April 23, 2018

Mr. John Kennedy
Orange County Water District
18700 Ward Street
Fountain Valley, CA 92708

Request for Review of the Geosyntec Report prepared for Poseidon to Evaluate the Feasibility of Subsurface Seawater Intakes in Bolsa, Sunset, and Alamitos Gaps for the Proposed Huntington Beach Desalination Plant dated July 25, 2017

Dear Mr. Kennedy:

For the revision of Poseidon's Huntington Beach Desalination Plant's NPDES permit, the Ocean Plan requires an evaluation of the feasibility of the Subsurface Seawater Intakes (SSI). An evaluation was completed in 2015 for the Talbert Gap, and your office provided comments on that report in a letter dated September 28, 2015. A similar SSI analyses were completed for Bolsa, Sunset, and Alamitos Gaps in the Geosyntec report entitled, 'Groundwater Modeling to Evaluate Feasibility of Subsurface Seawater Intakes in Bolsa, Sunset, and Alamitos Gaps, Water Board Request RCF 23 Alternative Sites Evaluation for the Proposed desalination Project at Huntington Beach' dated July 25, 2017 (2017 Geosyntec Report). The 2017 Geosyntec Report is attached for your use.

This letter is requesting that Orange County Water District (OCWD) review and comment on the 2017 Geosyntec Report. The report evaluated the maximum achievable rate of extraction from each Gap and concluded that pumping from each of the Gaps at these rates would result in negative impacts, including interfering with the seawater intrusion barriers and coastal wetlands. In addition, we are requesting that OCWD assist Regional Board staff with answering the question or providing guidance on how to determine the maximum yield of slant wells at the Gap locations that would not have a negative impact on the seawater intrusion barriers.

In evaluating the maximum safe yield that would not negatively impact groundwater resources and the seawater intrusion barriers, please include in your analysis the potential for existing contaminated groundwater plumes to be drawn in or mobilized if SSIs were installed.

Should you have any questions, please contact me at (951) 782-3284 or email at Jayne.Joy@waterboards.ca.gov.

Sincerely,

Jayne Joy
Assistant Executive Officer

Enclosure: Groundwater Modeling to Evaluate Feasibility of Subsurface Seawater Intakes in Bolsa, Sunset, and Alamitos Gaps, Geosyntec Consultants, July 25, 2017

Geosyntec consultants

595 Market Street, Suite 610
San Francisco, California 94105
PH 415.678.1988
FAX 415.243.0821
www.geosyntec.com

Scott Maloni
Poseidon Resources
5780 Fleet Street, Suite 140
Carlsbad, California 92008

25 July 2017

Subject: Groundwater Modeling to Evaluate Feasibility of Subsurface Seawater Intakes in Bolsa, Sunset, and Alamitos Gaps, Water Board Request RCF 23 Alternative Sites Evaluation for the Proposed Desalination Project at Huntington Beach

Dear Mr. Maloni:

This letter presents results of groundwater models developed to evaluate the feasibility of subsurface seawater intakes (SSIs) along the southern California coastline in Bolsa, Sunset, and Alamitos Gaps (Figure 1). Results of previous modeling of the SSIs along the Huntington Beach coastline in the Talbert Gap is also discussed. The new models were developed in response to remaining information requests by the California State Water Resource Control Board (Water Board, 2017) regarding RCF 23. RCF 23 is one of the Water Board's response, clarifications and findings (RCF) identified during their review (Water Board, 2016) of the application by Poseidon Water for a Water Code Section 13142.5(b) determination for the proposed desalination (desal) project at Huntington Beach. To address RCF 23, the Water Board requires specific estimates of maximum yield and potential impacts from coastal margin SSIs as part of further evaluation of three alternatives sites for desal facilities (1D, 1E, and 1H, Figure 1). Modeling of SSIs at alternative locations is the focus of this letter. The Water Board's remaining outstanding requests for RCF 23 are each listed and addressed in Appendix A.

An Executive Summary below is followed by a summary of previously reported results for the Talbert Gap (Geosyntec, 2013, 2015, 2017), which is followed by documentation of design and discussion of results for each of the three new models. The design for the Bolsa Gap model is provided as a detailed narrative description. This description also generally applies to the Sunset and Alamitos (and Talbert) Gap models. Because detailed descriptions for the three new models would largely be redundant, the design of each model is summarized by Table 1, and only a summary narrative description is provided for Sunset and Alamitos Gap. Sections on each of the models is followed by a Conclusions section that summarizes the findings of additional evaluation of feasibility of SSIs in each of the four gaps.

EXECUTIVE SUMMARY

Geosyntec developed three new groundwater models to evaluate the feasibility of subsurface seawater intakes (SSIs) for alternative locations of desal facilities along the coastline of Bolsa, Sunset, and Alamitos Gaps. The models are similar to those previously developed to evaluate feasibility of SSIs along the Huntington Beach in Talbert Gap (Geosyntec, 2013, 2015, 2017), but with hydrostratigraphy, subsurface geometry, hydraulic properties, and groundwater conditions adjusted for each specific setting based on models developed by Orange County Water District (OCWD) for groundwater resources management and operation of Talbert and Alamitos Injection Barriers (CDM, 2000; Intera, 2010). Table 1 summarizes the model designs and properties of the three new models.

Based on additional groundwater modeling, the estimated maximum possible production rates from subsurface seawater intakes (SSIs) along the coastline in Bolsa, Sunset, and Alamitos Gaps are approximately 15, 9, and 10 mgd, respectively, as compared to approximately 70 mgd for updated modeling of SSIs at Huntington Beach in Talbert Gap[1] (Geosyntec, 2017) using the same base case hydraulic properties for the shallow sediments (Upper Aquitard) overlying the Shallow Aquifer (e.g. Talbert Aquifer). Each is far less than the required design flow of 107 mgd for the proposed desal project. Results of the modeling of SSIs are summarized by Table 2 in terms of calculated portions of water from the ocean, wetlands and inland waterways, and inland aquifers.

The groundwater modeling indicates that a significant portion of the water pumped from SSIs would come from inland aquifers. At Huntington Beach, this would reduce the effectiveness of Talbert Injection Barrier, which is unacceptable to the Orange County Water District (OCWD, 2016). Similarly, at Alamitos Gap, pumping from SSIs would interfere with the performance of the Alamitos Injection Barrier, which is critical for protection of the Central Basin of Los Angeles County and the Orange County Groundwater Basin from seawater intrusion. Moreover, extraction by SSIs of groundwater from inland aquifers in Orange County would be subject to the Replenishment Assessment by the OCWD.

---

[1] The Independent Scientific Technical Advisory Panel (ISTAP) convened and facilitated by Concur under the auspices of the California Coastal Commission and Poseidon Resources determined that slant wells and other types of coastal margin wells are not feasible for the proposed desal project at Huntington Beach because they would interfere with the management of the Talbert Injection Barrier and management of the groundwater basin, and also likely would have complications due to mixing of waters with different geochemistry (ISTAP, 2014).

The pumping from SSIs would also impact ecologically sensitive coastal margin wetland and marsh areas, which is likely to be unacceptable particularly in Bolsa and Sunset Gaps, where large areas of wetlands are within the Bolsa Chica Basin State Marine Conservation Area and Seal Beach National Wildlife Refuge, respectively. Pumping from SSIs beneath Sunset Beach would also mobilize areas of contaminated groundwater.

Because of the low SSI production capability, the large number of slant wells required, and associated infrastructure and conveyance along thousands of feet of coastline, the environmental impact of construction of SSI systems outweighs the potential environmental benefit of a hybrid intake system consisting of both SSIs and an open ocean intake for a desal facility at these locations. Moreover, the SSI systems would be vulnerable to erosion of the beaches and would need to be constructed to withstand future sea level rise.

BACKGROUND

The proposed desalination project site (1G, Figure 1) is in a coastal lowland area known as the Talbert Gap, which is an erosional "gap" in the uplifted coastal margin. The Talbert Aquifer extends offshore through the Talbert Gap and facilitates discharge of groundwater to the sea and inland intrusion of seawater. The Bolsa, Sunset, and Alamitos Gaps, are also lowland areas along the coastline between the uplifted mesas along coastal margin[2]. Holocene coarse-grained sediments compromise shallow aquifers that extend offshore within these gaps. The locations of the erosional gaps between the mesas along the coastline are shown on Figure 1.

The hydrogeology of these erosional gaps along coastal margin have been studied for many years by the Department of Water Resources (DWR) and Orange County Water District (OCWD) because of their influence on seawater intrusion of the coastal margin aquifers. In the coastal portion of the Los Angeles and Orange County Groundwater Basins, the coarse-grained units in the upper aquifer system are overlain by fine-grained sediments of low permeability (e.g. DWR, 1966; Herndon 1992; Edwards et al., 2009).

A more extensive system of deeper aquifers that is the primary source of groundwater production from the Orange County Groundwater Basin underlies the shallow aquifer systems. Displacement along faults (e.g. Newport – Inglewood Fault Zone) approximately parallel to the coastline disrupts the continuity of the deeper aquifer system near the coastline, and locally limits the hydraulic connection of the inland deeper aquifer system to the deep subsurface sediments beneath the ocean. In the Bolsa Gap the faulting has been interpreted to also offset Holocene sediments and limit continuity within the Bolsa Aquifer (e.g. CDM, 2000). Groundwater models have been developed as tools for design and management of injection barriers in the Talbert and Alamitos Gaps that help to replenish th deeper aquifer system and prevent sea water intrusion through the shallow aquifers (e.g. CDM, 2000; Intera, 2010).

A site-specific groundwater model was developed for the proposed desalination project to evaluate feasibility of SSIs along the Huntington Beach coastline in the Talbert Gap (Geosyntec, 2013; 2015; 2017). Documentation of revisions to the slant well geometry in the Huntington Beach model conducted in response to requests by the Water Board (Geosyntec, 2017) also summarizes

[2] The Holocene Aquifer (Shallow Aquifer) is relatively discontinuous in Sunset Gap, which may be a structural depression rather than an erosional feature like the other Gaps.

reviews of the Huntington Beach SSI modeling and numerous sensitivity analyses conducted in response to requests by the Coastal Commission (Geosyntec, 2015).

The groundwater modeling of SSIs at Huntington Beach indicates that a significant portion of the water pumped from the SSIs would come from inland aquifers and reduce the effectiveness of Talbert Injection Barrier, which is unacceptable to the OCWD (2016). The pumping from SSIs would also impact ecologically sensitive coastal margin wetland and marsh areas. The numerous sensitivity analyses of the Huntington Beach SSI modeling show that vertical hydraulic conductivity of the strata overlying the Talbert Aquifer is the most important parameter that influences the relative portions of water from the ocean and inland aquifers that would flow to the hypothetical slant wells (e.g. Geosyntec, 2017).

The three new models presented herein that were developed to evaluate feasibility of SSIs at alternative locations represent generalized site-specific geometry and hydraulic properties of the subsurface in each "gap". Information on subsurface hydraulic properties and groundwater conditions are based primarily on groundwater models of the Orange County coastal margin and vicinity (e.g. CDM, 2000; Intera, 2010) developed for the OCWD, the Water Replenishment District of Southern California (WRD), and the Los Angeles County Department of Public Works (LACDPW).

TALBERT GAP (ALTERNATIVE SITE 1H AND 1G)

Alternative Site 1H is near the coastline adjacent to the Santa Ana River in the southeast portion of the Talbert Gap (Figure 1). The hydrogeologic data and analysis for the proposed site (Site 1G) is directly applicable to the 1H. Consequently, the same limitations for subsurface intakes at 1G apply to 1H. Moreover, modeled slant well SSIs for the proposed project site and for Alternative Site 1H would both need to span essentially the entire Talbert Gap for source water production to approach the design inflow rate of 107 mgd.

As indicated above, documentation of the model design and discussion of results of modeling of SSIs at Huntington Beach have been presented in several previous submittals (e.g. Geosyntec, 2013; 2015; 2017). Figure 2 shows a schematic layout of the modeled series of slant wells along the coastline of the Talbert Gap. To provide an indication of vulnerability of SSIs and associated infrastructure to sea level rise and erosion of the beach, Figure 2 and subsequent figures for the illustrating schematic layout of modeled slant wells in the other gaps include the calculated

shoreline after one-meter sea level rise, the estimated uncertainty of the sea level rise, and the beach erosion uncertainty[3]. Figure 3 is a cross-section illustrating the geometry and representation of slant wells in the Talbert Gap flow model. Figure 4 shows examples of model results of simulated pumping from a series 40 slant wells that would be necessary to achieve a total intake rate of 107 mgd.

The modeling of SSIs at Huntington Beach indicates that a significant portion of the water pumped from the SSIs would come from inland aquifers and reduce the effectiveness of Talbert Injection Barrier. Updated model calculations (Geosyntec, 2015, 2017) indicate that 6 to 15% of the water pumped by the slant wells would come from the injection-replenishment barrier. For a pumping rate of approximately 70 mgd , which is the estimated maximum achievable with Kh and Kv of the Upper Aquitard of 1 and 0.1 ft/d, model calculations indicate that approximately 15 mgd would come from inland aquifers, which is nearly 50% of the typical injection rate of 30 mgd at the barrier (Geosyntec, 2017). Any substantial pumping rate from SSIs beneath the coastline at Huntington Beach would interfere with the operation of the barrier and would be subject to replenishment assessment fees by the OCWD. The pumping from SSIs would also impact ecologically sensitive coastal margin wetland and marsh areas.

Modeling of reduced pumping rates from SSIs along the coastline of Talbert Gap indicates that impacts to inland aquifers and barriers occur regardless of pumping rate and a proportionally larger portion of source water comes from inland for lower pumping rates due relative ease of horizontal flow within the aquifer compared to vertical flow through the low-permeability shallow sediments (Geosyntec, 2015, 2017). Any reduction to the effectiveness of the Talbert Injection and Aquifer Replenishment Barrier is unacceptable to the OCWD (2015, 2016). The Independent Scientific Technical Advisory Panel (ISTAP) determined that slant wells and other types of coastal margin wells are not feasible for the proposed desal project at Huntington Beach because they would interfere with the management of the Talbert Injection Barrier and management of the groundwater basin, and also likely would have complications due to mixing of waters with different geochemistry (ISTAP, 2014).

In addition, while Site 1G is in the central portion of the Talbert Gap, 1H is near the southeastern margin of the Talbert Gap close to the Newport Mesa. Because of the proximity to the Newport

---

[3] Barnard, P.L., Erikson, L.H., Foxgrover, A.C., O'Neill, A.C., and Herdman, M., 2016, CoSMoS (Coastal Storm Modeling System) Southern California v3.0 Phase 2 storm-hazard projections: U.S. Geological Survey Data Release, http://dx.doi.org/10.5066/F7T151Q4

Mesa boundary, the production capacity from the Talbert Aquifer near 1H is lower than at 1G, and drawdown of groundwater levels due to pumping from subsurface intakes located near 1H would be greater than from the central portion. In addition, potential impacts to wetland and marsh areas along the Santa Ana River adjacent to the Newport Mesa would be greater. Therefore, a smaller scale SSI system in the Talbert Gap near Alternative Site 1H would cause more impact than one at the proposed site (1G).

BOLSA GAP (ALTERNATIVE SITE 1E)

Model design

Alternative Site 1E is near the southeast margin of the Bolsa Gap, which is bounded by the Huntington Beach Mesa on the southeast and by the Bolsa Chica Mesa on the northwest (Figure 1). Figure 5 shows the extent of the model domain and a cross-section illustrating the layering for the Bolsa Gap model. The width of the model domain is based on the width of the Bolsa Gap. The inland to offshore extent is similar to the Talbert Gap model and provides more than sufficient distance between the model boundary conditions and area of simulated SSI pumping along the coastline.

The numerical grid consists of 136 rows, 214 columns, and 10 layers. Grid cell horizontal dimensions vary from approximately 60 feet long by 60 feet wide near the coastline in the central portion of the Bolsa Gap, to as large as 500 feet by 500 feet near the margins of the model domain. The 60-foot grid-cell size near the coastline provides sufficient resolution of variation in hydraulic head near simulated slant wells beneath the shoreline and local representation of constant sea level for coastal margin wetland and marsh areas.

Model Layers and Hydraulic Conductivity

Each cell in the numerical model grid is assigned a hydraulic conductivity. The hydraulic gradient and the hydraulic conductivity determine the rate at which water flows through the subsurface medium (and model grid cell). The model is a screening-level tool that represents average hydraulic properties and does not represent variation of hydraulic conductivity within hydrostratigaphic units. Accordingly, uniform hydraulic properties are assigned for each layer in most of the model. Exceptions are areas of reduced hydraulic conductivity where faulting has interrupted continuity of sedimentary units in the Lower Aquifer System, and areas of high

conductivity where the Upper Aquitard between the shallow (Bolsa) aquifer and Lower Aquifer System has been eroded away, which are called mergence zones.

The hydrostratigraphy and model layering is discussed below. The model layering and assigned hydraulic conductivity for all four models is summarized by Table 1.

Layer 1 represents the hydraulic head of the ocean. The inland portion of Layer 1 is inactive except in wetland and inland waterway areas where groundwater levels are fixed at the same level as the ocean.

Layers 2 – 3 represent the generally fine-grained low-permeability sediments between the ground surface (or seafloor) and the top of the shallow aquifer. This interval is called the Upper Aquitard. Horizontal and vertical hydraulic conductivity (Kh and Kv) of 1 and 0.1 ft/d, respectively, is assigned to model Layers 2 – 3 for the base case model. As described above the vertical hydraulic conductivity of the Upper Aquitard is the most important constraint on the hydraulic connection between the underlying shallow aquifer and the sea.

A vertical hydraulic conductivity of 0.1 ft/d for the Upper Aquitard for the base case model is considered a reasonable estimate of large-scale vertical hydraulic conductivity for the Upper Aquitard sediments and is generally consistent with available site-specific data in the vicinity of the proposed desal facility in Huntington Beach (Geosyntec, 2015) and available information for the coastal margin at the other Gaps (Intera, 2010). In some areas, the large-scale vertical hydraulic conductivity of the shallow sediments (Upper Aquitard) may be substantially lower than 0.1 ft/d. However, the assigned value of 0.1 ft/d for the base case model provides a reasonable optimistic hydraulic connection between the shallow aquifer and the sea, and a screening level estimate of SSI production potential in the Bolsa Gap.

Sensitivity analyses were run with ten times lower and higher vertical hydraulic conductivity for the Upper Aquitard, which is the most important parameter controlling the hydraulic connection between the shallow aquifer and the ocean, and therefore the portion of source water derived from the ocean. Kh and Kv for the Upper Aquitard are 1 and 0.1 ft/day for the base case, 1 and 1 ft/d for the high K case, and 0.1 and 0.01 ft/d for the low K case.

Layers 4 – 9 represent the Shallow (Bolsa) Aquifer. The assigned thickness of 50 ft and hydraulic conductivity (Kh = 250 ft/d, Kv = 50 ft/d) near the coast is based on the OCWD groundwater

model (CDM, 2000) and discussion with the Water Board[4]. Multiple model layers within the Bolsa Aquifer facilitate representation of pumping from slant (angle) wells and variation of aquifer thickness.

The OCWD model (CDM, 2000) includes a low permeability zone with in the Bolsa Aquifer associated with the Newport-Inglewood Fault Zone. Kh and Kv of 5 and 1 ft/d are assigned in the Bolsa Aquifer along the fault zone based on the OCWD model.

Except for the low permeability zone in the Bolsa Aquifer along the Newport-Inglewood fault zone, a uniform planar geometry for the Bolsa Aquifer is assumed for modeling purposes in the inland coastal margin and offshore portions of the Bolsa Gap generally consistent with the inland geometry used in the OCWD model (CDM, 2000). The model does not represent the decrease in thickness of the Bolsa Aquifer near the mesas. Accordingly, lower production potential near the margins of the gap is not represented in the model and the model provides an optimistic screening-level estimate of production potential.

The uniform planar geometry and Kh and Kv of 250 and 50 ft/d for the offshore portion of the Bolsa Aquifer in the model, also contributes to an optimistically high transmissivity and hydraulic continuity of the aquifer in the model. The actual transmissivity of the Bolsa Aquifer, and the shallow aquifers in the other gaps, offshore is likely lower due to local channels with intervening fine-grained deposits, and structural segmentation, as exhibited by the geophysical survey conducted at Huntington Beach (Geosyntec, 2015).

Model Layers 10 and 11 represent relatively fine-grained, low-permeability sediments beneath the Shallow (Bolsa) Aquifer. This hydrostratigraphic unit, which is called the Lower Aquitard herein, is approximately 20 feet thick and assigned a Kh and Kv of 10 and 1 ft/d.

Layer 12 represents the underlying aquifers that are called the Lower Aquifer System. For the Bolsa Gap model the Lower Aquifer System is assigned Kh andKv of 300 ft/d, 60 ft/d, and a thickness of 50 ft. The resulting transmissivity of 15,000 ft^2/d is generally consistent with total transmissivity of the Lower Aquifer System including the C, B, A, and I Aquifers in the OCWD groundwater model (CDM, 2000). The detail of groundwater flow within and between the Lower Aquifer System is important for managing inland pumping and injection, but it has little bearing

[4] The Water Board requested a ratio of 5:1 for horizontal and vertical hydraulic conductivity values assigned to aquifer units in the models.

on the production potential and source water assessment for SSIs in the Shallow Aquifer at the coastal margin. Accordingly, the Bolsa Gap and other SSI models presented herein, do not represent individual aquifers in the Lower Aquifer System.

Boundary Conditions

Constant hydraulic heads are specified at the up-gradient margin of the model based on reported water levels (CDM, 2000) and groundwater level data provided by OCWD. The same water level is specified at the upgradient and downgradient boundaries for all model layers. The offshore margin is assigned a constant head of 0.57 ft MSL as in the OCWD model (CDM, 2000). A constant head of 0.57 ft MSL is also specified for all cells in the offshore portion of Layer 1, which represents the ocean.

A uniform recharge rate of 1 in/yr, based on the OCWD model (CDM, 2000) is assigned to the uppermost active layer in the model.

Model Pumping from Slant Wells

The width of the Shallow Aquifer in the Bolsa Gap along the coastal margin is approximately 8000 feet (1.5 miles). The model represents pumping from a series of eighteen slant wells[5], separated by ~470 ft and spanning approximately 1.5 miles of the shoreline (Figure 6). The total length of each hypothetical slant well is approximately 400 ft, of which the lower 200 ft is screened. The model slant wells are at an angle of approximately 20 degrees below horizontal and the vertical depth of each model slant well is approximately 125 ft. Due to the large width of the Bolsa Chica Beach, and vulnerability of the beach to erosion and sea level rise, the well heads of the slant well SSIs would need to be approximately 500 feet from the average shoreline. Consequently, most of the slant wells along the coastline in the Bolsa Gap would reach the bottom of the Bolsa Aquifer approximately 150 feet inland of the shoreline as is illustrated by Figure 7.

The geometry of the slant wells represented by the model is similar to the slant well installed at Dana Point (US Bureau of Reclamation, 2009) and is consistent with current drilling technology capability for angle-well drilling.

---

[5] Fewer slant wells are in the Bolsa Model than for Talbert Model because the length of the coastline (width of the gap), and thickness of the Shallow Aquifer is less in the Bolsa Gap. The number of wells in the models for Sunset and Alamitos Gaps are also related to the widths of the gaps and transmissivity of the Shallow Aquifer.

Model results for Bolsa Gap

The estimated maximum sustainable pumping rate from the shallow aquifer beneath the coastal margin of Bolsa Gap is approximately 15 million gallons per day (mgd), or 570 gpm per well for a series of 18 wells along 1.5 miles of coastline[6]. The actual production rate would vary per well and the sustainable rate per well could be considerably lower. Moreover, additional wells would be required to provide standby capacity to allow maintenance of the wells.

Model results for the base case properties indicate that 79% of the 15 mgd pumped by the slant wells comes from the ocean, 3% comes from the wetlands and inland water ways, and 18% comes from inland aquifers. Figure 8 shows contours of the calculated drawdown of the water table, and groundwater flowpaths induced by pumping of 15 mgd from the series of 18 slant wells in the Bolsa Aquifer beneath Bolsa Chica Beach.

Sensitivity analyses were run with ten times lower and higher vertical hydraulic conductivity for the Upper Aquitard, which is the most important parameter controlling the hydraulic connection between the shallow aquifer and the ocean, and therefore the portion of source water derived from the ocean. Kh and Kv for the Upper Aquitard are 1 and 0.1 ft/day for the base case, 1 and 1 ft/d for the high K case, and 0.1 and 0.01 ft/d for the low K case. A sensitivity run was also conducted based on mapping of a large inland area where the shallow aquifer is interpreted to merge with the Lower Aquifer System and thus the lower aquitard does not exist (CDM, 2000; OCWD email 6 June 2017). For this sensitivity run the "lower aquitard layers" in the mergence zone were assigned a Kh and Kv of 125 and 25 ft/d, respectively, as opposed to 10 and 1 ft/d. The model results for the base case model and sensitivity runs in terms of calculated portions of water from the ocean, wetlands and inland waterways, and inland aquifers are summarized by Table 2.

For the base case model, the calculated drawdown of the water table exceeds 10 feet to approximately 7000 ft inland from the shoreline and well beyond the ends of the 1.5-mile-long series of slant wells. Drawdown of the water table of more than 20 feet extends beneath portions of Pacific Coast Hwy. The large drop in the water table that would be caused by pumping of groundwater along the coastal margin of Bolsa Chica Beach at rates on the order of 15 mgd could

[6] Note that the results of the groundwater flow analysis depend on the total pumping rate and extent of the series of wells, but not the details of the number of slant wells.

also result in subsidence of the ground surface[7], which could impact the structural integrity of the Pacific Coast Hwy and other structures in the vicinity.

Pumping from the slant well SSIs beneath Bolsa Chica Beach would impact coastal margin wetlands, which is likely unacceptable in the Bolsa Chica Basin State Marine Conservation Area (Figure 1). A recent study of coastal margin wetlands near the Mediterranean Sea determined that groundwater provides 15 to 80% of the water in the lagoons during the dry season. The findings indicate that maintaining groundwater fluxes toward the ocean is necessary to preserve the coastal margin lagoons and their salinity conditions (Mencio et al., 2017).

SUNSET GAP (ALTERNATIVE SITE 1D)

Model design

The Sunset Gap is bounded by the Bolsa Chica Mesa on the southeast and by Landing Hill on the northwest (Figure 1). Alternative Site 1D is southeast of the San Gabriel River and inland of Landing Hill. It is within the inland part of Alamitos Gap, but since it is southeast of the San Gabriel River it would be more easily served by SSIs in Sunset Gap than in Alamitos Gap. Figure 9 shows the extent of the model domain and a cross-section illustrating the layering for the Sunset Gap model. The width of the model domain is based on the width of the Sunset Gap. The inland to offshore extent of the model is similar to the Talbert Gap model and provides more than sufficient distance between the model boundary conditions and area of simulated SSI pumping along the coastline.

The hydrostratigraphy and hydraulic properties for the Sunset Gap model are based on the southeastern portion of the Alamitos Barrier Model (Intera, 2010), which overlaps with the Sunset Gap area. A low hydraulic conductivity zone is assigned to lower aquifer along the Newport-Inglewood Fault Zone based on the Alamitos Barrier Model (Interra, 2010). The model design is summarized by Table 1.

[7] Groundwater pumping from unconsolidated alluvial aquifer systems has resulted in significant land subsidence at many localities in the world, particularly in settings were an alluvial aquifer is overlain by a fine-grained confining layer (e.g. Freeze and Cherry, 1979).

Model Pumping from Slant Wells

The width of the Shallow Aquifer in the Sunset Gap along the coastal margin is approximately 13,860 feet (nearly 2.6 miles). The model represents pumping from a series of 31 slant wells, separated by ~315 ft and spanning approximately 9400 ft (1.8 miles) of the shoreline (Figure 10). The total length of each hypothetical slant well is approximately 270 ft, and the lower 100 ft is screened within the Shallow Aquifer (Figure 11). The model slant wells are at an angle of approximately 17 degrees below horizontal and the vertical depth of each model slant well is approximately 80 ft.

As shown by Figure 11, the model represents the screened interval of the slant wells beginning beneath the coastline. However due to the shallow depth and small thickness of Shallow Aquifer at Sunset Gap, the well-heads for slant wells installed at an angle of 17 degrees below horizontal would be less than 200 feet from the coastline within the beach and require engineering measures to protect the wells from erosion and sea level rise. Installing the slant wells farther from the beach may be preferable, but would slightly decrease the portion of ocean water pumped.

Model results for Sunset Gap

The estimated maximum sustainable pumping rate from the shallow aquifer beneath the coastal margin of Sunset Gap is approximately 9 mgd, or 208 gpm per well for a series of 31 wells along 1.8 miles of coastline[8]. The actual production rate would vary per well and the sustainable rate per well could be considerably lower. Moreover, additional wells would be required to provide standby capacity to allow maintenance of the wells.

Model results for the base case properties indicate that 78% of the 9 mgd pumped by the slant wells comes from the ocean, 9% comes from the wetlands and inland water ways, and 13% comes from inland aquifers. Figure 12 shows contours of the calculated drawdown of the water table, and groundwater flowpaths induced by pumping of 9 mgd from a series of 31 slant wells in the Shallow Aquifer beneath Sunset Beach.

[8] Note that the results of the groundwater flow analysis depend on the total pumping rate and extent of the series of wells, but not the details of the number of slant wells.

Locations of environmental cleanup and waste disposal sites based Geotracker[9] are included on the model results shown on Figure 12. Contamination of groundwater may be associated with many of these sites. Figure 12 also shows the location of a large plume of trichloroethene (TCE) in groundwater at the Seal Beach Naval Weapons Station. Concentrations of TCE exceed 250 ug/L within the delineated plume (Tetra Tech, 2012). The model results (Figure 12) show that several of the environmental sites are within the extent of more than 20 feet of drawdown of the water table associated with pumping from SSIs along Sunset Beach, and flowpaths groundwater to the SSIs extend beneath the NWS TCE plume. The contaminated sites could impact the quality of water pumped by SSIs, and the pumping would mobilize contaminated groundwater and potentially interfere with remediation.

Sensitivity analyses were run with ten times lower and higher vertical hydraulic conductivity for the Upper Aquitard, which is the most important parameter controlling the hydraulic connection between the shallow aquifer and the ocean, and therefore the portion of source water derived from the ocean. Kh and Kv for the Upper Aquitard are 1 and 0.1 ft/day for the base case, 1 and 1 ft/d for the high K case, and 0.1 and 0.01 ft/d for the low K case. The model results for the base case model and sensitivity runs in terms of calculated portions of water from the ocean, wetlands and inland waterways, and inland aquifers are summarized by Table 2.

For the base case model, the calculated drawdown of the water table exceeds 10 feet to approximately 2000 ft inland from the shoreline and well beyond the ends of the 1.8-mile-long series of slant wells. Drawdown of the water table of more than 20 feet extends beneath portions of Pacific Coast Hwy and numerous residential properties along Sunset Beach. The large drop in the water table that would be caused by pumping of groundwater along the coastal margin of Sunset Beach at rates on the order of 9 mgd could also result in subsidence of the ground surface[10], which could impact the structural integrity of the Pacific Coast Hwy and other structures in the vicinity. Pumping from the slant well SSIs beneath Sunset Beach would impact coastal margin wetlands, which is likely unacceptable in the Seal Beach National Wildlife Refuge (Figure 1). A recent study of coastal margin wetlands near the Mediterranean Sea determined that groundwater

---

[9] Geotracker is the Water Board's web-based data management system for sites that impact or have potential to impact water quality, with emphasis on groundwater. https://geotracker.waterboards.ca.gov/

[10] Groundwater pumping from unconsolidated alluvial aquifer systems has resulted in significant land subsidence at many localities in the world, particularly in settings were an alluvial aquifer is overlain by a fine-grained confining layer (e.g. Freeze and Cherry, 1979).

provides 15 to 80% of the water in the lagoons during the dry season. The findings indicate that maintaining groundwater fluxes toward the ocean is necessary to preserve the coastal margin lagoons and their salinity conditions (Mencio et al., 2017).

Based on compilation and interpretation of data by OCWD[11], the Holocene coarse-grained sediments (Shallow Aquifer) in the Sunset Gap are relatively thin, discontinuous and generally of lower permeability compared to the Talbert, Bolsa and Alamitos Gaps. Sunset Gap may be a structural depression rather than an erosional feature like the other gaps. Accordingly, the actual production potential may be significantly lower than estimated with the model that approximates the Shallow Aquifer as continuous and uniform.

ALAMITOS GAP

Model design

The Alamitos Gap is bounded by Landing Hill on the southeast and by highlands on the northwest that include Bixby Ranch Hill and Signal Hill (Figure 1). Figure 13 shows the extent of the model domain and a cross-section illustrating the layering for the Alamitos Gap model. The width of the model domain is based on the width of the Alamitos Gap and Alamitos Barrier Model (Intera, 2010). The inland to offshore extent is similar to the Talbert Gap model and provides more than sufficient distance between the model boundary conditions and area of simulated SSI pumping along the coastline. The hydrostratigraphy and hydraulic properties for the Alamitos Gap model are based on the Alamitos Barrier Model (Intera, 2010). Table 1 summarizes the model design..

Model Pumping from Slant Wells

The width of the Shallow Aquifer in the Alamitos Gap along the coastal margin is approximately 10,500 feet (nearly 2 miles). The model represents pumping from a series of 22 slant wells, separated by ~380 ft and spanning approximately 8,000 ft (1.5 miles) of the shoreline (Figure 14). The total length of each hypothetical slant well is approximately 260 ft, and the lower 140 ft is screened within the Shallow Aquifer (Figure 15). The model slant wells are at an angle of approximately 15 degrees below horizontal and the vertical depth of each model slant well is

[11] Email from Tim Sovich (OCWD) 6/6/17

approximately 60 ft, which is the approximate depth of the base of the shallow aquifer beneath the coastline in Alamitos Gap.

As shown by Figure 15, the model represents the screened interval of the slant wells beginning beneath the coastline. However due to the shallow depth and small thickness of Shallow Aquifer at Alamitos Gap, for slant wells installed at an angle of 15 degrees below horizontal this would place the well heads only approximately 200 feet from the coastline within the beach and require engineering measures to protect the wells from erosion and sea level rise. Installing the slant wells farther from the coastline may be preferable, but would slightly decrease the portion of ocean water pumped.

Model results for Alamitos Gap

The estimated maximum sustainable pumping rate from the shallow aquifer beneath the coastal margin of Alamitos Gap is approximately 10 mgd, or 316 gpm per well for a series of 22 wells along 1.5 miles of coastline[12]. The actual production rate would vary per well and the sustainable rate per well could be considerably lower. Moreover, additional wells would be required to provide standby capacity to allow maintenance of the wells.

Model results for the base case properties indicate that 79% of the 10 mgd pumped by the slant wells comes from the ocean, 12% comes from the wetlands and inland water ways, and 9% comes from inland aquifers. Figure 16 shows contours of the calculated drawdown of the water table, and groundwater flowpaths induced by pumping of 10 mgd from the series of 22 slant wells in the Shallow Aquifer beneath the beach at Alamitos Peninsula and Belmont Shore.

Sensitivity analyses were run with ten times lower and higher vertical hydraulic conductivity for the Upper Aquitard, which is the most important parameter controlling the hydraulic connection between the shallow aquifer and the ocean, and therefore the portion of source water derived from the ocean. Kh and Kv for the Upper Aquitard are 1 and 0.1 ft/day for the base case, 1 and 1 ft/d for the high K case, and 0.1 and 0.01 ft/d for the low K case. The model results for the base case model and sensitivity runs in terms of calculated portions of water from the ocean, wetlands and inland waterways, and inland aquifers are summarized by Table 2.

---

[12] Note that the results of the groundwater flow analysis depend on the total pumping rate and extent of the series of wells, but not the details of the number of slant wells.

For the base case model, the calculated drawdown of the water table exceeds 10 feet to approximately 2400 ft inland from the shoreline and well beyond the ends of the 1.5-mile-long series of slant wells. Drawdown of the water table of more than 20 feet extends beneath portions of East Ocean Blvd. and numerous residential properties along Alamitos Peninsula and Belmont Shore. The large drop in the water table that would be caused by pumping of groundwater along the coastal margin of Alamitos Gap at rates on the order of 10 mgd could also result in subsidence of the ground surface,[13] which could impact the structural integrity of the roads and structures in the vicinity.

Groundwater flow to the slant wells from inland aquifers would interfere with the aquifer replenishment and the hydraulic barrier provided by the Alamitos Barrier, which is critical for protection of the Central Basin of Los Angeles County and the Orange County Groundwater Basin from seawater intrusion through the Alamitos Gap. The Injection Barrier is approximately two miles long and includes 43 injection wells. The average total annual injection rate is approximately 6,000 acre-feet per year (5.35 mgd). The portion of inland flow to the slant wells pumping for the base case model is 0.9 mgd (9% of 10 mgd), which is 17% of the typical injection rate at the Alamitos Barrier. Pumping from SSIs along the coastline in Alamitos Gap would draw a portion of the water from the Alamitos injection wells and reduce the effectiveness of aquifer replenishment inland of the barrier.

Moreover, the conveyance for source water pumped by SSIs at Alamitos Gap would need to cross the San Gabriel River to provide source water to a potential desalination facility in Orange County, such as alternative site 1D. The river crossing would present additional engineering challenges and is an additional reason that SSIs in Alamitos Gap are not a suitable alternative to the proposed desal project at Huntington Beach.

---

[13] Groundwater pumping from unconsolidated alluvial aquifer systems has resulted in significant land subsidence at many localities in the world, particularly in settings were an alluvial aquifer is overlain by a fine-grained confining layer (e.g. Freeze and Cherry, 1979).

CONCLUSIONS

Estimated maximum possible production rates from subsurface seawater intakes (SSIs) along the coastline in Bolsa, Sunset, and Alamitos Gaps are approximately 15, 9, and 10 mgd, respectively. Each is far less than the required design flow of 107 mgd for the proposed desal project. Moreover, as at Huntington Beach, a portion of water pumped from SSIs along the coastal margin in Bolsa, Sunset and Alamitos Gaps would be withdrawn from local wetlands and the inland freshwater basin. Extraction by SSIs of groundwater from inland aquifers in Orange County would be subject to the Replenishment Assessment by the OCWD.

The results for the base case models and sensitivity runs are summarized by Table 2 in terms of calculated portions of water from the ocean, wetlands and inland waterways, and inland aquifers.

Because of the low SSI production capability, the large number of slant wells required, and associated infrastructure and conveyance along thousands of feet of coastline, the environmental impact of constructing of SSI systems outweighs the potential environmental benefit of a hybrid intake system for a desal facility at these locations. Moreover, the SSI systems would be vulnerable to erosion of the beaches and would need to be constructed to withstand future sea level rise.

Negative consequences of pumping from SSIs along the coastlines of the Talbert, Bolsa, Sunset, and Alamitos Gaps are summarized below:

<u>Talbert (1G and 1H)</u>

- Drawdown of the water table could cause subsidence of the ground surface and associated impacts to the structural integrity of the roads and structures in the vicinity.

- Pumping from SSIs beneath Huntington Beach would impact coastal margin wetlands.

- Pumping from SSIs beneath Huntington Beach would interfere with optimum performance of the Talbert Injection Barrier, which is unacceptable to the OCWD (OCWD, 2015, 2016).

Bolsa (1E)

- Drawdown of the water table could cause subsidence of the ground surface and associated impacts to the structural integrity of the roads and structures in the vicinity.

- Pumping from SSIs beneath Bolsa Chica Beach would impact coastal margin wetlands, which is unacceptable in the Bolsa Chica Basin State Marine Conservation Area.

Sunset (1D)

- Drawdown of the water table could cause subsidence of the ground surface and associated impacts to the structural integrity of the roads and structures in the vicinity, including numerous residences along Sunset Beach.

- Pumping from SSIs beneath Sunset Beach would impact coastal margin wetlands, which is likely unacceptable in the Seal Beach National Wildlife Refuge.

- Pumping from SSIs beneath Sunset Beach would mobilize areas of contaminated groundwater.

Alamitos

- Drawdown of the water table could cause subsidence of the ground surface and associated impacts to the structural integrity of the roads and structures in the vicinity, including numerous residences on the Alamitos Peninsula and Belmont Shore.

- Pumping from SSIs beneath Sunset Beach would impact coastal margin wetlands, which is likely unacceptable in the Seal Beach National Wildlife Refuge.

- Pumping from SSIs beneath the coastline in Alamitos Gap would interfere with optimum performance of the Alamitos Injection Barrier. Performance of the Injection Barrier is critical for the protection of the Central Basin of Los Angeles County and the Orange County Groundwater Basin from seawater intrusion through the Alamitos Gap.

Sincerely,

Gordon Thrupp, PhD, PG, CHG
Principal Hydrogeologist

Maria Vishnevskiy, PE
Senior Staff Engineer

Attachments

References
Tables
Figures
Appendix A

Copies to

Stan Williams, Poseidon Resources
Austin Melcher, Dudek
Timothy Hogan, TWB Environmental Research and Consulting

REFERENCES

Anderson, M.P., W. Woessner, R. Hunt, 2015, Applied Groundwater Modeling, Simulation of Flow and Advective Transport, 2nd Edition, Academic Press, 630 p.

Barnard, P.L., Erikson, L.H., Foxgrover, A.C., O'Neill, A.C., and Herdman, M., 2016, CoSMoS (Coastal Storm Modeling System) Southern California v3.0 Phase 2 storm-hazard projections: U.S. Geological Survey Data Release, http://dx.doi.org/10.5066/F7T151Q4

California Department of Water Resources (DWR), 1966, Santa Ana Gap Salinity Barrier, Orange County, DWR Bulletin No. 147-1, December 1966.

California State Water Resources Control Board, 2015, Geotracker, Web-based data management system. https://geotracker.waterboards.ca.gov/

California State Water Resources Control Board, 2017, Proposed Poseidon Water Huntington Beach Desalination Project, Application for California Water Code Section 13142.5(b) Determination and Report of Waste Discharge: Remaining Outstanding Information Requests and Topics for Third Party Review, letter from Kurt Berchtold to Scott Maloni, May 23, 2017, 11 pp.

Cao, G., Zheng, C., Scanlon, B. R., Liu, J., and Li, W., 2013, Use of flow modeling to assess sustainability of groundwater resources in the North China Plain, Water Resources. Res., 49, 159–175, doi:10.1029/2012WR011899.

CDM, 2000, Development Information Memorandum #9A Barrier System Modeling/Design Criteria – 100% Submittal, Groundwater Replenishment System – Project Development Phase, June 2000.

Detwiler, R., 2015, Review of groundwater flow modeling developed by Geosyntec to simulate pumping from slant wells beneath the beach in Huntington Beach, Technical Memorandum to Scott McCreary, Concur, Inc., 18 December.

Dudek, June 2015, Huntington Beach Desalination Plant Alternative Sites Analysis, Memorandum to Scott Maloni, Poseidon, 139 pp.

Edwards, BD, RT Hanson, EG Reichard, TA Johnson, 2009, Characteristics of Southern California coastal aquifer systems, Geological Society of America, Special Paper 454, pp 319-344.

Freeze, RA, and JA Cherry, 1979, *Groundwater,* Prentice-Hall, Inc., Englewood Cliffs, NJ, 604 p.

Geoscience Support Services, 2009, Subsurface System Intake Feasibility Assessment, US Dept of the Interior Bureau of Reclamation, Desalination and Water Purification Research and Development Program Report No. 153, 112 pp.

Geosyntec, 2013, Feasibility Assessment of Shoreline Subsurface Collectors, Huntington Beach Seawater Desalination Project, Huntington Beach, California, September 2013, 79 pp.

Geosyntec, 2015, Revision and Sensitivity Analyses of Slant Well SSI Model Feasibility Assessment of Shoreline Subsurface Collectors Huntington Beach Seawater Desalination Project, Technical Memorandum to Scott McCreary, Concur, 9 November, 34 pp.

Geosyntec, 2017, Additional Sensitivity Analyses of Slant Well SSI Feasibility Modeling: Variation in The Location and Length of The Slant Wells Has Very Little Influence On The Portions of Source Water Pumped by The Slant Wells, letter to Scott Maloni, Poseidon Resources, 18 January 2017, 64 pp.

Herndon, RL, 1992, The Regressive Pleistocene Shoreline, Coastal Southern California, in Annual Field Trip Guide Book No. 20., South Geological Society, pp. 237-259.

Herndon, RL, and JD Bonsangue, 2006, Hydrogeology of the Orange County Groundwater Basin – An Updated Overview, in Geology of the Orange County Region, Southern California, eds. Bonsangue and Lemmer, Field Trip Guidbook No. 33, South Coast Geo Soc, pp. 157-179.

Intera, 2010, Alamitos Barrier Model, Task 7 Final Draft Report, September 20.

ISTAP, 2014. Technical Feasibility of Subsurface Intake Designs for the Proposed Poseidon Water Desalination Facility at Huntington Beach, California. October 9.

ISTAP, 2015. Phase 2 Report: Feasibility of Subsurface Intake Designs for the Proposed Poseidon Water Desalination Facility at Huntington Beach, California. August 17.

Mencio A., X Casamitjana, J. Mas-Pla, N Coll, J Compte, M Marinoy, J Pasual, XD Quintana, 2017, Groundwater dependence of coastal lagoons: the case of La Pletera sal marshes (NE Catalonia), Journal of Hydrology, accepted manuscript in press, http://www.sciencedirect.com/science/article/pii/S0022169417304948

Oasis International, 2012, Report of Monitoring Well Installation & 1st Quarter 2011 Groundwater Monitoring Results, 13 January, 97 pp, available from Geotracker.

OCWD, 2004, Groundwater Management Plan, Orange County Water District, Fountain Valley, California.

OCWD, 2013; OCWD GW Management Plan 2015 Update; Ted Jonson, WRD, Technical Bulletin, Vol 13, Fall 2007 http://www.wrd.org/sites/pr/files/TB13_Fall07_Seawater_Barriers.pdf

OCWD, 2013, Grant Proposal for Sunset Gap Seawater Intrusion Assessment, http://www.water.ca.gov/lgagrant/docs/applications/Orange%20County%20Water%20District%20(201209870019)/Orange%20County%20Water%20District%20Proposal.pdf
Attachment 4- Project Description
http://www.water.ca.gov/lgagrant/docs/applications/Orange%20County%20Water%20District%20(201209870019)/Att04_LGA12_OCWD_ProjD_1of1.pdf
Attachment 5, Work Plan.
http://www.water.ca.gov/lgagrant/docs/applications/Orange%20County%20Water%20District%20(201209870019)/Att05_LGA12_OCWD_WrkPln_1of1.pdf

OCWD, 2015, OCWD Groundwater Management Plan 2015 Update.

OCWD, 2015, OCWD Staff Comments on Modeling Evaluation of Huntington Beach Ocean Desalination Subsurface Intake Option Using Extraction Wells in Talbert Aquifer, letter to Scott McCreary, Concur Inc., from Roy Herndon, Chief Hydrogeologist, Orange County Water District, Fountain Valley, California, 28 September.

OCWD, 2016, OCWD Staff Comments on the Expert Third-Party Review of WIT Hydrologic Model for the Poseidon Huntington Beach Project, letter to Tom Luster, California Coastal Commission, from Roy Herndon, Chief Hydrogeologist, Orange County Water District, Fountain Valley, California, 12 February.

OCWD, 2017, 2015-2016 Engineer's Report on Groundwater Conditions, Water Supply, and Basin Utilization in the Orange County Water District, 15 February 2017, 45 pp.

Tetra Tech, 2013, Final 2012 Annual Performance Monitoring Report, Enhanced In Situ Bioremediation Installation Restoration Program Site 70, Naval Weapons Station Seal Beach, California, 183 pp.
https://geotracker.waterboards.ca.gov/profile_report.asp?global_id=DOD100355700

US Bureau of Reclamation, 2009, Results of Drilling, Construction, Development, and Testing of Dana Point Ocean Desalination Project Test Slant Well, Desalination and Water Purification Research and Development Program Report No. 152, January 2009, 277 pp.

US Geological Survey, 1956, Ground-water Geology of the Coastal Zone Long Beach-Santa Ana Area California, USGS Water-Supply Paper 1109.

Wong, F.L., Dartnell, Peter, Edwards, B.D., and Phillips, E.L., 2012, Seafloor geology and benthic habitats, San Pedro Shelf, southern California: U.S. Geological Survey Data Series 552.
http://pubs.usgs.gov/ds/552/

Yoshiba, GT, DL Mark, N Scheeval, OCWD, March 2013, Geologist's/Engineer's Report, Alamitos Barrier Improvement Project (Construction Unit 14).

Table 1
Summary of Model Hydrostratigraphy and Properties
Alternative Sites Analysis
Huntington Beach Seawater Desalination Project

	Alamitos Gap	Sunset Gap	Bolsa Gap
Upper Aquitard[1]			
Kh and Kv (ft/d)	1 and 0.1	1 and 0.1	1 and 0.1
Thickness (ft)	25	50	80
Shallow Aquifer			
Kh and Kv (ft/d)	100 and 20	50 and 10	250 and 50
Thickness (ft)	30	30	60 (onshore) - 20 (inland)
Fault Zone in Shallow Aquifer			
Kh and Kv (ft/d)	NA	NA	5 and 0.5
Width (ft)			2,000
Lower Aquitard			
Kh and Kv (ft/d)	0.1 and 0.1	0.1 and 0.1	10 and 1
Thickness (ft)	45	45	20 (onshore) - 60 (inland)
Mergence Zone in Lower Aquitard[2]			
Kh and Kv (ft/d)	50 and 20	NA	125 and 25
Thickness (ft)	45		20
Lower Aquifer System			
Kh and Kv (ft/d)	100 and 20	150 and 30	5 and 0.5
Thickness (ft)	250	150	150
Fault Zone in Lower Aquifer System			
Kh and Kv (ft/d)	0.5 and 0.5	0.5 and 0.5	5 and 0.5
Width (ft)	450	400	450

Notes:
[1]Properties of upper aquitard were varied for sensitivity analysis
High K = Kh and Kv of upper aquitard = 1 ft/d
Low K = Kh of upper aquitard = 0.1 ft/d; Kv of upper aquitard = 0.01 ft/d
[2]Mergence Zone in Lower Aquitard included for sensitivity analysis
NA = not applicable
ft = feet
ft/d = feet per day
Kh = horizontal hydraulic conductivity
Kv = vertical hydraulic conductivity

Table 2
Model Results Summary
Alternative Sites Analysis
Huntington Beach Seawater Desalination Project

	Alamitos Gap				Sunset Gap			Bolsa Gap			
Pumping Well Design											
	Base Case	**High K**	**Mergence**	**Low K**	**Base Case**	**High K**	**Low K**	**Base Case**	**High K**	**Mergence**	**Low K**
Width of Coastline with Wells (ft)	8,000				9,400			8,000			
Number of Wells along Coastline	22				31			18			
Pumping Rate per Well (gpm)	316			221.2	208		143	570			
Estimated Sustainable Production (MGD)	10			7	9		6	15			
Portions of Source Water Pumped by Slant Wells											
	Base Case	**Sensitivity Analysis**			**Base Case**	**Sensitivity Analysis**		**Base Case**	**Sensitivity Analysis**		
		High K	**Mergence**	**Low K**		**High K**	**Low K**		**High K**	**Mergence**	**Low K**
Portion of Pumping from Sea	79%	81%	78%	76%	78%	77%	70%	79%	80%	79%	64%
Portion of Pumping from Wetlands	12%	15%	12%	3%	9%	19%	3%	3%	15%	3%	0%
Portion of Pumping from Inland	9%	4%	10%	21%	13%	5%	27%	18%	5%	18%	36%

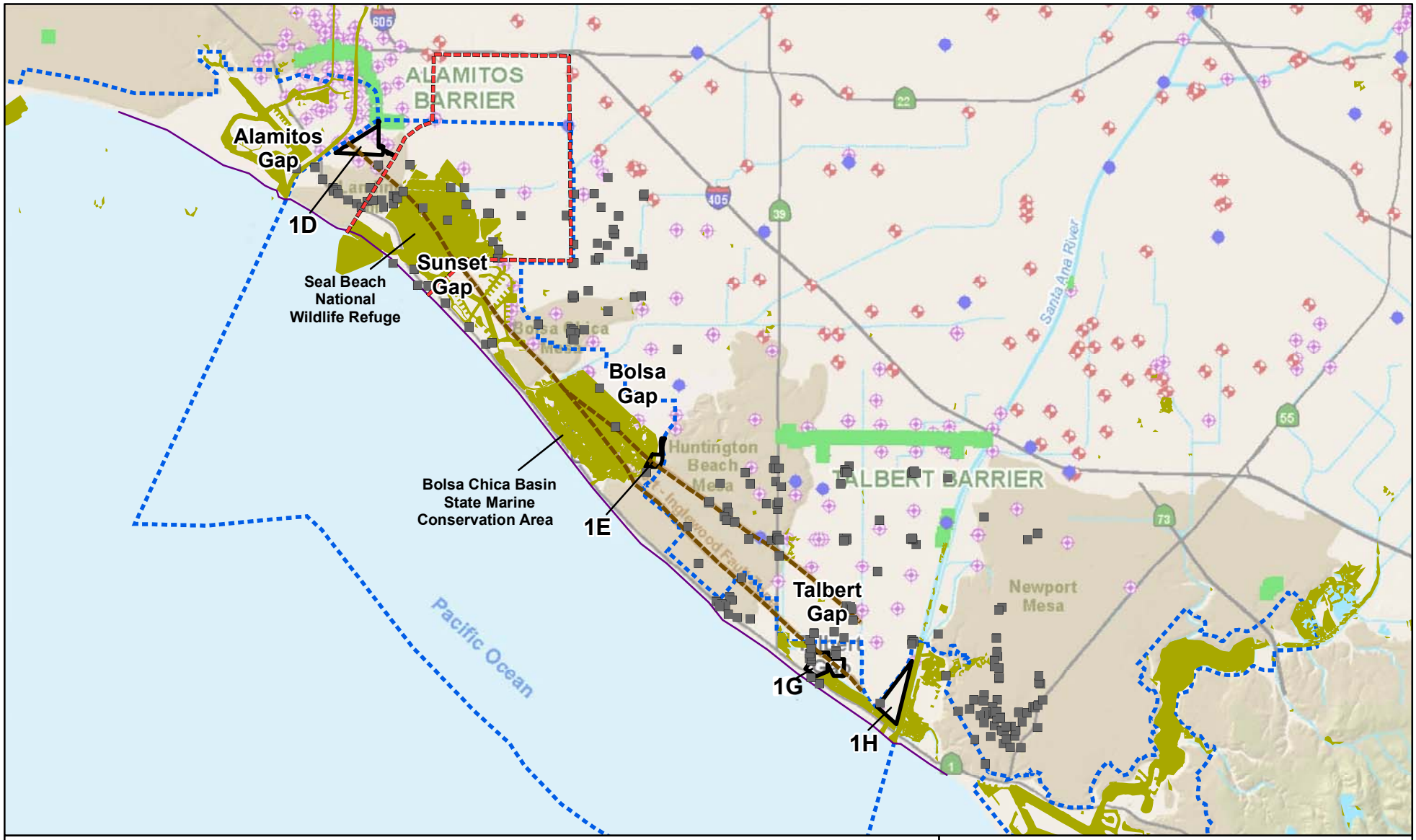
Notes:
Pumping rate per well and estimated sustainable production are approximate.

Base Case: Kh of upper aquitard = 1 ft/d; Kv of upper aquitard = 0.1 ft/d
High K: Kh and Kv of upper aquitard = 1 ft/d
Low K: Kh of upper aquitard = 0.1 ft/d; Kv of upper aquitard = 0.01 ft/d

ft = feet
ft/d = feet per day
gpm = gallons per minute
Kh = horizontal hydraulic conductivity
Kv = vertical hydraulic conductivity
MGD = million gallons per day

FIGURES

1. Erosional Gaps Along the Orange County Coastline
2. Location of Series of Slant Wells Evaluated in Talbert Gap
3. Model Representation of Slant Well in Talbert Gap
4. Example Talbert Gap Model Results
5. Bolsa Gap Model Domain and Cross-Section
6. Location of Series of Slant Wells Evaluated in Bolsa Gap
7. Model Representation of Slant Well in Bolsa Gap
8. Bosal Gap Model Results – Base Case Properties
9. Sunset Gap Model Domain and Cross-Section
10. Location of Series of Slant Wells Evaluated in Sunset Gap
11. Model Representation of Slant Well in Sunset Gap
12. Sunset Gap Model Results – Base Case Properties
13. Alamitos Gap Model Domain and Cross-Section
14. Location of Series of Slant Wells Evaluated in Alamitos Gap
15. Model Representation of Slant Well in Alamitos Gap
16. Alamitos Gap Model Results – Base Case Properties



Legend

- Marsh and Wetland Area
- Alternative Site Locations
- Faults
- Coast
- Coastal Zone
- Environmental Cleanup and Waste Disposal Site
- Production Well
- Monitoring Well

N

2 1 0 Miles

Notes:
All locations are approximate
Basemap source: Sunset Gap Seawater Intrusion Assessment Workplan (OCWD, 2013)

Erosional Gaps Along the Orange County Coastline

Alternative Sites Analysis
Huntington Beach Seawater Desalination Project

Geosyntec consultants

WR1794A | July 2017

Figure 1

P:\GIS\HuntingtonBeach\Project\2017Jul\Fig01_AlternateSites_w_GT_Sites.mxd

Legend

- Modeled Slant Well Intake
- Conveyance Pipeline
- Final Shoreline (after 1m Sea Level Rise Scenario)
- Final Shoreline Uncertainty
- Final Shoreline + Potential Erosion Uncertainty
- Alternative Site (Approximate)
- Mesas (No Shallow Aquifer)
- Wetlands and Estuaries

N

1,200 600 0 Feet

Notes:
All locations are approximate
Basemap source: ESRI 2013
1m Sea Level Rise Scenario Final Shoreline Source: Barnard, P.L., Erikson, L.H., Foxgrover, A.C., O'Neill, A.C., and Herdman, M., 2016, CoSMoS (Coastal Storm Modeling System) Southern California v3.0 Phase 2 storm-hazard projections: U.S. Geological Survey Data Release, http://dx.doi.org/10.5066/F7T151Q4

Location of Series of Slant Wells Evaluated in Talbert Gap

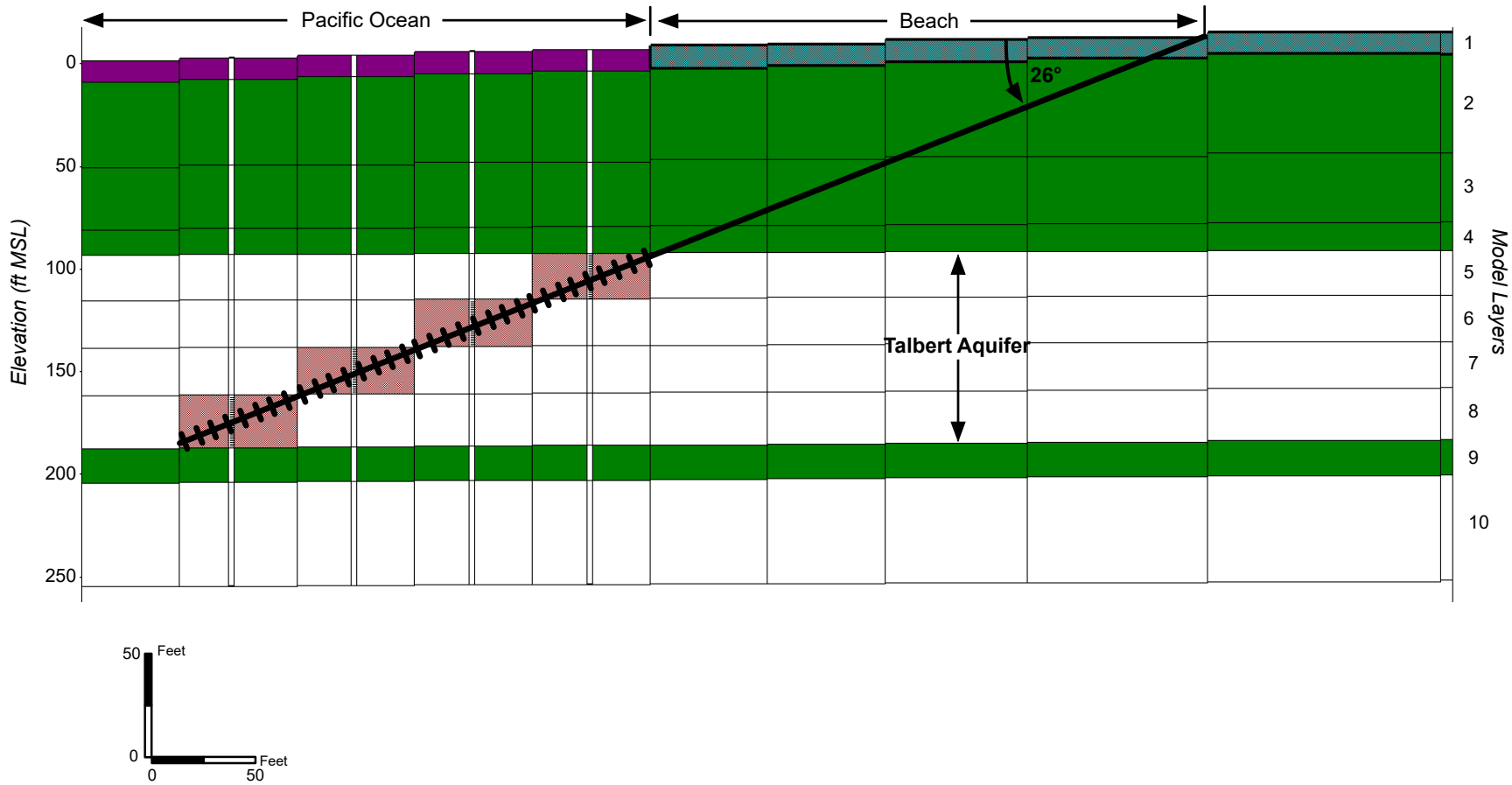
Alternative Sites Analysis
Huntington Beach Seawater Desalination Project

Geosyntec consultants

WR1794A | July 2017

Figure 2

P:\GIS\HuntingtonBeach\Project\2017Jul\Fig02_Talbert Gap.mxd



Notes:
The cross-section shows the representation of a slant well in the MODFLOW numerical groundwater model.
In the model each of the 40 hypothetical slant wells is represented by pumping from 4 consecutive cells in Layers 5 – 8, which is the Talbert Aquifer.
The slant well begins at the upper portion of the beach and is drilled at an angle of 26 degrees to a total vertical depth of ~200 ft.
The length of each slant well would be approximately 500 ft. The lower 250 ft is screened in the Talbert Aquifer.

Model Representation of Slant Well
Talbert Gap

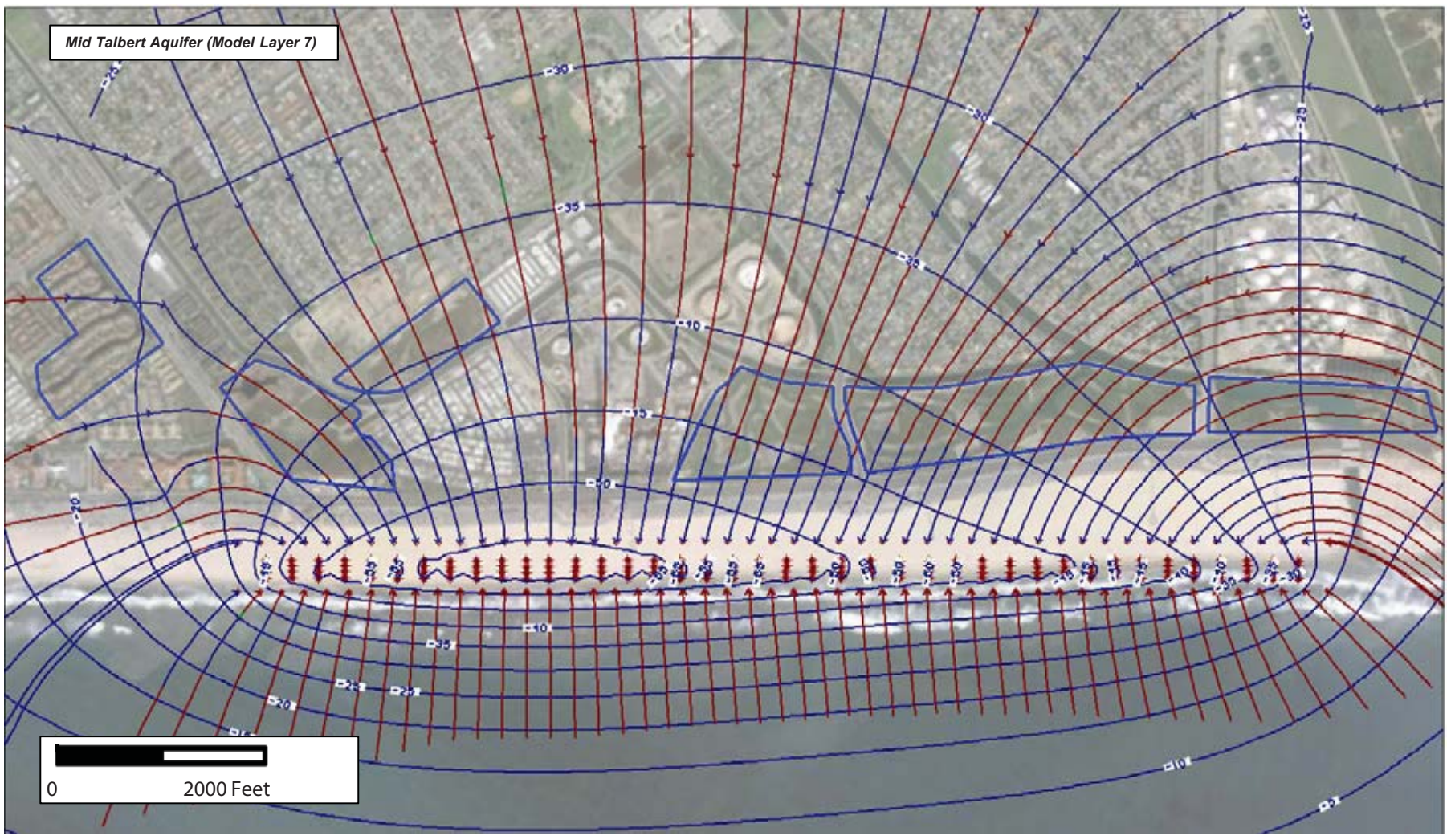
Alternative Sites Analysis
Huntington Beach Seawater Desalination Project

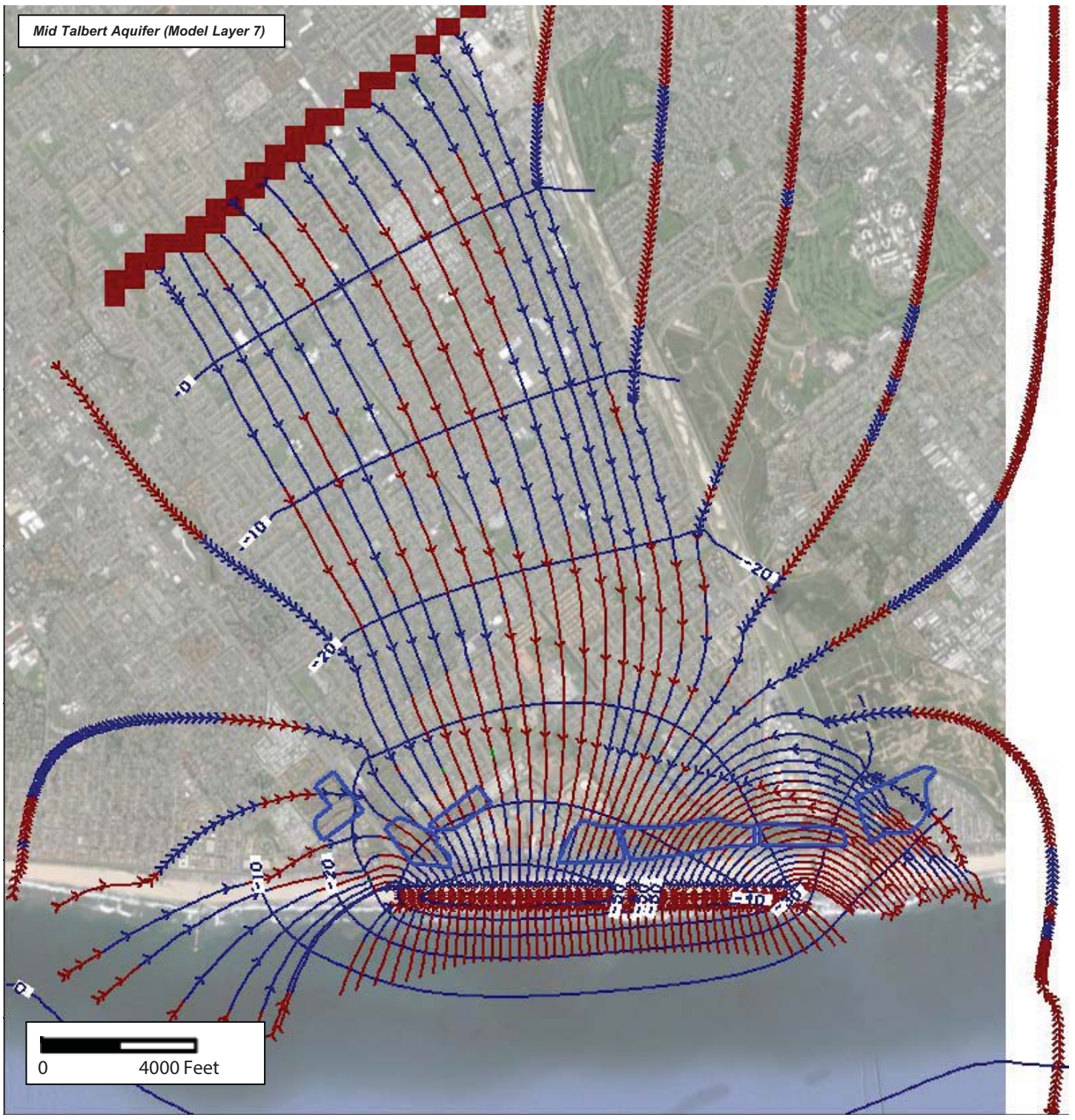
Geosyntec consultants

WR1794A	July 2017

Figure
3

P:\GIS\HuntingtonBeach\Project\2017Jul\Sections\Fig03_SlantWell_Talbert.ai





Particle Flow Direction

Pumping Well

Marsh and Wetland Area

Head Equipotential

Constant Head Boundary at Injection Barrier

Notes:
Model V10AP1 – pumping from forty approximately 425 ft long slant wells screened in the Talbert Aquifer. Total pumping 107 million gallons.
One year travel time between arrows on flowpaths for the zoomed out map.
Pathlines are calculated by "back-tracking" from "particles" placed adjacent to slant wells in the Talbert Aquifer.
Pathlines that end up in the NW and SE portions of the series of slant wells originate at upgradient boundaries in the Lower Aquifer, which is why the extent of pathlines is greater than the Talbert Gap.
All locations are approximate.

Example Talbert Gap Model Results

Alternative Sites Analysis
Huntington Beach Seawater Desalination Project

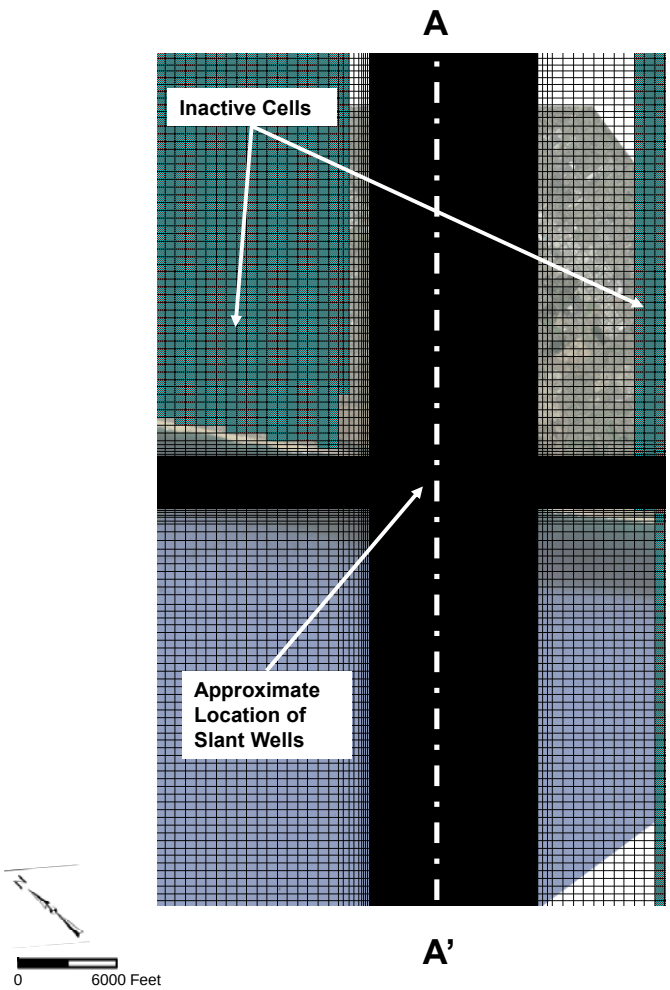
Geosyntec consultants

WR1794A | July 2017

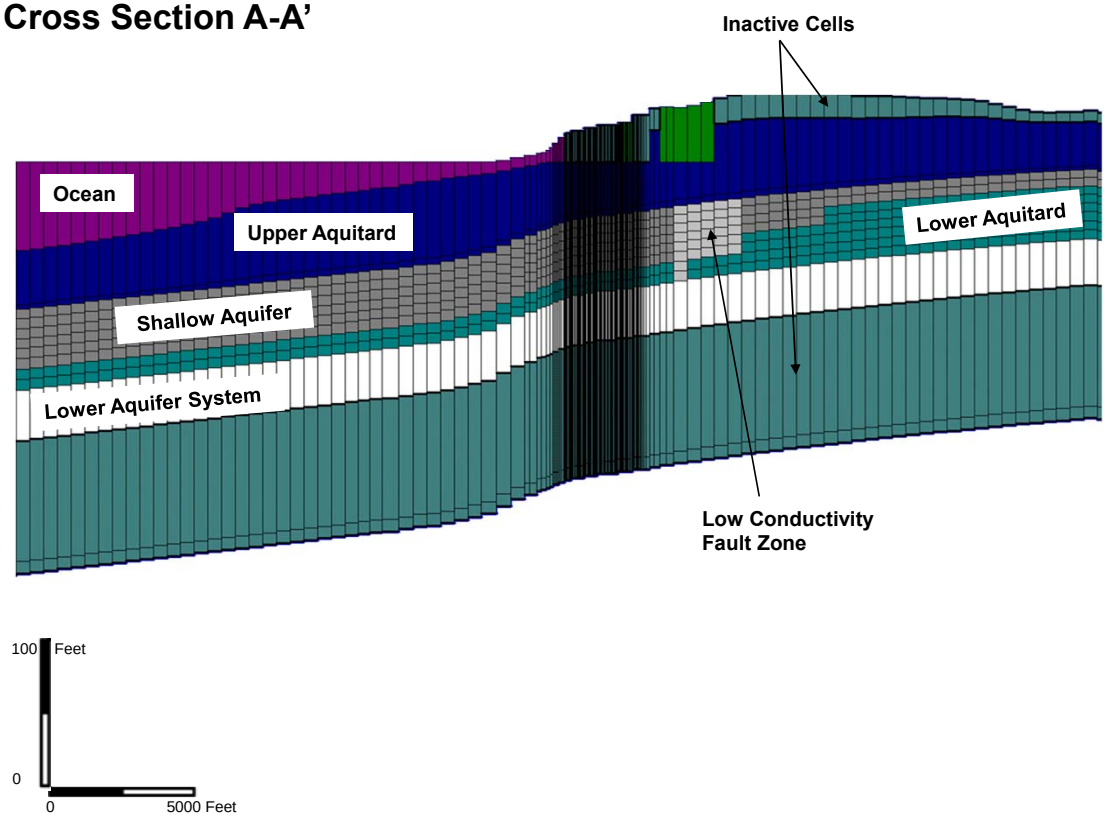
Figure 4

P:\GIS\HuntingtonBeach\Project\2017Jul\Fig04_Example Talbert Model Results.ai

Plan View of Model Grid



Cross Section A-A'



Notes:

The Bolsa Aquifer is represented by model layers 4 through 9 onshore and 4 through 5 inland.
The Lower Aquifer System is represented by model layer 12. Model layers below layer 12 are inactive.

Bolsa Gap Model Domain and Cross-Section

Alternative Sites Analysis
Huntington Beach Seawater Desalination Project

Geosyntec consultants

WR1794A	July 2017	Figure 5

file:///P:\PRJ2003REM\Poseidon%20Huntington%20Beach\Nov%202016%20Model%20Update\Model%20Output\Figures\Revised%20Groundwater%20Model%20Design.pptx

Legend

- Modeled Slant Well Intake
- Conveyance Pipeline
- Final Shoreline (after 1m Sea Level Rise Scenario)
- Final Shoreline Uncertainty
- Final Shoreline + Potential Erosion Uncertainty
- Alternative Site (Approximate)
- Mesas (No Shallow Aquifer)
- Wetlands and Estuaries

N

1,200 600 0 Feet

Notes:
All locations are approximate
Basemap source: ESRI 2013
1m Sea Level Rise Scenario Final Shoreline Source: Barnard, P.L., Erikson, L.H., Foxgrover, A.C., O'Neill, A.C., and Herdman, M., 2016, CoSMoS (Coastal Storm Modeling System) Southern California v3.0 Phase 2 storm-hazard projections: U.S. Geological Survey Data Release, http://dx.doi.org/10.5066/F7T151Q4

Location of Series of Slant Wells Evaluated in Bolsa Gap

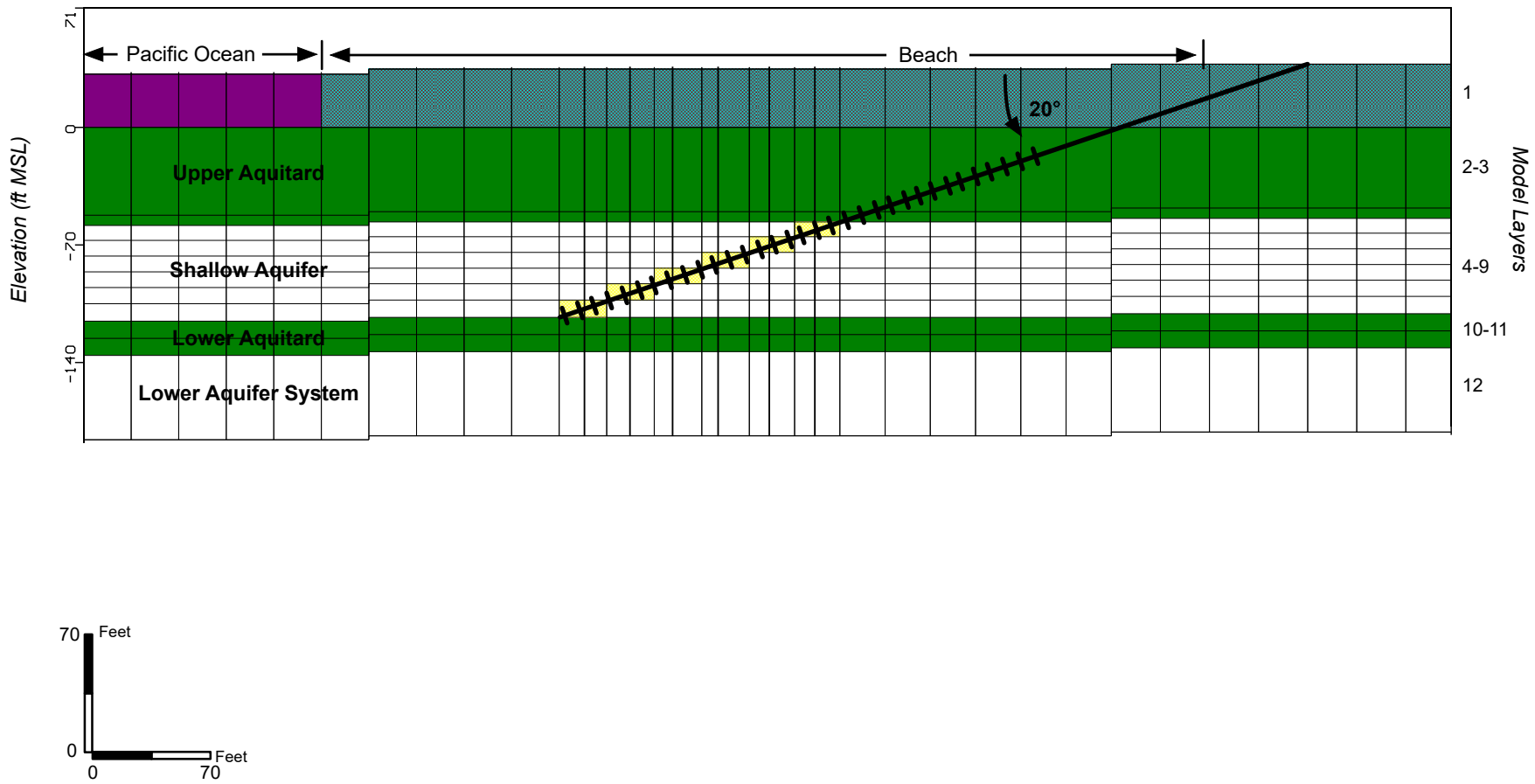
Alternative Sites Analysis
Huntington Beach Seawater Desalination Project

Geosyntec consultants

WR1794A | July 2017

Figure 6

P:\GIS\HuntingtonBeach\Project\2017Jul\Fig6_Bolsa Gap.mxd



Notes:
The cross-section shows the representation of a slant well in the MODFLOW numerical groundwater model.
In the model, each of the 18 hypothetical slant wells is represented by pumping from consecutive cells in Layers 4 – 9, which is the Bolsa Aquifer.
The slant well begins at the upper portion of the beach and is drilled at an angle of 20 degrees to a total vertical depth of ~125 ft.
The length of each slant well would be approximately 400 ft. The lower 200 ft is screened in the Bolsa Aquifer.

Model Representation of Slant Well
Bolsa Gap

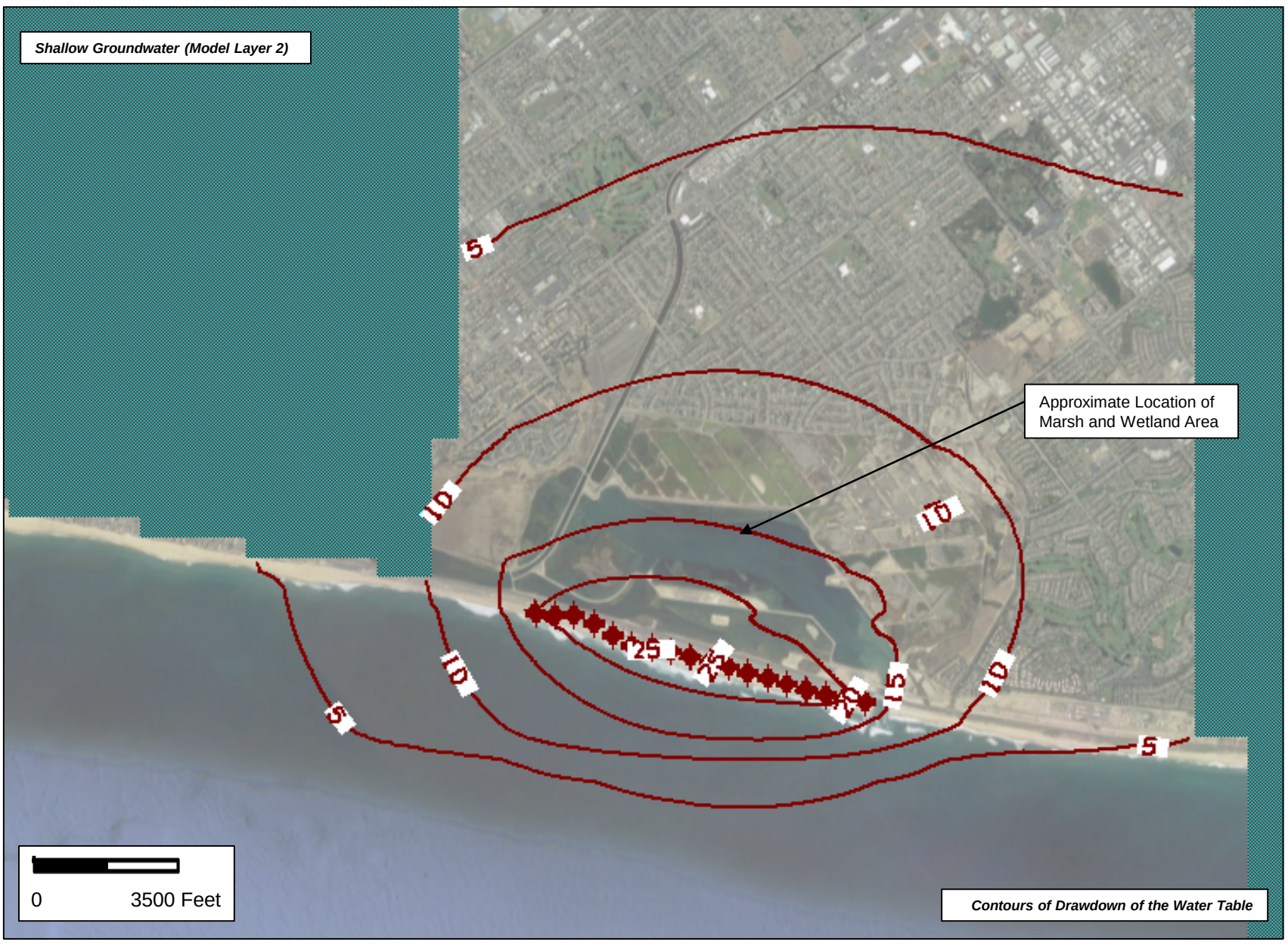
Alternative Sites Analysis
Huntington Beach Seawater Desalination Project

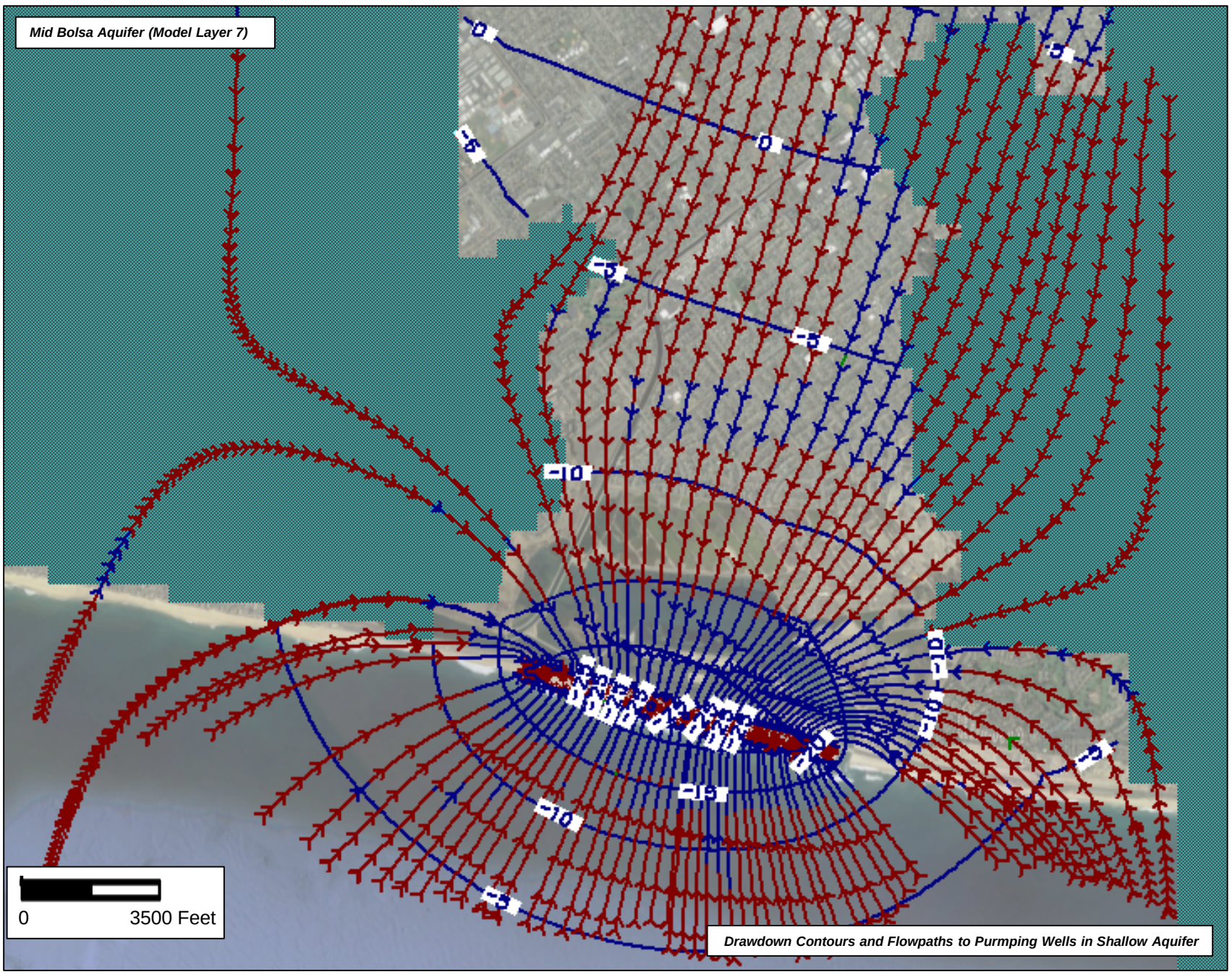
Geosyntec consultants

WR1794A | July 2017

Figure
7

P:\GIS\HuntingtonBeach\Project\2017Jul\Sections\Fig03_SlantWell_Talbert.ai





Drawdown Equipotential

Pumping Well

Inactive Cells

Head Equipotential

Particle Flow Direction

Notes:
Pumping from 18 approximately 500 foot long slant wells screened in the Bolsa Aquifer.
Total pumping 15 million gallons/day
One year travel time between arrows on flowpaths.
Pathlines are calculated by "back-tracking" from "particles" placed adjacent to slant wells in the Bolsa Aquifer.
All locations are approximate.

Bolsa Gap Model Results – Baseline Properties

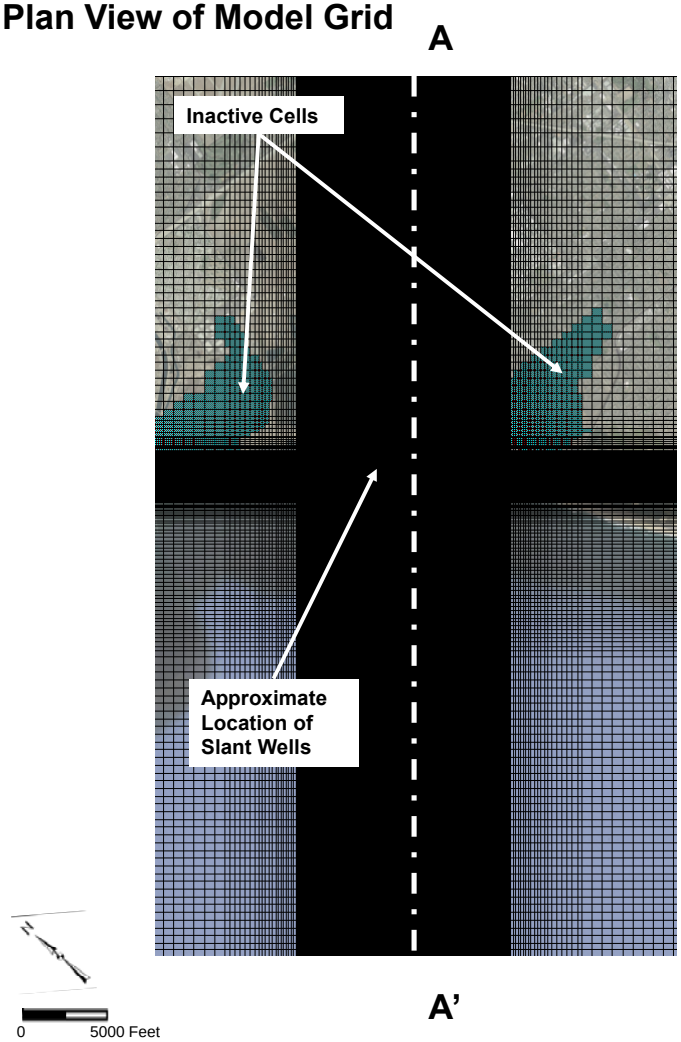
Alternative Sites Analysis
Huntington Beach Seawater Desalination Project

Geosyntec consultants

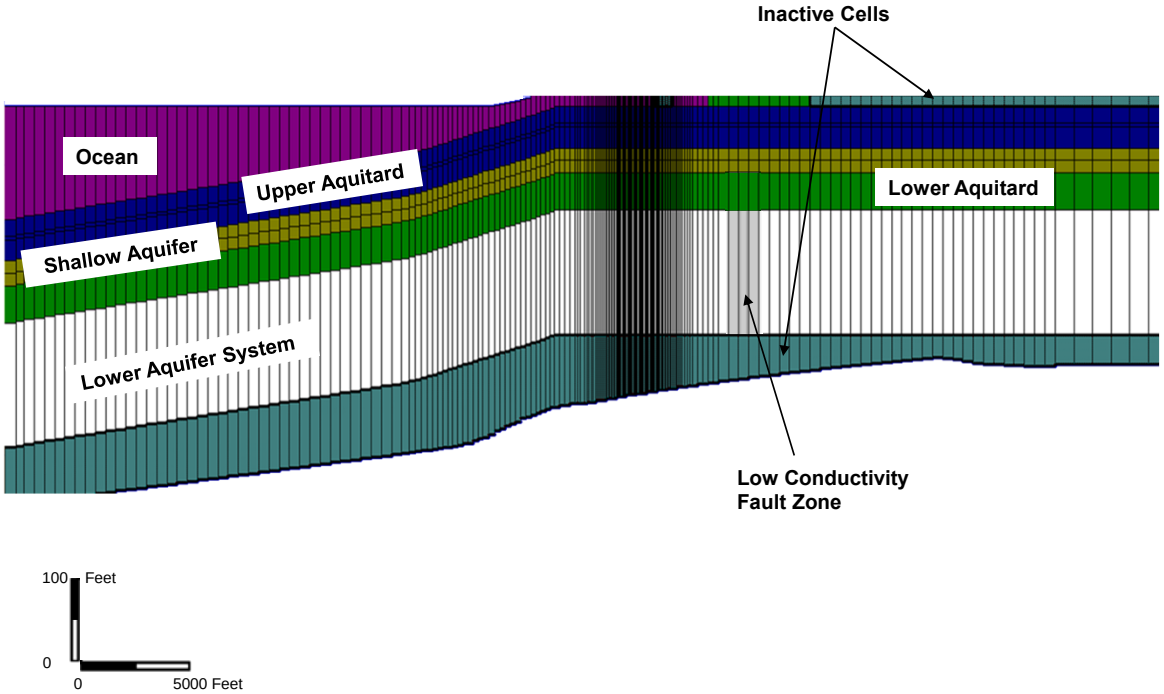
WR1794A | July 2017

Figure 8

Plan View of Model Grid



Cross Section A-A'



Notes:

The Shallow Aquifer is represented by model layers 5 through 6.
The Lower Aquifer System is represented by model layer 8. Model layer 9 is inactive.

Sunset Gap Model Domain and Cross-Section

Alternative Sites Analysis
Huntington Beach Seawater Desalination Project

Geosyntec consultants

WR1794A	July 2017	Figure 9

file:///P:\PRJ2003REM\Poseidon%20Huntington%20Beach\Nov%202016%20Model%20Update\Model%20Output\Figures\Revised%20Groundwater%20Model%20Design.pptx

Legend

- Modeled Slant Well Intake
- Conveyance Pipeline
- Final Shoreline (after 1m Sea Level Rise Scenario)
- Final Shoreline Uncertainty
- Final Shoreline + Potential Erosion Uncertainty
- Alternative Site
- Mesas (No Shallow Aquifer)
- Wetlands and Estuaries

N

2,500 1,250 0 Feet

Notes:
All locations are approximate
Basemap source: ESRI 2013
1m Sea Level Rise Scenario Final Shoreline Source: Barnard, P.L., Erikson, L.H., Foxgrover, A.C., O'Neill, A.C., and Herdman, M., 2016, CoSMoS (Coastal Storm Modeling System) Southern California v3.0 Phase 2 storm-hazard projections: U.S. Geological Survey Data Release, http://dx.doi.org/10.5066/F7T151Q4

Location of Series of Slant Wells Evaluated in Sunset Gap

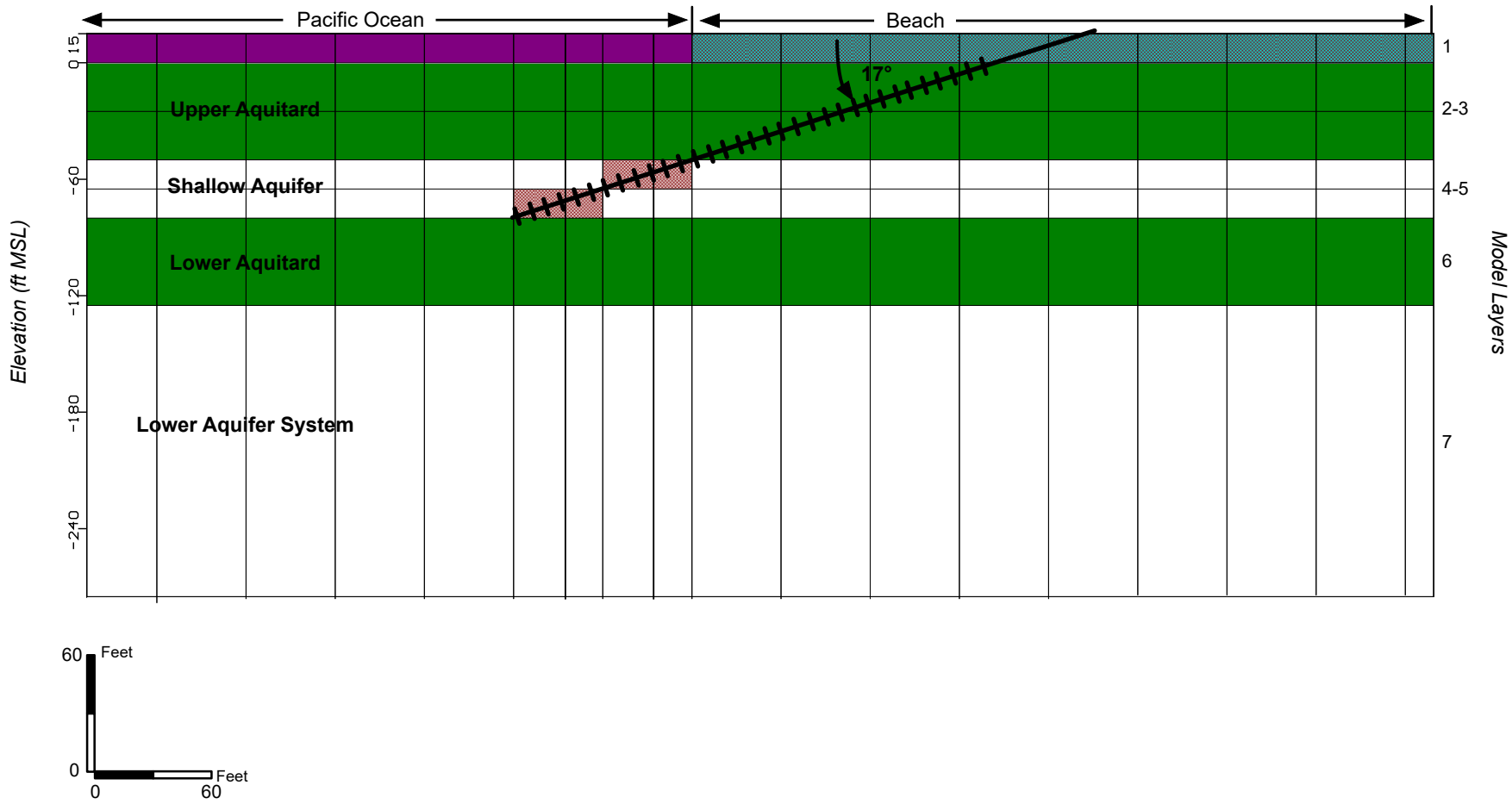
Alternative Sites Analysis
Huntington Beach Seawater Desalination Project

Geosyntec consultants

WR1794A | July 2017

Figure 10

P:\GIS\HuntingtonBeach\Project\2017Jul\Fig10_Sunset Gap.mxd



Notes:
The cross-section shows the representation of a slant well in the MODFLOW numerical groundwater model.
In the model, each of the 31 hypothetical slant wells is represented by pumping from consecutive cells in Layers 4 and 5, which is the Shallow Aquifer.
The slant well begins at the upper portion of the beach and is drilled at an angle of 17 degrees to a total vertical depth of ~80 ft.
The length of each slant well would be approximately 270 ft. The lower ~100 ft is screened in the Shallow Aquifer.

Model Representation of Slant Well
Sunset Gap

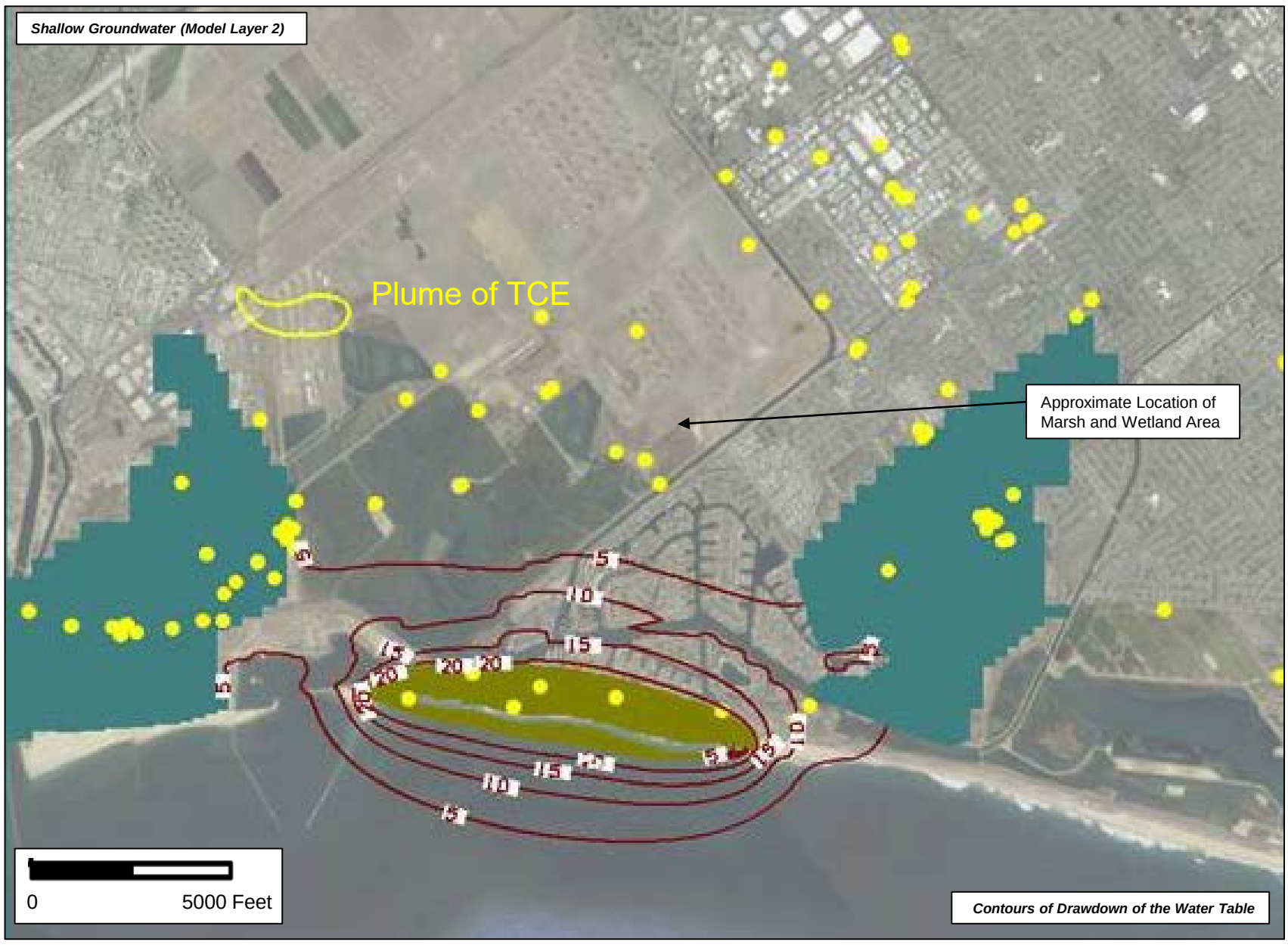
Alternative Sites Analysis
Huntington Beach Seawater Desalination Project

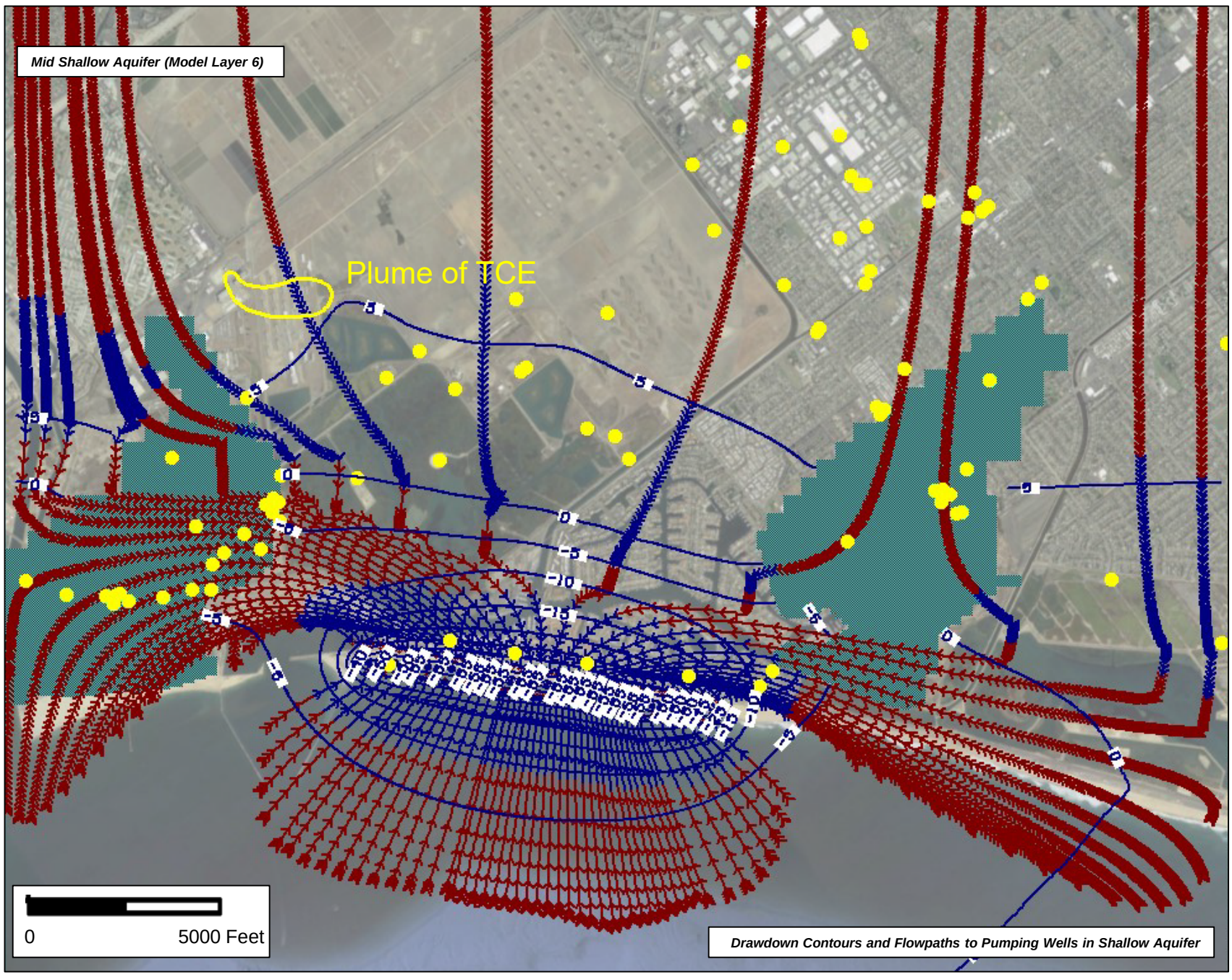
Geosyntec consultants

WR1794A | July 2017

Figure
11

P:\GIS\HuntingtonBeach\Project\2017Jul\Sections\Fig11_SlantWell_Sunset.ai





Drawdown Equipotential
Pumping Well
Inactive Cells
Environmental Cleanup and Waste Disposal Site
https://geotracker.waterboards.ca
Head Equipotential
Particle Flow Direction
Dry Cells

Notes:
Pumping from 31 approximately 450 foot long slant wells screened in the Shallow Aquifer.
Total pumping 9 million gallons/day
One year travel time between arrows on flowpaths.
Pathlines are calculated by "back-tracking" from "particles" placed adjacent to slant wells in the Shallow Aquifer.
All locations are approximate.

Sunset Gap Model Results – Baseline Properties

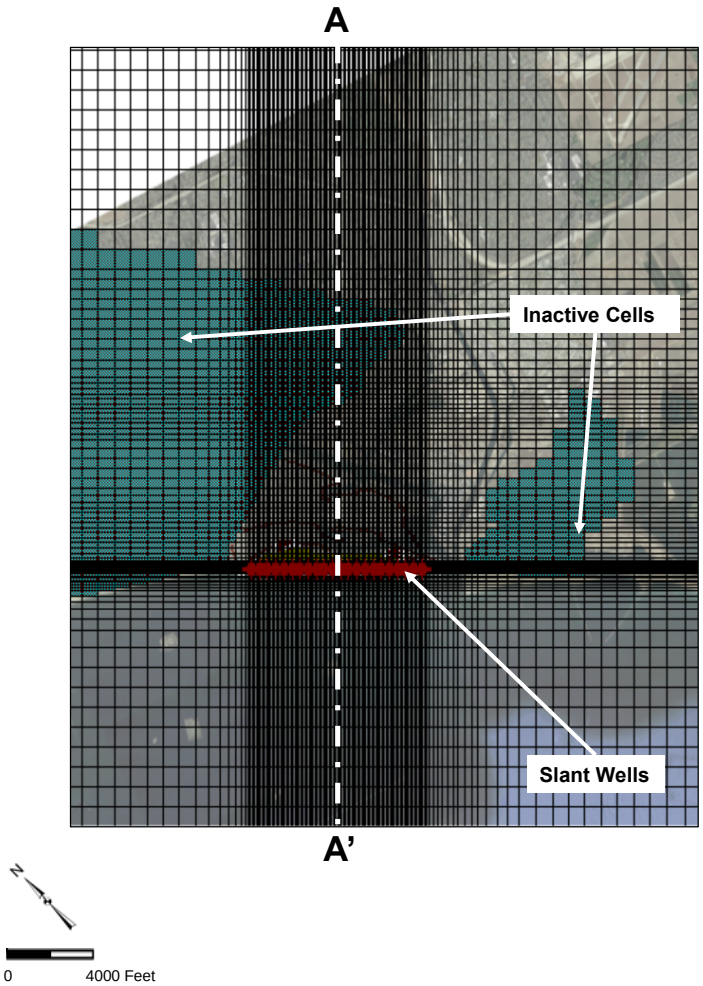
Alternative Sites Analysis
Huntington Beach Seawater Desalination Project

Geosyntec consultants

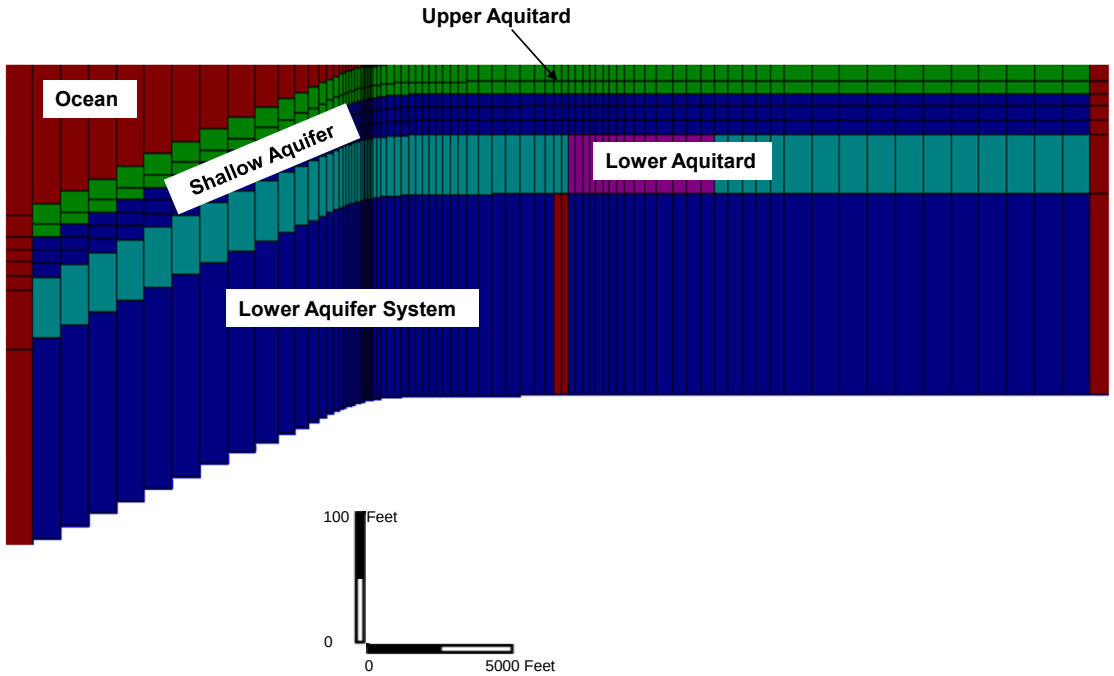
WR1794A | July 2017

Figure 12

Plan View of Model Grid



Cross Section A-A'



Notes:

The Shallow Aquifer is represented by model layers 4 through 6.
The Lower Aquifer System is represented by model layer 8.

Alamitos Gap Model Domain and Cross-Section

Alternative Sites Analysis
Huntington Beach Seawater Desalination Project

Geosyntec consultants

WR1794A	July 2017	Figure 13

file:///P:\PRJ2003REM\Poseidon%20Huntington%20Beach\Nov%202016%20Model%20Update\Model%20Output\Figures\Revised%20Groundwater%20Model%20Design.pptx

Legend

- Modeled Slant Well Intake
- Conveyance Pipeline
- Final Shoreline (after 1m Sea Level Rise Scenario)
- Final Shoreline Uncertainty
- Final Shoreline + Potential Erosion Uncertainty
- Alternative Site
- Mesas (No Shallow Aquifer)
- Wetlands and Estuaries

N

1,200 600 0 Feet

Notes:
All locations are approximate
Basemap source: ESRI 2013
1m Sea Level Rise Scenario Final Shoreline Source: Barnard, P.L., Erikson, L.H., Foxgrover, A.C., O'Neill, A.C., and Herdman, M., 2016, CoSMoS (Coastal Storm Modeling System) Southern California v3.0 Phase 2 storm-hazard projections: U.S. Geological Survey Data Release, http://dx.doi.org/10.5066/F7T151Q4

Location of Series of Slant Wells Evaluated in Alamitos Gap

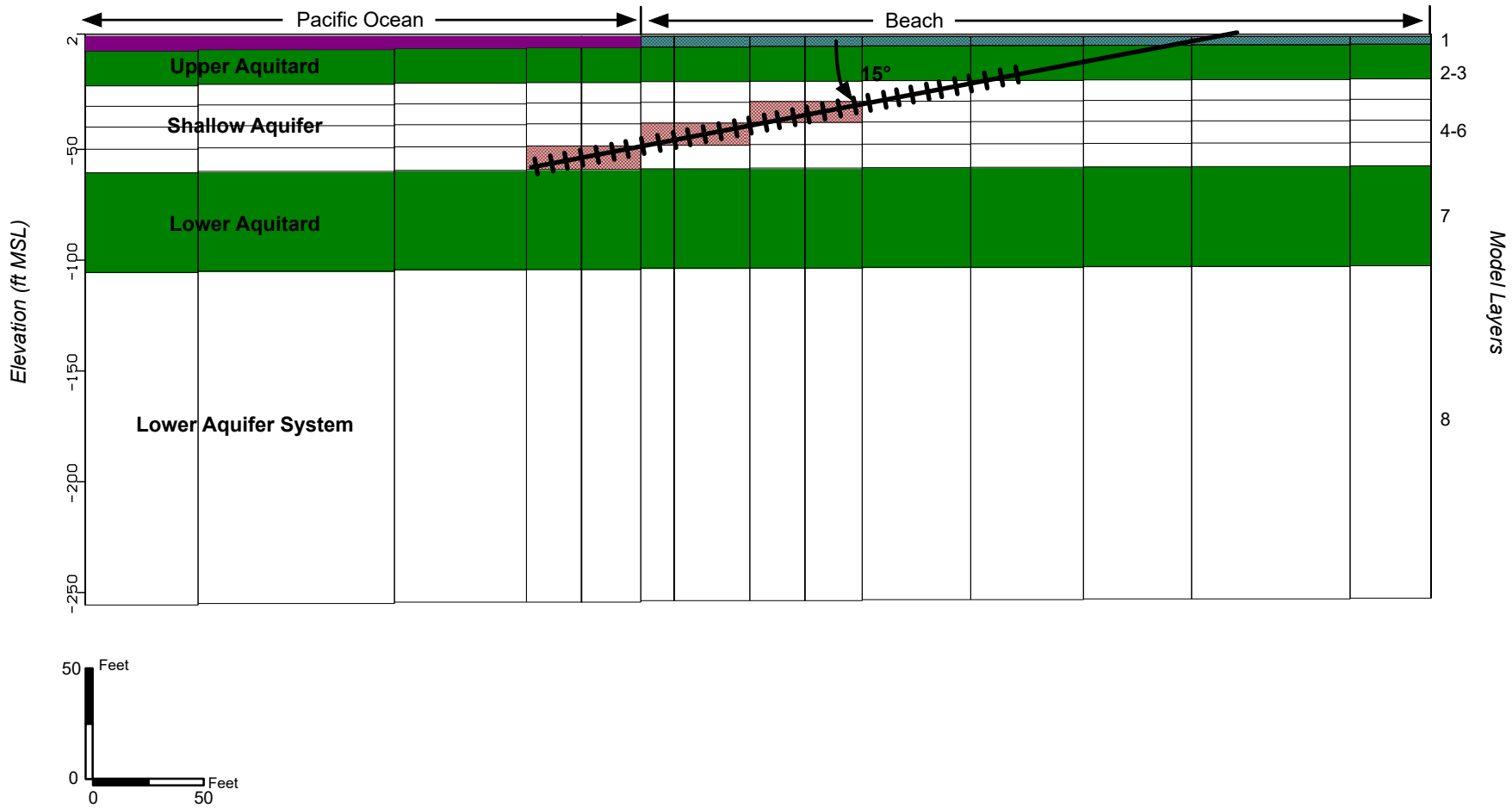
Alternative Sites Analysis
Huntington Beach Seawater Desalination Project

Geosyntec consultants

WR1794A | July 2017

Figure 14

P:\GIS\HuntingtonBeach\Project\2017Jul\Fig14_Alamitos Gap.mxd



Notes:
The cross-section shows the representation of a slant well in the MODFLOW numerical groundwater model.
In the model, each of the 22 hypothetical slant wells is represented by pumping from consecutive cells in Layers 4 – 6, which is the Shallow Aquifer.
The slant well begins at the upper portion of the beach and is drilled at an angle of 15 degrees to a total vertical depth of ~60 ft.
The length of each slant well would be approximately 260 ft. The lower 140 ft is screened in the Shallow Aquifer.

Model Representation of Slant Well
Alamitos Gap

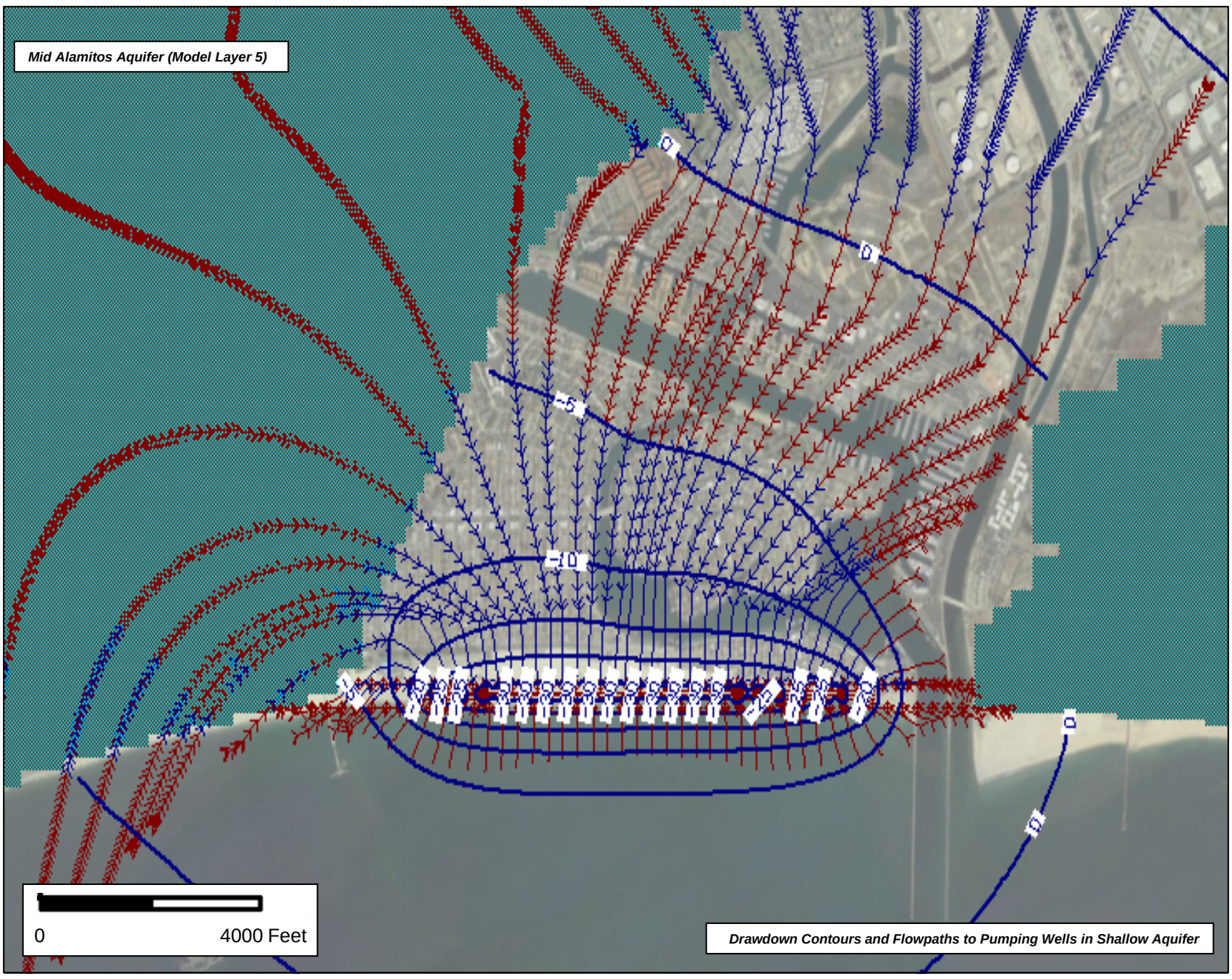
Alternative Sites Analysis
Huntington Beach Seawater Desalination Project

Geosyntec consultants

WR1794A | July 2017

Figure
15

P:\GIS\HuntingtonBeach\Project\2017Jul\Sections\Fig15_SlantWell_Alamitos.ai



Drawdown Equipotential

Pumping Well

Inactive Cells

Head Equipotential

Particle Flow Direction

Dry Cells

Notes:
Pumping from 22 approximately 500 foot long slant wells screened in the Shallow Aquifer.
Total pumping 10 million gallons/day
One year travel time between arrows on flowpaths.
Pathlines are calculated by "back-tracking" from "particles" placed adjacent to slant wells in the Shallow Aquifer.
All locations are approximate.

Alamitos Gap Model Results – Baseline Properties

Alternative Sites Analysis
Huntington Beach Seawater Desalination Project

Geosyntec consultants

WR1794A | July 2017

Figure 16

Appendix A

Remaining Outstanding Requests for RCF23
Alternative Sites Evaluation for the Proposed Desalination Project at Huntington Beach

Responses to the remaining outstanding requests for RCF23 included in the Water Board's 23 May 2017 letter are provided below. The Water Board comments and requests are **bold** and are followed by responses in *blue italics* prepared by Gordon Thrupp of Geosyntec Consultants

RCF 23: Conduct additional hydrogeological modeling to:

Estimate the maximum yield from slant wells. Conduct hydrogeological modeling to estimate maximum yield of slant wells sited at Talbert, Bolsa, and Sunset Gaps that can be achieved without negatively impacting coastal aquifers and wetlands.

Response: Based on calculations with groundwater models, the estimated maximum yield that could be achieved from slant wells or similar subsurface seawater intakes (SSIs) along the coastline in the Talbert, Bolsa, Sunset and Alamitos gaps are approximately 72[1], 15, 9 and 10 mgd respectively.

Include estimates of percentages of the source water coming from coastal aquifers, wetland areas, and seawater.

Response: The estimated source water percentages for SSIs in Bolsa, Sunset, and Alamitos Gaps are provided in Table 2 of the letter report to which this Appendix is attached. Table 1 to Additional Sensitivity Analyses of Slant Well SSI Feasibility Modeling (Geosyntec, 2017) provides source water percentages for modeling of SSIs at Huntington Beach (Talbert Aquifer).

Also discuss any potential impacts to existing seawater intrusion barriers.

Response: As is discussed in this letter and in previous documents on models of SSIs at Huntington Beach (Geosyntec, 2013, 2015, 2017), pumping from SSIs beneath the coastline at Huntington Beach would interfere with the performance of the Talbert Injection Barrier. The barrier counteracts seawater intrusion and replenishes drinking water aquifers. Orange County Water District has indicated that any reduction of the effectiveness of the Talbert Injection Barrier is unacceptable (OCWD, 2015 and 2016).

Pumping from SSIs at Alamitos Gap would impact the effectiveness of the Alamitos Injection Barrier. Performance of the of the Alamitos Injection Barrier is critical for protection of the Central Basin of Los Angeles County and the Orange County Groundwater Basin from seawater intrusion through the Alamitos Gap.

---

[1] *Very optimistic screening level modeling for Huntington Beach (Talbert Gap), with purposely high values of hydraulic conductivity assigned for the shallow sediments (Upper Aquitard) that overlie the Talbert Aquifer, indicated that yields approaching the design flow of 107 mgd may be possible. Updates to the model with more realistic hydraulic properties for the Upper Aquitard sediments (Kh = 1 ft/d and Kv = 0.1 ft/d), which are also used for the base case for the models for Bolsa, Sunset, and Alamitos Gaps, indicate a maximum yield of approximately 72 mgd for SSIs beneath Huntington Beach (Geosyntec, 2017).*

Modeling must include a range of expected permeability of sediment underlying coastal wetland areas that is based on the varying depositional environments associated with wetlands versus surrounding environments. Modeling must also include an appropriate range of vertical permeability for sediments overlying the aquifers, which should incorporate permeability data collected from existing offshore vibracore borings that have indicated vertical permeability ranging from 0.1 to 10 ft/day (average of 10 ft/day).

Response: Along the coast, the Holocene aquifers (shallow aquifers) are overlain by relatively fine-grained, low-permeability intervals that are regionally extensive semi-confining zones (Upper Aquitard). Approximate thickness of the Upper Aquitard sediments near the coast in the Talbert, Bolsa, Sunset, and Alamitos Gaps is 90, 80, 50, and 25 ft, respectively (CDM, 2000; Intera, 2010; Geosyntec, 2013). Although local discontinuous sandy intervals are present within the Upper Aquitard, extensive fine-grained sediments result in low vertical hydraulic conductivity on a large scale, which is why the sequence functions as a hydraulic confining unit above the shallow aquifer (e.g. Talbert, Bolsa, etc.).

Data establish that the Talbert Aquifer near the coastal margin, both onshore and offshore, is overlain by relatively fine-grained sediments—mostly silty sand, which is termed "muddy sand" by Wong et al, (2012) on the San Pedro Shelf.

Based on lithology and stratigraphy from the coastal margin borings, offshore geophysical surveys, and offshore vibracores, Kh and Kv of 10 ft/d and 1 ft/d, respectively, were assigned to the Upper Aquitard in the original Talbert Gap model to provide an optimistically high screening level assessment of SSI production potential and to determine the maximum portion of source water from the ocean (Geosyntec, 2013). Peer review determined that the assigned Kh and Kv of 10 and 1 ft/d for the Upper Aquitard were too high and likely resulted in an overly optimistic assessment of SSI yield and portion of source water from the ocean (WIT, 2015, and Detwiler, 2015).

Subsequent revisions of the Talbert Gap SSI model used lower values of Kh and Kv for the Upper Aquitard for sensitivity analyses. And values of Kh and Kv of 1 and 0.1 ft/d for the Upper Aquitard are considered reasonable values for base case models. The Kv of the Upper Aquitard is increased and decreased by ten for sensitivity analyses (Geosyntec, 2015, 2017).

Measurements of K on vibracore samples provide localized snapshots of disturbed samples and are generally not representative of Kv on a larger scale. The shallow sediments consist of numerous clay and silt layers with some interbedded more sandy lenses. Because of the layering, Kv on a large scale, is orders of magnitude lower than Kh (e.g., Anderson et al., 2015). For example, Cao et al. (2013) used a ratio of Kh to Kv of 10,000 in a model to represent unconsolidated alluvial sediments with interbedded clay layers. The large-scale Kh and Kv values of 1 and 0.1 ft/d assigned in the base case models for the shallow sediments are not inconsistent with the local vibracore measurements.

Kh >> Kv

For Bolsa Gap, the model should simulate the discontinuous nature of the Bolsa Aquifer associated with the Newport/Inglewood fault zone, using model input parameters from the calibrated Orange County Water District model.

Response: The low permeability zone along the Newport-Inglewood fault zone, is included in the Bolsa Aquifer based on the OCWD model (CDM, 2000).

Please see Attachment B to this letter for a response from Water Boards hydrogeologists to Geosyntec's 5/5/17 comments on this RCF.

Response: Addressed below.

Analyze potential intake of contaminated groundwater. If contaminated groundwater is a potential reason that a subsurface intake is not feasible at Sunset Gap, provide a narrative for how the slant wells in the analysis could be sited and designed in a manner to avoid intake of contaminated groundwater to the extent feasible. Overlay expected zone of pumping influence with existing plume maps that show the distribution of contaminated groundwater.

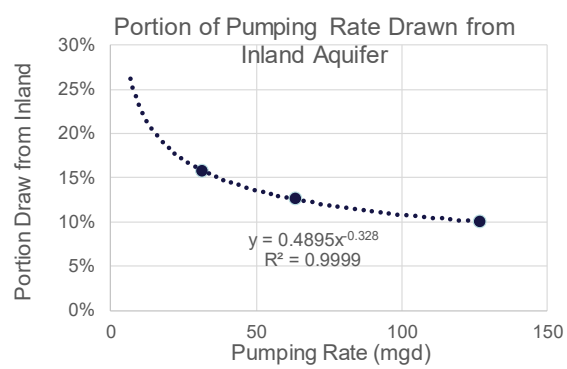
Response: Locations of environmental sites based on Geotracker and a TCE plume in the Seal Beach Naval Weapons Station are included on the figures showing model results for pumping from SSIs in Sunset Gap. The pumping would mobilize contaminated groundwater associated with some of these sites. Any measures to minimize potential influence on contaminated groundwater would further reduce the estimated potential yield from SSIs in the shallow aquifer in Sunset Gap, which is only 9 mgd, far less than the design intake rate for the proposed project. Figure 1 shows environmental sites based on Geotracker for Bolsa, Sunset and Talbert Gaps. Sunset Gap has the most environmental sites, some of which are close to coastline, however potential also exists in the other gaps for SSI pumping to mobilize contaminated groundwater.

Installing the SSIs in the lower aquifer system would reduce influence on contaminated groundwater, but would greatly reduce the portion of ocean water pumped by the SSIs.

Please see Attachment B to this letter for a response from Water Boards hydrogeologists to Geosyntec's 5/5/17 comments on this RCF.

Conduct hydrogeologic modeling to estimate maximum yield of slant wells at Talbert, Bolsa, and Sunset Gaps without negatively impacting seawater intrusion barriers and coastal wetlands.

Response: New models were developed as requested for Bolsa and Sunset Gaps. A model was also developed for Alamitos Gap. The models were used to estimate maximum yield for SSIs beneath the coastal margin of each gap. Any pumping rate from SSIs draws a substantial portion of water from inland aquifers. And relatively more water is drawn from inland aquifers for lower pumping rate, due to much higher Kh of aquifer than Kv of overlying fine-grained sediments.



Orange County Water District has indicated that any reduction of the effectiveness of the Talbert Injection Barrier is unacceptable (OCWD, 2015 and 2016).

Pumping from SSIs at Alamitos Gap would impact the effectiveness of the Alamitos Injection Barrier. Performance of the Alamitos Injection Barrier is critical for protection of the Central Basin of Los Angeles County and the Orange County Groundwater Basin from seawater intrusion through the Alamitos Gap.

There are no injection barriers in Sunset or Bolsa Gap, however OCWD has recently been investigating conditions and considering potential mitigation measures due to concern about sea water intrusion in Sunset Gap.

A recent study of coastal margin wetlands near the Mediterranean Sea determined that groundwater provides 15 to 80% of the water in the lagoons during the dry season. The findings indicate that maintaining groundwater fluxes toward the ocean is necessary to preserve the coastal margin lagoons and their salinity conditions (Mencio et al., 2017).

Pumping at any rate from SSIs along the coastline in Sunset Gap would draw a portion of the water from protected wetlands within the Seal Beach National Wildlife Refuge. We expect that any impact to protected wetlands would likely be considered unacceptable in the Seal Beach National Wildlife Refuge.

Pumping at any rate from SSIs along the coastline in Bolsa Gap would draw a portion of the water from protected wetlands within the Bolsa Chica Basin State Marine Conservation Area. We expect that any impact to protected wetlands would also likely be considered unacceptable in the Bolsa Chica Basin State Marine Conservation Area.

Few wetlands exist in the Alamitos Gap. Wetlands exist in portions of the coastal margin of Huntington Beach in Talbert Gap. They are likely subject so some environmental regulatory protection as well.

Modeling should include an appropriate range of expected permeability of sediment underlying the coastal margin wetlands areas. Modeling should include an appropriate range of vertical permeability for sediments overlying the aquifers, which should incorporate permeability data from offshore vibracore borings that have indicated vertical permeability in the range of 10 ft/d.

Response: It does. See discussion above.

For Sunset and Bolsa Gaps, please overlay expected zone of pumping influence with existing plume maps showing distribution of contaminated groundwater.

Response: This has been done for Sunset Gap. Few environmental sites are available from Geotracker in Bolsa Gap. The Geotracker environmental sites are shown on Figure 1 of the letter report.

For Bolsa Gap, the model should simulate the discontinuous nature of the Bolsa Aquifer associated with the Newport/Inglewood fault zone, using model input parameters from the calibrated Orange County Water District model.

Response: It does. See discussion above.