2010 Annual Monitoring Report

Northern Cities Management Area

Submitted to: The Northern Cities Management Area Technical Group
City of Arroyo Grande
City of Grover Beach
City of Pismo Beach
Oceano Community Services District

San Luis Obispo County, California

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Project Director

2010 Annual Monitoring Report
for the
Northern Cities Management Area
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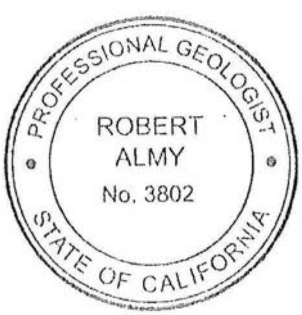
This report was prepared by the staff of GEI Consultants, Inc. under the supervision of professionals whose signatures appear hereon. The findings or professional opinions were prepared in accordance with generally accepted professional engineering and geologic practice.



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1 Introduction

This report summarizes hydrologic conditions in the Northern Cities Management Area (NCMA) of San Luis Obispo County California on behalf of four public agencies, namely the City of Arroyo Grande, City of Grover Beach, City of Pismo Beach and the Oceano Community Services District (Oceano CSD). These agencies, along with local land owners, the County of San Luis Obispo, and the San Luis Obispo County Flood Control & Water Conservation District (FC&WCD) have managed local surface- and ground-water resources since the late 1970s to preserve the long-term integrity of water supplies.

This longstanding approach was formalized in the 2002 Settlement Agreement among the Northern Cities, Northern Landowners, and Other Parties, and incorporated in the 2005 Settlement Stipulation for the Santa Maria Groundwater Basin Adjudication (Stipulation). The approach was then adopted by the Superior Court of California, County of Santa Clara, in its *Judgment After Trial*, entered January 25, 2008 (Judgment). The June 30, 2005 Stipulation was agreed upon by numerous parties, including the Northern Cities. Figure 1 shows the four Northern Cities relative to the Santa Maria groundwater basin, as defined in the adjudication and as defined as the Santa Maria Valley groundwater basin (Basin 3-12) by the Department of Water Resources (DWR).

The Judgment orders the stipulating parties to comply with each and every term of the Stipulation. The 2002 Settlement Agreement is generally affirmed as part of the Judgment and its terms incorporated into the Stipulation. However provisions of the Stipulation supersede the 2002 settlement agreement in the areas of continuing jurisdiction, groundwater monitoring, reporting, and the Technical Oversight Committee. The Technical Oversight Committee comprises representatives from both the NCMA and Nipomo Mesa Management Area (NMMA); its purpose is to coordinate data sharing and interpretation between the two management areas.

As specified in the Judgment, the Northern Cities agencies conduct groundwater monitoring in the Northern Cities Management Area. As shown in Figure 2, the Northern Cities Management Area (NCMA) represents the northernmost portion of the Santa Maria Groundwater Basin. Adjoining the NCMA to the southeast is the Nipomo Mesa Management Area (NMMA), while the Santa Maria Valley Management Area encompasses the remainder of the groundwater basin.

In accordance with requirements of the Judgment, the agencies comprising the NCMA group collect and analyze data pertinent to water supply and demand, including:

- land and water uses in the basin,

- sources of supply to meet those uses, and
- ground-water conditions (including water levels and water quality.

The Monitoring Program gathers and compiles pertinent information on a calendar year basis through requests to public agencies, necessary field work, and from online sources. Annual data are added to the comprehensive Northern Cities Management Area Database (NCMA DB) and analyzed. Results of the data compilation and analysis for calendar year 2010 are documented and discussed in this Annual Report.

2 Climate Conditions

Each year climatological and hydrologic (stream flow) data for the NCMA are added to the NCMA database. These data are discussed below.

2.1 Precipitation

Historical rainfall data have been compiled on a monthly basis for the NOAA Pismo Beach station for 1949 to 2005, while precipitation data from 2005 to present are available from a County-operated rain gage in Oceano. Figure 3 is a composite graph combining data from the two stations and illustrating annual rainfall totals from 1949 through 2010 (on a calendar year basis). Annual average rainfall for the NCMA is approximately 17 inches.

Abundant rainfall occurred during November and December 2010. During this period monthly rainfall was 200 percent of normal. However, this follows the period from 2007 through 2009, during which the precipitation conditions within the NCMA were been the second driest on record. The average three year precipitation for the period from 2007 through 2009 was only slightly higher than the average precipitation for the driest three year period on record, which ended in 1990. Inspection of Figure 3 shows several multi-year drought cycles followed by cycles of above average rainfall (such as occurred from March 1991 to March 1998).

Figure 4 shows monthly rainfall data on a calendar year basis for 2010 and, for comparison, on average monthly rainfall. Most rainfall typically occurs from November through April. The year 2010 was marked by substantially higher than average rainfall in January and October while rainfall in the months of February, April and November was slightly above average. The remaining months, most of which were in the dry season, experienced below average rainfall. Rainfall exceeded evapotranspiration in January, February and December 2010. Deep percolation, thus groundwater recharge, would have occurred during those periods, given that rainfall penetrated below the vegetation's root zone.

2.2 Evapotranspiration

The California Irrigation Management Information System (CIMIS) maintains weather stations in locations throughout the state in order to provide real time wind speed, humidity and evapotranspiration data. Nipomo and San Luis Obispo stations have gathered data since 2006 and 1986, respectively. Monthly ET data from the two stations is shown for 2010 and average conditions. Evapotranspiration rate affects recharge potential of rainfall and the amount of outdoor water use (irrigation).

3 Water Demand

Water demand refers to the total amount of water used to satisfy various needs. In the NCMA, water is primarily used to satisfy urban demand and applied irrigation demand. The third category, rural demand includes small community water systems, domestic, recreational and agriculture-related businesses and is relatively minor. Table 1 presents water demands for urban uses, applied irrigation, and rural uses. The values shown in Table 1 represent water demand in acre feet per year (AFY). Comparing demand to available supply (Section 4) allows development and comparison of water source options under a given set of conditions.

Table 1. Total Demand for Groundwater and Surface Water, AFY

Year	Arroyo Grande	Grover Beach	Pismo Beach	Oceano CSD	Total Urban	Applied Irrigation	Rural Water	Total Demand
2005	3,460	2,082	2,142	931	8,615	2,056	36	**10,707**
2006	3,425	2,025	2,121	882	8,453	2,056	36	**10,545**
2007	3,690	2,087	2,261	944	8,982	2,742	36	**11,760**
2008	3,579	2,051	2,208	933	8,771	2,742	36	**11,549**
2009	3,315	1,941	2,039	885	8,180	2,742	36	**10,958**
2010	2,956	1,787	1,944	855	7,542	2,056	38	**9,636**

3.1 Urban Demand

Actual urban water demands are presented in Table 1 for each of the Northern Cities from 2005 through 2010. These demand values reflect reported Lopez Reservoir and State Water Project (SWP) purchases and groundwater production data, which are incorporated in the NCMA database. These water demand values represent all water used within the entire service areas of the four agencies comprising Northern Cities, including the portions of Arroyo Grande and Pismo Beach that extend outside the NCMA (Figure 2). Urban demand amounts reported include water delivered to municipal customers and all other water used by the respective municipal agency as well as system losses.

3.2 Applied Irrigation Demand

The San Luis Obispo County Water Master Plan uses a crop-specific method for calculating Annual Gross Irrigation Water Requirement (AGIR) in acre-feet per acre (AFY/acre), based on crop evapotranspiration, effective rainfall, leaching requirements, irrigation efficiency, and frost protection. Calculation of the AGIR, which is then used to estimate the applied water for irrigation for an aggregated area, is described in the following equation:

Annual GWIR (Ft) = [(Crop ET – Effective Rainfall) / ((1-Leaching Requirement) x Irrigation Efficiency)] + Frost Protection Water

The calculated crop-specific applied water is multiplied by specific crop acres to obtain the irrigation demand for a given crop type. The individual crop demands are then summed for the agricultural area of interest. Recently, the San Luis Obispo County Water Master Plan was updated in 2008 and contains a determination of irrigated acres by a GIS method for areas in the county, with the exception of the NCMA, NMMA, and the SMVMA areas, since these areas had completed their own land use determinations at the time.

In the NCMA, annual crop statistics are aggregated into crop categories and the specific farm field location is not published and readily available; thus, the necessary land use data with crop-specific surveys are not available to be used to calculate the annual irrigation demand based on the crop survey information. The representative land use survey information provides an estimate of crop-specific acres that are aggregated into larger categories, such as, truck crops. In order to estimate the annual irrigation demand for the NCMA, the crop acres represented by an aggregated category are multiplied by the estimated gross irrigation requirements per acre from the San Luis Obispo County Water Master Plan. Recent crop surveys completed for the San Luis Obispo County Water Master Plan Update indicate the land use in this area has remained consistent. The 2010 annual report estimates the applied irrigation demand based on the method established in the previous annual reports completed by Todd. The estimate of gross irrigation requirements is based on the San Luis Obispo County Water Master Plan Update which includes low, average, and high estimates of irrigation demand by crop type for each of the Water Planning Areas (WPAs) in the County. The range in estimated irrigation demands is based upon climactic conditions and average irrigation efficiency, and includes double cropping for the category truck crops. Since the Water Master Plan Update does not include gross irrigation requirements for turf grass, the values for pasture grass were applied to turf grass areas in the NCMA to estimate their applied irrigation demand, recognizing that pasture grass is the most similar to turf grass. The representative gross irrigation requirements for crop groups are presented in Table 2.

As stated in the previous Annual Report, the areal extent of cultivated agricultural areas in the NCMA has been quantified using the 2007 land use survey by the San Luis Obispo County Agricultural Commission. Communication with the San Luis Obispo Agricultural Commission Office verified the observation that agriculture land use in the NCMA for 2010 is basically unchanged from 2009. Thus, the same land use acres were used to make the 2010 estimate of applied irrigation demand. The areas with irrigated turf grass have been previously identified by public works personnel within the Northern Cities. The acreages of these areas have been measured from publically available aerial photographs using GIS software tools.

Table 2. Gross Irrigation Requirement for WPA 5 by Crop Group

Crop Type	Low Annual Demand (AFY/acre)	Average Annual Demand (AFY/acre)	High Annual Demand (AFY/acre)
Alfalfa	2.5	2.9	3.3
Nursery	1.4	1.7	2.1
Pasture	2.6	3.0	3.5
Turf Grass	2.6	3.0	3.5
Citrus	1.3	1.6	1.9
Deciduous	2.6	2.9	3.2
Truck (vegetable)	1.2	1.4	1.6
Vineyard	0.9	1.1	1.4

There are about 1,600 acres of irrigated agriculture within the NCMA of which approximately four acres are in nursery crops, and the remainder is truck crops. There is a combined total of 44 acres of irrigated turf grass at the Oceano Elementary School, Arroyo Grande High School, Harloe Elementary School, and the Le Sage Riviera Golf Course. For 2010, the annual precipitation and evapotranspiration have been compared to average conditions to determine if the year in question had a low, average, or high irrigation water demand. For this evaluation, average irrigation efficiencies are assumed for the NCMA. Therefore, the annual irrigation demand for each crop type is assumed to be dependant only on that year's precipitation and evapotranspiration. The range of demand estimates for all applied irrigation uses are as follows:

- Wet years: 2,056 AF/yr (2005, 2006, and 2010),
- Average years: 2,397 AF/yr (2004),
- Dry years: 2,742 AF/yr (2007, 2008, and 2009).

In 2008, the irrigated crops consisted of approximately 4 acres of nursery crops and approximately 1,596 acres of crops such as broccoli, onions, and strawberries, which represents the total acres for irrigated crops in the NCMA. The 2010 agricultural water demand in NCMA is based on previous year estimates for land use and since the acres of land use have no indication they have changed.

3.3 Rural Demand

In the NCMA rural water demand refers to use not discussed as Urban Demand or Applied Irrigation Demand and includes small community water systems, individual domestic system, recreational uses and agriculture-related business systems. Small community water systems using groundwater in the NCMA were identified initially through review of a list of water purveyors compiled in the 2007 San Luis Obispo County Integrated Regional Water

Management Plan. These include the Halcyon Water System, Ken Mar Gardens, and Pacific Dunes RV Resort. The Halcyon Water System serves 35 homes in the community of Halcyon, while Ken Mar Gardens provides water supply to 48 mobile homes on South Halcyon Road. The Pacific Dunes RV Resort, with 215 RV sites, provides water supply to a largely transitory population and nearby riding stable. In addition, about 25 homes and businesses have been identified through inspection of aerial photographs of rural areas within NCMA. Irrigation of schools and parks from privately operated wells is included in the applied irrigation demand section. Two mobile home communities, Grande Mobile and Halcyon Estates, are served by the OCSD through the distribution system of the City of Arroyo Grande. The demand summary of OCSD includes these two communities. Based on prior reports, it is assumed that the number of private wells is negligible within the service areas of the four Northern Cities. The estimated rural water demand is shown in Table 3.

Table 3. Estimated Rural Water Demand

Groundwater User	No. of Units	Estimated Water Demand, AFY per Unit	Estimated Water Demand, AFY	Notes
Halcyon Water System	35	0.40	14	1
Ken Mar Gardens	48	0.17	8	2
Pacific Dunes RV Resort	215	0.03	6	3
Rural Users	25	0.40	10	1
Current Estimated Rural Use			**38**	

1 - Water demand/unit based on 2000 and 2005 Grover Beach water use per connection, 2005 UWMP.

2 - Demand based on metered water usage.

3 - Water demand/unit assumes 50 percent annual occupancy and 0.06 AFY per occupied site.

3.4 Changes in Water Demand

In general, urban water demand has varied, with a slight decrease during the past couple years (Table 1). This change is attributed primarily to the relatively slower economy and the conservation activities implemented by the Northern Cities in response to the prolonged drought and threat of seawater intrusion. In the applied irrigation category, agricultural acreage has remained fairly constant. Thus annual water demand for applied irrigation varies mostly with weather conditions. Acknowledging the variability due to weather conditions (see Table 1), applied irrigation water demand is not expected to change significantly, given the relative stability of applied irrigation acreage and cropping patterns in the NCMA south of Arroyo Grande Creek. Changes in rural demand have not been significant.

4 Water Supply Sources

Section 4 provides an overview of NCMA water supply sources, presents groundwater conditions that occurred in 2010, and discusses threats to water supply.

4.1 Sources of Supply

Three major sources supply water to the NCMA: Lopez Reservoir, State Water Project (Coastal Branch), and groundwater. In any give year these supplies have a defined capability to supply a certain volume of water (yield or allotment), but due to any one of a number of factors, the demand, or water actually used, may actually be more or less. Both capability (supply) and demand are discussed below. (Water demand is discussed in Section 5.0).

4.1.1 Lopez Supply

Lopez Reservoir is operated by Zone 3 of the San Luis Obispo County Flood Control and Water Conservation District (FC&WCD) and serves water to all four municipalities in the NCMA as well as making releases for habitat conservation purposes. The safe yield of Lopez Reservoir is 8,730 AFY, which reflects the amount of sustainable water supply during a drought of defined severity. Of this yield, 4,530 AFY have been apportioned by agreements to contractors, including each of the Northern Cities plus County service area (CSA) 12 (in the Avila Beach area). Zone 3 allotments are summarized in Table 4. Of the Safe yield, 4,200 AFY is available for release downstream to maintain flows in Arroyo Grande Creek and provide groundwater recharge.

Table 4. Zone 3 Contractor Water Allotment (AFY)

Contractor	Water Allotment, AFY
City of Arroyo Grande	2,290
City of Grover Beach	800
City of Pismo Beach	896
Oceano CSD	303
CSA 12 (not in NCMA)	241
Total	**4,530**
Downstream Releases	*4,200*
Safe Yield of Lopez Reservoir	*8,730*

Source: SLO County FC&WCD, Zone 3 UWMP 2005 Update

During 2010 the total discharge from Lopez Reservoir was 7,214 AF, of which 4,064 AF was delivered to contractors and 3,150 AF was released downstream to maintain flow in Arroyo Grande Creek (actual deliveries are shown in Table 7). In the past, when management of releases resulted in a portion of the 4,200 AFY remaining in the reservoir, the water was periodically offered to the contractors as surplus water. However, surplus water has been unavailable for a number of years.

4.1.2 State Water Project

The City of Pismo Beach and Oceano CSD have contracts with the San Luis Obispo County Flood Control & Water Conservation District to receive water from the California State Water Project (SWP). The San Luis Obispo County FC&WCD serves as the SWP contractor, providing the imported water to local retailers through the Coastal Branch pipeline. Pismo Beach has a contractual allotment of 1,240 AFY while Oceano has a contractual allotment of 750 AFY.

In response to drought in SWP source areas, the initial allocation to SWP contractors for 2010 was 5 percent of contractual allotment amounts, which was subsequently increased to 40 percent in May, and ultimately 60 percent due to above average precipitation in fall 2010. However, due to the nature of its contractual arrangements, San Luis Obispo County FC&WCD needed to request only a fraction of its entire 25,000 AF allocation in 2010 to satisfy local contractors. The requested amount met almost all of the local purveyors' requests. Unlike many water agencies in California that have experienced substantial restrictions in SWP deliveries, Pismo Beach and Oceano CSD (the only SWP participants in the NCMA) were able to receive 100 percent and 96.6 percent, respectively, of their requested 2010 SWP allocation. Pismo Beach actually took delivery of 1005.49 AF, while Oceano CSD took delivery of 724.28 AF, for a total of 1729.77 AF of SWP water (Shown in Table 7, rounded to the nearest AF).

4.1.3 Groundwater

Each of the Northern Cities has developed groundwater supply by means of wells which develop aquifers in the northern portion of the NCMA. Groundwater also supplies applied irrigation and rural uses in the NCMA. Groundwater use in the NCMA is governed by the Judgment and the 2002 Settlement Agreement which establishes that ground water will continue to be allocated and independently managed by the "Northern Parties" (4 Northern Cities, NCMA overlying owners, and the San Luis Obispo County Flood Control and Water Conservation District, SLOFC&WCD). The Settlement Agreement initially allocates 57 percent of groundwater safe yield to agriculture and 43 percent to the cities and stipulates that any increase or decrease in groundwater yield will be shared by the cities and landowners on a pro rata basis.

A safe yield value of 9,500 AFY for the NCMA groundwater basin was cited in the 2002 Groundwater Management Agreement among the Northern Cities with allotments for applied irrigation (5,300 AFY), subsurface outflow to the ocean (200 AFY), and urban use (4,000 AFY). The Management Agreement's safe yield allotment for urban use was subdivided as follows:

- City of Arroyo Grande 1,202 AFY
- City of Grover Beach 1,198 AFY
- City of Pismo Beach 700 AFY
- Oceano Community Services District 900 AFY

According to the "Water Balance Report" prepared for NCMA in 2007 (Todd, 2007), the *Groundwater Management Agreement*'s subdivision for applied irrigation is higher than the actual applied irrigation groundwater use and the amount designated for subsurface outflow is unreasonably low. Maintenance of subsurface outflow along the coast is essential to preventing seawater intrusion. While the minimum subsurface outflow needed to prevent seawater intrusion is unknown, a regional outflow on the order of 3,000 AFY has been estimated as a reasonable approximation (Todd, 2007).

The 2002 Settlement Agreement provides that the various urban parties' allocations can be increased when land within the corporate boundaries is converted from agricultural uses to urban uses, referred to as an agricultural conversion credit. Agricultural credits for the Cities of Arroyo Grande and Grover Beach remain unchanged for 2010 and are 112 AFY and 209 AFY, respectively, for a total of 321 AFY.

4.1.4 Developed Water

As defined in the Stipulation, "developed water" is "Groundwater derived from human intervention" and includes "Lopez Water, Return Flow, and recharge resulting from storm water percolation ponds." In 2008, the Cities of Arroyo Grande, Grover Beach, and Pismo Beach prepared storm water management plans; the cities currently are working with the Central Coast Regional Water Quality Control Board to address local storm water quality issues. In order to control storm water runoff, each City anticipates development of retention or detention ponds associated with new development that may provide ground water recharge. No new ponds were installed in the NCMA and no new data were available for 2010 so previous estimates of recharge were used in this report. Estimated recharge values should be updated and refined as new storm water ponds are installed and as additional information on pond size, infiltration rates, and tributary watershed area becomes available.

Construction of recharge basins or other means to increase storm water recharge could substantially augment the yield of the ground-water basin and thus warrant provision of recharge credits to one of more of the Northern Cities. Pursuant to the Settlement agreement, recharge credits would be based on a mutually-accepted methodology to evaluate the amount of recharge. This would involve quantification of such factors as storm water runoff amounts, determination effective recharge under various conditions, and methods to document actual recharge to developed aquifers.

4.1.5 Water Use by Supply Source

Table 5 summarizes the water supplies currently available to the four Northern Cities in terms of Lopez entitlements, SWP allocations, groundwater allotments, and agricultural credits. In addition to directly available supplies, Arroyo Grande has an ongoing agreement to purchase 100 AFY of Oceano CSD supplies from groundwater or Lopez. The category of "Other Supplies" includes groundwater from beyond the NCMA.

Table 5. Available Urban Water Supplies, AFY

Urban Area	Lopez Entitlement	SWP Allocation	Groundwater Allotment	Ag Credit	Transfers	Other Supplies	Total
Arroyo Grande	2,290	0	1,202	112	100	90	**3,794**
Grover Beach	800	0	1,198	209	0	0	**2,207**
Pismo Beach	896	1,240	700	0	0	0	**2,836**
Oceano CSD	303	750	900	0	-100	0	**1,853**
Total	**4,289**	**1,990**	**4,000**	**321**	**0**	**90**	**10,690**

Figure 5 illustrates the water use by supply source for each NCMA city since 1999. The graphs reveal changes in water supply availability and use over time, including the increased use of SWP water (to a maximum in 2001) and reduced and less variable Lopez water use after 2001 due to the unavailability of Lopez Reservoir surplus flows after 2001.

Figure 6 shows total NCMA water use for each supply source: Lopez, SWP, and groundwater. As shown, the full amount of Lopez supply (4,289 AFY) is currently used. In 2001 through 2003, SWP supplies (1,850 AFY) were used to the maximum extent. From 2004 to 2008, SWP use decreased to just over 1,100 AFY, mostly reflecting a partial shift by Pismo Beach from SWP to groundwater supply. This changed in 2009 and 2010 when Pismo Beach increased SWP use and significantly decreased groundwater use in response to continuing drought and the threat of seawater intrusion (see Figure 5). In addition, Oceano CSD effectively ceased its groundwater use during the last three months of 2009 and used approximately 17% of its normal pumping in 2010.

Total NCMA groundwater use is shown in Figure 6. Estimated applied irrigation and rural uses are added to the urban uses detailed in Figure 5. From 1999 through 2010, total estimated groundwater use averaged approximately 5,400 AFY and exceeded 6,000 AFY in 2007. With an estimated safe yield of 9,500 AFY, the remaining groundwater represents outflow to the ocean, an unknown but major portion of which is needed to repel seawater intrusion. In 2009 and 2010, overall groundwater use was significantly reduced and remained below average.

4.2 Groundwater Conditions

The NCMA groundwater monitoring program comprises: 1) compilation of groundwater elevation data from San Luis Obispo County, 2) Sentry Well water quality and groundwater elevation monitoring data from the network of sentry wells in the NCMA, and 3) water quality data from the California Department of Public Health (DPH) Analysis of these data is summarized below in accordance with the July 2008 *Northern Cities Monitoring Program*.

4.2.1 Groundwater Monitoring Network

Approximately 145 wells within the NCMA have been monitored by the County at some time during the past few decades. The County currently monitors 38 wells on a semi-annual basis (April and October), including five "sentry well" clusters (piezometers) located along the coast. The County monitors more than 70 additional wells in southern San Luis Obispo County. Following the findings of the 2008 Annual Report, the Northern Cities initiated a quarterly sentry well monitoring program to supplement the County's semi-annual schedule.

To monitor overall changes in ground-water conditions, representative wells within the NCMA have been selected for preparation of hydrographs and evaluation of water level changes. Wells have been selected based on the following criteria:

- part of the County's current monitoring program,
- detailed location information available,
- geographically well distributed, and
- long and relatively complete record.

It should be noted that many of the wells shown measured are production wells that were not designed for monitoring purposes and may be screened in various producing zones. Moreover, many of the wells are active production wells or located near active wells and thus are subject localized pumping effects that result in measurements that are lower than the "static" or more broadly representative water level. These effects are not always apparent at the time of measurement. As a result, the data cannot easily be identified as representing static groundwater levels in specific zones (e.g., unconfined or deep confined). Hence, the data should be considered as a whole in developing a general representation of groundwater conditions.

The "sentry wells", shown on Figure 7, are a critical element of the groundwater monitoring network; they provide a system to identify and quantify incipient seawater intrusion in the basin. Each sentry well comprises a cluster has multiple wells allowing for the measurement of groundwater elevation and quality from discrete depths. Also shown on Figure 7 is the Oceano Observation well, a dedicated monitor well cluster located just seaward of OCSD production wells 7 and 8. Figure 8 shows the depth and well names of the sentry well clusters and the Oceano observation well cluster. The wells are divided into three basic depth categories: shallow, intermediate, and deep. Since the initiation of the sentry well monitoring program 8 quarterly events have been completed; with one each in May, August, and October 2009 and January, May, July, and October 2010 and one in January 2011. These monitoring events include collection of synoptic groundwater elevation data and water quality samples for laboratory analysis.

4.2.2 Ground-water Levels

Groundwater elevation data is gathered from the network of wells listed in Appendix A. Water level measurements in these wells have been used to monitor effects of groundwater use, groundwater recharge, and as an indicator of risk of seawater intrusion. Analysis of these groundwater elevation data has included development of groundwater surface contour maps, hydrographs, and an index of key sentry well levels over time (Figures 10 through 12).

Contoured groundwater elevations for the October 2010 monitoring event, including data from the County of San Luis Obispo, are shown on Figure 9. Groundwater elevations were highest in the eastern portion of the NCMA near Arroyo Grande and Highway 101. Groundwater elevations were above mean sea level (msl) throughout the NCMA during the October monitoring event except in the immediate area of pumping wells in the lower Arroyo Grande creek area. Significantly, water level elevations were approximately 5 feet above sea level along the shoreline. This represents a significant recovery of groundwater elevations as compared to October 2008 and above levels measured in October 2009. This recovery is important because in 2008 water level elevations were as much as 10 feet below sea level in the north-central portion of the NCMA (Todd, 2009). Because the area below mean sea level appeared to extend to the coast there was potential for seawater intrusion (Todd, 2008). However, there remains an apparent depression is the water table in the so-called “pumping trough” which is the location of municipal well fields.

Figure 10 shows the locations of selected wells whose data are included in Appendix B. Hydrographs shown on Figure 10 illustrate long-term changes in groundwater levels in the NCMA. To provide geographic context, hydrographs from wells located just east of the NCMA in the Nipomo Mesa Management Area as presented as well. Noting that these hydrographs represent localized conditions at each well, most of the hydrographs indicate that groundwater elevations have historically varied over a range of about 20 feet above mean sea level and in the case of two inland wells, 40 feet.

The upper left and middle left portions of Figure 10 shows paired hydrographs for four wells located in the persistent pumping trough. (It should be noted that these wells are in active municipal well fields and water levels may remain below levels in other areas of the basin for prolonged periods of time.) Although the data sets are incomplete, the hydrographs show that, throughout the record, ground-water elevations in these wells have generally been above mean sea level. However, an area of lower groundwater elevations ("trough") beneath the active well field became more pronounced during the period of reduced rainfall in 2007 and 2008.

Most of the hydrographs in Figure 10 show that groundwater elevations have recovered to levels similar to 2006 (a wet year); this cycle shows the result of drought and increased pumping followed by recovery caused by increased rainfall and decreased pumping (see Figure 6). Although somewhat above sea level, a depression in ground-water levels persists in the area of the trough suggesting that the recharge and withdrawals are near balance in the area. Changes in groundwater elevations within the NCMA that occurred from October 2008 to October 2010 have been evaluated in the preparation of this report. Overall, water elevations within the NCMA rose by a few feet during water year 2010 and in most locations have continued to rise.

The sentry well clusters are the essential tool for tracking critical groundwater elevation changes at the coast. As shown by the hydrographs for the five sentry well clusters in Figure 11, the sentry wells provide a long history of groundwater elevations. In addition, groundwater elevations in these wells are monitored quarterly as part of the sentry well monitoring program. The deepest wells in the clusters adjacent to the NCMA urban area (wells 24B03, 30F03, and 30N02) are also screened at depths closely matching the screened depths of most local pumping wells. Hence, measured water elevations in these deepest wells reflect the net effect of changing groundwater recharge and discharge conditions in the most-used aquifer zone.

Averaging the groundwater elevations from these three wells provides a single, representative index for tracking the status of the basin. Historical variation of this index is shown as the average deep sentry well elevations on Figure 12. Figure 12 clearly shows three years of drought followed by recovery in this highly-developed aquifer zone. Specifically, the graph shows that this index has improved significantly since the 2008 Annual Report.

4.2.3 Water Quality

Water is used in several ways in the NCMA; each use requires a certain minimum water quality. Since contaminants from seawater intrusion or anthropogenic sources can potentially lower the quality of water in the basin, water quality is monitored at several locations in the NCMA. In the NCMA area, water quality data are available from dedicated monitoring wells, from water supply wells and from surface water. Four well clusters located along the coast were originally installed by the California Department of Water Resources to monitor for sea water intrusion. Each of these "sentry wells" has two or three individual wells (piezometers) completed at different depths. In addition, the Oceano Community Services District observation well cluster (located near Highway 1 in Oceano) includes four individual piezometers. Water quality information from each of the sentry wells and the OCSD monitoring wells is gathered quarterly. In addition to the monitoring wells, consolidated water quality information from the DPH for local municipal wells was reviewed.

4.2.3.1 Sentry Wells

Four separate monitoring events occurred in 2010, with each piezometer in the sentry wells and in the OCSD well measured in January, April, July, and October 2010. During each event, the wells were all sampled in accordance with ASTM International Standard D4448-01. Water quality data from these events and available historical data from these wells are presented on Tables 6a and 6b. Beginning in October 2010, water quality samples were obtained directly from the pump used to evacuate each well. Samples in January, April and July were obtained using a bailer after evacuation. This change was made because use of a bailer may have resulted in acquisition of a less representative sample from the small diameter piezometers given the depth of many of the wells. Less representative samples may have led to discrepancies in the expected relationship between field measurements of electrical conductivity (EC) and laboratory measurements of total dissolved solids (TDS) noted in some samples take prior to October 2010. (Prior or October 2010, field measurements of EC were based on water from the evaluation pump while TDS measurements in the laboratory were from sample obtained from the bailer and shipped to the laboratory.)

Since water quality trends are used to monitor for seawater intrusion, data collected in 2010 were added to previous data and the variation of selected constituents have been plotted against time. (Other geochemical plots are discussed below.) Figures 13 and 14 show variation of chloride and TDS concentration as a function of time. These figures show a wide variation in water quality during the past few years. However, samples obtained in 2010 show less variation and general improvement in overall quality compared to 2009. Todd (2010) suggested the observed *variation in water quality data could be due to a number of factors including: variable permeability of geologic materials, potential mixing with seawater, ion exchange in clay-rich units, and variability in surface recharge sources, such as Arroyo Grande and Meadow Creeks.* Changes in ground water demand and abundant rainfall may have contributed to the general improvement of ground-water quality in 2010. These factors are discussed in more detail in Section 5.

In general, no wells showed evidence of sea water intrusion in 2010. Several wells showed continued improvement of water quality compared to 2008 and 2009 monitoring results. Key observations are discussed below.

Table 6a: Northern Cities Sentry Well Water Quality Data Summary

Well	Construction	Top of Casing Elevation (feet NAVD)	Date	Depth to Water (feet)	Groundwater Elevation (feet NAVD)	Total Dissolved Solids (mg/L)	Chloride (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate (as CaCO3) (mg/L)	Sulfate (mg/L)	Nitrate (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Boron (mg/L)	Fluoride (mg/L)	Iodide (mg/L)	Manganese (mg/L)	Bromide (mg/L)	Alkalinity, Total (as CaCO3) (mg/L)	Carbonate (as CaCO3) (mg/L)	Hydroxide (as CaCO3) (mg/L)	Specific Conductance (umhos/cm)	Iron (mg/L)	Bromide / Chloride Ratio	Chloride / Bromide Ratio
32S/12E-24B01	Screened from 48-65' - 2-inch diameter	13.20																									
	Wellhead renovation in 6/2010 added to the TOC elevation	2.50	1/24/2011	5.78	7.42	2,380	1100	370	24	110	120	380	180	<0.15	1.8	0.16	<0.3	0.63	0.68	2.8	380	<2.0	<2.0	4,020	0.89	0.0025	393
	Pad elevation NAVD 88	10.70	10/28/2010	NA	NA	2,330	960	390	25	140	140	350	160	<0.1	3.9	0.15	<0.1	NA	0.75	2.6	350	<10	<10	3,860	1.3	0.0027	369
			10/21/2010	6.37	6.83	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TOC elevation prior to renovation (Approximate)	10.7	7/27/2010	6.48	6.72	616	43	52.5	6.21	115	44.7	341	160	< 0.10	2.9	0.063	< 0.10	0.11	0.274	0.18	341	< 1.0	< 1.0	1,000	9.34	0.0042	239
			4/27/2010	3.84	6.86	676	47	54.7	4.60	107	43.6	327	140	< 0.10	0.98	0.0714	< 0.10	< 0.10	0.0458	0.18	327	< 1.0	< 1.0	990	4.06	0.0038	261
			1/27/2010	3.13	7.57	694	55	56.2	6.80	123	43.2	340	150	0.40	1.7	0.12	< 0.10	0.33	0.875	0.19	340	< 1.0	< 1.0	1,000	16.6	0.0035	289
			10/19/2009	2.28	8.42	766	140	121	16.7	111	52.4	303	150	0.25	2.8	0.0959	0.11	< 0.10	0.208	0.47	303	< 1.0	< 1.0	1,200	7.79	0.0034	298
			8/20/2009	3.25	7.45	705	94	86.8	11.7	116	35.6	286	150	0.21	2.7	NA	< 0.10	0.12	0.248	0.38	286	< 1.0	< 1.0	1,000	7.15	0.0040	247
			5/12/2009	3.58	7.12	695	100	82.1	13.2	108	45	288	150	NA	NA	NA	0.11	NA	0.66	0.29	288	< 1.0	< 1.0	1,100	23.9	0.0029	345
			3/26/1996	NA	NA	1,870	773	380	24.0	125	95	427	154	0.2	NA	0.27	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
			6/9/1976	NA	NA	1,706	667	400	16.2	94	95	474	159	0.4	NA	0.12	0.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
			1/17/1966	NA	NA	1,700	652	406	20.0	95	83	440	175	1	NA	0.07	0.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
32S/12E-24B02	Screened from 120-145' - 2-inch diameter	13.22																									
	Wellhead renovation in 6/2010 added to the TOC elevation	2.52	1/24/2011	5.69	7.53	640	43	44	5.9	87	28	270	170	<0.05	<1.0	0.11	<0.1	0.14	0.085	<0.1	270	<2.0	<2.0	940	1.3	NA	NA
	Pad elevation NAVD 88	10.70	10/28/2010	NA	NA	650	43	50	4.5	110	35	270	160	<0.1	<1.0	0.12	<0.1	NA	0.085	<0.3	270	<10	<10	970	0.63	NA	NA
			10/21/2010	6.79	6.43	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TOC elevation prior to renovation (Approximate)	10.7	7/27/2010	7.05	6.17	598	42	48.9	4.29	111	40.5	318	160	< 0.10	1.3	0.0609	< 0.10	0.11	0.106	0.15	318	< 1.0	< 1.0	980	2.84	0.0036	280
			4/27/2010	4.34	6.36	668	46	52.7	4.73	111	43.2	349	150	< 0.10	1.3	0.0666	< 0.10	0.14	0.101	0.16	349	< 1.0	< 1.0	980	6.66	0.0035	288
			1/27/2010	3.38	7.32	622	45	58.0	5.39	115	32.2	270	160	0.18	0.84	0.117	< 0.10	0.14	0.209	0.16	270	< 1.0	< 1.0	920	3.49	0.0036	281
			10/19/2009	2.26	8.44	600	49	59.1	5.12	112	30.1	281	160	< 0.10	0.98	0.0776	0.14	< 0.10	0.163	0.19	281	< 1.0	< 1.0	870	1.14	0.0039	258
			8/20/2009	4.09	6.61	630	49	63.5	5.85	128	30.1	288	150	< 0.10	0.98	NA	< 0.10	< 0.10	0.203	0.20	288	< 1.0	< 1.0	920	3.22	0.0041	245
			5/12/2009	4.74	5.96	622	82	67.5	6.33	114	34.5	282	150	NA	NA	NA	0.11	NA	0.252	0.24	282	< 1.0	< 1.0	990	6.76	0.0029	342
			3/26/1996	NA	NA	652	54	46	5	107	24	344	169	0.2	NA	0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
			6/9/1976	NA	NA	565	34	52	4	104	27	337	153	0.6	NA	0.02	0.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
			1/17/1966	NA	NA	651	62	79	5	101	32	380	147	0	NA	0.05	0.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
32S/12E-24B03	Screened from 270-435' - 2-inch diameter	13.23																									
	Wellhead renovation in 6/2010 added to the TOC elevation	2.53	1/24/2011	2.65	10.58	660	46	44	5.6	87	33	320	160	<0.05	<1.0	NA	<0.1	0.15	0.0096	<0.1	320	<2.0	<2.0	1,020	0.22	NA	NA
	Pad elevation NAVD 88	10.70	10/28/2010	NA	NA	660	44	48	3.8	110	39	315	50	<0.1	<1.0	0.089	<0.1	NA	0.0120	<0.3	315	<10	<10	1,020	0.55	NA	NA
			10/21/2010	4.60	8.63	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TOC elevation prior to renovation (Approximate)	10.7	7/27/2010	4.54	8.69	610	44	51.4	8.34	112	41.6	328	160	< 0.10	1.8	0.0533	< 0.10	0.17	0.0602	0.16	328	< 1.0	< 1.0	1,000	6.7	0.0036	275
			4/27/2010	1.43	9.27	666	45	53.2	4.84	118	44	357	150	< 0.10	1.5	0.0636	< 0.10	0.1	0.0519	0.17	357	< 1.0	< 1.0	980	9.71	0.0038	265
			1/27/2010	0.94	9.76	672	48	56.4	5.40	119	43.4	336	150	< 0.10	1.4	0.101	< 0.10	0.15	0.140	0.15	336	< 1.0	< 1.0	1,000	5.18	0.0031	320
			10/19/2009	0.81	9.89	622	40	55.1	3.93	110	42.6	342	160	< 0.10	< 0.50	0.0613	< 0.10	0.13	0.0181	0.14	342	< 1.0	< 1.0	880	0.343	0.0035	286
			8/19/2009	4.18	6.52	680	47	54.9	5.21	128	43.4	337	150	< 0.10	2.2	NA	< 0.10	0.66	0.182	0.15	337	< 1.0	< 1.0	1,000	14.3	0.0032	313
			5/12/2009	3.18	7.52	645	44	53.2	4.53	108	41.8	332	140	NA	NA	NA	< 0.10	NA	0.124	0.16	332	< 1.0	< 1.0	1,000	5.9	0.0036	275
			3/26/1996	NA	NA	646	41	52	4.3	104	42	412	164	0.2	NA	0.12	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
			6/9/1976	NA	NA	569	36	53	3.7	85	39	330	165	0	NA	0.06	0.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
			1/17/1966	NA	NA	670	79	74	5	103	36	345	158	1	NA	0	0.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
32S/13E-30F01	Screened from 15- 30 and 40-55' - 1-inch diameter	23.30																									
	Wellhead renovation in 6/2010 added to the TOC elevation	2.94	1/24/2011	13.33	9.97	510	75	64	4.00	34	18	83	140	11	<1.0	0.170	0.11	<0.10	<0.005	<0.1	83	<2.0	<2.0	780	<0.1	NA	NA
	Pad elevation NAVD 88	20.36	10/21/2010	16.55	6.75	540	100	73	2.00	43	21	88	120	13	<1.0	0.067	<0.1	NA	<0.005	<0.3	88	<10	<10	894	<.1	NA	NA
	TOC elevation prior to renovation (Approximate)	20.4	7/26/2010	15.68	7.62	464	74	82.2	2.16	47.9	25.1	88.0	120	12	< 0.50	0.098	< 0.10	< 0.10	0.0817	0.37	88.0	< 1.0	< 1.0	710	0.79	0.0050	200
			4/27/2010	11.02	9.38	534	72	77.1	2.59	45.8	23.6	100	140	9.8	0.56	0.129	< 0.10	< 0.10	0.112	0.29	100	< 1.0	< 1.0	780	1.02	0.0040	248
			1/28/2010	12.73	7.67	725	140	99.9	2.70	76.4	35.8	214	170	1.6	0.84	0.120	< 0.10	< 0.10	0.112	0.56	214	< 1.0	< 1.0	1,200	0.640	0.0040	250
			10/19/2009	14.33	6.07	522	74	85.6	2.35	52.8	26.3	102	150	13	0.70	0.136	0.13	< 0.10	0.123	0.32	102	< 1.0	< 1.0	770	1.30	0.0043	231
			8/19/2009	14.34	6.06	648	92	98.9	3.84	63.1	31.9	113	190	10	0.56	NA	< 0.10	0.12	1.03	0.32	113	< 1.0	< 1.0	970	4.52	0.0035	288
			5/12/2009	12.38	8.02	792	110	108	2.89	80.2	39.9	136	280	NA	NA	NA	< 0.10	NA	0.0353	0.39	136	< 1.0	< 1.0	1,200	0.281	0.0035	282
32S/13E-30F02	Screened from 75-100' - 2-inch diameter	23.29																									
	Wellhead renovation in 6/2010 added to the TOC elevation	2.93	1/24/2011	14.36	8.93	600	51	43	4.9	71	31	210	140	12	<1.0	0.15	0.12	0.27	0.041	0.3	210	<2.0	<2.0	920	<0.1	0.0059	170
	Pad elevation NAVD 88	20.36	10/28/2010	NA	NA	610	49	38	2.3	70	30	210	130	11	<1.0	0.10	<0.1	NA	0.0094	<0.3	210	<10	<10	920	<0.1	NA	NA
			10/21/2010	7.39	15.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TOC elevation prior to renovation (Approximate)	20.4	7/26/2010	16.21	7.08	560	49	45.8	2.95	85.4	36.8	223	130	11	2.5	0.0928	< 0.10	0.13	0.0646	0.59	223	< 1.0	< 1.0	890	< 0.100	0.0120	83
			4/27/2010	12.14	8.26	634	51	50.3	3.12	87.9	38.6	225	130	10	0.8	0.112	< 0.10	< 0.10	0.615	0.51	225	< 1.0	< 1.0	880	3.28	0.0100	100
			1/28/2010	13.09	7.31	604	44	52.2	4.47	92.1	38.5	230	150	11	1.4	0.127	< 0.10	< 0.10	0.913	0.48	230	< 1.0	< 1.0	920	4.55	0.0109	92
			10/19/2009	14.36	6.04	566	49	49.5	2.80	88.3	37.6	240	140	11	1.0	0.0942	0.17	< 0.10	0.924	0.51	240	< 1.0	< 1.0	850	2.15	0.0104	96
			8/19/2009	14.81	5.59	614	49	51.8	3.19	87.3	36.8	225	130	11	2.00	NA	0.10	< 0.10	2.24	0.54	225	< 1.0	< 1.0	920	19.4	0.0110	91
			5/12/2009	14.34	2.96	514	54	48.7	3.26	81.1	34.9	206	120	NA	NA	NA	0.11	NA	1.87	0.53	206	< 1.0	< 1.0	890	3.23	0.0098	102
			3/27/1996	NA	NA	678	49	52	3.8	98	42	305	166	49	NA	0.16	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
			6/9/1976	NA	NA	637	48	55	2.8	98	43	343	172	17.6	NA	0.1	0.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
			1/20/1966	NA	NA	580	68	47	2	94	38	280	152	27	NA	0.08	0.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
32S/13E-30F03	Screened from 305-372' - 2-inch diameter	23.31																									
	Wellhead renovation in 6/2010 added to the TOC elevation	2.95	1/24/2011	12.67	10.64	650	46	36	4.7	87	38	300	170	<0.05	<1.0	0.11	0.17	0.24	0.016	<0.1	300	<2.0	<2.0	990	<0.1	NA	NA
	Pad elevation NAVD 88	20.36	10/28/2010	NA	NA	650	46	37	2.7	100	43	280	160	<0.1	<1.0	0.10	<0.1	NA	0.032	<0.3	280	<10	<10	1,000	0.53	NA	NA
			10/21/2010	6.62	16.69	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TOC elevation prior to renovation (Approximate)	20.4	7/26/2010	17.32	5.99	608	45	43.8	2.94	107	46.8	294	160	1.3	0.84	0.0479	< 0.10	0.10	0.129	0.24	294	< 1.0	< 1.0	900	7.55	0.0053	188
			4/27/2010	11.38	9.02	668	48	40.8	2.91	101	44.7	304	160	0.21	0.84	0.0733	0.14	0.11	0.0694	0.23	304	< 1.0	< 1.0	940	2.62	0.0048	209
			1/28/2010	10.98	9.42	656	40	43.1	3.91	112	47.2	310	180	< 0.20	2.8	0.0833	0.13	< 0.10	0.287	0.21	310	< 1.0	< 1.0	980	4.80	0.0053	190
			10/19/2009	14.18	6.22	626	48	43.3	3.14	108	46.2	308	170	< 0.10	1.8	0.0646	0.22	< 0.10	0.255	0.17	308	< 1.0	< 1.0	910	2.09	0.0035	282
			8/19/2009	20.23	0.17	672	45	43.1	3.15	111	44.3	290	170	< 0.10	2.5	NA	0.14	< 0.10	0.468	0.19	290	< 1.0	< 1.0	980	18.5	0.0042	237
			5/12/2009	17.68	2.72	678	49	44.8	3.32	109	42.9	276	180	NA	NA	NA	0.17	NA	0.146	0.18	276	< 1.0	< 1.0	960	1.16	0.0037	272
			3/27/1996	NA	NA	686	41	40	3.4	109	48	379	197	0.2	NA	0.13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
			6/7/1976	NA	NA	616	43	41	2.6	96	49	333	190	0.4	NA	0.05	0.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
			1/19/1966	NA	NA	642	69	49	4	109	40	321	182	1	NA	0.05	0.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
32S/13E-30N01	Screened from 15-40' - 1-inch diameter	15.53																									
	Wellhead renovation in 6/2010 added to the TOC elevation	2.00	1/24/2011	8.18	7.35	870	180	100	28	84	46	240	210	<0.05	<1.0	<0.1	0.34	0.12	0.24	3.63	240	<2.0	<2.0	1,430	18	0.0202	50
	Pad elevation NAVD 88	13.53	10/21/2010	9.99	5.54	890	190	120	26	58	45	246	200	<0.1	<1.0	<0.1	0.37	NA	0.078	2.3	246	<10	<10	1,498	<0.1	0.0121	83
	TOC elevation prior to renovation (Approximate)	13.5	7/27/2010	8.97	6.56	917	200	130	30.0	75.0	56.2	241	220	< 0.10	< 0.50	0.165	0.29	0.23	0.101	2.8	241	< 1.0	< 1.0	1,400	2.61	0.0140	71
			4/27/2010	6.14	7.36	808	150	130	29	136	55.6	286	210	0.76	1.7	0.171	0.37	0.19	0.276	2.6	286	< 1.0	< 1.0	1,300	20.4	0.0173	58
			1/26/2010	4.90	8.60	902	210	155	33.5	156	66.4	307	230	< 0.10	1.7	0.317	0.30	0.12	0.333	3.2	307	< 1.0	< 1.0	1,500	27.3	0.0152	66
			10/20/2009	6.53	7.00	828	200	159	34.3	118	59.8	238	230	< 0.10	1.3	0.241	0.38	< 0.10	0.157	3.2	238	< 1.0	< 1.0	1,300	5.33	0.0160	63
			8/20/2009	6.71	6.82	835	160	150	27.8	121	49.4	235	220	< 0.10	1.3	NA	0.37	0.12	0.228	2.9	235	< 1.0	< 1.0	1,400	15.9	0.0181	55
			5/11/2009	6.03	7.50	960	180	175	33.5	86.7	46.2	274	220	NA	NA	NA	0.36	NA	0.113	3.2	274	< 1.0	< 1.0	1,500	2.26	0.0178	56

Des. by: CNT
Ckd. by: MKR 08.09.10

Table 6a: Northern Cities Sentry Well Water Quality Data Summary

Well	Construction	Top of Casing Elevation (feet NAVD)	Date	Depth to Water (feet)	Groundwater Elevation (feet NAVD)	Total Dissolved Solids (mg/L)	Chloride (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate (as CaCO3) (mg/L)	Sulfate (mg/L)	Nitrate (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Boron (mg/L)	Fluoride (mg/L)	Iodide (mg/L)	Manganese (mg/L)	Bromide (mg/L)	Alkalinity, Total (as CaCO3) (mg/L)	Carbonate (as CaCO3) (mg/L)	Hydroxide (as CaCO3) (mg/L)	Specific Conductance (umhos/cm)	Iron (mg/L)	Bromide / Chloride Ratio	Chloride / Bromide Ratio
32S/13E-30N03	Screened from 60-135' - 2-inch diameter	15.43																									
	Wellhead renovation in 6/2010 added to the TOC elevation	1.90	1/24/2010	6.68	8.75	570	76	48	4.8	55	25	130	130	16	<1.0	0.12	0.2	<0.10	0.0088	1.7	130	<2.0	<2.0	900	<0.1	0.0224	45
	Pad elevation NAVD 88	13.53	10/21/2010	10.76	4.67	550	69	59	3.3	65	31	133	130	15	<1.0	<0.1	0.1	NA	<0.005	1.1	133	<10	<10	886	<0.1	0.0159	63
	TOC elevation prior to renovation (Approximate)	13.5	7/27/2010	9.53	5.90	528	72	55.1	3.41	68.7	31.0	139	130	15.0	< 0.50	0.0672	0.14	0.11	< 0.00500	1.3	139	< 1.0	< 1.0	860	< 0.100	0.0181	55
			4/27/2010	6.14	7.36	672	89	60.6	3.65	70.6	32.5	134	130	14.0	< 0.50	0.0779	0.18	0.11	< 0.00500	1.2	134	< 1.0	< 1.0	870	< 0.100	0.0135	74
			1/26/2010	5.88	7.62	606	110	75.0	4.51	77.8	34.3	126	130	14	1.4	0.0654	0.15	< 0.10	0.0130	1.3	126	< 1.0	< 1.0	990	0.653	0.0118	85
			10/20/2009	6.56	6.94	806	180	93.3	25.5	92.3	41.5	162	150	9.7	2.2	0.107	0.26	< 0.10	0.245	1.4	162	< 1.0	< 1.0	1,200	0.344	0.0078	129
			8/20/2009	7.50	6.00	1,070	190	151	61.6	112	44.2	130	130	16	3.4	NA	0.20	< 0.10	0.151	1.6	130	< 1.0	< 1.0	1,700	1.93	0.0084	119
			5/12/2009	6.33	7.17	602	97	63.4	3.96	72.9	32.2	122	120	NA	NA	NA	0.22	NA	24	1.2	122	< 1.0	< 1.0	900	2.24	0.0124	81
			3/27/1996	NA	NA	624	70	62	4	78	35	150	161	106.8	NA	0.13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
			6/7/1976	NA	NA	705	90	54	2.9	99	43	189	168	112.5	NA	0.08	0.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
			1/21/1966	NA	NA	804	57	54	3	132	59	410	250	1	NA	0.08	0.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
32S/13E-30N02	Screened from 175-255' - 2-inch diameter	15.43																									
	Wellhead renovation in 6/2010 added to the TOC elevation	1.90	1/24/2011	3.67	11.76	1,050	50	60	6.4	120	49	190	490	0.24	<1.0	0.17	0.17	<0.10	0.064	<0.1	190	<2.0	<2.0	1,380	0.12	NA	NA
	Pad elevation NAVD 88	13.53	10/21/2010	10.42	5.01	1,040	48	52	3.5	100	45	181	460	0.15	<1.0	<0.1	<0.1	NA	<0.005	<0.3	181	<10	<10	1,377	<0.1	NA	NA
	TOC elevation prior to renovation (Approximate)	13.5	7/27/2010	10.02	5.41	777	57	67.6	7.31	141	58.5	190	470	0.3	3.5	0.138	< 0.10	0.11	0.102	0.28	190	< 1.0	< 1.0	1,300	3.43	0.0049	204
			4/27/2010	5.26	8.27	800	93	71.9	12.50	108	46.3	159	300	7.0	3.2	0.123	0.13	0.11	0.0776	0.7	159	< 1.0	< 1.0	1,100	3.27	0.0075	133
			2/25/2010	1.72	11.78	1,000	48	71.4	4.70	141	58.1	195	490	0.16	< 0.50	0.15	0.15	< 0.10	0.0393	0.16	195	< 1.0	< 1.0	1,300	3.30	0.0033	300
	Confirmation Sample Collected from Pump Discharge at End of Purge:		2/25/2010	1.72	11.78	1,010	74	76.9	10.2	138	55.8	195	440	0.13	2.4	0.142	0.16	< 0.10	0.0579	0.24	195	< 1.0	< 1.0	1,400	1.69	0.0032	308
	Confirmation Sample Collected by Standard Method (Bailer):		1/26/2010	3.72	9.78	970	50	74.2	4.77	152	62.2	195	510	0.14	< 0.50	0.129	0.11	< 0.10	< 0.00500	0.16	195	< 1.0	< 1.0	1,300	< 0.100	0.0032	313
			10/20/2009	7.38	6.12	2,080	690	274	151	239	101.0	220	400	< 0.10	7.0	0.201	0.16	0.87	0.398	2.0	220	< 1.0	< 1.0	2,800	5.50	0.0029	345
			8/20/2009	11.94	1.56	1,350	500	199	82.2	123	49.0	199	220	6.4	6.3	NA	0.23	0.14	0.339	2.8	199	< 1.0	< 1.0	2,100	4.91	0.0056	179
			5/11/2009	6.98	6.52	1,290	170	129	52	137	66.9	176	470	NA	NA	NA	0.18	NA	0.128	0.56	176	< 1.0	< 1.0	1,800	5.24	0.0033	304
			3/27/1996	NA	NA	1,050	50	71	5.5	145	60	243	516	0.9	NA	0.23	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
			6/7/1976	NA	NA	1,093	48	62	4.7	150	60	248	484	0	NA	0.13	0.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
			1/21/1966	NA	NA	1,069	54	71	5	148	63	232	483	0	NA	0.12	0.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
12N/36W-36L01	Screened from 227-237' - 2-inch diameter	26.29																									
	Wellhead renovation in 6/2010 added to the TOC elevation	2.31	1/24/2011	17.61	8.68	890	41	55	5.1	98	36	180	400	0.50	<1.0	0.20	0.15	<0.10	<0.005	<0.1	180	<2.0	<2.0	1,200	<0.1	NA	NA
	Pad elevation NAVD 88	23.98	10/21/2010	20.75	5.54	910	38	76	3.6	130	47	169	400	0.39	<1.0	0.10	<0.1	NA	<0.005	<0.3	169	<10	<10	1,213	<0.1	NA	NA
	TOC elevation prior to renovation (Approximate)	24.0	7/27/2010	21.18	5.11	707	36	64.2	3.70	127	47.4	182	420	0.40	< 0.50	0.158	< 0.10	< 0.10	< 0.00500	0.11	182	< 1.0	< 1.0	1,100	< 0.100	0.0031	327
			4/26/2010	15.94	8.06	860	42	70.3	4.13	129	48.9	191	400	0.45	0.77	0.223	< 0.1	0.15	0.057	0.14	191	< 1.0	< 1.0	1,100	4.53	0.0033	300
			10/21/2009	17.72	6.28	856	38	72.0	4.64	131	48.2	192	420	0.49	0.84	0.150	0.12	< 0.10	0.0994	0.13	192	< 1.0	< 1.0	1,100	1.68	0.0034	292
			8/20/2009	19.16	4.84	890	39	78.0	4.21	138	48.1	184	390	0.49	0.56	NA	< 0.10	< 0.10	0.185	0.14	184	< 1.0	< 1.0	1,200	2.03	0.0036	279
			5/11/2009	17.68	6.32	832	63	83.8	4.88	111	45.4	204	330	NA	NA	NA	0.12	NA	0.551	0.22	204	< 1.0	< 1.0	1,200	4.02	0.0035	286
			3/26/1996	NA	NA	882	35	66	4.8	124	47	233	408	2	NA	0.24	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
			6/8/1976	NA	NA	936	38	72	3.5	130	48	223	423	0.6	NA	0.15	0.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
12N/36W-36L02	Screened from 535-545' - 2-inch diameter	26.29																									
	Wellhead renovation in 6/2010 added to the TOC elevation	2.31	1/24/2011	9.37	16.92	800	120	95	7.6	75	30	300	190	<0.05	2.3	0.39	0.16	1.31	0.13	0.53	300	<2.0	<2.0	1,270	1.40	0.0044	226
	Pad elevation NAVD 88	23.98	10/21/2010	19.77	6.52	770	120	130	7.6	89	44	275	160	<0.1	3.4	0.48	<0.1	NA	0.15	0.54	275	<10	<10	1,293	0.12	0.0045	222
	TOC elevation prior to renovation (Approximate)	24.0	7/27/2010	20.53	5.76	737	110	121	7.81	91.1	38.9	268	190	< 0.10	< 0.50	0.427	0.10	0.77	0.180	0.80	268	< 1.0	< 1.0	1,200	0.845	0.0073	138
			4/26/2010	9.24	14.76	720	100	116	6.88	85.4	32.4	215	210	1.5	0.77	0.382	0.2	0.28	0.167	0.7	215	< 1.0	< 1.0	1,100	3.870	0.0070	143
			10/21/2009	17.65	6.35	638	99	113	6.15	81.6	23.0	172	200	< 0.10	3.2	0.268	0.33	57	0.128	0.61	172	< 1.0	< 1.0	940	0.255	0.0062	162
			8/20/2009	19.15	4.85	785	100	131	6.66	89.8	36.6	290	190	< 0.10	3.8	NA	0.15	0.27	0.307	0.75	290	< 1.0	< 1.0	1,200	0.830	0.0075	133
			5/11/2009	14.38	9.62	775	120	132	7.24	84	39.7	294	180	NA	NA	NA	0.18	NA	0.426	0.78	294	< 1.0	< 1.0	1,300	0.958	0.0065	154
			3/26/1996	NA	NA	772	127	130	8.7	86	36	390	148	0.2	NA	0.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
			6/8/1976	NA	NA	820	126	118	6.6	94	44	393	184	0	NA	NA	0.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Oceano MW-Green	Screened from 110-130' - 3-inch diameter	30.86																									
	Casing relative to concrete pad	-4.14	1/24/2011	106.59	-71.96	310	98	22	8.1	34	9.2	19.0	53	<0.05	<1.0	<0.1	0.2	4.42	0.4	0.63	19.0	<2.0	<2.0	480	10	0.0064	156
	Pad elevation above MSL, approximate	35.0	10/28/2010	NA	NA	290	81	26	9.3	64	11	160.0	68	<0.1	<1.0	<0.1	0.2	NA	0.85	0.36	160.0	<10	<10	520	38	0.0044	225
			10/21/2010	112.71	-81.85	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	All elevations relative to MSL		7/26/2010	95.61	-64.75	438	85	34.3	1.93	61.7	30.4	30.0	210	< 0.10	< 0.50	0.0435	0.58	0.22	1.46	0.32	30.0	< 1.0	< 1.0	690	36	0.0038	266
			4/26/2010	63.90	-33.04	560	83	47.7	5.7	86.1	48.3	62	310	< 0.10	0.84	< 0.02	< 0.1	0.56	2.54	0.31	62.0	< 1.0	< 1.0	880	233	0.0037	268
			1/27/2010	43.71	-12.85	460	130	45.0	25.4	682	124	112	100	0.56	NA	< 0.0200	0.21	0.25	32.4	0.49	112.0	< 1.0	< 1.0	760	4,360	0.0038	265
			10/20/2009	29.20	1.66	362	92	39.6	2.92	19.2	45.1	76.8	110	< 0.10	< 0.50	0.0697	< 0.10	< 0.10	0.242	0.39	80.0	3.2	< 1.0	590	11.4	0.0042	236
			8/19/2009	24.55	6.31	420	160	48.4	3.37	49.9	20.4	17.6	54	< 0.10	1.1	NA	< 0.10	0.25	1.76	0.68	17.6	< 1.0	< 1.0	690	242	0.0043	235
			5/16/1983	15.80	15.06	665	35	40	NA	85	65	360	90	< 4	NA	NA	0.2	NA	0.01	NA	360	ND	ND	950	0.10	NA	NA
Oceano MW-Blue	Screened from 190-210' and 245-265' - 3-inch diameter	30.91																									
	Casing relative to concrete pad	-4.09	1/24/2011	24.87	9.76	680	110	60	17	64	22	5.0	330	<0.05	<1.0	<0.1	0.22	0.96	0.16	0.31	11.2	6.2	<2.0	1,040	10.0	0.0028	355
	Pad elevation above MSL, approximate	35.0	10/21/2010	30.11	0.80	770	100	68	12	88	31	14.0	380	<0.1	<1.0	<0.1	0.28	NA	0.054	<0.3	14.0	<10	<10	1,163	2.2	NA	NA
			7/26/2010	24.74	6.17	783	130	80.1	8.58	142	42.0	2.8	450	< 0.10	< 0.50	< 0.0200	0.26	0.31	3.97	0.8	2.8	< 1.0	< 1.0	1,200	593	0.0059	169
	All elevations relative to MSL		4/26/2010	18.52	12.39	1,130	160	70.2	6.48	208	50.7	8.4	530	< 0.10	0.56	< 0.02	0.23	0.54	3.10	1.0	8.4	< 1.0	< 1.0	1,600	383	0.0061	165
			1/27/2010	22.06	8.85	1,740	430	55.6	4.98	282	43.0	< 1.0	680	< 0.10	< 0.50	0.0819	0.14	0.41	9.41	2.0	< 1.0	< 1.0	< 1.0	2,300	170	0.0047	215
			10/20/2009	27.50	3.41	2,250	1,000	19.5	2.40	487	22.5	5.0	410	< 0.10	0.98	0.0532	0.13	< 0.10	13.1	4.5	5.0	< 1.0	< 1.0	3,100	236	0.0045	222
			8/19/2009	24.65	6.26	322	150	93.2	16.7	23.9	12.1	3.0	4.0	< 0.10	1.3	NA	0.19	0.5	0.7	0.74	23.0	20.0	< 1.0	640	153	0.0049	203
			5/16/1983	13.30	17.61	840	80	90	NA	100	50	250	160.0	< 4	NA	ND	0.2	NA	0.14	NA	250.0	ND	ND	1,200	0.10	NA	NA
Oceano MW-Silver	Screened from 395-435' and 470-510' - 3-inch diameter	30.85																									
	Casing relative to concrete pad	-4.15	1/24/2011	22.02	12.61	440	92	90	9.2	3.4	27	90	140	<0.05	<1.0	0.25	0.11	0.94	0.041	0.35	110	20	<2.0	810	2.2	0.0038	263
	Pad elevation above MSL, approximate	35.0	10/21/2010	29.11	1.74	460	90	110	15	6.8	32	94	140	<0.1	<1.0	0.2	0.1	NA	0.1	0.38	124	30	<10	868	3.5	0.0042	237
			7/26/2010	24.24	6.61	478	83	109	5.94	52.9	30.4	122.0	94	< 0.10	<0.50	0.255	< 0.10	0.41	0.477	0.56	130.0	8.0	< 1.0	730	61.0	0.0067	148
	All elevations relative to MSL		4/26/2010	19.04	11.81	452	83	83	7.42	29.3	34.5	72.0	190	< 0.1	0.56	0.134	< 0.10	0.65	0.702	0.4	86.0	14.0	< 1.0	810	71.0	0.0048	208
			1/27/2010	21.05	9.8	496	71	92.2	10.6	22.9	39.1	13.0	230	<0.10	< 0.50	0.323	< 0.10	0.20	0.604	0.29	51.0	38.0	< 1.0	780	54.4	0.0041	245
			10/20/2009	27.52	3.33	564	71	80.8	8.63	33.2	49.8	49.6	310	<0.10	< 0.50	0.148	< 0.10	< 0.10	0.337	0.32	64.0	14.4	< 1.0	850	20.0	0.0045	222
			8/19/2009	29.34	1.51	522	180	148	71.6	95.2	8.42	30.0	3.5	<0.10	1.7	NA	0.24	0.52	2.36	0.76	170	140	< 1.0	1,000	278	0.0042	237
			5/16/1983	13.50	17.35	630	40	40	NA	90	50	330	80	< 4	NA	NA	0.1	NA	0.02	NA	330	ND	ND	900	0.05	NA	NA
Oceano MW-Yellow	Screened from 625-645' - 3-inch diameter	30.89																									
	Casing relative to concrete pad	-4.11	1/24/2011	22.01	12.62	430	83	73	6	6.3	31	160	100	<0.05	<1.0	0.22	0.11	0.66	0.078	0.28	160	<2.0	<2.0	780	0.49	0.0034	296
	Pad elevation above MSL, approximate	35.0	10/21/2010	28.22	2.67	410	87	100	3.9	6.0	33	148	100	<0.1	<1.0	0.14	<0.1	NA	0.087	<0.3	148	<10	<10	796	0.66	NA	NA
			7/26/2010	25.50	5.39	446	94	93.0	8.81	10.2	32.0	38.4	120	< 0.10	< 0.50	0.142	< 0.10	0.32	0.196	0.48	56.0	17.6	< 1.0	700	22.4	0.0051	196
	All elevations relative to MSL		4/26/2010	19.17	11.72	416	96	87.6	9.86	14.8	37.1	46.0	150	< 0.1	0.63	0.132	< 0.10	0.39	0.579	0.44	58.0	12.0	< 1.0	780	56.2	0.0046	218
			1/27/2010	20.58	10.31	498	89	79.6	10.2	15.6	38.0	31.0	180	< 0.10	0.56	0.132	< 0.10	0.19	0.283	0.38	51.0	20.0	< 1.0	810	23.6	0.0043	234
			10/20/2009	25.80	5.09	446	100	97.1	12.8	16.4	37.9	26.6	180	< 0.10	0.56	0.168	0.15	< 0.10	0.18	0.42	42.6	16.0	< 1.0	760	18.9	0.0042	238
			8/19/2009	31.04	-0.15	426	160	101	18.9	93.2	29.1	64.4	36	< 0.10	0.98	NA	0.16	0.31	5.49	0.60	84.4	20	< 1.0	790	682	0.0038	267
			5/16/1983	14.30	16.59	770	60	70	NA	90	70	330	120	9	NA	NA	0.1	NA	0.02	NA	330	ND	ND	1,100	0.24	NA	NA

Des. by: CNT
Ckd. by: MKR 08.09.10

Table 6b: Northern Cities Sentry Well Water Quality Data Summary

Well	Production Interval	Date	Depth to Water (feet)	Groundwater Elevation (feet NAVD)	Total Dissolved Solids (mg/L)	Chloride (mg/L)	Sodium (mg/L)
32S/12E-24B01	Screened from 48-65'	1/24/2011	5.78	7.42	2,380	1100	370
		10/28/2010	NA	NA	2,330	960	390
		10/21/2010	6.37	6.83	NA	NA	NA
		7/27/2010	6.48	6.72	616	43	52.5
		4/27/2010	3.84	6.86	676	47	54.7
		1/27/2010	3.13	7.57	694	55	56.2
		10/19/2009	2.28	8.42	766	140	121
		8/20/2009	3.25	7.45	705	94	86.8
		5/12/2009	3.58	7.12	695	100	82.1
		3/26/1996	NA	NA	1,870	773	380
		6/9/1976	NA	NA	1,706	667	400
		1/17/1966	NA	NA	1,700	652	406
32S/12E-24B02	Screened from 120-145'	1/24/2011	5.69	7.53	640	43	44
		10/28/2010	NA	NA	650	43	50
		10/21/2010	6.79	6.43	NA	NA	NA
		7/27/2010	7.05	6.17	598	42	48.9
		4/27/2010	4.34	6.36	668	46	52.7
		1/27/2010	3.38	7.32	622	45	58.0
		10/19/2009	2.26	8.44	600	49	59.1
		8/20/2009	4.09	6.61	630	49	63.5
		5/12/2009	4.74	5.96	622	82	67.5
		3/26/1996	NA	NA	652	54	46
		6/9/1976	NA	NA	565	34	52
		1/17/1966	NA	NA	651	62	79
32S/12E-24B03	Screened from 270-435'	1/24/2011	2.65	10.58	660	46	44
		10/28/2010	NA	NA	660	44	48
		10/21/2010	4.60	8.63	NA	NA	NA
		7/27/2010	4.54	8.69	610	44	51.4
		4/27/2010	1.43	9.27	666	45	53.2
		1/27/2010	0.94	9.76	672	48	56.4
		10/19/2009	0.81	9.89	622	40	55.1
		8/19/2009	4.18	6.52	680	47	54.9
		5/12/2009	3.18	7.52	645	44	53.2
		3/26/1996	NA	NA	646	41	52
		6/9/1976	NA	NA	569	36	53
		1/17/1966	NA	NA	670	79	74
32S/13E-30F01	Screened from 15- 30 and 40-55'	1/24/2011	13.33	9.97	510	75	64
		10/21/2010	16.55	6.75	540	100	73
		7/26/2010	15.68	7.62	464	74	82.2
		4/27/2010	11.02	9.38	534	72	77.1
		1/28/2010	12.73	7.67	725	140	99.9
		10/19/2009	14.33	6.07	522	74	85.6
		8/19/2009	14.34	6.06	648	92	98.9
		5/12/2009	12.38	8.02	792	110	108
32S/13E-30F02	Screened from 75-100'	1/24/2011	14.36	8.93	600	51	43
		10/28/2010	NA	NA	610	49	38
		10/21/2010	7.39	15.9	NA	NA	NA
		7/26/2010	16.21	7.08	560	49	45.8
		4/27/2010	12.14	8.26	634	51	50.3
		1/28/2010	13.09	7.31	604	44	52.2
		10/19/2009	14.36	6.04	566	49	49.5
		8/19/2009	14.81	5.59	614	49	51.8
		5/12/2009	14.34	2.96	514	54	48.7
		3/27/1996	NA	NA	678	49	52
		6/9/1976	NA	NA	637	48	55
		1/20/1966	NA	NA	580	68	47

Table 6b: Northern Cities Sentry Well Water Quality Data Summary

Well	Production Interval	Date	Depth to Water (feet)	Groundwater Elevation (feet NAVD)	Total Dissolved Solids (mg/L)	Chloride (mg/L)	Sodium (mg/L)
32S/13E-30F03	Screened from 305-372'	1/24/2011	12.67	10.64	650	46	36
		10/28/2010	NA	NA	650	46	37
		10/21/2010	6.62	16.69	NA	NA	NA
		7/26/2010	17.32	5.99	608	45	43.8
		4/27/2010	11.38	9.02	668	48	40.8
		1/28/2010	10.98	9.42	656	40	43.1
		10/19/2009	14.18	6.22	626	48	43.3
		8/19/2009	20.23	0.17	672	45	43.1
		5/12/2009	17.68	2.72	678	49	44.8
		3/27/1996	NA	NA	686	41	40
		6/7/1976	NA	NA	616	43	41
		1/19/1966	NA	NA	642	69	49
32S/13E-30N01	Screened from 15-40'	1/24/2011	8.18	7.35	870	180	100
		10/21/2010	9.99	5.54	890	190	120
		7/27/2010	8.97	6.56	917	200	130
		4/27/2010	6.14	7.36	808	150	130
		1/26/2010	4.90	8.60	902	210	155
		10/20/2009	6.53	7.00	828	200	159
		8/20/2009	6.71	6.82	835	160	150
		5/11/2009	6.03	7.50	960	180	175
32S/13E-30N03	Screened from 60-135'	1/24/2011	6.68	8.75	570	76	48
		10/21/2010	10.76	4.67	550	69	59
		7/27/2010	9.53	5.90	528	72	55.1
		4/27/2010	6.14	7.36	672	89	60.6
		1/26/2010	5.88	7.62	606	110	75.0
		10/20/2009	6.56	6.94	806	180	93.3
		8/20/2009	7.50	6.00	1,070	190	151
		5/12/2009	6.33	7.17	602	97	63.4
		3/27/1996	NA	NA	624	70	62
		6/7/1976	NA	NA	705	90	54
		1/21/1966	NA	NA	804	57	54
32S/13E-30N02	Screened from 175-255'	1/24/2011	3.67	11.76	1,050	50	60
		10/21/2010	10.42	5.01	1,040	48	52
		7/27/2010	10.02	5.41	777	57	67.6
		4/27/2010	5.26	8.27	800	93	71.9
		2/25/2010	1.72	11.78	1,000	48	71.4
	Confirmation Sample Collected from Pump Discharge at End of Purge:	2/25/2010	1.72	11.78	1,010	74	76.9
	Confirmation Sample Collected by Standard Method (Bailer):	1/26/2010	3.72	9.78	970	50	74.2
		10/20/2009	7.38	6.12	2,080	690	274
		8/20/2009	11.94	1.56	1,350	500	199
		5/11/2009	6.98	6.52	1,290	170	129
		3/27/1996	NA	NA	1,050	50	71
		6/7/1976	NA	NA	1,093	48	62
		1/21/1966	NA	NA	1,069	54	71
12N/36W-36L01	Screened from 227-237'	1/24/2011	17.61	8.68	890	41	55
		10/21/2010	20.75	5.54	910	38	76
		7/27/2010	21.18	5.11	707	36	64.2
		4/26/2010	15.94	8.06	860	42	70.3
		10/21/2009	17.72	6.28	856	38	72.0
		8/20/2009	19.16	4.84	890	39	78.0
		5/11/2009	17.68	6.32	832	63	83.8
		3/26/1996	NA	NA	882	35	66
		6/8/1976	NA	NA	936	38	72

Table 6b: Northern Cities Sentry Well Water Quality Data Summary

Well	Production Interval	Date	Depth to Water (feet)	Groundwater Elevation (feet NAVD)	Total Dissolved Solids (mg/L)	Chloride (mg/L)	Sodium (mg/L)
12N/36W-36L02	Screened from 535-545'	1/24/2011	9.37	16.92	800	120	95
		10/21/2010	19.77	6.52	770	120	130
		7/27/2010	20.53	5.76	737	110	121
		4/26/2010	9.24	14.76	720	100	116
		10/21/2009	17.65	6.35	638	99	113
		8/20/2009	19.15	4.85	785	100	131
		5/11/2009	14.38	9.62	775	120	132
		3/26/1996	NA	NA	772	127	130
		6/8/1976	NA	NA	820	126	118
Oceano MW-Green	Screened from 110-130'	1/24/2011	106.59	-71.96	310	98	22
		10/28/2010	NA	NA	290	81	26
		10/21/2010	112.71	-81.85	NA	NA	NA
	All elevations relative to MSL	7/26/2010	95.61	-64.75	438	85	34.3
		4/26/2010	63.90	-33.04	560	83	47.7
		1/27/2010	43.71	-12.85	460	130	45.0
		10/20/2009	29.20	1.66	362	92	39.6
		8/19/2009	24.55	6.31	420	160	48.4
		5/16/1983	15.80	15.06	665	35	40
Oceano MW-Blue	Screened from 190-210' and 245-265'	1/24/2011	24.87	9.76	680	110	60
		10/21/2010	30.11	0.80	770	100	68
		7/26/2010	24.74	6.17	783	130	80.1
	All elevations relative to MSL	4/26/2010	18.52	12.39	1,130	160	70.2
		1/27/2010	22.06	8.85	1,740	430	55.6
		10/20/2009	27.50	3.41	2,250	1,000	19.5
		8/19/2009	24.65	6.26	322	150	93.2
		5/16/1983	13.30	17.61	840	80	90
Oceano MW-Silver	Screened from 395-435' and 470-510'	1/24/2011	22.02	12.61	440	92	90
		10/21/2010	29.11	1.74	460	90	110
		7/26/2010	24.24	6.61	478	83	109
	All elevations relative to MSL	4/26/2010	19.04	11.81	452	83	83
		1/27/2010	21.05	9.8	496	71	92.2
		10/20/2009	27.52	3.33	564	71	80.8
		8/19/2009	29.34	1.51	522	180	148
		5/16/1983	13.50	17.35	630	40	40
Oceano MW-Yellow	Screened from 625-645'	1/24/2011	22.01	12.62	430	83	73
		10/21/2010	28.22	2.67	410	87	100
		7/26/2010	25.50	5.39	446	94	93.0
	All elevations relative to MSL	4/26/2010	19.17	11.72	416	96	87.6
		1/27/2010	20.58	10.31	498	89	79.6
		10/20/2009	25.80	5.09	446	100	97.1
		8/19/2009	31.04	-0.15	426	160	101
		5/16/1983	14.30	16.59	770	60	70

Sentry well cluster 32S/13E 30N is located west of Highway 1 in Oceano and includes three piezometers. The sentry well cluster is also in an area of sufficient ground water production to cause a broad lowering of the water table (called a pumping trough by Todd 2010). The deep and intermediate level piezometers at this location showed low groundwater levels in 2008 and 2009. Data from this sentry well cluster was interpreted to indicate localized seawater intrusion affecting the deep zone (30N02) and, to a lesser extent, the middle zone (30N03) in 2009.

Data collected in 2010 from piezometers 30N02 and 30N03 show geochemical signatures of seawater intrusion on Schoeller geochemical plots (Figure 15). (A Schoeller diagram is a graphical representation of common cation and anion concentrations in water expressed in milliequivalents per liter (meq/l). Because several samples may be plotted on the same graph, variation in hydrogeochemical water characteristics may be easily recognized.) The most recent water quality data from this well cluster (January, April, July and October 2010) show continuing and significant improvement in water quality in 30N02, including a reduction in the concentrations of seawater indicators and a signature approaching the historical signature of groundwater in 30N02.

These water quality changes indicate that the local interface/mixing zone between seawater and fresh groundwater has shifted in the seaward direction. The location of the seawater interface is not known due to the heterogeneity of the aquifer; the only indication is when one or more monitored wells show an increase in TDS and a geochemical signature resembling seawater. Based on experience in the NCMA, retreat of the interface may be reversed, and again become shoreward, if seaward gradients are reduced or reversed. These changes may be brought on by reduced recharge (e.g. drought conditions) or if pumping exceeds available groundwater supply, or both. Ongoing sentry well monitoring is necessary to provide an early warning of future migration of the interface.

Sentry well cluster 32S/12E 24B has historically shown signs of possible seawater intrusion. This sentry well is located in the northwestern corner of the basin in Pismo Beach. The shallow well (24B01) shows a similar geochemical signature to that of seawater. Water samples from this well historically have shown high sodium and chloride concentrations. While these data have been interpreted by the California Department of Water Resources to be the result of solution of residual marine and evaporative salts indigenous to the geologic environment in this part of the basin, there may be another source. The location of 32S/12E 24B is near the lagoon at the mouth of Pismo Creek. This area is subject to storm surge and local flooding during storm and high sea conditions. The water sample from the shallow piezometer (24B01) showed elevated Cl and Na in October 2010 while samples from the two deeper piezometers showed no such effect. Occasional downward percolation of sea water or brackish lagoon water may influence the quality of sample from the shallow piezometer (24B01). A sensor has been installed to measure short term fluctuations in water level and TDS to provide additional insight as to the source of Cl and Na fluctuations.

Schoeller diagrams are geochemical representations that show the relative portions of major water quality constituents based on ionic charge (in milliequivalents per liter or meq/L). This approach allows graphical, or visual, means to evaluate measured water quality against potential water sources. Figure 15 is a Schoeller diagram illustrating the water quality in the DWR sentry wells for all of the 2010 quarterly monitoring events. Each line of connected points illustrates the water quality signature from a specific well (e.g., 24B01) at a specific time (May 2010, abbreviated as 0510). For comparison, Figure 15 (the Schoeller diagram) also shows the typical geochemical signature for seawater (in black) and the signature for a groundwater basin water supply well (Grover Beach Well#1, labeled as “GW Base”). Most of the water quality samples plot on the lower portion of the diagram, similar in shape to the groundwater basin sample; these are combined within the shaded area. However, several samples from 32S/13E 30N showed signatures more similar to seawater in the spring, summer, and fall 2009. In January 2010, the signatures for the 30N wells, especially 30N02, changed again to a signature more similar to the groundwater base. The temporal variation between the seawater and groundwater signatures indicates that the interface between seawater and fresh groundwater may have reached and then retreated from this location.

The Oceano Observation well cluster has four wells; from shallow to deep, they are identified as green, blue, silver, and yellow (see Figures 7 and 8). As documented in Table 6, the Oceano observation wells have been sampled in each quarterly monitoring event since August 2009, but have not shown consistent water quality chemistry. In general, the two deeper Oceano Observation wells show similar water quality to the rest of the groundwater basin with the exception of low sulfate values reported in August 2008. Chloride concentrations have been slightly elevated and peaked in August 2009; however, the overall water quality character does not appear to indicate seawater intrusion.

The water quality data from the two shallow Oceano Observation wells have shown significant variation in several water quality parameters. In addition the wells recover slowly after purging done as part of sampling. This suggests some disconnect from the screened zone and may indicate scaling or other chemical process is occurring. As documented in Table 6, chloride concentrations from the blue well were elevated in October 2009 but have fallen since January 2010 and are now in a range similar to other sentry wells. However, the water quality from this well now shows a signature close to Ground water “GW” in the figure), not seawater. In any event, water quality data from the two shallow Oceano Observation wells, coupled with anomalous water level and well recovery data suggest the data may not be as representative of ground water conditions as data collected from other wells. If these wells were replaced or rehabilitated, more reliable and useful data would be collected from shallower water bearing zones at this location.

4.2.3.2 Municipal Wells

Public water supply systems are required to provide water quality information to the California Department of Public Health (DPH). Data submitted from the NCMA area was reviewed and most recent data added to the NCMA data base. Although the data supplied by

DPH does not include specific well locations, individual public supply wells are identified and their location determined.

Although there is variation among wells, data from 2010 suggest that water quality in individual wells has remained generally consistent from year to year. High levels of Nitrate, Selenium and Manganese are present is some wells. These wells are subject to more frequent sampling and water produced is subject to treatment or blending. Treatment to remove selenium and manganese and blending result in the water delivered through the municipal systems meeting state and Federal water quality standards.

4.3 Threats to Water Supply

Both state-wide and local threats to the NCMA water supply exist. Because the water supply contains sources imported from other areas of the state, threats include State-wide drought, effects of climate change in the SWP source area, management and environmental protection issues in the Sacramento-San Joaquin Delta that affect the amount and reliability of SWP deliveries and seismic risk to the SWP delivery system. Local threats to NCMA water supply similarly include extended drought and climate change that affect the amount and reliability of Lopez as well as reduced recharge to the NCMA groundwater supply. There is a threat of seawater intrusion into the ground-water system if adequate monitoring (as discussed in Section 4.2.2 above) and preventive measures (as discussed in and Section 4.3.3 below) are not taken.

4.3.1 Threats to State Water Project Supply

Both extended drought and long term reduction in snowpack due to climate change can affect deliveries from the State Water Project. California has recently experienced a relatively short (2 year) drought that resulted in below-average precipitation and runoff in the SWP source area. State-wide runoff in 2007 and 2008 amounted to only 53 and 60 percent of average, respectively, and runoff in 2009 was only slightly better at 85 percent. As a result, storage in SWP reservoirs was reduced. In addition to drought conditions, SWP pumping capacity was reduced as the result of a May 2007 federal court ruling to protect Delta smelt.

The threat of reduced delivery to local SWP users—Oceano and Pismo Beach—has not materialized to date, as San Luis Obispo County's allocation continues to be approved in full because the SLOCFC&WCD is able to use some of its unallocated Table A amount to augment deliveries Nonetheless, in the future, the Delta's fragile ecosystem, uncertain precipitation patterns and reduced snowmelt may further reduce California's water supply reliability with potential ramifications for Oceano and Pismo Beach.

4.3.2 Seawater Intrusion

The NCMA is underlain by an accumulation of alluvial materials that slope gently offshore and extend for many miles under the ocean (DWR 1985). Coarser materials within the alluvial materials comprise aquifer zones that receive freshwater recharge in areas above sea level. The elevation difference causes fresh water in the aquifers to flow toward the ocean and form an interface between freshwater and seawater. Under natural and historical conditions the differential pressure between the aquifer and seawater induces net outflow of freshwater and establishes a dynamic interface between fresh water and salt water at depth. Sufficient outflow prevents the dynamic interface from moving onshore. Sufficient differential pressure to maintain a net outflow is indicated by onshore groundwater elevations that are above mean sea level.

The Annual Report for CY 2008 documented that a significant portion of the NCMA ground water basin exhibited water surface elevations below sea level (Todd 2009). Hydrographs for NCMA sentry wells (Figures 10 and 11) show coastal groundwater elevations that were at relatively low levels for as long as two years. Such sustained low levels had not occurred previously in the historical record and reflected the combined effect of drought and long-term, basin-wide increases in groundwater pumping. The low coastal groundwater levels indicated a potential for seawater intrusion. Increased TDS, Na and Cl concentrations were found in sentry well 32S/13E N03 in August 2009 and in 32S/13E N02 in August and October 2009.

As documented in Section 4.2.1 of this report, groundwater elevations in October 2010 showed a significant recovery of groundwater elevations relative to October 2008 and October 2009. In addition, groundwater quality in the sentry wells N02 and N03 showed improvement beginning in January 2010, including a reduction in the concentrations of seawater indicators. Water elevation and quality measurements in 2009 through October 2010 indicate the following:

- The monitoring of the sentry wells, notably 32S/13E 30N, provides an early warning of seawater intrusion. This well cluster may be relatively sensitive to seawater intrusion because of its location near Arroyo Grande Creek and the more permeable sediments deposited by the ancestral creek (Todd 2010).

- The initial portions of the seawater/groundwater interface were detected onshore at one site in beginning with elevated Chloride levels in May 2009; by October 2009 the interface had manifested in the middle and deep aquifer zones monitored by sentry wells 30-N02 and 30-N03. The extent to which seawater may have intruded other localized aquifer zones along the coast without being detected in the NCMA sentry wells is unknown due to heterogeneity of the aquifer and spacing of sentry wells. This uncertainty may be obviated by maintaining coastal groundwater elevations in all sentry wells above mean sea level.

- Above average precipitation and decreased ground water withdrawal in 2010 have resulted in increased water levels in the sentry wells on a comparative seasonal basis and an apparent decrease in water table depression in the “pumping trough” (Figure 9).

- Water quality in most wells remains similar to historic measurements thus indicating no effects of sea water intrusion.

4.3.3 Measures to Avoid Seawater Intrusion

In response to the early warning of seawater intrusion, the Northern Cities have developed and implemented a water quality monitoring program for the sentry wells and Oceano Observation wells, as described above in Section 4.2.2. The Northern Cities, County FC&WCD, and State of California have also worked cooperatively toward the protection of the sentry wells as long-term monitoring sites. To minimize the threat of seawater intrusion, the Northern Cities have reduced coastal groundwater pumping, decreased overall water use via conservation, and initiated plans, studies and institutional arrangements to secure additional surface water supplies. As a result, 2010 each of the 4 major municipal water users reduced ground water use between 25 and 90 percent between 2007 and.2010. The City of Pismo Beach and OCSD reduced their ground water demand between 90 and 50 percent respectively, in part by importing SWP supplies. A summary of the Northern Cities management objectives and activities is presented below in Section 6.

4.3.4 Change in Ground Water Recharge

Ground water recharge includes subsurface flow from adjacent areas into aquifers serving as water sources in the NCMA. The most recent NMMA annual report, (2009, *Figure 6-6. 2009 Fall Groundwater Elevations)* shows a NW/SE trending depression in the water level contours extending northwestward into the NCMA area beneath an area of agricultural land use. This zone of lower water levels appear to have persisted into fall 2010 (Figure 9). Contour maps prepared by California DWR for spring 1975, 1985, 1995 and 2000 indicate a similar depression (DWR 2002). Comparison of DWR, NMMA and NCMA maps suggest a general decline of water level in this area and also a decline in the gradient between higher water levels on the east and southeast, and lower water levels in the NCMA. This implies a reduction of recharge (from subsurface flow) to the NCMA groundwater basin.

DWR (2002) estimated recharge from NMMA to NCMA (as subsurface flow) to be 1,300 AFY on an average annual basis (for years 1986-1995). Ground water extraction in the NMMA continues to be greater than estimated recharge (NMMA 2009, page 56). Because groundwater extraction in NMMA has caused long term lowering of the ground water levels, significant reduction of underflow to the NCMA is likely. In fact the NMMA 2009 Annual report states in Section 6.1.5:

> *[T]he groundwater gradient between the NMMA and the Northern Cities Management Area consists of a saddle or divide in the groundwater elevations that separate the two management areas. The groundwater elevations along the divide are in the range of five to ten feet higher than adjacent areas. Thus, it appears that there is currently no flow to or from the Northern Cities Management Area. In the future, combined modeling efforts may be one effective tool to jointly manage this boundary*

Due to uncertainty regarding the detailed hydrogeology of the NCMA and NMMA aquifers, the precise impact of pumping in the NMMA to recharge to the NCMA cannot be calculated. This issue may be addressed through development of a numerical model of the groundwater basin, currently being discussed by the NCMA and NMMA technical groups.

5 Supply/Demand Comparison

This section presents a comparison of the 2010 water supplies and demands of the Northern Cities Management Area, applied irrigation, and rural water systems.

Table 5 in Section 4 outlines the Available Urban Water Supplies for each of the Northern Cities. The total available urban water supply is 10,690 AFY. As discussed in Section 4, the 2002 Settlement Agreement estimated that the historical safe yield from the groundwater basin was 9,500 AFY. Since all of the irrigation applied water demand is supplied by groundwater, the total available applied irrigation supply is based on a portion of the estimated groundwater safe yield, which was allocated as 5,300 AFY for agricultural and rural use. The agricultural conversion of 321 AFY reduces this allocation to 4,979 AFY. Of this estimated safe yield of 9,500 AFY, other than what is allocated for applied irrigation and rural use, the remaining 4,000 AFY is allocated for urban water use and 200 AFY allocated to subsurface outflow to the ocean.

In 2010, the total urban water demand, based on production, was 7,542 AF. Based on 2010 precipitation and ET data, 2010 applied irrigation water use was estimated at 2056 AF, while rural water use was estimated at 38 AF. The total combined demand for the NCMA in 2010 was 9,636AF. The following Table 7 displays the water demand, by source, of each city in 2010.

Table 7. 2010 Water Demand by Source (AF)

Urban Area	**Lopez Reservoir**	**State Water Project**	**Groundwater**	**Transfers**	**Other Supplies**	**Total**
Arroyo Grande	*2,246*	*0*	*540*	*100*	*70*	*2,956*
Grover Beach	*773*	*0*	*1,014*	*0*	*0*	*1,787*
Pismo Beach	*843*	*1,005*	*96*	*0*	*0*	*1,944*
Oceano CSD	*203*	*724*	*28*	*-100*	*0*	*855*
Urban Water Use Total	4,064	1,730	1,678	0	70	**7,542**
Applied Irrigation	0	0	2,056	0	0	**2,056**
Rural Water Users	0	0	38	0	0	**38**
Total	**4,064**	**1,730**	**3,772**	**0**	**70**	**9,636**

Urban water demand in 2010 to the NCMA totaled 4064 AF of Lopez Reservoir water, 1,730 AF of State Water Project water, and 1,678 AF of groundwater. Neither Arroyo Grande, nor Grover Beach, has a State Water Project allocation. Arroyo Grande has a temporary agreement to purchase 100 AFY of Lopez Reservoir or groundwater supplies from the OCSD. The agreement is in its 3rd year and is set to expire after 2013. The 70 AF of "Other

Supplies" delivered to Arroyo Grande consists of groundwater pumped from the Pismo Formation, which is located outside of the shared groundwater basin.

Based on the estimated groundwater safe yield, the total available supply for all uses is 15,669 AFY, which is the sum of 10,690 AFY for urban plus the allocation for applied irrigation and rural area of 4,979 AFY. Total applied water demand by source was estimated at 9,636 AFY for 2010.

6 Management Activities

Section 6 is divided into two parts: the first section presents the primary NCMA groundwater management objectives and summarizes major historical management activities relevant to the objectives. The second section describes management activities in 2010.

The group of NCMA ground-water users involved in the stipulation, the Northern Parties, comprises the Northern Cities, the overlying owners, San Luis Obispo County and San Luis Obispo County FC&WCD, have actively managed surface water and groundwater resources for more than 30 years. Management objectives and responsibilities were first established the 1983 *Gentlemen's Agreement* and updated in the 2002 Management Agreement. The responsibility and authority of the Northern Parties for NCMA groundwater management was formally established through the 2002 Settlement Agreement, 2005 Stipulation, and 2008 Judgment. The overarching management goal for the Northern Cities is to preserve the long-term integrity of water supplies in the NCMA portion of the Santa Maria Groundwater Basin.

6.1 Management Objectives

Six basic objectives have been established for ongoing NCMA groundwater management (Todd 2010):

1. Share Groundwater Resources and Manage Pumping
2. Monitor Supply and Demand and Share Information
3. Manage Groundwater Levels and Prevent Seawater Intrusion
4. Protect Groundwater Quality
5. Manage Cooperatively
6. Encourage Water Conservation

The history and rationale are discussed in the sections below. Other potential objectives are outlined in the final section.

6.1.1 Share Groundwater Resources and Manage Pumping.

A longstanding objective of water users in the NCMA has been to cooperatively share and manage groundwater resources. In 1983 the Northern Parties mutually agreed on an initial safe yield estimate (defined by DWR) and an allotment of pumping between the urban users and applied irrigation users of 57 percent and 43 percent respectively. In this agreement the

Northern Cities also established pumping allotments among themselves. Subsequently the 2002 Management Agreement included provisions to account for changes such as land conversion. The agreements provide that any increase or decrease in the safe yield based on ongoing assessments would be shared on a pro rata basis. Pursuant to the stipulation the Northern Cities conducted a water balance study to update the safe yield estimate (Todd 2007). Among other results, the parties agreed to maintain the existing pumping allotment among the urban users and established a consistent methodology to address agricultural land use conversion.

The water balance study also highlighted the threat of seawater intrusion as the most important potential adverse impact to consider in managing the basin. Sea-water intrusion would degrade the quality of water in aquifer and potentially render portions of the basin unsuitable for ground water production.

Another potential adverse impact of localized pumping includes reduction of flow in local streams, notably Arroyo Grande (Todd 2007). The Northern Cities (as Zone 3 contractors) have participated with the County and FC&WCD in preparation of the Arroyo Grande Creek Habitat Conservation Plan (HCP) that addresses reservoir releases to maintain both groundwater levels and habitat values in the creek.

6.1.2 Monitor Supply and Demand and Share Information

Regular monitoring of activities that affect the ground-water basin, and sharing that information, has occurred for many years. Monitoring includes gathering data on hydrologic conditions, water supply and demand, and groundwater pumping, levels, and quality. This was first established in 1983 and then formalized in 2002 to include quarterly meetings. The current monitoring program is managed by the Northern Cities in accordance with the 2005 Stipulation and 2008 Judgment, guided by the July 2008 Monitoring Program for the NCMA. The data and its implication to ground-water management are summarized in the Annual Reports.

6.1.3 Manage Groundwater Levels and Prevent Seawater Intrusion

Prevention of seawater intrusion through the management of groundwater levels is essential to protecting the shared resource. While closely related to the objectives to manage pumping, monitor supply and demand, and share information, this objective specifically recognizes the proximity of production wells to the coast and the threat of seawater intrusion. The Northern Cities, County and San Luis Obispo FC&WCD have long cooperated in the monitoring of groundwater levels, including measurement of groundwater levels in the sentry wells at the coast. As a result of lowering of water levels during 2007 and 2008, the Northern Cities reduced pumping from the basin and requested increased SWP deliveries. This response has allowed ground water levels to rise to a level apparently sufficient to prevent sea water intrusion (see Section 4.2 of this report).

6.1.4 Protect Groundwater Quality

The objective to protect ground-water quality is closely linked with the objective for monitoring and data sharing. To meet this objective all sources of water quality degradation, including the threat of seawater intrusion, need to be recognized. Water quality problems could affect the integrity of groundwater supplies, resulting in loss of use or expensive water treatment processes. The monitoring program includes evaluation of potential contaminants in addition to those that might indicate sea water intrusion. For example, local nitrate and selenium concentrations in excess of primary drinking water standards have been addressed through actions such as provision of municipal water to private domestic users and through nitrate removal or blending to ensure that delivered water meets all drinking water standards.

6.1.5 Encourage Water Conservation

Water conservation, or water use efficiency, is linked to the monitoring of supply and demand and the management of pumping. Water conservation would reduce overall demand on all sources, including ground water, and support management objectives to manage ground-water levels and prevent sea-water intrusion. In addition water conservation is consistent with State policies seeking to achieve significant water use reductions by the year 2020. Water conservation activities in the NCMA are summarized in various documents produced by the Northern Cities, including the Urban Water Management Plans of Arroyo Grande, Grover Beach, and Pismo Beach.

6.1.6 Manage Cooperatively

Since 1983, NCMA management has been based on cooperative efforts of the affected parties themselves including the four Northern Cities with ongoing collaboration with San Luis County, the San Luis County FC&WCD, and other local and state agencies. Other organizations participate as appropriate to the issues of the time. In addition to the efforts discussed in the report, cooperative management occurs through many means including communication by the Northern Cities in their respective public meetings and participation in the Water Resources Advisory Council (the County-wide advisory panel on water issues).

The NCMA Cities participated in preparation and adoption of the 2007 San Luis Obispo County Integrated Regional Water Management Plan (IRWMP). The IRWMP promotes integrated regional water management to ensure sustainable water uses, reliable water supplies, better water quality, environmental stewardship, efficient urban development, protection of agriculture, and a strong economy. The IRWMP integrates all of the programs, plans, and projects lead by entities within the region into water supply, water quality, ecosystem preservation and restoration, groundwater monitoring and management, and flood management programs.

6.1.7 Other Potential Management Objectives

Based on information developed in preparation of this Annual report and other management activities (discussed in Section 6.2), it may be appropriate to develop other management objectives to address:

- Optimizing sources to best provide for prolonged droughts (Todd 2007)
- Optimizing location and rate of groundwater pumping to protect groundwater quality (Todd 2007)
- Evaluating alternative sources of new developed water (Stipulation Section IV)
- Calculating target gradient to prevent seawater intrusion (Miller and Evenson 1966)
- Assessing basin response to recharge and use based on drought cycle

6.2 Update on Management Activities

The Northern Cities, both individually and jointly, are engaged in water resource management projects, programs, and planning efforts that address water supply and demand issues, particularly efforts to assure a long-term sustainable supply. This section discusses major management activities during 2010.

6.2.1 Control of Groundwater Levels and Seawater Intrusion

In 2009 the sentry well monitoring program was intensified to include quarterly water quality sampling and analysis. A project to renovate the sentry wells also was initiated. In July 2010 the tops each piezometer casing in the sentry well locations were raised above land surface to avoid the potential of surface runoff entering the casing. In addition the protective well casing was modified to prevent tampering. Each modified well was resurveyed relative to the North American Vertical Datum (NAVD) 88.

6.2.2 Other Responses to Drought and Seawater Intrusion

The two of the Northern Cities that may accept SWP deliveries have requested a one-time augmentation of their allocation. The San Luis Obispo County FC&WCD, Central Coast Water Authority and DWR are working on a one year agreement which would exchange SWP allocation for capacity within the Coastal Branch pipeline. This agreement will allow the users in NCMA to reduce groundwater demand and allow the County to store up to 1500 AF of emergency water to reduce coastal seawater intrusion and to store within the Lopez reservoir for future emergency use. In addition, each of the Northern Cities was able to reduce its ground-water use below its safe yield allotment in 2010.

6.2.3 Cooperative Water Supply Planning and Management

Water supply planning activities in 2009 included a water transfer agreement between Arroyo Grande and Oceano CSD, ongoing recharge using storm water detention ponds, sentry well maintenance, data sharing, regional agreements, and ongoing studies to acquire new water supply sources. In addition, Oceano CSD is in the process of completing its Water and Sewer Master Plan that details their water system and provides water shortage contingency plans.

Water Transfer
In January 2009, the City of Arroyo Grande entered into temporary agreement with Oceano CSD to purchase an additional 100 AF per year (AFY) of supplemental water supply. This agreement will be in place for the next five years; the agreement may be made permanent, if adequate resources exist.

Storm Water Ponds
The Cities of Arroyo Grande and Grover Beach and the Oceano Community Services District maintain storm water retention ponds. These ponds collect storm water runoff, allowing it to recharge the underlying aquifers. There are approximately 140 acres and 48 acres of detention ponds in Arroyo Grande and Grover Beach, respectively. The existing storm water detention pond in Oceano is approximately half an acre. Grover Beach recently modified its storm water system to direct additional flow into one of its recharge basins. San Luis Obispo County is currently evaluating creation of a 50-acre storm water detention pond near the Oceano Airport. This pond would also create an opportunity for recharge to the groundwater basin. The *Oceano Drainage and Flood Control Study* documents the need for such a pond and identifies the steps require to implement the facility.

Data Sharing
The Northern Cities cooperate with San Luis Obispo County and the Nipomo Mesa Management Area (NMMA) in the improvement of regional groundwater monitoring. During preparation of each Annual Report, the Northern Cities and NMMA also share water quality data and collaborate on the interpretation of groundwater level data and preparation of water elevation contour maps.

6.2.4 Water Conservation

The Northern Cities implement water conservation activities to reduce water use and thus reduce ground-water demand. The Cities participate in a wide range of water conservation activities designed to educate the public water on ways to reduce water use.

The City of Arroyo Grande supports a part time water conservation coordinator staff position to manage existing conservation activities, encourages public participation, and create new conservation programs for the community. The City of Arroyo Grande conservation program includes a “Cash for Grass” rebate program, washing machine rebates, a smart irrigation controller rebate program, a free plumbing retrofit program, water audits, public information and education. In the last six years, the City of Arroyo Grande spent over $800,000 on water conservation efforts. The City's water conservation efforts have been very successful to date; among its program elements the "Cash for Grass" program has prompted the removal of over 60,000 square feet of grass, 43 washing machine rebates have been processed, and 10 water audits of commercial and large Homeowners Associations have been completed. These measures have decreased water use per residential connection by 10 percent (from 190 gallons per household per day to 170 gallons per household per day). Public outreach is performed through a variety of channels including the city's website, bill inserts, local contractors, email, and word of mouth. The incentive flyer describing the city's programs is attached as Appendix C.

The City of Grover Beach's ongoing water conservation activities include a "Cash for Grass" rebate, a water-efficient washing machine rebate program, and smart irrigation controller and sensor rebate program. Ongoing water conservation activities in Pismo Beach include water hardware retrofitting, water audits, and public outreach. Water audits are provided free of charge to customers and include a review of water bills, a check of indoor and outdoor plumbing and suggest repairs or changes.

6.2.5 Alternative Water Supply Studies

The Northern Cities continue to evaluate alternative sources of water supply which could provide a reliable and sustainable water supply for the NCMA. An expanded portfolio of water supply sources will support sustainable management of the groundwater resource and help to reduce the risk of water shortages. These alternative sources include:

State Water Project
As discussed above, the Northern Cities have requested a short-term allocation of 1,500 AF for the NCMA. Oceano CSD and Pismo Beach are currently SWP customers and could use additional water immediately. Grover Beach is not a SWP customer; however, Grover Beach could indirectly benefit from the water assuming that the allocation is granted. If successful, a longer term allocation could be evaluated based on the existing SLOFC&WCD allotment from the SWP.

Water Recycling
In 2001, the South San Luis Obispo County Sanitation District completed a recycled water evaluation. More recently, in 2010 the City of Arroyo Grande initiated a feasibility study of water recycling in the NCMA. . Treated water from two wastewater treatment plants could be used as non-potable irrigation for parks, cemeteries, open spaces, and other areas.

Lopez Reservoir Expansion
In 2008, San Luis Obispo County sponsored a preliminary assessment of the concept of installing an inflatable rubber dam at the Lopez Dam spillway. The NCMA is in the process of assessing issues of dam safety, evaluation of project benefits (including identification of

participating parties), identification of alternatives, engineering feasibility studies, environmental review, permitting, design, and construction.

Desalination

In 2006, the City of Arroyo Grande, City of Grover Beach, and the Oceano CSD utilized Prop 50 funds to evaluation desalination as an additional water supply option for the NCMA.

Nacimiento Pipeline Extension

In 2006, the City of Arroyo Grande, City of Grover Beach, and Oceano CSD completed a Nacimiento pipeline extension evaluation to determine the feasibility of delivery water from the Nacimiento reservoir to the NCMA.

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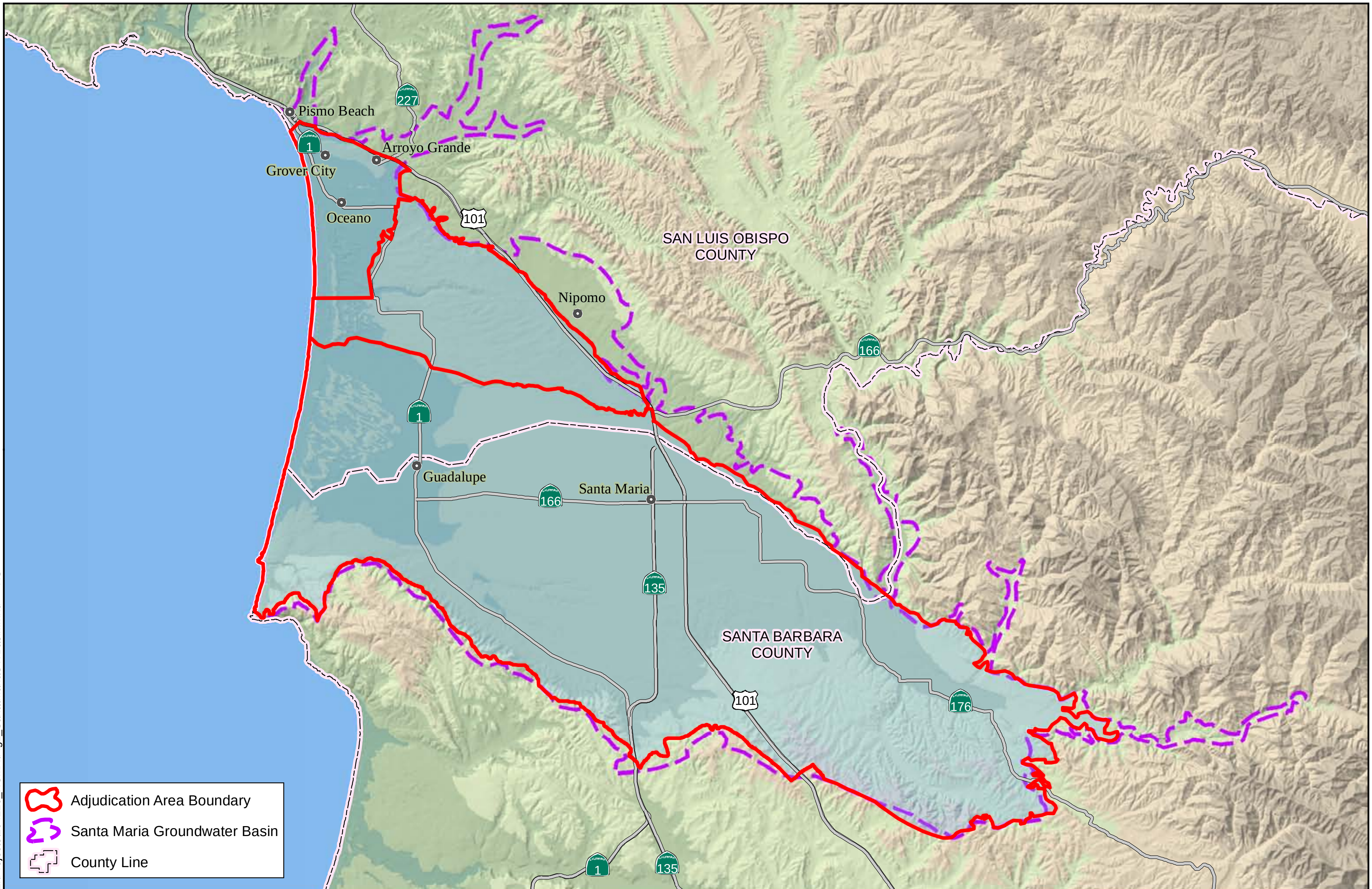

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San Luis Obispo and Santa Barbara Counties
Northern Cities Management Area

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SANTA MARIA GROUNDWATER BASIN

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FIGURE 1

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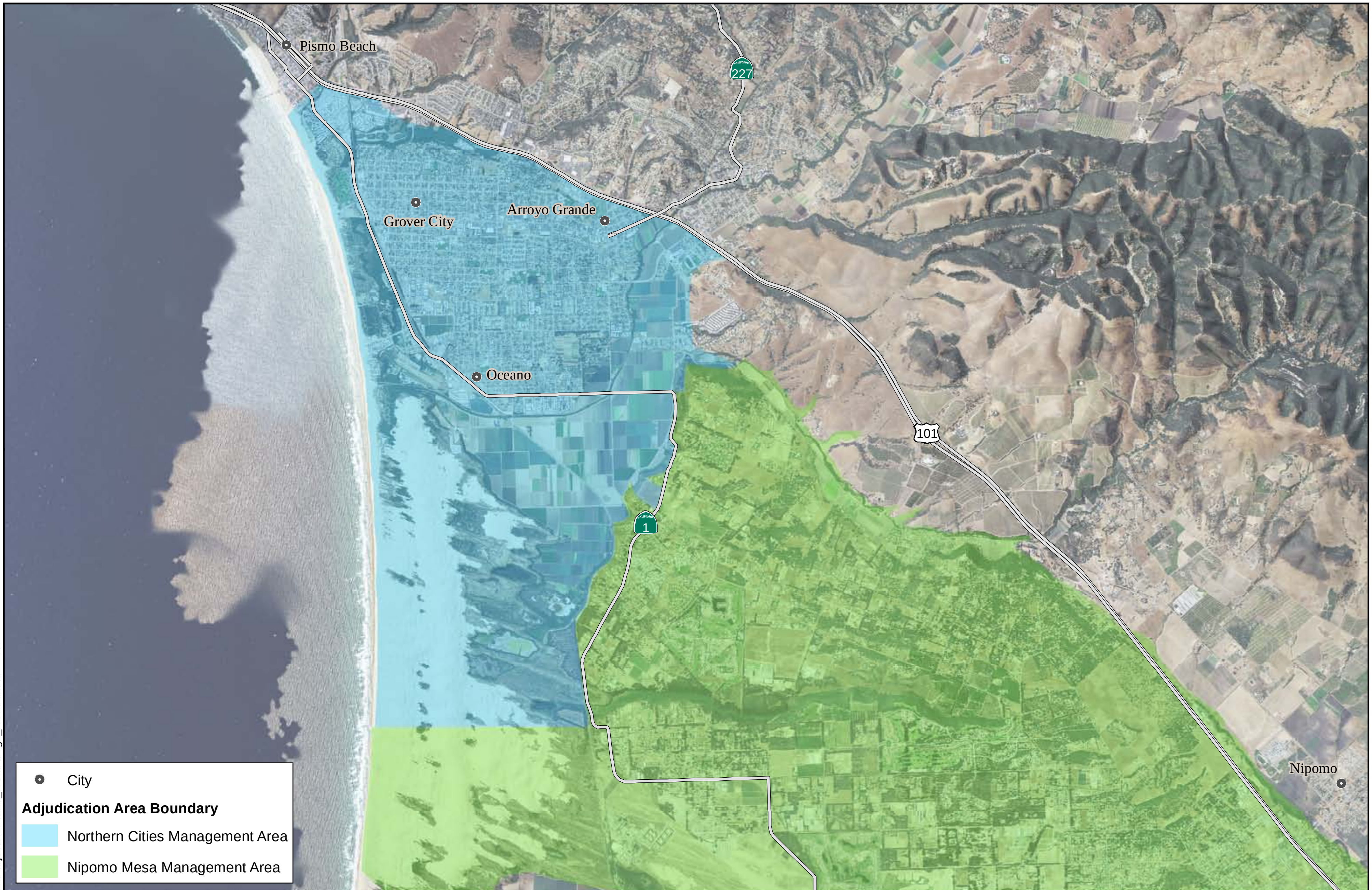

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2010 Annual Monitoring Report
San Luis Obispo County
Northern Cities Management Area

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NORTHERN CITIES MANAGEMENT AREA

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FIGURE 2

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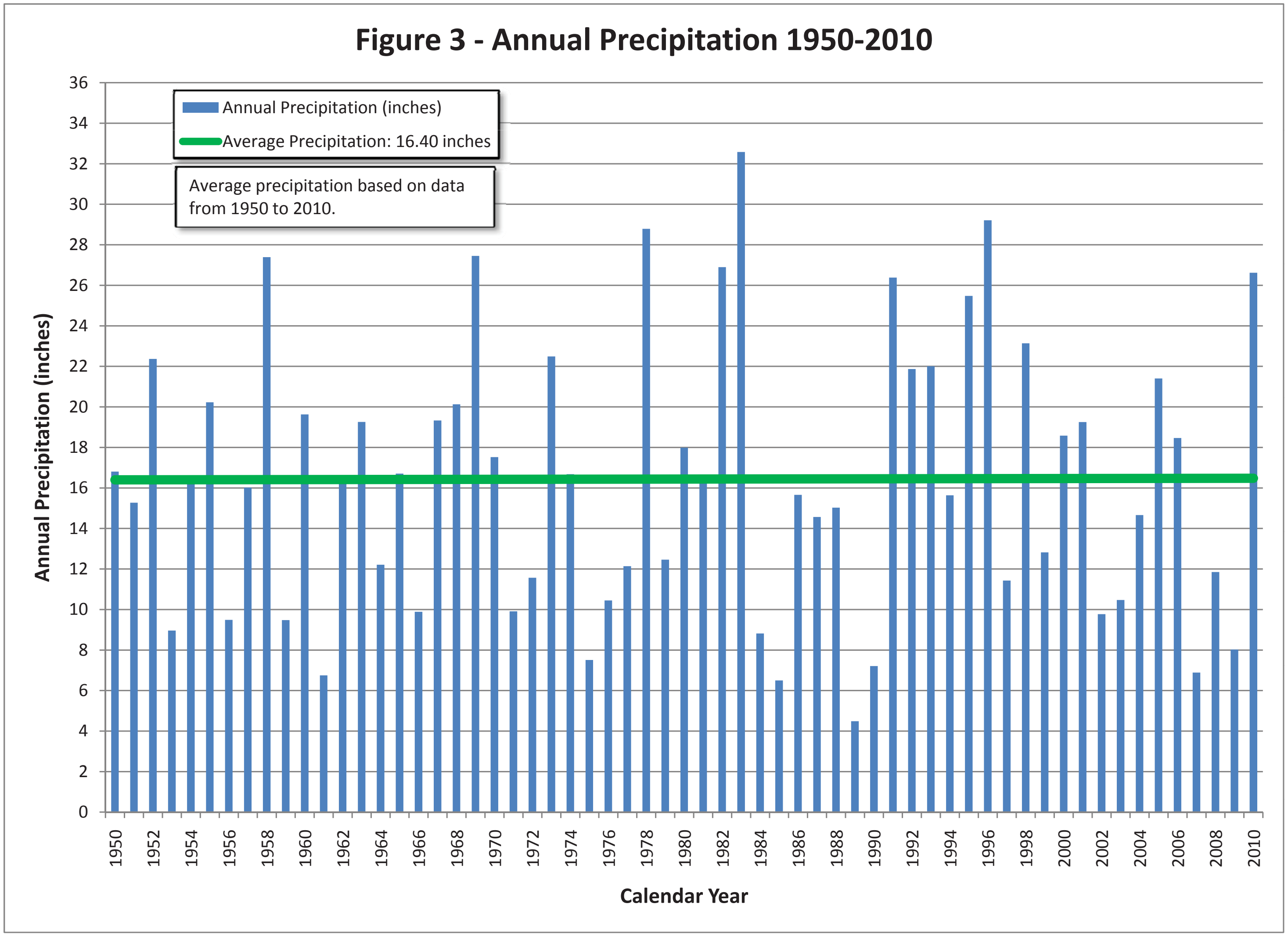

2010 ANNUAL MONITORING REPORT

NORTHERN CITIES MANAGEMENT AREA

ANNUAL PRECIPITATION 1950-2010

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FIGURE 3

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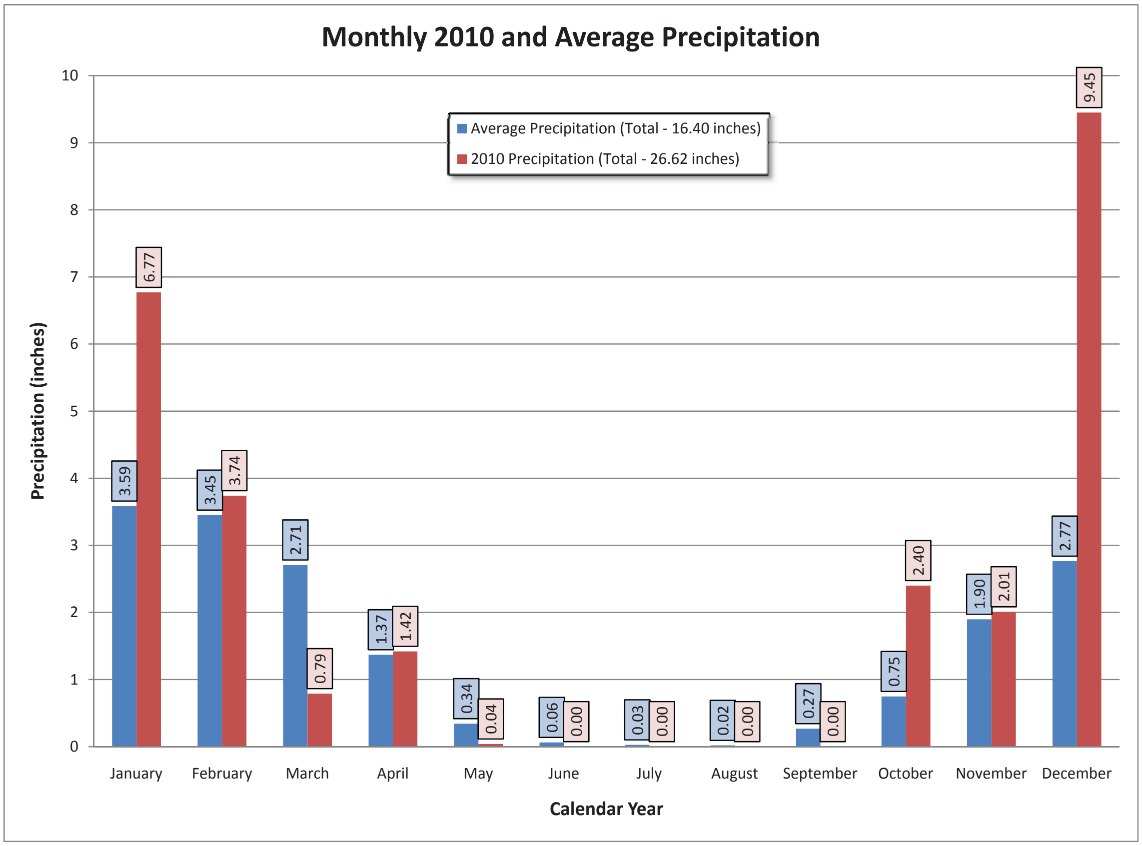

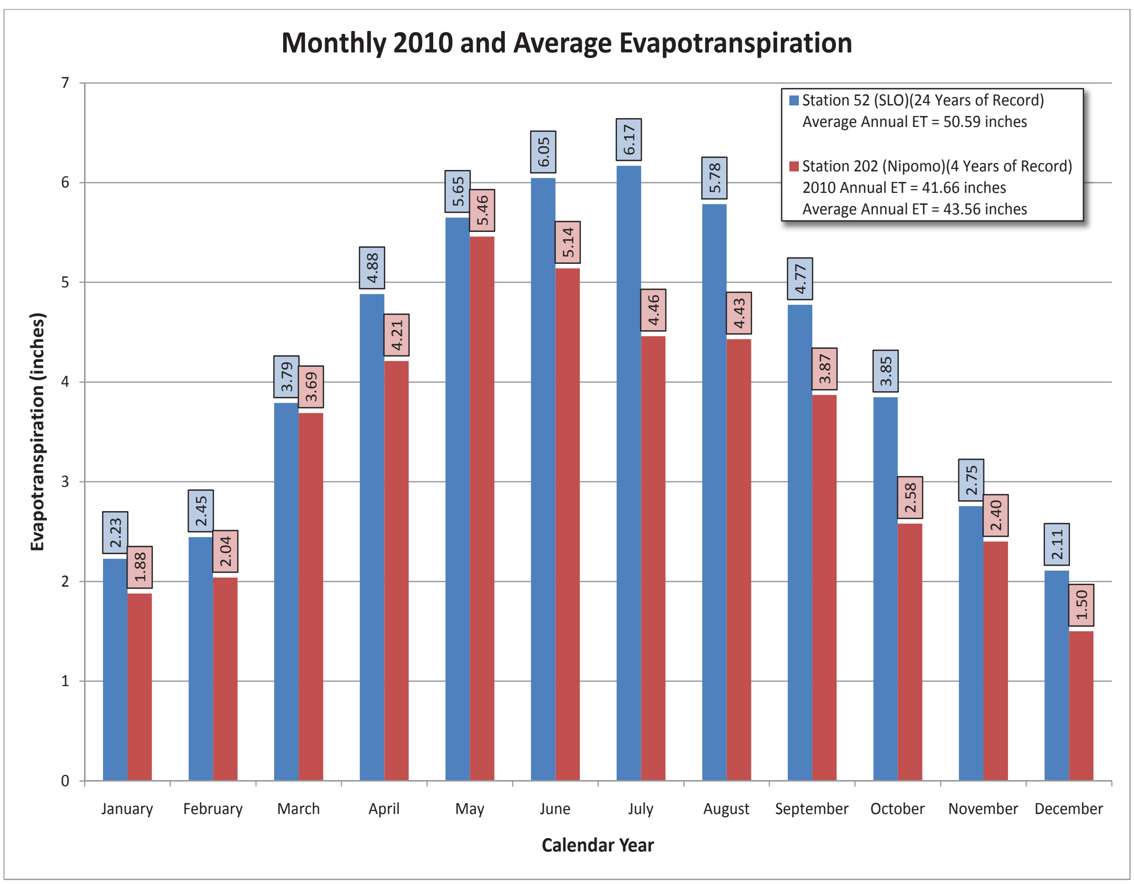

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NORTHERN CITIES MANAGEMENT AREA

MONTHLY 2010 AND AVERAGE PRECIPITATION AND EVAPOTRANSPIRATION

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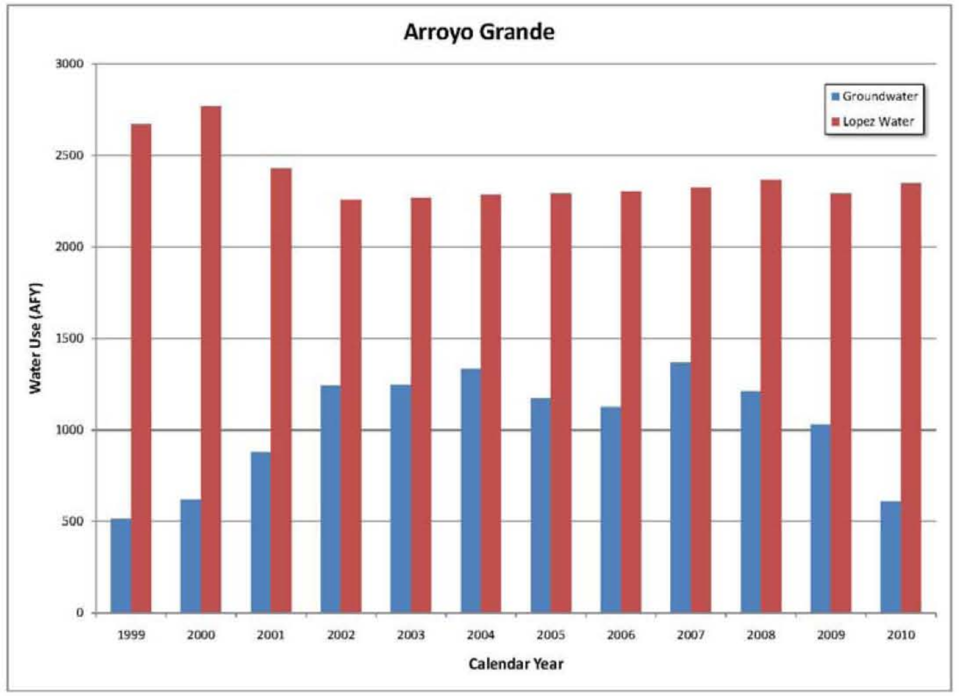
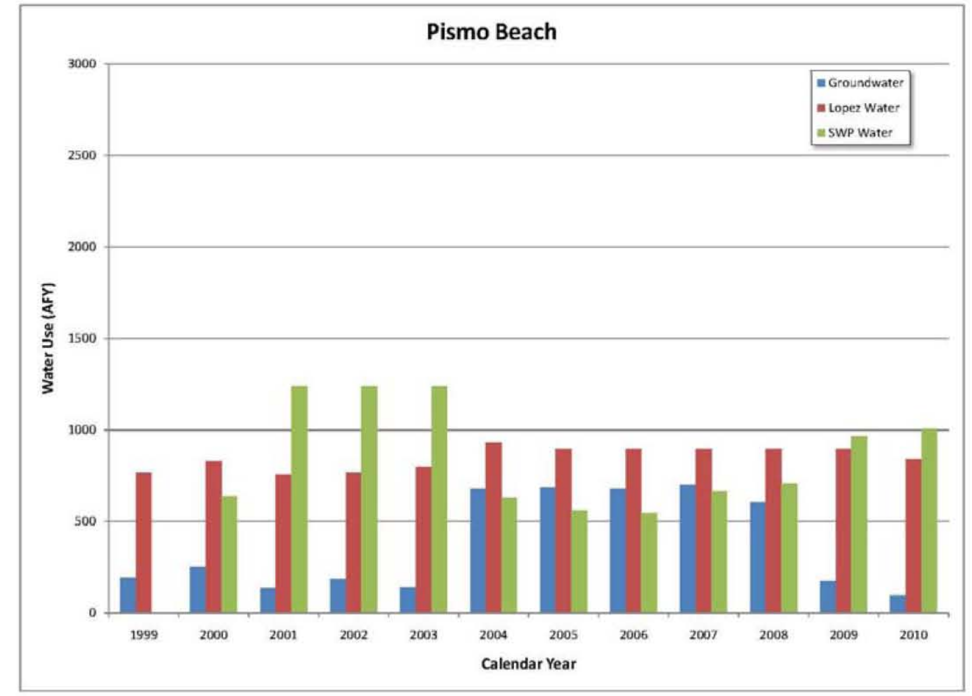
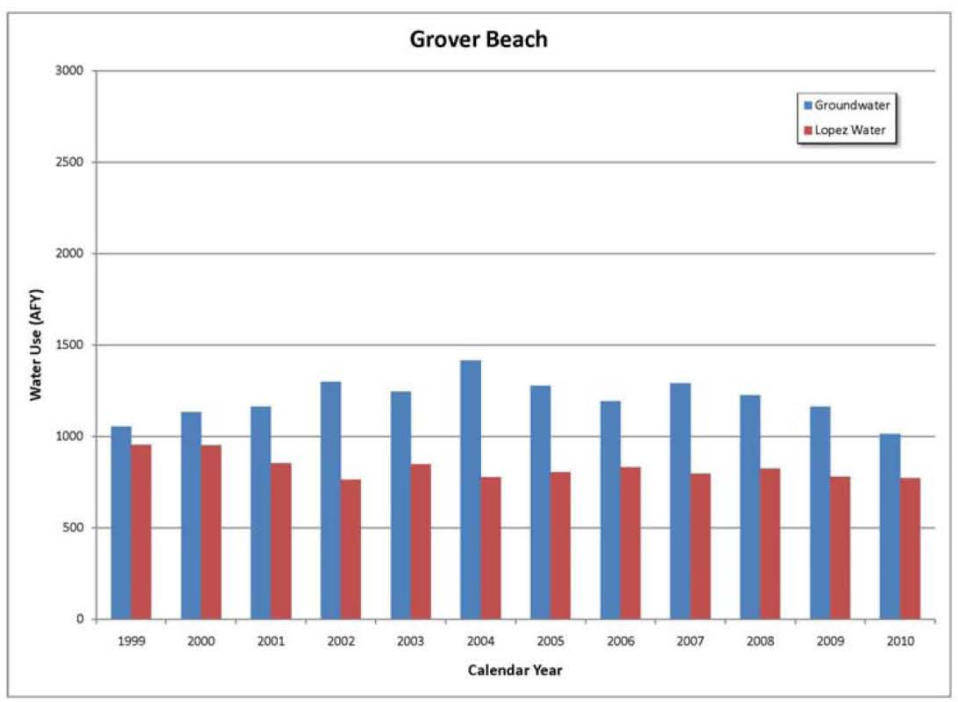
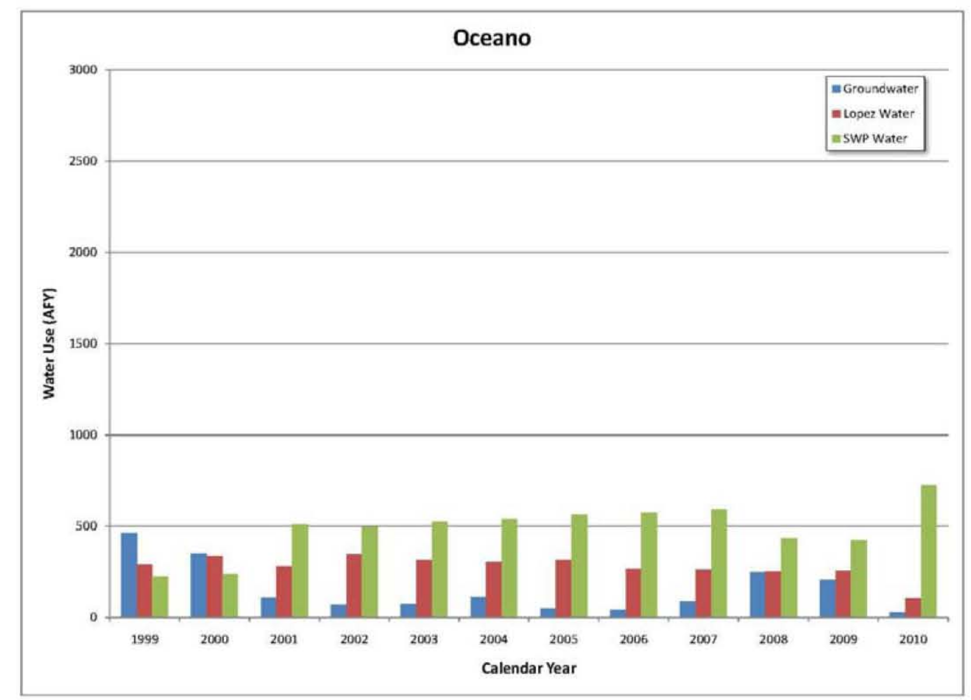
FIGURE 4









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2010 ANNUAL MONITORING REPORT

Project Title

Location

NORTHERN CITIES MANAGMENT AREA

Client

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Bookman-Edmonston Division

MUNICIPAL WATER USE BY SOURCE

FIGURE TITLE

APRIL 2011

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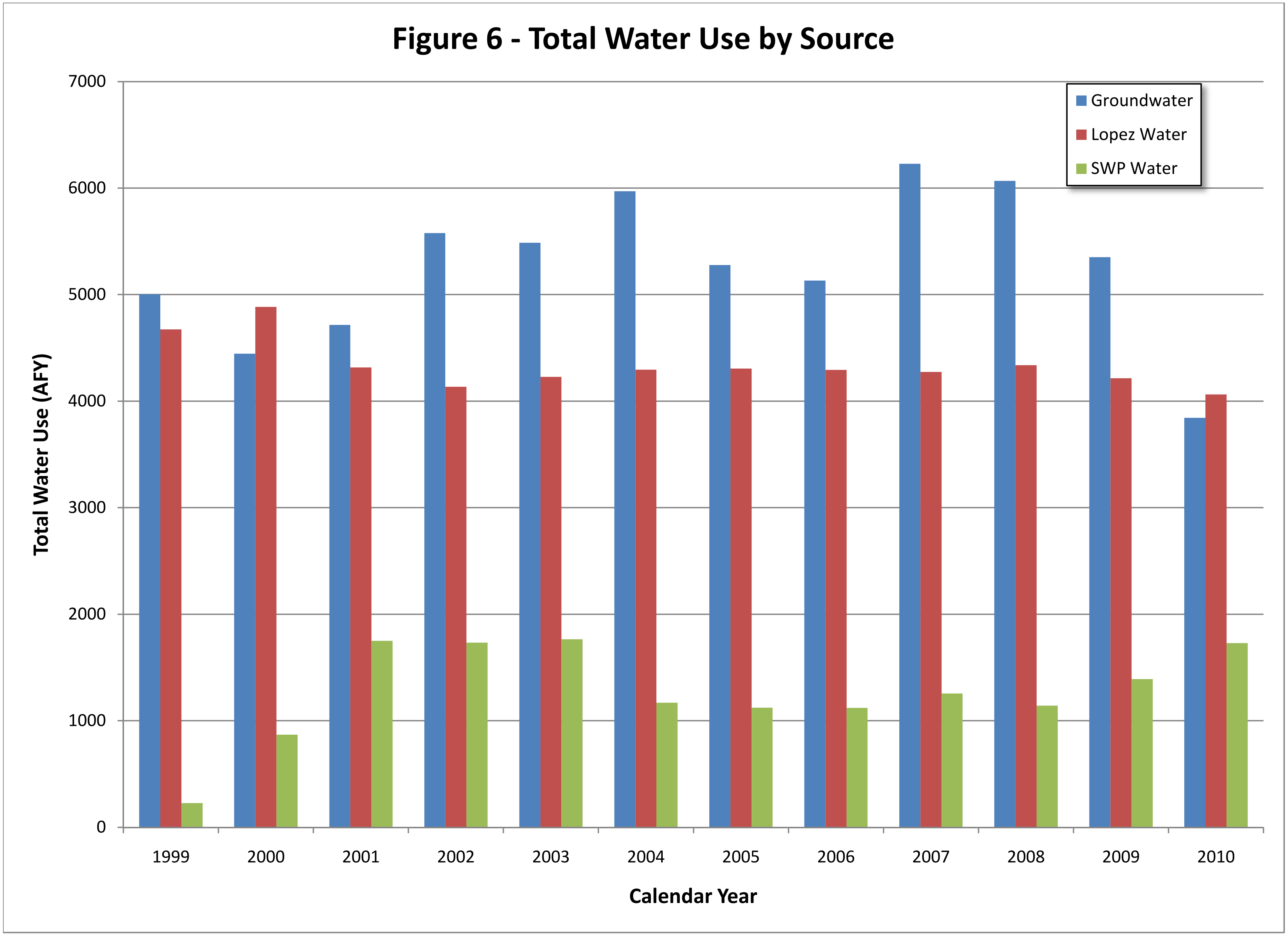
FIGURE 5

FIGURE



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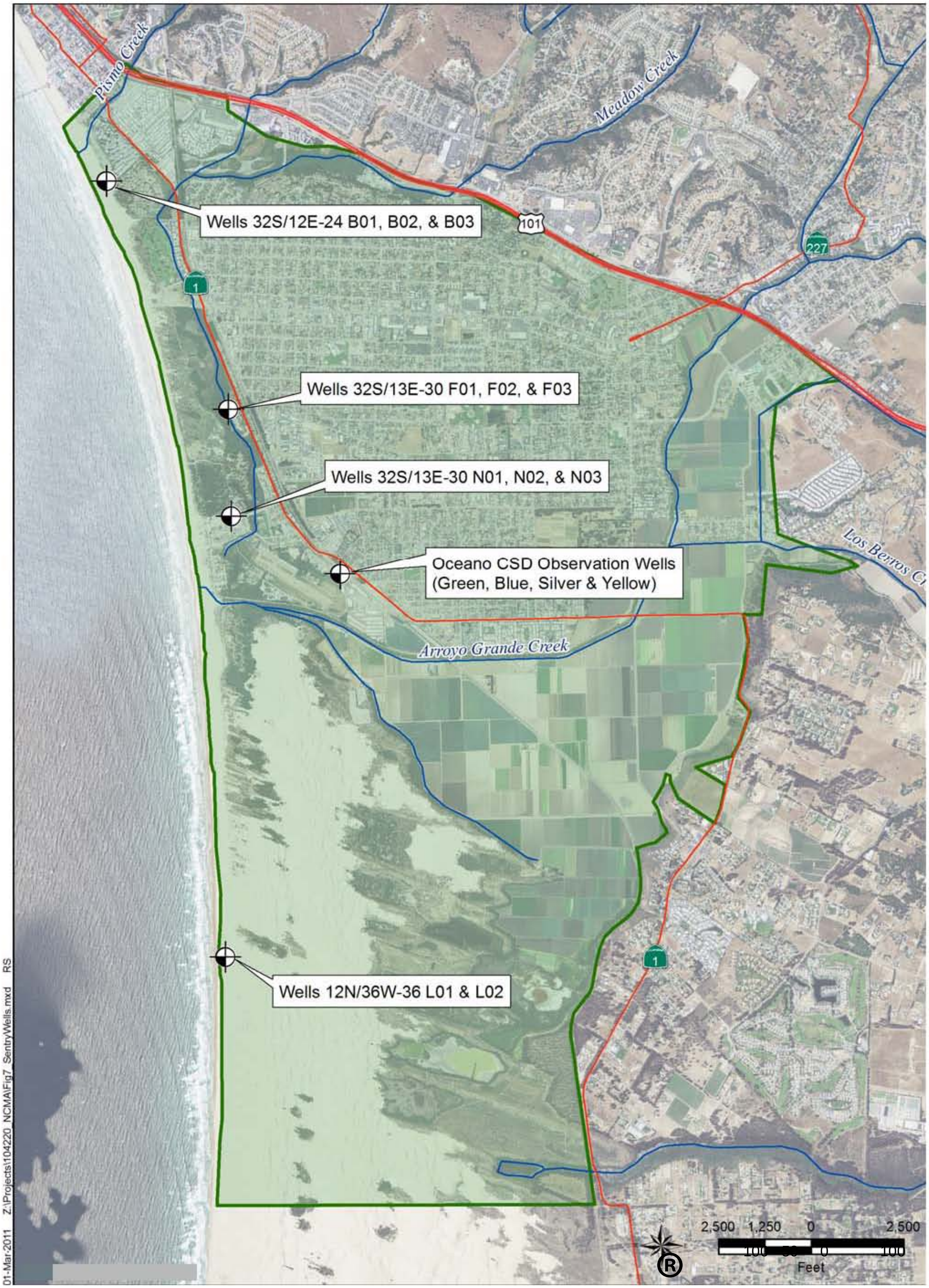
2010 ANNUAL MONITORING REPORT	GEI Consultants	TOTAL WATER USE BY SOURCE	
NORTHERN CITIES MANAGMENT AREA		APRIL 2011	FIGURE 6



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LOCATION OF SENTRY WELLS

FIGURE TITLE

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FIGURE

FIGURE 7

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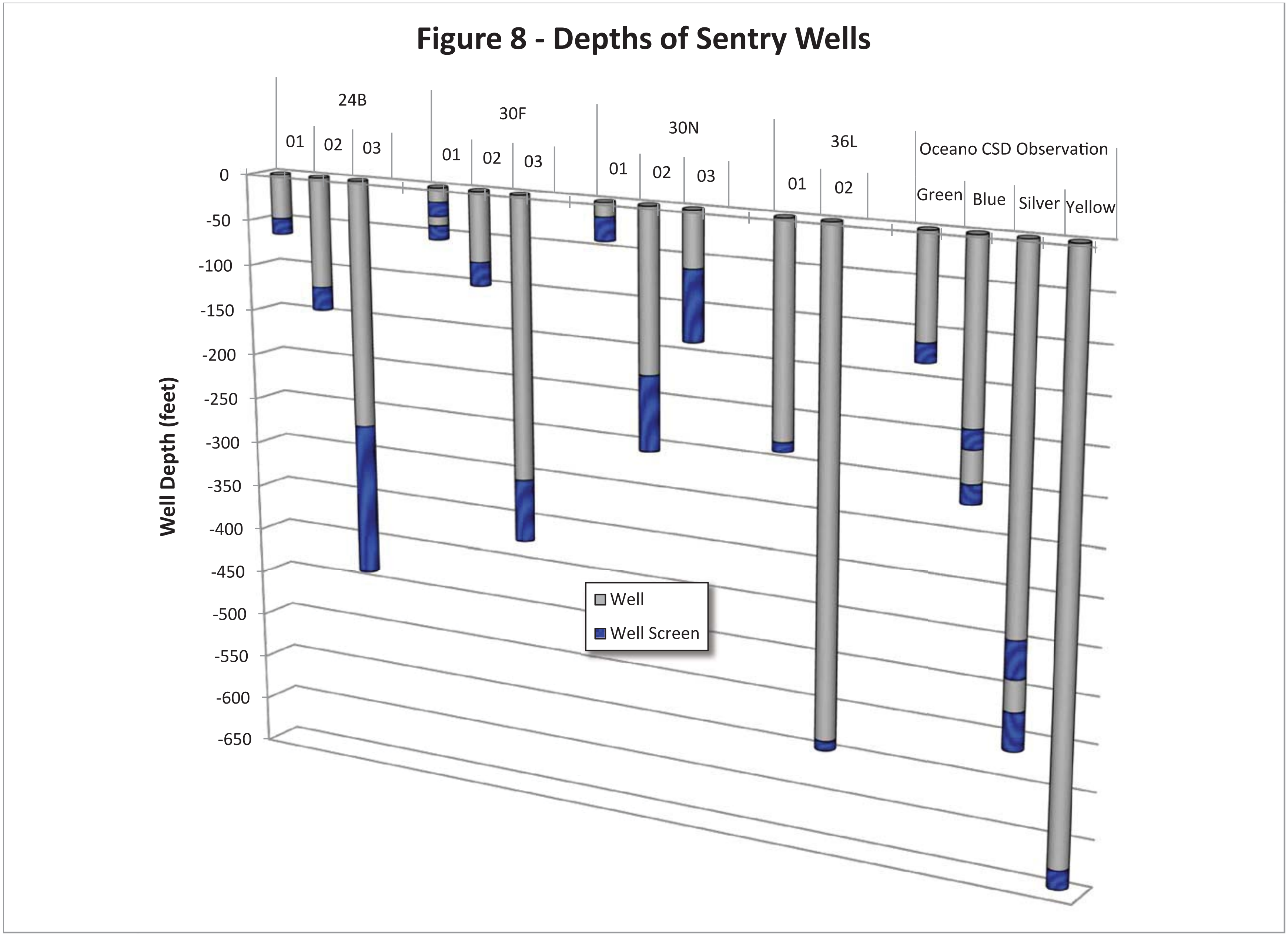

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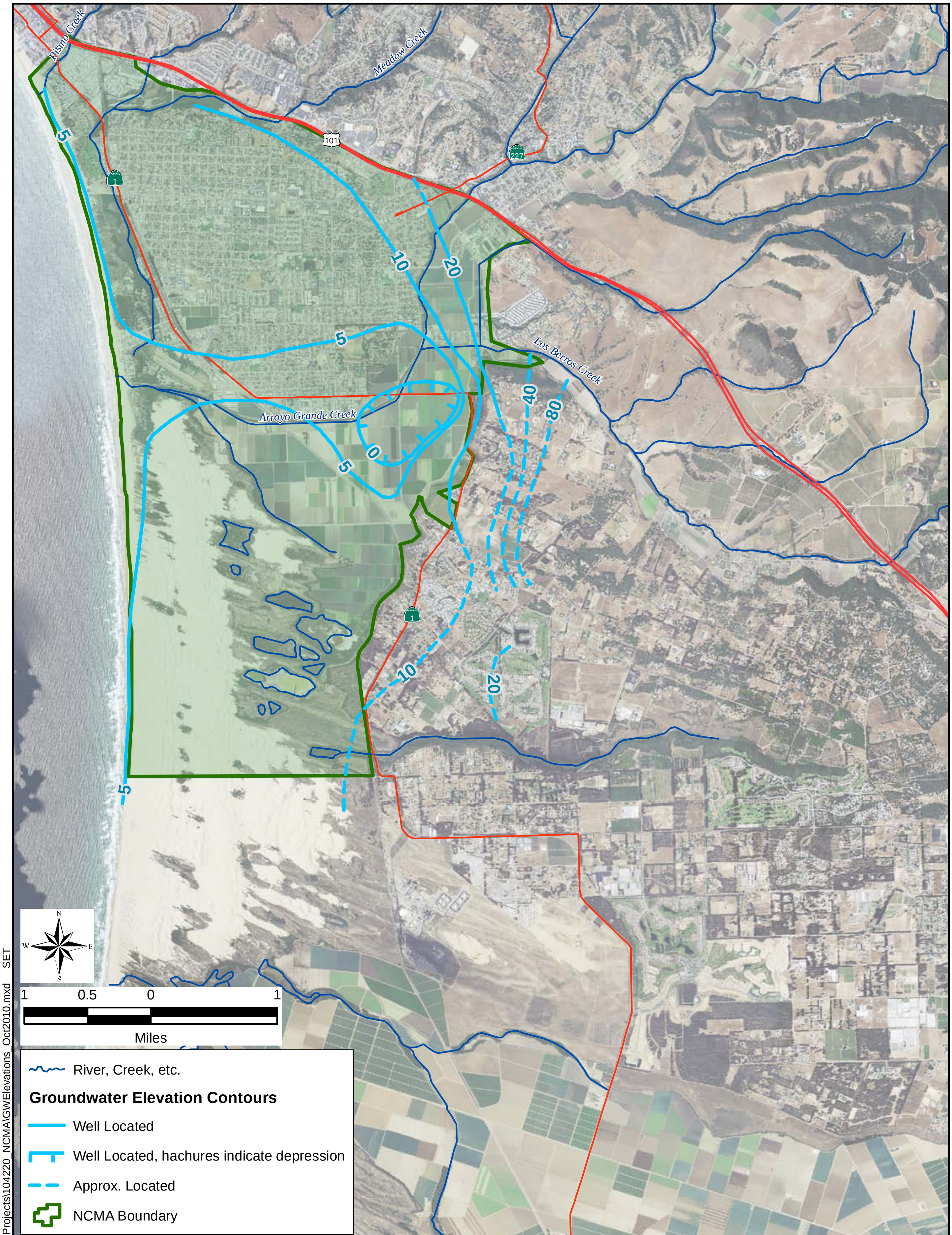
2010 ANNUAL MONITORING REPORT	GEI Consultants	DEPTHS OF SENTRY WELLS	
NORTHERN CITIES MANAGEMENT AREA		APRIL 2011	FIGURE 8



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Northern Cities Management Area

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Groundwater Elevation Contours for October 2010

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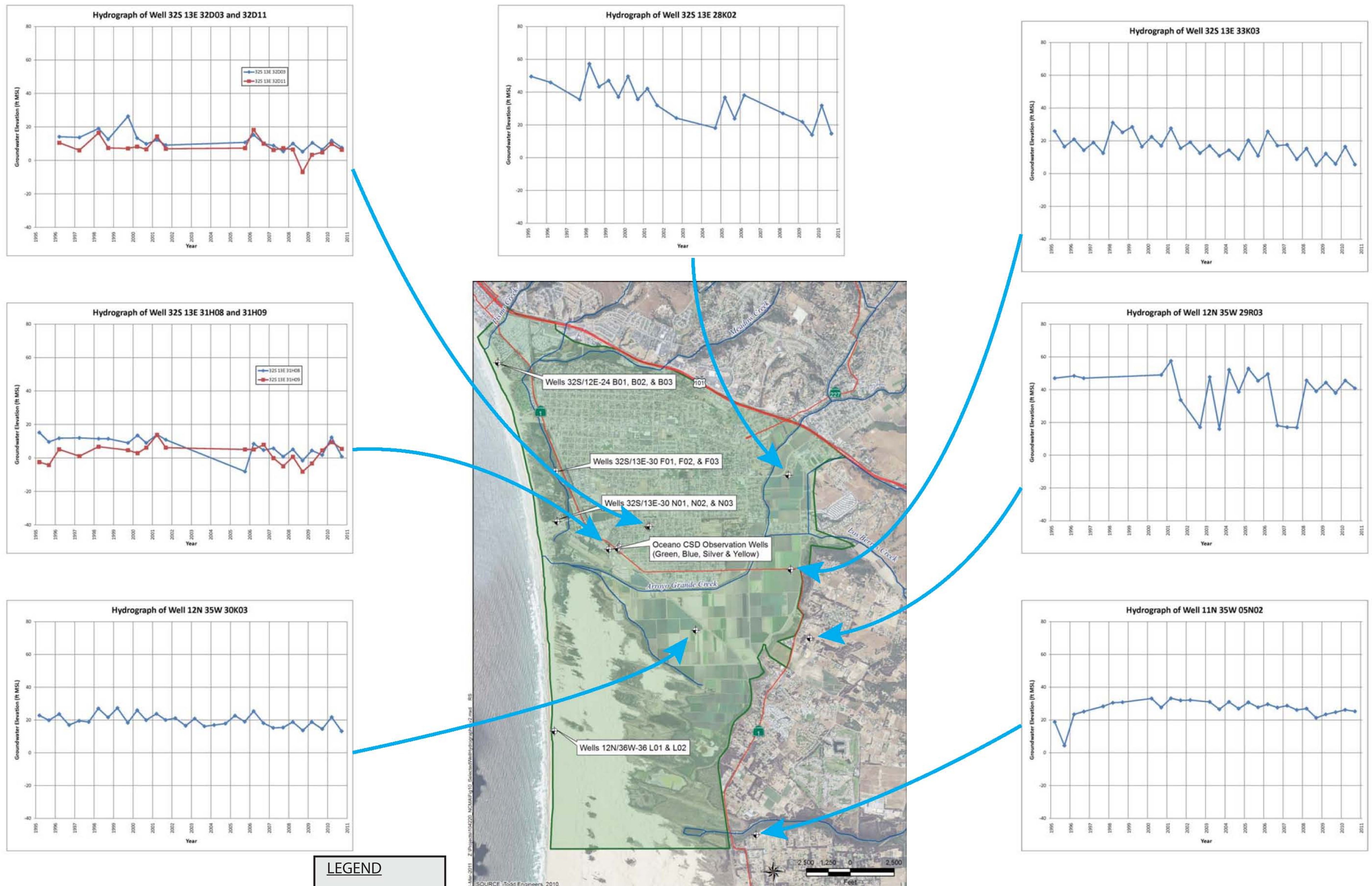
FIGURE 9



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Selected Well

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2010 ANNUAL MONITORING REPORT

Project Title

Location

NORTHERN CITIES MANAGEMENT AREA

Client

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Bookman-Edmonston Division

SELECTED WELL HYDROGRAPHS

FIGURE TITLE

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FIGURE 10

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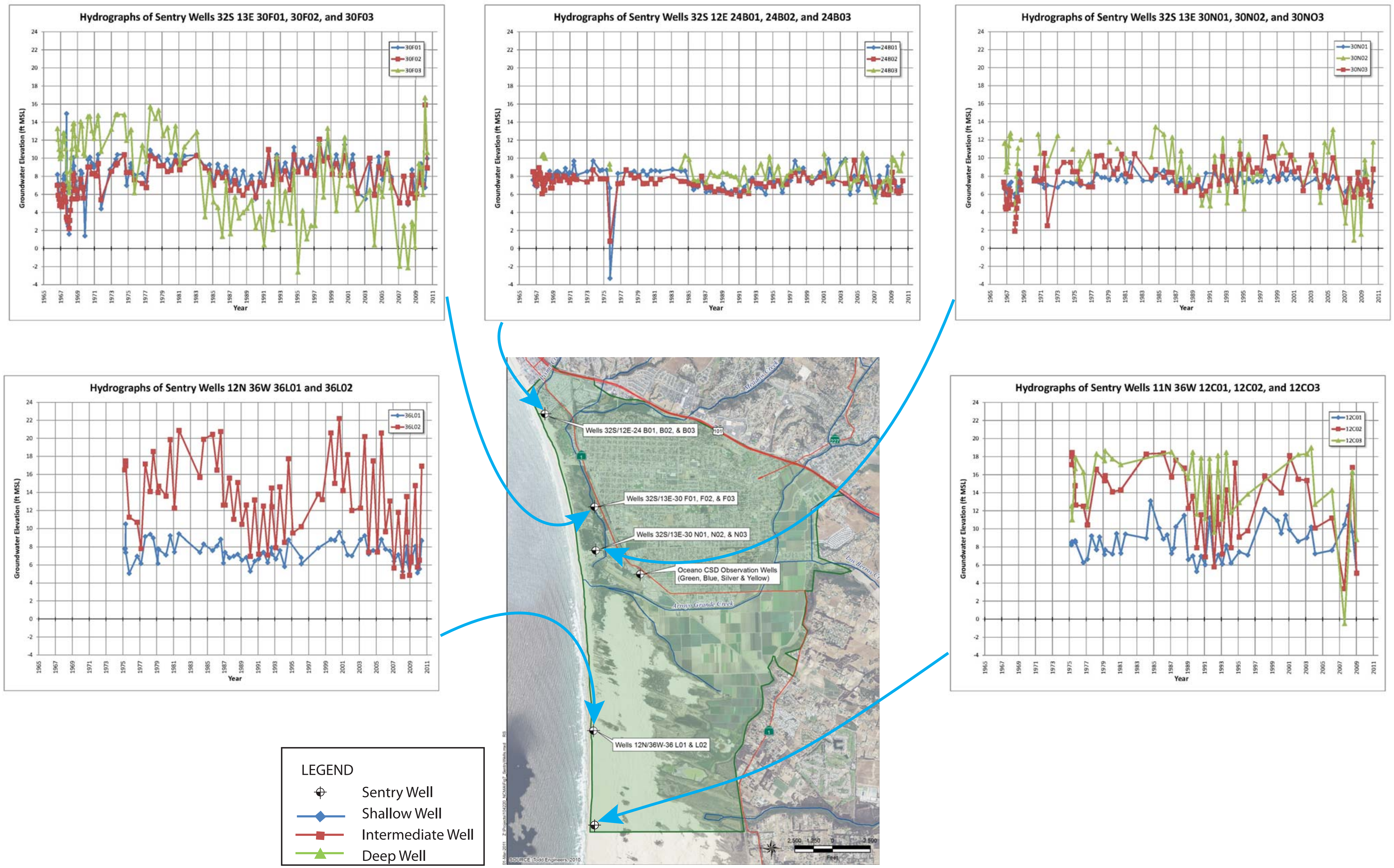

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2010 ANNUAL MONITORING REPORT

NORTHERN CITIES MANAGEMENT AREA

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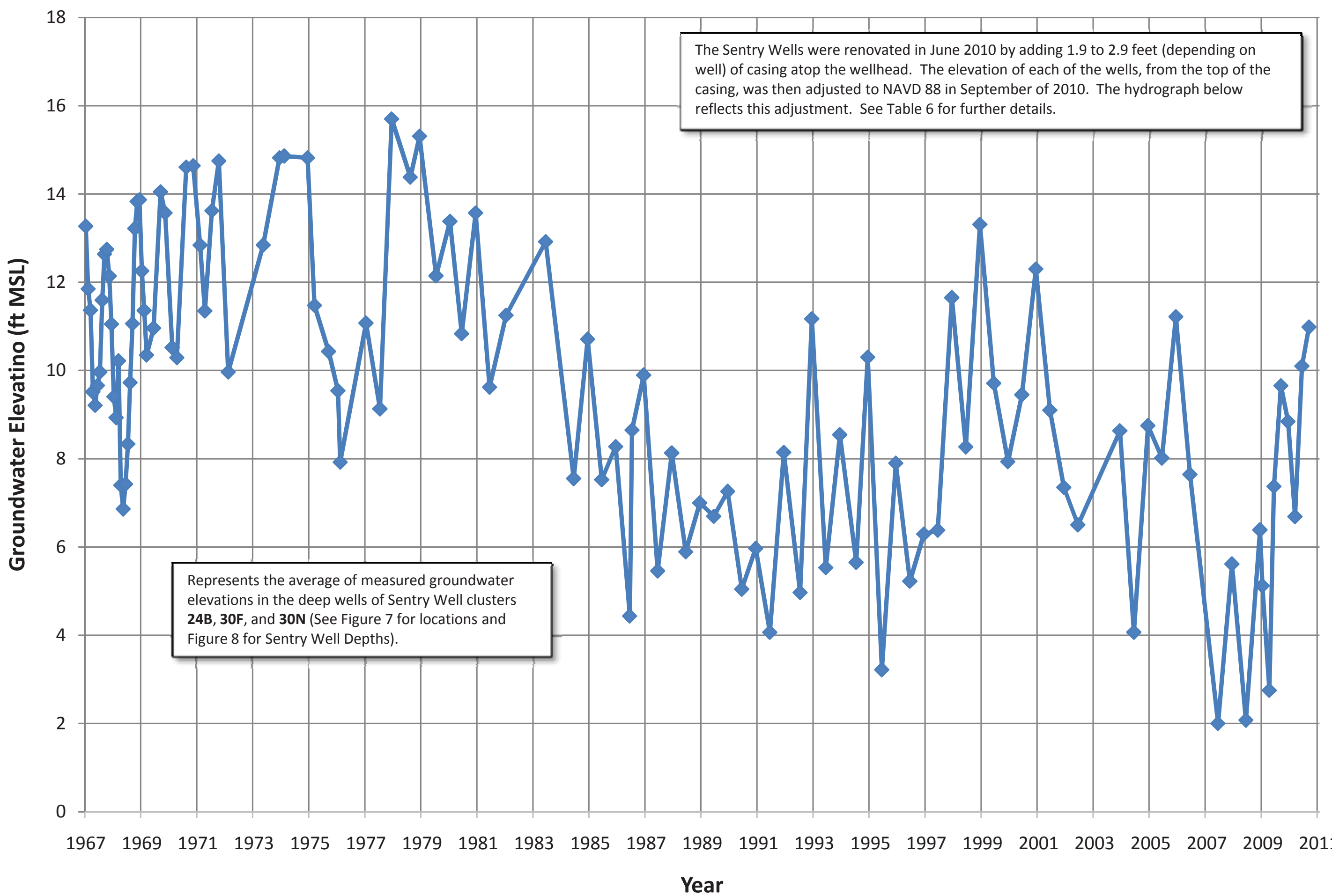
Bookman-Edmonston Division

SENTRY WELL HYDROGRAPHS

APRIL 2011

FIGURE 11

Figure 12 - Hydrograph of Average Deep Sentry Well Elevations



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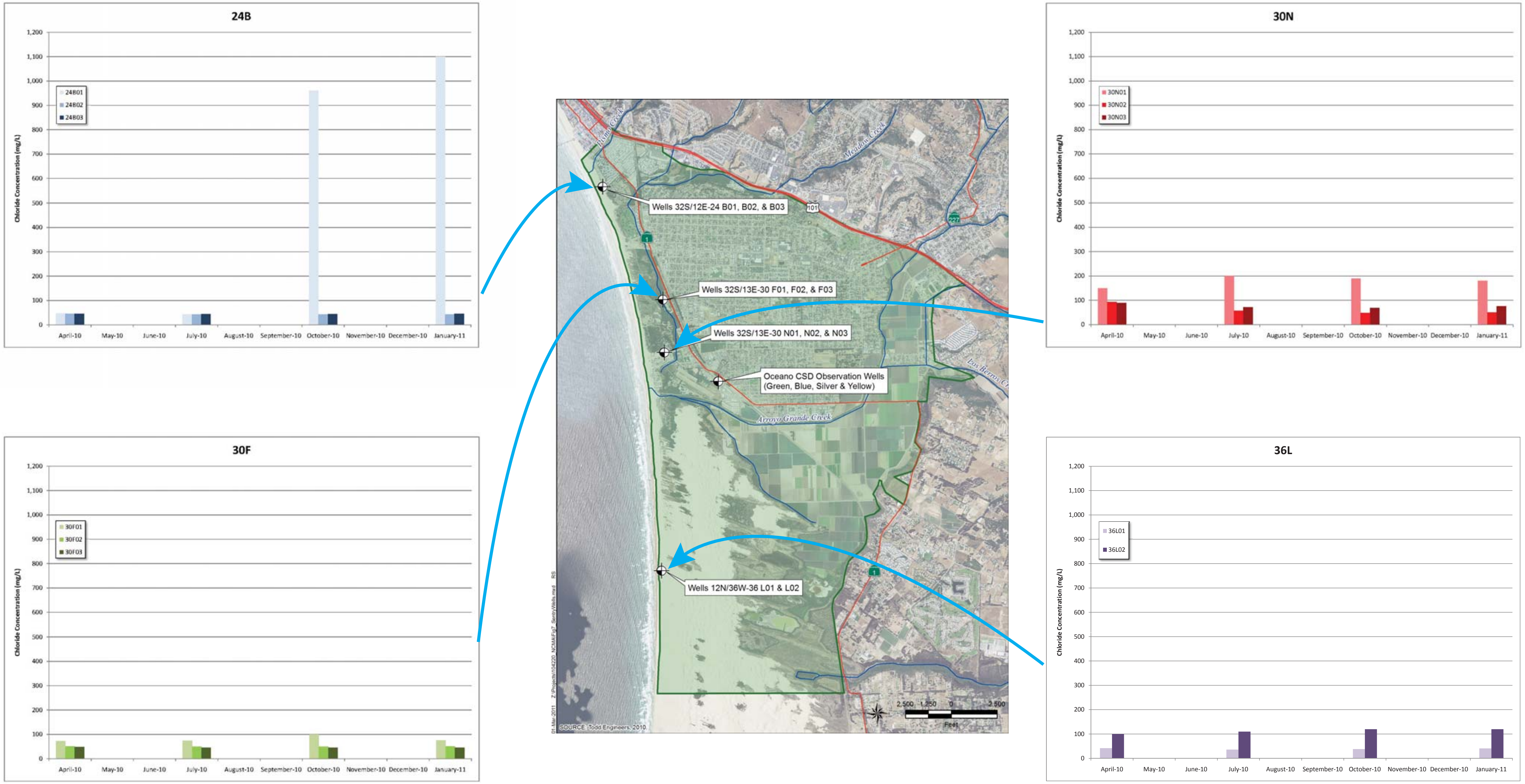
2010 ANNUAL MONITORING REPORT	GEI Consultants	HYDROGRAPH OF AVERAGE DEEP SENTRY WELL ELEVATIONS
NORTHERN CITIES MANAGEMENT AREA		APRIL 2011 FIGURE 12



LEGEND

Selected Well

2010 ANNUAL MONITORING REPORT	GEI Consultants Bookman-Edmonston Division	CHLORIDE CONCENTRATIONS OVER TIME IN SENTRY WELLS	
NORTHERN CITIES MANAGEMENT AREA		APRIL 2011	FIGURE 13

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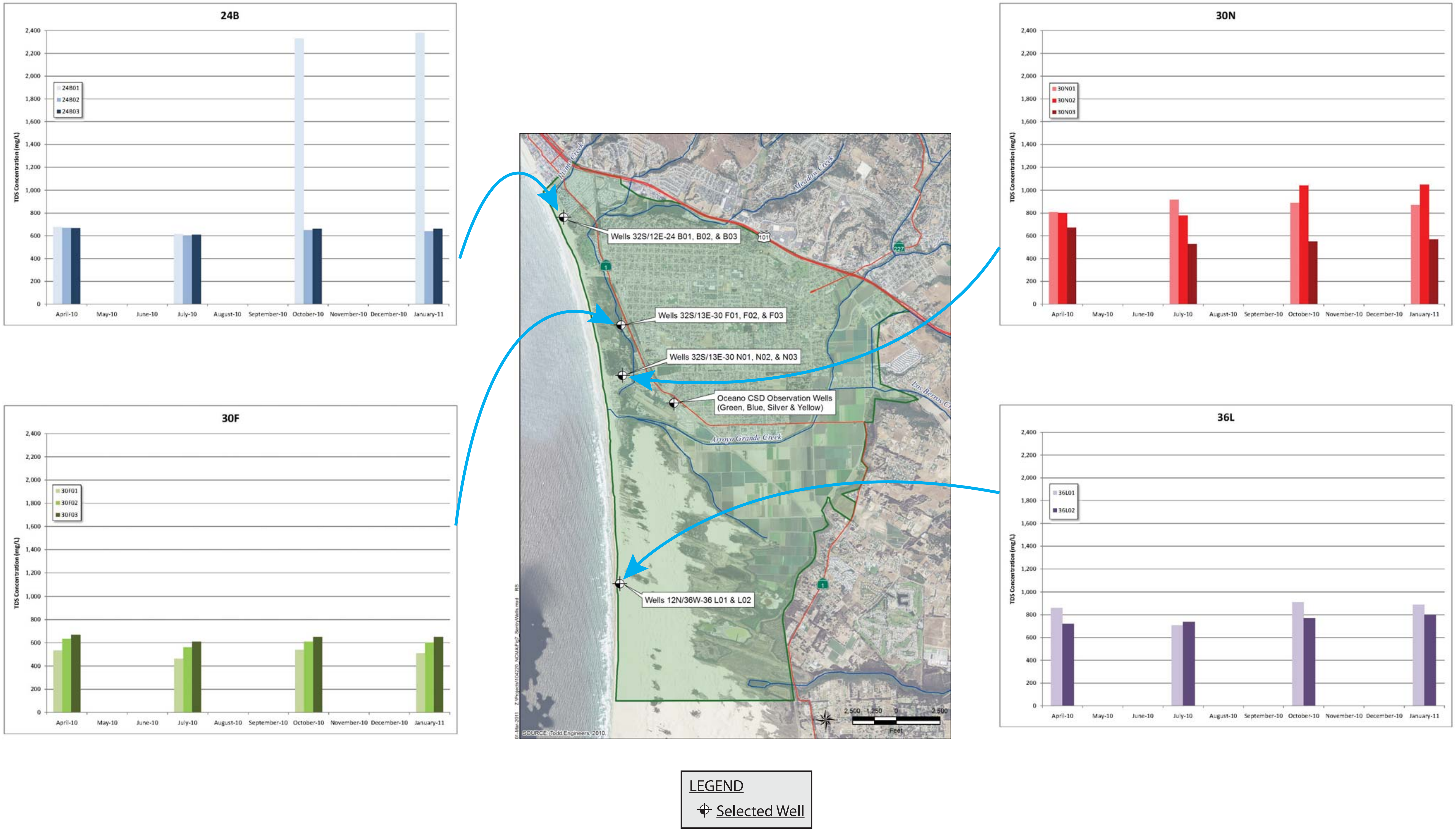

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NORTHERN CITIES MANAGEMENT AREA

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TOTAL DISOLVED SOLIDS CONCENTRATIONS OVER TIME IN SENTRY WELLS

APRIL 2011

FIGURE 14

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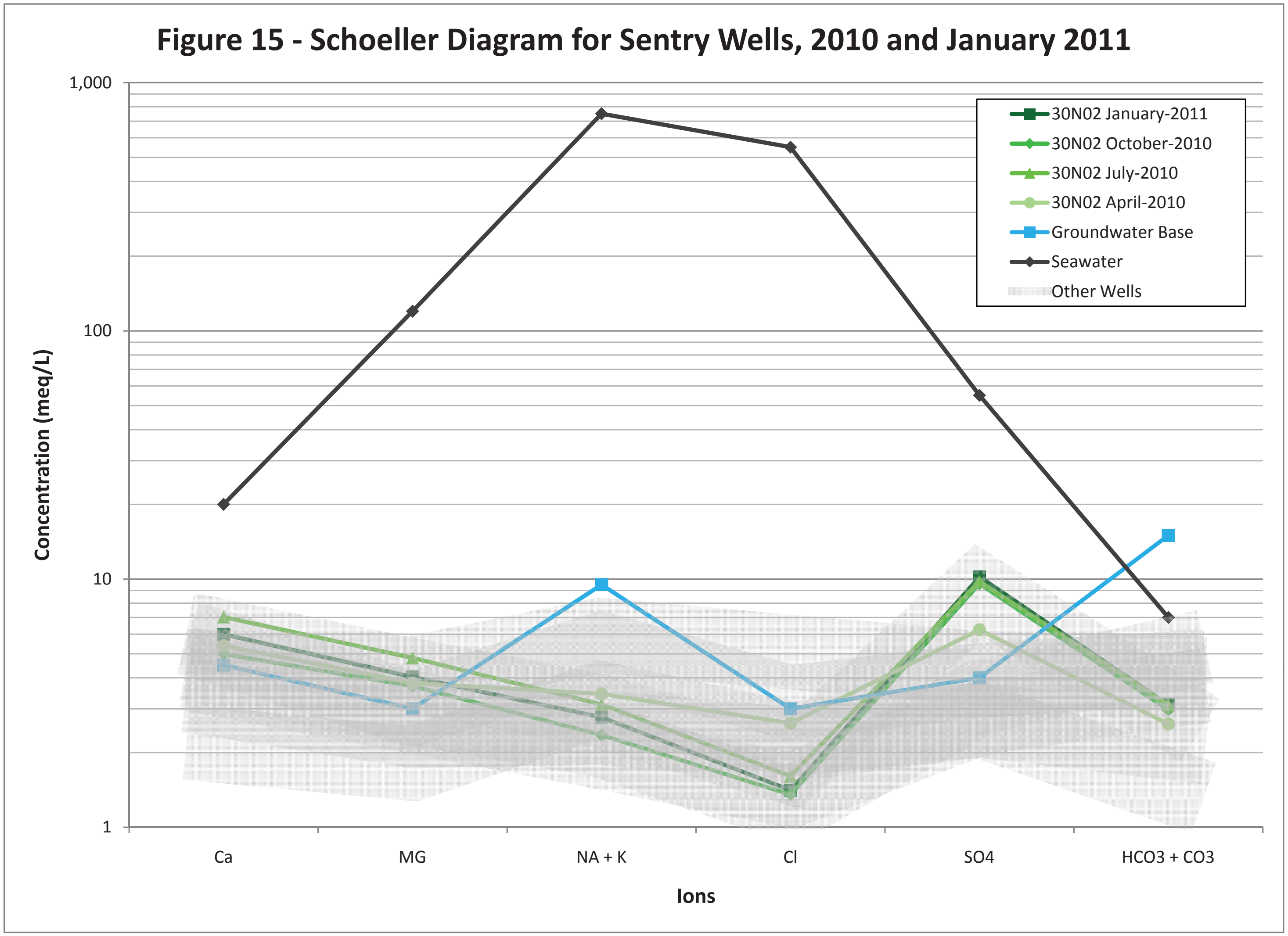

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NORTHERN CITIES MANAGEMENT AREA

SCHOELLER DIAGRAM FOR SENTRY WELLS
2010 AND JANUARY 2011

APRIL 2011

FIGURE 15

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