**
Average	**64**	**5,790**	**5,109**

[a]Data set for 1998 is incomplete

TABLE F-8
Estimated Annual Average Water Volume Available for Recharge

Station	Analysis Period	Total Water Volume Available Over the Analysis Period (AF)	Annual Average Water Volume Available (AF)
LA River above Arroyo Seco (F57C-R)	1971-2010 (excluding 1987-1989[a])	184,995	5,139
LA River below Firestone (F34D-R)	1971-2010 (excluding 1987-1991[a])	189,051	5,109

[a]Data sets for 1987 to 1989 are not complete.

This analysis indicated an available water volume of 5,139 AFY and 5,109 AFY at stations LA River above Arroyo Seco (F57C-R) and LA River below Firestone (F34D-R), respectively. Therefore, for the groundwater model simulations (discussed in Section 4 of the report) an estimated 5,000 AFY of stormwater above baseflow conditions was considered to be available for capture and recharge of the Central Basin in the LA Forebay.

As an example, Table F-9 and Figure F-14 present number of days with flows above 150 cfs at both stations. For the entire period, on an annual average basis, flows above 150 cfs occurred approximately 20 percent of the time. This is a conservatively low estimate because the baseflows for 1970 to 1990 and 1991 to 2000 were 50 cfs and 100 cfs (as shown in Figures F-12 and F-13), rather than 150 cfs applied in this analysis. For the 2001 to 2010 period with an actual average baseflow of 150 cfs, the percentage of days above baseflow was 24 percent.

TABLE F-9
Number of Days with Flows Greater Than 150 cfs at Stations F34D-R and F57C-R

	LA River Above Arroyo Seco (F57C-R)			LA River Below Firestone (F34D-R)		
Year	# of Days Flow >150	# of Data Records	% of Days >150	# of Days Flow >150	# of Data Records	% of Days >150
1971	27	365	7%	36	365	10%
1972	14	366	4%	16	366	4%
1973	35	365	10%	44	365	12%
1974	20	365	5%	23	365	6%
1975	21	365	6%	26	365	7%
1976	16	366	4%	21	366	6%
1977	16	365	4%	19	365	5%
1978	121	365	33%	120	365	33%
1979	42	365	12%	61	365	17%
1980	76	366	21%	80	366	22%
1981	21	365	6%	23	365	6%
1982	32	365	9%	55	365	15%
1983	134	365	37%	150	365	41%
1984	29	366	8%	49	366	13%
1985	21	365	6%	31	365	8%
1986	40	365	11%	31	365	8%
1987	N/A	N/A	N/A	N/A	N/A	N/A
1988	N/A	N/A	N/A	N/A	N/A	N/A
1989	N/A	N/A	N/A	N/A	N/A	N/A
1990	N/A	N/A	N/A	N/A	N/A	N/A
1991	N/A	N/A	N/A	N/A	N/A	N/A
1992	149	366	41%	125	366	34%
1993	233	365	64%	212	365	58%
1994	106	365	29%	89	365	24%
1995	237	365	65%	108	365	30%

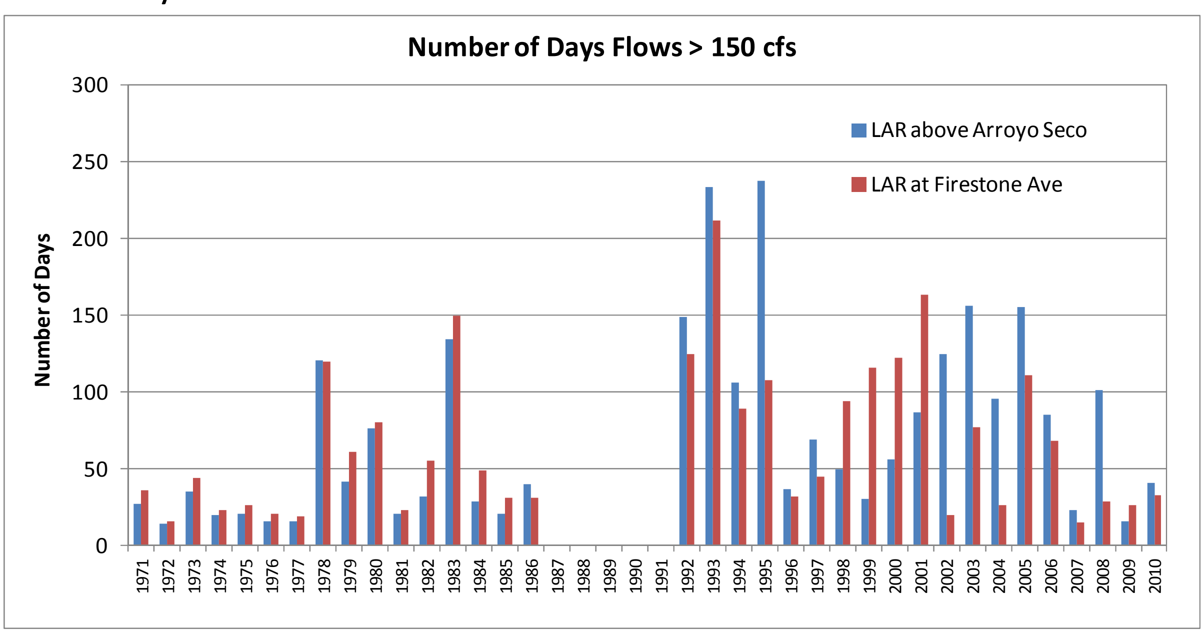
TABLE F-9
Number of Days with Flows Greater Than 150 cfs at Stations F34D-R and F57C-R

1996	37	366	10%	32	366	9%
1997	69	365	19%	45	365	12%
1998	50	365	14%	94	365	26%
1999	30	365	8%	116	365	32%
2000	56	366	15%	122	366	33%
2001	87	365	24%	163	365	45%
2002	125	365	34%	20	365	5%
2003	156	365	43%	77	365	21%
2004	96	366	26%	26	366	7%
2005	155	365	42%	111	365	30%
2006	85	365	23%	68	365	19%
2007	23	365	6%	15	365	4%
2008	101	366	28%	29	366	8%
2009	16	365	4%	26	365	7%
2010	41	365	11%	33	365	9%
2011	61	365	17%	60	365	16%
Total	**2,578**	**13,149**	**20%**	**2,356**	**13,149**	**18%**

Notes:

Years with incomplete data (1987 to 1991) were not included in the analysis.
= number
> = greater than

FIGURE F-14
Number of Days with Flows Greater Than 150 cfs at Stations F34D-R and F57C-R



Note: LAR = Los Angeles River

Summary

The analysis described in this appendix estimates the amount of stormwater available from the LA River that can be captured and used for recharge, instead of discharging these flows to the ocean. Section 4 of this report contains the description of the LA River ARRF that can use the storm flows from the LA River, (that is, the flows above the estimated average dry weather baseflow) for replenishment of the Central Basin.

The calculations of the available storm flows to estimate the amount of water available for recharge were based on monitoring data at the LA River above Arroyo Seco and LA River below Firestone Boulevard stations from water years 1971 through 2010. It was found that approximately 5,000 AFY could be used for groundwater recharge in the Central Basin. This estimate is conservative as the analysis indicated that more flows potentially could be available. However, for the GBMP planning process, this conservative estimate is appropriate.

The LA River storm flow analysis includes the following conservative assumptions:

- Assumed higher baseflows for the entire 40-year period of analysis. As presented in Table F-4, the actual baseflows based on the data are lower than the assumed values for every 10-year period. This means that more flows would become available for recharge if the lower baseflows were used.
- Assumed 50 days (per year) for diversion of storm flows. The actual number of days with storm flows are highly variable. The average number of days with flows greater than the baseflows is more than 50 (Tables F-6 and F-7).
- Assumed a practical limit of 10,000 AFY that can be used for recharge annually.

Section 4 of this report presents groundwater modeling results with the above assumptions for groundwater recharge of storm flows in the LA Forebay.

References

Ackerman, D., Schiff, K., Trim, H., and Mullin, M. 2003. "Characterization of water quality in the Los Angeles River." *Bulletin of the Southern California Academy of Sciences,* 102(1): 17-25.

Cleaner Rivers through Effective Stakeholder-led TMDLs (CREST). 2009a. *Draft Los Angeles River Watershed Bacteria TMDL – Technical Report Section 4: Bacteria TMDL Source Assessment.* July.

Cleaner Rivers through Effective Stakeholder-led TMDLs (CREST). 2009b. *Draft Los Angeles River Watershed Bacteria TMDL – Technical Report Section 4: Bacteria TMDL Source Assessment Appendix.* July. http://www.crestmdl.org/reports/working_documents.html.

Los Angeles Regional Water Quality Control Board (LARWQCB). 2005. *Total Maximum Daily Loads for Metals for Los Angeles River and Tributaries.* California Regional Water Quality Control Board, Los Angeles Region. June 2.

Los Angeles Regional Water Quality Control Board (LARWQCB). 2007. *Watershed Management Initiative Chapter.* California Regional Water Quality Control Board, Los Angeles Region. December. http://www.waterboards.ca.gov/losangeles/water_issues/programs/regional_program/wmi/wmi_chapter_2007.pdf.

Los Angeles Regional Water Quality Control Board (LARWQCB). 2010. *Los Angeles River Watershed Bacteria Total Maximum Daily Load.* California Regional Water Quality Control Board, Los Angeles Region. July 15.

Water Replenishment District (WRD). 1997. *Los Angeles Forebay Recharge Project – Conceptual Evaluation Report.*

U.S. Census Bureau. 2000. *2000 Census.*

Appendix G
Orange County Water District Contour Maps

This appendix contains the groundwater level maps that were used to develop the Orange County boundary conditions for the WRD/USGS groundwater model for the period from 2000 through 2010. The Orange County Water District (OCWD) compiles groundwater level data from throughout the Orange County groundwater basin and prepares groundwater level contour maps for each of the principal aquifers in the basin. These annual contour maps were obtained from OCWD and were digitized to assign groundwater levels to constant head grid cells of the three layers simulated along the boundary. Table G-1 presents a summary of the observed historical groundwater levels (as contoured from observation wells) for various aquifers.

TABLE G-1

AVAILABILITY OF GROUNDWATER LEVEL DATA FOR VARIOUS AQUIFERS IN THE ORANGE COUNTY BASIN

Year	Availability of Observed Groundwater Levels	
	Principal Aquifer	Shallow Aquifer
2001	√	
2002	√	
2003	√	
2004	√	√
2005	√	√
2006	√	√
2007	√	√
2008	√	√
2009	√	√
2010	√	√

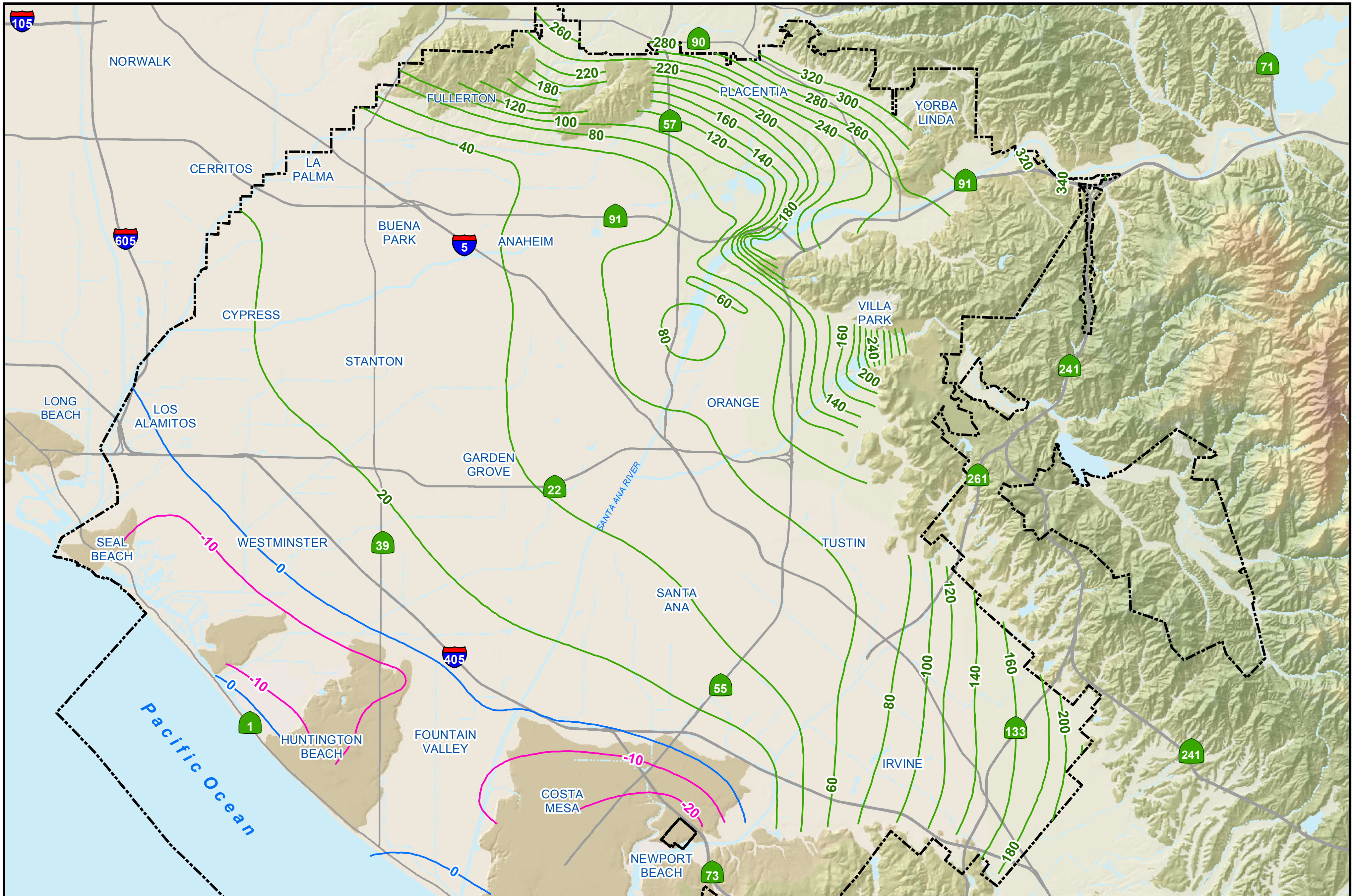
Assignment of groundwater level data to model layers

The following approach was used to assign the observed historical groundwater levels from the aquifers to three model layers along the boundary with Orange County.

For layer 2: Data from shallow aquifer from 2004 through 2010 were used. With the missing shallow aquifer data for years 2000 through 2003, the values used in the WRD/USGS model from 1971 through 1974 were used.

For layers 3 and 4: Principal Aquifer contour values from 2000 through 2010 were used. These values were assigned to both layers 3 and 4.

Maps of Shallow Aquifer from 2004 through 2010



Groundwater Elevations (Feet, MSL)

-20 to -10

0

20 - 360

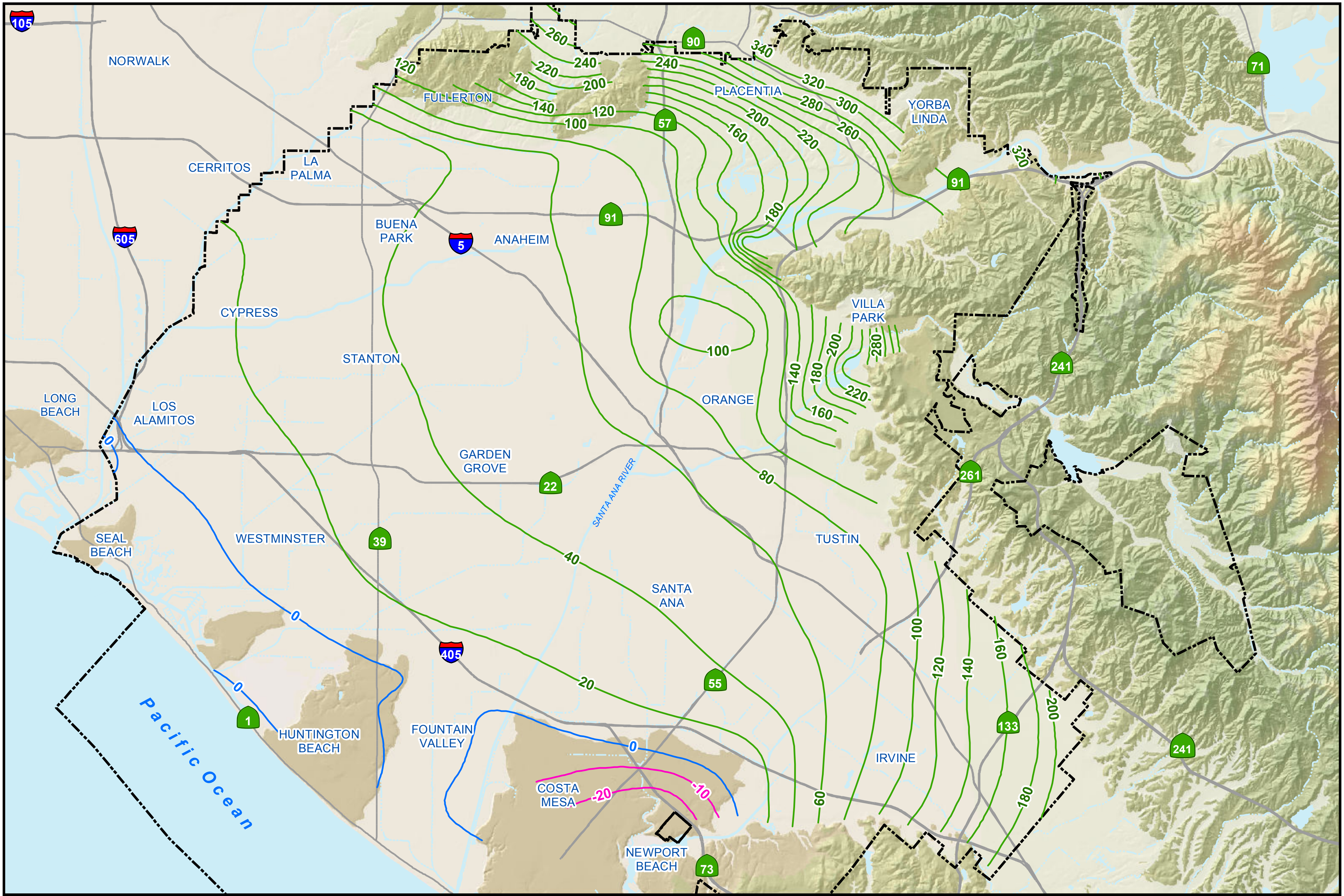
N S W E

0 15,000 30,000 Feet

K:\GW_Contour\MXD\wl_Jun2009.mxd

NOVEMBER 2004

Groundwater Elevation Contours for the **Shallow** Aquifer



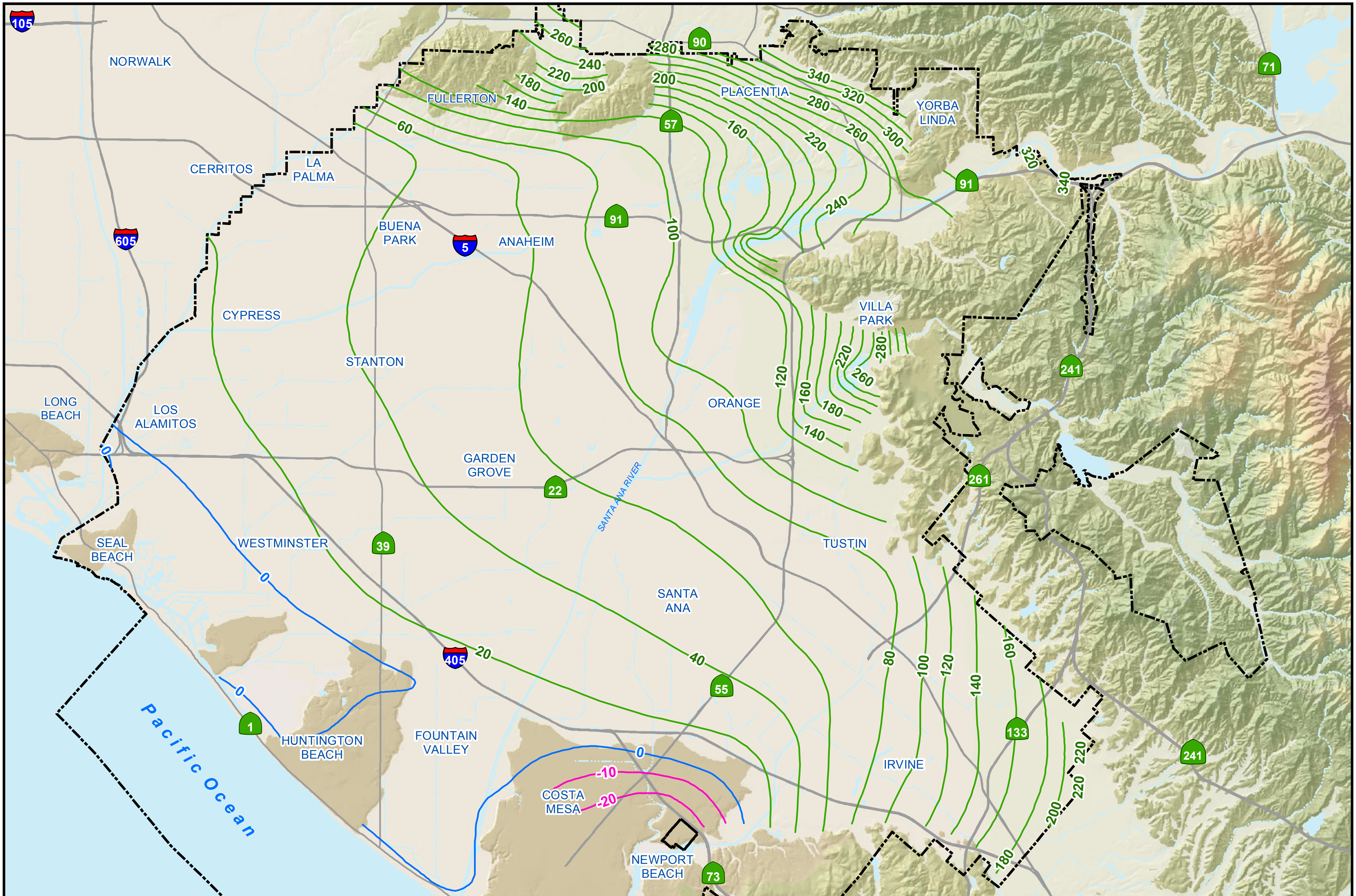
Groundwater Elevations (Feet, MSL)

- -20 to -10
- 0
- 20 to 360

NOVEMBER 2005

Groundwater Elevation Contours for the **Shallow** Aquifer

K:\GW_Contour\MXD\wl_Jun2009.mxd



N
W
E
S

0
15,000
30,000
Feet

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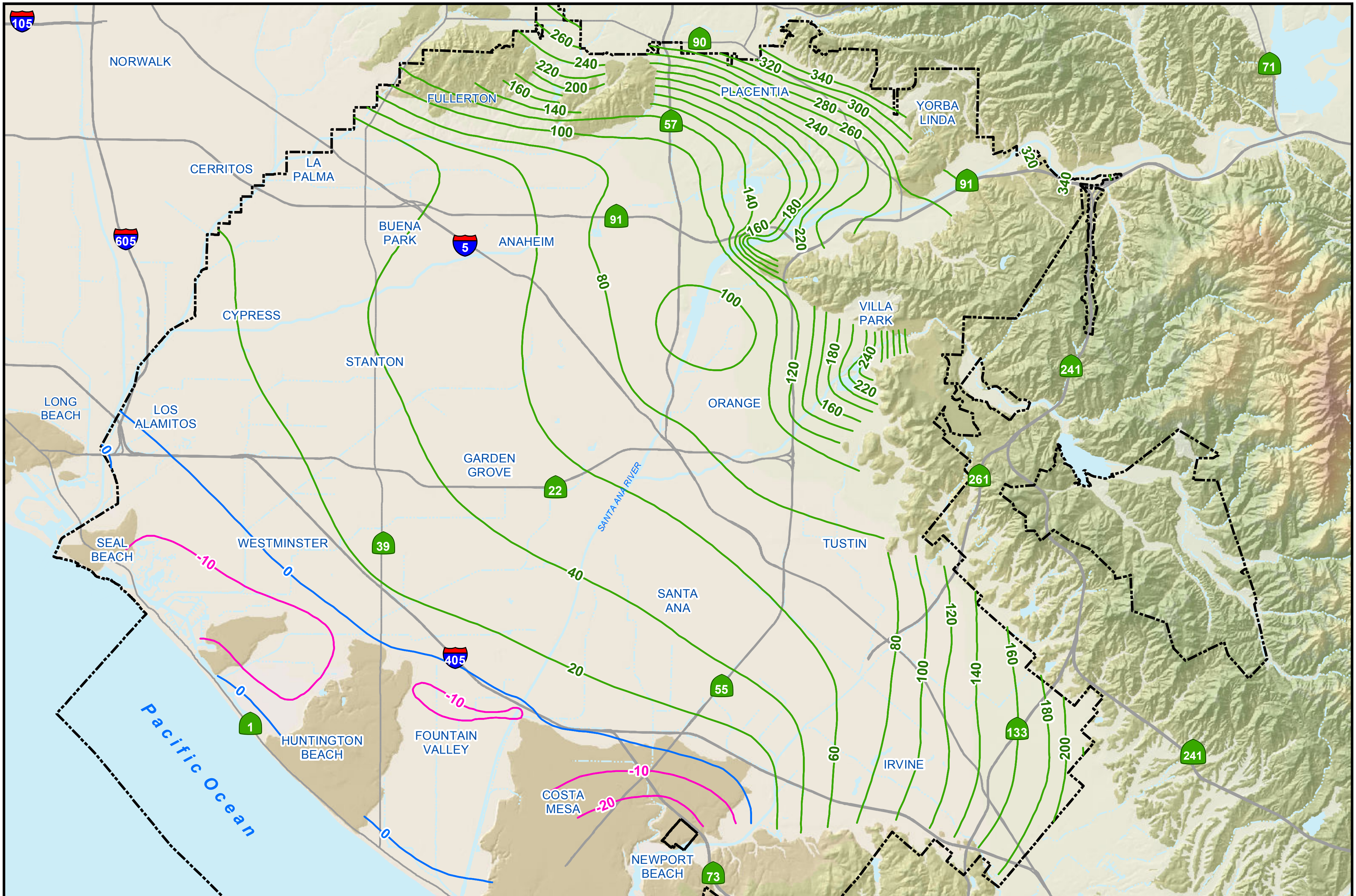
K:\GW_Contour\MXD\wl_Jun2009.mxd

Groundwater Elevations (Feet, MSL)

- -20 to -10
- 0
- 20 to 360

JUNE 2006

Groundwater Elevation Contours for the **Shallow** Aquifer



N
W E
S

0 15,000 30,000
Feet

Groundwater Elevations (Feet, MSL)

-20 to -10

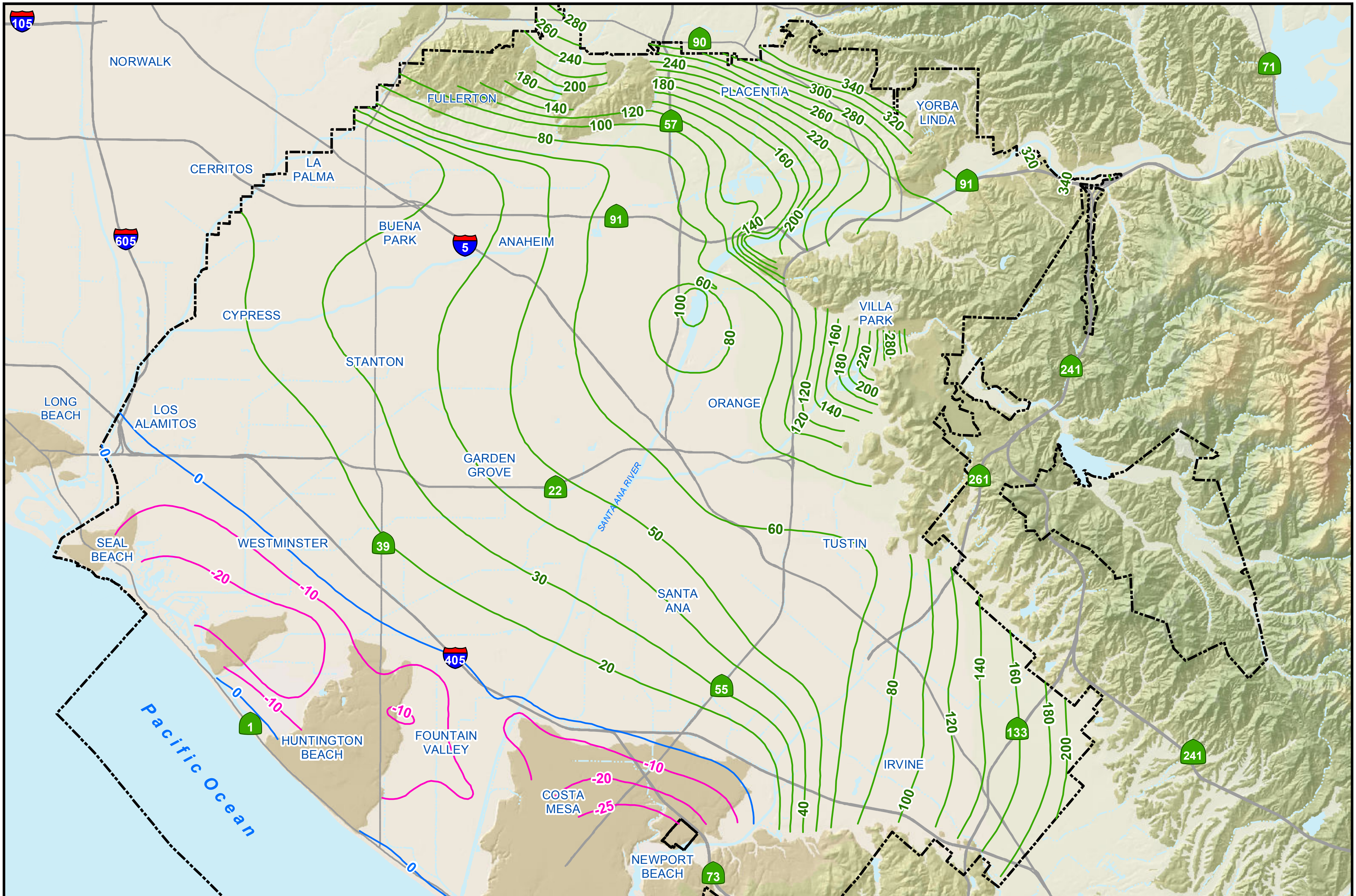
0

20 to 360

JUNE 2007

Groundwater Elevation Contours for the **Shallow** Aquifer

K:\GW_Contour\MXD\wl_Jun2009.mxd



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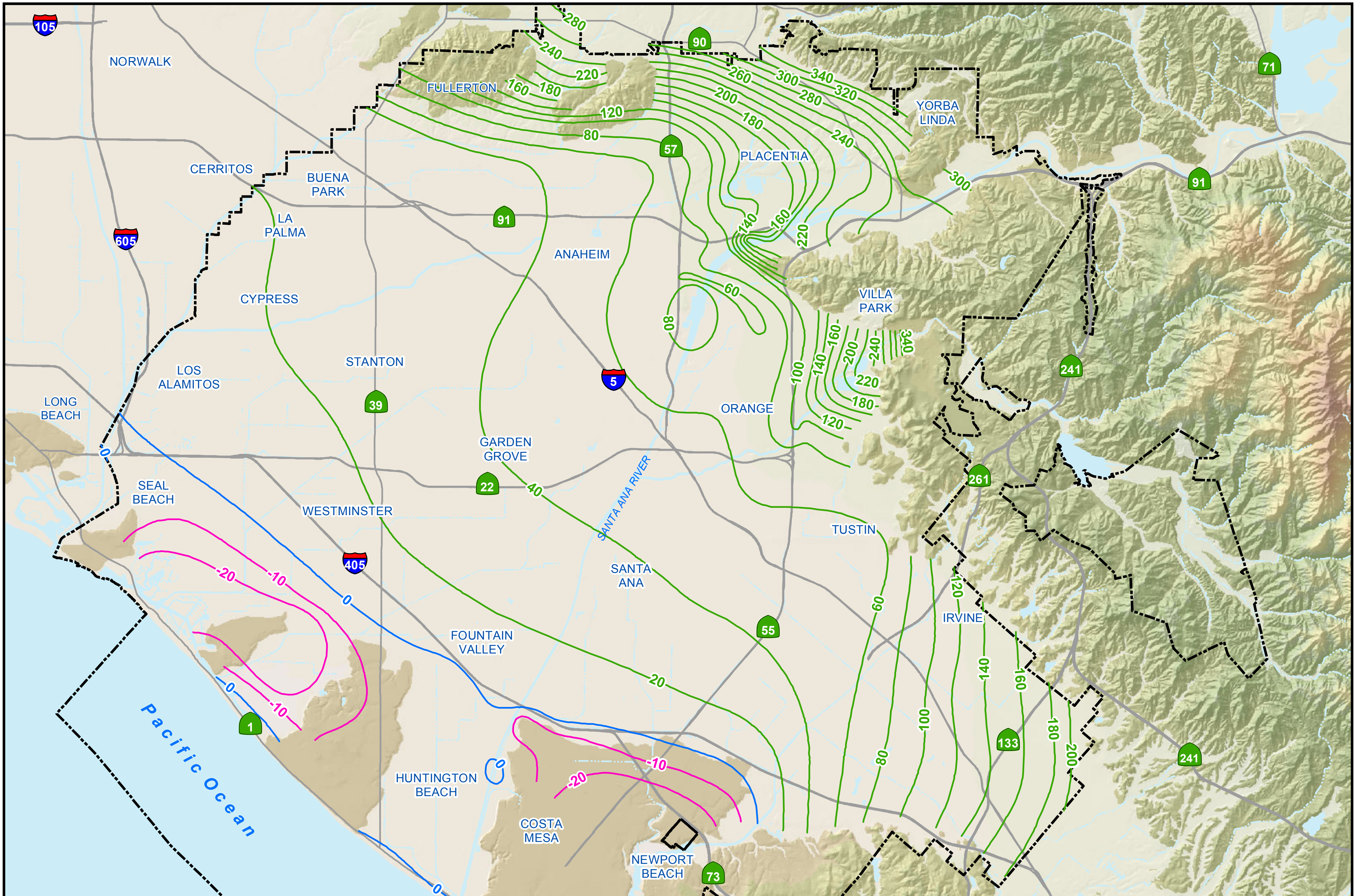
K:\GW_Contour\MXD\wl_Jun2009.mxd

Groundwater Elevations (Feet, MSL)

- -25 to -10
- 0
- 20 to 360

JUNE 2008

Groundwater Elevation Contours for the **Shallow** Aquifer



Groundwater Elevations (Feet, MSL)

-20 to -10

0

20 to 340

0 15,000 30,000 Feet

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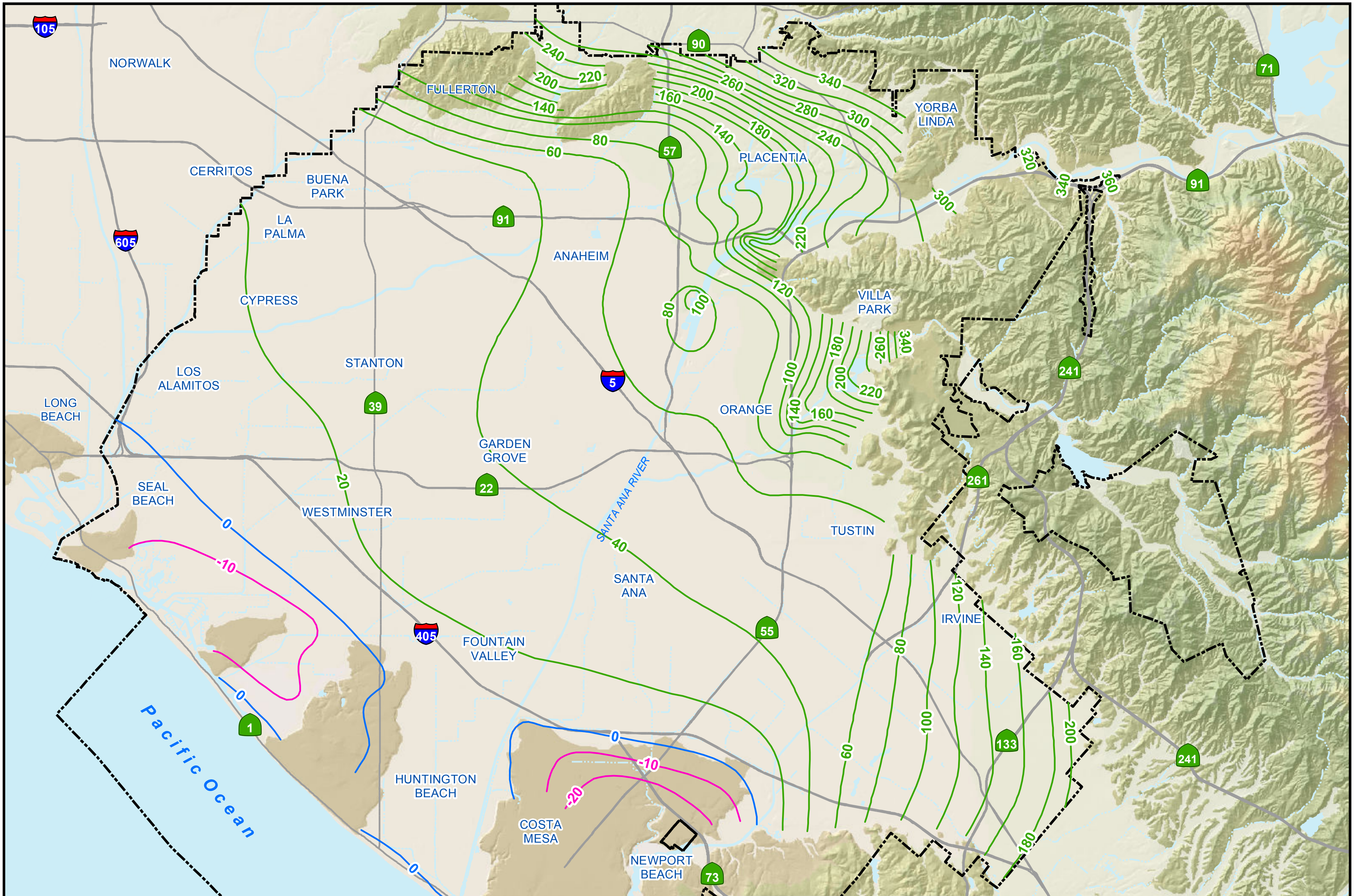
K:\GW_Contour\MXD\June_WL.mxd

JUNE 2009

Groundwater Elevation Contours for the **Shallow** Aquifer



N
W E
S

0 15,000 30,000
Feet

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K:\GW_Contour\MXD\June_WL.mxd

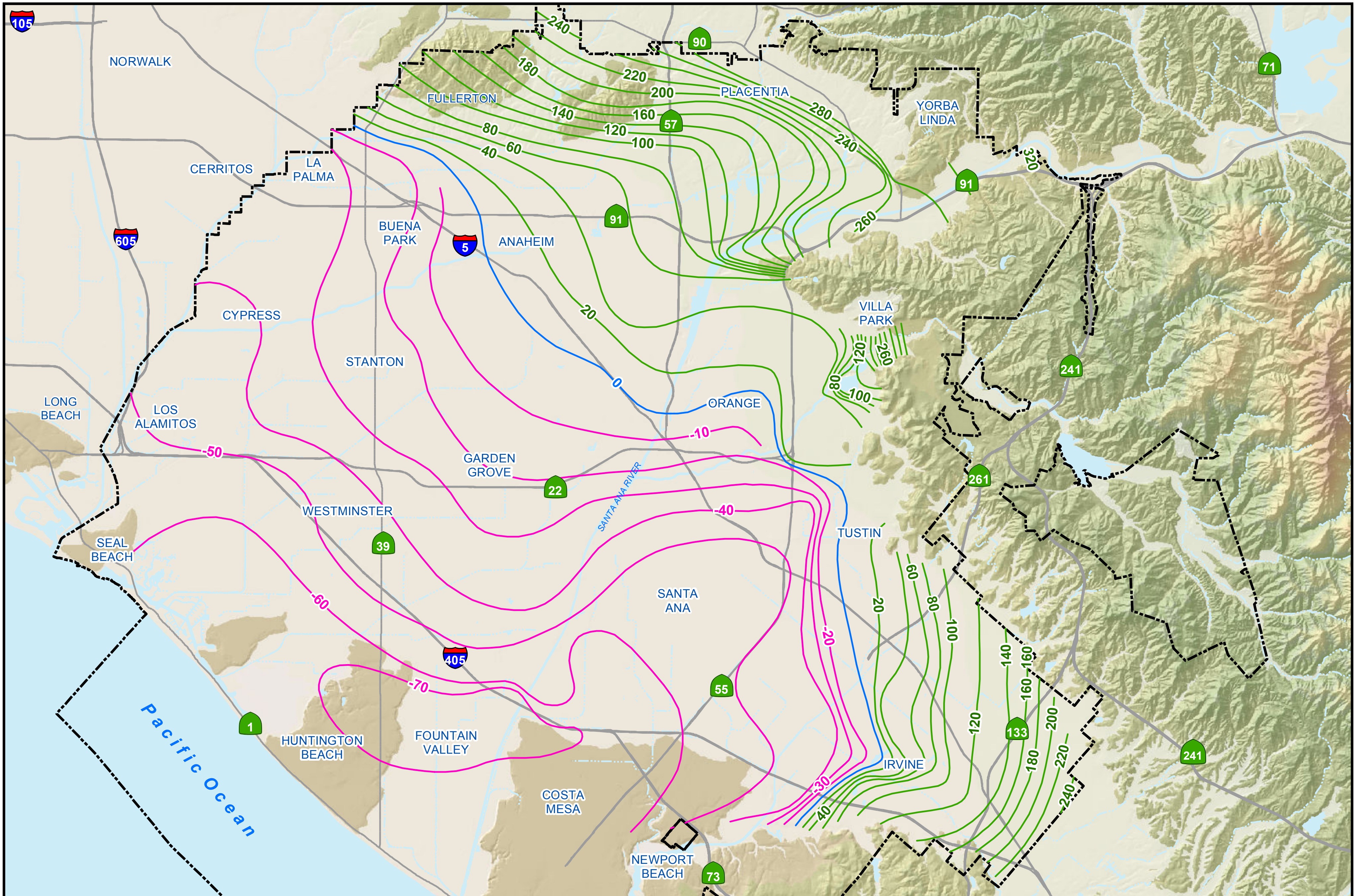
Groundwater Elevations (Feet, MSL)

- -20 to -10
- 0
- 20 to 360

JUNE 2010

Groundwater Elevation Contours for the **Shallow** Aquifer

Maps of Principal Aquifer from 2001 through 2010



Groundwater Elevations (Feet, MSL)

-70 to -10

0

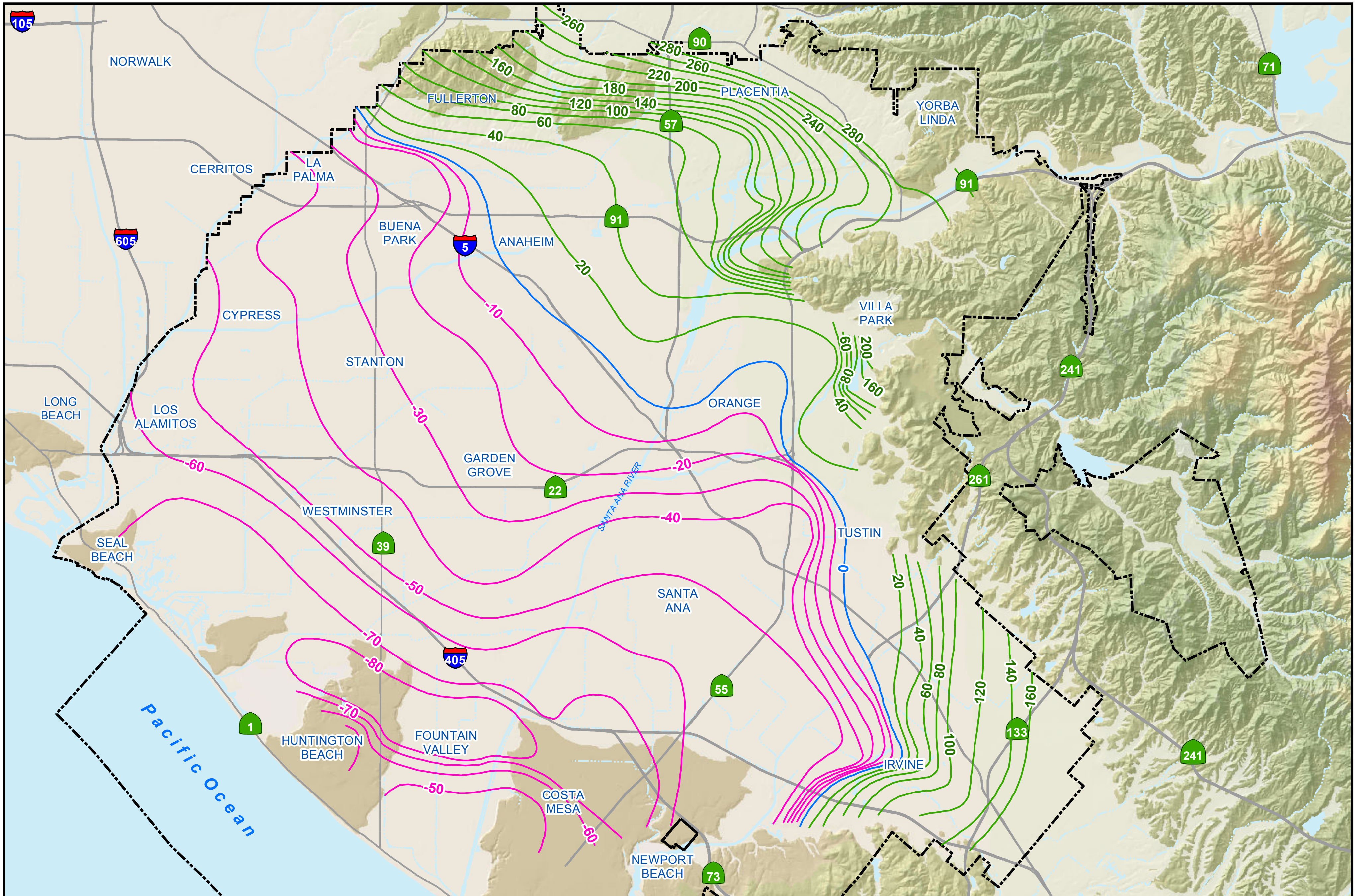
20 to 340

0 15,000 30,000 Feet

K:\GW_Contour\MXD\wl_Jun2009.mxd

NOVEMBER 2000

Groundwater Elevation Contours for the **Principal** Aquifer



NOVEMBER 2001

Groundwater Elevation Contours for the **Principal** Aquifer

Groundwater Elevations (Feet, MSL)

-80 to -10

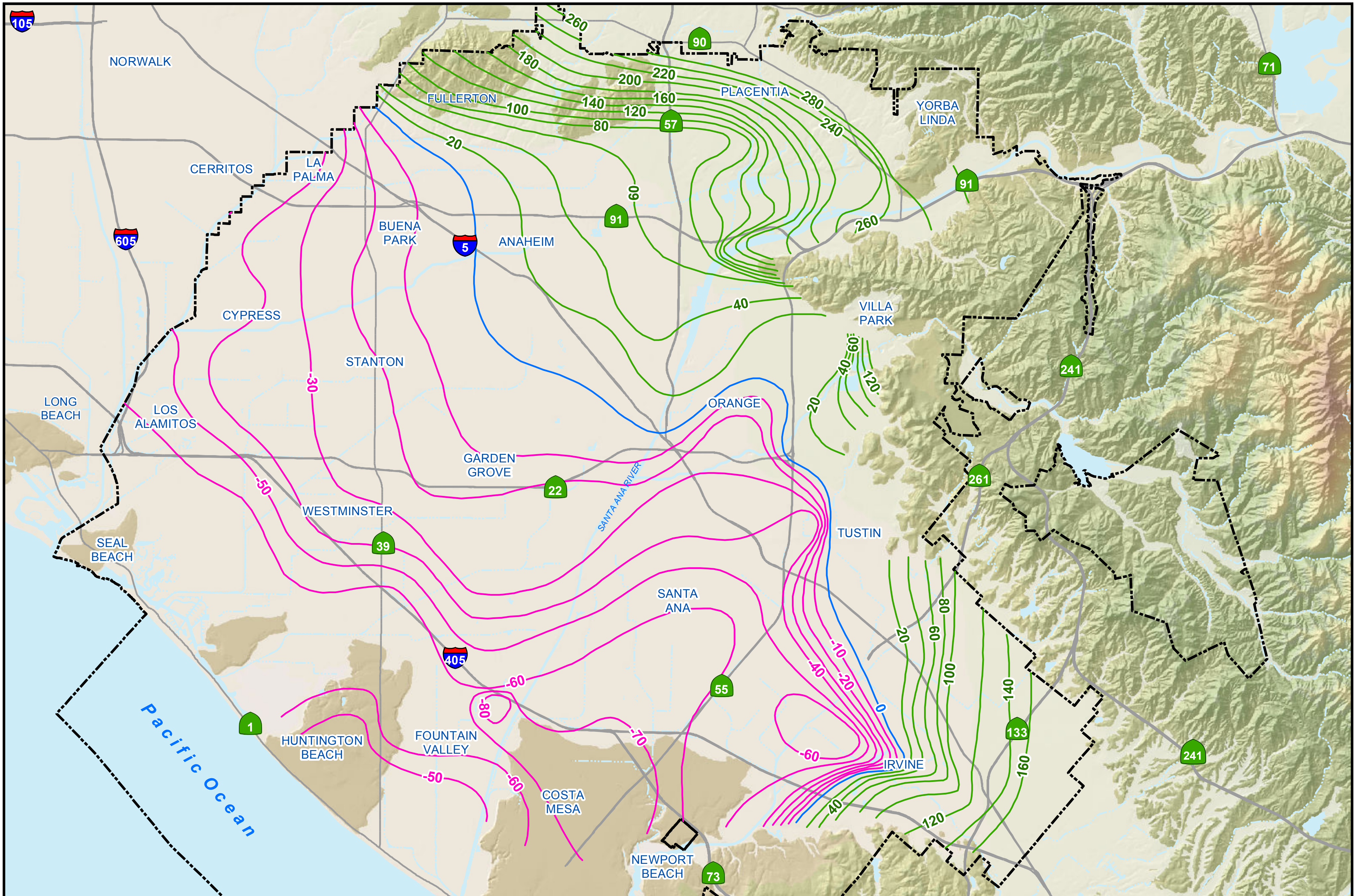
0

20 to 300

0 15,000 30,000 Feet

N S E W

K:\GW_Contour\MXD\wl_Jun2009.mxd



N
W
E
S

0 15,000 30,000 Feet

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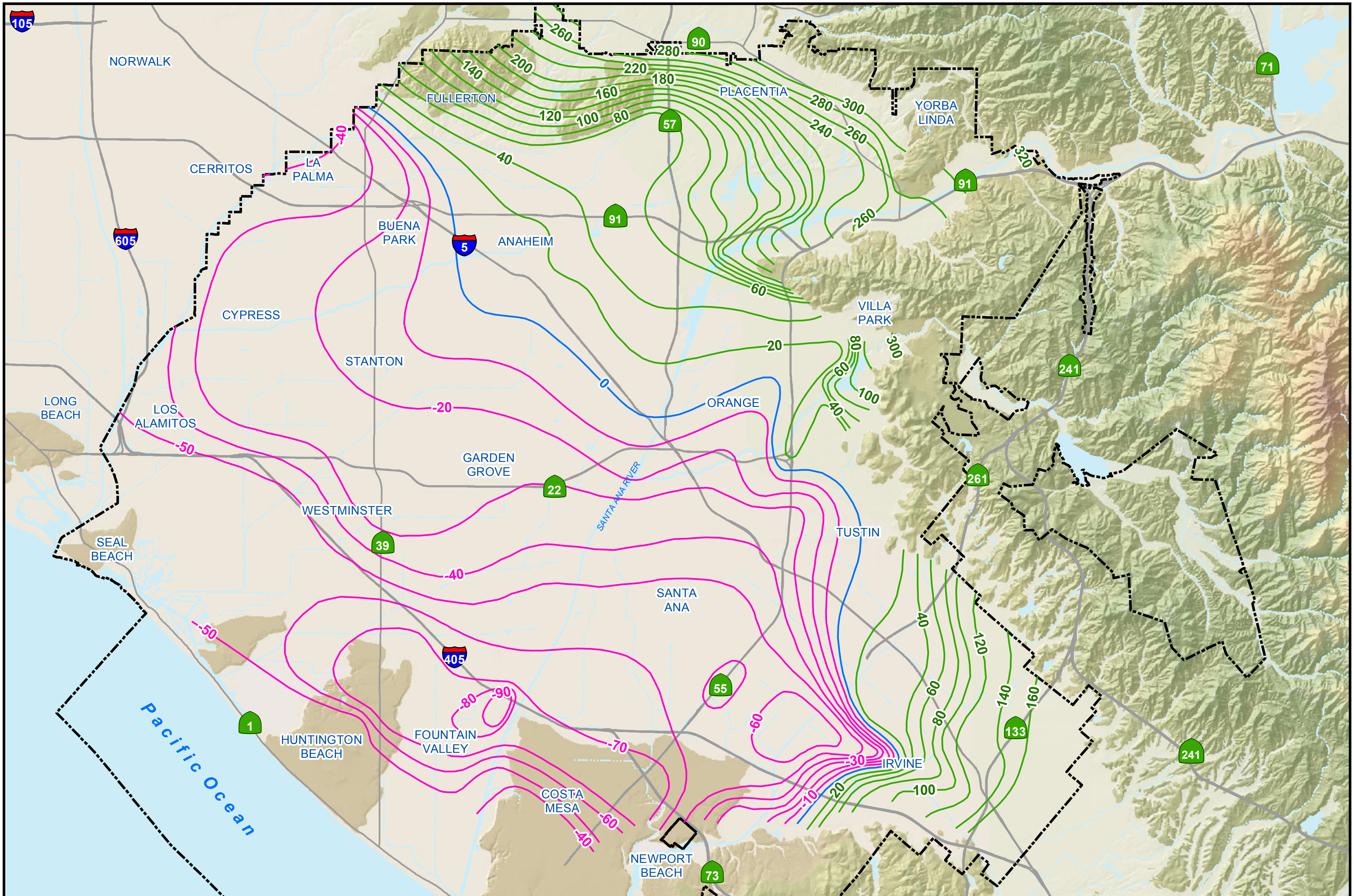
K:\GW_Contour\MXD\wl_Jun2009.mxd

Groundwater Elevations (Feet, MSL)

- -80 to -10
- 0
- 20 to 300

NOVEMBER 2002

Groundwater Elevation Contours for the **Principal** Aquifer



N
W E
S

0 15,000 30,000 Feet

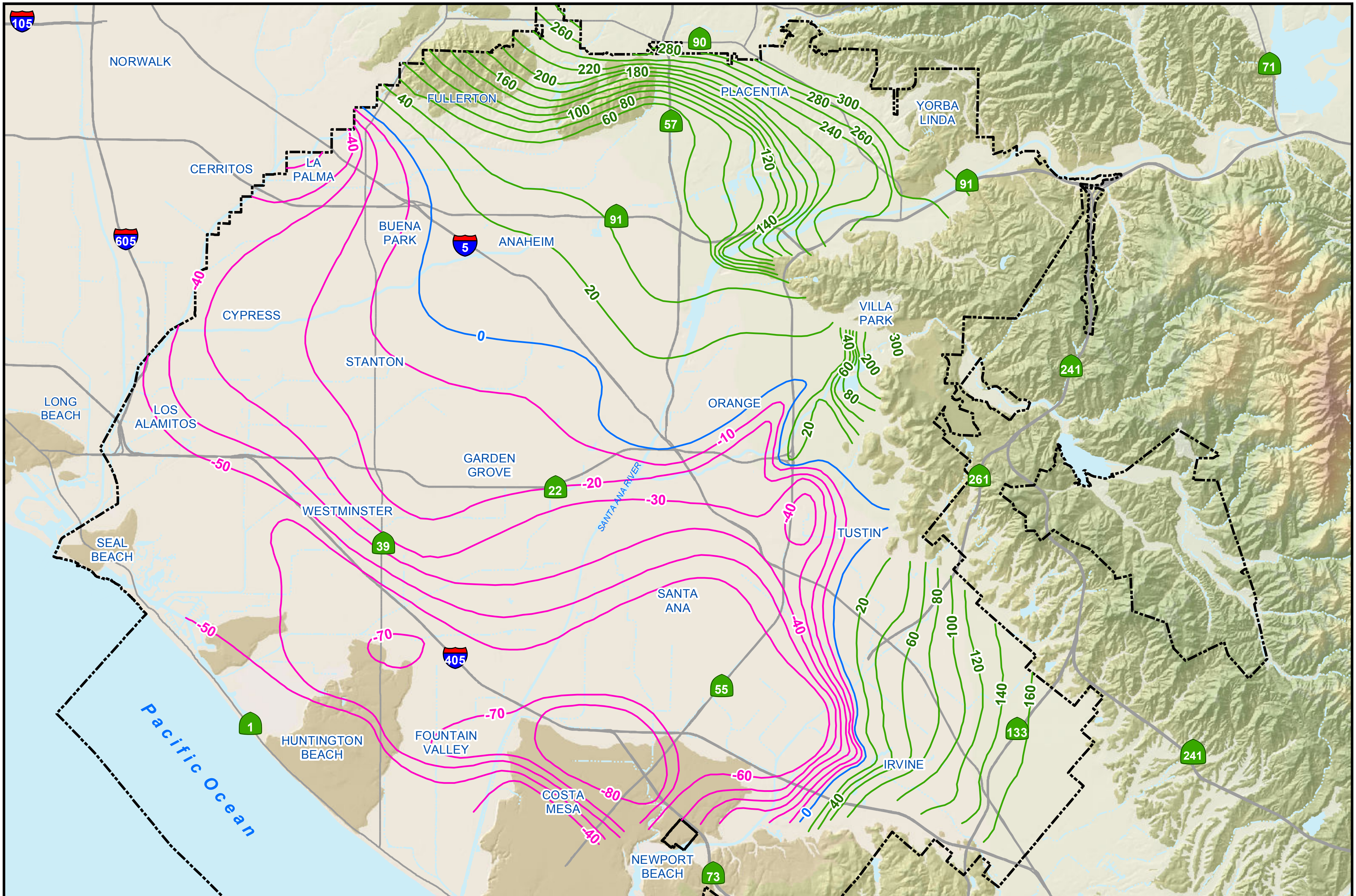
K:\GW_Contour\MXD\wl_Jun2009.mxd

Groundwater Elevations (Feet, MSL)

- -90 to -10
- 0
- 20 to 320

NOVEMBER 2003

Groundwater Elevation Contours for the **Principal** Aquifer



Groundwater Elevations (Feet, MSL)

- -80 to -10
- 0
- 20 to 300

0 15,000 30,000 Feet

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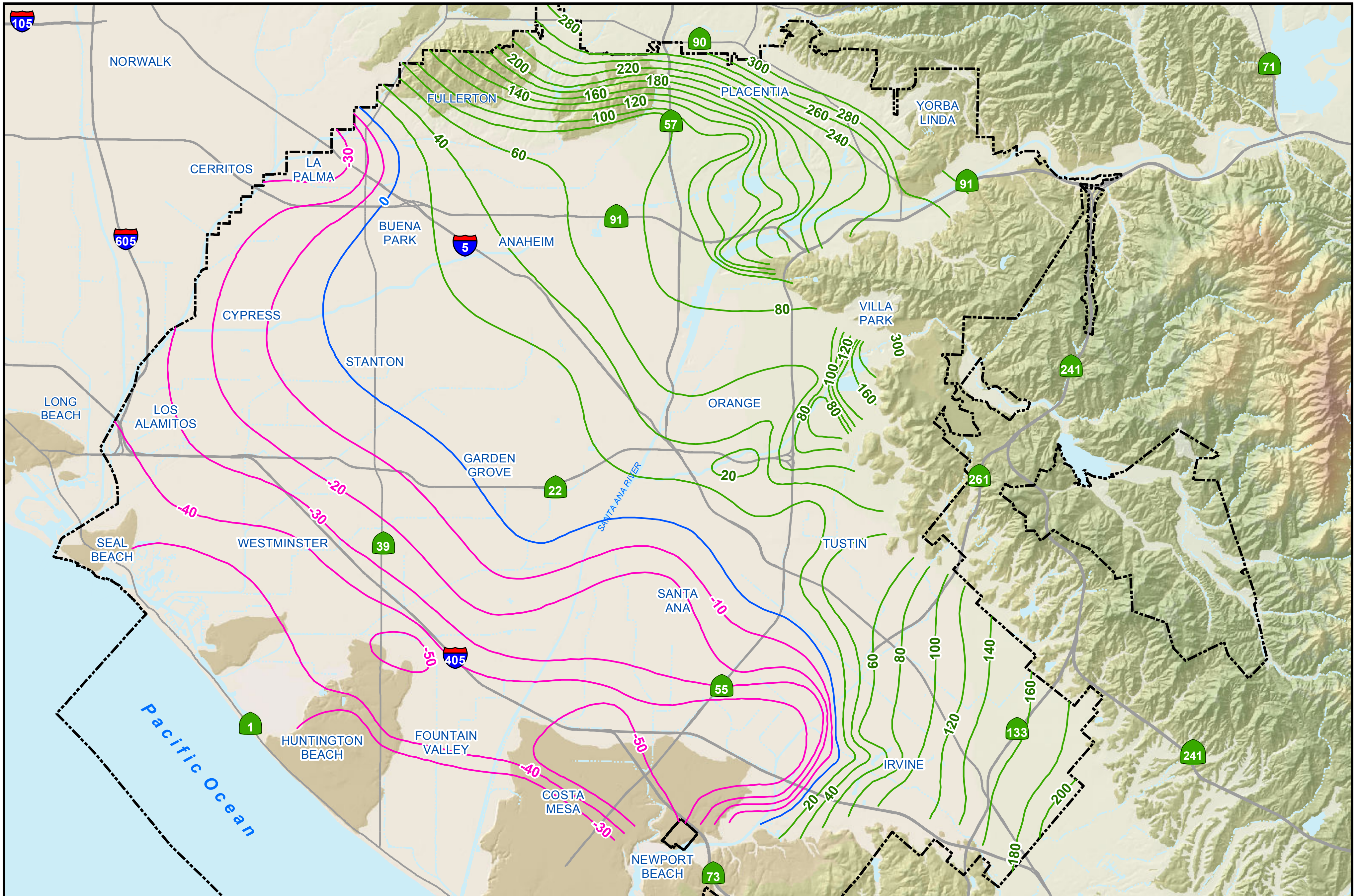
NOVEMBER 2004

Groundwater Elevation Contours for the **Principal** Aquifer



N
W E
S

0 15,000 30,000
Feet

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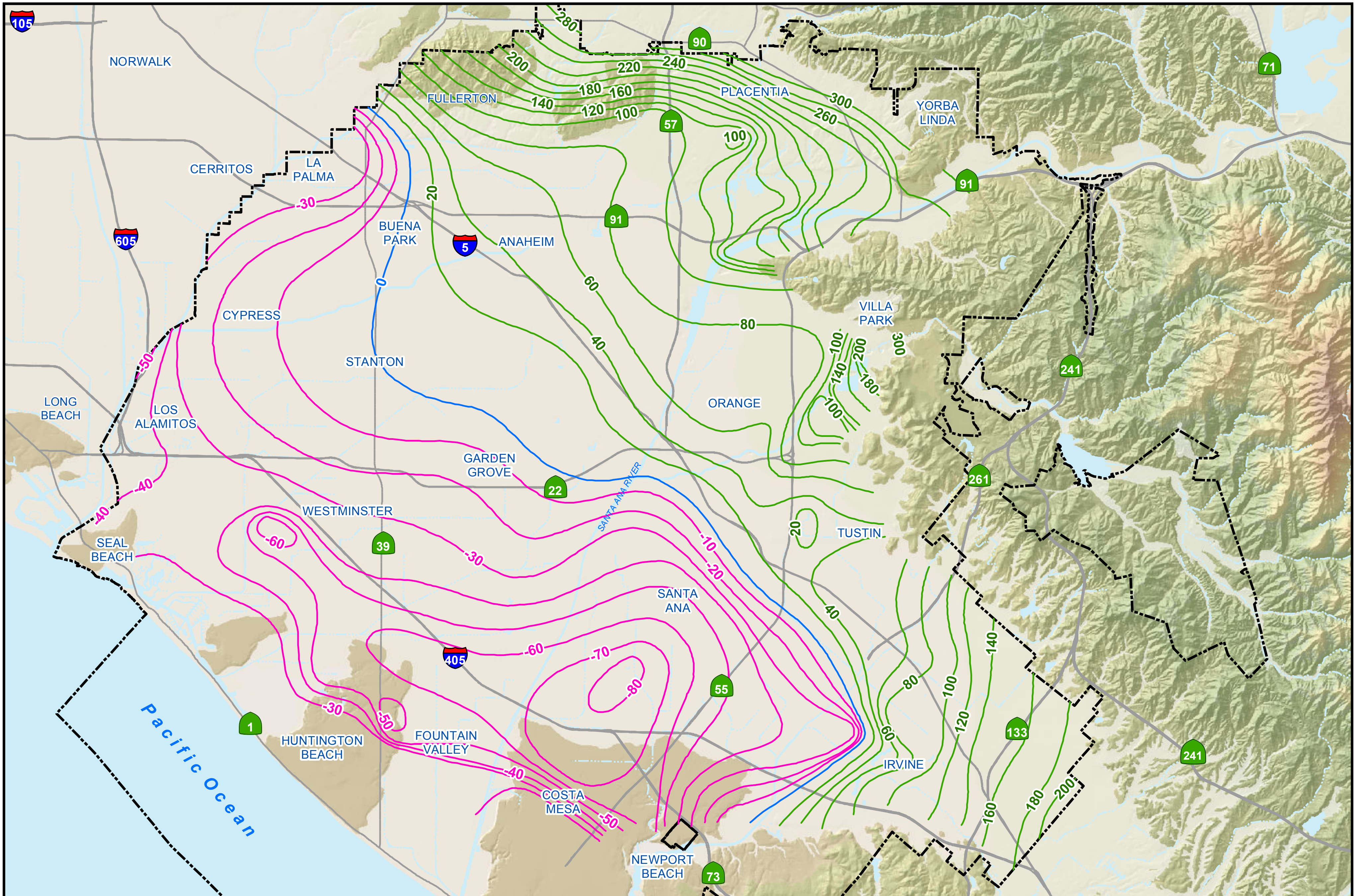
Groundwater Elevations (Feet, MSL)

- -50 to -10
- 0
- 20 to 300

NOVEMBER 2005

Groundwater Elevation Contours
for the **Principal** Aquifer

K:\GW_Contour\MXD\wl_Jun2009.mxd



N
W E
S

0 15,000 30,000 Feet

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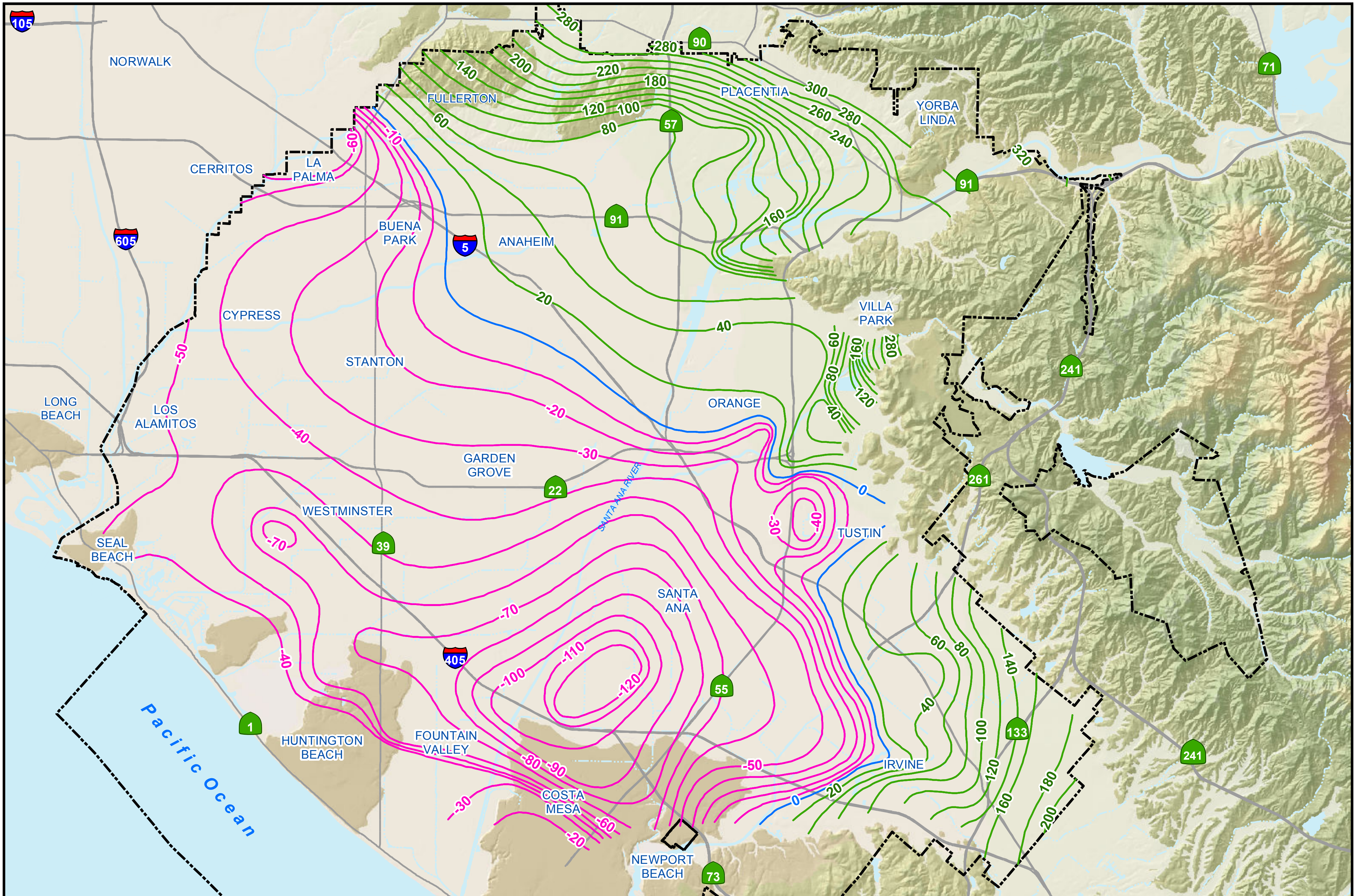
Groundwater Elevations (Feet, MSL)

- -80 to -10
- 0
- 20 to 300

JUNE 2006

Groundwater Elevation Contours for the **Principal** Aquifer

K:\GW_Contour\MXD\wl_Jun2009.mxd



N
W E
S

0 15,000 30,000
Feet

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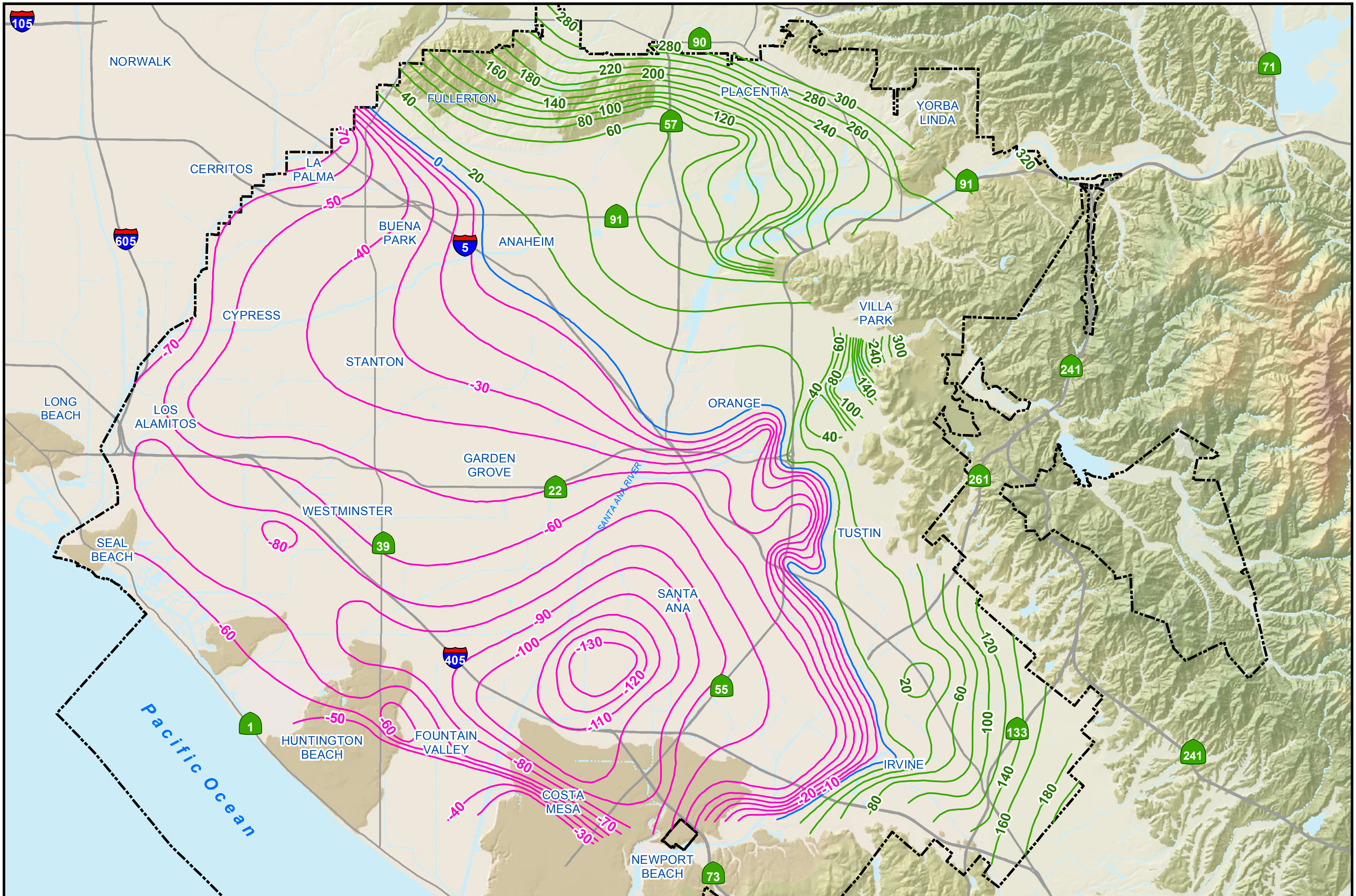
K:\GW_Contour\MXD\wl_Jun2009.mxd

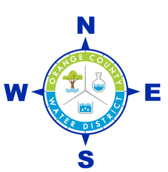
Groundwater Elevations (Feet, MSL)

- -120 to -10
- 0
- 20 to 360

JUNE 2007

Groundwater Elevation Contours for the **Principal** Aquifer





0 15,000 30,000 Feet

Groundwater Elevations (Feet, MSL)

- -130 to -10
- 0
- 20 to 360

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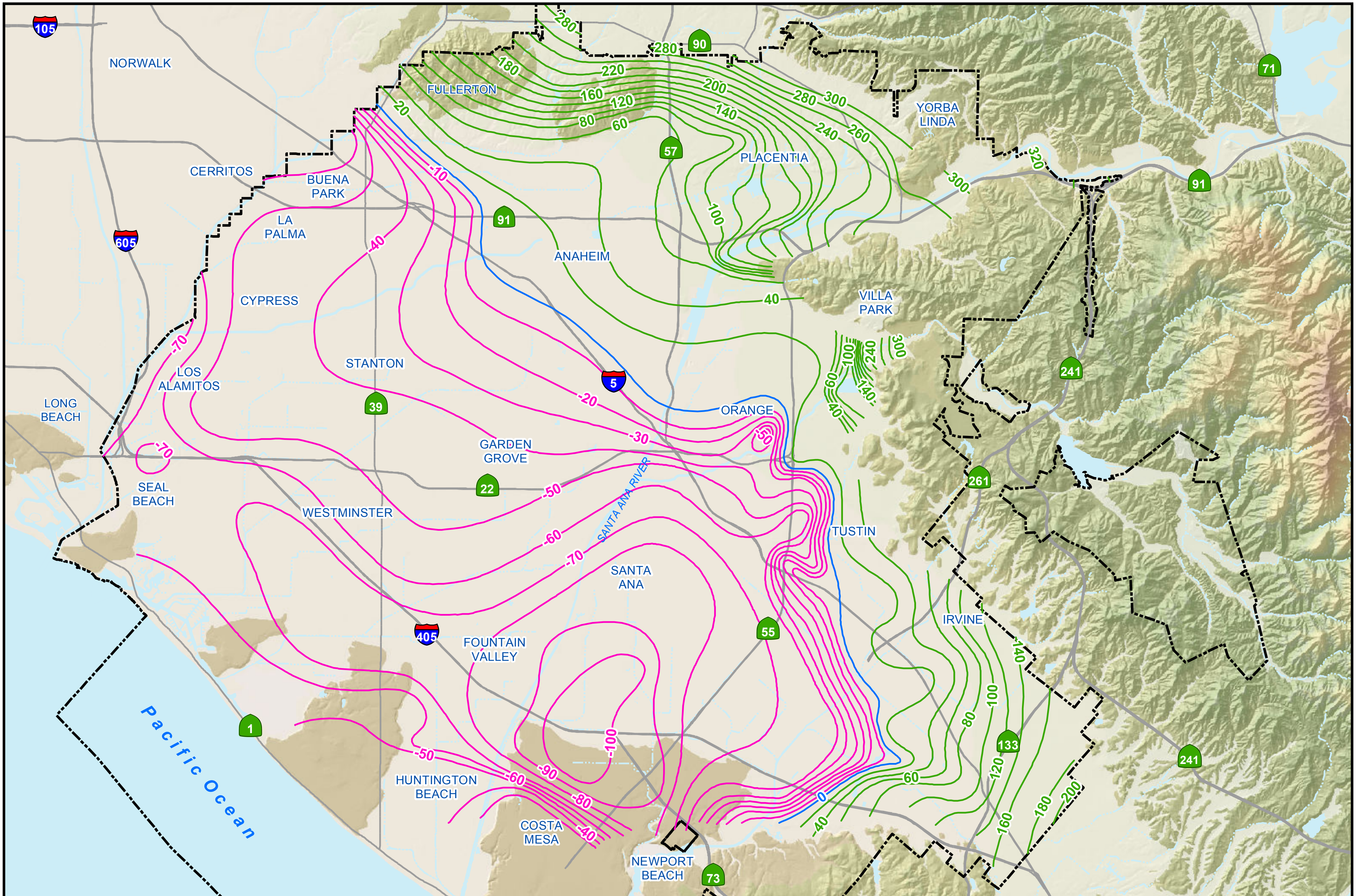
JUNE 2008

Groundwater Elevation Contours for the **Principal** Aquifer



N
W
E
S

0
15,000
30,000
Feet

Groundwater Elevations (Feet, MSL)

-100 to -10

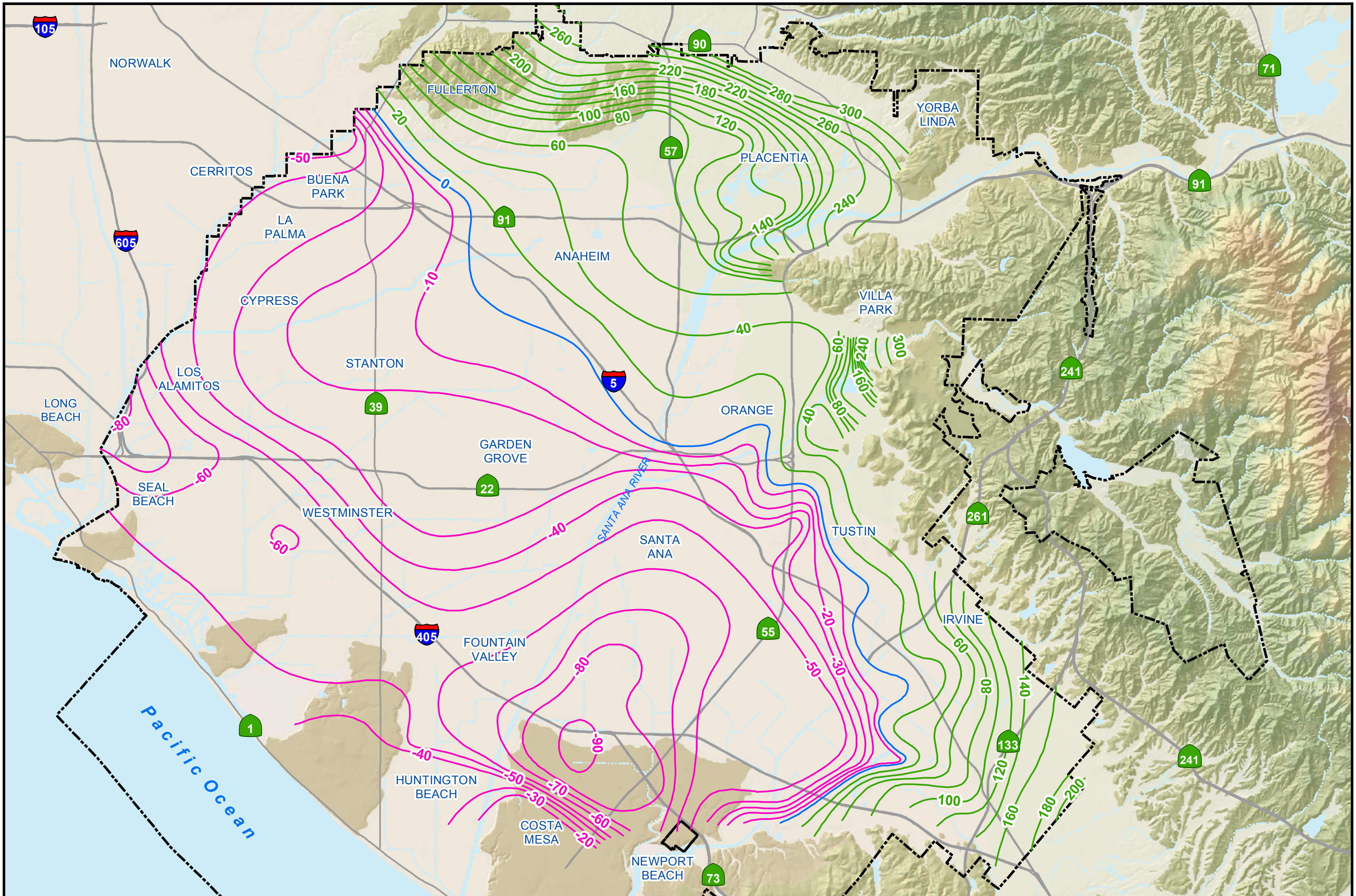
0

20 to 360

JUNE 2009

Groundwater Elevation Contours for the **Principal** Aquifer

K:\GW_Contour\MXD\June_WL.mxd



N
W
E
S

0
15,000
30,000
Feet

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K:\GW_Contour\MXD\June_WL.mxd

Groundwater Elevations (Feet, MSL)

-90 to -10

0

20 to 300

JUNE 2010

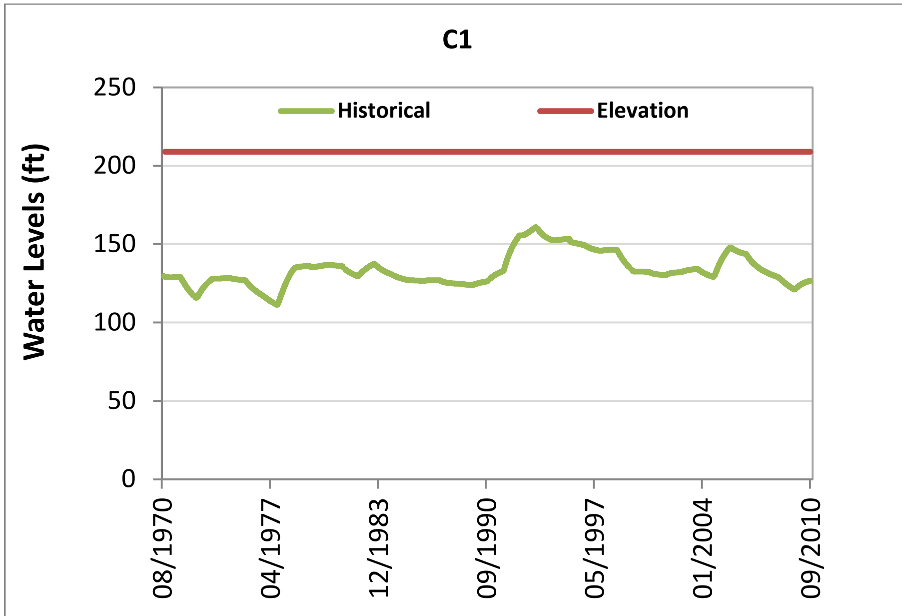
Groundwater Elevation Contours for the **Principal** Aquifer

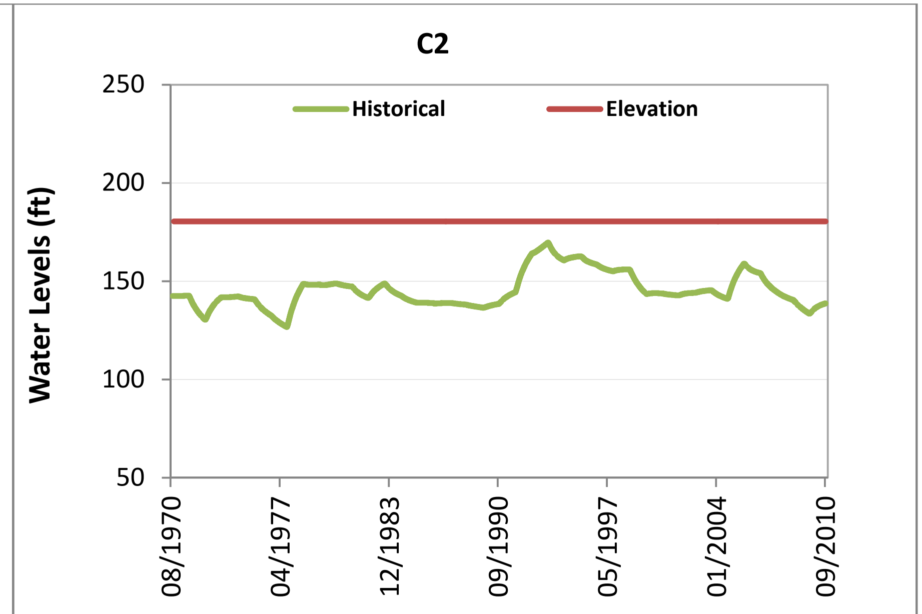
Appendix H
Groundwater Simulation Update Results - Through Water Year 2010

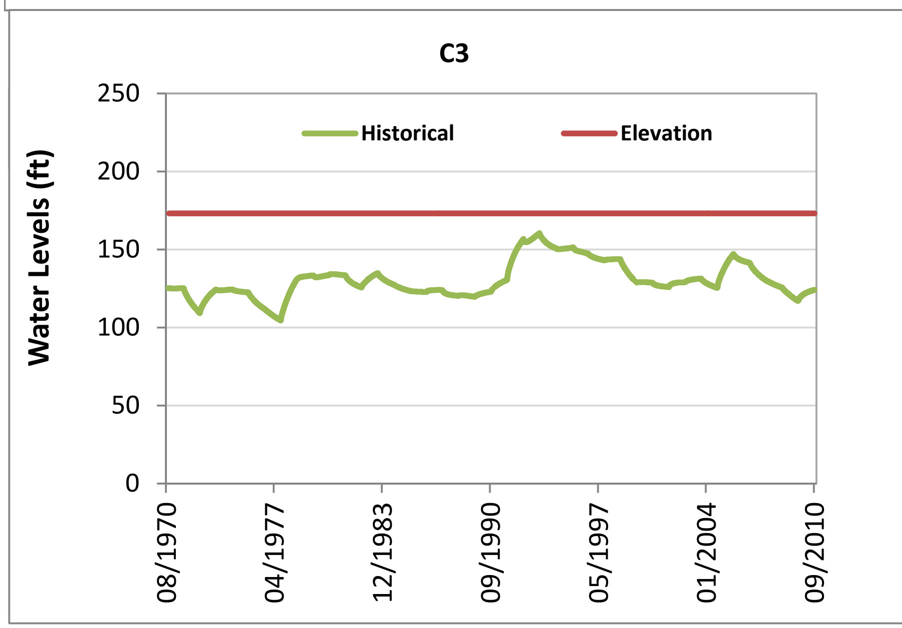
This appendix contains the model results for the historical period of water years 1971 through 2010 presented by:

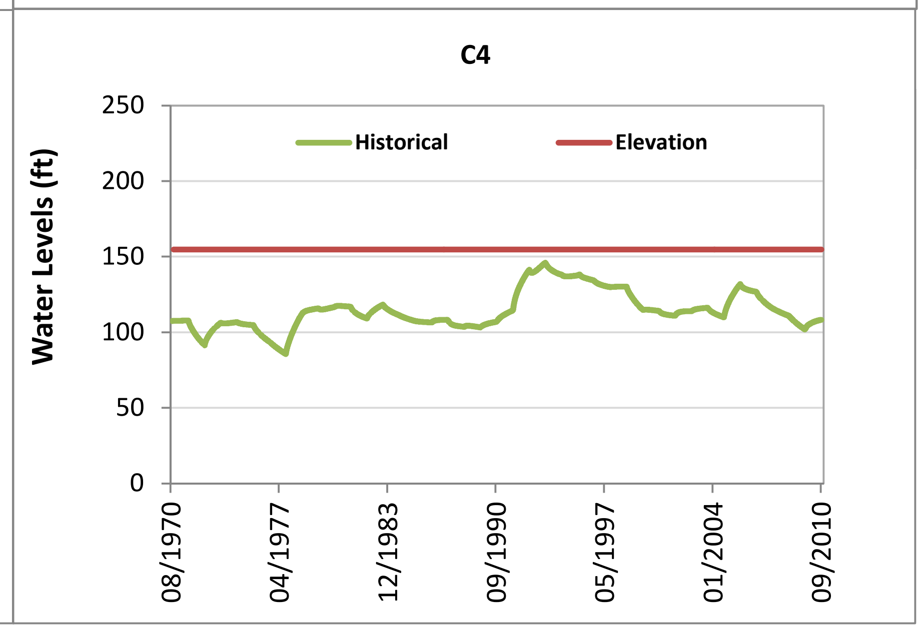
1. **Hydrographs** (showing groundwater-level fluctuations) at locations throughout the West Coast and Central Basins.
2. **Groundwater level contour maps** for two stress periods with: 1) the cumulative storage at its minimum value; and 2) the cumulative storage at its maximum value. The minimum and maximum cumulative storage were simulated at SP 2 (1972) and SP 28 (1998), respectively.

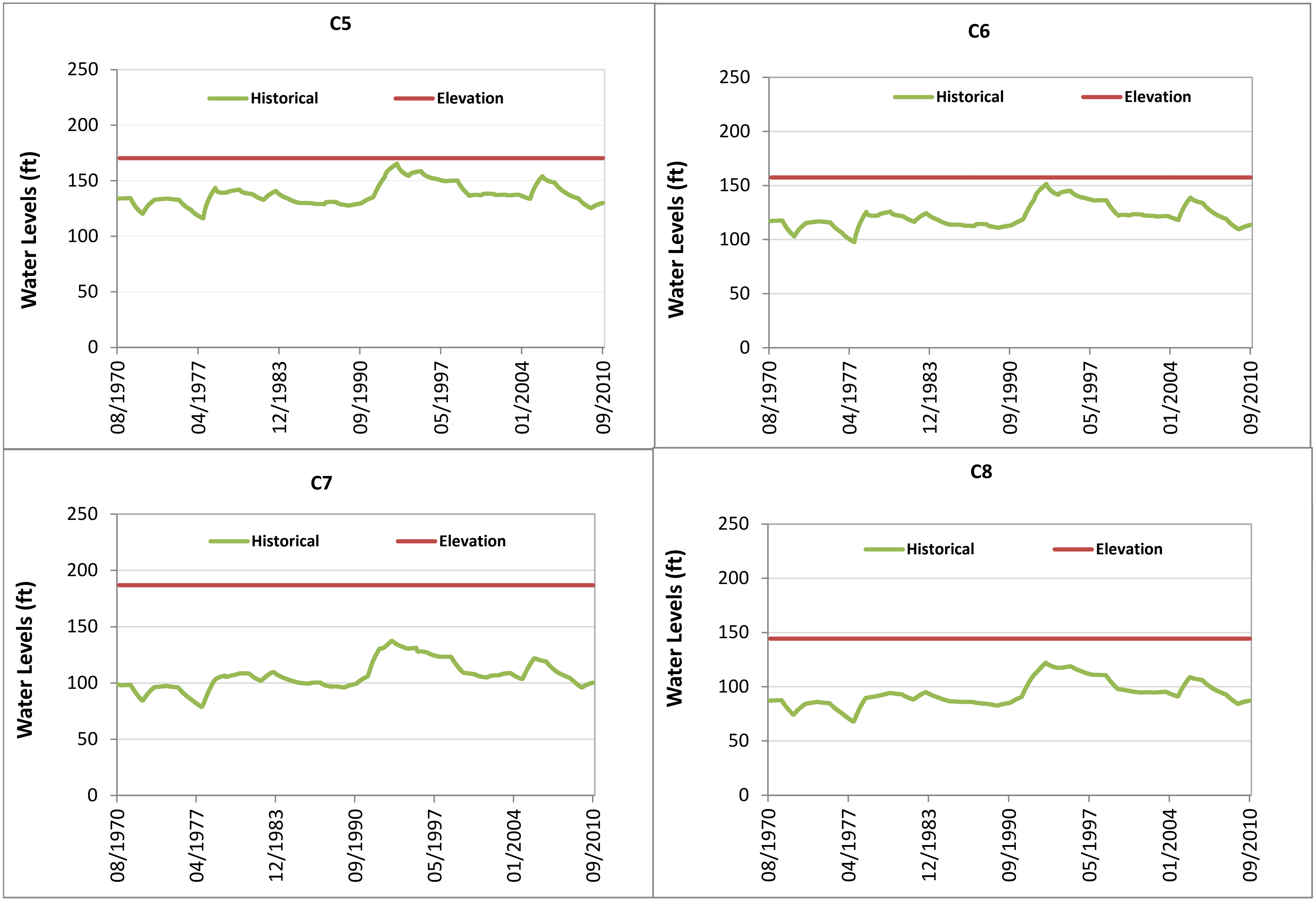
Historical Conditions Model Run Results:
1) Hydrographs
2) Groundwater Level Contour Maps

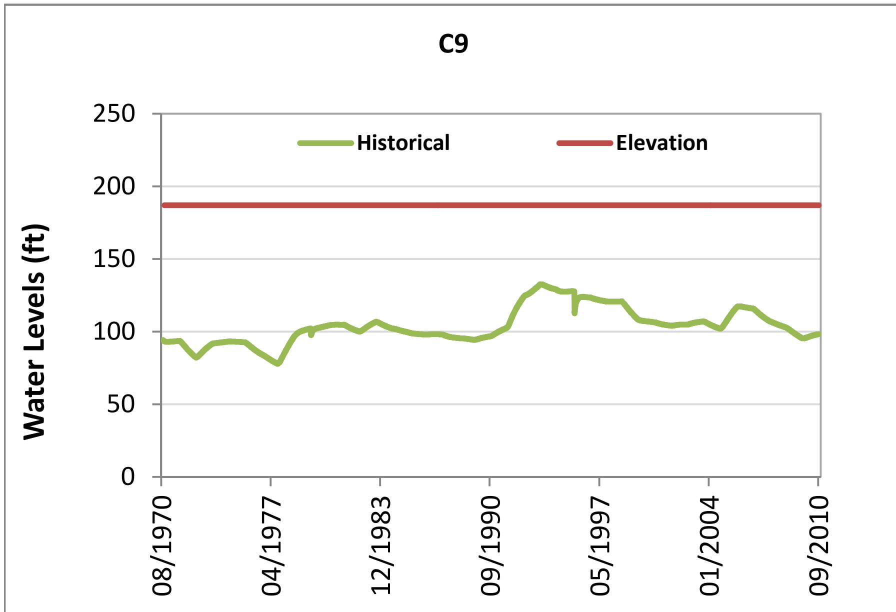

C1
Water Levels (ft)
Historical
Elevation
250
200
150
100
50
0
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

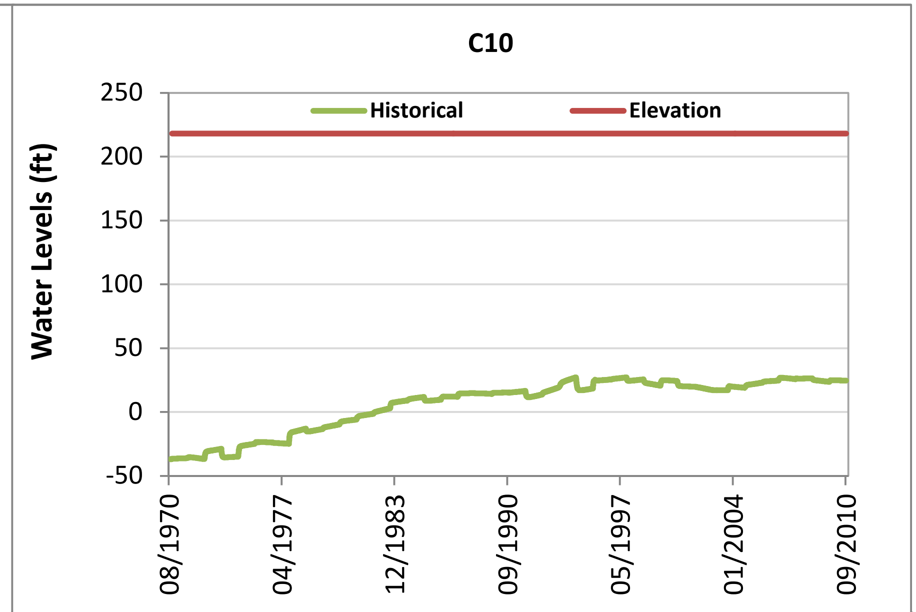

C2
Water Levels (ft)
Historical
Elevation
250
200
150
100
50
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

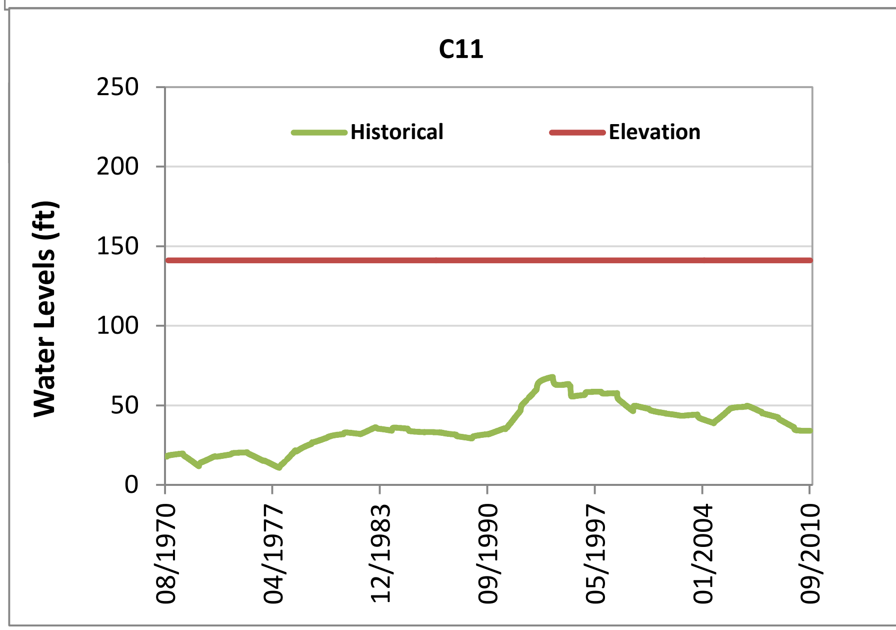

C3
Water Levels (ft)
Historical
Elevation
250
200
150
100
50
0
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

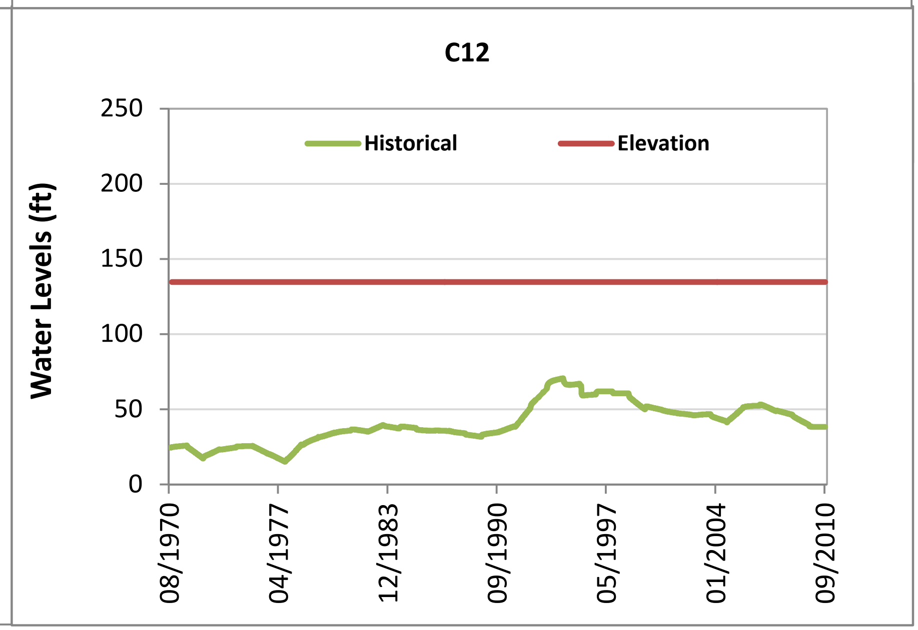

C4
Water Levels (ft)
Historical
Elevation
250
200
150
100
50
0
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

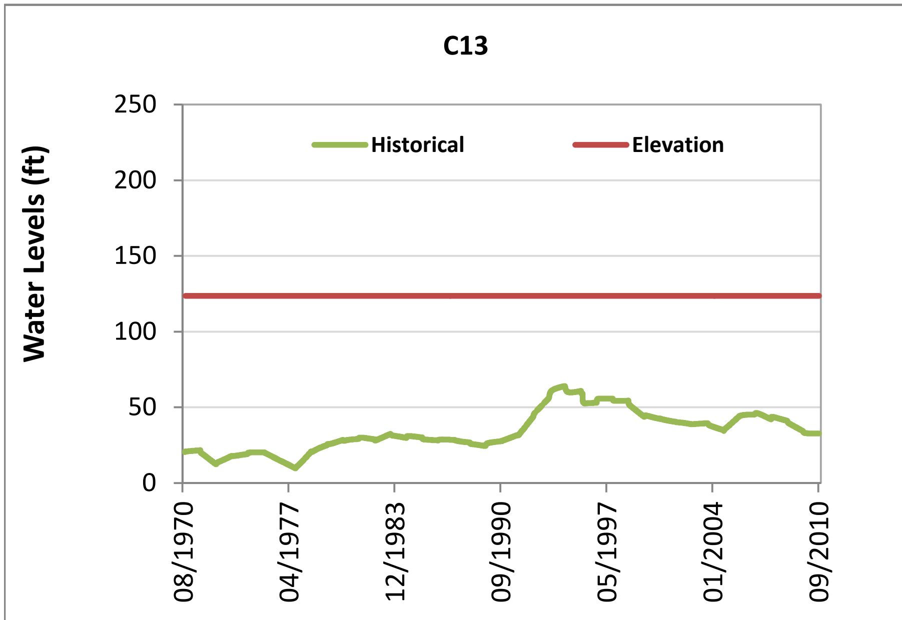

C5
Historical
Elevation
Water Levels (ft)
250
200
150
100
50
0
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010
C6
Historical
Elevation
Water Levels (ft)
C7
Historical
Elevation
Water Levels (ft)
C8
Historical
Elevation
Water Levels (ft)

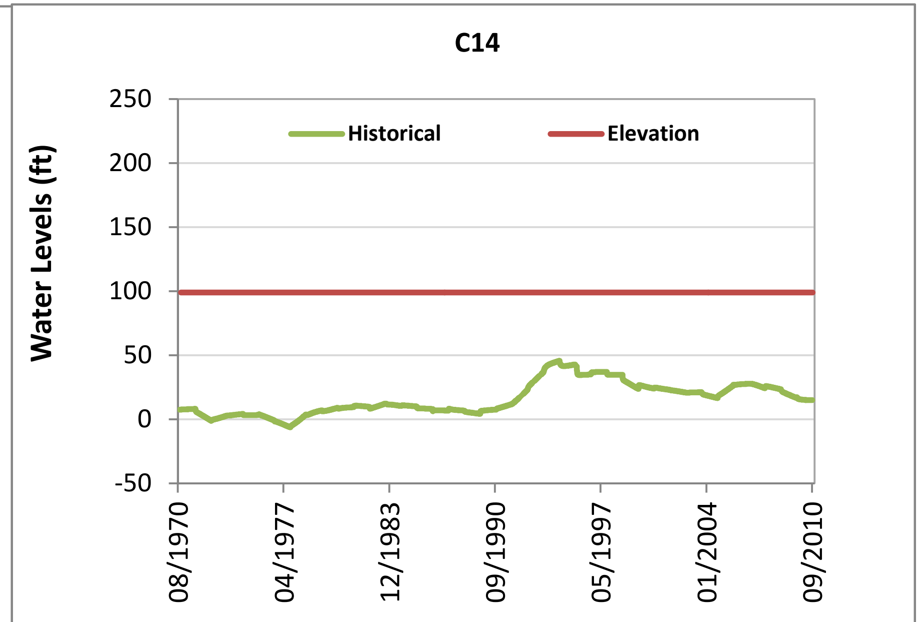

C9
Historical
Elevation
Water Levels (ft)
250
200
150
100
50
0
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

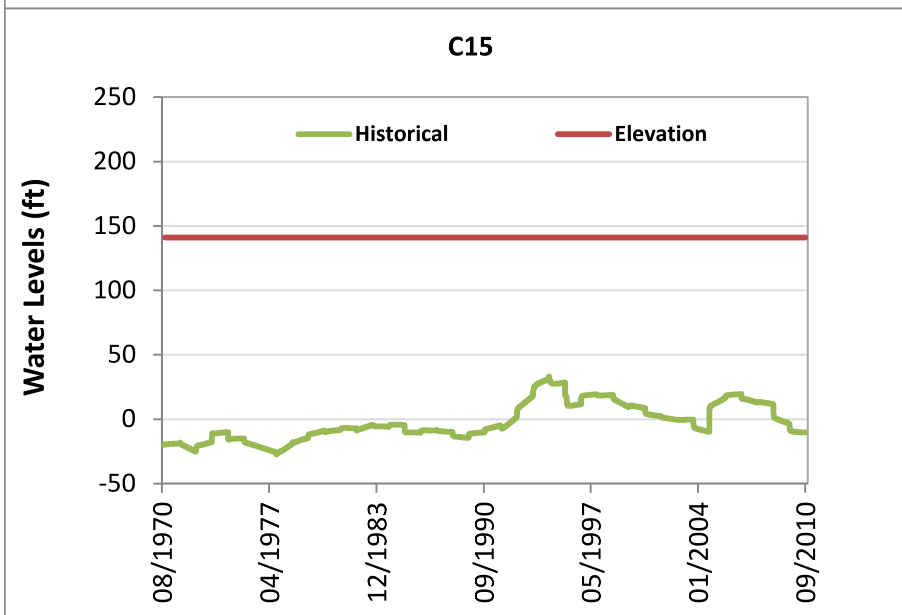

C10
Historical
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

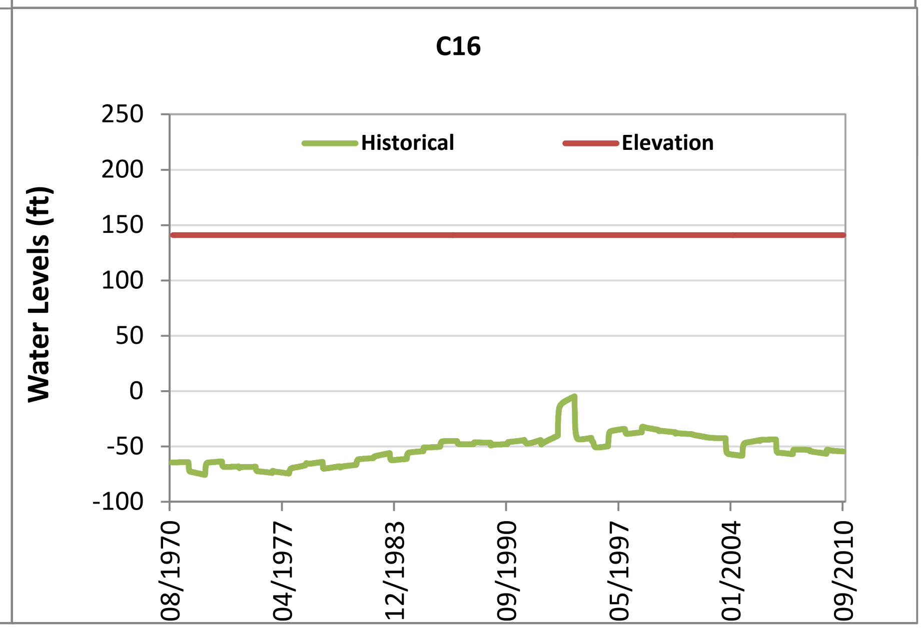

C11
Historical
Elevation
Water Levels (ft)
250
200
150
100
50
0
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

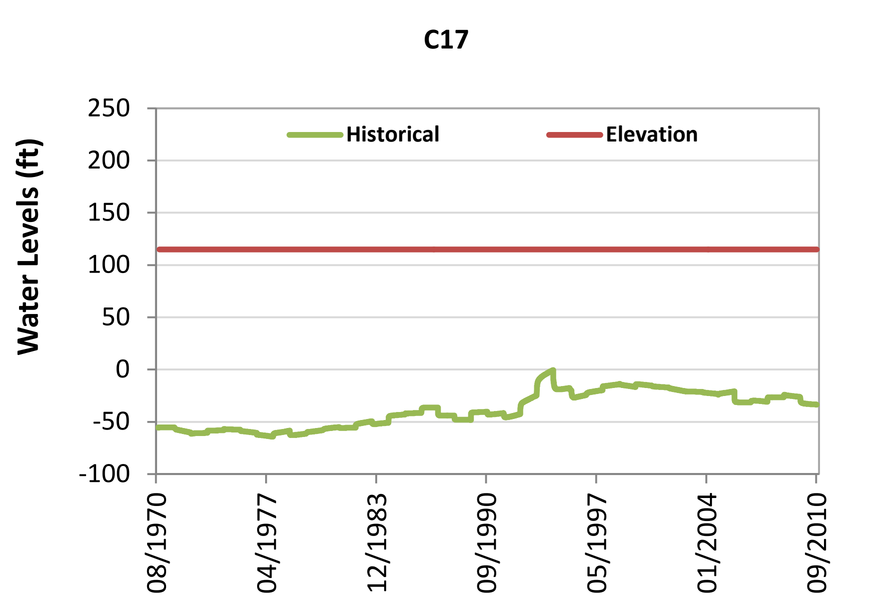

C12
Historical
Elevation
Water Levels (ft)
250
200
150
100
50
0
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

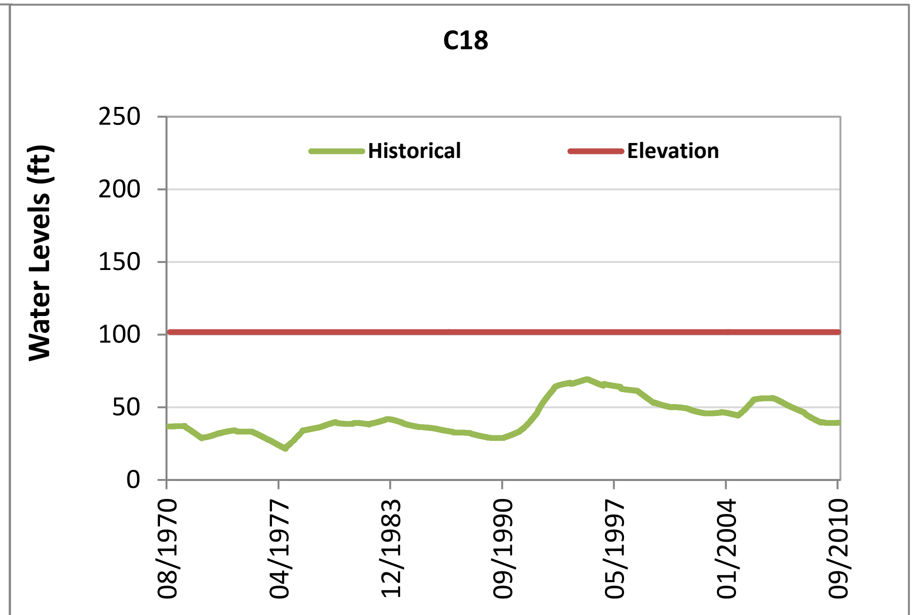

C13
Water Levels (ft)
250
200
150
100
50
0
Historical
Elevation
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

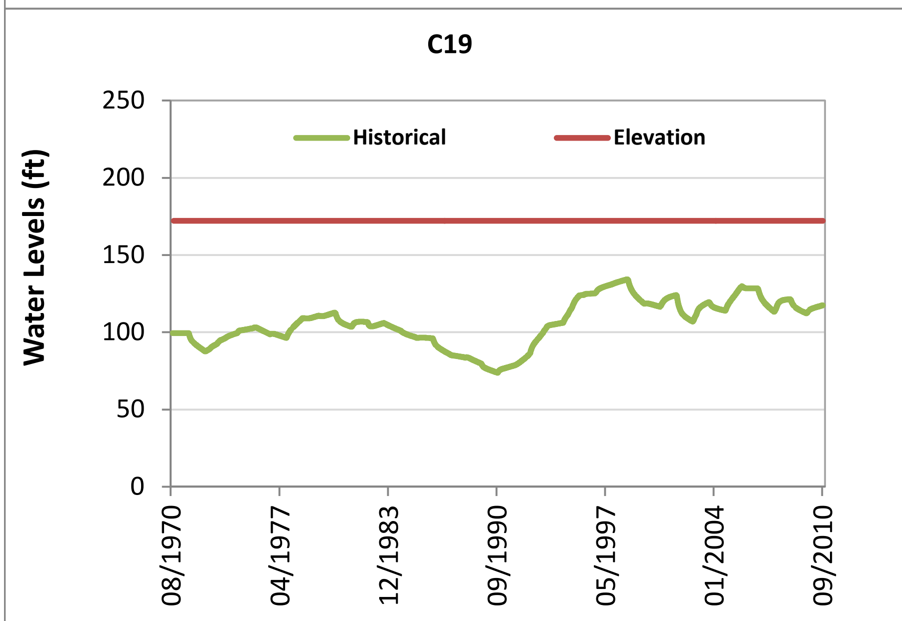

C14
Water Levels (ft)
250
200
150
100
50
0
-50
Historical
Elevation
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

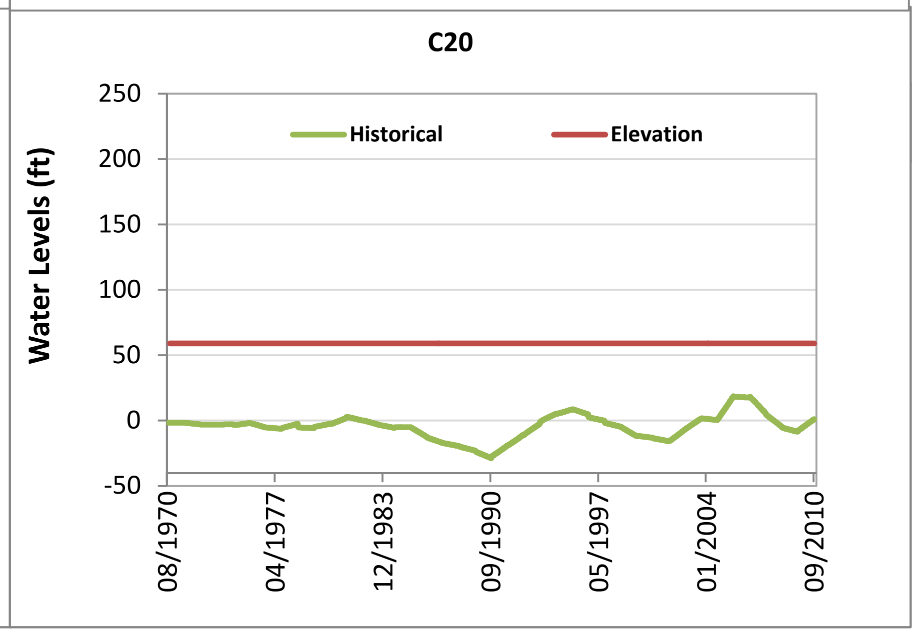

C15
Water Levels (ft)
250
200
150
100
50
0
-50
Historical
Elevation
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

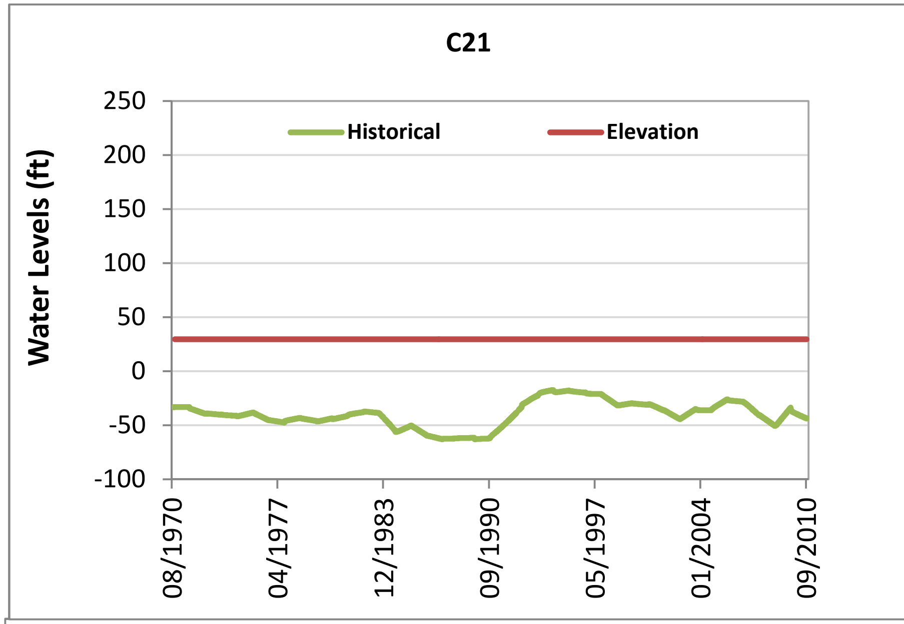

C16
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Elevation
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

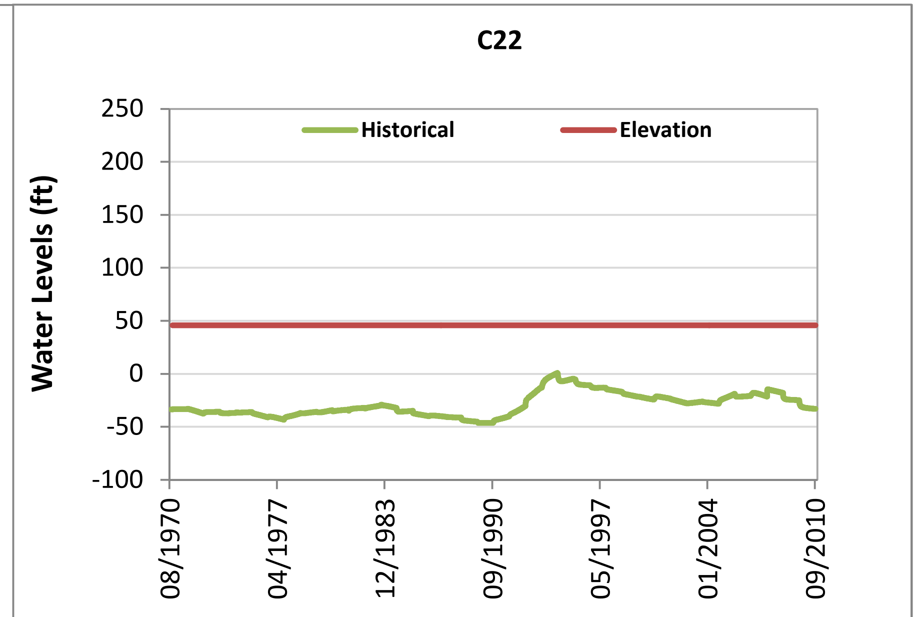

C17
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Elevation
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

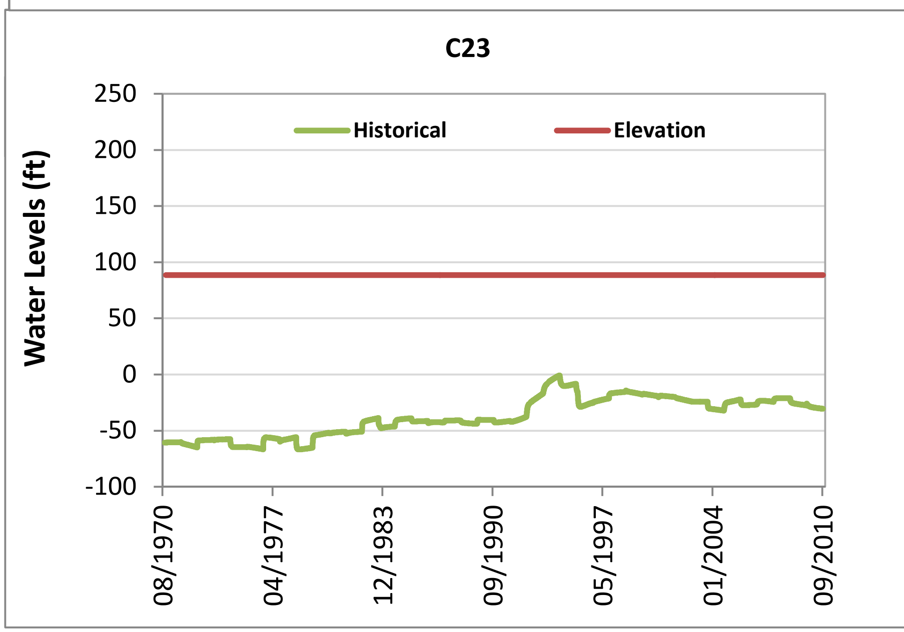

C18
Water Levels (ft)
250
200
150
100
50
0
Historical
Elevation
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

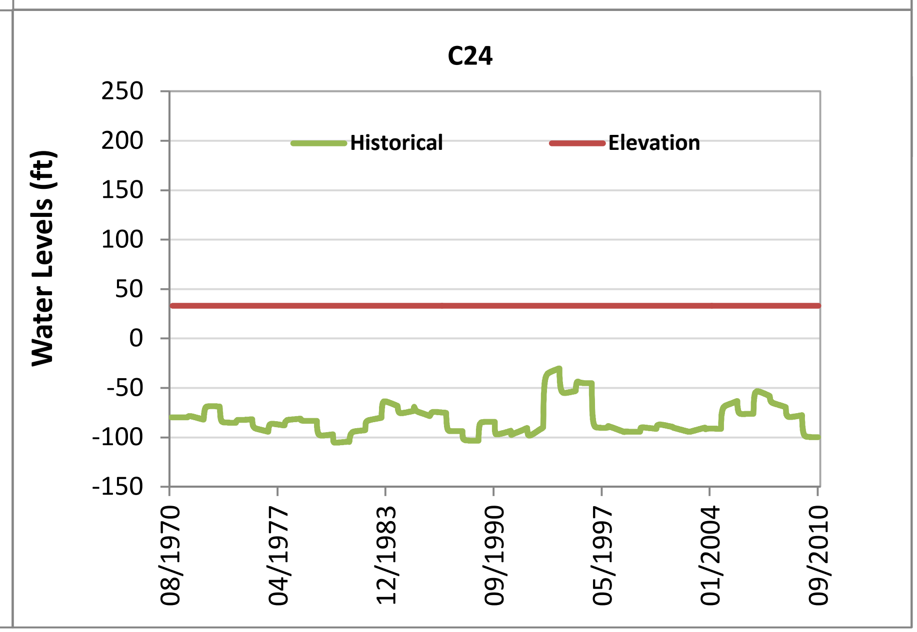

C19
Water Levels (ft)
250
200
150
100
50
0
Historical
Elevation
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

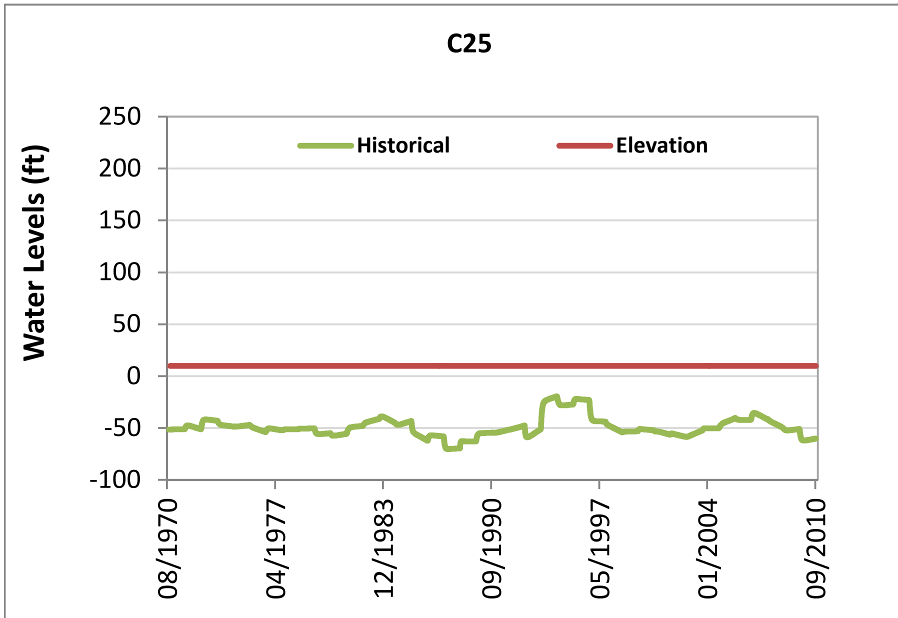

C20
Water Levels (ft)
250
200
150
100
50
0
-50
Historical
Elevation
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

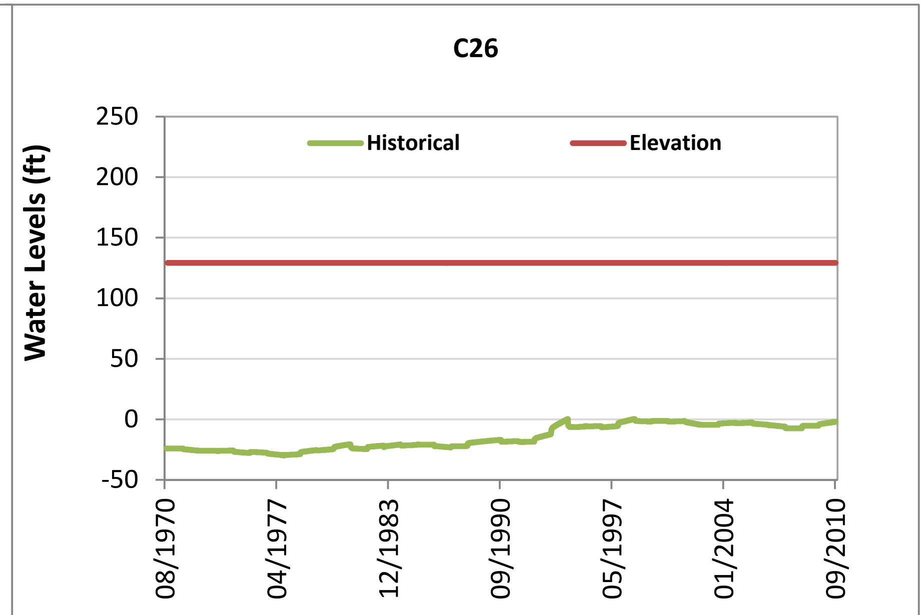

C21
Historical
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

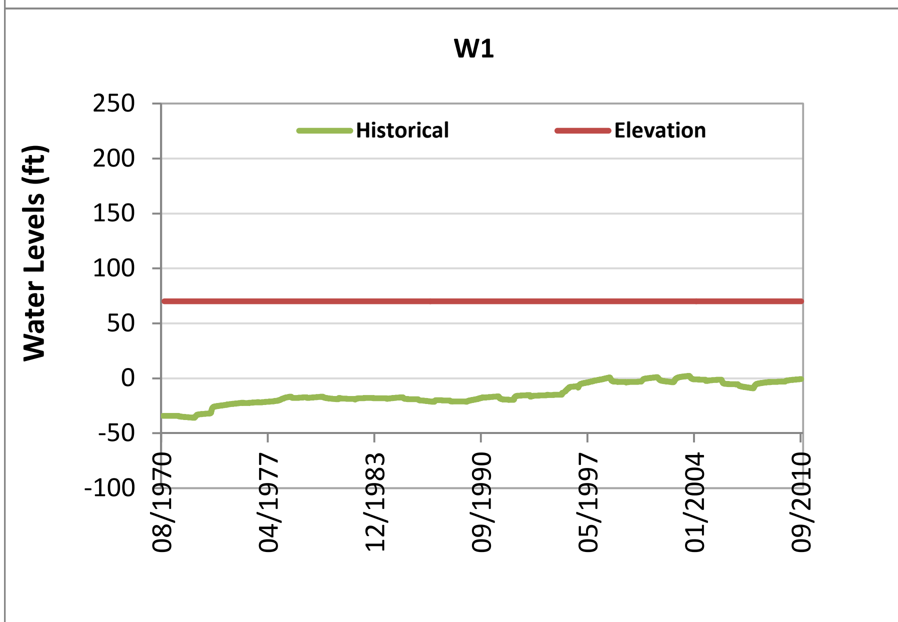

C22
Historical
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

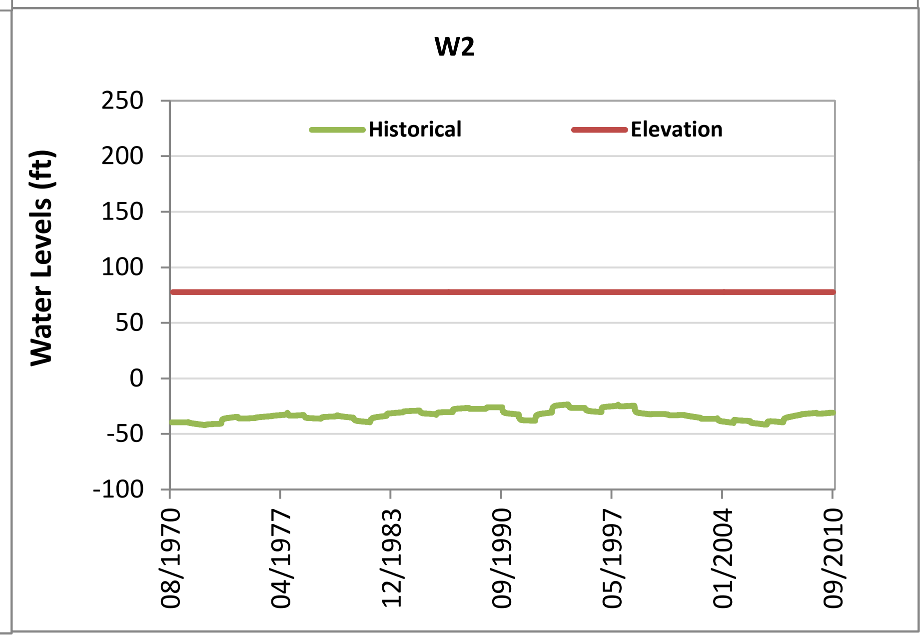

C23
Historical
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

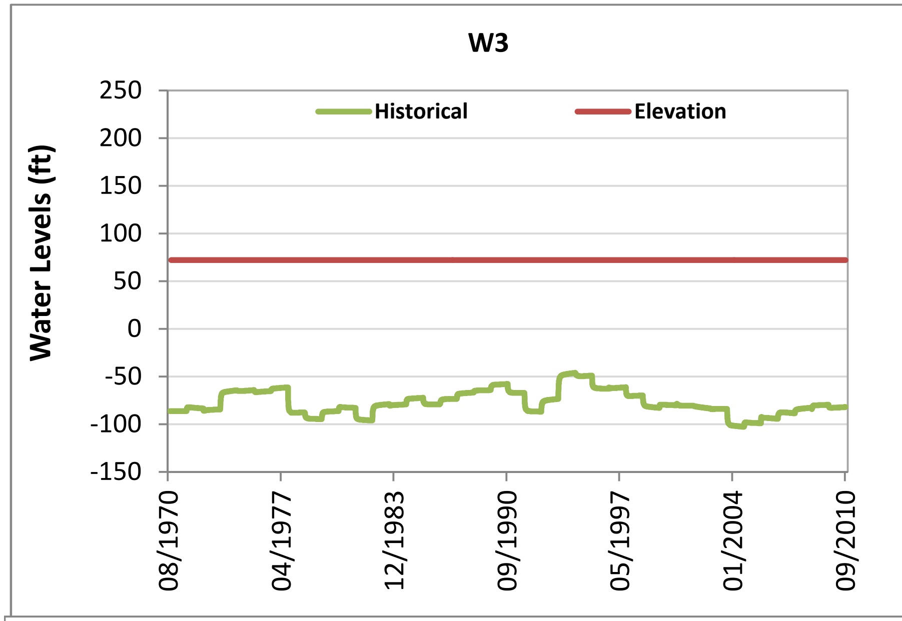

C24
Historical
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

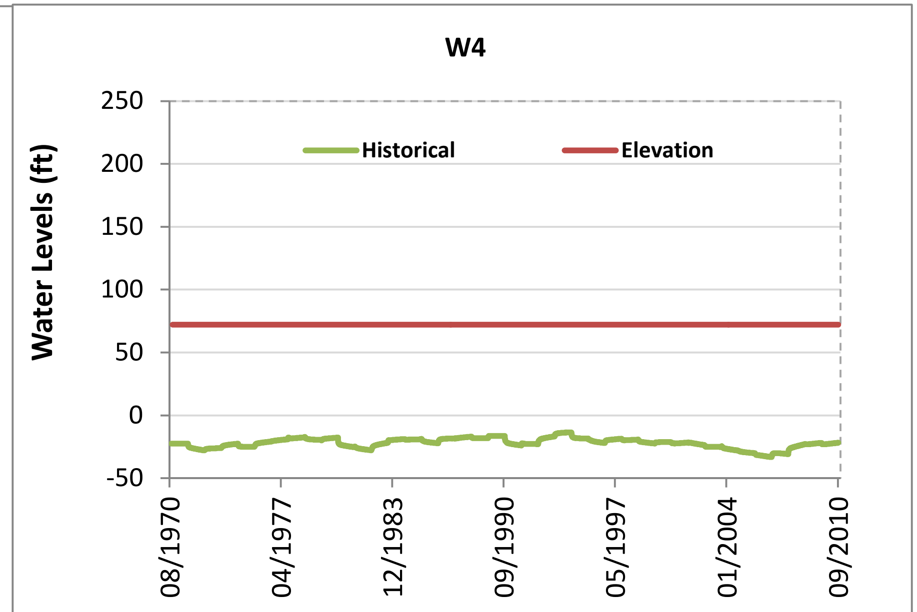

C25
Water Levels (ft)
Historical
Elevation
250
200
150
100
50
0
-50
-100
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

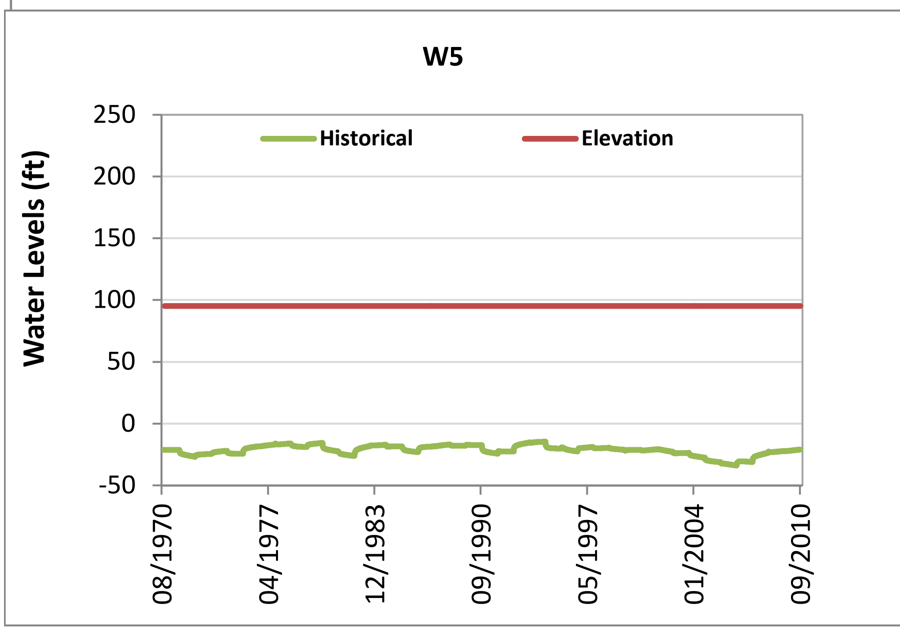

C26
Water Levels (ft)
Historical
Elevation
250
200
150
100
50
0
-50
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

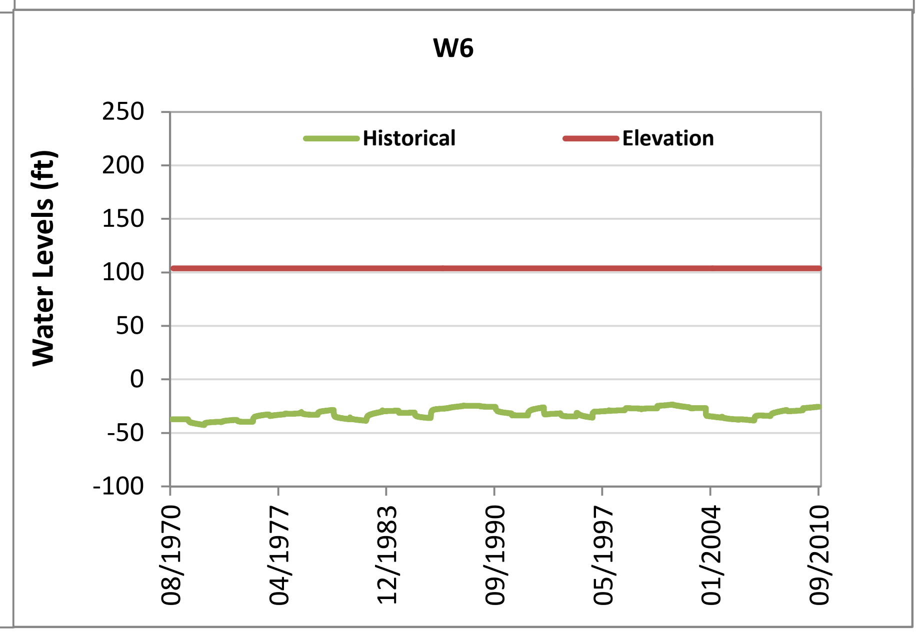

W1
Water Levels (ft)
Historical
Elevation
250
200
150
100
50
0
-50
-100
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

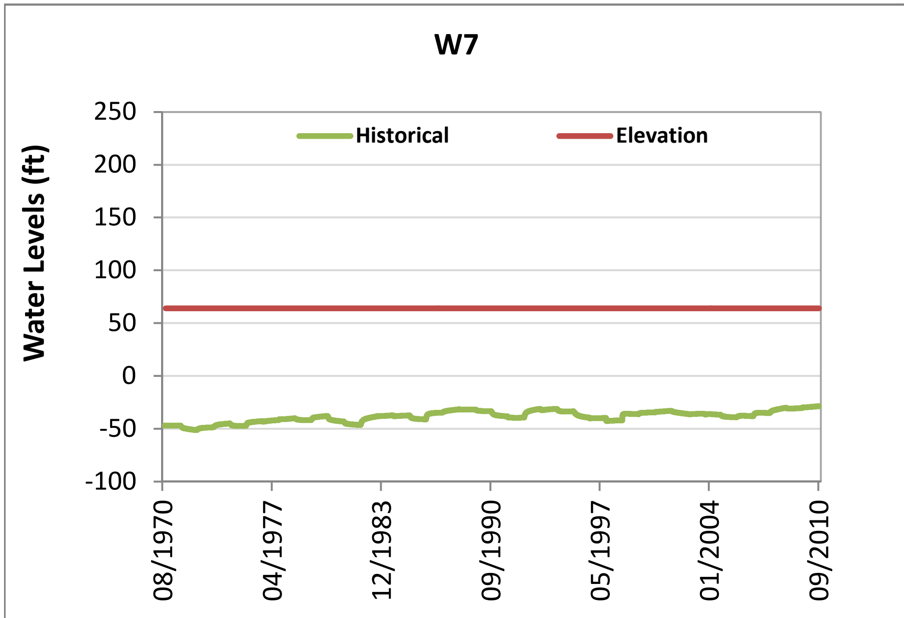

W2
Water Levels (ft)
Historical
Elevation
250
200
150
100
50
0
-50
-100
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

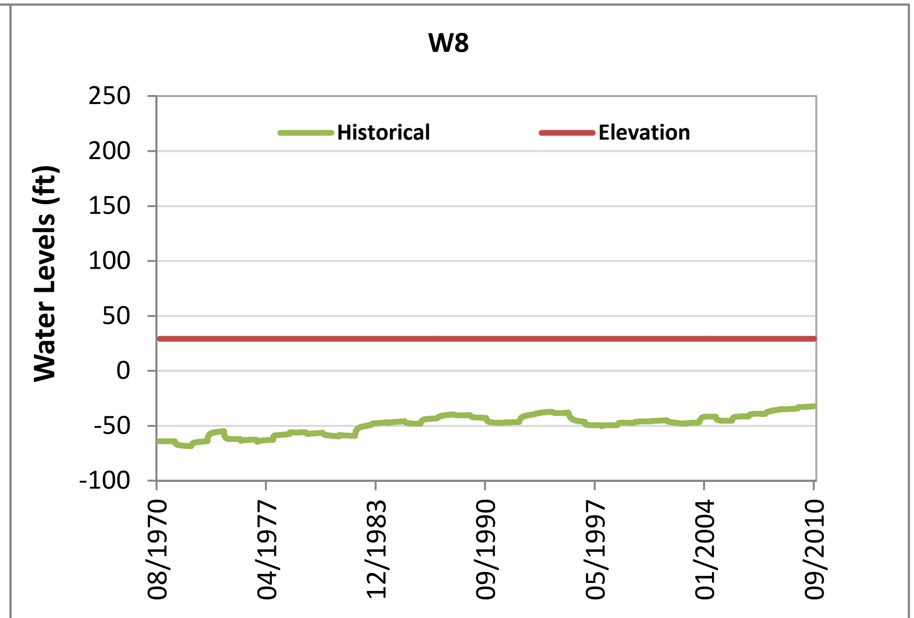

W3
Water Levels (ft)
Historical
Elevation
250
200
150
100
50
0
-50
-100
-150
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

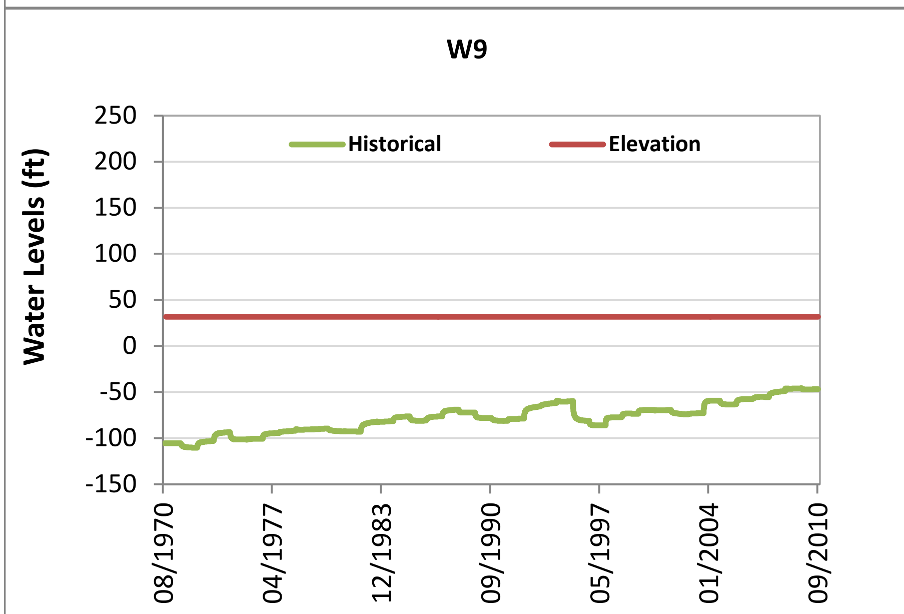

W4
Water Levels (ft)
Historical
Elevation
250
200
150
100
50
0
-50
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

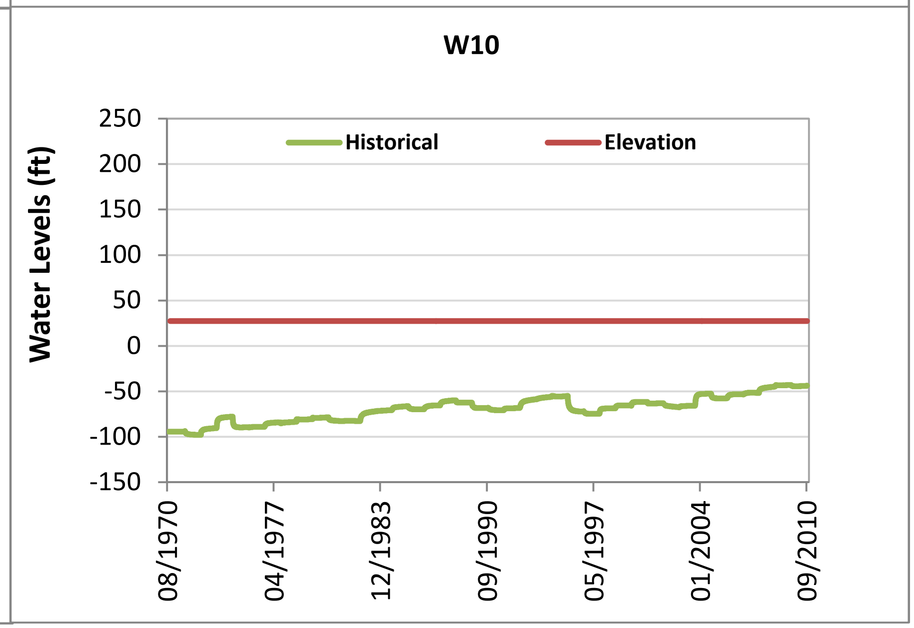

W5
Water Levels (ft)
Historical
Elevation
250
200
150
100
50
0
-50
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

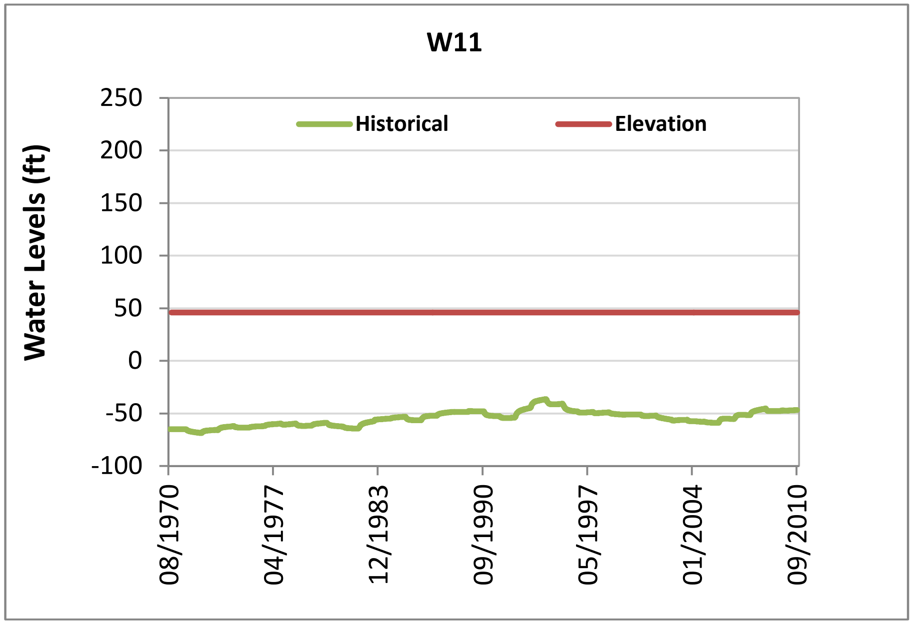

W6
Water Levels (ft)
Historical
Elevation
250
200
150
100
50
0
-50
-100
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010

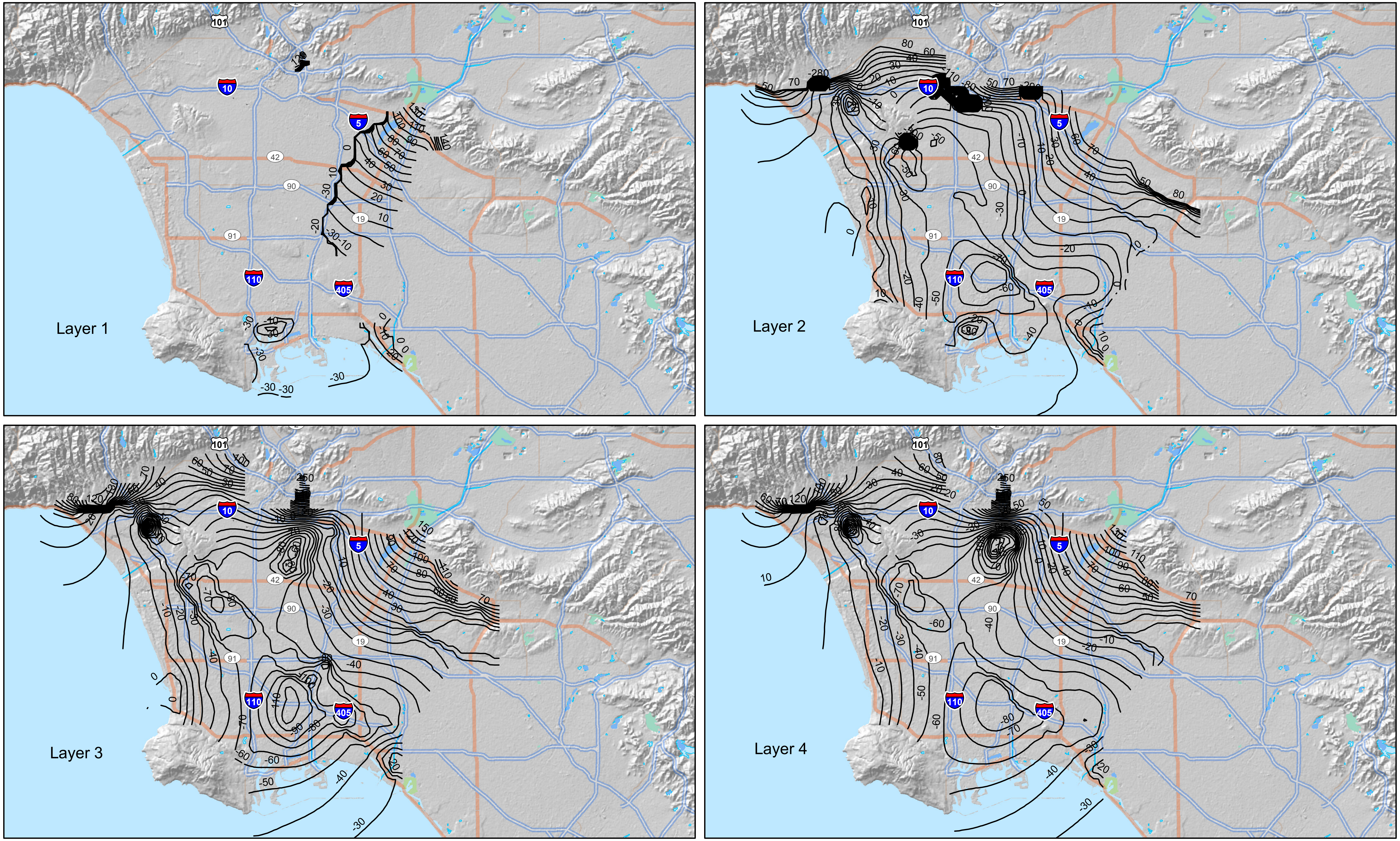

W7
Water Levels (ft)
Historical
Elevation
250
200
150
100
50
0
-50
-100
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010


W8
Water Levels (ft)
Historical
Elevation
250
200
150
100
50
0
-50
-100
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010


W9
Water Levels (ft)
Historical
Elevation
250
200
150
100
50
0
-50
-100
-150
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010


W10
Water Levels (ft)
Historical
Elevation
250
200
150
100
50
0
-50
-100
-150
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010


W11
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Elevation
08/1970
04/1977
12/1983
09/1990
05/1997
01/2004
09/2010



Legend

- Groundwater Basin Boundary
- Forebays
- Alamitos Barrier
- West Coast Basin Barriers
- Groundwater Level Contours
- Limited Access
- Highway
- Major Road

Water Bodies

Description

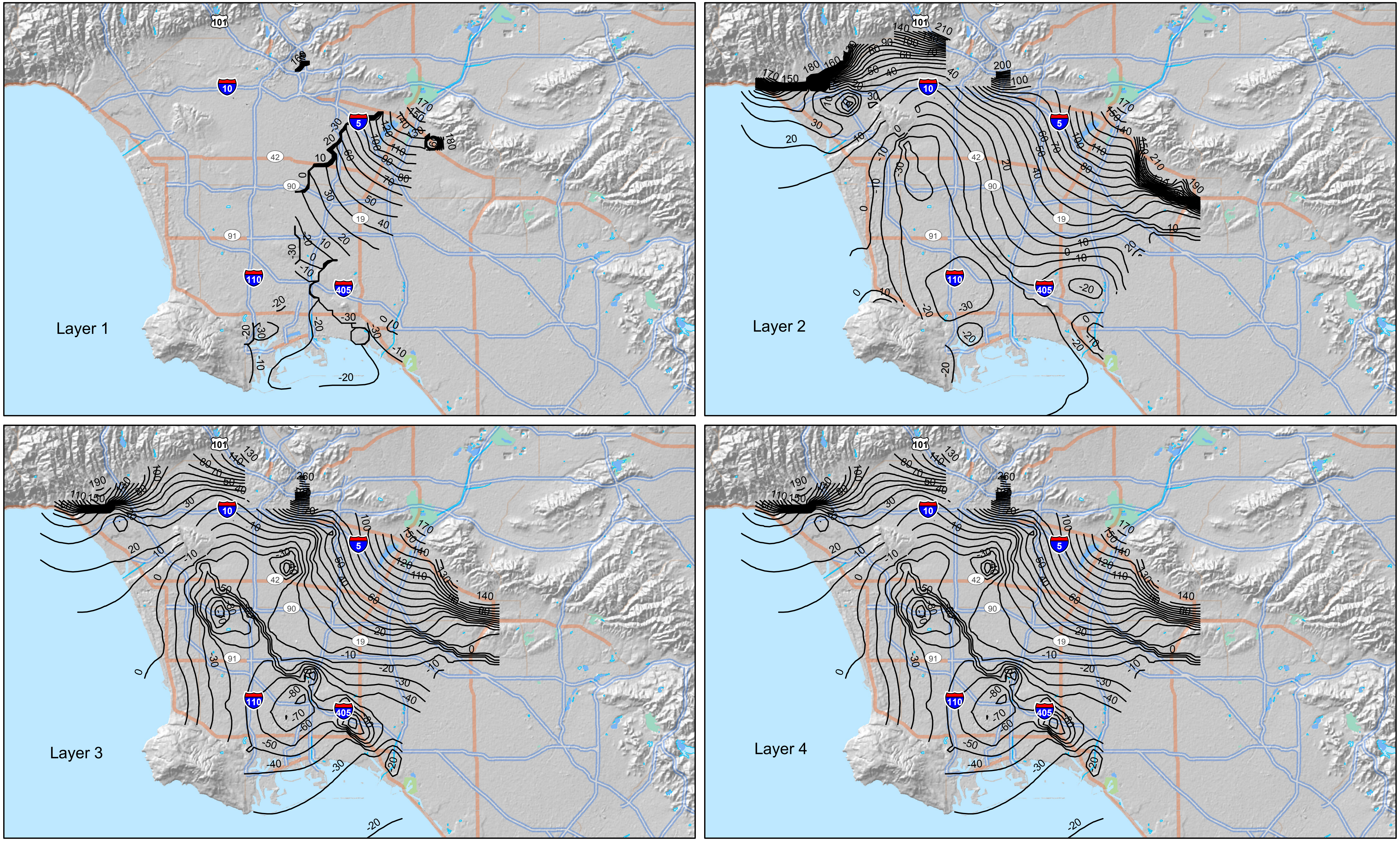
- Lake/Pond
- River/Stream
- Ocean
- Lake or Pond
- Swamp or Marsh
- Stream or River
- Inundation Area

N

0 0.5 1 2 3 4 Miles

Historical Conditions: Groundwater Level Contours at the Minimum Cumulative Storage in 1972

File Location



Legend

- Groundwater Basin Boundary
- Forebays
- Alamitos Barrier
- West Coast Basin Barriers
- Groundwater Level Contours
- Limited Access
- Highway
- Major Road

Water Bodies

Description

- Lake/Pond
- River/Stream
- Ocean
- Lake or Pond
- Swamp or Marsh
- Stream or River
- Inundation Area

N

0 0.5 1 2 3 4 Miles

Historical Conditions: Groundwater Level Contours at the Maximum Cumulative Storage in 1998

File Location

Appendix I
Groundwater Model Simulation Results

This appendix contains the results of each model combination run presented by:

1. **Hydrographs** showing groundwater-level fluctuations at locations throughout the West Coast and Central Basins, and
2. **Groundwater level contour maps** for two stress periods with: 1) the cumulative storage at its minimum value; and 2) the cumulative storage at its maximum value.

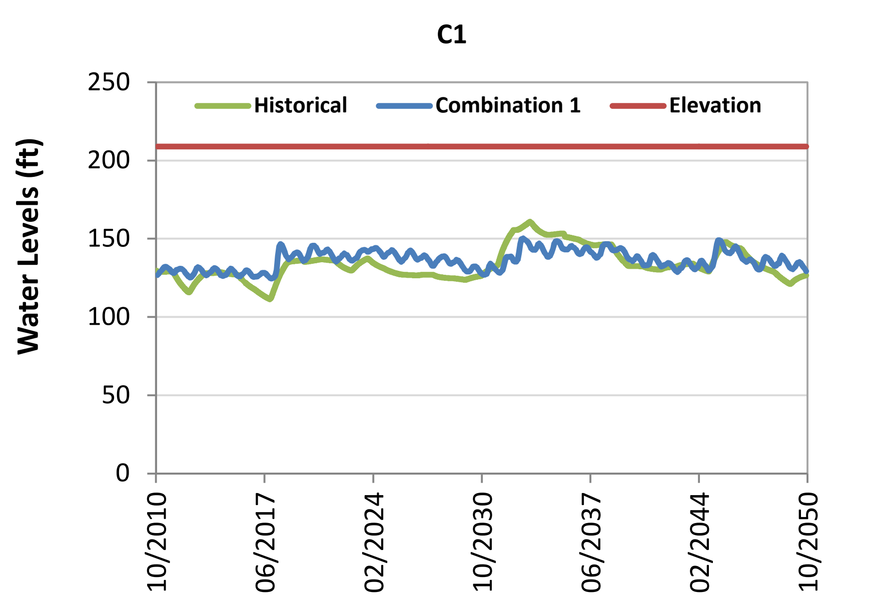
A summary of modeling conditions including stress periods for generating groundwater level contour maps for each model combination is presented in Table I-1.

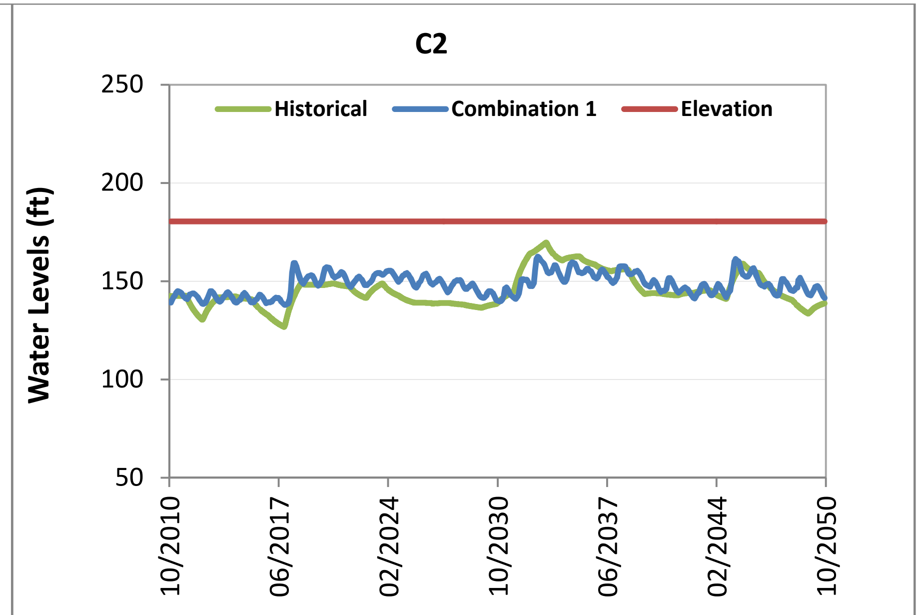
TABLE I-1

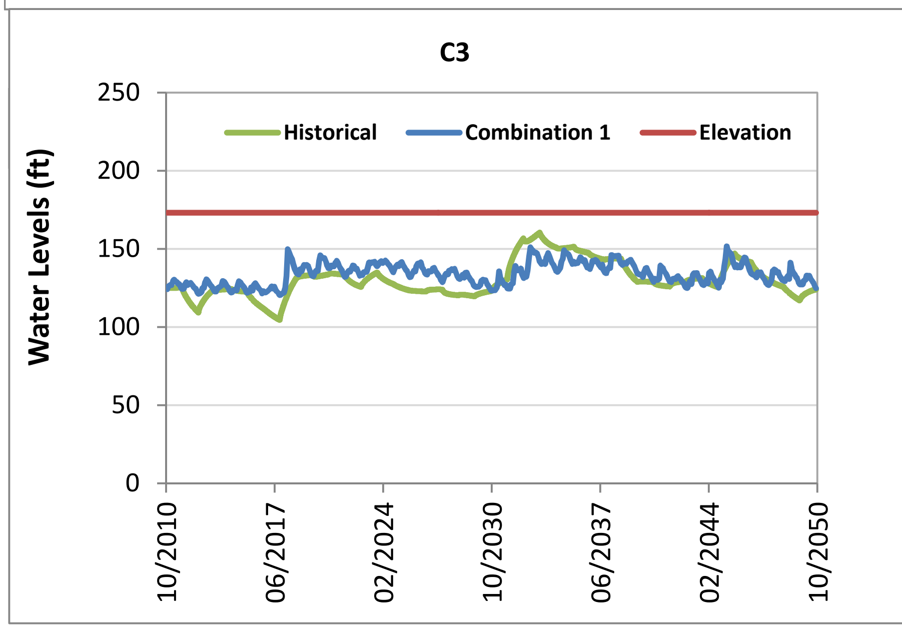
SUMMARY OF MODELING SCENARIOS AND MODEL OUTPUT CONDITIONS

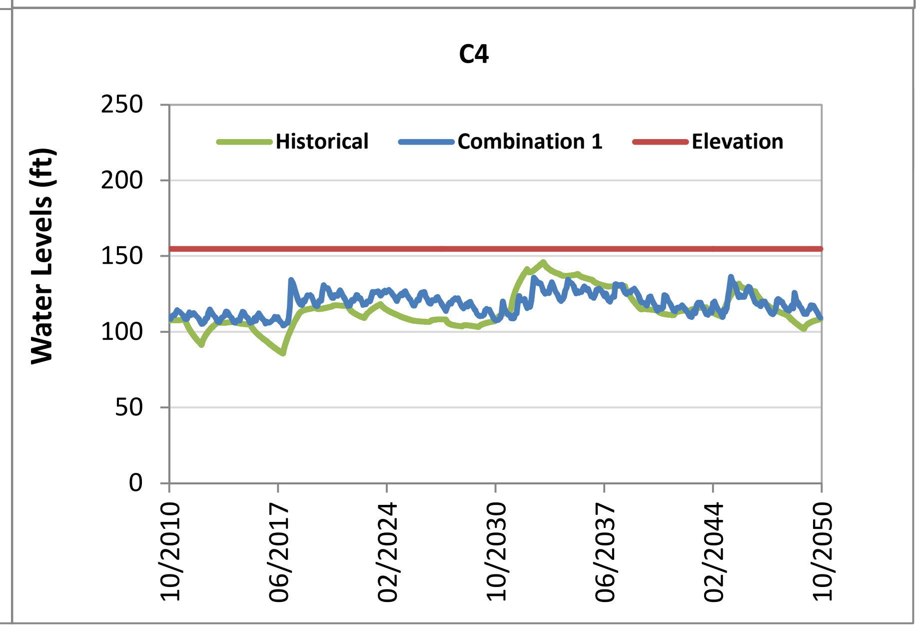
Scenario Combinations	Scenarios	Stress Period in months (corresponding year)	
		with Minimum Cumulative Storage	with Maximum Cumulative Storage
Combination 1 (WCB-A1a and CB-A1)	WCB: Pumping within water rights CB: Pumping within APA	24 (2012)	336 (2038)
Combination 2 (WCB-A1a and CB-A4)		84 (2017)	336 (2038)
Combination 3 (WCB-A1c and CB-A1)		24 (2012)	336 (2038)
Combination 4 (WCB-A1a and CB-B1)	WCB: Pumping within water rights CB: Pumping above APA	84 (2017)	336 (2038)
Combination 5 (WCB-A1a and CB-B2)		24 (2012)	336 (2038)
Combination 6 (WCB-B1 and CB-A1)	WCB: Pumping above water rights CB: Pumping within APA	24 (2012)	336 (2038)
Combination 7 (WCB-B1 and CB-B1)	WCB: Pumping above water rights CB: Pumping above APA	84 (2017)	336 (2038)

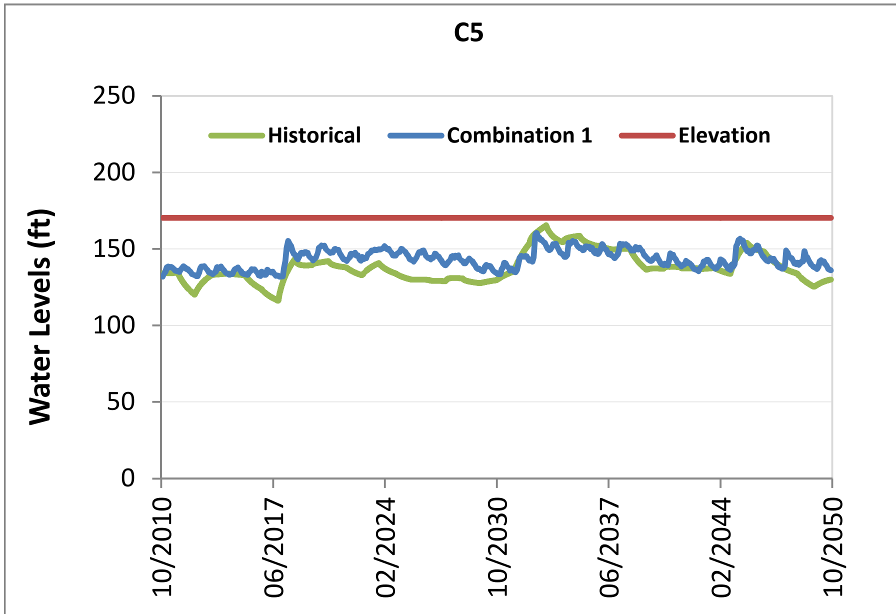
Combination 1 Model Results:
1) Hydrographs
2) Groundwater Level Contour Maps

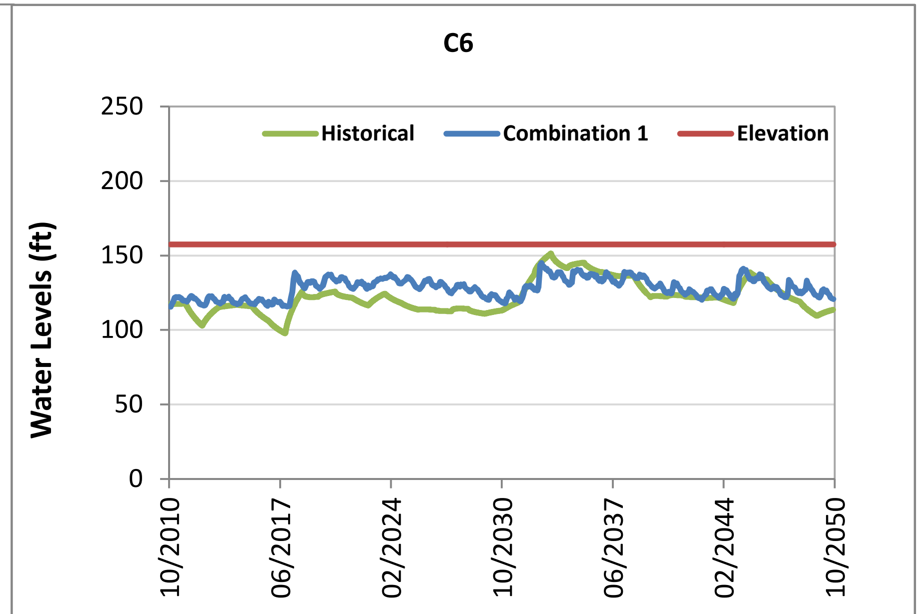

C1
Historical
Combination 1
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

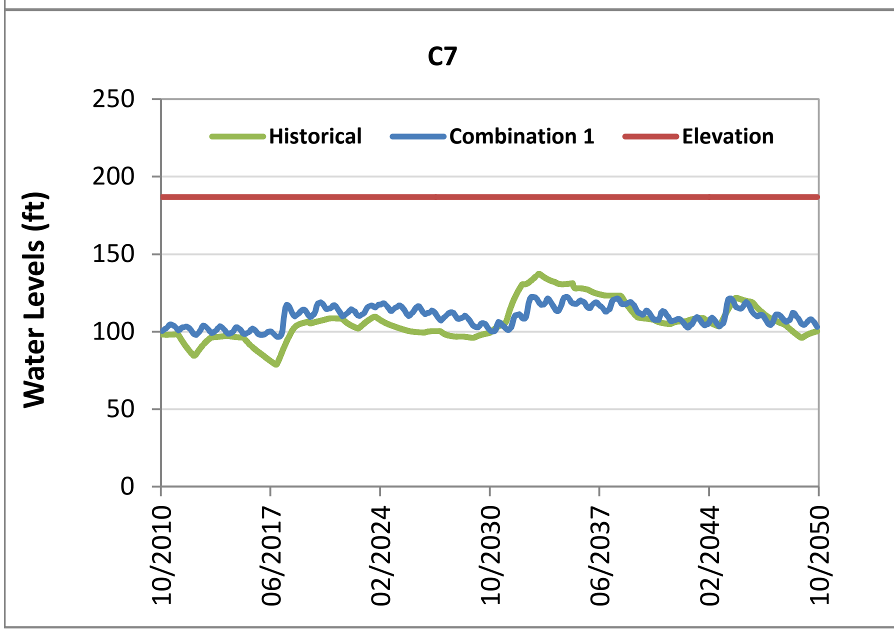

C2
Historical
Combination 1
Elevation
Water Levels (ft)
250
200
150
100
50
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

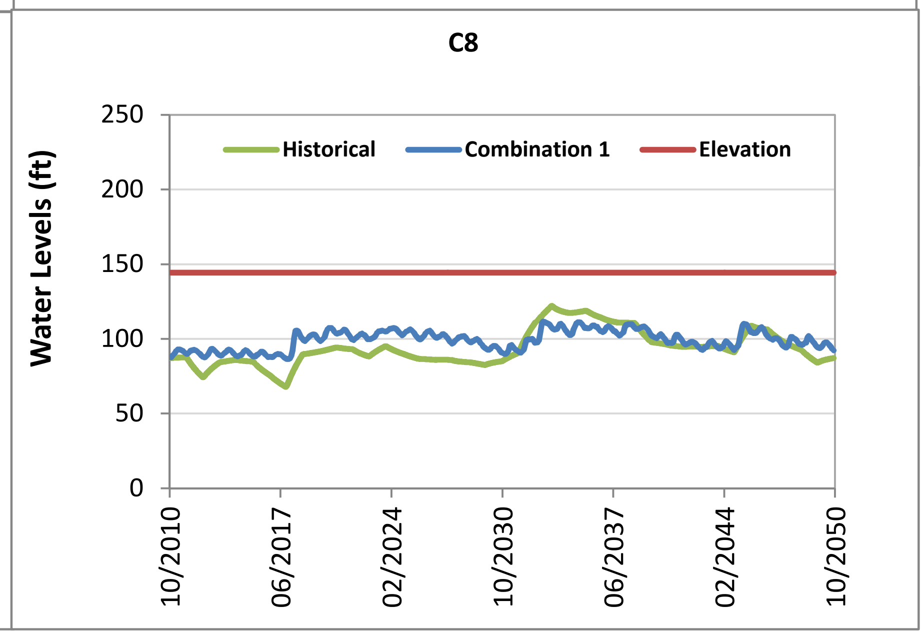

C3
Historical
Combination 1
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

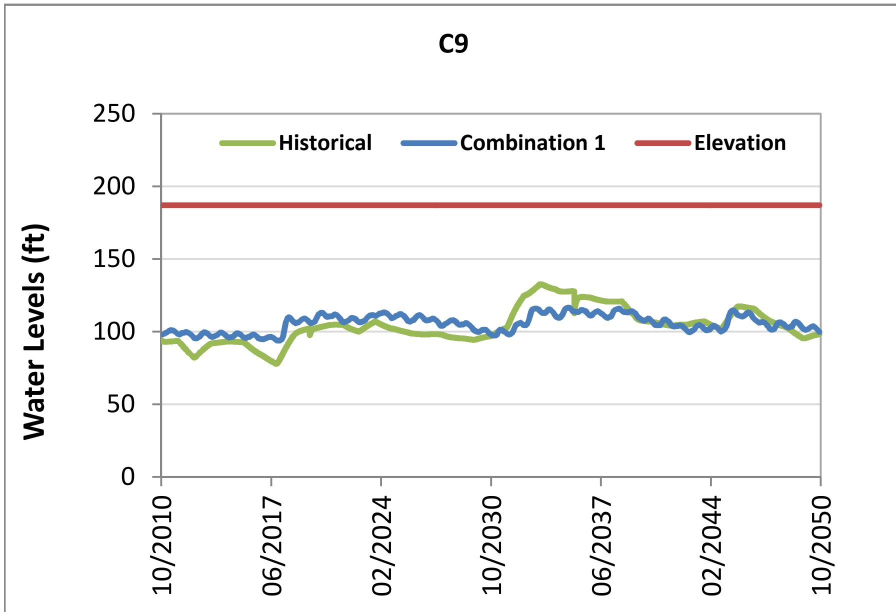

C4
Historical
Combination 1
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

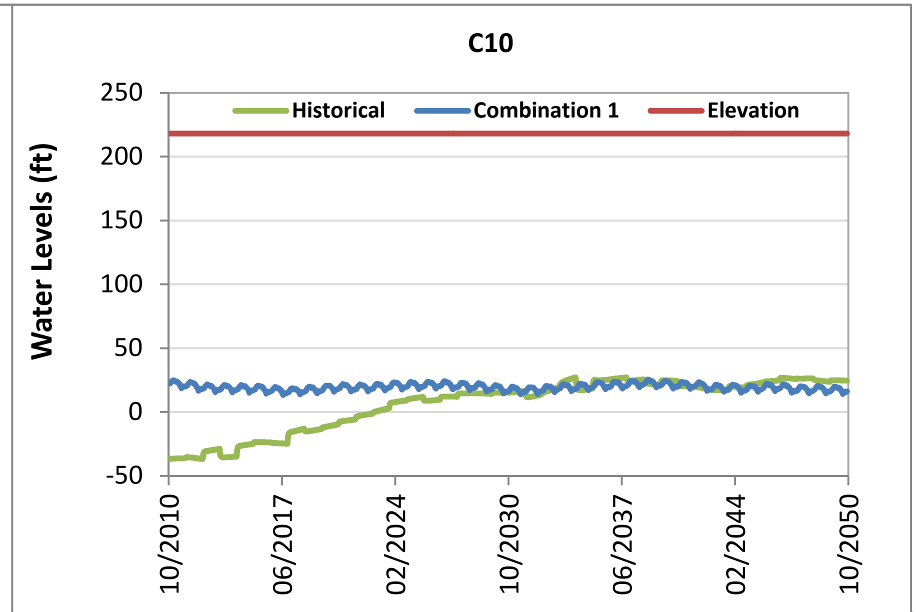

C5
Historical
Combination 1
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

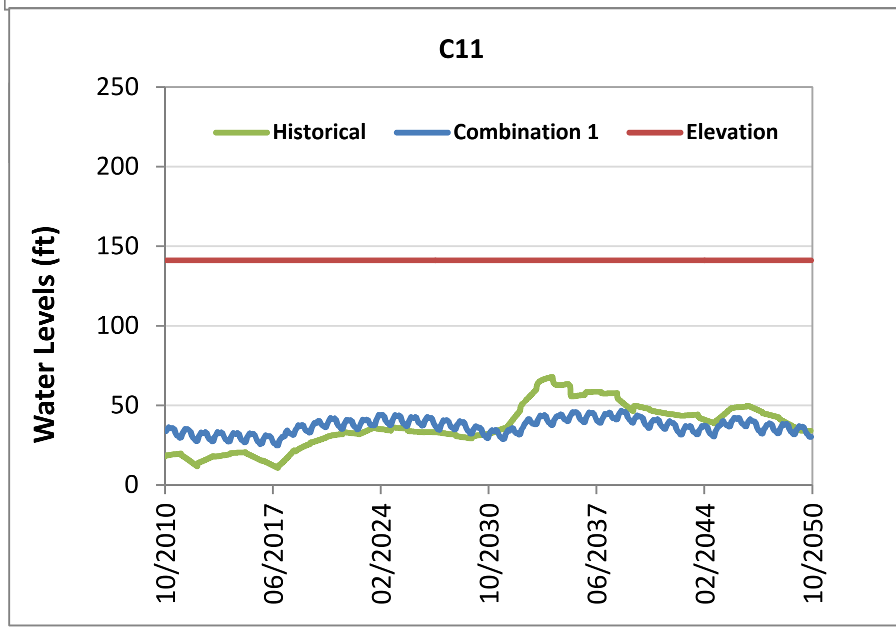

C6
Historical
Combination 1
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

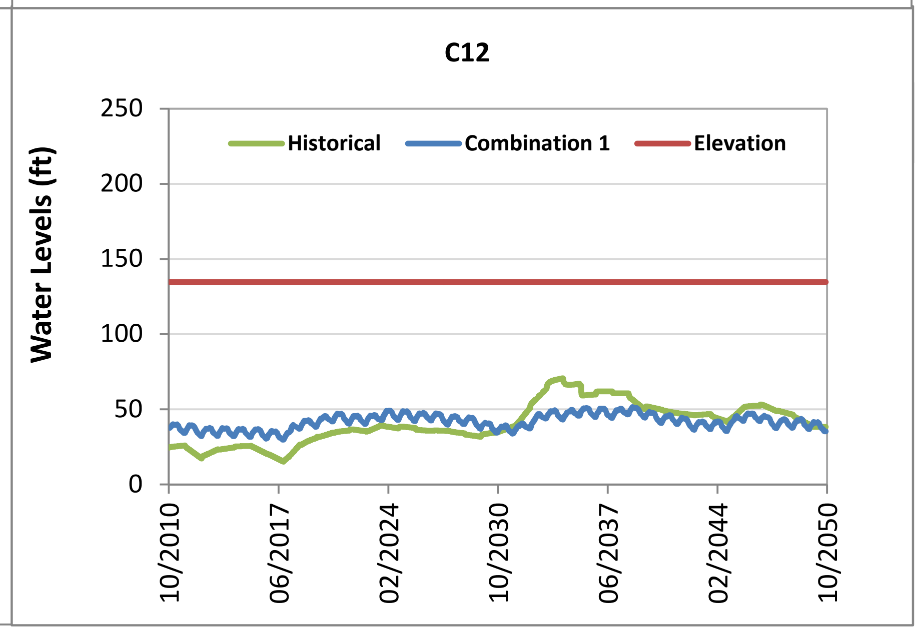

C7
Historical
Combination 1
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

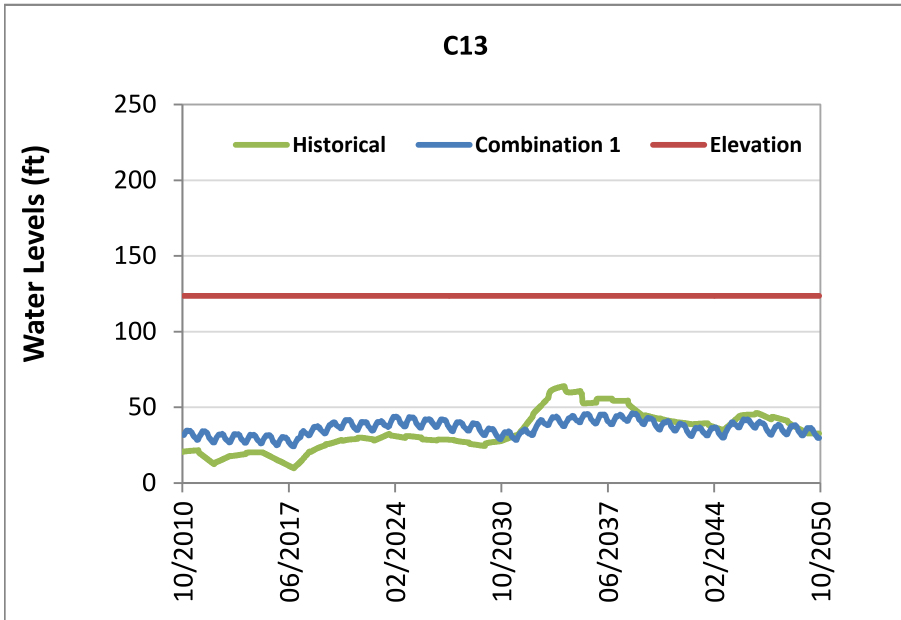

C8
Historical
Combination 1
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

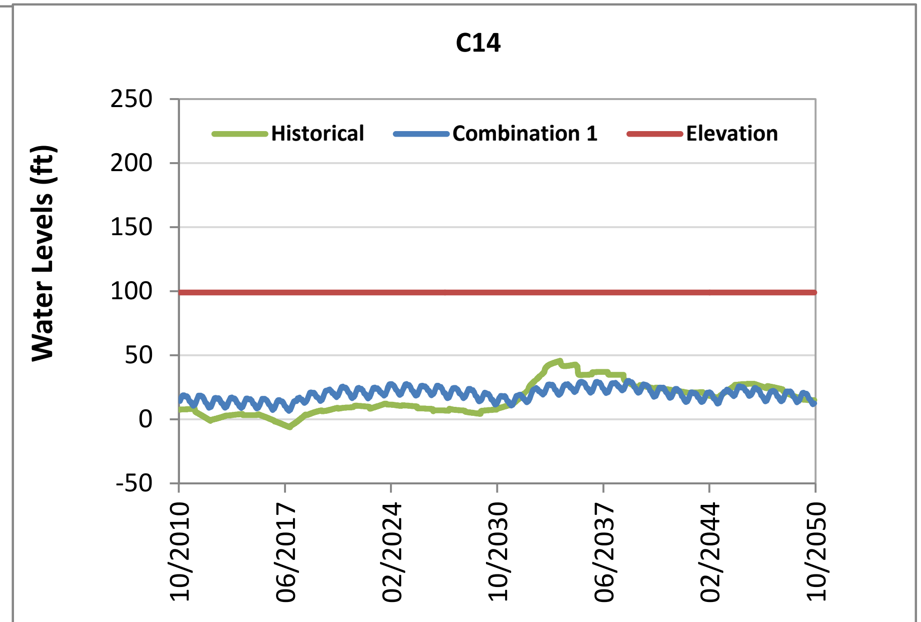

C9
Historical
Combination 1
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

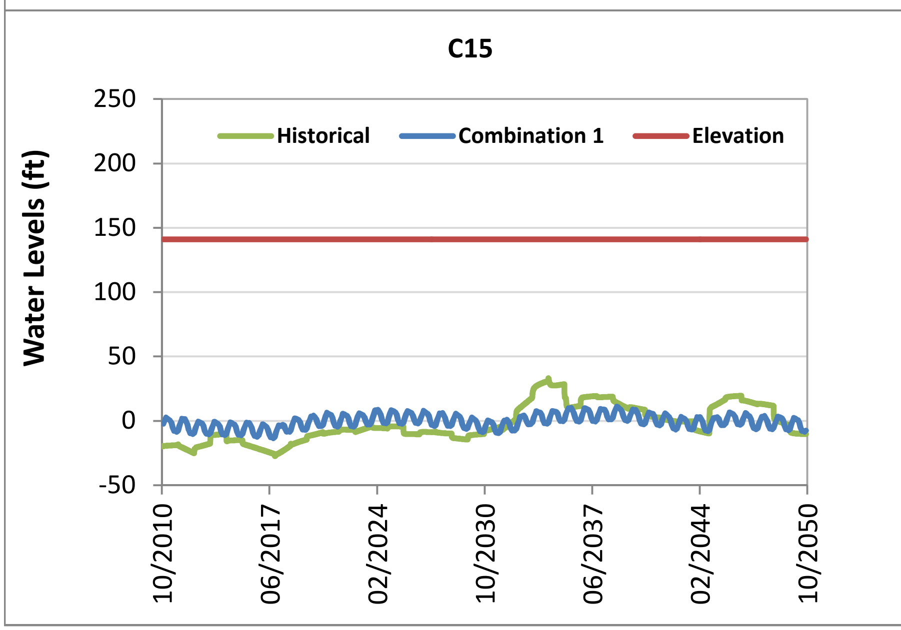

C10
Historical
Combination 1
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

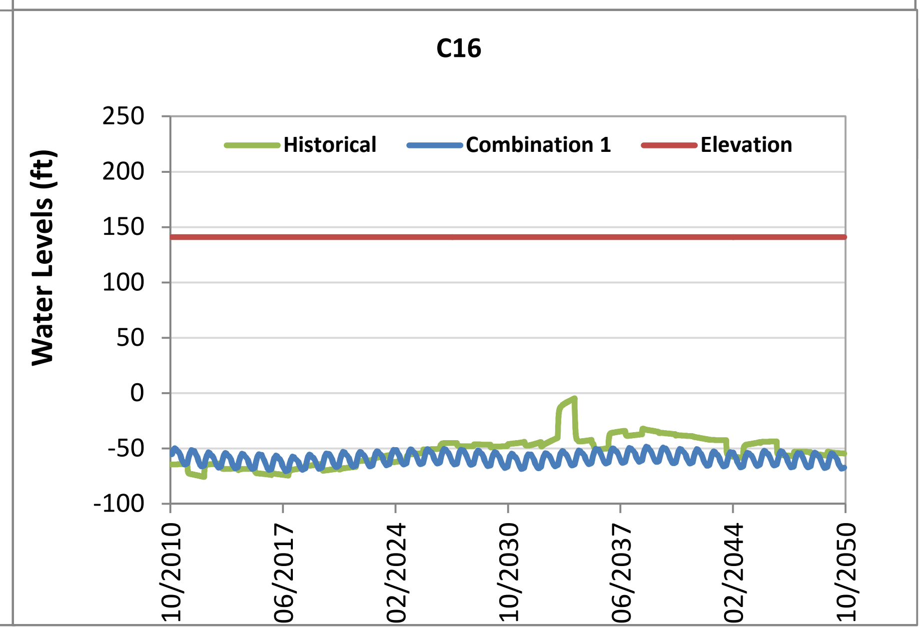

C11
Historical
Combination 1
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

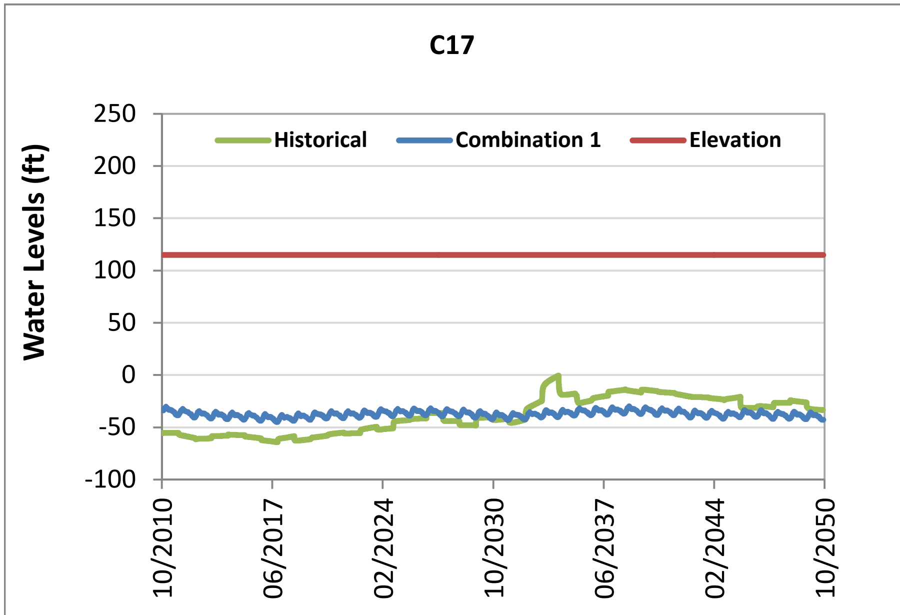

C12
Historical
Combination 1
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

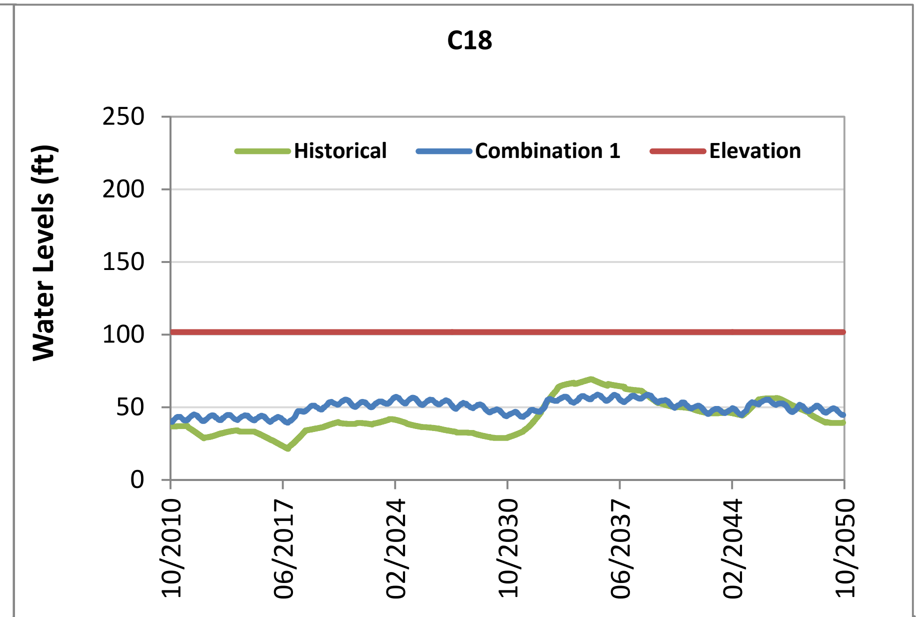

C13
Water Levels (ft)
250
200
150
100
50
0
Historical
Combination 1
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

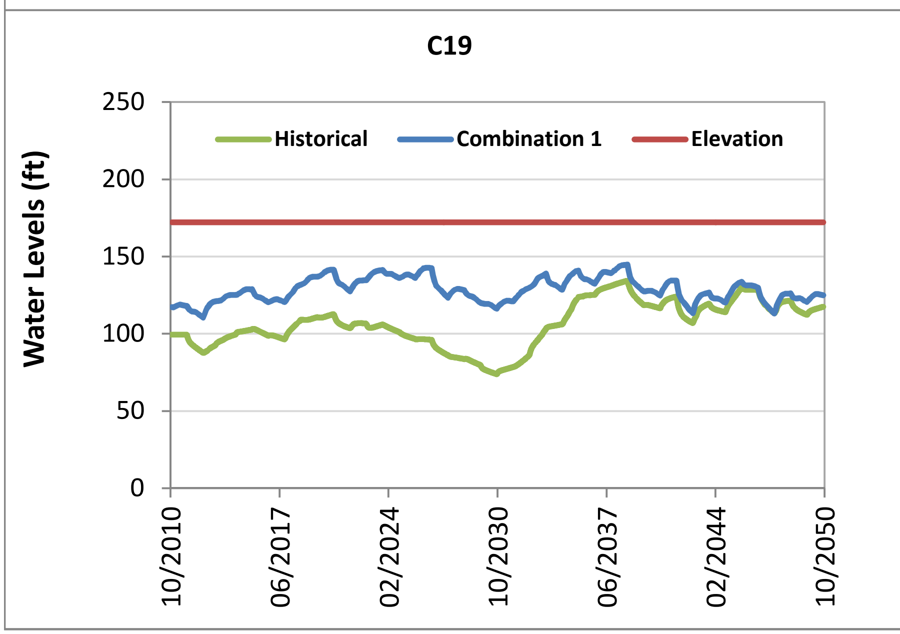

C14
Water Levels (ft)
250
200
150
100
50
0
-50
Historical
Combination 1
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

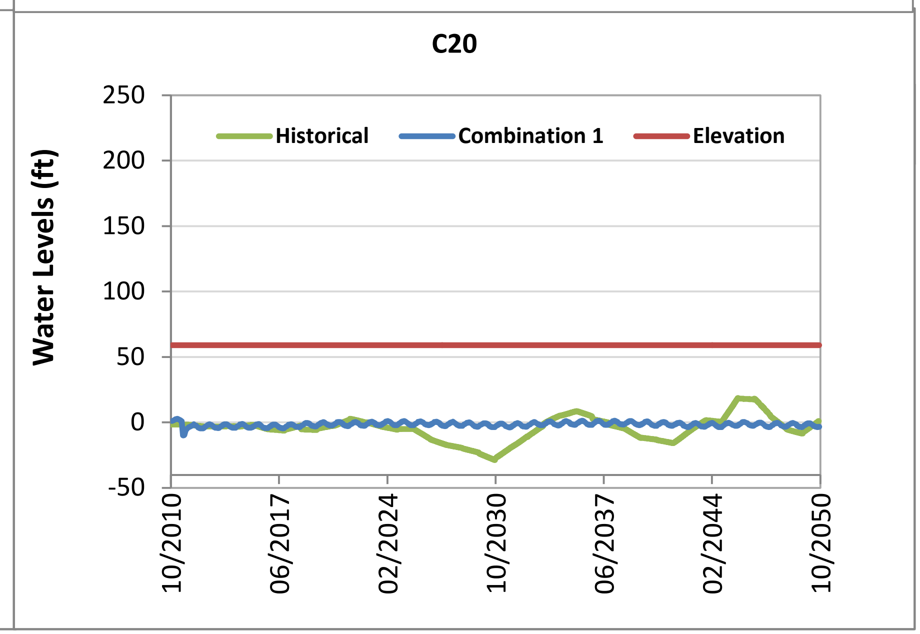

C15
Water Levels (ft)
250
200
150
100
50
0
-50
Historical
Combination 1
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

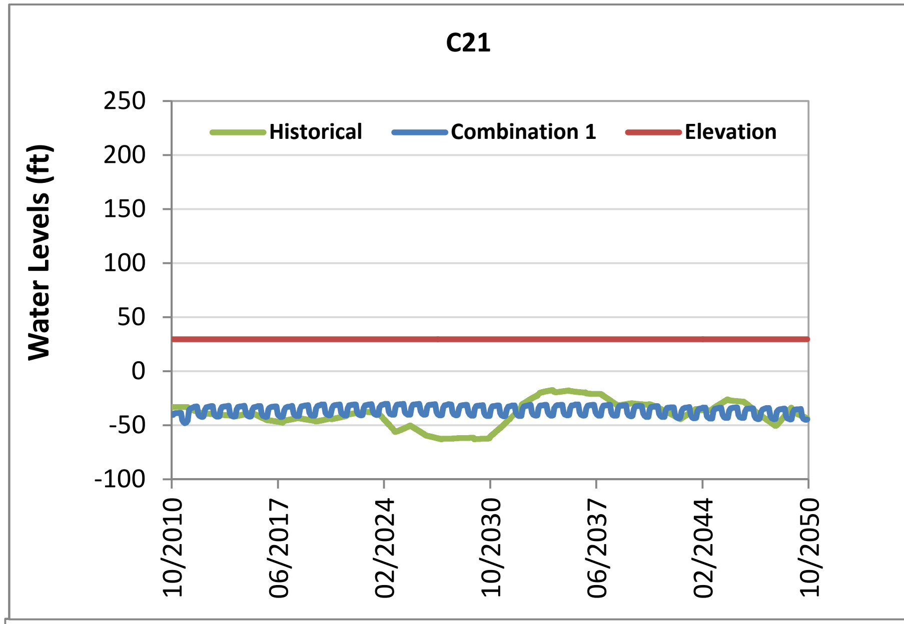

C16
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 1
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

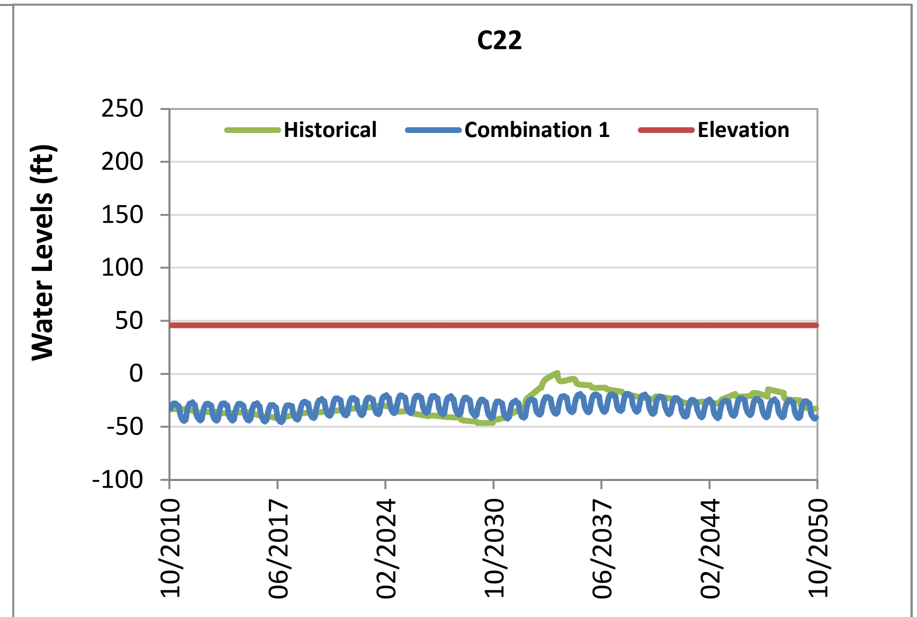

C17
Historical
Combination 1
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

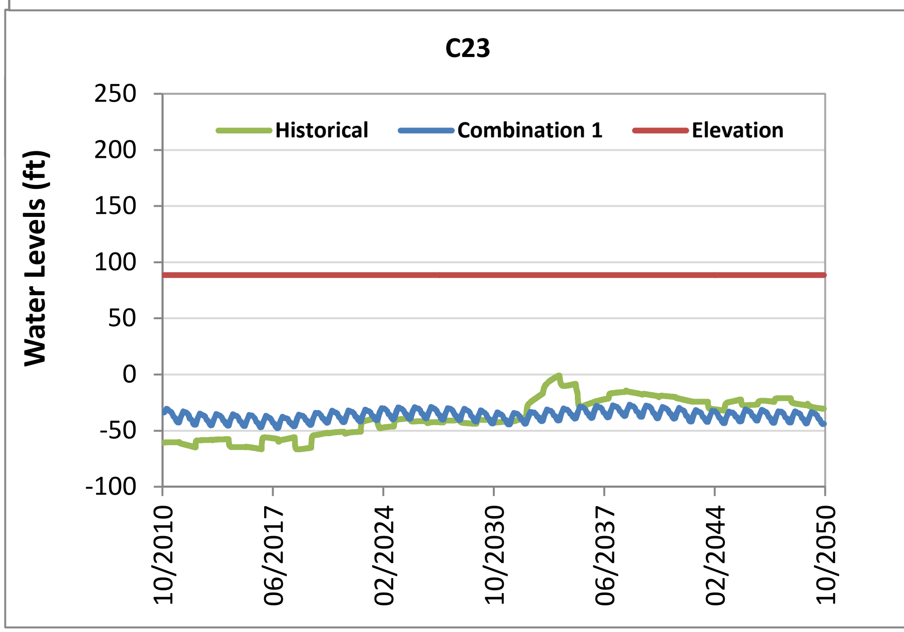

C18
Historical
Combination 1
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C19
Historical
Combination 1
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C20
Historical
Combination 1
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C21
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 1
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C22
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 1
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C23
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 1
Elevation
10/2010
06/2017
02/2024
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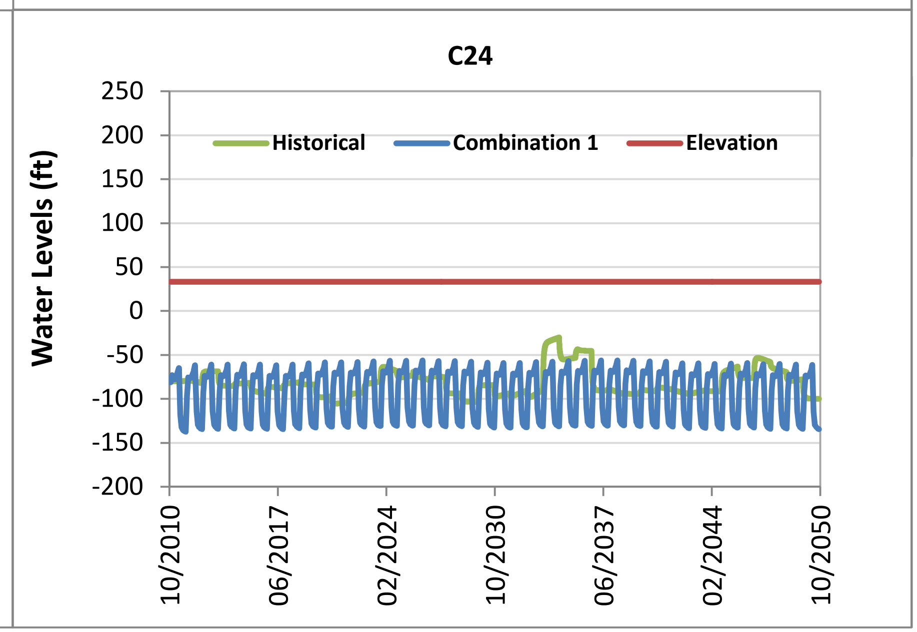
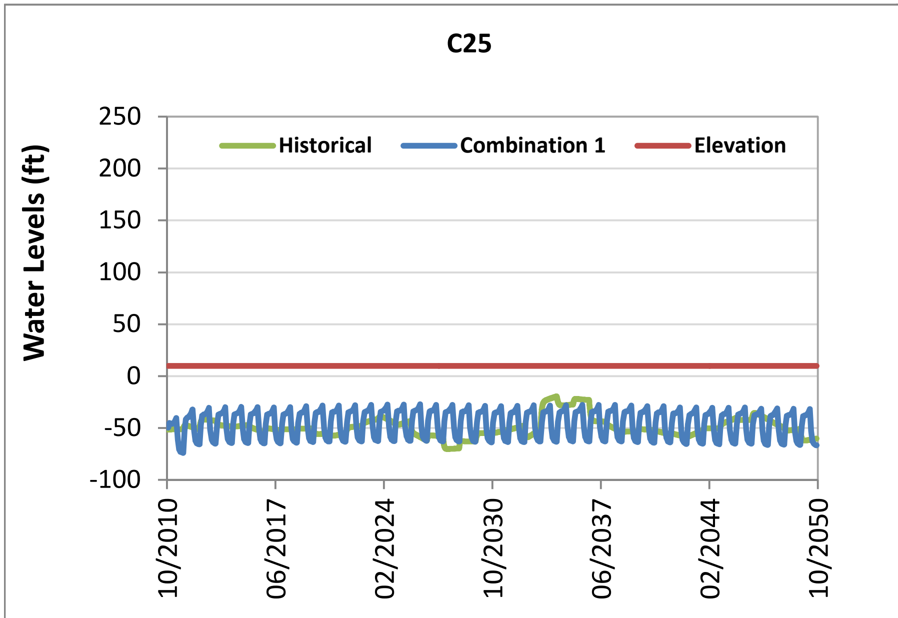
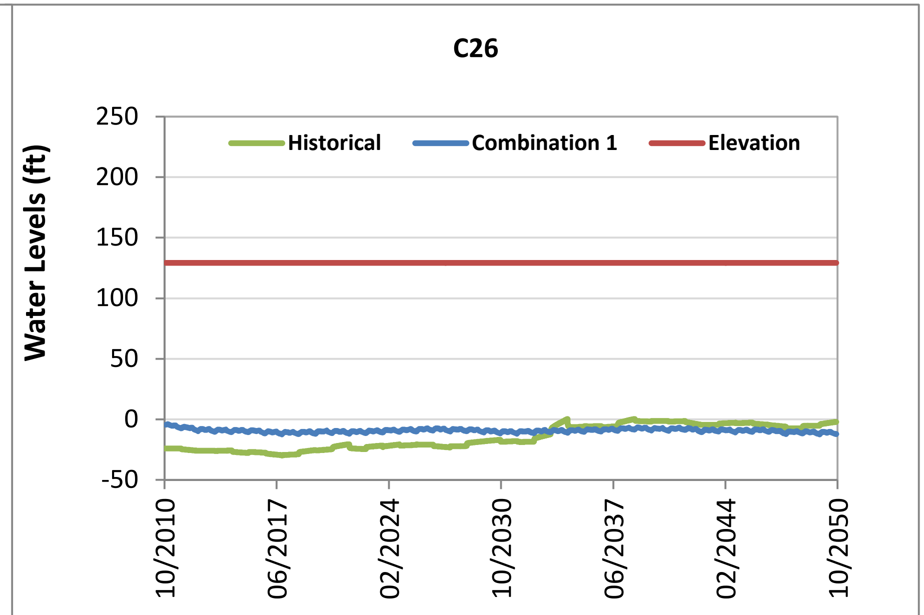
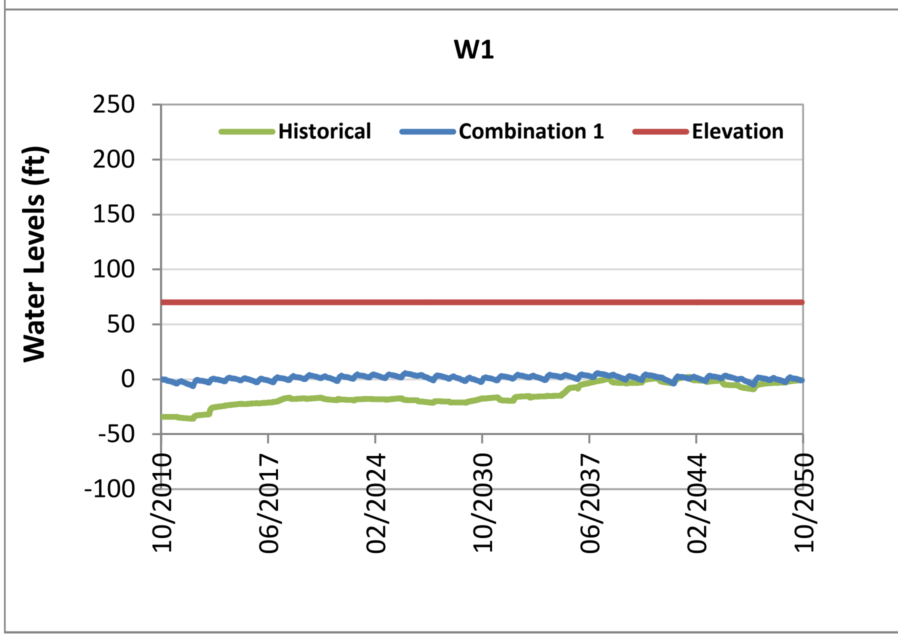
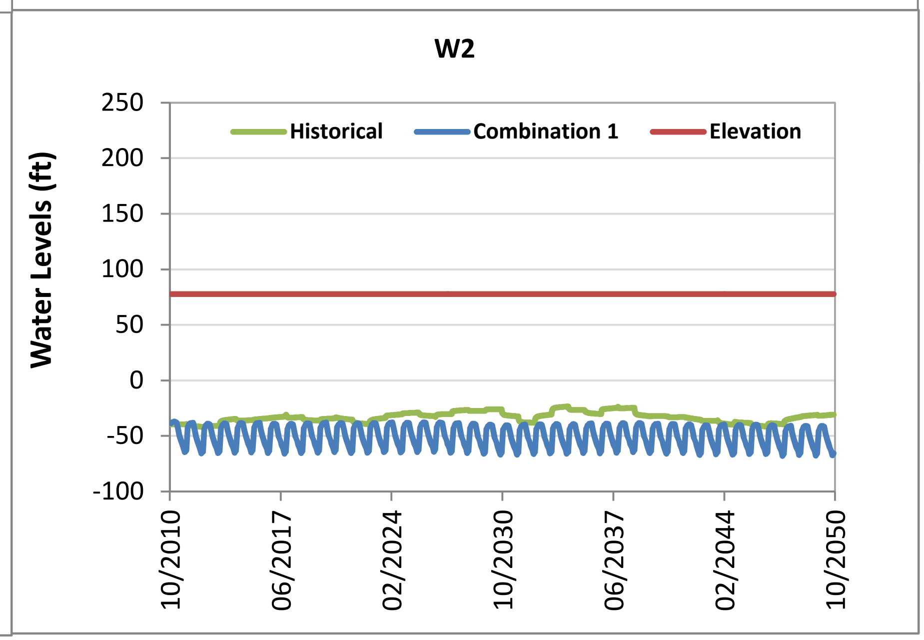
06/2037
02/2044
10/2050

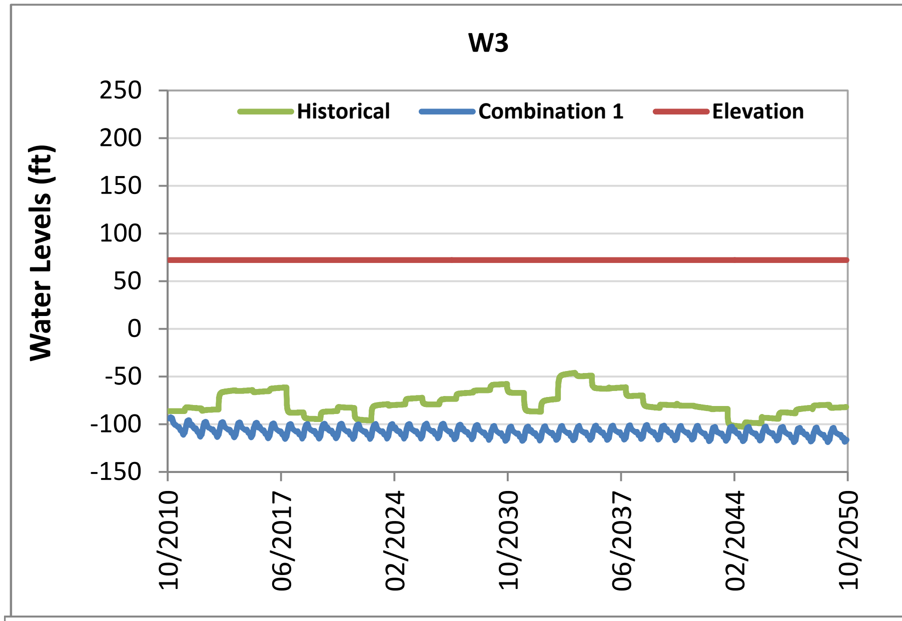

C24
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
-200
Historical
Combination 1
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

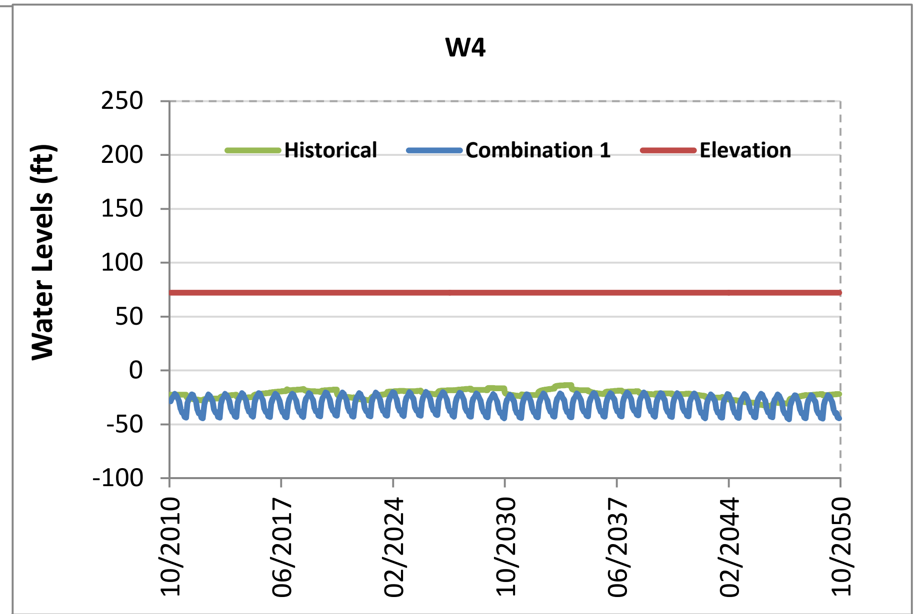

C25
Water Levels (ft)
Historical
Combination 1
Elevation
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

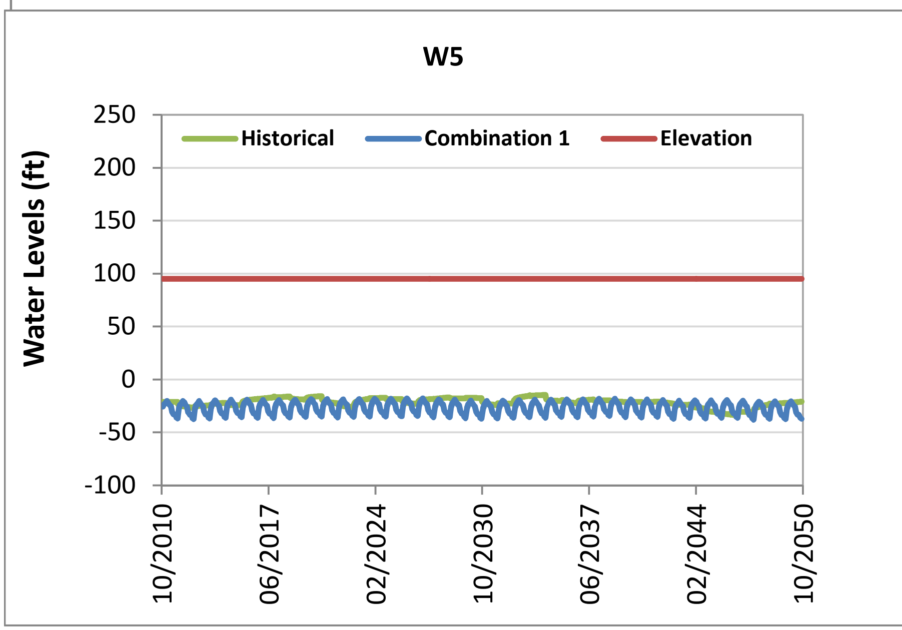

C26
Water Levels (ft)
Historical
Combination 1
Elevation
250
200
150
100
50
0
-50
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

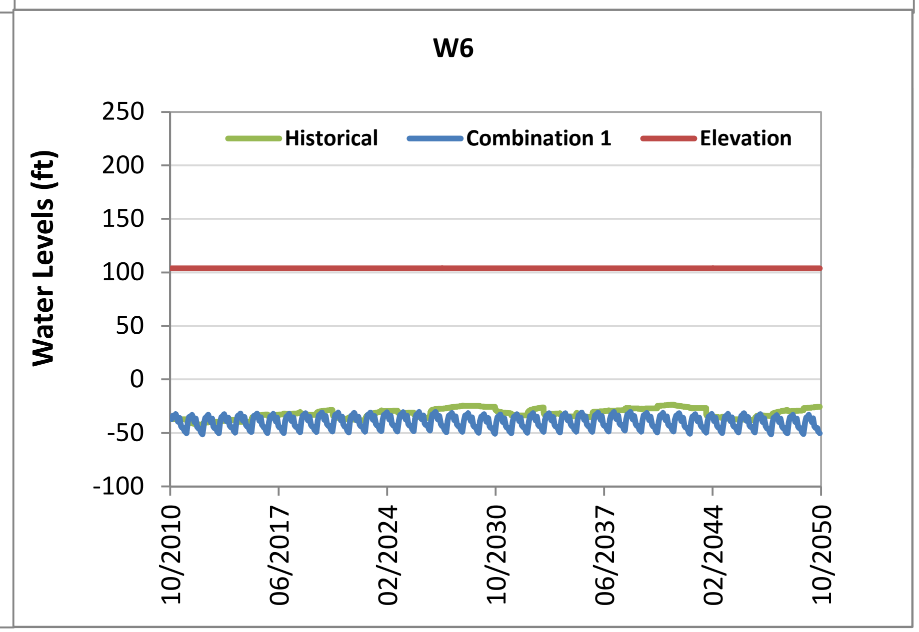

W1
Water Levels (ft)
Historical
Combination 1
Elevation
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

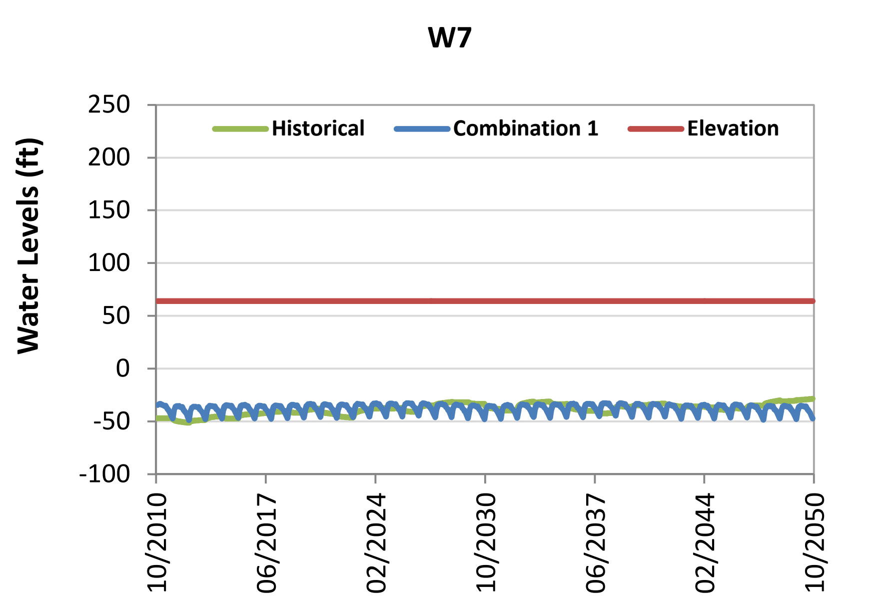

W2
Water Levels (ft)
Historical
Combination 1
Elevation
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

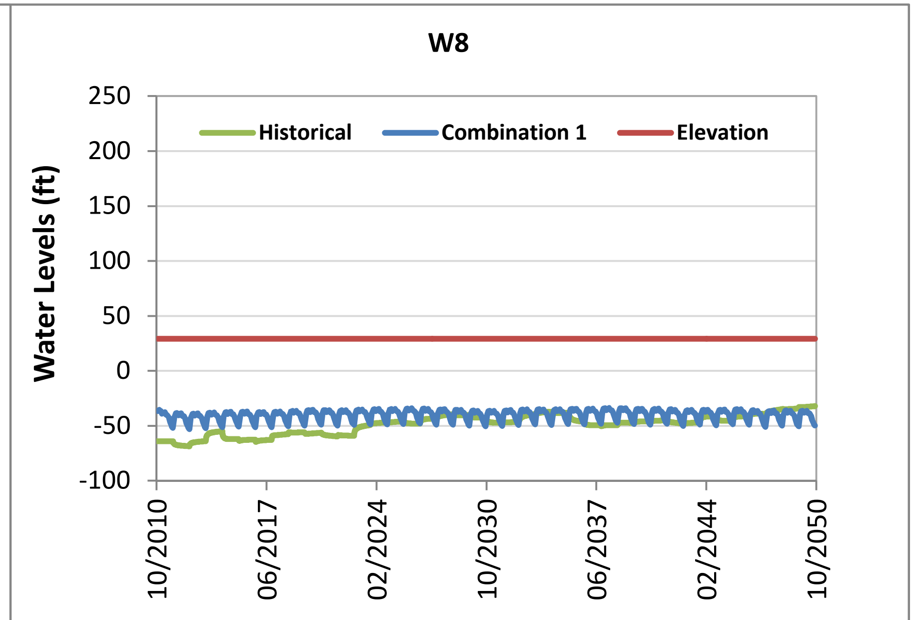

W3
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
Historical
Combination 1
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

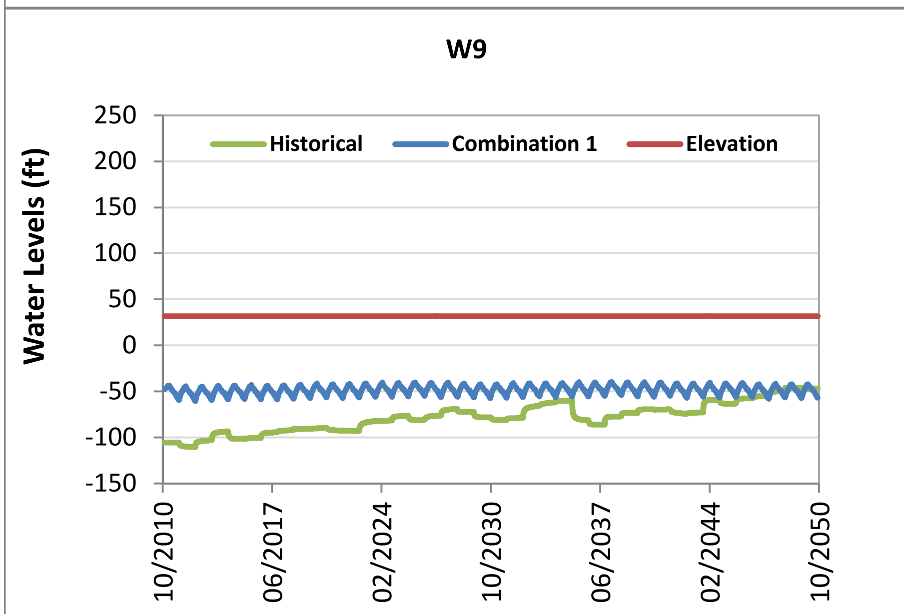

W4
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 1
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

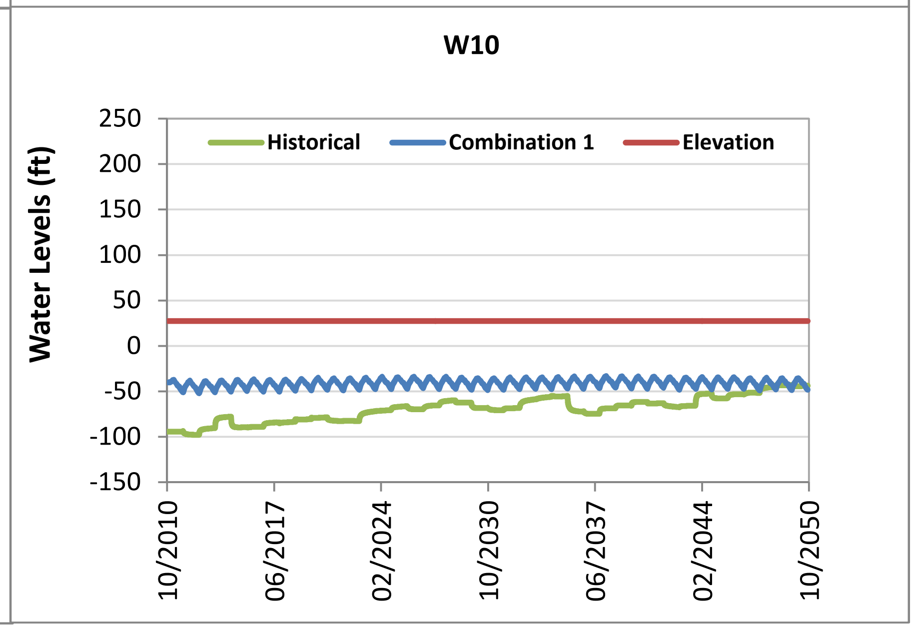

W5
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 1
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

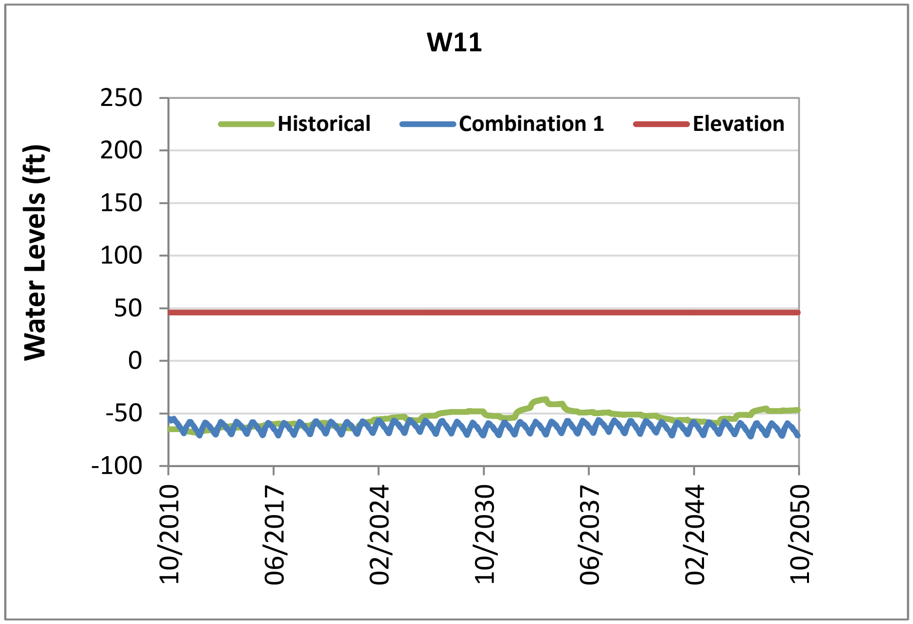

W6
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 1
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

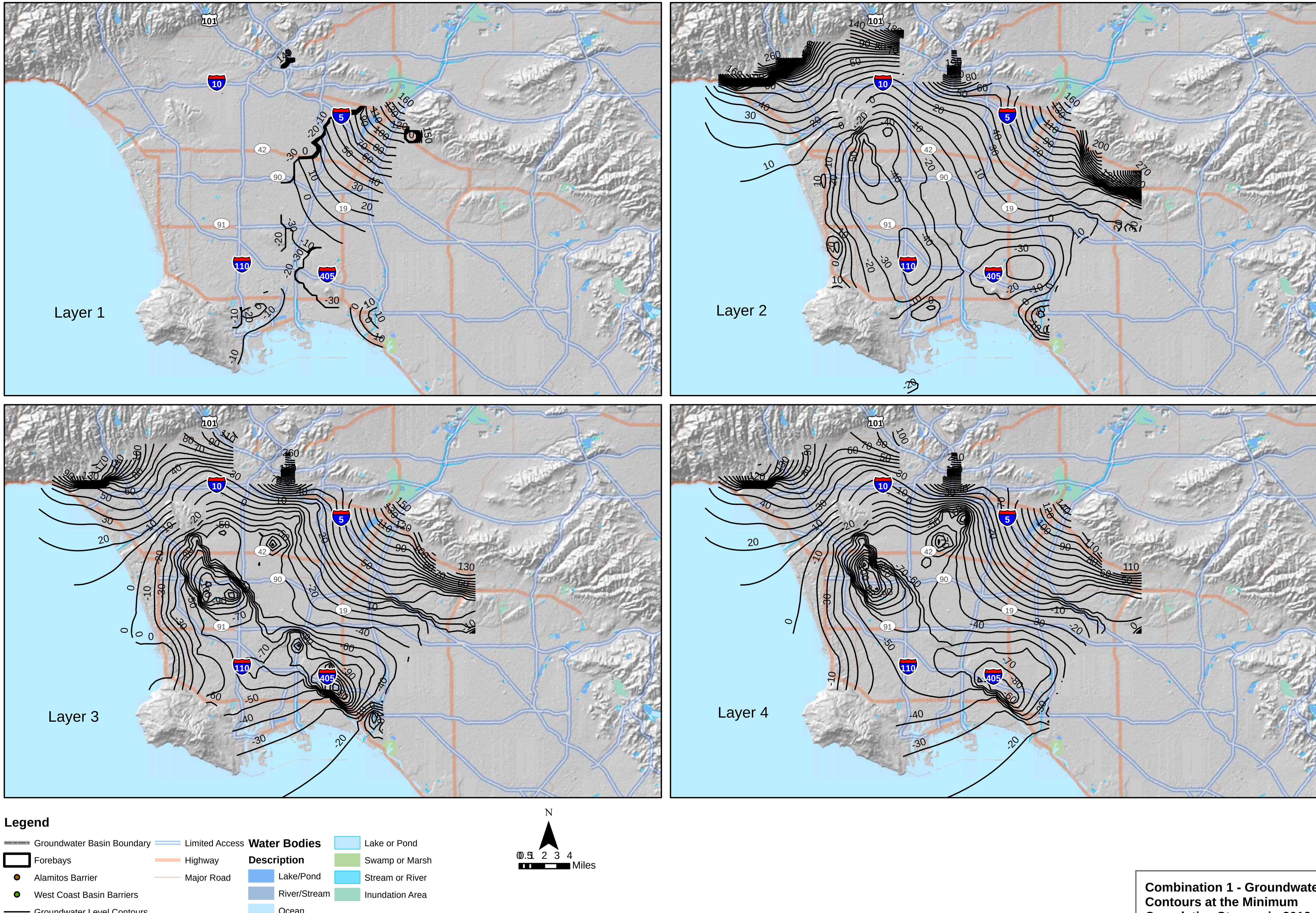

W7
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 1
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W8
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 1
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W9
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
Historical
Combination 1
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

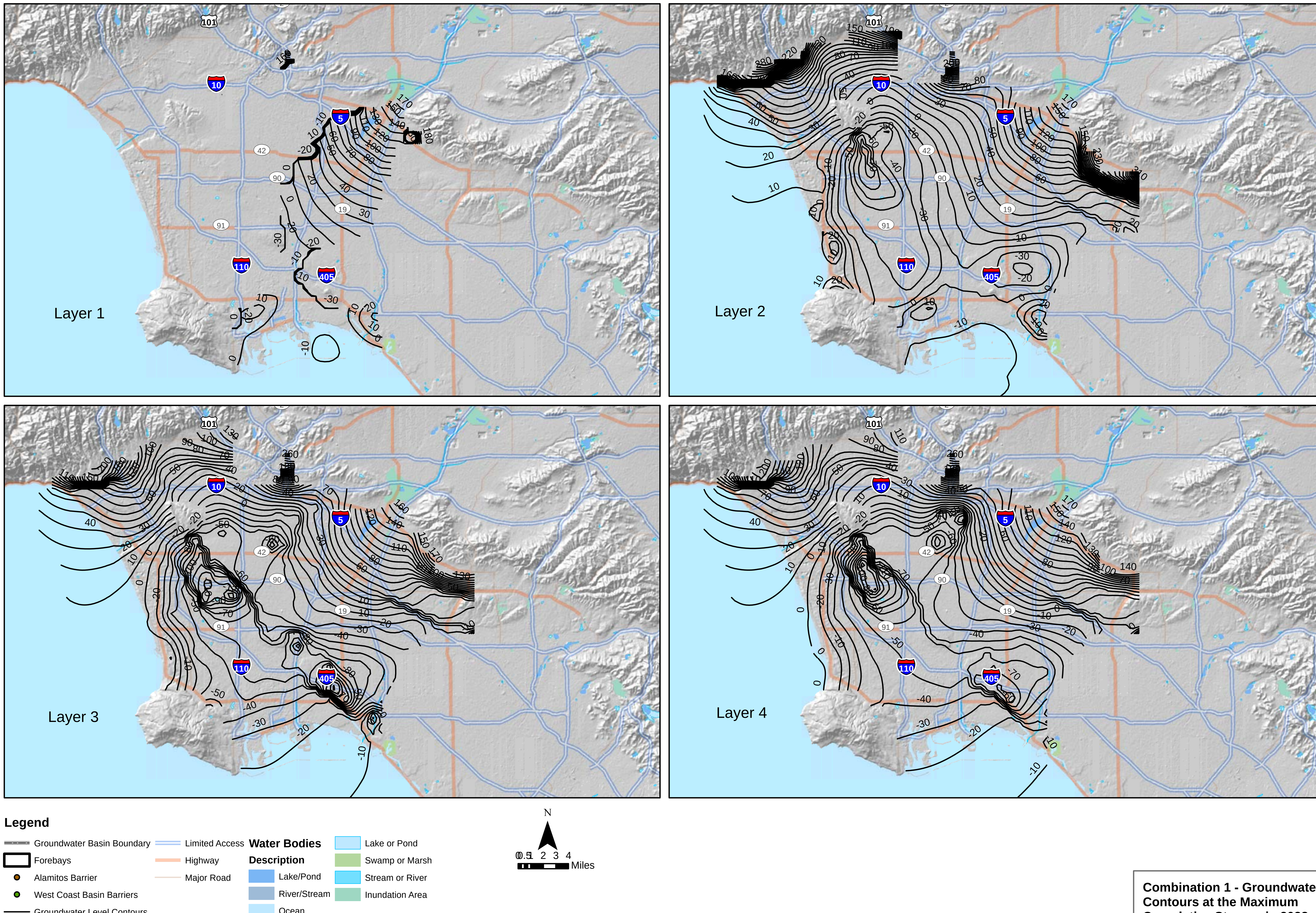

W10
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
Historical
Combination 1
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W11
Historical
Combination 1
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050



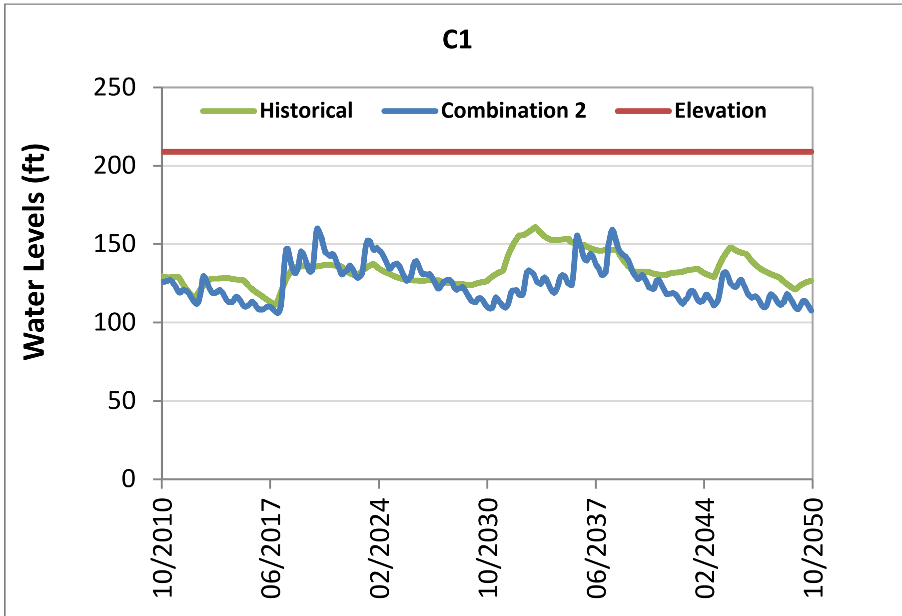
Combination 1 - Groundwater Level Contours at the Minimum Cumulative Storage in 2012

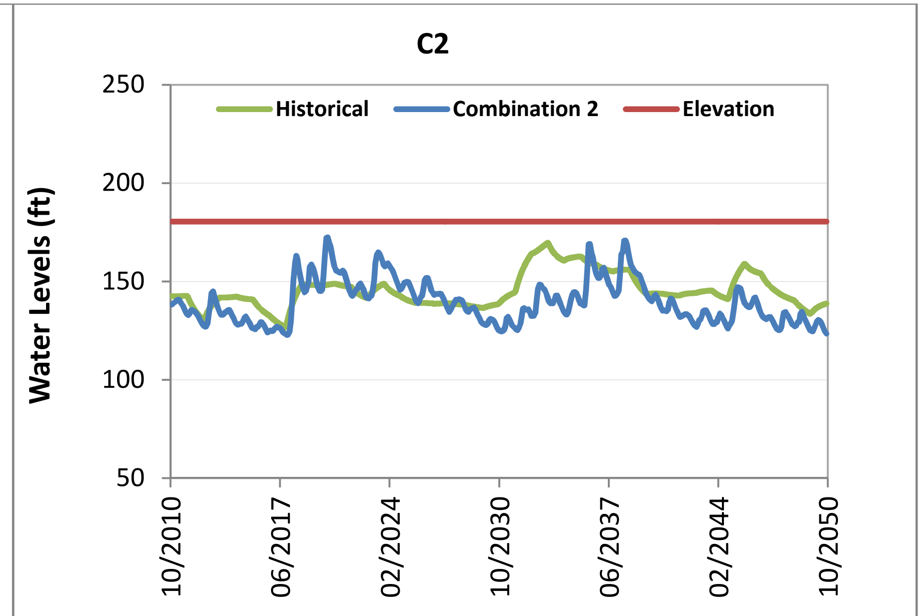
File Location

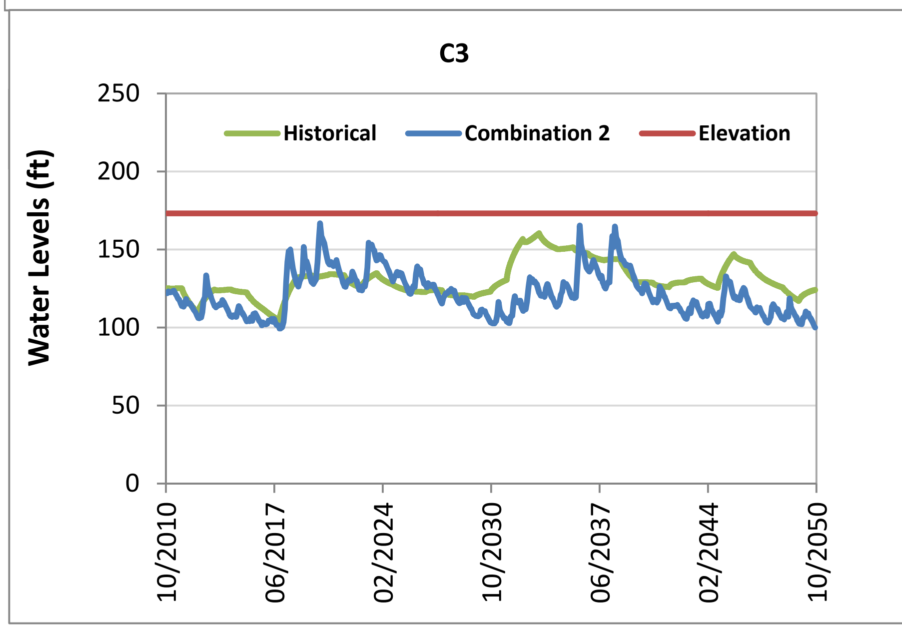


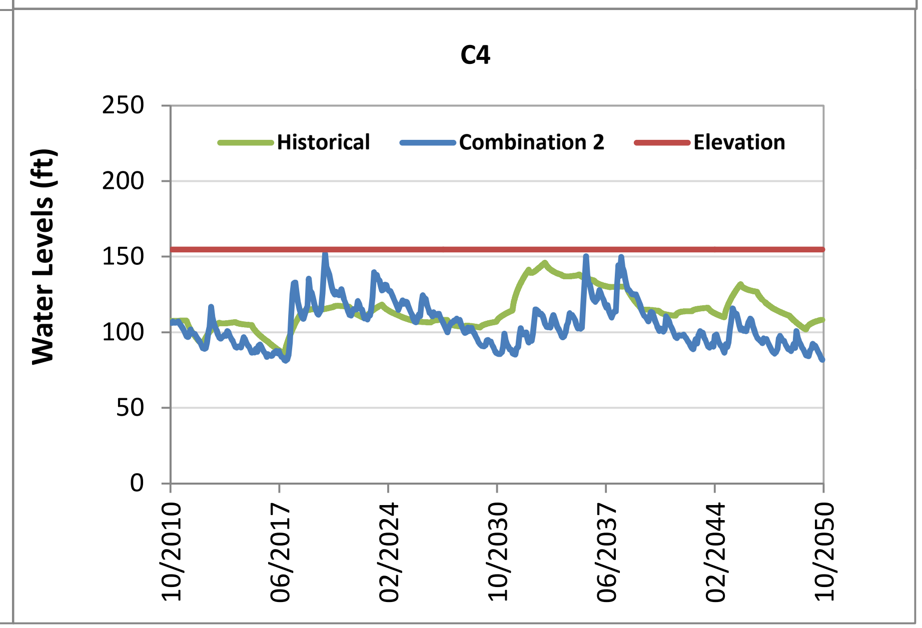
Combination 1 - Groundwater Level Contours at the Maximum Cumulative Storage in 2038

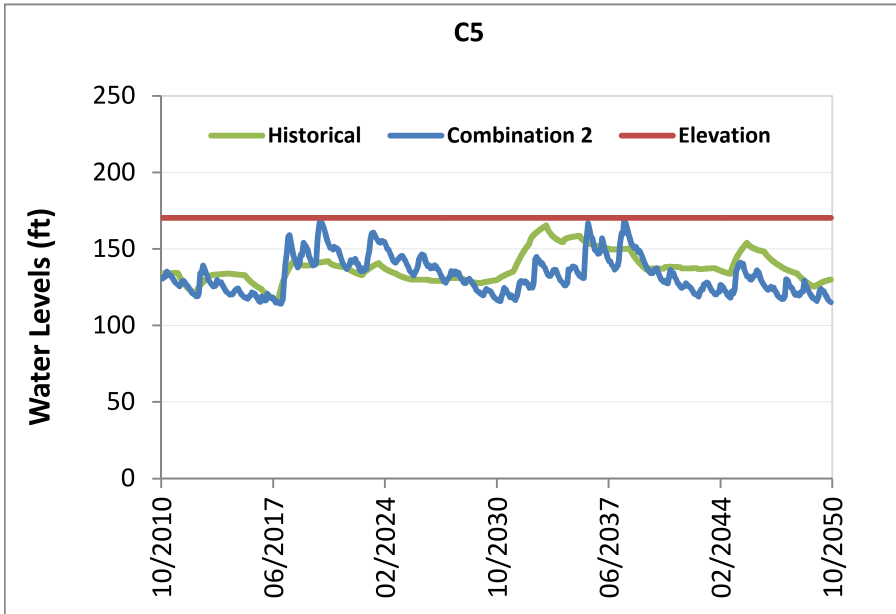
Combination 2 Model Results:
1) Hydrographs
2) Groundwater Level Contour Maps

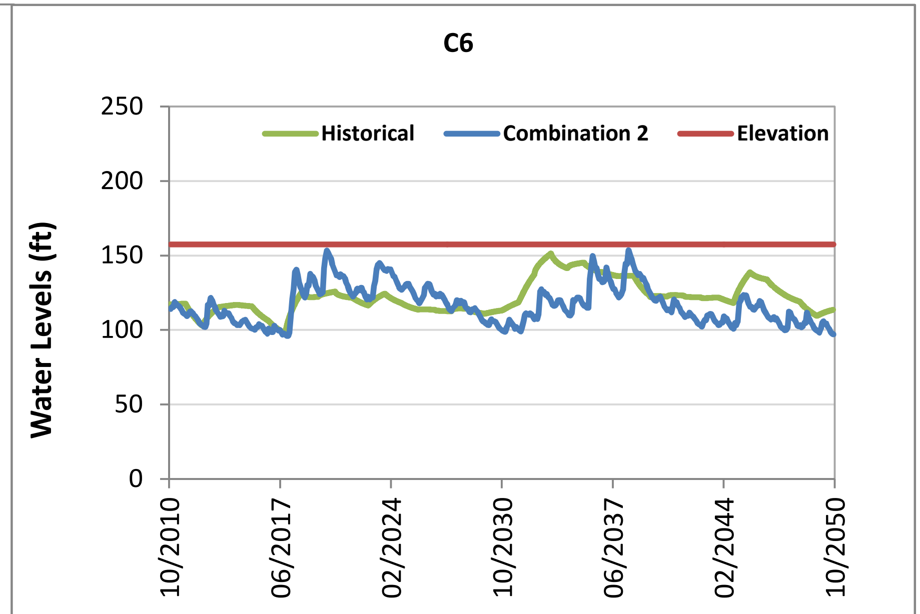

C1
Historical
Combination 2
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

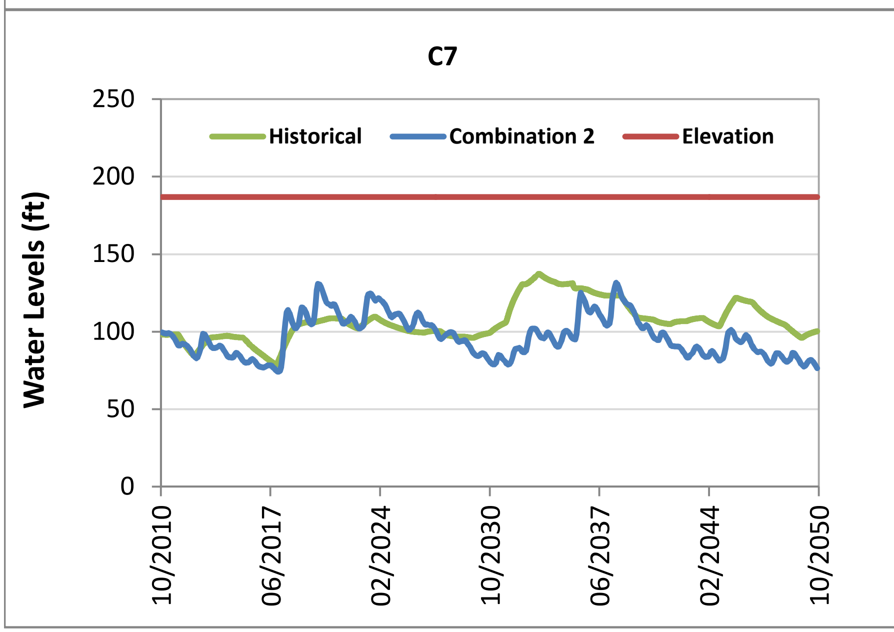

C2
Historical
Combination 2
Elevation
Water Levels (ft)
250
200
150
100
50
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

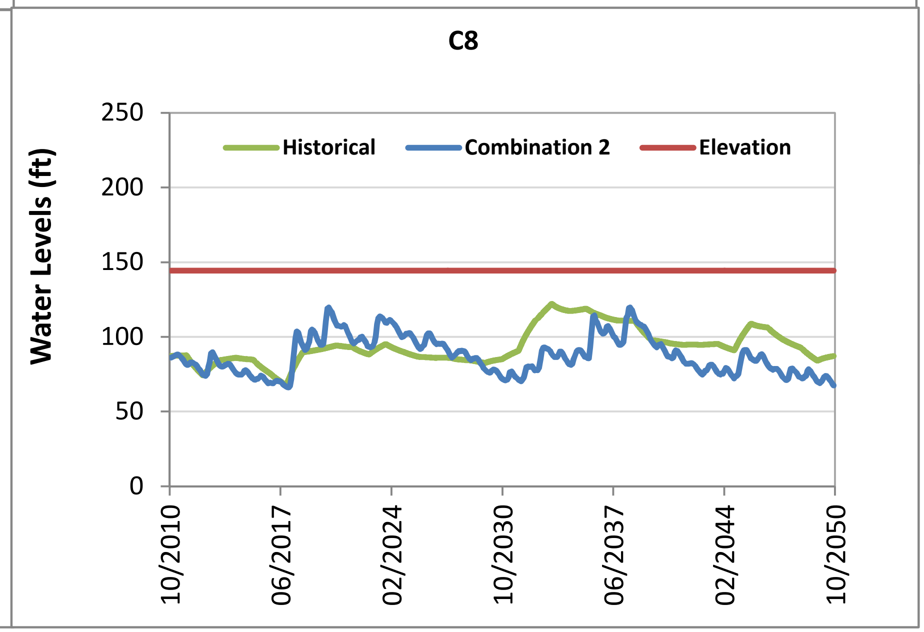

C3
Historical
Combination 2
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

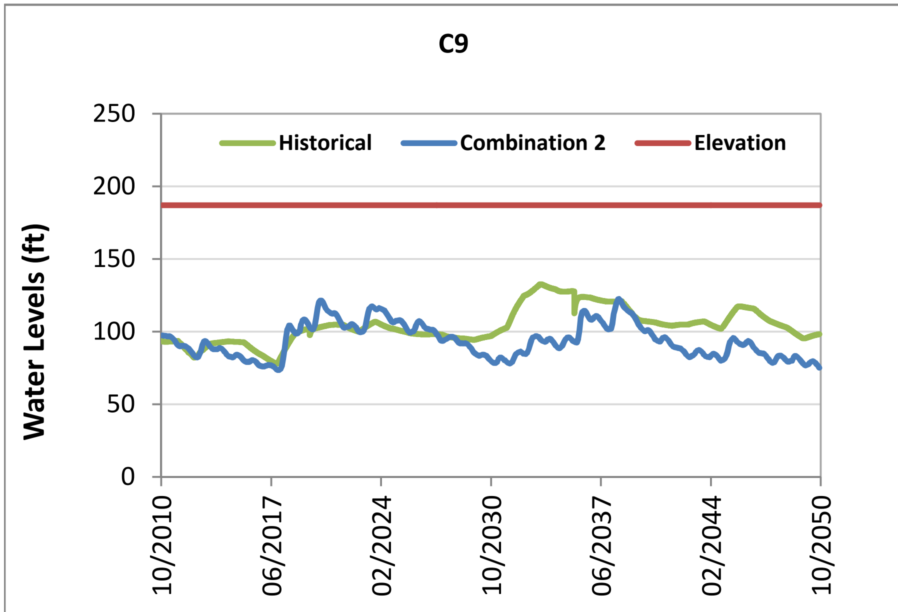

C4
Historical
Combination 2
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

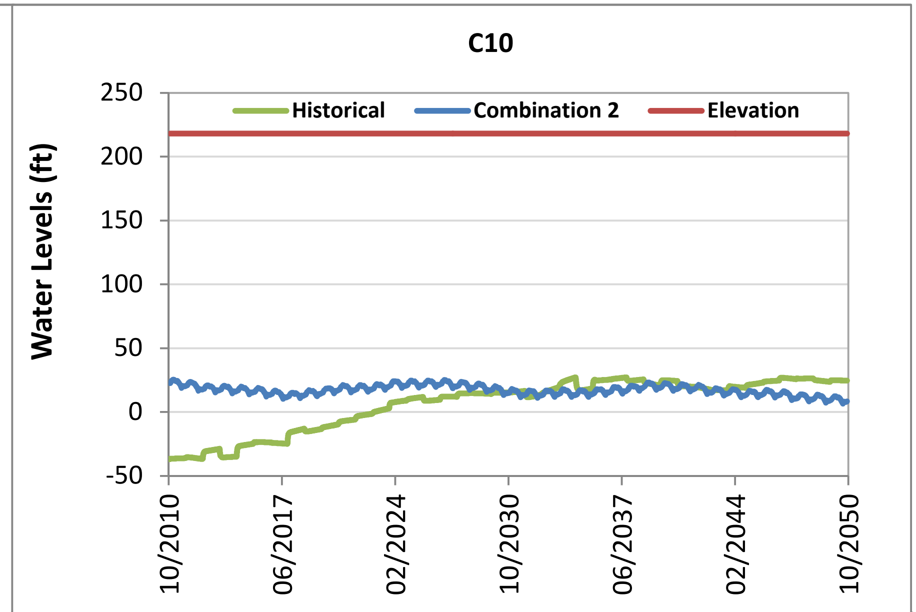

C5
Water Levels (ft)
250
200
150
100
50
0
Historical
Combination 2
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

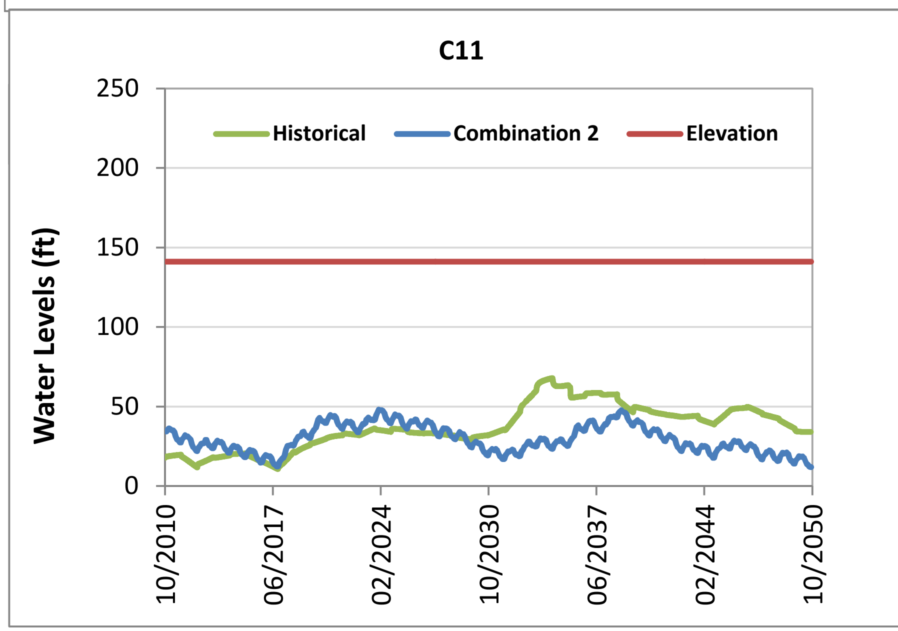

C6
Water Levels (ft)
250
200
150
100
50
0
Historical
Combination 2
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

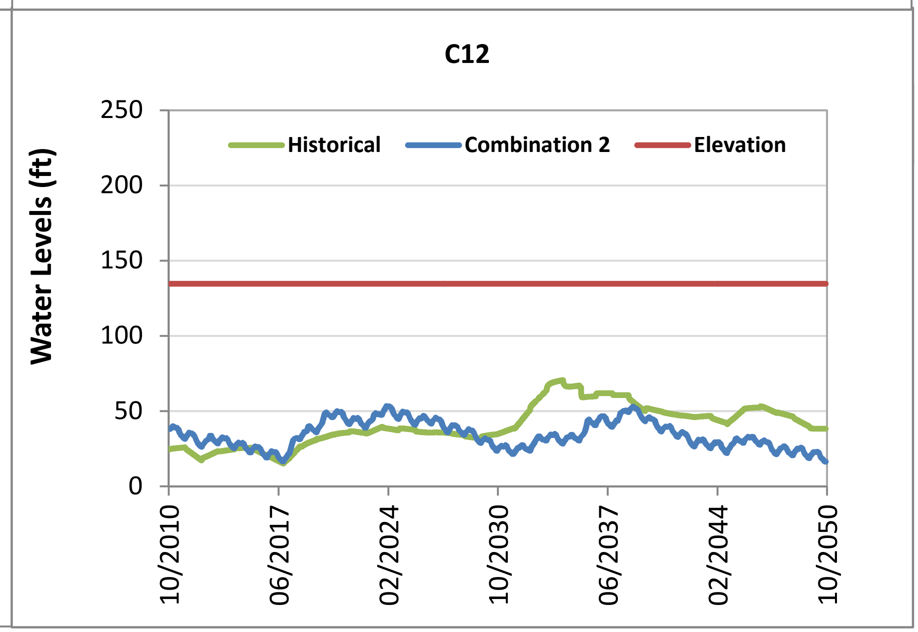

C7
Water Levels (ft)
250
200
150
100
50
0
Historical
Combination 2
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

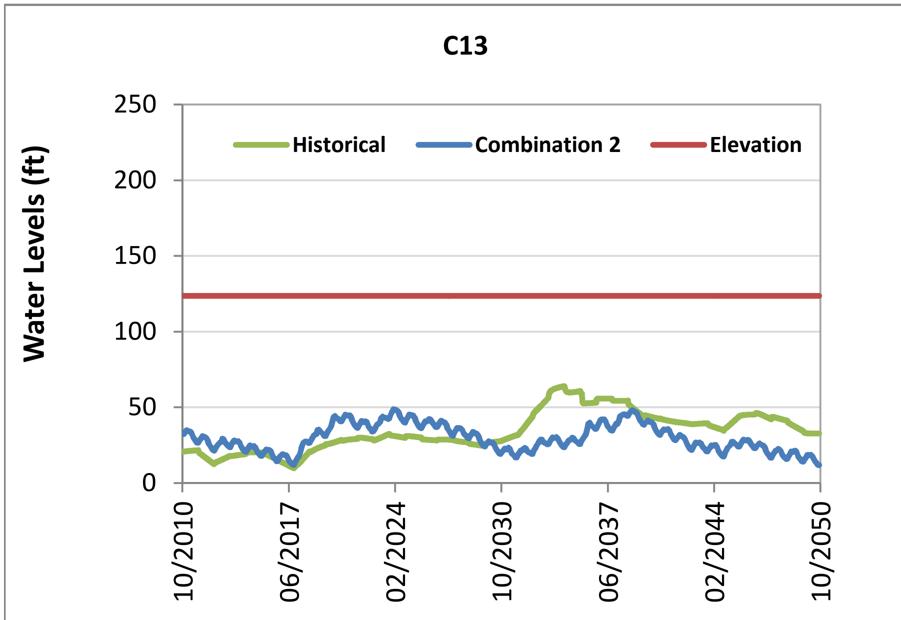

C8
Water Levels (ft)
250
200
150
100
50
0
Historical
Combination 2
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

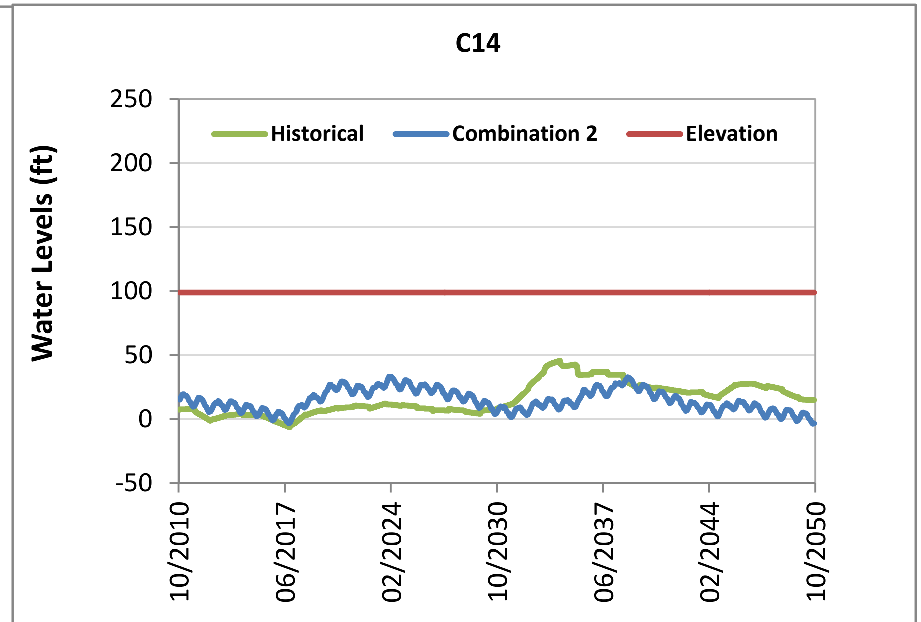

C9
Historical
Combination 2
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

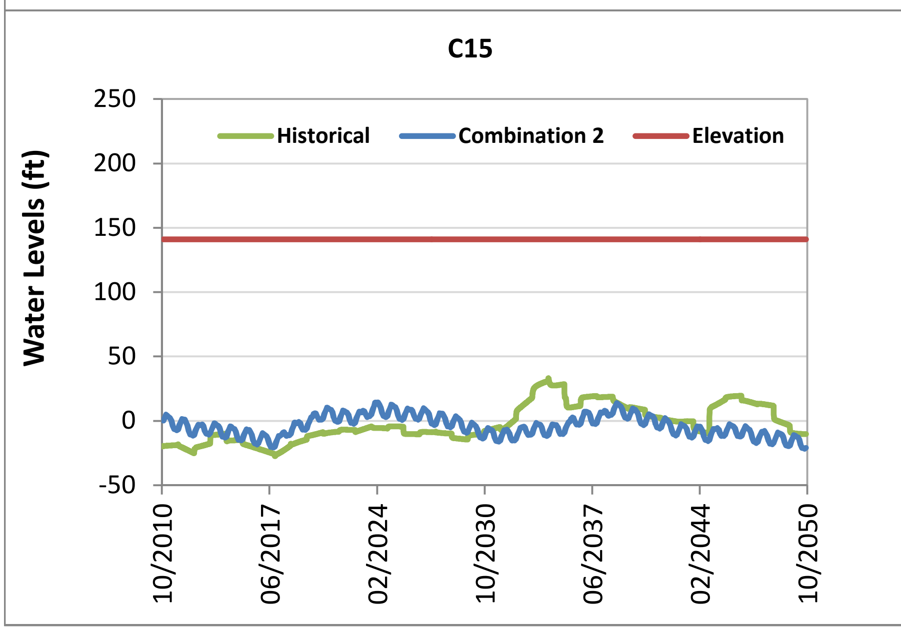

C10
Historical
Combination 2
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

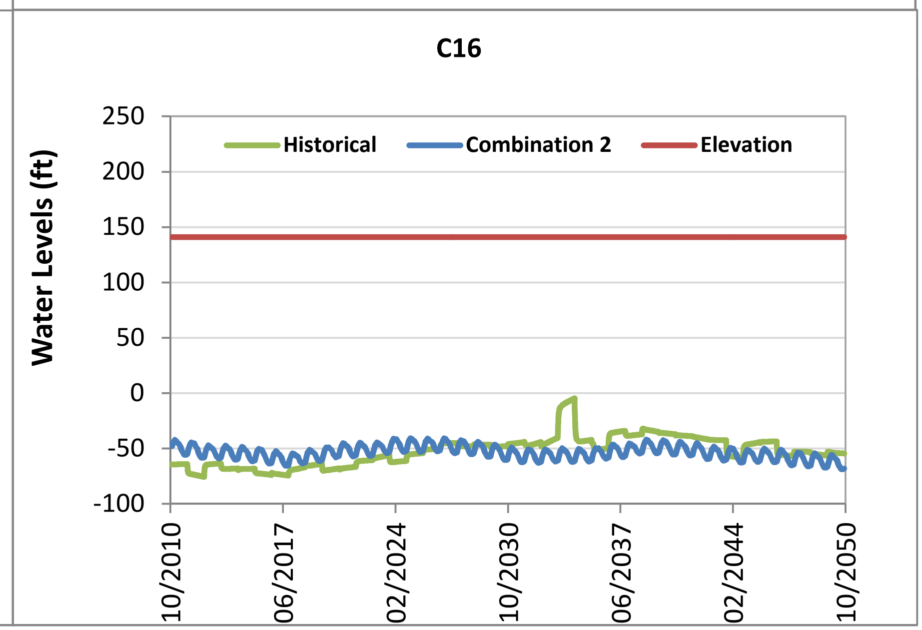

C11
Historical
Combination 2
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

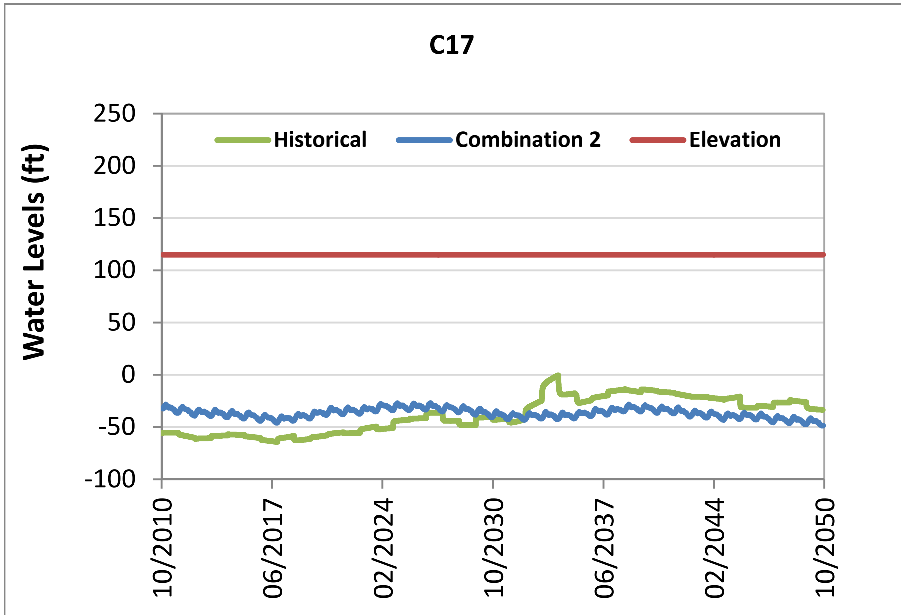

C12
Historical
Combination 2
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

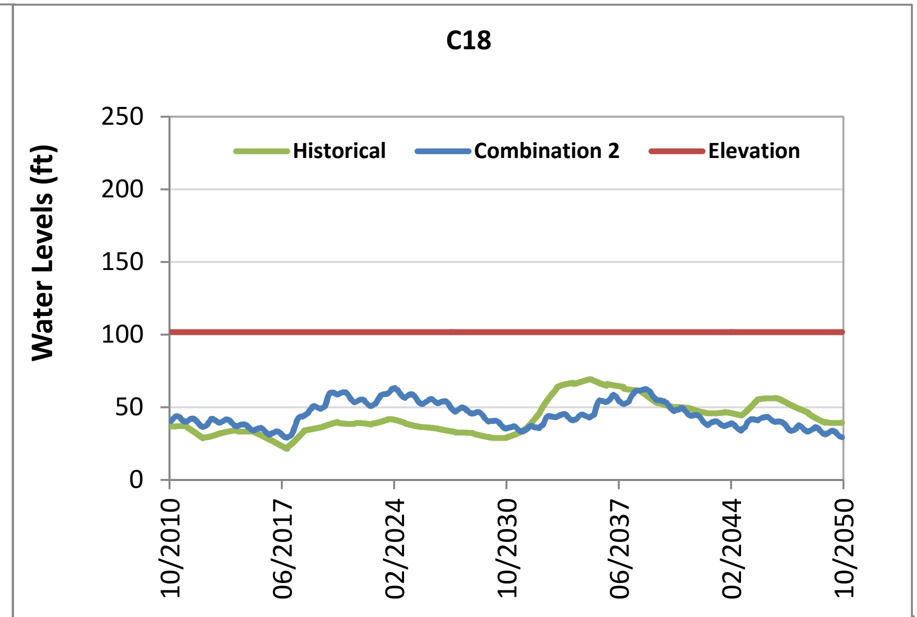

C13
Water Levels (ft)
250
200
150
100
50
0
Historical
Combination 2
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

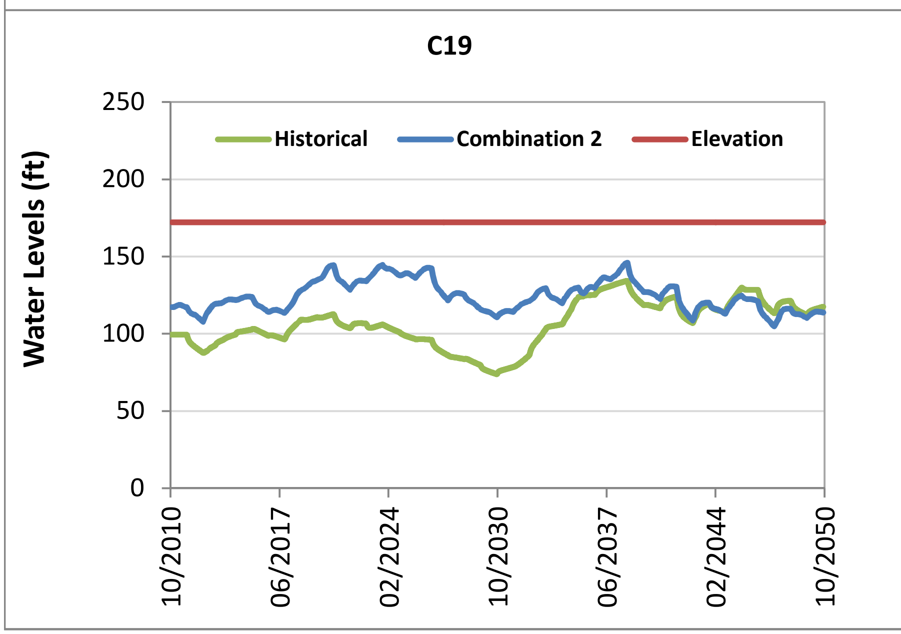

C14
Water Levels (ft)
250
200
150
100
50
0
-50
Historical
Combination 2
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

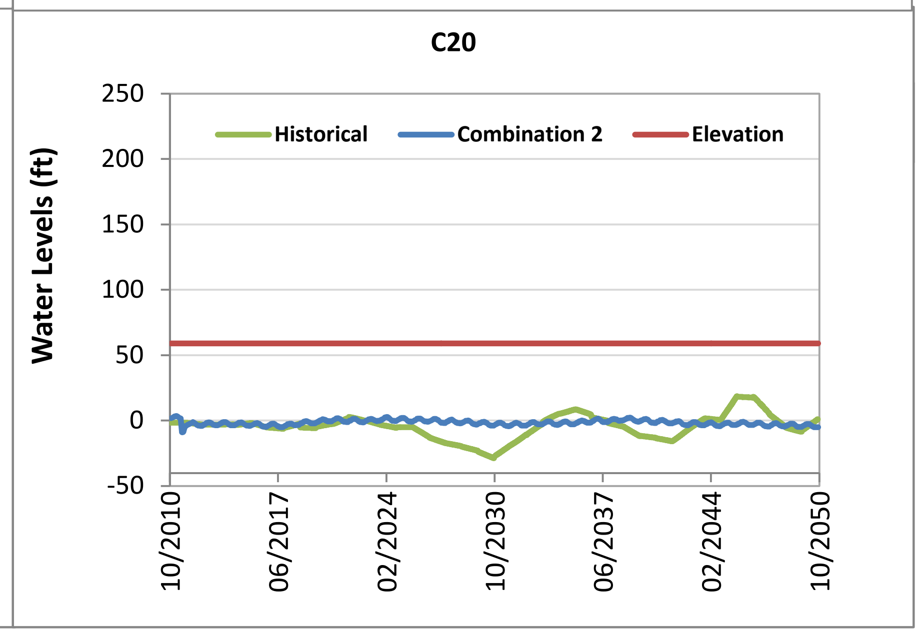

C15
Water Levels (ft)
250
200
150
100
50
0
-50
Historical
Combination 2
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

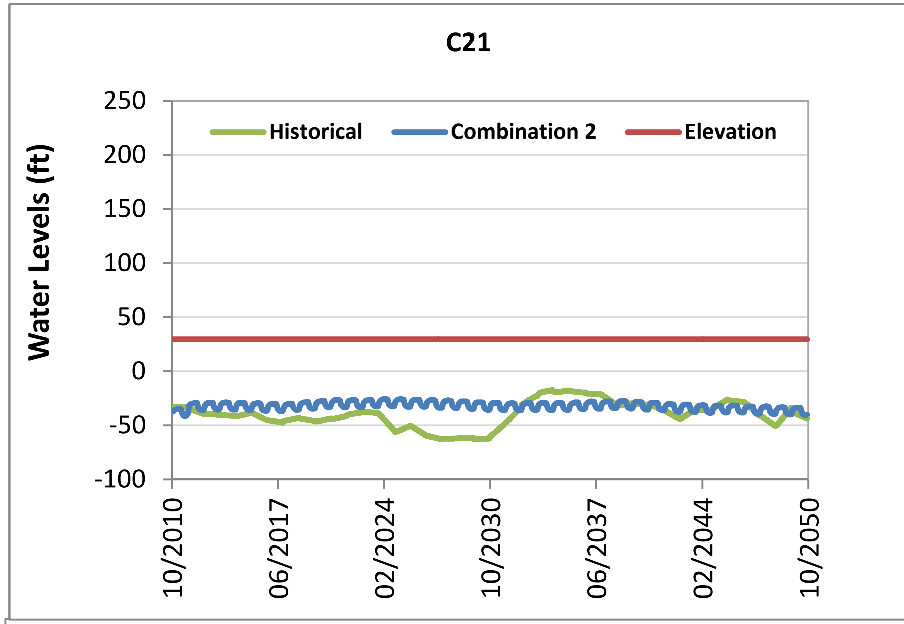

C16
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 2
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

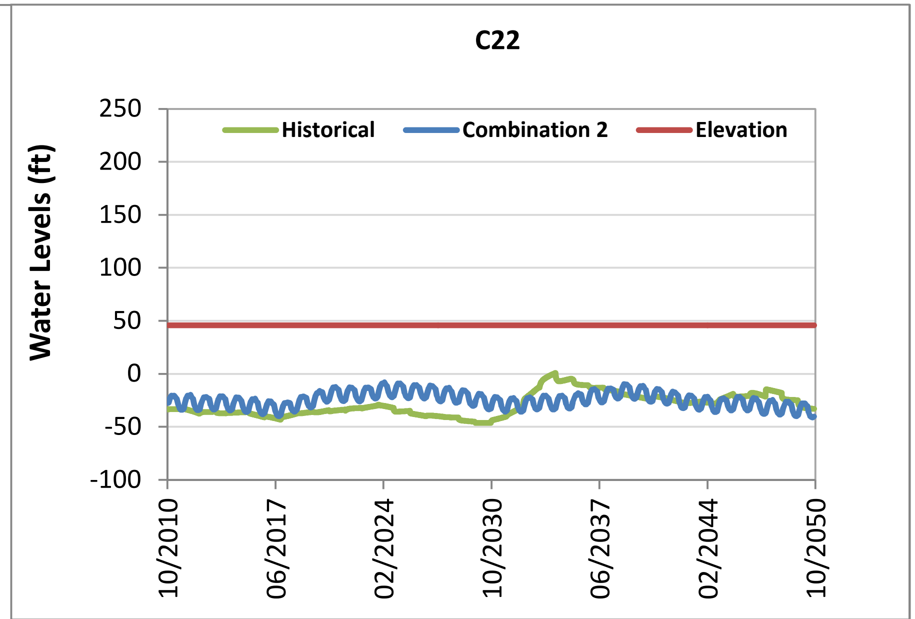

C17
Water Levels (ft)
Historical
Combination 2
Elevation
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

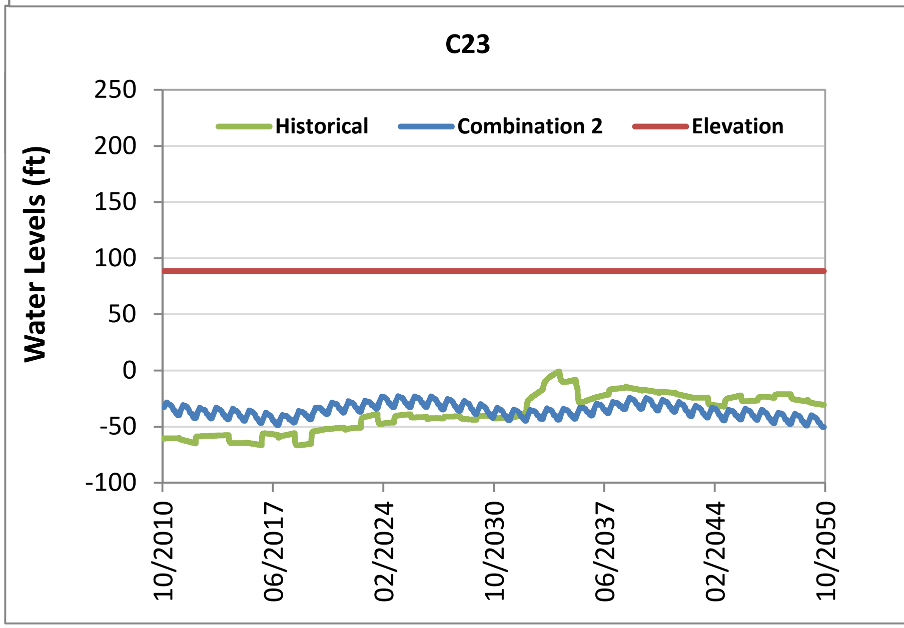

C18
Water Levels (ft)
Historical
Combination 2
Elevation
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

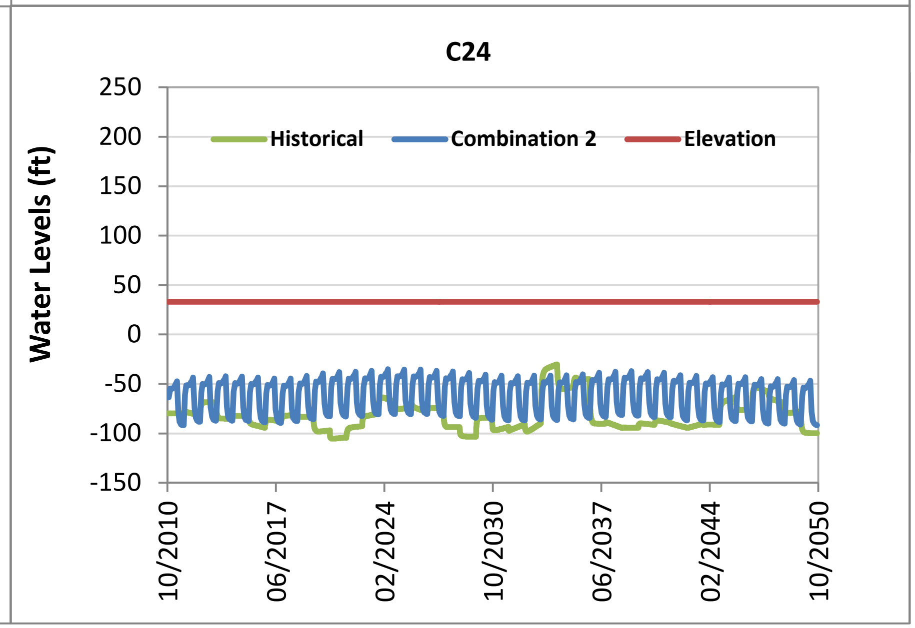

C19
Water Levels (ft)
Historical
Combination 2
Elevation
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

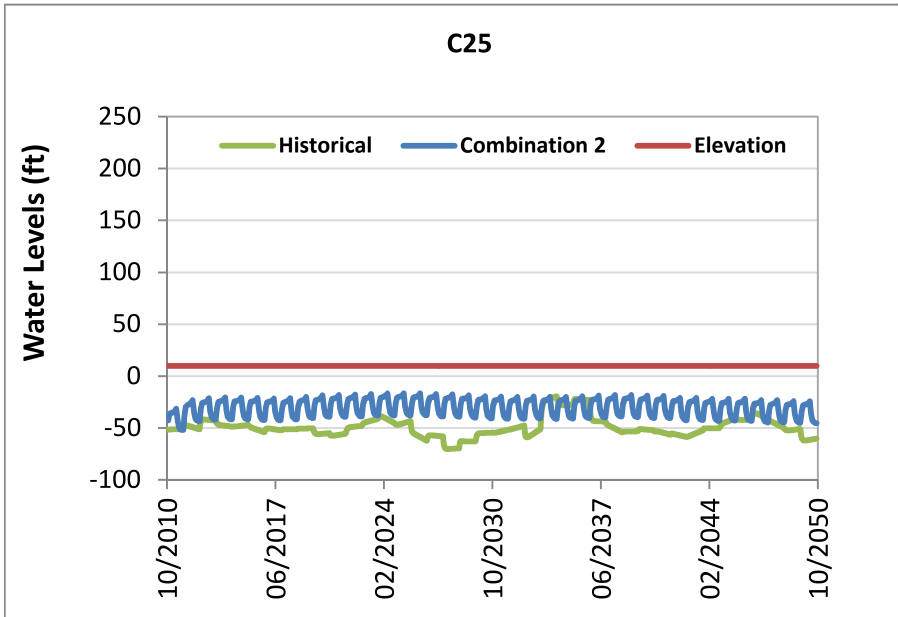

C20
Water Levels (ft)
Historical
Combination 2
Elevation
250
200
150
100
50
0
-50
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C21
Historical
Combination 2
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C22
Historical
Combination 2
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C23
Historical
Combination 2
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C24
Historical
Combination 2
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C25
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 2
Elevation
10/2010
06/2017
02/2024
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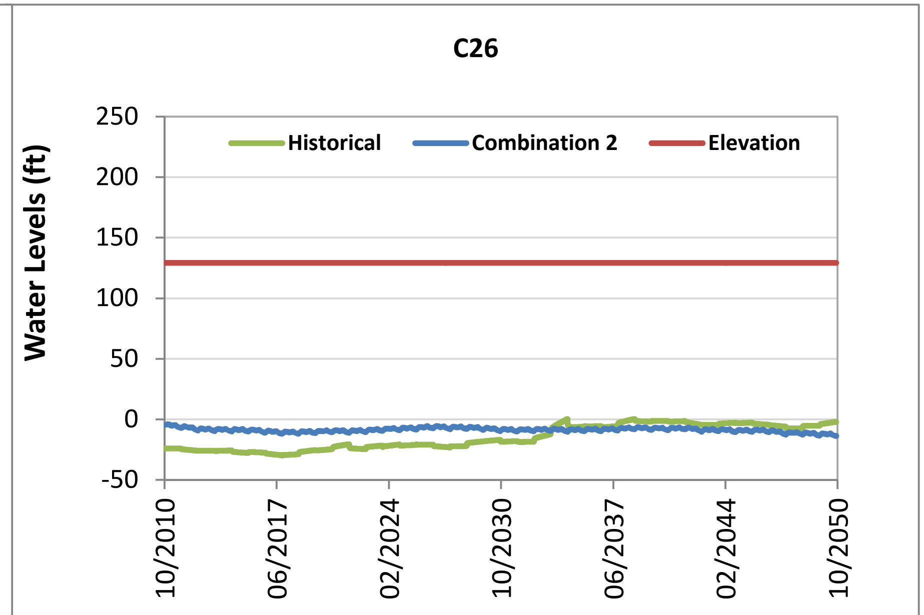
06/2037
02/2044
10/2050


C26
Water Levels (ft)
250
200
150
100
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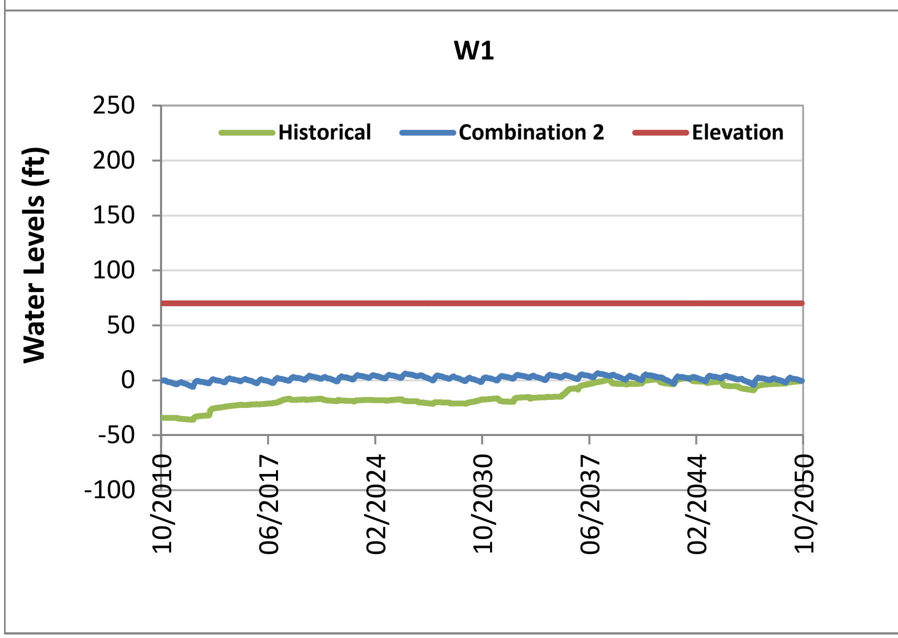
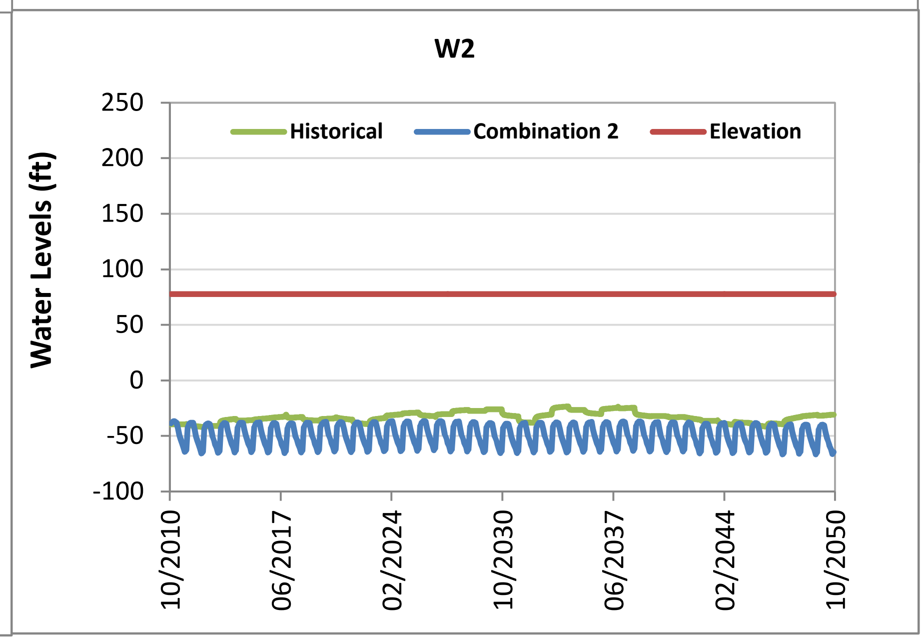
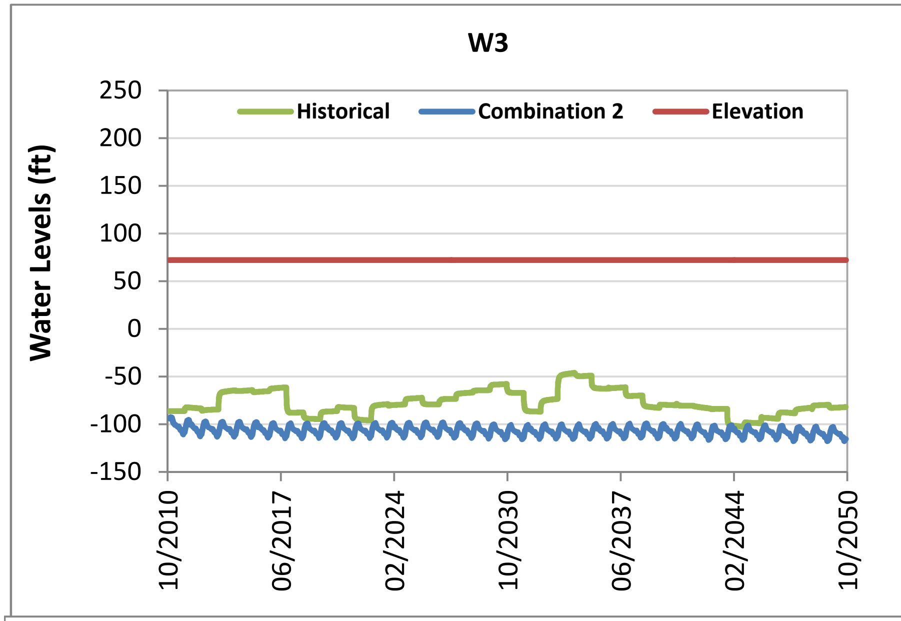
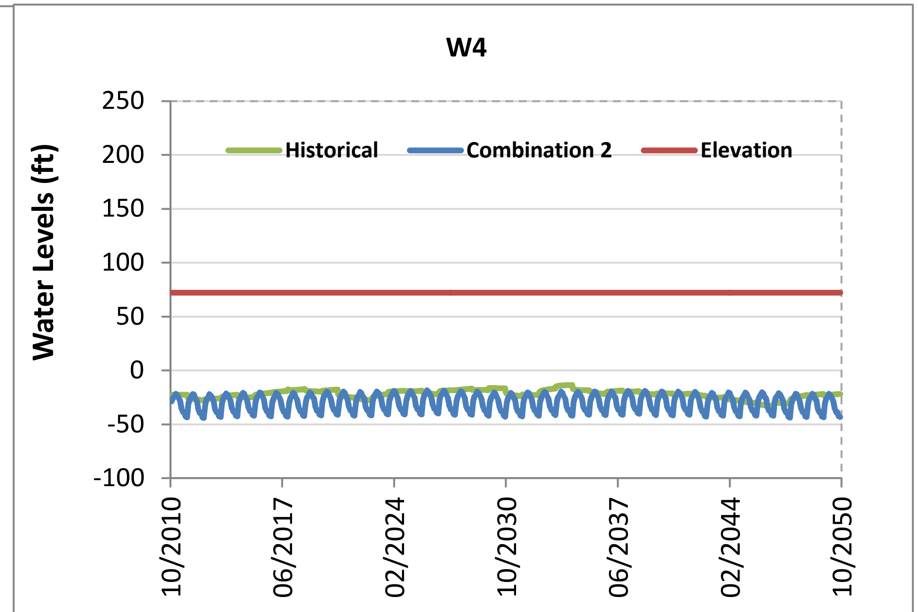
-50
Historical
Combination 2
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W1
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 2
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W2
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 2
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W3
Historical
Combination 2
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W4
Historical
Combination 2
Elevation
Water Levels (ft)
250
200
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100
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0
-50
-100
10/2010
06/2017
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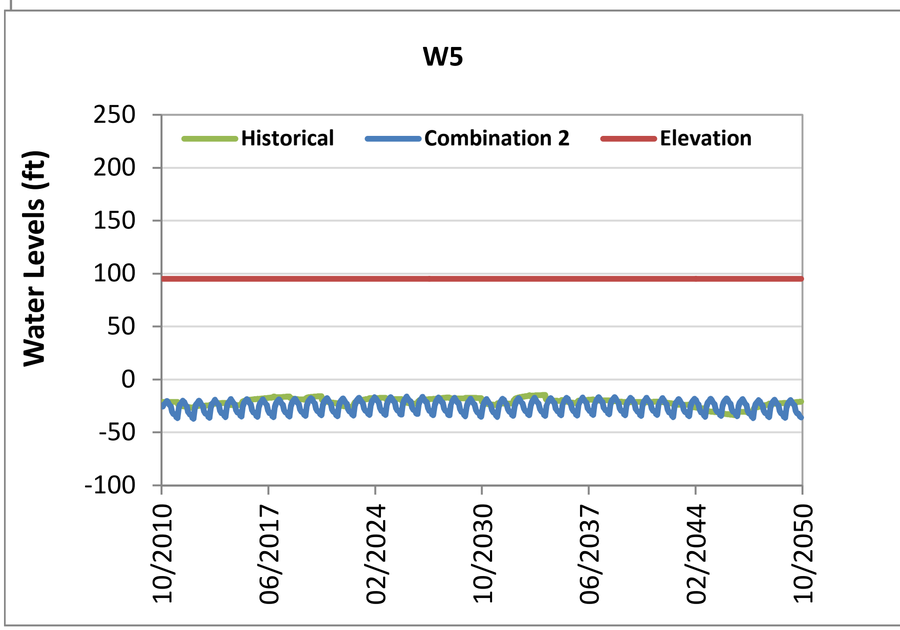
06/2037
02/2044
10/2050


W5
Historical
Combination 2
Elevation
Water Levels (ft)
250
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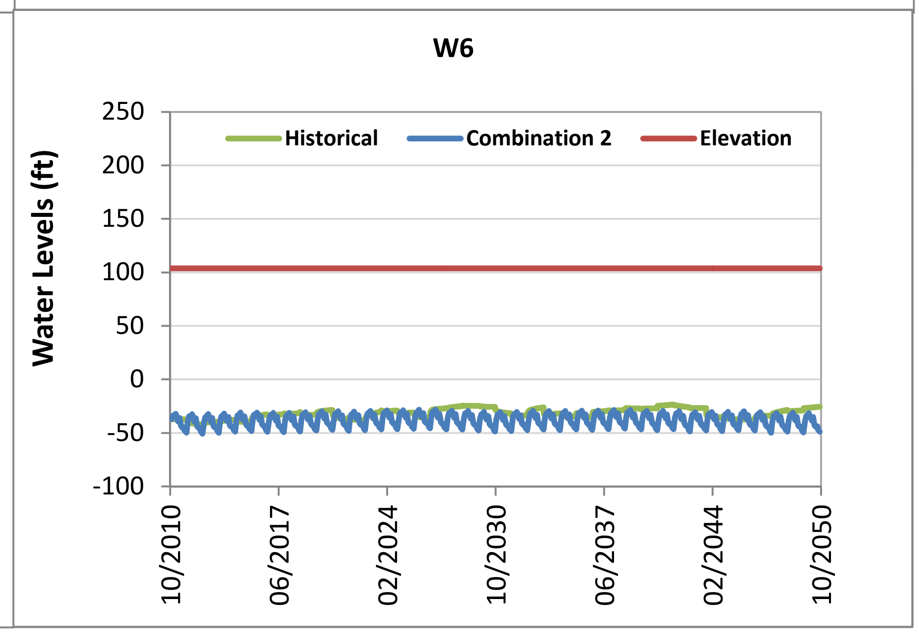
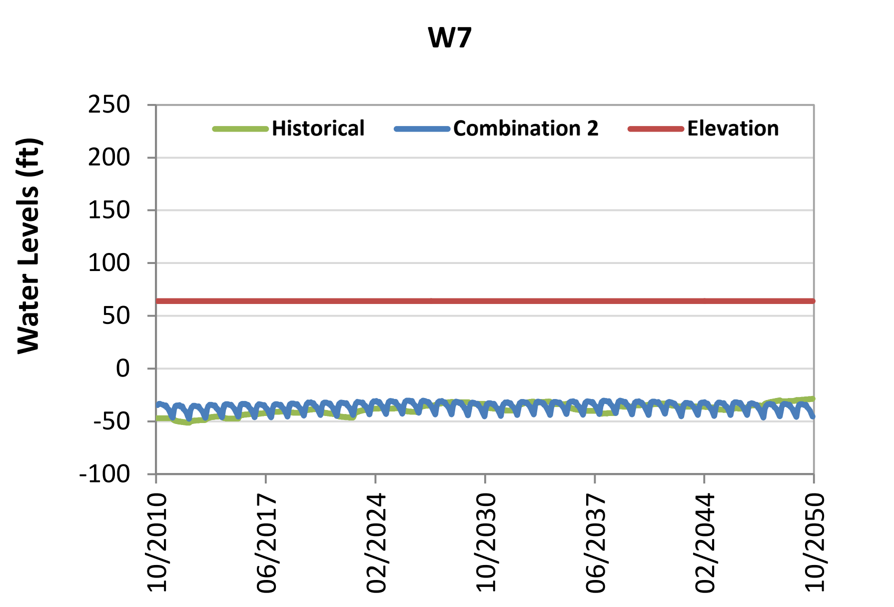
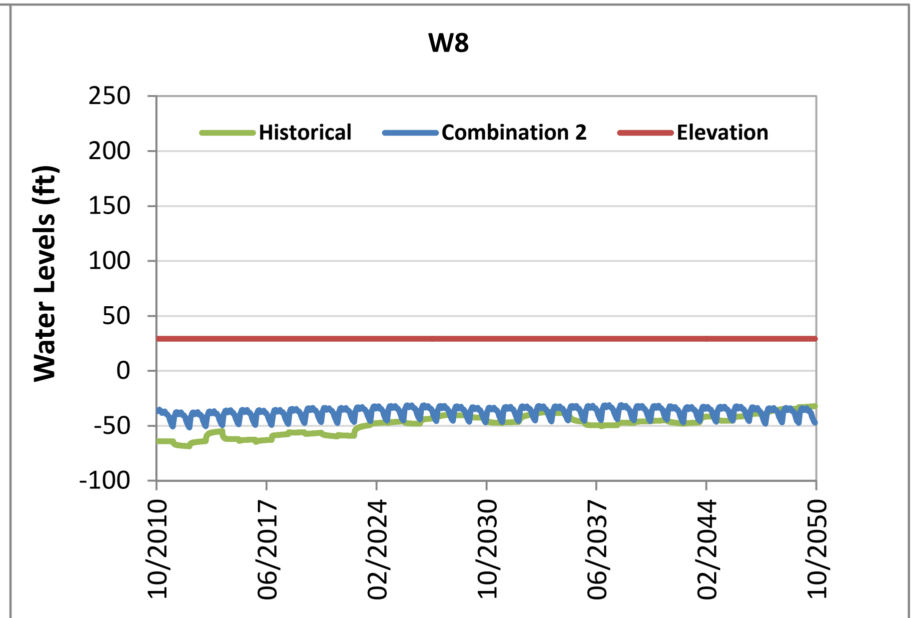
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W6
Historical
Combination 2
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W7
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 2
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W8
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 2
Elevation
10/2010
06/2017
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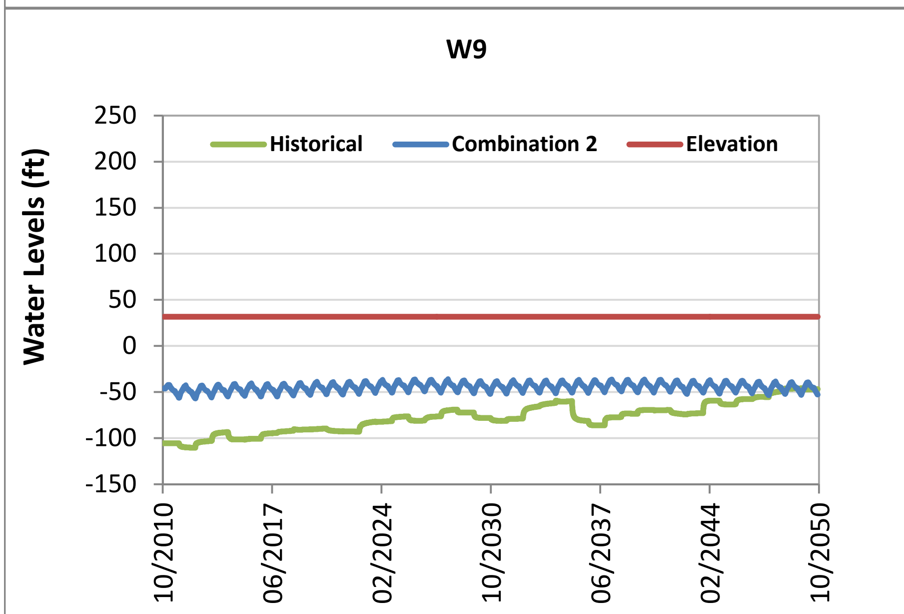
10/2030
06/2037
02/2044
10/2050


W9
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
Historical
Combination 2
Elevation
10/2010
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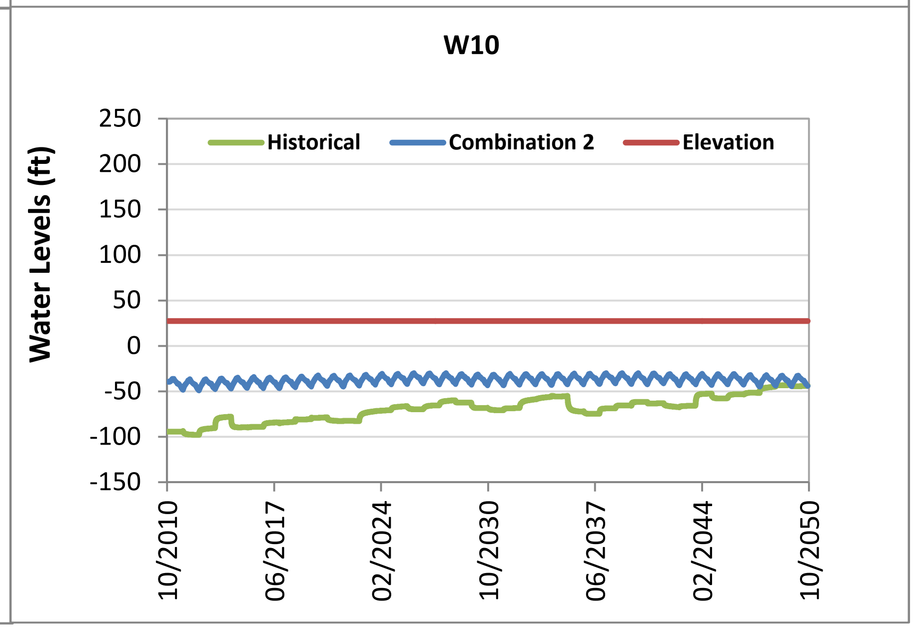
10/2030
06/2037
02/2044
10/2050


W10
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
Historical
Combination 2
Elevation
10/2010
06/2017
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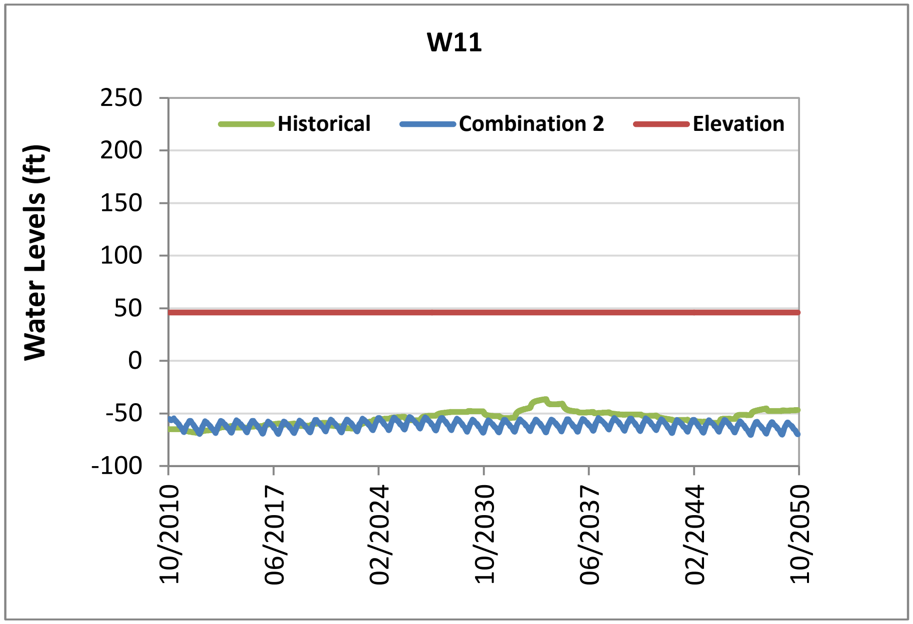
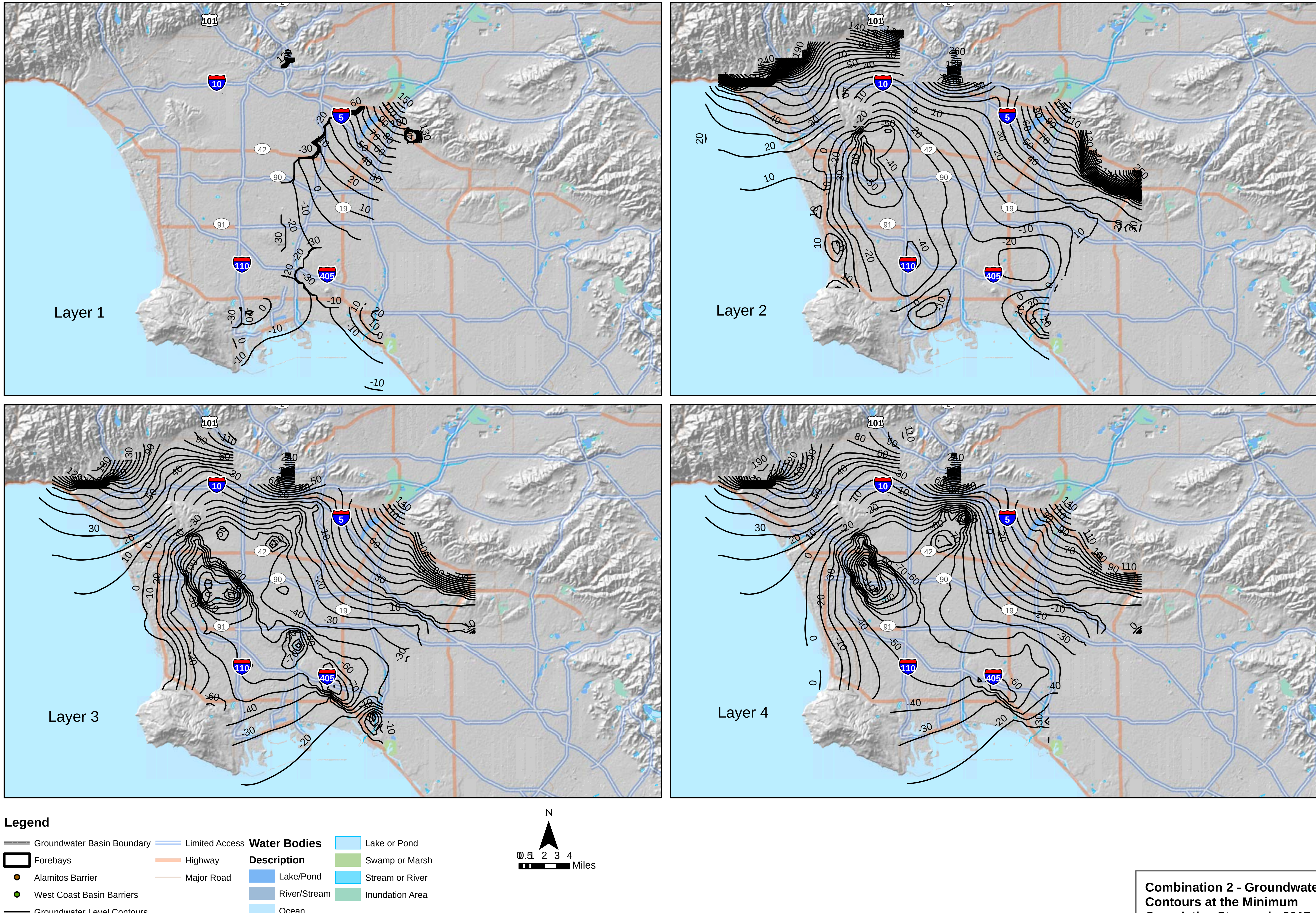
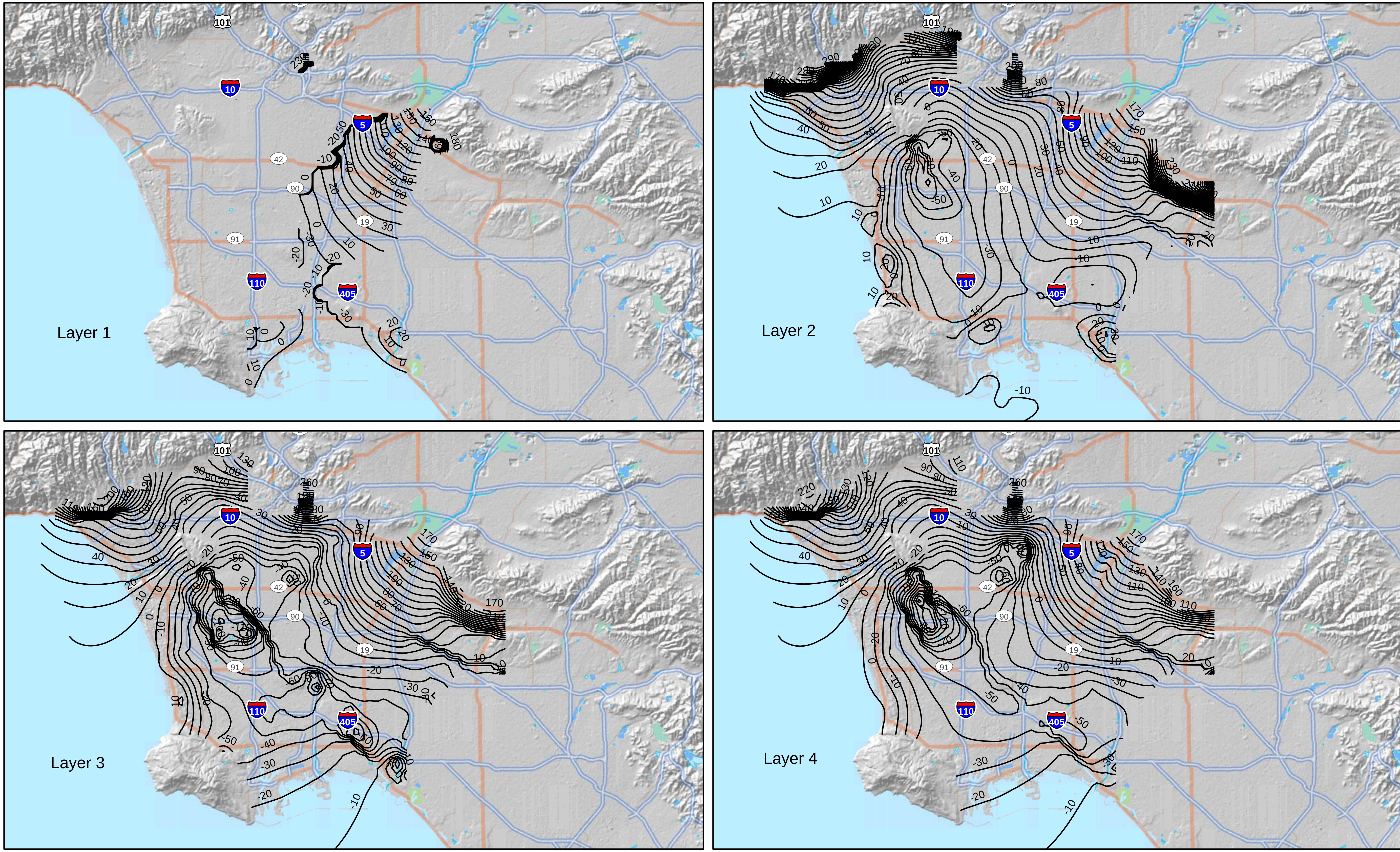
10/2030
06/2037
02/2044
10/2050


W11
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 2
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050



Combination 2 - Groundwater Level Contours at the Minimum Cumulative Storage in 2017



Legend

- Groundwater Basin Boundary
- Forebays
- Alamitos Barrier
- West Coast Basin Barriers
- Groundwater Level Contours
- Limited Access
- Highway
- Major Road

Water Bodies

Description

- Lake/Pond
- River/Stream
- Ocean
- Lake or Pond
- Swamp or Marsh
- Stream or River
- Inundation Area

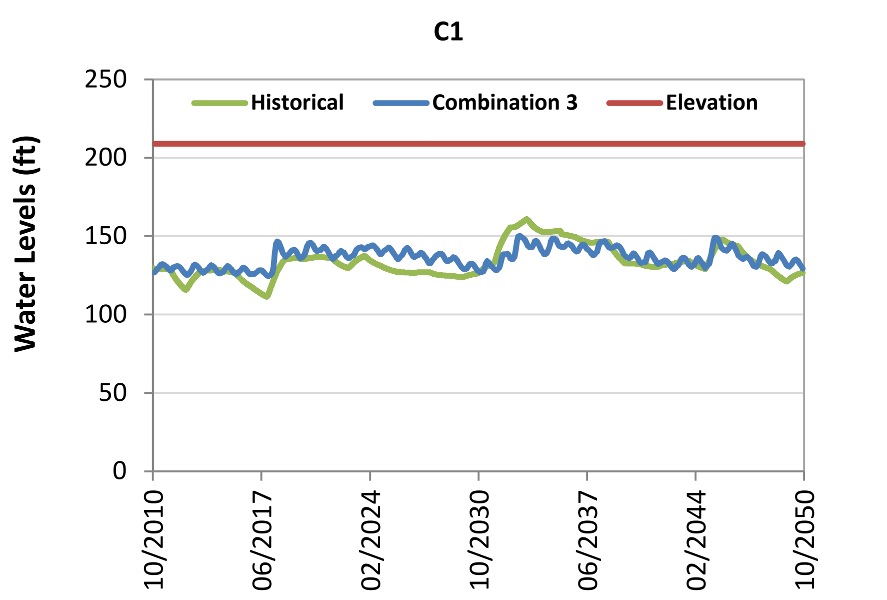
N

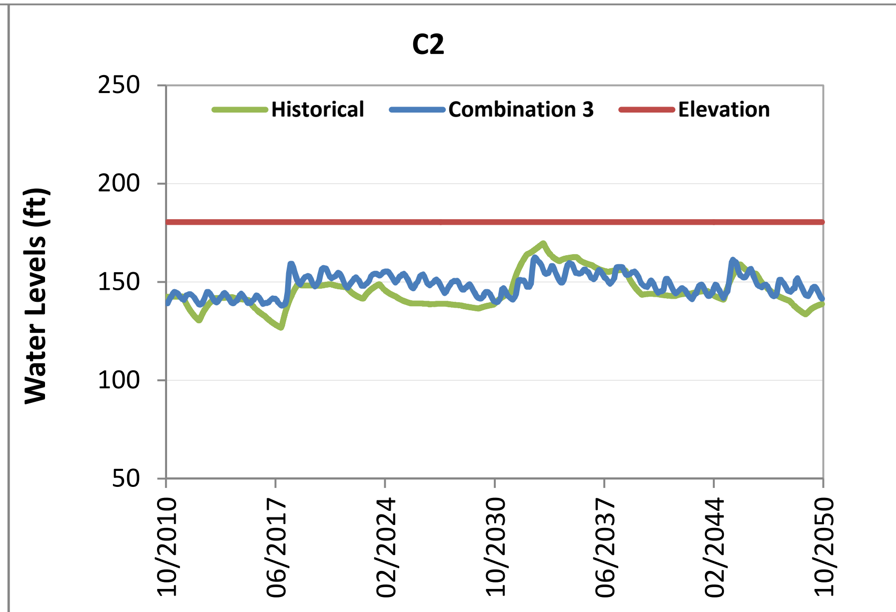
0 0.5 1 2 3 4 Miles

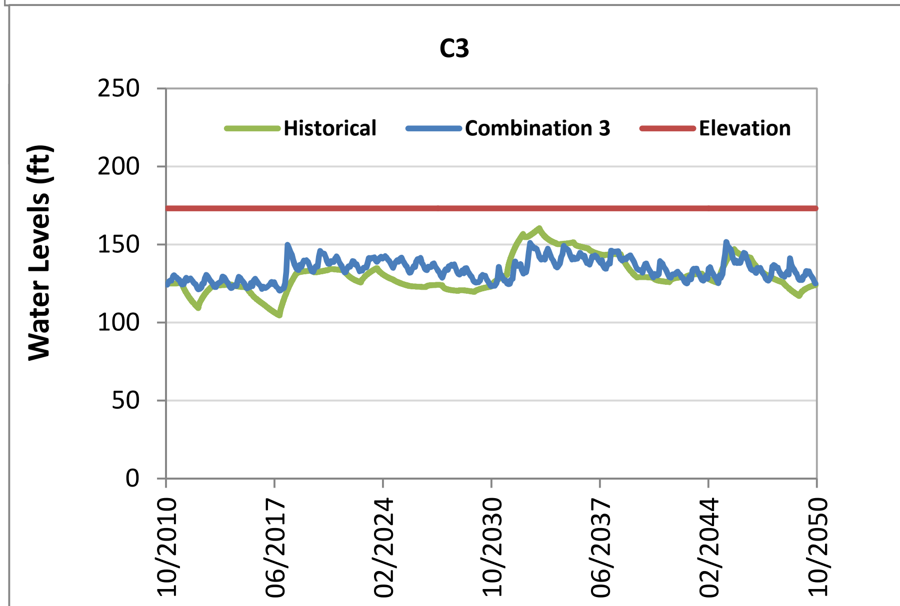
Combination 2 - Groundwater Level Contours at the Maximum Cumulative Storage in 2038

File Location

Combination 3 Model Results:
1) Hydrographs
2) Groundwater Level Contour Maps


C1
Water Levels (ft)
250
200
150
100
50
0
Historical
Combination 3
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C2
Water Levels (ft)
250
200
150
100
50
Historical
Combination 3
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C3
Water Levels (ft)
250
200
150
100
50
0
Historical
Combination 3
Elevation
10/2010
06/2017
02/2024
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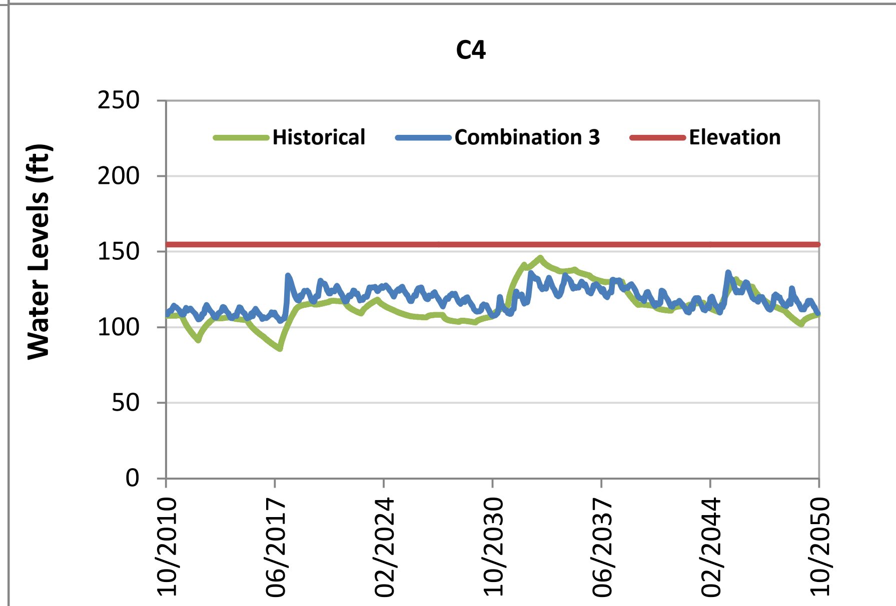
06/2037
02/2044
10/2050


C4
Water Levels (ft)
250
200
150
100
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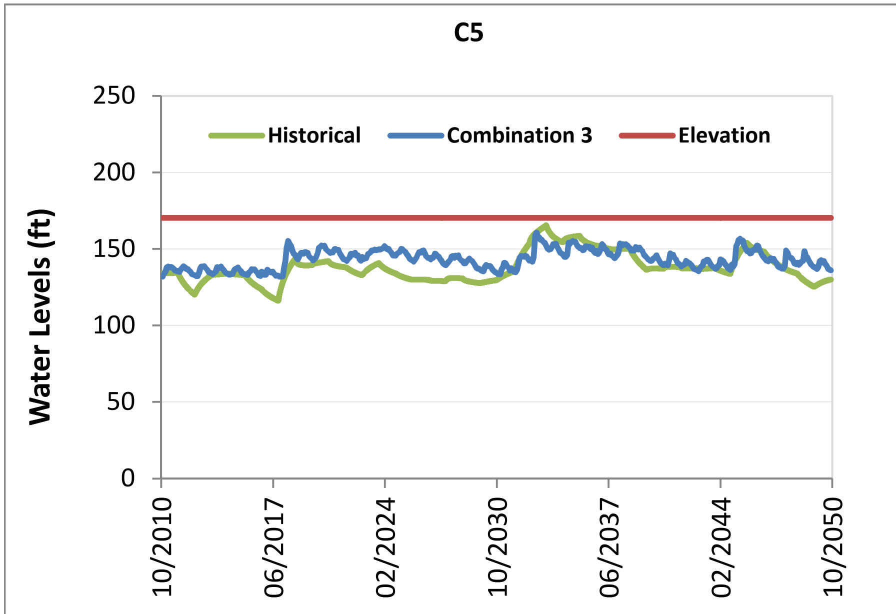
0
Historical
Combination 3
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C5
Historical
Combination 3
Elevation
Water Levels (ft)
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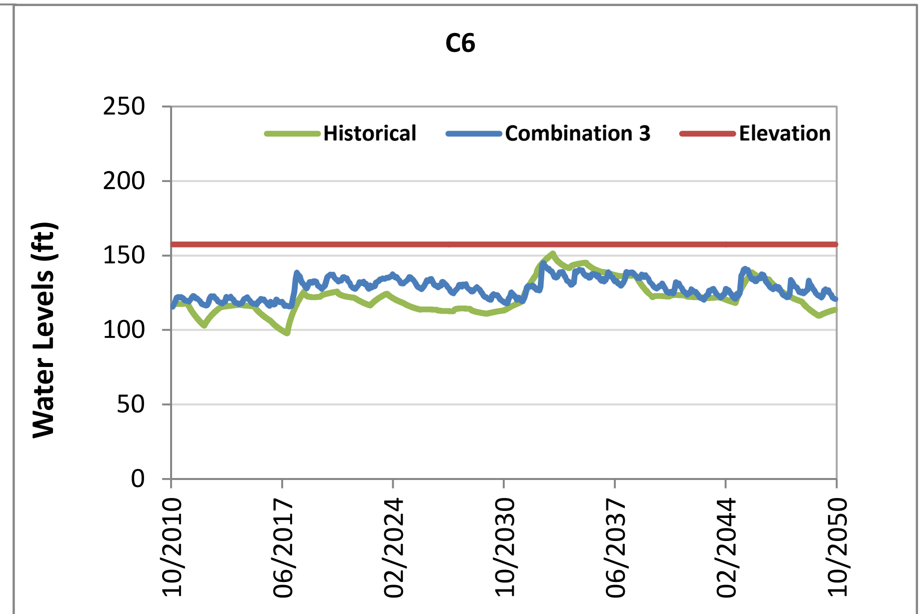
100
150
200
250
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C6
Historical
Combination 3
Elevation
Water Levels (ft)
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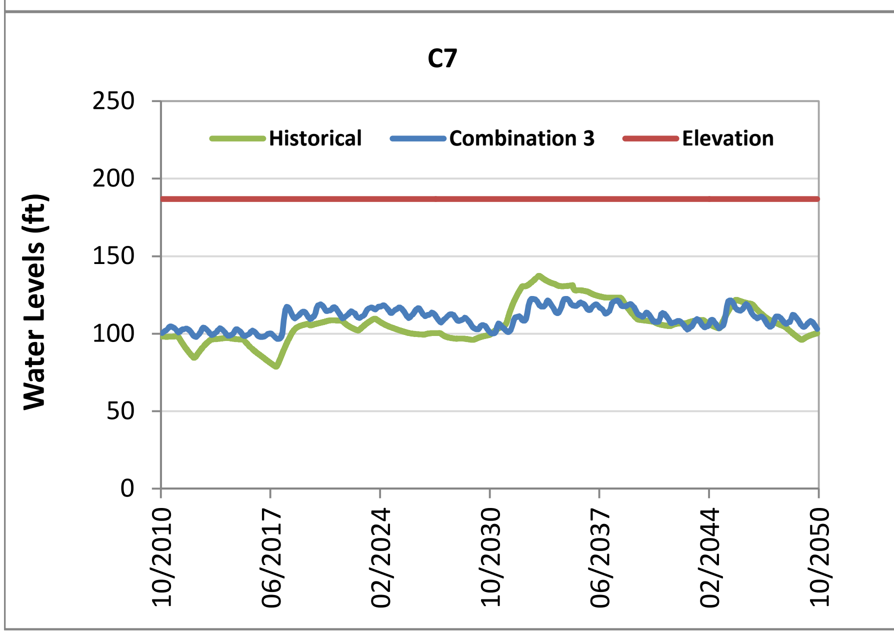
100
150
200
250
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C7
Historical
Combination 3
Elevation
Water Levels (ft)
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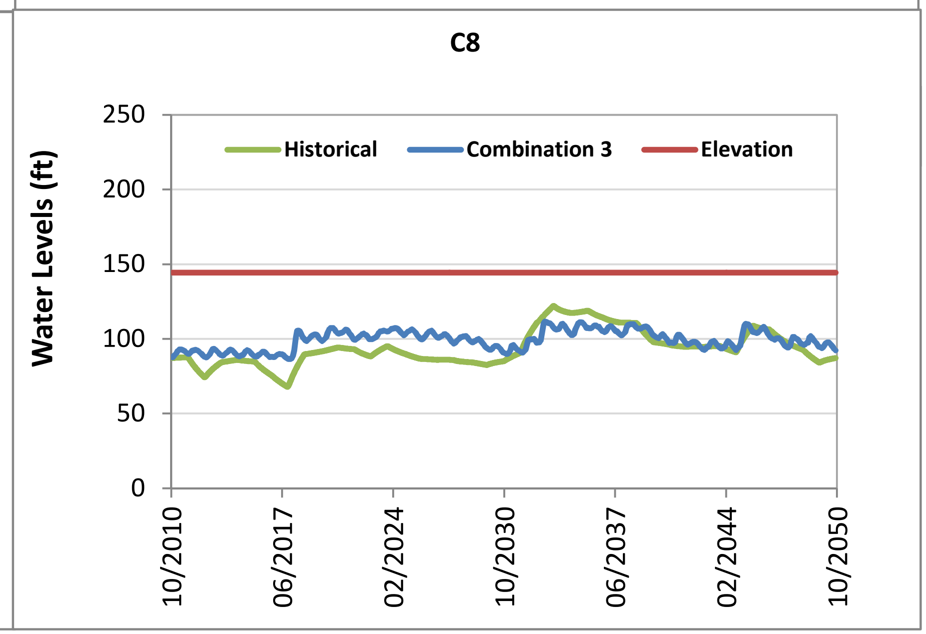
150
200
250
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C8
Historical
Combination 3
Elevation
Water Levels (ft)
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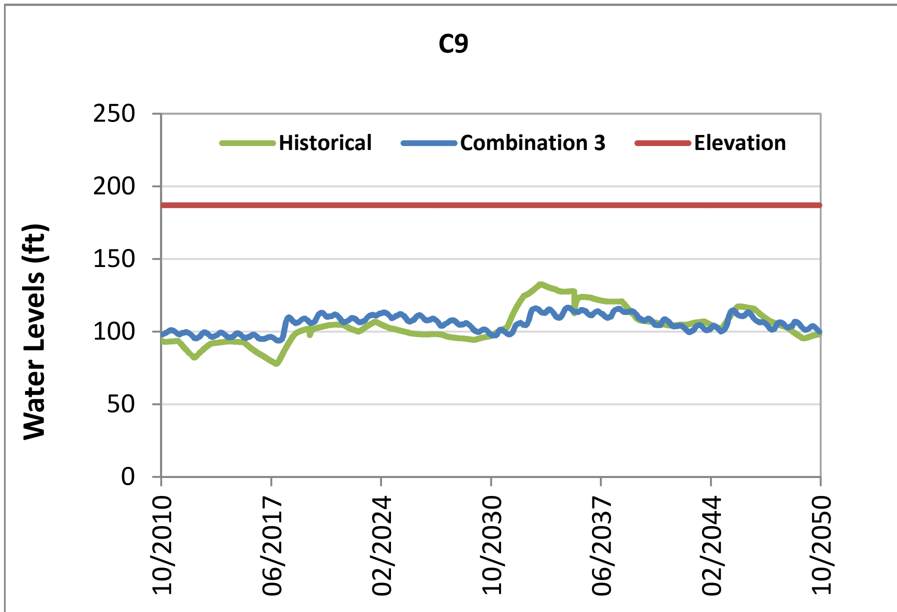
150
200
250
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C9
Historical
Combination 3
Elevation
Water Levels (ft)
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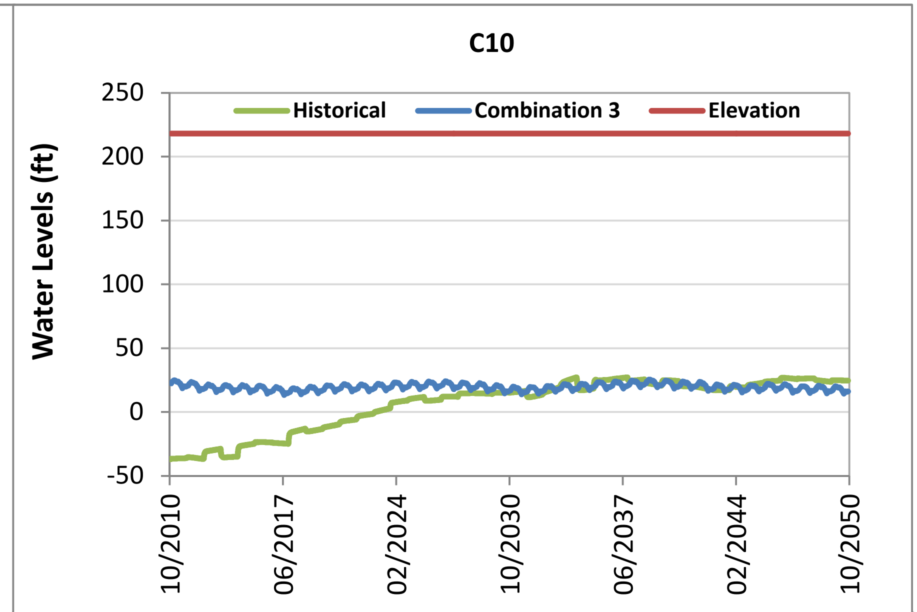
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C10
Historical
Combination 3
Elevation
Water Levels (ft)
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-50
10/2010
06/2017
02/2024
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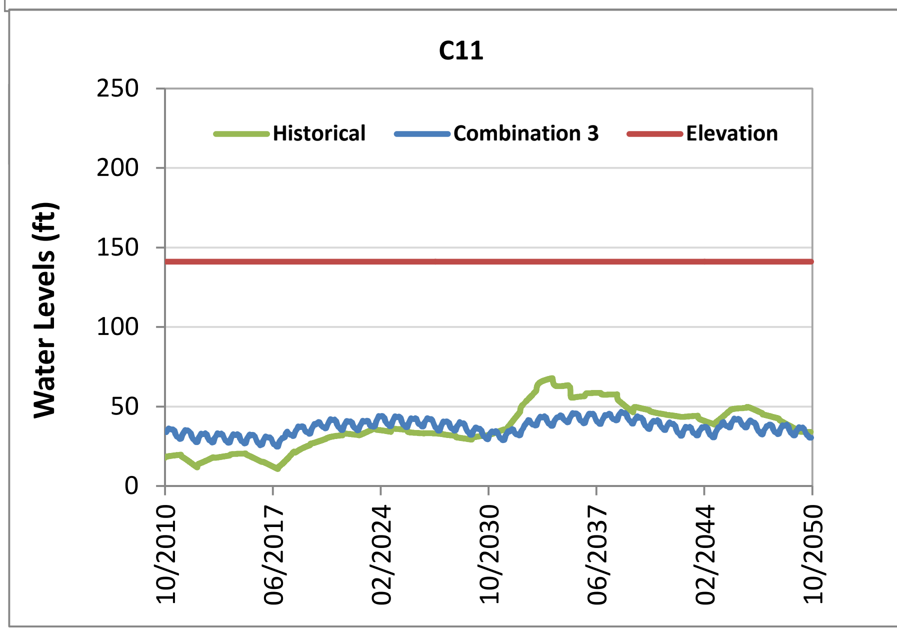
06/2037
02/2044
10/2050


C11
Historical
Combination 3
Elevation
Water Levels (ft)
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0
10/2010
06/2017
02/2024
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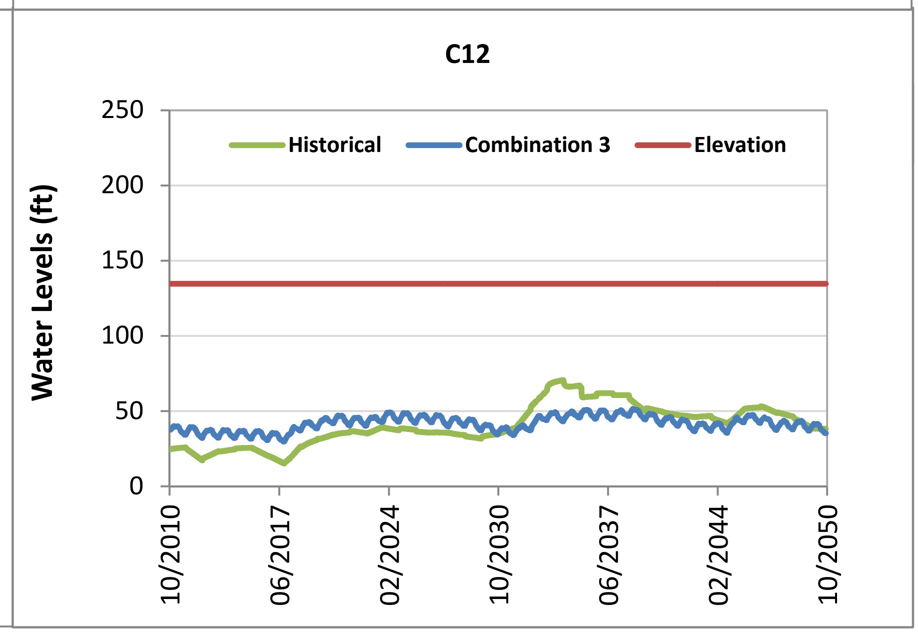
02/2044
10/2050


C12
Historical
Combination 3
Elevation
Water Levels (ft)
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10/2010
06/2017
02/2024
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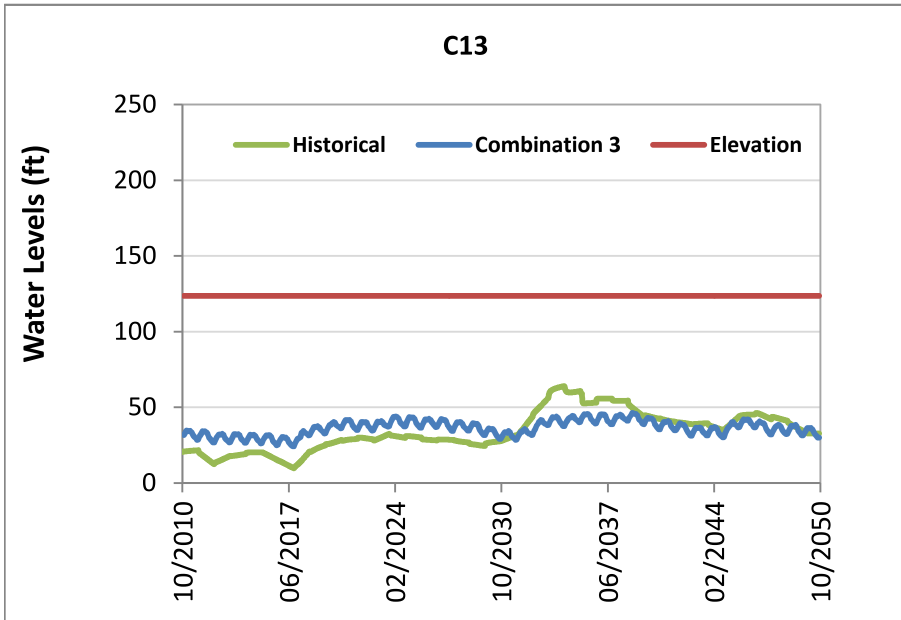
02/2044
10/2050


C13
Historical
Combination 3
Elevation
Water Levels (ft)
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100
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10/2010
06/2017
02/2024
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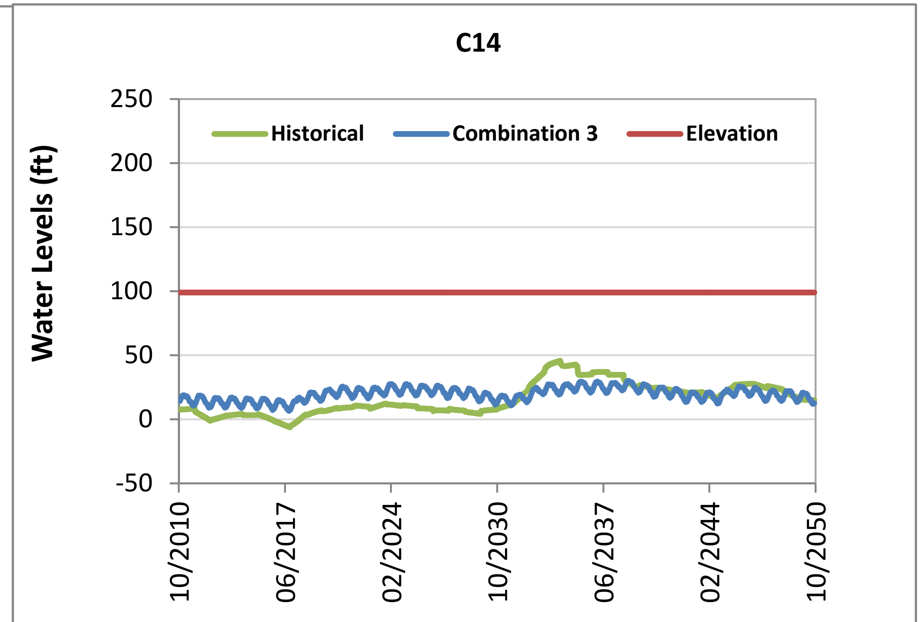
02/2044
10/2050


C14
Historical
Combination 3
Elevation
Water Levels (ft)
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-50
10/2010
06/2017
02/2024
10/2030
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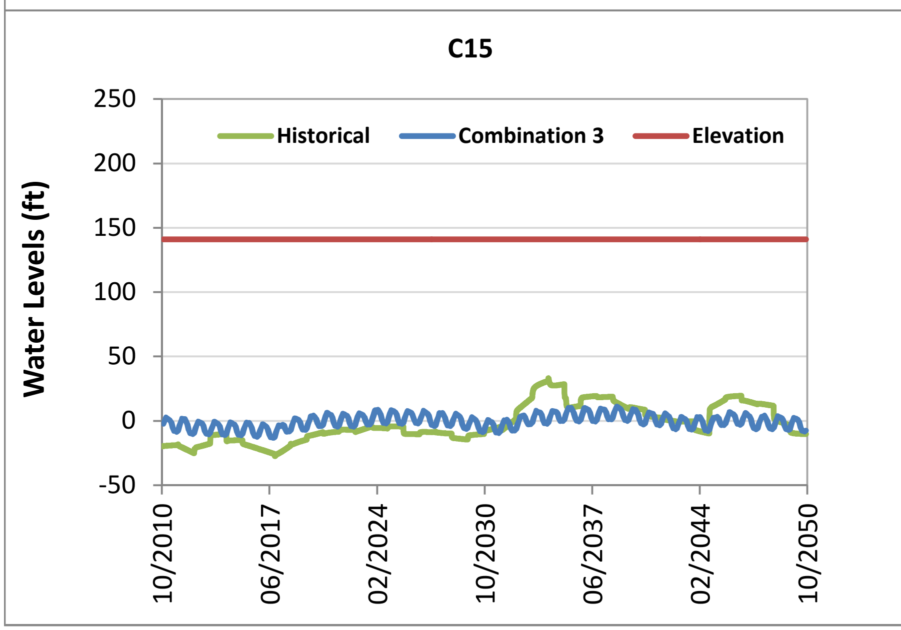
02/2044
10/2050


C15
Historical
Combination 3
Elevation
Water Levels (ft)
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-50
10/2010
06/2017
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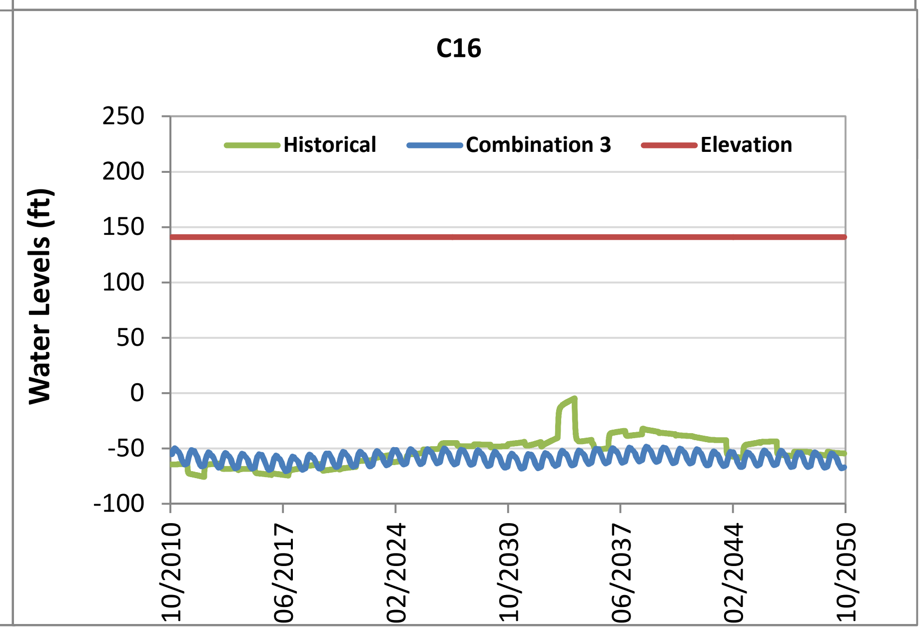
02/2044
10/2050


C16
Historical
Combination 3
Elevation
Water Levels (ft)
250
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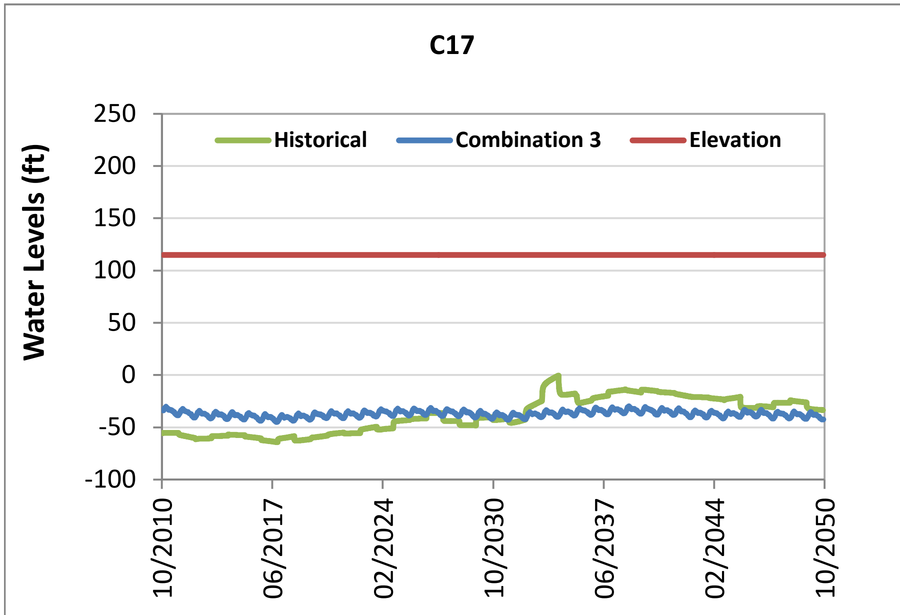
02/2044
10/2050


C17
Historical
Combination 3
Elevation
Water Levels (ft)
250
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-50
-100
10/2010
06/2017
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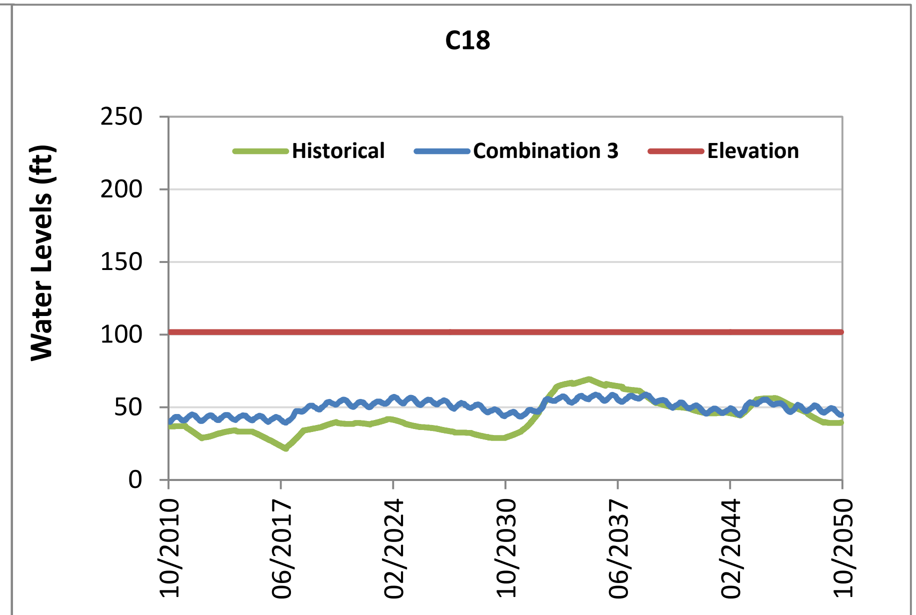
06/2037
02/2044
10/2050


C18
Historical
Combination 3
Elevation
Water Levels (ft)
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0
10/2010
06/2017
02/2024
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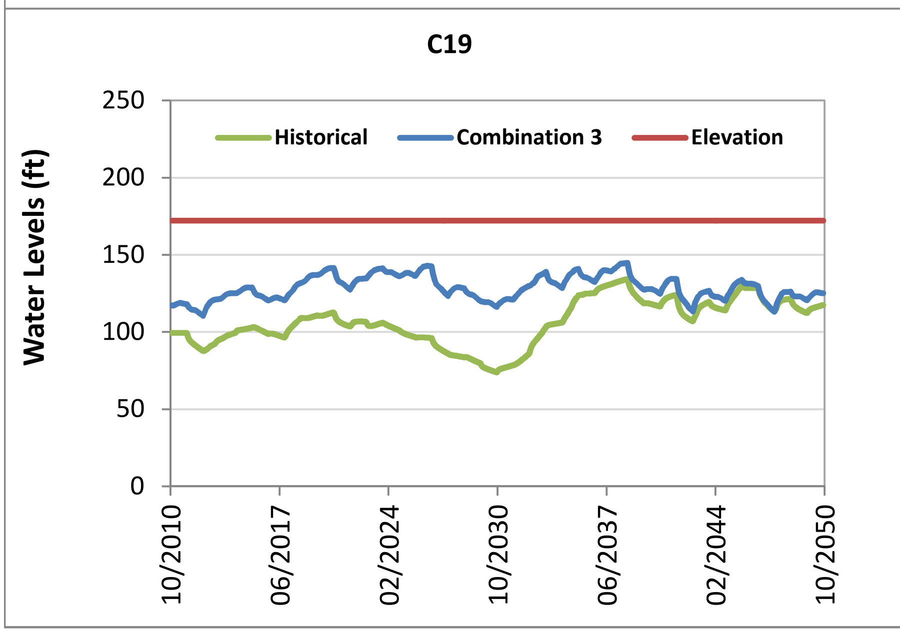
02/2044
10/2050


C19
Historical
Combination 3
Elevation
Water Levels (ft)
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10/2010
06/2017
02/2024
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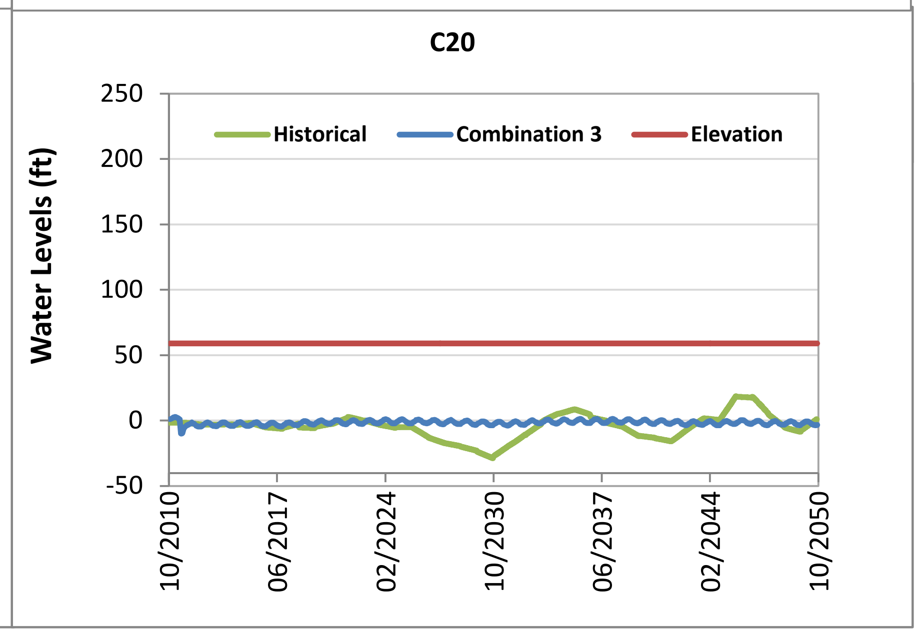
02/2044
10/2050


C20
Historical
Combination 3
Elevation
Water Levels (ft)
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06/2017
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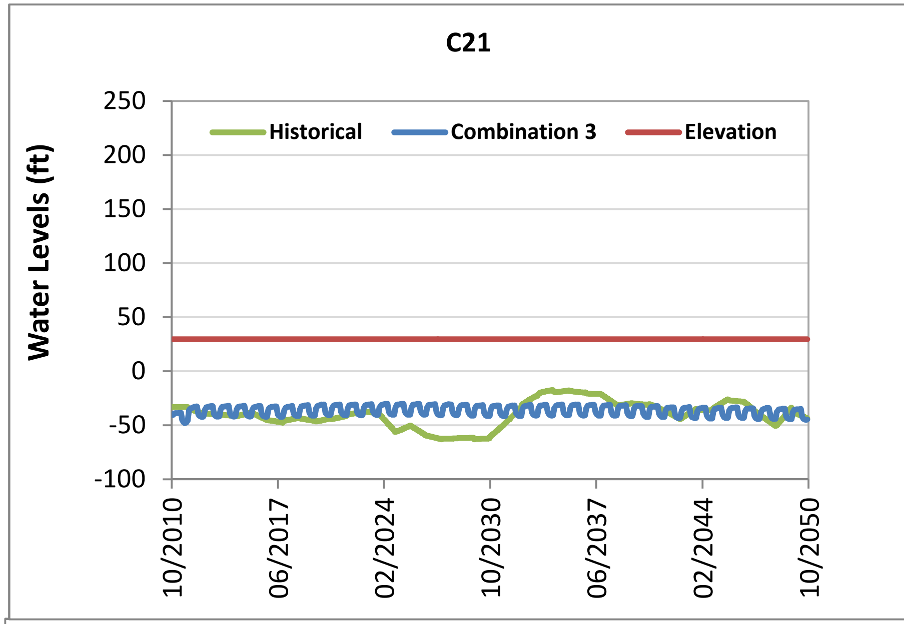
02/2044
10/2050


C21
Historical
Combination 3
Elevation
Water Levels (ft)
250
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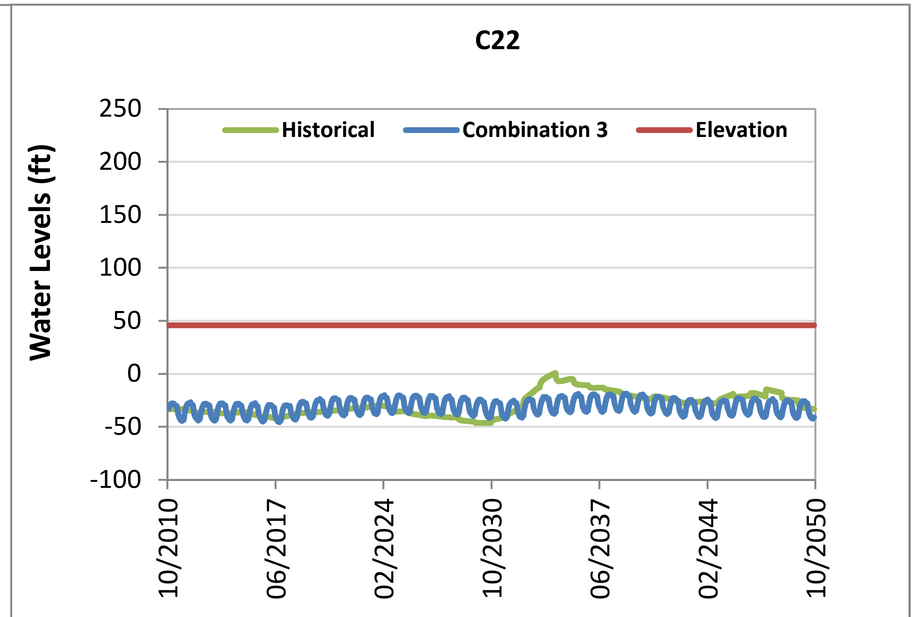
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C22
Historical
Combination 3
Elevation
Water Levels (ft)
250
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-100
10/2010
06/2017
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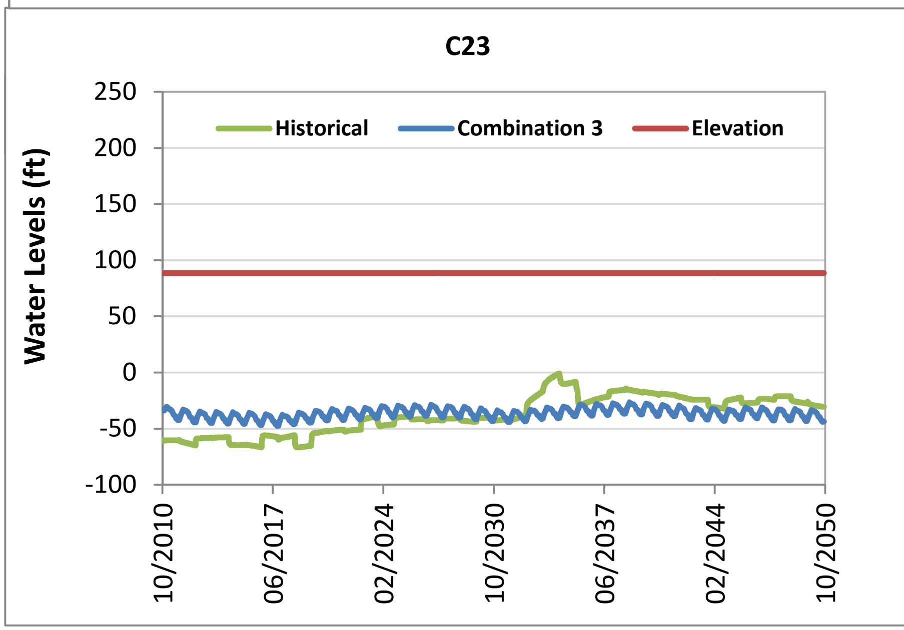
02/2044
10/2050


C23
Historical
Combination 3
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
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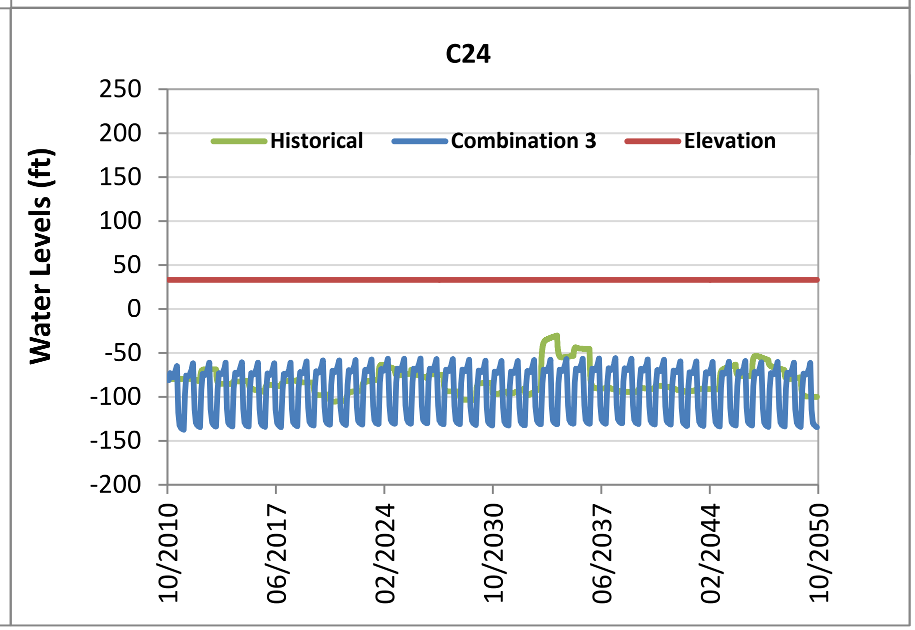
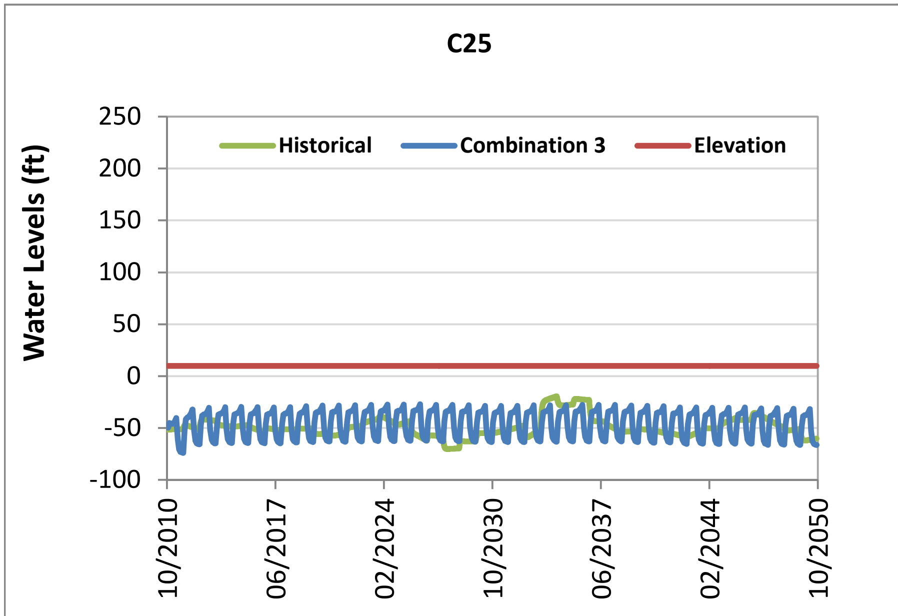
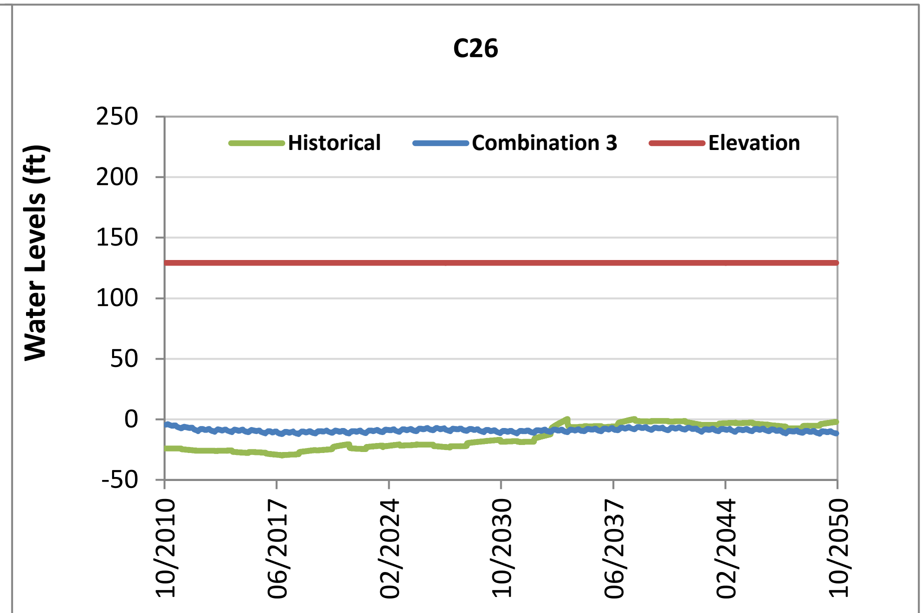
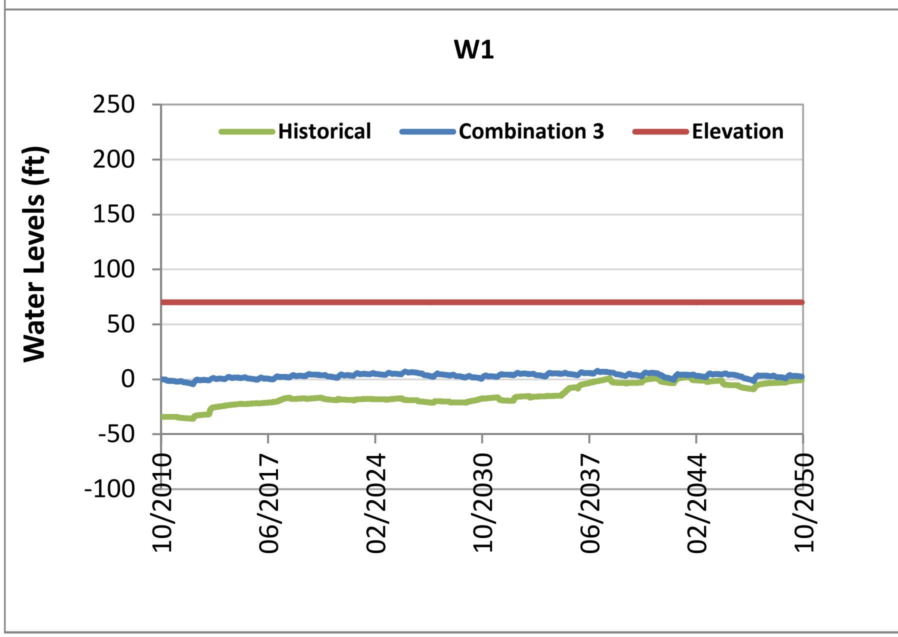
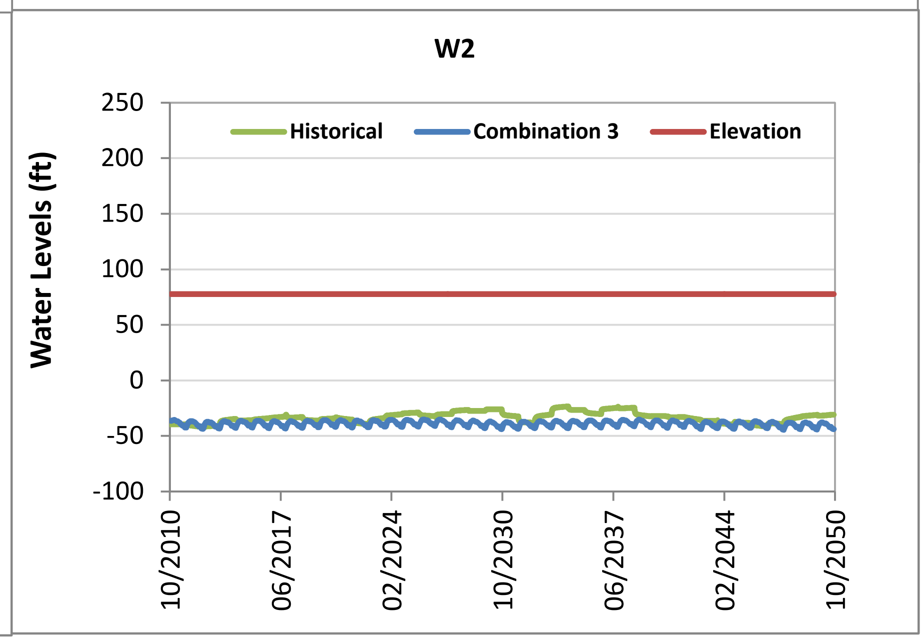
02/2044
10/2050

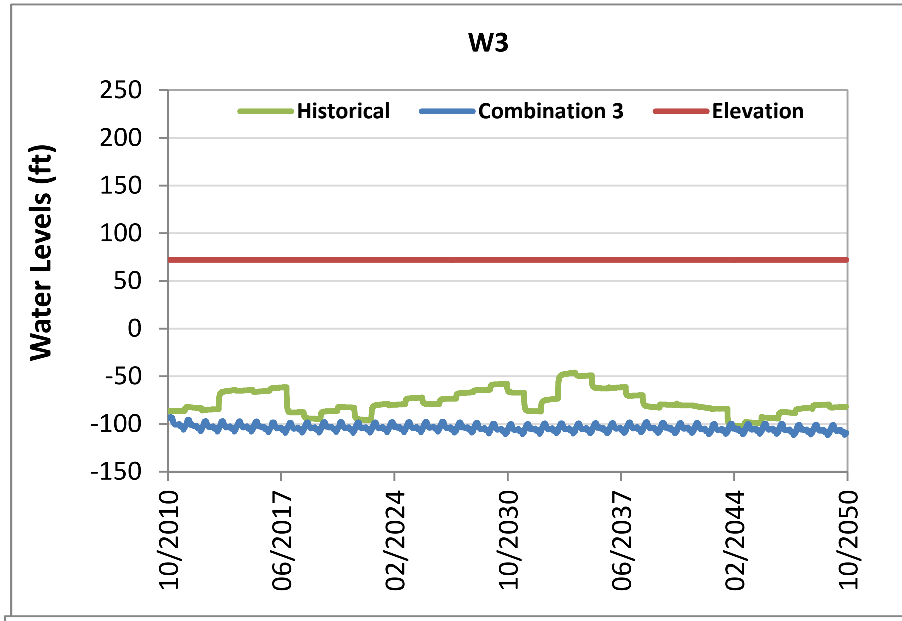

C24
Historical
Combination 3
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
-200
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

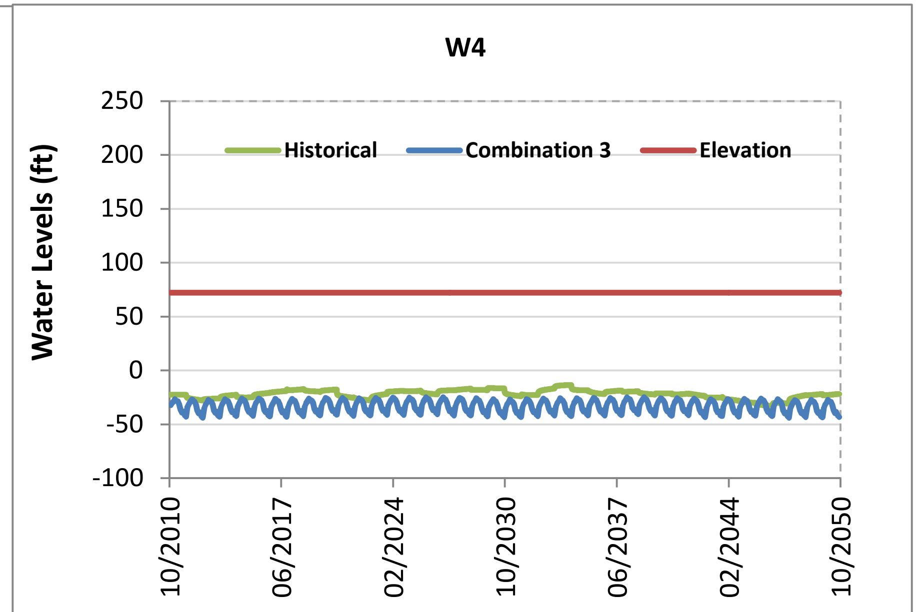

C25
Historical
Combination 3
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

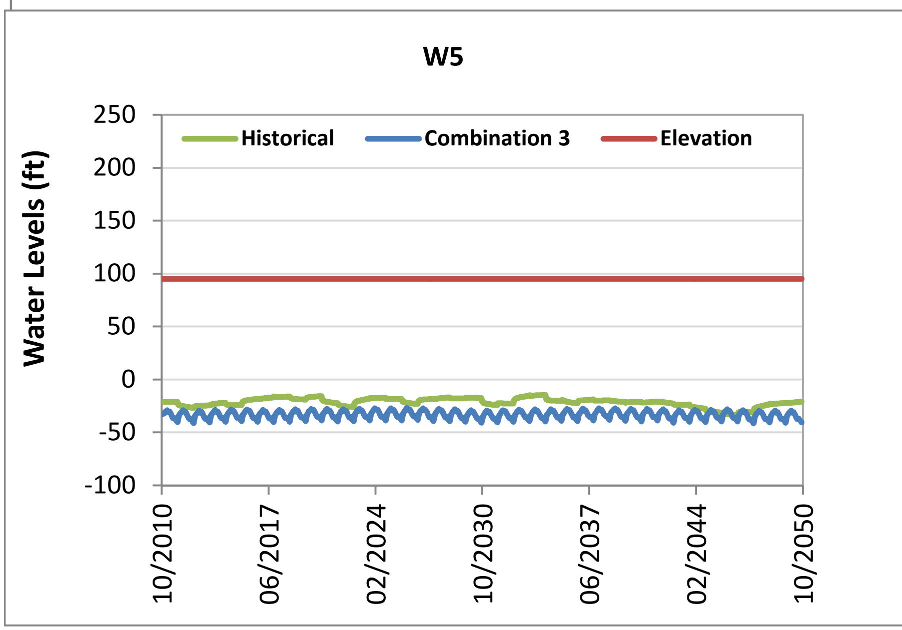

C26
Historical
Combination 3
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

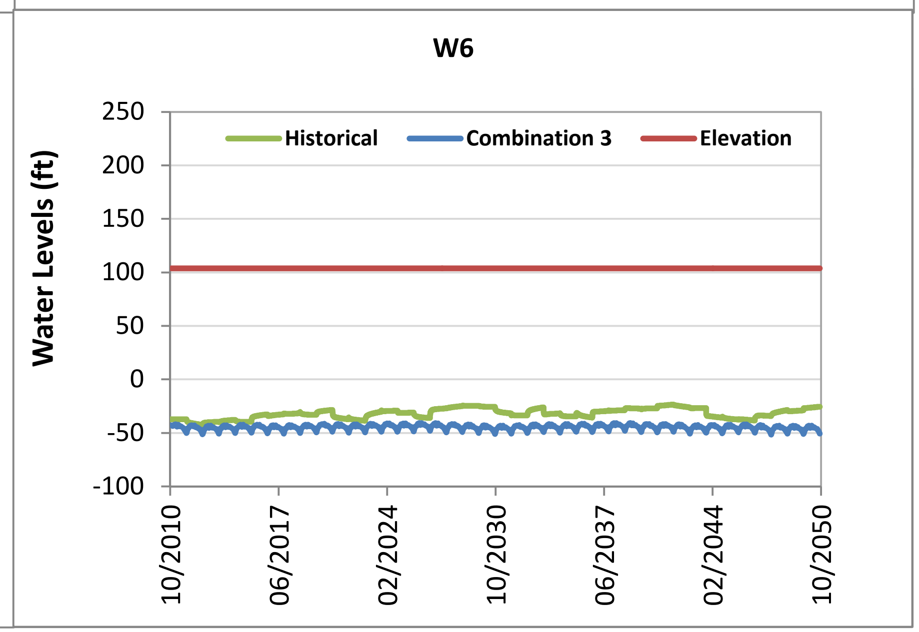

W1
Historical
Combination 3
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

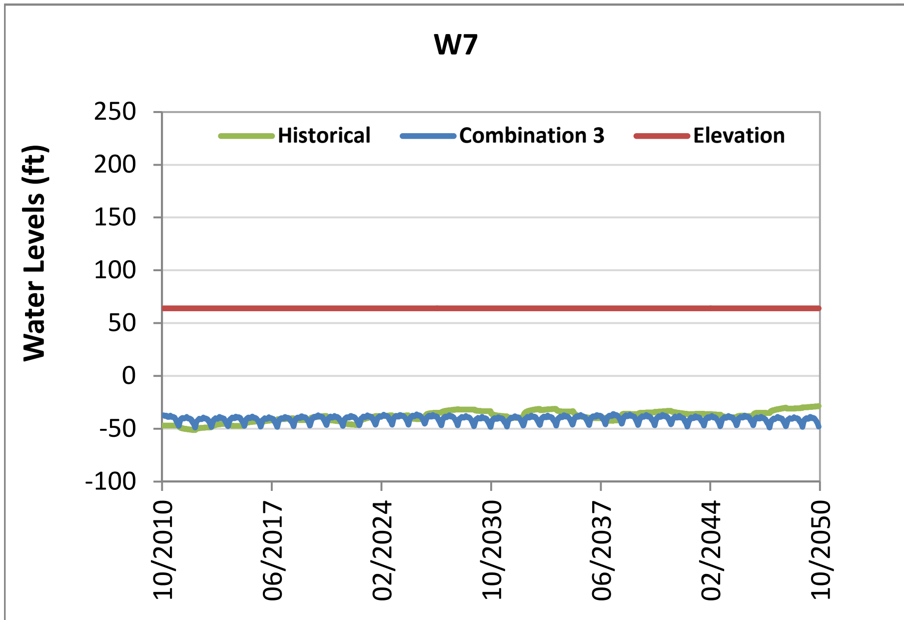

W2
Historical
Combination 3
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

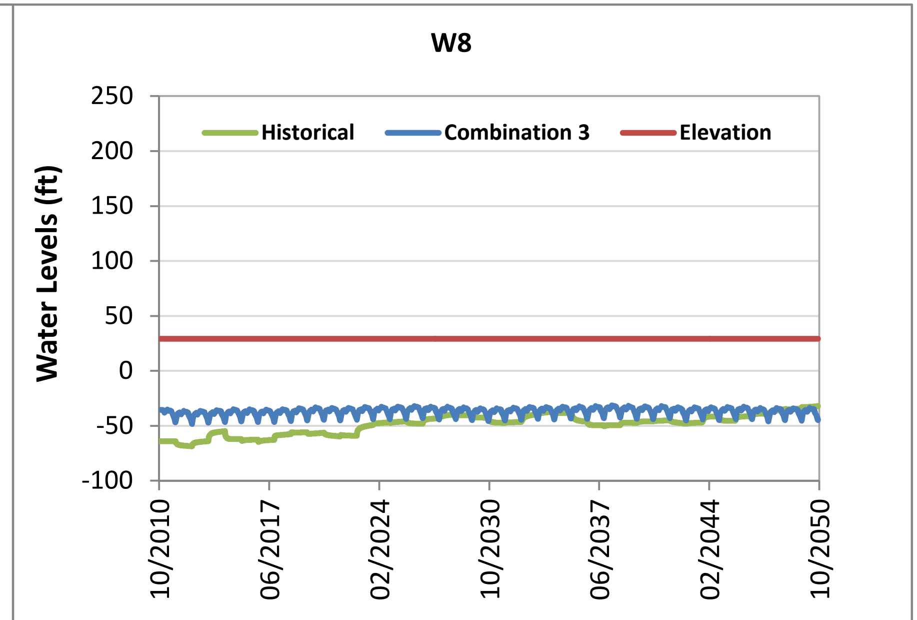

W3
Water Levels (ft)
Historical
Combination 3
Elevation
250
200
150
100
50
0
-50
-100
-150
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

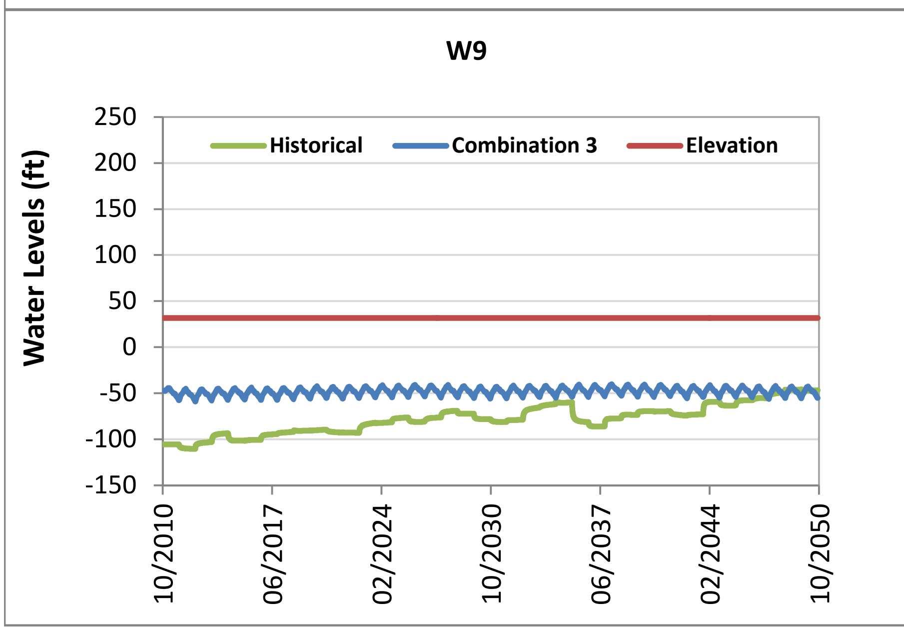

W4
Water Levels (ft)
Historical
Combination 3
Elevation
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

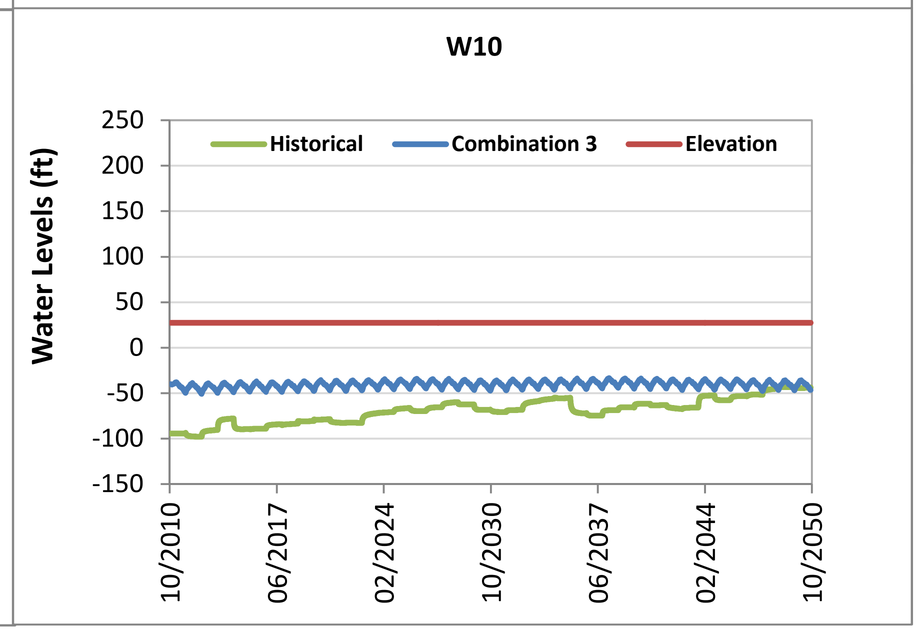

W5
Water Levels (ft)
Historical
Combination 3
Elevation
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

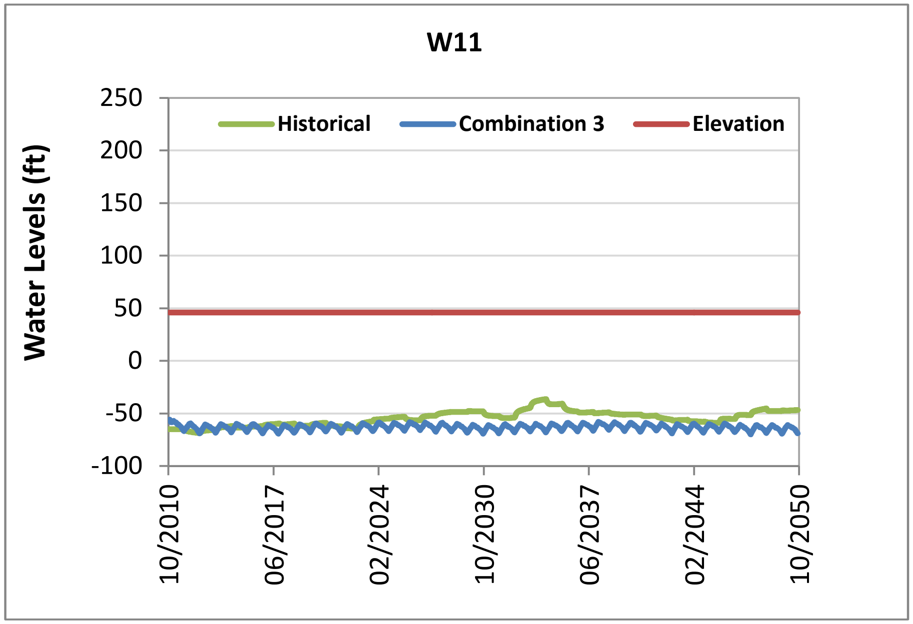

W6
Water Levels (ft)
Historical
Combination 3
Elevation
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

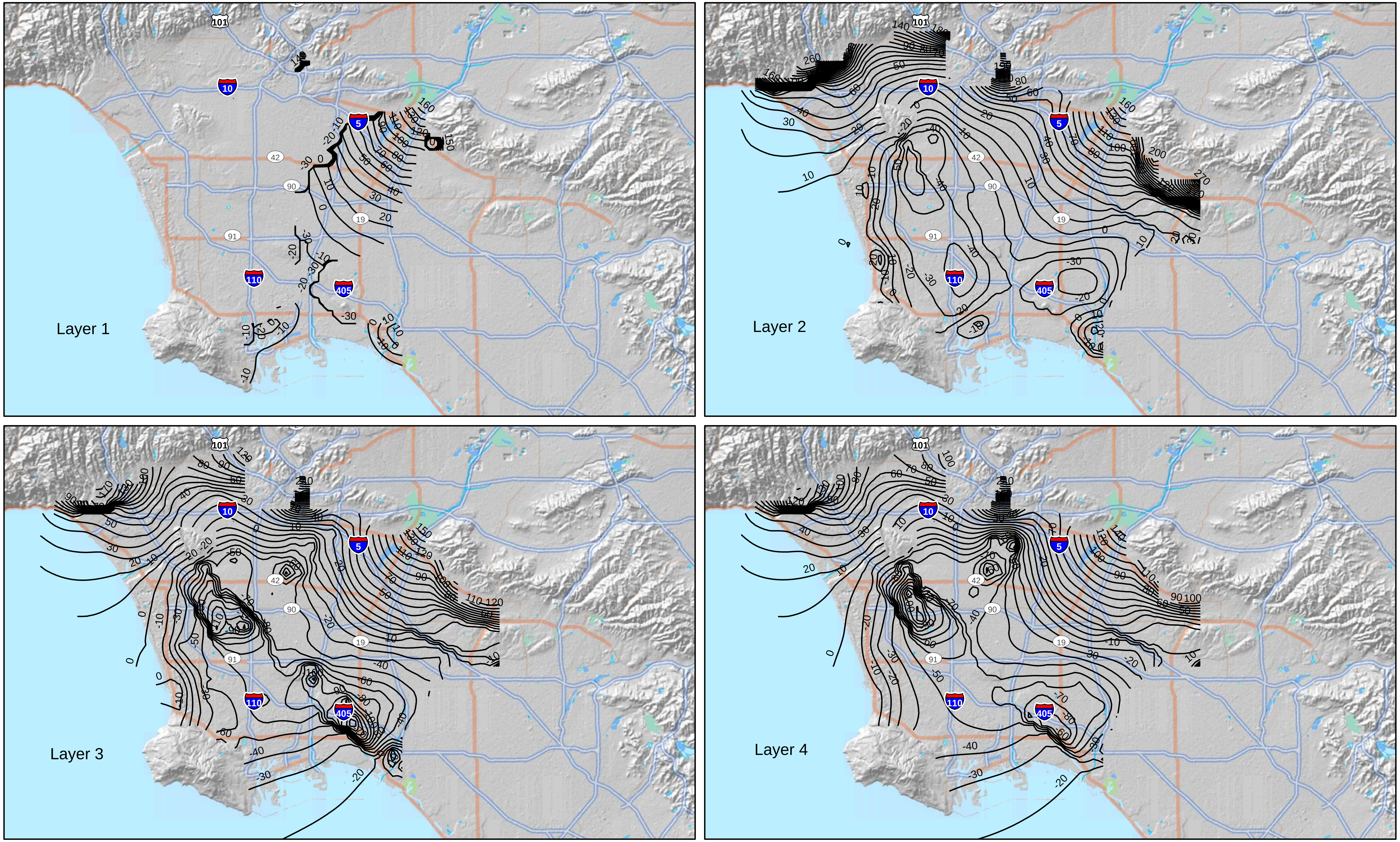

W7
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 3
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W8
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 3
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W9
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
Historical
Combination 3
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W10
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
Historical
Combination 3
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W11
Historical
Combination 3
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050



Legend

- Groundwater Basin Boundary
- Forebays
- Alamitos Barrier
- West Coast Basin Barriers
- Groundwater Level Contours
- Limited Access
- Highway
- Major Road

Water Bodies

Description

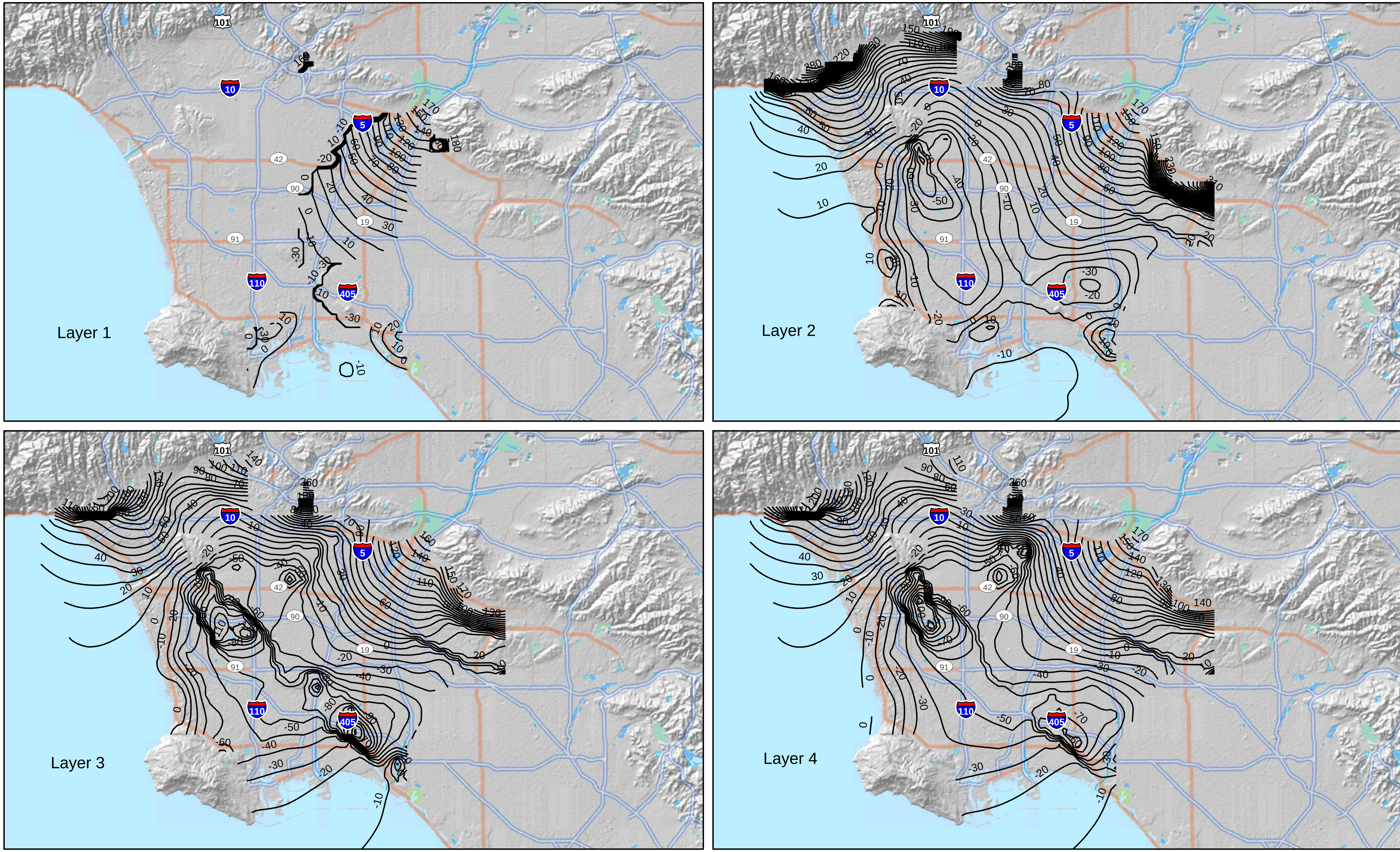
- Lake/Pond
- River/Stream
- Ocean
- Lake or Pond
- Swamp or Marsh
- Stream or River
- Inundation Area

N

0 0.5 1 2 3 4 Miles

Combination 3 - Groundwater Level Contours at the Minimum Cumulative Storage in 2012

File Location



Legend

- Groundwater Basin Boundary
- Forebays
- Alamitos Barrier
- West Coast Basin Barriers
- Groundwater Level Contours
- Limited Access
- Highway
- Major Road

Water Bodies

Description

- Lake/Pond
- River/Stream
- Ocean
- Lake or Pond
- Swamp or Marsh
- Stream or River
- Inundation Area

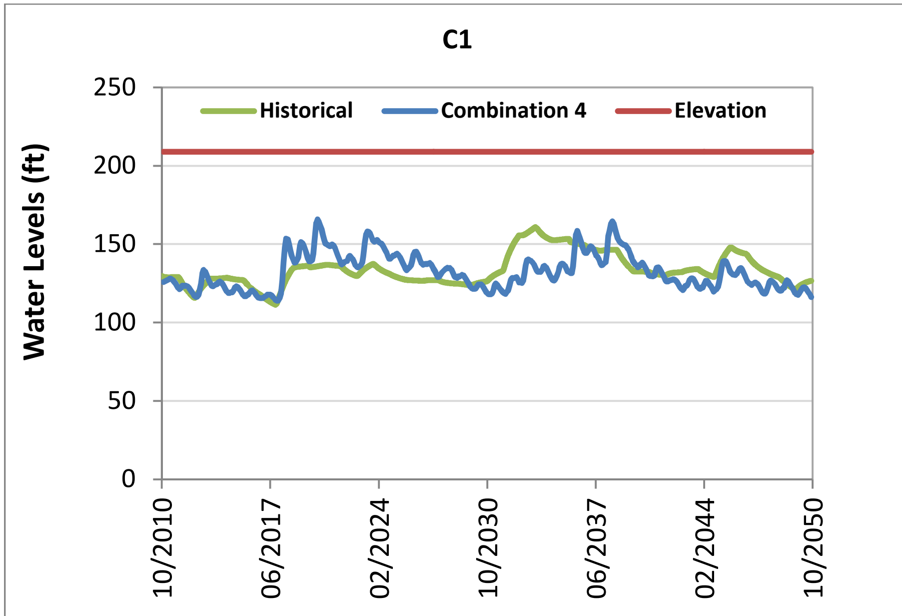
N

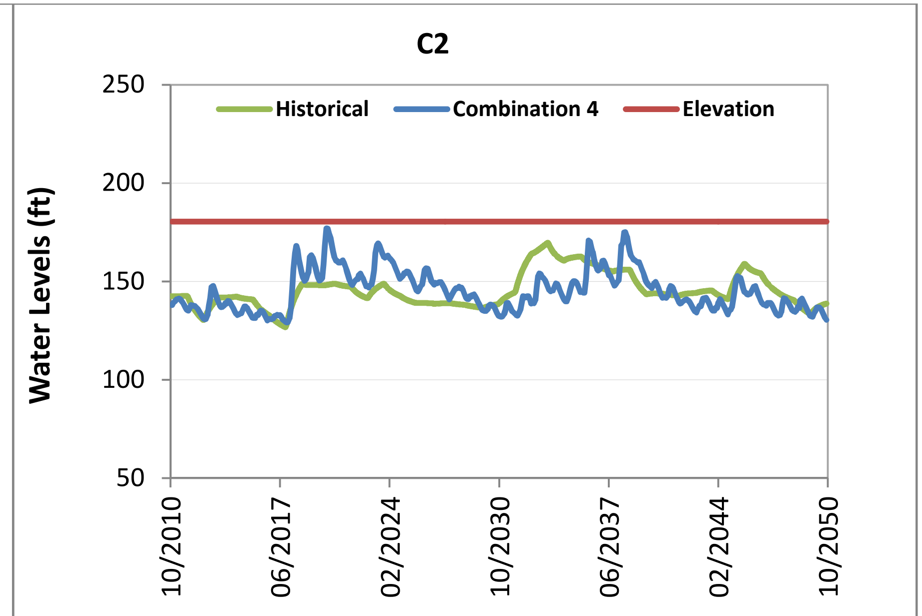
0 0.5 1 2 3 4 Miles

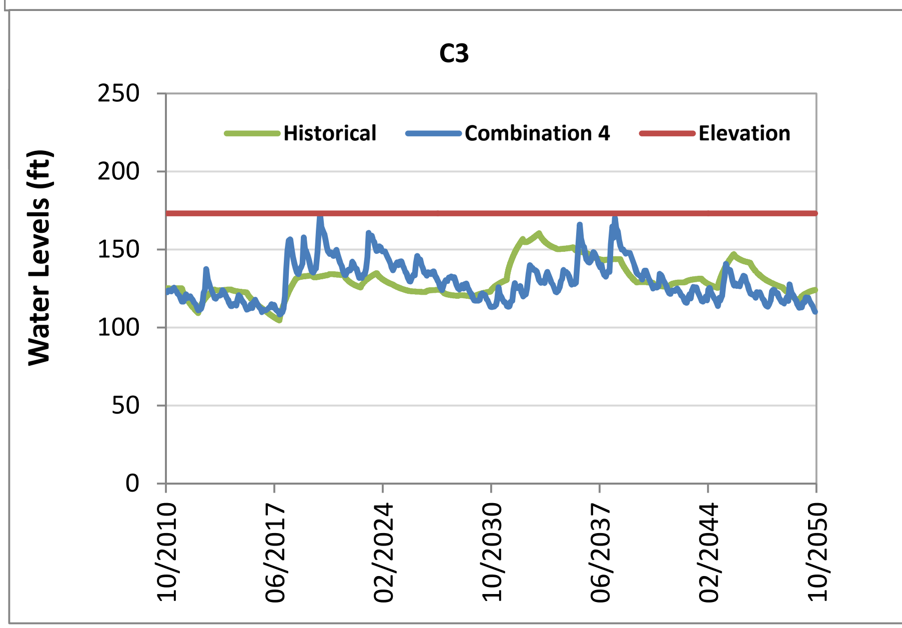
Combination 3 - Groundwater Level Contours at the Maximum Cumulative Storage in 2038

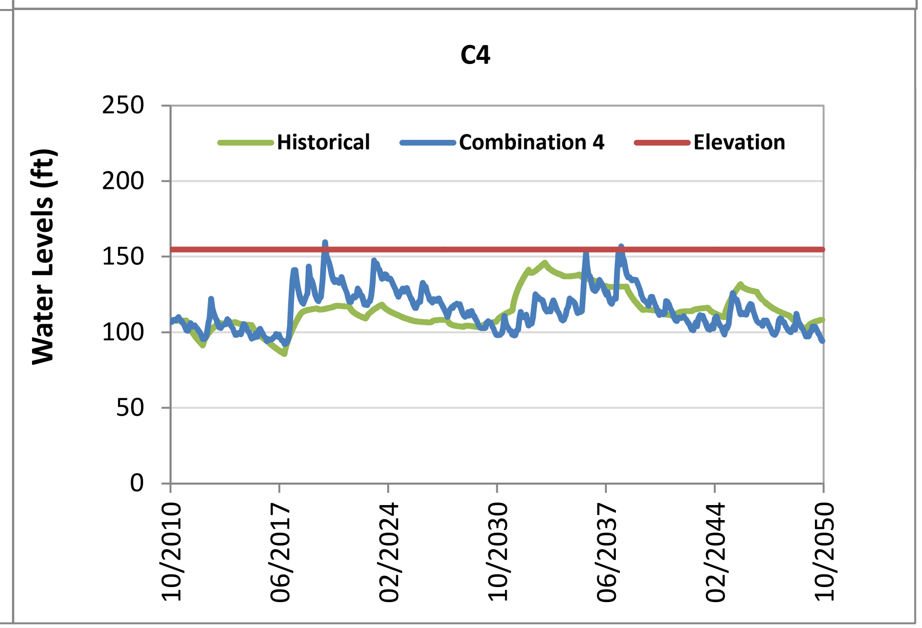
File Location

Combination 4 Model Results:
1) Hydrographs
2) Groundwater Level Contour Maps


C1
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C2
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C3
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C4
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
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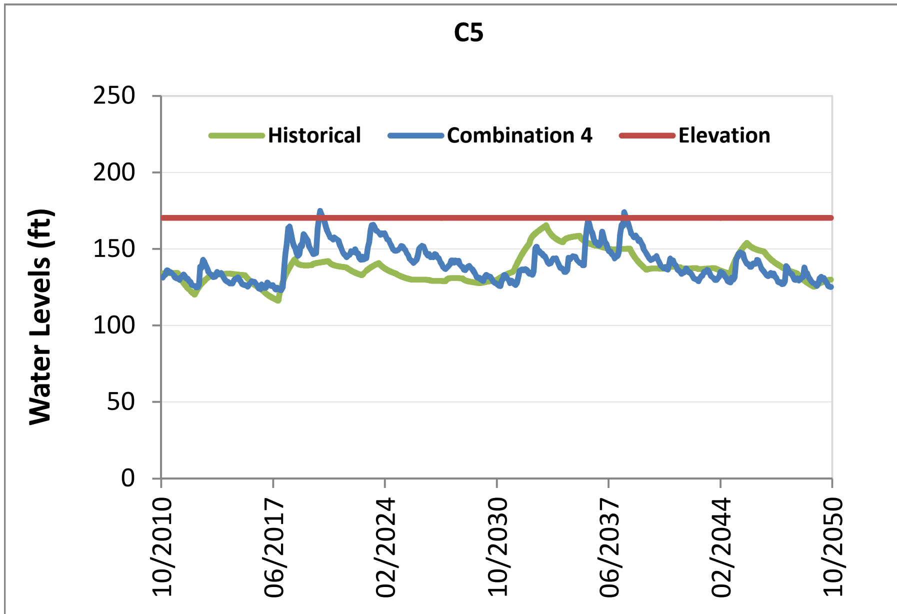
02/2044
10/2050


C5
Historical
Combination 4
Elevation
Water Levels (ft)
250
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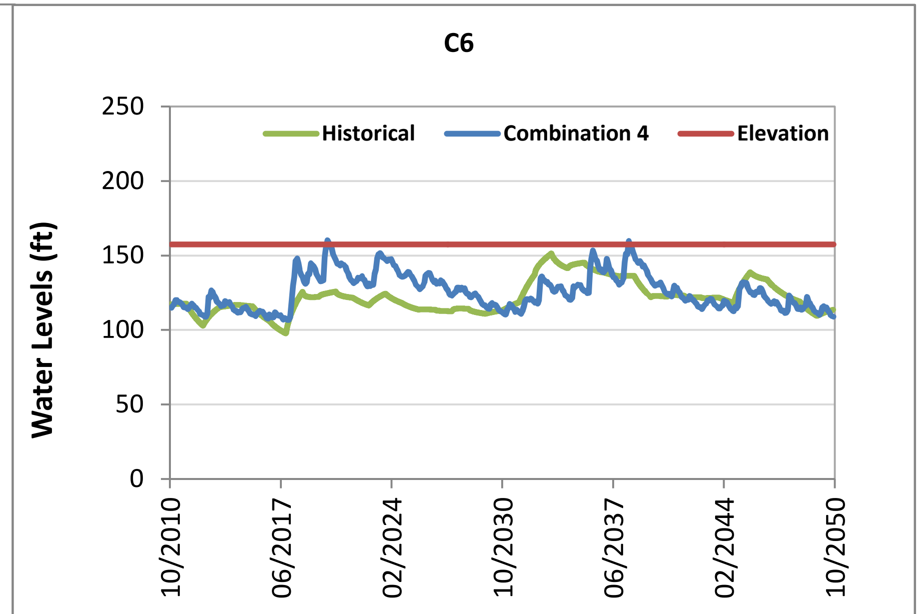
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C6
Historical
Combination 4
Elevation
Water Levels (ft)
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150
100
50
0
10/2010
06/2017
02/2024
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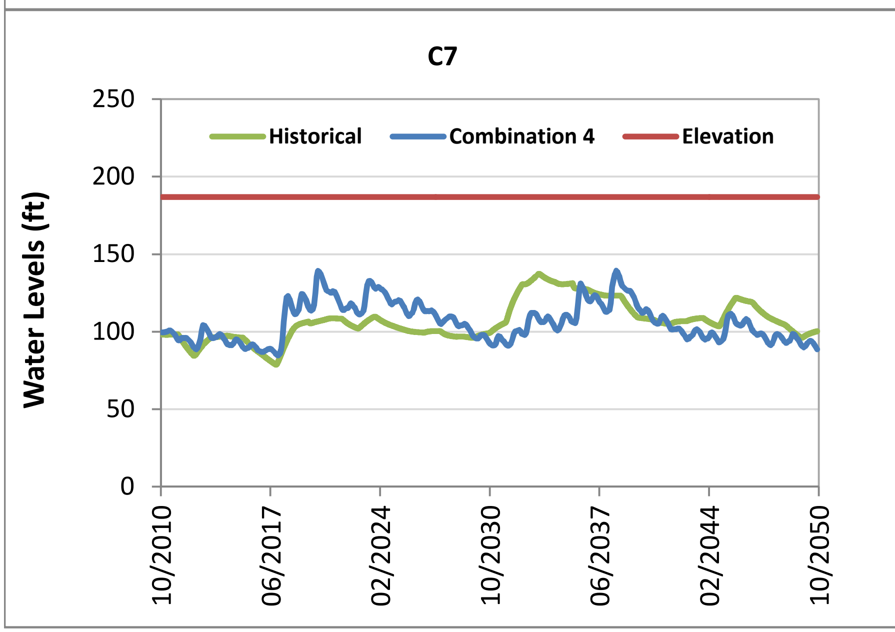
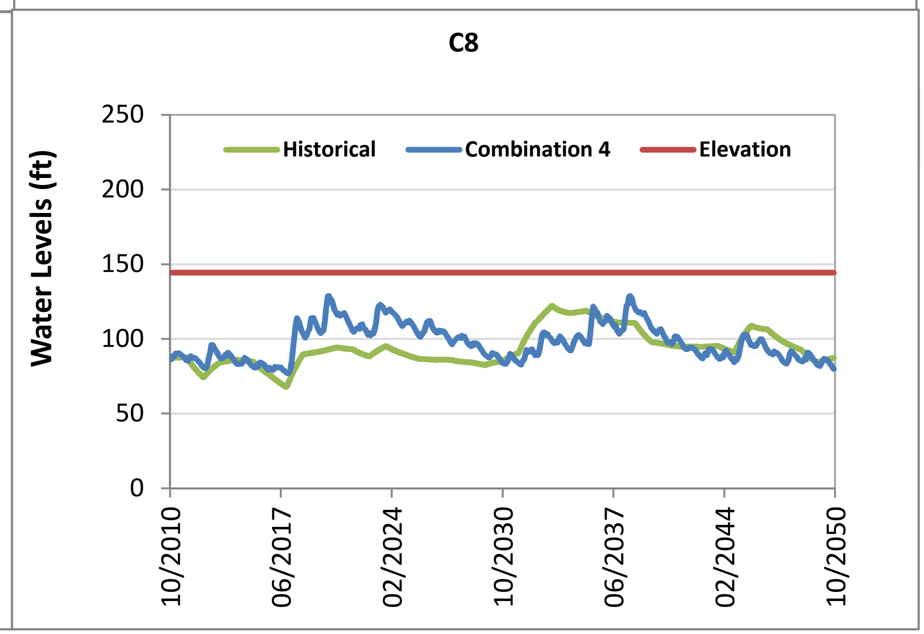
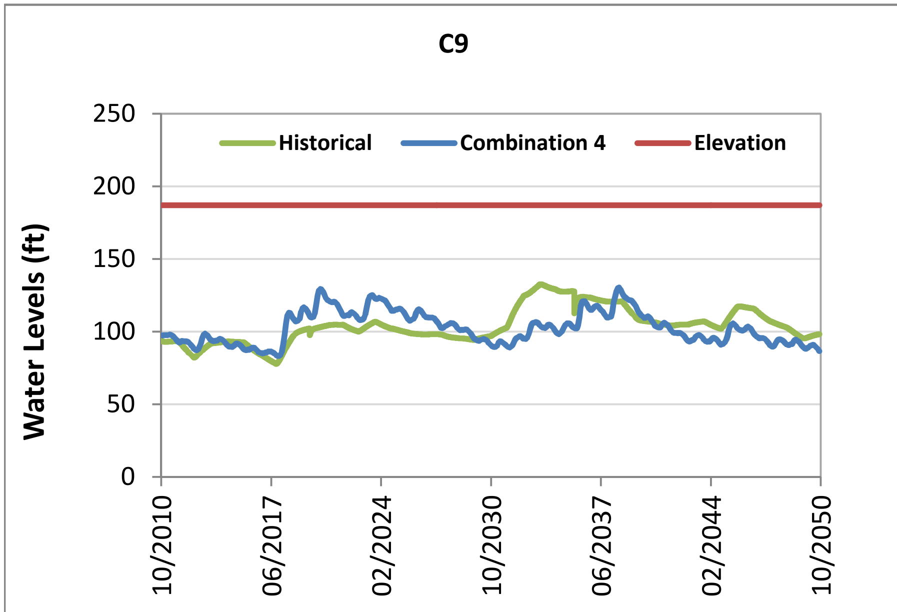
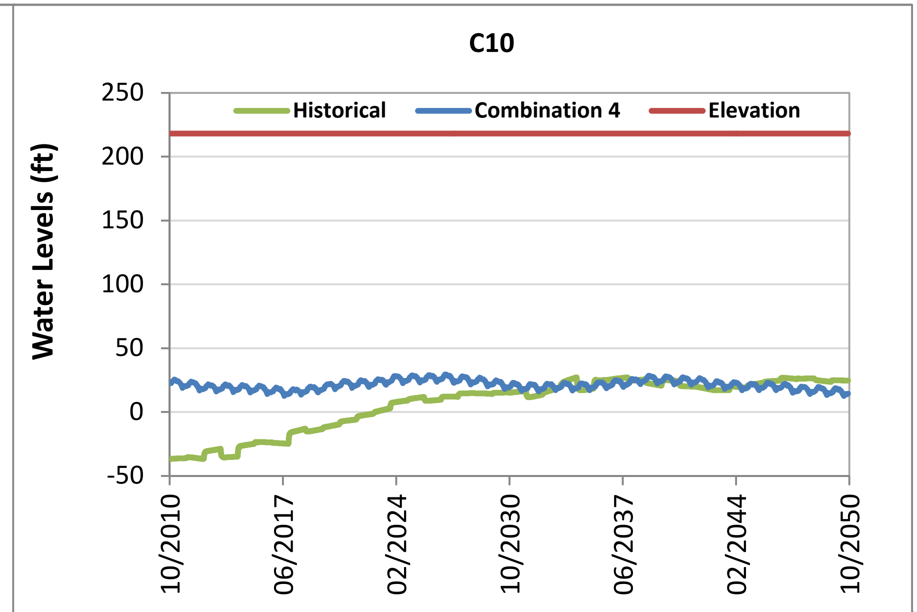
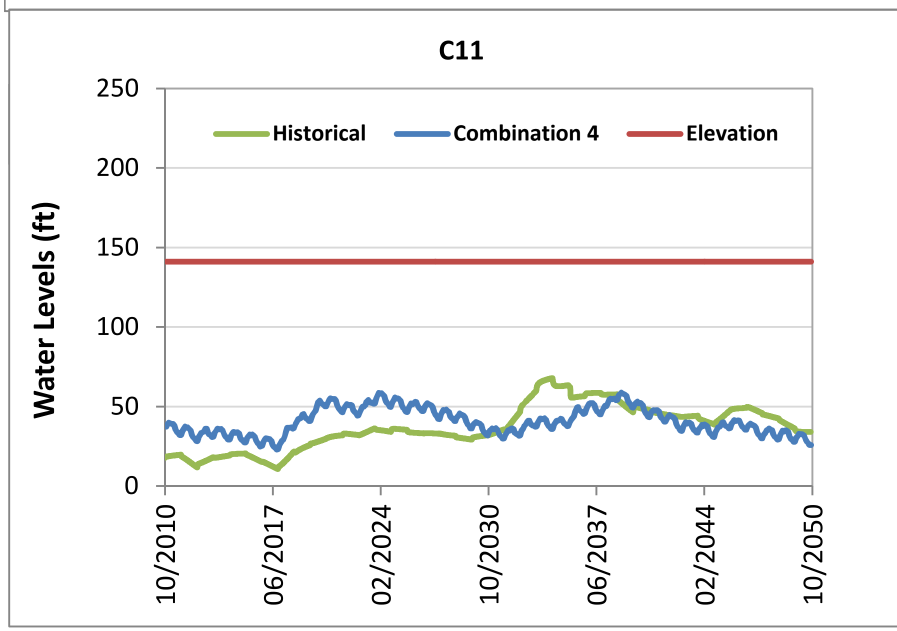
06/2037
02/2044
10/2050

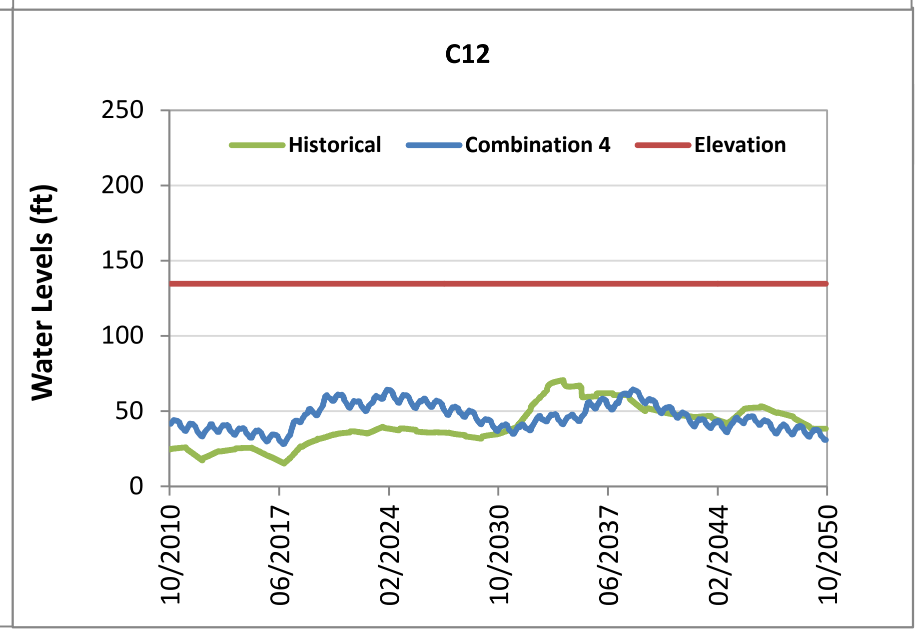

C7
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C8
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C9
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C10
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C11
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C12
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
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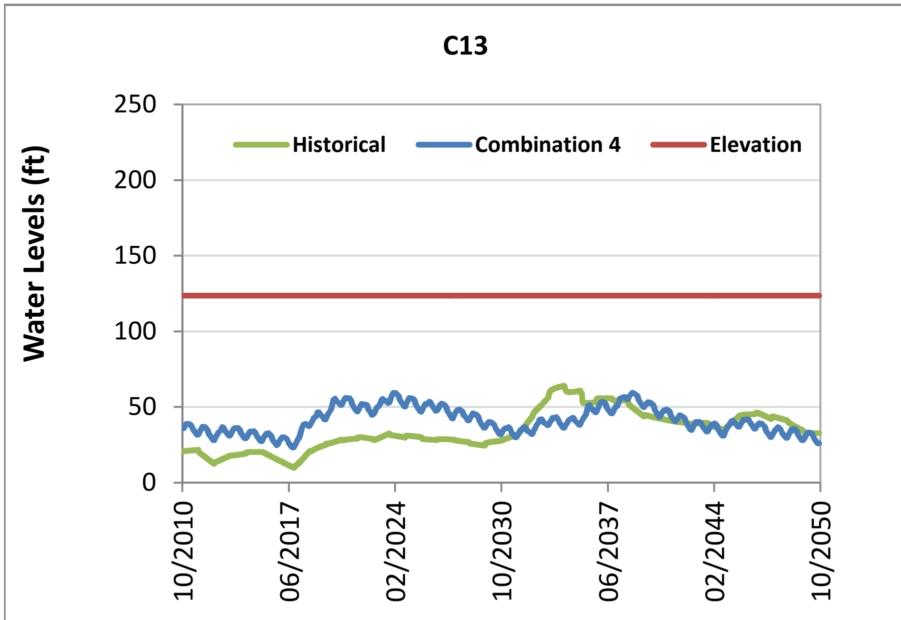
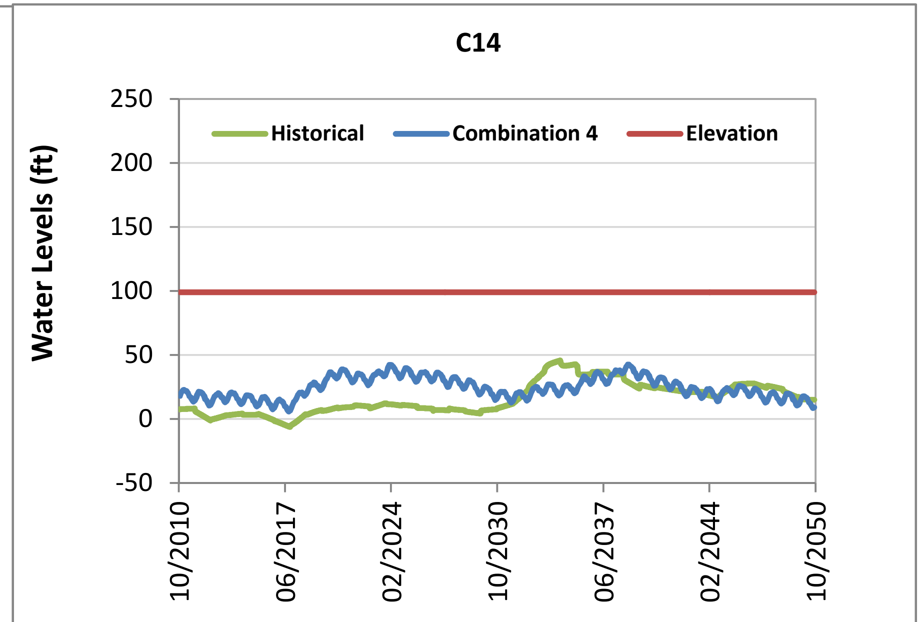
06/2037
02/2044
10/2050


C13
Water Levels (ft)
250
200
150
100
50
0
Historical
Combination 4
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C14
Water Levels (ft)
250
200
150
100
50
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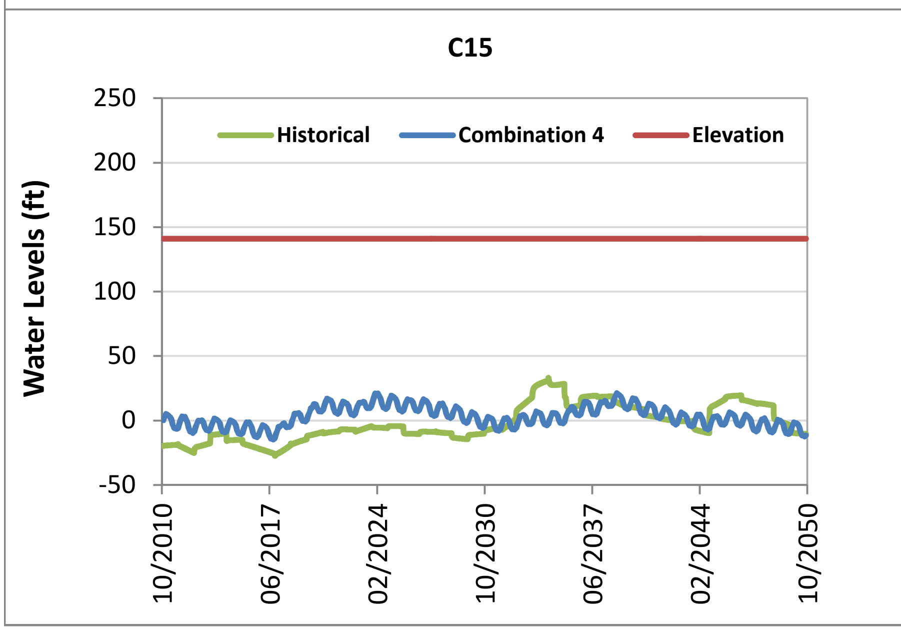
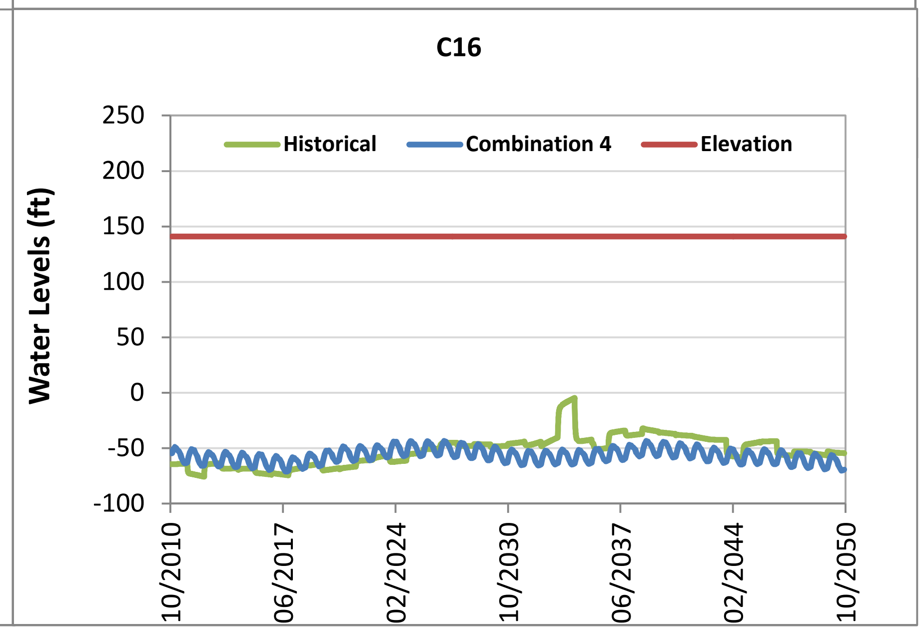
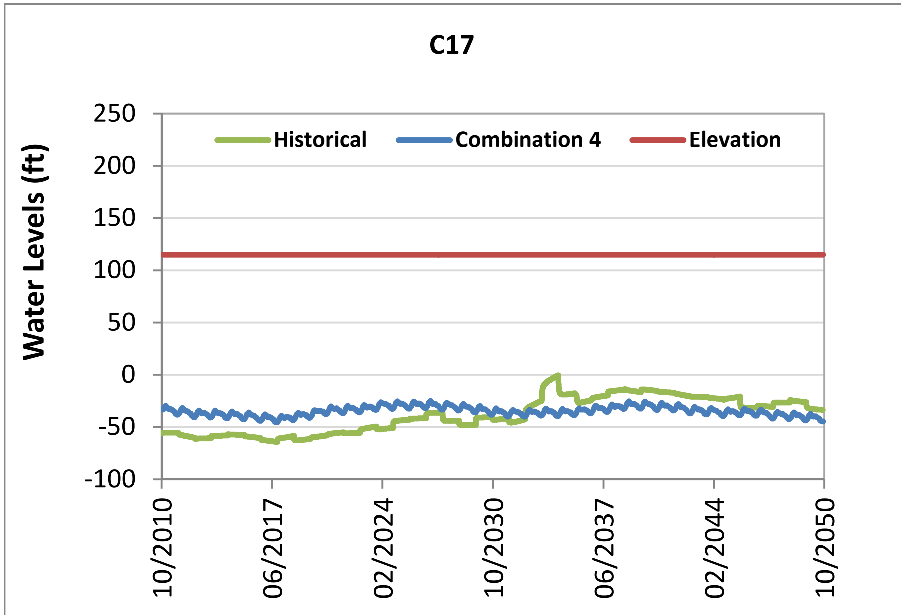
-50
Historical
Combination 4
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C15
Water Levels (ft)
250
200
150
100
50
0
-50
Historical
Combination 4
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C16
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 4
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C17
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
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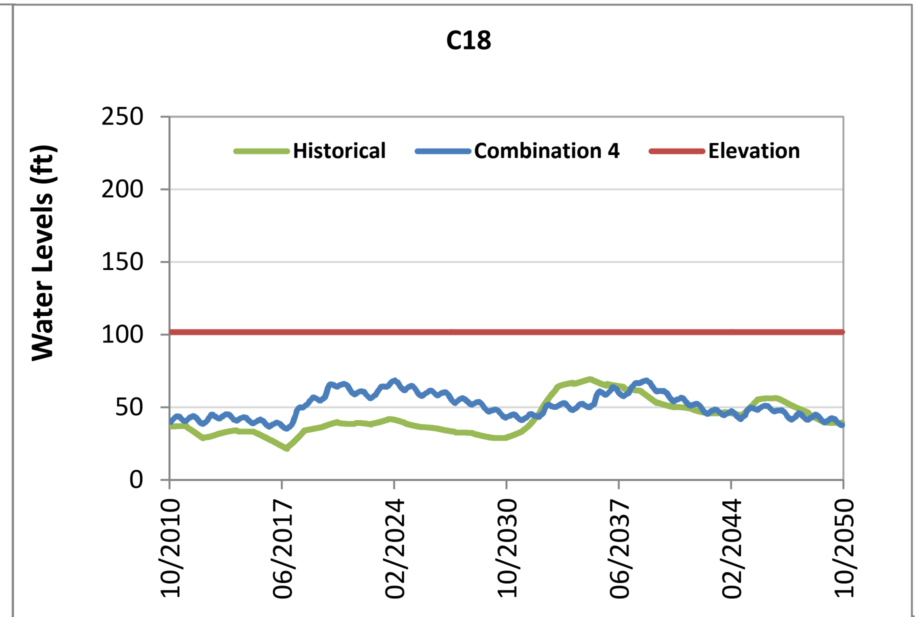
06/2037
02/2044
10/2050


C18
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
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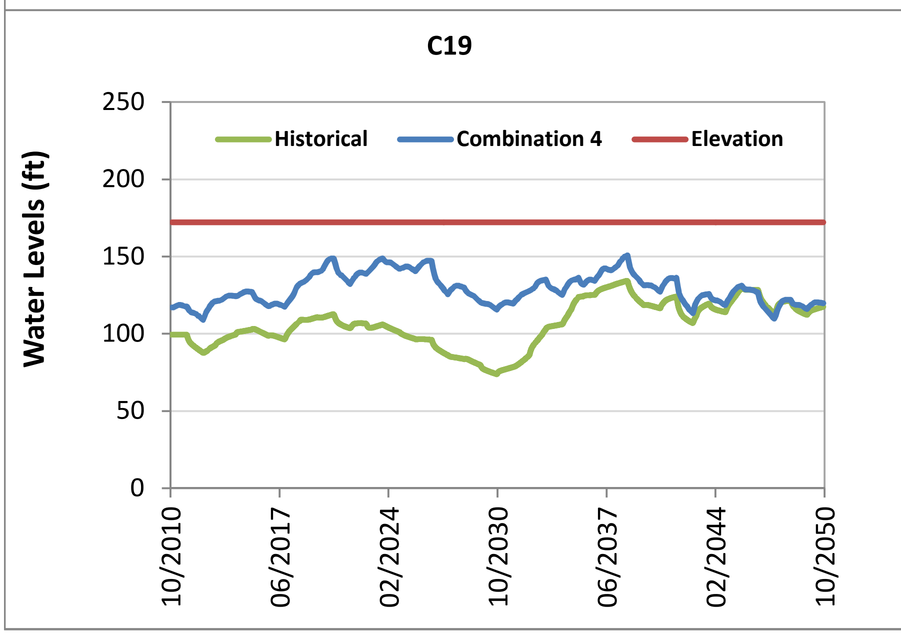
06/2037
02/2044
10/2050


C19
Historical
Combination 4
Elevation
Water Levels (ft)
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150
100
50
0
10/2010
06/2017
02/2024
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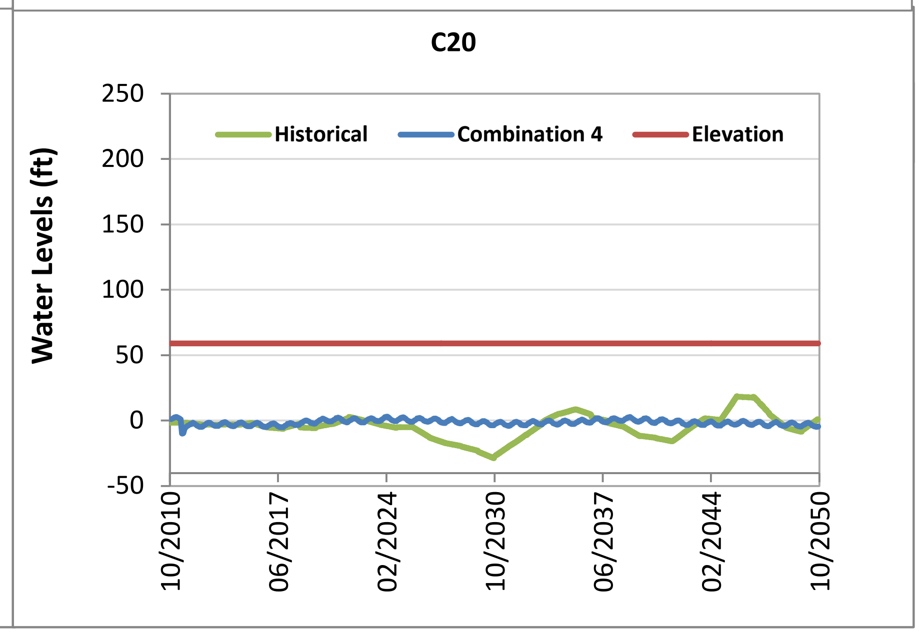
02/2044
10/2050


C20
Historical
Combination 4
Elevation
Water Levels (ft)
250
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150
100
50
0
-50
10/2010
06/2017
02/2024
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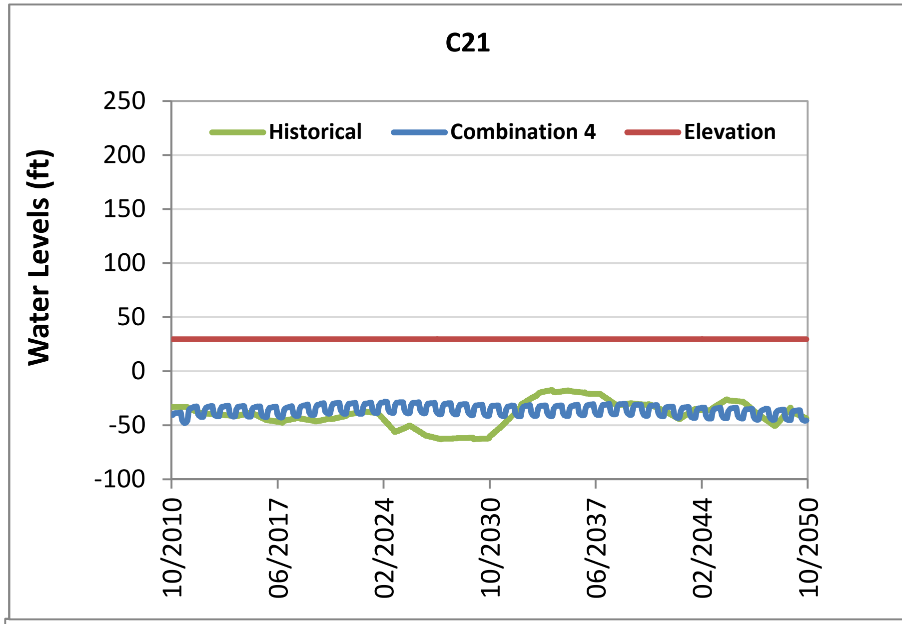
06/2037
02/2044
10/2050


C21
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
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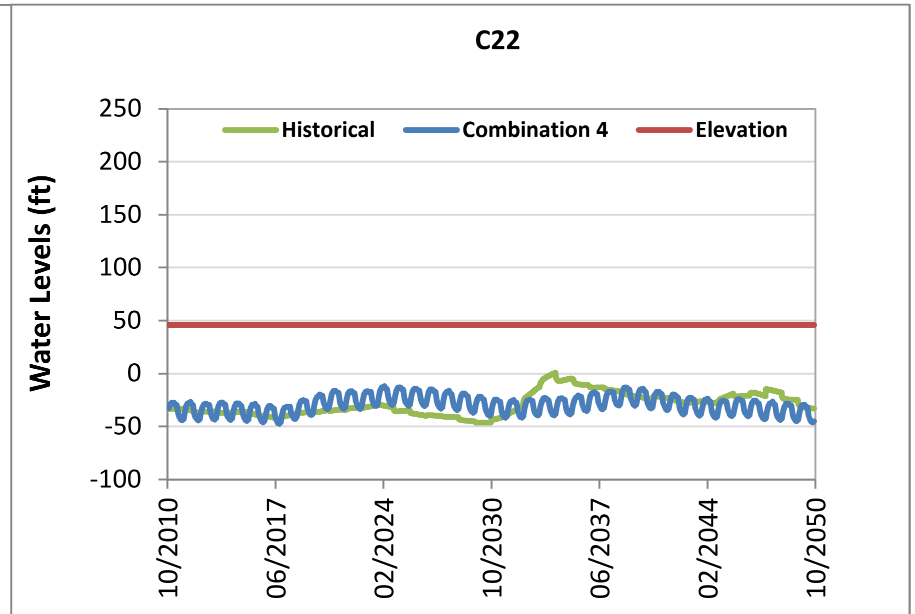
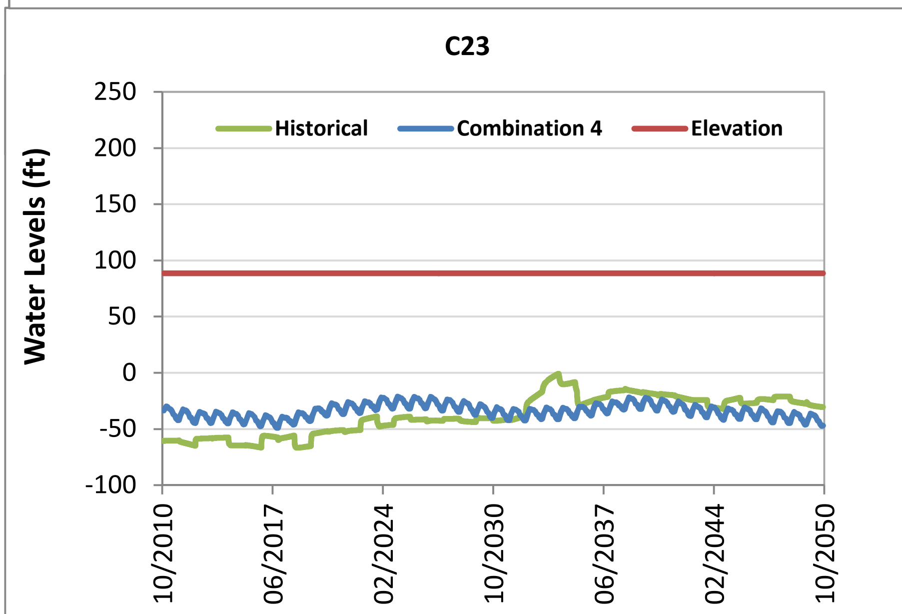
06/2037
02/2044
10/2050


C22
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C23
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
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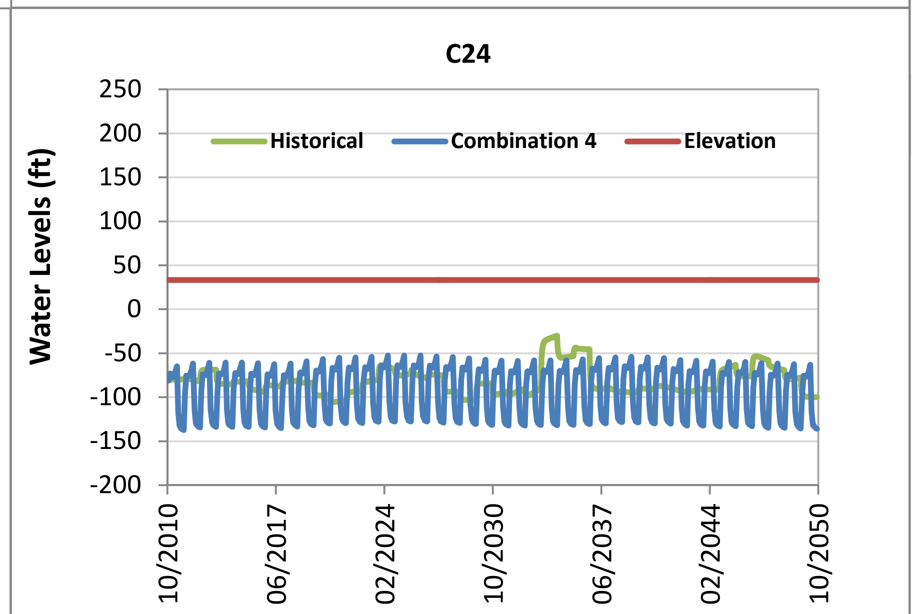
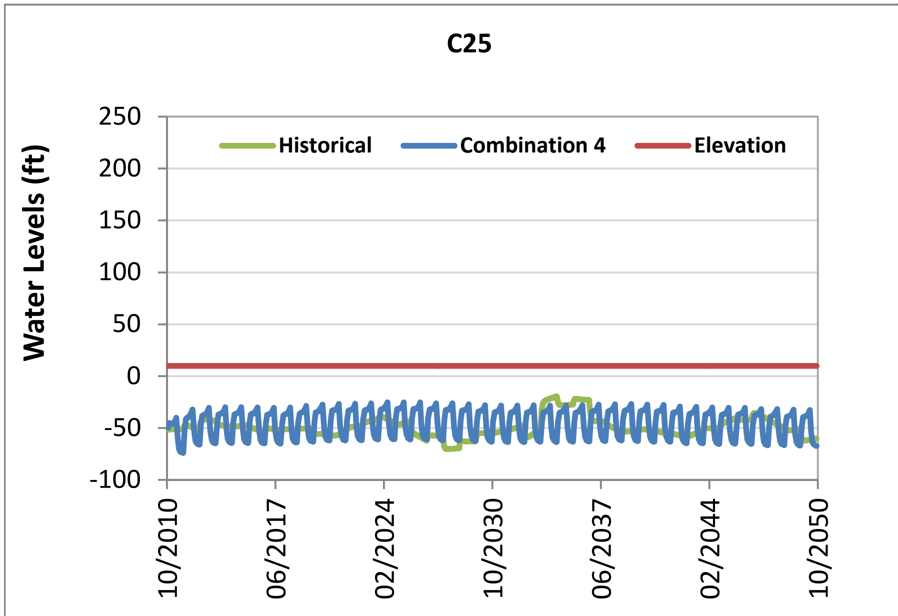
06/2037
02/2044
10/2050


C24
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
-200
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C25
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
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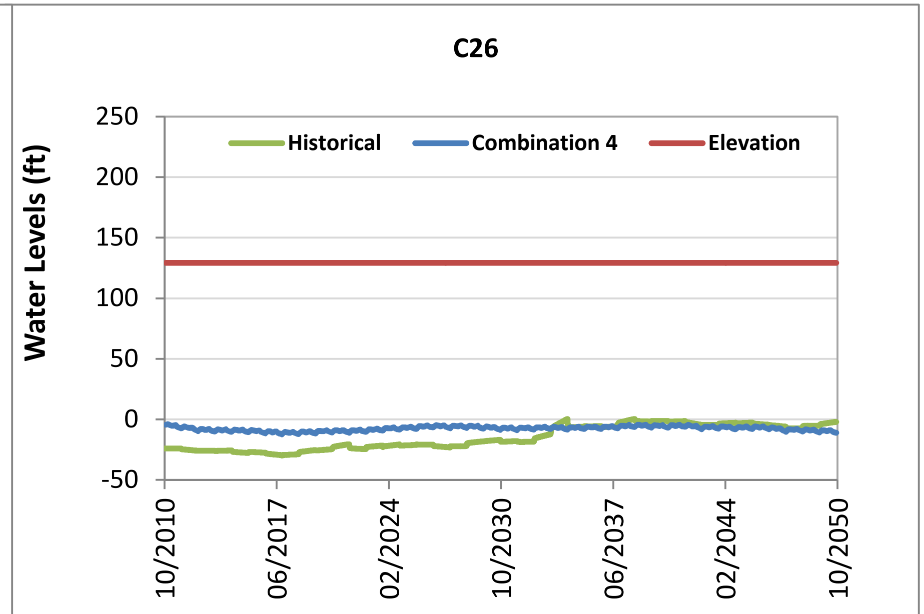
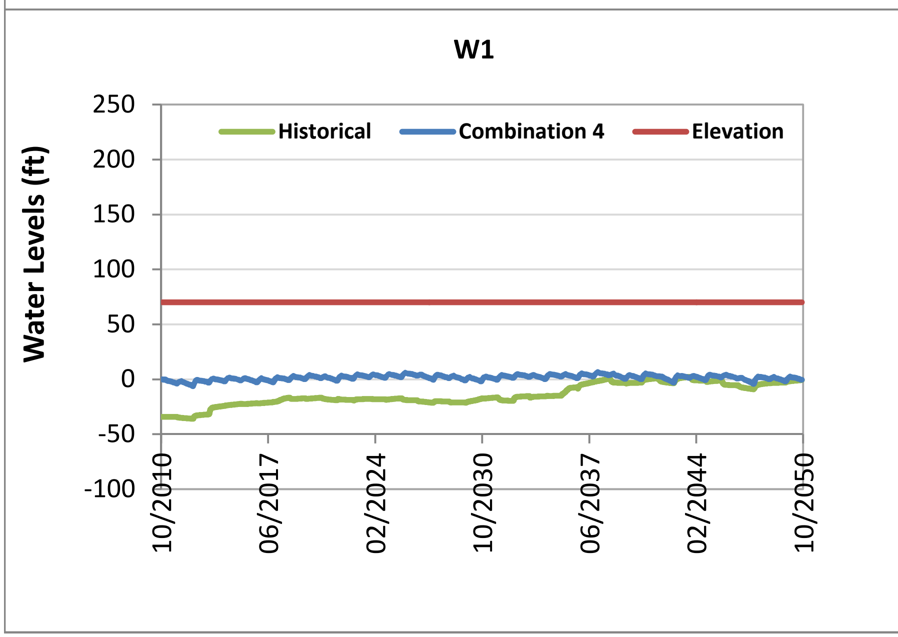
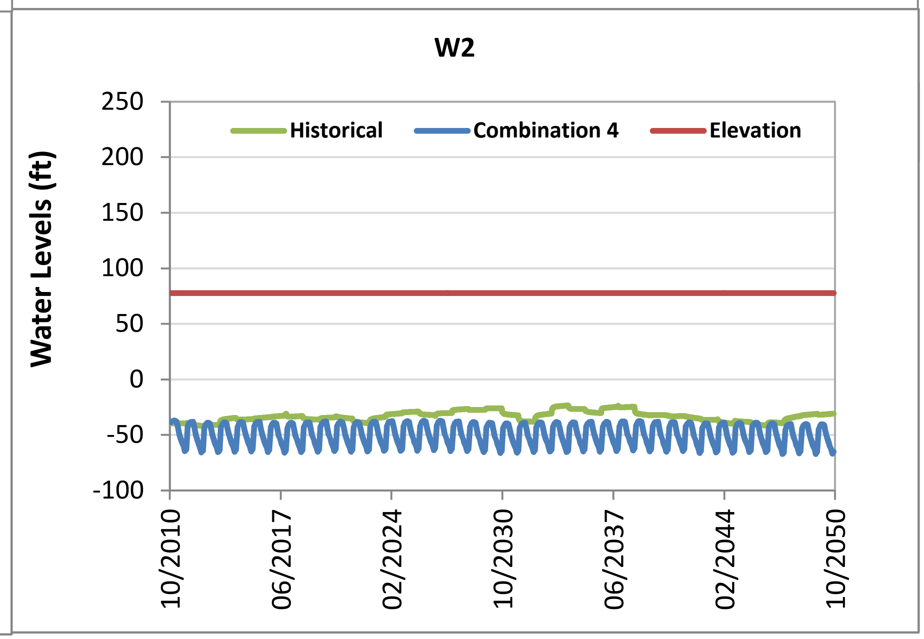
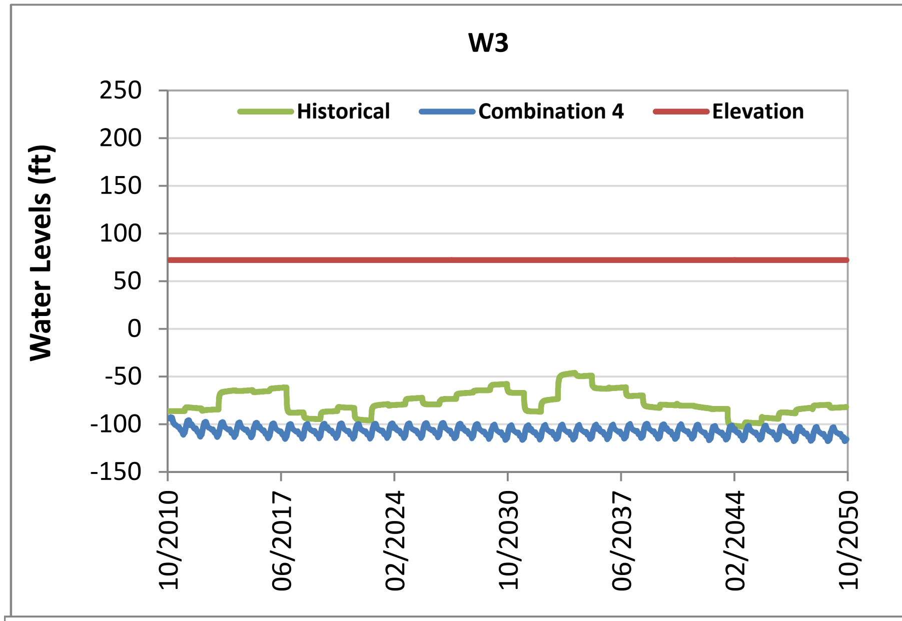
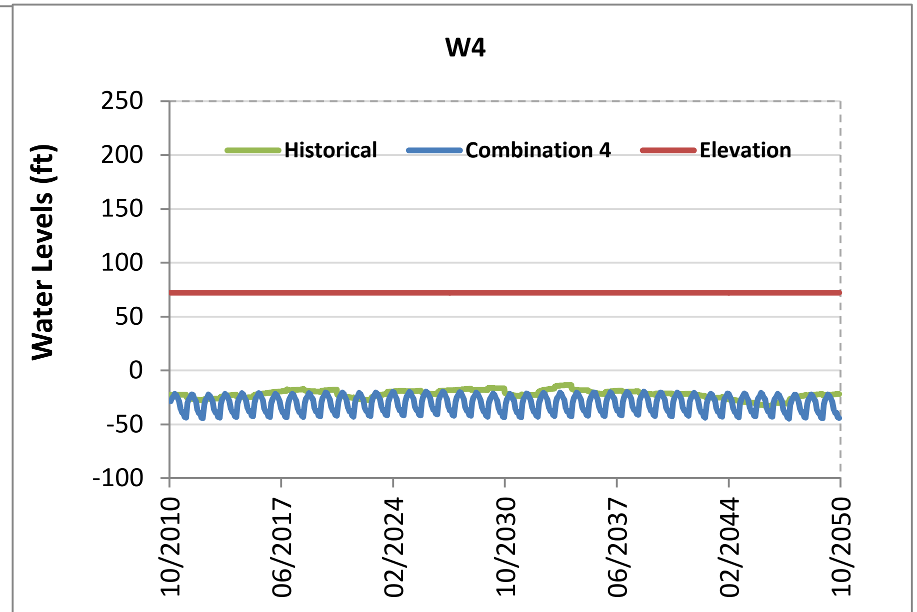
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C26
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W1
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W2
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W3
Water Levels (ft)
Historical
Combination 4
Elevation
250
200
150
100
50
0
-50
-100
-150
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W4
Water Levels (ft)
Historical
Combination 4
Elevation
250
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50
0
-50
-100
10/2010
06/2017
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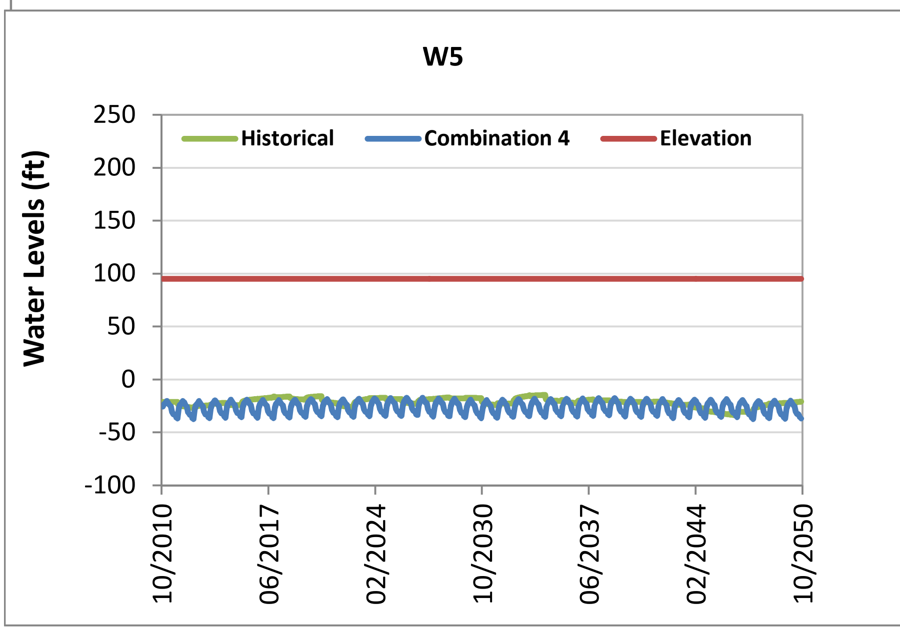
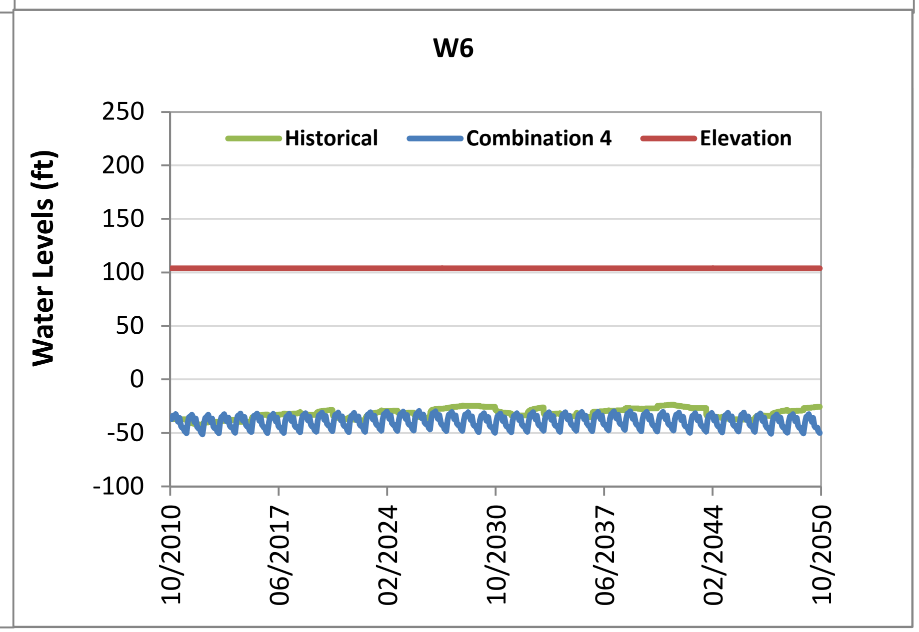
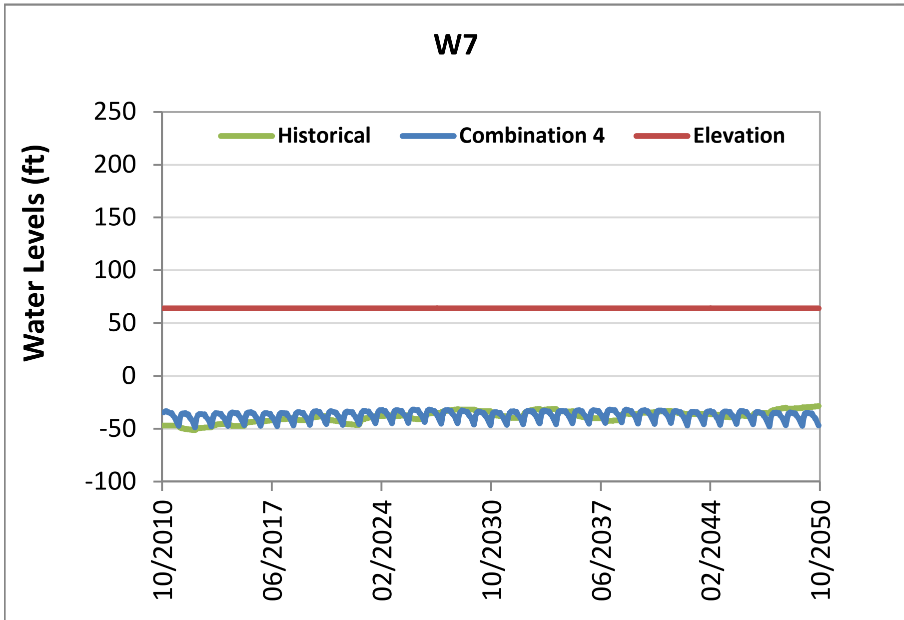
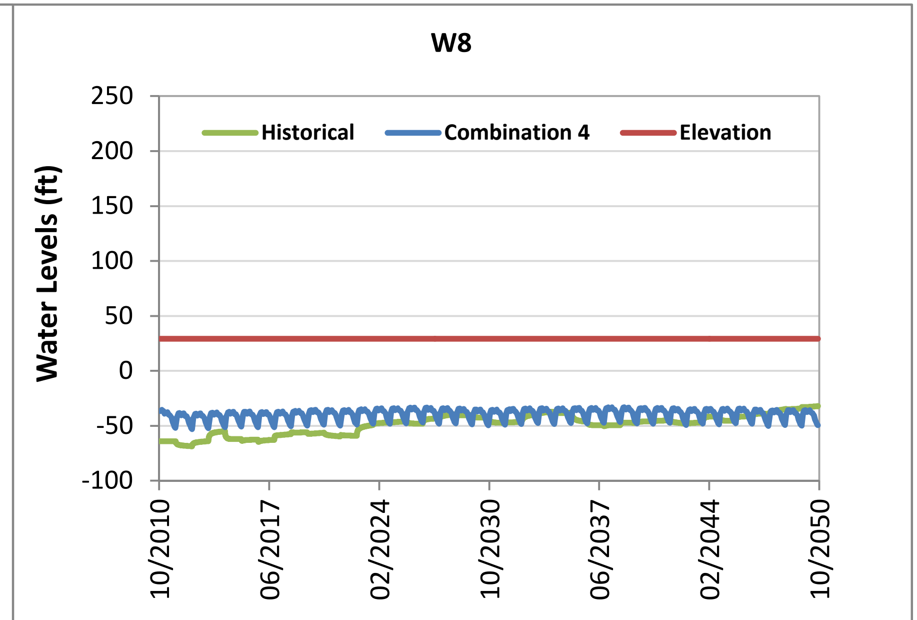
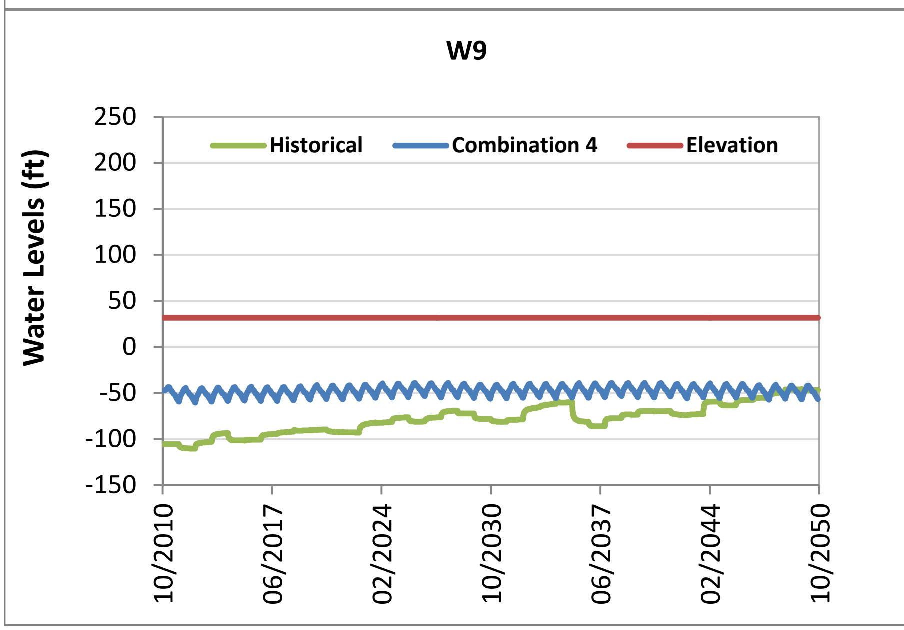
10/2030
06/2037
02/2044
10/2050

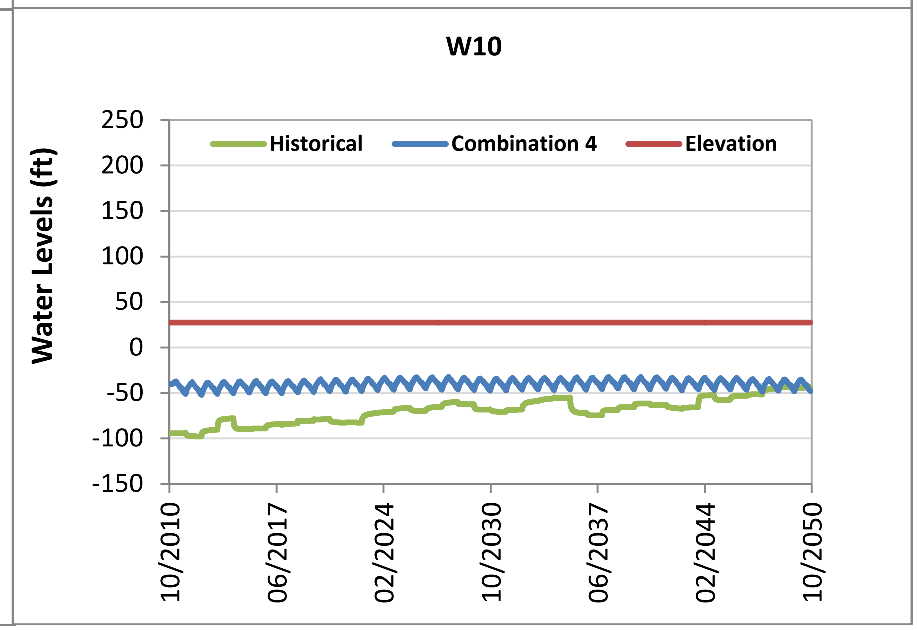

W5
Water Levels (ft)
Historical
Combination 4
Elevation
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

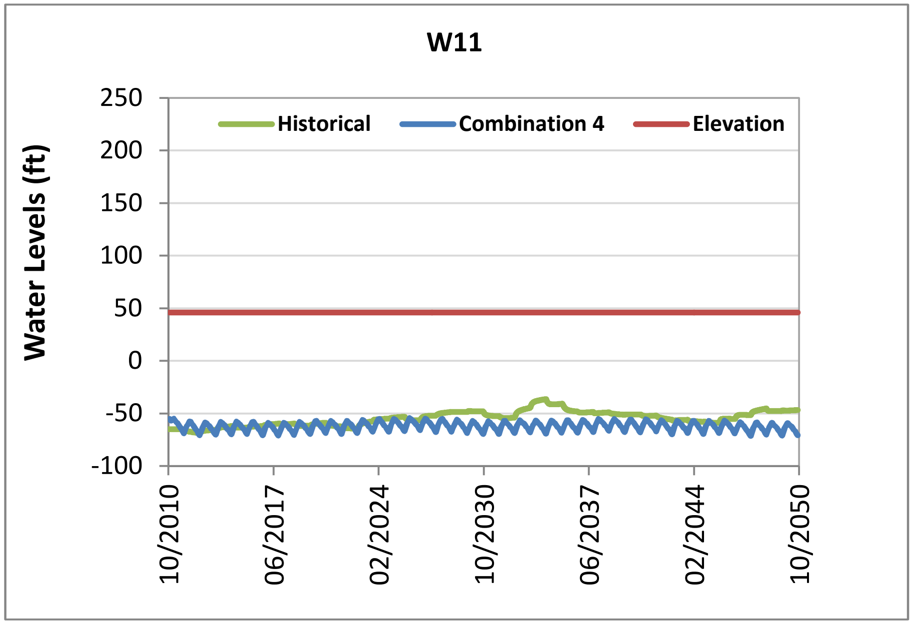

W6
Water Levels (ft)
Historical
Combination 4
Elevation
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W7
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

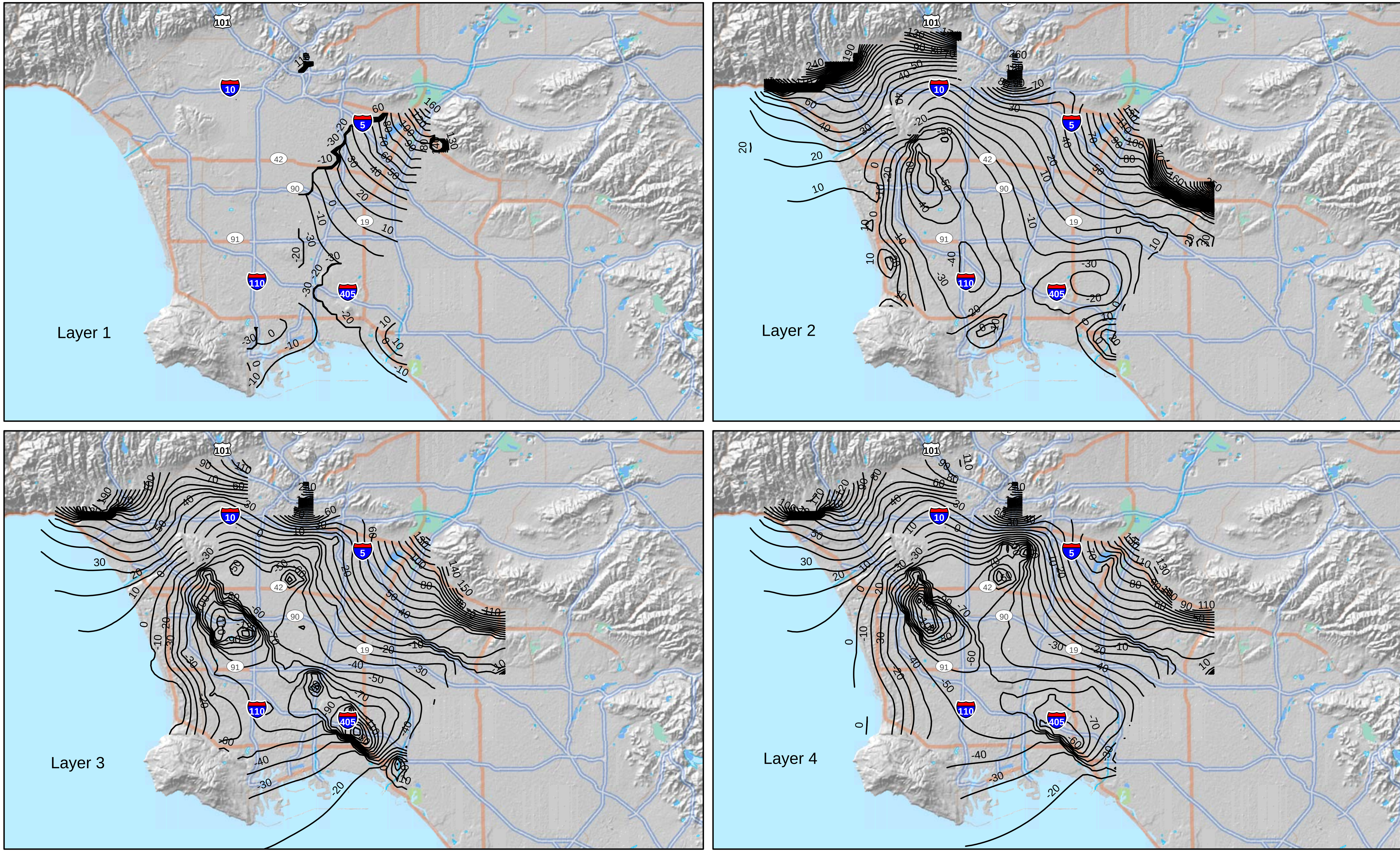

W8
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W9
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W10
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050



W11
Historical
Combination 4
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050



Legend

- Groundwater Basin Boundary
- Forebays
- Alamitos Barrier
- West Coast Basin Barriers
- Groundwater Level Contours
- Limited Access
- Highway
- Major Road

Water Bodies

Description

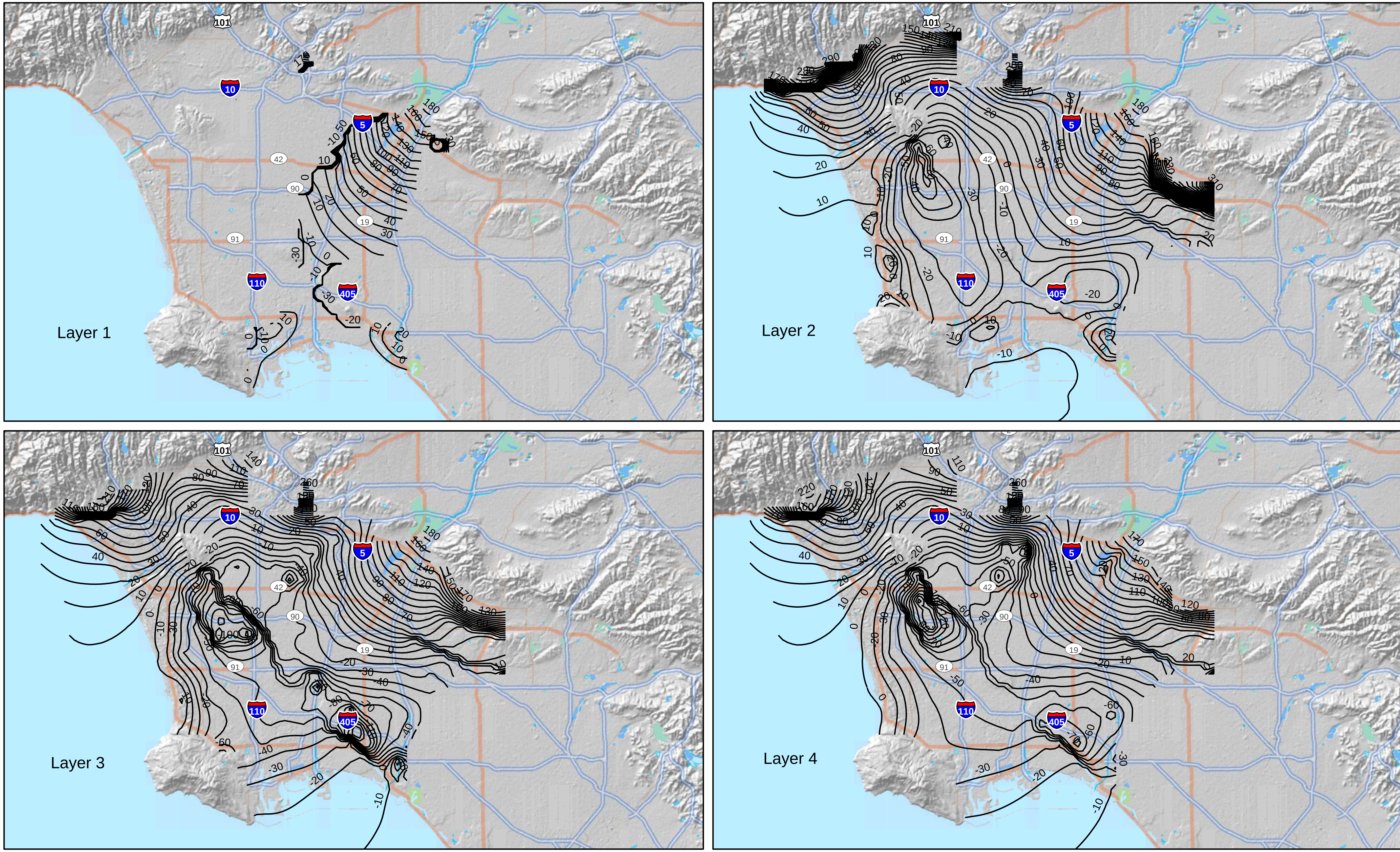
- Lake/Pond
- River/Stream
- Ocean
- Lake or Pond
- Swamp or Marsh
- Stream or River
- Inundation Area

N

0 0.5 1 2 3 4 Miles

Combination 4 - Groundwater Level Contours at the Minimum Cumulative Storage in 2017

File Location



Legend

- Groundwater Basin Boundary
- Forebays
- Alamitos Barrier
- West Coast Basin Barriers
- Groundwater Level Contours
- Limited Access
- Highway
- Major Road

Water Bodies

Description

- Lake/Pond
- River/Stream
- Ocean
- Lake or Pond
- Swamp or Marsh
- Stream or River
- Inundation Area

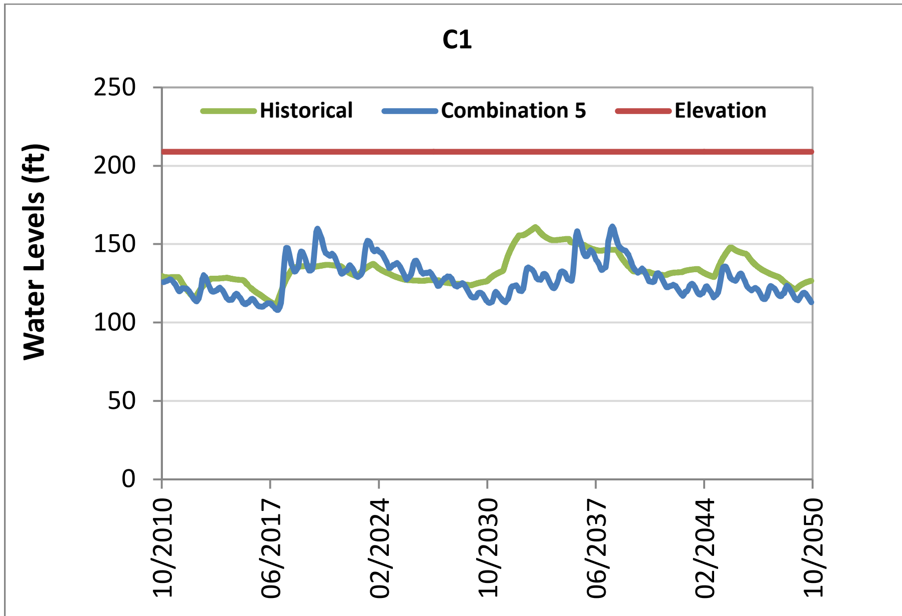
N

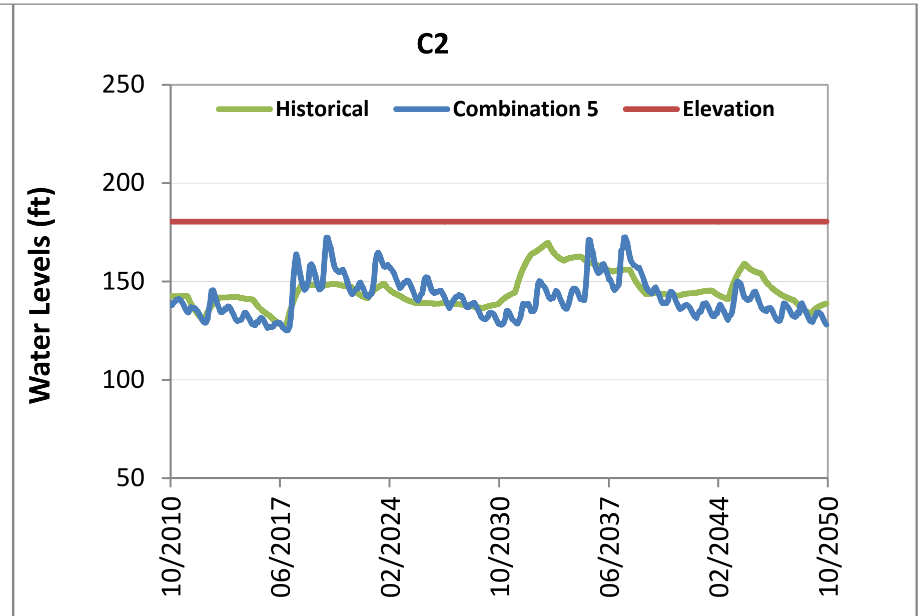
0 0.5 1 2 3 4 Miles

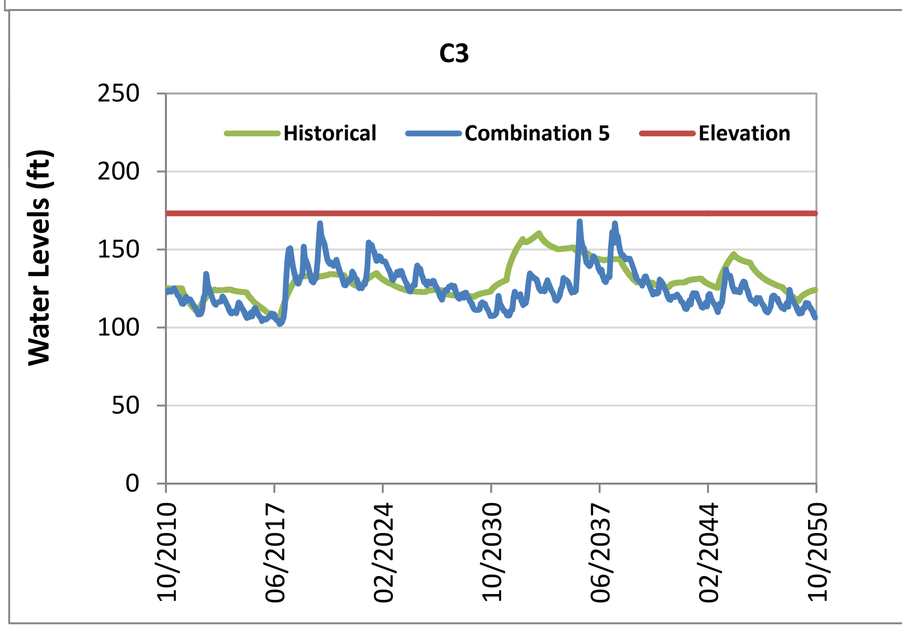
Combination 4 - Groundwater Level Contours at the Maximum Cumulative Storage in 2038

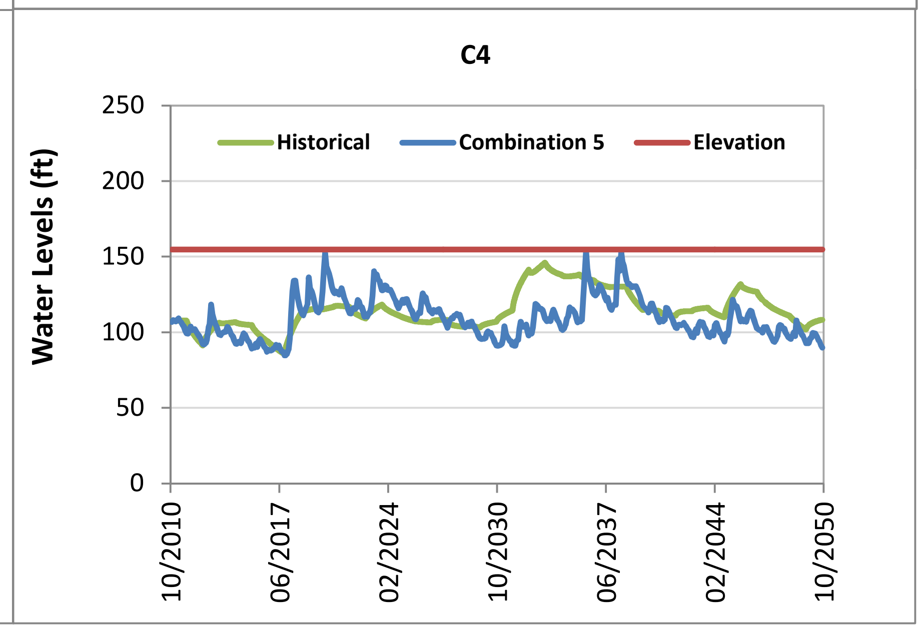
File Location

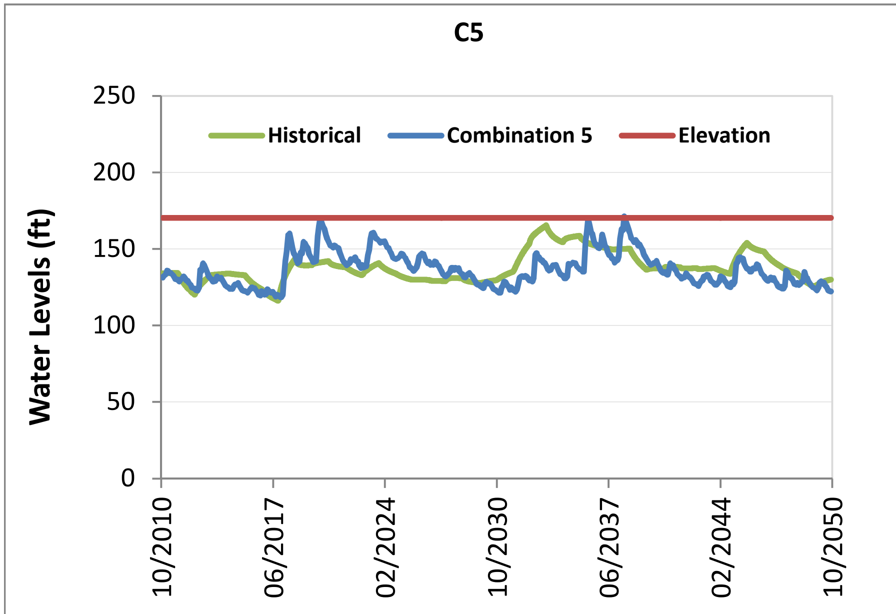
Combination 5 Model Results:
1) Hydrographs
2) Groundwater Level Contour Maps


C1
Water Levels (ft)
250
200
150
100
50
0
Historical
Combination 5
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C2
Water Levels (ft)
250
200
150
100
50
Historical
Combination 5
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C3
Water Levels (ft)
250
200
150
100
50
0
Historical
Combination 5
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C4
Water Levels (ft)
250
200
150
100
50
0
Historical
Combination 5
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C5
Historical
Combination 5
Elevation
Water Levels (ft)
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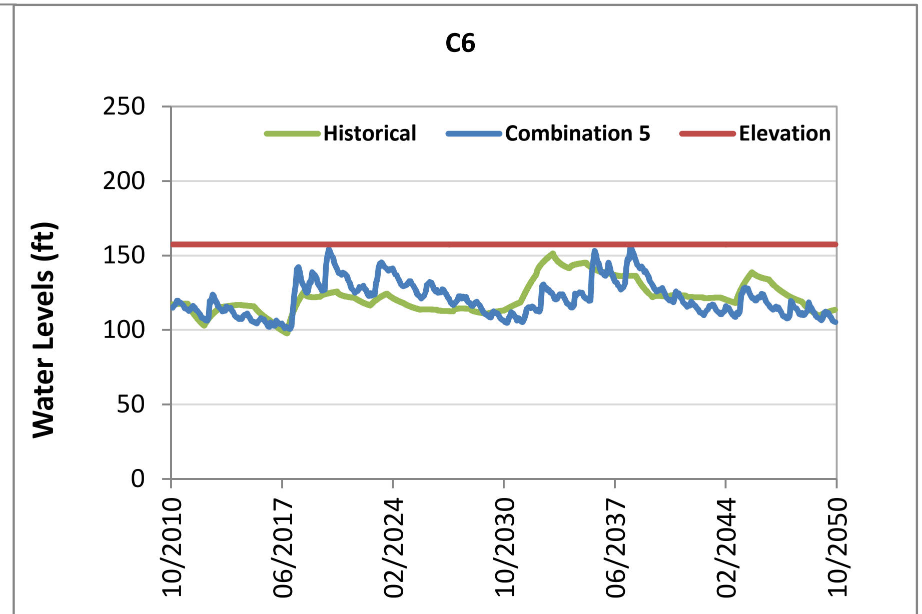
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C6
Historical
Combination 5
Elevation
Water Levels (ft)
250
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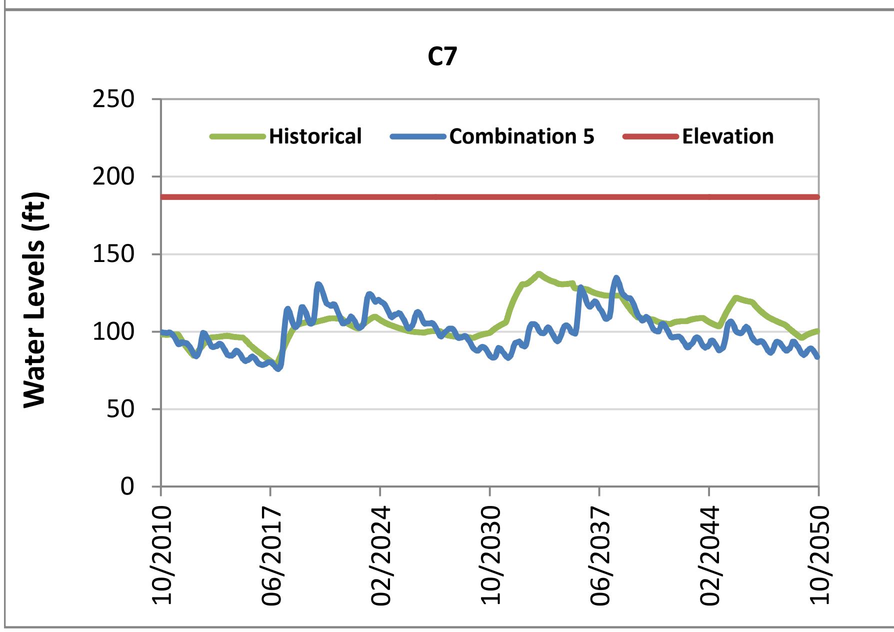
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C7
Historical
Combination 5
Elevation
Water Levels (ft)
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100
50
0
10/2010
06/2017
02/2024
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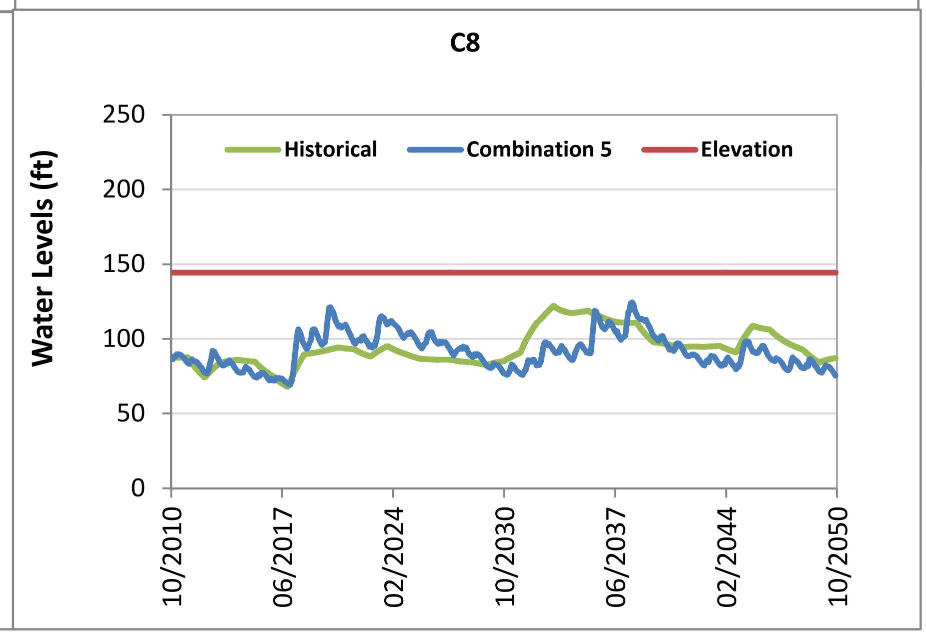
06/2037
02/2044
10/2050


C8
Historical
Combination 5
Elevation
Water Levels (ft)
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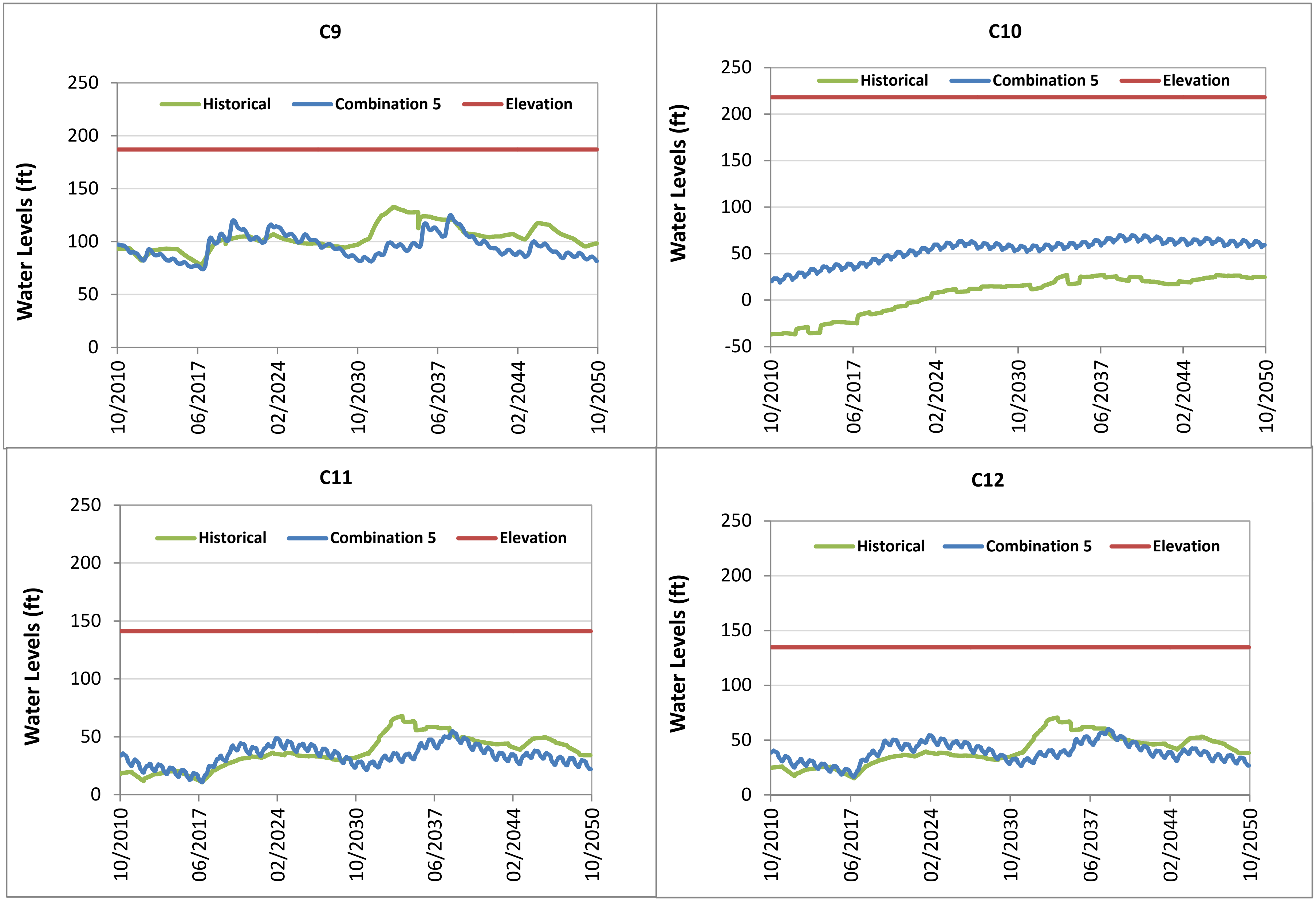
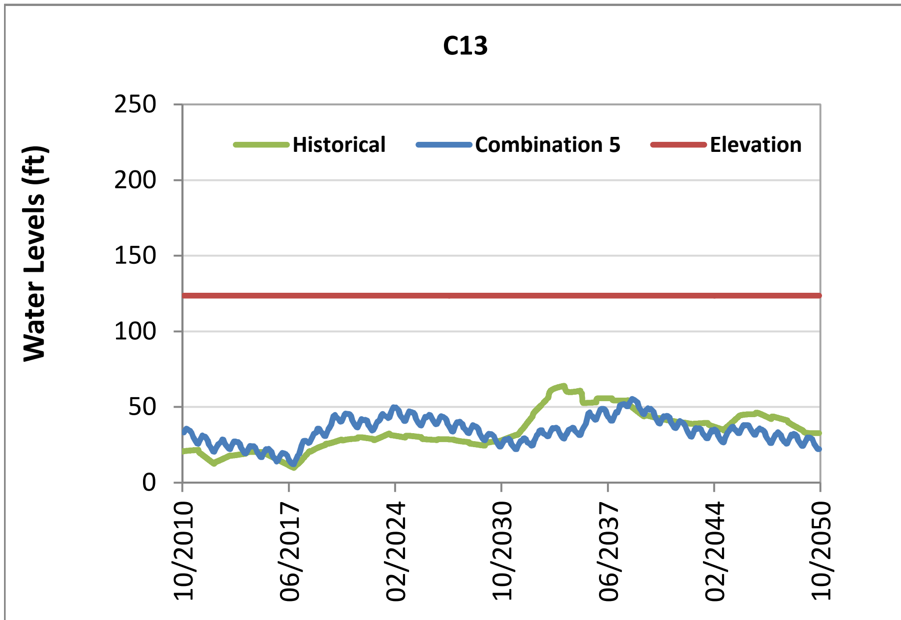
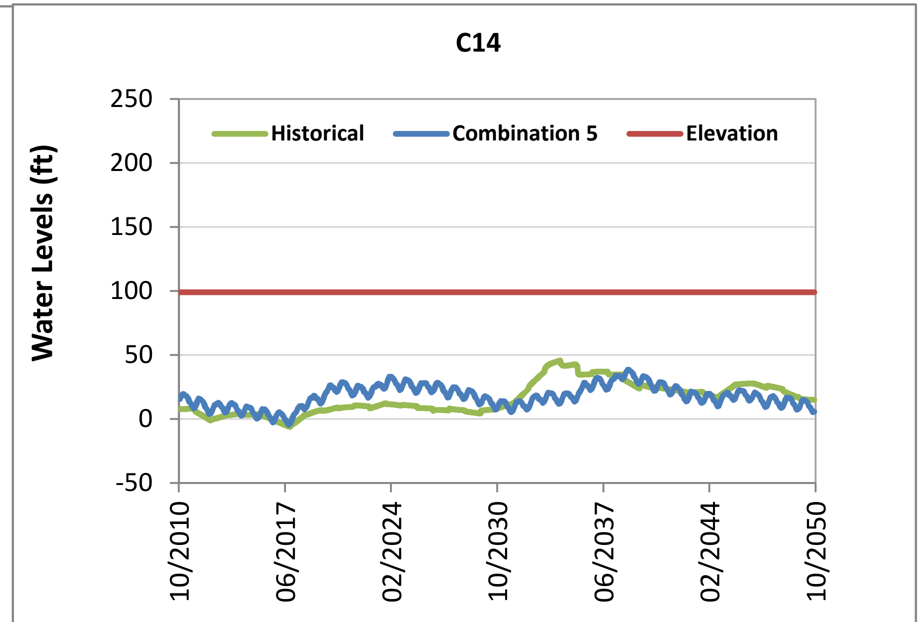
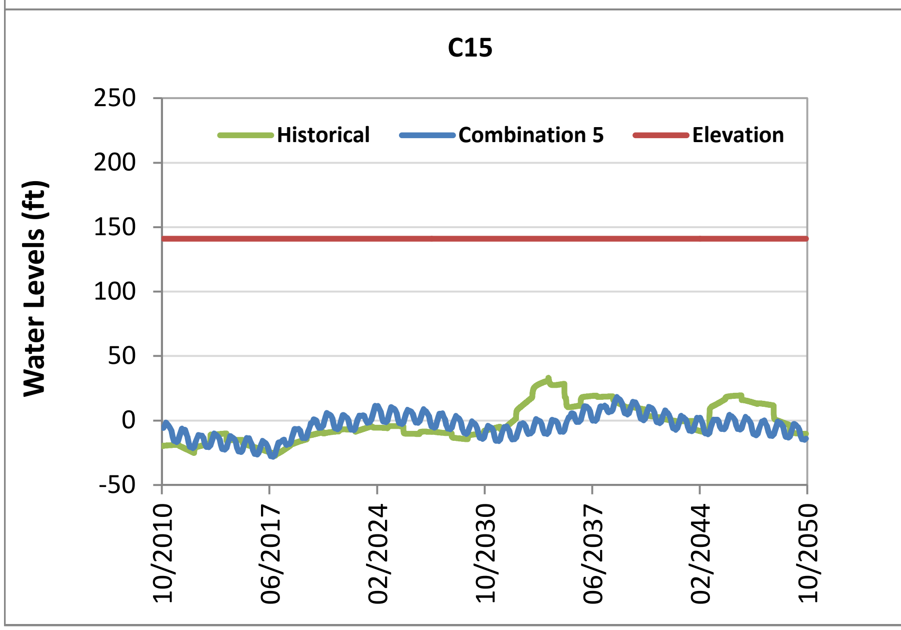
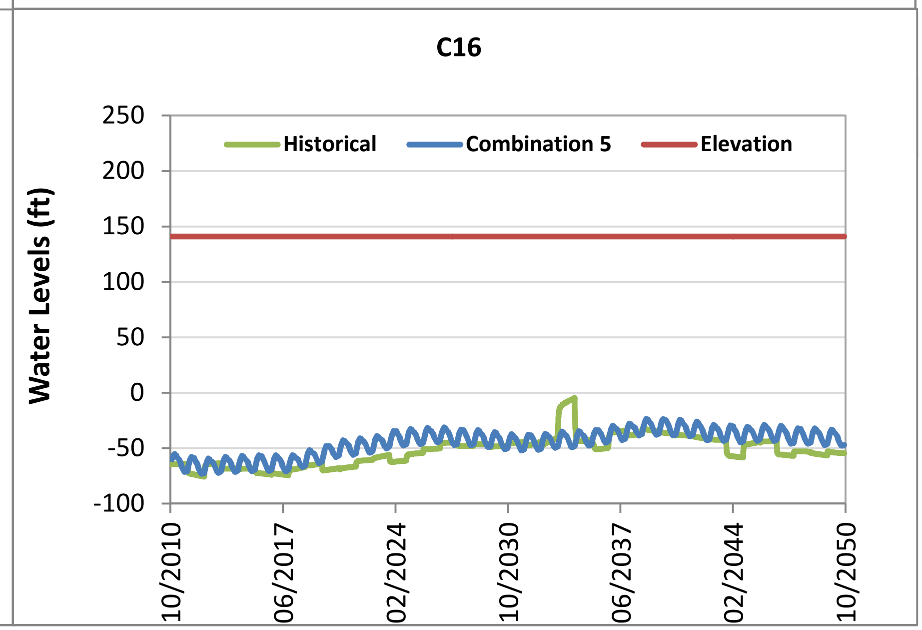
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C9
Historical
Combination 5
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050
C10
Historical
Combination 5
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050
C11
Historical
Combination 5
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050
C12
Historical
Combination 5
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C13
Water Levels (ft)
Historical
Combination 5
Elevation
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C14
Water Levels (ft)
Historical
Combination 5
Elevation
250
200
150
100
50
0
-50
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C15
Water Levels (ft)
Historical
Combination 5
Elevation
250
200
150
100
50
0
-50
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C16
Water Levels (ft)
Historical
Combination 5
Elevation
250
200
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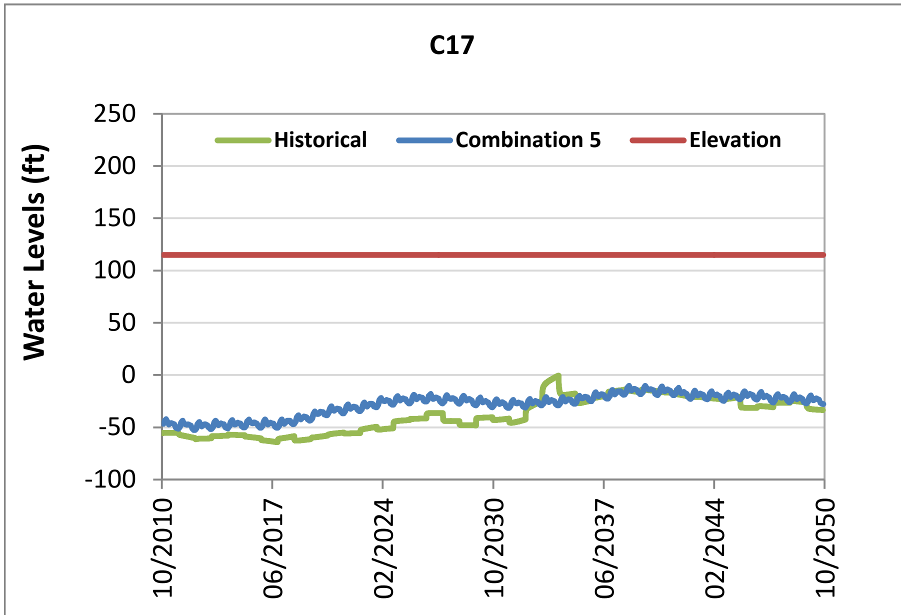
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C17
Water Levels (ft)
Historical
Combination 5
Elevation
250
200
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100
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0
-50
-100
10/2010
06/2017
02/2024
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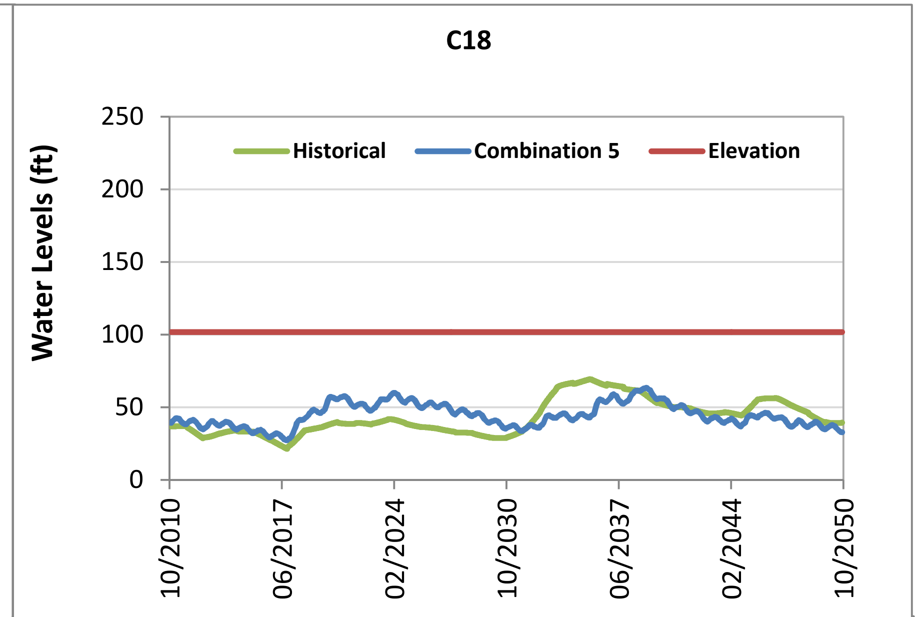
06/2037
02/2044
10/2050


C18
Water Levels (ft)
Historical
Combination 5
Elevation
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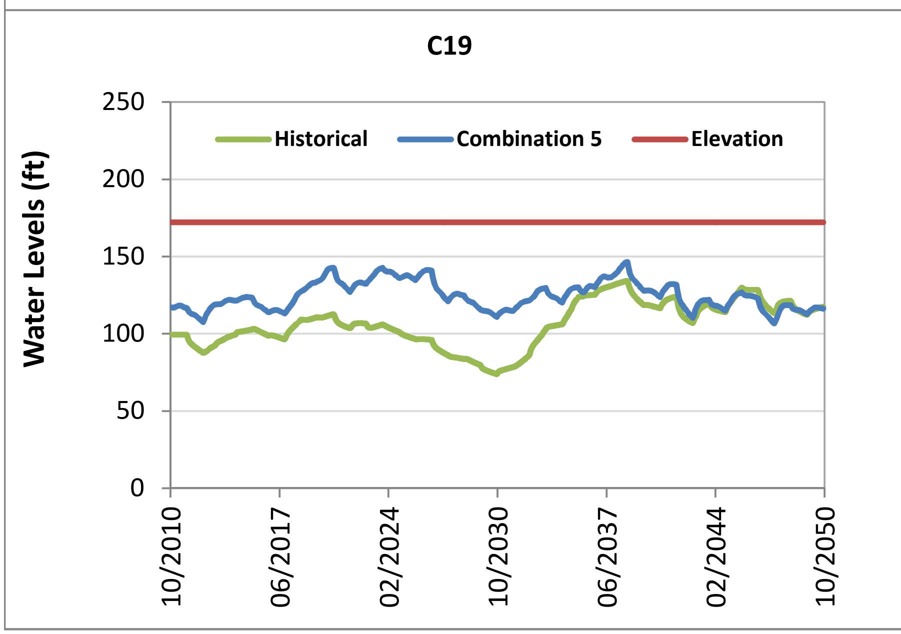
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C19
Water Levels (ft)
Historical
Combination 5
Elevation
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200
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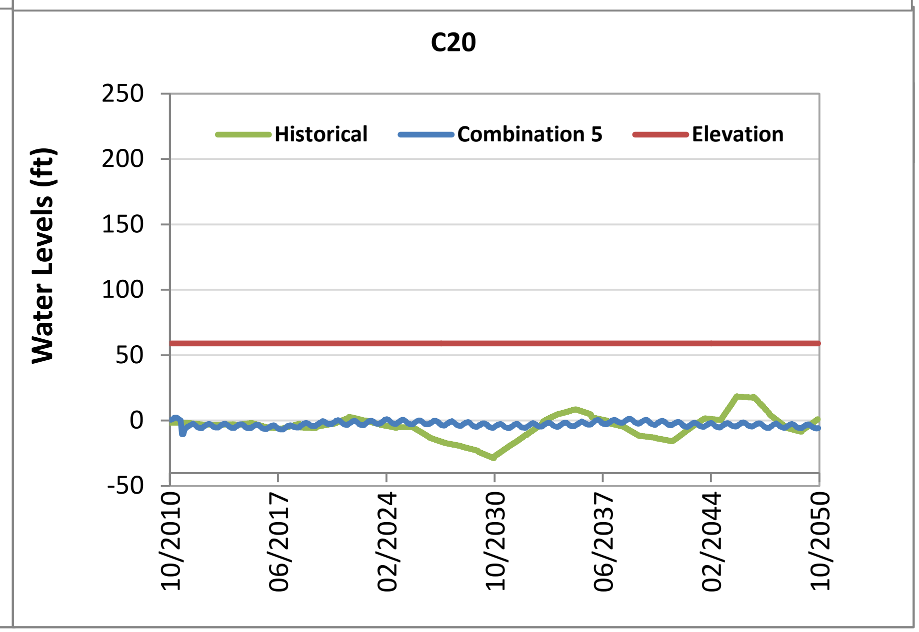
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C20
Water Levels (ft)
Historical
Combination 5
Elevation
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0
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10/2010
06/2017
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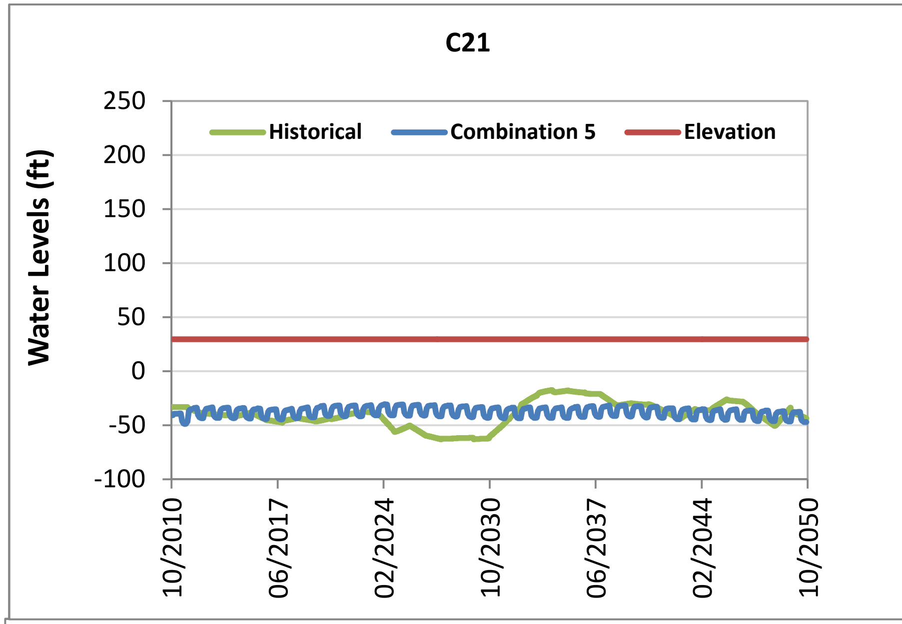
02/2044
10/2050


C21
Historical
Combination 5
Elevation
Water Levels (ft)
250
200
150
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50
0
-50
-100
10/2010
06/2017
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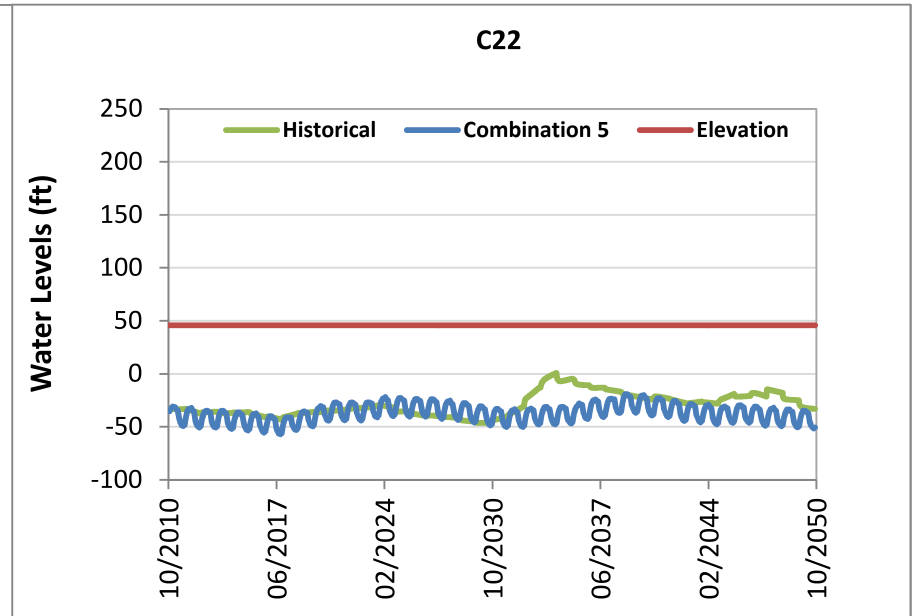
02/2044
10/2050


C22
Historical
Combination 5
Elevation
Water Levels (ft)
250
200
150
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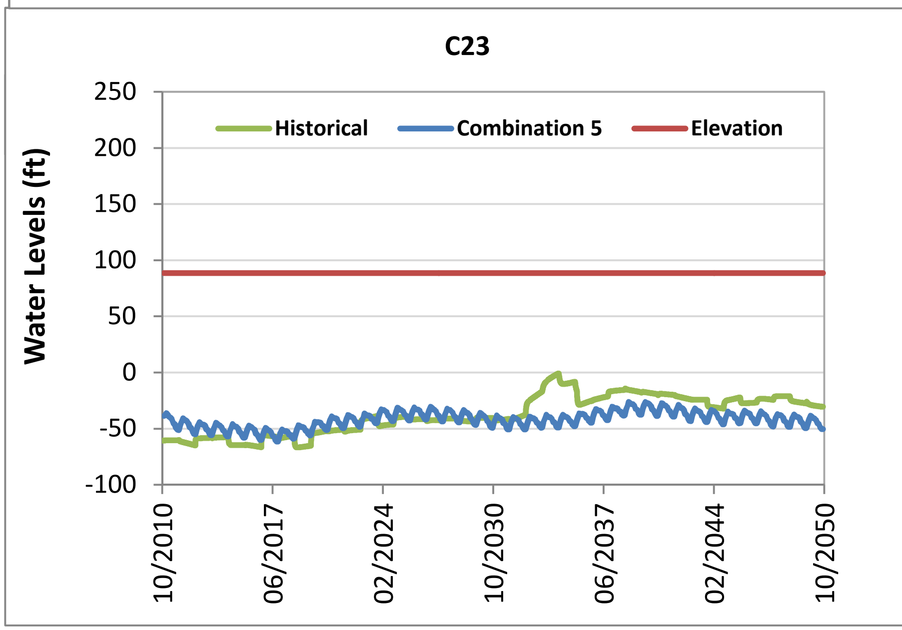
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C23
Historical
Combination 5
Elevation
Water Levels (ft)
250
200
150
100
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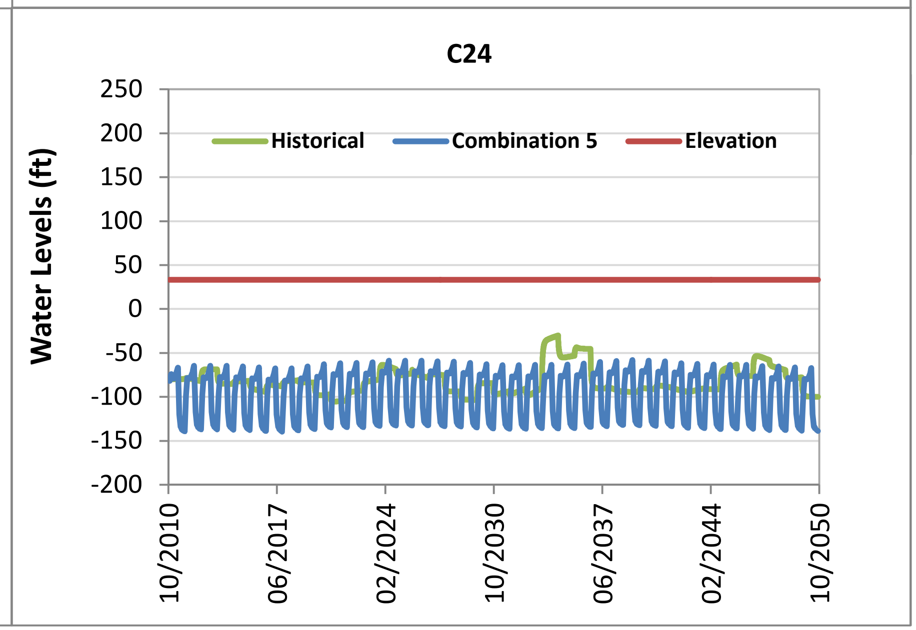
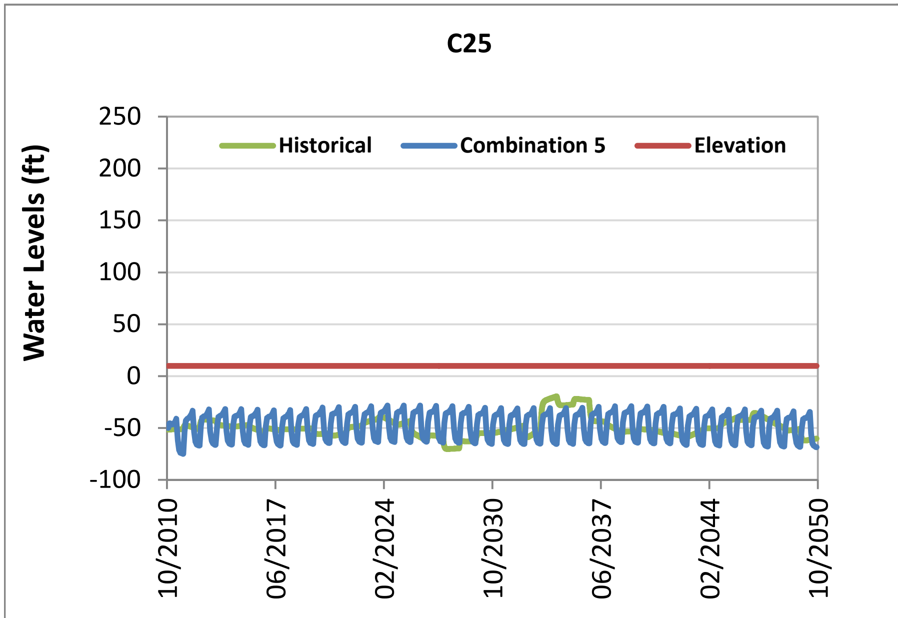
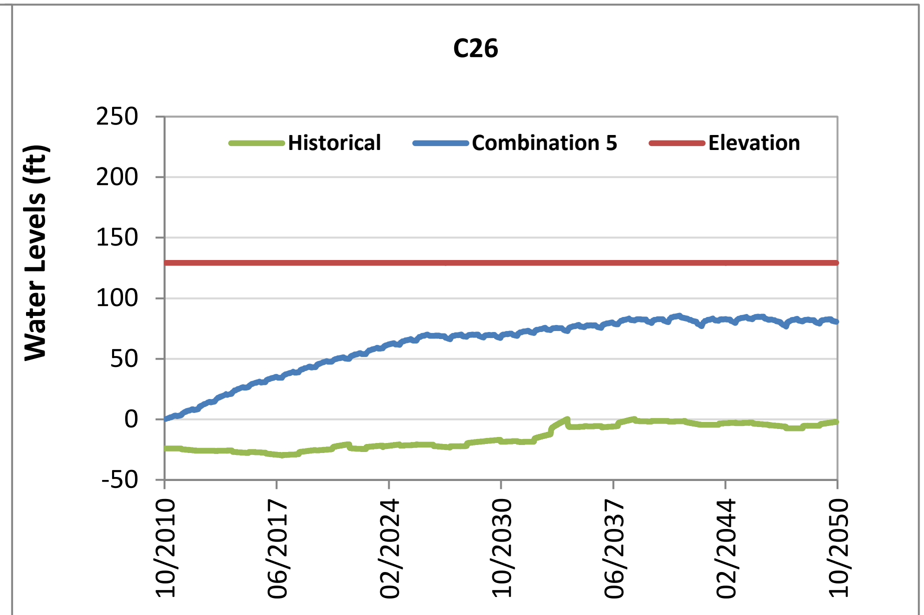
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C24
Historical
Combination 5
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
-200
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C25
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 5
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C26
Water Levels (ft)
250
200
150
100
50
0
-50
Historical
Combination 5
Elevation
10/2010
06/2017
02/2024
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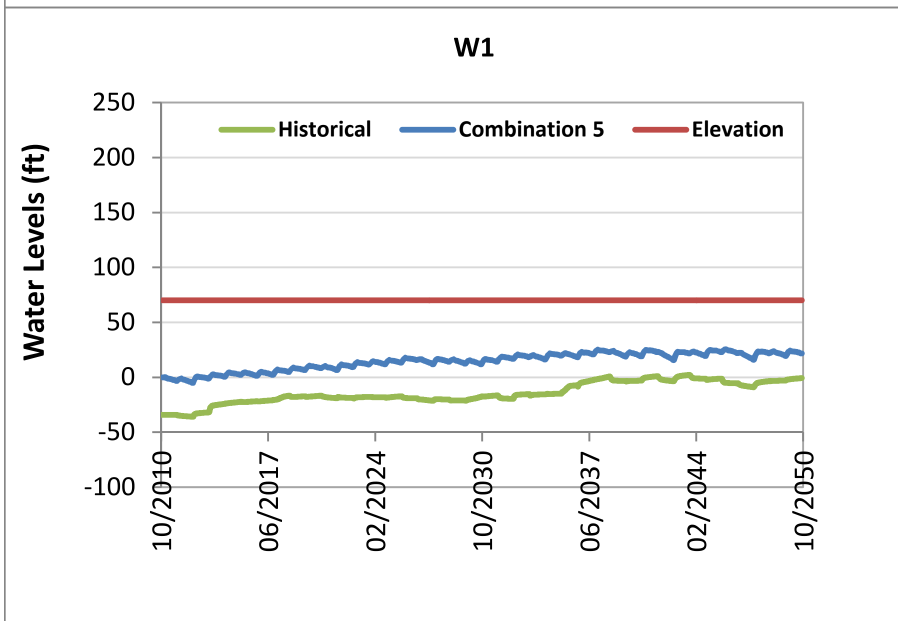
06/2037
02/2044
10/2050


W1
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 5
Elevation
10/2010
06/2017
02/2024
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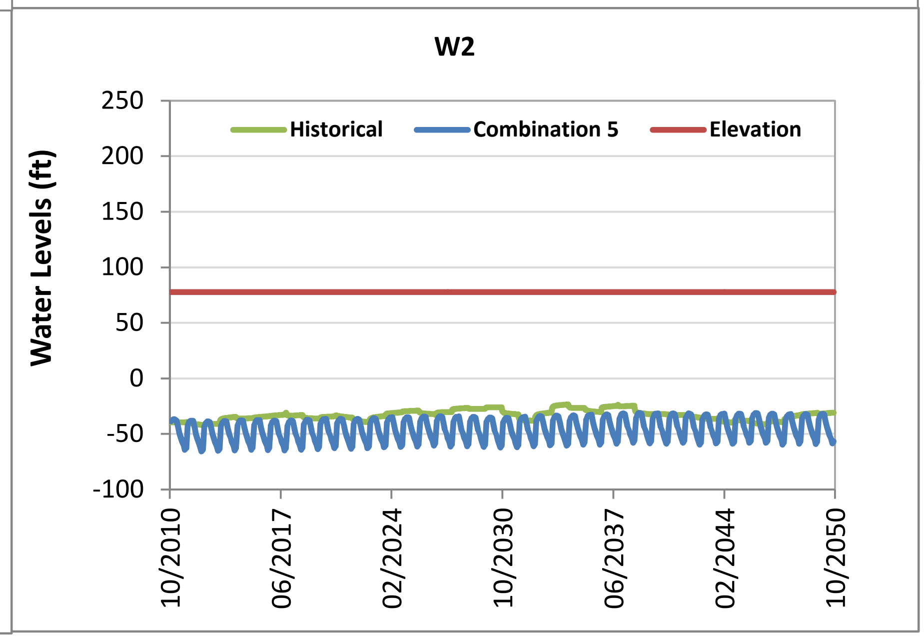
06/2037
02/2044
10/2050


W2
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 5
Elevation
10/2010
06/2017
02/2024
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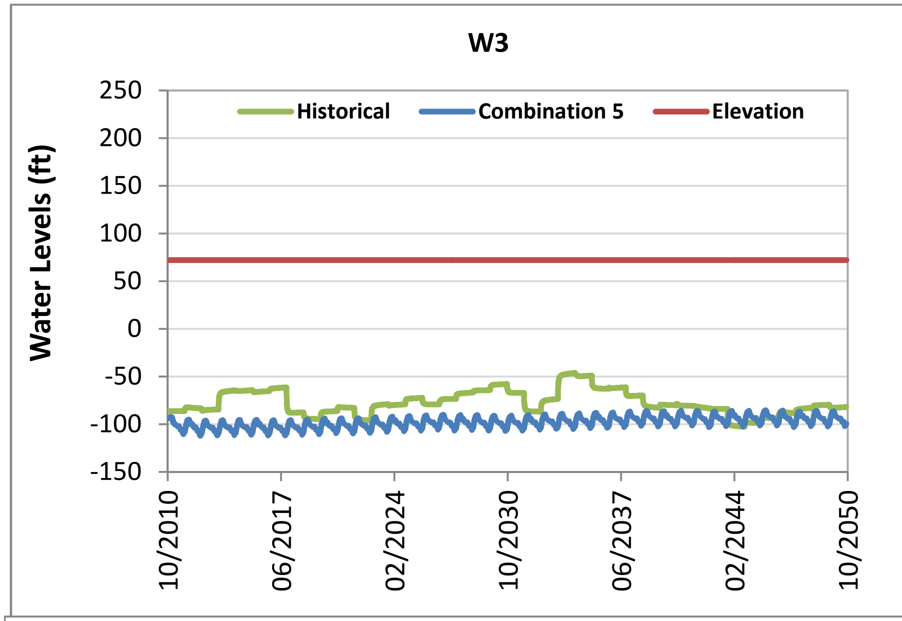
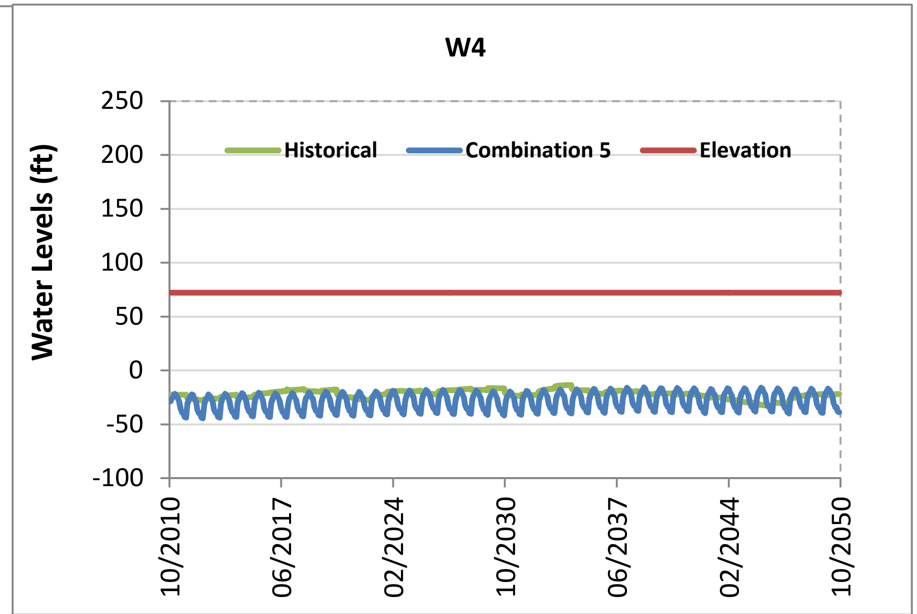
06/2037
02/2044
10/2050


W3
Historical
Combination 5
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W4
Historical
Combination 5
Elevation
Water Levels (ft)
250
200
150
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50
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-50
-100
10/2010
06/2017
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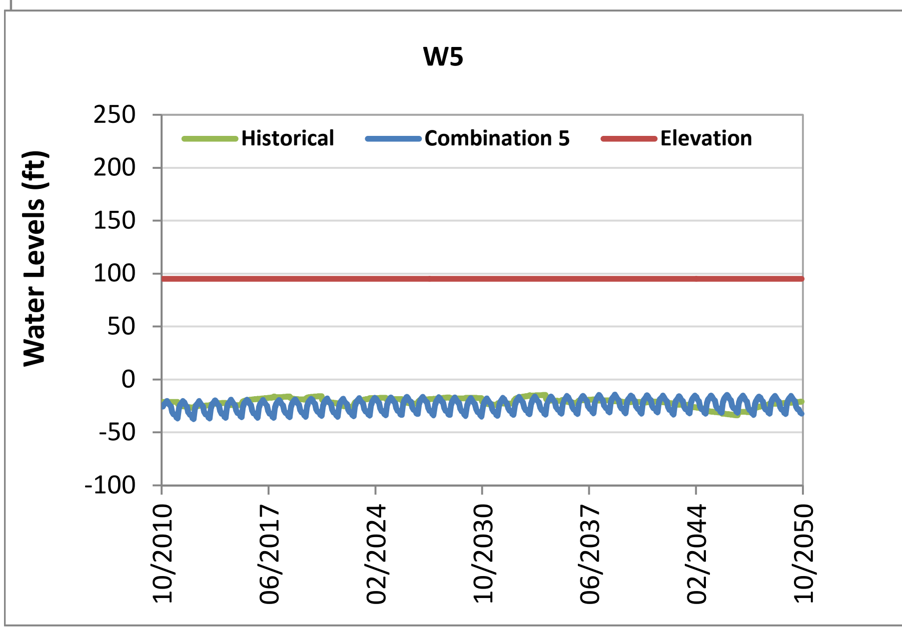
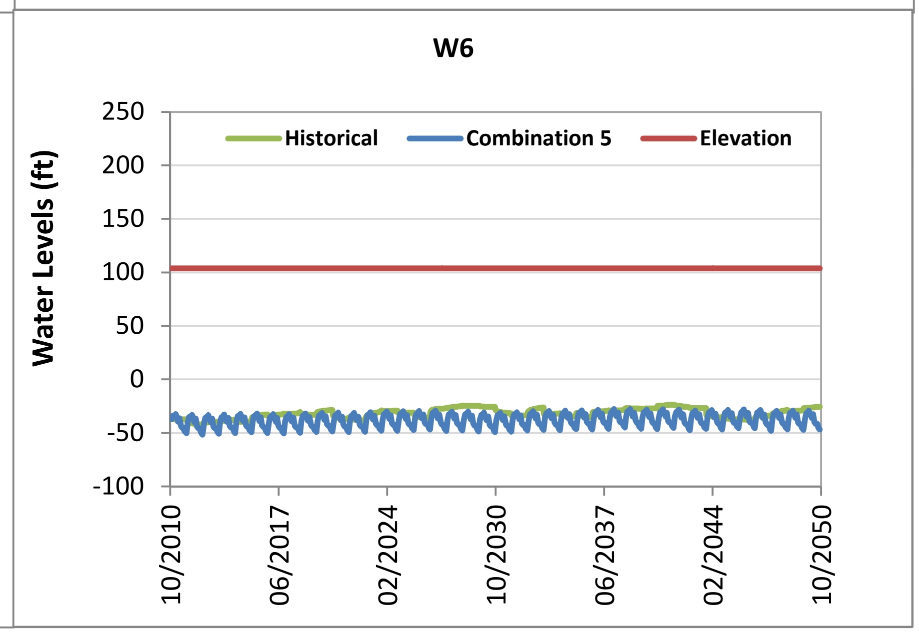
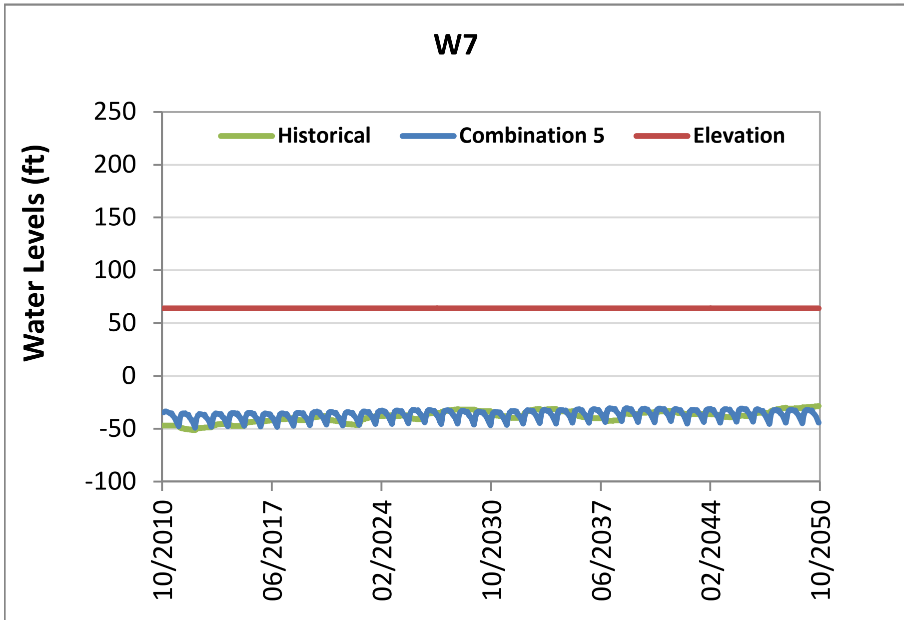
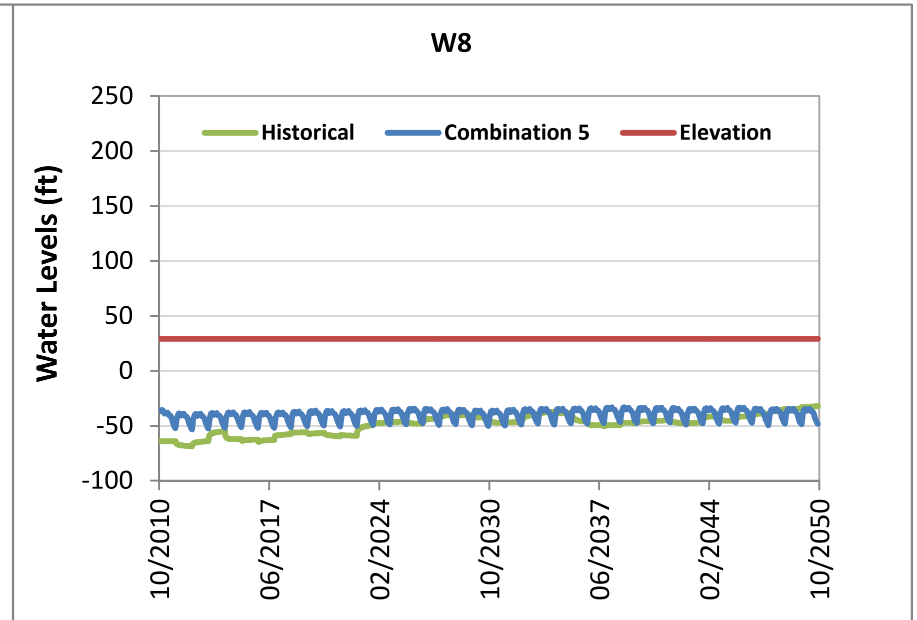
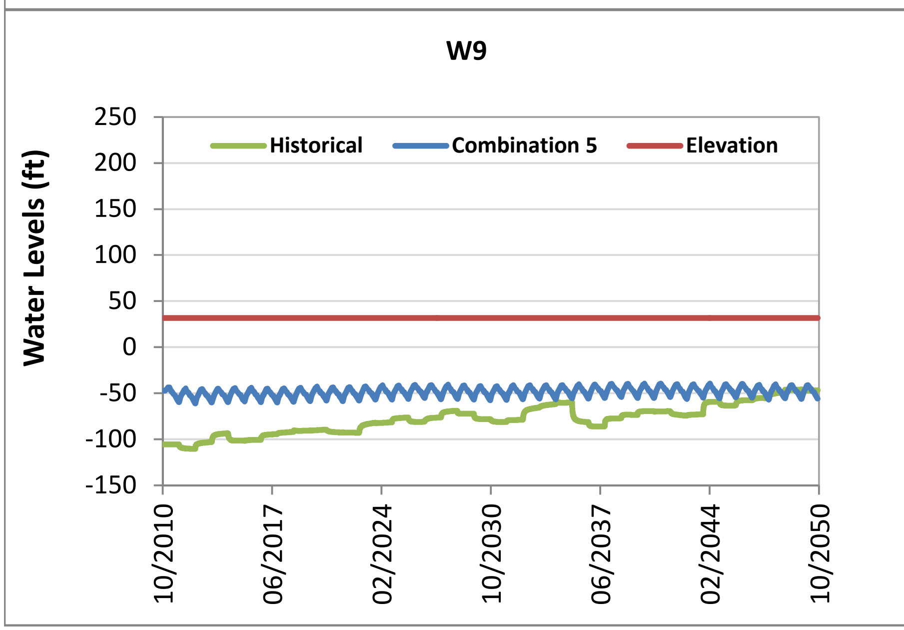
02/2044
10/2050

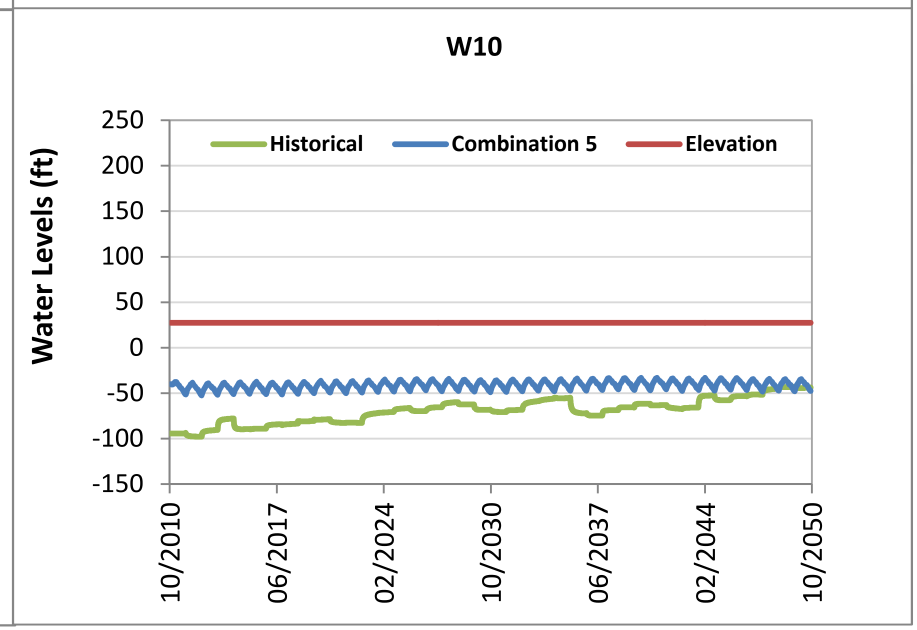

W5
Historical
Combination 5
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

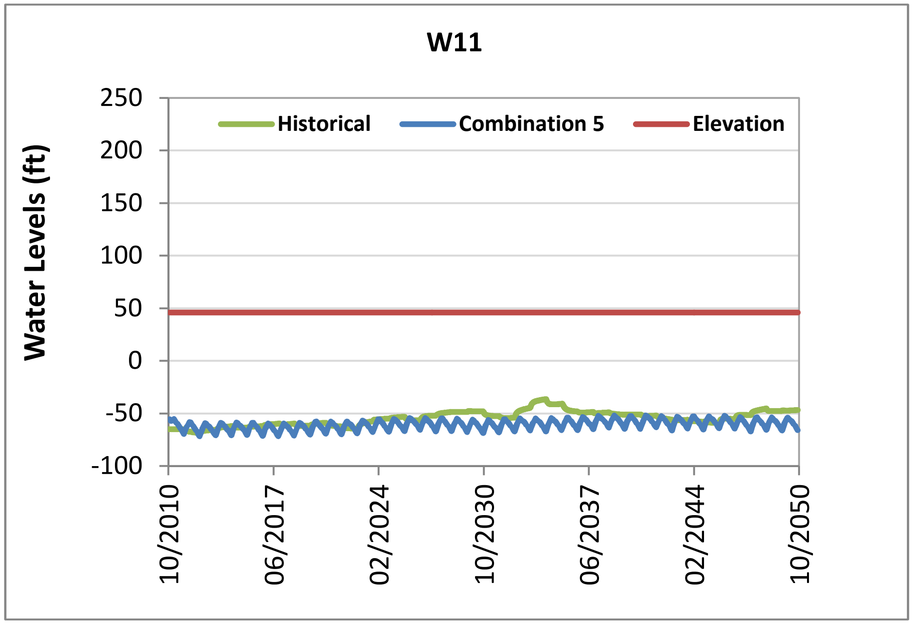

W6
Historical
Combination 5
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

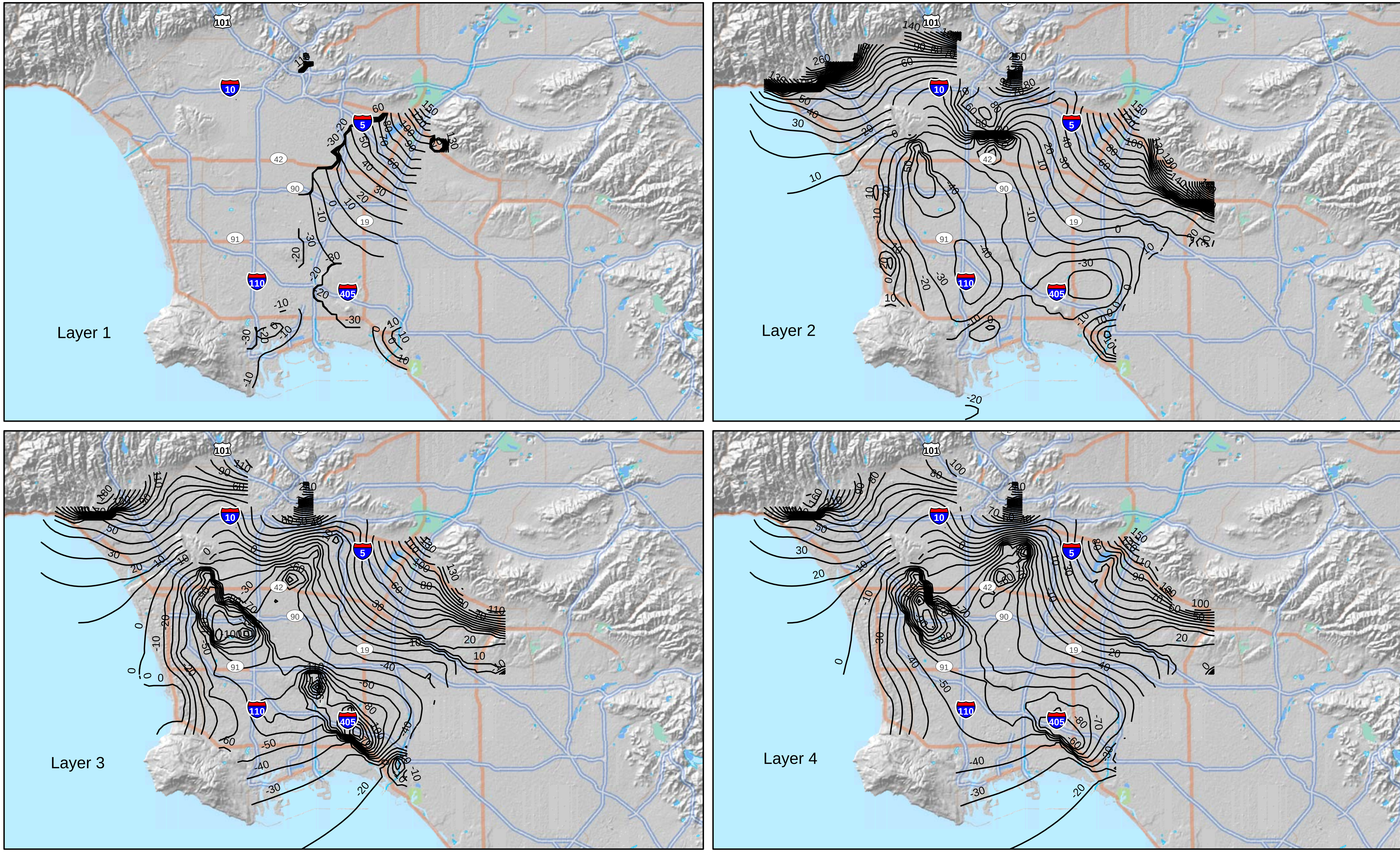

W7
Historical
Combination 5
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W8
Historical
Combination 5
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W9
Historical
Combination 5
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W10
Historical
Combination 5
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W11
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 5
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050



Legend

- Groundwater Basin Boundary
- Forebays
- Alamitos Barrier
- West Coast Basin Barriers
- Groundwater Level Contours
- Limited Access
- Highway
- Major Road

Water Bodies

Description

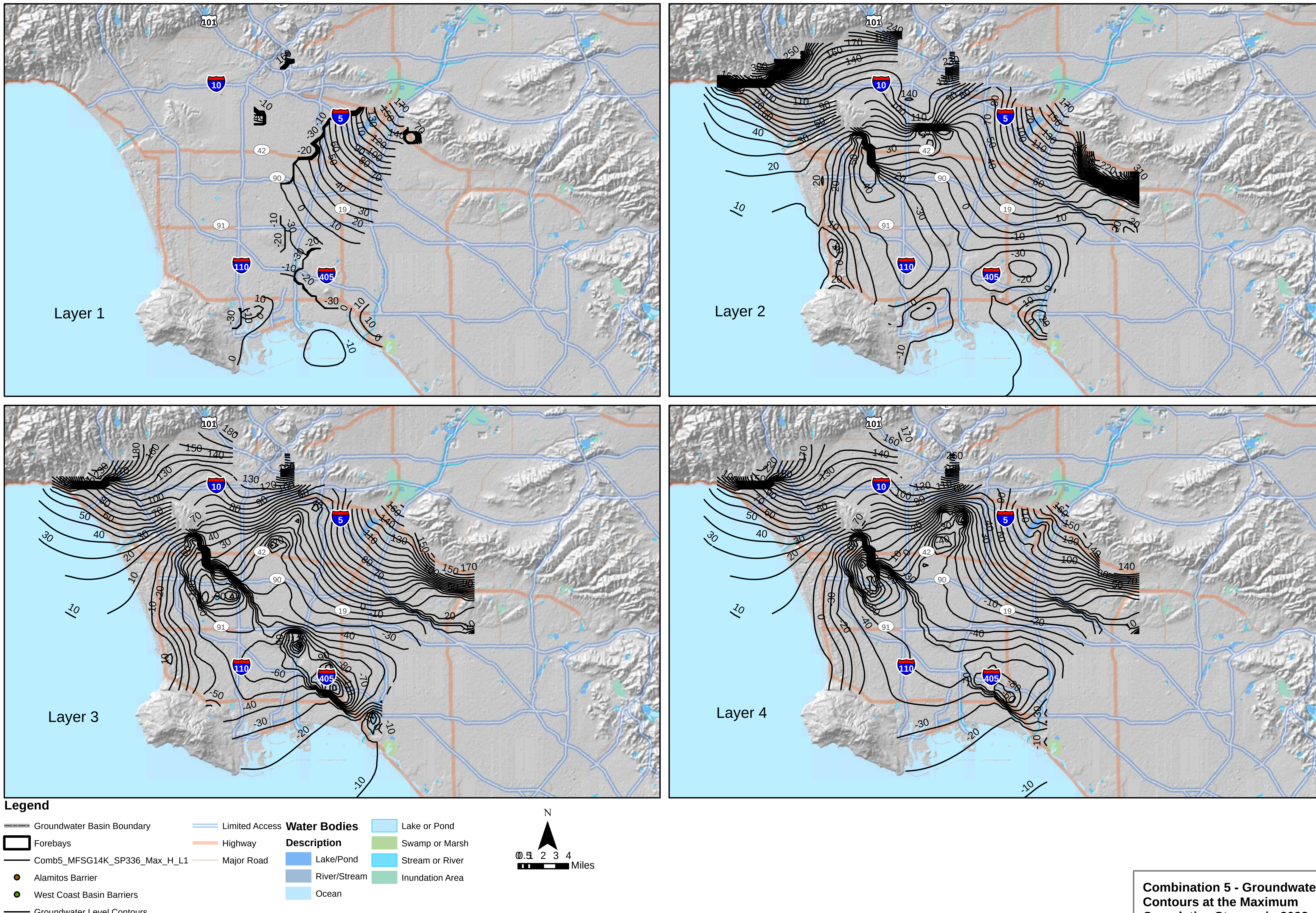
- Lake/Pond
- River/Stream
- Ocean
- Lake or Pond
- Swamp or Marsh
- Stream or River
- Inundation Area

N

0 0.5 1 2 3 4 Miles

Combination 5 - Groundwater Level Contours at the Minimum Cumulative Storage in 2012

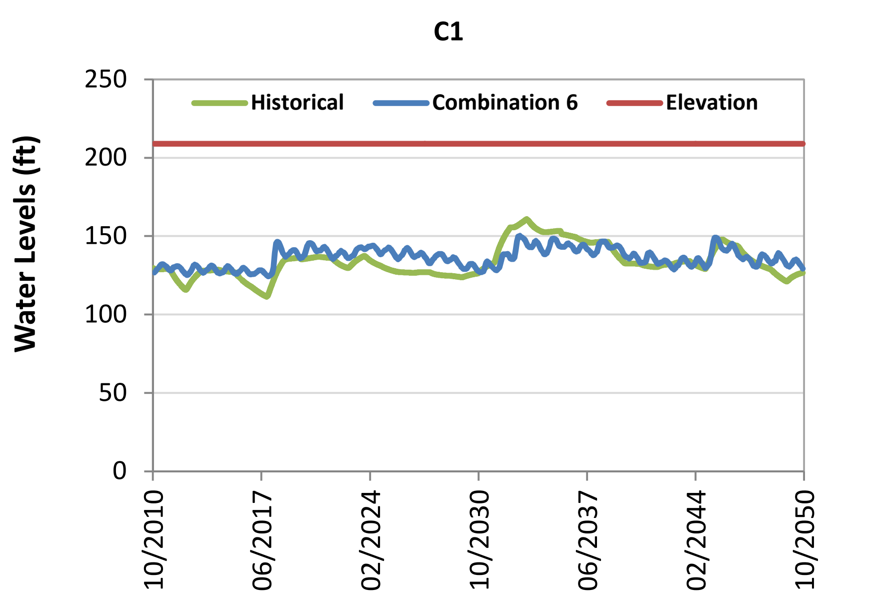
File Location

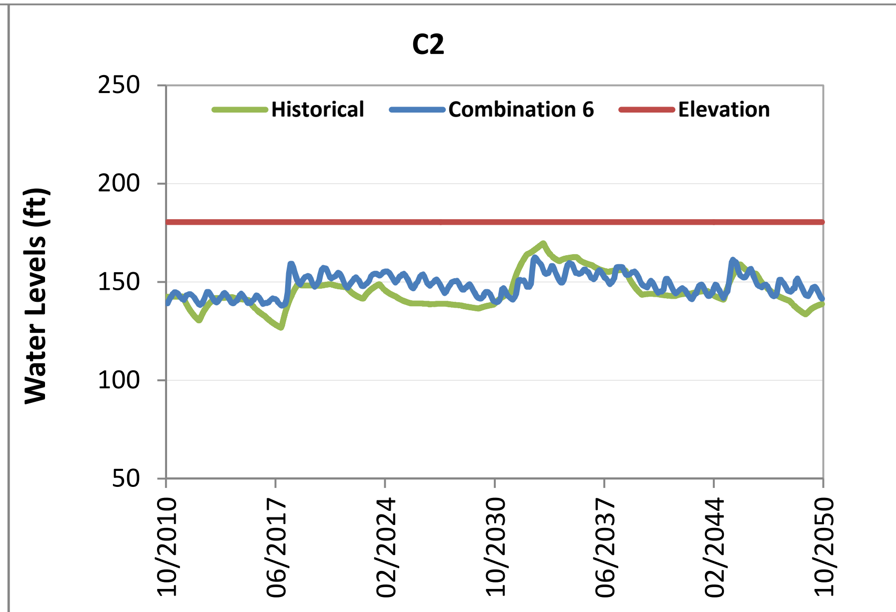


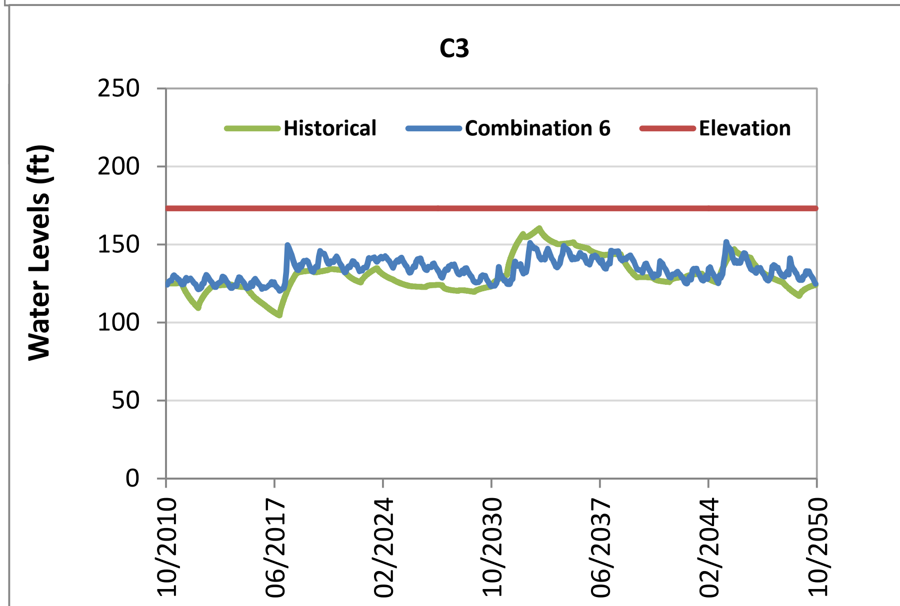
Combination 5 - Groundwater Level Contours at the Maximum Cumulative Storage in 2038

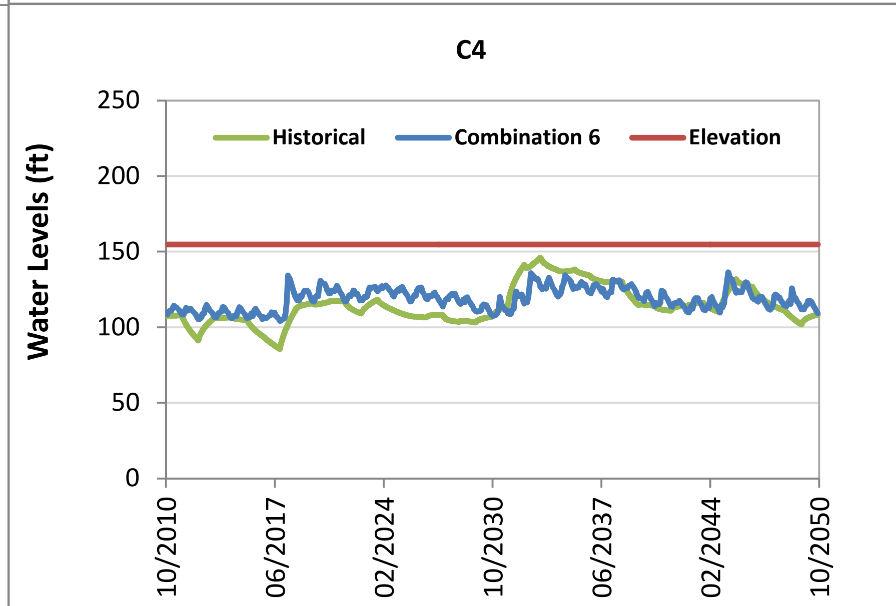
File Location

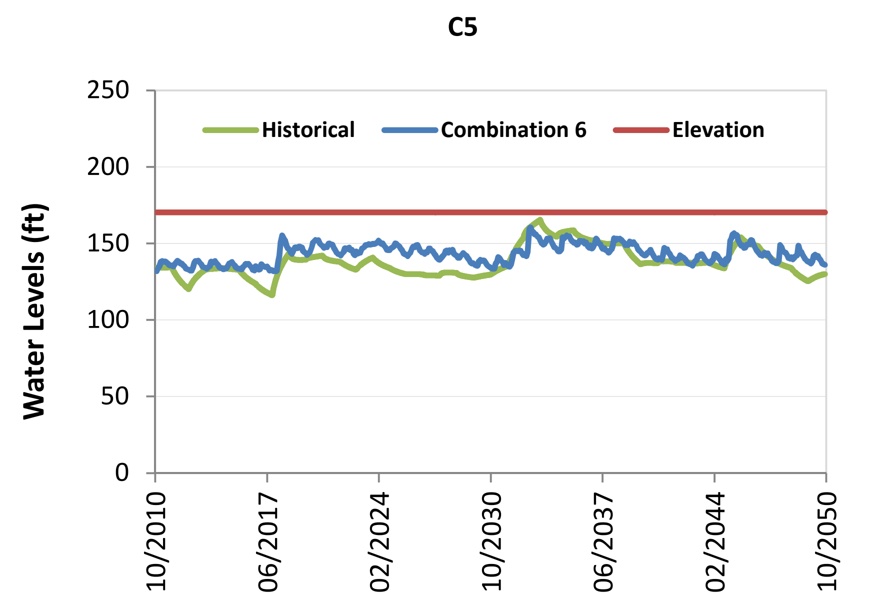
Combination 6 Model Results:
1) Hydrographs
2) Groundwater Level Contour Maps

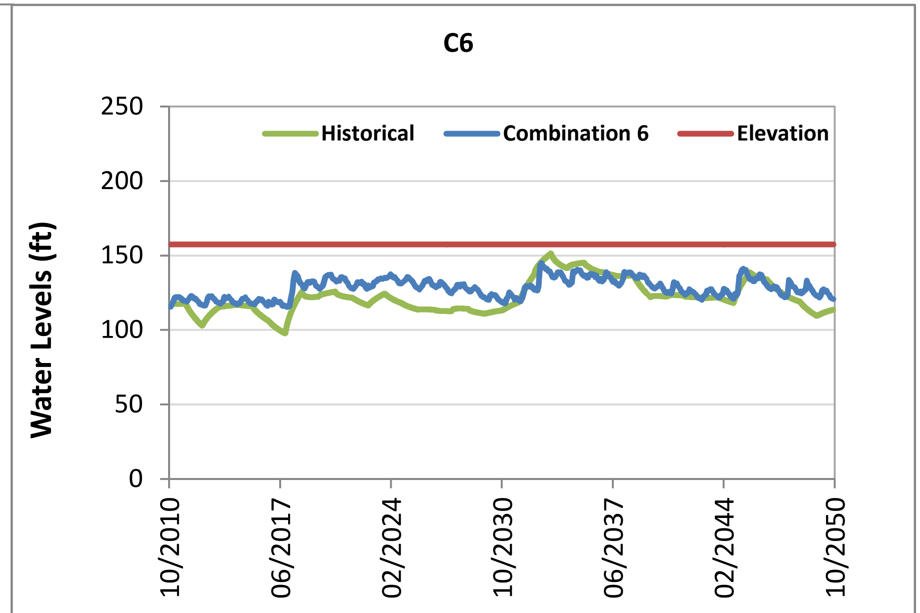

C1
Historical
Combination 6
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

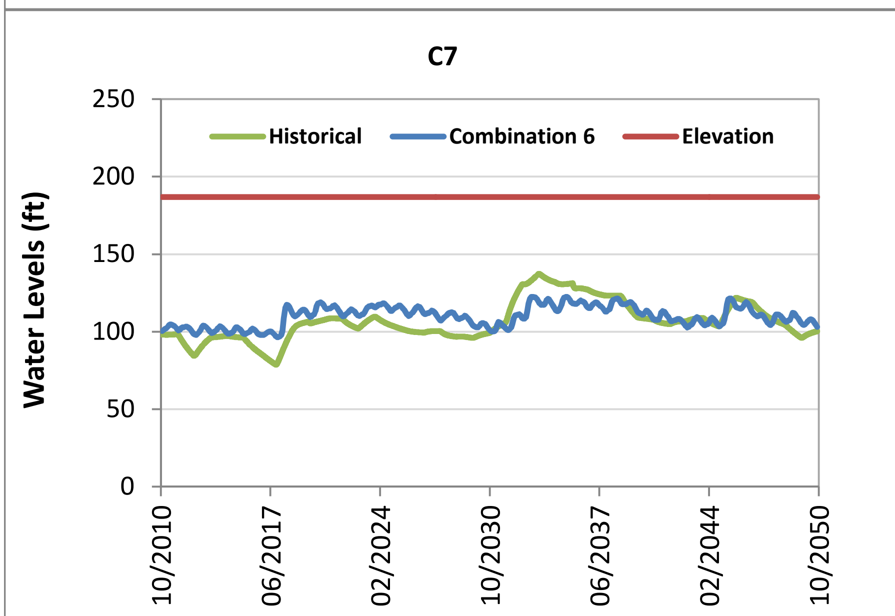

C2
Historical
Combination 6
Elevation
Water Levels (ft)
250
200
150
100
50
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

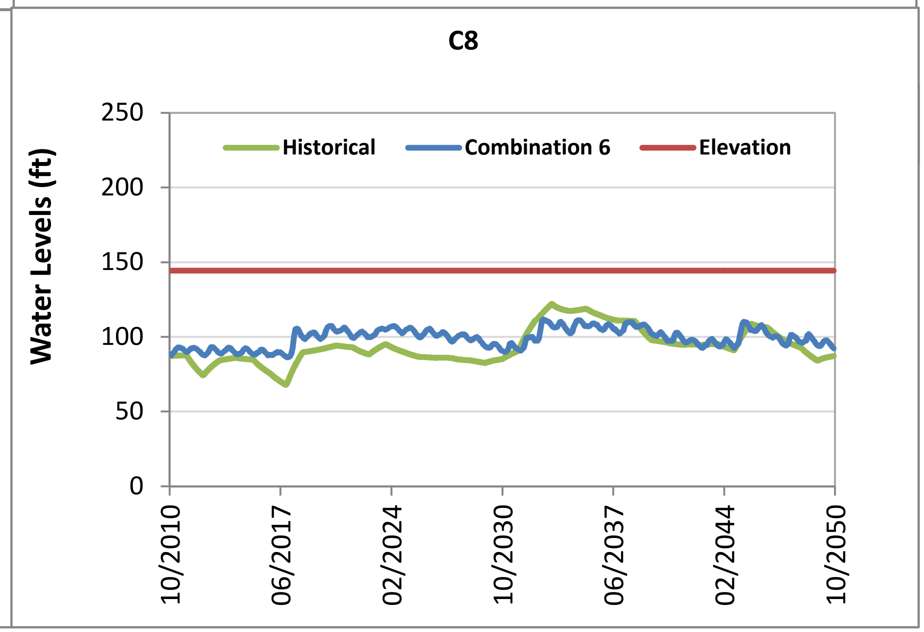

C3
Historical
Combination 6
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

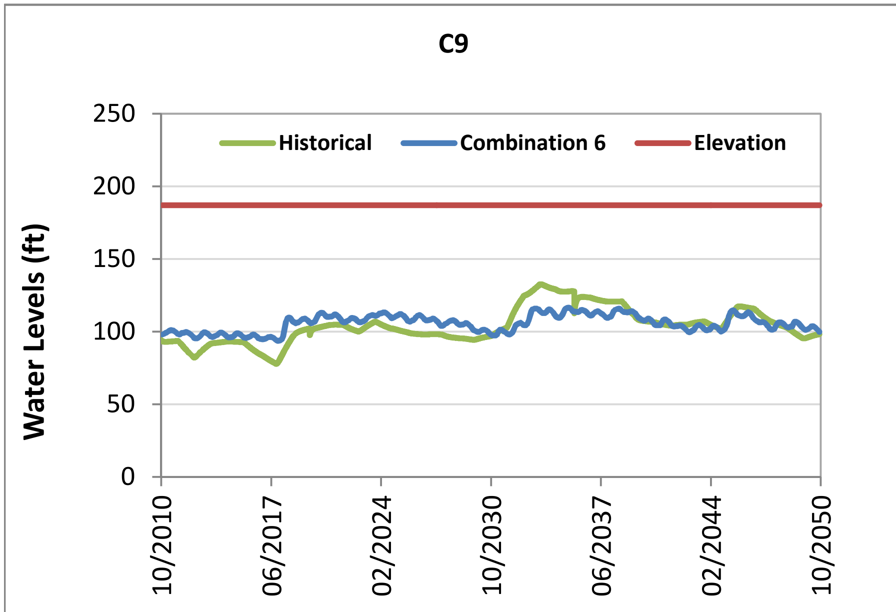

C4
Historical
Combination 6
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

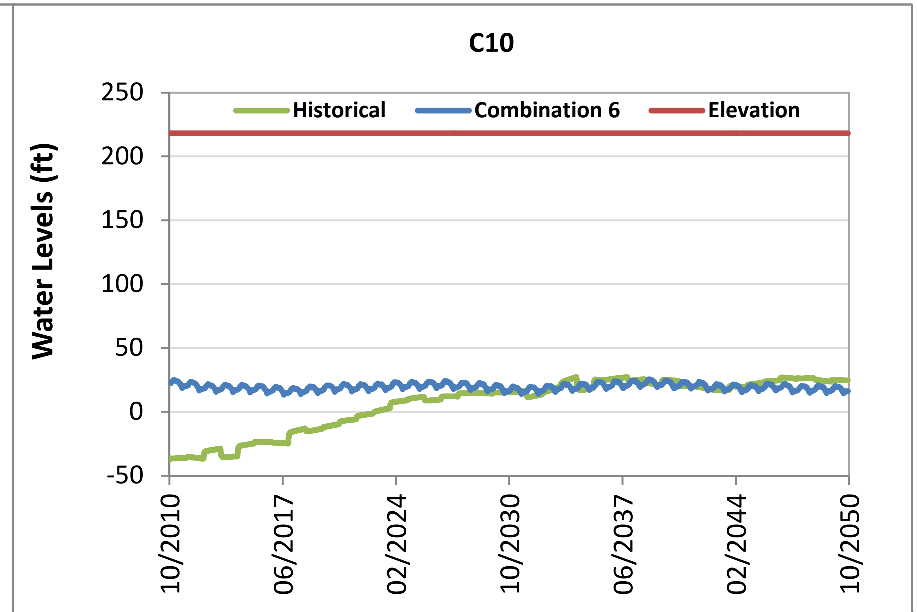

C5
250
200
150
100
50
0
Water Levels (ft)
Historical
Combination 6
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

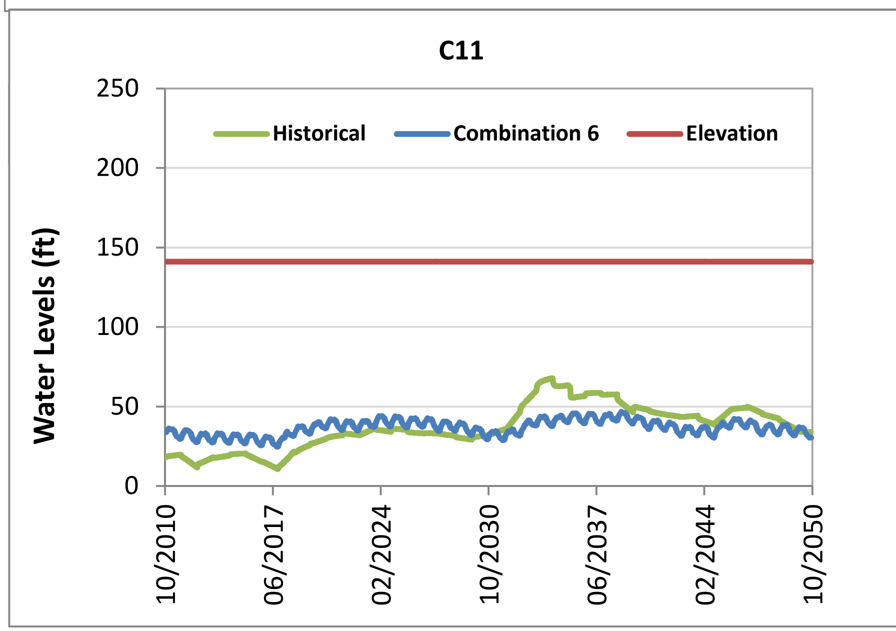

C6
250
200
150
100
50
0
Water Levels (ft)
Historical
Combination 6
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

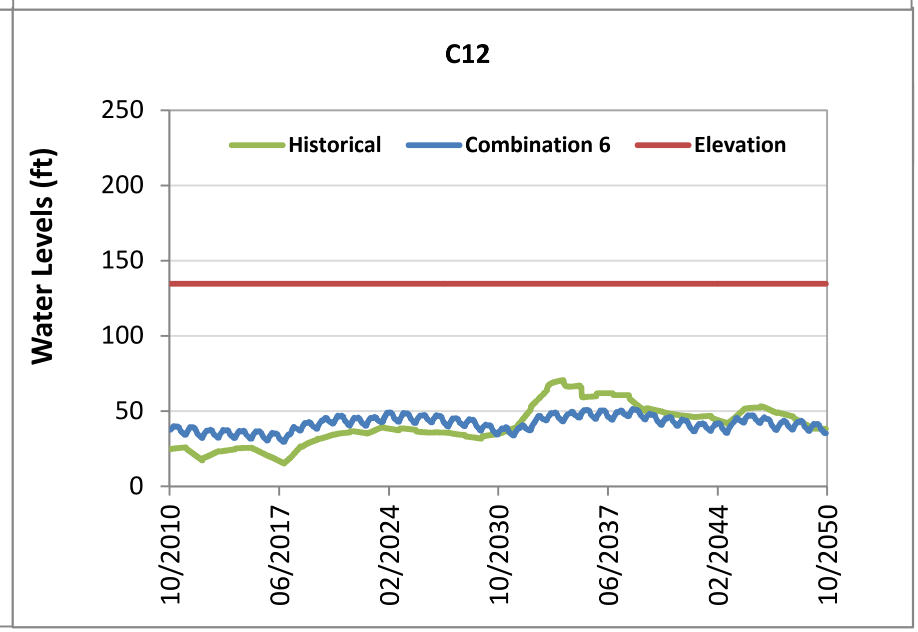

C7
250
200
150
100
50
0
Water Levels (ft)
Historical
Combination 6
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

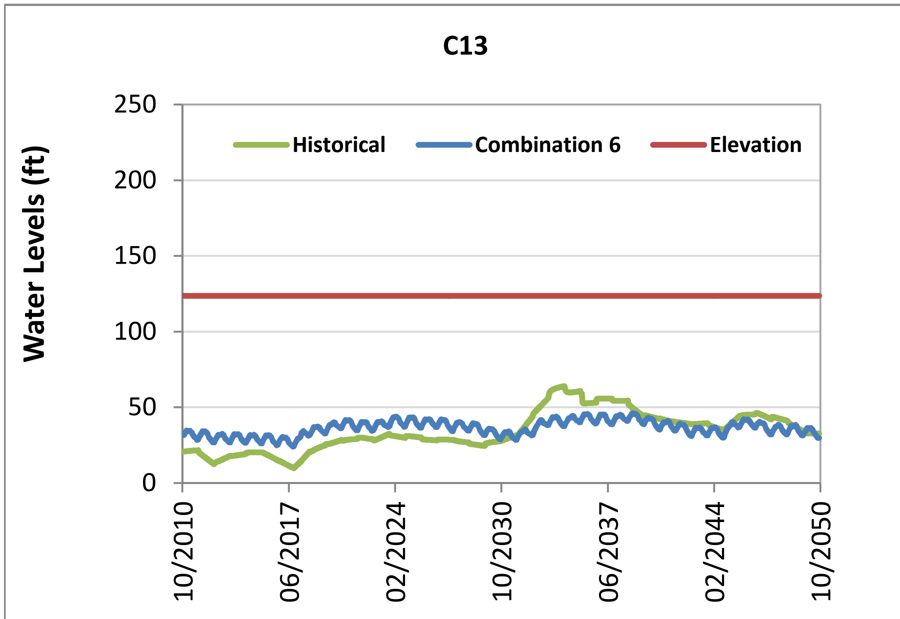

C8
250
200
150
100
50
0
Water Levels (ft)
Historical
Combination 6
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C9
Historical
Combination 6
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

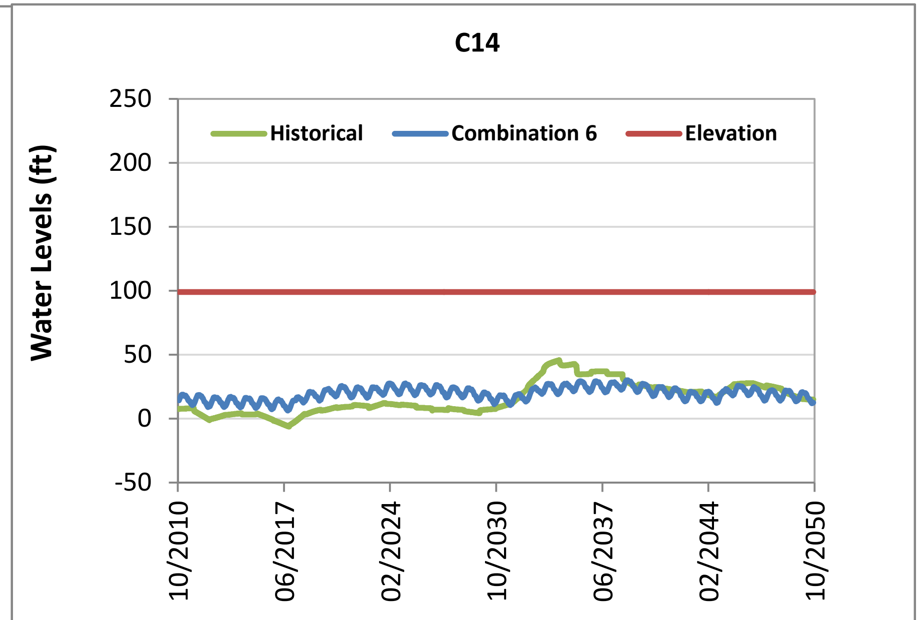

C10
Historical
Combination 6
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C11
Historical
Combination 6
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C12
Historical
Combination 6
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050



C13
Water Levels (ft)
250
200
150
100
50
0
Historical
Combination 6
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050



C14
Water Levels (ft)
250
200
150
100
50
0
-50
Historical
Combination 6
Elevation
10/2010
06/2017
02/2024
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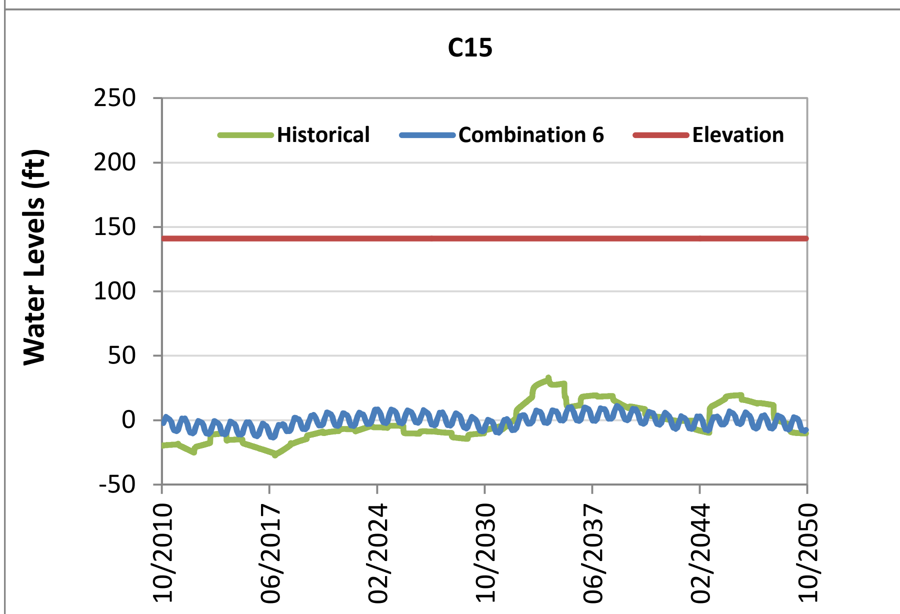
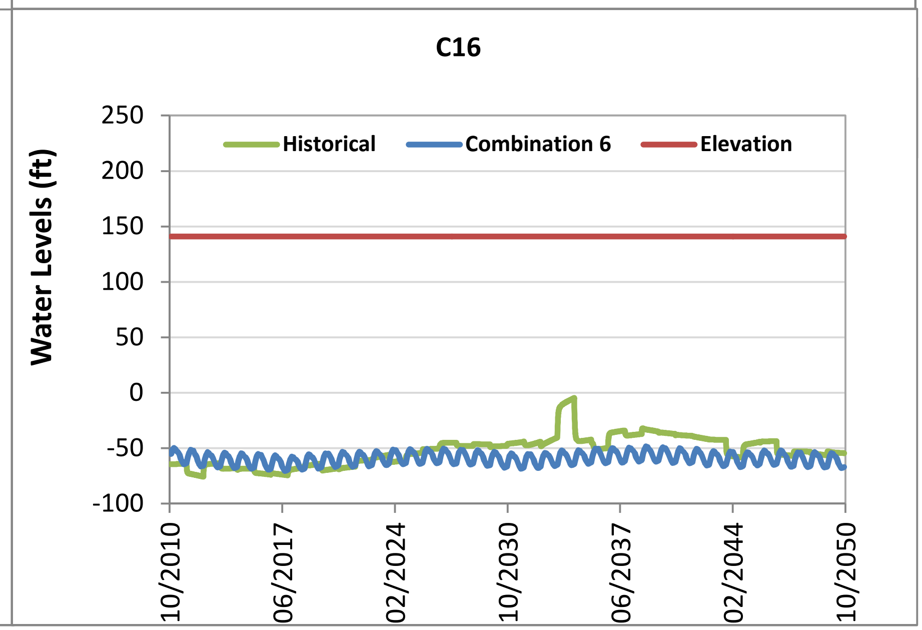
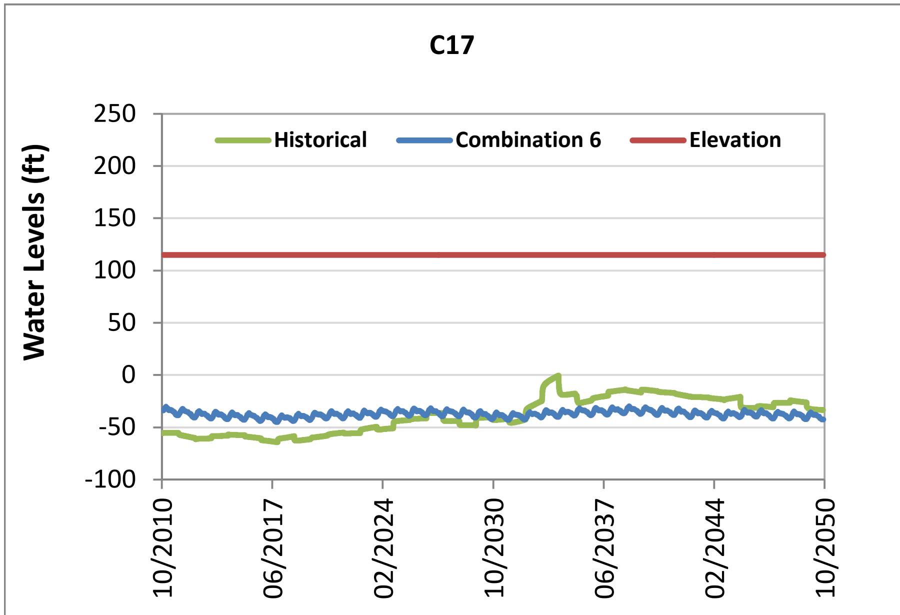
06/2037
02/2044
10/2050

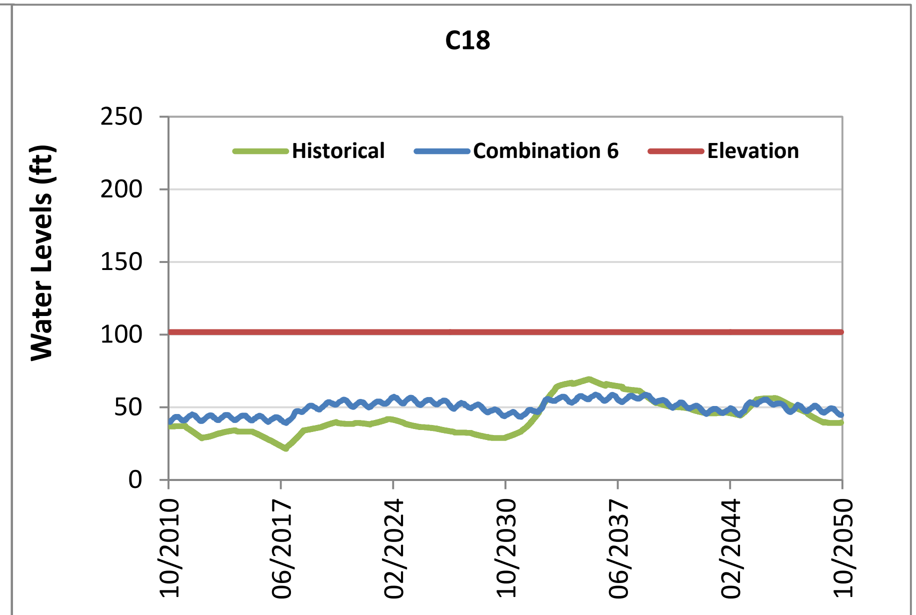


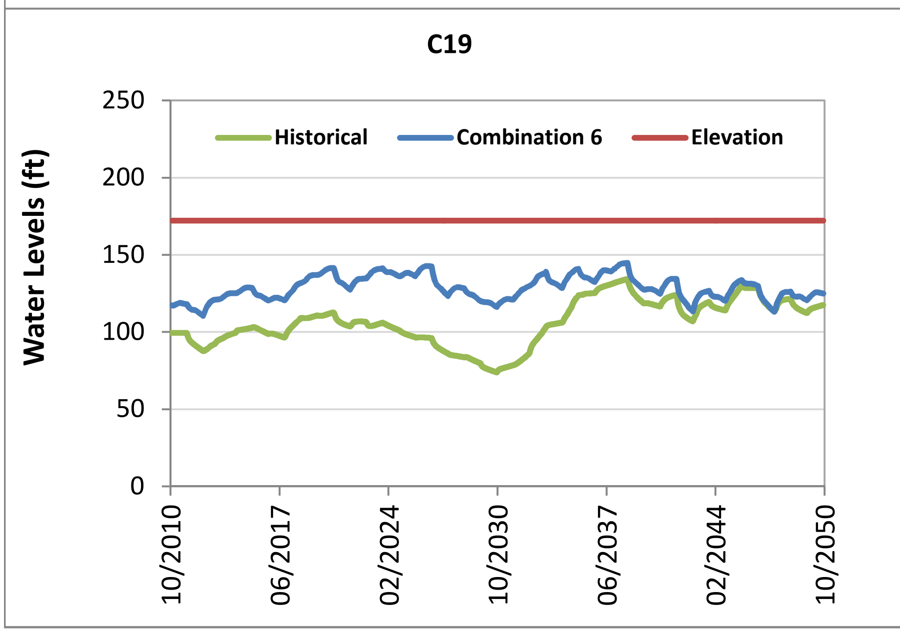
C15
Water Levels (ft)
250
200
150
100
50
0
-50
Historical
Combination 6
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

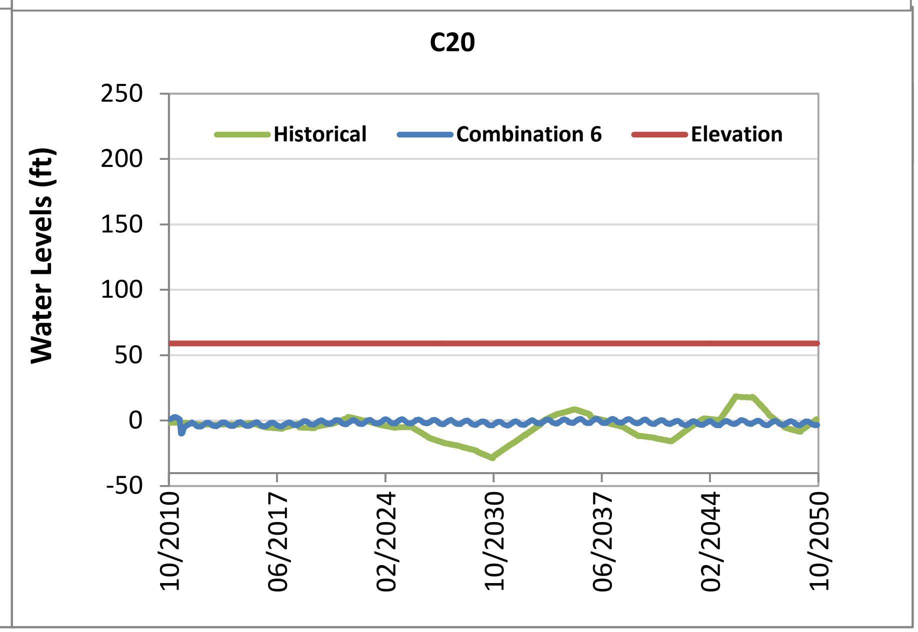


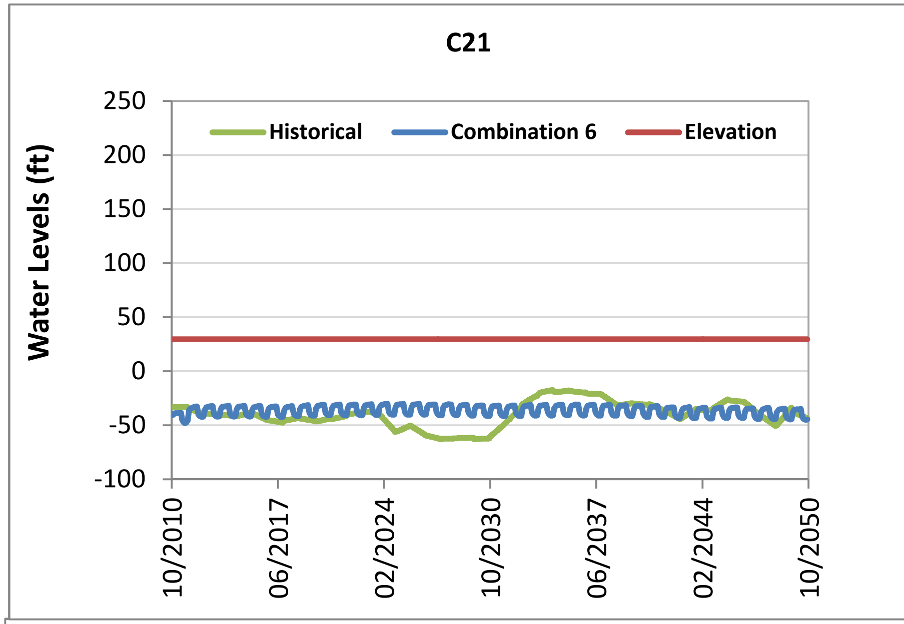
C16
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 6
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

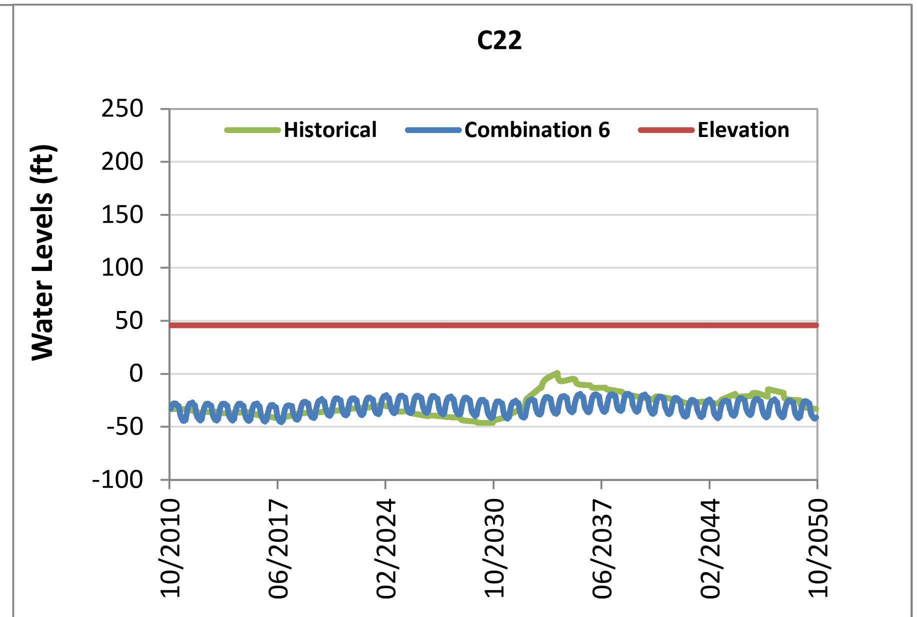

C17
Historical
Combination 6
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

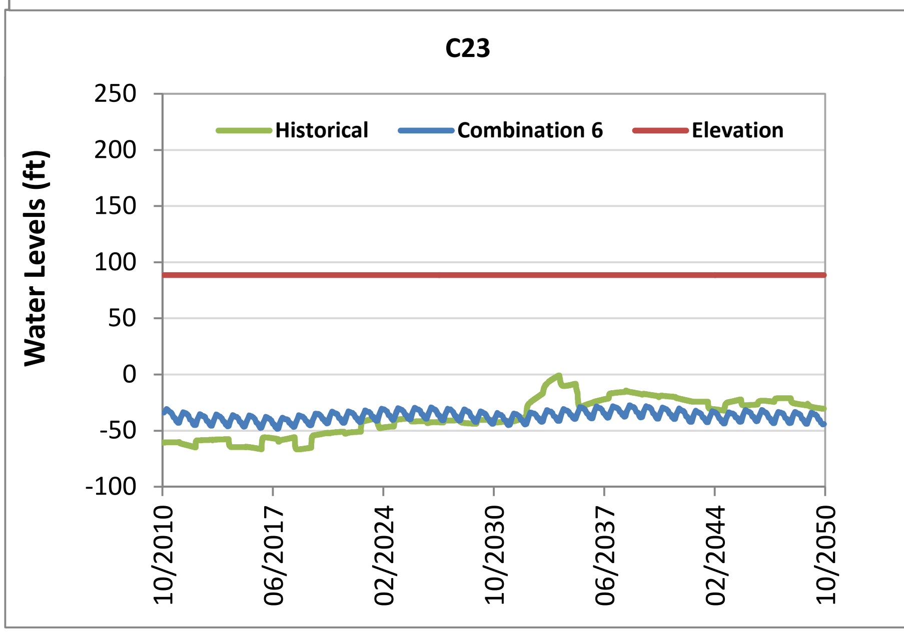

C18
Historical
Combination 6
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

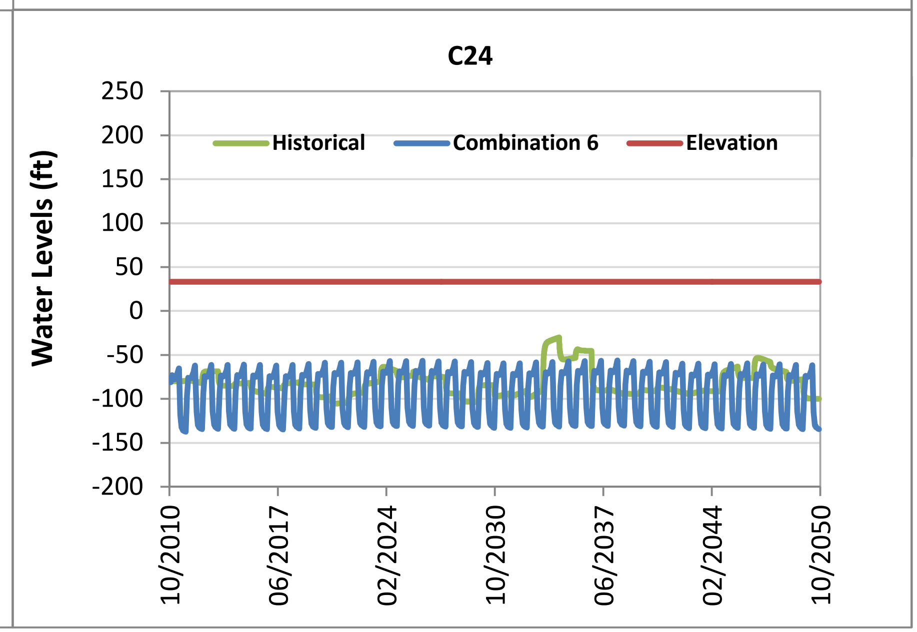

C19
Historical
Combination 6
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

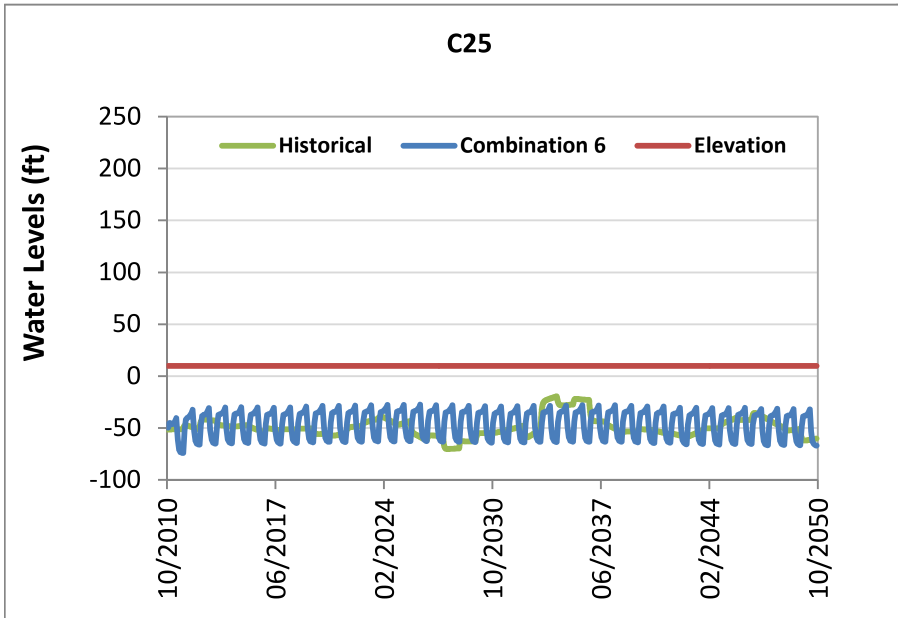

C20
Historical
Combination 6
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

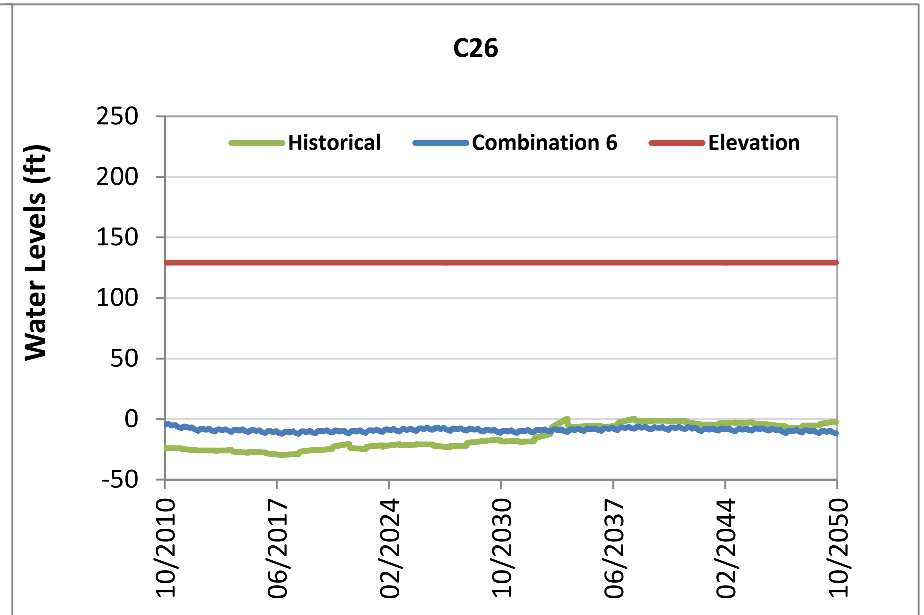

C21
Water Levels (ft)
Historical
Combination 6
Elevation
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

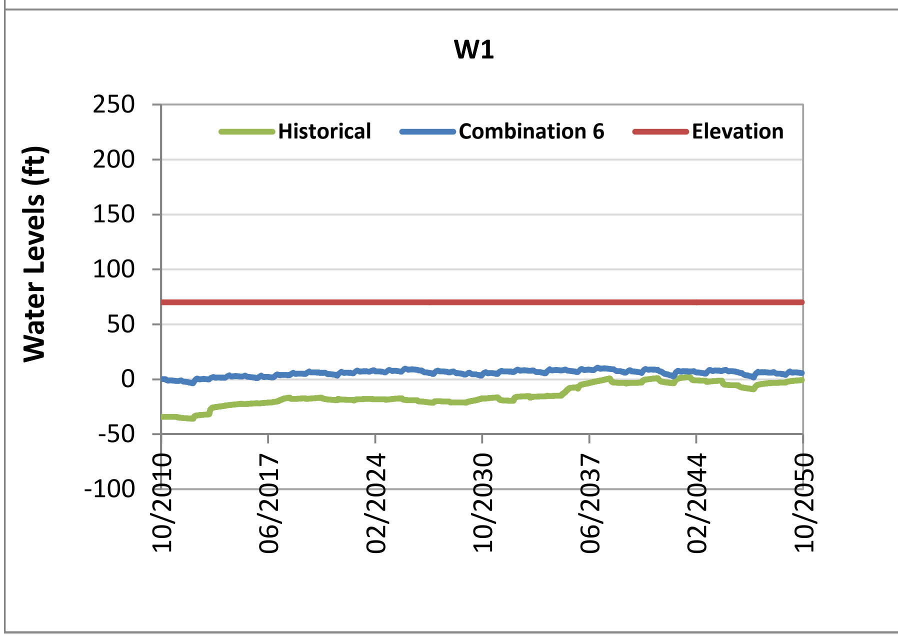

C22
Water Levels (ft)
Historical
Combination 6
Elevation
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

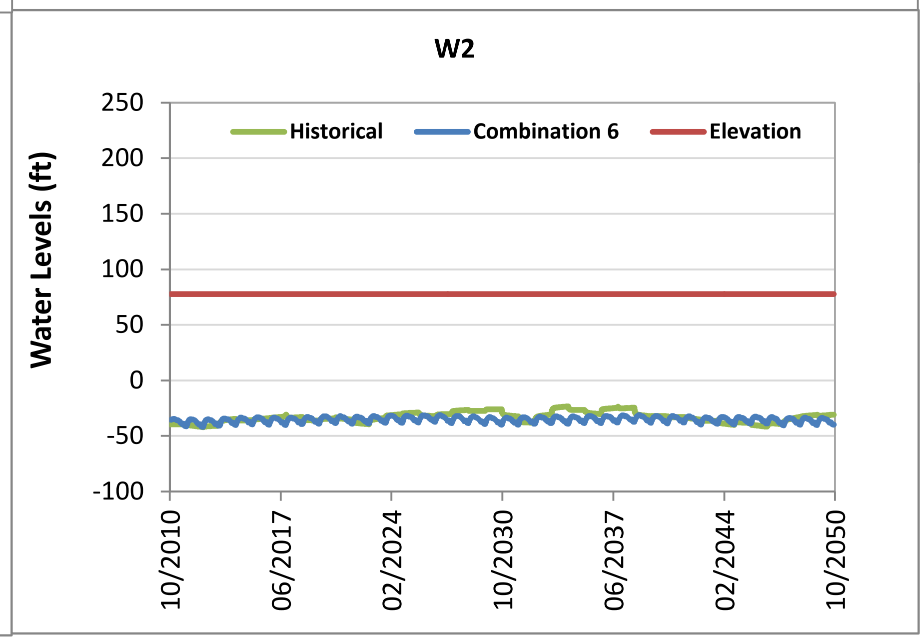

C23
Water Levels (ft)
Historical
Combination 6
Elevation
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

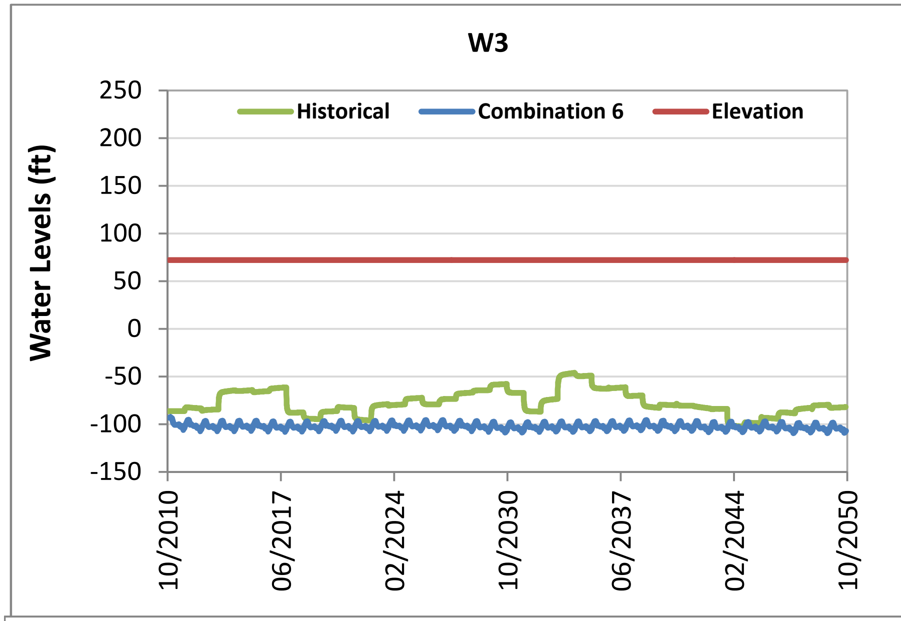

C24
Water Levels (ft)
Historical
Combination 6
Elevation
250
200
150
100
50
0
-50
-100
-150
-200
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

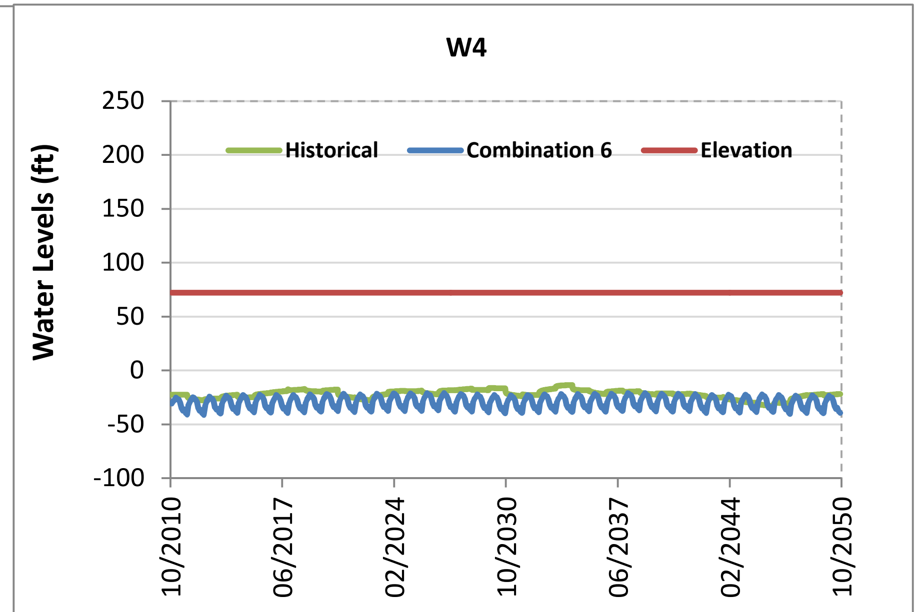

C25
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 6
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

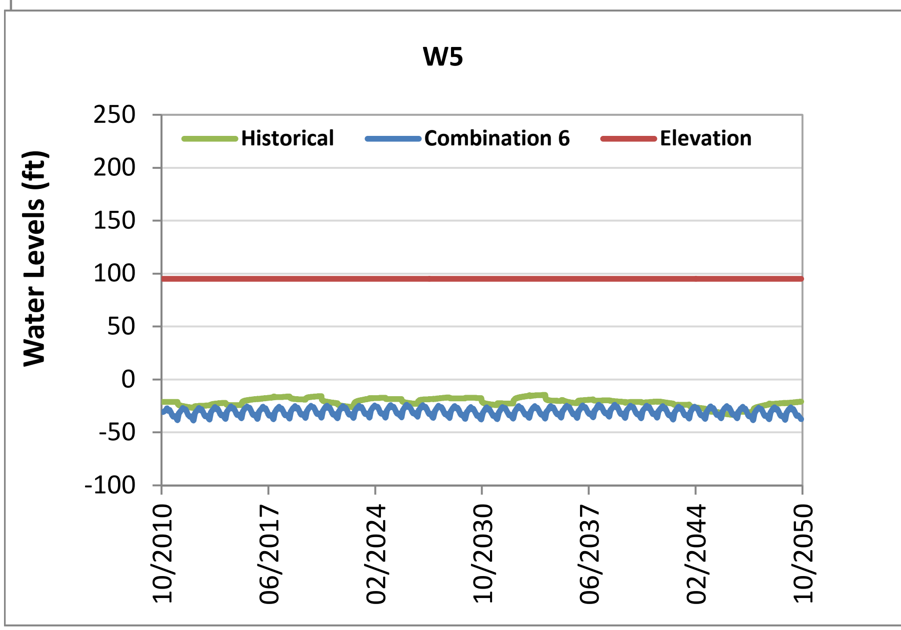

C26
Water Levels (ft)
250
200
150
100
50
0
-50
Historical
Combination 6
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

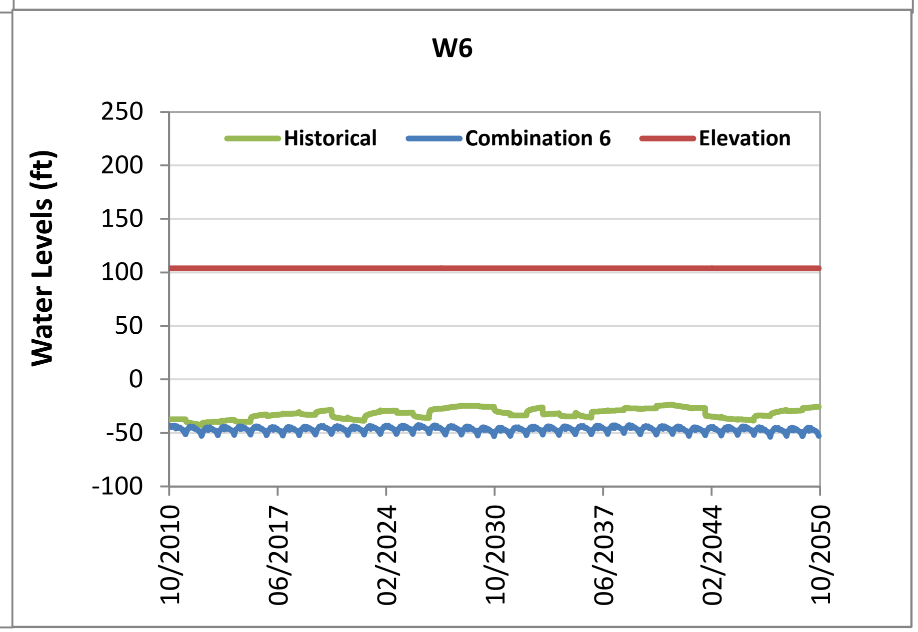

W1
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 6
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

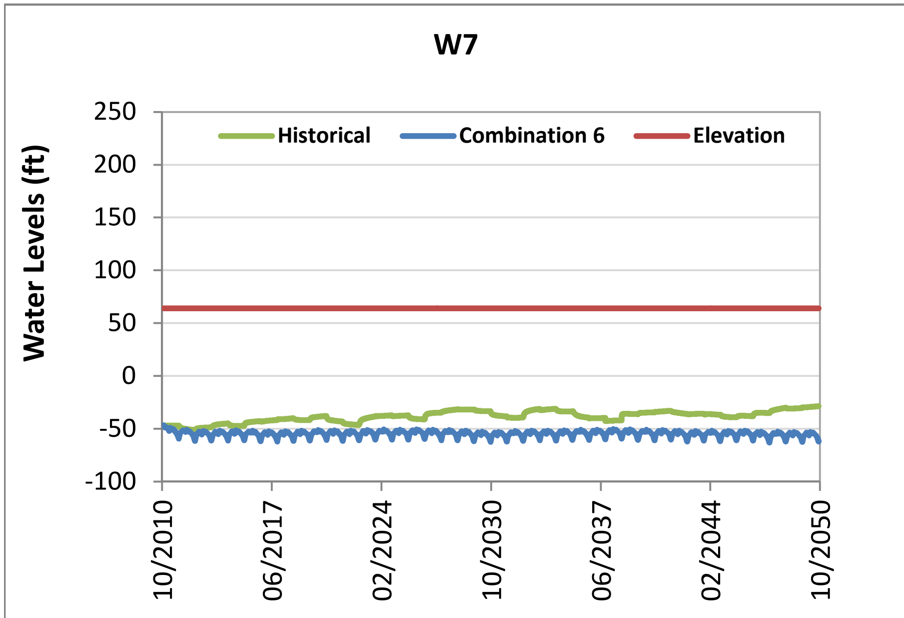

W2
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 6
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

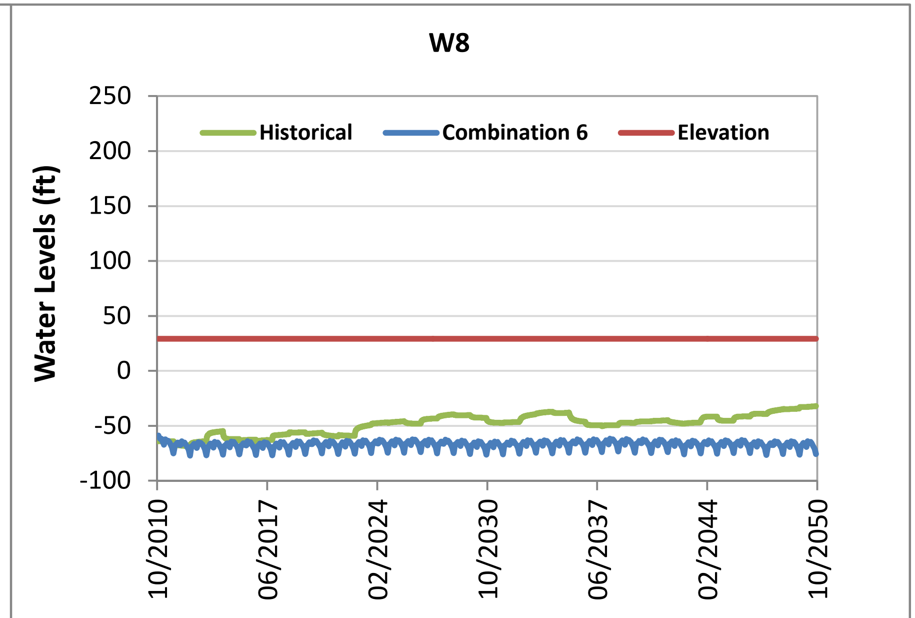

W3
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
Historical
Combination 6
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

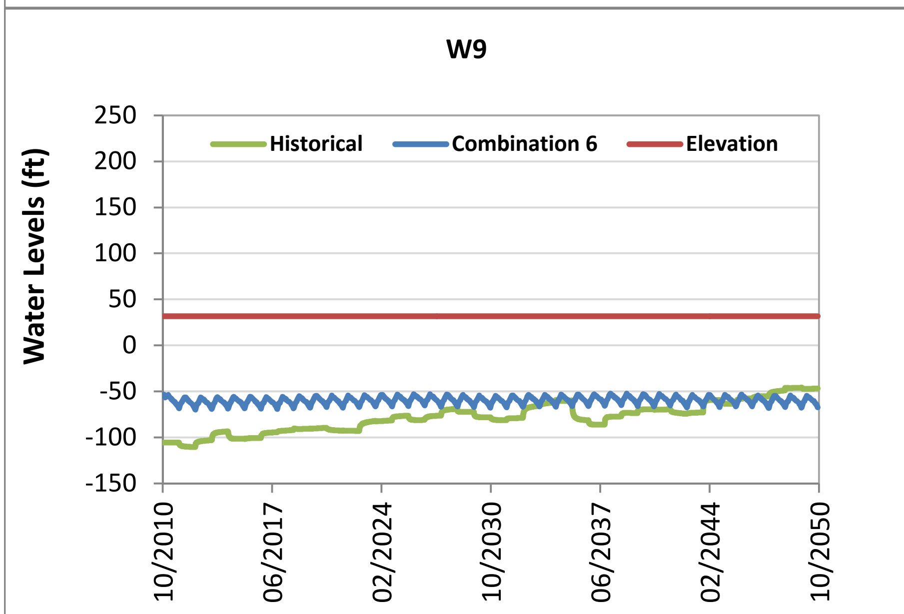

W4
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 6
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

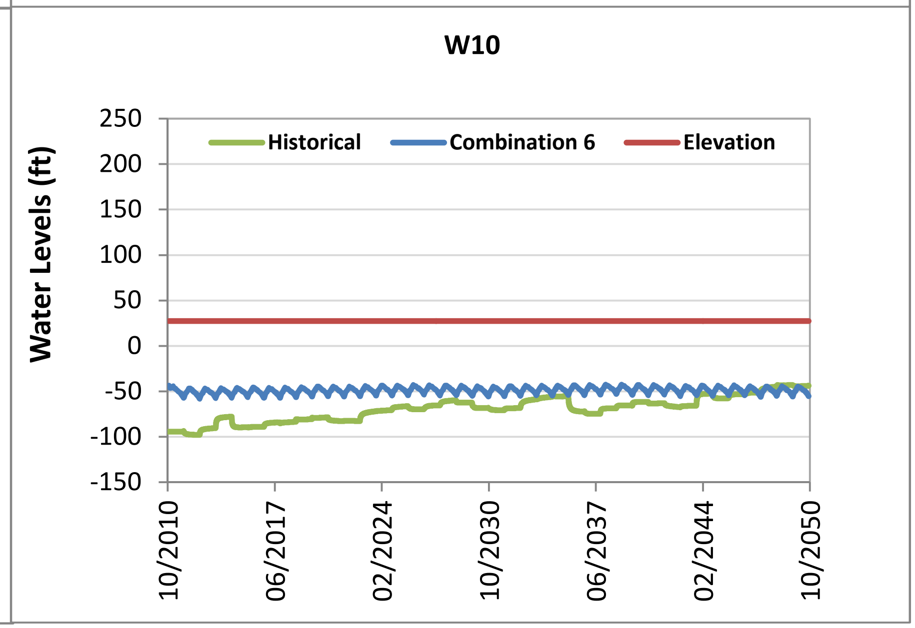

W5
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 6
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

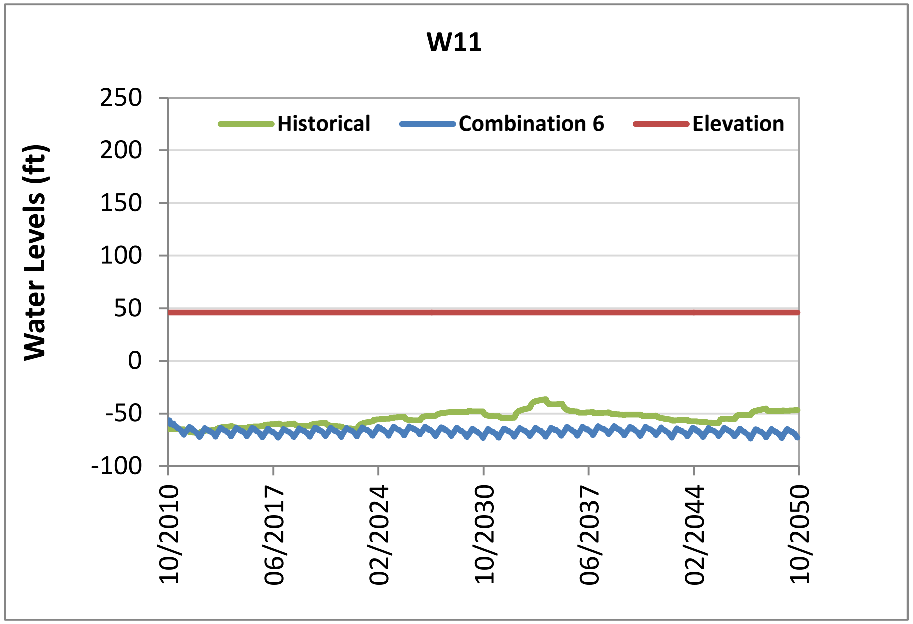

W6
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 6
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

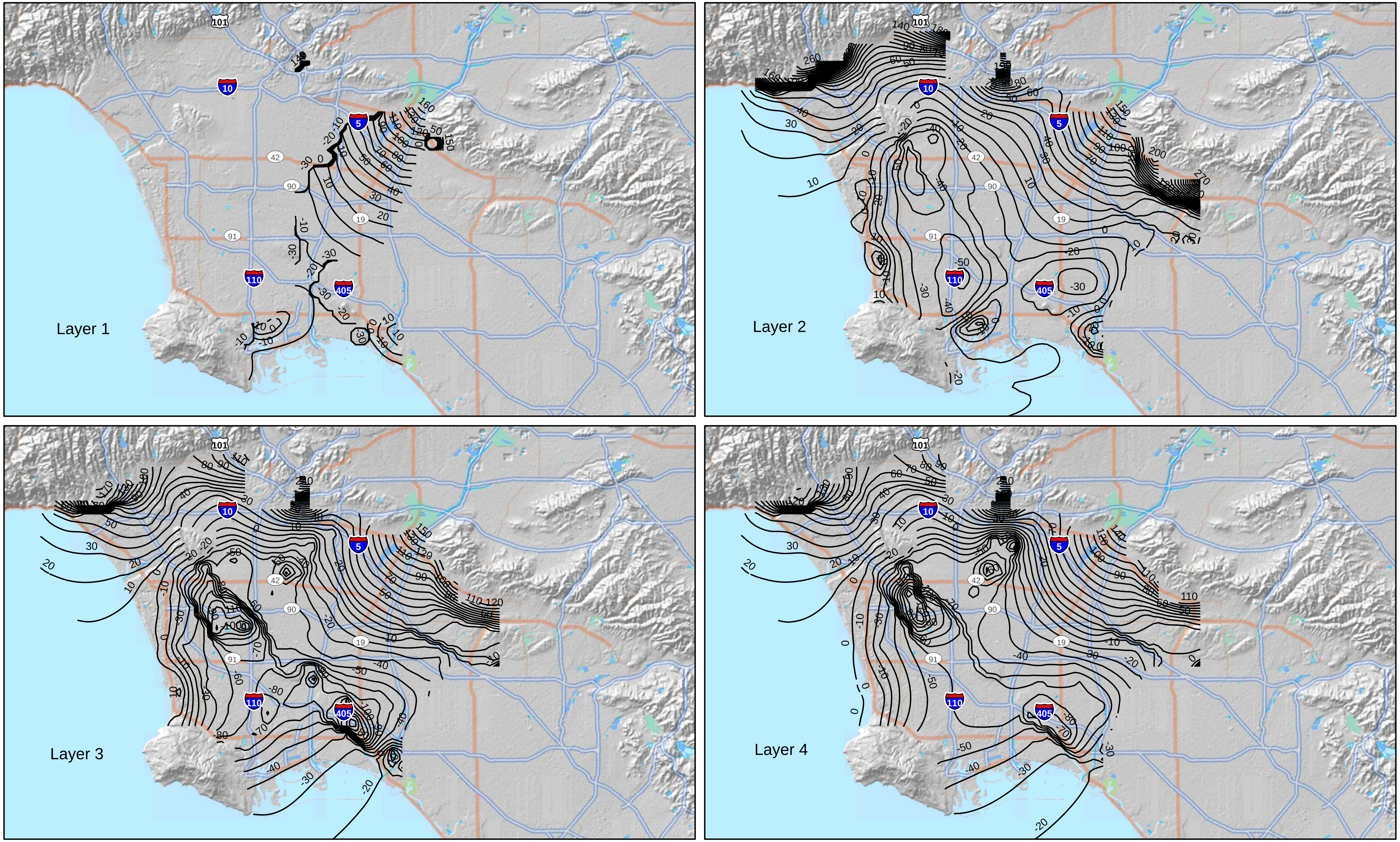

W7
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 6
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W8
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 6
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W9
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
Historical
Combination 6
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W10
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
Historical
Combination 6
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W11
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 6
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050



Legend

- Groundwater Basin Boundary
- Forebays
- Alamitos Barrier
- West Coast Basin Barriers
- Groundwater Level Contours
- Limited Access
- Highway
- Major Road

Water Bodies

Description

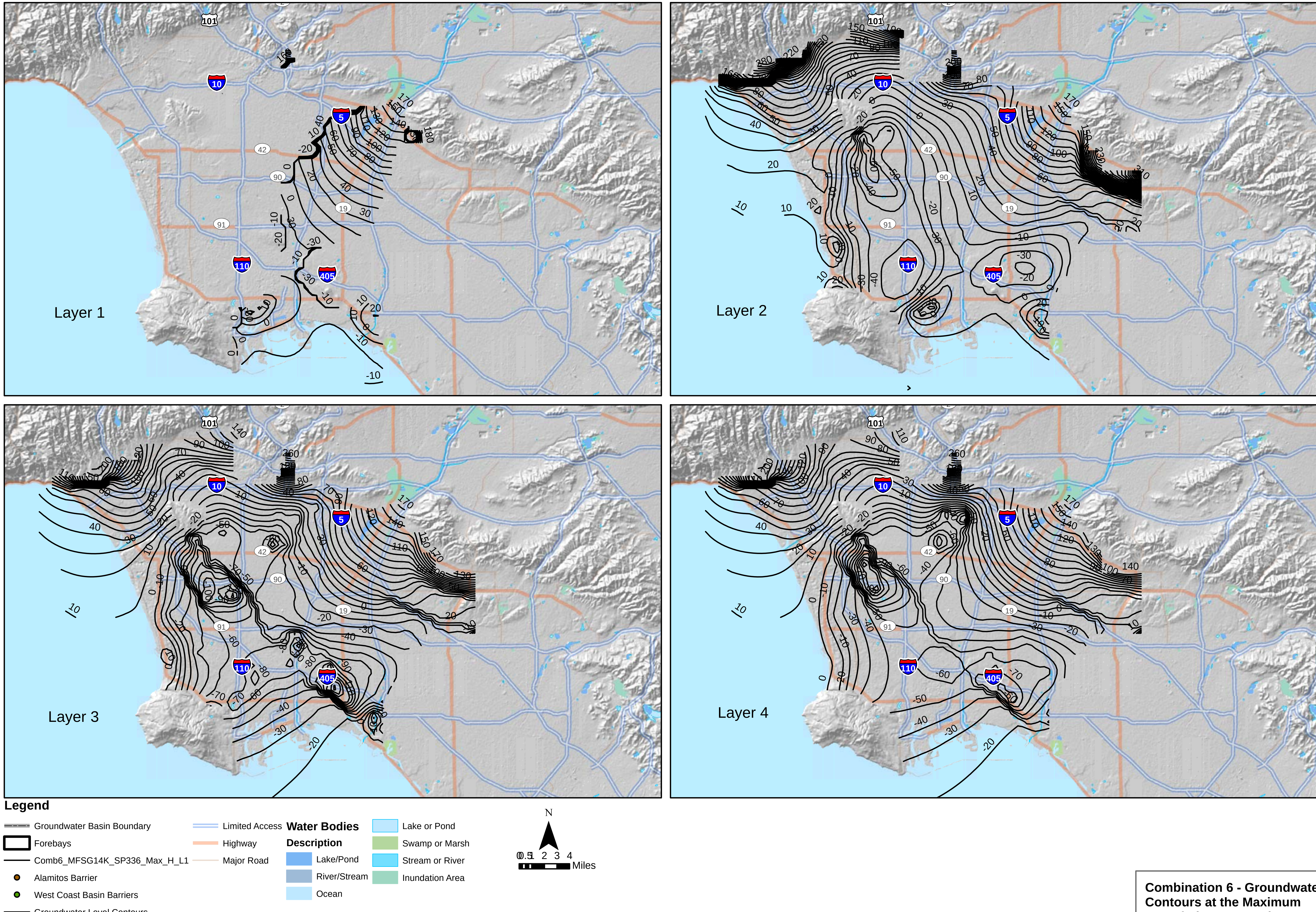
- Lake/Pond
- River/Stream
- Ocean
- Lake or Pond
- Swamp or Marsh
- Stream or River
- Inundation Area

N

0 0.5 1 2 3 4 Miles

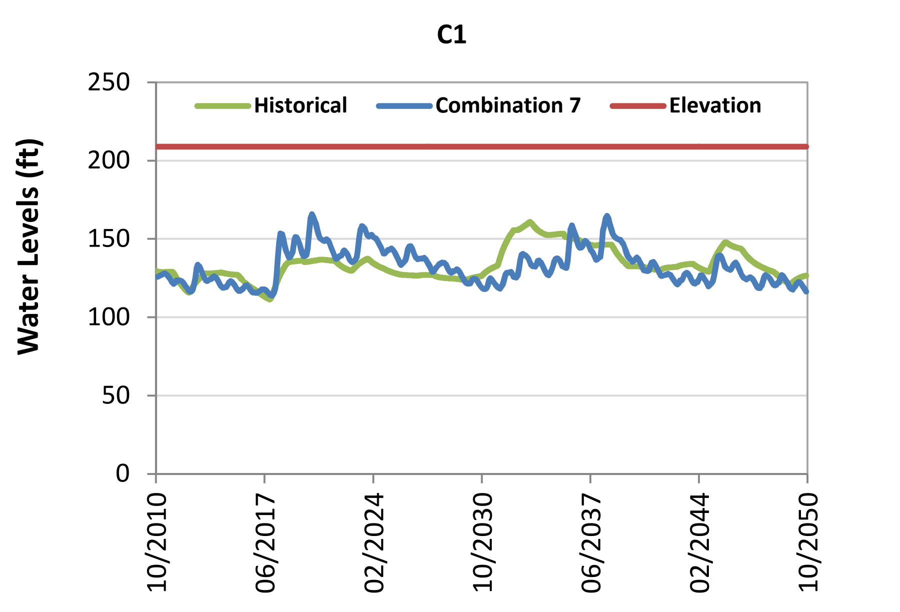
Combination 6 - Groundwater Level Contours at the Minimum Cumulative Storage in 2012

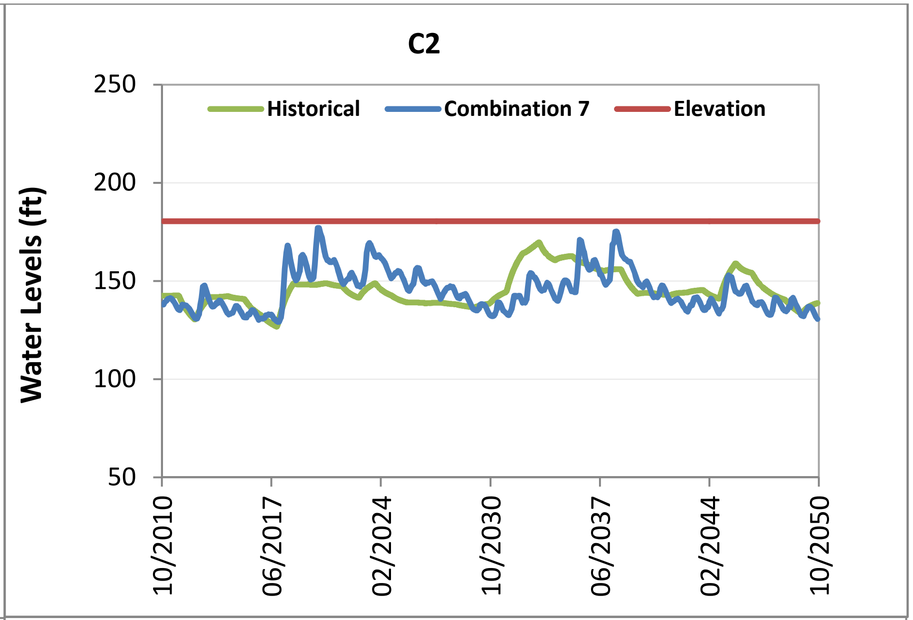
File Location

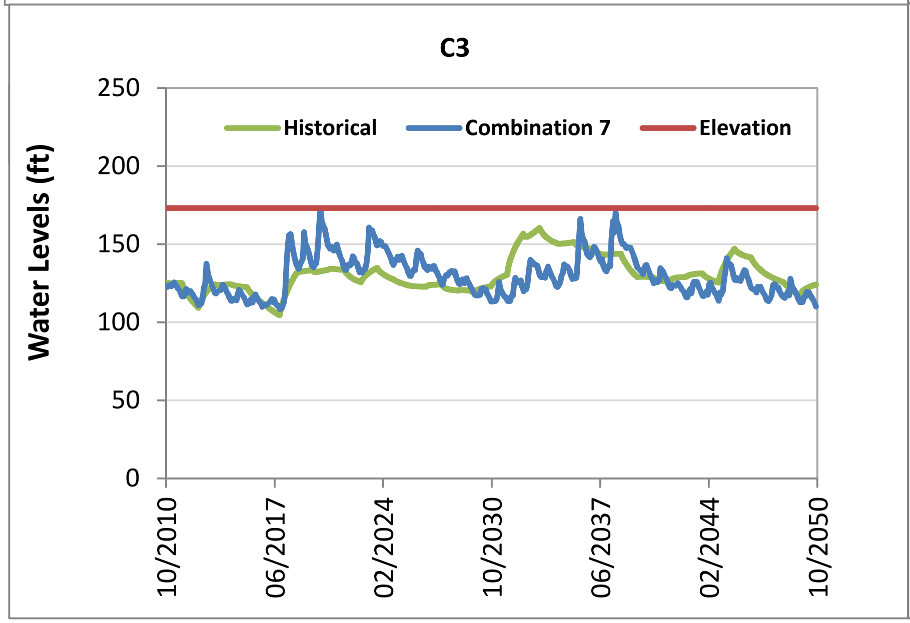


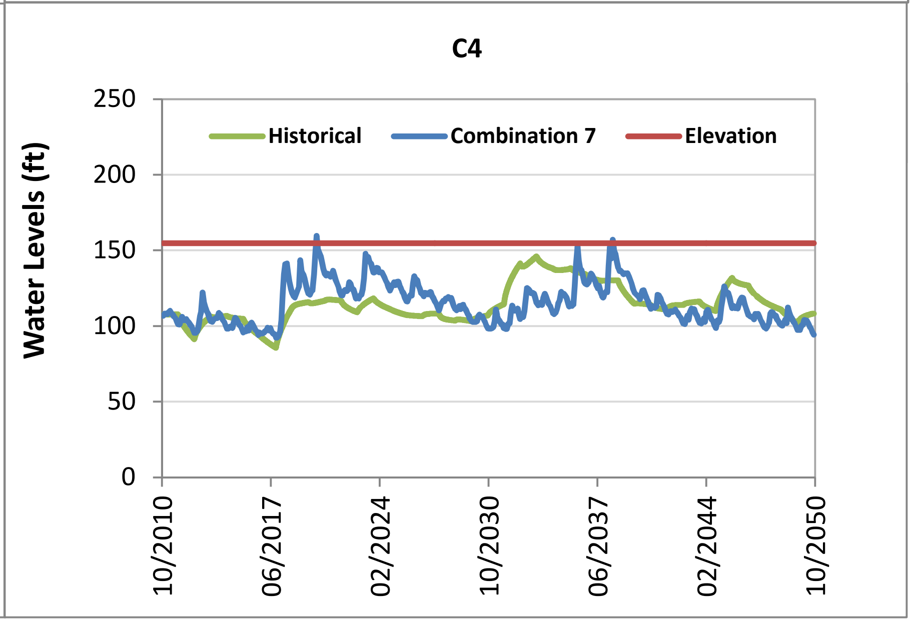
Combination 6 - Groundwater Level Contours at the Maximum Cumulative Storage in 2038

Combination 7 Model Results:
1) Hydrographs
2) Groundwater Level Contour Maps


C1
Historical
Combination 7
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C2
Historical
Combination 7
Elevation
Water Levels (ft)
250
200
150
100
50
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C3
Historical
Combination 7
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C4
Historical
Combination 7
Elevation
Water Levels (ft)
250
200
150
100
50
0
10/2010
06/2017
02/2024
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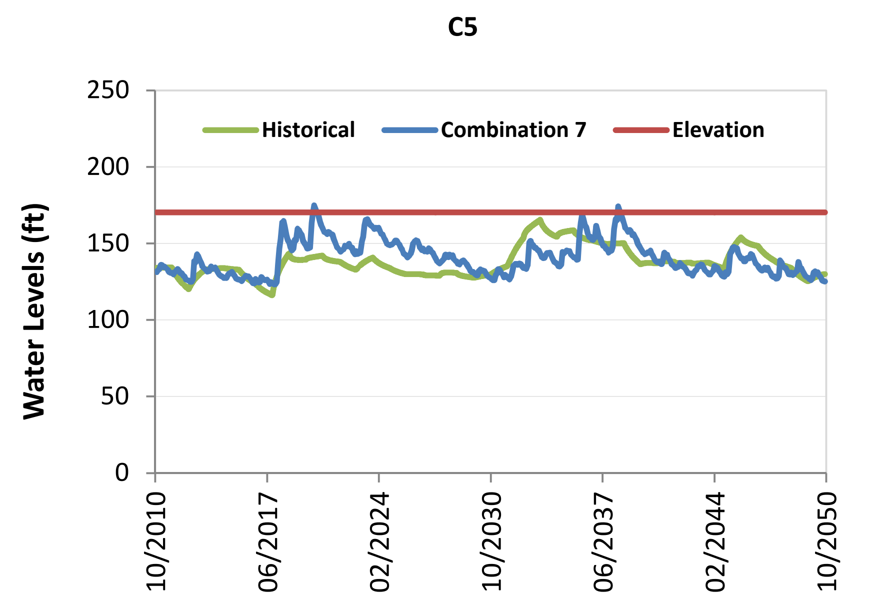
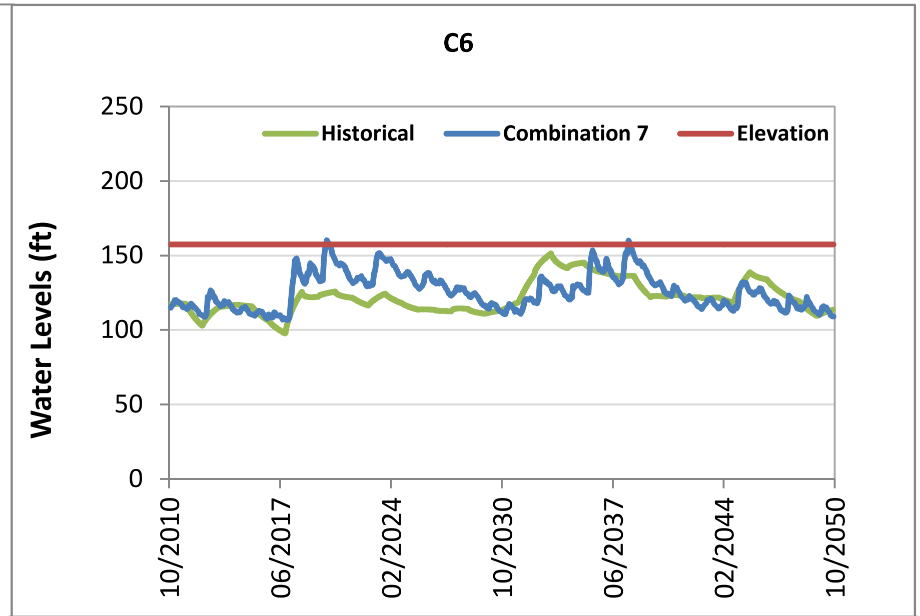
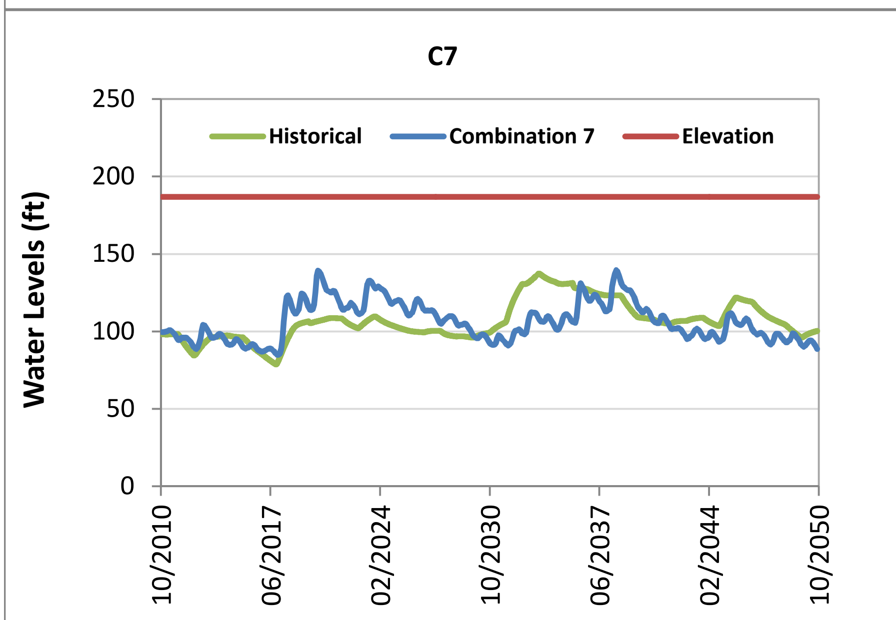
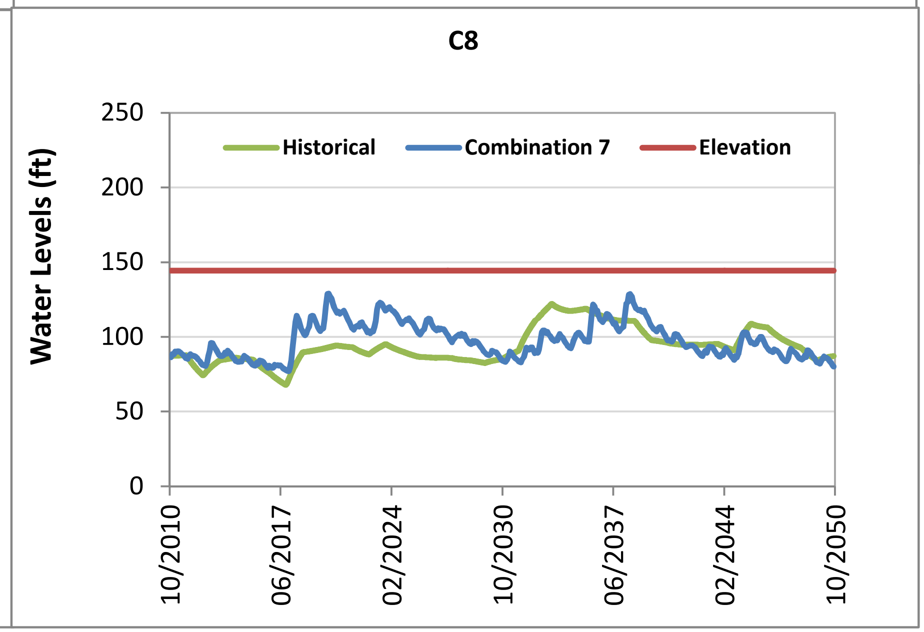
02/2044
10/2050


C5
Water Levels (ft)
250
200
150
100
50
0
Historical
Combination 7
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C6
Water Levels (ft)
250
200
150
100
50
0
Historical
Combination 7
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C7
Water Levels (ft)
250
200
150
100
50
0
Historical
Combination 7
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C8
Water Levels (ft)
250
200
150
100
50
0
Historical
Combination 7
Elevation
10/2010
06/2017
02/2024
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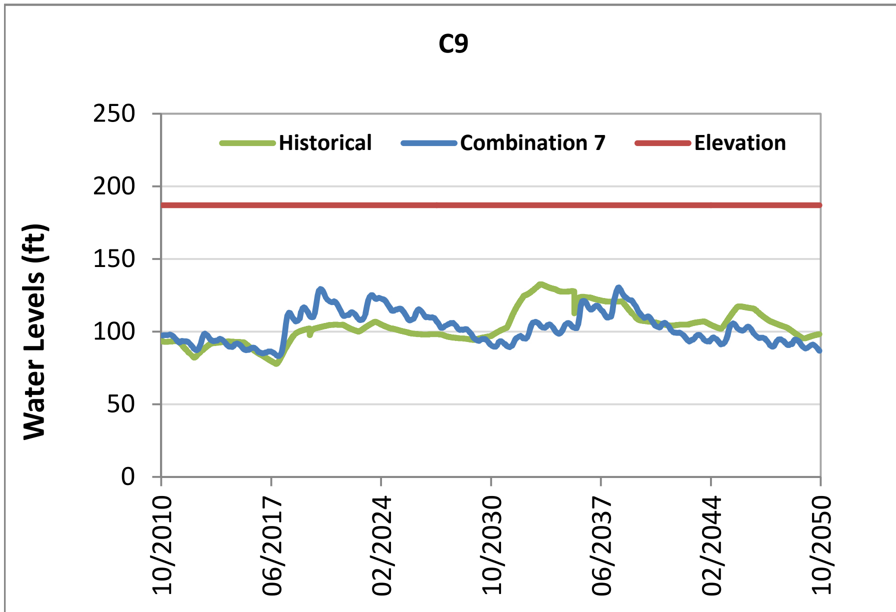
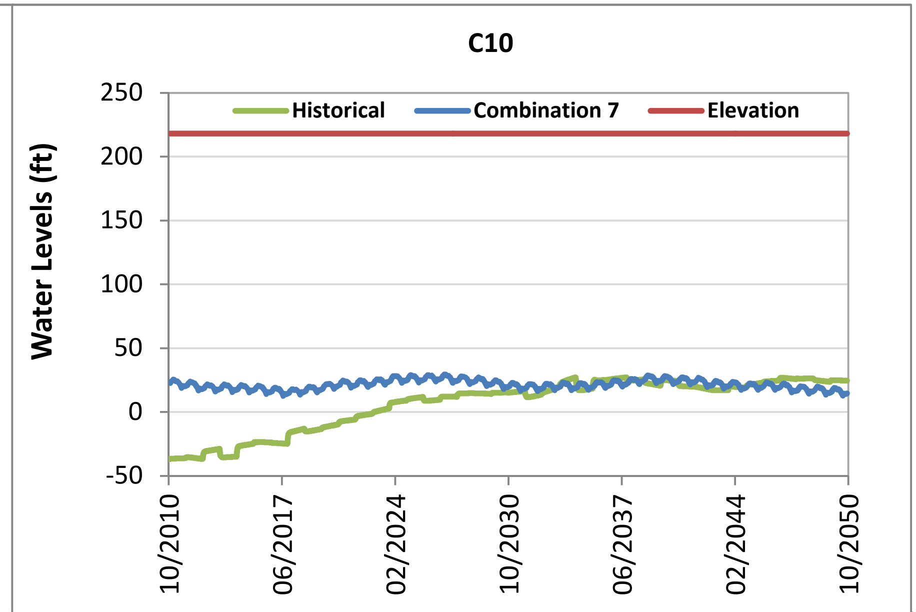
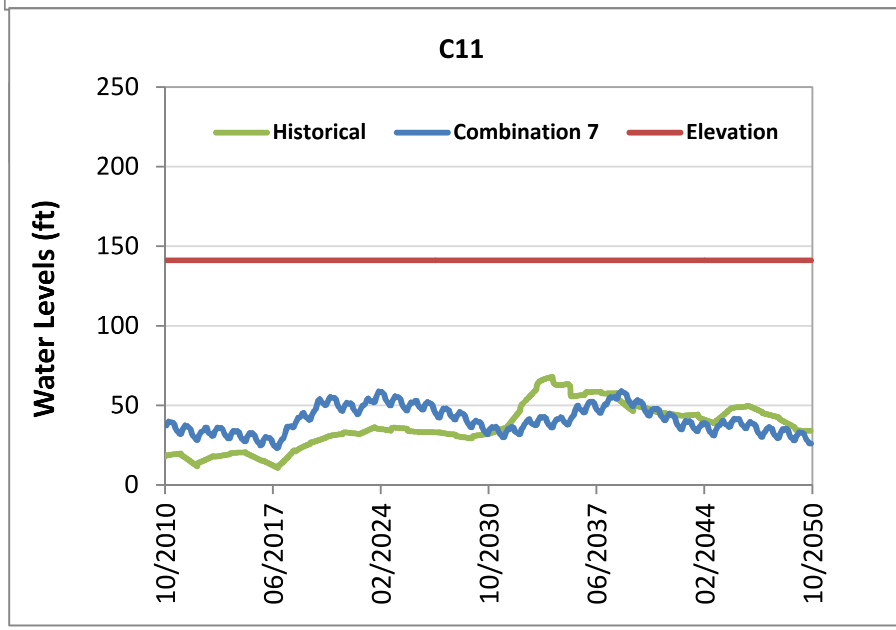
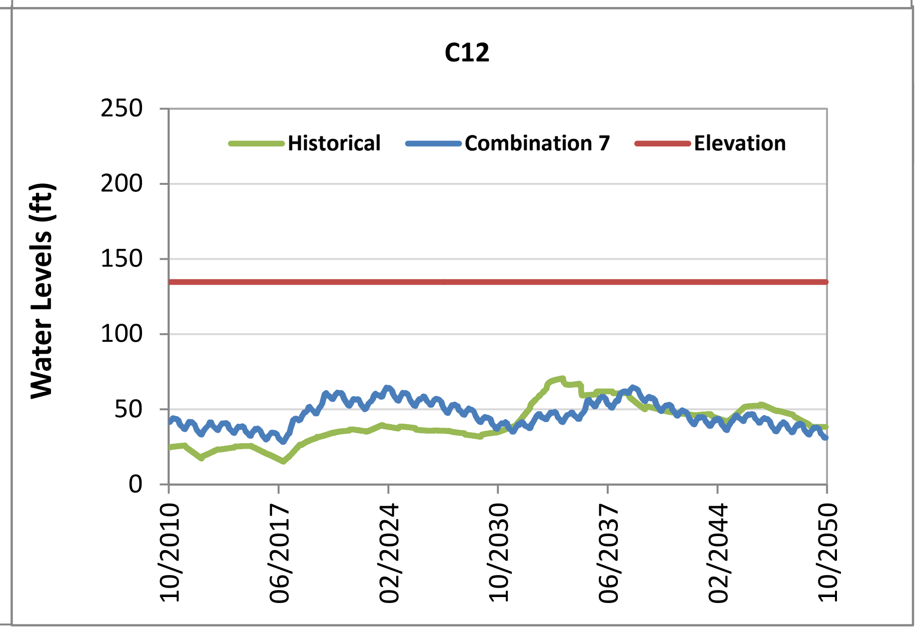
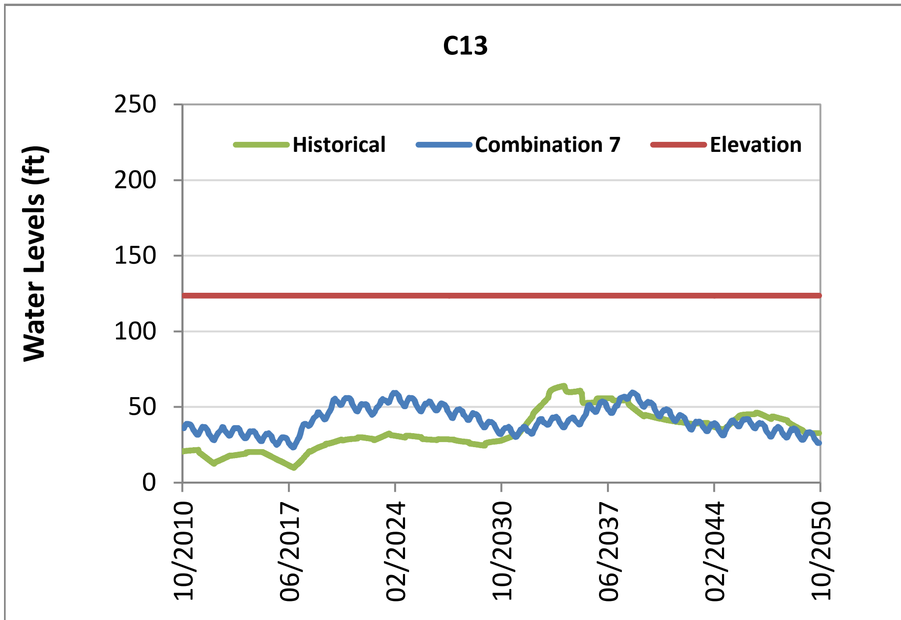
06/2037
02/2044
10/2050

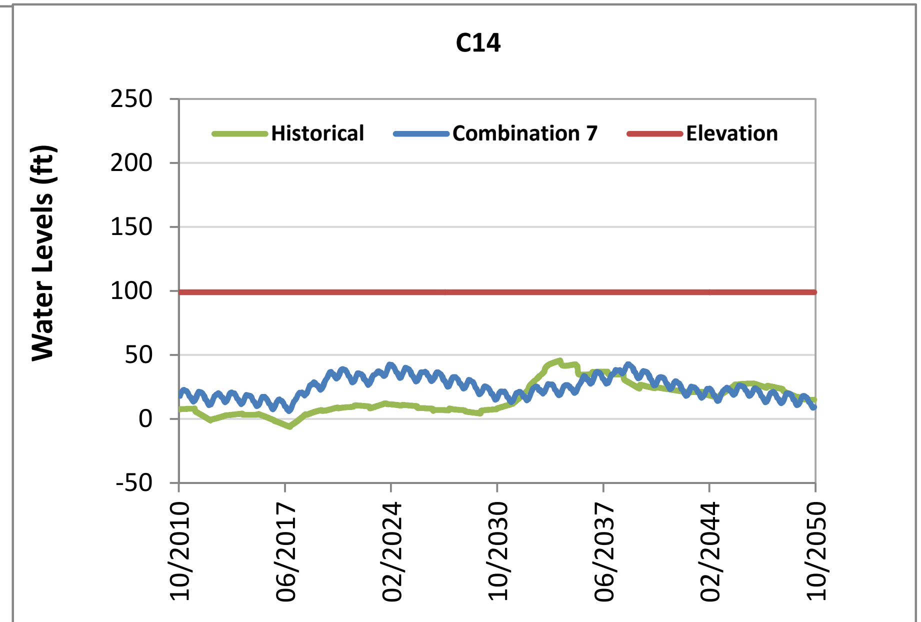

C9
Water Levels (ft)
250
200
150
100
50
0
Historical
Combination 7
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

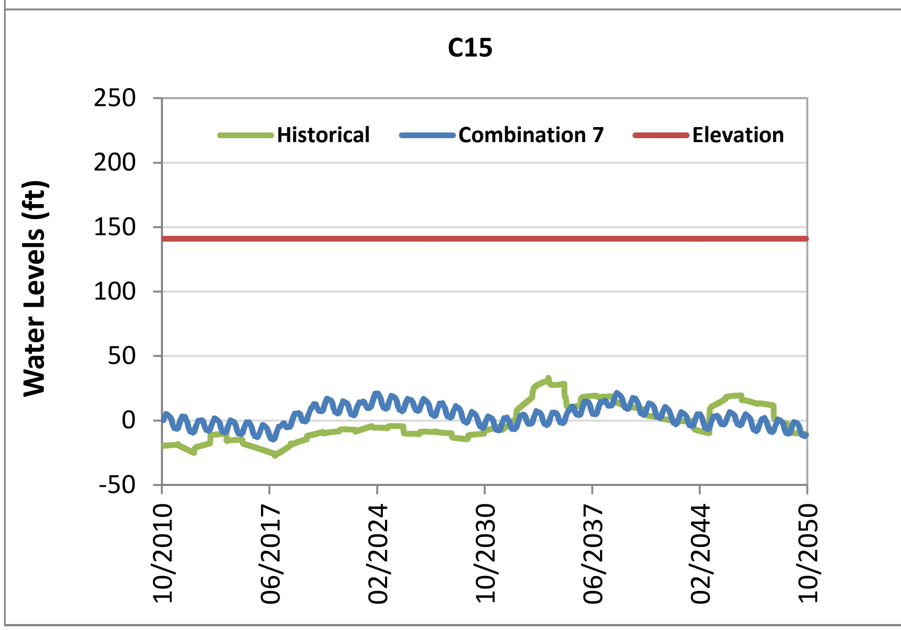

C10
Water Levels (ft)
250
200
150
100
50
0
-50
Historical
Combination 7
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

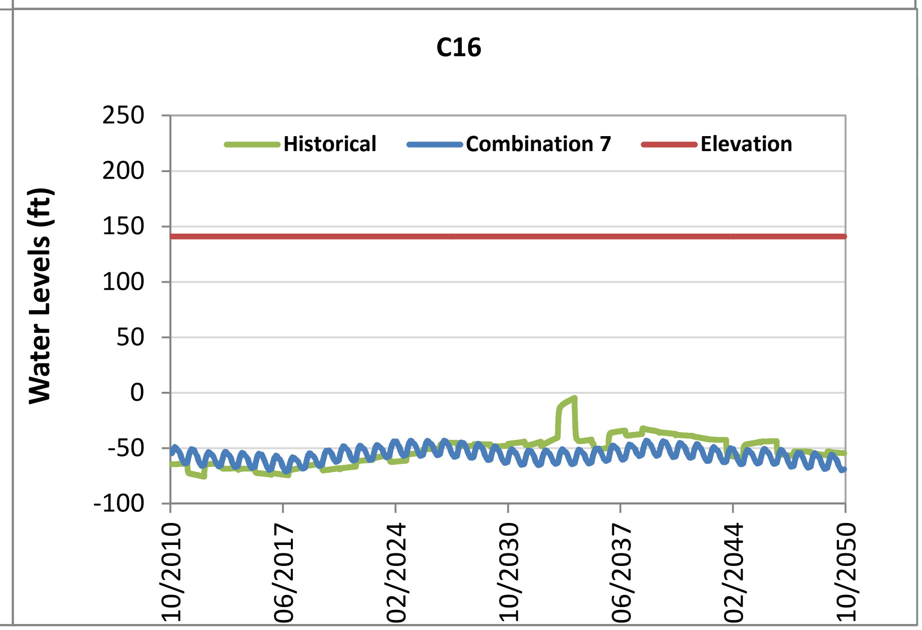

C11
Water Levels (ft)
250
200
150
100
50
0
Historical
Combination 7
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C12
Water Levels (ft)
250
200
150
100
50
0
Historical
Combination 7
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C13
Water Levels (ft)
250
200
150
100
50
0
Historical
Combination 7
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C14
Water Levels (ft)
250
200
150
100
50
0
-50
Historical
Combination 7
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C15
Water Levels (ft)
250
200
150
100
50
0
-50
Historical
Combination 7
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C16
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 7
Elevation
10/2010
06/2017
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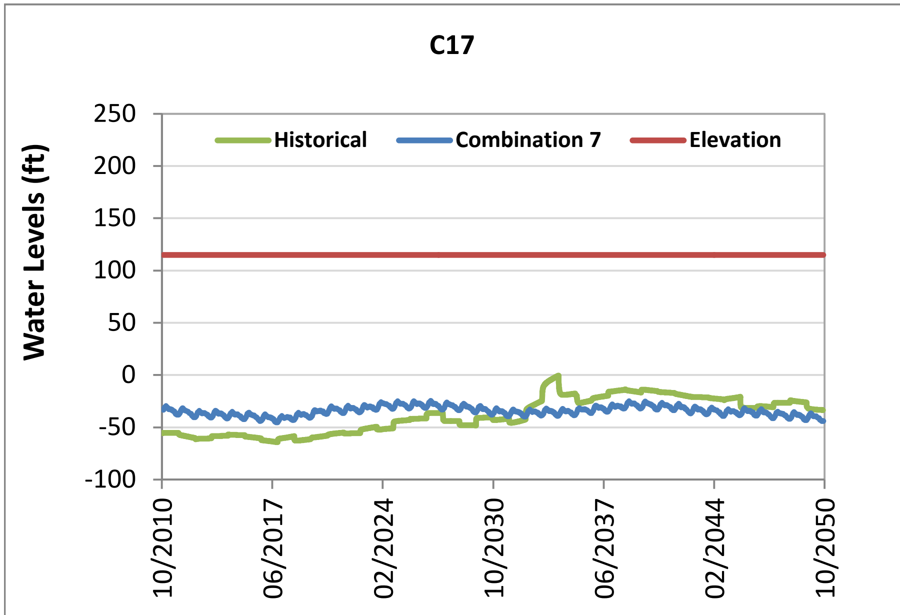
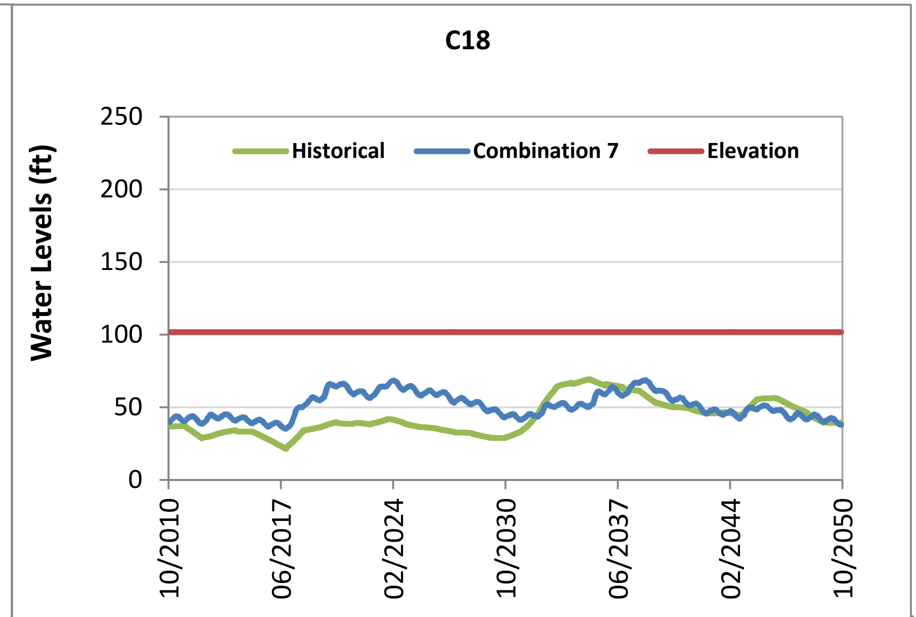
02/2044
10/2050



C17
Water Levels (ft)
Historical
Combination 7
Elevation
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050



C18
Water Levels (ft)
Historical
Combination 7
Elevation
250
200
150
100
50
0
10/2010
06/2017
02/2024
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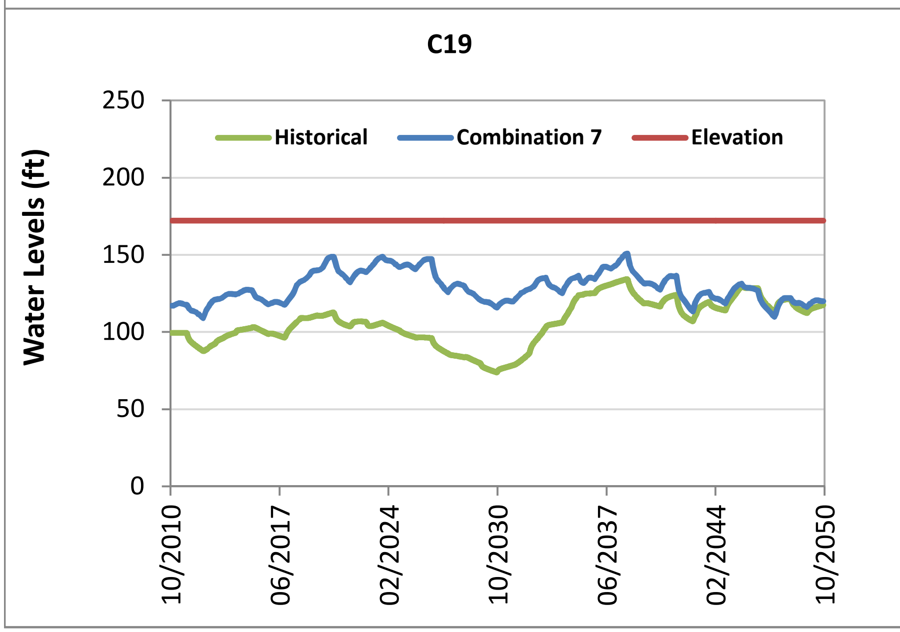
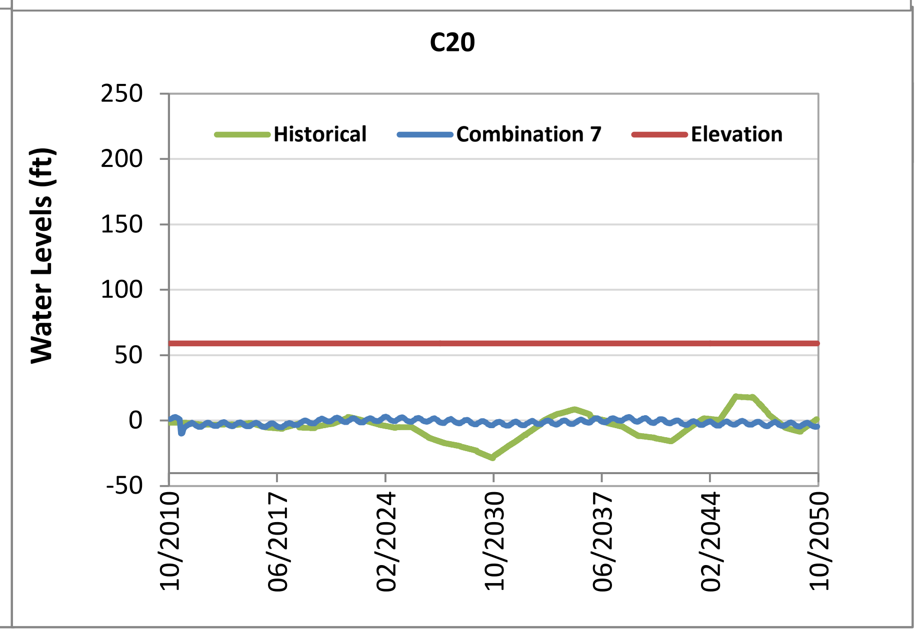
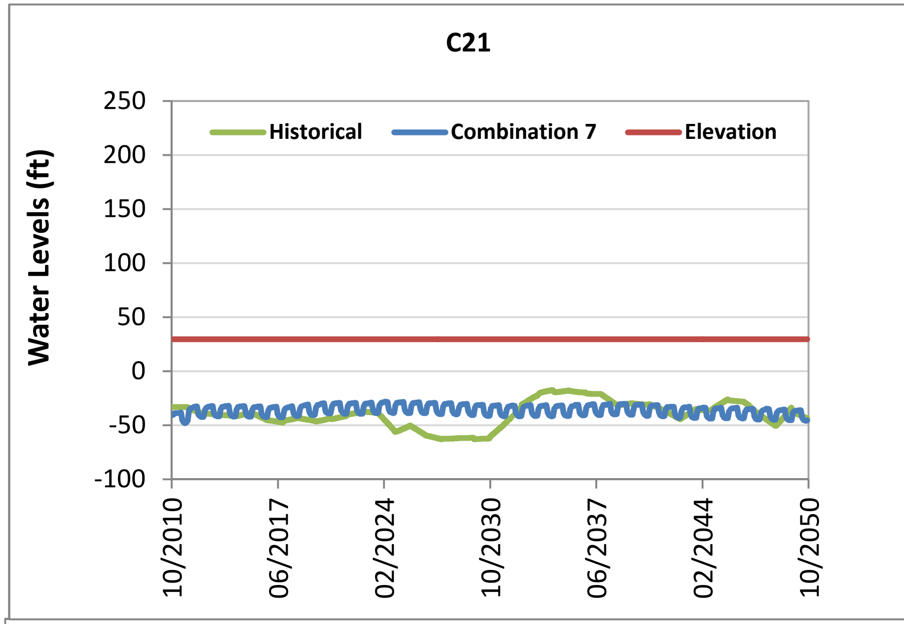
02/2044
10/2050



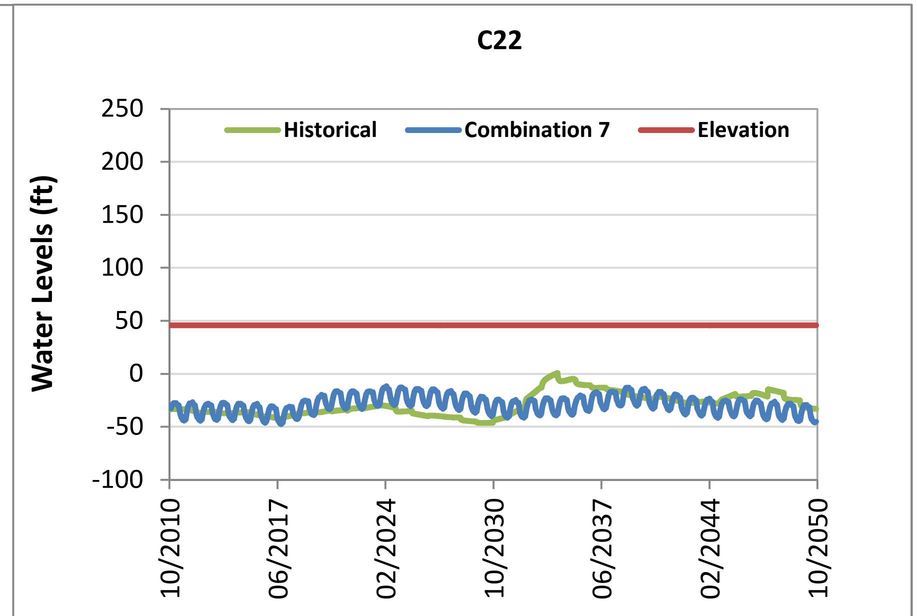
C19
Water Levels (ft)
Historical
Combination 7
Elevation
250
200
150
100
50
0
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050



C20
Water Levels (ft)
Historical
Combination 7
Elevation
250
200
150
100
50
0
-50
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050



C21
Historical
Combination 7
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050



C22
Historical
Combination 7
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
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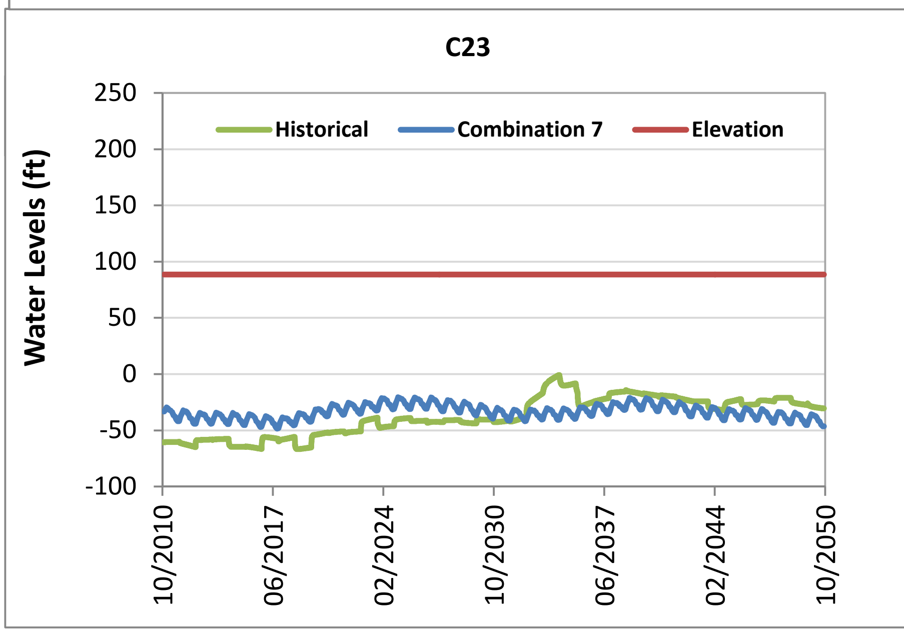
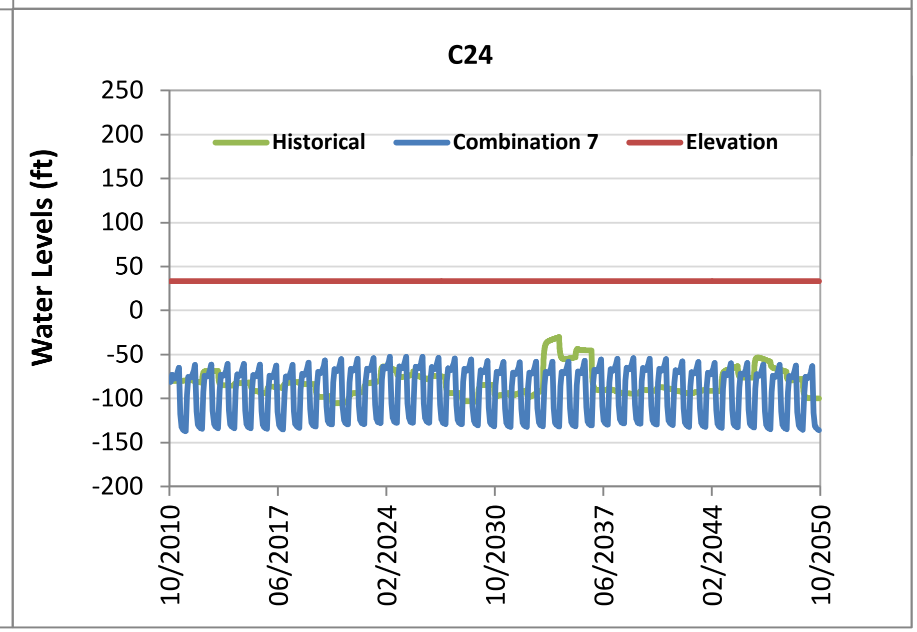
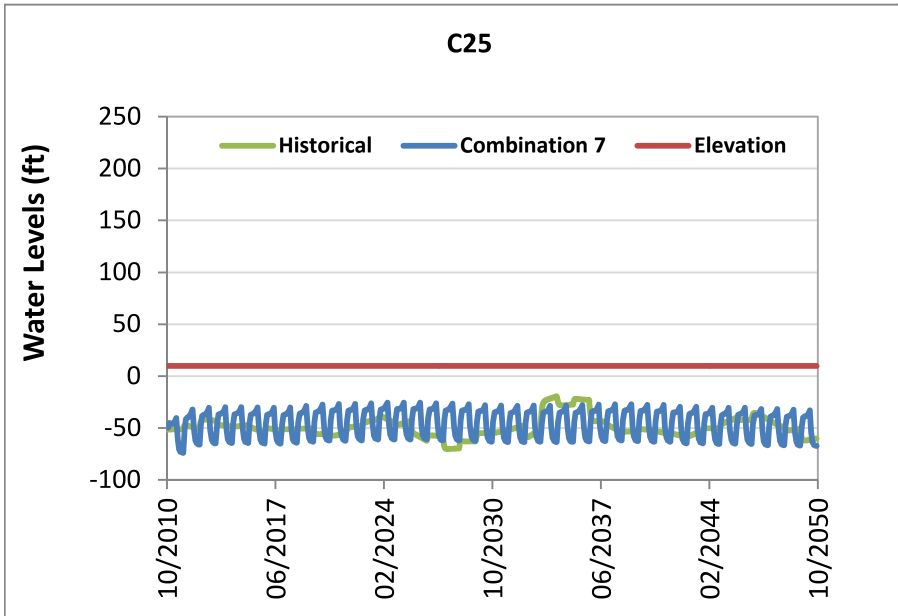
10/2050

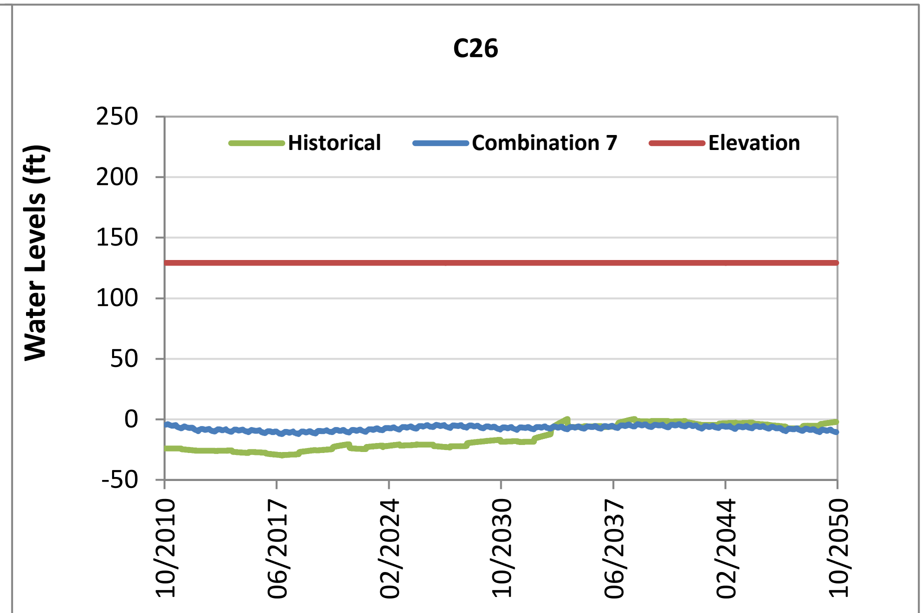


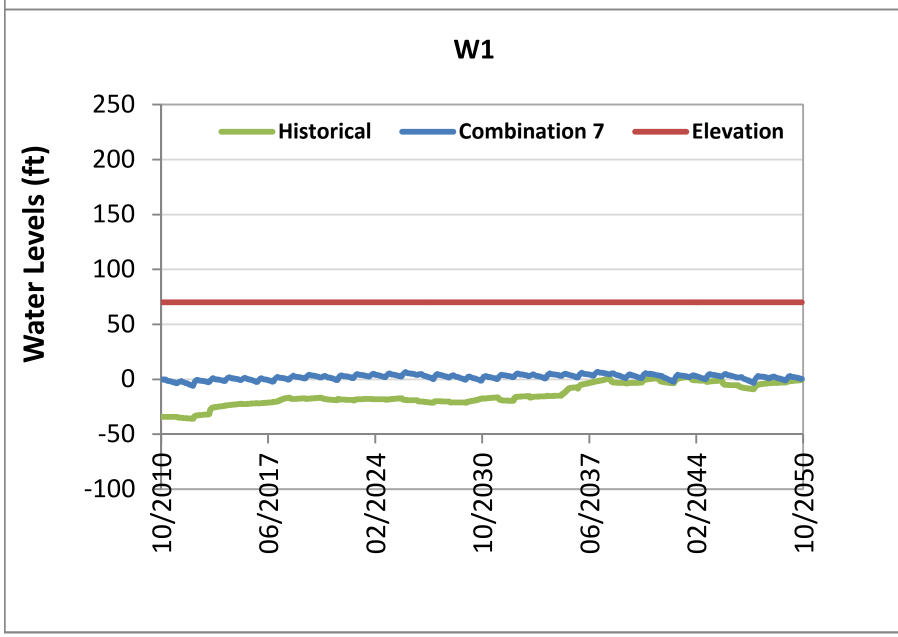
C23
Historical
Combination 7
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050



C24
Historical
Combination 7
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
-200
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C25
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 7
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


C26
Water Levels (ft)
250
200
150
100
50
0
-50
Historical
Combination 7
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W1
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 7
Elevation
10/2010
06/2017
02/2024
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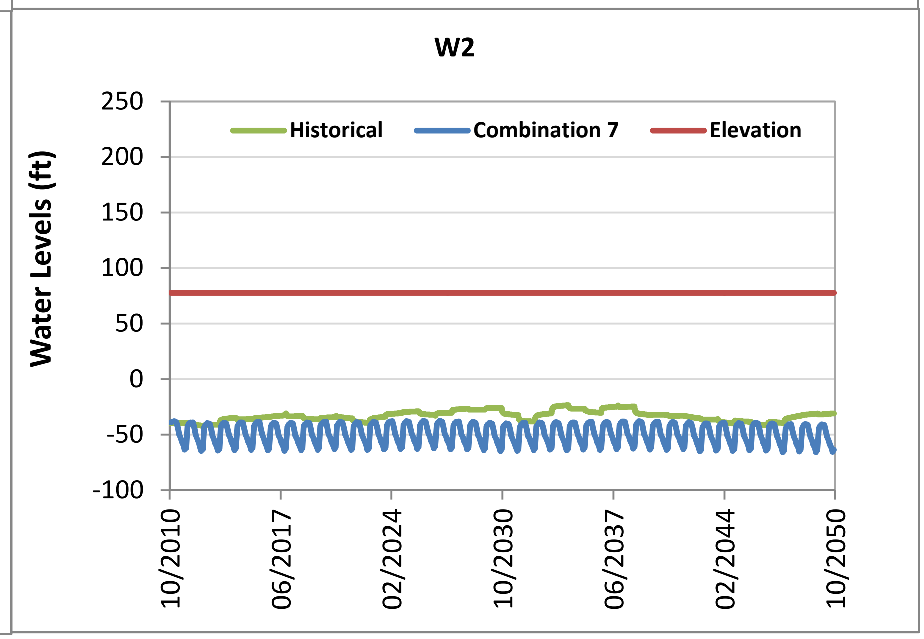
06/2037
02/2044
10/2050


W2
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 7
Elevation
10/2010
06/2017
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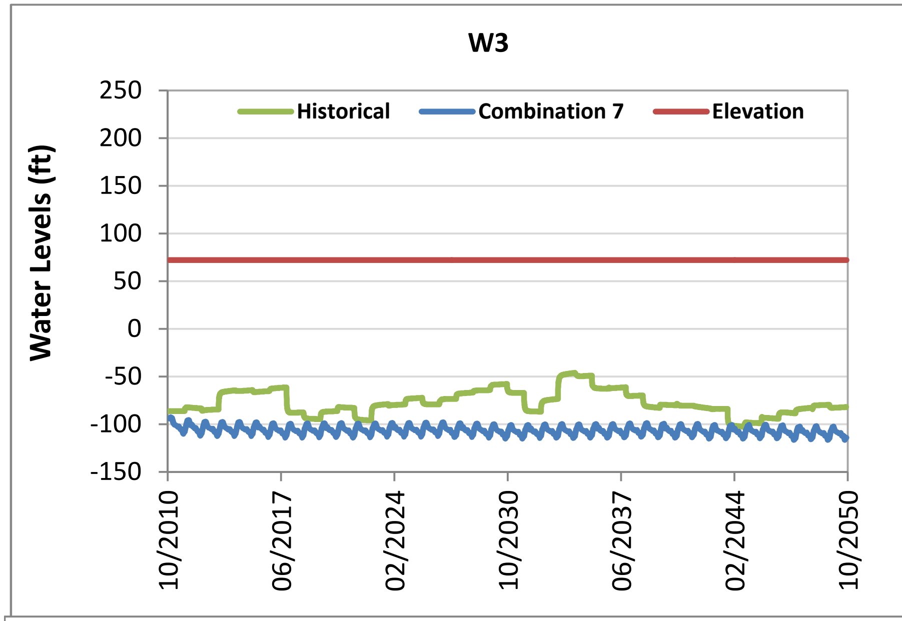
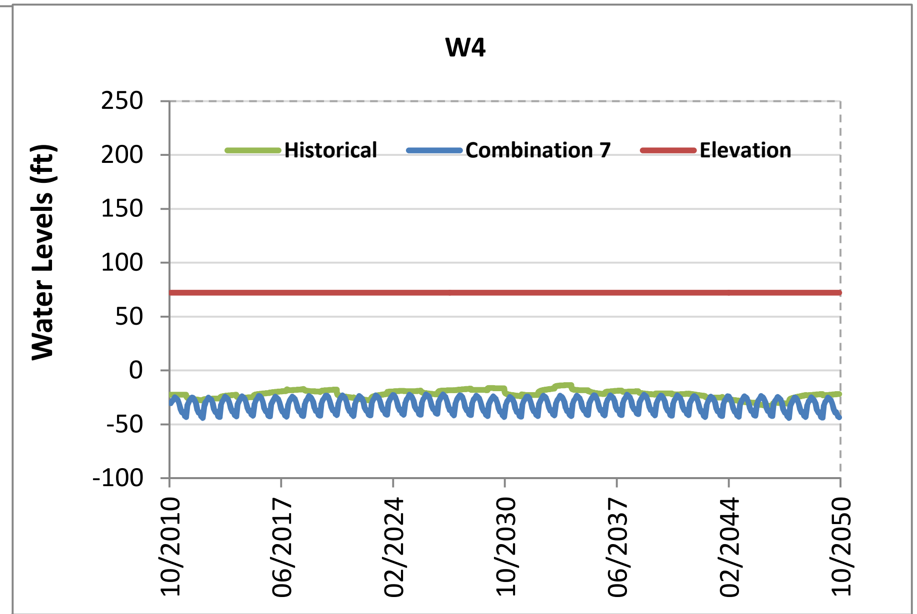
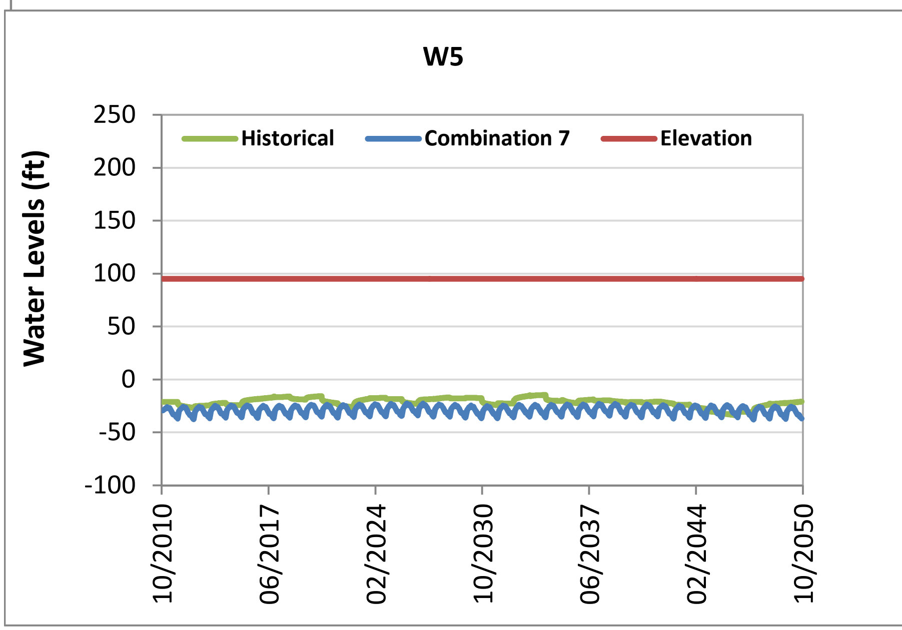
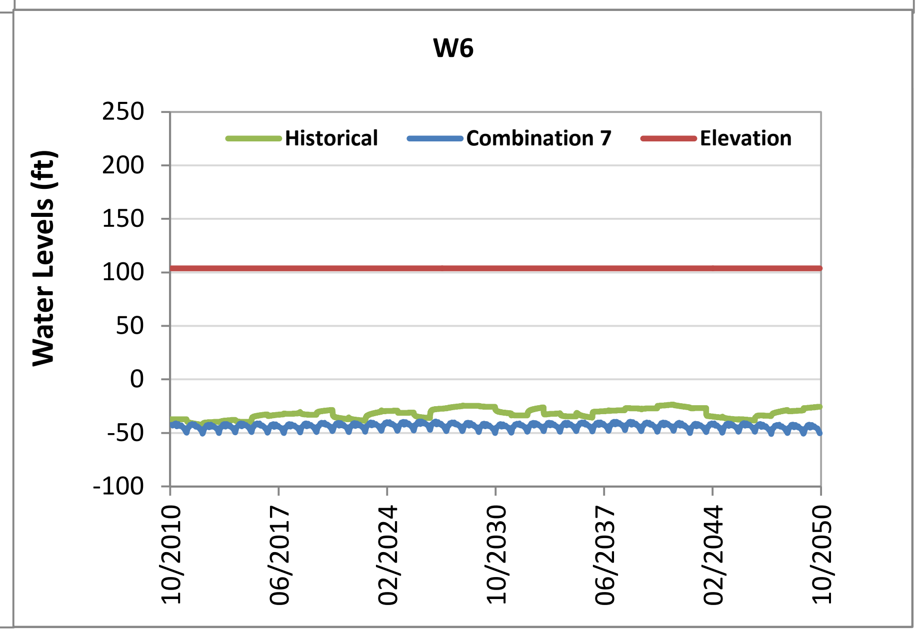
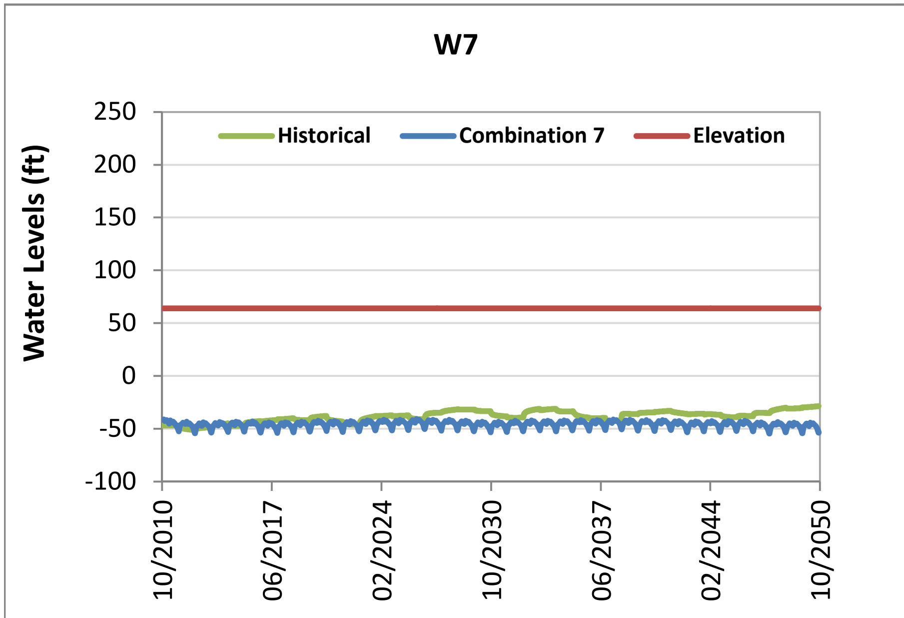
06/2037
02/2044
10/2050

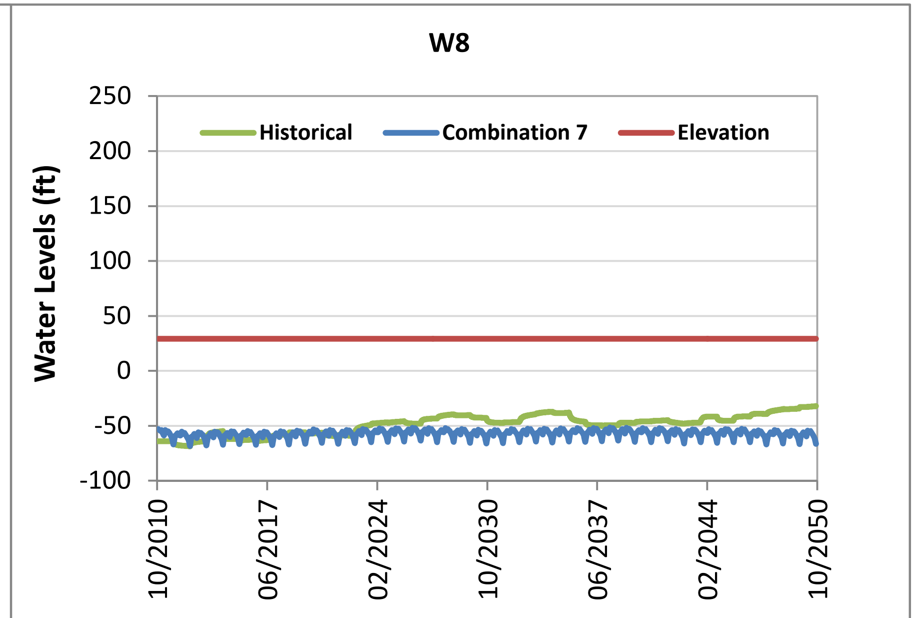

W3
Historical
Combination 7
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

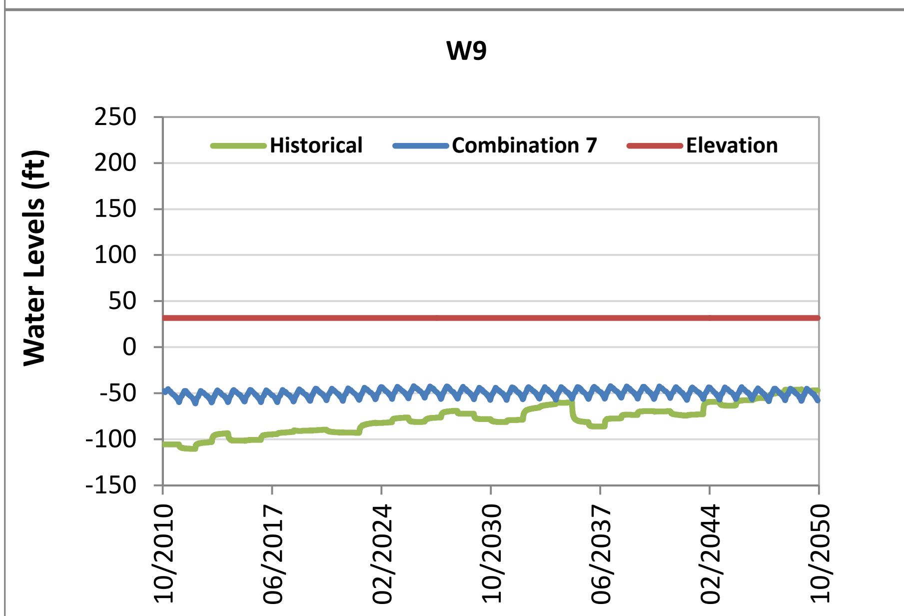

W4
Historical
Combination 7
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

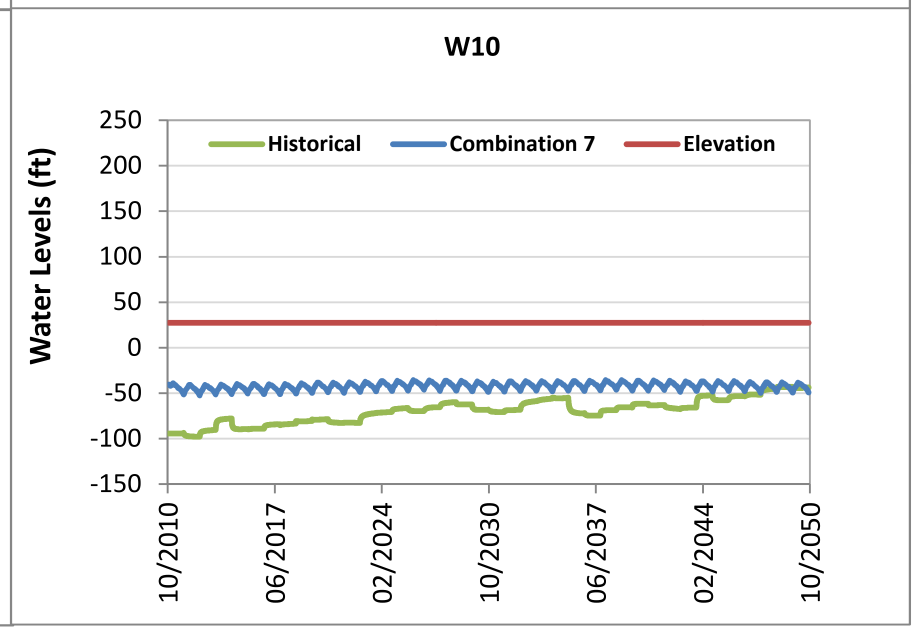

W5
Historical
Combination 7
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

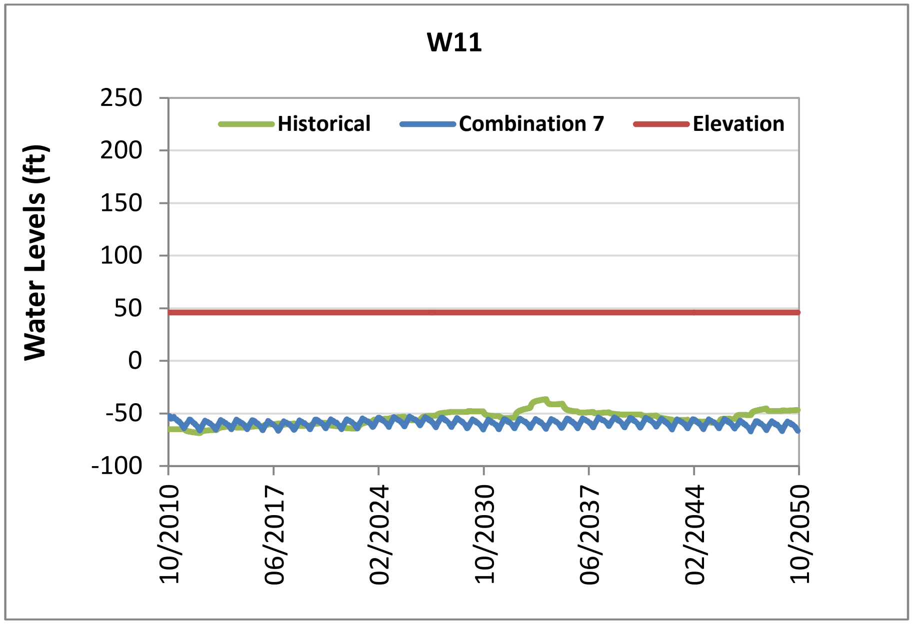

W6
Historical
Combination 7
Elevation
Water Levels (ft)
250
200
150
100
50
0
-50
-100
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050

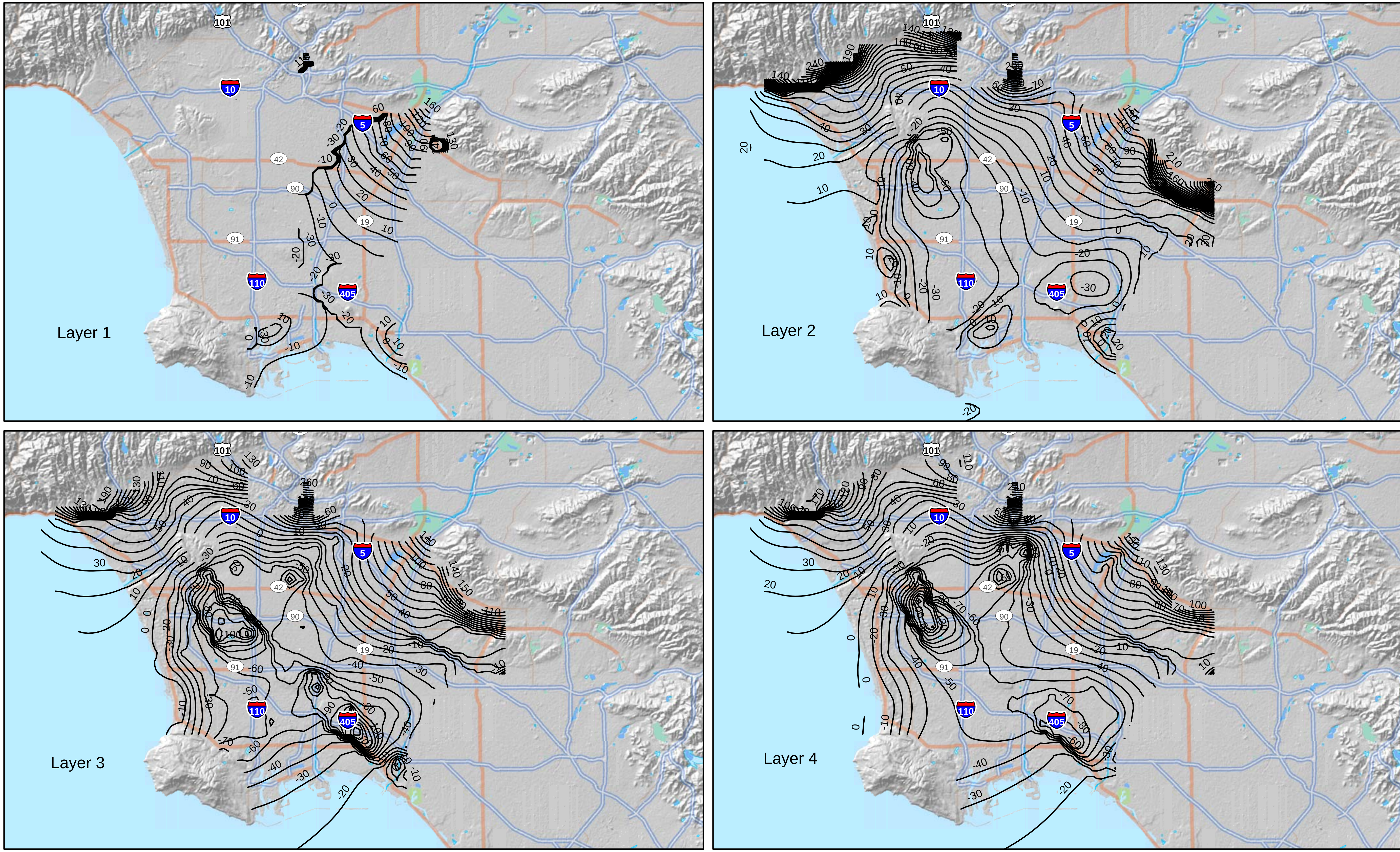

W7
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 7
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W8
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 7
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W9
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
Historical
Combination 7
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W10
Water Levels (ft)
250
200
150
100
50
0
-50
-100
-150
Historical
Combination 7
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050


W11
Water Levels (ft)
250
200
150
100
50
0
-50
-100
Historical
Combination 7
Elevation
10/2010
06/2017
02/2024
10/2030
06/2037
02/2044
10/2050



Legend

- Groundwater Basin Boundary
- Forebays
- Alamitos Barrier
- West Coast Basin Barriers
- Groundwater Level Contours
- Limited Access
- Highway
- Major Road

Water Bodies

Description

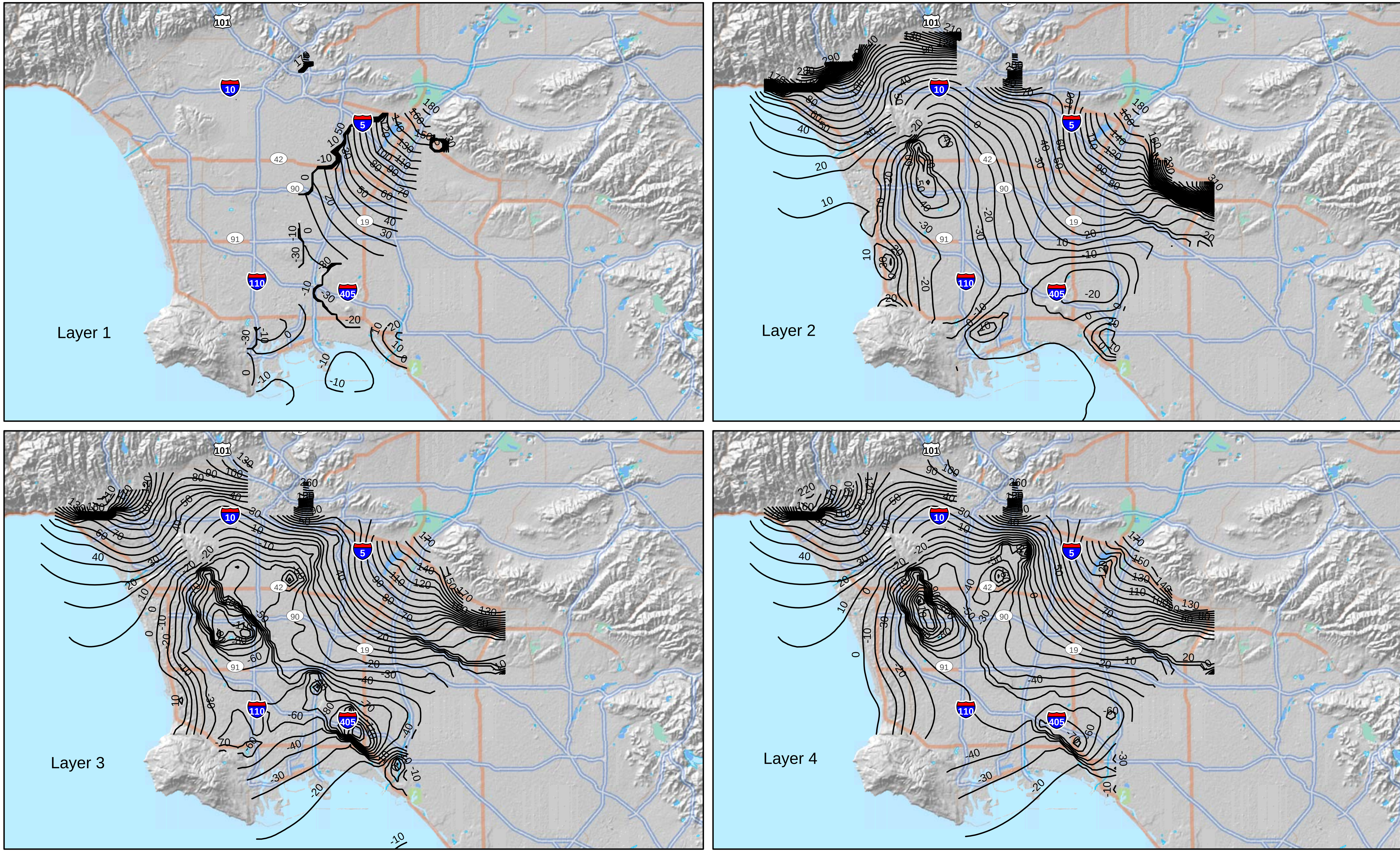
- Lake/Pond
- River/Stream
- Ocean
- Lake or Pond
- Swamp or Marsh
- Stream or River
- Inundation Area

N

0 0.5 1 2 3 4 Miles

Combination 7 - Groundwater Level Contours at the Minimum Cumulative Storage in 2017

File Location



Legend

- Groundwater Basin Boundary
- Forebays
- Alamitos Barrier
- West Coast Basin Barriers
- Groundwater Level Contours
- Limited Access
- Highway
- Major Road

Water Bodies

Description

- Lake/Pond
- River/Stream
- Ocean
- Lake or Pond
- Swamp or Marsh
- Stream or River
- Inundation Area

N

0 0.5 1 2 3 4 Miles

Combination 7 - Groundwater Level Contours at the Maximum Cumulative Storage in 2038

File Location

Appendix J
Cost Estimates and Greenhouse Gas Emission Calculations

APPENDIX J

Cost Estimates and Greenhouse Gas Emission Calculations

This appendix contains the detailed cost estimates and calculations used to estimate greenhouse gas (GHG) emissions for the Groundwater Basins Master Plan (GBMP) projects and alternatives.

J.1 Project and Alternatives Cost Estimates

Concept-level, often referred to as “order-of-magnitude”, capital and operations and maintenance (O&M) planning cost estimates were developed for each of the project components of the GBMP alternatives. Costs were considered for major project elements, such as treatment, flow equalization, conveyance, land purchase, injection wells, and one-time sanity sewer connection fees for reverse osmosis (RO) brine discharge. O&M costs include brine surcharge fees related to assumed continuous discharge of RO brine to the sewer system. The purchase of recycled water for spreading and for further advanced treatment is also included. Sewer connection and surcharge fees are based on formulas applied by Los Angeles County Sanitation Districts.

Present value costs were developed for each project and alternative, using an interest rate of 5.5 percent, inflation rate of 2.5 percent, and a discount rate of 5.5 percent, over a 30-year financing period. Present value unit costs in $/acre-foot were derived by applying the same discounting to the annual project yield as is applied to the annual O&M costs. This methodology is consistent with the Department of Water Resources’ use of a Delta Water Charge, which, when applied to each acre-foot of water for the project repayment period, results in repayment of all project costs, with appropriate interest, by the end of the repayment period.

The breakdown of cost components for each of the GBMP project and alternative is provided in Section J.1.

J.2 Desalter and Wellhead Treatment Cost Curves

The availability of existing pumping capacity, and associated need for additional capacity under any of the GBMP alternatives will vary for each purveyor. Extraction may be conducted with new wells by individual pumpers or combined in a regional wellfield. Existing but unused wells may be refurbished and reactivated, or the system might have available capacity that can be utilized to increase extraction over the range of GBMP alternatives. Additionally, potential wellhead treatment costs will vary with timing and location of well installation. As such, extraction costs were not included in the GBMP cost estimates. However, to assist individual pumpers with consideration of additional extraction that they might need under a given alternative, wellhead treatment cost curves were developed and are provided in Section J.2, along with a cost estimate for an estimated seven desalter systems to mitigate the West Coast Basin saline plume. The same financing terms described for Section J.1 costs were applied to these cost estimates.

J.3 Greenhouse Gas Emission Calculations

A critical parameter for evaluating the potential environmental impact of the GBMP projects and alternatives is the associated generation of greenhouse gas emissions, namely carbon dioxide, methane, and nitrous oxide. The GHG emission calculations, shown in Tables J.3-1 through J.3-5 in Section J.3, are based on estimated electrical usage for each of the GBMP projects and alternatives. These calculations are based on the California Climate Action Registry (CCAR) Local Government Operations Protocol For the quantification and reporting of greenhouse gas emissions inventories, Version 1.0, September, 2008.

Section J.1
Project and Alternative Cost Estimates

	Central Basin Alternatives					
	CB-A1a	CB-A1b	CB-A1c	CB-A1d	CB-A1e	CB-A1f
	SJC-0%	SJC-100% FAT	SJC-50% FAT	SJC-100% NF	SJC-50% NF	SJC-O_3/BAC/GAC/UV
Annual Yield (AFY)	10,000	10,000	10,000	10,000	10,000	10,000
Total Capital Cost	$ -	$ 84,807,000	$ 52,061,000	$ 59,855,000	$ 50,204,000	$ 29,839,000
Total Annual O&M	$ -	$ 3,946,000	$ 2,571,000	$ 1,965,000	$ 2,528,000	$ 1,127,000
Total Water Purchase	$ 3,000,000	$ 1,176,000	$ 2,088,000	$ 1,136,000	$ 1,156,000	$ 1,176,000
Total PV	$ 59,370,000	$ 206,298,000	$ 144,263,000	$ 121,223,000	$ 123,110,000	$ 75,415,000
Project Yield (AF)	300,000	300,000	300,000	300,000	300,000	300,000
PV Unit Cost ($/af)	**$300**	**$1,040**	**$730**	**$610**	**$620**	**$380**

	CB-A2a	CB-A2b	CB-A3a	CB-A3b	CB-A4a	CB-A4b
	P1a + LC-Spread	P1b + LC-Spread	P1a + LC-Inject	P1b + LC-Inject	P1a + ARRF	P1b + ARRF
Annual Yield (AFY)	10,000	10,000	10,000	10,000	10,000	10,000
Total Capital Cost	$ 82,279,000	$ 112,157,000	$ 102,151,000	$ 154,211,000	$ 60,665,000	$ 118,376,000
Total Annual O&M	$ 2,971,000	$ 5,629,000	$ 3,062,000	$ 3,062,000	$ 1,021,000	$ 12,435,000
Total Water Purchase	$ 2,088,000	$ 1,176,000	$ 5,238,000	$ 1,176,000	$ 7,800,000	$ 588,000
Total PV	$ 182,397,000	$ 246,828,000	$ 266,408,000	$ 288,664,000	$ 235,233,000	$ 376,102,000
Project Yield (AF)	300,000	300,000	300,000	300,000	300,000	300,000
PV Unit Cost ($/af)	**$920**	**$1,250**	**$1,350**	**$1,460**	**$1,190**	**$1,900**

	CB-B1a	CB-B1b	CB-B2a	CB-B2b
	Max SJC-0%	Max SJC-100%	Max SJC-0%	Max SJC-100%
Annual Yield (AFY)	67,770	67,770	113,250	113,250
Total Capital Cost	$ 610,142,000	$ 809,320,000	$ 2,189,827,000	$ 2,664,998,000
Total Annual O&M	$ 24,508,000	$ 12,407,000	$ 84,835,000	$ 97,388,000
Total Water Purchase	$ 10,414,000	$ 5,385,000	$ 10,414,000	$ 5,385,000
Total PV	$ 1,301,248,000	$ 1,578,834,000	$ 4,074,805,000	$ 4,698,876,000
Project Yield (AF)	2,033,100	2,033,100	3,397,500	3,397,500
PV Unit Cost ($/af)	**$970**	**$1,180**	**$1,820**	**$2,100**

	West Coast Basin Alternatives	
	WB A1	WB B1
	WCBB+DGB	+30k
Annual Yield (AFY)	18,000	30,000
Total Capital Cost	$ 213,042,600	$ 357,950,000
Total Annual O&M	$ 10,032,000	$ 12,900,000
Total Water Purchase	$ 2,268,000	$ 2,009,000
Total PV	$ 456,460,000	$ 652,999,000
Project Yield (AF)	540,000	900,000
PV Unit Cost ($/af)	**$1,280**	**$1,100**

	Central Basin Projects								
	CB-P1a	CB-P1b	CB-P1c	CB-P2a	CB-P2b	CB-P2c	CB-P3	CB-P4	CB-P5
	SJCWRP 100% Tertiary	SJCWRP 100% Tertiary	SJCWRP 100% Tertiary	SJCWRP 100% AWT	SJCWRP 100% AWT	SJCWRP 100% AWT	SJCWRP 50% AWT	SJCWRP 100% NF	SJCWRP 50% NF
Annual Yield (AFY)	5,000	10,000	17,600	5,000	10,000	17,600	10,000	10,000	10,000
Total Capital Cost	$ -	$ -	$ -	$ 52,061,000	$ 84,807,000	$ 133,962,000	$ 52,061,000	$ 59,855,000	$ 50,204,000
Total Annual O&M	$ -	$ -	$ -	$ 2,571,000	$ 4,963,000	$ 8,662,000	$ 2,571,000	$ 1,965,000	$ 2,528,000
Total Water Purchase	$ 1,500,000	$ 3,000,000	$ 5,280,000	$ 588,000	$ 1,176,000	$ 2,071,000	$ 2,088,000	$ 1,136,000	$ 1,156,000
Total PV	$ 29,685,000	$ 59,370,000	$ 104,491,000	$ 114,578,000	$ 206,298,000	$ 346,368,000	$ 144,263,000	$ 121,223,000	$ 123,110,000
Project Yield (AF)	150,000	300,000	528,000	150,000	300,000	528,000	300,000	300,000	300,000
PV Unit Cost ($/af)	**$300**	**$300**	**$300**	**$1,160**	**$1,040**	**$990**	**$730**	**$610**	**$620**

	Central Basin Projects							
	CB-P6	CB-P7	CB-P8a	CB-P8b	CB-P9	CB-P10	CB-P11	CB-P12
	SJCWRP O_3/BAC/GAC/UV	LCWRP AWT to MFSG	LCWRP AWT to Injection	LCWRP to Injection	ARRF	GBOP	SJCWRP to MF Injection	Satellite AWT
Annual Yield (AFY)	10,000	5,000	5,000	4,500	5,000	17,000	8,690	45,480
Total Capital Cost	$ 29,839,000	$ 77,250,000	$ 93,757,000	$ 98,683,000	$ 60,665,000	$ 147,593,000	$ 206,011,000	$ 1,511,023,000
Total Annual O&M	$ 1,127,000	$ 2,773,000	$ 2,850,000	$ 2,768,000	$ 1,021,000	$ 2,343,000	$ 16,920,000	$ 61,330,000
Total Water Purchase	$ 1,176,000	$ 588,000	$ 588,000	$ 529,000	$ -	$ -	$ 1,022,000	$ -
Total PV	$ 75,415,000	$ 156,354,000	$ 174,385,000	$ 163,931,000	$ 80,871,000	$ 193,961,000	$ 561,083,000	$ 4,397,988,000
Project Yield (AF)	300,000	150,000	150,000	135,000	150,000	510,000	260,700	1,364,400
PV Unit Cost ($/af)	**$380**	**$1,580**	**$1,760**	**$1,840**	**$820**	**$580**	**$3,260**	**$4,890**

	West Coast Basin Projects			
	WCB-P1a	WCB-P1b	WCB-P2	WCB-P3
	ECLWRF AWT to WCBB	ECLWRF AWT to WCBB	JWPCP AWT to Mid-Basin	JWPCP AWT to DGB
Annual Yield (AFY)	15,500	7,500	15,000	2,000
Total Capital Cost	$ 203,105,000	$ 93,768,000	$ 275,246,000	$ 34,105,000
Total Annual O&M	$ 9,676,000	$ 4,710,000	$ 7,802,000	$ 910,000
Total Water Purchase	$ 18,000	$ 9,000	$ 1,765,000	$ 235,000
Total PV	$ 394,949,000	$ 187,157,000	$ 479,266,000	$ 58,718,000
Project Yield (AF)	465,000	225,000	450,000	60,000
PV Unit Cost ($/af)	**$1,290**	**$1,260**	**$1,610**	**$1,480**

Groundwater Basins Master Plan
Unit Costs

Item	Unit Cost	Units	Notes	Source
Capital Costs				
Treatment				
SJCWRP AWTF		LS		CPES
SJCWRP NF		LS		CPES
SJCWRP ozone/BAC/GAC/UV		LS		CPES
LCWRP AWTF		LS		CPES
ECLWRF AWTF				
Expansion On-site	$ 7,936,232	per MGD	up to 10 MGD	CPES
Expansion Off-site	$ 7,936,232	per MGD	up to 10 MGD	CPES
Land purchase for 10-mgd off-site	$ 267,000	per MGD	10 to 20 MGD	WBMWD, 2011
JWPCP AWTF	$ 7,985,224	MGD	Based on 13.4 mgd	CPES
LA Satellite AWTF	$ 18,764,726	per MGD	Based on 40.6 mgd	CPES
ARRF	$ 42,127,779	LS		CH2M
Equalization	$ 2,500,000	MG		RMC, 2011
Conveyance	$25	in-diam*LF		RMC, 2011
River Crossings	$ 2,000,000	EA		RMC
Injection Wells	$ 2,000,000	EA		CH2M
Extraction Wells	$ 2,000,000	EA		CH2M
Desalter	$ 5,317,900	EA	for 2,143 AFY	CH2M
Land Purchase	$ 2,000,000	EA	for parking lot adjacent to ECLWF	WBMWD, 2011
Brine	Connection Fee (One-Time)			
SJCWRP + LCWRP	$ 9,513	per AFY of brine produced		RMC, 2011
SJCWRP NF	$ 9,588	per AFY of brine produced		RMC, 2011
ECLWRF AWTF	$ 600	per AFY of brine produced		WBMWD, 2011
JWPCP AWTF	$ 600	per AFY of brine produced		WBMWD, 2011
LA Satellite AWTF	$ 9,513	per AFY of brine produced		RMC, 2011
O&M Costs ($ / Year)				
AWTF				
SJCWRP AWTF	varies	LS		CPES
LCWRP AWTF	varies	LS		CPES
ECLWRF AWTF	$395	AF		CPES
TIWRP AWTF	$0	AF	Included in purchase price	
JWPCP AWTF	$336	AF		CPES
LA Satellite AWTF	$1,000	AF	For 40.6-mgd plant	RMC, 2012b
Other				
SJCWRP NF	varies	LS		CPES
SJCWRP ozone/GAC/ozone	$113	AF		CPES
ARRF	$888,000	LS		CH2M
Brine	Annual Payments			
SJCWRP + LCWRP	$ 241	per AFY	Based on LACSD discharge fee computation	
SJCWRP NF	$ 248	per AFY	Based on LACSD discharge fee computation	
ECLWRF AWTF	$ 250	per AFY		
JWPCP AWTF	$ 250	per AFY		N/A
LA Satellite AWTF	$ 240	per AFY		CPES

Item	Unit Cost	Units	Notes	Source
Maintenance				
Equalization	0.5%	construction cost		
Pump Station	5.0%	construction cost		
Conveyance	0.5%	construction cost		
Injection Wells	0.5%	construction cost		
Extraction Wells	0.5%	construction cost		
Desalter	$240	per AF		CH2M
Electricity	$0.12	kWhr		
Recycled Water Purchase				
SJCWRP for Tertiary Reuse	$300	AF		RMC, 2011
SJCWRP for NF	$100	AF		
SJCWRP for Ozone/GAC/ozone	$100	AF		
SJCWRP AWTF	$100	AF		RMC, 2011
LCWRP AWTF	$100	AF		RMC, 2011
ECLWRF AWTF	$1	AF		
TIWRP AWTF	$900	AF		RMC
JWPCP AWTF	$100	AF	Assume same as SJCWRP & LCWRP	
LA Satellite AWTF	$0	AF		RMC
Contigencies				
Construction Cost Contigency	20%			
Implementation Cost	20%			
O&M Cost Contigency	15%			
Financing Assumptions				
Interest Rate	5.5%			
Period	30	yr		
Inflation Rate	2.5%			
Discount Rate	5.5%			
Present Value Calculations				
Initial Capital Cost	1.0	factor		
Annual O&M Costs	19.8	factor		
Recycled Water Cost	19.8	factor		

References

CH2MHILL Parametric Estimating System (CPES), 2016
LACSD, 2010. Recycled Water Supply for GRIP - August 2010 Update Memoradum (August 23, 2010)
RMC, 2011. GRIP Alternatives Analysis Final Report (June 2011)
RMC, 2012a. TIWRP Report (March 2012)
RMC, 2012b. Long-Term Report (March 2012)
WBMWD, 2011. Preliminary Cost Estimate for 10 MGD ECLWRF AWTF Expansion and 10 MGD off-site expansion (10/11/2011)

Alternative CB-A1a (Project CB-P1a)
SJCWRP (100% Tertiary) to MFSG

Annual Yield (AFY)
5,000

Item		Qty	Units	Unit Cost		Cost
Capital Costs						
Treatment						
Equalization - Tertiary						
Pump Station						
Conveyance	Diam. (in)	Length (ft)				
Injection Wells		0	EA	$2,000,000	$	-
Extraction Wells		0	EA	$2,000,000	$	-
				Construction Subtotal	**$**	**-**
			Contingency Costs	20%	$	-
				Construction Total	**$**	**-**
			Implementation Costs	20%	$	-
				SubTotal Capital Cost	**$**	**-**
Brine Connection Fee						
				SubTotal Capital Cost	**$**	**-**
				TOTAL CAPITAL COST	**$**	**-**
O&M Costs ($ / Year)						
Treatment						
Equalization						
Pump Station						
Conveyance			construction cost	0.5%	$	-
Injection Wells		$ -	construction cost	0.5%	$	-
Extraction Wells						
Maintenance		$ -	construction cost	0.5%	$	-
Electricity		-	kWh	$0.12	$	-
				O&M Subtotal	**$**	**-**
			Contingency Costs	15%	$	-
				SubTotal O&M Cost	**$**	**-**
Brine Surcharge Fee		0	AFY	$241	$	-
				TOTAL O&M COST	**$**	**-**
Recycled Water Purchase						
SJCWRP		5,000	AF	$300	$	1,500,000
				Recycled Water Purchase Total	**$**	**1,500,000**
Economic Cost Summary						
Present Value Calculations				PV Factor		
Initial Capital Cost		$ -		1.00	$	-
Annual O&M Costs		$ -		19.79	$	-
Recycled Water Cost		$ 1,500,000		19.79	$	29,685,000
				Total PV	**$**	**29,685,000**
				Project Yield (AF)		**150,000**
				PV Unit Cost ($/af)		**$300**

Alternative CB-A1a (Project CB-P1b)
SJCWRP (100% Tertiary) to MFSG

Annual Yield (AFY)
10,000

Item		Qty	Units	Unit Cost		Cost
Capital Costs						
Treatment						
Equalization - Tertiary						
Pump Station						
Conveyance	Diam. (in)	Length (ft)				
Injection Wells		0	EA	$2,000,000	$	-
Extraction Wells		0	EA	$2,000,000	$	-
				Construction Subtotal	**$**	**-**
			Contingency Costs	20%	$	-
				Construction Total	**$**	**-**
			Implementation Costs	20%	$	-
				SubTotal Capital Cost	**$**	**-**
Brine Connection Fee						
				SubTotal Capital Cost	**$**	**-**
				TOTAL CAPITAL COST	**$**	**-**
O&M Costs ($ / Year)						
Treatment						
Equalization						
Pump Station						
Conveyance			construction cost	0.5%	$	-
Injection Wells		$ -	construction cost	0.5%	$	-
Extraction Wells						
Maintenance		$ -	construction cost	0.5%	$	-
Electricity		-	kWh	$0.12	$	-
				O&M Subtotal	**$**	**-**
			Contingency Costs	15%	$	-
				SubTotal O&M Cost	**$**	**-**
Brine Surcharge Fee		0	AFY	$241	$	-
				TOTAL O&M COST	**$**	**-**
Recycled Water Purchase						
SJCWRP		10,000	AF	$300	$	3,000,000
				Recycled Water Purchase Total	**$**	**3,000,000**
Economic Cost Summary						
Present Value Calculations				PV Factor		
Initial Capital Cost		$ -		1.00	$	-
Annual O&M Costs		$ -		19.79	$	-
Recycled Water Cost		$ 3,000,000		19.79	$	59,370,000
				Total PV	**$**	**59,370,000**
				Project Yield (AF)		**300,000**
				PV Unit Cost ($/af)		**$300**

Project CB-P1c
SJCWRP (100% Tertiary) to MFSG

Annual Yield (AFY)
17,600

Item		Qty	Units	Unit Cost		Cost
Capital Costs						
Treatment						
Equalization - Tertiary						
Pump Station						
Conveyance	Diam. (in)	Length (ft)				
Injection Wells		0	EA	$2,000,000	$	-
Extraction Wells		0	EA	$2,000,000	$	-
				Construction Subtotal	**$**	**-**
			Contingency Costs	20%	$	-
				Construction Total	**$**	**-**
			Implementation Costs	20%	$	-
				SubTotal Capital Cost	**$**	**-**
Brine Connection Fee						
				SubTotal Capital Cost	**$**	**-**
				TOTAL CAPITAL COST	**$**	**-**
O&M Costs ($ / Year)						
Treatment						
Equalization						
Pump Station						
Conveyance			construction cost	0.5%	$	-
Injection Wells	$	-	construction cost	0.5%	$	-
Extraction Wells						
Maintenance	$	-	construction cost	0.5%	$	-
Electricity		-	kWh	$0.12	$	-
				O&M Subtotal	**$**	**-**
			Contingency Costs	15%	$	-
				SubTotal O&M Cost	**$**	**-**
Brine Surcharge Fee						
				TOTAL O&M COST	**$**	**-**
Recycled Water Purchase						
SJCWRP		17,600	AF	$300	$	5,280,000
				Recycled Water Purchase Total	**$**	**5,280,000**
Economic Cost Summary						
Present Value Calculations				PV Factor		
Initial Capital Cost	$	-		1.00	$	-
Annual O&M Costs	$	-		19.79	$	-
Recycled Water Cost	$	5,280,000		19.79	$	104,491,000
				Total PV	**$**	**104,491,000**
				Project Yield (AF)		**528,000**
				PV Unit Cost ($/af)		**$300**

Alternative CB-A1b (Project CB-P2a)
SJCWRP (100% AWT) to MFSG

Annual Yield (AFY)
5,000

Capital Costs						
Treatment						
SJCWRP (4.5 MGD)		1	LS	$ 25,824,000	$	25,824,000
Equalization - Tertiary						
SJCWRP		1	MG	$2,500,000	$	2,500,000
Conveyance	Diam. (in)	Length (ft)				
			in-diam*LF	$25	$	-
Injection Wells		0	EA	$2,000,000	$	-
Extraction Wells		0	EA	$2,000,000	$	-
River Crossing		1	EA	$2,000,000	$	2,000,000
				Construction Subtotal	**$**	**30,324,000**
			Contingency Costs	20%	$	6,065,000
				Construction Total	**$**	**36,389,000**
			Implementation Costs	20%	$	7,278,000
				SubTotal Capital Cost	**$**	**43,667,000**
Brine Connection Fee						
SJCWRP		882	AFY	$ 9,513	$	8,394,000
				SubTotal Capital Cost	**$**	**8,394,000**
				TOTAL CAPITAL COST	**$**	**52,061,000**
O&M Costs ($ / Year)						
Treatment						
SJCWRP		1	LS	$ 2,038,000	$	2,038,000
Equalization	$	2,500,000	construction cost	0.5%	$	13,000
Conveyance	$	-	construction cost	0.5%	$	-
Injection Wells	$	-	construction cost	0.5%	$	-
Extraction Wells						
Maintenance	$	-	construction cost	0.5%	$	-
Electricity		-	kWh	$0.12	$	-
				O&M Subtotal	**$**	**2,051,000**
			Contingency Costs	15%	$	308,000
				SubTotal O&M Cost	**$**	**2,359,000**
Brine Surcharge Fee						
SJCWRP		882	AFY	$ 241	$	212,000
				TOTAL O&M COST	**$**	**2,571,000**
Recycled Water Purchase						
SJCWRP AWTF		5,880	AF	$100	$	588,000
				Recycled Water Purchase Total	**$**	**588,000**
Economic Cost Summary						
Present Value Calculations				PV Factor		
Initial Capital Cost	$	52,061,000		1.00	$	52,061,000
Annual O&M Costs	$	2,571,000		19.79	$	50,880,000
Recycled Water Cost	$	588,000		19.79	$	11,637,000
				Total PV	**$**	**114,578,000**
				Project Yield (AF)		**150,000**
				PV Unit Cost ($/af)		**$1,158**

Alternative CB-A1b (Project CB-P2b)
SJCWRP (100% AWT) to MFSG

Annual Yield (AFY)
10,000

Item		Qty	Units	Unit Cost		Cost
Capital Costs						
Treatment						
SJCWRP (8.9 MGD)		1	LS	$ 40,236,000	$	40,236,000
Equalization - Tertiary						
SJCWRP		2	MG	$2,500,000	$	5,000,000
Conveyance	Diam. (in)	Length (ft)				
					$	-
Injection Wells		0	EA	$2,000,000	$	-
Extraction Wells		0	EA	$2,000,000	$	-
River Crossing		1	EA	$2,000,000	$	2,000,000
				Construction Subtotal	**$**	**47,236,000**
			Contingency Costs	20%	$	9,447,000
				Construction Total	**$**	**56,683,000**
			Implementation Costs	20%	$	11,337,000
				SubTotal Capital Cost	**$**	**68,020,000**
Brine Connection Fee						
SJCWRP		1,765	AFY	$ 9,513	$	16,787,000
				SubTotal Capital Cost	**$**	**16,787,000**
				TOTAL CAPITAL COST	**$**	**84,807,000**
O&M Costs ($ / Year)						
Treatment						
SJCWRP		1	LS	$ 3,921,000	$	3,921,000
Equalization	$	5,000,000	construction cost	0.5%	$	25,000
Conveyance	$	-	construction cost	0.5%	$	-
Injection Wells	$	-	construction cost	0.5%	$	-
Extraction Wells						
Maintenance	$	-	construction cost	0.5%	$	-
Electricity		-	kWh	$0.12	$	-
				O&M Subtotal	**$**	**3,946,000**
			Contingency Costs	15%	$	592,000
				SubTotal O&M Cost	**$**	**4,538,000**
Brine Surcharge Fee						
SJCWRP		1,765	AFY	$ 241	$	425,000
				TOTAL O&M COST	**$**	**4,963,000**
Recycled Water Purchase						
SJCWRP AWTF		11,760	AF	$100	$	1,176,000
				Recycled Water Purchase Total	**$**	**1,176,000**
Economic Cost Summary						
Present Value Calculations				PV Factor		
Initial Capital Cost	$	84,807,000		1.00	$	84,807,000
Annual O&M Costs	$	4,963,000		19.79	$	98,218,000
Recycled Water Cost	$	1,176,000		19.79	$	23,273,000
				Total PV	**$**	**206,298,000**
				Project Yield (AF)		**300,000**
				PV Unit Cost ($/af)		**$1,042**

WRD Groundwater Basins Master Plan

Project CB-P2c
SJCWRP (100% AWT) to MFSG

Annual Yield (AFY)
17,600

Item		Qty	Units	Unit Cost		Cost
Capital Costs						
Treatment						
SJCWRP (15.7 MGD)		1	LS	$ 62,511,000	$	62,511,000
Equalization - Tertiary						
SJCWRP		4	MG	$2,500,000	$	10,000,000
Conveyance						
Use CB-P2 Facilities						
Injection Wells		0	EA	$2,000,000	$	-
Extraction Wells		0	EA	$2,000,000	$	-
				Construction Subtotal	**$**	**72,511,000**
			Contingency Costs	20%	$	14,502,000
				Construction Total	**$**	**87,013,000**
			Implementation Costs	20%	$	17,403,000
				SubTotal Capital Cost	**$**	**104,416,000**
Brine Connection Fee						
SJCWRP		3,106	AFY	$ 9,513	$	29,546,000
				SubTotal Capital Cost	**$**	**29,546,000**
				TOTAL CAPITAL COST	**$**	**133,962,000**
O&M Costs ($ / Year)						
Treatment						
SJCWRP		1	LS	$ 6,833,000	$	6,833,000
Equalization	$	10,000,000	construction cost	0.5%	$	50,000
Conveyance	$	-	construction cost	0.5%	$	-
Injection Wells	$	-	construction cost	0.5%	$	-
Extraction Wells						
Maintenance	$	-	construction cost	0.5%	$	-
Electricity		-	kWh	$0.12	$	-
				O&M Subtotal	**$**	**6,883,000**
			Contingency Costs	15%	$	1,032,000
				SubTotal O&M Cost	**$**	**7,915,000**
Brine Surcharge Fee						
SJCWRP		3,106	AFY	$ 241	$	747,000
				TOTAL O&M COST	**$**	**8,662,000**
Recycled Water Purchase						
SJCWRP AWTF		20,710	AF	$100	$	2,071,000
				Recycled Water Purchase Total	**$**	**2,071,000**
Economic Cost Summary						
Present Value Calculations				PV Factor		
Initial Capital Cost	$	133,962,000		1.00	$	133,962,000
Annual O&M Costs	$	8,662,000		19.79	$	171,421,000
Recycled Water Cost	$	2,071,000		19.79	$	40,985,000
				Total PV	**$**	**346,368,000**
				Project Yield (AF)		**528,000**
				PV Unit Cost ($/af)		**$994**

Alternative CB-A1c (Project CB-P3)
SJCWRP (50% AWT & 50% Tertiary) to MFSG

Annual Yield (AFY)
10,000

Item		Qty	Units	Unit Cost		Cost
Capital Costs						
Treatment						
SJCWRP (4.5 MGD)		1	LS	$ 25,824,000	$	25,824,000
Equalization - Tertiary						
SJCWRP		1	MG	$2,500,000	$	2,500,000
Conveyance	Diam. (in)	Length (ft)				
Injection Wells		0	EA	$2,000,000	$	-
Extraction Wells		0	EA	$2,000,000	$	-
River Crossing		1	EA	$2,000,000	$	2,000,000
				Construction Subtotal	**$**	**30,324,000**
			Contingency Costs	20%	$	6,065,000
				Construction Total	**$**	**36,389,000**
			Implementation Costs	20%	$	7,278,000
				SubTotal Capital Cost	**$**	**43,667,000**
Brine Connection Fee						
SJCWRP		882	AFY	$ 9,513	$	8,394,000
				SubTotal Capital Cost	**$**	**8,394,000**
				TOTAL CAPITAL COST	**$**	**52,061,000**
O&M Costs ($ / Year)						
Treatment						
SJCWRP		1	LS	$ 2,038,000	$	2,038,000
Equalization	$	2,500,000	construction cost	0.5%	$	13,000
Conveyance	$	-	construction cost	0.5%	$	-
Injection Wells	$	-	construction cost	0.5%	$	-
Extraction Wells						
Maintenance	$	-	construction cost	0.5%	$	-
Electricity		-	kWh	$0.12	$	-
				O&M Subtotal	**$**	**2,051,000**
			Contingency Costs	15%	$	308,000
				SubTotal O&M Cost	**$**	**2,359,000**
Brine Surcharge Fee						
SJCWRP		882	AFY	$ 241	$	212,000
				TOTAL O&M COST	**$**	**2,571,000**
Recycled Water Purchase						
SJCWRP Tertiary		5,000	AF	$300	$	1,500,000
SJCWRP AWTF		5,880	AF	$100	$	588,000
				Recycled Water Purchase Total	**$**	**2,088,000**
Economic Cost Summary						
Present Value Calculations				PV Factor		
Initial Capital Cost	$	52,061,000		1.00	$	52,061,000
Annual O&M Costs	$	2,571,000		19.79	$	50,880,000
Recycled Water Cost	$	2,088,000		19.79	$	41,322,000
				Total PV	**$**	**144,263,000**
				Project Yield (AF)		**300,000**
				PV Unit Cost ($/af)		**$729**

Alternative CB-A1d (Project CB-P4)
SJCWRP (100% NF) to MFSG

Annual Yield (AFY)
10,000

Item		Qty	Units	Unit Cost		Cost
Capital Costs						
Treatment						
SJCWRP NF (8.9 mgd)		1	LS	$ 25,486,000	$	25,486,000
Equalization - Tertiary						
SJCWRP		2	MG	$2,500,000	$	5,000,000
Conveyance	Diam. (in)	Length (ft)				
Injection Wells		0	EA	$2,000,000	$	-
Extraction Wells		0	EA	$2,000,000	$	-
River Crossing		1	EA	$2,000,000	$	2,000,000
				Construction Subtotal	**$**	**32,486,000**
			Contingency Costs	20%	$	6,497,000
				Construction Total	**$**	**38,983,000**
			Implementation Costs	20%	$	7,797,000
				SubTotal Capital Cost	**$**	**46,780,000**
Brine Connection Fee						
SJCWRP NF		1,364	AFY	$ 9,588	$	13,075,000
				SubTotal Capital Cost	**$**	**13,075,000**
				TOTAL CAPITAL COST	**$**	**59,855,000**
O&M Costs ($ / Year)						
Treatment						
SJCWRP		1	LS	$ 1,390,000	$	1,390,000
Equalization	$	5,000,000	construction cost	0.5%	$	25,000
Conveyance	$	-	construction cost	0.5%	$	-
Injection Wells	$	-	construction cost	0.5%	$	-
Extraction Wells						
Maintenance	$	-	construction cost	0.5%	$	-
Electricity		-	kWh	$0.12	$	-
				O&M Subtotal	**$**	**1,415,000**
			Contingency Costs	15%	$	212,000
				SubTotal O&M Cost	**$**	**1,627,000**
Brine Surcharge Fee						
SJCWRP NF		1,364	AFY	$ 248	$	338,000
				TOTAL O&M COST	**$**	**1,965,000**
Recycled Water Purchase						
SJCWRP NF		11,360	AF	$100	$	1,136,000
				Recycled Water Purchase Total	**$**	**1,136,000**
Economic Cost Summary						
Present Value Calculations				PV Factor		
Initial Capital Cost	$	59,855,000		1.00	$	59,855,000
Annual O&M Costs	$	1,965,000		19.79	$	38,887,000
Recycled Water Cost	$	1,136,000		19.79	$	22,481,000
				Total PV	**$**	**121,223,000**
				Project Yield (AF)		**300,000**
				PV Unit Cost ($/af)		**$613**

WRD Groundwater Basins Master Plan

Alternative CB-A1e (Project CB-P5)
SJCWRP (50% NF & 50% Tertiary) to MFSG

Annual Yield (AFY)
10,000

Item		Qty	Units	Unit Cost		Cost
Capital Costs						
Treatment						
SJCWRP NF (4.5 mgd)		1	LS	$ 25,824,000	$	25,824,000
Equalization - Tertiary						
SJCWRP		1	MG	$2,500,000	$	2,500,000
Conveyance	Diam. (in)	Length (ft)				
Injection Wells		0	EA	$2,000,000	$	-
Extraction Wells		0	EA	$2,000,000	$	-
River Crossing		1	EA	$2,000,000	$	2,000,000
				Construction Subtotal	**$**	**30,324,000**
			Contingency Costs	20%	$	6,065,000
				Construction Total	**$**	**36,389,000**
			Implementation Costs	20%	$	7,278,000
				SubTotal Capital Cost	**$**	**43,667,000**
Brine Connection Fee						
SJCWRP NF		682	AFY	$ 9,588	$	6,537,000
				SubTotal Capital Cost	**$**	**6,537,000**
				TOTAL CAPITAL COST	**$**	**50,204,000**
O&M Costs ($ / Year)						
Treatment						
SJCWRP		1	LS	$ 2,038,000	$	2,038,000
Equalization	$	2,500,000	construction cost	0.5%	$	13,000
Conveyance	$	-	construction cost	0.5%	$	-
Extraction Wells						
Maintenance	$	-	capital cost	0.5%	$	-
Electricity		-	kWh	$0.12	$	-
				O&M Subtotal	**$**	**2,051,000**
			Contingency Costs	15%	$	308,000
				SubTotal O&M Cost	**$**	**2,359,000**
Brine Surcharge Fee						
SJCWRP NF		682	AFY	$ 248	$	169,000
				TOTAL O&M COST	**$**	**2,528,000**
Recycled Water Purchase						
SJCWRP NF		5,680	AF	$100	$	568,000
SJCWRP AWTF		5,880	AF	$100	$	588,000
				Recycled Water Purchase Total	**$**	**1,156,000**
Economic Cost Summary						
Present Value Calculations				PV Factor		
Initial Capital Cost	$	50,204,000		1.00	$	50,204,000
Annual O&M Costs	$	2,528,000		19.79	$	50,029,000
Recycled Water Cost	$	1,156,000		19.79	$	22,877,000
				Total PV	**$**	**123,110,000**
				Project Yield (AF)		**300,000**
				PV Unit Cost ($/af)		**$622**

Alternative CB-A1f (Project CB-P6)
SJCWRP (100% ozone/BAC/GAC/UV) to MFSG

Annual Yield (AFY)
10,000

Item		Qty	Units	Unit Cost		Cost
Capital Costs						
Treatment						
SJCWRP (8.9 mgd)		1	LS	$ 18,722,000	$	18,722,000
Pump Station						
Conveyance	Diam. (in)	Length (ft)				
Injection Wells		0	EA	$2,000,000	$	-
Extraction Wells		0	EA	$2,000,000	$	-
River Crossing		1	EA	$2,000,000	$	2,000,000
				Construction Subtotal	**$**	**20,722,000**
			Contingency Costs	20%	$	4,144,000
				Construction Total	**$**	**24,866,000**
			Implementation Costs	20%	$	4,973,000
				SubTotal Capital Cost	**$**	**29,839,000**
Brine Connection Fee						
				SubTotal Capital Cost	**$**	**-**
				TOTAL CAPITAL COST	**$**	**29,839,000**
O&M Costs ($ / Year)						
Treatment						
SJCWRP		1	LS	$ 980,000	$	980,000
Equalization						
Conveyance	$	-	construction cost	0.5%	$	-
Injection Wells	$	-	construction cost	0.5%	$	-
Extraction Wells						
Maintenance	$	-	construction cost	0.5%	$	-
Electricity		-	kWh	$0.12	$	-
				O&M Subtotal	**$**	**980,000**
			Contingency Costs	15%	$	147,000
				SubTotal O&M Cost	**$**	**1,127,000**
				TOTAL O&M COST	**$**	**1,127,000**
Recycled Water Purchase						
SJCWRP		11,765	AF	$100	$	1,176,000
				Recycled Water Purchase Total	**$**	**1,176,000**
Economic Cost Summary						
Present Value Calculations				PV Factor		
Initial Capital Cost	$	29,839,000		1.00	$	29,839,000
Annual O&M Costs	$	1,127,000		19.79	$	22,303,000
Recycled Water Cost	$	1,176,000		19.79	$	23,273,000
				Total PV	**$**	**75,415,000**
				Project Yield (AF)		**300,000**
				PV Unit Cost ($/af)		**$381**

Project CB-P7
LCWRP 100% AWT to MFSG

Annual Yield (AFY)
5,000

Item		Qty	Units	Unit Cost		Cost
Capital Costs						
Treatment						
LCWRP (4.5 mgd)		1	LS	$ 25,824,000	$	25,824,000
Equalization - Tertiary						
LCWRP		1	MG	$2,500,000	$	2,500,000
Pump Station						
LCWRP		3,100	gpm	formula	$	2,172,000
Conveyance	Diam. (in)	Length (ft)				
LCWRP to MFSG	18	47,000	in-diam*LF	$25	$	21,150,000
Injection Wells		0	EA	$2,000,000	$	-
Extraction Wells		0	EA	$2,000,000	$	-
River Crossing		1	EA	$2,000,000	$	2,000,000
				Construction Subtotal	**$**	**53,646,000**
			Contingency Costs	20%	$	10,729,000
				Construction Total	**$**	**64,375,000**
			Implementation Costs	20%	$	12,875,000
				SubTotal Capital Cost	**$**	**77,250,000**
LCWRP		882	AFY	$ 9,513	$	8,394,000
				SubTotal Capital Cost	**$**	**8,394,000**
				TOTAL CAPITAL COST	**$**	**85,644,000**
O&M Costs ($ / Year)						
Treatment						
LCWRP		1	LS	$ 2,038,000	$	2,038,000
Equalization						
LCWRP	$	2,500,000	capital cost	0.5%	$	13,000
Pump Station						
PS1 - Maintenance	$	2,172,000	capital cost	5.0%	$	109,000
PS1 - Electricity		1,211,400	kWh	$0.12	$	145,000
Conveyance	$	21,150,000	capital cost	0.5%	$	106,000
Injection Wells	$	-	capital cost	0.5%	$	-
Extraction Wells						
Maintenance	$	-	capital cost	0.5%	$	-
Electricity		-	kWh	$0.12	$	-
				O&M Subtotal	**$**	**2,411,000**
			Contingency Costs	15%	$	362,000
				SubTotal O&M Cost	**$**	**2,773,000**
Brine Surcharge Fee						
LCWRP		882	AFY	$ 241	$	212,000
				TOTAL O&M COST	**$**	**2,985,000**
Recycled Water Purchase						
LCWRP		5,880	AF	$100	$	588,000
				Recycled Water Purchase Total	**$**	**588,000**
Economic Cost Summary						
Present Value Calculations				PV Factor		
Initial Capital Cost	$	85,644,000		1.00	$	85,644,000
Annual O&M Costs	$	2,985,000		19.79	$	59,073,000
Recycled Water Cost	$	588,000		19.79	$	11,637,000
				Total PV	**$**	**156,354,000**
				Project Yield (AF)		**150,000**
				PV Unit Cost ($/af)		**$1,580**

Project CB-P8a
LCWRP 100% AWT to MF Injection

Annual Yield (AFY)
5,000

Item		Qty	Units	Unit Cost		Cost
Capital Costs						
Treatment						
LCWRP (4.5 mgd)		1	LS	$ 25,824,000	$	25,824,000
Equalization - Tertiary						
LCWRP		1	MG	$2,500,000	$	2,500,000
Pump Station						
LCWRP		3,125	gpm	formula	$	2,185,000
Conveyance	Diam. (in)	Length (ft)				
LCWRP to Injection	16	66,500	in-diam*LF	$25	$	26,600,000
Injection Wells		4	EA	$2,000,000	$	8,000,000
Extraction Wells		0	EA	$2,000,000	$	-
				Construction Subtotal	**$**	**65,109,000**
			Contingency Costs	20%	$	13,022,000
				Construction Total	**$**	**78,131,000**
			Implementation Costs	20%	$	15,626,000
				SubTotal Capital Cost	**$**	**93,757,000**
LCWRP		882	AFY	$ 9,513	$	8,394,000
				SubTotal Capital Cost	**$**	**8,394,000**
				TOTAL CAPITAL COST	**$**	**102,151,000**
O&M Costs ($ / Year)						
Treatment						
LCWRP		1	LS	$ 2,038,000	$	2,038,000
Equalization						
LCWRP	$	2,500,000	capital cost	0.5%	$	13,000
Pump Station						
PS1 - Maintenance	$	2,185,000	capital cost	5.0%	$	109,000
PS1 - Electricity		1,211,400	kWh	$0.12	$	145,000
Conveyance	$	26,600,000	capital cost	0.5%	$	133,000
Injection Wells	$	8,000,000	capital cost	0.5%	$	40,000
Extraction Wells						
Maintenance	$	-	capital cost	0.5%	$	-
Electricity		-	kWh	$0.12	$	-
				O&M Subtotal	**$**	**2,478,000**
			Contingency Costs	15%	$	372,000
				SubTotal O&M Cost	**$**	**2,850,000**
Brine Surcharge Fee						
		882	AFY	$ 241	$	212,000
				TOTAL O&M COST	**$**	**3,062,000**
Recycled Water Purchase						
LCWRP		5,880	AF	$100	$	588,000
				Recycled Water Purchase Total	**$**	**588,000**
Economic Cost Summary						
Present Value Calculations				PV Factor		
Initial Capital Cost	$	102,151,000		1.00	$	102,151,000
Annual O&M Costs	$	3,062,000		19.79	$	60,597,000
Recycled Water Cost	$	588,000		19.79	$	11,637,000
				Total PV	**$**	**174,385,000**
				Project Yield (AF)		**150,000**
				PV Unit Cost ($/af)		**$1,762**

Project CB-P8b
LCWRP 100% AWT to MF Injection

Annual Yield (AFY)
4,500

Item		Qty	Units	Unit Cost		Cost
Capital Costs						
Treatment						
LCWRP (4.0 mgd)		1	LS	$ 24,186,000	$	24,186,000
Equalization - Tertiary						
LCWRP		1	MG	$2,500,000	$	2,500,000
Pump Station						
LCWRP		2,778	gpm	formula	$	1,998,000
Conveyance	Diam. (in)	Length (ft)				
LCWRP to Injection	16	66,500	in-diam*LF	$25	$	26,600,000
Injection Wells		4	EA	$2,000,000	$	8,000,000
Extraction Wells		0	EA	$2,000,000	$	-
				Construction Subtotal	**$**	**63,284,000**
			Contingency Costs	20%	$	12,657,000
				Construction Total	**$**	**75,941,000**
			Implementation Costs	20%	$	15,188,000
				SubTotal Capital Cost	**$**	**91,129,000**
LCWRP		794	AFY	$ 9,513	$	7,554,000
				SubTotal Capital Cost	**$**	**7,554,000**
				TOTAL CAPITAL COST	**$**	**98,683,000**
O&M Costs ($ / Year)						
Treatment						
LCWRP		1	LS	$ 1,824,000	$	1,824,000
Equalization						
LCWRP	$	2,500,000	capital cost	0.5%	$	13,000
Pump Station						
PS1 - Maintenance	$	1,998,000	capital cost	5.0%	$	100,000
PS1 - Electricity		1,090,300	kWh	$0.12	$	131,000
Conveyance	$	26,600,000	capital cost	0.5%	$	133,000
Injection Wells	$	8,000,000	capital cost	0.5%	$	40,000
Extraction Wells						
Maintenance	$	-	capital cost	0.5%	$	-
Electricity		-	kWh	$0.12	$	-
				O&M Subtotal	**$**	**2,241,000**
			Contingency Costs	15%	$	336,000
				SubTotal O&M Cost	**$**	**2,577,000**
Brine Surcharge Fee						
		794	AFY	$ 241	$	191,000
				TOTAL O&M COST	**$**	**2,768,000**
Recycled Water Purchase						
LCWRP		5,290	AF	$100	$	529,000
				Recycled Water Purchase Total	**$**	**529,000**
Economic Cost Summary						
Present Value Calculations				PV Factor		
Initial Capital Cost	$	98,683,000		1.00	$	98,683,000
Annual O&M Costs	$	2,768,000		19.79	$	54,779,000
Recycled Water Cost	$	529,000		19.79	$	10,469,000
				Total PV	**$**	**163,931,000**
				Project Yield (AF)		**135,000**
				PV Unit Cost ($/af)		**$1,841**

Project CB-P9

ARRF (LA River to LA Forebay)

Annual Yield (AFY)
5,000

Item		Qty	Units	Unit Cost		Cost
Capital Costs						
Treatment						
LA River ARRF		1.0	LS	$ 42,127,779	$	42,128,000
Equalization						
Pump Station						
Conveyance						
Injection Wells		0	EA	$2,000,000	$	-
Extraction Wells		0	EA	$2,000,000	$	-
				Construction Subtotal	**$**	**42,128,000**
			Contingency Costs	20%	$	8,426,000
				Construction Total	**$**	**50,554,000**
			Implementation Costs	20%	$	10,111,000
				SubTotal Capital Cost	**$**	**60,665,000**
Brine Connection						
				SubTotal Capital Cost	**$**	**-**
				TOTAL CAPITAL COST	**$**	**60,665,000**
O&M Costs ($ / Year)						
Treatment						
LA River to LA Forebay		1	LS	$887,542	$	888,000
Equalization						
Pump Station						
Injection Wells	$	-	capital cost	0.5%	$	-
Extraction Wells						
Maintenance	$	-	capital cost	0.5%	$	-
Electricity		1,044	kWh	$0.12	$	-
				O&M Subtotal	**$**	**888,000**
			Contingency Costs	15%	$	133,000
				SubTotal O&M Cost	**$**	**1,021,000**
Brine Surcharge Fee						
				TOTAL O&M COST	**$**	**1,021,000**
Recycled Water Purchase						
				Recycled Water Purchase Total	**$**	**-**
Economic Cost Summary						
Present Value Calculations				PV Factor		
Initial Capital Cost	$	60,665,000		1.00	$	60,665,000
Annual O&M Costs	$	1,021,000		19.79	$	20,206,000
Recycled Water Cost	$	-		19.79	$	-
				Total PV	**$**	**80,871,000**
				Project Yield (AF)		**150,000**
				PV Unit Cost ($/af)		**$817**

Project CB-P10
GBOP

Annual Yield (AFY)
17,000

Item		Qty	Units	Unit Cost		Cost
Capital Costs						
Treatment						
Equalization						
Pump Station						
Conveyance	Diam. (in)	Length (ft)				
MFSG to Junction 1	36	12,300	in-diam*LF	$25	$	11,070,000
Junction 1 to SFS	12	11,000	in-diam*LF	$25	$	3,300,000
Junction 1 to Junction 2	36	30,750	in-diam*LF	$25	$	27,675,000
Junction 2 to GSW	14	15,000	in-diam*LF	$25	$	5,250,000
Junction 2 to Junction 3	30	12,200	in-diam*LF	$25	$	9,150,000
Junction 3 to Paramount	14	8,500	in-diam*LF	$25	$	2,975,000
Junction 3 to Long Beach	30	28,100	in-diam*LF	$25	$	21,075,000
Injection Wells		0	EA	$2,000,000	$	-
Extraction Wells		9	EA	$2,000,000	$	18,000,000
River Crossing		2	EA	$2,000,000	$	4,000,000
				Construction Subtotal	**$**	**102,495,000**
			Contingency Costs	20%	$	20,499,000
				Construction Total	**$**	**122,994,000**
			Implementation Costs	20%	$	24,599,000
				SubTotal Capital Cost	**$**	**147,593,000**
Brine Connection						
				SubTotal Capital Cost	**$**	**-**
				TOTAL CAPITAL COST	**$**	**147,593,000**
O&M Costs ($ / Year)						
Treatment						
Equalization						
Pump Station						
Conveyance	$	80,495,000	capital cost	0.5%	$	402,000
Injection Wells	$	-	capital cost	0.5%	$	-
Extraction Wells						
Maintenance	$	18,000,000	capital cost	0.5%	$	90,000
Electricity		12,878,600	kWh	$0.12	$	1,545,000
				O&M Subtotal	**$**	**2,037,000**
			Contingency Costs	15%	$	306,000
				SubTotal O&M Cost	**$**	**2,343,000**
Brine Surcharge Fee						
				TOTAL O&M COST	**$**	**2,343,000**
Recycled Water Purchase						
				Recycled Water Purchase Total	**$**	**-**
Economic Cost Summary						
Present Value Calculations				PV Factor		
Initial Capital Cost	$	147,593,000		1.00	$	147,593,000
Annual O&M Costs	$	2,343,000		19.79	$	46,368,000
Recycled Water Cost	$	-		19.79	$	-
				Total PV	**$**	**193,961,000**
				Project Yield (AF)		**510,000**
				PV Unit Cost ($/af)		**$577**

Project CB-P11
SJCWRP to MF Injection

Above APA (AFY)	Annual Yield (AFY)
57,770	8,690

Item		Qty	Units	Unit Cost	Cost
Capital Costs					
Treatment					
SJCWRP AWTF (23 mgd)		1	LS	$ 86,423,000	$ 86,423,000
Equalization - Tertiary					
SJCWRP		2	MG	$2,500,000	$ 5,000,000
Pump Station					
SJCWRP AWTF		15,972	gpm	formula	$ 7,528,000
Conveyance	Diam. (in)	Length (ft)			
					$ -
Injection Wells		17	EA	$2,000,000	$ 34,000,000
Extraction Wells			EA	$2,000,000	$ -
River Crossing			EA	$2,000,000	$ -
				Construction Subtotal	**$ 132,951,000**
			Contingency Costs	20%	$ 26,590,000
				Construction Total	**$ 159,541,000**
			Implementation Costs	20%	$ 31,908,000
				SubTotal Capital Cost	**$ 191,449,000**
Brine Connection Fee					
SJCWRP		1,534	AFY	$ 9,496	$ 14,562,000
				SubTotal Capital Cost	**$ 14,562,000**
				TOTAL CAPITAL COST	**$ 206,011,000**
O&M Costs ($ / Year)					
Treatment					
SJCWRP AWTF		1	LS	$ 9,958,000	$ 9,958,000
Equalization					
SJCWRP		$ 5,000,000	construction cost	0.5%	$ 25,000
Pump Station					
PS1 - Maintenance		$ 7,528,000	construction cost	5.0%	$ 376,000
PS1 - Electricity		2,807,400	kWh	$0.12	$ 337,000
Conveyance		$ -	construction cost	0.5%	$ -
Injection Wells		$ 34,000,000	construction cost	0.5%	$ 170,000
Extraction Wells					
Maintenance		$ -	construction cost	0.5%	$ -
Electricity		29,414,600	kWh	$0.12	$ 3,530,000
				O&M Subtotal	**$ 14,396,000**
			Contingency Costs	15%	$ 2,159,000
				SubTotal O&M Cost	**$ 16,555,000**
Brine Surcharge Fee					
SJCWRP		1,534	AFY	$ 238	$ 365,000
				TOTAL O&M COST	$ 16,920,000
Recycled Water Purchase					
SJCWRP Tertiary		0	AF	$300	$ -
SJCWRP AWTF		10,224	AF	$100	$ 1,022,000
LCWRP		0	AF	$100	$ -
				Recycled Water Purchase Total	**$ 1,022,000**
Economic Cost Summary					
Present Value Calculations				PV Factor	
Initial Capital Cost		$ 206,011,000		1.00	$ 206,011,000
Annual O&M Costs		$ 16,920,000		19.79	$ 334,847,000
Recycled Water Cost		$ 1,022,000		19.79	$ 20,225,000
				Total PV	**$ 561,083,000**
				Project Yield (AF)	**260,700**
				PV Unit Cost ($/af)	**$3,263**

Project CB-P12
New Satellite AWT to LA Forebay

Annual Yield (AFY)
45,480

Item		Qty	Units	Unit Cost		Cost
Capital Costs						
Treatment (MBR/AWT)		40.6	mgd	$ 18,764,726	$	762,334,000
Equalization - Tertiary		8	MG	$2,500,000	$	20,000,000
Pump Station						
New Satellite AWT		28,212	gpm	formula	$	11,588,000
Conveyance	Diam. (in)	Length (ft)				
AWT to LAF Injection	48	26,900	in-diam*LF	$25	$	32,280,000
Injection Laterals #1	36	17,500	in-diam*LF	$25	$	15,750,000
Injection Laterals #2	36	15,700	in-diam*LF	$25	$	14,130,000
Injection Laterals #3	36	9,600	in-diam*LF	$25	$	8,640,000
Extraction to LADWP	48	35,500	in-diam*LF	$25	$	42,600,000
Injection Wells		50	EA	$2,000,000	$	100,000,000
Extraction Wells		21	EA	$2,000,000	$	42,000,000
				Construction Subtotal	**$**	**1,049,322,000**
			Contingency Costs	20%	$	209,864,000
				Construction Total	**$**	**1,259,186,000**
			Implementation Costs	20%	$	251,837,000
				SubTotal Capital Cost	**$**	**1,511,023,000**
Land Purchase		54	acres	$ 2,000,000	$	108,000,000
Brine Connection						
New Satellite AWT		11,375	AFY	$9,513	$	108,208,000
				SubTotal Capital Cost	**$**	**1,727,231,000**
				TOTAL CAPITAL COST	**$**	**3,238,254,000**
O&M Costs ($ / Year)						
Treatment		45,500	AF	$1,000	$	45,500,000
Equalization	$	20,000,000	capital cost	0.5%	$	100,000
Pump Station						
PS1 - Maintenance	$	11,588,000	capital cost	5.0%	$	579,000
PS1 - Electricity		5,741,700	kWh	$0.12	$	689,000
Conveyance	$	113,400,000	capital cost	0.5%	$	567,000
Injection Wells	$	100,000,000	capital cost	0.5%	$	500,000
Extraction Wells						
Maintenance	$	42,000,000	capital cost	0.5%	$	210,000
Electricity		23,439,000	kWh	$0.12	$	2,813,000
				O&M Subtotal	**$**	**50,958,000**
			Contingency Costs	15%	$	7,644,000
				SubTotal O&M Cost	**$**	**58,602,000**
Brine Surcharge Fee						
New Satellite AWT		11,375	AFY	$240	$	2,728,000
				TOTAL O&M COST	**$**	**61,330,000**
Recycled Water Purchase						
				Recycled Water Purchase Total	**$**	**-**
Economic Cost Summary						
Present Value Calculations				PV Factor		
Initial Capital Cost	$	3,238,254,000		1.00	$	3,238,254,000
Annual O&M Costs	$	58,602,000		19.79	$	1,159,734,000
Recycled Water Cost	$	-		19.79	$	-
				Total PV	**$**	**4,397,988,000**
				Project Yield (AF)		**1,364,400**
				PV Unit Cost ($/af)		**$4,886**

Alternative CB-A2a (Projects CB-P1a + CB-P7)
SJCWRP (100% Tertiary) to MFSG & LCWRP (100% AWT) to MFSG

Annual Yield (AFY)
10,000

Item		Qty	Units	Unit Cost		Cost
Capital Costs						
Treatment						
LCWRP (4.5 mgd)		1	LS	$ 25,824,000	$	25,824,000
Equalization - Tertiary						
LCWRP		1	MG	$2,500,000	$	2,500,000
Pump Station						
LCWRP		3,125	gpm	formula	$	2,185,000
Conveyance	Diam. (in)	Length (ft)				
LCWRP to MFSG	16	47,000	in-diam*LF	$25	$	18,800,000
River Crossing		1	EA	$2,000,000	$	2,000,000
				Construction Subtotal	**$**	**51,309,000**
			Contingency Costs	20%	$	10,262,000
				Construction Total	**$**	**61,571,000**
			Implementation Costs	20%	$	12,314,000
				SubTotal Capital Cost	**$**	**73,885,000**
Brine Connection Fee						
LCWRP		882	AFY	$ 9,513	$	8,394,000
				SubTotal Capital Cost	**$**	**8,394,000**
				TOTAL CAPITAL COST	**$**	**82,279,000**
O&M Costs ($ / Year)						
Treatment	LCWRP	1	LS	$ 2,038,000	$	2,038,000
Equalization	LCWRP	$ 2,500,000	construction cost	0.5%	$	13,000
Pump Station						
PS1 - Maintenance		$ 2,185,000	construction cost	5.0%	$	109,000
PS1 - Electricity		1,211,400	kWh	$0.12	$	145,000
Conveyance		$ 18,800,000	construction cost	0.5%	$	94,000
				O&M Subtotal	**$**	**2,399,000**
			Contingency Costs	15%	$	360,000
				SubTotal O&M Cost	**$**	**2,759,000**
Brine Surcharge Fee						
LCWRP		882	AFY	$ 241	$	212,000
				TOTAL O&M COST	**$**	**2,971,000**
Recycled Water Purchase						
SJCWRP Tertiary		5,000	AF	$300	$	1,500,000
LCWRP		5,880	AF	$100	$	588,000
				Recycled Water Purchase Total	**$**	**2,088,000**
Economic Cost Summary						
Present Value Calculations				PV Factor		
Initial Capital Cost		$ 82,279,000		1.00	$	82,279,000
Annual O&M Costs		$ 2,971,000		19.79	$	58,796,000
Recycled Water Cost		$ 2,088,000		19.79	$	41,322,000
				Total PV	**$**	**182,397,000**
				Project Yield (AF)		**300,000**
				PV Unit Cost ($/af)		**$922**

Alternative CB-A2b (Projects CB-P2a + CB-P7)
SJCWRP (100% AWT) to MFSG & LCWRP (100% AWT) to MFSG

Annual Yield (AFY)
10,000

Item			Qty	Units	Unit Cost	Cost
Capital Costs						
Treatment						
LCWRP (4.5 mgd)			1	LS	$ 25,824,000	$ 25,824,000
SJCWRP (4.5 mgd)			1	LS	$ 25,824,000	$ 25,824,000
Equalization - Tertiary						
LCWRP			1	MG	$2,500,000	$ 2,500,000
SJCWRP			1	MG	$2,500,000	$ 2,500,000
Pump Station						
LCWRP			10,764	gpm	formula	$ 5,581,000
Conveyance	Diam. (in)		Length (ft)			
				in-diam*LF	$25	$ -
River Crossing			2	EA	$2,000,000	$ 4,000,000
					Construction Subtotal	**$ 66,229,000**
				Contingency Costs	20%	$ 13,246,000
					Construction Total	**$ 79,475,000**
				Implementation Costs	20%	$ 15,895,000
					SubTotal Capital Cost	**$ 95,370,000**
Brine Connection Fee						
LCWRP & SJCWRP			1,765	AFY	$ 9,513	$ 16,787,000
					SubTotal Capital Cost	**$ 16,787,000**
					TOTAL CAPITAL COST	**$ 112,157,000**
O&M Costs ($ / Year)						
Treatment	LCWRP		1	LS	$ 2,038,000	$ 2,038,000
	SJCWRP		1	LS	$ 2,038,000	$ 2,038,000
Equalization	LCWRP	$	5,000,000	construction cost	0.5%	$ 25,000
Pump Station						
PS1 - Maintenance		$	5,581,000	construction cost	5.0%	$ 279,000
PS1 - Electricity			1,211,400	kWh	$0.12	$ 145,000
Conveyance		$	-	construction cost	0.5%	$ -
					O&M Subtotal	**$ 4,525,000**
				Contingency Costs	15%	$ 679,000
					SubTotal O&M Cost	**$ 5,204,000**
Brine Surcharge Fee						
SJCWRP and LCWRP			1,765	AFY	$ 241	$ 425,000
					TOTAL O&M COST	**$ 5,629,000**
Recycled Water Purchase						
SJCWRP AWTF			5,880	AF	$100	$ 588,000
LCWRP			5,880	AF	$100	$ 588,000
					Recycled Water Purchase Total	**$ 1,176,000**
Economic Cost Summary						
Present Value Calculations					PV Factor	
Initial Capital Cost		$	112,157,000		1.00	$ 112,157,000
Annual O&M Costs		$	5,629,000		19.79	$ 111,398,000
Recycled Water Cost		$	1,176,000		19.79	$ 23,273,000
					Total PV	**$ 246,828,000**
					Project Yield (AF)	**300,000**
					PV Unit Cost ($/af)	**$1,247**

Alternative CB-A3a (Projects CB-P1a + CB-P8a)
SJCWRP (100% Tertiary) to MFSG & LCWRP (100% AWT) to MF Injection

Annual Yield (AFY)
10,000

Item		Qty	Units	Unit Cost	Cost
Capital Costs					
Treatment					
LCWRP (4.5mgd)		1	LS	$ 25,824,000	$ 25,824,000
Equalization - Tertiary					
LCWRP		1	MG	$2,500,000	$ 2,500,000
Pump Station					
LCWRP		3,125	gpm	formula	$ 2,185,000
Conveyance	Diam. (in)	Length (ft)			
LCWRP to Injection	16	66,500	in-diam*LF	$25	$ 26,600,000
Injection Wells		4	EA	$2,000,000	$ 8,000,000
Extraction Wells		0	EA	$2,000,000	$ -
				Construction Subtotal	**$ 65,109,000**
			Contingency Costs	20%	$ 13,022,000
				Construction Total	**$ 78,131,000**
			Implementation Costs	20%	$ 15,626,000
				SubTotal Capital Cost	**$ 93,757,000**
Brine Connection Fee					
LCWRP		882	AFY	$ 9,513	$ 8,394,000
				SubTotal Capital Cost	**$ 8,394,000**
				TOTAL CAPITAL COST	**$ 102,151,000**
O&M Costs ($ / Year)					
Treatment					
LCWRP		1	LS	$ 2,038,000	$ 2,038,000
Equalization					
LCWRP	$	2,500,000	construction cost	0.5%	$ 13,000
Pump Station					
PS1 - Maintenance	$	2,185,000	construction cost	5.0%	$ 109,000
PS1 - Electricity		1,211,400	kWh	$0.12	$ 145,000
Conveyance	$	26,600,000	construction cost	0.5%	$ 133,000
Injection Wells	$	8,000,000	construction cost	0.5%	$ 40,000
Extraction Wells					
				O&M Subtotal	**$ 2,478,000**
			Contingency Costs	15%	$ 372,000
				SubTotal O&M Cost	**$ 2,850,000**
Brine Surcharge Fee					
SJCWRP and LCWRP		882	AFY	$ 241	$ 212,000
				TOTAL O&M COST	**$ 3,062,000**
Recycled Water Purchase					
SJCWRP Tertiary		15,500	AF	$300	$ 4,650,000
LCWRP		5,880	AF	$100	$ 588,000
				Recycled Water Purchase Total	**$ 5,238,000**
Economic Cost Summary					
Present Value Calculations				PV Factor	
Initial Capital Cost	$	102,151,000		1.00	$ 102,151,000
Annual O&M Costs	$	3,062,000		19.79	$ 60,597,000
Recycled Water Cost	$	5,238,000		19.79	$ 103,660,000
				Total PV	**$ 266,408,000**
				Project Yield (AF)	**300,000**
				PV Unit Cost ($/af)	**$1,346**

Alternative CB-A3b (Projects CB-P2a + CB-P8a)
SJCWRP (100% AWT) to MFSG & LCWRP (100% AWT) to MF Injection

Annual Yield (AFY)
10,000

Item		Qty	Units	Unit Cost	Cost
Capital Costs					
Treatment					
SJCWRP (4.5 mgd)		1	LS	$ 25,824,000	$ 25,824,000
LCWRP (4.5 mgd)		1	LS	$ 25,824,000	$ 25,824,000
Equalization - Tertiary					
LCWRP		1	MG	$2,500,000	$ 2,500,000
SJCWRP		1	MG	$2,500,000	$ 2,500,000
Pump Station					
LCWRP		3,125	gpm	formula	$ 2,185,000
Conveyance	Diam. (in)	Length (ft)			
LCWRP to Injection	16	66,500	in-diam*LF	$25	$ 26,600,000
Injection Wells		4	EA	$2,000,000	$ 8,000,000
Extraction Wells		0	EA	$2,000,000	$ -
River Crossing		1	EA	$2,000,000	$ 2,000,000
				Construction Subtotal	**$ 95,433,000**
			Contingency Costs	20%	$ 19,087,000
				Construction Total	**$ 114,520,000**
			Implementation Costs	20%	$ 22,904,000
				SubTotal Capital Cost	**$ 137,424,000**
LCWRP & SJCWRP		1,765	AFY	$ 9,513	$ 16,787,000
				SubTotal Capital Cost	**$ 16,787,000**
				TOTAL CAPITAL COST	**$ 154,211,000**
O&M Costs ($ / Year)					
Treatment					
LCWRP		1	LS	$ 2,038,000	$ 2,038,000
SJCWRP		1	LS	$ 2,038,000	$ 2,038,000
Equalization					
LCWRP	$	2,500,000	construction cost	0.5%	$ 13,000
Pump Station					
PS1 - Maintenance	$	2,185,000	construction cost	5.0%	$ 109,000
PS1 - Electricity		1,211,400	kWh	$0.12	$ 145,000
Conveyance	$	26,600,000	construction cost	0.5%	$ 133,000
Injection Wells	$	8,000,000	construction cost	0.5%	$ 40,000
Extraction Wells					
				O&M Subtotal	**$ 4,516,000**
			Contingency Costs	15%	$ 677,000
				SubTotal O&M Cost	**$ 5,193,000**
Brine Surcharge Fee					
LCWRP & SJCWRP		1,765	AFY	$ 241	$ 425,000
				TOTAL O&M COST	**$ 5,618,000**
Recycled Water Purchase					
SJCWRP AWTF		5,880	AF	$100	$ 588,000
LCWRP		5,880	AF	$100	$ 588,000
				Recycled Water Purchase Total	**$ 1,176,000**
Economic Cost Summary					
Present Value Calculations				PV Factor	
Initial Capital Cost	$	154,211,000		1.00	$ 154,211,000
Annual O&M Costs	$	5,618,000		19.79	$ 111,180,000
Recycled Water Cost	$	1,176,000		19.79	$ 23,273,000
				Total PV	**$ 288,664,000**
				Project Yield (AF)	**300,000**
				PV Unit Cost ($/af)	**$1,459**

Alternative CB-A4a (Projects CB-P1a + CB-P9)
SJCWRP (100% Tertiary) to MFSG & LA River to LA Forebay (ARRF)

Annual Yield (AFY)
10,000

Item	Qty	Units	Unit Cost		Cost
Capital Costs					
Treatment					
LA River ARRF	1	LS	$ 42,127,779	$	42,128,000
Equalization					
Pump Station					
Conveyance					
Injection Wells	0	EA	$2,000,000	$	-
Extraction Wells	0	EA	$2,000,000	$	-
			Construction Subtotal	**$**	**42,128,000**
		Contingency Costs	20%	$	8,426,000
			Construction Total	**$**	**50,554,000**
		Implementation Costs	20%	$	10,111,000
			SubTotal Capital Cost	**$**	**60,665,000**
Brine Connection Fee					
			SubTotal Capital Cost	**$**	**-**
			TOTAL CAPITAL COST	**$**	**60,665,000**
O&M Costs ($ / Year)					
Treatment					
LA River ARRF	1	LS	$888,000	$	888,000
Equalization					
Pump Station					
Injection Wells	$ -	construction cost	0.5%	$	-
Extraction Wells					
Maintenance	$ -	construction cost	0.5%	$	-
Electricity	-	kWh	$0.12	$	-
			O&M Subtotal	**$**	**888,000**
		Contingency Costs	15%	$	133,000
			SubTotal O&M Cost	**$**	**1,021,000**
Brine Surcharge Fee					
			TOTAL O&M COST	**$**	**1,021,000**
Recycled Water Purchase					
SJCWRP Tertiary	26,000	AF	$300	$	7,800,000
			Recycled Water Purchase Total	**$**	**7,800,000**
Economic Cost Summary					
Present Value Calculations			PV Factor		
Initial Capital Cost	$ 60,665,000		1.00	$	60,665,000
Annual O&M Costs	$ 1,021,000		19.79	$	20,206,000
Recycled Water Cost	$ 7,800,000		19.79	$	154,362,000
			Total PV	**$**	**235,233,000**
			Project Yield (AF)		**300,000**
			PV Unit Cost ($/af)		**$1,189**

WRD Groundwater Basins Master Plan

Alternative CB-A4b (Projects CB-P2a + CB-P9)
SJCWRP (100% AWT) to MFSG & LA River to LA Forebay (ARRF)

Annual Yield (AFY)
10,000

Item		Qty	Units	Unit Cost	Cost
Capital Costs					
Treatment					
SJCWRP (4.5 mgd)		1	LS	$ 25,824,000	$ 25,824,000
LA River ARRF		1	LS	$ 42,127,779	$ 42,128,000
Equalization - Tertiary					
SJCWRP		1	MG	$2,500,000	$ 2,500,000
Pump Station					
Conveyance	Diam. (in)	Length (ft)			
Injection Wells		0	EA	$2,000,000	$ -
Extraction Wells		0	EA	$2,000,000	$ -
River Crossing		1	EA	$5,925,000	$ 5,925,000
				Construction Subtotal	**$ 76,377,000**
			Contingency Costs	20%	$ 15,275,000
				Construction Total	**$ 91,652,000**
			Implementation Costs	20%	$ 18,330,000
				SubTotal Capital Cost	**$ 109,982,000**
Brine Connection Fee					
SJCWRP		882	AFY	$ 9,513	$ 8,394,000
				SubTotal Capital Cost	**$ 8,394,000**
				TOTAL CAPITAL COST	**$ 118,376,000**
O&M Costs ($ / Year)					
Treatment		1	LS	$ 8,635,000	$ 8,635,000
LA River ARRF		1	LS	$888,000	$ 888,000
Brine SJCWRP		1	LS	$ 1,093,000	$ 1,093,000
Equalization	$	2,500,000	construction (	0.5%	$ 13,000
Pump Station					
Conveyance	$	-	construction (	0.5%	$ -
Injection Wells	$	-	construction (	0.5%	$ -
Extraction Wells					
Maintenance	$	-	construction (	0.5%	$ -
Electricity		-	kWh	$0.12	$ -
				O&M Subtotal	**$ 10,629,000**
			Contingency Costs	15%	$ 1,594,000
				SubTotal O&M Cost	**$ 12,223,000**
Brine Surcharge Fee					
		882	AFY	$ 241	$ 212,000
				TOTAL O&M COST	**$ 12,435,000**
Recycled Water Purchase					
SJCWRP AWTF		5,882	AF	$100	$ 588,000
				Recycled Water Purchase Total	**$ 588,000**
Economic Cost Summary					
Present Value Calculations				PV Factor	
Initial Capital Cost	$	118,376,000		1.00	$ 118,376,000
Annual O&M Costs	$	12,435,000		19.79	$ 246,089,000
Recycled Water Cost	$	588,000		19.79	$ 11,637,000
				Total PV	**$ 376,102,000**
				Project Yield (AF)	**300,000**
				PV Unit Cost ($/af)	**$1,900**

Alternative CB-B1a (Projects CB-P8b, CB-P9, CB-P10, CB-P1b + CB-P1c+P11)
SJCWRP (100% Tertiary) to MFSG, LCWRP to MF Injection, GBOP, LA River to LA Forebay (ARRF)

Above APA (AFY)	Annual Yield (AFY)
57,770	67,770

Item		Qty	Units	Unit Cost	Cost
Capital Costs					
Treatment					
SJCWRP AWTF (23 mgd)		1	LS	$ 86,423,000	$ 86,423,000
LCWRP AWTF (8.5 mgd)		1	LS	$ 24,186,000	$ 24,186,000
LA RiverARRF		1	LS	$ 42,127,779	$ 42,128,000
Equalization - Tertiary					
SJCWRP		5	MG	$2,500,000	$ 12,500,000
LCWRP		2	MG	$2,500,000	$ 5,000,000
Pump Station					
SJCWRP AWTF		15,972	gpm	formula	$ 7,528,000
LCWRP AWTF		7,362	gpm	formula	$ 4,184,000
Conveyance	Diam. (in)	Length (ft)			
SJCWRP to MF Injection	36	22,400	in-diam*LF	$25	$ 20,160,000
LCWRP to MF Injection	24	66,500	in-diam*LF	$25	$ 39,900,000
GBOP Pipeline					$ 84,495,000
Injection Wells		17	EA	$2,000,000	$ 34,000,000
Extraction Wells		18	EA	$2,000,000	$ 36,000,000
River Crossing		3	EA	$2,000,000	$ 6,000,000
				Construction Subtotal	**$ 402,504,000**
			Contingency Costs	20%	$ 80,501,000
				Construction Total	**$ 483,005,000**
			Implementation Costs	20%	$ 96,601,000
				SubTotal Capital Cost	**$ 579,606,000**
Brine Connection Fee					
SJCWRP		1,534	AFY	$ 9,513	$ 14,588,000
LCWRP		1,676	AFY	$ 9,513	$ 15,948,000
				SubTotal Capital Cost	**$ 30,536,000**
				TOTAL CAPITAL COST	**$ 610,142,000**
O&M Costs ($ / Year)					
Treatment					
SJCWRP AWTF		1	LS	$ 8,415,000	$ 8,415,000
LCWRP AWTF		1	LS	$ 5,671,000	$ 5,671,000
LA RiverARRF		1	LS	$888,000	$ 888,000
Equalization					
SJCWRP & LCWRP	$	17,500,000	construction cost	0.5%	$ 88,000
Pump Station					
PS1 - Maintenance	$	7,528,000	construction cost	5.0%	$ 376,000
PS1 - Electricity		947,100	kWh	$0.12	$ 114,000
PS2 - Maintenance		4,184,000	construction cost	5.0%	$ 209,000
PS2 - Electricity		2,301,700	kWh	$0.12	$ 276,000
Conveyance	$	144,555,000	construction cost	0.5%	$ 723,000
Injection Wells	$	34,000,000	construction cost	0.5%	$ 170,000
Extraction Wells					
Maintenance	$	36,000,000	construction cost	0.5%	$ 180,000
Electricity		29,414,600	kWh	$0.12	$ 3,530,000
				O&M Subtotal	**$ 20,640,000**
			Contingency Costs	15%	$ 3,096,000
				SubTotal O&M Cost	**$ 23,736,000**
Brine Surcharge Fee					
SJCWRP and LCWRP		3,210	AFY	$ 241	$ 772,000
				TOTAL O&M COST	**$ 24,508,000**
Recycled Water Purchase					
SJCWRP Tertiary		27,580	AF	$300	$ 8,274,000
SJCWRP AWTF		10,224	AF	$100	$ 1,022,000
LCWRP		11,176	AF	$100	$ 1,118,000
				Recycled Water Purchase Total	**$ 10,414,000**
Economic Cost Summary					
Present Value Calculations				PV Factor	
Initial Capital Cost	$	610,142,000		1.00	$ 610,142,000
Annual O&M Costs	$	24,508,000		19.79	$ 485,013,000
Recycled Water Cost	$	10,414,000		19.79	$ 206,093,000
				Total PV	**$ 1,301,248,000**
				Project Yield (AF)	**2,033,100**
				PV Unit Cost ($/af)	**$970**

Alternative CB-B1b (Projects CB-P8b, CB-P9, CB-P10, CB-P2b + CB-P2c+P11)
SJCWRP (100% AWT to MFSG, LCWRP to MF Injection, GBOP, LA River to LA Forebay (ARRF)

Above APA (AFY)	Annual Yield (AFY)
57,770	67,770

Item		Qty	Units	Unit Cost	Cost
Capital Costs					
Treatment					
SJCWRP AWTF (24.6+23=47.6 mgd)		1	LS	$ 178,088,000	$ 178,088,000
LCWRP AWTF (8.5 mgd)		1	LS	$ 24,186,000	$ 24,186,000
LA RiverARRF		1	LS	$ 42,127,779	$ 42,128,000
Equalization - Tertiary					
SJCWRP		10	MG	$2,500,000	$ 25,000,000
LCWRP		2	MG	$2,500,000	$ 5,000,000
Pump Station					
SJCWRP AWTF		15,972	gpm	formula	$ 7,528,000
LCWRP AWTF		7,362	gpm	formula	$ 4,184,000
Conveyance	Diam. (in)	Length (ft)			
SJCWRP to MF Injection	36	22,400	in-diam*LF	$25	$ 20,160,000
LCWRP to MF Injection	24	66,500	in-diam*LF	$25	$ 39,900,000
GBOP Pipeline					$ 84,495,000
Injection Wells		17	EA	$2,000,000	$ 34,000,000
Extraction Wells		18	EA	$2,000,000	$ 36,000,000
River Crossing		4	EA	$2,000,000	$ 8,000,000
				Construction Subtotal	**$ 508,669,000**
			Contingency Costs	20%	$ 101,734,000
				Construction Total	**$ 610,403,000**
			Implementation Costs	20%	$ 122,081,000
				SubTotal Capital Cost	**$ 732,484,000**
Brine Connection Fee					
SJCWRP and LCWRP		8,077	AFY	$ 9,513	$ 76,836,000
				SubTotal Capital Cost	**$ 76,836,000**
				TOTAL CAPITAL COST	**$ 809,320,000**
O&M Costs ($ / Year)					
Treatment					
SJCWRP AWTF		1	LS	$ 10,643,000	$ 10,643,000
LCWRP AWTF		1	LS	$ 9,958,000	$ 9,958,000
LA RiverARRF		1	LS	$888,000	$ 888,000
Equalization					
SJCWRP & LCWRP	$	30,000,000	construction cost	0.5%	$ 150,000
Pump Station					
PS1 - Maintenance	$	7,528,000	construction cost	5.0%	$ 376,000
PS1 - Electricity		2,807,400	kWh	$0.12	$ 337,000
PS2 - Maintenance		4,184,000	construction cost	5.0%	$ 209,000
PS2 - Electricity		2,301,700	kWh	$0.12	$ 276,000
Conveyance	$	144,555,000	construction cost	0.5%	$ 723,000
Injection Wells	$	34,000,000	construction cost	0.5%	$ 170,000
Extraction Wells					
Maintenance	$	36,000,000	construction cost	0.5%	$ 180,000
Electricity		29,414,600	kWh	$0.12	$ 3,530,000
				O&M Subtotal	**$ 27,440,000**
			Contingency Costs	15%	$ 4,116,000
				SubTotal O&M Cost	**$ 31,556,000**
Brine Surcharge Fee					
SJCWRP and LCWRP		8,077	AFY	$ 241	$ 1,943,000
				TOTAL O&M COST	**$ 33,499,000**
Recycled Water Purchase					
SJCWRP AWTF		42,670	AF	$100	$ 4,267,000
LCWRP		11,180	AF	$100	$ 1,118,000
				Recycled Water Purchase Total	**$ 5,385,000**
Economic Cost Summary					
Present Value Calculations				PV Factor	
Initial Capital Cost	$	809,320,000		1.00	$ 809,320,000
Annual O&M Costs	$	33,499,000		19.79	$ 662,945,000
Recycled Water Cost	$	5,385,000		19.79	$ 106,569,000
				Total PV	**$ 1,578,834,000**
				Project Yield (AF)	**2,033,100**
				PV Unit Cost ($/af)	**$1,177**

Alternative CB-B2a (CB-B1a+P12)
New Satellite AWT to LA Forebay w/ SJCWRP-100% Tertiary

Above APA (AFY)	Annual Yield (AFY)
103,250	113,250

Item		Qty	Units	Unit Cost	Cost
Capital Costs					
Alternative CB-B1a Construction Subtotal					$ 402,504,000
Treatment					
New Satellite AWT		40.6	mgd	$ 18,764,726	$ 761,999,000
Equalization - Tertiary					
New Satellite AWT		6	MG	$2,500,000	$ 15,000,000
Pump Station					
New Satellite AWT		28,200	gpm	formula	$ 11,585,000
Conveyance	Diam. (in)	Length (ft)			
AWT to LAF Injection	48	26,900	in-diam*LF	$25	$ 32,280,000
Injection Laterals #1	36	17,500	in-diam*LF	$25	$ 15,750,000
Injection Laterals #2	36	15,700	in-diam*LF	$25	$ 14,130,000
Injection Laterals #3	36	9,600	in-diam*LF	$25	$ 8,640,000
Extraction to LADWP	48	35,500	in-diam*LF	$25	$ 42,600,000
Injection Wells		50	EA	$2,000,000	$ 100,000,000
Extraction Wells		21	EA	$2,000,000	$ 42,000,000
				Construction Subtotal	**$ 1,446,488,000**
			Contingency Costs	20%	$ 289,298,000
				Construction Total	**$ 1,735,786,000**
			Implementation Costs	20%	$ 347,157,000
				SubTotal Capital Cost	**$ 2,082,943,000**
Alternative CB-B1a Capital Subtotal					$ 30,536,000
Brine Connection Fee					
New Satellite AWT		8,026	AFY	$ 9,513	$ 76,348,000
				SubTotal Capital Cost	**$ 106,884,000**
				TOTAL CAPITAL COST	**$ 2,189,827,000**
O&M Costs ($ / Year)					
Alternative CB-B1a O&M Subtotal					$ 20,640,000
Treatment					
New Satellite AWT		45,480	AF	$1,000	$ 45,480,000
Equalization					
New Satellite AWT		$ 15,000,000	construction cost	0.5%	$ 75,000
Pump Station					
PS1 - Maintenance		$ 11,585,000	construction cost	5.0%	$ 579,000
PS1 - Electricity		4,683,300	kWh	$0.12	$ 562,000
Conveyance		$ 113,400,000	construction cost	0.5%	$ 567,000
Injection Wells		$ 100,000,000	construction cost	0.5%	$ 500,000
Extraction Wells					
Maintenance		$ 42,000,000	construction cost	0.5%	$ 210,000
Electricity		23,428,700	kWh	$0.12	$ 2,811,000
				O&M Subtotal	**$ 71,424,000**
			Contingency Costs	15%	$ 10,714,000
				SubTotal O&M Cost	**$ 82,138,000**
Alternative CB-B1a O&M Subtotal					$ 772,000
Brine Surcharge Fee					
New Satellite AWT		8,026	AFY	$ 240	$ 1,925,000
				TOTAL O&M COST	**$ 84,835,000**
Recycled Water Purchase					
Alternative B1a RW Purchase Total					$ 10,414,000
LA Raw Wastewater		56,850	AF	$0	$ -
				Recycled Water Purchase Total	**$ 10,414,000**
Economic Cost Summary					
Present Value Calculations				PV Factor	
Initial Capital Cost		$ 2,189,827,000		1.00	$ 2,189,827,000
Annual O&M Costs		$ 84,835,000		19.79	$ 1,678,885,000
Recycled Water Cost		$ 10,414,000		19.79	$ 206,093,000
				Total PV	**$ 4,074,805,000**
				Project Yield (AF)	**3,397,500**
				PV Unit Cost ($/af)	**$1,818**

Alternative CB-B2b (CB-B1b+P12)
New Satellite AWT to LA Forebay w/ SJCWRP-100% AWT

Above APA (AFY)	Annual Yield (AFY)
103,250	113,250

Item		Qty	Units	Unit Cost	Cost
Capital Costs					
Alternative CB-B1b Construction Subtotal					$ 732,484,000
Treatment					
New Satellite AWT		40.6	mgd	$ 18,764,726	$ 761,999,000
Equalization - Tertiary					
New Satellite AWT		6	MG	$2,500,000	$ 15,000,000
Pump Station					
New Satellite AWT		28,200	gpm	formula	$ 11,585,000
Conveyance	Diam. (in)	Length (ft)			
AWT to LAF Injection	48	26,900	in-diam*LF	$25	$ 32,280,000
Injection Laterals #1	36	17,500	in-diam*LF	$25	$ 15,750,000
Injection Laterals #2	36	15,700	in-diam*LF	$25	$ 14,130,000
Injection Laterals #3	36	9,600	in-diam*LF	$25	$ 8,640,000
Extraction to LADWP	48	35,500	in-diam*LF	$25	$ 42,600,000
Injection Wells		50	EA	$2,000,000	$ 100,000,000
Extraction Wells		21	EA	$2,000,000	$ 42,000,000
				Construction Subtotal	**$ 1,776,468,000**
			Contingency Costs	20%	$ 355,294,000
				Construction Total	**$ 2,131,762,000**
			Implementation Costs	20%	$ 426,352,000
				SubTotal Capital Cost	**$ 2,558,114,000**
Alternative CB-B1a Capital Subtotal					$ 30,536,000
Brine Connection Fee					
New Satellite AWT		8,026	AFY	$ 9,513	$ 76,348,000
				SubTotal Capital Cost	**$ 106,884,000**
				TOTAL CAPITAL COST	**$ 2,664,998,000**
O&M Costs ($ / Year)					
Alternative CB-B1b O&M Subtotal					$ 31,556,000
Treatment					
New Satellite AWT		45,480	AF	$1,000	$ 45,480,000
Equalization					
New Satellite AWT		$ 15,000,000	construction cost	0.5%	$ 75,000
Pump Station					
PS1 - Maintenance		$ 11,585,000	construction cost	5.0%	$ 579,000
PS1 - Electricity		4,683,300	kWh	$0.12	$ 562,000
Conveyance		$ 113,400,000	construction cost	0.5%	$ 567,000
Injection Wells		$ 100,000,000	construction cost	0.5%	$ 500,000
Extraction Wells					
Maintenance		$ 42,000,000	construction cost	0.5%	$ 210,000
Electricity		23,428,700	kWh	$0.12	$ 2,811,000
				O&M Subtotal	**$ 82,340,000**
			Contingency Costs	15%	$ 12,351,000
				SubTotal O&M Cost	**$ 94,691,000**
Alternative CB-B1a O&M Subtotal					$ 772,000
Brine Surcharge Fee					
New Satellite AWT		8,026	AFY	$ 240	$ 1,925,000
				TOTAL O&M COST	**$ 97,388,000**
Recycled Water Purchase					
Alternative B1b RW Purchase Total					$ 5,385,000
LA Raw Wastewater		56,850	AF	$0	$ -
				Recycled Water Purchase Total	**$ 5,385,000**
Economic Cost Summary					
Present Value Calculations				PV Factor	
Initial Capital Cost		$ 2,664,998,000		1.00	$ 2,664,998,000
Annual O&M Costs		$ 97,388,000		19.79	$ 1,927,309,000
Recycled Water Cost		$ 5,385,000		19.79	$ 106,569,000
				Total PV	**$ 4,698,876,000**
				Project Yield (AF)	**3,397,500**
				PV Unit Cost ($/af)	**$2,097**

Project WCB-P1a
ECLWRF 100% AWT to WCBBP

Annual Yield (AFY)
15,500

Item		Qty	Units	Unit Cost	Cost
Capital Costs					
Treatment					
ECLWRF					
On-Site		10.0	mgd	$ 7,936,232	$ 79,362,000
Off-Site		3.8	mgd	$ 8,203,232	$ 31,172,000
Pump Station					
HTP		11,979	gpm	formula	$ 6,052,000
ECLWRF		9,583	gpm	formula	$ 5,110,000
Conveyance	Diam. (in)	Length (ft)			
HTP to ECLWRF	36	16,400	in-diam*LF	$25	$ 14,760,000
ECLWRF to WCBB	30	4,600	in-diam*LF	$25	$ 3,450,000
				Construction Subtotal	**$ 139,906,000**
			Contingency Costs	20%	$ 27,981,000
				Construction Total	**$ 167,887,000**
			Implementation Costs	20%	$ 33,577,000
				SubTotal Capital Cost	**$ 201,464,000**
Brine Connection					
ECLWRF		2,735	AFY	$ 600	$ 1,641,000
				SubTotal Capital Cost	**$ 1,641,000**
				TOTAL CAPITAL COST	**$ 203,105,000**
O&M Costs ($ / Year)					
Treatment		15,500	AF	$395	$ 6,121,000
Pump Station					
PS1 - Maintenance	$	6,052,000	capital cost	5.0%	$ 303,000
PS1 - Electricity		6,609,900	kWh	$0.12	$ 793,000
PS2 - Maintenance	$	5,110,000	capital cost	5.0%	$ 256,000
PS2 - Electricity		2,125,300	kWh	$0.12	$ 255,000
Conveyance	$	18,210,000	capital cost	0.5%	$ 91,000
				O&M Subtotal	**$ 7,819,000**
			Contingency Costs	15%	$ 1,173,000
				SubTotal O&M Cost	**$ 8,992,000**
Brine Surcharge Fee					
ECLWRF		2,735	AFY	$ 250.0	$ 684,000
				TOTAL O&M COST	**$ 9,676,000**
Recycled Water Purchase					
ECLWRF		18,240	AF	$1	$ 18,000
				Recycled Water Purchase Total	**$ 18,000**
Economic Cost Summary					
Present Value Calculations				PV Factor	
Initial Capital Cost	$	203,105,000		1.00	$ 203,105,000
Annual O&M Costs	$	9,676,000		19.79	$ 191,488,000
Recycled Water Cost	$	18,000		19.79	$ 356,000
				Total PV	**$ 394,949,000**
				Project Yield (AF)	**465,000**
				PV Unit Cost ($/af)	**$1,288**

Project WCB-P1b
ECLWRF 100% AWT to WCBB

Annual Yield (AFY)
7,500

Item		Qty	Units	Unit Cost	Cost
Capital Costs					
Treatment					
ECLWRF					
On-Site		0.0	mgd	$ 7,936,232	$ -
Off-Site		6.7	mgd	$ 8,203,232	$ 54,962,000
Pump Station					
HTP		5,816	gpm	formula	$ 3,499,000
ECLWRF		4,653	gpm	formula	$ 2,954,000
Conveyance	Diam. (in)	Length (ft)			
HTP to ECLWRF - 6" upsize from WCB-P1	6	16,400	in-diam*LF	$25	$ 2,460,000
ECLWRF to WCBB 6" upsize from WCB-P1	6	4,600	in-diam*LF	$25	$ 690,000
				Construction Subtotal	**$ 64,565,000**
			Contingency Costs	20%	$ 12,913,000
				Construction Total	**$ 77,478,000**
			Implementation Costs	20%	$ 15,496,000
				SubTotal Capital Cost	**$ 92,974,000**
Brine Connection					
ECLWRF		1,324	AFY	$ 600	$ 794,000
				SubTotal Capital Cost	**$ 794,000**
				TOTAL CAPITAL COST	**$ 93,768,000**
O&M Costs ($ / Year)					
Treatment		7,500	AF	$395	$ 2,962,000
Pump Station					
PS1 - Maintenance	$	3,499,000	capital cost	5.0%	$ 175,000
PS1 - Electricity		3,198,300	kWh	$0.12	$ 384,000
PS2 - Maintenance	$	2,954,000	capital cost	5.0%	$ 148,000
PS2 - Electricity		1,028,400	kWh	$0.12	$ 123,000
Conveyance	$	3,150,000	capital cost	0.5%	$ 16,000
				O&M Subtotal	**$ 3,808,000**
			Contingency Costs	15%	$ 571,000
				SubTotal O&M Cost	**$ 4,379,000**
Brine Surcharge Fee					
ECLWRF		1,324	AFY	$ 250.0	$ 331,000
				TOTAL O&M COST	**$ 4,710,000**
Recycled Water Purchase					
ECLWRF		8,820	AF	$1	$ 9,000
				Recycled Water Purchase Total	**$ 9,000**
Economic Cost Summary					
Present Value Calculations				PV Factor	
Initial Capital Cost	$	93,768,000		1.00	$ 93,768,000
Annual O&M Costs	$	4,710,000		19.79	$ 93,211,000
Recycled Water Cost	$	9,000		19.79	$ 178,000
				Total PV	**$ 187,157,000**
				Project Yield (AF)	**225,000**
				PV Unit Cost ($/af)	**$1,261**

WCB-P2
JWPCP to Mid-Basin

Annual Yield (AFY)
15,000

Item		Qty	Units	Unit Cost	Cost
Capital Costs					
Treatment					
JWPCP AWT		13.4	mgd	$ 7,985,224	$ 106,947,000
Pump Station					
JWPCP		9,301	gpm	formula	$ 4,996,000
Conveyance	Diam. (in)	Length (ft)			
JWPCP to Mid Basin Wells	30	25,600	in-diam*LF	$25	$ 19,200,000
Injection Wells		14	EA	$2,000,000	$ 28,000,000
Extraction Wells		16	EA	$2,000,000	$ 32,000,000
				Construction Subtotal	**$ 191,143,000**
			Contingency Costs	20%	$ 38,229,000
				Construction Total	**$ 229,372,000**
			Implementation Costs	20%	$ 45,874,000
				SubTotal Capital Cost	**$ 275,246,000**
Brine Connection					
JWPCP		2,647	AFY	$ 600	$ 1,588,000
				SubTotal Capital Cost	**$ 1,588,000**
				TOTAL CAPITAL COST	**$ 276,834,000**
O&M Costs ($ / Year)					
Treatment					
JWPCP		15,000	AF	$336	$ 5,039,000
Equalization					
JWPCP	$	-	capital cost	0.5%	$ -
Pump Station					
PS3 - Maintenance	$	4,996,000	capital cost	5.0%	$ 250,000
PS3 - Electricity		1,434,000	kWh	$0.12	$ 172,000
Conveyance	$	19,200,000	capital cost	0.5%	$ 96,000
Injection Wells	$	28,000,000	capital cost	0.5%	$ 140,000
Extraction Wells					
Maintenance	$	32,000,000	capital cost	0.5%	$ 160,000
Electricity		7,727,200	kWh	$0.12	$ 927,000
				O&M Subtotal	**$ 6,784,000**
			Contingency Costs	15%	$ 1,018,000
				SubTotal O&M Cost	**$ 7,802,000**
Brine Surcharge Fee					
JWPCP		2,647	AFY	$ 249.9	$ 662,000
				TOTAL O&M COST	**$ 8,464,000**
Recycled Water Purchase					
JWPCP		17,650	AF	$100	$ 1,765,000
				Recycled Water Purchase Total	**$ 1,765,000**
Economic Cost Summary					
Present Value Calculations				PV Factor	
Initial Capital Cost	$	276,834,000		1.00	$ 276,834,000
Annual O&M Costs	$	8,464,000		19.79	$ 167,503,000
Recycled Water Cost	$	1,765,000		19.79	$ 34,929,000
				Total PV	**$ 479,266,000**
				Project Yield (AF)	**450,000**
				PV Unit Cost ($/af)	**$1,615**

Project WCB-P3
JWPCP to DGB

Annual Yield (AFY)
2,000

Item		Qty	Units	Unit Cost		Cost
Capital Costs						
Treatment						
JWPCP		1.8	mgd	$ 7,985,224	$	14,260,000
Pump Station						
JWPCP		1,240	gpm	formula	$	1,084,000
Conveyance	Diam. (in)	Length (ft)				
JWPCP to DGB	12	27,800	in-diam*LF	$25	$	8,340,000
				Construction Subtotal	**$**	**23,684,000**
			Contingency Costs	20%	$	4,737,000
				Construction Total	**$**	**28,421,000**
			Implementation Costs	20%	$	5,684,000
				SubTotal Capital Cost	**$**	**34,105,000**
Brine Connection						
JWPCP		353	AFY	$ 600	$	212,000
				SubTotal Capital Cost	**$**	**212,000**
				TOTAL CAPITAL COST	**$**	**34,317,000**
O&M Costs ($ / Year)						
Treatment						
JWPCP		2,000	AF	$336	$	672,000
Equalization						
JWPCP	$	-	capital cost	0.5%	$	-
Pump Station						
PS3 - Maintenance	$	1,084,000	capital cost	5.0%	$	54,000
PS3 - Electricity		191,200	kWh	$0.12	$	23,000
Conveyance	$	8,340,000	capital cost	0.5%	$	42,000
				O&M Subtotal	**$**	**791,000**
			Contingency Costs	15%	$	119,000
				SubTotal O&M Cost	**$**	**910,000**
Brine Surcharge Fee						
JWPCP		353	AFY	$ 249.9	$	88,000
				TOTAL O&M COST	**$**	**998,000**
Recycled Water Purchase						
JWPCP		2,350	AF	$100	$	235,000
				Recycled Water Purchase Total	**$**	**235,000**
Economic Cost Summary						
Present Value Calculations				PV Factor		
Initial Capital Cost	$	34,317,000		1.00	$	34,317,000
Annual O&M Costs	$	998,000		19.79	$	19,750,000
Recycled Water Cost	$	235,000		19.79	$	4,651,000
				Total PV	**$**	**58,718,000**
				Project Yield (AF)		**60,000**
				PV Unit Cost ($/af)		**$1,484**

Alternative WB-A1 (Project WCB-P1a)
ECLWRF to WCBB & TIWRP to DGB

Annual Yield (AFY)
18,000

Item		Qty	Units	Unit Cost	Cost
Capital Costs					
Treatment					
ECLWRF					
On-Site		10.0	mgd	$ 7,936,232	$ 79,362,319
Off-Site		3.8	mgd	$ 8,203,232	$ 31,172,281
TIWRP AWT					Included in purchase price
Equalization					Included in treatment cost
Pump Station					
HWRP		11,979	gpm	formula	$ 6,052,000
ECLWRF		9,583	gpm	formula	$ 5,110,000
TIWRP					Included in Treatment Cost
Conveyance	Diam. (in)	Length (ft)			
To new DGB Connection	24	11,500	in-diam*LF	$25	$ 6,900,000
HWRP to ECLWRF	36	16,400	in-diam*LF	$25	$ 14,760,000
ECLWRF to WCBB	30	4,600	in-diam*LF	$25	$ 3,450,000
			in-diam*LF	$25	$ -
Injection Wells		0	EA	$2,000,000	$ -
Extraction Wells		0	EA	$2,000,000	$ -
				Construction Subtotal	**$ 146,806,600**
			Contingency Costs	20%	$ 29,361,000
				Construction Total	**$ 176,167,600**
			Implementation Costs	20%	$ 35,234,000
				SubTotal Capital Cost	**$ 211,401,600**
Brine Connection Fee					
ECLWRF		2,735	AFY	$ 600	$ 1,641,000
TIWRP		441	AFY	$ -	$ -
				SubTotal Capital Cost	**$ 1,641,000**
				TOTAL CAPITAL COST	**$ 213,042,600**
O&M Costs ($ / Year)					
Treatment					
ECLWRF		15,500	AF	$ 395	$ 6,121,000
TIWRP AWT		2,500	AF		Included in purchase price
Equalization					
Pump Station					
PS1 - Maintenance		$ 6,052,000	construction cost	5.0%	$ 303,000
PS1 - Electricity		6,618,400	kWh	$0.12	$ 794,000
PS2 - Maintenance		$ 5,110,000	construction cost	5.0%	$ 256,000
PS2 - Electricity		4,081,300	kWh	$0.12	$ 490,000
PS3 - Maintenance		$ -	construction cost	5.0%	$ -
PS3 - Electricity		322,400	kWh	$0.12	$ 39,000
Conveyance		$ 25,110,000	construction cost	0.5%	$ 126,000
				O&M Subtotal	**$ 8,129,000**
			Contingency Costs	15%	$ 1,219,000
				SubTotal O&M Cost	**$ 9,348,000**
Brine Surcharge Fee					
ECLWRF		2,735	AFY	$ 250.0	$ 684,000
TIWRP		441	AFY	$ -	$ -
				TOTAL O&M COST	**$ 10,032,000**
Recycled Water Purchase					
ECLWRF		18,240	AF	$1	$ 18,000
TIWRP		2,500	AF	$900	$ 2,250,000
				Recycled Water Purchase Total	**$ 2,268,000**
Economic Cost Summary					
Present Value Calculations				PV Factor	
Initial Capital Cost		$ 213,042,600		1.00	$ 213,043,000
Annual O&M Costs		$ 10,032,000		19.79	$ 198,533,000
Recycled Water Cost		$ 2,268,000		19.79	$ 44,884,000
				Total PV	**$ 456,460,000**
				Project Yield (AF)	**540,000**
				PV Unit Cost ($/af)	**$1,281**

Alternative WB-B1 (Projects WCB-P1b, WCB-P2, WCB-P3)
ECLWRF to WCBB & JWPCP to WCB-Inland & JWPCP to DGB

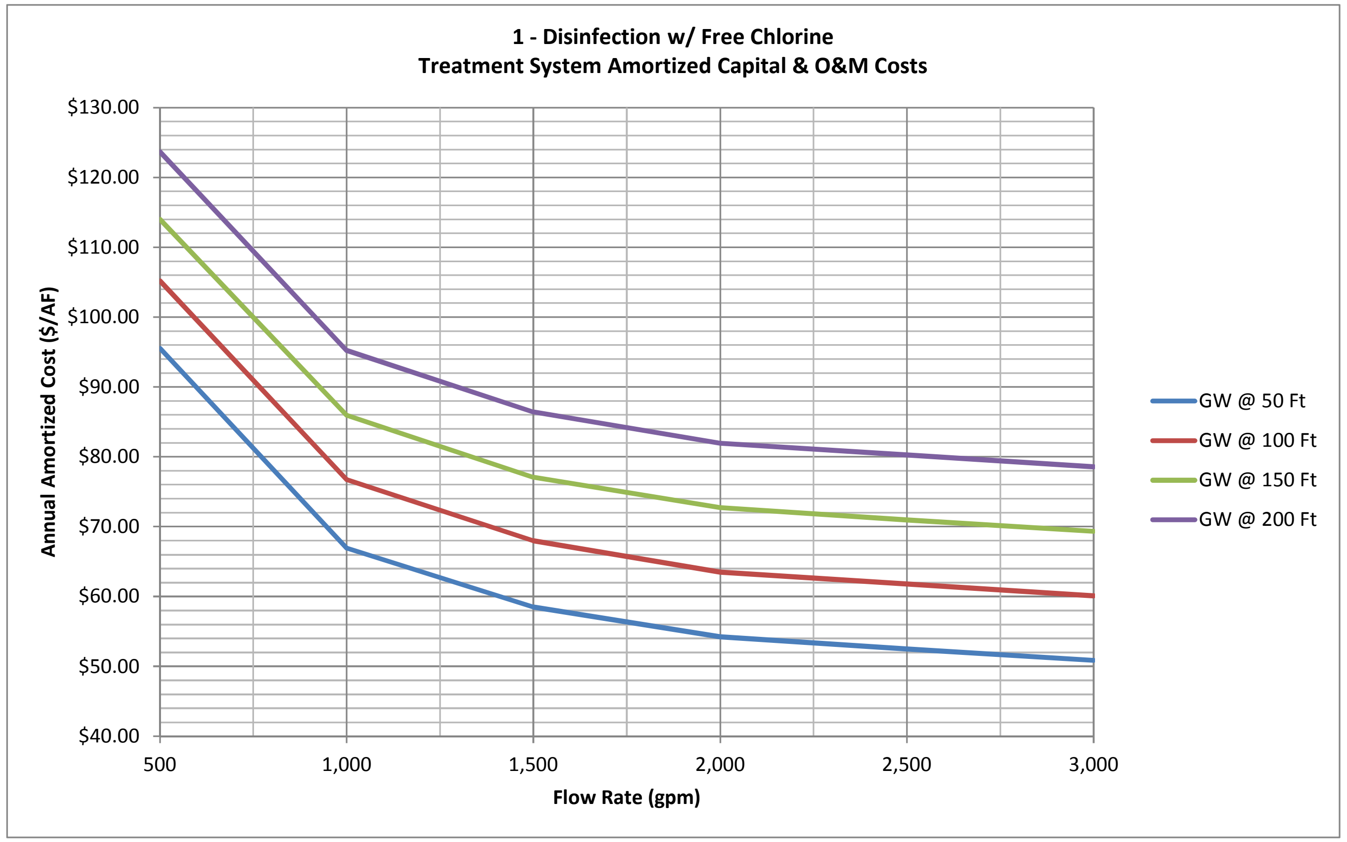
Annual Yield (AFY)
30,000

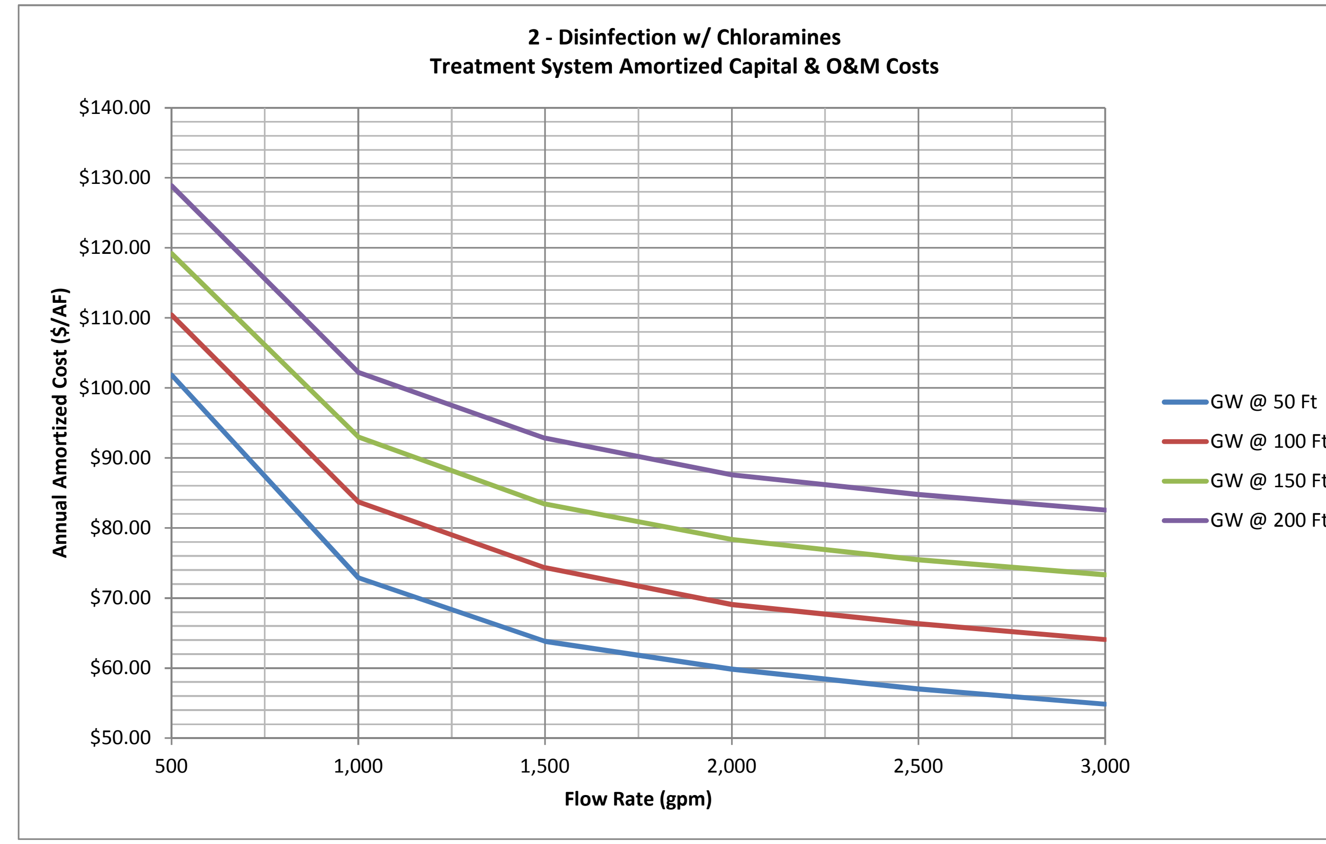
Item		Qty	Units	Unit Cost	Cost
Capital Costs					
Treatment					
ECLWRF		6.7	mgd	$ 8,203,232	$ 54,934,000
JWPCP		15.2	mgd	$ 7,985,224	$ 121,207,000
Pump Station					
HTP to ECLWRF		5,813	gpm	formula	$ 3,498,000
ECLWRF to WCBB		4,650	gpm	formula	$ 2,953,000
JWPCP to DGB and Inland		10,541	gpm	formula	$ 5,493,000
Conveyance	Diam. (in)	Length (ft)			
JWPCP to Mid Basin Wells	30	25,600	in-diam*LF	$25	$ 19,200,000
JWPCP to DGB	12	27,800	in-diam*LF	$25	$ 8,340,000
HWRP to ECLWRF - 6" upsize from WB-A1	6	16,400	in-diam*LF	$25	$ 2,460,000
ECLWRF to WCBB - 6" upsize from WB-A1	6	4,600	in-diam*LF	$25	$ 690,000
Injection Wells		14	EA	$2,000,000	$ 28,000,000
				Construction Subtotal	**$ 246,775,000**
			Contingency Costs	20%	$ 49,355,000
				Construction Total	**$ 296,130,000**
			Implementation Costs	20%	$ 59,226,000
				SubTotal Capital Cost	**$ 355,356,000**
Brine Connection					
ECLWRF		1,324	AFY	$ 600	$ 794,000
JWPCP		3,000	AFY	$ 600	$ 1,800,000
				SubTotal Capital Cost	**$ 2,594,000**
				TOTAL CAPITAL COST	**$ 357,950,000**
O&M Costs ($ / Year)					
Treatment					
ECLWRF		7,500	AF	$395	$ 2,962,000
JWPCP		17,000	AF	$336	$ 5,710,000
Equalization					
JWPCP		$ -	construction cost	0.5%	$ -
Pump Station					
PS1 - Maintenance		$ 2,953,000	construction cost	5.0%	$ 148,000
PS1 - Electricity		3,200,900	kWh	$0.12	$ 384,000
PS2 - Maintenance		$ 3,498,000	construction cost	5.0%	$ 175,000
PS2 - Electricity		1,126,800	kWh	$0.12	$ 135,000
PS3 - Maintenance		$ 5,493,000	construction cost	5.0%	$ 275,000
PS3 - Electricity		1,625,200	kWh	$0.12	$ 195,000
Conveyance		$ 30,690,000	construction cost	0.5%	$ 153,000
Injection Wells		$ 28,000,000	capital cost	0.5%	$ 140,000
Extraction Wells					
Maintenance		$ -	construction cost	0.5%	$ -
Electricity			kWh	$0.12	$ -
				O&M Subtotal	**$ 10,277,000**
			Contingency Costs	15%	$ 1,542,000
				SubTotal O&M Cost	**$ 11,819,000**
Brine Surcharge Fee					
ECLWRF		1,324	AFY	$ 250.0	$ 331,000
JWPCP		3,000	AFY	$ 249.9	$ 750,000
				TOTAL O&M COST	**$ 12,900,000**
Recycled Water Purchase					
ECLWRF		8,820	AF	$1	$ 9,000
JWPCP		20,000	AF	$100	$ 2,000,000
				Recycled Water Purchase Total	**$ 2,009,000**
Economic Cost Summary					
Present Value Calculations				PV Factor	
Initial Capital Cost		$ 357,950,000		1.00	$ 357,950,000
Annual O&M Costs		$ 12,900,000		19.79	$ 255,291,000
Recycled Water Cost		$ 2,009,000		19.79	$ 39,758,000
				Total PV	**$ 652,999,000**
				Project Yield (AF)	**900,000**
				PV Unit Cost ($/af)	**$1,100**

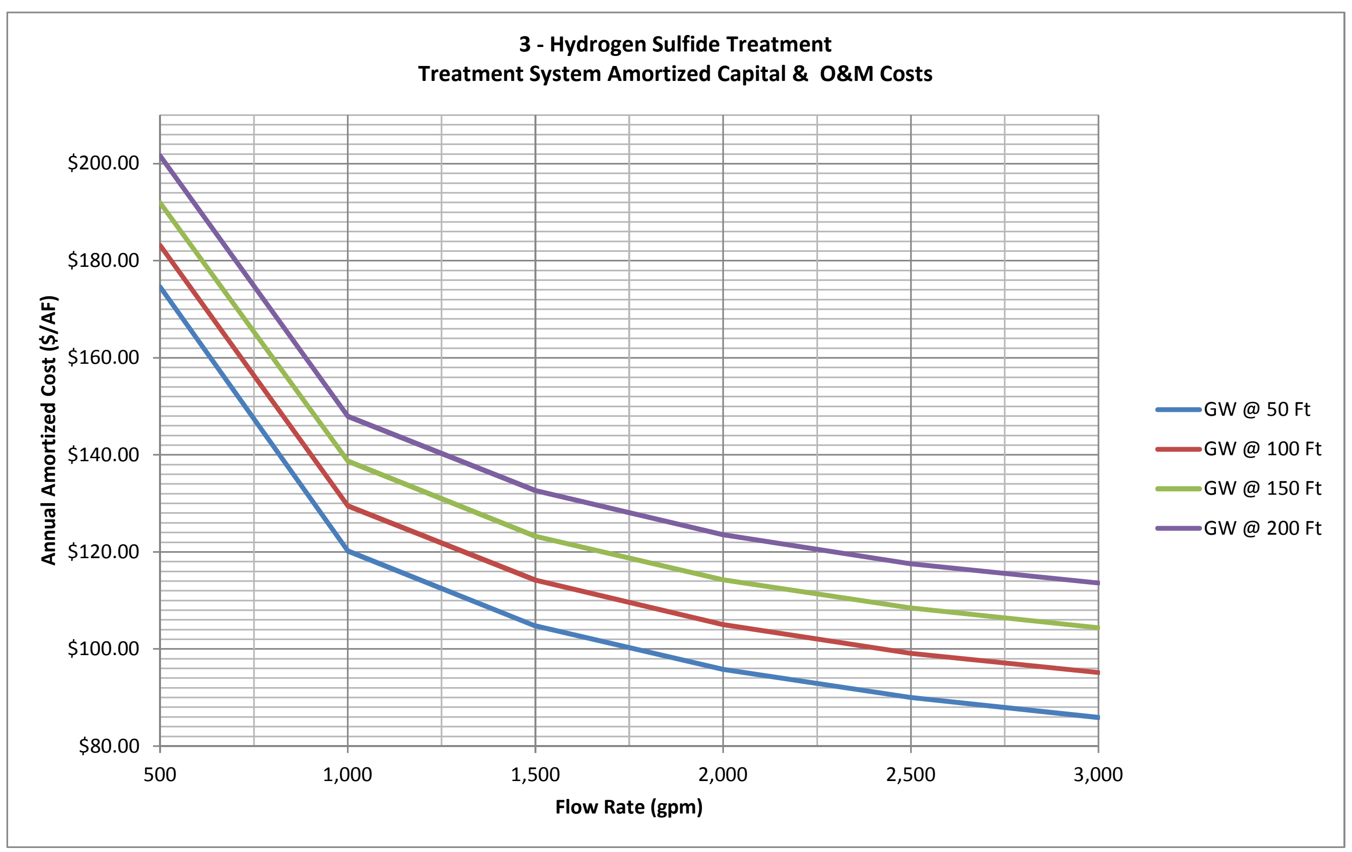
Section J.2
Wellhead Treatment Cost Curves

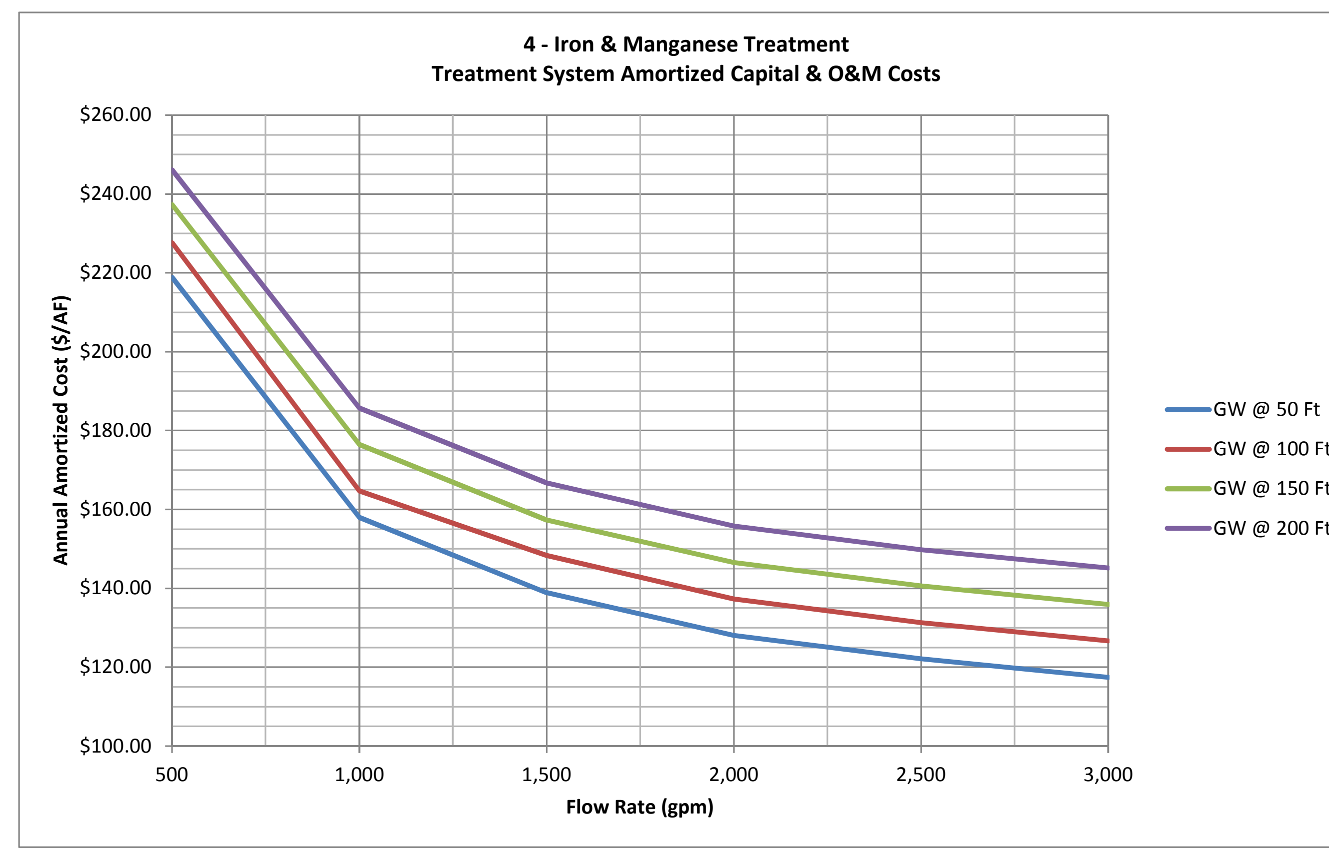
Desalters

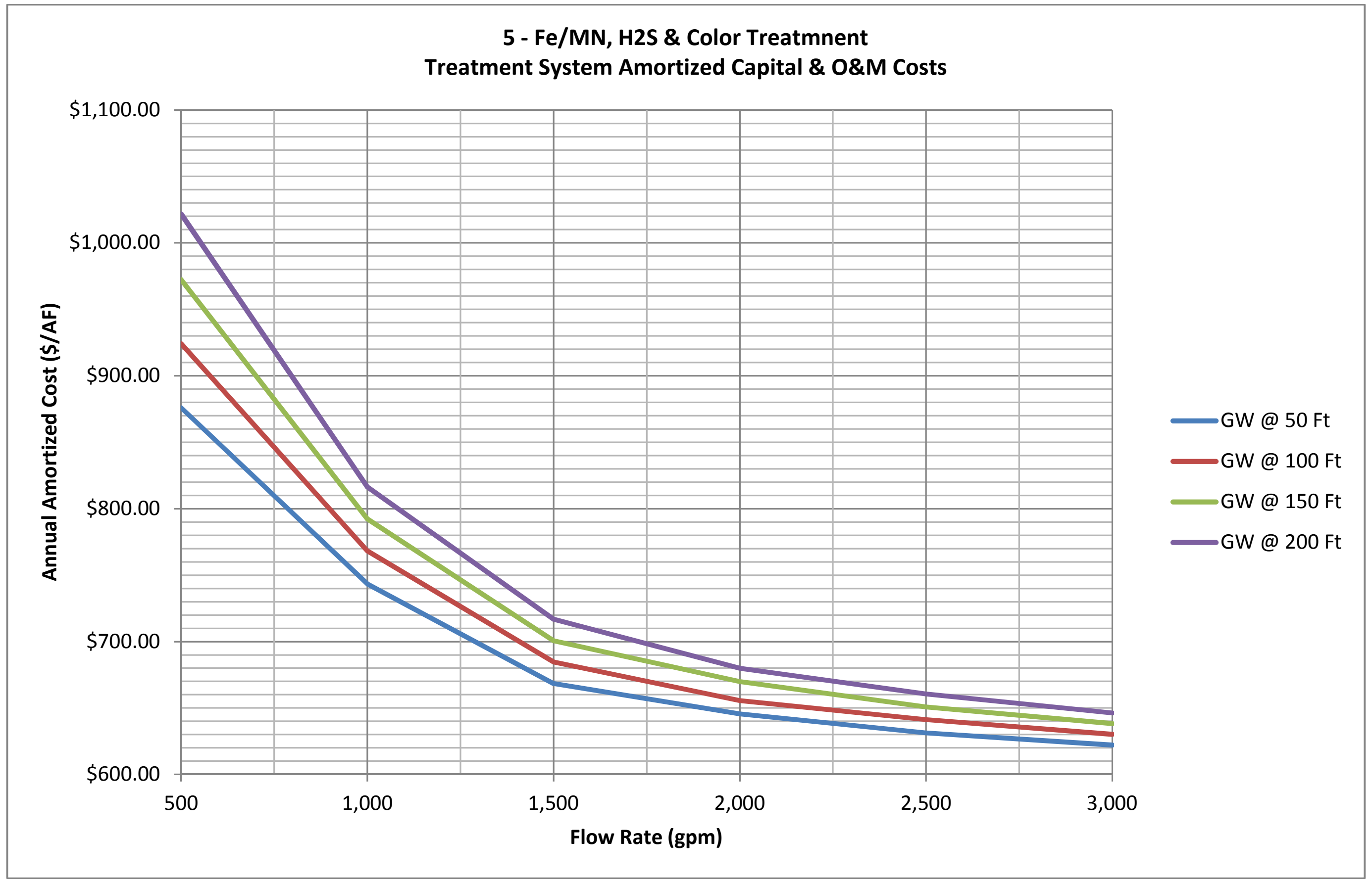
					Annual Yield (AFY) 15,000
Item	**Qty**	**Units**	**Unit Cost**		**Cost**
Capital Costs					
Treatment					
Desalter	7	EA	$ 5,317,900	$	37,225,000
Equalization					
Pump Station					
Conveyance					
Injection Wells		EA	$2,000,000	$	-
			Construction Subtotal	**$**	**37,225,000**
		Contingency Costs	20%	$	7,445,000
			Construction Total	**$**	**44,670,000**
		Implementation Costs	20%	$	8,934,000
			SubTotal Capital Cost	**$**	**53,604,000**
Brine Connection					
Desalter	370	AFY	$10,380	$	3,836,000
			SubTotal Capital Cost	**$**	**3,836,000**
			TOTAL CAPITAL COST	**$**	**57,440,000**
O&M Costs ($ / Year)					
Treatment					
Desalter	15,000	AFY	$240	$	3,595,000
Equalization					
Pump Station					
Conveyance	$ -	construction cost	0.5%	$	-
Injection Wells	$ -	construction cost	0.5%	$	-
Extraction Wells					
Maintenance		construction cost	0.5%	$	-
Electricity	-	kWh	$0.12	$	-
			O&M Subtotal	**$**	**3,595,000**
		Contingency Costs	15%	$	539,000
			SubTotal O&M Cost	**$**	**4,134,000**
Brine Surcharge Fee					
Desalter	370	AFY	$245	$	91,000
			TOTAL O&M COST	**$**	**4,225,000**
Recycled Water Purchase					
			Recycled Water Purchase Total	**$**	**-**
Economic Cost Summary					
Present Value Calculations			PV Factor		
Initial Capital Cost	$ 57,440,000		1.00	$	57,440,000
Annual O&M Costs	$ 4,225,000		19.79	$	83,613,000
Recycled Water Cost	$ -		19.79	$	-
			Total PV	**$**	**141,053,000**
			Project Yield (AF)		**450,000**
			PV Unit Cost ($/af)		**$475**


1 - Disinfection w/ Free Chlorine
Treatment System Amortized Capital & O&M Costs
Annual Amortized Cost ($/AF)
$130.00
$120.00
$110.00
$100.00
$90.00
$80.00
$70.00
$60.00
$50.00
$40.00
500
1,000
1,500
2,000
2,500
3,000
Flow Rate (gpm)
GW @ 50 Ft
GW @ 100 Ft
GW @ 150 Ft
GW @ 200 Ft

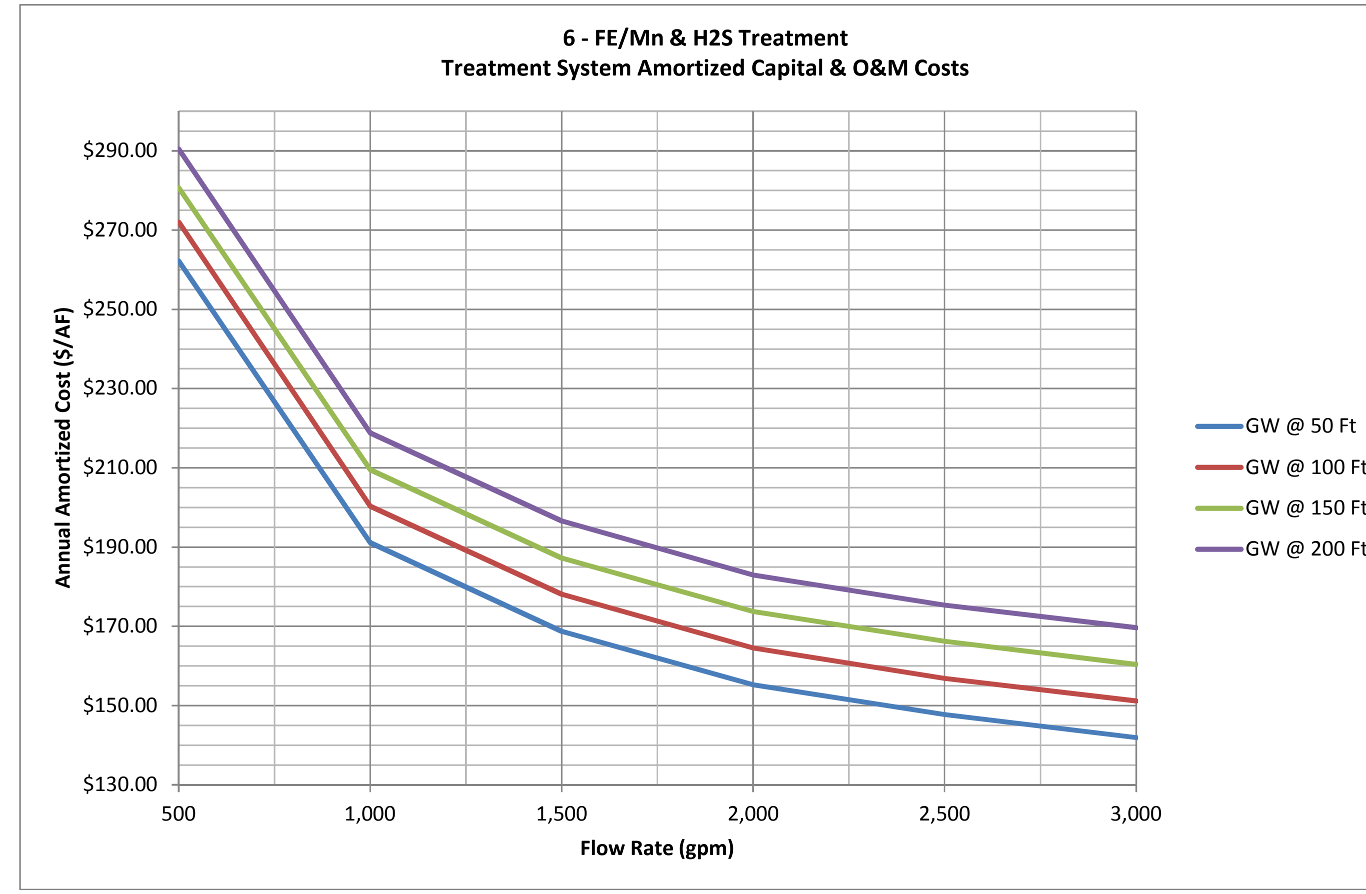

2 - Disinfection w/ Chloramines
Treatment System Amortized Capital & O&M Costs
Annual Amortized Cost ($/AF)
$140.00
$130.00
$120.00
$110.00
$100.00
$90.00
$80.00
$70.00
$60.00
$50.00
500
1,000
1,500
2,000
2,500
3,000
Flow Rate (gpm)
GW @ 50 Ft
GW @ 100 Ft
GW @ 150 Ft
GW @ 200 Ft


3 - Hydrogen Sulfide Treatment
Treatment System Amortized Capital & O&M Costs
Annual Amortized Cost ($/AF)
$200.00
$180.00
$160.00
$140.00
$120.00
$100.00
$80.00
500
1,000
1,500
2,000
2,500
3,000
Flow Rate (gpm)
GW @ 50 Ft
GW @ 100 Ft
GW @ 150 Ft
GW @ 200 Ft


4 - Iron & Manganese Treatment
Treatment System Amortized Capital & O&M Costs
Annual Amortized Cost ($/AF)
$260.00
$240.00
$220.00
$200.00
$180.00
$160.00
$140.00
$120.00
$100.00
500
1,000
1,500
2,000
2,500
3,000
Flow Rate (gpm)
GW @ 50 Ft
GW @ 100 Ft
GW @ 150 Ft
GW @ 200 Ft



5 - Fe/MN, H2S & Color Treatmnent
Treatment System Amortized Capital & O&M Costs
$1,100.00
$1,000.00
$900.00
$800.00
$700.00
$600.00
Annual Amortized Cost ($/AF)
500
1,000
1,500
2,000
2,500
3,000
Flow Rate (gpm)
GW @ 50 Ft
GW @ 100 Ft
GW @ 150 Ft
GW @ 200 Ft



6 - FE/Mn & H2S Treatment
Treatment System Amortized Capital & O&M Costs
$290.00
$270.00
$250.00
$230.00
$210.00
$190.00
$170.00
$150.00
$130.00
Annual Amortized Cost ($/AF)
500
1,000
1,500
2,000
2,500
3,000
Flow Rate (gpm)
GW @ 50 Ft
GW @ 100 Ft
GW @ 150 Ft
GW @ 200 Ft

Section J.3
Greenhouse Gas Emission Calculations

Table J.3-1. Total Electricity Deliveries

1,227.89 lbs CO_2/MWh

Table J.3-2. California Grid Average Electricity Emission Factors

Year	CH_4 (lbs/MWh)	N_2O (lbs/MWh)
2004	0.029	0.011

Table J.3-3. Global Warming Potential (GWP) Factors

CO_2	CH_4	N_2O
1	21	310

Source:

CCAR, 2008. *Local Government Operations Protocol*. Version 1.0. September 25.

http://www.arb.ca.gov/cc/protocols/localgov/pubs/final_lgo_protocol_2008-09-25.pdf

Example Equation

CO_2 Emissions = Electricity Usage (kWh/yr) x (0.001 MWh/kWh) x Emission Factor (lb/MWh) x (453.6 g/lb) / (1,000,000 metric ton/g)

CB-P1a = kWh/yr x 0.001 MWh/kWh x 1,227.89 lb/MWh x 453.6 g/lb / 1,000,000 metric ton/g = metric ton/yea

CH_4 and N_2O Emissions = Emissions (metric ton/year) x GWP

Table J.3-4. Emissions from Purchased Electricity - By Project

Project Option		Annual Flow (AFY)	Electricity Use (kWh/yr)	GHG Emissions (metric tons/yr) CO_2	CH_4	N_2O	CO_2e Emissions (metric ton/yr) CO_2	CH_4	N_2O	Total	Total per AFY	Total AFY	Annual Electricity Use (kWh/AF)	Total Metric Tons/AF
CB-P1a	SJCWRP (100%) Tertiary	5,000	0	0	0.00	0.00	0	0	0	0	0.0	5,000	0	0.0
CB-P1b	SJCWRP (100%) Tertiary	10,000	0	0	0.00	0.00	0	0	0	0	0.0	10,000	0	0.0
CB-P1c	SJCWRP to MFSG – 100% Tertiary (+17,600 AFY)	17,600	0	0	0.00	0.00	0	0	0	0	0.0	17,600	0	0.0
CB-P2a	SJCWRP - 100 % AWT	5,000	4,900,000	2,729	0.06	0.02	2,729	1	8	2,738	0.5	5,000	980	0.5
CB-P2b	SJCWRP - 100 % AWT	10,000	9,800,000	5,458	0.13	0.05	5,458	3	15	5,476	0.5	10,000	980	0.5
CB-P2c	SJCWRP AWT to MFSG	17,600	17,248,000	9,607	0.23	0.09	9,607	5	27	9,638	0.5	17,600	980	0.5
CB-P3	SJCWRP – 50 % AWT/50% Tertiary	10,000	4,900,000	2,729	0.06	0.02	2,729	1	8	2,738	0.3	10,000	490	0.3
CB-P4	SJCWRP – 100 % NF	10,000	3,700,000	2,061	0.05	0.02	2,061	1	6	2,068	0.2	10,000	370	0.2
CB-P5	SJCWRP – 50 % NF/50% Tertiary	10,000	1,850,000	1,030	0.02	0.01	1,030	1	3	1,034	0.1	10,000	185	0.1
CB-P6	SJCWRP – 100 % ozone/BAC/GAC/Uv	10,000	3,900,000	2,172	0.05	0.02	2,172	1	6	2,179	0.2	10,000	390	0.2
CB-P7	LCWRP – 100 % AWT - spreading	5,000	6,111,400	3,404	0.08	0.03	3,404	2	9	3,415	0.7	5,000	1,222	0.7
CB-P8a	LCWRP – 100 % AWT - injection	5,000	6,111,400	3,404	0.08	0.03	3,404	2	9	3,415	0.7	5,000	1,222	0.7
CB-P8b	LCWRP – 100 % AWT expansion	4,500	5,500,300	3,064	0.07	0.03	3,064	2	9	3,074	0.7	4,500	1,222	0.7
CB-P9	ARRF (5,000 AFY)	5,000	3,008,916	1,676	0.04	0.02	1,676	1	5	1,681	0.3	5,000	602	0.3
CB-P10	GBOP San Gabriel River/Rio-Hondo	17,000	12,878,600	7,173	0.17	0.06	7,173	4	20	7,196	0.4	17,000	758	0.4
CB-P11	Injection at Montebello Forebay	8,690	40,738,200	22,690	0.54	0.20	22,690	11	63	22,764	2.6	8,690	4,688	2.6
CB-P12	Satellite AWT	45,480	73,751,100	41,077	0.97	0.37	41,077	20	114	41,212	0.9	45,480	1,622	0.9
WCB-P1a	ECLWRF AWT	15,500	23,925,200	13,326	0.31	0.12	13,326	7	37	13,369	0.9	15,500	1,544	0.9
WCB-P1b	ECLWRF AWT	7,500	1,960,000	1,092	0.03	0.01	1,092	1	3	1,095	0.1	7,500	261	0.1
0	TIWRP AWT	2,500	3,087,800	1,720	0.04	0.02	1,720	1	5	1,725	0.7	2,500	1,235	0.7
WCB-P2	JWPCP AWT	15,000	23,861,200	13,290	0.31	0.12	13,290	7	37	13,333	0.9	5,500	4,338	2.4
WCB-P3	JWPCP AWT	2,000	7,350,000	4,094	0.10	0.04	4,094	2	11	4,107	2.1	2,000	3,675	2.1
0	TIWRP AWT	5,500	7,048,300	3,926	0.09	0.04	3,926	2	11	3,939	0.7	15,000	470	0.3
		Pump Efficiency	75%											

Table J.3-5. Emissions from Purchased Electricity - By Alternative

Alternative Option		Total AFY	Electricity Use (kWh/yr)	GHG Emissions (metric tons/yr) CO_2	CH_4	N_2O	CO_2e Emissions (metric ton/yr) CO_2	CH_4	N_2O	Total	Total per AFY	Total AFY CK	Annual Electricity Use (kWh/AF)	Total Metric Tons/AF
CB-A1a	SJC-0%	5,000	-	0	0.00	0.00	0	0	0	0		5,000	0	0.0
CB-A1b	SJC-100%	5,000	9,800,000	5,458	0.13	0.05	5,458	3	15	5,476		5,000	1,960	1.1
CB-A1c	SJC-50%	10,000	4,900,000	2,729	0.06	0.02	2,729	1	8	2,738		10,000	490	0.3
CB-A1d	SJC-NF	10,000	3,700,000	2,061	0.05	0.02	2,061	1	6	2,068		10,000	370	0.2
CB-A1e	SJC-50% NF	10,000	1,850,000	1,030	0.02	0.01	1,030	1	3	1,034		10,000	185	0.1
CB-A1f	SJC-100% ozone/BAC/GAC/Uv	10,000	3,900,000	2,172	0.05	0.02	2,172	1	6	2,179		10,000	390	0.2
CB-A2a	P1a + LC-Spread	10,000	6,111,400	3,404	0.08	0.03	3,404	2	9	3,415		7,500	611	0.3
CB-A2b	P1b + LC-Spread	10,000	11,011,400	6,133	0.14	0.05	6,133	3	17	6,153		7,500	1,101	0.6
CB-A3a	P1a + LC-Inject	10,000	6,111,400	3,404	0.08	0.03	3,404	2	9	3,415		7,500	611	0.3
CB-A3B	P1b + LC-Inject	10,000	11,011,400	6,133	0.14	0.05	6,133	3	17	6,153		7,500	1,101	0.6
CB-A4a	P1a + ARRF (P9)	10,000	3,008,916	1,676	0.04	0.02	1,676	1	5	1,681		9,194	301	0.2
CB-A4b	P2a + ARRF (P9)	10,000	7,908,916	4,405	0.10	0.04	4,405	2	12	4,419		9,194	791	0.4
CB-B1a	Max SJC-0%	67,770	68,237,416	38,006	0.90	0.34	38,006	19	106	38,131		67,790	1,007	0.6
CB-B1b	Max SJC-100%	67,770	95,285,416	53,071	1.25	0.48	53,071	26	147	53,245		67,790	1,406	0.8
CB-B2a	Max SJC-0%	113,250	141,988,516	79,083	1.87	0.71	79,083	39	220	79,342		113,270	1,254	0.7
CB-B2b	Max SJC-100%	113,250	169,036,516	94,148	2.22	0.84	94,148	47	261	94,457		113,270	1,493	0.8
WB-A1	WCBB+DGB	18,000	27,013,000	15,045	0.36	0.13	15,045	7	42	15,095		18,000	1,501	0.8
WB-B1	+30k	30,000	20,967,400	11,678	0.28	0.10	11,678	6	32	11,716		24,500	699	0.4
No Project	100% Imported Water												2500	1.4

Appendix K
Modeling of Basin Filling Operations

APPENDIX K
Basin Filling Simulation

K.1 Simulation Purpose and Assumptions

This section provides the results a modeling analysis conducted to estimate the impact of additional recharge at the Montebello Forebay Spreading Grounds (MFSG) relative to historical conditions, without additional corresponding extraction.

The WRD/USGS MODFLOW groundwater model, updated for the Groundwater Basins Master Plan (GBMP) as described in Section 4.1 of this report, was used to simulate the effects of capturing additional stormwater at the MFSG.

In the Central Basin, the modeling assumed that the 220,000 acre-feet of storage would be filled using combination of Carryover Conversion (130,400 acre-feet) and additional spreading at the MFSG (89,600 acre-feet). It was assumed that replenishment of 1/3 of the Carryover Conversion, 43,500 acre-feet, and all of the 89,600 acre-feet of MFSG spreading, a total of 133,100 AFY, would occur at the MFSG within 7 years of the 10-year modeling period.

For the first simulation, the 40-years of historical hydrology in the model (Water Years 1971/72-2010/11) was used to simulate projections for the period 2011-2050.

These results were compared with those of a second simulation that represented the additional basin filling without corresponding pumping. During the 10-year period from WY 1991/92 through WY 2000/01 (projected WYs 2029/30-2038/39) an additional 19,009 acre-feet of conserved water at the MFSG was applied to each of 7 average or dry WYs during this period (i.e., WYs 1991/92, 1993/94, 1995/96, 1996/97, 1998/99, 1999/2000 and 2000/01), for a total of 133,063 AFY.

The water level impacts of the additional recharge at the MFSG in the second simulation relative to the historical operations are shown in Figure K-1. The results indicate that the increase in water levels is relatively minimal, with the highest increase of 15 feet occurring at and near the MFSG where replenishment of storage water occurs.

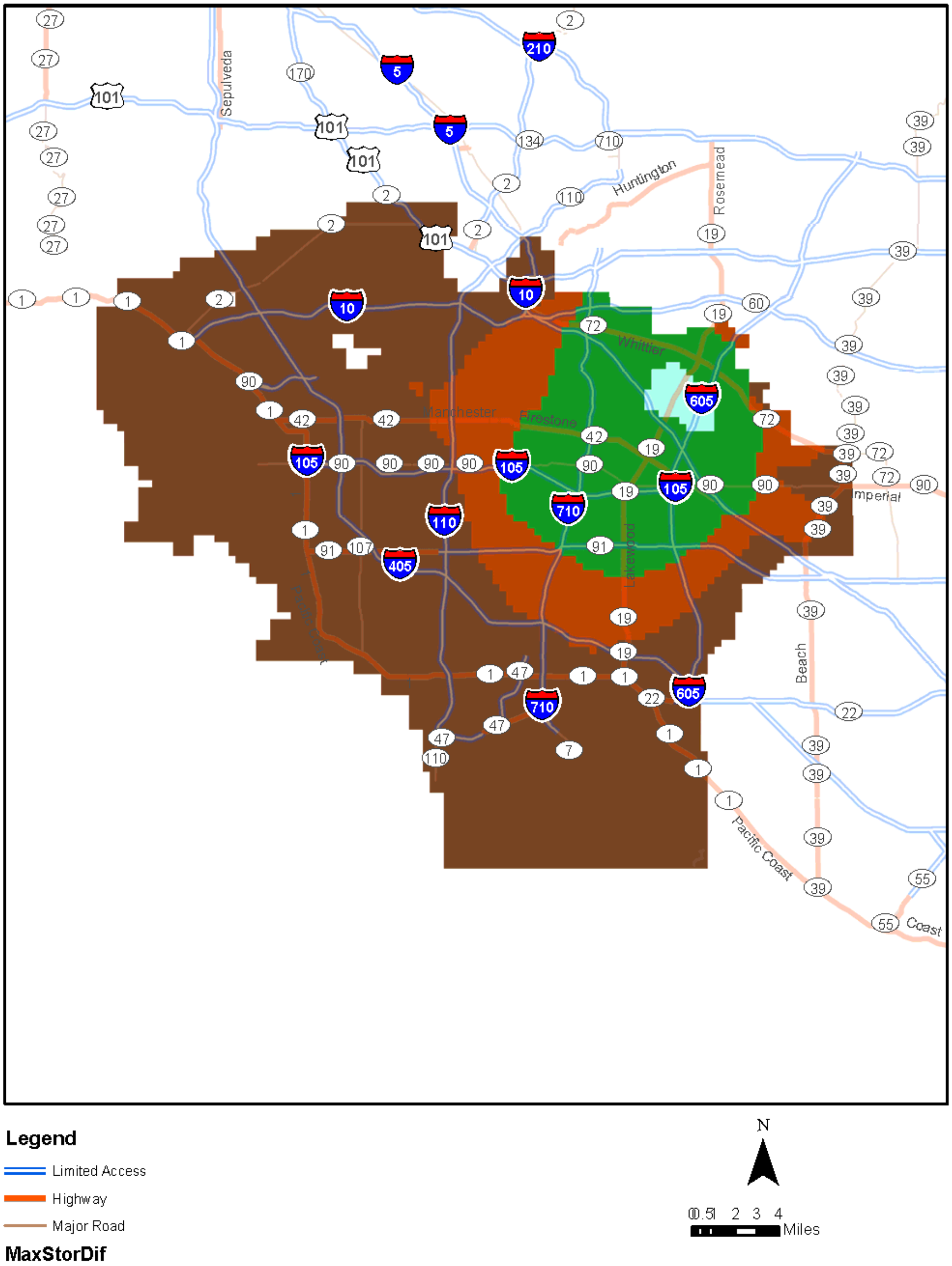


Figure K-1
Groundwater Level Difference For Water Year 2001 Max. Storage Scenario
Groundwater Basins Master Plan

File Location

Appendix L
GRIP Analysis of Potential Groundwater Impacts Technical Memorandum

Groundwater Reliability Improvement Program (GRIP) Analysis of Potential Groundwater Impacts

PREPARED FOR: Esther Rojas/Water Replenishment District of Southern California

PREPARED BY: Richard Sturn/CH2M HILL SCO
Judi Miller/CH2M HILL LAC

DATE: March 26, 2015

PROJECT NUMBER: 393041.T4.P3.01

This technical memorandum has been prepared for the Water Replenishment District of Southern California (WRD) and presents an analysis of potential groundwater impacts associated with the Groundwater Reliability Improvement Program (GRIP). This memorandum is organized as follows:

1. Groundwater Reliability Improvement Program Overview

The Montebello Forebay Spreading Grounds (MFSG) is the principle groundwater recharge area for the Central Groundwater Basin (Central Basin) of Southern California. Groundwater replenishment in the Central Basin involves multiple water sources, including imported water, that are spread at the MFSG. GRIP would allow WRD to offset the current use of imported water with a combination of tertiary treated and advanced water treatment (AWT) recycled water. GRIP would replace imported water supplies with 21,000 acre-feet per year (AFY) of recycled water consisting of an additional 11,000 AFY of tertiary treated recycled water purchased from Los Angeles County Sanitation Districts (LACSD) and approximately 10,000 AFY of AWT water produced at a new AWT plant.

The tertiary treated recycled water would be supplied from the San Jose Creek Water Reclamation Plant (SJCWRP) (east or west plants), and would be conveyed in the existing outfall pipeline to the MFSG. WRD would construct an AWT plant that would discharge AWT water from the AWT plant to a connection point with the existing outfall pipeline; this AWT water would be blended with the tertiary treated recycled water prior to spreading at the San Gabriel Coastal Basin Spreading Grounds (SGCBSG) and the Rio Hondo Coastal Basin Spreading Grounds (RHCBSG).

2. Hydrogeology and Groundwater Quality of the Montebello Forebay Area

The MFSG is located within the Montebello Forebay area of the Central Basin, adjacent to the Rio Hondo and San Gabriel Rivers, south of the Whittier Narrows (Figure 1). Surface water from upper watersheds of the Rio Hondo and San Gabriel Rivers discharge through the narrows onto the Los Angeles Coastal Plain. Likewise, groundwater from the San Gabriel Groundwater Basin flows through the narrows into the Central Basin.

The water-bearing units in the Central Basin consist of unconsolidated to partly consolidated nonmarine and marine deposits from the Holocene through Pleistocene age (Reichard et al., 2003). These water-bearing deposits have been subdivided into four aquifer systems: Recent, Lakewood, Upper San Pedro, and Lower San Pedro (Reichard et al., 2003).

Base map from U.S. Geological Survey digital maps 1:24,000

Geology redrawn from Reichard and others, 2003

Source: Anders and Schroder, 2003 (Figure 1)

FIGURE 1
Project Location Map
Groundwater Reliability Improvement Program

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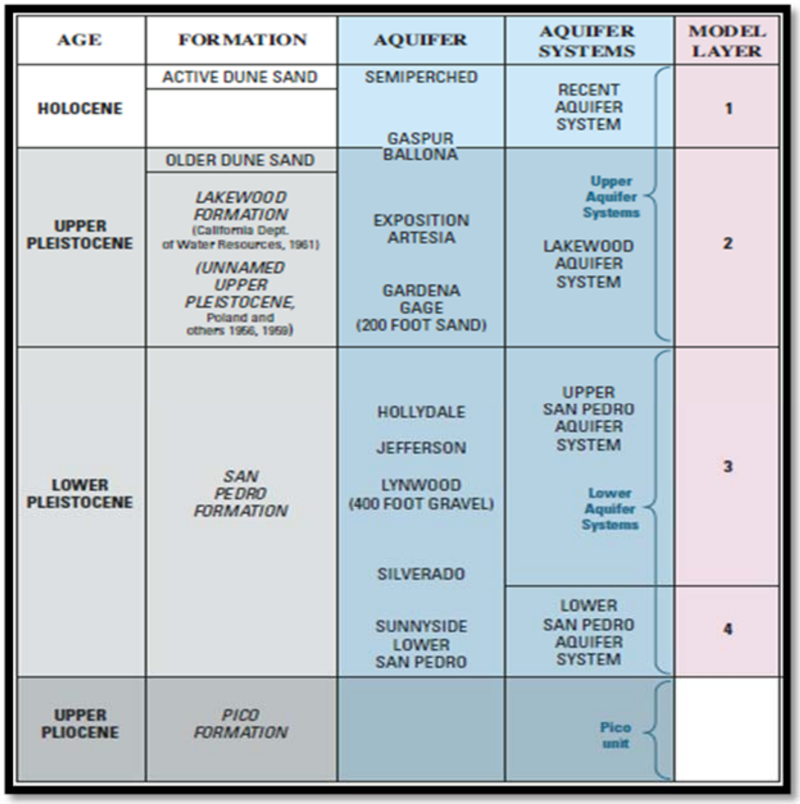
The individual aquifer systems contain designated aquifer units composed predominantly of sand and gravel (for example, the Silverado aquifer), which are separated by intervening finer-grained units. Figure 2 summarizes the age, formations, and aquifer designations of the water-bearing units in the Central Basin. Figure 2 also shows corresponding model layering implemented in the U.S Geological Survey (USGS) groundwater flow model for the Los Angeles Coastal Plain groundwater basins (Reichard et al., 2003). An updated version of this model was used to evaluate potential impacts to groundwater flow conditions associated with GRIP. See Section 4.1 for a discussion of modeling activities.

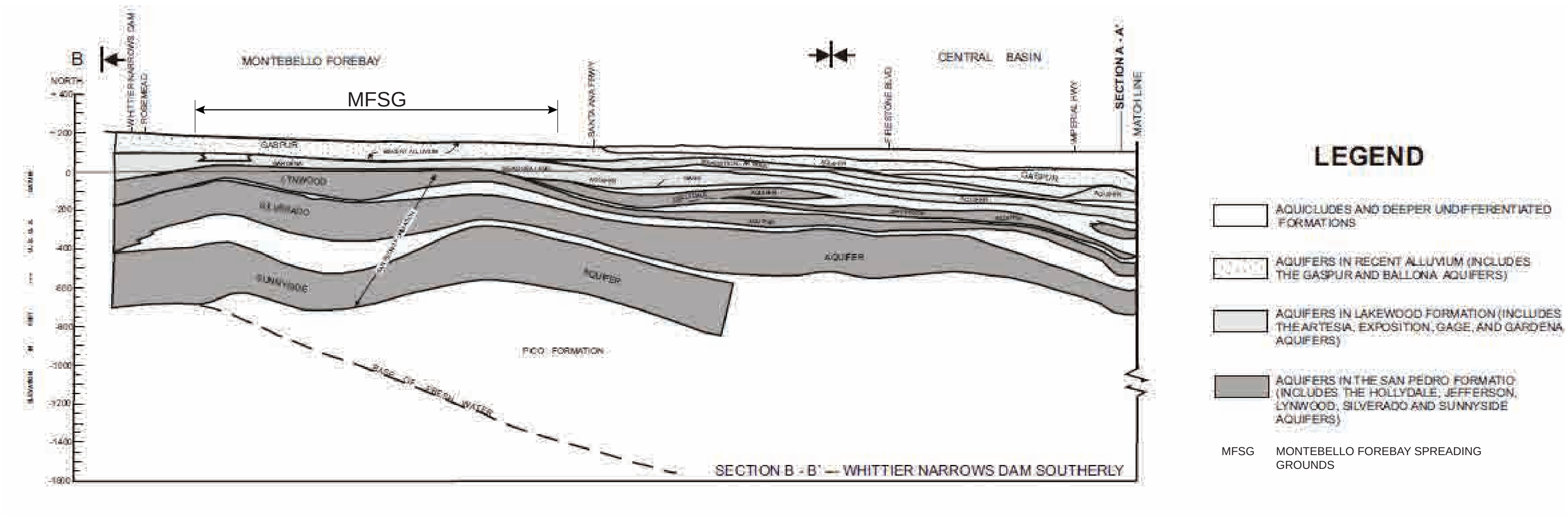


Source: Reichard et al., 2003 (Figure 3)

FIGURE 2
Aquifer Units – Central Basin
Groundwater Reliability Improvement Program

The fine-grained units separating the aquifer units are thin or absent in the Montebello Forebay. There is a high degree of mergence among the aquifer units relative to conditions in the Central Basin Pressure Area (Figure 3). This configuration facilitates vertical groundwater migration from the Recent Aquifer System (Gasper aquifer) into the underlying Lakewood and Upper San Pedro Aquifer Systems, which recharges the deeper units.

Aquifer units in the Montebello Forebay are highly transmissive. Model-calibrated hydraulic conductivities range from 51 to 800 feet per day (ft/day) for the Recent Aquifer System and 11 to 150 ft/day for the Lakewood, Upper San Pedro, and Lower San Pedro Aquifer Systems (Kennedy/Jenks/Todd LLC and LLNL [KJT/LLNL], 2008).



Not to scale

FIGURE 3
Hydrogeologic Cross Section
Groundwater Reliability Improvement Program

Source: WRD, 2013 (Figure 1.4)

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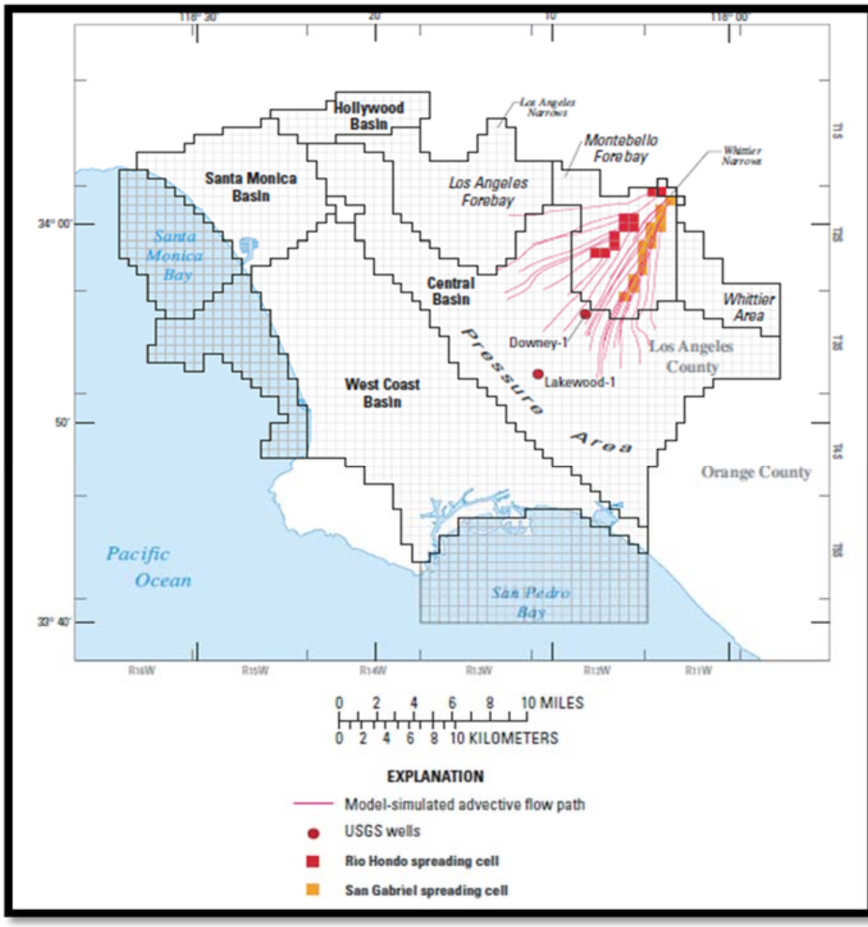
2.1 Groundwater Flow Conditions

Groundwater flows from the San Gabriel Groundwater Basin through the Whittier Narrows, mixes with groundwater recharged at the MFSG, and diverges radially into the Central Basin. Figure 4 shows model-simulated advective flow paths from the MFSG into the Central Basin Pressure Area, illustrating this radial flow pattern.

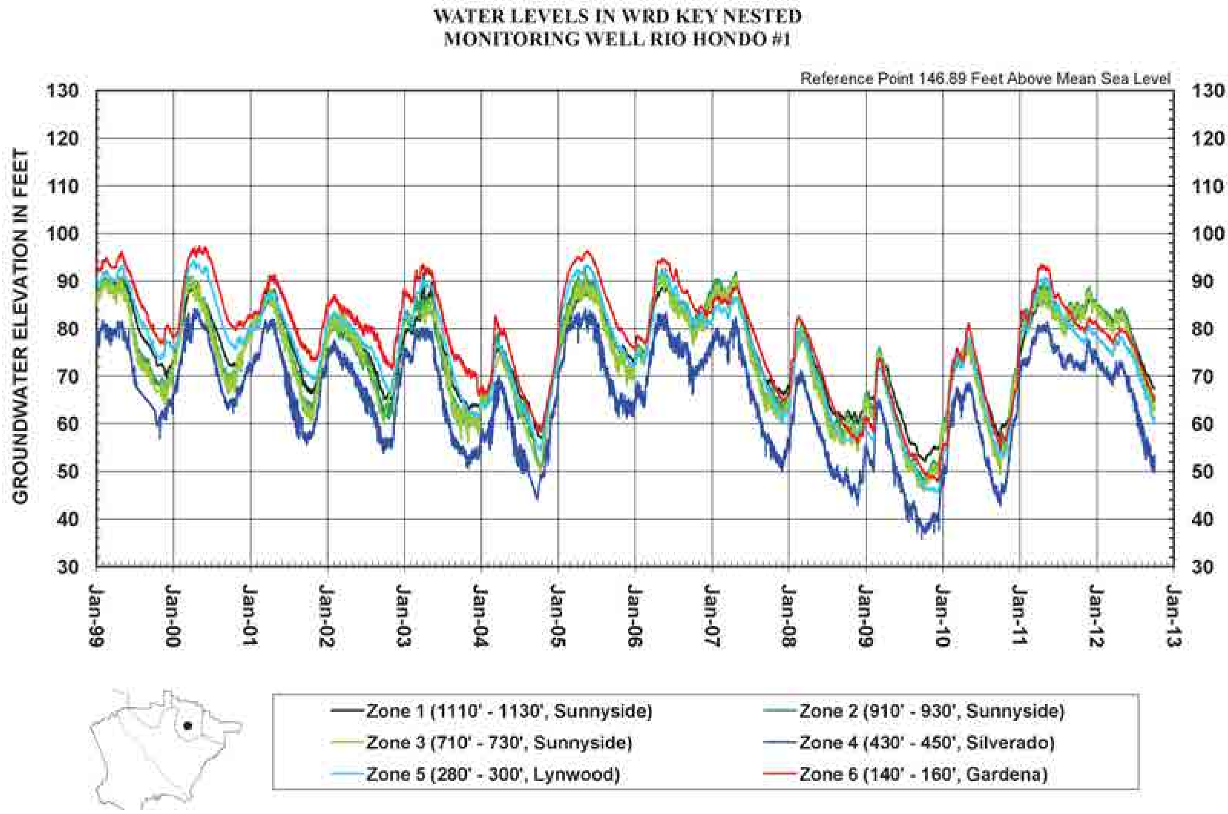


Source: Reichard et al., 2003 (Figure 38)

FIGURE 4
Advective Flow Paths – MFSG to Central Basin Pressure Area
Groundwater Reliability Improvement Program

2.1.1 Vertical Gradients

Vertical hydraulic gradients are generally downward in the Montebello Forebay area. Figure 5 shows groundwater level hydrographs for WRD's Pico #2 and Rio Hondo #1 nested monitoring wells. The wells are located near the southern ends of the SGCBSG and RHCBSG, respectively. At Pico #2, the vertical gradient is downward across all aquifer units, with approximately 30 feet of head difference between the Gardena aquifer (shallow) and Lower Sunnyside aquifer (deep) well screens. At Rio Hondo #1, the vertical gradient is downward from the Gage through Silverado aquifers, with approximately 10 feet of head difference across these units. Hydraulic heads are higher, however, in the underlying Sunnyside aquifer and there is an upward hydraulic gradient from the Sunnyside to the Silverado; occasionally, heads in the Sunnyside have been higher than those in the Gage and Lynwood aquifers. The upward hydraulic gradient from the Sunnyside at this location is likely caused by pumping from the Silverado aquifer. In contrast, little groundwater production occurs from the Sunnyside aquifer in the Montebello Forebay (Reichard et al., 2003).



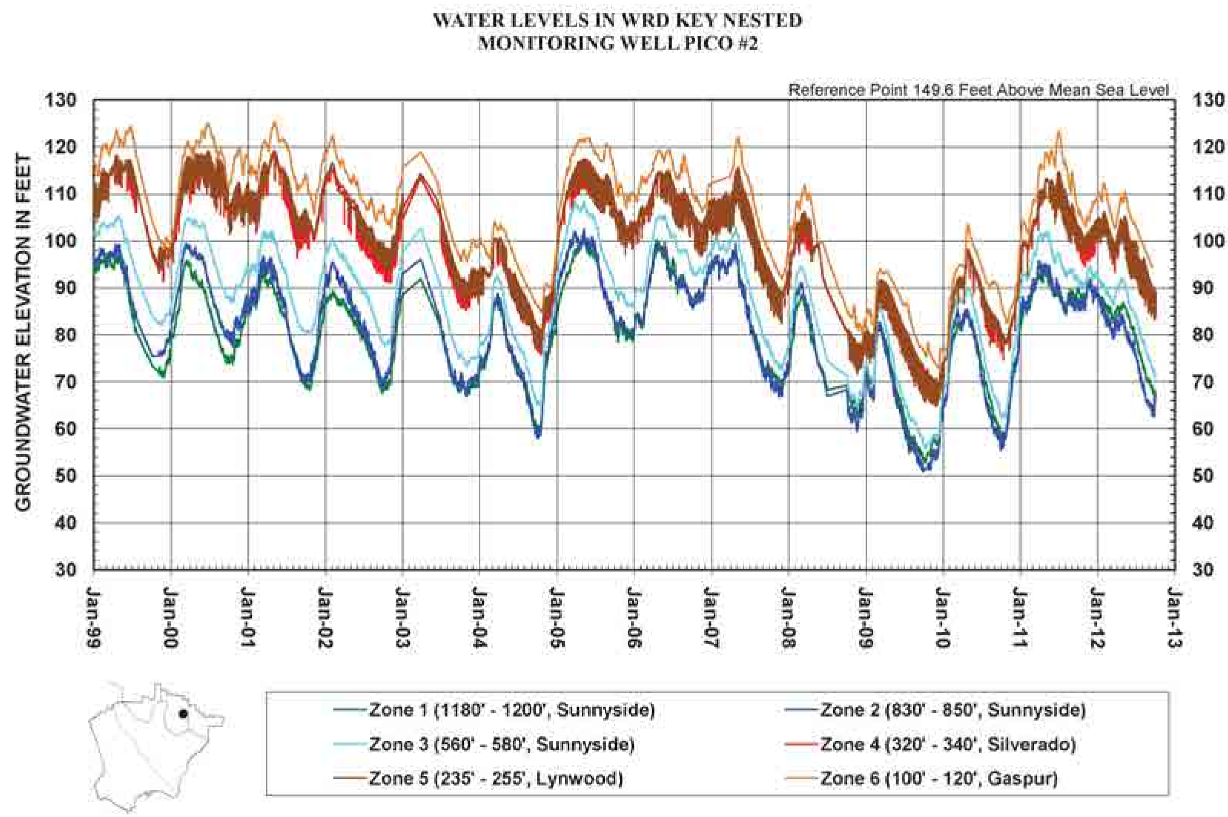


FIGURE 5
Key Well Hydrographs
Groundwater Reliability Improvement Program

Source: WRD, 2013 (Figures 2.3 and 2.4)

2.1.2 Groundwater Budget

Spreading operations at the MFSG are the most significant source of groundwater recharge in the Central Basin. On average, approximately 132,000 AFY of water was spread between 1971 and 2000, which exceeds the estimated areal and mountain front recharge for the entire Los Angeles Coastal Plain (67,500 AFY) (Reichard et al., 2003).

Figure 6 illustrates the simulated average groundwater flows between model layers, basins, and subareas in the USGS groundwater flow model for years 1996 through 2000 (Reichard et al., 2003). A key feature of this figure is the vertical flow component within the Montebello Forebay. Approximately 110,600 AFY of groundwater flows from Model Layer 1 (Recent Aquifer System) to Layer 2 (Lakewood Aquifer System), and approximately 107,700 AFY flows from Layer 2 to Layer 3 (Upper San Pedro Aquifer System). Significant lateral flow occurs within Layer 3 from the Montebello Forebay to the Central Basin Pressure Area (61,500 AFY). Lateral flow in the Upper San Pedro Aquifer System (for example, Silverado aquifer) from the Montebello Forebay is the largest source of groundwater inflow to the Central Basin Pressure Area (Figure 6).

Figure 6 also illustrates significant lateral flow (21,000 AFY) in Layer 1 from the Montebello Forebay to the Central Basin Pressure Area.

2.2 Groundwater Quality

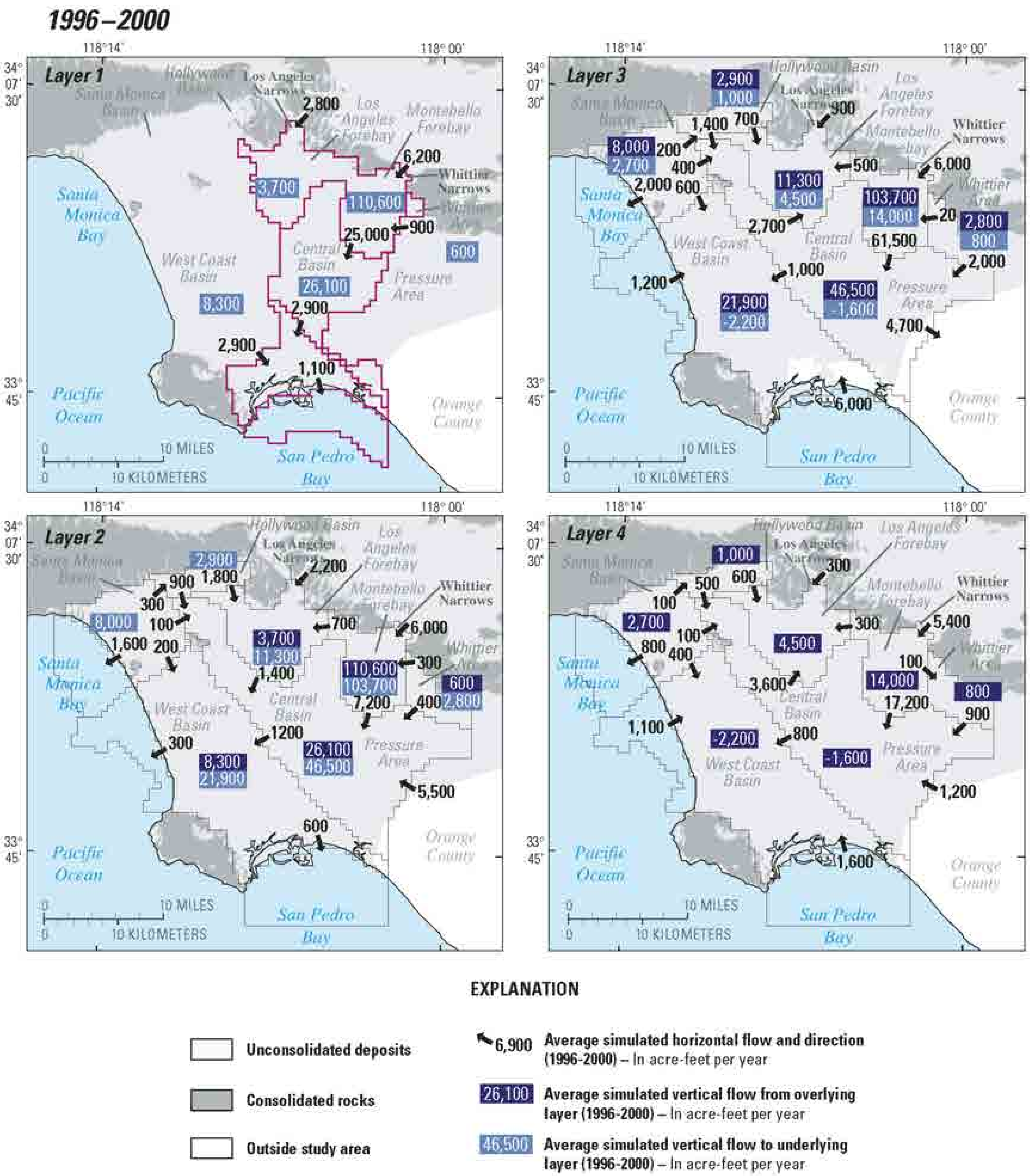
Groundwater quality standards for the Montebello Forebay (and Central Basin) are incorporated into the Water Quality Control Plan for the Los Angeles Region (Basin Plan) (LARWQCB, 1994). The beneficial uses of groundwater include municipal supply; therefore, the water quality objectives for regulated substances are equivalent to drinking water standards. In addition, the Basin Plan specifies area-specific water quality objectives (Basin Plan Objectives) for total dissolved solids (TDS), chloride, sulfate, nitrogen compounds, and boron. The Basin Plan Objectives for the Montebello Forebay and Central Basin Pressure Area include:

- TDS – 700 milligrams per liter (mg/L)
- Chloride – 150 mg/L
- Sulfate – 250 mg/L
- Nitrogen compounds – 10 mg/L nitrate or nitrate plus nitrite (as N), 1 mg/L nitrite (as N)
- Boron – 1.0 mg/L

Groundwater quality in the Montebello Forebay has been extensively monitored as part of WRD's regional groundwater monitoring program, monitoring for the MFSG, and required monitoring for drinking water supply wells. In general, existing groundwater quality meets drinking water standards and applicable Basin Plan Objectives, although concentrations of select compounds may locally exceed some of these limits. TDS concentrations locally exceed the recommended secondary maximum contaminant level (MCL) of 500 mg/L. Concentrations of select metals (for example, iron and manganese) locally exceed MCLs due to site-specific aquifer conditions. Local groundwater impacts also occur at environmental release sites. In addition, several large volatile organic compound (VOC) plumes under U.S. Environmental Protection Agency (EPA) oversight occur in the area. An overview of groundwater quality for salts, nutrients, metals, other constituents, and existing VOC plumes is presented in the following sections.

2.2.1 Salts and Nutrients

An evaluation of salt and nutrient inputs to the Central and West Coast Basin, including GRIP, is presented in the *Draft Salt and Nutrient Management Plan, Central Basin and West Coast Basin, Southern Los Angeles County, California* (SNMP) (Todd Engineers, 2014). The SNMP assessed potential water quality parameters to identify those most representative of salts and nutrients in the Central Basin. TDS, chloride, and nitrate were selected as the representative indicator parameters.



Source: Reichard and others, 2003 (Figure 34B)

FIGURE 6
Simulated Inter-Zone Flows
Groundwater Reliability Improvement Program

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The distributions of the TDS, chloride, and nitrate concentrations reported in groundwater production wells in the Montebello Forebay (2012 to 2009) are illustrated in Figure 7. Chloride concentrations are less than the recommended secondary MCL (250 mg/L); nitrate concentrations are less than the primary MCL (10 mg/L). TDS concentrations locally exceed the recommended secondary MCL but are less than the upper limit secondary MCL (1,000 mg/L).

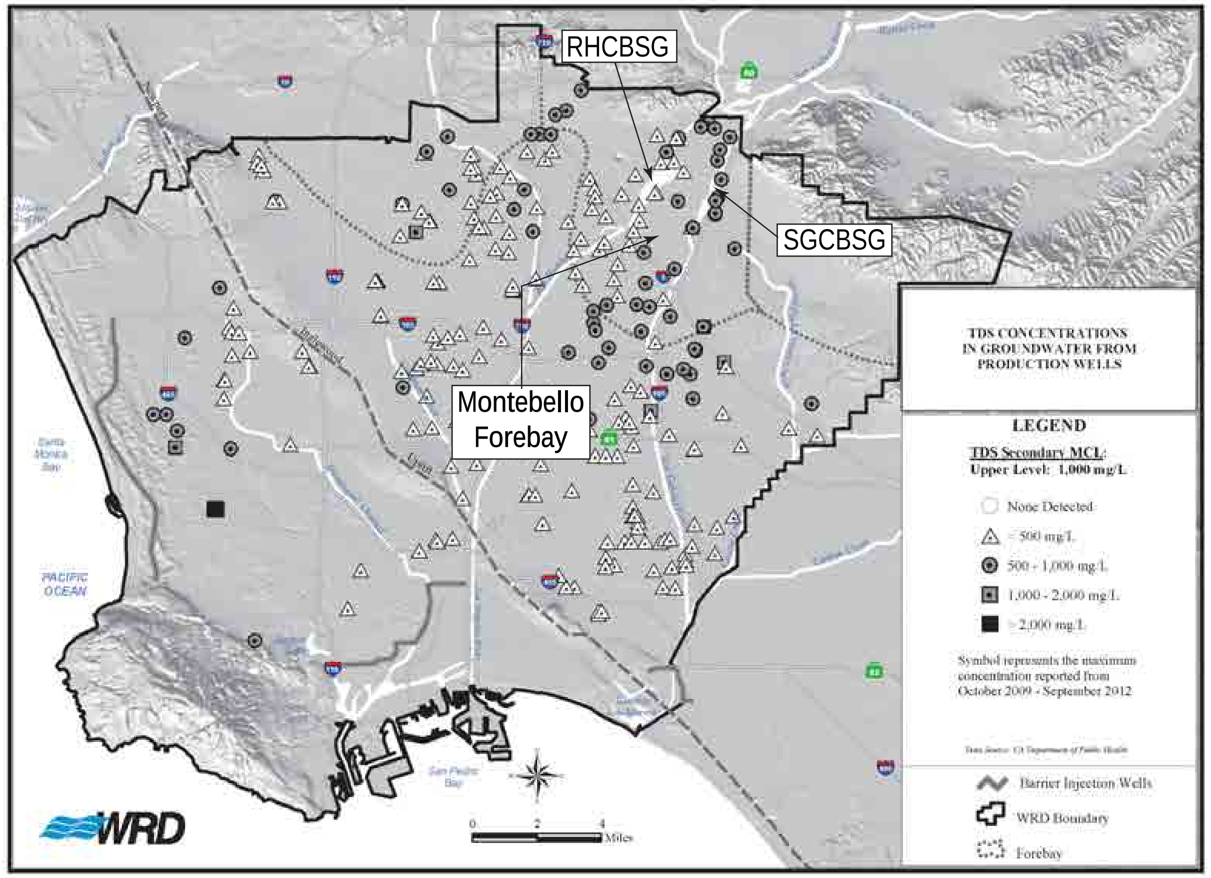
In general, TDS and chloride concentrations in the Montebello Forebay have been below Basin Plan Objectives and relatively stable. Figure 8 shows groundwater TDS and chloride concentration trends for WRD's Pico #2 and Rio Hondo #1 nested monitoring wells for 1998 through 2012. The wells are located near the southern end of the SGCBSG and RHCBSG, respectively. At Rio Hondo #1, chloride and TDS concentrations have been less than the Basin Plan Objectives (150 and 700 mg/L, respectively) for all screen depths. At Pico #2, chloride and TDS concentrations have been less than the Basin Plan Objectives for all screen depths except the screen completed in the middle Sunnyside aquifer (830 to 850 feet below ground surface). TDS exceeded the Basin Plan Objective in that well screen during one sampling event in 2008.

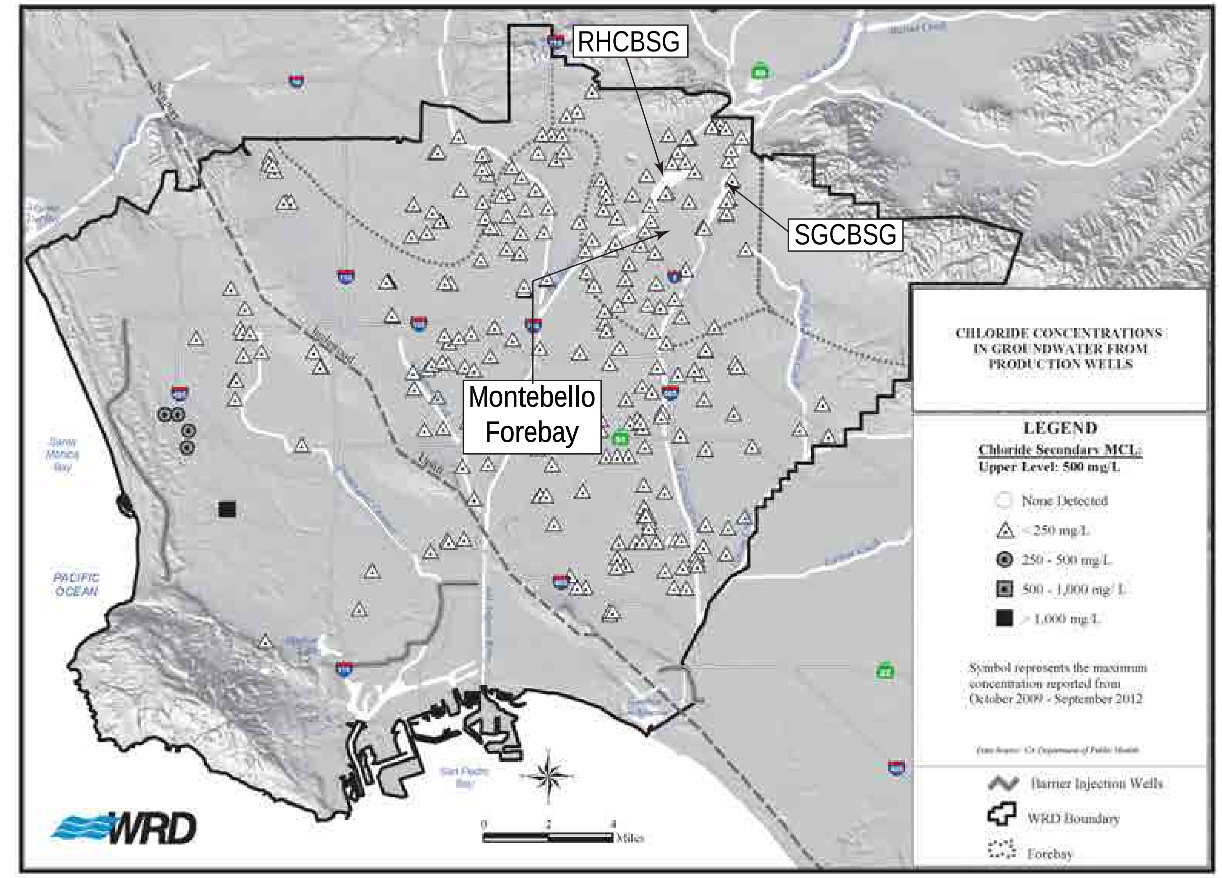
2.2.2 Metals and Other Groundwater Constituents

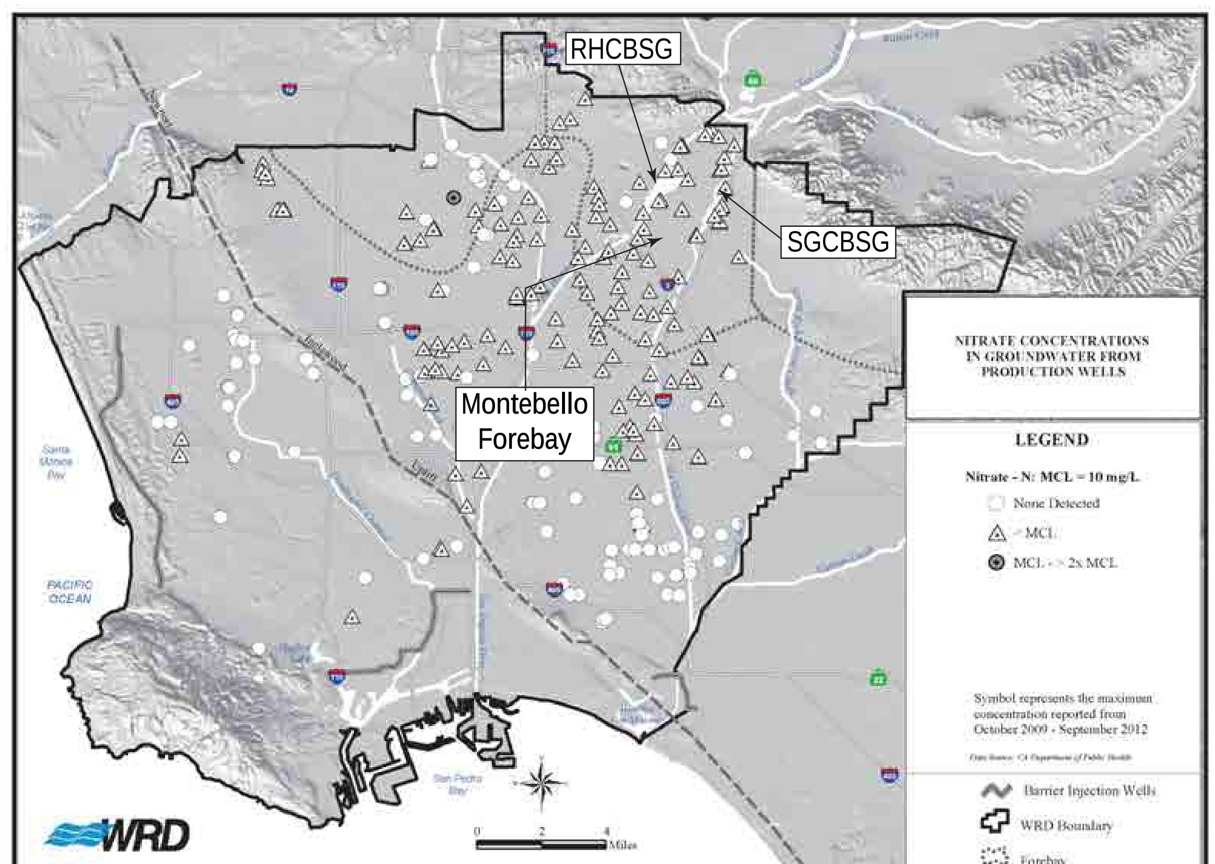
WRD tracks and assesses basinwide water quality for other parameters in addition to salt and nutrient indicators. WRD's regional groundwater monitoring reports include results for iron, manganese, arsenic, hexavalent chromium, trichloroethylene (TCE), tetrachloroethylene (PCE), 1,4-dioxane, 1,2,3-trichloropropane (1,2,3-TCP), and perchlorate. A general summary of these constituents for the Montebello Forebay is presented below for water year 2011-2012 (WRD, 2013).

- **Iron, magnesium, arsenic, and hexavalent chromium**: The concentrations of these metals reported for WRD monitoring wells and production wells are generally below the respective MCLs. Localized exceedances of iron and manganese MCLs, however, are likely caused by local aquifer conditions.
- **TCE and PCE**: These VOCs have been detected at low concentrations (less than MCLs) at select WRD monitoring wells in the Montebello Forebay (including Pico #2), and at concentrations exceeding MCLs at a few production wells. The PCE and TCE concentrations detected in these monitoring wells are likely associated with local environmental release sites.
- **1,4-Dioxane**: An MCL for 1,4-dioxane has not yet been promulgated, but the drinking water notification level (NL) is 1 microgram per liter (μg/L). 1,4-Dioxane has been detected at concentrations exceeding the NL in WRD monitoring wells and production wells in the Montebello Forebay. 1,4-Dioxane has been used as a solvent stabilizer for 1,1-trichloroethane (1,1-TCA) formulations and is commonly associated with environmental release of 1,1-TCA. It also occurs at low levels (1 to 2 μg/L) in tertiary treated effluent from the Pomona, Whittier Narrows, and San Jose Creek wastewater treatment plants (Todd Engineers, 2014). It is rarely detected in shallow MFSG monitoring wells; consequently, the 1,4-dioxane detections in the Montebello Forebay are thought to be associated with environmental release sites and not managed aquifer recharge at the MFSG (Todd Engineers, 2014).
- **1,2,3-TCP**: Like 1,4-dioxane, an MCL has not been established for 1,2,3-TCP. The NL, however, is very low (0.005 μg/L). 1,2,3-TCP was not detected in WRD monitoring well samples in water year 2011-2012, which were analyzed using low-detection-limit methods, nor was it detected in production wells, although higher-detection-limit methods were used for analysis.
- **Perchlorate**: The perchlorate MCL is 6 μg/L. Perchlorate has been detected in select WRD monitoring wells at concentrations less than the MCL, but it is rarely detected in production wells.

In general, existing monitoring results suggest there are no widespread groundwater quality issues in the Montebello Forebay associated with these parameters. Where concentrations exceed regulatory limits, the exceedances are likely associated with site-specific aquifer conditions or environmental releases.



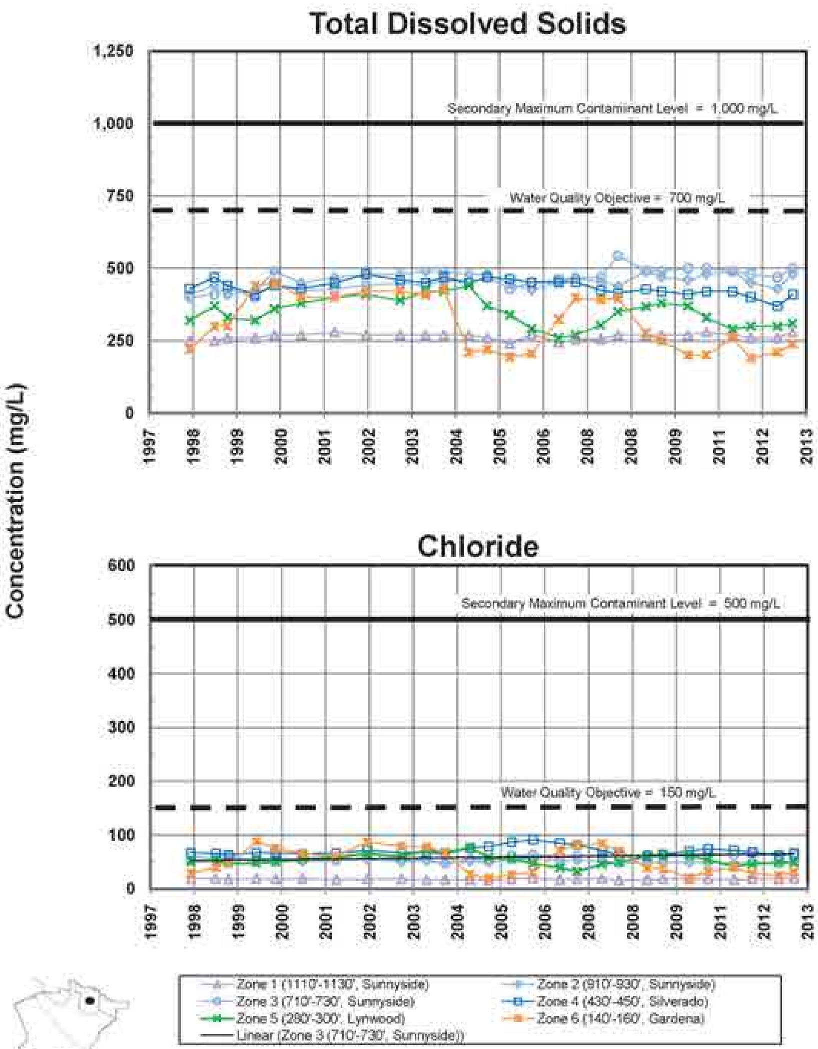




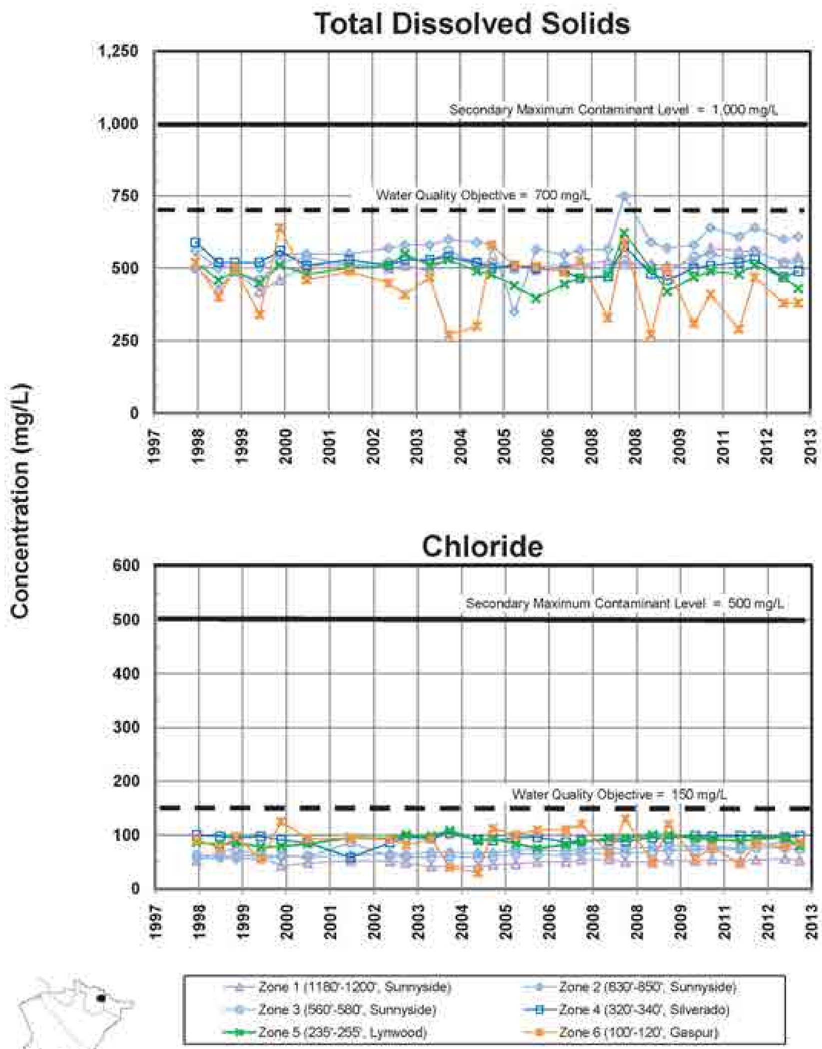
RHCBSG - Rio Hondo Coastal Basin Spreading Grounds
SGCBSG - San Gabriel Coastal Basin Spreading Grounds

Source: WRD, 2013 (Figures 3.2, 3.8, 3.10)

FIGURE 7
Distribution Nitrate, Chloride, and TDS Concentrations in Production Wells
Groundwater Reliability Improvement Program



WATER QUALITY CONCENTRATIONS IN
WRD KEY MONITORING WELL RIO HONDO #1



WATER QUALITY CONCENTRATIONS IN
WRD KEY MONITORING WELL PICO #2

FIGURE 8
TDS and Chloride Concentration Trends in Key Wells
Groundwater Reliability Improvement Program

Source: WRD, 2013 (Figure 4-2 and 4-3)

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2.2.3 Volatile Organic Compound (VOC) Plumes

Two large, composite VOC plumes associated with EPA Superfund sites occur in the Montebello Forebay area. Figure 9 shows the generalized distribution of the Whittier Narrows Operable Unit (WNOU) and Omega Chemical Operable Unit 2 (Omega OU2) VOC plumes.

The WNOU is located north (upgradient) of the MFSG (Figure 9) and encompasses approximately 4 square miles in the southern portion of the San Gabriel Basin. It represents the primary discharge point for groundwater and surface water flow exiting the San Gabriel Basin into the Central Basin. PCE and TCE are the primary groundwater contaminants found upgradient and within the WNOU. EPA signed an Interim Record of Decision (IROD) on March 31, 1993, and an IROD Amendment on November 10, 1999, requiring implementation of hydraulic containment north of the Whittier Narrows Flood Control Dam (WND). The remedy is ongoing and is intended to contain groundwater impacts and protect groundwater resources in Whittier Narrows and the Montebello Forebay.

Omega OU2 is located southeast (cross-gradient) of the MFSG (Figure 9). PCE, TCE, and Freons are the primary groundwater contaminants in Omega OU2. The feasibility study for OU2 is complete; an IROD was approved in 2011. The IROD remedy requires hydraulic containment of the high-concentration portions of the OU2 VOC plume. EPA is currently negotiating a Unilateral Administrative Order with the respondents to implement the interim remedy.

3. Summary of Existing and Proposed Recharge Operations

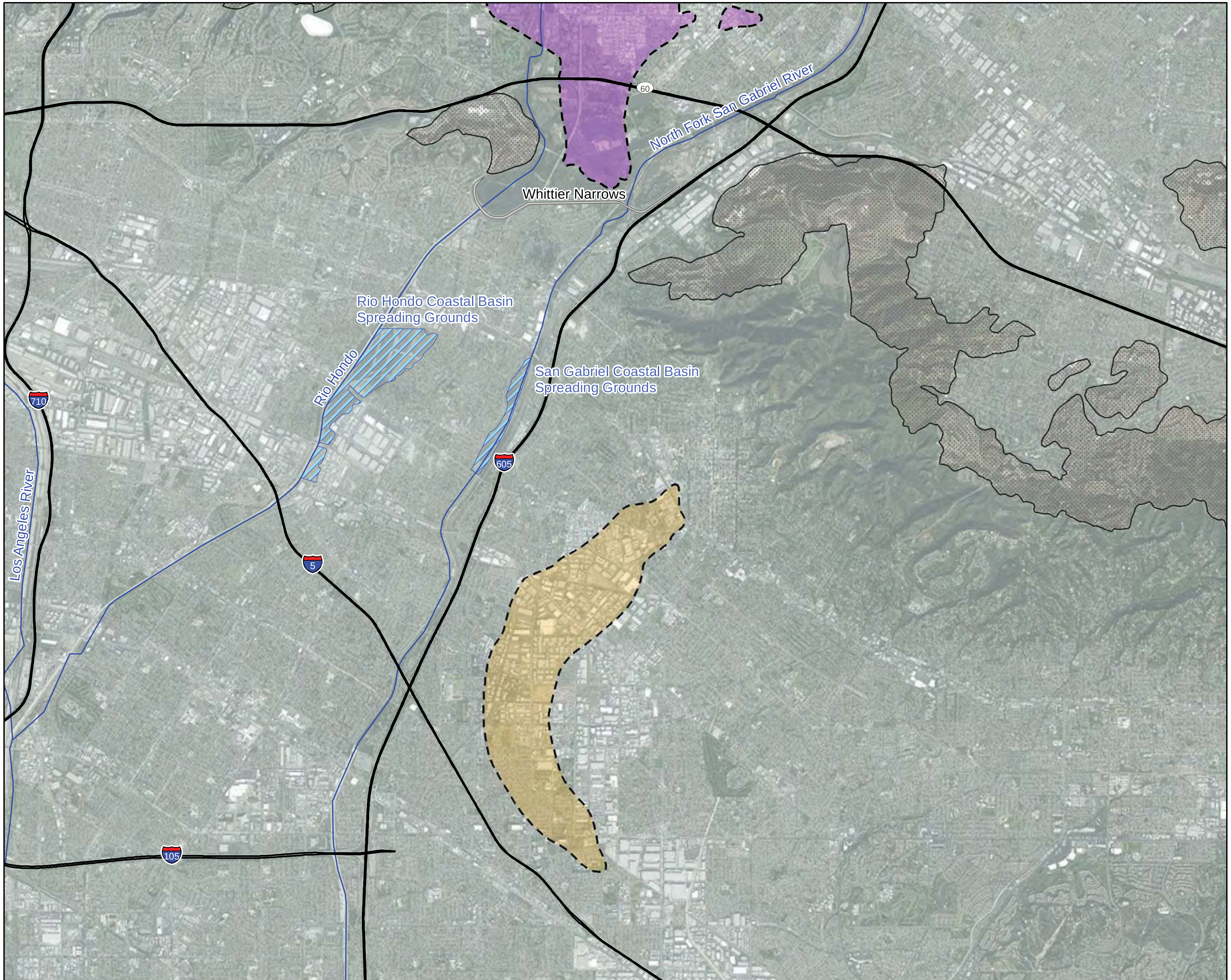
The MFSG is located downstream of the WND. The WND discharges to two different watersheds: the Rio Hondo on the west (Los Angeles River Watershed), and the San Gabriel River on the east (San Gabriel River Watershed). Both facilities are located approximately 2 miles downstream of the WND. The RHCBSG is located on both sides of the Rio Hondo. The SGCBSG is located along the west side of the San Gabriel River. Figure 10 shows the locations of the MFSG, WND, and other important features.

3.1 Existing Recharge Operations

One of the main objectives of the MFSG is to recharge local water flow released from the WND. The system also has the capacity to take tertiary treated recycled water flows from the Whittier Narrows Wastewater Reclamation Plant (WNWRP), the SJCWRP, and the Pomona Wastewater Treatment Plant, as well as imported water from upstream Metropolitan Water District of Southern California (MWD) connections. The MFSG can accept recycled water flows from upstream wastewater treatment plants that discharge to lined streambeds that flow to the San Gabriel River. When stormwater flows exceed the infiltration capacity of the MFSG, stormwater can be temporarily stored behind the WND in a conservation pool and released when infiltration capacity is available.

The Rio Hondo is lined below the WND. Stormwater and recycled water flow from upstream sources are diverted into the basins via diversion gates along the Rio Hondo. The San Gabriel River below the WND is unlined north of Firestone Boulevard. The SGCBSG incorporates seven in-channel basins separated by inflatable dams, as well as three off-channel basins fed by diversion gates. In addition, tertiary treated recycled water can be diverted from the SJCWRP outfall pipeline into the basins.

Figure 11 shows the annual volumes of water sources applied (spread) at the MFSG for water years 2001 through 2010. Table 1 summarizes important water quality parameters for these water sources. Figure 11 and Table 1 exclude non-applied inflow components (groundwater underflow and infiltration of precipitation) to the MFSG because this discussion focuses on the quality of applied water. Refer to Section 3.3.4 for a discussion of the non-applied inflow components and the recycled water contribution (RWC) limit for the MFSG.



LEGEND

- Major Road
- River/Stream
- Whittier Narrows Dam
- Spreading Basin
- Bedrock
- Whittier Narrows OU Composite Shallow and Intermediate Zone PCE Plume
- Omega Chemical Superfund Site OU2 Boundary

Notes:
Whittier Narrows OU Composite Shallow and Intermediate Zone PCE Plume based on the maximum extent of PCE above the California MCL in the Shallow and Intermediate Zones through November 2012.
Omega Chemical Superfund Site OU2 Boundary based on the maximum extent of VOC plumes through the first quarter of 2011.
MCL = maximum contaminant level
OU = operable unit
PCE = tetrachloroethene
VOC = volatile organic compound

Aerial Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Map Projection: UTM Zone 11N
Datum: NAD 1983

0 3,000 6,000
Approximate scale in feet
1 inch = 6,000 feet

N

FIGURE 9
Major Groundwater VOC Plumes
Groundwater Reliability Improvement Program

EN0113151018SCO Figure_9_v2.mxd

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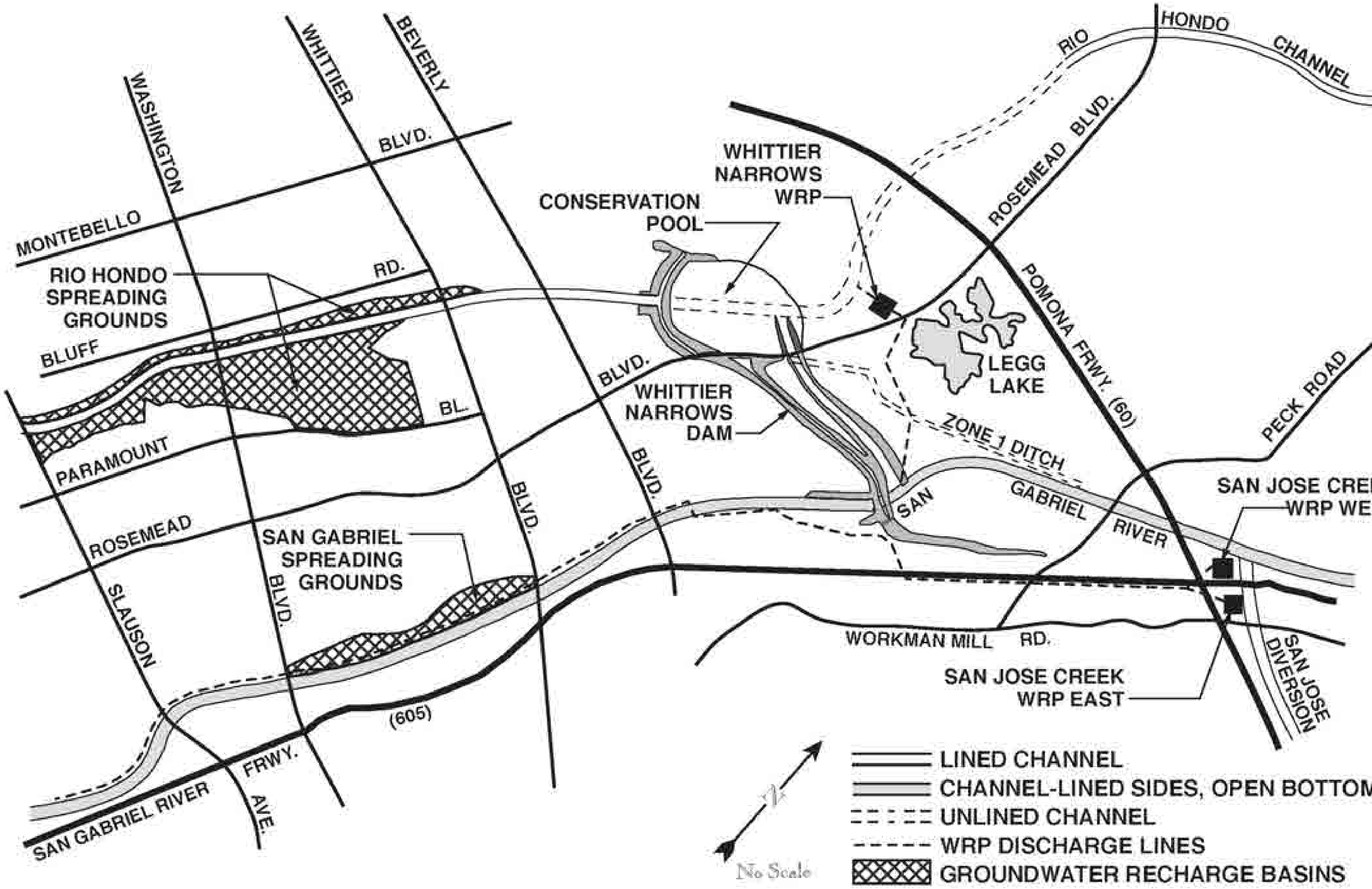

FIGURE 10
Montebello Forebay Groundwater Recharge Facilities
Groundwater Reliability Improvement Program

Source: LACSD, 2014 (Figure 2.1)

EN0113151018SCO Montebello_Forebay_GW_recharge_facilities.ai 1/15

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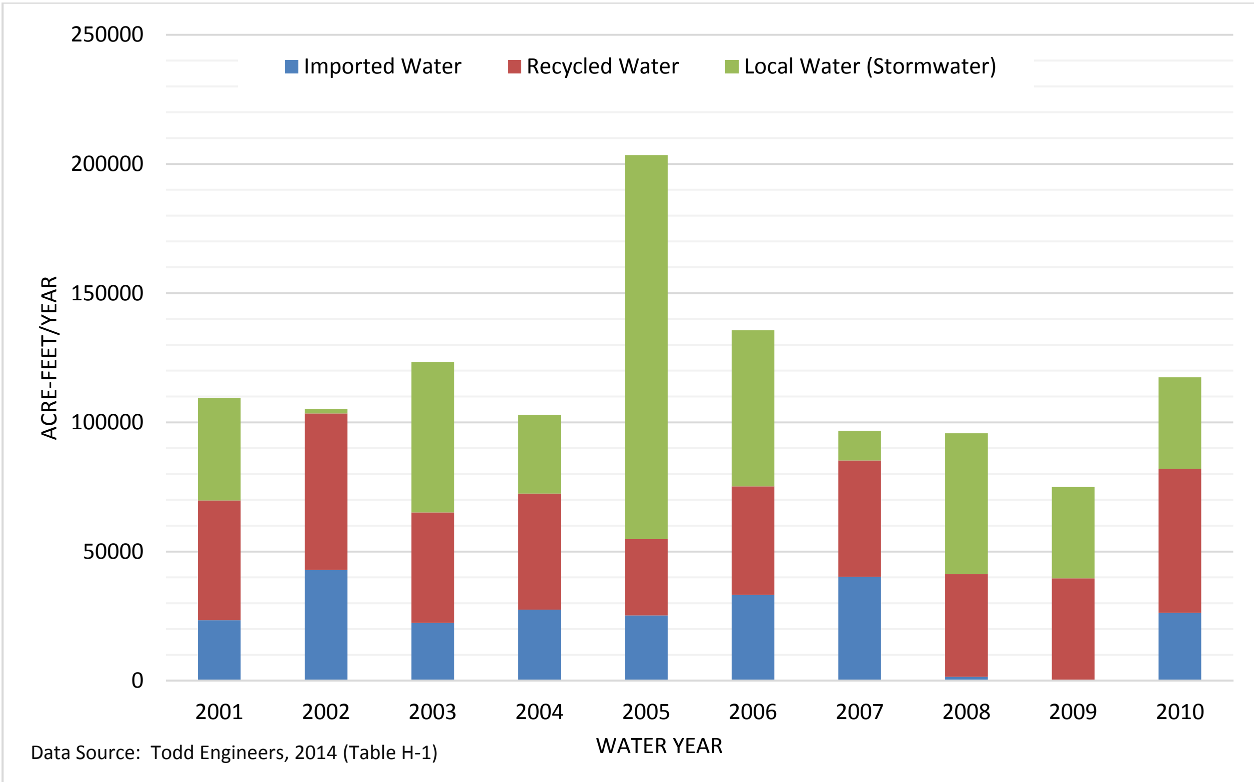


FIGURE 11
Sources of Applied Water MFSG – Water Years 2001-2010
Groundwater Reliability Improvement Program

TABLE 1
Quality of Applied Water MFSG – Water Years 2001-2010
Groundwater Reliability Improvement Program

Water Source	TDS (mg/L)	CL (mg/L)	NO_3 - (N) (mg/L)	Average Annual Volume Applied (AFY)[a]
Local Water	259	40	1.58	49,120
Imported Water				
Colorado River	624	88	0.21	7,233
State Water Project	251	68	0.67	16,347
Recycled Water				
San Jose Creek West	533	109	5.63	34,493
San Jose Creek East	626	149	3.41	
Whittier Narrows	550	105	6.31	6,987
Pomona	545	126	4.41	3,154
Volume Average Baseline (2001-2010)	419	86	2.36	

[a] Average annual volume for water years 2001-2010

CL – chloride

NO_3 - (N) – nitrate as nitrogen

Data source: Todd Engineers, 2014 (Tables 10, H-1, 1-9,1-4 and 1-5)

3.2 Proposed Operations—GRIP

The annual volume of imported water used for groundwater replenishment at the MFSG has varied over time (Figure 11) based on availability and cost. GRIP would replace this uncertain and variable source of supply for replenishment with a relatively constant supply of recycled water. The project would increase the quantity of recycled water available for recharge in the MFSG from approximately 50,000 AFY to 71,000 AFY. The additional 21,000 AFY of recycled water applied to the basins would be a combination of tertiary recycled water obtained from the SJCWRP (11,000 AFY) and AWT obtained from a newly constructed treatment plant (10,000 AFY).

Figure 12 illustrates projected annual volumes of applied water sources that would be spread at the MFSG over a 10-year period under GRIP assuming the baseline applied-water components for water years 2001 through 2010, with the exception that imported water supplies have been replaced with 21,000 AFY of GRIP recycled water. Table 2 summarizes projected water quality parameters for these applied water sources. The average quality of applied water under GRIP (Table 2) is similar to baseline conditions (Table 1) because the quality of the AWT/tertiary treated blend is similar to that of the imported water.

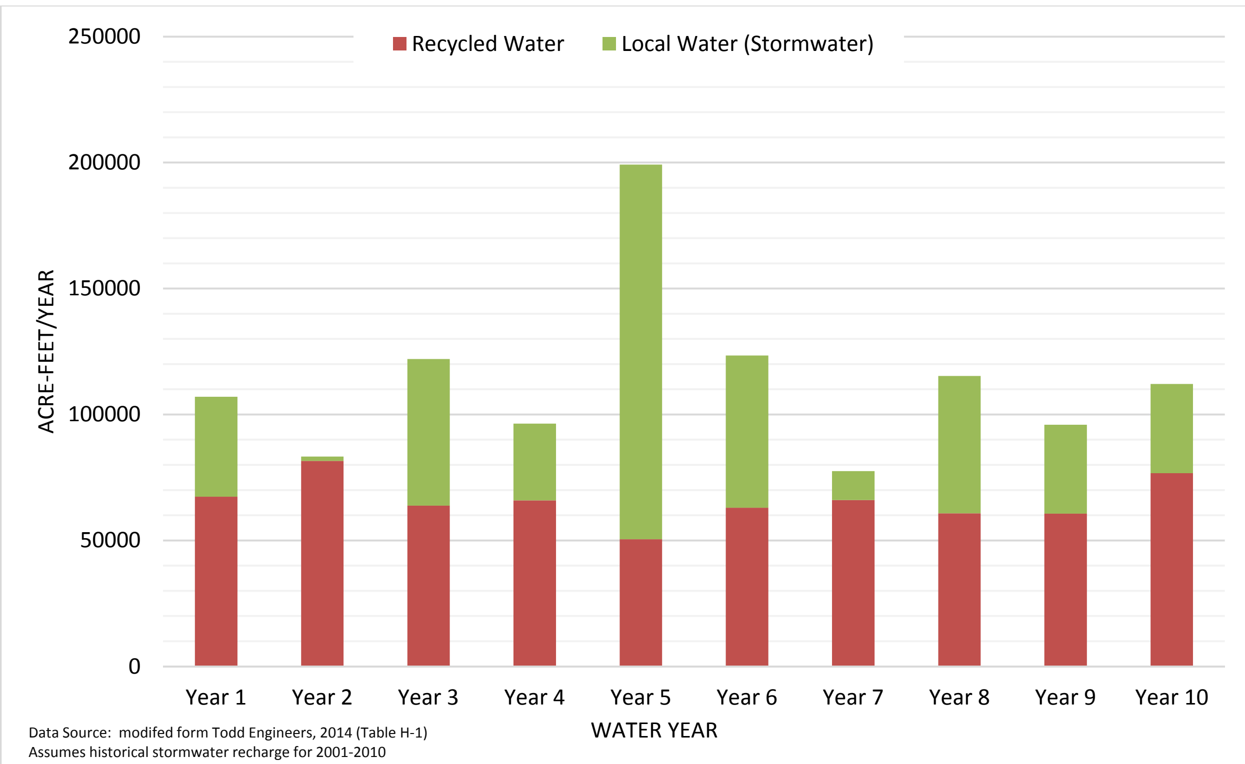


FIGURE 12
Projected Sources of Applied Water – GRIP
Groundwater Reliability Improvement Program

TABLE 2
Projected Quality of Applied Water MFSG – GRIP
Groundwater Reliability Improvement Program

Water Source	TDS (mg/L)	CL (mg/L)	NO_3 - (N) (mg/L)	Average Annual Volume Applied (AFY)[a]
Local Water	259	40	1.58	49,120
Tertiary Recycled Water				
San Jose Creek West	533	109	5.63	45,493
San Jose Creek East	626	149	3.41	
Whittier Narrows	550	105	6.31	6,987
Pomona	545	126	4.41	3,154
AWT Recycled Water	98	37	0.79	10,000
Volume Average, GRIP	422	89	2.60	

[a] Assumes projected average annual volume for water years 2001-2010, an additional 11,000 AFY of tertiary recycled water, and an additional 10,000 AFY of AWT recycled water

Data source: Todd Engineers, 2014 (Tables 10, H-1, I-9, 1-4 and 1-5)

3.3 Potential Operational Constraints

Potential constraints associated with the GRIP project include:

- Availability of recycled water for application at the MFSG
- Competing use for recharge capacity of stormwater flows
- Maintaining a mix of tertiary treated and AWT recycled water for effective soil aquifer treatment (SAT)
- Compliance with the RWC criterion

3.3.1 Availability of Recycled Water

The availability of recycled water for GRIP was evaluated previously (CH2M HILL, 2013). A “worst case” scenario was examined to evaluate the adequacy of the SJCWRP’s recycled water supply versus projected demands. The analysis conservatively assumed summer period recycled water supply, when SJCWRP recycled water production and the additional recycled water available from minor diversions would be at their lowest levels. The analysis included existing WRD recycled water demands, new demands from GRIP, and non-WRD demands.

The findings confirm that supply of recycled water at the SJCWRP is adequate for the additional 21,000 AFY of recycled water demand for GRIP. Table 3 summarizes the findings of this analysis.

TABLE 3
Summer Month Recycled Water Availability – SJCWRP
Groundwater Reliability Improvement Program

Category	Recycled Water (AFM)
Supply	
Available Recycled Water	6,519
Supplies from Minor Diversions	1,447
Total Available Supply	7,966
Demand	
Non-WRD Demand	1,775
Baseline WRD Demand	4,150
GRIP Demand	1,750
Total Demand	7,675
Available Recycled Water	+ 291

AFM – acre-feet per month
Data source: CH2M HILL, 2013 (Table 4-4)

3.3.2 Recharge Capacity Limitations

The MFSG currently recharges a combination of stormwater, imported water, and recycled water. GRIP replaces variable imported water supplies with a relatively constant supply of tertiary treated and AWT recycled water (approximately 6,000 AFM), but the project does not impact the overall recharge capacity of the basins. Stormwater flows, however, are highly variable, unpredictable, and can compete with recycled water sources for available recharge capacity. Figure 13 illustrates historical monthly variability in recycled water and stormwater sources applied at the MFSG.

The average sustainable recharge capacity of the MFSG is estimated at 15,000 AFM (CH2M HILL, 2013). Historical recharge records for water years 2000 to 2010 suggest that during a typical year, capacity would be available for the additional recycled water recharge under GRIP. For 1 to 2 months per year, however, stormwater recharge has exceeded the average recharge capacity (Figure 13), indicating recharge capacity may not be available to accept all stormwater and recycled water supplies during those months. During exceptionally wet weather, stormwater recharge has exceeded the average recharge capacity for extended periods (3 to 4 months).

Historically, the MFSG has been managed to preferentially apply stormwater for spreading when available. In the case of GRIP, however, a relatively constant supply of ATW would be available year-round for spreading. The ATW would be produced solely to supply high-quality water for groundwater replenishment. Given this fact, operators may choose to preferentially apply AWT (approximately 800 AFM) water, even when stormwater is available for recharge. It may be possible to temporarily impound stormwater flows in the conservation pool behind the WND until recharge capacity is available for both water sources.

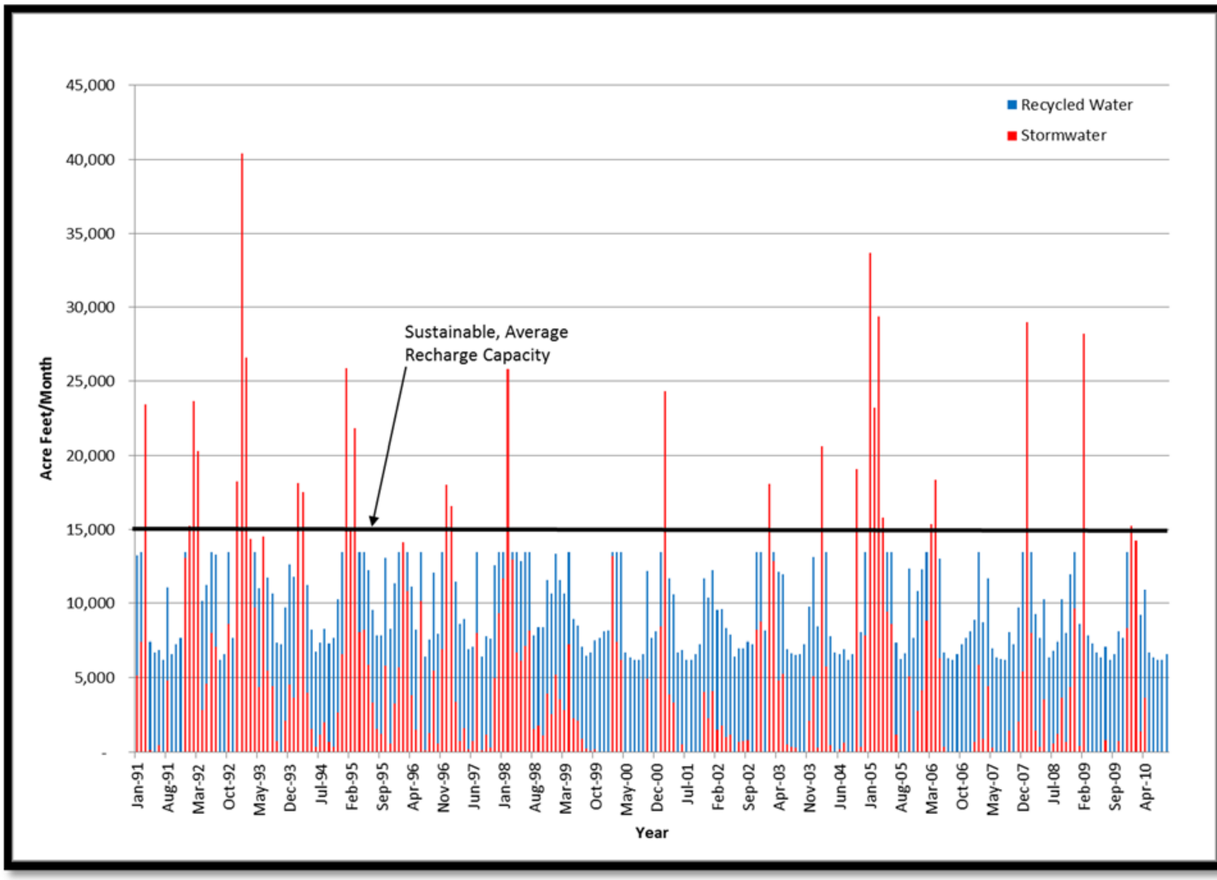


FIGURE 13
Monthly Recycled and Stormwater Recharge, 1991-2010
Groundwater Reliability Improvement Program

3.3.3 Blending of AWT and Tertiary Treated Water

Surface application of tertiary treated recycled water at the MFSG relies on SAT within the recharge basin and shallow vadose zone to remove residual pathogens, nitrogen, organic carbon, and contaminants of emerging concern (CECs) prior to recharge. SAT is biologically mediated and requires a continuous delivery of dissolved organic carbon and nutrients to maintain this natural attenuation process. AWT typically results in high-quality effluent with no detectable pathogens, low concentrations of nitrogen species, and less than 0.5 mg/L of total organic carbon (TOC). Such low levels of TOC will not support abundant microbial growth, and sequential spreading of tertiary treated recycled water and AWT recycled water may impact SAT performance (CH2M HILL, 2013).

GRIP would apply a blend of AWT and tertiary treated recycled water recharge in the MFSG. Previous studies have demonstrated that recycled water blends up to 75 percent AWT water and 25 percent tertiary treated water would not adversely impact SAT performance (CH2M HILL, 2013). Although not evaluated in that study, blending of AWT recycled water with stormwater flows is also expected to sustain SAT processes, because stormwater flows to the MFSG contain higher concentrations of degradable TOC than tertiary treated recycled water (Ly and Johnson, 2011).

Future operations would manage recycled water blends so the AWT component does not exceed this threshold. Based on expected total recycled water application rates (71,000 AFY), the annual average recycled water blend under GRIP would be approximately 14 percent AWT water (10,000 AFY) and 86 percent tertiary treated water (61,000 AFY).

3.3.4 Recycled Water Contribution (RWC)

The permitted maximum RWC for the MFSG is 45 percent (Los Angeles Regional Water Quality Control Board [LARWQCB] Order R4-2009-0048-A-01). In accordance with Order R4-2009-0048-A-01, the following inflow components to the MFSG are used to compute the RWC: recycled water, imported water, stormwater (local water), groundwater underflow, and infiltration of precipitation that occurs at the spreading basins. GRIP would replace imported water supplies with recycled water.

The existing permit requires the RWC to be calculated by computing the amount of recycled water applied over a 10-year period, divided by the total inflow from all sources over the same 10-year period. Table 4 summarizes the inflow components at MFSG for water years 2001 through 2010 and the corresponding RWC. The total volume of inflows to the MFSG during this period was approximately 1,497,000 acre-feet. The corresponding RWC was 30 percent.

TABLE 4
MFSG Inflow Components, Water Years 2001-2010
Groundwater Reliability Improvement Program

Water Year	Imported (acre-feet)	Recycled (acre-feet)	Local (acre-feet)	Rainfall (acre-feet)	Underflow (acre-feet)	Total (acre-feet)
2000/01	23,451	46,343	39,725	7,102	27,900	144,520
2001/02	42,875	60,596	17,000	1,195	27,400	149,065
2002/03	22,365	42,796	58,202	7,100	24,000	154,463
2003/04	27,520	44,925	30,467	3,665	24,200	130,777
2004/05	25,296	29,503	148,523	7,100	21,600	232,022
2005/06	33,229	42,022	60,377	5,386	24,300	165,314
2006/07	40,214	45,039	11,495	924	26,400	124,072
2007/08	1,510	39,767	54,518	7,100	30,300	133,195
2008/09	0	39,611	35,348	4,499	31,300	110,758
2009/10	26,286	55,731	35,398	6,220	29,400	153,035
Totals	**242,745**	**446,332**	**491,053**	**50,290**	**266,800**	**1,497,221**
			Recycled Water Contribution 30 percent [a]			

[a] Computed as the total volume of recycled water for previous 10 years divided by the total of all inflows for the same period.

Assuming the 2001 through 2010 baseline inflows for stormwater, groundwater underflow, and infiltration of precipitation; omitting imported water; and increasing recycled water inflows beyond 2001 through 2010 baseline values by an additional 21,000 AFY; the 10-year total volume of inflows under GRIP would be approximately 1,464,000 acre-feet (Table 5). The RWC would be 45 percent (Table 5), which is in compliance with the current permit limit. Ultimately, the recycled water application rates would be managed based on availability of nonrecycled water (diluent water) inflows to comply with the permitted RWC criterion.

TABLE 5
Projected MFSG Inflow Components -GRIP
Groundwater Reliability Improvement Program

Water Year	Imported (acre-feet)	Recycled (acre-feet)	Local (acre-feet)	Rainfall (acre-feet)	Underflow (acre-feet)	Total [a] (acre-feet)
Year 1	0	67,343	39,725	7,102	27,900	142,069
Year 2	0	81,596	17,000	1,195	27,400	127,190
Year 3	0	63,796	58,202	7,100	24,000	153,098
Year 4	0	65,925	30,467	3,665	24,200	124,257
Year 5	0	50,503	148,523	7,100	21,600	227,726
Year 6	0	63,022	60,377	5,386	24,300	153,085
Year 7	0	66,039	11,495	924	26,400	104,858
Year 8	0	60,767	54,518	7,100	30,300	152,685
Year 9	0	60,611	35,348	4,499	31,300	131,758
Year 10	0	76,731	35,398	6,220	29,400	147,749
Totals	**0**	**656,332**	**491,053**	**50,290**	**266,800**	**1,464,475**

Recycled Water Contribution 45 percent [b]

[a] Assumes recycled water, local (storm) water, rainfall, and underflow from 2001-2010 baseline period, an additional 11,000 AFY of tertiary recycled water, and an additional 10,000 AFY of AWT recycled water.

[b] Computed as the total volume of recycled water for previous 10 years divided by the total of all inflows for the same period.

3.3.5 Summary

Recycled water supplies are adequate for the additional 21,000 AFY of recycled water demand for GRIP. In addition, historical records indicate that during a typical water year, recharge capacity would be available for the additional applied recycled water. The actual recycled water application rates, however, would need to be managed to comply with the permitted 45 percent RWC criterion, based on availability of nonrecycled water inflows, and maintain recycled water blends that do not exceed 75 percent AWT to preserve the effectiveness of SAT.

4. Analysis of Potential Groundwater Impacts

The future availability and cost of imported water supplies for groundwater replenishment are uncertain. GRIP would offset the current use of imported water for replenishment with a combination of tertiary treated and AWT recycled water. The overarching goal of the project is to enhance reliability of supply for groundwater replenishment in the Central Basin. The following sections discuss an evaluation of potential impacts to groundwater levels, flow conditions, and quality associated with the project.

4.1 Groundwater Levels and Flow Conditions

Groundwater flow simulation of the proposed GRIP project was performed to evaluate potential changes in groundwater levels, flow directions, and velocities associated with proposed recharge operations under GRIP. The WRD/USGS three-dimensional groundwater flow model, as updated and revised by CH2M HILL for the Groundwater Basin Master Plan (CH2M HILL, 2012), was used to perform the simulations. To simulate potential changes in the groundwater conditions under GRIP, a transient baseline simulation was performed for water years 1991 through 2010 that included the actual imported, recycled, and stormwater components of recharge at the MFSG. A second simulation was performed that excluded the variable component of imported water recharge spread at the MFSG, and replaced it with a constant source of recycled water equivalent to the average imported water component for the simulation period. The results of the two simulations were compared to evaluate potential impacts of GRIP on groundwater levels, flow directions, and velocities.

4.1.1 Groundwater Flow Model Setup for Simulating Recycled Water Recharge

Water years 1991 through 2010 were selected for the period of analysis. This period represents 20 years of operations, with wet and dry periods, so it provides good representation of hydrological variations, and thus variations in groundwater levels. Imported water volumes used for replenishment are highly variable during this period (Table 6). For a conservative assessment of potential impacts, CH2M HILL assumed that all of the imported water recharge was replaced by recycled water recharge. The average annual spreading rate is 24,233 AFY, which exceeds the additional recycled water recharge proposed for GRIP (21,000 AFY).

TABLE 6
Historical Spreading of Imported Water and Model Input Changes to Simulated Spreading
Groundwater Reliability Improvement Program

Water Year Historical	Water Year Projected	Historical Imported Water Spread (acre-feet)	Simulated Recycled Water Spread (acre-feet)	Annual Difference (acre-feet)
1991	2031	56,286	24,233	32,053
1992	2032	43,103	24,233	18,870
1993	2033	16,561	24,233	(7,672)
1994	2034	20,411	24,233	(3,822)
1995	2035	21,837	24,233	(2,396)
1996	2036	17,959	24,233	(6,274)
1997	2037	19,990	24,233	(4,243)
1998	2038	889	24,233	(23,344)
1999	2039	0	24,233	(24,233)
2000	2040	45,037	24,233	20,804
2001	2041	23,451	24,233	(782)
2002	2042	42,875	24,233	18,642
2003	2043	22,365	24,233	(1,868)
2004	2044	27,520	24,233	3,287
2005	2045	25,145	24,233	912
2006	2046	33,229	24,233	8,996
2007	2047	40,214	24,233	15,981
2008	2048	1,510	24,233	(22,723)
2009	2049	0	24,233	(24,233)
2010	2050	26,286	24,233	2,053

( ) = negative values

Recycled water recharge was allocated among the spreading grounds using historical distribution of recharged imported water: 58 percent Rio Hondo Spreading Grounds, 32 percent San Gabriel Spreading Grounds, and 10 percent WND.

4.1.2 Change in Simulated Groundwater Levels

The potential change in groundwater levels associated with GRIP was evaluated at locations near the MFSG, where impacts are expected to be largest. Simulated groundwater levels were evaluated at eight well locations for both baseline (historical) conditions and recharge operations under GRIP. Figure 14 shows the well locations where groundwater levels were evaluated. Figures 15 and 16 show simulated groundwater level hydrographs for both simulation scenarios. To provide a frame of reference for long-term groundwater level responses, the hydrographs show baseline responses for a 40-year simulation period (model years 2010 to 2050, corresponding to water years 1970 to 2010). Relevant findings are as follows.

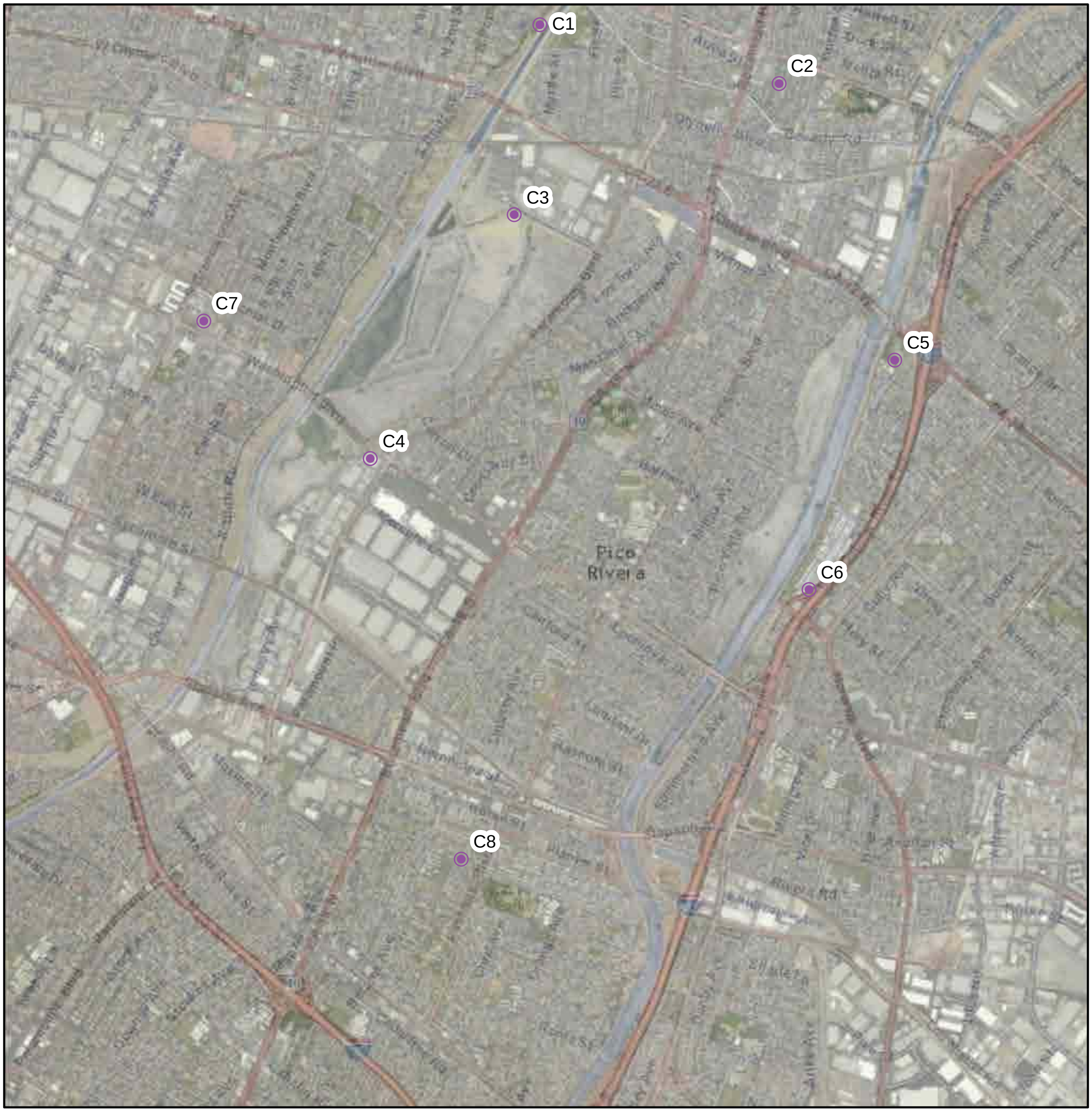
- The simulated groundwater levels for the baseline and GRIP conditions are similar. Differences between the two are nearly imperceptible.
- The simulated groundwater level fluctuations for GRIP are slightly dampened relative to baseline conditions. This reflects the substitution of variable imported water recharge with a constant source of recycled water recharge.
- The simulated groundwater levels are within the range of historical high and low groundwater levels for the simulation period, suggesting that spreading under GRIP will not result in excessive groundwater mounding or adversely lower groundwater levels.

4.1.3 Flow Rate and Direction

Potential changes in groundwater flow directions and velocities associated with GRIP spreading were evaluated by comparing model output of simulated flow vectors. Similar to groundwater level responses, potential changes in groundwater flow were evaluated for the area near the MFSG, where changes would be greatest. Figure 17 shows the output for projected water year 2040 (baseline simulation 2000). The direction of the arrows represents the direction of groundwater flow; the length of the arrows is proportional to groundwater velocity. Vectors were plotted at 5-year intervals. This water year is at the end of a 3-year period with the greatest fluctuations in historical imported water, when the difference between historical and GRIP spreading rates are largest (Table 6). Outputs for other simulation years also were produced and evaluated. Relevant findings are as follows.

- For 2040, the flow velocity is similar for both simulations, but there is a minor (3 degree) difference in flow direction between the scenarios.
- For 2040, the change in flow direction is well within the historical variation of flow direction.
- There is no perceptible difference in groundwater flow conditions or velocities between the two simulations for other time periods evaluated (water years 1995, 2005, and 2010).

Based on this analysis, spreading operations under GRIP would not significantly impact groundwater flow conditions in the vicinity of the MFSG. Potential impacts would be greatest near the MFSG; therefore, these findings also suggest that GRIP would not impact groundwater flow conditions in the wider Montebello Forebay and Central Basin, including the Omega OU2 and WNOU Superfund sites.



LEGEND

Well with hydrograph

0 1,000 2,000 4,000 6,000
Feet

FIGURE 14
Hydrograph Locations
Groundwater Reliability Improvement Program

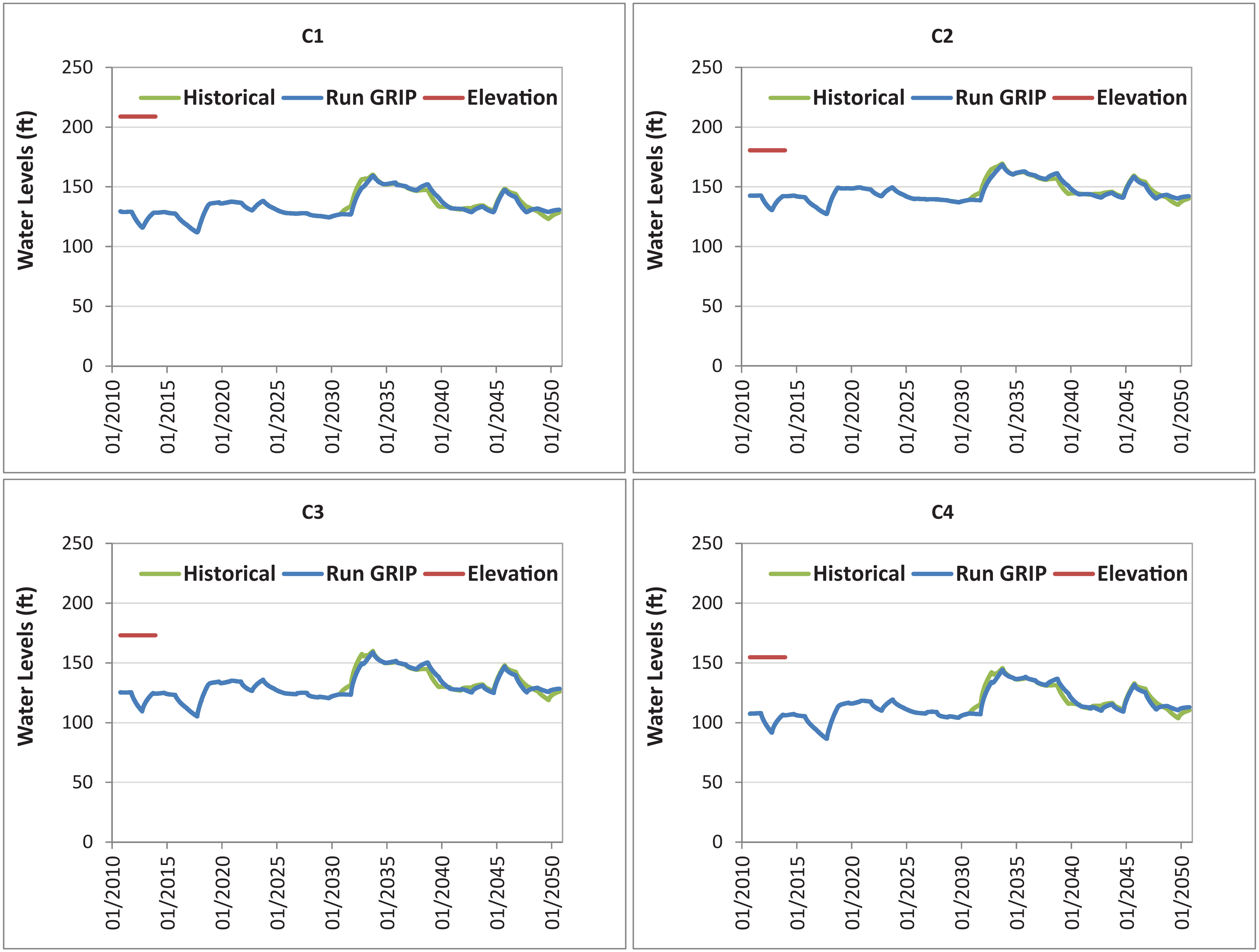


FIGURE 15
Hydrographs, C1 - C4
Groundwater Reliability Improvement Program
CH2MHILL

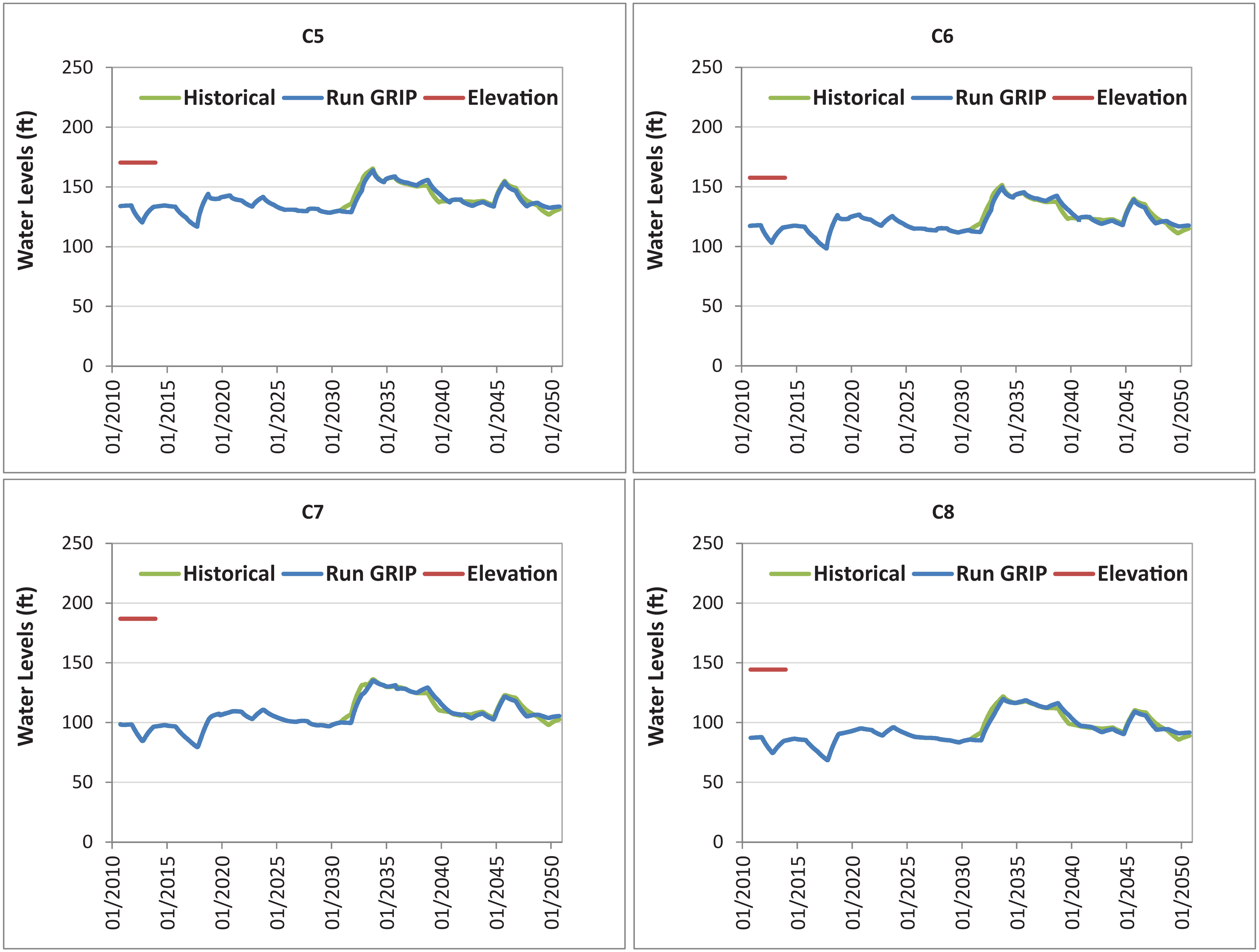


FIGURE 16
Hydrographs, C5 - C8
Groundwater Reliability Improvement Program

CH2MHILL

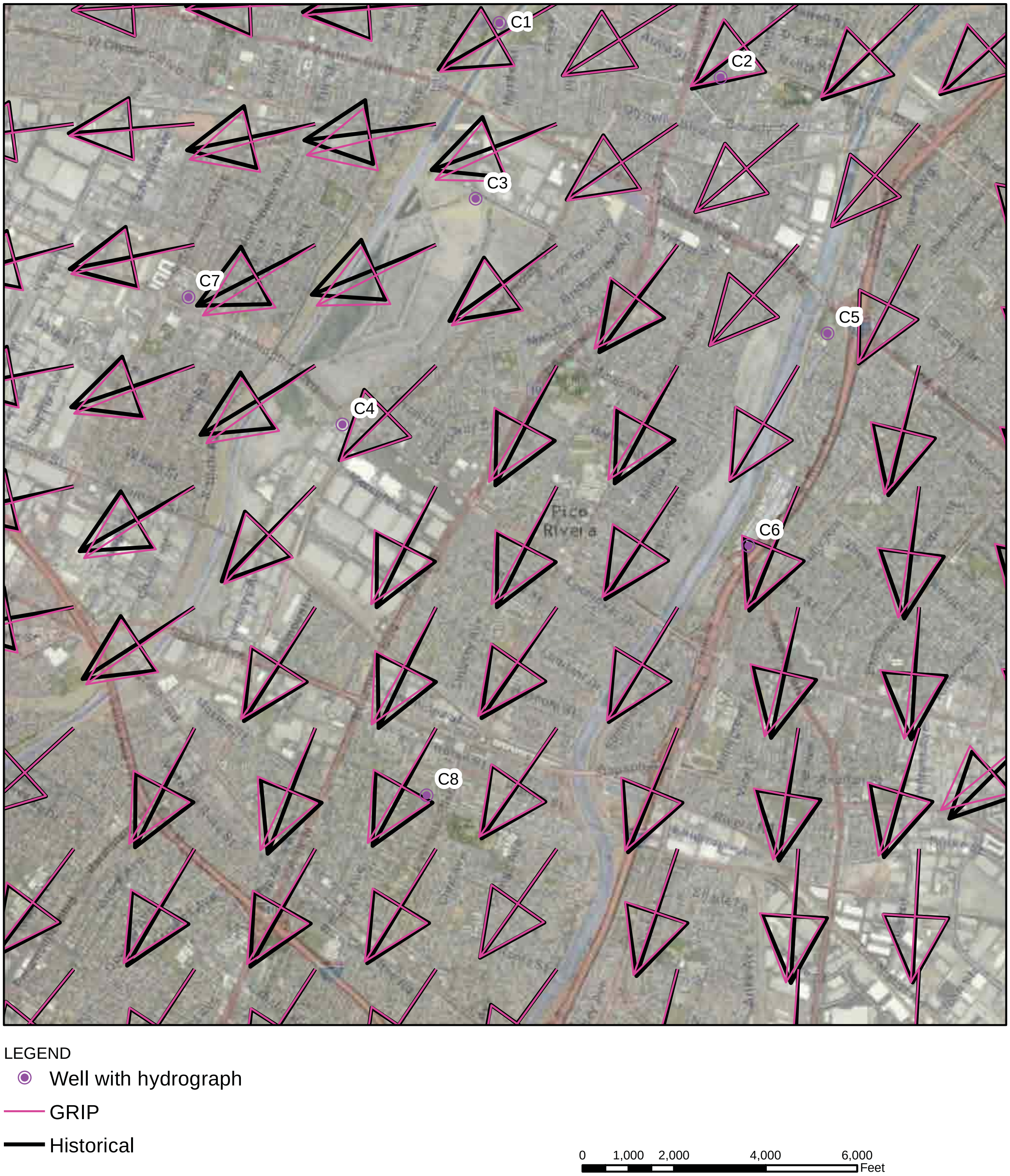


FIGURE 17
Flow Vectors
Layer 1, 2040
Groundwater Reliability Improvement Program

4.1.4 Summary

Changes in simulated groundwater levels, flow rates, and flow directions in response to MFSG operations under GRIP are minor relative to baseline historical conditions. The changes to groundwater levels and flow are small because the total volume of recharge that would be applied under GRIP is the same (on average) as the historical values for the MFSG. The project simply exchanges the variable imported recharge component with a relatively constant source of recycled water recharge. In addition, the absolute differences between the annual imported (historical) and recycled (GRIP) sources (Table 6) are small compared to other recharge components for the Central Basin.

Groundwater production wells in the area have been operated successfully over the range of groundwater levels observed between 1971 and 2010. The simulation results show that predicted water levels under GRIP will remain within this historical range. The findings indicate the project will not adversely impact groundwater production wells (by lowering water levels) in the vicinity of the MFSG.

In addition, the simulation findings indicate GRIP would not significantly modify groundwater flow conditions in the vicinity of the MFSG or the wider Montebello Forebay and Central Basin. The project, therefore, would not adversely impact contaminant plume migration in these areas.

4.2 Groundwater Quality

Approximately 50,000 AFY of recycled water is currently applied at the MFSG. GRIP will increase the volume of recycled water recharge to approximately 71,000 AFY by spreading a combination of AWT recycled water (10,000 AFY) and additional tertiary treated recycled water (11,000 AFY). There is a long history of monitoring and other studies at the MFSG that demonstrate compliance with applicable water quality objectives at the current annual recycled water application rates. This discussion focuses on potential groundwater quality impacts associated with the increased annual recycled water application rate under GRIP. Potential impacts were assessed by evaluating compliance with the following regulatory water quality requirements and policies.

- 2013 State Water Resources Control Board (SWRCB) Recycled Water Policy (RWP)
- 2014 Groundwater Replenishment Regulations (GRRs)
- Basin Plan

4.2.1 2013 Recycled Water Policy (RWP)

The RWP was adopted by the SWRCB on February 3, 2009, and subsequently amended in 2013 to include monitoring for CECs. The RWP includes provisions for managing salts and nutrients on a basinwide, rather than project, basis by developing Salt and Nutrient Plans. The RWP requires Salt and Nutrient Plans to evaluate (1) sources and sinks of salts and nutrients, (2) measures to manage their loading, and (3) compliance with state anti-degradation requirements. The RWP specifies anti-degradation thresholds for groundwater recycling projects based on use of assimilative capacity for a water quality constituent. The RWP also includes requirements for monitoring CECs at projects that apply recycled water for groundwater recharge.

Potential Salt and Nutrient Impacts. WRD submitted the SNMP to LARWQCB in August 2014 (Todd Engineers, 2014). The SNMP evaluated a range of water quality parameters and identified three indicator parameters representative of salts and nutrients in the basins: TDS, chloride, and nitrate. The SNMP evaluated baseline conditions for the MFSG and potential water quality impacts associated with GRIP. Table 7 summarizes the average annual TDS, chloride, and nitrate concentrations for groundwater recharged under baseline conditions (2000-2010) and projected future operations under GRIP (2011-2025). Both are less than the Basin Plan water quality objectives.

TABLE 7
Average Annual TDS, Chloride, and Nitrate Concentrations in Applied Water at MFSG – Baseline and GRIP
Groundwater Reliability Improvement Program

Category	TDS (mg/L)	CL (mg/L)	NO_3 - (N) (mg/L)
Basin Plan Water Quality Objectives [a]	700	150	10
Average Baseline (2000-2010) [b]	419	86	2.36
GRIP (2011-2025) [a]	422	89	2.60

[a] Data source: LARWQCB, 1994

[b] Data source: Todd Engineering, 2014 (Table 10)

mg/L – volume-weighted average concentration of all sources in milligrams per liter

Projected salt and nutrient concentrations of water recharged at the MFSG under GRIP are similar to baseline conditions because the water quality of the AWT/tertiary treated blend that would be applied is similar to that of the imported water it replaces. Consequently, projected salt and nutrient impacts in the Central Basin associated with GRIP are negligible. The project is expected to decrease average TDS concentrations slightly (0.5 mg/L) and increase average chloride and nitrate concentrations by only 0.4 and 0.03 mg/L, respectively, by the end of the 2025 (Todd Engineers, 2014). Based on the findings of the SNMP, GRIP would not cause groundwater concentrations of TDS, chloride, or nitrate to exceed Basin Plan Objectives or utilize significant (greater than 10 percent) assimilative capacity in the Central Basin (Todd Engineers, 2014).

CEC Monitoring and Compliance. The RWP also specifies monitoring requirements for CECs and concentration levels for CECs that trigger response actions. The RWP requires monitoring of eight CECs and surrogate parameters (for example, TOC) for surface application projects like GRIP, in both recycled water and groundwater. LACSD has performed significant monitoring of CECs in effluent from their plants either as a permit requirement or for voluntary effluent characterization.

The current discharge permit for the MFSG does not include monitoring requirements for all of the CECs required by the RWP, but extensive monitoring for one of these compounds, n-nitrosodimethylamine (NDMA), has been performed. NDMA is formed at low levels during wastewater treatment and occurs in tertiary recycled water applied at the MFSG. Previous studies have concluded that a combination of photolytic degradation in surface water and biodegradation in the vadose zone and groundwater significantly reduce NDMA concentrations in recharged water at the MFSG (KJT/LLNL, 2008). In addition, NDMA rarely has been detected at concentrations above the NL (10 nanograms per liter) in shallow monitoring wells in the vicinity of the MFSG (KJT/LLNL, 2008). Reported removal rates of NDMA concentrations between the headworks for recycled water and shallow groundwater have ranged from 74 to 98 percent (KJT/LLNL, 2008). The increase in recycled water recharge proposed under GRIP (from 50,000 to 71,000 AFY) would not impact these attenuation processes. Furthermore, NDMA is not expected to occur at detectable concentrations in the applied AWT recycled water, which may reduce NDMA concentrations in the recycled water blends through dilution.

Laboratory studies have been performed to assess the SAT performance for CECs in tertiary treated/AWT blends in applied recycled water (CH2M HILL, 2013). The findings of these studies suggest that biodegradable CECs would continue to be effectively removed by SAT processes during the increase in the annual recharge volume proposed under GRIP (CH2M HILL, 2013). Concentrations of CECs that are more recalcitrant may increase slightly in groundwater, but that increase may be offset by dilution from the AWT recycled water component of recharge (CH2M HILL, 2013).

Monitoring to assess the effectiveness of CEC removal at the project scale, consistent with RWP requirements, is expected to be incorporated into future discharge permit modifications for the MFSG.

4.2.2 Groundwater Replenishment Regulations (GRRs)

The GRRs were adopted on June 18, 2014. The GRRs specify compliance requirements for groundwater replenishment projects. Requirements for important groundwater quality parameters are summarized briefly in Table 8.

TABLE 8
Groundwater Replenishment Regulations – Water Quality Parameters
Groundwater Reliability Improvement Program

Water Quality Parameter	Requirement
Pathogen Control	10-log Giardia reduction, 10-log Cryptosporidium reduction, and 12-Log Virus reduction, demonstrated through treatment studies and retention time underground, is required.
Nitrogen Compounds	Concentration of total nitrogen in recycled water before or after recharge must be less than 10 mg/L.
Regulated Chemicals and Physical Characteristics	Concentrations of regulated chemicals in recycled water must be less than drinking water MCLs or action levels.
Total Organic Carbon (TOC)	TOC concentration in recycled water after recharge cannot exceed 0.5 mg/L divided by the permitted RWC.
Chemicals of Emerging Concern (CECs)	Demonstrate at least 90 percent removal of CEC indicator compound selected based on an occurrence study of treated recycled water.
Response Retention Time	Minimum retention time underground to respond to treatment failure is 2 days.

The following discussion focuses on the potential impacts to the water quality parameters and requirements presented in Table 8. Compliance requirements for the GRR RWC criterion are discussed in Section 3.2.4.

Pathogen Control. Approximately 50,000 AFY of tertiary treated recycled water is currently applied to the MFSG for groundwater recharge. A minimum of three treatment processes is required, with only 6-log-cycle reduction allowed for each process, to achieve the required reduction in pathogens (Table 8). Current operations comply with the required pathogen reduction through treatment (tertiary treated recycled water) and a minimum retention time underground of 6 months, as determined by tracer testing (using an added tracer). GRIP would increase the annual volume of tertiary recycled water that would be applied, but the average annual volume of water recharged under GRIP (all sources) would be similar to current levels; analysis of future flow conditions suggests little or no change in groundwater flow directions and gradients. Furthermore, the pathogen reduction due to in-plant treatment processes under GRIP would be equivalent (or better for the AWT component) than current levels. Thus, GRIP would not modify existing pathogen-reduction processes (treatment or retention time underground) and is expected to comply with this GRR requirement.

Nitrogen Compounds. GRRs require the total nitrogen concentrations in recycled water before or after recharge to be less than 10 mg/L. Frequent monitoring of tertiary treated recycled water at the wastewater treatment plants that supply recycled water to the MFSG (weekly) and at the headworks for the SGCBSG and RHCBSG (quarterly) have demonstrated compliance with this requirement (LACSD, 2014). The increased volume of tertiary recycled water applied under GRIP would also comply with this requirement; in addition, the AWT component of recharge would have lower total nitrogen concentrations. Blending of these two components may result in lower total nitrogen concentrations in the applied recycled water.

Regulated Compounds and Physical Characteristics. Similar to nitrogen compounds, existing monitoring of tertiary treated recycled water applied at the MFSG demonstrates compliance with drinking water standards for regulated compounds and physical characteristics. The increased volume of tertiary recycled water applied under GRIP would also comply with drinking water standards. The AWT component of recharge is expected to have lower concentrations of these parameters.

Total Organic Carbon. TOC is treated as a surrogate for unregulated organic compounds in recycled water applied for groundwater recharge. The maximum allowable TOC concentration in recycled water after recharge is equal to 0.5 mg/L divided by the permitted RWC. The current RWC for the MFSG is 45 percent, so the maximum TOC concentration currently allowed in recharged recycled water is 1.11 mg/L. TOC compliance is evaluated based on a 20-week running average and the average of the last 4 weekly measurements.

Previous monitoring at the MFSG to assess SAT efficiency has demonstrated significant TOC reductions in the recycled water (and stormwater) during recharge (Ly and Johnson, 2011). The average TOC concentration in recycled water during this testing was approximately 5.61 mg/L; the average concentration of TOC in groundwater was 0.91 mg/L, which demonstrates that approximately 84 percent of TOC in tertiary recycled water applied at the MFSG is removed by SAT processes.

Application of the additional tertiary and AWT recycled water under GRIP is not expected to impact the existing SAT performance, provided the recycled water blend does not exceed 75 percent AWT recycled water. Blends with 25 percent or more of tertiary treated recycled water would provide sufficient TOC and nutrients to maintain SAT (CH2M HILL, 2013).

CEC Indicator Reduction. The GRRs require the project sponsor to identity three indicator CECs based on an occurrence study in the recycled water applied for recharge, and demonstrate greater than 90 percent reduction though SAT processes. Similar to TOC, the increase in annual volume of recycled water is not expected to impact the existing efficiency of SAT removal of degradable CEC indicator compounds. Laboratory studies to assess SAT performance for CECs in tertiary treated/AWT blends in applied recycled water suggest degradable CECs would continue to be effectively removed by SAT processes during the increase in the annual recharge volume proposed under GRIP (CH2M HILL, 2013).

Response Retention Time. Previous tracer testing (using an added tracer) has demonstrated minimum retention times underground for recycled water recharged at the MFSG that exceed the minimum response retention time (2 months) for existing water supply wells in the vicinity of the MFSG. The average annual volume of water recharged under GRIP (all sources) would be similar to current levels, and little or no change in groundwater flow conditions relative to existing conditions is predicted to occur under GRIP. Consequently, the additional recycled water recharge proposed under GRIP would not impact existing response retention time estimates.

4.2.3 Basin Plan Objectives

The Basin Plan designates beneficial uses and water quality objectives for groundwater basins in the Los Angeles Region (LARWQCB, 2003). For the Central Basin, the beneficial uses include municipal drinking water supply; consequently, the Basin Plan incorporates primary and secondary MCLs as groundwater water quality objectives. In addition, the Basin Plan incorporates Central Basin-specific water quality objectives for TDS (700 mg/L), chloride (150 mg/L), sulfate (250 mg/L), and boron (1.0 mg/L), as well as regional requirements for nitrogen compounds (for example, 10 mg/L as N). Long-term water quality monitoring of tertiary treated recycled water applied at the MFSG has demonstrated compliance with these requirements. The additional tertiary recycled water that would be applied under GRIP would also comply with the Basin Plan Objectives. Furthermore, the blends of AWT and tertiary recycled water that would be spread may actually decrease the concentration of these constituents because of the superior water quality of the AWT component.

4.2.4 Summary

Based on the above evaluation, GRIP would comply with the water quality requirements of the GRR, RWP, and Basin Plan. Consistent with the history of groundwater quality compliance at current recycled water application rates, the increased annual recycled water application rate proposed under GRIP would not adversely impact groundwater quality within the Montebello Forebay.

5. Mitigation Requirements

As described above, GRIP would not adversely impact groundwater flow conditions or groundwater quality in the Montebello Forebay area. The project does not require mitigation for these issues. The LARWQCB may require modification to the existing MFSG discharge permit to reflect the planned application of AWT water. Future permit revisions are expected to incorporate the new monitoring requirements of the GRRs and RWP. Monitoring would be performed in accordance with the revised permit conditions.

6. References

Anders, Robert and Roy A. Schroeder. 2003. *Use of Water-Quality Indicators and Environmental Tracers to Determine the Fate and Transport of Recycled Water in Los Angeles County, California.* U.S. Geological Survey Water-Resources Investigations Report 03-4279.

CH2M HILL. 2012. *Draft Report Groundwater Basins Master Plan*. July.

CH2M HILL. 2013. *Preliminary Engineering Report, Groundwater Reliability Improvement Program.* February.

Kennedy Jenks Todd, LCC, and LLNL (KJT/LLNL). 2008. *Final Project Report for Montebello Forebay Attenuation and Dilution Studies Los Angeles County, California*. March.

Los Angeles Regional Water Quality Control Board (LARWQCB). 1994. *Water Quality Control Plan, Los Angeles Region*. June 13.

Ly, Phuong and Ted Johnson. 2011. *75 Consecutive Weeks of Groundwater Sampling For Total Organic Carbon at the Montebello Forebay Spreading Grounds, Los Angeles County, California*.

Reichard, Eric G., Michael Land, Steven M. Crawford, Tyler Johnson, Rhett R. Everett, Trayle V. Kulshan, Daniel J. Ponti, Keith J. Halford, Theodore A. Johnson, Katherine S. Paybins, and Tracy Nishikawa. 2003. *Geohydrology, Geochemistry, and Ground-water Simulation-optimization of the Central and West Coast Basins, Los Angeles County, California.* U.S. Geological Survey Water-Resources Investigations Report 03-4065.

Todd Engineering. 2014. *Draft Salt and Nutrient Management Plan, Central Basin and West Coast Basin, Southern Los Angeles County, California*. August.

Water Replenishment District of Southern California (WRD). 2011. *Water Replenishment District of Southern California, Engineering Survey and Report.* May 6.

Water Replenishment District of Southern California (WRD). 2013. *Regional Groundwater Monitoring Report, Central Basin and West Coast Basin Los Angeles County, California. Water Year 2011-2012*. March.