City of Ventura Special Studies

Estuary Subwatershed Study
FINAL 2009–2010 Monitoring Plan

Prepared for
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1 INTRODUCTION

1.1 Background

The City of San Buenaventura (City; also known as Ventura) owns and operates the Ventura Water Reclamation Facility (VWRF), which discharges treated municipal wastewater to the Santa Clara River Estuary (Estuary) just south of the City near the mouth of the Santa Clara River. With a design capacity of 14 million gallons per day (MGD), the VWRF currently treats approximately 9 MGD of municipal wastewater to tertiary standards (i.e., partial denitrification and filtration) under waste discharge requirements contained in Order No. R4-2008-0011, adopted by the California Regional Water Quality Control Board, Los Angeles Region (Regional Board), on March 6, 2008 (NPDES Permit No. CA0053651).

Under the Water Quality Control Policy for the Enclosed Bays and Estuaries of California (Enclosed Bay and Estuaries Policy), originally adopted by the State Water Resources Control Board in 1974 and updated as Resolution No. 95-84 on November 16, 1995, discharges of municipal wastewater to enclosed bays and estuaries are to be phased out except in circumstances "when the Regional Board finds that the wastewater in question would consistently be treated and discharged in such a manner that it would enhance the quality of receiving waters above that which would occur in the absence of the discharge." In discussions prior to the adoption of Order R4-2008-0011, a number of questions arose regarding the definition of enhancement, the benefits that the discharge provides to the Estuary and adjacent subwatershed, and how discharge practices could be modified over time to protect and enhance habitat and water quality of the portion of the Estuary directly affected by the VWRF discharge.

To address this issue regarding a finding of enhancement, the Regional Board required the City to complete a series of three Special Studies under Order R4-2008-0011. The Special Studies, described briefly below, are designed to assess the impacts and benefits of the VWRF discharge to the Estuary and to develop potential alternatives for the VWRF discharge.

- **Estuary Subwatershed Study** – evaluate the physical and biological function of the Estuary affected by the discharge to determine whether the discharge to the Estuary provides an ecological enhancement now or under different conditions such as a decreased discharge to the Estuary.

- **Treatment Wetlands Study** – determine how a constructed treatment wetland could further improve the water quality of the VWRF tertiary discharge by reducing copper, other metals, and nutrient concentrations to meet effluent limits and further promote receiving water quality improvements.

- **Recycled Water Market Study** – evaluate and quantify expansion the City's existing reclaimed water system through evaluation of potential users and uses within a five-mile radius of the VWRF.

The City submitted Workplans to the Regional Board for each of these studies on September 10, 2008 outlining the elements needed to address the information needs of the permit. The Workplans were approved on December 8, 2008 and form the foundation for the studies that will be developed for the Regional Board by March 6, 2011.

1.2 Estuary Subwatershed Study Workplan

For the Estuary Subwatershed Study, the approved Workplan divides this study into three primary investigations intended to supplement and synthesize existing information as follows:

1) **Estuary Water Balance.** The goals of the Estuary Water Balance are to identify the area of the subwatershed and Estuary that is influenced by the VWRF discharge, quantify the various inflows, and evaluate the hydrologic dynamics of the System. This information will support conclusions on the dynamic relationship between flows, hydrologic conditions and the seasonal spatial extent of the lagoon as the different surface water elevations impact available habitat area. Tasks to reach this end include:

    a. Define the relevant extent of the subwatershed and Estuary that are influenced by the discharge spatially, hydrologically, and functionally by utilizing existing studies and reports to determine how the discharge may have altered conditions over time;
    b. Quantify the average monthly inflow from all quantifiable sources including; groundwater, Santa Clara River flows, VWRF discharges, and agriculture and urban surface water runoff;
    c. Define the relationship between inflows and Estuary habitat area, lagoon depth and volume under various discharge scenarios. Evaluate how different species require varied water depths, riparian habitats, and in-stream cover within the lagoon and the impact of altering the current discharge regime might have on these species.
    d. Evaluate breaching frequency and breaching types and their effect on the lagoon, backwater habitats, water quality, and how each impacts federal and state listed species present in the Estuary. Compile historic information to identify breaching changes over time considering activities such as dredge material management practices, mining, urbanization, agriculture, and other potential influences.

2) **Functionality of the Estuary and Subwatershed.** Using information from the Water Balance effort, this study element will help identify the function of the subwatershed and Estuary as a single unit. In particular, effects of potential changes in the discharge volume upon water quality, overall habitat area, and changes habitat quality for birds, fish, flora, and human uses will be evaluated. These tasks include:

    a. Provide mapping of the various habitat types and their extent;
    b. Analyze the system to predict how changes to the amount of the VWRF discharge could alter water quality, side stream habitat, lagoon surface area, and groundwater influences;
    c. Investigate the role VWRF discharge plays in vegetation growth in the subwatershed and whether this factor and any changes in riverbed vegetation and sediment management practices that may have occurred over time;
    d. Identify alternate VWRF discharge scenarios considering flow volumes, the quality of the various inflows, and treatment wetlands feasibility;
    e. Under each scenario predict changes to spatial inundation characteristics of the Estuary and McGrath State Park including depth and volume;

f. Predict how groundwater quality could influence lagoon water quality under each scenario;
g. Identify how each VWRF discharge scenario changes breaching and those impacts on water quality and beach water quality in the area influenced by the discharge;
h. Identify how each scenario affects habitats for state and federally listed species including steelhead trout, tidewater goby, Western Snowy Plover, and critical habitat areas for birds such as the California least tern;
i. Evaluate the impacts of global warming on the potential increase on sea level elevation to the Estuary and subwatershed area, sustainability of the system and VWRF alternatives being evaluated, and the potential impacts to the outcome of the special studies; and
j. Recommend a management strategy for the VWRF discharge in order to optimize the function of the Estuary affected by the discharge to demonstrate enhancement of the Estuary, or determine that no enhancement exists.

3) **Targeted Research Monitoring and Sampling.** This study element included a series of potential efforts to collect additional data to provide the evidence to support conclusions regarding the best practices to optimize the VWRF discharge.

a. Identify existing and potential groundwater monitoring locations, appropriate sampling frequency, and proper constituents to determine water quality within the influence of the discharge;
b. Conduct daily visual observations, record lagoon discharge volume to the ocean, and map by hand the extent of the lagoon from the point of discharge;
c. Research existing LiDAR mapping to predict spatial Estuary inundation and available habitat areas under the various discharge scenarios pertaining to the McGrath State Park bird habitat areas;
d. Conduct an inventory of existing and potential bird nesting and foraging habitats within the Estuary; and conduct four, one each quarter throughout a consecutive twelve-month period, inventories of bird species and their numbers within the Estuary;
e. Conduct monthly sampling and monitoring to evaluate dissolved oxygen (DO) and nutrient concentrations in the lagoon taking into account seasonal and daily natural background DO levels and cycles. Prepare a DO trend analysis based on existing and new data as available;
f. Conduct the annual Fish Survey and Macroinvertebrate Monitoring Plan; and
g. Over a twelve-month consecutive period, install and maintain a tidewater gauge to determine actual periods of inundation, elevation of the impounded lagoon, lagoon water temperature, and conductivity.

1.3 Overall Approach

The City hired Stillwater Sciences and Carollo Engineers to develop the Estuary Subwatershed Study. The Study will synthesize findings from previous work within and adjacent to the Estuary and incorporate new monitoring data to establish technically defensible linkages between flow regimes and Estuary habitat. The overall approach is to develop estimates of Estuary water surface areas and volumes as a function of water stage and Estuary inflows (i.e., river, groundwater, and VWRF discharge) to allow for the evaluation of changes in inundated areas,

water quality, and habitat suitability for various focal species, as well as human uses. An Estuary stage vs. area relationship will be extended to develop stage vs. suitable habitat area relationships using a habitat criteria mapping approach that includes important physical and water quality attributes for various focal species (e.g., tidewater goby, steelhead). Historical and up-to-date data on breaching will be combined with the Estuary Water Balance and water quality data to identify changes in suitable habitat areas (Section 1.3.2) and how these conditions may have changed over time in association with various factors (e.g., dredge material management practices, mining, urbanization, agriculture, etc.).

Once the stage relationships with inundation and suitable habitat areas have been developed along with the Estuary Water Balance and water quality assessment, a series of VWRF discharge scenarios will be identified. Using the stage vs. habitat relationships and simplified models of future water flows, water quality, and sea level rise, each scenario will be evaluated for changes in Estuary stage, breaching frequency, habitat area, water quality, and habitat suitability for focal species. As described in the approved Workplan, a management strategy will be developed to optimize VWRF discharge and Estuary functionality across a range of alternatives designed to either enhance existing beneficial uses or to completely divert the VWRF discharge if no enhancement exists.

1.4 Recognizing Project Uncertainty

It is well known that the Santa Clara River Estuary is a very dynamic ecosystem, and that this dynamic nature has the potential to impact project uncertainty. For example, the current Estuary morphology may be greatly affected by future large storm events, which may alter the stage-volume and stage-habitat area relationships developed in this study and the subsequent ability to predict future Estuary conditions with a high level of certainty. For the past several decades, the lower Santa Clara River and Estuary have been constrained by levees, resulting in the stabilization of the Estuary location within the larger Oxnard plain and flood flows that move quickly through the Estuary, depositing little sediment before reaching the ocean. Comparison of aerial photographs of the Estuary over the past 40 years suggests that although flood flows change the location of Estuary morphologic features (i.e., the main channel continues to migrate between banks), the total spatial extent of these features has remained relatively similar (i.e., dynamic equilibrium). Comparison of past survey data on Estuary channel thalweg elevation indicates that the Estuary channel has changed on average by less than 1 meter over the past 50 years. Combined, these data suggest that, under current watershed conditions, present-day Estuary stage-volume and stage-area relationships can be used for future conditions provided the proper caveats regarding fluctuations around an average condition are made as well as inclusion of the potential impacts due to sea level rise. A more in-depth analysis of this topic and the associated morphologic data sources will be conducted as part of the Estuary Subwatershed Study.

1.5 Data Gaps Analysis

In developing more detailed approaches for completing the Estuary Subwatershed Study, the project team compiled a list of existing data and identified the data gaps, or missing data, that would be needed to complete the Study (Appendix A). Data sources used included physical and biological data and reports for the Estuary, adjacent floodplain (including McGrath State Beach and McGrath Lake), and the lower Santa Clara River watershed upstream of the Estuary. As the Estuary Subwatershed Study is focused on current and projected future Estuary conditions, the data gaps analysis focused on data collected recently (i.e., over the past 20 years).

Assessment of the existing data gaps highlighted the need to update and add to existing Estuary physical and biological data. Data gaps were identified through assessment of the length of existing data records and applicability of existing data to current Estuary physical condition (i.e., post-2005 storm events). The identified data gaps (Appendix A) and their relationship with project investigations are summarized below.

- **Estuary stage** – Estuary stage will be used in developing groundwater hydraulic gradients and groundwater discharge estimates for determining the Estuary Water Balance, nutrient loading, to help determine controls on mouth breaching frequency, and to help determine stage vs. volume, stage vs. inundation area, and stage vs. available habitat for the Estuary under various hydrologic/hydraulic conditions (e.g., open mouth, closed mouth, high river flow, low river flow, etc.). Current Estuary stage-related data includes a continuous record of Estuary inundation for 2001–2002, a continuous record of Estuary stage for 2004, and daily sketches of Estuary inundation area since 2001. In order to better develop the relationships between Estuary stage and groundwater discharge, inundation area, and available habitat for current morphologic conditions, a continuous record of Estuary stage for a range of hydrologic/hydraulic conditions (e.g., open mouth, closed mouth, high river flow, low river flow) is needed.

- **Groundwater elevation** – Groundwater elevation adjacent to the Estuary will be used to estimate hydraulic gradients and develop groundwater flow estimates. The groundwater data will be combined with available surface water inflow data and evapotranspiration to determine the Estuary Water Balance and nutrient loading. Currently, there is a continuous 5-year record of shallow groundwater data collected on a bi-annual basis near the upstream extent of the Estuary and an intermittent record of groundwater elevation for this "perched" aquifer on the floodplain near the downstream end of the Estuary that has been collected over the past 20 years. A continuous record of groundwater elevation data over a range of conditions (e.g., open mouth, closed mouth, high river flow, low river flow) is needed at the downstream end of the Estuary to better quantify shorter-term and longer-term variations in groundwater hydraulic gradients and to better understand the impacts to groundwater discharge dynamics under current Estuary morphologic conditions.

- **Surface water and groundwater quality** – Estuary surface water and adjacent floodplain groundwater quality data will be combined with water quality data from Estuary inflows to construct Estuary nutrient load estimates and mass balances. This information will be combined with developed habitat suitability criteria for focal species to develop Estuary stage vs. suitable habitat area relationships under various hydrologic/hydraulic conditions. Seasonal water quality data at several sampling locations throughout the Estuary has been collected since 1999, continuous *in situ* data (e.g., DO, Temperature, pH, Conductivity) at two locations within the Estuary has been collected since the beginning of 2009, and groundwater quality at the upstream extent of the Estuary has been collected since 2004. Additional surface and groundwater quality data is needed over a range of seasonal and hydrologic/hydraulic conditions to better quantify spatial variations in water quality and the relationship to suitable habitat area under current Estuary morphologic conditions.

- **Upland and aquatic habitat type and extent** – Vegetation distribution maps under open and closed mouth conditions will be developed for the intertidal and adjacent terrestrial habitats within the Estuary subwatershed. These maps will allow examination of the influences of breaching frequency, hydroperiod, and water quality on current vegetation distribution, as well as suitable areas for focal fish (e.g., tidewater goby and steelhead) and bird species (e.g., Western snowy plover and California least tern). Relevant data sources included recent (2006) detailed mapping of the Estuary tidal vegetation and adjacent upland vegetation, annual fish (including tidewater goby and steelhead) and macroinvertebrate sampling throughout the Estuary since 1999, and recent snowy plover and least tern nesting data for the upland area adjacent to the Estuary (Ventura Audubon Society). Combined, the existing data provide a wealth of information. However, recent Estuary subtidal vegetation extent needs to be mapped and the combination of physical and biological conditions into suitable habitat areas for individual focal species for current morphologic conditions needs to be determined.

- **Seasonal bird surveys within the Estuary** – A separate monitoring plan is currently under development to provide seasonal baseline data on existing and potential bird nesting and foraging habitats within the Estuary. The plan will build off of existing data and ongoing monitoring efforts by the Ventura Audubon Society and others (Appendix A). The resulting data will be used to inform the evaluation of potential impacts of the discharge scenarios developed as part of the Estuary Subwatershed Study.

1.6 2009-2010 Monitoring Schedule

To address the data collection needs identified in the data gaps analysis, we have developed monitoring plans covering three types of surveys: 1) an Estuary Hydrology and Morphology Survey; 2) an Estuary Water Quality and Nutrient Survey; and 3) a Tidal and Upland Vegetation and Aquatic Habitat Mapping (See Sections 2 through 4). Each of the identified data gaps (Appendix A) summarized above is included in the proposed monitoring surveys. The Estuary Hydrology and Morphology Survey (described in Section 2) will focus on collecting Estuary stage and groundwater elevation data. The Estuary Water Quality and Nutrient Survey (described in Section 3) will focus on collecting Estuary surface water and adjacent groundwater quality, and the Tidal and Upland Vegetation and Aquatic Habitat Mapping effort (described in Section 4) will focus on updating recent vegetation mapping and delineating suitable habitat areas.

Field data will be collected from summer 2009 through fall 2010 (Table 1-1). Eight field visits are anticipated for taking samples, downloading data from installed instruments, and conducting field surveys and habitat mapping. The timing of the field visits ensures that a range of conditions (e.g., inflows, Estuary stage, Estuary mouth closure status, water quality, focal species life stage residency, etc.) over several seasons are sampled. This sampling schedule will also allow regular data downloads from installed instruments to ensure minimal data loss over the monitoring period.

Table 1-1. 2009-2010 sampling schedule for the Estuary Subwatershed Study.

Sampling Event*	Estuary Hydrology and Morphology Survey	Estuary Water Quality and Nutrient Survey	Tidal and Upland Vegetation and Aquatic Habitat Mapping
Summer 2009 (August)	X	X	X
Fall 2009 (Sept or Oct)	X	X	X
Winter 2009 (Jan)	X	X	
Winter 2009 (Feb)	X	X	
Spring 2010 (Apr)	X	X	X
Summer 2010 (July)	X	X	
Summer 2010 (August)	X	X	
Fall 2010 (Oct or Nov)	X	X	X

*Anticipated month to conduct sampling is indicated in parentheses.

We have detailed monitoring plans for the three focus areas in the following sections.

2 ESTUARY HYDROLOGY AND MORPHOLOGY SURVEY

2.1 Goals and Objectives

The overall goals of the Estuary Hydrology and Morphology Survey are to determine 1) the contribution of groundwater flows relative to other components of the overall seasonal and average monthly water balance for the Estuary (i.e., VWRF inflows, SCR inflows, Estuary discharge, and evapotranspiration), and 2) the influence of Estuary stage upon local water table elevation, mouth breaching dynamics, and Estuary inundation extent.

To meet these goals, two study objectives have been developed for the Hydrology and Morphology Survey to fill known data gaps and characterize physical conditions and the Estuary water balance for a range of conditions (e.g., mouth open, mouth closed, low river flow, high river flow) over multiple seasons.

- A continuous record of Estuary stage will be developed for use in: topographic modeling of inundation extent to be used to predict seasonal habitat availability (see Section 4); characterization of local groundwater gradient for estimation of groundwater discharge to the Estuary; and the identification of thresholds for initiation of mouth breaching events.
- A continuous record of groundwater elevation will be developed along a transect for use in: characterizing effects of Estuary stage on local groundwater table elevation; and characterizing seasonal and average monthly groundwater gradients and associated groundwater flow rates.

These data will ultimately be combined with data collected within concurrent surveys (Water Quality and Nutrient Survey and Tidal and Upland Vegetation and Aquatic Habitat Mapping) and pre-existing information to determine the impact of VWRF discharge upon the Estuary water balance and the influence of potential VWRF discharge scenarios upon water quality, vegetation, overall habitat area, and habitat quality for birds, fish, and human uses.

2.2 Existing Information

There have been several studies conducted over the past 20 years and many past and on-going data collection efforts that provide hydrologic (e.g., river and groundwater discharge), hydraulic (e.g., Estuary stage and groundwater elevation), and morphologic (i.e., mouth condition) data for the Estuary and contributing watershed. Existing studies and data sources for Estuary and lower Santa Clara River surface and groundwater hydrology/hydraulics and morphology that will be essential for completing this project are presented in Table 2-1.

Table 2-1. Existing information on Estuary and lower river hydrology/hydraulics and morphology.

Existing Estuary hydrology/hydraulics and morphology information	Estuary stage	Mouth breaching	Groundwater elevation and discharge	Surface flow discharge
STUDIES				
Swanson et. al. 1990		X	X	
K/J 2002			X	
ESA 2003	X		X	
URS 2004			X	
URS 2005			X	
Nautilus 2005 (*including Entrix and KH&E studies*)	X	X		
KH&E 2007	X	X		
DATA SOURCES				
City of Ventura daily mouth status and Estuary flow estimate (1984–present)		X		X
City of Ventura daily VWRF flow estimate (1984–present)				X
City of Ventura daily Estuary inundation extent estimate (2001–present)	X	X		
Bailard and Coastal SC landfill groundwater data (2004–present)			X	
River discharge at Montalvo (USGS; 1955–2004)				X
River discharge at Freeman Diversion (VCWPD; 2005)				X
River discharge at Victoria Ave. (VCWPD; 2008–present)				X
SCCWRP Bight 08 WQ monitoring program (in progress; 2009)	X			

2.3 Survey Design

The design for the Estuary Hydrology and Morphology Survey is to continuously record the Estuary water surface elevation (stage) and groundwater elevations in the adjacent floodplain under a range of Estuary conditions (i.e., open mouth, closed mouth, low river flow, high river flow) from summer 2009 (late August) through fall 2010 (October or November).

2.3.1 Monitoring Locations

Estuary stage will be recorded at two (2) locations along the south bank of the Santa Clara River adjacent to McGrath State Beach (see Table 2-2 and Figure 2-1). The downstream location will be in the Lower Estuary adjacent to the channel on the south bank of the Estuary at McGrath State Beach that originates in the McGrath State Beach campgrounds. The upstream location will be in the Middle Estuary also along the south bank approximately 200 m upstream of the downstream gage. The installation of two stage recorders in the Estuary is to decrease the probability of data loss due to one recorder failing as a result of instrument malfunction or being lost altogether due to theft or high flow. These two locations were chosen for instrument installation for several reasons. First, measuring Estuary stage along the south bank allows for the full range of Estuary stage to be recorded as the stage recorders will be installed within the Estuary main channel. Second, the south bank morphology provides small protected 'pockets' where the recorders will be shielded from flow and protected during storm events. Third, these locations are adjacent to McGrath State Beach trails and therefore will be very easy to monitor and maintain throughout the duration of the study.

Table 2-2. Site description and identification code for stage recorders and groundwater monitoring wells

Site description	Site code
Estuary Stage Recorders	
Lower Estuary	SR-1
Middle Estuary	SR-2
Groundwater Wells	
Upper Estuary[2]	GW-1
Floodplain west of McGrath State Beach campgrounds[1,2]	GW-2
Floodplain west of McGrath State Beach campgrounds [1,3]	GW-3
Floodplain south of McGrath State Beach campgrounds [1,4]	GW-4

[1] New groundwater well installed for the City of Ventura Estuary Subwatershed Study.
[2] Near well 2 from ESA (2003) study
[3] Near well 3 from ESA (2003) study
[4] Near well 5 from ESA (2003) study

Water table elevation will be recorded at four (4) locations within and adjacent to the Estuary along a transect extending through McGrath State Beach to estimate groundwater gradients under various hydrologic/hydraulic conditions. Within the Estuary, a monitoring well will be installed along the south bank on a vegetated bar approximately 50 m downstream of the Harbor Blvd. bridge (see Table 2-2 and Figure 2-1). The remaining monitoring wells will be installed on the floodplain adjacent to the Estuary, extending southeast through the McGrath State Beach campground towards McGrath Lake. The locations of the monitoring wells were chosen for following reasons. First, the Estuary monitoring well location will help determine longitudinal groundwater gradients during when the river and Estuary stage is low and will help determine upstream Estuary inundation extent when the Estuary is full. Second, the floodplain monitoring wells will be close to monitoring well locations from previous studies (i.e., ESA 2003 and URS 2005), allowing for direct comparison between and compilation of the pre-existing and newly collected water table elevation data. Lastly, all well locations have very good access and will be easily monitored during the study period.

2.3.2 Schedule

The Estuary stage and groundwater elevation recorders will collect continuous data from August 2009 to October or November 2010. Visiting the data recorders and downloading data regularly throughout the monitoring period will ensure that equipment is functioning properly, to allow for 'real-time' assessment of data quality, and to guard against losing data for long time periods should the equipment become damaged or lost. Data will be downloaded seven times between August 2009 and October or November 2010 during seasonal and synoptic surveys; once in 2009 (September or October) and six times in 2010 (January, February, April, July, August, and October or November).

2.4 Methods

2.4.1 Instrument Installation

2.4.1.1 Estuary stage

Estuary stage will be recorded using two pressure transducers (InSitu® miniTroll) installed in August 2009. The pressure transducers will be placed in a protective PVC pipe housing and installed approximately 5–10 ft from the south bank close to the Estuary bed. The pressure transducers will be installed at an elevation low enough to record stage when the Estuary water volume is low, but above the Estuary bed to ensure that the pressure transducers will not become buried with sediment during the course of the study. To ensure that the Estuary stage is constantly being recorded from a fixed elevation, the pressure transducers will be fastened to metal stakes driven into the Estuary bed to a depth that will limit potential movement due to scour and/or high flow velocity. A protective PVC pipe housing for the pressure transducers' data cable will be installed on the Estuary bank and will terminate at an elevation just above the adjacent south bank floodplain, approximately 30–40 ft from the pressure transducer. The protective PVC housing will be secured to the ground surface using rebar and foundation stakes. To ensure that the instruments are not visible to McGrath State Beach visitors and staff, the PVC housing will be painted brown and covered with loose vegetation.

Following installation, the elevation of the pressure transducer will be measured using a total station (Sokkia® SET600 or similar) and prism. If possible, the pressure transducer elevations will be tied directly to an established elevation datum in the area (e.g., NGS benchmark EW6035). If this is not possible due to our inability to locate an established datum, the pressure transducer elevation will be tied to an installed temporary benchmark. Survey-grade GPS will then be used to obtain the coordinates (NAD83) and elevation (ft NAVD88) of the temporary benchmark.

2.4.1.2 Groundwater elevation

Groundwater monitoring wells will be installed in late August 2009. Since the goal is to monitor the 'semi-perched aquifer' water table elevation (i.e., the surface aquifer that interacts with the Estuary extends approximately 40 ft deep), all of the monitoring wells will be installed to a shallow depth. The Estuary monitoring well will be installed to a depth of approximately 10 ft and will be a 15-ft long, 2-in diameter perforated PVC pipe wrapped in plastic mesh. The floodplain monitoring wells will be installed to a depth of 20 ft and will be 25 ft long, 2-in diameter PVC pipes. Following placement of the well casings in the ground, homogenous sand will be used to fill-in the space between the hole and the well and bentonite clay (or similar) will

be placed at the ground surface around the well to prohibit surface water infiltration into the sand adjacent to the well. Wells will then be assessed by a 'slug test' (or similar test) to ensure that they are functioning properly and capable of capturing short-term fluctuations in water table elevation. Locking caps will be placed on all wells and locked external casings will be also installed around the floodplain monitoring wells to guard against well damage. All wells and external casings will be painted brown and installed in locations with the lowest degree of visibility by McGrath State Beach visitors and staff. Floodplain wells, and possibly the Estuary well, will installed by a local well installation contractor. If the Estuary stage is high during the late August 2009 field visit, the Estuary monitoring well will be installed during the next field visit when Estuary stage is low enough to allow well installation (e.g., October 2009).

Following well installation, pressure transducers (Solinst® Leveloggers) will be installed in each well to record continuous water table elevation. At each well, the pressure transducer will be attached to the cap (or another fixed point on the well) by a Kevlar cord and suspended to a depth below the anticipated minimum groundwater elevation and above the bottom of the well. This depth for the Estuary well pressure transducer will be approximately 7 ft below the ground surface for the floodplain wells pressure transducers will be approximately 15 ft below the ground surface. As local barometric pressure needs to be accounted for when determining water table elevation from the pressure transducers, a barometer (Solinst® Barologger) will be installed in one of the floodplain wells.

Following instrument installation, the elevation of the well datum, or point on each well where the Kevlar cord is attached (well caps or another fixed point on the wells), and the ground surface adjacent to each well will be recorded using a total station (Sokkia® SET600 or similar) and prism. If possible, these elevations will be tied directly to an established elevation datum in the area (e.g., NGS benchmark EW6035). If this is not possible due to our inability to locate an established datum, the pressure transducer elevation will be tied to a temporary benchmark. Survey-grade GPS will be used to obtain the coordinates (NAD83) and elevation (ft NAVD88) of the temporary benchmark. The combination of each well datum elevation and the length of the Kevlar cord will enable the determination of actual water table elevation (see below).

2.4.2 Data Collection

2.4.2.1 Estuary stage

The installed pressure transducers will record Estuary stage at a 30-minute time interval from August 2009 to October or November 2010 and will be downloaded seven times during the monitoring period. Each time stage data is downloaded, pressure transducer elevations will be re-measured with a total station and prism to determine if the there has been an elevation shift since the previous field visit. The pressure transducers will also be assessed to see if they appear in good working order and if there has been movement due to scour or sediment accumulation.

2.4.2.2 Groundwater elevation

Similar to the Estuary stage, the installed pressure transducers will record groundwater elevation and barometric pressure at a 30-minute time interval from August 2009 to October or November 2010 and will be downloaded seven times during the monitoring period. During each field visit, the depth to groundwater at each well will be measured using a hand-held well level logger for comparison with the pressure transducer reading, the length of each Kevlar cord will be re-measured to see if there has been any change, and the elevation of each well datum will be re-

measured with a total station and prism to determine if the there has been an elevation shift since the previous time data was downloaded. The pressure transducers will also be assessed to see if they are in good working order and the wells will be assessed for any sediment accumulation.

2.4.3 Data Analysis

2.4.3.1 Estuary stage

As a quality assurance measure prior to leaving the field after downloading stage data, the pressure transducer elevations and Estuary stage data will be reviewed and assessed for irregularities. The pressure transducer elevations will first be compared to elevation recorded during the previous field visit. If the elevations differ by more than 5 mm, then it will be assumed that the pressure transducer has moved and this shift will be taken into account when determining water surface elevation (see below). The pressure transducer will then be checked very closely to determine if it is currently at a secured elevation. Once the elevation is determined to be secure, the pressure transducer elevation will be re-measured. As an additional quality assurance review, Estuary stage data for the period between data downloads will then be examined for anomalous values. If the values are determined to be erroneous, the pressure transducer will be assessed to determine if it is functioning properly and/or if there is any visible cause for the erroneous measurements (e.g., debris or sediment). Erroneous values will be removed from the data.

Following the initial stage data quality assessment, the sorted data will then be converted to ft NAVD88 (using the known elevation of the survey benchmark) and added to the comprehensive Estuary water surface elevation data set. Where appropriate, the shift in pressure transducer elevation between field visits will be included in determining the Estuary water surface elevation for a given time period. It will be assumed that the elevation shift should be applied to the entire time period between field visits unless there is specific information indicating otherwise.

2.4.3.2 Groundwater elevation

Prior to leaving the field after downloading groundwater elevation data, Kevlar cord lengths, well datum elevations, and the water table elevation data will be assessed for irregularities. The Kevlar cord length and well datum elevations will first be compared to elevation recorded during the previous field visit. If the cord lengths and/or elevations differ by more than 5 mm, then it will be assumed that the cord length has changed and/or the well moved and this shift will be taken into account when determining actual water table elevation (see below). The Kevlar cords will be checked to make sure that there is no potential more change in length and wells will then be checked very closely to determine if they are currently at a secured elevation. Once the elevation is determined to be secure, each well datum elevation will be re-measured. As with the Estuary stage data above, a quality assurance review will be conducted for the water table elevation and barometric pressure data for the period between data downloads will then be examined for erroneous values. As a final data check, the water table depth measurement from the hand-held well level logger will be compared to the pressure transducer value for the same approximate time to ensure that the pressure transducer is still recording properly.

Following the initial groundwater elevation data assessment, the water table elevation data will be corrected with barometric pressure, converted to ft NAVD88 (using the known elevation of the survey benchmark), and added to the comprehensive ground water table elevation data set. Where appropriate, the shift in Kevlar cord length and/or well datum elevation between field

visits will be included in determining the Estuary water surface elevation for a given time period. It will be assumed that the length change and/or elevation shift should be applied to the entire time period between field visits unless there is specific information indicating otherwise.

2.5 Work Products

Work products from the Estuary Hydrology and Morphology Survey include the following:

- 30-minute time series of Estuary water surface elevation (in ft NAVD88) from August 2009 through November 2010
- 30-minute time series of groundwater elevation (in ft NAVD88) at four (4) wells in McGrath State Beach from August 2009 through November 2010
- 30-minute time series of ground water/surface water elevation (in ft NAVD88) at one (1) well in the Estuary from August 2009 through September 2009 and from April 2010 through September 2010

These work products will be included as part of the following Estuary Subwatershed Study deliverables:

- Data summary containing physical, water quality, and biological field data collected during Year 1 (August 2009–Dec 2009)
- Data summary containing physical, water quality, and biological field data collected during Year 2 (Jan 2010–Dec 2010)
- Technical memorandum detailing findings during the monitoring period

2.6 Equipment

Instrumentation and data collection

- Two (2) pressure transducers for recording Estuary stage (InSitu® miniTroll)
- Five (5) pressure transducers for recording water table elevation (Solinst® Leveloggers)
- One (1) pressure transducer for recording barometric pressure (Solinst® Barologger)
- PVC piping for monitoring wells and to house stage recording pressure transducers
- Five (5) locking well caps
- Four (4) locking well casings
- Kevlar cord
- Total station (Sokkia® SET600 or similar) and prism
- Survey-grade GPS (Trimble® ProXT), as needed
- Hand-held GPS
- Hand-held well level logger
- Laptop computer with appropriate software and cables for downloading data from pressure transducers
- Measuring tape
- Digital camera

Installation

- Rebar
- Foundation stakes
- Spray paint
- Hand augur
- Powered augur (to be used by contractor installing wells)
- Homogeneous sand and bentonite (or similar)

2.7 Permits

Permits are required by county and state agencies for hydrology and morphology data collection within and adjacent to the Santa Clara River Estuary. The table below summarizes the permits required by the various agencies for this portion of the larger Estuary Subwatershed Study.

Table 2-3. Hydrology and Morphology Monitoring Survey task permit requirements.

Monitoring Task	Agency Permit Requirement	
	Ventura County	California Department Parks & Recreation
Site access and general data collection		X
Estuary stage recorder installation		X
Well installation	X	X

We anticipate having permits to install equipment and collect data by the end of August 2009. If necessary, we will begin data collection for activities that we have permits for and proceed with the other activities once the appropriate permits are obtained.

2.8 References

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3 ESTUARY WATER QUALITY AND NUTRIENT SURVEY

3.1 Goals and Objectives

The overall goals of the water quality and nutrient survey are to determine 1) if water quality in the Estuary is affected by discharge from the VWRF, 2) the current trophic status of the Estuary, and 3) if the VWRF discharge currently enhances water quality in the Estuary or could provide an enhancement under a different discharge scenario (i.e., overall decreased discharge).

To meet the stated project goals, three study objectives have been developed to characterize water quality and Estuary trophic status over multiple seasons and hydrologic conditions.

- Conduct quarterly synoptic surveys of *in situ* water quality (i.e., water temperature, DO, pH, conductivity), nutrients (i.e., nitrogen and phosphorus species) and chlorophyll-*a* in the Estuary and the lower Santa Clara River;
- Collect quarterly nitrate (NO_3^-) samples at up to four groundwater wells adjacent to the Estuary and lower Santa Clara River in order to characterize average seasonal groundwater nitrate contributions from the adjacent watershed to the Estuary;
- Conduct up to three synoptic surveys that pair open and closed mouth conditions during both seasonal low-flow (summer/fall) and high-flow (winter/spring) periods in order to elucidate the relative importance of inputs from the lower Santa Clara River, VWRF discharge, and groundwater on water quality in the Estuary.

3.2 Existing Information

Multiple studies and data collection efforts have characterized elements of surface water and groundwater quality in or near the Estuary and lower Santa Clara River, including efforts by federal and state agencies (e.g., USFWS, ACOE, CDFG, State Parks and Recreation) as well as regional and local entities (Southern California Coastal Water Research Project [SCCWRP], City of San Buenaventura). Existing studies and data sources for water quality in the Estuary and lower Santa Clara River are presented in Table 3-1. Ongoing monitoring efforts, including the City's monthly receiving water monitoring program, and the continuation of the continuous in situ data collection efforts by SCCWRP will be extended by the City through the 2009-2010 monitoring period to address identified data gaps (Appendix A).

Table 3-1. Existing studies and data sources for water quality.

Existing water quality information	*In situ* surface water parameters (e.g., water temp, DO, pH, salinity, conductivity)	Surface water nutrients (N, P, some speciation)	Groundwater parameters (e.g., elevation, contaminants)
STUDIES			
Swanson et al. 1990	X		
USFWS 1999	X		
URS 2005	X[a]		X[a]
K/J 2002	X[a]		
Entrix 2002 (*Metals Translator Study*)	X		
Nautilus 2005 (*including Entrix and Kamman studies*)	X	X	
Kelley 2008	X		
DATA SOURCES			
City of Ventura Monthly WQ monitoring program (1997–present)	X	X	
Bailard and Coastal SC landfill groundwater data (2004–present)			X
SCCWRP Bight 08 WQ monitoring program (in progress; 2009)	X		

[a] Available data is for McGrath Lake.

3.3 Study Design

To build upon existing and ongoing data collection efforts, additional *in situ* and analytical water quality data will be collected at locations within the Estuary and lower Santa Clara River from summer 2009 through fall 2010. The study design is based upon our current understanding of Estuary configuration, which is derived from available Google Earth imagery (2006) and includes the prevailing channel network, vegetation cover, and location of the VWRF outfall channel. Using available imagery, the Estuary possesses a braided main channel flowing southwest from upstream of the Harbor Blvd. bridge to a small mouth at the southwest corner of the system (Figure 3-1). A narrow high-flow channel is also apparent, flowing roughly parallel to the main channel along the northern edge of McGrath State Beach. The VWRF outfall channel enters the Estuary from the north in a relatively more vegetated portion of the Estuary, flows southwest, then turns directly south and flows along to enter the lower Estuary. The mouth is assumed to be in the southwest corner of the SCRE (shown by red line in Figure 3-1). Should Estuary configuration under current conditions vary significantly from that described above, the study design will be adjusted to accommodate updated information.

3.3.1 Monitoring Sites

Proposed water quality monitoring sites are distributed amongst the channel network of the Estuary and lower Santa Clara River and on the adjacent floodplain, and include existing locations where water quality data has recently been or is currently being collected. Seven Estuary monitoring sites and one lower Santa Clara River site have been identified as representative of either ambient conditions or waters potentially affected by permitted discharges of the VWRF to the Estuary (Figure 3-1, Table 3-2). The single river site is located just upstream of the Harbor Blvd crossing and is intended to characterize surface water conditions entering the Estuary from Reach 1 of the lower Santa Clara River (Stillwater Sciences 2008). The seven Estuary sites will be located in the upper, middle, and lower zones of the Estuary, which are broadly defined using reported elevation above mean sea level (MSL) from 2001 McGrath State Beach mapping efforts (ESA 2003), as follows:

- Upper Estuary: ≥ 1.83 m (6 ft) above MSL
- Middle Estuary: 1.22 m (4 ft) to 1.52 m (5 ft) above MSL
- Lower Estuary: 0.31 m (1 ft) to 0.92 m (3 ft) above MSL

In addition to the sites in Estuary, groundwater water quality within and adjacent to the Estuary will be measured along the four installed monitoring wells (Figure 2-1,Table 3-2). The wells will be installed along a transect extending from the southern edge the Estuary through the McGrath State Beach campground, extending south towards McGrath Lake (see Section 2.4.1.2).

Table 3-2. Proposed monitoring sites in lower Santa Clara River and Estuary.

Site description	Site code
Lower Santa Clara River	
Upstream of Harbor Blvd bridge	R-1
Santa Clara River Estuary	
Upper Estuary main channel (d/s of Harbor Blvd bridge)	E-U1
Upper Estuary high-flow channel	E-U2
Upper Estuary d/s of VWRF Outfall	E-U3
Middle Estuary main channel	E-M1
Middle Estuary d/s of VWRF Outfall	E-M2
Lower Estuary main channel	E-L1
Lower Estuary at mouth[1]	E-L2
Groundwater Wells	
Upper Estuary[2]	GW-1
Floodplain west of McGrath State Beach campgrounds[2]	GW-2
Floodplain west of McGrath State Beach campgrounds[2]	GW-3
Floodplain south of McGrath State Beach campgrounds[2]	GW-4

[1] Depending on mouth location, this site may be relocated to sample the south deepwater arm of SCRE depicted in the 2006 available imagery.
[2] New groundwater well installed for the City of Ventura Estuary Subwatershed Study.

3.3.2 Sampling schedule and timing

Seasonal synoptic surveys will be conducted on a quarterly basis from summer 2009 through fall 2010 (Table 3-3). While the surveys will be timed to represent both open and closed mouth

conditions, the focus will be on periods when the mouth is closed and VWRF discharges are most likely to have an effect on Estuary water quality. Application of a synoptic design is intended to provide a "snapshot" of water quality conditions within the Estuary and its major freshwater and saltwater inputs. Sampling approaches during open mouth and closed mouth conditions are discussed below.

Table 3-3. Anticipated water quality sampling schedule.

Site Code	Sampling Frequency							
	Phase II				Phase III			
	Summer 2009 (August)	Fall 2009 (Sept/Oct)	Winter 2010 (Jan/Feb)		Spring 2010 (Apr)	Summer 2010 (July/Aug)		Fall 2010 (Oct/Nov)
	Closed Mouth	*Closed Mouth*	*Open Mouth*	*Closed Mouth*	*Open or Closed Mouth*	*Open Mouth*	*Closed Mouth*	*Closed Mouth*
R-1[a]	X	X	X	X		X	X	X
E-U1	X	X	X	X	-	X	X	-
E-U2	X	X	X	X	-	X	X	-
E-U3	X	X	X	X	X	X	X	X
E-M1	X	X	X	X	X	X	X	X
E-M2	X	X	X	X	X	X	X	X
E-L1	X	X	X	X	X	X	X	X
E-L2	X	X	X	X	X	X	X	X
GW-1[b]	-	X	X	X	X	X	X	X
GW-2[b]	-	X	X	X	X	X	X	X
GW-3[b]	-	X	X	X	X	X	X	X
GW-4[b]	-	X	X	X	X	X	X	X

X = *In situ* and analytical samples (TKN, NH3, NO3+NO2, PO4, TP, chl-a) will be collected.
[a] Sample will be collected from the lower Santa Clara River just upstream of the estuary. Site location may vary over the course of the study, depending on SCRE mouth status.
[b] Only NO3+NO2 will be collected.

3.3.2.1 Closed mouth conditions

The Estuary will be sampled 4–6 times under closed mouth conditions to characterize water quality when VWRF discharges are most likely to have a measurable impact (Table 3-3). When the Estuary mouth is closed, water quality and nutrient sampling will be conducted at least 2 weeks following mouth closure to capture conditions when VWRF discharges have accumulated as a large fraction of the total volume of water in the Estuary.

3.3.2.2 Open mouth conditions

The Estuary will be sampled 2–3 times under open mouth conditions to characterize water quality when VWRF discharges are least likely to have a measurable impact. If possible, open mouth survey periods will be selected as one half of a pair of seasonal open-closed mouth conditions (Table 3-3) so that they may approximate a 'control' for the closed mouth conditions.

When the Estuary mouth is open, water quality and nutrient sampling will be conducted at roughly the same point in the tidal cycle for all sites that are tidally inundated. These sites are expected to include E-M1, E-M2, E-L1, and EL-2 but may also include one or more sites in the upper Estuary. Samples will be collected during daylight hours over two days, to allow for sampling during the same point in the tidal cycle. Sampling time for all tidally inundated sites

will correspond to the period between medium and low tides, so that gradients in water quality between the lower Santa Clara River, VWRF discharge, and the Pacific Ocean will be discernable in the data. Sampling at low tide will be targeted to continue existing sampling under the Bight'08 marine monitoring program (SCCWRP 2009), which currently focuses on low tide sampling at sites overlapping with the City of Ventura study.

3.4 Methods

3.4.1 Sampling Methods

3.4.1.1 Estuary and lower Santa Clara River *in situ* sampling

All monitoring sites will be located using Global Positioning System (GPS) units. It is anticipated that for open mouth conditions at mid-tide, most samples can be collected on foot, but a boat may be required for lower Estuary sites. For closed mouth conditions, a boat may be necessary for all Estuary sites.

In-situ water quality parameters (Table 3-4) will be measured using a portable Yellow Springs Instruments (YSI) multi-parameter probe, including water temperature, pH, salinity, conductivity, and dissolved oxygen (temperature compensation, manual salinity correction, self-stirring probe). General sampling methodology will follow SCWWRP (2009) and Surface Water Ambient Monitoring Program (SWAMP) protocols for calibration and sample collection. Field calibration of the YSI multi-parameter probe will occur daily, and if applicable, after every 20 measurements in a given day. In addition, Winkler titrations will be run pre- and post-field calibration of the YSI dissolved oxygen probe each day as an independent check on the internal instrument field calibration. For dissolved oxygen measurements, the probe will be allowed to equilibrate in-stream for at least 90 seconds before recording results to the nearest 0.1 mg/L. Temperature will be measured to the nearest tenth of a degree centigrade. Once placed in the stream, the pH probe will be allowed to equilibrate for 60 seconds before recording to the nearest 0.1 of a pH unit. Turbidity will be measured using grab samples collected at each location using a clean, rinsed sample bottle and a portable Hach 2100 P turbidimeter. Four to six turbidity samples will be used to provide an average turbidity at each location. Field calibration of the turbidimeter will occur daily or after every 50 measurements. Vertical water clarity will be measured using a Secchi disc. If the water is too clear or shallow for a Secchi disc disappearing depth to be recorded, the deepest point in the sampled habitat unit will be measured and Secchi depth will be recorded as "> X", where X is the greatest depth observed.

Table 3-4. *In-situ* water quality parameter methods and instrument accuracy levels.

Parameter	Method No.	Specified instrument accuracy	Reference
Temperature	170.1	0.1 C	USEPA 2003
Dissolved oxygen	4500-O	0.03 mg/L (0.03 %)	APHA 1998
Conductivity	2510-B	1.0 umhos/cm	APHA 1998
pH	4500-H	0.1s.u.	APHA 1998
Turbidity	2130 B	0.1 NTU	APHA 1998
Secchi depth	NA	0.1 m	USGS 1977

At the lower Estuary monitoring sites, representative sample depths for analytical parameters will be determined by *in-situ* conductivity profiles, to determine the extent of vertical mixing in the water column. If stratification is observed, as either the result of a salt wedge (a density gradient formed in the bay when marine water moves inland on and near the bottom and lighter fresh water moves seaward on top) or a freshwater thermal density gradient, remaining *in-situ* parameters will be measured at 0.5 m depth increments.

3.4.1.2 Estuary and lower Santa Clara River analytical sample collection

Grab samples for nutrients and chlorophyll-a (Table 3-5) will be collected at the surface for each monitoring site. If stratification is observed (see above), analytical samples will be measured at the surface and at one location below the depth of the thermocline (or pycnocline). For each survey effort, duplicate samples will be collected at one site and sent to the laboratory as a quality control measure. Equipment blank samples will also be collected in the field where necessary and then shipped along with the rest of the samples. All nutrient and chlorophyll-a samples will be packaged with ice in coolers and shipped overnight to Sierra Environmental Laboratories (Reno, NV). Analytical laboratory methods are shown in Table 3-5.

Table 3-5. Analytical methods with reporting and detection limits.

Parameter/Constituent	Method	Units	MDL[1]	MRL[2]
Total Kjeldahl Nitrogen as N	SM4500 N(org)	mg/L	0.03	0.1
Total Ammonia as N	EPA 350.3	mg/L	0.03	0.1
Nitrate + Nitrite as N	EPA 300.0	mg/L	0.05	0.0076
Orthophosphate as P	EPA 365.3	mg/L	0.02	0.05
Total Phosphorous	EPA 365.3	mg/L	0.02	0.008
Chlorophyll-a	SM 10200H	mg/L	0.0005	0.002

[1] The MDL (Method Detection Limit) is defined as the concentration at which the laboratory can report with 99 percent confidence that the analytical result is not actually zero.
[2] The MRL (Method Reporting Limit) is defined by the laboratory for each method, and is an estimate of the minimum concentration at which the laboratory is confident in reporting a numerical value.

3.4.1.3 Groundwater sample collection

All groundwater wells at McGrath State Beach will be sampled for conductivity using a portable Sonde (Table 3-4) and samples will be collected for laboratory nitrate+nitrite analysis (Table 3-5). A 12-volt submersible pump and/or clear PVC disposable bailers (15–20 ft extendable line) that are small enough to be deployed in a 2-inch diameter well casing will be used to extract groundwater samples. At least three well volumes will be purged prior to sampling to ensure that the sample is representative of groundwater conditions. In addition to routine sampling at the groundwater wells, a one-time sampling event will be conducted in each well to screen potential contaminants that may be transported in the groundwater to the Estuary under low Estuary stage conditions. All samples will be collected using appropriate protocols (e.g., EPA 1631 "clean hands/dirty hands" technique) with handling and preservation appropriate for the analytes to be tested, including total metals, cyanide, PCBs, pesticides, and VOCs.

3.4.2 Analysis Methods

Quality control review will be performed on all analytical data, using blank and duplicate laboratory results. Data correction will be performed where necessary. The accuracy of the analytical methods will be estimated using the results from duplicate samples.

In situ and chlorophyll-a results from the eight designated water quality monitoring sites will be analyzed to identify spatial and temporal (seasonal) patterns indicating a potential change in water quality between the river, VWRF discharge, and the Estuary. On a seasonal basis, the data will be examined for possible gradients in all measured water quality parameters through the assumed channel network of the Estuary (see Section 3.3). For example, water quality data along the transect from the Santa Clara River site to the upper, middle, and lower Estuary sites will be analyzed for possible trends on a seasonal basis, as will data along the high-flow channel and VWRF discharge channel transects. While analysis of nitrate+nitrite data will also include the identification of potential concentration gradients in groundwater and Estuary sites, in general, nutrient data will be analyzed using a simplified mass balance approach to include the effects of flow volume on the Estuary. A seasonal nutrient mass balance will be calculated using a simplified box model, parameterized with measured concentration data and results from the Estuary Water Balance (See Section 1.3.1) along with literature based values for denitrification, settling of particulate forms, and biomass nutrient uptake. All water quality data (i.e., *in situ*, nutrient, and chlorophyll-a) from paired closed- and open-mouth surveys undertaken during both low-flow and high-flow conditions will be considered separately to compare potential effects of VWRF discharges on the Estuary under differing hydrologic regimes.

Estuarine trophic status will be assessed using multiple indicators of estuarine eutrophication including dissolved oxygen, pH (Bricker et al. 2003), and the biological response indicators chlorophyll-a, macroalgal biomass, and SAV spatial coverage (Bricker et al. 2003, SCCWRP 2009). Macroalgal biomass and SAV spatial coverage will be assessed as part of the Tidal & Upland Vegetation and Aquatic Habitat Mapping Surveys (Section 4). Measured chlorophyll-a and dissolved oxygen concentrations at all sample sites will be compared with thresholds for primary and secondary symptoms of estuarine eutrophication (Bricker et al. 2003). Results of SAV biomass surveys will also be compared with general spatial coverage thresholds for estuarine eutrophication (Bricker et al. 2003), as well as more specific trends for specific SAV species collected in the Estuary during scheduled 2008–2009 SCWWRP surveys (SCCWRP 2009), assuming data for the latter is available prior to December 2010.

3.5 Work Products

Work products from the Estuary Water Quality and Nutrient Survey include the following:

- Quarterly synoptic data from *in situ* water quality (i.e., water temperature, DO, pH, conductivity), nutrient (i.e., nitrogen and phosphorus species) and chlorophyll-*a* surveys at eight sites in the Estuary and the lower Santa Clara River from August 2009 through November 2010;
- Quarterly nitrate (NO_3^-) data from up to four groundwater wells adjacent to the Estuary and lower Santa Clara River from Sept/Oct 2009 through November 2010;
- Metals and organics data from groundwater wells adjacent to the Estuary and lower Santa Clara River from Sept/Oct 2009 through November 2010; and,

- Synoptic data from up to three paired open and closed mouth conditions during both seasonal low-flow (summer/fall) and high-flow (winter/spring) periods from Sept/Oct 2009 through November 2010.

These work products will be included as part of the following Estuary Subwatershed Study deliverables:

- Data summary containing physical, water quality, and biological field data collected during Year (August 2009–Dec 2009)
- Data summary containing physical, water quality, and biological field data collected during Year 2 (Jan 2010–Dec 2010)
- Technical memorandum detailing findings during the monitoring period

3.6 Equipment

Water quality sampling equipment

- YSI probe unit and data logger
- Barometer
- Standard solutions (pH 4,7; 100, 1,000 and 10,000 uS/cm)
- Calibration and data sheets
- Laboratory bottles (sample, QA/QC)
- Coolers, ziploc baggies, ice
- COC sheets
- Hand-held GPS unit
- Digital camera
- Secchi disk and line
- Tape measure or marked line for depth
- Carboy for blank water
- Teflon grab sample bottle
- Swing sampler (pole + attachment + "belt")
- Winkler kit w/BOD bottles and caps
- HACH kit + reagents
- Turbidimeter

Boat (if needed)

- Zodiac inflatable
- Motor
- Battery and battery charger
- Multi-meter (volt meter)
- Electric pump (spare foot pump)
- Oars
- Bailer/sea anchor (bucket)
- Life vests

3.7 Permits

A data collection permit from the California Department of Parks and Recreation is required for all biological, geological, and soil investigations or collections occurring in McGrath State Beach

property, including within the Estuary and on the south bank floodplain downstream of Harbor Blvd bridge. The permit application for activities planned during the Estuary Subwatershed Survey, including collection of water quality samples, is currently under review by staff at the State of California Department of Parks and Recreation. We anticipate having this permit by the end of August 2009.

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4 TIDAL & UPLAND VEGETATION AND AQUATIC HABITAT MAPPING

4.1 Goals and Objectives

The overall goal of the Tidal and Upland Vegetation and Aquatic Habitat mapping effort is to provide current information to help assess the relationship between Estuary stage and the extent of suitable habitat for aquatic and terrestrial focal species.

To meet this goal, the following two study objectives for Tidal and Upland Vegetation and Aquatic Habitat mapping effort have been developed to:

- delineate the type and extent of upland, tidal, and subtidal vegetation under varying Estuary stage and hydrologic conditions (i.e., mouth open, mouth closed, low river flow, high river flow); and,
- determine the area of suitable habitat for focal species in the Estuary.

These data will ultimately be combined with data collected within concurrent surveys (Sections 2 and 3) and pre-existing information to determine the impact of VWRF discharge upon suitable habitat for aquatic and terrestrial focal species and the influence of potential VWRF discharge scenarios upon water quality, overall habitat area, and habitat quality for birds, fish, flora, and humans.

4.2 Existing Information

Recently, there have been several studies and data collection efforts that provide upland, tidal, and subtidal vegetation distribution and focal species abundance and habitat distribution for the Estuary and adjacent areas. Existing studies and data sources for the Estuary and lower Santa Clara River floodplain vegetation and habitats essential for completing this project are presented in Table 4-1. Ongoing monitoring efforts, including the annual benthic macroinvertebrate sampling and Tidewater goby surveys conducted by the City will be extended through the 2009-2010 monitoring period to address identified data gaps on habitat use under a range of Estuary conditions (Appendix A). Additional bird survey data collected by the Ventura Audubon society will also be integrated with the planned habitat mapping surveys.

Table 4-1. Existing information on Estuary vegetation and aquatic and terrestrial habitat.

Estuary Vegetation and Habitat Existing Vegetation Information	Upland Vegetation Mapping	Upland Vegetation Classification	Tidal and Subtidal Vegetation Mapping	Steelhead abundance and location	Tidewater goby abundance and location	Snowy Plover and Least Tern abundance and location
STUDIES						
ESA 2003	X	X	X			
CDFG and CNPS 2005		X				
Evens and San 2005		X				
Entrix 2002				X	X	
Entrix 2004					X	
Kelley 2004				X		
Kelley 2008				X		
Klein and Evens 2005		X				
Nautilus 2005					X	
Nautilus 2008					X	
Stillwater Sciences and URS Corporation 2007	X	X				
DATA SOURCES						
Ventura County 2005 digital orthophotography and LiDAR	X		X			
CDPR 2009 vegetation mapping in McGrath State Beach	X		X			
Ventura Audubon Society nesting data						X

4.3 Study Design

The design for the Tidal and Upland Vegetation and Aquatic Habitat Mapping is to 1) delineate subtidal, tidal wetland, and upland vegetation alliances, updating detailed vegetation mapping by Stillwater Sciences and URS Corporation (2006) for current (2009) conditions, 2) use vegetation maps, data collected within concurrent surveys (Hydrology and Morphology Survey and Water Quality and Nutrient Survey), and additional targeted surveys to determine the quantity of suitable habitat within the Estuary for California least tern (*Sterna antillerum browni*) western snowy plover (*Charadrius alexandrinus nivosus*), steelhead (*Oncorhynchus mykiss*), and tidewater goby (*Eucycloglobius newberryi*) over a range of Estuary conditions (i.e., open mouth, closed mouth, low river flow, high river flow) from summer 2009 (late August) through fall 2010 (October or November).

4.3.1 Monitoring Sites

Tidal and upland vegetation and aquatic habitat will be mapped within the same area as Stillwater Sciences and URS Corporation (2006) (Figure 4-1). Downstream of Harbor Blvd., vegetation will be mapped within the 500-yr floodplain (as defined by the Federal Emergency Management Agency [FEMA]) including the vegetated area through which the VWRF outfall channel flows and McGrath State Beach. Upstream of Harbor Blvd., vegetation will be mapped within the 'active' Santa Clara River channel between adjacent floodplain levees. The upstream boundary of the mapping extent will be defined by the current (2009) extent of inundation during closed-mouth, low-flow conditions (as defined by daily observations by the City) in combination with the upstream extent of the City's benthic macroinvertebrate sampling program. As most vegetation was mapped by Stillwater Sciences and URS (2006) after the last major flood event in the watershed (i.e., February 2005), this study will concentrate on previously unmapped areas.

4.3.2 Sampling Schedule

Field mapping of tidal and upland vegetation will occur in summer 2009 and fall 2010. Summer 2009 field mapping will likely occur in September and concentrate on inundated areas not mapped by Stillwater Sciences and URS (2006). A streamlined, follow-up mapping effort will occur in 2010 when the river mouth is open (most likely fall or winter 2010) to document subtidal vegetation and any tidal wetland or upland areas inundated during Stillwater Sciences and URS Corporation (2006), and to document any changes in tidal and upland vegetation and habitats associated with high flows that may occur during winter 2010. Changes to suitable habitat area as a result of lagoon bar breaching and buildup will be documented from summer 2009 to fall 2010, taking place over four efforts consisting of two open-mouth surveys and two-closed mouth surveys. The initial habitat mapping effort will take place in summer 2009, with follow-up efforts occurring in fall 2009, spring 2010, and fall 2010.

4.4 Methods

4.4.1 Data Collection

4.4.1.1 Existing information review and preliminary mapping

Existing information will be gathered and reviewed to generate an initial list of the tidal and upland vegetation alliances and habitat types that occur in the mapping area. Stillwater Sciences and URS Corporation (2006) captured 2006 conditions in the Estuary (after the high-flow event of 2005), and will serve as the preliminary field base map for tidal wetland and upland areas (mudflat and channel areas – referred to as subtidal areas – in the Estuary were not mapped by Stillwater Sciences and URS Corporation (2006)). This 2006 base map of the Estuary will be used to identify preliminary vegetation sampling sites, such that each vegetation type is sampled more than once. Since Stillwater Sciences and URS Corporation (2006) does not extend into subtidal areas of the Estuary, existing 2005 aerial photography and Light Detection and Ranging (LiDAR) data will be used to develop a subtidal base map for field mapping and to identify preliminary sampling sites. Recent mapping of the Estuary by the California Department of Parks and Recreation may also be used, but this data has not yet been reviewed and will likely not be available until fall 2009.

Focal species habitat will be described according to key vegetative, physical, and water quality (e.g., water temperature, salinity and DO for aquatic focal species) characteristics identified from detailed reviews of peer reviewed literature, previous reports, and other relevant information. For California least tern and western snowy plover the information review and habitat description will focus on nesting and foraging habitat, while for steelhead the focus will be on juvenile rearing and adult holding habitat, and for tidewater goby, spawning, rearing, and adult overwintering habitat. The potential distribution of suitable habitat will be estimated within a geographic information system (GIS) using the above determined habitat characteristics, concurrently collected water quality and vegetation data, previously collected habitat data (e.g., Stillwater Sciences and URS Corporation 2007, ESA 2003 [McGrath State Park vegetation maps]), and available spatial data (e.g., Ventura County 2005 digital orthophotography, Ventura County 2005 LiDAR data). Data will be integrated within the GIS to delineate polygons of potentially suitable habitat, representing areas where, according to known habitat preferences and recently collected data, focal species are most likely to exist within the Study Area. These preliminary habitat suitability maps will be used as base maps for field based mapping.

4.4.1.2 Field-based Mapping

In summer 2009, above identified tidal and upland vegetation sites will be surveyed using the CNPS rapid assessment protocol (CNPS Vegetation Committee 2003a). At each sample site, the occurrence and percent cover of dominant and characteristic plant species in three height strata: low (<0.5 m), medium (0.4–5 m), and high (>5 m) will be recorded. In addition, Stillwater Sciences and URS Corporation (2006) vegetation alliance boundaries will be modified on the base map as necessary to more accurately reflect current conditions. A streamlined CNPS reconnaissance-level approach, which records just the dominant and characteristic plant species, may be used at sites that were inundated during 2006 vegetation mapping (i.e., were below the Estuary water level at the time of mapping). The vegetation sampling and field mapping will be used to refine the boundaries of Stillwater Sciences and URS Corporation (2006), and the resulting quantitative vegetation composition data will be used to classify the vegetation into associations and/or alliances. Vegetation classification will utilize Stillwater Sciences and URS Corporation (2006), CDFG and CNPS (2005), Evens and San (2005), and Klein and Evens (2005) classification schemes, and maintain consistency with the latest *Manual of California Vegetation* (Sawyer and Keeler-Wolf, in preparation).

During the second 2010 tidal and upland vegetation field survey likely fall or early winter), areas of the Estuary inundated in the 2005 aerial photography will be mapped and surveyed to the extent feasible. The entire subtidal area will be traversed on foot (as conditions allow), and micro-habitat conditions will be mapped based on changes in topography, substrate, and/or aquatic vegetation. Each mapped micro-habitat area will be surveyed for general conditions, the occurrence and percent cover of any aquatic plant species, and substrate size.

Field based mapping will also be conducted to validate and refine the preliminary habitat suitability maps. A field crew will visit each polygon of potentially suitable habitat identified with the preliminary base map, then record the actual extent of key habitat characteristics. For terrestrial focal species (California least tern and western snowy plover), potentially suitable habitat will likely coincide with key vegetation and habitat types recorded during the Tidal and Upland Vegetation Mapping, similar to Stillwater Sciences (2007). For aquatic focal species (steelhead and tidewater goby), potentially suitable habitat will be based upon key physical (e.g., substrate, water depth and velocity) and water quality thresholds (e.g., salinity, dissolved oxygen). Suitable habitat polygons identified in preliminary maps will be verified by collecting

additional data along the perimeter (e.g., depth, velocity, substrate) or at the centroid (e.g., in situ water quality using methods in Section 3.4.1.1) of the polygon. The field verified and revised polygons will then be merged within a GIS to determine the actual extent of suitable habitat (see below).

4.4.2 Data Analysis

A quality assurance/quality control check for completeness and errors will be performed on all field data shortly after collection and again following data entry. Data collected in the field will be integrated into GIS by scanning field maps at 600 dpi resolution, digitizing field-delineated vegetation types and habitat variables (e.g. depth, bed substrate, water velocity) and entering GPS point data on water temperature, dissolved oxygen, and salinity.

A Microsoft® Access database linked to a GIS will be created to store, organize, and analyze the vegetation and subtidal sampling data. Field data will be entered into the database shortly after returning from the field, and, along with hand digitizing, will be checked for errors and corrected as necessary. The database will be used to derive the full list of tidal habitats and vegetation alliances in the Estuary, and to calculate their extent for both the 2009 and 2010 survey efforts. For any areas remapped in 2010, changes in extent between 2009 and 2010 will be quantified and evaluated to identify temporal changes in the condition and extent of those areas. Tidal and upland vegetation maps will be georeferenced to 2005 source orthophotography and field delineated mapping units will be digitized. Each mapping unit will be designated a vegetation classification, subtidal and tidal vegetation, or land cover type (e.g., agriculture) attribute. Photo-interpretation will be used to digitize the boundaries of vegetation stands or subtidal areas not directly surveyed or observed during the field mapping. This map development effort will be repeated for the subtidal sampling effort and any areas below the most recent peak in Estuary levels that are remapped.

Habitat suitability maps will be revised and updated based on the recently collected and integrated data. Further map updates will be made following surveys during varying Estuary conditions. Fluctuations in the area of suitable habitat related to changes in environmental conditions will be quantified and evaluated to identify relationships between focal species habitat, water quality, hydrology, and lagoon status.

4.5 Work Products

Work products from the Tidal and Upland Vegetation and Aquatic Habitat Mapping include the following:

- Electronic version of subtidal, tidal, and upland vegetation maps under varying Estuary stage and hydrologic conditions (i.e., mouth open, mouth closed, low river flow, high river flow) with appropriate source data and metadata;
- Up to five color hardcopies of subtidal, tidal, and upland vegetation maps
- Electronic version of distribution and area of potential habitat for terrestrial and aquatic focal species under varying Estuary stage and hydrologic conditions (i.e., mouth open, mouth closed, low river flow, high river flow) with appropriate source data and metadata;
- Up to five color hardcopies of version of distribution and area of potential habitat for terrestrial and aquatic focal species

These work products will be included as part of the following Estuary Subwatershed Study deliverables:

- Data summary containing physical, water quality, and biological field data collected during Year 1 (August 2009–Dec 2009)
- Data summary containing physical, water quality, and biological field data collected during Year 2 (Jan 2010–Dec 2010)
- Technical memorandum detailing findings during the monitoring period

4.6 Equipment

Tidal and upland habitat mapping

- Base map, clipboards, and pens
- local and California botanical keys
- hand lens
- hand-held GPS unit
- digital camera
- sampling quadrat
- measuring tape and meter stick

Aquatic habitat mapping

- base map, datasheets, clipboards, and pens
- tidebook
- hand-held GPS unit
- water quality meter
- digital camera
- stadia rod
- tape measure
- hip chain
- densiometer
- flowmeter (Marsh-McBirney Flowmeter)
- topsetting rod
- flagging

4.7 Permits

A data collection permit from the California Department of Parks and Recreation is required for all biological, geological, and soil investigations or collections occurring in McGrath State Beach property, including within the Estuary and on the south bank floodplain downstream of Harbor Blvd bridge. The permit application for activities planned during the Estuary Subwatershed Survey, including mapping of upland and tidal vegetation and subtidal aquatic habitat, is currently under review by staff at the State of California Department of Parks and Recreation. We anticipate having this permit by the end of August 2009.

4.8 References

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FIGURES

Figure 2-1 Proposed monitoring well (GW) and stage recorder (SR) locations (2006 aerial photograph)

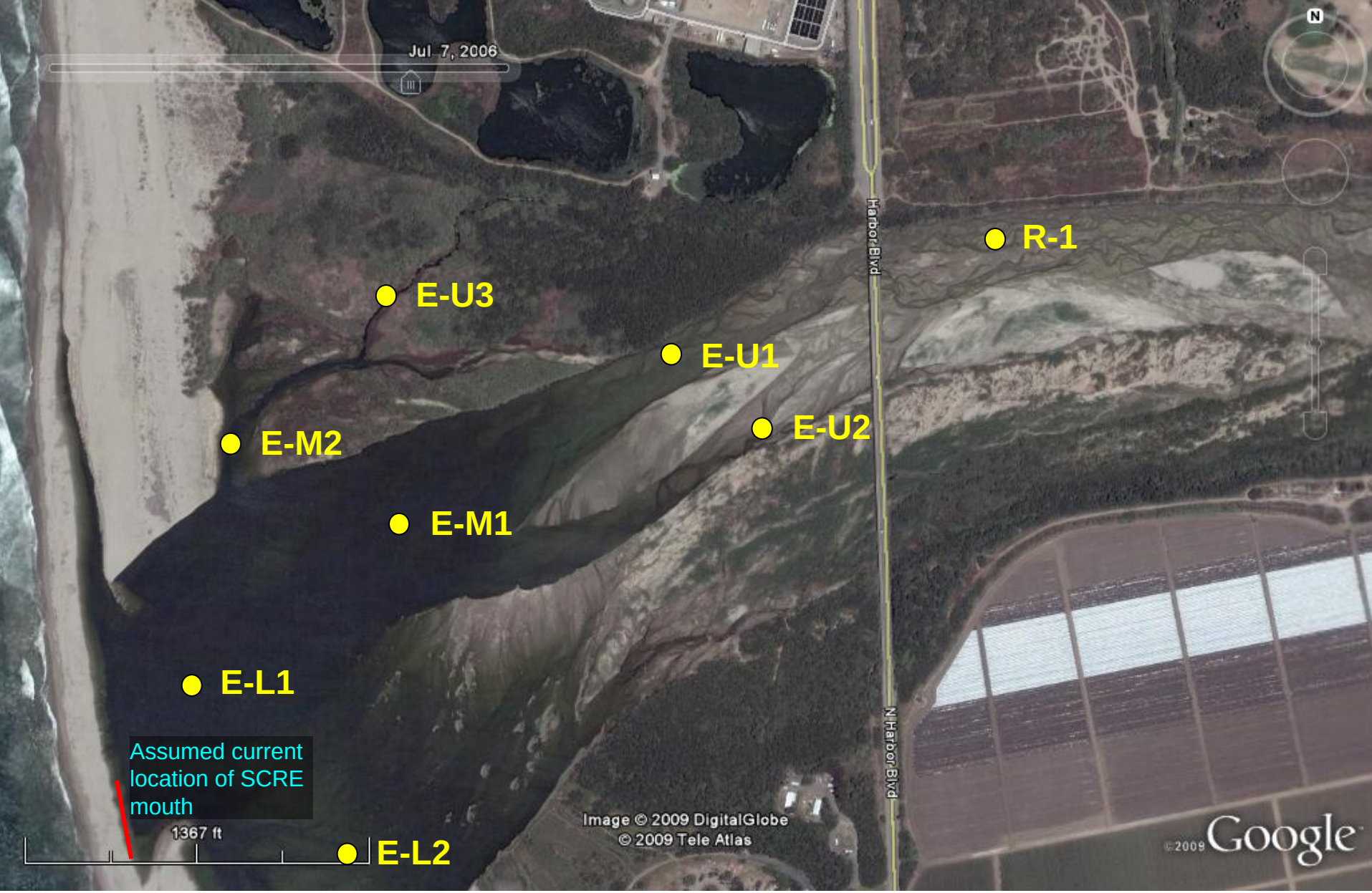

Figure 3-1 Proposed water quality sampling locations (2006 aerial photograph)

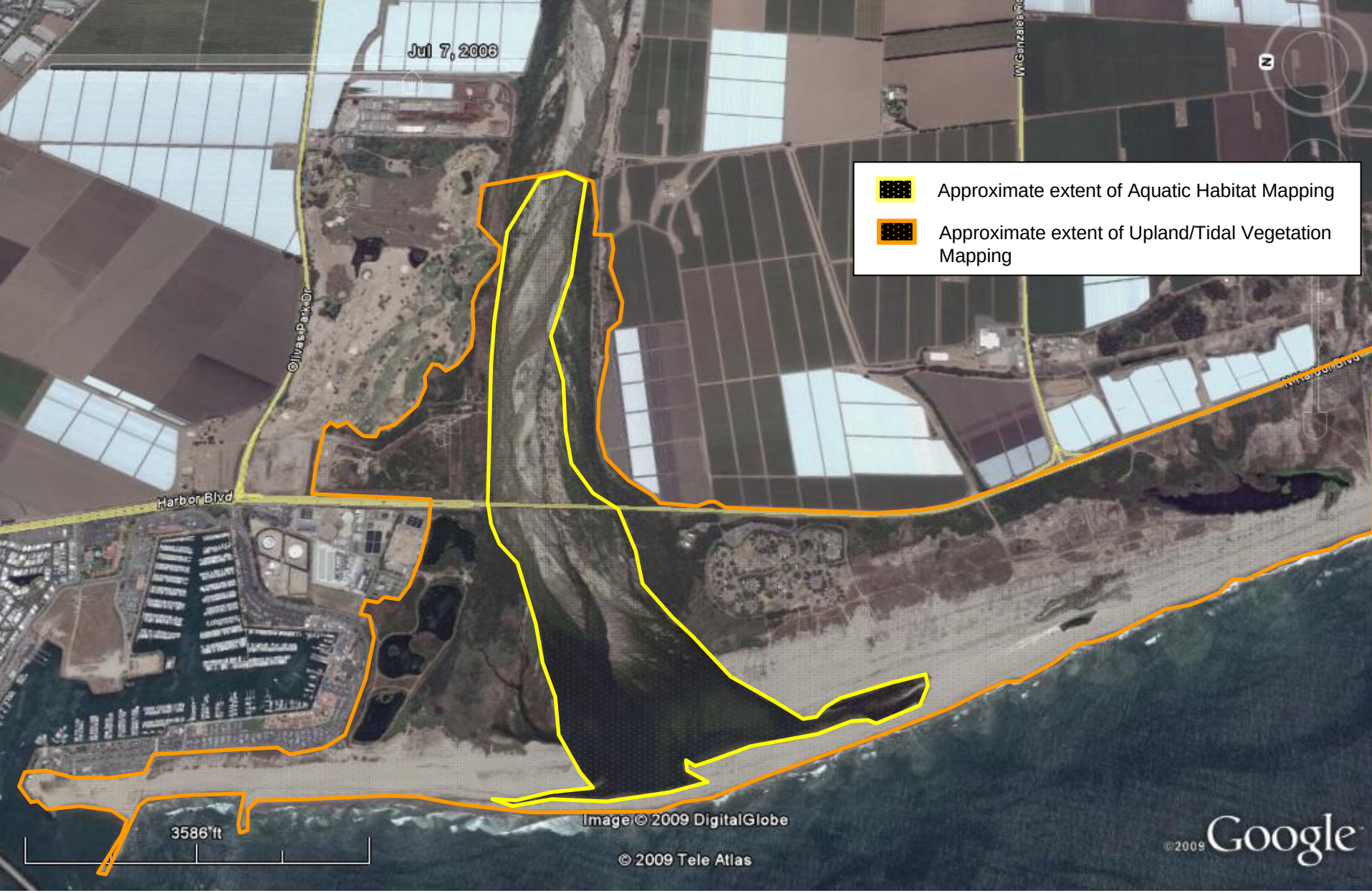

Figure 4-1 Approximate vegetation and aquatic habitat mapping extent (2006 aerial photograph)

APPENDIX A
Updated Data Gaps Analysis

City of Ventura Special Studies
Estuary Subwatershed Study

Draft Data Gaps Analysis
6/30/09
Edits to the 6/18/09 version are highlighted in red

Study Component	Task	Available Data and Reference	Data Gaps
1. Estuary Water Balance	1a. Define the relevant extent of the Subwatershed and Estuary that are influenced by the VWRF discharge spatially, hydrologically, and functionally by utilizing existing studies and reports to determine how the discharge may have altered conditions over time	• Estuary bathymetry [2001], 1-ft contour (ESA 2003) • LiDAR of Estuary [2005], 1-ft resolution (Ventura County) • Estuary inundation extent from 6/2001 to present (City) • Anecdotal evidence and short-term measurements of hydraulic connectivity of Estuary and adjacent areas to the south including McGrath State Park and McGrath Lake (Swanson et al., 1990; ESA 2003; Nautilus 2005; URS 2004 & 2005)	• Spatial extent of groundwater elevation increase due to impounded water in the Estuary during closed-mouth conditions • Spatial extent of inundated area over a spring-tide tidal cycle when the mouth is open.
	1b. Quantify the average monthly inflow from all quantifiable sources including; groundwater, Santa Clara River flows, VWRF discharges, and agriculture and urban surface water runoff	• VWRF discharge (City) • Estuary inflow and outflow estimates from 1984 to present (City) • Santa Clara River flows at Montalvo (1927-2004) (USGS) • Santa Clara River Flows at Freeman Diversion (2005-2008) (VCWPD) • Santa Clara River flows at Victoria Ave (2008 to present)	• Continuous groundwater elevation data adjacent to the Estuary for dry and wet seasons (i.e., longer than 1 year) • Estimates of agricultural and urban run-off between Freeman Diversion and Harbor Blvd bridge

Study Component	Task	Available Data and Reference	Data Gaps
		(VCWPD) • Groundwater gradients from McGrath Lake to the Estuary (URS 2004 & 2005) • Modeled watershed-scale groundwater gradient 1984-1993 (Hanson et al 2003) • Short-term groundwater and Estuary water level monitoring from 1/2004 to 1/2005 (Nautilus 2005) • Short-term Estuary water balance (Kamman H&E 2007) • Short-term well monitoring adjacent to the Estuary (Swanson et al 1990; ESA 2003) • Tidal elevation adjacent to Estuary (Stillwater Sciences 2005, Nautilus 2005)	
	1c. Define the relationship between inflows and Estuary habitat area, lagoon depth, and volume under various discharge scenarios. Evaluate how different species require varied water depths, riparian habitats, and in-stream cover within the lagoon and the impact of altering the current discharge regime might have on these species.	• Estuary bathymetry [2001], 1-ft contour (ESA 2003) • LiDAR of Estuary [2005], 1-ft resolution (Ventura County) • Estuary inundation extent from 6/2001 to present (City) • BMI bioassessment from 2003-2008 (AB&C Laboratories) • Short-term fish usage and macroinvertebrate abundance (USF&WS 1999) • Vegetation and habitat mapping within and adjacent to Estuary	• Estuary water depth-area relationship • Estuary water depth-volume relationship • More defined relationship between water depth and vegetation and habitat type • Contribution of VWRF discharge to monthly and annual Estuary water budget • More data on tidewater goby abundance and habitat usage • More data on southern steelhead

Study Component	Task	Available Data and Reference	Data Gaps
		(Swanson et al 1990; ESA 2003, Stillwater Sciences 2008, CDPR 2009) • Short-term tidewater goby abundance and habitat usage (Entrix 2004 and Nautilus 2008 and 2009) • Short-term southern steelhead abundance and habitat usage (Kelley 2008) • Short-term least Bell's vireo abundance and habitat usage (Labinger and Greeves 2001) • Snowy plover and Least tern annual nesting locations and population estimates (Ventura Audubon Society)	abundance and habitat usage • More information on least Bell's vireo and other shorebirds abundance and habitat usage
	1d. Evaluate breaching frequency and breaching types and their effect on the lagoon, backwater habitats, water quality, and how each impacts federal and state listed species present in the Estuary. Compile historic information to identify breaching changes over time considering activities such as dredge material management practices, mining, urbanization, agriculture, and other potential influences.	• Estuary inflow and outflow estimates from 1984 to present (City) • Estuary inundation extent from 6/2001 to present (City) • Daily Estuary water level and mouth closure status from 5/2001 to 4/2002 (Nautilus 2005) • Continuous Estuary water level monitoring and mouth closure status from 1/2004 to 1/2004 (Nautilus 2005) • Mouth 'inlet stability analysis' (Nautilus 2005) • Water quality measurements in	• More defined relationship between water depth and vegetation and habitat type • Time-series of water quality parameters at several locations throughout the Estuary for open- and closed-mouth conditions • Accounts of changes in breaching dynamics • Channel/estuary dredging records • Better data on gravel mining extraction rates

Study Component	Task	Available Data and Reference	Data Gaps
		McGrath Lake (in ESA 2003) • Water quality measurements in the Estuary from 1997-1999 (USFWS 1999) • Short term water quality measurements in the Estuary (Kelley 2008) • Water quality measurements (temp. DO, salinity, pH) in the Estuary from 2000 to present (City) • Short term continuous water quality parameters (DO, temp, pH, salinity, turbidity, Chl-a) and targeted macroalgae measurements in the Estuary (SCCWRP) • Water quality measurements in the Estuary during open- and closed-mouth conditions for 2003-2005 (Nautilus 2005) • Water column toxicity measurements for 2003-2005 (Nautilus 2005) • Known changes to river flow and sediment delivery over time (Warrick 2001, Stillwater Sciences 2005) • Aggregate mining estimates (Simons and Li 1983)	
2. Functionality of the Subwatershed and Estuary	2a. Provide mapping of the various habitat types and their extent (*was Task 2d*)	• Vegetation and habitat mapping within and adjacent to Estuary	• More defined relationship between water depth and

Study Component	Task	Available Data and Reference	Data Gaps
		(Swanson et al 1990; ESA 2003, Stillwater Sciences 2008, CDPR, 2009)	vegetation and habitat type
	2b. Analyze the system to predict how changes to the amount of the discharge could alter water quality, side stream habitat, lagoon surface area, and groundwater influences	• Estuary bathymetry [2001], 1-ft contour (ESA 2003) • LiDAR of Estuary [2005], 1-ft resolution (Ventura County) • VWRF discharge (City) • Estuary inundation extent from 6/2001 to present (City) • Short term water quality measurements in the Estuary (Kelley 2008) • Short-term water quality and measurements in the Estuary (USF&WS 1999). • Water quality measurements (temp. DO, salinity, pH) in the Estuary from 2000 to present (City) • Short term continuous water quality parameters (DO, temp, pH, salinity, turbidity, Chl-a) and targeted macroalgae • Short-term monitoring of relationship between Estuary water level and groundwater discharge in McGrath State Park (Nautilus 2005) • BMI bioassessment from 2003-2008 (AB&C Laboratories)	• Estuary water depth-area relationship • Estuary water depth-volume relationship • More defined relationship between water depth and vegetation and habitat type • More knowledge on groundwater contribution to Estuary water budget • More defined relationship between Estuary water surface elevation and groundwater/surface water elevation in McGrath State Park • Knowledge of each hydrologic component's current relative contribution to Estuary water quality
	2c. Investigate the role wastewater	• VWRF discharge (City)	• Better understanding of the

Study Component	Task	Available Data and Reference	Data Gaps
	discharge plays in vegetation growth in the subwatershed and whether this factor and any changes in riverbed vegetation and sediment management practices that may have occurred over time *(was Task 2f)*	• Water quality measurements in McGrath Lake (in ESA 2003) • Water quality measurements in the Estuary from 1997-1999 (USFWS 1999). • Water quality measurements in the Estuary during open- and closed-mouth conditions for 2003-2005 (Nautilus 2005) • Water column toxicity measurements for 2003-2005 (Nautilus 2005) • Water quality measurements (temp. DO, salinity, pH) in the Estuary from 2000 to present (City) • Short term continuous water quality parameters (DO, temp, pH, salinity, turbidity, Chl-a) and targeted macroalgae	wastewater discharge water quality and it's contribution to the seasonal and annual Estuary water quality • Updated information on current Estuary subtidal, tidal, and adjacent upland vegetation assemblages
	2d. Identify alternate VWRF discharge scenarios considering flow volumes, the quality of the various inflows, and treatment wetlands feasibility (*was Task 2a*)	• VWRF discharge (City) • River discharge downstream from Freeman Diversion/Montalvo, Victoria Ave. (VCWPD/USGS) • Water quality measurements in McGrath Lake (ESA 2003 and URS 2004 & 2005) • Water quality measurements in the Estuary from 1997-1999 (USF&WS 1999). • Estuary inflow and outflow	• Better understanding of the relative contribution of each water budget component on total water volume, particularly groundwater and surface water downstream of Freeman Diversion Dam • Better understanding of the relative contribution of each water budget component on seasonal and annual Estuary water quality

Study Component	Task	Available Data and Reference	Data Gaps
		estimates from 1984 to present (City) • Water quality measurements in the Estuary during open- and closed-mouth conditions for 2003-2005 (Nautilus 2005) • Water column toxicity measurements for 2003-2005 (Nautilus 2005) • Water quality measurements (temp. DO, salinity, pH) in the Estuary from 2000 to present (City) • Short term continuous water quality parameters (DO, temp, pH, salinity, turbidity, Chl-a) and targeted macroalgae	
	2e. Under each discharge scenario, predict changes to spatial inundation characteristics of the Estuary and McGrath State Park including depth and volume (*was Task 2c*)	• Estuary bathymetry [2001], 1-ft contour (ESA 2003) • LiDAR of Estuary [2005], 1-ft resolution (Ventura County) • Estuary inundation extent from 6/2001 to present (City) • Vegetation and habitat mapping within and adjacent to Estuary (Swanson et al 1990; ESA 2003, Stillwater Sciences 2008, CDPR 2009) • River discharge downstream from Freeman Diversion/Montalvo, Victoria Ave. (VCWPD/USGS)	• Estuary water depth-area relationship • Estuary water depth-volume relationship • More defined relationship between Estuary water surface elevation and groundwater/surface water elevation in McGrath State Park • Hydraulic conductivity for soils underlying McGrath State Beach • Spatial extent of groundwater elevation increase due to impounded VWRF water in the Estuary during closed-mouth

Study Component	Task	Available Data and Reference	Data Gaps
		• Groundwater gradients from McGrath Lake to the Estuary (URS 2004 & 2005)	conditions
	2f. Predict how groundwater quality could influence lagoon water quality under each scenario (*was Task 2h*)	• Water quality measurements in McGrath Lake (in ESA 2003) • Water quality measurements in the Estuary from 1997-1999 (USFWS 1999). • Water quality measurements in the Estuary during open- and closed-mouth conditions for 2003-2005 (Nautilus 2005) • Water column toxicity measurements for 2003-2005 (Nautilus 2005) • Groundwater gradients from McGrath Lake to the Estuary (URS 2004 & 2005)	• Measurements of groundwater quality • Better understanding of groundwater contribution to Estuary water budget • More in-depth understanding of the relative seasonal and annual water budget components contribution to Estuary water quality
	2g. Identify how each VWRF discharge scenario changes breaching and those impacts on water quality and beach water quality in the area influenced by the discharge	• Estuary inflow and outflow estimates from 1984 to present (City) • Daily Estuary water level and mouth closure status from 5/2001 to 4/2002 (Nautilus 2005) • Mouth 'inlet stability analysis' (Nautilus 2005) • Continuous Estuary water level monitoring and mouth closure status from 1/2004 to 1/2004 (Nautilus 2005) • Water quality measurements in McGrath Lake (in ESA 2003)	• Relative seasonal and annual contributions of individual water budget components • More in-depth understanding of the relative seasonal and annual water budget components contribution to Estuary water quality

Study Component	Task	Available Data and Reference	Data Gaps
		• Water quality measurements in the Estuary from 1997-1999 (USFWS 1999). • Water quality measurements in the Estuary during open- and closed-mouth conditions for 2003-2005 (Nautilus 2005) • Water column toxicity measurements for 2003-2005 (Nautilus 2005) • Water quality measurements (temp. DO, salinity, pH) in the Estuary from 2000 to present (City) • Short term continuous water quality parameters (DO, temp, pH, salinity, turbidity, Chl-a) and targeted macroalgae	
	2h. Identify how each scenario effects habitats for state and federally listed species including steelhead trout, tidewater goby, Western Snowy Plover, and critical habitat areas for birds such as the California least tern (*was Task 2e*)	• Vegetation and habitat mapping within and adjacent to Estuary (Swanson et al 1990; ESA 2003, Stillwater Sciences 2008, CDPR, 2009) • Short-term tidewater goby abundance and habitat usage (Entrix 2004 and Nautilus 2008 and 2009) • Short-term southern steelhead abundance and habitat usage (Kelley 2008) • Short-term least Bell's vireo abundance and habitat usage	• Estuary water depth-area relationship • Estua ry water depth-volume relationship • Better understanding of habitat preference for species of interest (in particular those species with little to no information to date) • More defined relationship between water depth and vegetation and habitat type

Study Component	Task	Available Data and Reference	Data Gaps
		(Labinger and Greeves 2001) • Snowy plover and Least tern annual nesting locations and population estimates (Ventura Audubon Society)	
	2i. Evaluate the impacts of global warming on the potential increase on sea level elevation to the Estuary and Subwatershed area, sustainability of the system and VWRF alternatives being evaluated, and the potential impacts to the outcome of the special studies	• Estuary bathymetry [2001], 1-ft contour (ESA 2003) • LiDAR of Estuary [2005], 1-ft resolution (Ventura County) • Tidal elevation adjacent to Estuary (Stillwater Sciences 2005, Nautilus 2005)	• Current projection of increase in relative mean sea level over the next 50-100 years • More defined relationship between water depth and vegetation and habitat type
	2j. Recommend a management strategy for the VWRF discharge in order to optimize the function of the Estuary affected by the discharge to demonstrate enhancement of the Estuary, or determine that no enhancement exists	• All of the above	• All of the above