Appendix 1-10: CASGEM Compliance

The City of San Diego applied to be a monitoring entity for the San Diego River Valley Groundwater Basin on December 21, 2010, and provided a CASGEM monitoring plan for DWR for review (see monitoring plan herein). The City was informed by DWR that they cannot qualify as an authorized monitoring entity for the San Diego River Valley Basin without an established groundwater management plan for the San Diego River Valley Groundwater Basin. As such, the City can continue to submit CASGEM groundwater levels to DWR for the San Diego River Valley Groundwater Basin on a voluntary basis.

Figure 1-1 in Attachment 1 shows the location of the identified medium-priority groundwater basins in the Region along with the service areas of each project sponsor and the location of each project, including latitude and longitude. A folder titled “Agency Service Area Boundaries” that includes GIS shape files for each of the implementing agencies’ (SDCWA, City of San Diego, Carlsbad, Fallbrook, Rincon, and Sweetwater) service area boundaries is included within the supporting CD that has been mailed to DWR with the hard copy of the grant application.

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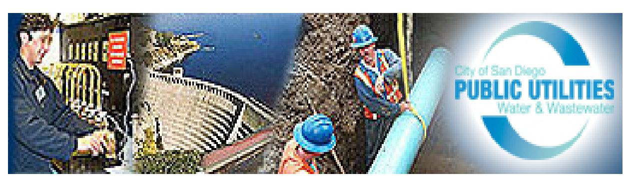
Water Level Monitoring Plan
City of San Diego

for Submittal to California State Department of Water Resources Under the CASGEM Program

(6 June 2013)



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K/J Project No. 1187103*00

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Executive Summary

This groundwater elevation monitoring plan has been prepared to fulfill the requirements of the State of California Department of Water Resources (DWR), California Statewide Groundwater Elevation Monitoring (CASGEM) Program, in compliance with Senate Bill X7-6 (SBX7-6).

The City of San Diego (City) submitted a monitoring entity notification to the DWR CASGEM Program to indicate the City's intent to become a monitoring entity and to monitor groundwater levels in seven groundwater basins located in the City's local water resources area in San Diego County (County). This is a detailed monitoring plan for the proposed City's seven groundwater basins under the DWR CASGEM Program, in compliance with the legislation SBX7-6.

On November 4, 2009 the State legislature amended the Water Code with SBX7-6, which mandates a statewide, locally-managed groundwater elevation monitoring program to track seasonal and long-term trends in groundwater elevations in California's groundwater basins. To achieve that goal, the new law directs that groundwater elevations in all basins and sub-basins in California be regularly and systematically monitored, preferably by local entities, with the goal of demonstrating seasonal and long-term trends in groundwater elevations. In accordance with the SBX7-6, DWR developed the CASGEM Program to establish a permanent, locally-managed system to monitor groundwater elevations in California's groundwater basins and sub-basins identified in DWR Bulletin 118. The legislation requires collaboration between local monitoring entities and DWR to collect groundwater elevation data.

The primary objective of the CASGEM Program is to define the seasonal and long-term trends in groundwater elevations in California's groundwater basins. The scale for this evaluation should be the static regional groundwater table or potentiometric surface. A secondary objective is to provide sufficient data to draw representative contour maps of the elevations. These maps could be used to estimate changes in groundwater storage and to evaluate potential areas of overdraft and subsidence.

The City has been contacted by DWR and notified of its status as a monitoring entity. The City qualifies as a monitoring entity per the DWR CASGEM Guideline (DWR, 2010) under Scenario A – One Monitoring Entity submitting data for the region. A monitoring entity notification was submitted to DWR stating the City's intent to monitor groundwater levels in the following seven basins with their groundwater basin numbers as defined in the DWR Bulletin 118.

- San Pasqual Valley Groundwater Basin (Groundwater Basin Number: 9-10)
- Mission Valley Groundwater Basin (Groundwater Basin Number: 9-14)
- San Diego River Valley Groundwater Basin (Groundwater Basin Number: 9-15)
- El Cajon Valley Groundwater Basin (Groundwater Basin Number: 9-16)
- Sweetwater Valley Groundwater Basin (Groundwater Basin Number: 9-17)
- Otay Valley Groundwater Basin (Groundwater Basin Number: 9-18); and
- Tijuana Groundwater Basin (Groundwater Basin Number: 9-19).

The City submitted a monitoring entity notification to the DWR CASGEM Program to monitor groundwater levels in seven groundwater basins located in the City's local water resources area in the County. Among the seven basins, only the San Pasqual Valley Basin has a formal Groundwater Management Plan (GMP) adopted in compliance with the California Assembly Bill (AB) 3030.

Assembly Bill 1152 permits the DWR to authorize the City to conduct monitoring and reporting of groundwater elevations on an interim basis for all basins with the exception of San Pasqual Basin. The City accepts the role and responsibility of an interim monitoring entity. The City anticipates preparation of groundwater management plan(s) that may include the six groundwater basins that are without a plan by January 1, 2014.

Upon DWR review of the City's submittal of the notification, DWR provided inputs on the basin boundaries to be considered for the CASGEM Program. Modified boundaries were agreed on between the DWR and the City on 11 June 2012 to include portions of basins that were not in Bulletin 118. Five of the seven groundwater basins now have extended boundaries with no changes for the remaining two basins, namely San Pasqual Valley and El Cajon Valley. At the request of DWR, the City submitted new notifications on CASGEM system to indicate new Partial Basin monitoring with the recent modified basin boundaries.

Monitoring Well Network

In general, the wells selected in the CASGEM Program monitoring network avoid shallow groundwater and are not near active pumping wells. The climatic regime of coastal California is bi-seasonal with most rainfall occurring in the winter, and little rainfall throughout most of the rest of the year. Therefore, *semi-annual monitoring is deemed appropriate* for the wells to be monitored. Water levels will be measured in the fall during the month of November, before the winter wet period, and in the spring during the month of May, right after the wet season. This will capture both the theoretical lowest and highest water levels in the basins.

The selection of wells for the CASGEM Program includes a systematic assessment of the existing well locations based on a set of well selection criteria identified in the DWR guidance. These criteria are:

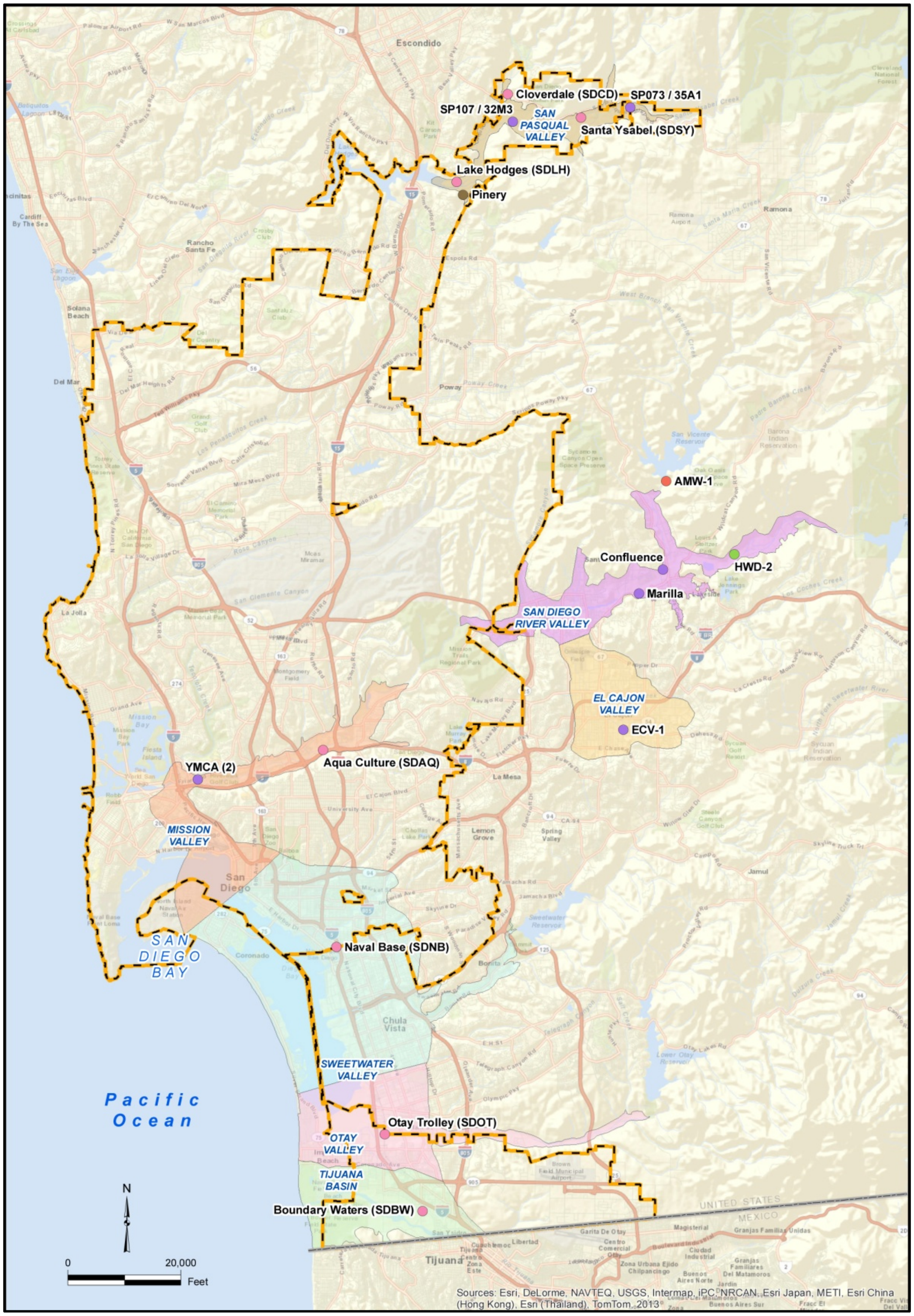
1. Wells that can provide static water levels for seasonal and long-term trends
2. Wells readily available and assumed to be accessible
3. Wells with known well screen data and are compatible with the primary water bearing zone(s)
4. Wells with known ownership
5. Well locations that can provide representative water level data within the basin; and
6. Relatively new wells.

There are a total of 16 monitoring wells currently proposed to be in the CASGEM network. Figure ES-1 depicts the proposed monitoring well locations and lists well names as part of the City's CASGEM Program.

Groundwater Basin	Area (mi^2)	No. of Proposed Wells
San Pasqual Valley	5.50	6
Mission Valley	15.6	2
San Diego River Valley	13.8	4
El Cajon Valley	2.70	1
Sweetwater Valley	42.3	1
Otay Valley	16.1	1
Tijuana	12.3	1
Total CASGEM Network Wells	108.3	16

This monitoring plan is the City's submittal of an initial monitoring network. The plan will be updated periodically if needed primarily to address potential monitoring data gaps as the program collects groundwater data and more importantly to coordinate with the DWR to possibly improve the program by modifying the network of wells.

Figure ES-1 Monitoring Well Locations - City of San Diego CASGEM Monitoring Network



San Pasqual Valley – Six monitoring wells are selected to represent the groundwater condition. Well 1. SP073/35A1; Well 2. Santa Ysabel (SDSY); Well 3. SP107/32M3; Well 4. Cloverdale (SDCD); Well 5. Lake Hodges (SDLH); and Well 6. Pinery.

Mission Valley – Two monitoring wells are selected to represent the groundwater condition in this east-west trending elongate groundwater basin. Well1. Aqua Culture (SDAQ); and Well 2. YMCA (2).

San Diego River Valley (Santee El Monte Basin) – Four monitoring wells are selected to represent the groundwater condition. Well 1. HWD-2; Well 2. AMW-1; Well 3. Confluence; and Well 4. Marilla.

El Cajon Valley – One monitoring well identified as 16S001W11R004S (referred to as ECV-1) is selected to represent the groundwater condition.

Sweetwater Valley – One monitoring well, Naval Base (SDNB), is selected to represent the groundwater condition.

Otay Valley – One monitoring well, Otay Trolley (SDOT), is selected to represent the groundwater condition.

Tijuana Basin – One monitoring well, Boundary Waters (SDBW), is selected to represent the groundwater condition.

Section 1: Introduction

The City of San Diego submitted a monitoring entity notification to the DWR CASGEM Program to indicate the City's intent to become a monitoring entity and to monitor groundwater levels in seven groundwater basins located in the City's local water resources area in San Diego County (County) (Appendix A). This is a detailed monitoring plan for the City's seven groundwater basins under the DWR CASGEM Program, in compliance with Senate Bill X7-6 (SBX7-6).

This monitoring plan is the City's submittal of an initial monitoring network. The plan will be updated periodically if needed primarily to address potential monitoring data gaps as the program collects groundwater data and more importantly to coordinate with the DWR to possibly improve the program by modifying the network of wells.

The plan was prepared by Kennedy/Jenks Consultants and City of San Diego staff. Questions regarding information in this plan can be directed to the following:

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1.1 Background and CASGEM Purpose

On November 4, 2009 the State legislature amended the Water Code with SBX7-6, which mandates a statewide, locally-managed groundwater elevation monitoring program to track seasonal and long-term trends in groundwater elevations in California's groundwater basins. To achieve that goal, the new law directs that groundwater elevations in all basins and sub-basins in California be regularly and systematically monitored, preferably by local entities, with the goal of demonstrating seasonal and long-term trends in groundwater elevations. In accordance with the SBX7-6, DWR developed the CASGEM Program to establish a permanent, locally-managed system to monitor groundwater elevation in California's groundwater basins and sub-basins identified in DWR Bulletin 118. The legislation requires collaboration between local monitoring entities and DWR to collect groundwater elevation data. DWR's main role is to administer the CASGEM Program in addition to coordinating information collected locally through the CASGEM Program and maintaining the collected groundwater elevation data in a readily and widely available public database. DWR prepared the first status report on the CASGEM Program to the Governor and the legislature by January 1, 2012 and will prepare future status reports thereafter in years ending in 5 or 0.

1.2 CASGEM Monitoring Objectives

The primary objective of the CASGEM Program is to define the seasonal and long-term trends in groundwater elevations in California's groundwater basins. The target in this monitoring program is the static regional groundwater table or potentiometric surface. A secondary objective is to provide sufficient data in a publicly available data warehouse in the future to construct representative contour maps of groundwater elevations. Future groundwater maps could be used to estimate changes in groundwater storage and to evaluate potential areas of overdraft and subsidence.

The City qualifies as a monitoring entity per the DWR CASGEM Guideline (DWR, 2010) under Scenario A – One Monitoring Entity submitting data for the region. A monitoring entity notification was submitted to DWR stating the City's intent to monitor groundwater levels in the following seven basins with their groundwater basin numbers as defined in the DWR Bulletin 118.

- San Pasqual Valley Groundwater Basin (Groundwater Basin Number: 9-10);
- Mission Valley Groundwater Basin (Groundwater Basin Number: 9-14);
- San Diego River Valley Groundwater Basin (Groundwater Basin Number: 9-15);
- El Cajon Valley Groundwater Basin (Groundwater Basin Number: 9-16);
- Sweetwater Valley Groundwater Basin (Groundwater Basin Number: 9-17);
- Otay Valley Groundwater Basin (Groundwater Basin Number: 9-18); and
- Tijuana Groundwater Basin (Groundwater Basin Number: 9-19).

Upon DWR review of the City's submittal of the notification, DWR provided inputs on the basin boundaries to be considered for the CASGEM Program. The basin boundaries initially submitted by the City as part of the monitoring entity notification followed the local basin boundary descriptions that are different than the DWR Bulletin 118 basin descriptions. Since the CASGEM Program is based on the DWR Bulletin 118 basin boundaries, DWR made some modifications to the basin boundaries for the San Pasqual Valley, Mission Valley, Sweetwater Valley, Otay Valley, and Tijuana groundwater basins, mainly to tie these basin boundaries to a known DWR defined basin boundary. The San Pasqual Valley groundwater basin was modified based on the newly interpreted DWR defined boundary because this basin boundary has been recently updated by DWR during work performed in that area. Based on discussions and coordination between the City and DWR, the updated basin boundaries as recommended by DWR are used in the CASGEM Program. Figure 1 (Appendix B) shows the boundaries of the seven basins considered for the CASGEM Program and the City's service area – a.k.a. City's jurisdictional boundary. At the request of DWR, the City submitted new notifications on CASGEM system to indicate new Partial Basin monitoring with the recent modified basin boundaries.

As part of the City's monitoring entity notification, the City is interested in being the monitoring entity for the basins within and outside of the City's boundary. The San Diego River Valley and El Cajon Valley groundwater basins, and portions of the Sweetwater Valley and Otay Valley groundwater basins are outside of the City boundary (Figure 1- Appendix B). As a local agency and water supplier, the City has managed all or parts of these seven basins, including the basins outside of the City boundary, and collected groundwater elevation data in these basins. The monitoring notification under the CASGEM Program is the City's effort to continue to manage and collect groundwater level data in these seven basins. The City is qualified in basin management activities with operations personnel experienced in groundwater data collection.

1.3 Assembly Bill No. 1152 CHAPTER 280

This bill allows local agencies that have been collecting and reporting groundwater elevations without an adopted groundwater management plan to conduct monitoring and reporting of groundwater elevations in all or part of a basin or subbasin, with authorization from DWR. It was approved by the governor on 7 September 2011 and took effect on 1 January 2012.

The City submitted a monitoring entity notification to the DWR CASGEM program to monitor groundwater levels in seven groundwater basins located in the City's local water resources area in the County. Only the San Pasqual Valley Basin has a current groundwater management plan out of the seven basins proposed for monitoring.

Assembly Bill 1152 permits the DWR to authorize the City to conduct monitoring and reporting of groundwater elevations on an interim basis for all basins with the exception of San Pasqual Basin. The City accepts the role and responsibility of an interim monitoring entity for the remaining basins.

Section 2: CASGEM Monitoring Plan Components

The organization in this monitoring plan takes off from the DWR CASGEM Program requirements. The CASGEM Program first requires local agencies to submit monitoring entity notification to DWR through the CASGEM website on or before January 1, 2011. The City submitted its notification to monitor the aforementioned seven basins of which five are located within the City's service area (see Figure 1 – Appendix B). The City's submission has been formally accepted and the basin boundaries for the CASGEM program were established based on coordination and discussions between DWR and the City. Figure 1 (Appendix B) shows the basin boundaries based on the outcome of the recommended changes by DWR as part of the City's monitoring entity notification.

The CASGEM Program requires the monitoring entity, in this case the City, to develop and submit a monitoring plan through the CASGEM Program website. The monitoring plan must include detailed discussions in five key sections, as briefly described below:

Monitoring Well Network (Section 3)
The monitoring networks as whole and selected wells for CASGEM are summarized, resulting from reviews of existing monitoring programs. The City's CASGEM monitoring network is a distillation from existing monitoring points to a smaller and CASGEM-focused network that best represents the groundwater conditions and hydrogeological characteristics of the seven hydrologic basins.

Rationale for Monitoring Plan (Section 4)
Discussed are well network design with selected (current) wells, monitoring frequency to capture seasonal highs and lows, monitoring density, rationale for selection of timing, table identifying wells to be monitored and timing of monitoring, maps and shape files with selected monitoring well locations.

Monitoring Well Information (Section 5)
Discussed are the information required in the final monitoring plan and regular data submittals to DWR.

Field Methods for Groundwater Monitoring (Section 6)
Discussed are standard procedures for the collection and documentation of groundwater elevations, including consistent collection of data and step-by-step description of methodologies for measuring reference point (RP), static water level, and depth to water table, and standardized form for data collection.

Data Reporting for Groundwater Levels (Section 7)
Online submissions by January 1 and July 1 each year. DWR will provide standard forms for the monitoring entity to submit groundwater elevation data online electronically.

Section 3: Monitoring Well Network

This CASGEM monitoring well network is the result of reviews of existing monitoring programs and a distillation from existing monitoring points to a smaller and CASGEM-focused network that best represents the groundwater conditions and hydrogeological characteristics of the seven hydrologic basins. Detailed summaries of the physical and hydrogeological descriptions of the seven basins are provided in this section and summarized in Appendix C. First, an overview is provided for the region being discussed then each of the seven hydrologic basins is discussed separately.

3.1 Background and Existing Data Collection and Evaluation

Existing hydrogeologic reports, maps, and documents were compiled and reviewed to describe the general basin characteristics and identify existing wells (Figures 2 to 5 – Appendix B). Many USGS installed monitoring wells in the lower Mission Valley, Sweetwater Valley and Otay Valley basins, their lithologic logs, and well construction diagrams were examined and included as part of the final CASGEM well network. The results of these efforts are summarized here and in Appendix A. Wells for the CASGEM Program were identified in the seven hydrogeologic basins listed in Section 1.2

3.2 General Geologic and Hydrogeologic Conditions in San Diego County

San Diego County is located along the Pacific Rim, an area characterized by mountain ranges and earthquakes. Alluvium and four general rock types are found within the County: 1) Cretaceous Age crystalline rocks, 2) Upper Jurassic metavolcanics; 3) Mesozoic Age metamorphic rocks; and 4) Tertiary Age sedimentary rocks.

Deposits of recent alluvium, including sand, gravel, silt, and clay are found in river and stream valleys, around lagoons, in intermountain valleys, and in the desert basins. Within San Diego County, several different hydrogeologic environments exist. These different environments can be grouped into three generalized categories: alluvial and sedimentary aquifers, fractured rock aquifers, and desert basins.

Alluvial and sedimentary aquifers account for approximately 13 percent of the unincorporated areas of the County. These aquifers are typically found in river and stream valleys, around lagoons, near the coastline, and in the intermountain valleys. Sediments in these aquifers are comprised of mostly consolidated (defined as sedimentary rock) or unconsolidated (defined as alluvium or colluvium) gravel, sand, silt, and clay. Most of these aquifers have relatively high hydraulic conductivity, porosity, and storage and in general would be considered good aquifers on the basis of their hydrogeologic characteristics. It should be noted that some alluvial and sedimentary aquifers in the County have relatively thin saturated thickness and therefore limited storage. Alluvial and sedimentary aquifers can be underlain by fractured rock aquifers such as that in the San Diego Formation, which provides additional storage. Fractured rock underlies approximately 73 percent of the unincorporated area of the County. These rocks are typically crystalline or metavolcanics associated with the Peninsular Ranges batholith of southern California and Baja California. Desert basins account for approximately 14 percent of the unincorporated area of the County and they are typically considered alluvial basins. Desert basins are located in the extreme eastern portions of the County and characterized by extremely limited recharge, but typically have large storage capacities.

In accordance with the SBX7-6, DWR developed the CASGEM Program to establish a permanent, locally-managed system to monitor groundwater elevation in California's alluvial groundwater basins and sub-basins identified in DWR Bulletin 118. The alluvial and sedimentary aquifers are the primary groundwater units that are being monitored as part of CASGEM in San Diego County.

3.3 Hydrogeological Implications for Monitoring Well Selections

The hydrogeology and groundwater conditions of the seven hydrologic basins determine which wells were selected, based on well constructions and screen depth-intervals. This section describes the general hydrogeology and groundwater conditions of each of the seven DWR-designated basins in San Diego County. This section also includes an assessment of hydrogeologic conditions and what bearing it has on the selection of monitoring wells for developing the City's CASGEM program. Descriptions are provided for the seven basins in the order listed below:

1. San Pasqual Valley Groundwater Basin (9-10);
2. Mission Valley Groundwater Basin (9-14);
3. San Diego River Valley Basin (Santee – El Monte Basin) (9-15);
4. El Cajon Valley Groundwater Basin (9-16);
5. Sweetwater Valley Groundwater Basin (9-17);
6. Otay Valley Groundwater Basin (9-18); and
7. Tijuana Groundwater Basin (9-19).

Among the seven basins, only the San Pasqual Valley Basin has a formal Groundwater Management Plan (GMP) adopted in compliance with the California Assembly Bill (AB) 3030.

The Tijuana River Valley Groundwater Basin has a GMP developed by the Tia Juana Valley County Water District in 1995. The City will serve as an interim monitoring entity for this basin under AB 1152 (Section 1.3). Because it was not developed by the City and is outdated, the City ill not accept it as a GMP and plans to develop an updated GMP for the Tijuana Basin in the future.

3.3.1 San Pasqual Valley Groundwater Basin

The San Pasqual Valley Groundwater Basin (San Pasqual Valley Basin) lies within the City, approximately 25 miles northeast of downtown San Diego, in northern San Diego County

(Figure 1 – Appendix B). The basin covers a surface area of 5.5 square miles (3,498 acres), and is bounded by Lake Hodges on the southwest and by nonwater-bearing rocks of the Peninsular Ranges to the northeast. The basin lies within the San Dieguito River Watershed and is identified as Groundwater Basin Number 9-10 in the DWR Bulletin 118 (DWR, 2003). Santa Ysabel and Guejito drain into the watersheds and converge with Santa Maria Creeks to form the San Diegueno River, which flows out of the basin into Lake Hodges (DWR, 2003).

The City owns the majority of the land within the San Pasqual Valley Basin. The land owned by the City is leased to a variety of tenants for primarily agricultural uses (City, 2007). In the basin, agricultural water demand is met almost solely from groundwater. Based on the land use, water use demand for agricultural uses is estimated to be approximately 8,800 acre feet per year (afy) for the entire basin (City, 2007).

3.3.1.1 Groundwater Basin Characteristics

The San Pasqual Valley Basin is composed of three main geologic layers, from top to bottom: alluvial aquifer, residuum (also referred to as residual), and crystalline rocks. Only the alluvial aquifer is considered in Bulletin 118 to be part of the groundwater basin. The Quaternary alluvium ranges from 120 feet in the San Pasqual Narrows (area extending from the uppermost influence with Lake Hodges to the confluence of Cloverdale Creek) to greater than 200 feet thick in the upper part of the basin, with increasing trend toward the eastern portion of the basin. This unit is described as non-active Holocene age alluvial deposits, composed of unconsolidated gravel, sand, silt, and clay. Beneath the alluvial aquifer, the residuum, also referred to as decomposed granite, is typically deeply weathered Green Valley Tonalite (DWR, 1993), with a maximum thickness of 100 feet (Izbicki, 1983). The alluvial deposits are laterally adjacent or underlain by the crystalline rocks that are resistant to weathering and form the hills and ridge tops surrounding the basin (Izbicki, 1983; SDCWA, 1995). No geologic faults of major significance are present in the basin (SDCWA, 1995).

The water bearing unit which makes up the local aquifer in the San Pasqual Valley Basin is the Quaternary alluvium. Groundwater in the alluvium aquifer is unconfined, with an average specific yield of about 16 percent (Izbicki, 1983). Well yields in the alluvium can be as high as 1,600 gallons per minute (gpm). The transmissivity (T) of the alluvial aquifer was estimated by USGS to be less than 25,000 square feet per day (ft^2/day), but, a small portion of the aquifer which extends along the Santa Ysabel Creek is believed to have a T value greater than 25,000 ft^2/day (City, 2007). The residuum underlying the alluvium aquifer has a maximum thickness of 100 feet and average specific yield of about 1 percent (Izbicki, 1983).

Groundwater storage estimates for the entire basin range from 63,000 acre-feet (af) (Izbicki, 1983) to 73,000 af (DWR, 1975), with a total storage of about 58,000 af in the alluvium only (CDM, 2010). Estimated basin safe yield was reported as 5,800 af (SDCWA, 1995).

The primary source of recharge to the alluvial aquifer within the basin originates from the outside of the basin as streamflow of the Santa Ysabel, Gueijito, and Santa Maria creeks. The recharge areas extend along the ephemeral stream and river channels where coarse alluvial sediments exist. Additional source of recharge comes from infiltration of precipitation to the valley floor, in addition to agricultural return flows from irrigation with groundwater and imported water (City, 2007). During typical years, no stream flow leaves the valley and all surface runoff becomes groundwater recharge (Izbicki, 1983). The primary outflows include groundwater pumping, evapotranspiration from native wetland, and underflow out to Lake Hodges (CDM, 2010). Estimates of groundwater pumping for agriculture range from 8,600 afy (Greeley and Hansen, 1992) to 8,800 afy based on the DWR land use map (City, 2007).

Groundwater generally moves westward through the basin (DWR, 2003), and is deeper on the eastern edge of the basin near the Santa Ysabel Creek and Santa Maria Creek, and shallower on the western edge near Lake Hodges (City, 2007). Early records of groundwater level data indicate groundwater was near the land surface in the early 1900s and gradually began to decline in 1940s through 1960s. During the historic low periods in the early 1960s and mid-1970s, groundwater storage was reduced by 50 percent, where water levels in the middle of the basin declined by 20 feet to 50 feet, and water levels at the edges of the basin declined by even greater levels. The drought in the late 1970s resulted in groundwater decline throughout the basin. Groundwater levels started to recover after the 1977 drought through the early 1980s to a full basin condition in 1982 (Izbicki, 1983). However, some locations experienced another decline in the early 1990s potentially in response to a dry period or increased pumping (City, 2007). In general, the eastern portion of the basin shows the greatest variability in groundwater levels in response to pumping and hydrologic year type (City, 2007).

Groundwater levels and water quality in the basin are monitored by the City, as part of the GMP. The City is currently monitoring groundwater levels from 12 wells every month and groundwater quality from 10 wells semi-annually (spring and fall) (City, 2007). Total dissolved solids (TDS) and nitrate are the two primary constituents of concern within the basin. Water quality in the eastern portion of the basin is substantially better than the western portion, with lower concentrations of TDS and nitrate (CDM, 2010). Average TDS concentrations measured from 2004 to 2007 ranged from approximately 580 milligrams per liter (mg/l) to 2,460 mg/l. Nitrate concentrations exceeded the drinking water standard (Maximum Contaminant Level (MCL) of 45 mg/l) in some areas.

3.3.2 Mission Valley Groundwater Basin

Mission Valley Groundwater Basin (Mission Valley Basin) underlies an east-west trending valley, which is drained by the San Diego River (Figure 1 – Appendix B). During the preparation of the City's CASGEM program, the Mission Valley Basin boundary was modified from the Bulletin 118 boundary. The modified boundary was agreed on between the DWR and the City to include portions of basin that were not in Bulletin 118. Selected monitoring area in the Mission Valley Basin extends beyond the Bulletin 118 boundary and includes the San Diego Formation Aquifer. The modified basin boundary includes an area of 15.6 square miles (9,951 acres) and is identified as Groundwater Basin Number 9-14 in the DWR Bulletin 118 (DWR, 2003). The basin is bounded by the contacts of alluvium with the semi-permeable San Diego and Poway Formations and the impermeable Lindavista Formation. The southwestern boundary is the San Diego Bay.

3.3.2.1 Groundwater Basin Characteristics

Geologic units in the Mission Valley Basin include Quaternary alluvium and the San Diego Formation. The principle water-bearing deposit in the basin is the Quaternary age alluvium. Quaternary age alluvium consists of medium to coarse-grained sand and gravel. This alluvium has an average thickness of about 80 feet and a maximum thickness of about 100 feet. The average well yield is about 1,000 gpm. The San Diego Formation is found in this basin and thickens westward across the Rose Canyon fault. The San Diego Formation is generally less than 100 feet thick east of the Rose Canyon fault system, reaching a maximum thickness of about 1,000 feet west of the Rose Canyon fault. The effect of this fault on groundwater movement is unknown.

Estimated storage capacity of the basin ranges from 40,000 af (SDCWA, 1997) to 42,000 af (DWR, 1975); with an estimated basin safe yield of 6,700 af (SDCWA, 1995). Approximate sustainable yield of the basin is 2,000 to 4,000 afy (City of San Diego, 2009). Average groundwater production is reported to be 807 afy (MWDSC, 2007).

Historically, the primary recharge to the alluvial aquifer was infiltration of streamflow from the San Diego River.

The Mission Valley Basin, located in the central region of San Diego, is a basin of interest. This basin is being studied to determine the feasibility of pumping and desalinating the groundwater using reverse osmosis. Desalinated water would be conveyed to the potable distribution system. The primary constituents of concerns in the basin include magnesium and sulfate for domestic use and TDS and chloride with high concentrations both for domestic and irrigation use (DWR, 2003). The water quality in this basin has been also negatively impacted due to petroleum products having been discharged by an adjacent storage facility since 1986. In 1992, a clean-up order was issued by the Regional Water Quality Control Board. Joint efforts by the USGS and the City are underway to collect and analyze groundwater data to estimate water supply potential of the basin. The City has conceptual plans to develop groundwater in the most favorable part of the basin; however, it is in the most favorable part of the basin that the contamination has occurred and remediation is ongoing. The most prudent course of action for the City is to let the discharger complete the remediation before any development occurs in this portion of the basin.

3.3.3 San Diego River Valley (Santee - El Monte) Groundwater Basin

The San Diego River Valley Groundwater Basin (San Diego River Valley Basin) is commonly known in San Diego as the Santee-El Monte Basin (Santee through El Monte Basin). The extent of the groundwater basin in the San Diego River Valley Basin is actually four separate but connected basins and from west-to-east they are named the: Santee Basin, Lakeside Basin, Moreno Valley Basin and El Monte Basin. San Diego River Valley Basin is located in the eastern portion of the greater San Diego metropolitan area (Figure – Appendix B). The San Vicente and El Capitan Reservoirs are located at the eastern and northern edges of the basin, respectively (SDCWA, 2001). During the preparation of the City's CASGEM program, the San Diego River Valley Basin boundary was modified from the Bulletin 118 boundary. The modified boundary was agreed on between the DWR and the City to include portions of basin that were not in Bulletin 118. The modified basin boundary includes an area of 13.8 square miles (8,818 acres), and is identified as Groundwater Basin Number 9-15 in the DWR Bulletin 118 (DWR, 2003). The basin is comprised of commingling alluvial valleys of the San Diego River, San Vicente Creek, Forester Creek, Los Coaches Creek, and Sycamore Canyon Creek (SDCWA, 2001). The California Supreme Court decreed in 1930 that the City has Pueblo Water Rights to all of the water (surface and underground) of the San Diego River including its tributaries, from its source to its mouth.

The San Diego River Valley Basin is currently used as a source of groundwater by local residents of Helix Water District (WD), Lakeside WD, Riverview WD, and historically used as a source of groundwater by the City (SDCWA, 2001). Given the presence of multiple water service districts in the basin, the local water agencies have a collective interest in the groundwater study, monitoring, protection, and management of the groundwater resources of the basin. Currently, Padre Dam Municipal WD is evaluating the potential for additional development and management of the resources of the basin.

3.3.3.1 Groundwater Basin Characteristics

In the San Diego River Valley Basin, four hydrogeologic units are defined on the basis of water-bearing characteristics: the Quaternary alluvium deposits, unweathered fractured plutonic and metamorphic rocks, residuum, and Eocene sedimentary rocks. Unweathered fractured plutonic and metamorphic rocks, residuum, and Eocene sedimentary rock lie adjacent to and underlie the alluvium. No geologic faults of major significance are present in the basin (SDCWA, 1995).

The alluvial aquifer represents the primary geologic unit for groundwater storage and development based on its favorable hydraulic properties (SDCWA, 2001). Geologic units other than the alluvium yield water to domestic wells in many areas, but these units are not generally considered to be significant source for municipal supply due to the limited storage capacity and permeability, and variable well yields (SDCWA, 1997). Hydraulic communication between the fractured rock system and alluvium appears to exist, but conflicting evidence is presented regarding the degree of hydraulic communication (DWR, 1955, Black and Veatch, 1994, SDCWA, 2001).

As the primary source of water supply, the Quaternary alluvium deposits consist of unconsolidated river and stream deposits of gravel, sand, silt, and clay, occupying a southwesterly trending valley about 13 miles long and 1,500 feet to 5,000 feet wide. The alluvium has a thickness of exceeding 200 feet near Lakeside and 150 feet east of Moreno Valley and thins to the west, typically about 70 feet thick. The alluvial aquifer in the San Diego River Valley consists of younger alluvial deposits (Holocene age) and underlain by older alluvial fill (Pleistocene age). The older alluvial fill composed of gravel, sand, silt, and clay is very similar to younger alluvium, with the exception that it is generally thicker and has been partly cemented and weathered and contains more frequent lenses of coarse sand and gravel.

In the alluvium aquifer, the most productive materials are buried river channels and a layer of coarse gravels near the base of the aquifer east of Moreno Valley (Izbicki, 1985). Groundwater in the alluvium is unconfined, with estimates of specific yield ranging from 0.05 for partly cemented sands and silts to 0.22 for clean sands. Well yields may exceed 2,000 gpm and average more than 500 gpm. In general, well yields are less in shallower parts of the alluvial aquifer west of the basin, but at least one well in this area yields more than 1,000 gpm. Transmissivities may exceed 5,000 ft^2/day. Similar to the Mission Valley Basin, well yields are less in the older alluvial fill than in younger alluvial fill and groundwater tends to move freely between the older and younger units.

Estimated aquifer storage of the alluvial aquifer is 55,000 af based on a USGS study (Izbicki, 1985), compared to the previous estimates ranging from 24,000 af (Kimble, 1934) to 97,000 af (DWR, 1975).

Historically, the primary recharge to the alluvial aquifer has been stream flow in the San Diego River and San Vicente Creek. Natural recharge from these surface water bodies has been greatly altered by construction of water supply reservoirs upstream of the alluvial aquifer.

Movement of groundwater is from the major source recharge, which is the San Diego River below El Capitan Dam, and from smaller recharge areas in Moreno Valley, downgradient to the discharge area near Mission Gorge. With the exception of transpiration losses, all water entering the alluvial aquifer discharges to the San Diego River at Mission Gorge. Water levels in the 1940s declined significantly and continued to decline through 1960s. By the late 1950s, groundwater levels were as much as 50 feet below land surface, compared to a few feet prior to groundwater development. In general, groundwater drawdown was less in the western parts of the aquifer than in the eastern (Izbicki, 1985).

The San Diego River Valley Basin has experienced increasing concentrations of TDS over time. Historically, the alluvium aquifer had TDS concentrations exceeding 1,000 mg/l, as high as 2,990 mg/l (Izbicki, 1985). The study conducted by USGS, in coordination with SDCWA and DWR, evaluated the feasibility of reclaimed water use in this basin for improving groundwater quality by pumping poor quality groundwater and replacing it with reclaimed water that has lower dissolved solids concentrations (Izbicki, 1985). The study indicated that reclaimed water use plans may be feasible in the western part of the aquifer.

3.3.4 El Cajon Valley Groundwater Basin

The El Cajon Valley Groundwater Basin (El Cajon Valley Basin) lies in the south central part of San Diego County (Figure 1 – Appendix B). During the preparation of the City's CASGEM program, the El Cajon Valley Basin boundary was modified from the Bulletin 118 boundary. The modified boundary was agreed on between the DWR and the City to include portions of basin that were not in Bulletin 118. The modified basin boundary includes an area of 2.7 square miles (1,752s acres) and is identified as Groundwater Basin 9-16 by DWR Bulletin 118 (DWR, 2003). The basin is bounded by impermeable crystalline rocks on the south and east, by semi-permeable older Tertiary sedimentary rocks on the west, and by the San Diego River Valley Basin on the north. Surface waters drain northwestward to the San Diego River.

3.3.4.1 Groundwater Basin Characteristics

Water-bearing materials in the El Cajon Valley Basin include Pleistocene age alluvium, the Eocene age Poway Conglomerate, and an older, an underlying sandy siltstone unit (DWR, 1986). In addition, water is produced from the underlying fractured crystalline rocks. Total thickness of valley fill ranges to about 350 feet (DWR 1986). An average specific yield for this basin is about 5 percent (DWR 1986).

Pleistocene age alluvium ranges to 50 feet thick and consists of gravel, sand, and silt (DWR 1967; 1986). Wells in this unit yield as much as 250 gpm (DWR 1986). The Eocene age Poway Conglomerate consists of sandy conglomerate and conglomeratic sandstone with some interbeds of sand and shale (DWR 1986), with a thickness of more than 300 feet thick (DWR 1986). A sandy siltstone to mudstone unit underlying the Poway Conglomerate reaches a maximum of about 325 feet thick (DWR 1986). This unit bears some water, but wells typically yield less than 5 gpm.

The total capacity of the basin is estimated to be about 32,500 af (DWR 1986). Groundwater in storage was previously estimated to be about 27,800 af (DWR 1986).

Groundwater in the basin moves northwestward towards the San Diego River (DWR 1986). The dominant source of natural recharge to the basin is from percolation of precipitation, with lesser contributions from underflow from underlying fractured crystalline rocks (DWR 1986). Additional recharge comes from return of applied irrigation water and percolation of septic tank effluent DWR 1986).

The primary constituents of concerns in the basin include TDS, chloride, and nitrate. Groundwater is generally of sodium chloride character (DWR 1967; 1986). Historical water quality data showed TDS concentrations ranging from 637 to 3,960 mg/l with a mean value of

1,640 mg/l (DWR 1986); nitrate concentrations ranging to 185 mg/l with a mean concentration of 69 mg/l, chloride concentrations ranging from 186 to 1,910 mg/l with a mean of 412 mg/l, and sulfate concentrations of 78 to 680 mg/l with a mean of 345 mg/l (DWR 1986).

3.3.5 Sweetwater Valley Groundwater Basin

The Sweetwater Valley Groundwater Basin (Sweetwater Valley Basin) is located adjacent the Pacific coast in southwestern San Diego County, situated south of the Mission Valley Basin and north of the Otay Valley Groundwater Basin (Figure 1 – Appendix B). The western boundary is the San Diego Bay. The basin underlies an alluvial valley that empties into the San Diego Bay. During the preparation of the City's CASGEM program, the Sweetwater Valley Basin boundary was modified from the Bulletin 118 boundary. The modified boundary was agreed on between the DWR and the City to include portions of basin that were not in Bulletin 118. The Sweetwater Valley with a modified basin boundary includes a surface area of 42.3 square miles (27,060 acres), and is identified as Groundwater Basin Number 9-17 in the DWR Bulletin 118 (DWR, 2003).

3.3.5.1 Groundwater Basin Characteristics

Water-bearing formations in the Sweetwater Valley Basin include the Quaternary alluvium and the Pliocene age San Diego Formation. Impermeable basement rocks have limited significance in terms of groundwater storage. The La Nacion fault zone trends north and northwest and crosses the eastern part of the basin, but does not appear to create a barrier to groundwater movement (DWR 1986).

The most permeable water-bearing deposit in the basin is Quaternary alluvium, which consists of unconsolidated stream deposits of sandy silt, sand, and cobbles. This unit is the principal source of groundwater in the basin with an estimated average thickness of 80 feet (SDCWA 1997) to 100 feet (USACOE 1982) and specific yields ranging from 10 to 12 percent (DWR 1986). Groundwater in these deposits is unconfined, and wells produce an average yield of about 300 gpm (SDCWA 1997).

Groundwater is also produced from the San Diego Formation that is slightly to moderately consolidated and characterized by a wide range of textures. Sediments range from clay to gravel, and include well-sorted medium to coarse sand, silty sand, and clayey sand (Huntley and others 1996). The San Diego Formation reaches 800 feet thick based on borehole data (Huntley and others 1996), but SDCWA (1997) estimates that the average thickness is about 700 feet and the maximum thickness may exceed 2,000 feet. Well yields are as high as 1500 gpm (Huntley et. al., 1996), with an average well yield of about 500 gpm (SDCWA, 1997). The San Diego Formation is typically characterized as a confined aquifer (SDCWA, 1997). The top of the underlying Otay Formation is probably acting as a deep basal confining layer, due to thick clay at the geologic contact. The upper part of the San Diego Formation aquifer may have relatively low stratigraphic confinement, inasmuch as the near surface sediments (above the water table) are mostly relatively pervious sand and gravel, similar to the sediments below the water table. The site stratigraphy suggests there may be some unconfined aquifer behavior in the upper part of the aquifer (URS, 2012). The basin is reported to have a mean storage coefficient of about 0.001 (SDCWA, 1997). Based on data from the recently installed monitoring well Mt. Hope MW-1 by the City, T ranges approximately from 5,200 ft^2/day to 5,600 ft^2/day (CDM, 2007).

Groundwater storage capacity was estimated at 13,000 af in the Quaternary alluvium and about 960,000 af in the San Diego Formation, suggesting a total storage capacity of about 973,000 af for this basin (SDCWA, 1997). DWR (1986) estimated that between 17,000 and 20,000 af of groundwater was in storage.

Recharge in the basin is derived from the runoff of seasonal precipitation in the upper reaches of the Sweetwater River Valley, discharge from the Sweetwater Reservoir, and underflow from the reservoir. Subsurface flow may also contribute recharge (DWR, 1986). Annual groundwater production was estimated at 900 afy from the Quaternary alluvium and about 2,000 afy from the San Diego Formation (SDCWA, 1997).

Groundwater level data showed that the groundwater surface in the early 1980s was relatively stable, and higher than in the years preceding 1959. This is attributed to decreased groundwater pumping due to the importation of Colorado River water (USACOE, 1982). A study by the Sweetwater Authority indicates that water levels in production wells near National City have remained stable since about 1957 (Garrod, 2001). Groundwater flow follows surface flow of the Sweetwater River (DWR, 1986).

The Sweetwater Valley Basin has TDS, chloride and sodium content generally exceeding the recommended limits for drinking (DWR, 1986). Historical data indicate TDS concentrations ranging from 300 mg/l to more than 50,000 mg/l in the alluvium and ranging from 600 mg/l to 1,600 mg/l in the San Diego Formation (USACOE, 1982). Based on water quality data measured in 2007 from the City's recently installed monitoring well (Mt. Hope MW-1), TDS and chloride concentrations were 555 mg/l and 149 mg/l, respectively (CDM, 2007).

3.3.6 Otay Valley Groundwater Basin

The Otay Valley Groundwater Basin (Otay Valley Basin) is located adjacent the Pacific Ocean in southwestern San Diego County (Figure 1 – Appendix B). During the preparation of the City's CASGEM program, the Otay Valley Basin boundary was modified from the Bulletin 118 boundary. The modified boundary was agreed on between the DWR and the City to include portions of basin that were not in Bulletin 118. The modified basin boundary includes a surface area of 16.1 square miles (10,281 acres), and is identified as Groundwater Basin Number 9-18 in the DWR Bulletin 118 (DWR, 2003). The Otay River flows east to west through the valley toward the ocean, and numerous small lakes and ponds exist along the river's course (DWR 1986). The basin is bounded on the east by the San Ysidro Mountains, on the north and south by semi-permeable marine deposits, and on the west by the Pacific Ocean.

3.3.6.1 Groundwater Basin Characteristics

The primary water bearing units in this area consist of the Quaternary alluvium, the Pliocene to Pleistocene age San Diego and the Miocene to Pliocene age Otay Formations. The alluvium yields water freely to wells that may discharge as much as 300 gpm. However, the alluvium is too thin to be considered a viable aquifer because the thickness is not more than 50 feet (DWR, 1986).

Coarse deposits within the San Diego Formation form the primary water-bearing materials in the basin (DWR, 1986; SDCWA, 1997). The formation is regional in extent and forms some of the most productive deposits in the Tijuana, Sweetwater Valley, and Mission Valley Groundwater Basins. The San Diego Formation consists of slightly- to moderately-consolidated, medium to coarse sand, silty sand, and clayey sand (Huntley et. al., 1996). These deposits generally thicken westward from about 100 feet east of La Nacion fault zone to as much as 1,400 feet near Tijuana (Huntley et. al., 1996), and average about 800 feet thick west of La Nacion fault zone that crosses the basin from north to south (SDCWA, 1997). Well yields range from 150 to 400 gpm (DWR, 1986), though wells in the same formation yield as much as 1,500 gpm (Huntley et. al., 1996). The average specific yield for this formation is approximately 10 percent.

The Otay Formation has not been extensively developed. These deposits consist of sand that is weakly cemented and moderately permeable layered within finer materials (Huntley et. al., 1996). The few wells drilled into this deposit yield from 10 to 50 gpm (DWR, 1986).

The basin receives groundwater recharge from percolation of precipitation, stream-flow originating in the valley highlands, return of applied water, and rare releases from the Lower Otay Reservoir during flood conditions.

The primary constituents of concerns in groundwater include TDS and chloride. Groundwater in the coastal plain part of this basin had TDS ranging from about 500 mg/l to more than 2,000 mg/l (DWR, 1967). Historical data show concentration of TDS in the San Diego Formation ranging from 342 mg/l to about 12,000 mg/l throughout the region (SDCWA, 1997).

3.3.7 Tijuana Groundwater Basin

The Tijuana Groundwater Basin (Tijuana Basin) is located in the southwest corner of San Diego County along the Mexico border (Figure 1 – Appendix B). During the preparation of the City's CASGEM program, the Tijuana Basin boundary was modified from the Bulletin 118 boundary. The modified boundary was agreed on between the DWR and the City to include portions of basin that were not in Bulletin 118. The modified basin boundary includes a surface area of approximately 12.3 square miles (7,858 acres), and is defined as Groundwater Basin Number 9-19 in the DWR Bulletin 118 (DWR, 2003). The Tijuana Basin underlies the portion of the Tijuana River Valley that lies within California. The basin's southern boundary is the international border with Mexico; the eastern and northern boundaries are the contacts with semi-permeable marine deposits; and the western boundary is the Pacific Ocean. The La Nacion fault and several other smaller faults cross the Tijuana Basin (Izbicki, 1985).

The City is currently examining the feasibility of using the lower Tijuana River Valley alluvial aquifer and underlying San Diego Formation as a potential aquifer storage and recovery system to seasonally store recycled water during the wet season, and extract the recycled water from the ground and distribute it to meet maximum day demands during the warmer, drier season (Dudek, 2011). The study evaluated the additional storage capacity in the alluvial and San Diego Formation and the feasibility of injecting and extracting recycled water in these two formations. The source of recycled water is from the City of San Diego South Bay Water Reclamation Plant (SBWRP), located near the international border between the U.S. and Mexico. The injection and recovery of recycled water from the San Diego Formation is not considered feasible based on the relatively low hydraulic conductivity and T found in this formation. This investigation focused on the eastern portion of the alluvium formation where the depth to water table is greater than 10 feet below ground surface (bgs) (Dudek, 2011). In the western portion, water table is typically less than 10 feet bgs and extraction and recovery of recycled water may be of concern due to historical pumping that led seawater intrusion and degradation of water quality in the western basin.

Tijuana Basin has a GWP adopted in 1995 by Tijuana Valley County WD, in accordance with procedures by California AB 3030 (Dudek and Associates, 1995).

3.3.7.1 Groundwater Basin Characteristics

The water bearing units in the Tijuana Basin are the Quaternary age alluvium and the San Diego Formation (DWR, 2003). The marine deposits overlying the San Diego Formation can also be water bearing and do not yield water to wells as these deposits are generally less than 25 feet think and frequently above the regional groundwater surface (Izbicki, 1985).

The Tijuana River has deposited alluvium along its stretch from the City of Tijuana westward to the Pacific Ocean. The alluvium is the most productive unit, consisting of river and stream deposits of gravel, sand, silt, and clay, covering approximately 7.4 square miles in the river valley (Dudek, 2011). As reported in the DWR Bulletin 118, the thickness of the alluvium is less than 150 feet and averages about 80 feet thick. The alluvial aquifer is divided into two separate hydrostratigraphic units: the upper silty sand unit and the lower sand and gravel unit. The upper silty sand unit of the alluvial aquifer is characterized by loose to medium dense, olive gray to olive brown, sandy silty to silty fine to medium sand interbedded with clay and some thin gravel lenses (Woodward-Clyde Consultants, 1994). The lower sand and gravel unit of the alluvial aquifer is characterized by very dense, well-graded with silt and sand that graded downward to poorly graded gravel with sand (Woodward-Clyde Consultants, 1994). Based on driller's information, the principal water-yielding zone of the alluvial aquifer is the lower sand and gravel unit (Izbicki, 1985). Many agricultural wells in the valley were completed in the upper silty sand unit and the lower sand and gravel unit (Dudek, 2011). Based on driller's information, estimated well yields in the alluvial aquifer may exceed 2,000 gpm and average 550 gpm (Izbicki, 1985) to 1000 gpm (SDCWA, 1997). Transmissivity was estimated at 3,800 ft^2/day, compared to a higher T value of the lower sand and gravel unit estimated at 7,500 ft^2/day (Dudek, 2011). Groundwater in this unit is unconfined and the specific yield is about 15 percent (SDCWA, 1997). Specific capacities for wells screened in the lower sand and gravel unit were found typically twice the specific capacities for wells completed in the upper silty sand unit of the alluvial aquifer.

Underlying the alluvium is the San Diego Formation consisting of Pliocene age well-sorted medium to coarse sand, silty and clayey sand, sandy silt, and sandy clay (Huntley and others 1996). Thickness of this unit is at least 1,700 feet in the basin. Well yields range from 60 gpm to 1,000 gpm with an average of about 350 gpm, based on well driller's information (Izbicki, 1985). Aquifer and drawdown tests conducted in this unit indicated low hydraulic conductivity and T estimates and the inability to sustain high pumping rates (e.g., 150 gpm) for more than a few hours (Dudek, 1997). Groundwater in this unit is confined with a storage coefficient of about 0.001 (SDCWA, 1997).

Recharge to the basin is mainly from the Tijuana River and controlled releases from the Barrett and Morena Reservoirs in San Diego County and Rodriguez Reservoir in Mexico. Recharge to the alluvial aquifer originates primarily outside the basin as flow in the Tijuana River. In a typical year, all flow in the river becomes groundwater recharge (Izbicki, 1985). In a wet year considerable potential recharge leaves the basin as stream flow and is discharged to the Pacific Ocean (Izbicki, 1985). Irrigation accounts for more than one third of the recharge in the basin (DWR, 2006). Some applied irrigation water recharge the basin by deep percolation and discharges from septic tanks also contribute to recharge.

Groundwater storage capacity was estimated to be about 50,000 af to 80,000 af for the alluvial aquifer for the part of the U.S. and 137,000 af for the entire alluvial aquifer (DWR, 1975). SDCWA reports about 1,500 afy of groundwater is pumped from the alluvium and extraction data for the San Diego Formation are not available.

Movement of groundwater is from the major source of recharge, the Tijuana River near the international border, downgradient to the discharge area east of the basin toward the Pacific Ocean (Izbicki, 1985). Water levels declined in the alluvial aquifer during the 1950s through the early 1970s, as a result of extensive groundwater development, eventually reversing the historical westward groundwater flow. By the early 1950s water levels were below sea level in parts of the alluvial aquifer. Maximum water level drawdown throughout the aquifer occurred in the early 1960s. This reversal allowed seawater to infiltrate the alluvial aquifer and move eastward, degrading the groundwater quality and the productivity of agriculture in the western part of the valley. Changes in pumping in the 1970s allowed water levels to rebound. By the early 1990s, groundwater had resumed its historical flow direction (Dudek and Associates, 1994). Groundwater elevations measured in the alluvial aquifer since the 1990s indicated a westward groundwater flow direction from the international border to the Pacific Ocean (Dudek, 2011). The alluvial aquifer monitoring well network shows that groundwater elevations were above mean seal level in 2008 (Dudek, 2011).

Groundwater quality in the basin is generally poor; however some deeper wells yield water of good quality from partly consolidated sediments (Izbicki, 1985). Concerns of constituents in the alluvium aquifer include TDS, chloride, sulfate, and occasionally nitrate (Izbicki, 1985). A study conducted by the USGS, in coordination with SDCWA and DWR, evaluated the feasibility of improving groundwater quality and replacing it with reclaimed water that has lower dissolved solid concentrations (Izbicki, 1985). The study indicated reclaimed water use plans may be feasible, providing seawater intrusion can be controlled.

Section 4: Rationale for Monitoring Plan

This section discusses the selection of existing wells recommended for monitoring. Discussions include the hydrogeological rationale used for well selections, spatial density, and frequency of monitoring.

4.1 Well Network Design

DWR (2010b) provides some guidance for designing a monitoring well network, but gives no recommendations. Monitoring wells can be constructed in grids, at randomly selected points, or to target certain aquifer zones or hydrologically important locations. The CASGEM Program objective is to collect data at locations where collectively they could be beneficial to support the determination of natural seasonal or artificial groundwater elevation trends, storage, and gradient (flow direction). Hence, the primary rationale is to have a monitoring network of wells to represent a groundwater basin or adjacent basins in terms of temporal variability in water levels and to determine spatial groundwater flow directions (gradient). Where possible, selected wells in individual and adjacent basins have sufficient spacing such that groundwater contours can be constructed based on locations and historical trends.

This project targets existing and near-term planned wells and therefore the exercise to design a monitoring well network is largely unnecessary. Future existing or new wells added to the network may be needed based on the upcoming data collection and groundwater elevations. Where future wells may be necessary, they should be located such that water levels would not be significantly affected by nearby pumping, wells are accessible, and only the regional aquifer is being measured.

4.1.1 Monitoring Well Spatial Density

Selected monitoring wells in Table 2 (Appendix A) were considered based on their geographic spacing relative to each other to assess groundwater gradient in the regional aquifer system. Future focus on enhancing spatial density of data will be in basins that currently have only one designated monitoring point.

As an example for assessment of regional gradient, the San Pasqual Basin averaged horizontal gradient is about 20-foot vertical change per one mile distance or 0.004 foot/foot. The six well sites proposed in San Pasqual in this work plan are no more than three (3) miles apart, providing current and new data to be analyzed for horizontal gradient as well as temporal trends representative of the aquifer in the basin.

DWR (2010b) provides quantitative measures of monitoring well density, with recommended spatial densities ranging from about 2 to 10 monitoring wells per 100 square miles. The approximate areas of the seven hydrologic basins are listed below, along with the range of wells considered appropriate based on the above DWR recommended densities.

Groundwater Basin	Area (mi^2)	No. of Proposed Wells
San Pasqual Valley	5.50	6
Mission Valley	15.6	2
San Diego River Valley	13.8	4
El Cajon Valley	2.70	1
Sweetwater Valley	42.3	1
Otay Valley	16.1	1
Tijuana	12.3	1
Total CASGEM Network Wells	108.3	16

In general, wells should not be located too close together, nor should they be located exceedingly close to the edges of the basins or to surface water bodies such as rivers and lakes. The monitoring wells included in this plan were selected based on their best known locations to neighboring wells. The utility of all wells were researched plus information related to their proximity to natural basin boundaries, manmade surface water bodies, recharge basins, and production wells were compiled in a project-well-database. The wells in the database were mapped in a GIS that was used to assist in avoiding inclusion of monitoring wells that are close to the above boundaries. Qualitative information such as recharge history of basins and groundwater productions were gathered from groundwater reports to assess minimum distances from boundaries for each selected well.

4.1.2 Monitoring Frequency

In general, the monitoring wells targeted in this monitoring well network avoid shallow groundwater and are not near active pumping wells. The climatic regime of coastal California is bi-seasonal with most rainfall occurring in the winter, and little rainfall throughout most of the rest of the year. Therefore, *semi-annual monitoring is deemed appropriate* for the wells to be monitored. Water levels should be measured in the fall during November, before the winter wet period, and in the spring during May, right after the wet season. This will capture both the theoretical lowest and highest water levels in the basins.

DWR (2010b) also discusses the frequency with which water level measurements should be taken. Soundings should be recorded at least semi-annually, unless conditions within the basins being monitored dictate more frequent measurements. Reasons for increasing the frequency of monitoring include large withdrawals, rapid recharge, and shallowness of the aquifer, highly conductive aquifer materials, and variable climate conditions.

4.2 Selected Monitoring Wells

Selected monitoring wells listed in Table 2 (Appendix A) and depicted in Figure 6 (Appendix B) are for inclusion in the current CASGEM network. The following sections described the selected wells in each of the seven basins.

4.2.1 San Pasqual Valley Basin – Selected Monitoring Wells

Six monitoring wells are selected to represent the San Pasqual Valley groundwater basin (Figure 6 – Appendix B).

The San Pasqual monitoring well SP073/35A1 is the furthest east monitoring location for collection of upgradient water level measurements.

About 1.8 miles west is the second selected monitoring well Santa Ysabel (SDSY) (012S001W34L004S). The shallow piezometer in this multi-level well will be used for the CASGEM Program.

About 2.7 miles downgradient is the third monitoring well SP107/32M3 for collection of water levels in the middle of the sinuous basin. This well was monitored by the USGS in the past from the 1960s to early 1970s.

The fourth selected well site in this basin is the USGS Cloverdale (SDCD) well (012S001W30J005S). This well is located about 4,500 feet north of third monitoring well SP107/32M3 and was constructed early 2013. The shallow piezometer in this multi-level well will be used for the CASGEM program.

The fifth selected monitoring well site is the Lake Hodges (SDLH) well (013S002W12M003S). This well is located about 2.6 miles southwest of selected well SP107/32M3. The fifth selected well is now the westernmost data point in the current CASGEM program for the San Pasqual Basin. The shallow piezometer in this multi-level well will be used for the CASGEM Program.

The sixth selected monitoring well is the Pinery well located about 0.55 mile from the fifth selected well Lake Hodges (SDLH).

4.2.2 San Diego River Valley Basin (Santee - El Monte Basin) – Selected Monitoring Wells

Four monitoring wells are currently selected to represent the San Diego River Valley Basin (Figure 6 – Appendix B). Three monitoring points represent the main east and central portions of the basin and one well represents the northern extension of the basin where it connects to the middle of the main basin.

The easternmost monitoring point is well HWD-2 selected for an upgradient water level collection. In the middle of the basin, the selected wells include the Confluence monitoring well and the Marilla monitoring well, located about two and a half (2.5) and three and a half (3.5) miles, respectively, west and downgradient from HWD-2. Northwest of HWD-2 is the selected AMW-1 monitoring well located about three miles upgradient at the northern tip of the north-extension of the main groundwater basin.

These four monitoring wells will be joined by a fifth monitoring point (well) to be located in the western extent of the basin where the existing wells MW-1, 2, 4, 5, and 7 are located. Wells in this area are operated by the San Diego County Water Authority (SDCWA). The City is currently requesting information from the SDCWA and will assess their potential inclusion in the CASGEM Program.

4.2.3 Mission Valley Basin – Selected Monitoring Wells

Two monitoring wells are selected to represent the east-west trending elongate Mission Valley Basin (Figure 6 – Appendix B). Selected monitoring well Aqua Culture (SDAQ) (016S002W18J007S) is located in the eastern half of the basin to collect upgradient water levels. Selected monitoring well YMCA (2) located 3.7 miles west of the Aqua Culture (SDAQ) well will represent downgradient water levels. It is noted that there is an inactive YMCA production well located close to the monitoring well YMCA (2).

These two wells can represent the entire basin in water level trends and flow gradient. It is noted that all monitoring wells in this basin are close to the river because of the narrow basin configuration (i.e., the paleo-channel) of the San Diego River. There are currently no identifiable wells in the large southwestern portion of this groundwater basin. City staff will continue its effort to locate existing monitoring wells that could be appropriate for the CASGEM Program and will report findings to DWR in the future.

4.2.4 Sweetwater Valley Basin – Selected Monitoring Wells

A monitoring well, Naval Base (SDNB) (017S002W20F005S), is selected to collect data in the Sweetwater Valley Basin in the CASGEM Program (Figure 6 – Appendix B). The shallowest well (screened at 20 feet to 25 feet below ground surface, bgs) will be used for the CASGEM Program.

The Naval Base (SDNB) well is located in the center of the Sweetwater Valley Basin. The three monitoring points in the Sweetwater Valley Basin, Otay Valley Basin, Tijuana Basin, and the monitoring well in the adjacent Mission Valley Basin on the north is currently intended to provide sufficient water level data to represent trends and gradient in two groundwater basins combined.

It is the City's intention that other monitoring wells in this groundwater basin will be evaluated in the future to assess their conditions, screen depths, and groundwater levels. The City will then decide on their inclusion in the CASGEM Program to provide additional information to aid in characterizing groundwater flow gradients and potentially contouring groundwater levels.

4.2.5 Otay Valley Basin – Selected Monitoring Wells

A monitoring well Otay Trolley (SDOT) (018S002W22E007S) is selected to collect data in the Otay Valley Basin in the CASGEM Program (Figure 6 – Appendix B). The well screened at 45 feet to 65 feet bgs is currently under USGS oversight.

Because this well is located in the southern portion of the County, the potable groundwater depths are greater than those in the north (e.g., shallower groundwater in the San Pasqual Valley).

It is the City's intention that other monitoring wells in this groundwater basin will be evaluated in the future to assess their conditions, screen depths, and groundwater levels. The City will then decide on their inclusion in the CAGSEM Program to provide additional information to aid in characterizing groundwater flow gradients and potentially contouring groundwater levels.

4.2.6 Tijuana Basin – Selected Monitoring Wells

A monitoring well Boundary Waters (SDBW) (019S002W02C0011S) is selected to collect data in the Tijuana Basin (Figure 6 – Appendix B). This well is screened at 260 feet to 280 feet bgs which is most likely monitoring the shallowest potable groundwater zone of the San Diego Formation in this southern portion of the County. Currently, this monitoring well is the shallowest well identified in the basin for monitoring groundwater conditions of the water-bearing units.

It is the City's intention that other monitoring wells in this groundwater basin will be evaluated in 2013 to assess their conditions, screen depths, and groundwater levels. The City will then decide on their inclusion in the CASGEM Program to provide additional information to aid in characterizing groundwater flow gradients and potentially contouring groundwater levels.

4.2.7 El Cajon Valley Basin – Selected Monitoring Well

The ECV-1 well (16S001W11R004S) is registered in the DWR Water Data Library and will be used for the CASGEM Program (Figure 6 – Appendix B).

Section 5: Monitoring Well Information

This section discusses the information required in this monitoring plan, subsequent updates, and regular data submittals to DWR. Available State Well Number of a well (Table 2-Appendix A) is retained to identify a selected monitoring well. Alternatively, an existing well designation (well name) is also used in Table 2 (Appendix A) to identify a selected monitoring well based on a local well name. Since the wells included in the monitoring network are mostly made up of wells owned by other public agencies, their existing designations are retained for ease of reference. Ground water data will be provided by other agencies to the City for CASGEM groundwater level submittals.

Under the DWR (2010a) guidelines, each well must have a unique identifier. DWR provides few rules in their guidelines that would restrict how well designations are constructed, except that they must be 15 characters or less, should avoid specific information referring to private owners or locations, and should not be so common as to be likely to be duplicated by other wells (e.g., MW-1).

5.1 Spatial Coordinates

Spatial coordinates for most of the wells included in Table 2 (Appendix A), and shown on Figures 1 through 6 (Appendix B) are based on coordinates received from the well owning agency or monitoring entity. Only the selected wells in Table 2 (Appendix A) are included in preparing this monitoring network; these well locations are surveyed and existing coordinates are verified by the owners or users of the monitoring wells.

5.2 Land Surface and Reference Point Elevations

Only a small percentage of wells have available land surface elevation information. Land surveys will be performed for monitoring wells with no site coordinates and are selected for the program (Table 2 –Appendix A). Reference point (RP) elevations relative to land surface will be determined during well location surveying.

Because most of the wells are owned by public agencies, having water levels measured regularly, these wells have established RP locations. Where the elevation of the reference point is not currently known or accurately known (e.g., due to unknown land surface elevation, minor changes in land surface elevation due to subsidence and hence inaccurate RP elevation). It shall be determined based on a well visit if the RP elevation needs to be surveyed (see Sections 6.1 and 6.2). The monitoring entity which is the City or a designated representative will perform the survey.

Establishment of RPs for wells in the current monitoring network was professionally surveyed by high precision GPS or by optical land surveys to obtain precise horizontal and vertical control data. Future wells will be surveyed in the same manner. If possible, the RP shall be flush with the top of the well lid or well vault, on the highest side or due north, punch marked and spray painted. All water level measurements will be made from this RP.

5.3 Well Type and Well Owner

Of the 16 wells currently selected for monitoring in Table 2 (Appendix A), the ownership of all the selected wells are known. In addition, the well 016S001W11R004S identified in El Cajon Valley is registered in the DWR Water Data Library. All 16 wells are known to be monitoring wells.

5.4 Well Construction Data

Of the 16 wells currently selected for monitoring in Table 2 (Appendix A), four wells remain with unknown screen intervals - SP107/32M3, Pinery, ECV-1, and YMCA (2). With the recent video survey by DWR staff, SP073/35A1 has screen intervals at 103-123 feet and 163-183 feet. Screen intervals for SP107/32M3 were not visible when the video survey was conducted. Well construction data for the well 016S001W11R004S (ECV-1) identified in El Cajon Valley with DWR registration in the Water Data Library is currently unknown.

Section 6: Field Methods for Groundwater Monitoring

6.1 Introduction

This guideline describes the field procedure that will be followed by City of San Diego when measuring groundwater levels in monitoring wells for the CASGEM Program. Following these guidelines help ensure that groundwater level measurements are accurate and consistent among the monitoring wells included in the CASGEM Program. The City's CASGEM Program currently includes only monitoring wells. Therefore, this guideline is prepared for water levels measurements from monitoring wells.

6.2 Well Coordinates

Well location coordinates for the selected monitoring wells are submitted to the DWR in the CASGEM online portal. High precision or optical land surveys of the horizontal locations for wells included in this and future updates of the monitoring program will provide the best possible comparability between water level measurements collected at different locations and times.

DWR (2010b) provided guidelines for the coordinate systems to be used in locating the well; with horizontal coordinates in decimal degrees, referenced to the North American Datum of 1983 (NAD83). The vertical elevation should be in feet, referenced to the North American Vertical Datum of 1988 (NAVD88).

6.3 Reference Point and Land Surface Elevation

Establishment of RPs for wells in the current monitoring network was professionally surveyed by high precision GPS or by optical land surveys to obtain precise vertical control data. Future wells will be surveyed in the same manner. Reference point elevations are updated in the DWR CASGEM web portal. Establishment of a consistent reference point (RP) location is important for comparability between different water level measurements at the same well.

If possible, the RP shall be flush with the top of the well lid or well vault, on the highest side or due north, punch marked and spray painted. DWR (2010b) recommends that a clearly labeled photograph of the reference point be produced for each well.

All water level measurements will be made from the RP. In the absence of unanticipated access restrictions, water levels will be measured from the RP of a well casing or sounding tube. Where this is not possible, a detailed description of the reference point used will be recorded so that the RP can be used for comparison with previous measurements. If the marker of the permanent RP is lost or rendered unviable, the RP used during that monitoring event will be marked and a survey will be conducted to reestablish that rim elevation as the permanent RP.

The horizontal and vertical coordinates of the RP should be surveyed (see Section 6.1). In addition, the land surface datum should be surveyed. DWR (2010b) recommends re-measuring the distance between the RP and land surface datum every 3 to 5 years to account for changes in the land surface.

6.4 Static Water Level

The water level collected should be confirmed to be representative of the regional static water level. If possible, it should not be affected by pumping in or near the monitored well. If the water level in the well to be measured is affected by pumping, measurement should be delayed until such time as the water level returns to a static level. If this is not possible (for example, because some nearby well is heavily relied-upon for water supply), the occurrence of pumping should be noted on the field forms. If known, the time since the last pumping in the area should also be noted, even if the water level has rebounded to its static level.

No selected monitoring wells are screened across multiple water-bearing zones. Currently, wells Santa Ysabel (SDSY), Aqua Culture (SDAQ), and Naval Base (SDNB) are recommended for monitoring of the shallowest screens. This is to ensure data collection of the most representative regional water level and to ascertain which paired wells are representative of regional data and the eventual elimination of one screen.

In the encounter that certain wells may be screened across multiple water-bearing zones, the regional water level is likely below one of the zones (i.e. that zone is perched), water may drip or cascade down the side of the well casing above the regional water level. Without proper precautions, this may lead to erroneous readings as an electronic sounding tape reacts to this water. If cascading water is suspected, the guidelines in DWR Groundwater Elevation Monitoring Guidelines (Guidelines for Measuring Water Levels) should be followed, and the presence of cascading water should be noted on the field form.

6.5 Detailed Field Method: Depth to Water Table

DWR (2010b) provides detailed guidelines for measuring water levels in wells for the CASGEM Program. The following step-by-step field procedures for sounding of water levels are consistent with the DWR Groundwater Elevation Monitoring Guidelines (Field Guidelines for CASGEM Water-Level Measurements).

An electric sounding tape is preferred for water level measurements because of its ease of use. The electric sounder used should be inspected before use to ensure that it is properly functioning and providing accurate measurements.

6.5.1 Equipment

- Electronic water level monitoring probe or other measuring device
- Decontamination supplies (e.g., buckets, Alconox, distilled water, squirt bottle)
- Groundwater Level Data Form (Appendix D)
- Field notebook
- Keys for locks (if necessary)
- Tools to open well covers (e.g., socket wrench, spanner wrench); and

- Disposable gloves (as a minimum), and other protective clothing (as necessary).

6.5.2 General Procedure

1. Static groundwater level measurements shall be conducted at each monitoring well to an accuracy of one-hundredth of a foot (0.01 foot). The depth to groundwater will be measured to the nearest 0.01 foot from the reference point (RP) at the top of casing using an electronic water level meter. The water level meter will be decontaminated prior to the initial use for each event and rinsed with clean water between well locations. The depth to water will be measured three (3) times to ensure that the water level readings are the same (i.e., the water level has stabilized). In cases where the water level continues to rise or drop very slowly, the groundwater will be allowed to stabilize and a measurement will be taken until two consecutive readings are in agreement, if feasible.

2. Remove well caps from all wells prior to initiation of water level measurement activities. This will allow water levels in the wells to equilibrate, if necessary.

   Well caps are commonly used in monitoring wells to prevent the introduction of foreign materials to the well casing. There are two general types of well caps, vented and unvented. Vented well caps allow air movement between the atmosphere and the well casing. Unvented well caps provide an airtight seal between the atmosphere and the well casing.

   In most cases it is preferred to use vented well caps because the movement of air between the atmosphere and the well casing is necessary for normal water level fluctuation in the well. If the cap is not vented the fluctuation of groundwater levels in the well will cause increased or decreased air pressure in the column of air trapped above the water in the casing. The trapped air can prevent free movement of the water in the casing and potentially impact the water level that is measured. Vented caps will allow both air and liquids into the casing so they should not be used for wells where flooding with surface water is anticipated or contamination is likely from surface sources near the well.

   Unvented well caps seal the top of the well casing and prevent both air and liquid from getting into the well. They are necessary in areas where it is anticipated that the well will be flooded from surface water sources or where contamination is likely if the casing is not sealed. Because the air above the water in the casing is trapped in the casing and cannot equalize with the atmospheric pressure, normal water level fluctuation may be impeded. When measuring a well with an unvented cap it is necessary to remove the cap and wait for the water level to stabilize. The wait time will vary with many different factors, but if several sequential water-level measurements yield the same value it can be assumed the water level has stabilized (consistent with DWR Guideline 2010a,b).

3. If the potential exists for floating product (i.e. non aqueous phase) to be present, use an electric oil-water interface probe or oil-sensitive paper to measure depth of the floating product and the electronic depth probe to measure the depth-to-water. Record both depths in field notebook and note the water depth as the "depth with oil layer present." Unless

otherwise instructed, always measure depths to floating product layer and groundwater from the RP of the well casing.

4. When floating product is not present, measure depth-to-water using a pre-cleaned water level probe from the RP of the well casing.

5. Repeat measurements a minimum of three times or have field partner confirm measurement.

6. Record time of day the measurement was taken using military time (e.g., 16:00).

7. Decontaminate water level and/or oil-water interface probe and line prior to reuse in another well.

6.5.3 Electric Sounding Tape Method

Electric sounding tape method will be typically used for water level measurements. Step-by-step field guideline for this method is prepared following the method described in the DWR Groundwater Elevation Guidelines (DWR, 2010).

Before making a measurement:

1. Inspect the electric sounding tape and electrode probe before using it in the field. Check the tape for wear, kinks, frayed electrical connections and possible stretch; the cable jacket tends to be subject to wear and tear. Test that the battery and replacement batteries are fully charged.

2. Check the distance from the electrode probe’s sensor to the nearest foot marker on the tape, to ensure that this distance puts the sensor at the zero foot point for the tape. If it does not, a correction must be applied to all depth-to-water measurements. Record this in an equipment log book and on the field form.

3. Prepare the field forms and place any previous measured water-level data for the well into the field folder.

4. After reaching the field site, check that the RP is clearly marked on the well and is accurately described in the well file or field folder. If a new RP needs to be established, follow the procedures above.

5. Check the circuitry of the electric sounding tape before lowering the electrode probe into the well. To determine proper functioning of the tape mechanism, dip the electrode probe into tap water and observe whether the indicator needle, light, and/or beeper (collectively termed the “indicator” in this document) indicate a closed circuit. For an electric sounding tape with multiple indicators (sound and light, for instance), confirm that the indicators operate simultaneously. If they do not operate simultaneously, determine which is the most accurate and use that one.

6. Wipe off the electrode probe and the lower 5 to 10 feet of the tape with a disinfectant wipe, rinse with de-ionized or tap water, and dry.

Making a measurement:

1. If the water level was measured previously at the well, use the previous measurement(s) to estimate the length of tape that should be lowered into the well. Preferably, use measurements that were obtained during the same season of the year.

2. Lower the electrode probe slowly into the well until the indicator shows that the circuit is closed and contact with the water surface is made. Avoid letting the tape rub across the top of the well casing. Place the tip or nail of the index finger on the insulated wire at the RP and read the depth to water to the nearest 0.01 foot. Record this value in the column labeled "Tape at RP", with the appropriate measurement method code and the date and time of the measurement (see Table 5 - Appendix A).

3. Lift the electrode probe slowly up a few feet and make a second measurement by repeating step 2 and record the second measurement with the time in the row below the first measurement in the Depth Measurement Log (Appendix D). Make all readings using the same deflection point on the indicator scale, light intensity, or sound so that water levels will be consistent between measurements. If the second measurement does not agree with the first measurement within 0.02 of a foot, make a third measurement, recording this measurement with the time in the row below the second measurement. If more than two readings are taken, record the average of all reasonable readings.

After making a measurement:

1. Wipe down the electrode probe and the section of the tape that was submerged in the well water, using a disinfectant wipe and rinse thoroughly with de-ionized or tap water. Dry the tape and probe and rewind the tape onto the tape reel. Do not rewind or otherwise store a dirty or wet tape.

Section 7: Data Reporting for Groundwater Levels

DWR (2010a) provides details on the reporting of groundwater levels collected as part of the CASGEM Program. As part of the program, data should be submitted to DWR via their online system, located at http://www.water.ca.gov/groundwater/casgem/submittal_system.cfm. DWR recommends that data be submitted as soon as possible after the measurements are taken, with annual deadlines of January 1 and July 1. With the recommended monitoring frequency (see Section 4.1.2) of twice a year, in the fall (November) and spring (May), it is reasonable for the City to collect all semi-annual measurements from the network of monitoring wells and within two months process the data and upload them to the DWR web site. The following subsection discusses what information is required and recommended by DWR to be uploaded to the online system for the wells and the water level measurements.

7.1 Online Data Submittal

Data are submitted online using the hyperlink provided above. A variety of data are required or recommended for data submittal.

7.1.1 Information of the City's Responsible Party

- The name, address, phone number, contact name, contact e-mail, and any other contact information of City staff;
- The name, address, phone number, e-mail address, and any other contact information for any separate entities that collect data for the City; and
- The groundwater basins monitored (including an indication of which basins are fully monitored by the City and which are only partially monitored).

7.1.2 Information Required for Each Well

- A unique well identification number (can be the State Well Number, if available);
- Latitude and longitude of the well, as well as the method used to determine them (for privacy of well owners, false coordinates within 1,000 feet of the actual coordinates may be submitted);
- The groundwater basin or sub-basin in which the well is located;
- The elevation of the reference point;
- The elevation of the Land Surface Datum;
- The use of the well;
- The well completion type;

- The depth of the screened interval(s) and the total depth of the well; and
- The Well Completion Report number.

7.1.3 Information for Each Groundwater Elevation Data Point

- The unique well identification number for the well provided by the Monitoring Entity;
- The date of the measurement;
- The reference point elevation of the well, in feet;
- The Land Surface Datum elevation of the well, in feet;
- The depth to water below the reference point, in feet;
- The method of measuring the depth to water (e.g. electric sounding tape, pressure transducer);
- Measurement Quality Codes;
- No Measurement Code, if applicable;
- Questionable Measurement Code, if applicable;
- The measuring agency;
- The time of the measurement; and
- Any applicable comments about the well and measurements.

7.1.4 Measurement Quality

- “No Measurement”, and “Questionable Measurement” will have standard codes available on the online system. These codes will allow for the reporting of issues that could affect the quality of a measurement, such as pumping at a nearby well, obstructions present in the well casing, or the presence of oil on the water surface within the well.

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Appendix A: Tables

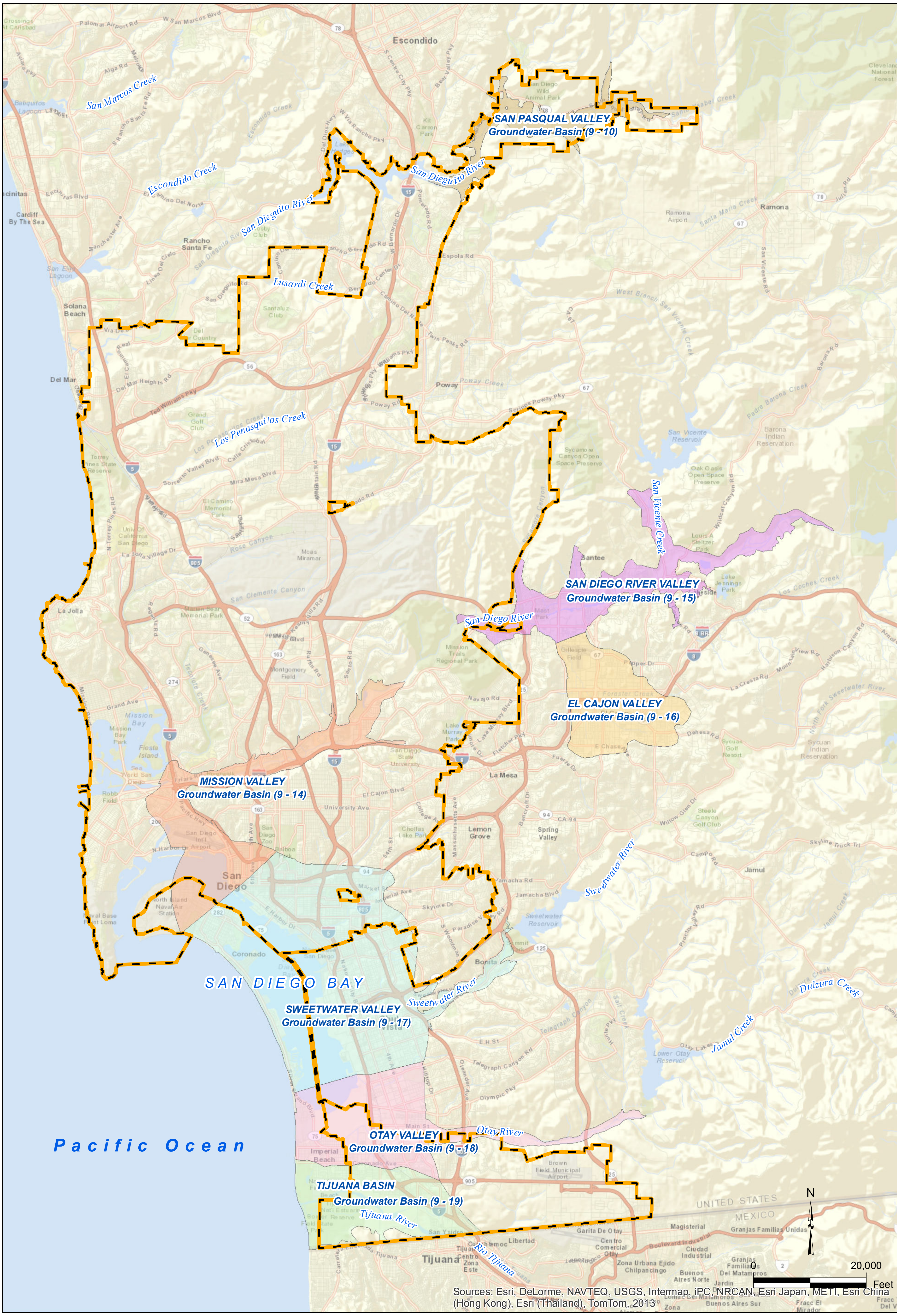
Table 1: Groundwater Basin Characteristics

Groundwater Basin (Bulletin 118)	Primary Aquifers (green) /Formations	Approximate Groundwater Depths (feet BGS)	Approximate Thickness
San Pasqual Valley	**Alluvium** – primary aquifer with high well yields; mostly unconfined conditions.	6 to 50	0 to over 200 ft; avg. 150 ft
	Crystalline rocks – yields small quantities of water from fractures		Basement complex
	Residual – yields a small quantity of water that can be important locally; thickness of about 100 feet.		100± ft, variable
Mission Valley	**Alluvium** – primary aquifer with high well yields; mostly unconfined conditions.	10 to 70	80 to 100 ft
	San Diego Formation – primary aquifer with relatively high well yields.	100 to 600	< 100 to max 1,000 ft
San Diego River Valley	**Alluvium** – primary aquifer with high well yields; thickness from 150 feet to over 200 feet; mostly unconfined conditions.	10 to 40	>200 ft
	Poway Group – yields variable quantities of water, but much less than the alluvial aquifer.		1,000 ft
	Crystalline rocks – yields small quantities of water from fractures.		Basement complex
El Cajon Valley	**Alluvium** – yields relatively significant quantities of water.		50 ft
	Poway Group – yields relatively significant quantities of water.		>300 ft
	Sandy siltstone unit – yields small quantities of water.		325 ft
	Crystalline rocks – yields small quantities of water from fractures.		Basement complex
Sweetwater Valley	**Alluvium** – principle source of groundwater; unconfined conditions.	10 to 70	80 ft
	San Diego Formation – yields significant quantities of water; confined conditions.		700-800 ft; max. 2,000 ft
Otay Valley	**Alluvium** – yields small quantities; too thin as a viable aquifer.		50 ft
	San Diego Formation – principle source of water with high yields.	10 to 70	800 ft
	Otay Formation – yields small quantities of water.		Unknown
Tijuana Basin	**Alluvium** – primary aquifer with high well yields; thickness exceeding 150 feet;	10 to 70	150± ft
	Marine terrace deposits – permeable but generally above regional water table		300 ft
	San Diego Formation – primary aquifer with relatively high well yields.	100 to 600	1,250 ft
Note: Highlighted rows represent aquifers/formations that are considered principal water source.			

Table 2: Selected Wells for Monitoring Plan

State Well ID	#	Well Name	Owner	User	Well Location	Groundwater Basin	Primary Water Supply Zone (Thickness)	Primary Water Supply Aquifer	Well Type	Installed Date	Screen Depths (ft) (Selected in red)	Comments
	1	SP073 / 35A1	County of San Diego	City of San Diego	Witman Ranch, near City/County border	San Pasqual Valley		Alluvium	Monitoring	unknown	**103 – 123** **163 – 183**	Video survey conducted by DWR staff
012S001W34L004S	2	Santa Ysabel (SDSY)	City of San Diego	USGS	Witman Ranch	San Pasqual Valley	100 <> 200	Alluvium	Monitoring	1/06/2011	**70 – 90**	
	3	SP107 / 32M3	AMSOD	City of San Diego	AMSOD	San Pasqual Valley		Alluvium	Monitoring	Unknown	**undetermined**	Video survey conducted by DWR staff
012S001W30J005S	4	Cloverdale (SDCD)	City of San Diego	USGS	South of SR-78, southeast of Cloverdale Bridge	San Pasqual Valley		Alluvium	Monitoring	Spring 2013	**30-50**	
013S002W12M003S	5	Lake Hodges (SDLH)	City of San Diego	USGS	Western end of basin, approx. 1000' north of San Dieguito River	San Pasqual Valley		Alluvium	Monitoring	Fall 2012	**30-50**	
	6	Pinery	The Pinery	The Pinery	The Pinery	San Pasqual Valley		Alluvium	Monitoring	unknown	**unknown**	
	1	HWD-2	Helix Water District	Helix Water District	South of Willow Rd., approx. 0.5 mile east of Stelzer County Park	San Diego River Valley (Santee)	>200	Alluvium	Monitoring	2008	**6 – 95**	
	2	AMW-1	SDCWA	SDCWA	Approx. 600 feet south of San Vicente Dam	San Diego River Valley (Santee)	>200	Alluvium	Monitoring	5/2/2008	**30 – 70**	
	3	Confluence	City of San Diego	City of San Diego	East side of Channel Rd., Lakeside, in Anderson Drilling steel yard	San Diego River Valley (Santee)	>200	Alluvium	Monitoring	6/7/2010	**18 – 38**	
	4	Marilla	City of San Diego	City of San Diego	Vacant lot north of Woodside Ave., east of Marilla Dr. in Lakeside	San Diego River Valley (Santee)			Monitoring	5/21/2010	**15 – 35**	
016S001W11R004S	1	ECV-1	Villa Las Palmas	City of San Diego	West of S. Anza St, north of E. Washington Ave (to be confirmed)	El Cajon Valley	-	-	Monitoring	Unknown	**Unknown**	No info available from facility
016S002W18J007S	1	Aqua Culture SDAQ	City of San Diego	USGS	North side of Camino Del Rio North, between I-805 & I-15	Mission Valley	220	Alluvium	Monitoring	11/22/2004	**30 – 50**	Most wells in Mission Valley are near the San Diego River
	2	YMCA (2)	City of San Diego	City of San Diego	South of YMCA parking lot	Mission Valley	220	Alluvium	Monitoring	unknown	**unknown**	Need blockage cleared
017S002W20F005S	1	Naval Base (SDNB)	Sweetwater Authority	USGS	Between I-5 and W. Division St., north end of parking lot at 32nd St Naval Base	Sweetwater Valley	80 <> 100	San Diego Formation	Monitoring	7/24/2006	**20 – 25**	
018S002W22E007S	1	Otay Trolley (SDOT)	Sweetwater Authority	USGS	East of Hollister St., east of trolley tracks, north of Otay River	Otay Valley	below 50 feet; 100 to 1400 feet thick	San Diego Formation	Monitoring	3/15/2008	**45 – 65**	
019S002W02C011S	1	Boundary Waters (SDBW)	City of San Diego	USGS	IBWC parking lot, east side of Dairy Mart Rd.	Tijuana Basin	~150	Alluvium / San Diego Formation	Monitoring	6/13/1995	**260 – 280**	Established as continuous monitoring site 5/27/2007

Appendix B: Figures



Kennedy/Jenks Consultants

City of San Diego California Statewide
Groundwater Elevation Monitoring (CASGEM) Program

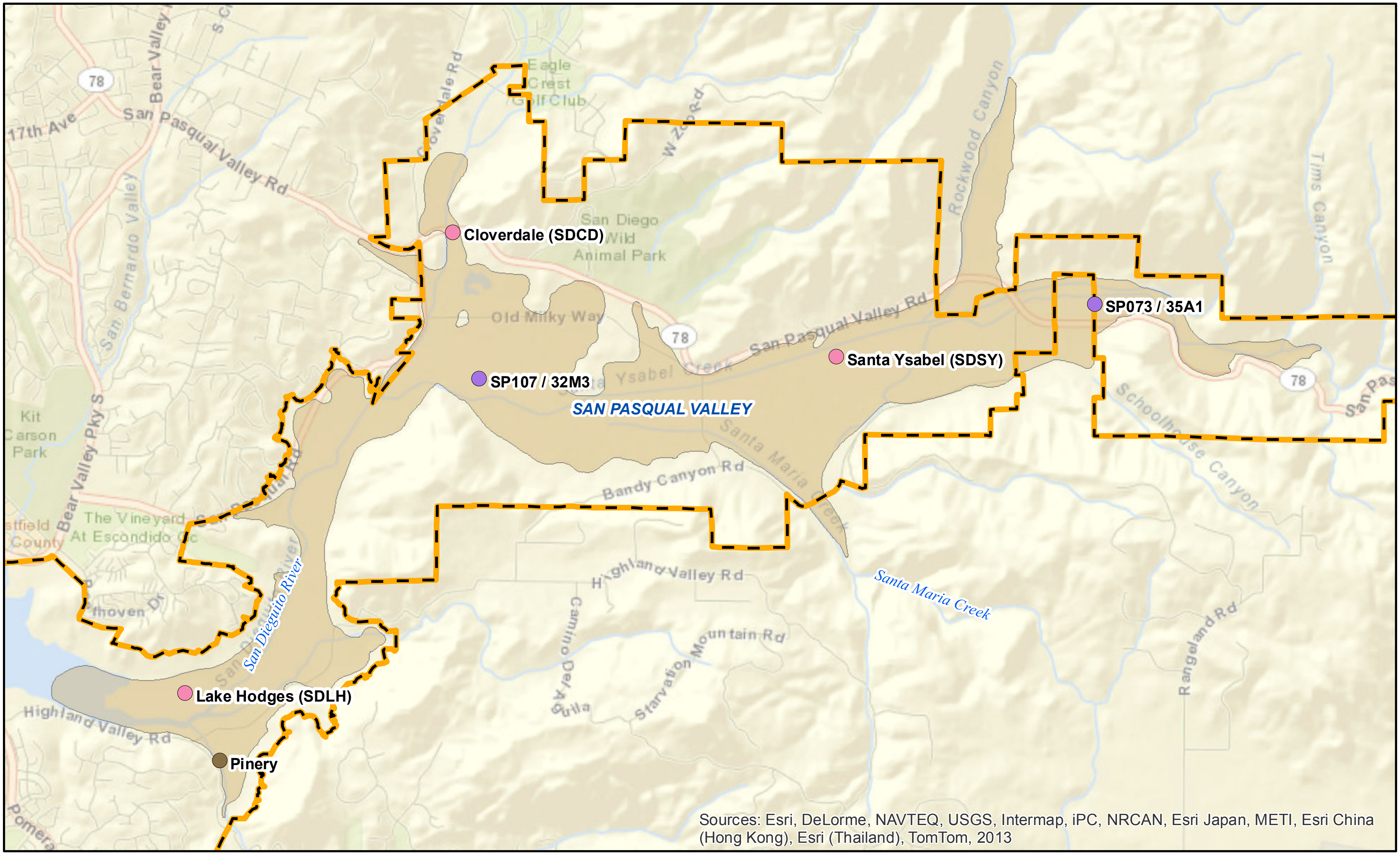
Regional Map

K/J 1187103*00
June 2013

Figure 1

Legend

San Diego City Boundary



Legend

Selected Wells

User

- City of San Diego
- The Pinery
- USGS

San Diego City Boundary

N

0 0.5 1 Miles

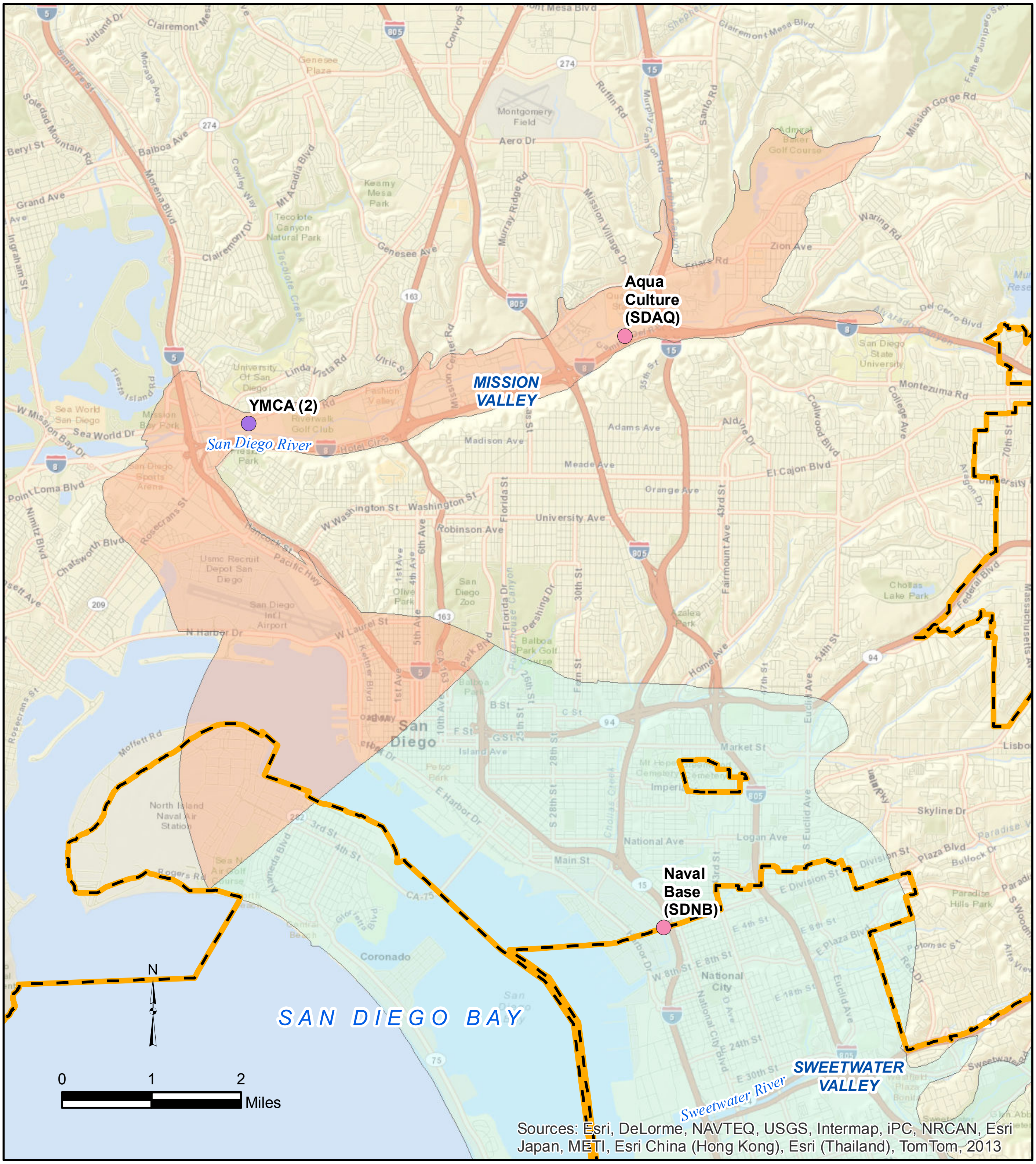
Kennedy/Jenks Consultants

City of San Diego California Statewide Groundwater Elevation Monitoring (CASGEM) Program

San Pasqual Valley Basin
Selected Well Locations

K/J 1187103*00
June 2013

Figure 2



Legend

Selected Wells

User

- City of San Diego
- USGS

San Diego City Boundary

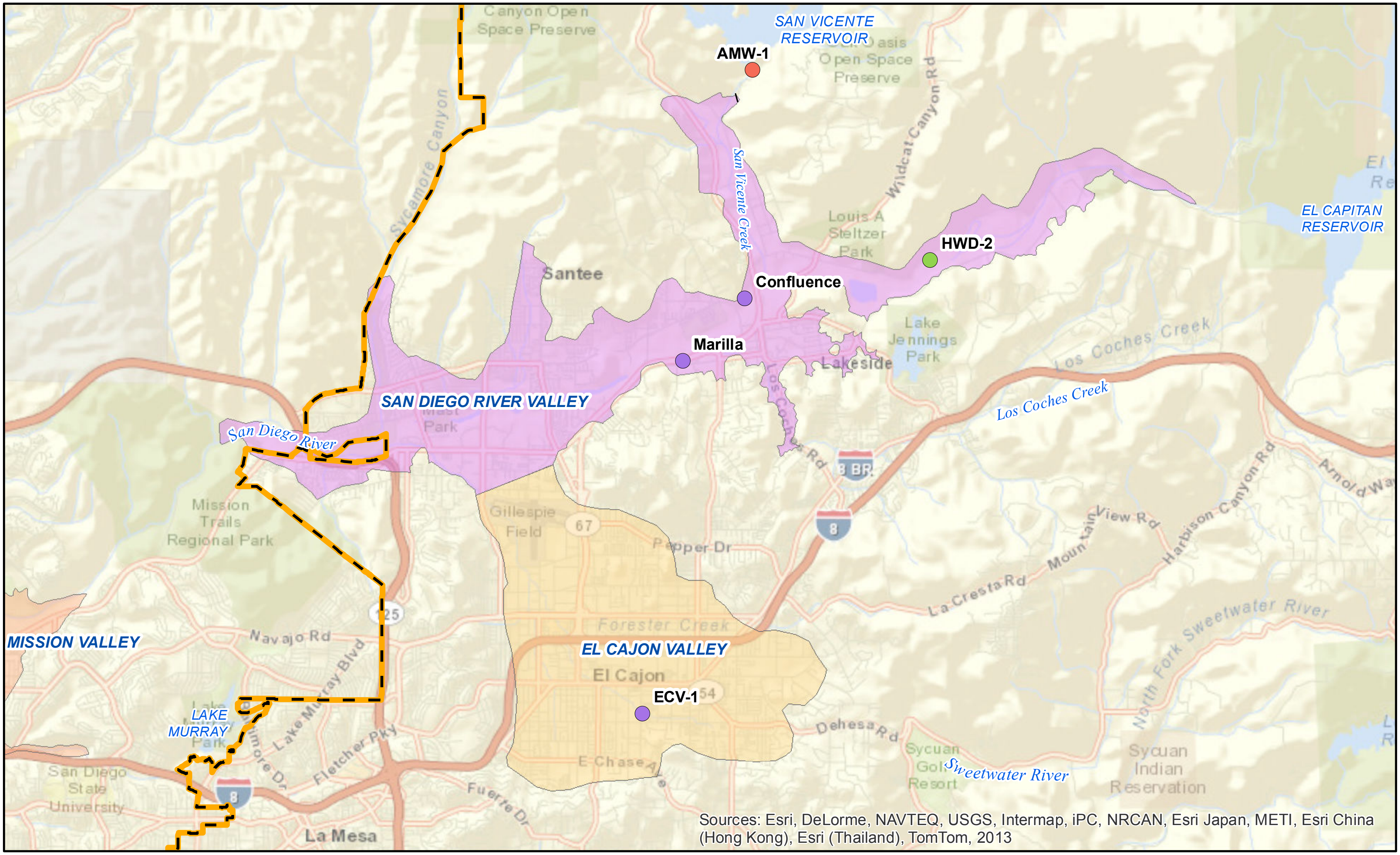
Kennedy/Jenks Consultants

City of San Diego California Statewide
Groundwater Elevation Monitoring (CASGEM) Program

Mission Valley Basin
Selected Well Locations

K/J 1187103*00
June 2013

Figure 3



Legend

Selected Wells

User

- City of San Diego
- Helix Water District
- San Diego County Water Authority

San Diego City Boundary

N

0 1 2 Miles

Kennedy/Jenks Consultants

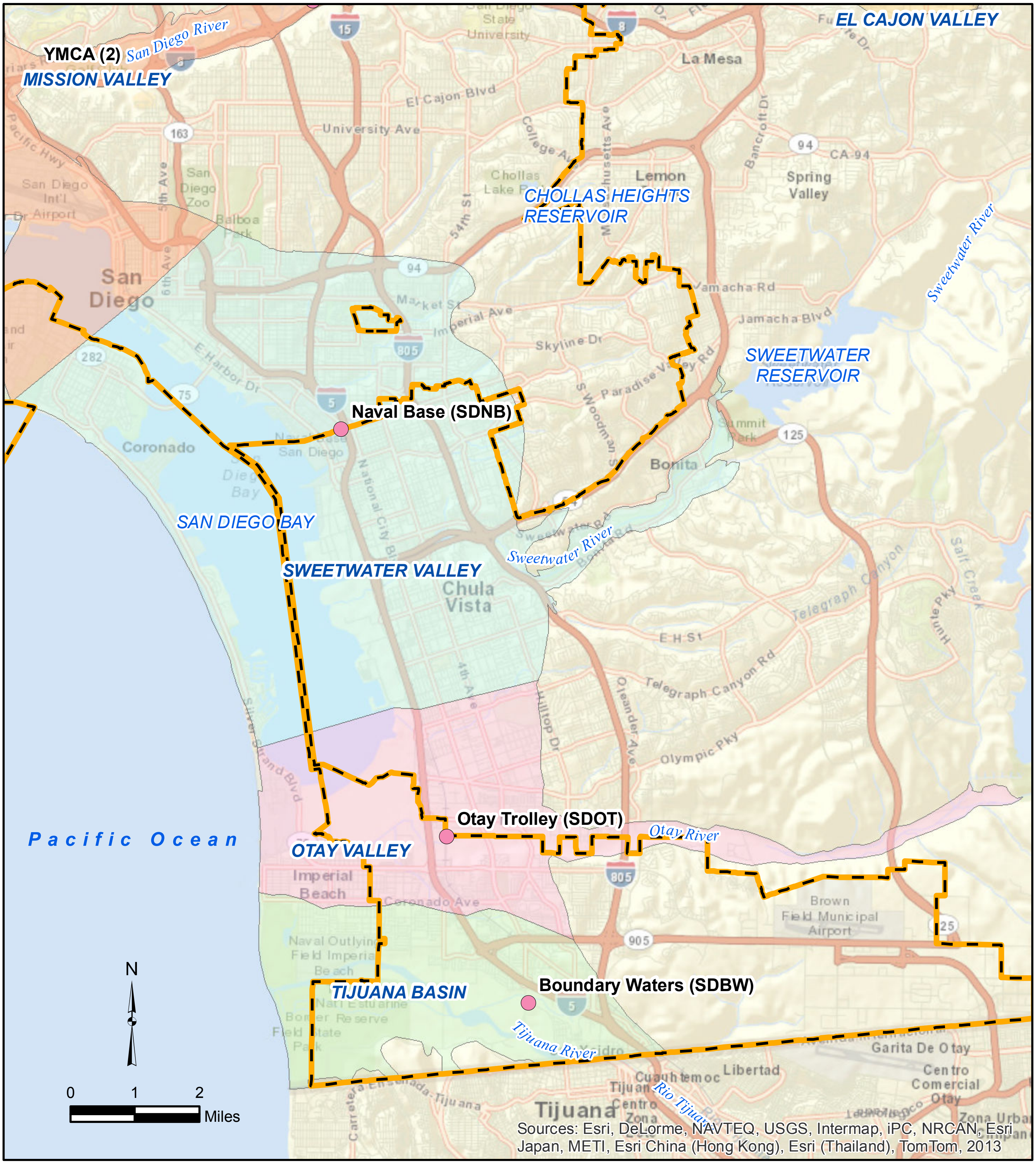
City of San Diego California Statewide Groundwater Elevation Monitoring (CASGEM) Program

San Diego River Valley Basin & El Cajon Basin Selected Well Locations

K/J 1187103*00

June 2013

Figure 4



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City of San Diego California Statewide Groundwater Elevation Monitoring (CASGEM) Program

Sweetwater Valley Basin, Otay Valley Basin & Tijuana Basin Selected Well Locations

K/J 1187103*00
June 2013

Figure 5

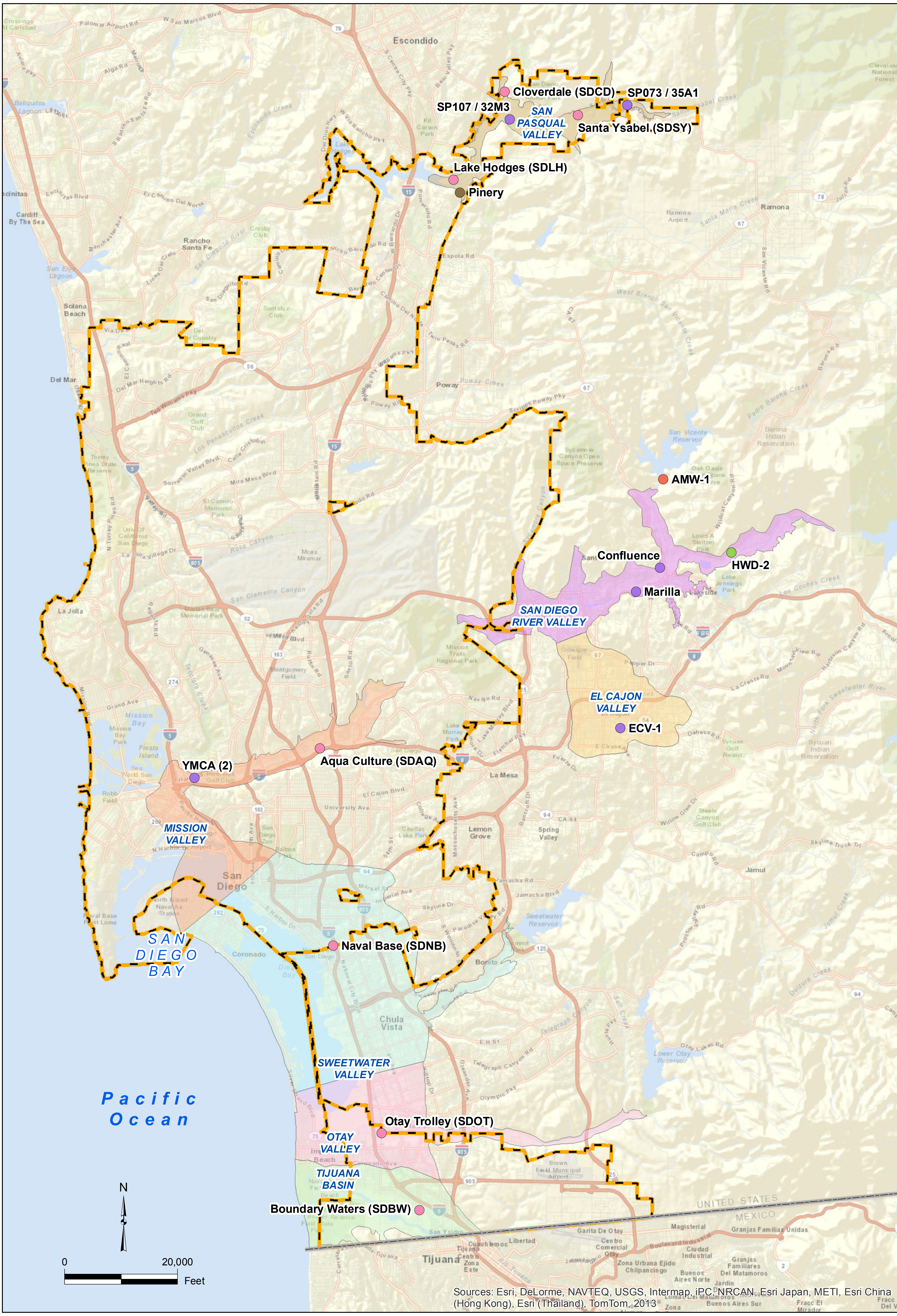
Legend

Existing Wells

San Diego City Boundary

User

USGS



Legend

Selected Wells

User

- San Diego County Water Authority
- City of San Diego
- Helix Water District
- The Pinery
- USGS
- San Diego City Boundary

Kennedy/Jenks Consultants

City of San Diego California Statewide Groundwater Elevation Monitoring (CASGEM) Program

Selected Well Locations

K/J 1187103*00
June 2013

Figure 6

Appendix C: Hydrogeologic Basin Descriptions

This section provides a brief description of the general hydrogeology and groundwater conditions for each of the seven DWR-designated basins in San Diego County.

1. San Pasqual Valley Groundwater Basin

The San Pasqual Valley Basin is located in the northeastern part of the City above Lake Hodges, and is predominately agricultural. There are three main geologic layers in the basin: Holocene alluvium (top), residuum, and crystalline bedrock. Of these, the bedrock can be considered non-water bearing. Although not enough information is available to make a full comparison between the alluvium and the residuum, the specific yield of the alluvium was reported to be sixteen times that of the residuum (Izbicki, 1983), indicating that the alluvium is likely the most important source of groundwater in the basin. Only the alluvium or alluvial aquifer is considered in Bulletin 118 to be part of the groundwater basin. The hydrogeologic data indicate that monitoring wells should be chosen that are not near active irrigation wells and are screened in the lower part of the alluvial aquifer.

2. Mission Valley Groundwater Basin

The Mission Valley Basin surrounds the San Diego River north of downtown San Diego, and extends to the San Diego Bay in the southwest. Of the two main geologic units in the basin (Quaternary alluvium, and the San Diego Formation), the alluvium is the principal water-bearing unit and should be targeted for monitoring. This groundwater basin has historically been used as a groundwater source to the City. In addition, wells were selected far enough from surface water bodies that are known to interact with groundwater so as not to simply reflect surface water levels.

3. San Diego River Valley Groundwater Basin

The San Diego River Valley Basin is located outside the eastern boundary of the City, surrounding the San Diego River and its tributaries, and begins just downstream of San Vicente and El Capitan Reservoirs. It has historically been used as a groundwater source to the City. Of the four main geologic units in the basin (Quaternary alluvium, unweathered fractured plutonic and metamorphic rocks, residuum, and Eocene sedimentary rocks), the alluvium is the principal water-bearing unit and should be targeted for monitoring. In addition, wells were selected far enough away from surface water bodies (e.g. the reservoirs and San Diego River) that are known to interact with groundwater so as not to simply produce a reflection of nearby surface water levels.

4. El Cajon Valley Groundwater Basin

The El Cajon Valley Basin is located outside the eastern boundary of the City, just south of the San Diego River Valley Basin. Of the main geologic units present in the basin (Pleistocene alluvium, Eocene Poway Conglomerate, and an older sandy siltstone unit), the Pleistocene alluvium produces the majority of groundwater, while the Poway Conglomerate produces an unknown amount and the underlying sandy siltstone yields a small amount of groundwater. Until the importance of the Poway Conglomerate is definitely known, it would be consistent with the intent of the CASGEM Program to monitor the alluvial aquifer in this groundwater basin. Major surface water bodies are not present in the basin, so distance from rivers and lakes need not be considered.

5. Sweetwater Valley Groundwater Basin

The Sweetwater Valley Basin is located along the Pacific coast just southeast of the Mission Valley Basin, and stretches up the Sweetwater River Valley to below Sweetwater Reservoir. Of the two main geologic units present in the basin (Quaternary alluvium and Pliocene San Diego Formation), the alluvium is the principal water-bearing deposit, although the San Diego Formation can produce up to 1,500 gallons per minute (gpm) (Huntley et al., 1996). Both units should be targeted for monitoring. Wells were targeted that are not so close to the Sweetwater River and the Pacific Ocean that they simply reflect the water level in these surface water bodies.

6. Otay Valley Groundwater Basin

The Otay Valley Basin is located along the Pacific coast just south of the Sweetwater Valley Basin, and is transected by the Otay River. Of the three main geologic units present in the basin (Quaternary alluvium, Pliocene to Pleistocene San Diego Formation, and Miocene to Pliocene Otay Formation), the San Diego Formation is the principal water-bearing unit, and should be targeted for monitoring. While the alluvium can produce significant groundwater, it is generally too thin to be an extensive aquifer (DWR, 1986). The Otay Formation has only a few wells completed in it, and they do not yield large discharge rates. Wells were not selected so close to the Otay River or Pacific Ocean that their water levels are simply reflections of water levels in surface water bodies.

7. Tijuana Groundwater Basin

The Tijuana Basin is located in the southwestern corner of the City, along the Pacific Ocean between the Otay Valley Basin to the north and Mexico to the south. The two main geologic units in the basin, the Quaternary alluvium and Pliocene San Diego Formation, are the primary water-bearing units, and should be targeted for monitoring. The Tijuana River runs northwest through the basin from the border with Mexico to the Pacific Ocean, and wells should be selected far enough away from the river and the ocean so that water levels in the wells are not simply reflections of water levels in the surface water bodies.

City of San Diego CASGEM Groundwater Head Measurements

GROUNDWATER LEVEL DATA FROM MANUAL MEASUREMENTS													
STATE WELL NUMBER	WELL NAME	DATE	TIME	NM	QM	MM	TAPE at RP	TAPE at WS	RP to WS	LSD to WS	OBS	MEASURING AGENCY	COMMENTS
	SP073/35A1												
012S001W34L004S	Santa Ysabel (SDSY)												
	SP107/32M3												
012S001W30J005S	Cloverdale (SDCD)												
013S002W12M003S	Lake Hodges (SDLH)												
	Pinery												
	HWD-2												
	AMW-1												
	Confluence												
	Marilla												
016S001W11R004S	ECV-1												
016S002W18J007S	Aqua Culture (SDAQ)												
	YMCA (2)												
017S002W20F005S	Naval Base (SDNB)												
018S002W22E007S	Otay Trolley (SDOT)												
019S002W02C011S	Boundary Waters (SDBW)												

NM: No Measurement; QM: Questionable Measurement; MM: Measurement Method; RP: Reference Point; WS: Water Surface; LSD: Land Surface Datum; OBS: Observation

NO MEASUREMENT (NM)		QUESTIONABLE MEASUREMENT (QM)		MEASUREMENT METHOD (MM)
0. Measurement discontinued	5. Unable to locate well	0. Caved or deepened	5. Air or pressure gauge measurement	0. Steel tape
1. Pumping	6. Well has been destroyed	1. Pumping	6. Other	1. Electric sounding tape
2. Pump house locked	7. Special	2. Nearby pump operating	7. Recharge operation at or nearby well	2. Transducer
3. Tape hung up	8. Casing leaky or wet	3. Casing leaky or wet	8. Oil in casing	3. Other
4. Can't get tape in casing	9. Temporarily inaccessible	4. Pumped recently		

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